THE VERTEBRATE FAUNAS OF THE PLIOCENE RINGOLD FORMATION, SOUTH-CENTRAL WASHINGTON

by

Eric Paul Gustafson

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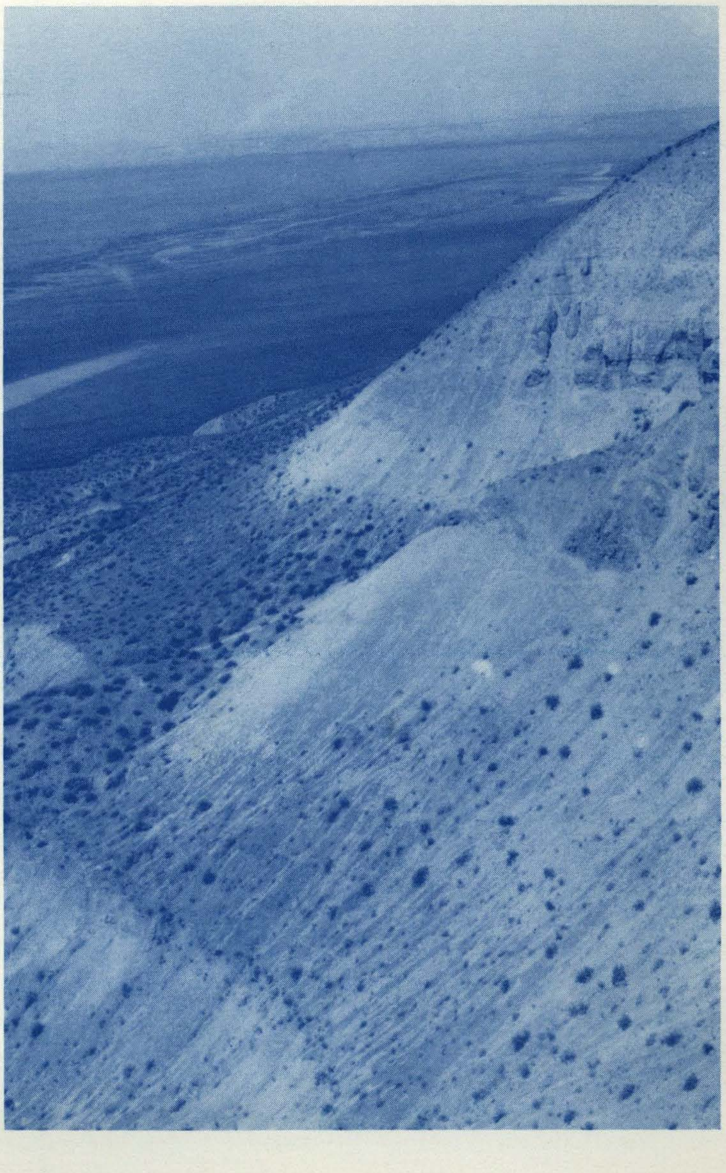

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Dedicated to the late Willis E. Fry, Dr. Claude W. Hibbard, and to my father, Dr. Paul V. Gustafson, all of whom should have lived to see the publication of this report.

The Vertebrate Faunas of the Pliocene Ringold Formation, South-Central Washington

by

ERIC PAUL GUSTAFSON

ABSTRACT

The vertebrate fauna of the upper Ringold Formation at the White Bluffs, south-central Washington, has been the subject of several short papers since its discovery in the late 19th century. Additional information from more recent collections, which include remains of many small mammals, expands the knowledge of this White Bluffs local fauna. A rhinoceros mandible from the lowest exposures provides evidence of a second, distinctly earlier fauna, the River Road local fauna.

Fossiliferous localities can be correlated by reference to two key beds, the White Bluffs tuff and the Taylor Flat conglomerate, both of which are widely exposed. Vertebrate fossils are most commonly preserved in stream channel conglomerates and less frequently in silt deposits.

The White Bluffs local fauna includes three genera of fresh-water snails, two genera of fish (*Ictalurus* and *Archoplites*), unidentified anuran amphibians and small reptiles, two or three genera of turtles (*Clemmys*, *Chrysemys*?, and possibly *Testudo*), and 25 genera of mammals. Among the mammalian genera are a mole (*Scapanus*), two leporids (*Hypolagus* and *Nekrolagus*), nine rodents (*Paenemarmota* or *Marmota*, *Spermophilus*?, *Ammospermophilus*, *Thomomys*, *Castor*, *Dipoides*, *Peromyscus*, *Neotoma*, and *Ophiomys*), an edentate (*Megalonyx*), six carnivores (*Canis*, *Borophagus*, *Ursus*, *Trigonictis*, *Felis*, and a machairodont), a proboscidean (*Mammut*), an equid (*Equus*), and four artiodactyls (*Platygonus*, *Megatylopus*, *Hemiauchenia*, and *Bretzia*). New species are: *Hypolagus ringoldensis*, a leporid probably derived from *H. oregonensis* Shotwell; *Spermophilus*? *russelli*, a large ground squirrel of uncertain affinities; *Ammospermophilus hanfordi*, a large antelope ground squirrel; *Peromyscus nosher*, a deer mouse; *Ophiomys mcknighti*, a microtine closely related to *O. magilli* Hibbard from the Sand Draw local fauna of Nebraska but more primitive than the latter; and *Megalonyx rohrmanni*, a small ground sloth similar in form to specimens from Hagerman, Idaho.

The White Bluffs local fauna is early Blancan (Pliocene) in age. The faunal assemblage is most similar to that of the Hagerman local fauna of Idaho but is probably slightly older.

The predominance of browsing forms among the large mammals (particularly *Bretzia*, *Megalonyx*, and *Platygonus*) indicates that the Ringold flood plain supported considerable riparian forest and open woodland, environments extremely restricted in eastern Washington today. Savanna or open grassland, suggested by the presence of *Equus* and possibly by *Megatylopus*, may have been important away from the streams, but the absence so far of antilocaprids suggests that these habitats were not important near areas of stream deposition.

The River Road local fauna, containing *Teleoceras* and ?*Megatylopus*, is probably late Hemphillian in age.

INTRODUCTION

The vertebrate fauna of the Ringold Formation has been neglected since publication of its discovery in 1893. Enough well-documented material has now come to light to allow the beginnings of a thorough study. Because of the desirability of detailed stratigraphic analysis of carefully documented specimens, this study was restricted primarily to the collections from the Ringold in the Thomas Burke Memorial Washington State Museum. These specimens were collected by V. S. Mallory and others in 1963 and by myself and others commencing in 1967, especially during the summers of 1969 and 1970. The collection has been further augmented by donations of specimens collected by Willis E. Fry over a period of several years.

Undescribed specimens in the Burke Museum from sediments in other areas of the Columbia Basin which may be correlative with the type Ringold Formation at the White Bluffs are not included in this study. Collections from the White Bluffs exist in other institutions, including the University of California Museum of Paleontology, the Los Angeles County Museum of Natural History, the National Museum of Natural History, and the Conner Museum at Washington State University.

The White Bluffs fauna is similar in its general composition to the classic early Blancan fauna from Hagerman, Idaho; however, there are a number of important differences. A somewhat different environment has been sampled, so that some animals which left few remains at Hagerman are common in the White Bluffs. The additions to the described early Blancan fauna of North America, the geographic location in the far northwest of the contiguous U. S., and the unusual abundance of forms, such as the cervid and ground sloth, which are considered to be browsers or indicators of forest habitat, contribute to the importance of this locality and fauna.

LOCATION, TOPOGRAPHY, AND CLIMATE

The type exposures of the Ringold Formation are located in the south central part of the State of Washington, near the center of the Columbia Basin and within a broad local downwarp known as the Pasco Basin. These fossiliferous sediments form a series of cliffs (the White Bluffs) averaging about 500 feet high along the east bank of the Columbia River (map, Fig. 1). The bluffs start several miles north of the city of Richland and extend northward for about 25 miles. The type exposures range in altitude from 340 feet (about the level of the Columbia River) to about 960 feet above mean sea level.

Although the Ringold Formation is mainly exposed east of the Columbia River, well logs show that Ringold sediments are present beneath the surface of most of the Pasco Basin. They are consistently covered by glaciofluvial sediments in the basin area between the south end of the bluffs and Wallula Gap and in the area of the Atomic Energy Commission's Hanford Reservation, which occupies much of the Pasco Basin west of the Columbia. The Pasco Basin is bordered on all sides by basalt of the Miocene-early Pliocene Columbia River Group.

The climate over the Ringold area and most of the Columbia Basin is semiarid. The yearly rainfall of less than ten inches supports sagebrush and bunchgrass. The bluffs themselves are sparsely vegetated, and steep slopes are often bare of vegetation. Few permanent streams other than the throughflowing Columbia, Yakima, and Snake Rivers are present. A few minor streams, whose flow has recently been augmented by irrigation, have cut narrow canyons into the White Bluffs, but much of the rainfall evaporates or escapes into the permeable sediments of the Ringold Formation and overlying deposits.

HISTORY OF INVESTIGATIONS

Published information on the White Bluffs sediments began with a report by I. C. Russell (1893), who referred the sediments to the "John Day System" of Oregon, published a stratigraphic section, and reported the presence of fossil bones. Merriam and Buwalda (1917) separated the Ringold Formation from other central Washington sediments on the basis of lithology and a fauna which at the White Bluffs contained an "advanced or specialized species of *Equus*" which they concluded could represent late Pliocene or Pleistocene time. They chose the White Bluffs sediments as their type section. Further faunal descriptions by McKnight (1923), Stock (1925), Beck (1936, 1937, 1940, 1949), Strand and Hough (1952), and Taylor (1966), provided minor additions to the fauna described by Merriam and Buwalda.

Fry and Gustafson (1974) described the cervid *Bretzia pseudalces* from specimens in the Burke Museum White Bluffs collection, and listed a fauna which includes most of the forms described in this paper. Gustafson (1977) noted the presence of *Teleoceras* in the Taylor Flat conglomerate.

Recent work on the geology of the Ringold Formation includes papers by Newcomb (1958), which redefined the formation and described the sediments in some detail, by Brown and McConiga (1960), which described deformation and plotted the position of several key beds, and by Newcomb, Strand, and Frank (1972) which includes a geological map of the central Pasco Basin area, including most of the White Bluffs.

Culver (1937) proposed an extension of the use of the name Ringold Formation to include sediments over wide areas of the Columbia Basin, particularly in the Othello and Quincy Basins to the north and in the vicinity of Delight (McChesney Springs) to the east. Fossils from the Othello and Quincy Basins seem to be Blancan in age, thus agreeing with Culver's interpretations. However, the fauna from Delight, which has been described by Cope (1889), Matthew (1902), and Hay (1927), may be Irvingtonian (middle Pleistocene) in age, judging from the presence of a *Cervus*-like deer, *Paramylodon*, and *Mammuthus* tooth fragments, and the absence so far of *Bison* (Fry and Gustafson, 1974).

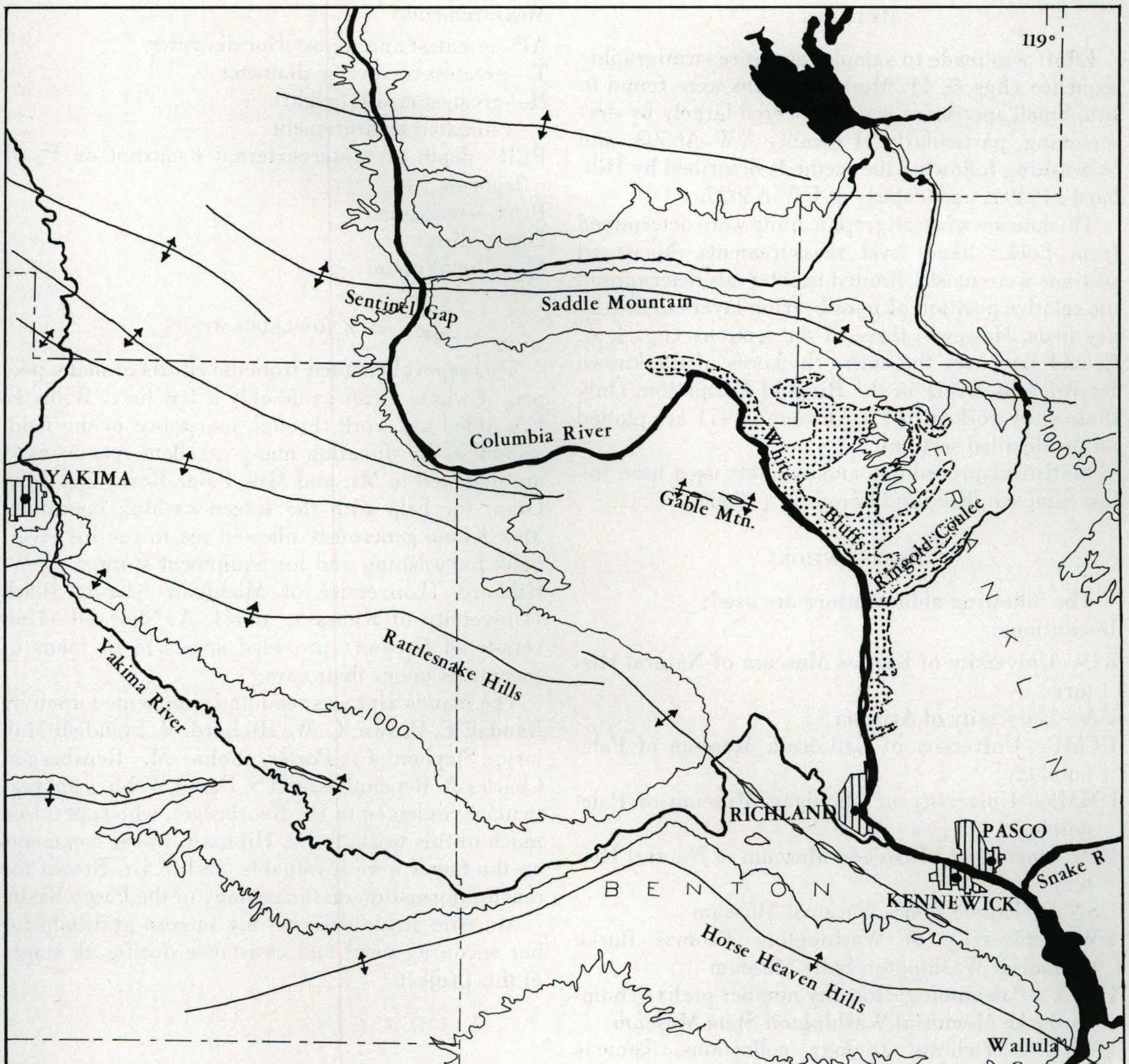

Figure 1. Map of south-central Washington, showing major structures and outcrop area of type Ringold Formation. Contour line shown is 1000 feet above mean sea level.

METHODS

Effort was made to sample the entire stratigraphic sequence (figs. 3, 4). Most specimens were found *in situ.* Small specimens were recovered largely by dry-screening, particularly at locality UW A6503, and by washing following the methods described by Hibbard (1949), particularly at UW A5927.

Thicknesses of stratigraphic units were determined from Locke hand level measurements. Measured sections were mostly limited to intervals determining the relative position of fossilbearing layers to nearby key beds. However, three of the sections (fig. 4, A, C, and E) cover the entire thickness of the known fossiliferous strata in the Ringold Formation. Only those sites worked in 1967 through 1971 are plotted on the detailed sections.

Statistical procedures and symbols used here follow Simpson, Roe, and Lewontin (1960).

ABBREVIATIONS

The following abbreviations are used:

Institutions:

KU—University of Kansas Museum of Natural History

UA—University of Arizona

UCMP—University of California Museum of Paleontology

UMMP—University of Michigan Museum of Paleontology

UO—University of Oregon Museum of Natural History

USNM—United States National Museum

UW—University of Washington, Thomas Burke Memorial Washington State Museum

UW A—Paleontologic locality number prefix, Thomas Burke Memorial Washington State Museum

UWVZ—Vertebrate Zoology collections, Thomas Burke Memorial Washington State Museum

Measurements:

AP—greatest anteroposterior diameter

T—greatest transverse diameter

H—greatest crown height

e—estimated measurement

PER—depth of posteroexternal reentrant on P_3 of leporids

Prox.—proximal

Dist.—distal

Max.—maximum

ACKNOWLEDGEMENTS

This report benefited from the efforts of many people, of whom I can name only a few here. Willis E. Fry aided my work through assistance in the field, as well as by donating many excellent specimens. I am indebted to Mr. and Mrs. Paige Burns and John Oram for help with the screen-washing operation. Max Kinne generously allowed me to use his riverbank for washing and for equipment storage. C. W. Hibbard (University of Michigan), Craig Black (University of Kansas), and J. A. Shotwell (University of Oregon) provided access to or loans of specimens under their care.

The manuscript was read and commented upon by Randall E. Brown, C. W. Hibbard, V. Standish Mallory, Stephen C. Porter, John M. Rensberger, Charles A. Repenning, and S. David Webb. I am particularly indebted to Dr. Rensberger, who supervised much of this work, to Dr. Hibbard, whose comments on the fauna were invaluable, and to Dr. Brown for much information on the geology of the Pasco Basin.

My wife Jessie deserves my intense gratitude for her encouragement and assistance during all stages of this project.

STRATIGRAPHY

PHYSICAL UNITS AND RELATIONSHIPS

Merriam and Buwalda (1917) proposed the name Ringold Formation to encompass the thick continental deposits exposed in the White Bluffs. They included a type section of 503 feet of sediments measured at a site "three to four miles below Hanford," apparently in the area of the north end of Savage Island. They did not describe areal or stratigraphic limits to the formation. Subsequently Culver (1937) informally proposed the lateral extension of the Ringold Formation to include sediments outside the Pasco Basin, and Newcomb (1958) formally extended the formation in the type area downward to the top of the underlying basalt flows of the Columbia River Group. The position of the upper basalt surface in the Pasco Basin (or generally the bottom of the Ringold Formation) is known from numerous well logs, and has been mapped by R. E. Brown and D. J. Brown 1957). R. E. Brown (1969) suggests that the

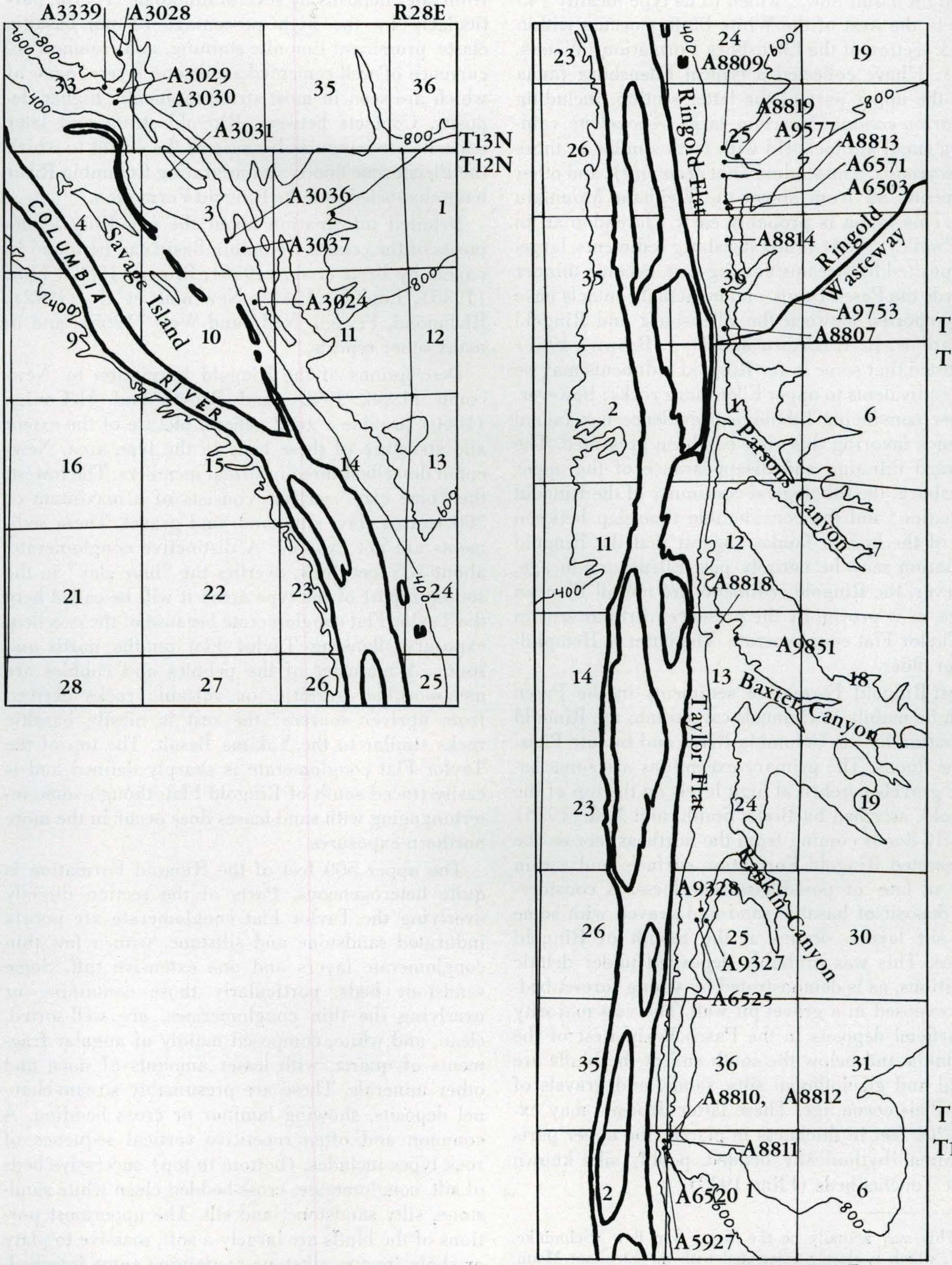

Figure 2. Map of southern White Bluffs, showing locations of UW fossil localities. Ringold Coulee (see fig. 1) reaches the Columbia River at section 24, T12N, R28E.

Ringold sediments rest mainly on the Elephant Mountain basalt flow*, which in its type locality (45 miles to the west of the White Bluffs) occurs within a thick section of the Ellensburg Formation (Waters, 1955). I have collected a typical Ellensburg fauna from the upper part of the latter section, including *Hipparion condoni* Merriam, large *Geochelone*, camelid, a small antilocaprid with teeth similar to those of *Merycodus*, a mastodont (not *Mammut*), and other fragments, all from above the Elephant Mountain flow. This fauna is probably early Clarendonian in age (Smiley, 1963). The Ellensburg sediments, largely deposited by streams flowing east, become thinner towards the Pasco Basin, and no actual contacts have been reported between the Ellensburg and Ringold formations. R. E. Brown and D. J. Brown (1961) suggested that some lower Ringold sediments may be time-equivalents to upper Ellensburg rocks; however, neither convincing lithological evidence nor faunal evidence favoring this view has been presented. The eastward thinning and disappearance of the upper Ellensburg, the lithological continuity of the Ringold Formation, and the considerable time gap between ages of the known faunas suggest that the Ringold Formation may be entirely post-Ellensburg in age. However, the Ringold sediments are not all Blancan in age, as is proven by the presence of rhinoceros in the Taylor Flat conglomerate. The latter is Hemphillian or older.

Post-Ringold Formation sediments in the Pasco Basin lie mainly in channels carved into the Ringold Formation by the Columbia River and by late Pleistocene floods. The primary exceptions are some basaltic gravels perched at high levels on the top of the Ringold, ascribed by Bretz, Smith, and Neff (1956) to early floods coming from the northeast across the undissected Ringold Formation surface, and a thin layer of late- or post-Pleistocene loess. A considerable deposit of basaltic sand and gravel, with some thin silt layers, occurs at the mouth of Ringold Coulee. This was probably deposited under deltaic conditions, as is demonstrated by strong foreset bedding exposed in a gravel pit wall. The vast majority of surficial deposits in the Pasco Basin west of the Columbia and below the south end of the bluffs are fluvial and glaciofluvial silts, sands, and gravels of later Pleistocene age. These latter deposits may exceed 200 feet in thickness in places; the upper parts are often rhythmically bedded, pebbly silts known as the Touchet beds (Flint, 1938).

Ringold Formation sediments can be distinguished from later deposits by several lithologic criteria, particularly by the high percentage of non-basaltic clasts, prominent limonite staining, and common occurrence of well-cemented sandstone layers, none of which are seen in most stratigraphically higher deposits. Contacts between Ringold strata and later deposits are irregular because of the extent to which the Pleistocene floods and migrating Columbia River have channeled into the Ringold Formation.

Detailed information about the post-Ringold deposits of the central Columbia Basin can be found in papers by Bretz et al., (1956), Brown (1968), Flint (1938), Lupher (1944), Newcomb et al., (1972), Richmond, Fryxell, Neff,, and Weis (1965), and in many other reports.

Descriptions of the Ringold Formation by Newcomb (1958, 1972) and Brown and McConiga (1960) provide a good general picture of the extent and structure of these beds in the type area. Newcomb described three informal members. The lowest, the "blue clay" section, consists of a maximum of 300 feet of clay, silt, sand, and gravel. These sediments are not exposed. A distinctive conglomerate, about 165 feet thick, overlies the "blue clay" in the southern part of the type area; it will be called here the Taylor Flat conglomerate because of the excellent exposures flanking Taylor Flat on the north and south. A majority of the pebbles and cobbles are metamorphic, granitic, or volcanic rocks derived from upriver sources; the rest is mostly basaltic rocks similar to the Yakima Basalt. The top of the Taylor Flat conglomerate is sharply defined and is easily traced south of Ringold Flat, though some intertongueing with sand lenses does occur in the more northern exposures.

The upper 500 feet of the Ringold Formation is quite heterogeneous. Parts of the section directly overlying the Taylor Flat conglomerate are poorly indurated sandstone and siltstone, with a few thin conglomerate layers and one extensive tuff. Some sandstone beds, particularly those containing or overlying the thin conglomerates, are well-sorted, clean, and white, composed mainly of angular fragments of quartz, with lesser amounts of mica and other minerals. These are presumably stream-channel deposits, showing laminar or cross bedding. A common and often repetitive vertical sequence of rock types includes, (bottom to top) successive beds of silt, conglomerate, cross-bedded clean white sandstone, silty sandstone, and silt. The uppermost portions of the bluffs are largely a soft, massive to platy or shaly impure siltstone containing some interbedded sandstone.

A thick, extensive tuff bed, here named the White

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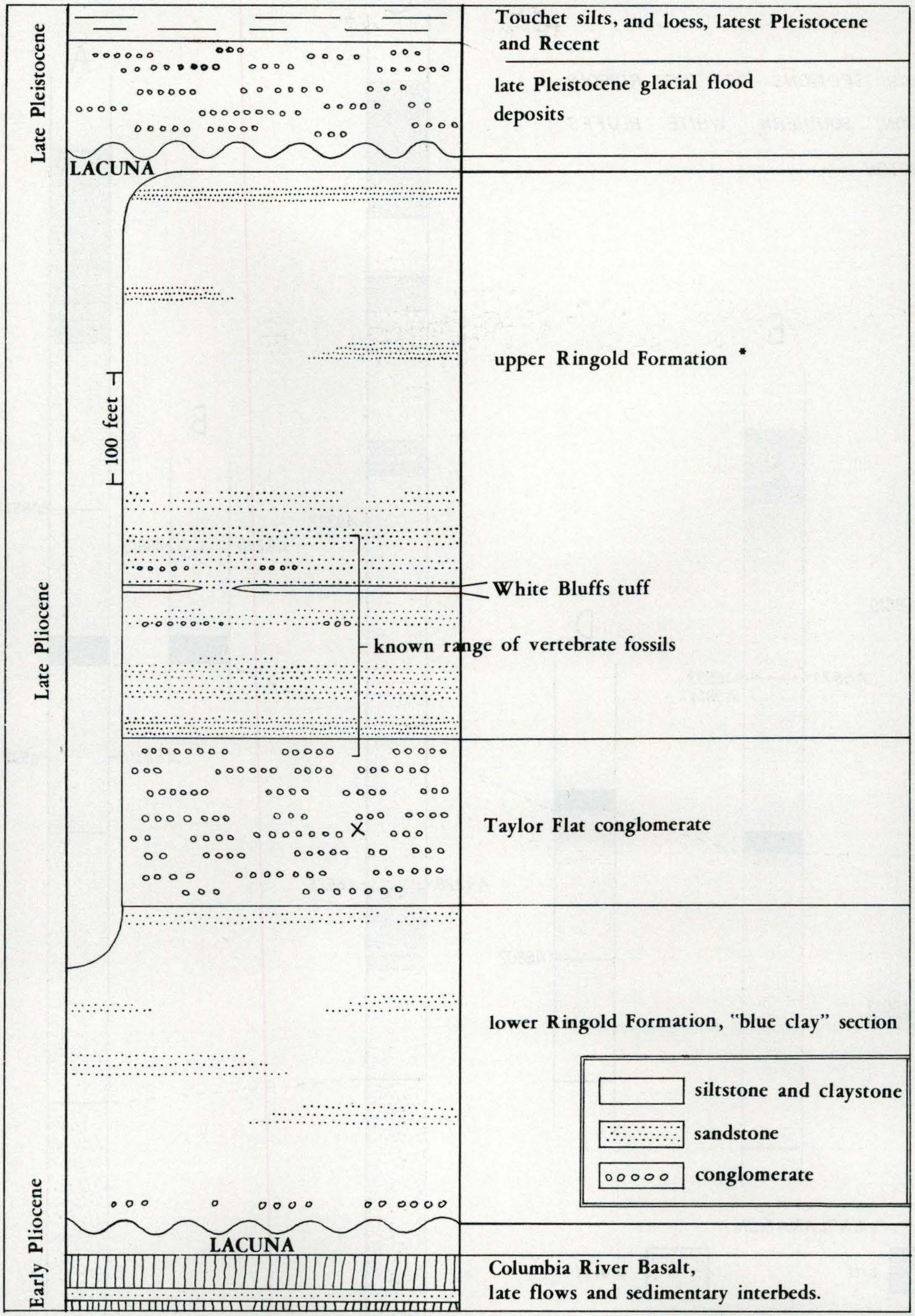
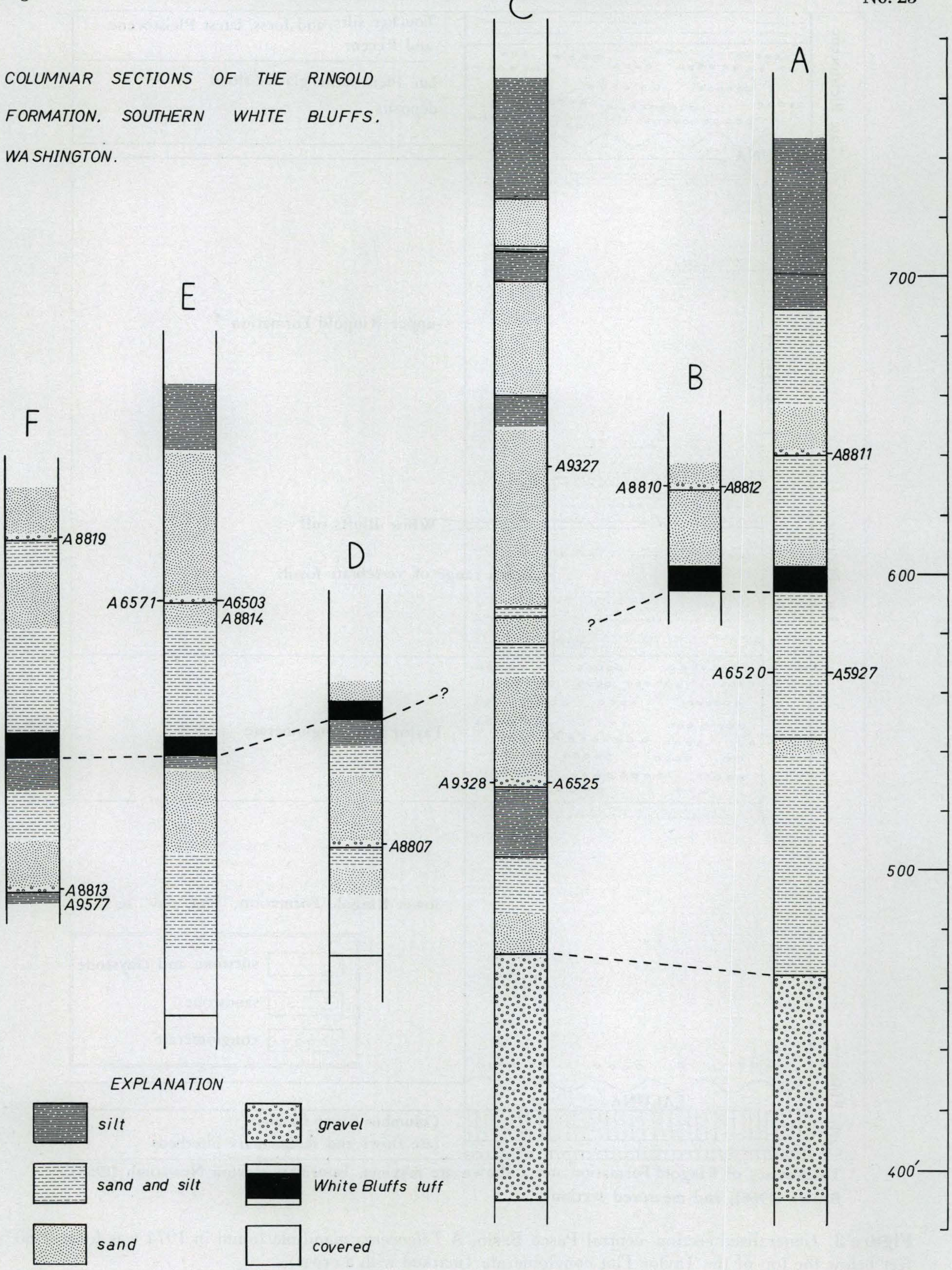
* This may actually be the Ward Gap flow (Schminke, 1967), which is closely associated with the Elephant Mountain flow over much of the central plateau, or the Ice Harbor flow, which is the uppermost major flow (Brown and Ledgerwood, 1973).



* Thicknesses of Ringold Formation strata shown are maxima. Information from Newcomb (1958), Brown (1968), and measured sections.

Figure 3. Generalized section, central Pasco Basin. A *Teleoceras* mandible found in 1974 was located 80 feet below the top of the Taylor Flat conglomerate (marked with a cross).


COLUMNAR SECTIONS OF THE RINGOLD FORMATION, SOUTHERN WHITE BLUFFS, WASHINGTON.
C
A
E
B
F
D
700
600
500
400′
A8811
A8810
A8812
A9327
A8819
A6571
A6503
A8814
?
A6520
A5927
?
A9328
A6525
A8807
A8813
A9577
EXPLANATION
silt
sand and silt
sand
gravel
White Bluffs tuff
covered

Bluffs tuff (figs. 3, 4, 5, and 6) occurs within the most fossiliferous part of the section. The tuff is easily recognized by its fine grained texture, white color, and blocky fracture. Microscopically the tuff is almost entirely fine particles of glass, with the largest fragments being less than 0.2mm in diameter. The stratigraphic position and lateral extent of this key bed was traced by Brown and McConiga (1960). Where the White Bluffs tuff is not preserved, for instance in the area of Taylor Flat (fig. 4), large amounts of stream-channel sediments occur in that part of the section where the ash would be expected. Where it is preserved, however, it is remarkably uniform in thickness and suggests a depositional surface of very low relief. In some places it rests on a definite buried soil.

Several of the aforementioned thin conglomerate layers are noteworthy because of their significance concerning depositional environments (see below) and because they contain concentrations of fossil bone. A number of productive localities in the area of the south end of Ringold Flat are all in two laterally extensive (though discontinuous) beds of conglomerate. Locality A6503 is a small quarry in the upper fossiliferous bed 45 feet above the White Bluffs tuff; the lower, less extensive conglomerate is 40 feet below the tuff (fig. 4).

At A6503, the fossiliferous conglomerate is bounded above and below by clean white sand. The conglomerate at this point is seldom over 20 cm thick. Its level may vary by 15 or 20 cm over the 10 meter long exposure. Other conglomerate lenses at the same level, extending at least half a mile north and south of the quarry, reach a thickness of over a meter in places. Within the quarry, another horizontal, very thin conglomerate lens truncates the cross-bedding in the meter-thick sand overlying the fossiliferous bed.

Pebbles and small cobbles (up to 10 cm in diameter) in the fossiliferous conglomerate include granitic and volcanic rocks, quartzite, agate, and nodules of clay in varying colors, some being grey, light brown, or brick red. The conglomerate at A6503 is dominated by irregular limonite nodules which occur among and cement other particles. The nodules, mostly 2 or 3 cm in diameter, have a brownish rind and a yellow, softer, often partly hollow interior. Sand grains and larger particles occur in the rind but not in the interior. Numerous pieces of fibrous, very poorly preserved wood impregnated with limonite were found.

The end of deposition of Ringold sediments is marked by a thick layer of caliche found in the uppermost levels of the bluffs. This caliche is not present in areas which have been eroded (Newcomb, 1958); it presumably records a dry interval after final floodplain deposition, but prior to the large scale erosion of Ringold sediments which occurred during the Pleistocene. A second caliche layer, developed in Ringold sediments beneath the Pleistocene sediments in the AEC Hanford reservation area, presumably records a second dry interval after the first stripping of the Ringold Formation, and before Pleistocene sedimentation (R. E. Brown, personal communication, 1973).

OCCURRENCE OF FOSSILS

Fossils from the Ringold Formation at the White Bluffs in the Burke Museum collection came from more than fifty localities. Some of these, particularly the older sites, may be duplications because of collection done by several persons at different times from the same bed or quarry.

Two distinct faunas seem to be represented. The best known assemblages, from strata above the Taylor Flat conglomerate, may be termed the White Bluffs local fauna; the less well known, from within the Taylor Flat conglomerate, may be termed the River Road local fauna. Biostratigraphic terminology as used by vertebrate paleontologists is currently in a state of flux. The term "local fauna," used to denote an assemblage of fossils from a narrow stratigraphic and geographic range and with essentially uniform taxonomic composition, has been standard for many years. A rationale for the continued use of "local fauna" names has been provided by Tedford (1970), but some authors (notably Fisher and Rensberger, 1972, and Downs and White, 1968) have used zone terminology (local range zones or concurrent-range zones) commonly used by marine biostratigraphers. The local faunas named above should be considered biostratigraphic in nature; the boundary between them can be conveniently placed at the

Figure 4. Detailed columnar sections. *A* measured up gully between localities A6520 and A5927 visible in fig. 5, near north end of boundary between sections 1 and 2, T10N, R28E. *B* measured at A8810, about 300 feet north of A. *C* measured up gully beside A6525 in central section 25, T11N, R28E. *D* measured up dirt road just north of Ringold Wasteway chute, about one-fourth mile north of boundary between section 1, T11N, R28E, and section 36, T12N, R28E. *E* measured at A6503, near southern boundary of section 25, T12N, R28E. *F* measured up north side of canyon in south central section 25, T12N, R28E. Scale at right indicates feet above sea level.

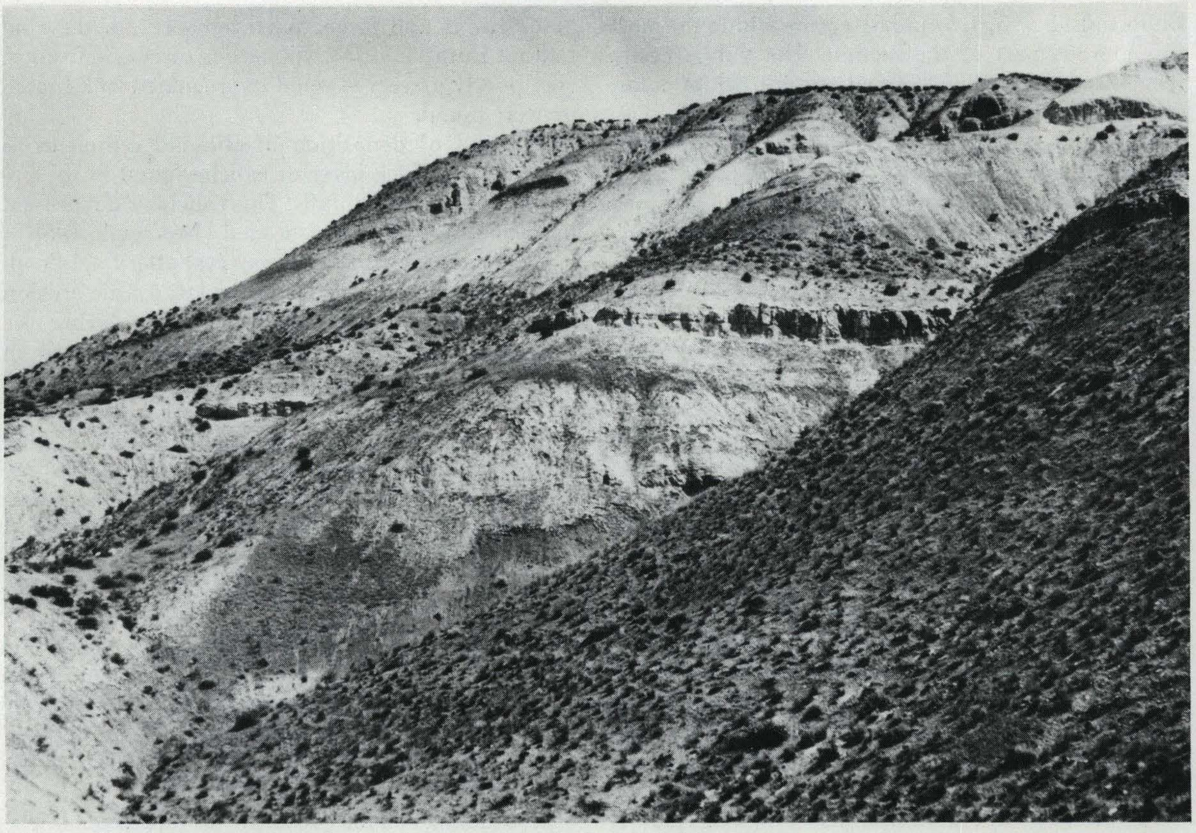


Figure 5. Bluffs at locality A6520 (near center of photograph); resistant stratum just above center is White Bluffs tuff, about 8 feet thick at this site (2.4 meters).

top of the Taylor Flat conglomerate, but this is purely a matter of convenience at present.

The White Bluffs geographic area may be considered a collecting field by the definition of MacIntyre (1966). Five major areas exist in which fossiliferous beds are most common (fig. 2). These are at the south end of the bluffs, the south end of Taylor Flat, Baxter Canyon, the Ringold Flat area, and the Savage Island area. The precise stratigraphic position of the sites in the Savage Island area with respect to those further south is not certain because of changes in lithology, lack of northern exposures of the White Bluffs tuff, and major landsliding in the intervening area.

Two kinds of sediments in the upper Ringold Formation, the stream channel gravels and a fine light brown silt, have produced fossils. Most of the sites are local lenses of conglomerate. Since the two types of sediment contain substantially different faunas, field work was concentrated especially on a locality in each lithology. These are UW A5927, a silt deposit, and UW A6503, a stream channel conglomerate (see above and fig. 4).

The bones and teeth at UW A6503 were usually embedded in a mixed matrix of limonite nodules, clay nodules, pebbles, and sand. Larger bones often lie upon the upper surface of the conglomerate. Most of the bones lay within 15° of horizontal.

No articulated bones were found in the conglomerate. All bones and teeth show some sign of abrasion, often so extreme that identification is difficult. The abrasion must have occurred while the bones were fairly fresh. The preserved bone material is very brittle, and the many thin or elongated pieces of bone found would not have survived reworking.

Concentration of secondary minerals, particularly iron oxides, in the conglomerate lenses has produced a wide variety of colors in the enclosed bones.

In contrast to most of the fossiliferous sites, specimens from UW A5927 and UW A6520, near the south end of the bluffs, are found in fine clayey siltstone. The two sites are at the same stratigraphic level, about a hundred meters apart (fig. 4, A). Surface exploration at UW A5927 revealed a group of associated rodent foot bones and a partial skeleton of *Ammospermophilus*, a small ground squirrel. Screenwashing of sediments from this deposit produced a large number of isolated rodent teeth and bones, two unerupted peccary teeth, snake vertebrae, and miscellaneous other bones. Most specimens are less than 2 cm in greatest dimension.

At least two bone fragments from this site show signs of having been gnawed by rodents or carnivores. There are no indications of surficial wear from stream transport, and very delicate structures (for example, single fish scales) are preserved undamaged. Most of the bones are a pale tan color, apparently because of the uniformity of the fine-grained sediments.

MODE OF DEPOSITION OF THE RINGOLD FORMATION

Deposition of the Ringold Formation was almost certainly initiated by a combination of settling in the area of the Pasco Basin and uplift of the Horse Heaven Hills anticline across the downstream course of the ancestral Columbia River. Sediment accumulation occurred earliest towards the basin center (Brown, 1969, p. 9), and Ringold sediments may eventually have covered most of the central Columbia Plateau (Culver, 1937, and Brown, 1969).

Present evidence suggests that the Ringold Formation is composed largely of stream-channel and flood plain deposits. Several early investigators, including Russell (1893), Smith (1903), and Calkins (1905) suggested a lacustrine environment for all or a major part of the White Bluffs sediments. More recently, Newcomb (1958) has returned to this hypothesis as the major explanation for Ringold Formation deposition. Newcomb states that "the successions of silt, fine sand, clay, and volcanic ash exhibit some rhythmic changes in a vertical direction, as though they resulted from deposition by the gradually shifting of currents in a large lake." The rhythmic changes observed by Newcomb do exist, but an alternate explanation (see below) is available and seems more probable. Most recent authors, including Waters (1955) and Brown (1969), have accepted the hypothesis propounded by Merriam and Buwalda (1917), that the Ringold Formation is by and large a complex flood plain deposit. Merriam and Buwalda cited as evidence the poor sorting of most sands, silts, and clays, the rarity of freshwater molluscs usually common in lacustrine environments, and the presence of mammalian fossils at several localities. Although fish bones occur in association with the mammal remains, the bones are always disassociated and usually show wear from transportation in an abrasive medium. No complete fish skeletons are known, even from the finer shaly beds in the upper part of the secton.

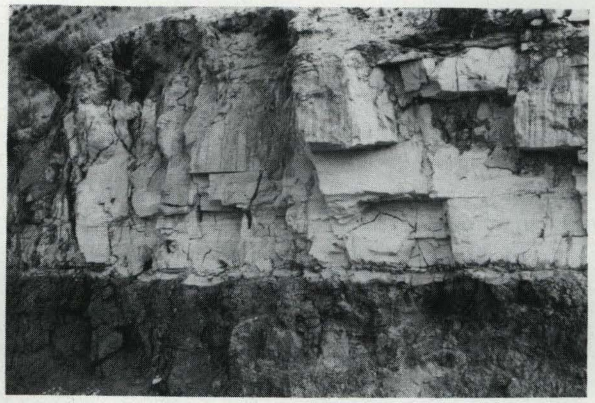


Figure 6. Close view of White Bluffs tuff just north of Ringold Wasteway; note thin layer of tuff at bottom separated from the main body of tuff by a darker layer; thickness of tuff in photo is about four and one half feet (1.4 meters).

Many sections which I examined in the lower bluffs south of Ringold Coulee contain one or more sequences of sediment types closely matching that sequence shown by Allen (1971, fig. 3) to be typical of the deposits of meandering streams. For example, the Ringold Wasteway North section (fig. 4 D) contains the following sequence:

1. an underlying sandy siltstone truncated by a smooth erosion surface;
2. a thin conglomerate with many clay fragments;
3. clean, cross-bedded sandstone, grading upward into
4. overlying thick sandy siltstone.

The extensive erosion surface on the top of bed 1 could have been produced by the sideways and downstream migration of the meandering channel. The coarser fraction of the channel bed sediments, including gravel, chunks of clay and silt, and occasional bones and teeth, was deposited first, and was immediately buried by downstream migration of point-bar deposits, which are mainly fine clean sand, commonly cross-bedded. As the stream migrated out of the area, deposits became less well sorted, and finally only overbank sediments, mainly impure silt, were deposited by floods. Repetition of this sequence or parts of it, with local variations, is probably the mechanism responsible for Newcomb's "rhythmic changes."

The above is not intended to deny the presence of lacustrine lenses in the Ringold Formation. As Waters (1955) states, ". . . although the Ringold Formation contains thinly stratified clays, silts, and diatomite layers that were doubtless deposited in lakes, these lakes appear to have been shallow and to have shifted position." Typical modern floodplains have numerous oxbow lakes and other depressions which fill with water during floods. Fossil mollusks have been found at three sites (McKnight, 1923, and Taylor, 1966). Taylor, referring to the three species of snails he reports, states: "This assemblage probably represents a shallow-water environment, such as a flood-plain or the edges of a stream or lake, rather than an open lake. The water body might have been subject to seasonal fluctuation, but probably did not dry up entirely."

SUMMARY OF PLIOCENE AND PLEISTOCENE EVENTS

In earliest Pliocene time the area that is now the Pasco Basin was near the center of a broad, flat plain formed by the upper surface of the last flood basalt flows of the Columbia River Group. The basalts and interbedded sediments beneath the Pasco Basin area are over 10,000 feet thick (Raymond and Tillson, 1968); the earliest known flows may be as old as late Eocene or early Oligocene (Newman, 1969). As Brown (1969) has emphasized, deposition of this enormous thickness of basalt required fairly continuous basining at a rate sufficient to offset the thickening of the basalt pile.

Deformation of the basalts, other than the continuing basining, began during latest Miocene to earliest Pliocene time, on the order of 12 to 15 million years before present (Holmgren, 1969). Tectonic activity beginning at this time included the first significant rise of the Cascade Mountains (Smiley, 1963) and the beginning of the warping of the basalt along east-west or northwest-southeast axes. Considerable increase in relief had occurred during or before the inception of deposition of the Ellensburg Formation on the east flank of the Cascades, and before the outpouring of the last basalt flows which are interbedded with the Ellensburg Formation (Holmgren, 1967).

The present Columbia River drainage basin was evidently formed during this initial period of Cascade uplift and basalt deformation. Quartzitic conglomerates within the Ellensburg Formation indicate the presence of a large river flowing from north to south which could have drained much of the area now drained by the Columbia. The position of the main drainage channel apparently shifted widely due to displacement by late basalt flows and subsequent reestablishment of drainage toward the Columbia Basin center, near Pasco. Cessation of basalt eruptions allowed the center of drainage to become permanently established near its present position, setting the stage for the deposition cycle which produced the Ringold Formation.

The first Ringold Formation sediments were deposited sometime after the main phase of deposition of the Ellensburg Formation, but before the end of the Hemphillian mammalian faunal stage. Most of the visible White Bluffs sediments were deposited in early Blancan time (late Pliocene as usually used by vertebrate paleontologists) according to evidence presented in this paper, except for the Taylor Flat conglomerate which is pre-Blancan at least in part. Regional topography suggests that a combination of continued settling near the basin center and uplift of the Horse Heaven Hills anticline produced sufficient river grade changes to initiate aggradation in the Pasco Basin. Other factors, such as altered precipitation patterns or increased sediment load, may well have been involved.

Contrary to statements by Newcomb (1958) and earlier authors, the Columbia River was probably never completely impounded. Sedimentation occurred on a broad flood plain. The present gradient of the Columbia River is quite low, less than 1.5 feet per mile along the White Bluffs. Late Pliocene gradients must have been considerably less, perhaps near the 0.5 feet per mile suggested by Brown (1969). Several streams flowing into the Pasco Basin from the east, north, and west may have contributed to sedimentation. Sediments in the Othello and Quincy basins further north, referred to the Ringold Formation by some authors, may have been deposited by such tributary streams.

The cause of the end of Ringold deposition is not certain. A number of factors may have been involved, for example, a slowing or stoppage of anticlinal uplift at Wallula Gap, increased precipitation, regional uplift, decreased sediment load, or any combination of these and other factors.

Newcomb (1958) thought that the end of Ringold deposition occurred rather suddenly, and that the ancestral Columbia became quickly entrenched in the Ringold sediments in the area to the west of the White Bluffs. Presence of the high-level caliche suggests some delay in incisement; however, once downcutting was underway it may have been rapid. During most of the Pleistocene the sediments of the Pasco Basin underwent degradation primarily by stream and aeolian erosion. The relatively undissected nature of the upper surface of much of the remaining Ringold Formation suggests that rainfall (and therefore flow in tributary streams in the area) remained low throughout the Pleistocene. Aeolian erosion of the Ringold sediments seems to have provided much of the material now composing the Palouse Formation further to the east (Bryan, 1927; Lewis, 1960).

The present topography of the Pasco Basin is largely the result of glacial meltwater floods, vast in scale, originating in Lake Missoula, Montana, during the Wisconsin glaciation (Bretz *et al.*, 1956). Early floods, coming from the north and east, deposited basalt gravels over much of the upper Ringold surface. Later floods carved Ringold Coulee and other

LIST OF VERTEBRATES FROM THE WHITE BLUFFS

TABLE 1

Previously reported	Recognized in this report
Fish	Fish
Carcharius? sp. (b)	
catfish (b)	*Ictalurus vespertinus*
percoid? (b)	*Archoplites taylori*
	Salmonidae indet.
	Amphibia
	Anura indet.
Reptilia	Reptilia
Testudo sp. (a)	?*Testudo* sp.
Clemmys marmorata (d)	*Clemmys marmorata*
	Chrysemys? sp.
	Squamata indet.
Aves	
Marila? sp. (b)	
Mammalia	Mammalia
	Scapanus sp.
leporid (a)	*Hypolagus ringoldensis* n. sp.
	Nekrolagus sp. cf. *N. progressus*
	Paenemarmota or *Marmota* sp.
	Spermophilus? russelli n. sp.
	Ammospermophilus hanfordi n. sp.
	Thomomys sp. cf. *T. gidleyi*
	Castor californicus
	Dipoides rexroadensis
	Peromyscus nosher n. sp.
	Neotoma sp. cf. *N. quadriplicatus*
microtine (primitive) (b)	*Ophiomys mcknighti* n. sp.
Megalonyx sp. (a,c)	*Megalonyx rohrmanni* n. sp.
	Canis davisi
	Borophagus sp.
	Ursus sp. cf. *U. abstrusus*
	Trigonictis cooki
	Felis sp.
	Machairodontinae
Mammut americanum (c)	*Mammut americanum*
Equus or *Pliohippus* sp. (a)	*Equus* (*Dolichohippus*) sp. cf. *E. simplicidens*
Equus sp. (a)	
	Teleoceras sp.*
Platygonus sp. (c)	*Platygonus pearcei*
Camelops sp. (c)	*Megatylopus* cf. *M. cochrani*
camelid (large) (a)	
	?*Megatylopus* sp.*
camelid near *Pliauchenia* (a)	*Hemiauchenia* sp.
cervid (a)	*Bretzia pseudalces*
Rangifer sp. (c)	

(a) Merriam and Buwalda, 1917
(b) McKnight, 1923
(c) Strand and Hough, 1952
(d) Brattstrom and Sturn, 1959
* Member of River Road local fauna; all others from White Bluffs local fauna.

channels, and still later floods, travelling down the Columbia valley, formed the huge gravel bars of the basin area and carved the Bluffs back to their present position. The Touchet beds overlie all but a few aeolian deposits. They consist of rhythmically bedded silts and sands, apparently deposited during frequent fluctuations of a large lake during the waning stages of the last glaciation. Post-Pleistocene changes have apparently been slight.

SYSTEMATIC PALEONTOLOGY

WHITE BLUFFS LOCAL FAUNA

Phylum CHORDATA
Subphylum VERTEBRATA

Class OSTEICHTHYES

Identifiable fish bones have been recovered from ten sites. Pectoral fin spines of the catfish (Family Ictaluridae) *Ictalurus vespertinus* Miller and Smith (1967) are the most common identifiable bones. Remains of the centrarchid sunfish *Archoplites taylori* Miller and Smith are also fairly common; both of these species were first reported from the Glenns Ferry Formation of Idaho. Specimens of a large salmonid have also been found. The above identifications were made by R. R.Miller (personal communication, June 1973), who is currently studying the Ringold fishes. Miller (1965) also reported *Ictalurus* and *Archoplites* from sediments of possible Ringold Formation age near Moses Lake, Washington.

Class AMPHIBIA
Order ANURA

Frog or toad bones, including humeri, ilia, and others, were found at UW A5927 and UW A6520.

Class REPTILIA
Order TESTUDINATA
Family Testudinidae
Subfamily Emydinae
Genus *Clemmys* Ritgen

Clemmys marmorata (Baird and Girard), 1852

Discussion—Brattstrom and Sturn (1959) reported this living species from a site opposite the old town of White Bluffs. Their 17 fragments of bone, mostly marginals, are in the old California Institute of Technology collection, now in the Los Angeles County Museum of Natural History.

Genus *Chrysemys* Gray

Chrysemys? sp.
(Figure 7)

Material—UW A6503: UW 35143, hyoplastron; UW 35203, epiplastron. UW A9328: UW 42455, entoplastron. The Burke Museum collection also includes many other specimens from several localities whch may belong in this taxon.

Discussion—The predominant turtle in the White Bluffs is an emydine with plastron elements very similar in morphology to those of Recent *Chrysemys*, and probably referable to that genus at least in the broad sense used by McDowell (1964). The primary character differentiating these specimens from *Clemmys* is the posterior position of the humeral-pectoral sulcus, which does not cross the entoplastron in any specimen in the Burke Museum collection. Differences in size and form of several marginals suggests that more than one taxon is present in this collection.

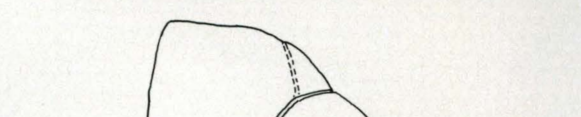


Figure 7. Plastron of *Chrysemys*? sp., ventral view. Hyoplastron, UW 35143; epiplastron, UW 35203, both from A6503. Entoplastron, UW 42455, from A9328. Scale line indicates one centimeter. Anterior towards top of page.

Order SQUAMATA

A number of small reptile bones were found, primarily at UW A5927.

Class MAMMALIA

Order INSECTIVORA

Family Talpidae

Genus *Scapanus* Pomel, 1848

Scapanus sp.

(Figure 8)

Material—UW A6503: UW 35108, left humerus.

Stratigraphic position—Ringold Formation, 45 feet above White Bluffs tuff, early Blancan.

Description—A single humerus, lacking portions of the proximal end, wide in proportion to length (though not as wide as in *Scalopus*), with well developed processes as in advanced fossorial talpids.

Size is very close to that of *Scapanus orarius* True. The length of the unbroken humerus was probably about 12.5 mm.; the preserved length is 9.6 mm. The distal maximum width is 8.3 mm. Minimum shaft width (taken in the same plane as distal width) is 4.3 mm.

The White Bluffs specimen is closer in morphology to Recent species of *Scapanus* than to *S. (Xeroscapheus) proceridens* Hutchison (1968) from the Hemphillian Westend Blowout site (UO2349) in northern Oregon. Judging from comparison with seven specimens of the latter, the White Bluffs specimen is slightly shorter, and is wider in proportion to length.

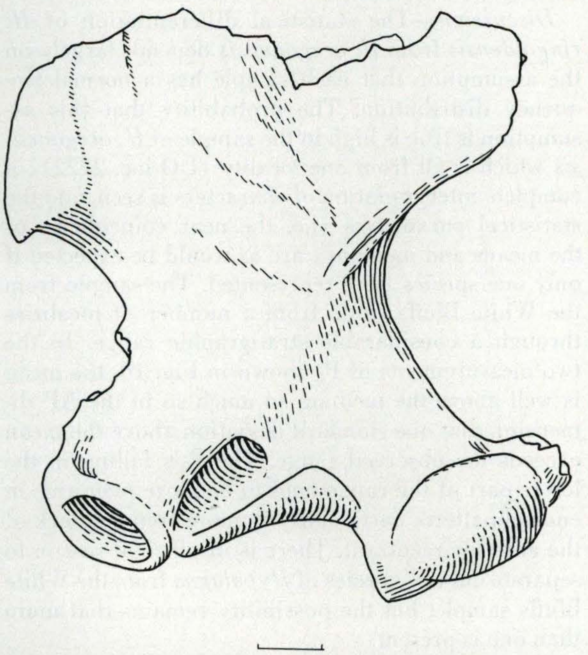


Figure 8. *Scapanus* sp., left humerus, UW 35108, anterior side. Scale line indicates one millimeter.

Order LAGOMORPHA

Family Leporidae

Subfamily Archeolaginae

Genus *Hypolagus* Dice, 1917

Hypolagus ringoldensis new species

(Figure 9a-d)

Type—UW 45015, partial mandible with P_3-M_2 and broken M_3, collected by William Shawver in 1965.

Type locality—UW A8814, White Bluffs south of Ringold Coulee, Franklin County, Washington, from conglomerate about 45 feet above White Bluffs tuff.

Diagnosis—A species of *Hypolagus* similar in size and morphology to *H. oregonensis* Shotwell; anterior reentrant of P_3 much more consistently present and usually deeper; P_3 is slightly longer antero-posteriorly; posteroexternal reentrant deeper and more often with distinct anterad inflection at its tip.

Referred specimens—The following are UW localities and specimen numbers: A3029: 41548, P_3. A3037: 41975, P_3. A5927: 34977, P_3. A6503: 35118-A, 35118B, 35129, 35145A, 35145B, 40396, 40428, 45020, all P_3. A6520: 40313, P_3. A6525: 35237, mandible with I, P_{3-4}. A8810: 40259, P_3; 40286, mandible with P_3-M_2; 40293, mandible with P_3-M_1. A8812: 42220, P_3. A9305: 42148, P_3. A9851: 46169 4613, both P_3.

Stratigraphic range—Ringold Formation, from 40 feet below to 45 feet above White Bluffs tuff, early Blancan.

Description—The most distinctive tooth is P_3, of which 21 are known from 11 localities. The P_3 is archeolagine in character, having a posteroexternal reentrant extending from half to two-thirds of the width of the tooth. *H. ringoldensis* is larger than most species of *Hypolagus* but is within the size range of *H. oregonensis* Shotwell (1956) from the Hemphillian McKay Reservoir fauna of northern Oregon. However, the mean anteroposterior diameter of P_3 in *H. ringoldensis* is significantly larger than in *H. oregonensis* (Student's *t* probability of derivation from identical populations is less than .01). Mean transverse diameters of P_3 for the two species are not significantly different.

H. ringoldensis can be distinguished from all other species of *Hypolagus* except *H. oregonensis* by the usual presence of a strong anterior reentrant on P_3. This structure is strong (deep or V-shaped) on 72% of the P_3's of *Hypolagus* from the White Bluffs but is strong on only 38% of the P_3's from McKay Reservoir; on the other specimens this reentrant is weak (shallow, broadly U-shaped) or absent. A second, usually weaker anterior reentrant is present on the anterointernal face of P_3 of some individuals; when a groove is not present this face is usually flattened and finely striated. The anteroexternal reentrant is shallow and is usually not complicated by minor crenulations, though such crenulations do occur. The posteroexternal reentrant is deeper than in *H. oregonensis* in most cases; the depth in specimens from the Ringold Formation includes larger measurements than found in the *H. oregonensis* sample. The smaller values of depth in *H. oregonensis* are below the range in *H. ringoldensis*, and the difference in the means is highly significant (Student's *t* probability of derivation from identical populations is less than .001). In *H. ringoldensis* the tip of the posteroexternal reentrant bends slightly anterad in a majority (57%) of the speciments (12 of 21). This anterad bend was found in only 12% of the specimens (4 of 34) of *H. oregonensis*.

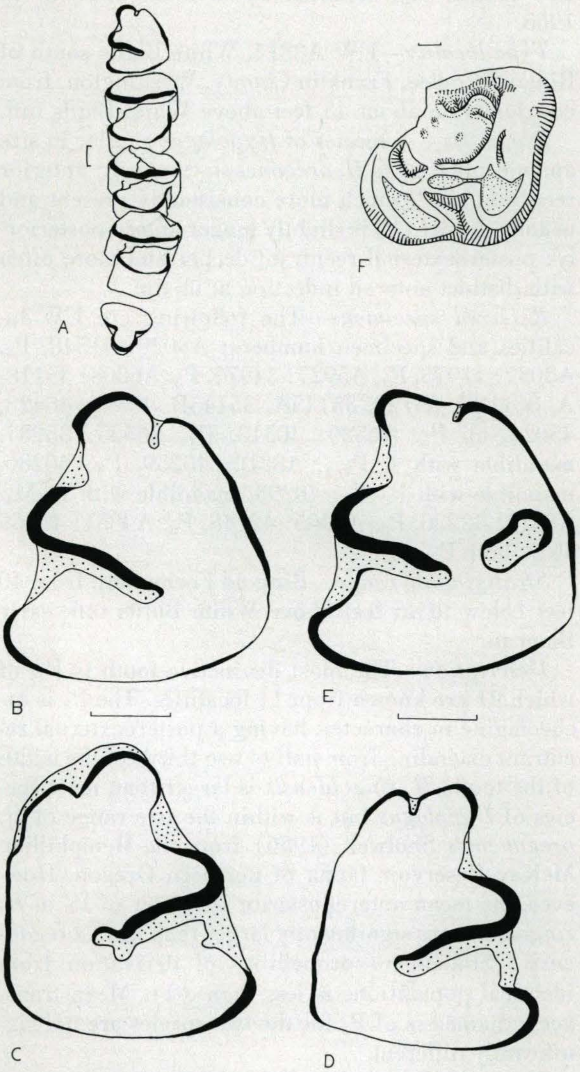


Figure 9. Rabbits and marmot. A. *Hypolagus ringoldensis*, type left P_3-M_3, UW 45015, occlusal view. B. *H. ringoldensis*, left P_3 of type specimen, occlusal view. C. *H. ringoldensis*, right P_3, UW 42148. D. *H. ringoldensis*, right P_3, UW 40313. E. *Nekrolagus* cf. *N. progressus*, left P_3, UW 351188. F. *Paenemarmota* or *Marmota* sp., right M_3, UW 35248. Scale lines indicate one millimeter. Anterior towards top of page in A-E, to right in F.

The other cheek teeth, P_4-M_3, are quite typical for *Hypolagus*, and show no unusual features. The talonids of these teeth (except M_3) are of lesser transverse width and greater length than in the Recent *Lepus californicus* Gray. The enamel borders show no minor crenulations.

The lower incisor of *H. ringoldensis* is similar to that of *H. oregonensis*; in both the posterior end of the incisor is positioned opposite the posterior part of the trigonid of P_3, and the incisor is considerably longer and less curved than in Recent *Lepus californicus* Gray.

Fenestration of the mandible is less developed than in *L. californicus*. The lateral surface of the one anterior mandible available (UW 35237) is practically smooth and solid in the areas below P_3 and the incisor where fenestrae are present in the Recent form. The dorsal outline of the diastema is nearly straight, as in *H. oregonensis*. The horizontal ramus is generally similar in depth and form to that of *L. californicus*, which is of nearly the same size.

Discussion—The statistical differentiation of *H. ringoldensis* from *H. oregonensis* depends largely on the assumption that each sample has a normal frequency distribution. The probability that this assumption is true is high in the sample of *H. oregonensis* which is all from one locality (UO loc. 2222); a complete intergradation of characters is seen, and the statistical parameters (i.e. the near coincidence of the means and medians) are as would be expected if only one species were represented. The sample from the White Bluffs came from a number of localities through a considerable stratigraphic range. In the two measurements of P_3 shown in Fig. 10, the mean is well above the median, so much so in the AP dimension that one standard deviation above the mean exceeds the observed range. The P_3's falling in the lower part of the range tend to be more primitive in enamel pattern, particularly in more frequent lack of the anterior reentrant. There is insufficient reason to separate out two species of *Hypolagus* from the White Bluffs sample, but the possibility remains that more than one is present.

Hypolagus oregonensis was probably ancestral to *H. ringoldensis*. The type localities are separated by

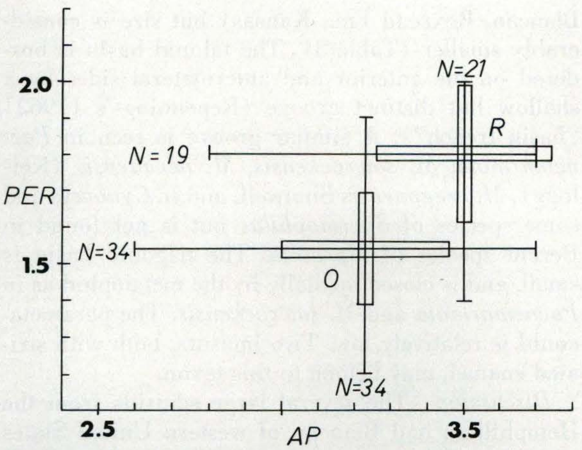


Figure 10. Comparison of anteroposterior length, and depth of posteroexternal reentrant in *Hypolagus ringoldensis* n. sp. from the upper Ringold Formation and *H. oregonensis* Shotwell from McKay Reservoir, Oregon. Narrow lines indicate ranges; vertical and horizontal lines intersect at means of both. Broad bars extend one standard deviation from means. N = number of measurements used in calculation.

only 80 miles. The differences are mainly in character frequencies and means, rather than in discontinuities in morphological type. *H. ringoldensis* tended towards a more complex enamel pattern in P_3, away from the simple pattern characteristic of *H. vetus* (Kellogg) and other earlier and contemporary populations of *Hypolagus*. There is some evidence, in the form of a single P_3 reported by Downey (1968, figure 2d) from the Benson local fauna of Arizona, that this line of rabbits was not restricted to the Pacific Northwest. The latter tooth, called *Nekrolagus*? by Downey, but lacking the enamel lake characteristic of *Nekrolagus*, is apparently identical in all characters to *H. ringoldensis* and to some individuals of *H. oregonensis*.

Subfamily Leporinae

Genus *Nekrolagus* Hibbard, 1939

Nekrolagus cf. *N. progressus* (Hibbard)
(Figure 9e)

Material—UW A6503; UW 35188, P_3.

Stratigraphic position—Ringold Formation, 45 feet above White Bluffs tuff, early Blancan.

Description—A single P_3 possesses the diagnostic characters of the genus *Nekrolagus*. An oval enamel lake is separated from both the posterolingual enamel border and the posteroexternal reentrant. The anterior face has a small but distinct and cement-filled anterior reentrant. The tooth is similar in size and proportions to the P_3 of *Nekrolagus progressus* (Hibbard) from the Rexroad Formation of Kansas. The White Bluffs tooth differs from *N. progressus* holotype (KU 4570) in the pinching of the enamel lake, lack of several very small enamel crenulations, and slightly larger size. Measurements of UW 35188 are: AP=3.7 mm, T=3.6 mm. whereas those of *N. progressus* are: AP=3.5 mm, T=3.7 mm.

Discussion—*Nekrolagus* has been known primarily from specimens from the Rexroad Formation of Kansas, but it has also been mentioned from sites in Arizona and Southern California. As noted above, the Arizona specimen may not be *Nekrolagus*. The Southern California species (Downs and White,

TABLE 2

P_3 MEASUREMENTS OF *Hypolagus* FROM THE WHITE BLUFFS, WASHINGTON, AND MCKAY RESERVOIR, OREGON

H. ringoldensis, White Bluffs, Washington

	no. of specimens	*mean*	*range*	*standard deviation*
AP	19	3.43	2.8-3.7	0.24
T	21	3.04	2.5-3.5	0.27
PER	21	1.79	1.4-2.0	0.19

H. oregonensis, McKay Reservoir, Oregon

	no. of specimens	*mean*	*range*	*standard deviation*
AP	34	3.23	2.6-3.7	0.23
T	33	2.98	2.5-3.5	0.28
PER	34	1.51	1.2-1.9	0.15

1968) has not been described. The White Bluffs occurrence extends the range of the genus into the Pacific Northwest.

The genus *Nekrolagus* is apaprently ancestral to many of the modern leporids, including *Lepus* and *Sylvilagus* (Hibbard, 1963).

Order RODENTIA

Family Sciuridae

Genus *Paenemarmota* Hibbard and Schultz 1948, or *Marmota* Frisch, 1775.

Paenemarmota or *Marmota* sp. indet.

(Figure 9f)

Material—UW A3037: UW 41974, lower I. UW A6503: UW 35248, M_3; UW 42264, upper I.

Stratigraphic position—Ringold Formation, 45 feet above White Bluffs tuff, early Blancan.

Description—Terminology used here for sciurid tooth structures generally follows Bryant (1945).

UW 35248 is a large, moderately worn M_3. The tooth is slightly smaller (AP=8.0 vs. 8.5 mm) than the M_3 of *Marmota sawrockensis* Hibbard 1964, (late Hemphillian, XI member of Rexroad Fm., Kansas), but is larger than M_3 of Recent species of *Marmota*. The occlusal outline is similar to that of M_3 of *Paenemarmota barbouri* Hibbard and Schultz (early Blancan, Rexroad Fm., Kansas) but size is considerably smaller (Table 3). The talonid basin is bordered on the anterior and anterolateral sides by a shallow but distinct groove (Repennings's [1962] "basin trench"). A similar groove is seen in *Paenemarmota*, *M. sawrockensis*, *M. nevadensis* (Kellogg), *M. oregonensis* Shotwell, and in *Cynomys* and some species of *Spermophilus* but is not found in Recent species of *Marmota*. The trigonid basin is small, and is closed medially by the metalophid as in *Paenemarmota* and *M. sawrockensis*. The parametaconid is relatively low. Two incisors, both with striated enamel, may belong to this taxon.

Discussion—The several large sciurids from the Hemphillian and Blancan of western United States which possess an anterolateral groove on the talonid have been placed in two genera largely because of the extreme size and proportionately large P_4^4 of one form, *Paenemarmota*. A generic identification would be premature in the absence of a P_4.

TABLE 3

Paenemarmota OR *Marmota* SP., MEASUREMENTS OF TEETH

	Paenemarmota or *Marmota* sp., Ringold Formation I/UW 42264 /I 41974 M_3 35248	*Paenemormota barbouri*, from Repenning, 1962, Tables 1-2 max. and min.*	*Marmota caligata*, UWVZ 18837
I/ AP Depth	6.7	?7.5-9.9 (5)[2]	7.6
T Width	4.4	?4.8-6.8 (5)	5.1
curvature[3]	23e[1]	?28--45 (5)	19e
/I AP Depth	7.2	7.0-8.7 (10)	7.1
T Width	5.0	4.7-5.8 (10)	4.4
curvature[3]	36e	41--49 (10)	30e
M_3 T Width[4]	7.3	7.8-9.3 (7)	6.3e
AP Length[4]	8.0	9.2-11.0 (8)	7.4

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* From individuals of several widespread localities not necessarily of a single time period, or therefore of a single population.

[1] *e* indicates estimated measurement.

[2] Numbers in parentheses are the number of specimens listed by Repenning (1962).

[3] Measured for the anterodorsal or anteroventral surface.

[4] Measurements or M_3 made parallel or at right angle to the labial edge of the tooth.

Genus *Spermophilus* Cuvier, 1825

Spermophilus? *russelli* new species

(Fig. 11)

Type—UW 33038, left mandible with broken I and P_4-M_3.

Type locality—UW A5927, (near south end of White Bluffs), Franklin County, Washington.

Etymology—Named for I. C. Russell, who first mentioned in print the presence of fossils in the White Bluffs.

Diagnosis—A moderately large sciurid, larger than most species of *Spermophilus* (except *S. pattersoni* Wilson) but smaller than most species of *Marmota*; mandible exceptionally deep (10.5-10.8 mm below P_4); incomplete protolophid on P_4 not attached to base of metaconid; protoconulid frequently present; P^3 about one-third the size of P^4; mesostyle present on P^4 and M^3; metaloph not attached to protocone on P^4; metaloph incomplete on M^3; metaconule present on M^3, M^3 longer than wide.

Referred specimens—The following are UW localities and specimen numbers: A5927: 33040, P^3-P^4; 33041, M^3; 33052, upper incisors (2); 33058, P_4; 33062, mandible with I, P_4-M_3; 33069, lower I; 33070, upper I; 33076, lower I, 33077, upper I, 33079, M_2; 40599, upper I.

Stratigraphic position—Ringold Formation, from a siltstone 30 feet below White Bluffs tuff, early Blancan.

Discussion—*Spermophilus*? *russelli* bears some resemblance, particularly in size, to *Marmota vetus* (Marsh, 1871, p. 121), a form of uncertain age from "Loup Fork Beds" of northern Nebraska, which is known only from the type mandible. *S.*? *russelli* differs from *M. vetus* by lacking any grooving of the lower incisor, having greater depth of the mandible, and by the presence of prominent mesostylids. It differs further from the other marmots in a number of characters, particularly in relatively small size, small P_4 relative to M_1, small size of the protolophid of P_4, lack of grooving of the incisors, moderate size of the parastyle of P^4, lack of connection between metaloph and protocone on P^4, and incompleteness of the metaloph on M^3.

M^3 of *S.*? *russelli* is very similar in size and shape to two teeth reported by Zakrzewski (1969, p. 5) from Hagerman, Idaho, as *Citellus* sp. (large). The Hagerman specimens differ by the lesser prominence of the protoconule and metaconule. The large ground squirrel from Hagerman may prove to be *S.*? *russelli* when more material is recovered.

The only known species of *Spermophilus* which is larger than *S.* ?*russelli* (P_4 AP=3.4 mm) is *S. patter-*

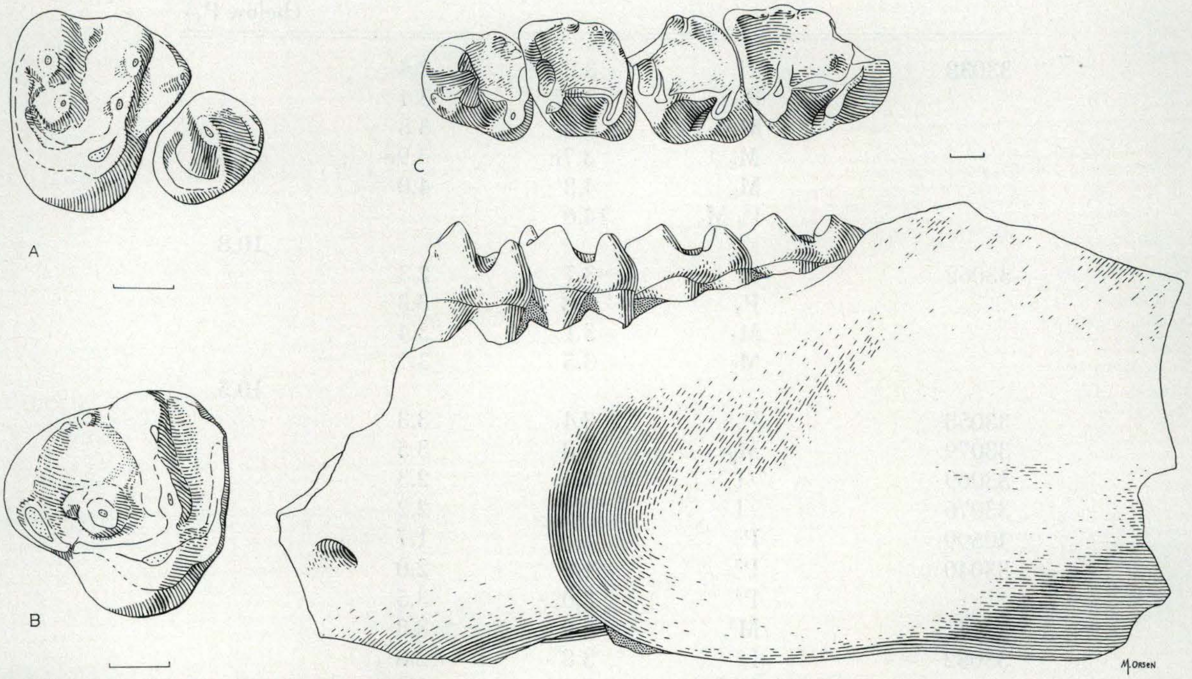

Figure 11. *Spermophilus*? *russelli* n. sp.. A. right P^3-^{4}, UW 33040, occlusal view. B. right M^3, UW 33041, occlusal view. C. Type left mandible with P_4-M_3, UW 33038, lateral and occlusal views. Anterior to right in A-B, to left in C. Drawing 11C by Mark Orsen. Scale lines indicate one millimeter.

soni (P_4 AP=4.1 mm, Wilson, 1949, p. 170) from the Hemphillian Yepomera fauna of Mexico. The latter resembles Recent species of *S.* (*Otospermophilus*) except for size and presence of a strong metaloph on M^3, and it differs from *S.? russelli* in the latter character.

In its general features *S.? russelli* is similar to the subgenus *Otospermophilus* which Black (1963) emphasizes as the most primitive structural group within the genus *Spermophilus*. *S.? russelli* differs markedly from the primitive marmotlike sciurid *Palaearctomys* in the relatively larger cheek-tooth series and smaller incisors, and from *Protospermophilus* in having relatively more distinct lophs, higher tooth crowns, and a P^3 with distinct anterior and posterior cingula. The teeth of *Protospermophilus* (comparison here is primarily with *P. angusticeps* specimens from the Deep River Formation, late Hemingfordian of Montana) are more rounded, with robust, almost bulbous cusps. The ancestry of *S.? russelli* remains in doubt. It seems possible to derive the observed morphology from either a primitive *Spermophilus* pattern (in which case *S.? russelli* is rather specialized, particularly for large size) or from the primitive *Marmota* pattern (in which case it is quite primitive, lacking specializations such as increased size of P_4^4, which are seen in Hemphillian marmots). Given the present information, questioned placement into the broadly defined genus *Spermophilus* seems to be most convenient.

Genus *Ammospermophilus* Merriam, 1892

Ammospermophilus hanfordi new species

(Fig. 12)

Type—UW 33078: fragmentary skull including partial frontals, parietal, right I, P^3-M^3, left I and P^4, complete mandibular dentition, most of right and part of left dentaries; several vertebrae and ribs, partial scapula, both humeri, part of radius and ulna, metacarpal.

Type locality—UW A5927, Franklin County, Washington.

Diagnosis—Largest species of *Ammospermophilus*, skull apparently about size of skull of *Spermophilus lateralis* (Say). *Ammospermophilus* generic

TABLE 4

MEASUREMENTS OF *Spermophilus? russelli* N. SP.

Specimen Number	Tooth	AP	T	Mnd. depth (below P_4)
33038	/I	3.8	2.4	
	P_4	3.4	3.4	
	M_1	3.6	3.8	
	M_2	3.7e	3.9e	
	M_3	4.8	4.0	
	P_4-M_3	14.6		
				10.8
33062	/I	3.7	2.3	
	P_4	2.8	3.3	
	M_1	3.1	3.4	
	M_2	3.5	3.7	
				10.5
33058	P_4	3.4	3.3	
33079	M_2	3.8	3.5	
33069	/I	3.7	2.3	
33076	/I	3.8	2.2	
40599	P^3	1.8	1.7	
33040	P^3	1.8	2.0	
	P^4	3.0	3.5	
33041	M^3	3.9	3.8	
33052	I/	3.8	2.8	
	I/	3.9	2.6	
33070	I/	4.1	2.5	
33077	I/	4.1	2.7	

characters include: cheek teeth relatively small, low crowned; P^3 a simple single-cusped peglike tooth; metaloph of P^4-M^2 separated from protocone by deep notch; protolophid absent and protoconid and parametaconid appressed on P_4; interorbital region relatively wide; interorbital width narrower than postorbital constriction; zygomatic notch opposite anterior M^1. Specific characters include relatively large size; mesostyles present on $M^{1\text{-}2}$; metaconule very distinct; mandible relatively deep; small protoconulid present or absent, $M_{1\text{-}2}$ with little anteroposterior compression.

Referred specimens—The following are UW localities and specimen numbers: A5927: 33048, P_4-M_3; 34953, $M^{1\text{ or }2}$; 34954, $M^{1\text{ or }2}$; 34956, $M^{1\text{ or }2}$; 34957, M_2; 35229, P_4-M_2; 35230, P_4; 35232, P_4; 40371, $M^{1\text{ or }2}$; 40584, M^3; 40597, M^3; 40601, $M_{1\text{-}3}$; 40608, M_2; 40612, P^4; 45291, M^3; 45303, P^4, 45311, $M^{1\text{ or }2}$; 45313, $M^{1\text{ or }2}$; 45315, $M^{1\text{ or }2}$.

Stratigraphic position—Ringold Formation, from siltstone 30 feet below White Bluffs tuff, early Blancan.

Description—The skull, as is apparent from the available fragments, is larger than in the Recent species of *Ammospermophilus.* Portions of the premaxillary, nasal, maxillary, frontal, parietal, and squamosal bones and the right bulla, are present and seem to indicate a skull the size of that of Recent *Spermophilus lateralis*, or about 42 to 44 mm in maximum length. The frontals are a little wider at the interorbital notch than in *S. lateralis*. The bulla is very similar in size and form to that of *S. lateralis*, and does not have transverse indentations at the intrabullar septa as in *Eutamias*. The zygomatic notch is not as far posterior as in most Recent *Spermophilus* or as far anterior as in *Eutamias* or *A. fossilis* (Clarendonian, Cuyama Valley, California; James, 1963, p. 75), but is similar in position to that of Recent *Ammo-*

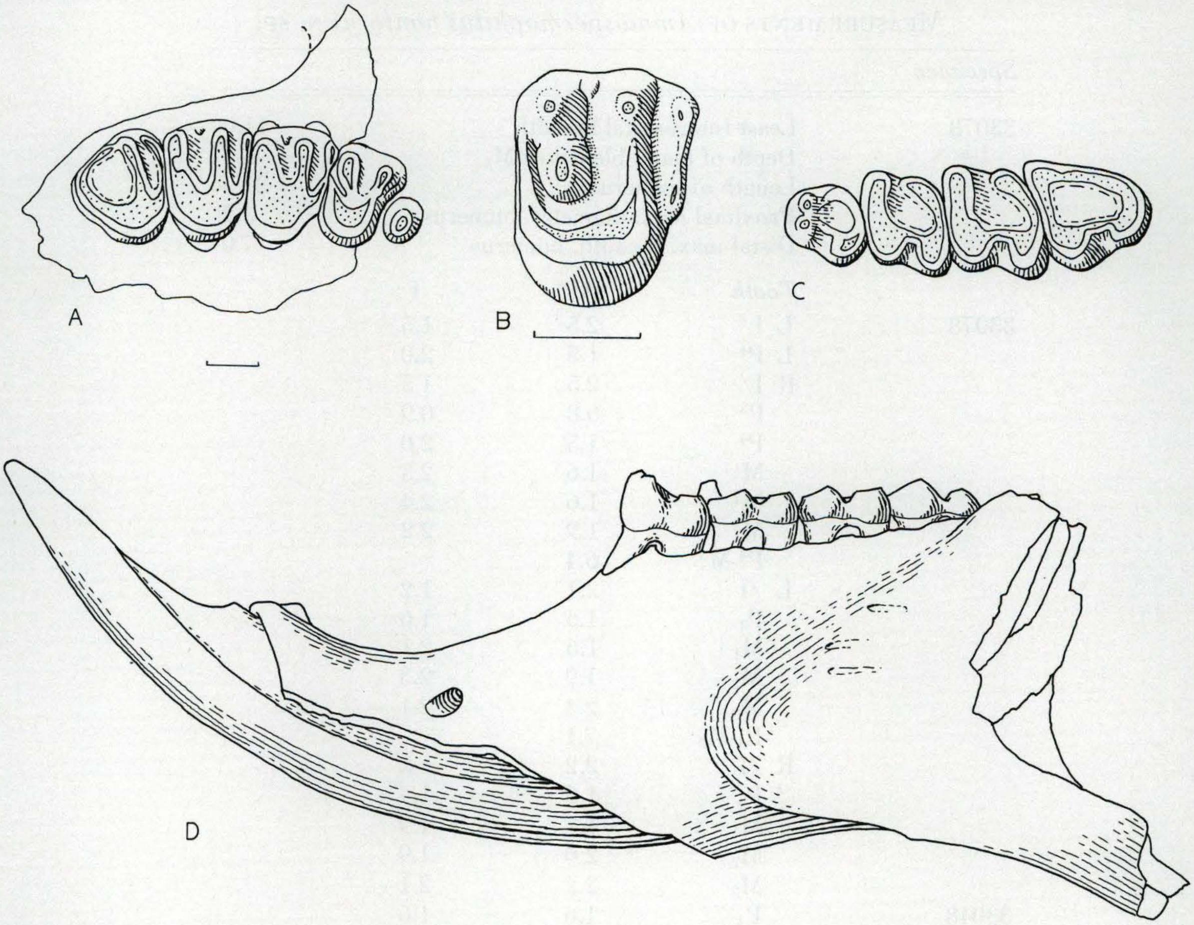

Figure 12. *Ammospermophilus hanfordi* n. sp.. A, C,and D from holotype UW 33078. A. right P^3-M^3, occlusal view, anterior to right. B. right $M^{1\text{or}2}$, UW 34956,occlusal view, anterior to right. C. left P_4-M_3, occlusal view, anterior to left. D. left mandible, lateral view,anterior to left. Scale lines indicate one millimeter.

spermophilus, opposite the anterior portion of M^1.

P^3 is a simple peglike tooth, about ½ of the transverse width of P^4. It is proportionately slightly larger than in *Eutamias townsendi* Bachman.

P^4 is highly variable in occlusal shape, from ovate to triangular, depending on the prominence of the parastyle and anterior cingulum. In specimen UW 45308 the anterior cingulum is quite small and there is no parastyle; in the type the anterior cingulum is larger and a very small parastyle is present; and in UW 40612 the parastyle is a prominent cusp nearly as large as the paracone. The lingual attachment of the cingulum is at the anterior middle of the tooth. The protocone is large, placed slightly forward of the middle of the lingual side of the tooth. The paracone is slightly smaller than the metacone. The protoloph is lower than the metaloph and includes no protoconule. The metaconule is large and distinct. The metaloph does not connect to the protocone until late wear. The posterior cingulum is strong, and connects labially to the posterior side of the metacone. There is no mesostyle.

M^1 and M^2 are not separable as isolated teeth. In the type, M^1 is equal to M^2 in anteroposterior length but slightly narrower transversely. The anterior cingulum is straight, nearly parallel to the protoloph, and joins the protocone with a sharp bend about one-fourth the distance from the lingual side of the tooth. The parastyle is distinct. The protocone is large, with the tip just anterior to the middle of the lingual side. The protoloph is a high straight ridge, with no protoconule. A mesostyle is present, though small. The metacone and paracone are equal in size; the metaconule is distinct and only slightly smaller than the

TABLE 5

MEASUREMENTS OF *Ammospermophilus hanfordi* N. SP.

Specimen		
33078	Least Interorbital breadth	11.0
	Depth of mandible below M_1	5.7
	Length of humerus	27.3
	Proximal max. diameter, humerus	5.2
	Distal max. breadth, humerus	7.0

	Tooth	AP	T
33078	L I/	2.5	1.5
	L P^4	1.5	2.0
	R I/	2.5	1.5
	P^3	0.8	0.9
	P^4	1.5	2.0
	M^1	1.6	2.3
	M^2	1.6	2.4
	M^3	1.9	2.2
	P^4-M^3	6.4	
	L /I	2.1	1.2
	P_4	1.6	1.6
	M_1	1.6	2.1
	M_2	1.9	2.3
	M_3	2.4	2.1
	P_4-M_3	7.1	
	R /I	2.2	1.2
	P_4	1.6	1.4
	M_1	1.7	1.9
	M_2	2.0	1.9
	M_3	2.2	2.1
33048	P_4	1.6	1.6
	M_1	1.7	2.0
	M_2	1.7	2.3
	M_3	2.2	2.1
	P_4-M_3	7.2	

metacone. The metacone and metaconule are connected by a low ridge, and the metaconule is distinctly separated from the protocone until late wear. The posterior cingulum is rather weak and low.

M^3 is triangular, with a smaller parastyle and weaker anterior cingulum than the other molars. The anterior cingulum connects to the protocone with a sharp bend as in the other molars. The paracone is strong, and the protoloph is straight but lacks a protoconule. There is no distinct metacone, and the metaconule is very small or absent. The posterior cingulum is separated from the protocone by a distinct notch; it is strong and curved strongly and evenly. A small mesostyle is present on 2 of the 4 examples. The posterior cingulum is separated from the paracone by a deep notch.

The upper incisors are not grooved, unlike those of *Eutamias*. They are about the size and form of those of *S. lateralis*, with a more rounded anterior face than in *Eutamias*.

The mandible is similar in size to that of *S. lateralis*, although the diastema is slightly shorter. The mental foramen is in the same position as in *S. lateralis*. The masseteric fossa is like that of *Eutamias townsendi* in form, but with stronger dorsal and ventral ridges. The cheek tooth row is relatively shorter than in *Spermophilus*, and the low- crowned teeth are similar to those of *E. townsendi* in general aspect.

The lower incisors are nearly identical in size and form to those of *S. lateralis*; they lack the grooving seen in *Eutamias*. The incisors of *E. townsendi* are much less procumbent and more strongly curved.

P_4 is narrow anteriorly, with the protoconid and the metaconid closely appressed. A small anterior cusp (protoconulid of Bryant, 1945, fig. 43) is present on two specimens. The protoconid is larger at the base but lower than the metaconid. The protoconid and hypoconid are equal in size though the hypoconid is lower. The ectolophid is low; it is distinct on less-worn teeth but disappears with wear. The posterolophid is low but distinct, nearly semicircular, with no visible entoconid. The talonid basin is smooth.

DP_4 is similar to P_4 but smaller, with sharper cusps, a relatively larger talonid basin, the ectolophid indistinct, and two anteroposteriorly flared roots.

TABLE 5 (Continued)

Specimen	*Tooth*	AP	T	
35229	P_4	1.5	1.2	
	M_1	1.8	2.1	
	M_2	2.0	2.2	
35230	P_4	1.7	1.6	
35232	DP_4	1.3	1.2	
45303	P_4	1.5	1.3	
40601	M_1	1.8	2.1	
	M_2	2.1	2.2	
	M_3	2.3	2.1	
34957	M_2	2.1	2.5	
40608	M_2	2.0	2.3	
40612	P^4	1.6	1.6	
45308	P^4	1.5	2.0	
34953	M^{1or2}	1.8	-	
34954	M^{1or2}	1.8	2.2	
34956	M^{1or2}	1.6	2.0	
40371	M^{1or2}	1.9	2.1	
45311	M^{1or2}	1.9	2.3	
45313	M^{1or2}	1.9	2.4	
45315	M^{1or2}	1.7	2.1	
40584	M^3	2.1	2.0	
40597	M^3	1.9	2.2	
45291	M^3	2.2	2.1	
34981	Length of humerus			27.6
	Prox. max. diameter, humerus			5.5
	Dist. max. breadth, humerus			7.3

M_1 is a subquadrate tooth with a low protoconid, weak protolophid, and a short, weak metalophid. The trigonid basin is small and is placed just anteromediad from the protoconid. The protoconid and metaconid are placed slightly less far apart than the hypoconid and entoconid, with the cusps set near the corners of the tooth. The metaconid is the highest cusp, though it is still rather low. The talonid basin is large and smooth. The ectolophid is quickly worn away. The posterolophid is low and only slightly curved. The ectoconid is distinct on less-worn teeth. A distinct notch is present between the entoconid and the posterior side of the metaconid. M_1 is a little smaller in length and width than M_2 but larger than P_4.

M_2 is similar to M_1 except that the protoconid and metaconid are placed further apart than the hypoconid and entoconid. The entoconid is less distinct than on M_1.

M_3 is the largest of the lower cheek teeth. The trigonid is similar to that of M_2, with a small basin anteromediad from the protoconid. The hypoconid is large, the entoconid and ectolophid are small and disappear quickly with wear. The tooth shape tends to be more triangular than quadrate. A small mesostylid is present on less-worn specimens. The notch between the entoconid and the mesostylid is less deep than on M_{1-2}. The posterolophid is strongly curved.

The postcranial bones of *A. hanfordi* have not been compared to those of Recent *Ammospermophilus*; thus a detailed description will not be attempted at present. An exception is made for the humerus, which is especially well preserved.

Two complete humeri were found, one of which was associated (with another partial humerus) with the type, the other found during screenwashing. They are nearly identical in size. The humerus is slender and is proportioned (as in other *Ammospermophilus*) more as in *Sciurus* than in *Spermophilus*. The lesser trochanter is identical in form to that of *Sciurus*. The head of the humerus is ovate in dorsal view, narrower than that of *Spermophilus*, and very similar to that of *Sciurus*. The deltoid crest is similar to that of *A. fossilis* James (1963), higher than in *Sciurus*. The lateral epicondylar ridge is about as prominent as in *Sciurus* and more prominent than in *Spermophilus*; however the proximal end of the ridge connects to the shaft farther distad than in *Sciurus*, so that the ridge flares more abruptly from the shaft. An entepicondylar foramen is present. The humerus resembles that of *Sciurus* in characters which are found also in other species of *Ammospermophilus*, and in species of *Eutamias*, particularly the slender proportions and ovate head. The ratio between the length of the humerus and the (estimated) length of the skull (James, 1963, fig. 32) is close to the regression line drawn by James for the antelope ground squirrels (*Ammospermophilus*), chipmunks (*Tamias*), and ground squirrels (*Spermophilus*); the humerus is relatively shorter than in *A. fossilis*, flying squirrels (*Glaucomys*), and tree squirrels (*Sciurus*).

Discussion—*A. hanfordi*, though slightly larger, was evidently rather similar to living *Ammospermophilus* in structure. This genus is not now found north of the Great Basin; Recent species are adapted to hot, dry climates. *A. hanfordi* was (as is indicated by the morphology of the humerus) probably a ground-dwelling form without marked adaptations for either arboreal or fossorial life, and which appears to have been rather abundant in at least some areas of the Ringold flood plain.

Family Geomyidae
Genus *Thomomys* Wied-Neuwied, 1839

Thomomys cf. *T. gidleyi* Wilson, 1933
(Fig. 13)

Type locality—Hagerman, Idaho.

Material—UW A5927: UW 40596, $M^{1\text{ or }2}$, UW A6503: UW 35110, $M_{1\text{ or }2}$; UW 35111, P^4; UW 35139, $M^{1\text{ or }2}$; UW 35209, $M^{1\text{ or }2}$; UW 40427, ?$M^{1\text{ or }2}$; UW 45026, $M_{1\text{ or }2}$.

Stratigraphic position—Ringold Formation, from 30 feet below to 45 feet above White Bluffs tuff.

Description—Several isolated cheek teeth represent a small pocket gopher referable to the genus *Thomomys*. The teeth are similar to but slightly smaller than those of Recent *Thomomys talpoides* (Richardson, 1828) and *T. gidleyi* (early Blancan, Hagerman, Idaho) and are nearly as hypsodont as *T. talpoides*. Dentine tracts extend the full height of all

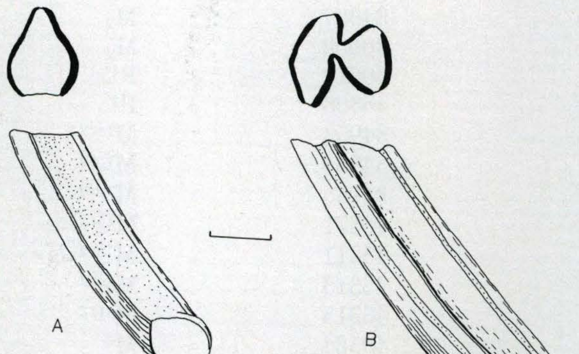

Figure 13. *Thomomys* cf. *T. gidleyi*. A. left $M_{1\text{or}2}$, UW 45026, occlusal and labial views, anterior to left. B. left P^4, UW 35111, occlusal and labial views, anterior to right. Line indicates one millimeter.

TABLE 6
MEASUREMENTS OF *Thomomys* CF. *T. gidleyi**

				T. gidleyi (range) Hagerman, Idaho	
Specimen	Tooth	AP	T	AP	T
UW 35111	P^4	1.70	1.56	1.60	1.45
UW 35139	M^{1or2}	1.02	1.51		
UW 35209	M^{1or2}	0.80	1.78		
UW 40596	M^{1or2}	0.80	1.47		
UW 40427	?M^{1or2}	0.89	1.78		
UW 35110	M_{1or2}	1.16	1.51	1.16-1.36	1.81-2.05
UW 45026	M_{1or2}	1.11	1.47		

* Measurements taken along occlusal plane.

teeth. The shape of the occlusal surfaces, including lingual constriction of the lower molars and labial constriction of the upper molars (a generic character of *Thomomys*), is variable, as in *T. gidleyi*. One tooth (UW 35209), evidently in a late stage of wear, has closed off the lower end and formed a vestigal root. The latter tooth shows no evidence of constriction, and could represent another geomyid.

The P^4, while approximating the occlusal form of P^4 of *T. talpoides*, differs in several respects. The anterior surface as well as the sides of the reentrant angles, are less strongly curved than in *T. talpoides*. The tips of the reentrant angles are further apart, leaving more room for the dentine connecting the anterior and posterior loops. A P^4 from a young individual of *T. gidleyi* is similar to but slightly smaller than the White Bluffs specimen.

Discussion—Except for size (which is not greatly different) these molars compare well with those of *T. gidleyi* Wilson (Zakrzewski, 1969, Text-fig 3). The Ringold specimens may or may not be specifically separable from *T. gidleyi*, but they certainly represent a species at very nearly the same stage of evolution. The presence of a root on the tooth of an old individual may be an indication of a slightly more primitive condition than in *T. gidleyi*.

Family Castoridae
Genus *Castor* Linnaeus, 1758

Castor californicus Kellogg, 1911
(Fig. 14B-E)

Type locality—North end of Kettleman Hills, Fresno County, California; "upper Etchegoin," *Pecten coalingensis* zone, late Pliocene.

Material—UW A6571: 50389, right $M^{1\ or\ 2}$. UW A8819: 50387, right $M^{1\ or\ 2}$, and 50388, right $M_{1\ or\ 2}$. UW A9305: 51749, M_3, 51750, mandible fragment, and 51751, I fragment, all probably from one individual.

Stratigraphic position—Ringold Formation, all specimens probably from above White Bluffs tuff, early Blancan.

Description—The specimens listed for this taxon are generally slightly larger than in available Recent adult specimens of *Castor canadensis*. The incisor is identical in size to that listed for *C. californicus* by Stirton (1935, p. 445, T=8.8 mm). The enamel pattern of the molars (Fig. 14 c, d, e) is generally similar to that seen in both *C. canadensis* and *C. californicus*; the sample is too small to allow differentiation. The stria and striids are shorter than seen in *C. canadensis* and similar to those of *C. californicus*.

The jaw fragment (UW 51750) has two distinctive features: size (larger than in *C. canadensis*), and the shape of the mental process. In *C. canadensis* this process is concave on the posterior side, while the anterior side blends smoothly with the anterior border of the jaw. In contrast, the mental process in the Ringold specimen is larger, forms a distinct obtuse angle with the anterior jaw, and has a straight posterior border; thus it seems to jut forward much more strongly. A similar mental process is seen in a specimen from Grand View, Idaho (Shotwell, 1970, fig. 15) which was assigned to *C. accessor* Hay. The mental foramina on UW 51750 are adjacent to the dorsal border of the incisor and are farther dorsal than in most specimens of *C. canadensis*.

Discussion—Two similar-sized Blancan species of *Castor* have been described from North America. *Castor californicus* Kellogg (1911) from the "upper Etchegoin" beds of the Kettleman Hills, California, and *C. accessor* Hay (1927) from Froman Ferry, Idaho, each had single cheek teeth as holotypes. Stirton (1935) described additional material (apparently topotypic) of *C. californicus*. No topotypic

TABLE 7

MEASUREMENTS OF *Castor californicus* FROM THE RINGOLD FORMATION

Specimen	Tooth	AP			
50388	$M_{1\text{or}2}$	---		8.1e	occlusal
		---		10.0e	maximum near base
51749	M_3	8.9	occlusal	7.9	occlusal
50387	$M^{1\text{or}2}$	9.5e	occlusal	9.6e	occlusal
50389	$M^{1\text{or}2}$	7.0	occlusal	7.1	occlusal
		7.3	maximum	11.0	maximum near base

specimens of *C. accessor* have been described, although Shotwell (1970) assigned a number of specimens from Grand View, Idaho, to this species. This assignment was based on geographic proximity and length of stria and striids (terminology of Stirton, 1935), which in the Grand View specimens are intermediate between those of *C. californicus* and the living *C. canadensis*.

Both of the Blancan species have stria and striids shorter than *C. canadensis* (in this respect like the White Bluffs specimens), but no adequate quantitative data is available for lengths of these structures. Because *C. californicus* appears to be the better founded as well as the earlier name, I prefer to assign the White Bluffs specimens to this species.

Genus *Dipoides* Schlosser, 1902

Dipoides rexroadensis Hibbard and Riggs, 1949
(Fig. 14A)

Type locality—Keefe Canyon, Kansas, University of Kansas locality 22, Rexroad Formation, late Pliocene.

Material—UW A9849: 45673, right lower jaw with broken I, complete P_4-M_3, found by Marvin Gross, April 1967.

Stratigraphic position—Ringold Formation, exact level not known, but probably above level of White Bluffs tuff, early Blancan.

Description—Dental terminology after Woodburne, 1961.

The mandible is broken behind M_3. The remaining portion is close in size to the mandible of *Castor canadensis*, and its form is similar to that of the mandible of *Procastoroides sweeti* (Hibbard, 1972, fig. 36D). A well defined fossa for attachment of the anterior masseter muscles is present on the lateral side between anterior P_4 and the middle of M_2. There are four mental foramina near the base of P_4, one (anterior) large, the others smaller and just posterior to the large one. A mental process smaller than that present in *Castor canadensis* projects below the ventral border at the posteroventral end of the symphysis. The anterodorsal border between P_4 and the incisor is sharply angled, more so than in *P. sweeti* or *P. idahoensis* Shotwell from Grand View, Idaho. The anterior root of the coronoid process is situated opposite the posterior portion of M_1.

The lower incisor is rounded on its ventrolateral side, with smooth enamel like other species of *Dipoides* and *P. sweeti*, and unlike *Castoroides* and *Procastoroides idahoensis* which have grooved incisors.

P_4, like the molars, is an extremely hypsodont tooth. Paraflexid, mesoflexid, and hypoflexid are

TABLE 8

MEASUREMENTS OF *Dipoides rexroadensis*, RINGOLD FORMATION

Specimen	Tooth	AP	T	
UW 45673	P_4	7.2	7.2	
	M_1	7.1	5.9	
	M_2	7.4	5.8	
	M_3	6.5	5.3	
	I	7.8	6.7	
	Depth of jaw, medial side, measured from posterior P_4 alveolus rim			25.0

present, extending almost completely across the tooth, with the terminations not quite contacting the opposite enamel wall. The parastriid, mesostriid, and hypostriid extend as parallel-sided grooves into the alveolus, so their total length is not visible. The parastriid is 9.3 mm long above the rim of the alveolus. The hypoflexid is straight and extends mediad and slightly posterad; the mesoflexid and paraflexid extend laterad and anterad, with the anterior side slightly concave. The median loph is uninflated (parallel sides) and both parts of the anterior loph and the posterior loph are slightly inflated.

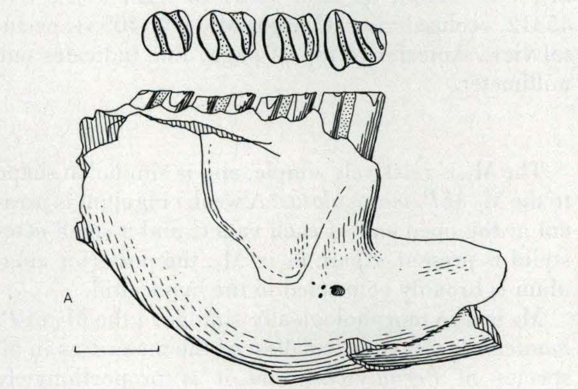

Figure 14. A. *Dipoides rexroadensis*, UW 45673, right mandible with P_4-M_3, occlusal and lateral views, anterior to right. B-E, *Castor californicus*. B. fragment of right mandible, lateral view, anterior to right, UW 51750. C. right M_3, UW 51749, occlusal and lateral views, anterior to right, found with UW 51750. D. right M^{1or2}, UW 50389, occlusal and lateral views, anterior to left. E. right M^{1or2}, UW 50387, occlusal and lateral views, anterior to left. Lines indicate one centimeter; A-C all to same scale.

The P_4 of the White Bluffs specimen resembles a specimen of *D. rexroadensis* from the type locality (Woodburne, 1961, fig. 2M) in the presence of three flexids and the general shape of the anterior and median lophs; however it differs, perhaps through individual variation, in having the posterior loph extending farther laterad than in the Kansas specimen and in being slightly smaller. The White Bluffs P_4 differs from the holotype P_4 (USNM 24933) of *Dipoides intermedius* Zakrzewski (1969) from Hagerman, Idaho, in the presence of the paraflexid (which is absent in the Hagerman specimen) and in being slightly smaller (length of P_4 is 7.2 mm in UW 45673, versus 9.3 in USNM 24933). The P_4 of the White Bluffs specimen is less than 1 mm longer than the average for P_4 (AP=6.4 mm) of *D. stirtoni* Wilson (measurements of 19 specimens, from Shotwell, 1955) but is considerably wider (T=7.2 mm, versus average for *D. stirtoni* T=4.3 mm). *D. stirtoni*, from the Rome local fauna, Oregon, is the largest of the Hemphillian *Dipoides*; it has a paraflexid on P_4 but appears to be more primitive in that the flexids do not extend as far across the tooth as in *D. rexroadensis.*

The lower first and second molars are similar to each other and to an equivalent molar of *D. rexroadensis*, but slightly smaller. Mesoflexids and hypoflexids are present and extend almost to the opposite enamel. Although the upper edges of the teeth have some postmortem wear, some dentine is visible on the sides of the teeth between the terminations of the flexids and the outer tooth enamel in all cases. Median and posterior lophs are slightly inflated. The mesoflexids are slightly concave on the posterior side, and the hypoflexids are nearly straight. M_3 is similar to M_2 except for smaller size and some posterad taper.

Discussion—The White Bluffs specimen of *Dipoides* is referred to *D. rexroadensis* on the basis of presence of the paraflexid on P_4 and size intermediate between *D. stirtoni* and *D. intermedius.* Little is known about enamel pattern variation in the lower teeth of *D. rexroadensis*; however, judging from what is known about closely related forms (Shotwell, 1955), the patterns on UW 45673 are sufficiently similar to specimens of *D. rexroadensis* from the type locality to be easily referred to that species.

Family Muridae
Genus *Peromyscus* Gloger, 1841

Peromyscus nosher new species
(Fig. 15)

Type—UW 34963, mandible fragment containing M_1-M_2.

Type locality—UW A5927, south end of White Bluffs near Pasco Pumping Plant.

Etymology—Yiddish, "nibbler."

Diagnosis—About size of *P. maniculatus* (Wagner). M_2 and M_3 similar to those of *P. maniculatus* but M_1 relatively complex with bilobed anteroconid, lobes of anteroconid and metaconid subcircular, ectolophid and mesostylid present, posterior cingulum broadly connected to hypoconid. M^1 anterocone weakly grooved, broad; anterior groove disappearing with moderate wear; mesoloph and parastyle present; center of anterocone in line with axial valley of tooth; entostyle weak.

Referred specimens—The following are UW localities and specimen numbers: A5927; 34962, 40554, and 40598, all M^1, 45312, mandible fragment with M_2-M_3.

Stratigraphic position—Type locality only, Ringold Formation, 35 feet below White Bluffs tuff, early Blancan.

Description—The size of *Peromyscus nosher* is similar to that of *P. maniculatus*. The available mandible fragments allow few observations, but seem to resemble closely the mandible of *P. maniculatus*. The cusp terminology used here follows Shotwell (1967, fig. 2).

The M_1 of *P. nosher* is characterized by a large, bilobed anteroconid. This structure seems to be wider than in most species of *Peromyscus*, and the two lobes are aligned with the posterior cusp rows. In the one available specimen, each lobe has worn to a subcircular shape. The protoconid is slightly smaller than the hypoconid. A strong mesostylid is present, and the mesolophid is suggested by a bulge on the anterior side of the entoconid in the proper position, though it is not well developed. The ectolophid is strong and straight, and is deflected slightly posterad from a right angle to the longitudinal tooth axis. The posterior cingulum is wide and is broadly connected to the hypoconid after moderate wear.

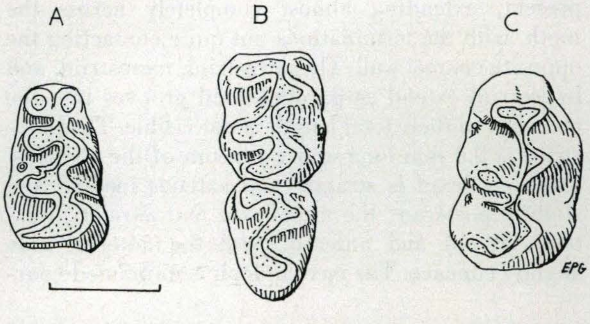

Figure 15. *Peromyscus nosher* n. sp. A. Type right M_1, UW 34963, occlusal view. B. right M_{2-3}, UW 45312, occlusal view. C. right M^1, UW 40554, occlusal view. Anterior to top of page; line indicates one millimeter.

The M_2 is relatively simple, and is similar in shape to the M_2 of *P. maniculatus*. A weak cingulum is present at the open end of each valley, and a small ectostylid is present. Again as in M_1, the posterior cingulum is broadly connected to the hypoconid.

M_3 is also morphologically similar to the M_3 of *P. maniculatus*. It is the smallest of the molars, as in all species of *Peromyscus*, and it is proportionately smaller than in the early Pliocene species described by Shotwell (1967).

M^1 of *P. nosher* is quite similar in general shape to the M^1 of *P. maniculatus*, but differs in the shape of the anterocone. In *P. maniculatus* the anterocone possesses a strong anterior groove for much of its height, while in *P. nosher* the anterior groove is shallow and disappears after moderate wear. The cingulum at the open end of each valley is distinct. The anterior cingulum is strong and sharp. A parastyle, mesostyle, and mesoloph are present in each of the three available specimens. The mesoloph and mesostyle are connected in only one of the three.

Peromyscus nosher is distinguished from *P. valensis* Shotwell (1967) of the Hemphillian of Oregon by its bilobed anteroconid; from the Blancan and Irv-

TABLE 9

MEASUREMENTS OF *Peromyscus nosher* N. SP.

Tooth	Specimen number	AP	T
M_1	UW 34963	1.4	1.0
M_2	UW 34963	1.2	0.9
M_2	UW 45312	1.3	1.0
M_3	UW 45312	1.1	0.8
M^1	UW 34962	1.8	1.1
M^1	UW 40554	1.6	1.1
M^1	UW 40598	1.6	1.1

ingtonian species from Kansas by the presence of lophids and stylids.

P. nosher is similar in size and in the general form of M^1 to *P. hagermanensis* Hibbard (1962). It differs, however, in that the parastyle is small and cuspoid, not lophoid and large as in *P. hagermanensis*. The anteroconid of M_1 in *P. hagermanensis* is not strongly bilobed as in *P. nosher*. In M_2 of *P. nosher* the posterior cingulum connects broadly and smoothly with the hypocone, and is not notched on the posterolabial side as in *P. hagermanensis*. The anterior cingulum of M_2 in *P. hagermanensis* is longer.

Discussion—The position of *P. nosher* in the phylogeny of *Peromyscus* must be regarded as uncertain, though it is an essentially modern form. Shotwell (1967) working with a sequence of late Tertiary forms of *Peromyscus* from Oregon found that simpler-toothed forms of *Peromyscus* occurred in stratigraphically higher faunas. It may be, as several authors have suggested, that the presence of lophs and styles is ecologically controlled. Hershkovitz (1955, p. 644) for example, states that these accessory structures, (like those of *P. nosher*), especially the mesoloph(id), occur generally in forest-dwelling forms but much less often in cricetines inhabiting open country or scrubland; this suggestion was essentially adopted by Shotwell (1967) and Hooper (1957).

Genus *Neotoma* Say and Ord, 1825
Subgenus *Paraneotoma* Hibbard, 1967

Neotoma (*Paraneotoma*) sp. cf. *N. quadriplicatus* (Hibbard)
(Figure 16)

Hibbard, 1941, p. 356, Plate 1, 2.

Material—UW A6503: UW 35109, left M_2.

Stratigraphic position—Ringold Formation, 45 feet above White Bluffs tuff, early Blancan.

Description—This tooth, from a young adult, is less hypsodont and possesses thicker enamel than Recent *Neotoma* but matches the members of the subgenus *Paraneotoma* in these characters. Dimensions of the occlusal surface are: AP=2.7 mm, T=1.8 mm. Maximum dimensions of the tooth, measured just above the base of the enamel, are: AP=3.2 mm, T=2.4 mm.

The M_2 occlusal enamel pattern consists of a posterior loop with a shallow posterior inflection (which disappears about halfway down the tooth crown), two confluent alternating triangles, and a wide, anteroposteriorly short anterior loop.

The available M_2 represents an animal in the lower size range of *N. quadriplicatus* (Hibbard) from the type locality in the Rexroad Formation of Kansas, with a slightly less hypsodont M_2. The Ringold Formation form is, however, closer in form to the latter species than to either *N.* (*P.*) *sawrockensis* Hibbard (1967), which is considerably lower-crowned, or *N.* (*P.*) *taylori* Hibbard (1967), a higher-crowned form with a less irregular enamel pattern and enamel thickness. *N. quadriplicatus* also differs from the White Bluffs form in being proportionately longer anteroposteriorly in early stages of wear and having a shallower posterior inflection on M_2. However, some individual teeth from the Wendell Fox locality (UM-K3-53), referred to *N. quadriplicatus*, approximate the specimen from the Ringold Formation in occlusal enamel pattern.

Discussion—The differences between *N. quadriplicatus* and the White Bluffs tooth are not sufficient to indicate a specific separation (or identity). More specimens will be needed to understand the Ringold species adequately.

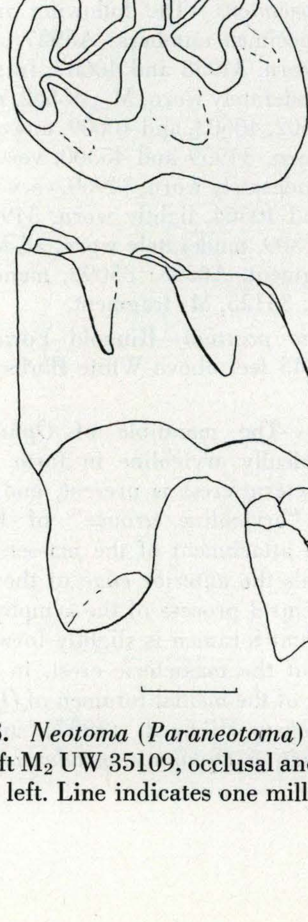

Figure 16. *Neotoma* (*Paraneotoma*) cf. *N. quadriplicatus*, left M_2 UW 35109, occlusal and labial views, anterior to left. Line indicates one millimeter.

Genus *Ophiomys* Hibbard and Zakrzewski, 1967

Ophiomys mcknighti new species
(Figure 17)

Type—UW 35227, M_1 of a young adult.

Type locality—UW A5927, Franklin County, Washington.

Etymology—Named for E. T. McKnight, who in 1923 first reported a primitive arvicoline (specimen now lost) from the Ringold Formation.

Diagnosis—Similar in size to *O. magilli* Hibbard (1972), larger than *O. taylori* (Hibbard, 1959), but smaller than *Ogmodontomys poaphagus* Hibbard (1941), and *Cosomys* Wilson (1932). Molars rooted, lacking cement, lacking dentine tracts. M_1 with three alternating triangles. Base of enamel on anterior loop of M_1 near same level as on labial alternating triangles, not retracted upwards as in *O. magilli* or *O. taylori*. Apices of reentrant angles on lingual side of M_1 (except second) at right angles to the longitudinal plane of the tooth in young individuals, sometimes constricted and turned anterad in older individuals but with less constriction than in *O. magilli*. Enamel pit on anterior loop present in type M_1; anterolabial margin of anterior loop rounded, some times possessing multiple grooves in early wear. M^1 and M^2 with three roots, other molars with two.

Referred specimens—The following are UW localities and specimen numbers: A5927: 40600 and 45314, very worn, 34958 and 40607, fragments, all M_1; 40604, moderately worn, M_2; 45562, moderately worn, M_3; 40602, 40603, and 40609, unworn, 33080, moderately worn, 34959 and 45300, very worn, all M^1; 40565, moderately worn, 34960, very worn, both M^2; 40563 and 40564, lightly worn, 34961, 40568, 40594, and 45309, moderately worn, all M^3; 40561, mandible fragment. A6503: 35098, mandible fragment with M_2; 35125, M_2 fragment.

Stratigraphic position—Ringold Formation, 35 feet below to 45 feet above White Bluffs tuff, early Blancan.

Description—The mandible of *Ophiomys mcknighti* is typically arvicoline in form. A strong, shelflike masseteric crest is present, and a shallow groove (the "arvicoline groove" of Repenning, 1968) for the attachment of the masseter medialis muscle parallels the anterior edge of the ascending ramus. The ventral process of the symphysis is distinct. The mental foramen is slightly forward of the anterior end of the masseteric crest, in a position similar to that of the mental foramen of *Ogmodontomys sawrockensis* Hibbard, (1957) and slightly more dorsal than on *Ophiomys meadensis* (Hibbard, 1956).

M_1 consists of a posterior loop, three alternating triangles, and a complex anterior loop. An enamel pit is present on the anterior loop of the two available complete specimens of M_1. The anterolabial border of the anterior loop is rounded, and is crenulated in the less-worn adult tooth (the type). A fourth lingual

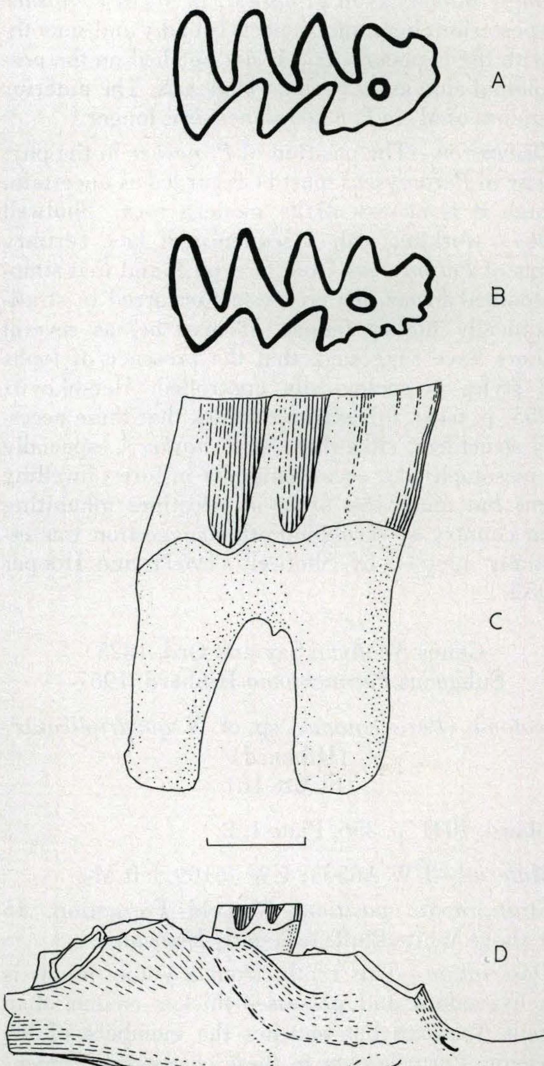

Figure 17. *Ophiomys mcknighti* n. sp.. A. Right M_1, UW40600, occlusal view. B-C. Holotype right M_1, UW 35227, occlusal and labial views. D. Right mandible with M_2, UW 35098, lateral view. Lines indicate one millimeter. Anterior to right.

reentrant is present on the unbroken teeth; on the adult it is about half as deep as the three posterior lingual reentrants, and on the late adult tooth it is very shallow. This fourth lingual reentrant is shallower in late stages of wear than in *O. taylori.* A weak "prism fold" is present on the type M_1, but is only suggested on the late adult. All of the grooves on the anterior loop become much shallower and disappear towards the base of the enamel.

Lingual reentrants may or may not constrict and turn forward at the tip, depending on the individual and the state of wear. When heavily worn all lingual reentrants turn slightly anterad at the tips, though they are little constricted. In the type, a younger individual (wear stage 3; see table 10), only the second lingual reentrant narrows and turns anterad. In both *Cosomys primus* Wilson (1932) and *Ophiomys taylori* (Glenns Ferry Formation, Hagerman, Idaho, early Blancan) the first lingual reentrant frequently fails to turn anterad; however, in these species and in other species of *Ophiomys* the other lingual reentrants turn anterad consistently.

Dentine tracts (notches in the enamel at the base of the labial angles) are absent, at a stage equivalent to that seen in *Ogmodontomys sawrockensis* Hibbard (Zakrzewski, 1967b, fig. 2d).

The M_1 of *Ophiomys mcknighti* is similar in size and general morphology to that of *O. magilli* Hibbard of the late Blancan Sand Draw local fauna of Nebraska (Skinner and Hibbard, 1972), though it appears to be lower crowned. *O. mcknighti* can be distinguished by the lesser relative height of the dentine tracts, which are more strongly developed in all other species assigned to the genus, particularly on the posterior labial angle and on the anterolabial side of the anterior loop. In *O. mcknighti* the anterad inflection of the reentrant angles occurs less consistently in all the molars.

TABLE 10

MEASUREMENTS OF *Ophiomys mcknighti* NEW SPECIES

Tooth	Specimen number	Wear[1]	AP[2]	T[2]	H[3]
M_1	UW 34958	3	--	1.2	1.9
	UW 35227	3	2.7	1.3	1.6
	UW 40600	3	2.7	1.4	1.0
	UW 40607	3	--	1.2	1.2
M_2	UW 35098*	4	1.8	1.4	0.5
	UW 35125*	4	--	1.4	0.5
M_3	UW 40562	4	1.5	1.0	0.8
M^1	UW 33080	3	2.3	1.3	1.3
	UW 34959	4	2.1	1.4	0.9
	UW 40602	1	--	1.2e	2.3
	UW 40603	1	2.2	1.3e	2.6
	UW 40609	1	2.2	1.3e	2.5
M^2	UW 34960	4	2.0	1.5	0.9
	UW 40565	3	--	1.3	1.5
M^3	UW 34961	3	1.8e	1.2	1.2
	UW 40563	2	1.8	1.1	1.2
	UW 40564	2	--	1.0	1.3
	UW 40568	3	--	1.2	1.3
	UW 40594	3	1.9e	1.2e	1.0

* From UW A6503; all other specimens from UW A5927.

[1] Wear stages: 1=little wear, no roots developed
2=slight wear, roots open at base
3=moderate wear, roots fully developed
4=heavy wear, crown usually less than 1 mm high, but no interrupted enamel pattern
5=heavy wear, interrupted enamel pattern

[2] AP and T measurements taken at occlusal plane.

[3] Height of crown measured from base of enamel to occlusal surface on posterolabial side of lower teeth, anterolabial side of upper teeth.

The M_2 of the Ringold species consists of a posterior loop, two alternating triangles, and an anterior loop. The lingual reentrants do not turn anterad at the tips. In *O. magilli* the anterior lingual reentrant turns forward but the posterolingual one does not. Two roots are present. A partial M_2 from Hanford 27 (UW A6503) has distinct grooves on the anterior and posterior sides of the posterior root, suggesting the fusion of two roots.

M_3 is similar to M_2. The single M_3 available seems to represent a relatively small individual. Lingual reentrants curve slightly anterad at the tips, though the anterior lingual reentrant is not constricted at the tip as it is in *O. magilli.*

M^1 consists of an anterior loop, three alternating triangles, and a posterior loop. In the younger individuals the triangles open widely into each other, but in later wear the dentine connecting the triangles becomes much narrower. In adult stages of wear (but not in little-worn teeth), all reentrants except the first lingual turn sharply posterad at their tips. Of three roots present, the lingual root is smallest, though a little larger than that in *O. magilli.* A distinct ridge on the posterior side of the posterior loop tends to disappear at late stages of wear. The enamel is retracted slightly ventrad at the base of the posterolingual triangle as it is in *O. magilli*, but not (unlike the latter species) on the anterior lingual triangle or on the posterior end.

M^2 consists of an anterior loop, two alternating triangles, and a posterior loop. Three roots are present on both specimens, one posterior and two anterior. The number of roots on M^2 in other species of *Ophiomys* is variable; 8 of 15 specimens of M^2 of *O. magilli* have 3 roots, a majority of specimens of *O. taylori* have two roots on M^2, and other species of *Ophiomys* generally have two roots on M^2. As in M^1, the dentine connecting the triangles becomes narrower with wear. All reentrants except the anterolabial one turn posterad at the tips in the worn specimen; in a less-worn but broken M^2 the posterior labial reentrant appears not to have had a posterad inflection.

M^3 consists of an anterior loop, two alternating triangles, and a posterior loop. The anterior portion of the posterior loop is separated by a very shallow reentrant, tending to appear like a third alternating triangle, which opens widely into the posterior loop. Only the posterolingual reentrant consistently turns posterad at the tip. In *O. magilli* all but the posterolabial reentrant turn posterad, usually with more constriction at the tip than seen in *O. mcknighti.* Tips of the first labial and lingual and second lingual angles tend to be squared off in younger individuals. M^3 has 2 roots.

Discussion—I consider *O. mcknighti* to be most closely related to *O. magilli* from the late Blancan (but pre-Pleistocene) Sand Draw local fauna of Nebraska, on the basis of similar size, presence of three alternating triangles on M_1, tendancy to retain the enamel pit on the anterior loop of M_1, and relatively weak tendency of reentrant angles (especially the first lingual reentrant of M_1) to constrict and turn anterad. Some of these characters are shared with *Cosomys primus* and *O. taylori*; there is in addition a strikingly similar general appearance when teeth of *O. magilli* and *O. mcknighti* are held next to each other which I did not find in comparisons with *C. primus* and *O. taylori.* The lesser height of crown and dentine tracts, the lesser extent of anterad (or posterad) inflection of the reentrants in all the molars, and the larger lingual root on M^1 indicate that the Ringold arvicoline is less advanced than the Sand Draw *Ophiomys.*

Hibbard (1972, p. 99) has suggested that *O. magilli* may represent a new genus, but has placed it in *Ophiomys* because of a lack of adequate diagnostic characters and because of the absence of a dentine tract on the base of the apex of the first labial triangle (second alternating) of M_1 and M_2 and the labial side of the posterior loop of M_2. Hibbard also suggests that the species of *Ophiomys* branched off from an *Ogmodontomys* stock in Hemphillian time; however, I can find no reason why both *Ogmodontomys* and *Ophiomys* could not be independently derived from *Promimomys* from the Hemphillian of Oregon (Shotwell, 1956).

Author's note.—C. A. Repenning (personal communication, 1977) has several specimens apparently indistinguishable from *Ophiomys mcknighti* from Alturas, California. He intends to refer his specimens to the European taxon *Mimomys (Cseria)*. I have not seen his evidence, but the genus *Ophiomys* has proven difficult of definition and his generic assignment may be correct.

Order EDENTATA

Family Megalonychidae

Genus *Megalonyx* Harlan 1825

Megalonyx rohrmanni new species
(Figure 18)

Megalonyx sp., Stock, 1925, pp. 110-112.

Type—UW 32704, skull fragment with maxillary, palate, and upper left dentition including C^1 and M$^{1-3}$.

Type locality—UW A9753, near south end of Ringold Flat, Franklin County, Washington.

Etymology—Named for George Rohrmann, who collected the type specimen in 1963 and generously presented it to the Burke Museum.

Diagnosis—Slightly smaller than *M. leptostomus* Cope (1893), smaller than all later Pleistocene species of *Megalonyx.* Caniniforms elongated anteroposteriorly, with lingual median bulge. Anterior base of zygomatic arch merging smoothly with maxillary near base of caniniform, not flaring anteriorly as in *M. leptostomus.* Jugal projecting ventrad and curving posterad along anteroventral border. Shelflike dorsal surface of mandible lateral to alveoli relatively narrow and rounded.

Referred specimens—The following are UW localities and specimen numbers: A3028; 41528, distal phalanx, 41530, M^2 or M^3. A3339; 41560, palate, 41561, M^2 or M^3. A6503; 35121, M^4. A6525; 42446, distal phalanx fragment, 40471, C^1. A8812; 42182,

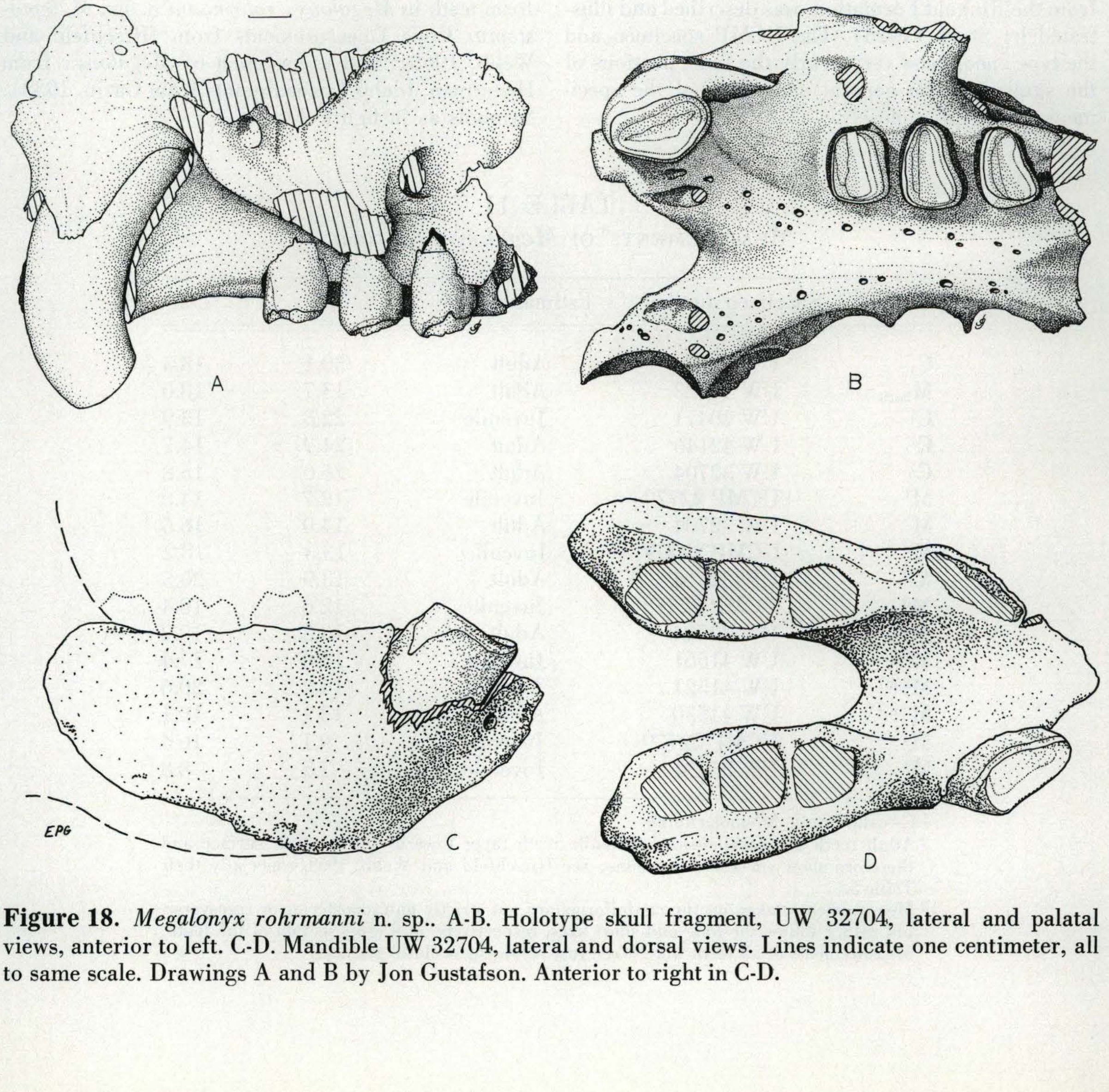

Figure 18. *Megalonyx rohrmanni* n. sp.. A-B. Holotype skull fragment, UW 32704, lateral and palatal views, anterior to left. C-D. Mandible UW 32704, lateral and dorsal views. Lines indicate one centimeter, all to same scale. Drawings A and B by Jon Gustafson. Anterior to right in C-D.

distal phalanx fragment. A8816; 41521, M^2 or M^3. A8818; 41523, M_2 or M_3. A9753; 32704, dentary containing right C_1 and all alveoli.

Stratigraphic position—Ringold Formation, highest specimen was 45 feet above the White Bluffs tuff; the lower range is not certain. The lowest specimen (80 feet below tuff) was float, and the lowest other site (UW A6525) is not located securely in relation to the tuff bed. The exact stratigraphic position from which the type skull fragment and jaw (UW 32704) came is not known.

Description—A considerable amount of material in the Burke Museum collections represents *Megalonyx rohrmanni*. No evidence for the presence of more than one species of sloth in the Ringold Formation was seen.

A skull fragment of a juvenile including the maxillary with all cheek teeth referable to *M. rohrmanni* (UCMP 22779), collected by Merriam and Buwalda from the Ringold Formation, was described and illustrated by Stock (1925). The UCMP specimen and the type encompass very nearly the same portions of the skull, and the general characters of the specimens match quite closely.

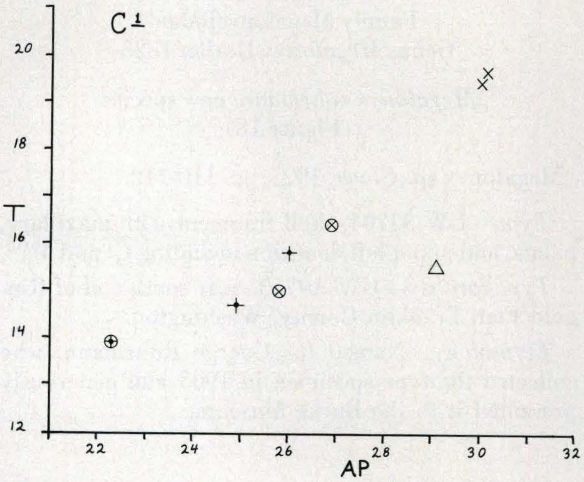

Figure 19. Comparison of measurements of caniniform teeth in *Megalonyx rohrmanni* n. sp., *M. leptostomus* Cope (measurements from Hirschfeld and Webb, 1968), and a specimen of *Megalonyx* from Hagerman, Idaho (measuremnts from Gazin, 1935). Symbols as in figure 20.

TABLE 11

MEASUREMENTS[3] OF *Megalonyx rohrmanni*

Tooth[1]	Specimen number	Estimated age[2]	AP	T
C_1	UW 32704	Adult	30.1	13.3
M_{2or3}	UW 41523	Adult	13.7	18.0
C^1	UW 40471	Juvenile	22.3	13.9
C^1	UW 42146	Adult	24.9	14.7
C^1	UW 32704	Adult	26.0	15.8
M^1	UCMP 22779	Juvenile	12.7	14.8
M^1	UW 32704	Adult	14.0	16.5
M^2	UCMP 22779	Juvenile	13.3	18.2
M^2	UW 32704	Adult	13.9	20.5
M^3	UCMP 22779	Juvenile	12.6	18.4
M^3	UW 32704	Adult	13.5	19.2
M^{2or3}	UW 41561	Juvenile	12.0	17.4
M^{2or3}	UW 41521	Adult	14.2	20.6
M^{2or3}	UW 41530	Adult	13.1	19.1
M^4	UCMP 22779	Juvenile	9.1	16.4
M^4	UW 35121	Juvenile	7.5	8.8

[1] C=caniniform, M=molariform

[2] Adult teeth are parallel-sided, juvenile teeth taper towards the occlusal surface and therefore show smaller dimensions; see Hirschfeld and Webb, 1968, especially their Table 5.

[3] Measurements taken on the caniniforms are not strictly anteroposterior or transverse, but rather follow the long and short axes, respectively, of a cross-section of the tooth. Measurements of all teeth were taken just below the occlusal surface.

TABLE 11 (Continued)

Palate	UW 41560	Width between M^1 Alveoli	22		
		Width between C^1 alveoli	41		
	UW 32704	Width between M^1 alveoli	24		
		Width between C^1 alveoli	50		
		Palate length, minimum, from anterior notch to posterior end	94		
		Palate length, maximum, from anterior maxillaries to posterior end	119		
		Diastema length, post. C. to ant. M	35		
Mandible	UW 32704	Width, maximum preserved	92		
		Width of dentary at M_2		L 34	R 33
		Length of all alveoli, M_{1-3}		L 57	R 55
		Length of diastema		L 20	R 22
		Depth of jaw at M_1			R 54
		Length of symphysis, taken along anterior edge	68		

The upper caniniform of *M. rohrmanni* is anteroposteriorly elongated, as in all species of *Megalonyx* except *M. mathisi* Hirschfeld and Webb (1968, upper Mehrten Fm., Calif., Hemphillian), and a median lingual bulge is present, though variable. On the type specimen, the lingual bulge is very pronounced, giving the tooth an almost triangular section, while on the juvenile (UW 40471) and on another adult (UW 42146) the lingual bulge is relatively low. The lingual bulge is bordered by wide, very shallow grooves, not nearly so deep and prominent as seen in *M. jeffersonii* Harlan (1825, Pleistocene of W. Virginia; see Leidy, 1855, plate 16). A wide, shallow groove is present on the labial side of the adult caniniforms.

The upper molariform teeth are very similar to those seen in other species of *Megalonyx;* the first three are straight, while the last is somewhat curved, concave anteriorly. M^1 is wider and more squared on the labial side than the M^1 figured by Leidy (1855, plate 3) in a skull of *M. jeffersonii*, resembling more closely the tooth in his plate 16, fig. 9d. In the type of *M. rohrmanni*, the anterior side of all the upper molariforms is less convex than shown by Leidy (plate 6, fig. 1, and plate 16, figures 9 and 10). These teeth are variable in shape, however, and no great significance can be placed on the observed differences in the shape of the cheek teeth. The upper molariforms are not as proportionately wide as in *M. leptostomus* Cope (1893) from the Blanco local fauna of Texas.

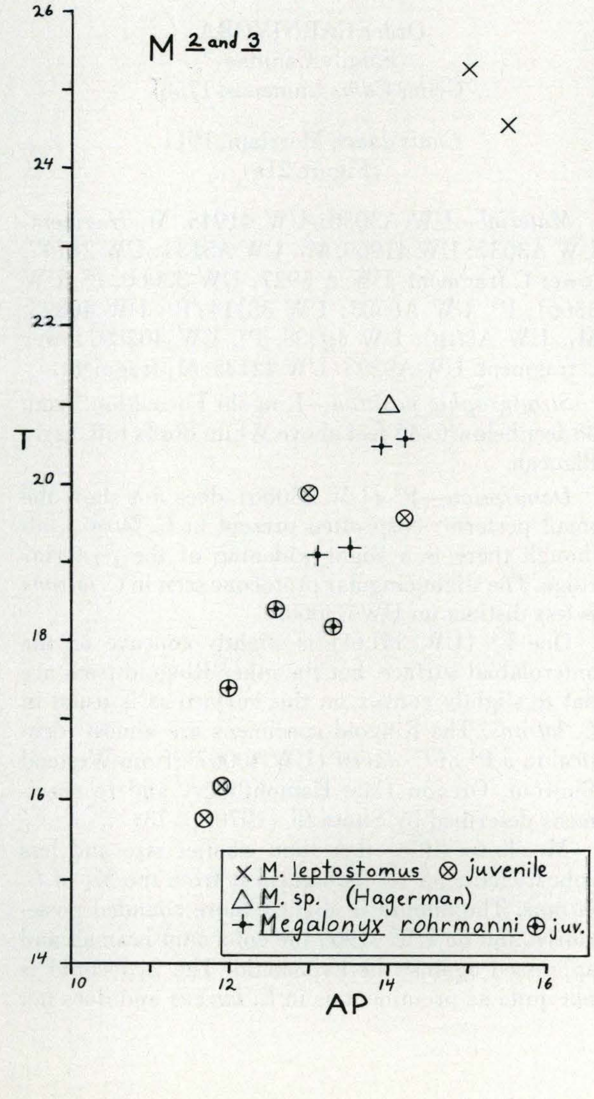

Figure 20. Comparison of measurements of molariform teeth in *Megalonyx rohrmanni* n. sp., *M. leptostomus* Cope, and a specimen of *Megalonyx* from Hagerman, Idaho.

The shape of the anterior portion of the zygomatic arch of *M. rohrmanni* differs from that seen in other described species of *Megalonyx*. In *M. rohrmanni* the anterior surface of the zygomatic arch merges smoothly with the lateral surface of the maxilliary near the base of C^1. This anterior surface descends posterad and slightly laterad, initially at an angle of about 45° (the palate between the cheek teeth is considered horizontal), then curves posterad to an angle of 25° to 35°. In *M. jeffersonii*, the anterior surface of the zygomatic arch merges with the maxillary, at an angle of 80° to 90° from the horizontal, then curves slightly to descend at an angle of about 45°. In *M. leptostomus* the anterior zygomatic arch flares abruptly from the maxillary surface and projects slightly anterad (Hirschfeld and Webb, 1968 fig. 2). The anterior zygomatic arch in *M. rohrmanni* is slightly more prominent laterally than in *M. jeffersonii* (Leidy, 1855, plate 6, fig. 2).

Only two of the lower teeth of *M. rohrmanni* are available, a lower caniniform and a cheek tooth (probably M_2 or M_3), both from adult individuals. The mandible (UW 32704) includes alveoli of all lower teeth. The lower caniniform is an anteroposteriorly elongated oval in shape, very flat on the labial surface, with a slight bulge on the lingual surface. The tooth shows little, if any curvature along its length. The cheek tooth alveoli increase slightly in anteroposterior diameter from first to third. The M_2 or M_3 (UW 41523) is oval in outline, slightly narrower on one side. It is very slightly curved, though evidently not so much as in *M. curvidens* Matthew (1924, Upper Snake Creek Beds, Nebraska).

The anterior border of the symphysis of the mandible (UW 32704) is nearly straight for the lower three-quarters of its length, and projects forward more than in Leidy's specimens of *M. jeffersonii* (1855, plate 1). It resembles more the mandible of *M. leptostomus* figured by Meade (1945, plate 55), and even more the specimen from Hagerman, Idaho, (USNM 13477) which Gazin (1935) assigned to *M. leptonyx*? The anterior point of the symphysis of *M. rohrmanni* is not spread laterally as in the mandible of *M. curvidens* figured by Hirschfeld and Webb (1968, fig. 6). The dorsal surface of the mandible on the labial side of the cheek tooth alveoli is narrow and rounded in *M. rohrmanni*, not shelflike as in the mandible of *M. leptostomus* (Meade, 1945, plate 55), resembling, again, Gazin's (1935) mandible from Hagerman, Idaho. The diastema of the Ringold specimen is relatively short and wide, with a distinct sulcus on the labial surface.

Discussion—There is no species described in the literature whose characters match those of the specimens from the Ringold Formation. The sloth specimens from the Glenns Ferry Formation near Hagerman, Idaho (Gazin, 1935) come closest to *M. rohrmanni* in size (fig. 15) as well as in characters of the mandible. Gazin referred the Idaho specimens to *M. leptonyx?* (Marsh, 1874). Hirschfeld and Webb (1968) considered *M. leptonyx* a *nomen dubium* because the type, an ungual phalanx, is probably not specifically determinable, its age and locality are uncertain, and the type specimen has been misplaced since before Gazin's paper of 1935. It may be that the Hagerman and Ringold sloths are conspecific; skull material of the Idaho sloth is needed for comparison. There is no way of ascertaining specific identity or lack of identity between the Ringold specimens and Marsh's type of *M. leptonyx*, or, for that matter, between the Hagerman sloth and *M. leptonyx*. It seems altogether preferable to describe the excellent material from the Ringold Formation as a new species, and, for the present, to apply the name *M. leptonyx* only to the (missing) type specimen of that species.

Order CARNIVORA

Family Canidae

Genus *Canis* Linnaeus, 1758

Canis davisi Merriam, 1911

(Figure 21a)

Material—UW A3036: UW 41945, M_1 fragment. UW A3037: UW 41969, M_1. UW A5134: UW 28747, lower C fragment. UW A 5927: UW 33060, P^2, UW 33061, P^4. UW A6503: UW 35114, P^4, UW 40393, M_1. UW A8810: UW 40288, P^4, UW 40289, lower C fragment. UW A9293: UW 42135, M_1 fragment.

Stratigraphic position—Ringold Formation, from 35 feet below to 45 feet above White Bluffs tuff, early Blancan.

Description—P^2 (UW 33060) does not show the small posterior cusp often present in *C. latrans*, although there is a slight widening of the posterior ridge. The slight cingular protocone seen in *C. latrans* is less distinct on UW 33060.

One P^4 (UW 35114) is slightly concave on the anterolabial surface, but the other Ringold teeth are flat to slightly convex on this surface as is usual in *C. latrans*. The Ringold specimens are almost identical to a P^4 of *C. davisi* (UW 40067) from Westend Blowout, Oregon (late Hemphillian) and to specimens described by Shotwell (1970, p. 73).

M_1 shows little other than smaller size and less robust character to distinguish it from the M_1 of *C. latrans*. The talonid is slightly more rounded posteriorly, and on UW 41969 the entoconid is small and appressed against the hypoconid. The hypoconid is not quite as prominent as in *C. latrans* and does not show a labial basal swelling as in the modern species. The Ringold specimens lack any sign of a cingulum such as that seen on both labial and lingual sides of M_1 of a specimen (UMMP V53910) from the Hagerman fauna, which Bjork (1970, p. 13) referred to *C. lepophagus* Johnston (1938, type specimen from Cita Canyon, Texas). The Hagerman *Canis* M_1, though near the size of the larger Ringold M_1 (UW 41969), is wider and more robust.

Discussion—The material from the Ringold Formation referable to *Canis* is indistinguishable from specimens referred to *Canis davisi* from the Hemphillian of northern Oregon. All of the Ringold specimens are smaller than any specimen of the living *Canis latrans* or the extinct late Blancan *C. lepophagus* which were available to me.

Merriam (1911) described *Canis davisi* from a maxillary fragment containing M^1 and M^2, which was found downhill from outcrops of the Rattlesnake Formation (Hemphillian) in north-central Oregon. Shotwell (1970) added a number of specimens from other Oregon Hemphillian localities to the hypodigm of the species, including a partial skull with complete dentition. In addition, the Burke Museum collections from Westend Blowout (UW A8803) and Krebs Ranch include specimens referable to *C. davisi*. In total, this material is quite adequate for identification of the White Bluffs *Canis* materials despite the absence of any upper molars in our collection.

Genus *Borophagus* Cope 1892

Borophagus sp.
(Figure 21b)

Material—UW A6503: UW 35115, left P_4.

Stratigraphic position—Ringold Formation, 40 feet above White Bluffs tuff.

Description—This unworn tooth is dominated by the massive central cusp. A distinct ridge connects the tip of the central cusp to a low swelling at the anterolingual corner. This swelling continues posterad along the lingual enamel border, rising at the posterolingual corner to form the rim of the heel or posterior cingulum. The posterior cingulum is wide transversely and is curved convexly upwards. A short ridge is present on the posterior side of the central cusp. Squeezed in between the central cusp and the posterior cingulum is a much smaller posterior cusp.

The labial surface of this tooth is very convex, while the lingual surface is slightly concave in profile.

Discussion—This specimen is evidently from a borophagine dog, and agrees in general with various species of the Hemphillian genus *Osteoborus* in the possession of a small cusp on the posterior side of the P_4. However, it also agrees in this character with a specimen from the late Blancan Grand View local fauna of Idaho, identified by Shotwell (1970) as *Borophagus* sp., and differs from other specimens of *Borophagus* and *Osteoborus progressus* Hibbard (1944), which lack a posterior cusp on P_4. The size and relatively great width (Table 11) of the Ringold tooth support the reference to *Borophagus*; presence or absence of the small posterior cusp is probably less significant. The single P_4 is insufficient evidence for specific identification.

TABLE 12

MEASUREMENTS OF *Canis davisi*

Specimen number	Tooth	AP	T	H
UW 28747	/C	--	4.7e	15.0
UW 40289	/C	--	4.7e	16.8
UW 40393	M_1	17.0	6.3	
UW 41945	M_1	--	6.3e	
UW 41969	M_1	18.5	7.4	
UW 42135	M_1	--	6.3e	
UW 33060	P^2	11.9	4.2	
UW 33061	P^4	18.5	8.7	
UW 35114	P^4	17.1	8.0	
UW 40288	P^4	18.4e	7.9e	

TABLE 13

MEASUREMENTS OF P_4 IN *Borophagus*

	AP (Length- in plane at right angle to flat posterior surface)	T (max. width of posterior tooth)	H (crown height along post. lingual surface)	Height of post. cusp above cingulum
Borophagus sp. UW 35115 Ringold Fm.	18.5	15.8	17.2	2.6
Borophagus sp. UO-F16343 Glenns Ferry Fm. Grand View, Idaho	19.7	15.3	20.0	2.6
Borophagus diversidens Midwestern U. 8034 Blanco Fm.	20.0	14.3		
Osteoborus cyonides KU 6791 Hemphill Fm.	14.85	10.5		

Family Ursidae Gray, 1825

Genus *Ursus* Linnaeus, 1758

Ursus sp. cf. *U. abstrusus* Bjork, 1970

(Figure 21 c-d)

Bjork, 1970, P. 16, figure 96.

Material—UW A3036: UW 41944, partial M^1. UW A9292: UW 42328, partial M_1.

Stratigraphic position—Ringold Formation, level uncertain, early Blancan.

Description—The first lower molar, though only an anterior fragment, is comparable to the type of *Ursus abstrusus* from Hagerman, Idaho, which it matches closely in size and morphology. The trigonid is simple, and is proportioned as in *U. abstrusus*. The paraconid is lower than the protoconid. A small metaconid, appressed to the posterolingual border of the protoconid, is slightly larger than that on *U. abstrusus*. Unlike *U. americanus* Pallas, no accessory cuspules are present anterior to the metaconid. The transverse measurement of the trigonid is 7.0 mm.

The upper first molar is missing fragments from the posterolingual corner and the anterolabial side, but enough remains to show that the tooth was proportioned as in *U. americanus* and is not as proportionately wide as in the tremarctine bears. The paracone and metacone are set close to the labial edge of the tooth, not further lingually as in the tremarctines. The metacone is divided into two cuspules by a transverse groove. The protocone is elongate, and is split, as in the metacone, into two cuspules by a transverse groove. The anterior end of the protocone merges with a vague cingulum, which connects to a small parastyle on the anterior side of the paracone. Unlike *U. americanus*, there is no labial cingulum and only a suggestion of a lingual cingulum. The transverse measurement is 13.1 mm, and the preserved anteroposterior diameter is 18.5 mm. The M^1 is quite distinct from that of *Indarctos oregonensis* Merriam, Stock, and Moody (Hemphillian of Oregon) in smaller size, narrower proportions, and and numerous details of enamel morphology (Shotwell, 1970, Fig. 37A).

Discussion—The two available specimens are very incomplete, making it difficult to precisely assess affinities. The similarity of the M_1 fragment to the type of *U. abstrusus* and the ursine proportions of the M^1 suggest that a true ursine is represented.

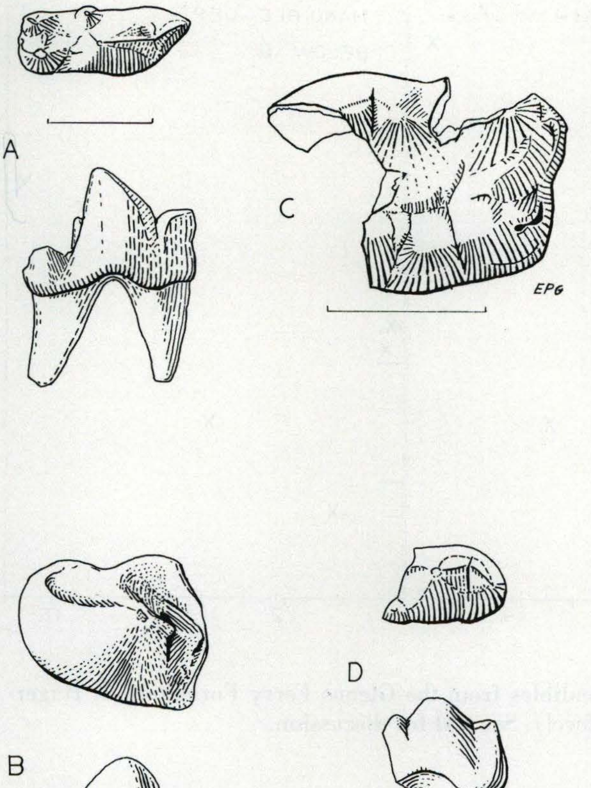

Figure 21. Carnivora. A. *Canis davisi* right M_1, UW 40393, occlusal and labial views. B. *Borophagus* sp., P_4, UW 35115, occlusal and labial views. C-D. *Ursus* sp. cf. *U. abstrusus*. C. Left M^1, UW 41944, occlusal view. D. Left M_1, anterior fragment, UW 42328, occlusal and lingual views. Lines indicate one centimeter. Anterior to right in A, D; to left in B, C.

Family Mustelidae
Genus *Trigonictis* Hibbard, 1941

Trigonictis cooki (Gazin), 1934
(Figure 22)

Gazin, C. L., 1934, p. 142, fig. 2.

Material—UW A3027: UW 41527, partial left mandible with P_4-M_1, and alveoli of P_3 and M_2.

Stratigraphic position—Ringold Formation, the single specimen was float, found 150 to 200 feet above level of road, probably from above White Bluffs tuff, early Blancan.

Description—The single available specimen, a partial mandible, is almost identical in morphology to specimens of *Trigonictis idahoensis* and *T. cooki* from Hagerman, Idaho.

The mandible appears to have been chewed upon by some predator or scavenger. Two distinct round punctures (about 10 mm apart) and a crushed area slightly dorsal to the punctures are present on the medial side of the mandible. Additional grooves, apparently tooth marks, are seen near the posterior mental foramen.

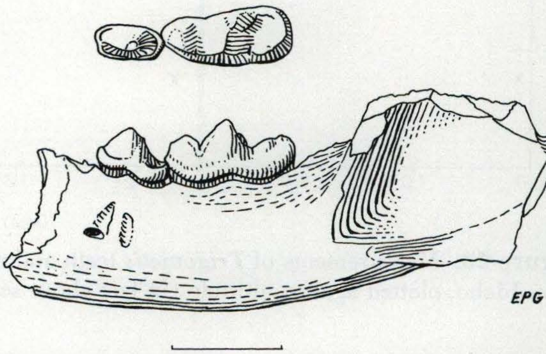

Figure 22. *Trigonictis cooki*, mandible with P_4-M_1, UW 41527, occlusal and labial views. Line indicates one centimeter. Anterior to left.

Discussion—Zakrzewski (1967a) and Bjork (1970) found no consistent morphological characters other than size to separate the two species of *Trigonictis* described by Gazin (1934), *T. cooki* and *T. idahoensis*. The Ringold specimen, with an M_1 length of 12.0 mm falls into the gap (M_1 AP length from 11.7 to 12.6 mm) used by Bjork to separate these species.

The primary statistic favoring division of the Hagerman *Trigonictis* sample into two species is the high variability in size. The coefficient of variation (Simpson, et al., 1960) for the entire sample (AP length of 23 lower first molars plotted by Bjork) is about 10.1, higher than normally seen in dental characters in a concurrent population of one species. Zakrzewski presented statistics suggesting correctly that more variation in size is present in the Hagerman sample than is present in Recent sexually dimorphic mustelids. In addition to the statistical evidence, there is stratigraphic evidence that at least two distinct populations of *Trigonictis* are present in the Hagerman sample.

Figure 23 plots altitude (approximately=stratigraphic position) versus size for three parameters,

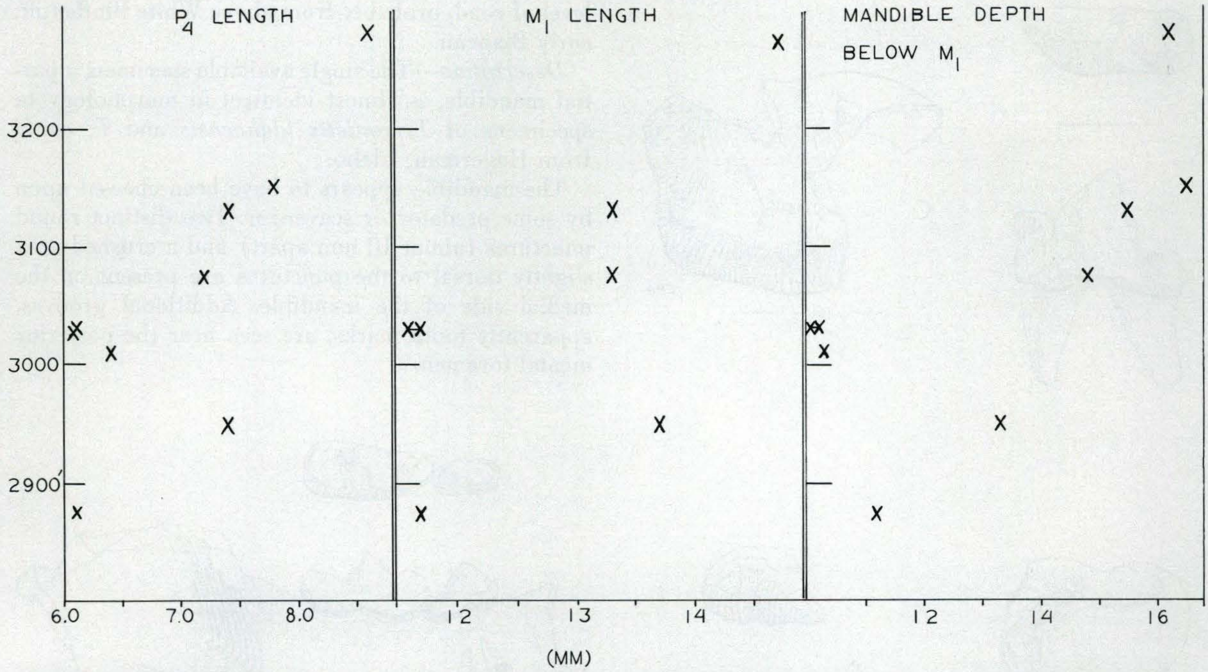

Figure 23. Measurements of *Trigonictis* teeth and mandibles from the Glenns Ferry Formation at Hagerman, Idaho, plotted against altitude (in feet above sea level). See text for discussion.

AP length of P_4 and M_1 and depth of mandible below anterior end of M_1, measured in 8 specimens of *Trigonictis* from the UMMP Hagerman collection. The small size of this sample, despite the rather large number of *Trigonictis* specimens known from the Glenns Ferry Formation, is due to lack of stratigraphic information about many specimens, including the types in the U.S. National Museum. An apparent increase in size with increasing altitude is evident in all three measurements, with the strongest increase above an altitude of 3050 feet. The significance of this size increase was determined with the chi-square test (Simpson et al., 1960, p. 186). Subsamples were formed above and below the 3050 foot level and above and belowe 7.0 mm for P_4, 13.0 mm for M_1, and 14.0 mm for mandible depth. The chi-square test for difference in M_1 length is not significant at the 5% confidence level (null probability=.05-.10); however, the differences in P_4 length (null probability=.025-.05) and mandible depth (null probability= less than .005) are statistically significant.

It is worthy of note that Galbreath (1972), in a review of Bjork's 1970 paper, also suggested that *T. cooki* and *T. idahoensis* were part of a single evolving population. He suggested including Bjork's genus *Sminthosinis*, a smaller *Trigonictis*-like animal, in this evolving population, but since the *Sminthosinis* specimens are from the upper part of the Hagerman section, the direction of size change would be reversed from enlargement to diminution through time.

The samples of *Trigonictis* above and below 3050 elevation are distinct; they may represent simply two populations or the differences may be the result of a chronocline. Additional stratigraphically controlled material may show the latter to be the case. At present we can continue to recognize two arbitrarily partitioned species; smaller specimens (*T. cooki*) in the lower Hagerman section; large specimens (*T. idahoensis*) in the upper part of the section.

The Ringold specimen of *Trigonictis* falls into the size range of specimens found below the 3050 foot level at Hagerman, and therefore can be placed in *T. cooki*.

Family Felidae Gray, 1821
Genus *Felis* Linnaeus, 1758

Felis sp.
(Figure 24)

Material—UW A6571: UW 35258, anterior right mandible with broken canine, complete P_{3-4}.

Stratigraphic position—Ringold Formation, 45 feet above White Bluffs tuff, early Blancan.

Description—This mandible fragment of a cougar-sized cat presents several unusual features. The P_3

TABLE 14

MEASUREMENTS, *Trigonictis cooki*

	Trigonictis cooki Ringold Fm. UW 41527 Anterior—posterior Length	Transverse width	*T. cooki** Glenns Ferry Fm. Idaho AP mean	AP range	*T. idahoensis** Glenns Ferry Fm. Idaho AP mean	AP range
P_4	6.5	3.7				
M_1	12.0	5.3	11.4	10.7-11.7	13.7	12.6-14.9
Mandible Depth below M_1	12.7					

* from Bjork, 1970

TABLE 15

MEASUREMENTS OF *Felis* SP.

	Ringold Fm. *Felis* sp. UW 35258	Glenns Ferry Fm. *Felis lacustris* USNM 13743R from Bjork, 1970	Recent *F. concolor* UW 27392
Diastema, C-P_3	23.6	11.4	12.6
Depth of jaw between P_3 & P_4	27.7	23.8	24.2
C AP	14.9	12.2	15.2
T	11.0	9.0	9.9
P_3 AP	13.5	11.6	14.2
T	7.0	6.4	7.1
P_4 AP	16.9	15.6	17.0
T	7.7	7.3	8.1

and P_4 are within the size range of *Felis concolor* in anteroposterior and transverse dimensions, but the mandible is deeper and more elongate than in *F. concolor*. The diastema is relatively longer than in any species of *Felis* or *Pseudaelurus* of which I have seen a specimen or description; however, there is no flange along the ventral margin of the mandible, and this together with the form of premolars and the probably small incisors suggest a lack of any close relationship to any of the sabertooth cats. The symphysis is rounded anteroventrally as in *Lynx*, *Felis lacustris* Gazin (1933, Hagerman, Idaho), and species of *Pseudaelurus*, and not angular as in *F. concolor*. The symphysis does not extend as far posteroventrad as in *F. concolor*. One large mental foramen is located below the center of the diastema. Two very small additional foramina are present, one lower in

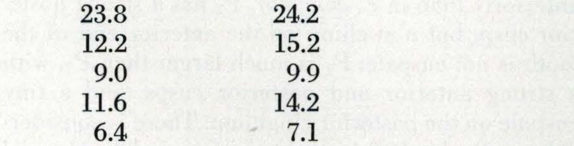

Figure 24. *Felis* sp., mandible fragment with P_{3}-$_4$, UW 35258, labial view. Line indicates one centimeter. Anterior to right.

the mandible and below the middle of P_3, and the other slightly anterior to and slightly higher than the large foramen. Most cats have at least two large mental foramina; *F. concolor* usually has four nearly equal-sized foramina (Savage, 1960); *F. lacustris, Panthera onca, Lynx,* and *Pseudaelurus* generally have two subequal mental foramina. The type of *Nimravides thinobates* (Macdonald 1948, fig. 13, Clarendonian, Black Hawk Ranch, Calif.), has a single large mental foramen in a position similar to that of the Ringold specimen, as well as having an unusually long diastema; *N. thinobates* is, however, much larger. The anteroventral portion of the Ringold mandible is somewhat swollen, in a manner suggestive of some species of *Pseudaelurus.* A sharp dorsal ridge along the diastema is most prominent opposite the small anterodorsal mental foramen.

The incisors are missing. The alveolus of I_2 is set behind the other two alveoli, as is seen in *Lynx* and *F. lacustris.* The alveolus of I_3 is largest of the three.

The canine is broken off at the base of the enamel. It is relatively wider than the canine of *F. concolor,* and is similar in proportions to the canine of *F. lacustris* though larger. Neither P_1 nor P_2 were present. Both P_3 and P_4 are large, high-crowned teeth. Their height is considerably greater than in *F. concolor* or other Recent *Felis,* and they approach the proportions found in the much smaller *Lynx.* P_3 is narrower anteriorly than in *F. concolor.* P_3 has a strong posterior cusp, but a swelling on the anterior end of the tooth is not cuspate. P_4 is much larger than P_3, with a strong anterior and posterior cusps, and a tiny cuspule on the posterior cingulum. There is considerable vertical relief in the lower enamel borders of the Ringold specimen; the enamel descends much lower over the roots and is higher between the roots than in *F. lacustris* or *concolor,* being more like the condition seen in *Lynx.*

Discussion—This specimen shares characters of several taxa of cats, but is probably more closely allied to *F. lacustris* and the *Lynx*-like cats than to *F. concolor.* There are several characters shared with *Pseudaelurus,* but with the lack of anterior premolars and the late age of the deposits, it is better placed in *Felis.* Although the species is probably new, I prefer to defer formally recognizing it until it can be determined whether the unusual mandibular diastema is a normal feature.

Subfamily MACHAIRODONTINAE Gill 1872

genus and species indeterminate

Material—UW A3028: UW 41532, upper canine fragment. UW A3037: UW 41970, upper canine fragment.

Stratigraphic position—Ringold Formation, early Blancan.

Description—Fragments of two large, transversely flattened canines demonstrate the presence of a machairodont in the White Bluffs local fauna. At the base of the enamel, the better preserved fragment (UW 41970) has an anteroposterior diameter of 26.3 mm and a transverse diameter of 10.5 mm. The other (UW 41532) has a transverse diameter of 12.1 mm. No serrations are visible on the damaged anterior and posterior margins of the fragments. They are slightly smaller than upper canines of *Homotherium serum* (Texas Memorial Museum no. 933-3582, left canine AP=31.3, T=13.2, from Friesenhahn Cave, Texas, late Pleistocene) and appear to have tapered to form a similar rather short blade. *H. serum* canines have serrations almost to the base of the anterior enamel. This is a considerably smaller animal than ?*Ischyrosmilus idahoensis* Merriam (1918) of the Grand View local fauna, which has canine measurements of 38.0 and 18.2 mm respectively (Shotwell, 1970). The Ringold specimens are approximately the size of the canines of *Barbourofelis morrisi* Schultz, Schultz, and Martin (1970, Hemphillian, Ash Hollow Fm. Nebraska), but they lack the lateral longitudinal grooves of *Barbourofelis.*

Order PROBOSCIDEA
Family Mammutidae

Genus *Mammut* Blumenbach, 1799
Mammut americanum (Kerr)

Material—UW A3031: UW 42668, thoracic vertebra centrum. UW A5927: UW 34939, tooth fragment. UW A8812: UW 42171, ?tooth fragment.

Stratigraphic position—Ringold Formation, from 35 feet below to 45 feet above White Bluffs tuff, early Blancan.

Discussion—The mastodon material from the Ringold Formation available in the Burke Museum collections alone is not diagnostic. *M. americanum* was reported by Strand and Hough (1952). The identification was based on an excellent specimen (USNM 19101), which includes parts of two tusks, right M^{1-2}, left M^{1-3}, and M_{2-3} from both sides, along with parts of both mandibular rami. I could find no major differences between USNM 19101 and undoubted specimens of *M. americanum* from the late Pleistocene, and therefore concur with this identification. The early Blancan date given to these specimens is unexpectedly early for this species. Webb (1974) records *M. americanum* from the early Pleistocene (Nebraskan-Aftonian) Santa Fe River IB fauna of Florida, a later Blancan locality. Other reports of

Blancan *Mammut* (Blanco local fauna, Texas; Broadwater quarries, Nebraska; and Hagerman local fauna, Idaho) give no species name. The Blanco specimens are probably not *Mammut.*

Order PERISSODACTYLA

Family Equidae

Genus *Equus* Linnaeus, 1758

Equus (*Dolichohippus*) sp. cf. *E. simplicidens* Cope, 1893

(Figure 26)

Material—UW A3029: UW 41553, fragmentary mandible with dP$_2$, anterior half of dP$_3$, dP$_4$, M$_1$, and M$_2$. UW A3030: UW 41922, astragalus. UW A3036: UW 41943, lower cheek tooth fragment; UW 42331, P$^{3 \text{ or } 4}$. UW A3340: UW 41991, P$^{3 \text{ or } 4}$. UW A6571: UW 45033, maxillary fragment with M$^{1\text{-}3}$. UW A-9292: UW 42321, mandible fragment with P$_3$-M$_1$: UW 42323, M^3: UW 42324, M$^{1 \text{ or } 2}$. UW A9293: UW 42136, M$^{1 \text{ or } 2}$.

Stratigraphic position—Ringold Formation, up to 45 feet above White Bluffs tuff, early Blancan.

Description—All specimens seem to pertain to a single large species of horse with very hypsodont teeth. The measurements (Table 14) fall into the range of *E. simplicidens* from the Broadwater quarries of Nebraska (Howe, 1970).

The deciduous lower premolars, heavily worn in the specimen from the Ringold Formation (UW 41553), are similar in most details to the equivalent teeth of *E. simplicidens* from Hagerman in a similar state of wear (Gazin, 1936, fig. 22). The dP$_2$ in material from the Ringold Formation appears less pointed anteriorly because of a relatively wider protoconid. The median valleys are slightly deeper and straighter than in *E. simplicidens* at a similar wear stage. The flexure between the metaconid and metastylid is U-shaped in dP$_4$ but V-shaped in dP$_2$.

The permanent lower premolars (UW 42321) are little worn, so that the enamel pattern can not be entirely determined from the occlusal surfaces. The broken lower ends, however, show some details. A number of minor crenulations visible on the occlusal surfaces disappear further down the teeth. The lingual flexure between metaconid and metastylid is V-shaped, and the median valley does not extend between the metaflexid and entoflexid. A small parastylid is visible in both P$_3$ and P$_4$ near the bases of the teeth. The metaconid is slightly longer anteroposteriorly than the metastylid. There is no sign of a pli caballinid on P$_4$, but one is present on P$_3$ in an early stage of wear.

Four lower molars are available, two little worn first molars, an unworn M$_2$, and a moderately worn M$_{1 \text{ or } 2}$. The molars are longest near the occlusal surface, due to the anteroposterior elongation of the hypoconulid. Further down the teeth, the hypoconulid becomes flattened posteriorly, and the teeth become anteroposteriorly shorter.

The teeth definitely identified as M$_1$ have a relatively simple pattern, lacking a parastylid or pli caballinid; it is not unusual for the pli caballinid to be absent on M$_1$ but present in premolars and M$_{2\text{-}3}$ in *E. simplicidens* (Skinner and Hibbard, 1972, fig.

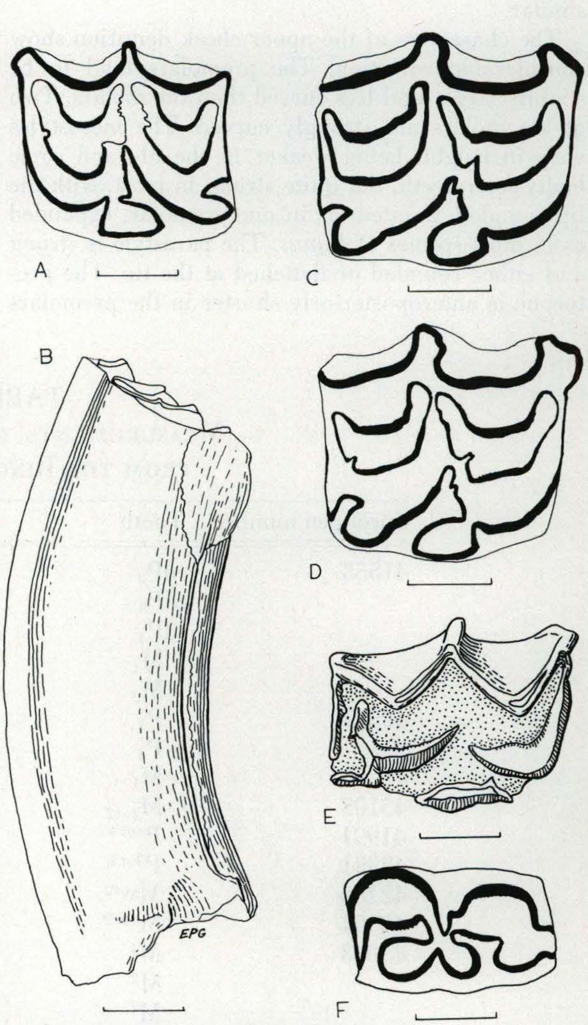

Figure 26. *Equus* (*Dolichohippus*) sp. cf. *E. simplicidens*. A-B. M$^{1\text{or}2}$, UW 42136, occlusal and anterior views. C. P$^{3\text{or}4}$, UW 41991. D. P$^{3\text{or}4}$, UW 42331. E. Unworn M$^{1\text{or}2}$, UW 42324, occlusal view. F. M$_{1\text{or}2}$, UW 45103, occlusal view. Lines indicate one centimeter. Anterior to left in A, F; to right in C. D, and E.

57B). The lingual flexure between the metaconid and metastylid is V-shaped, as in the premolars. On UW 41553 the median valley extends between the metaflexid and entoflexid, but on UW 42321 it does not extend as far linguad. The $M_{1 \text{ or } 2}$ (UW 45103) features a small pli caballinid and more rounded metaconid and metastylid. The median valley extends well between the flexids.

The protoconid and hypoconid of the Ringold specimens seem to be narrower than in Hagerman *E. simplicidens*, but this feature varies with wear, and the enamel patterns of the lower molars of the Ringold and Hagerman specimens seem otherwise similar.

The characters of the upper cheek dentition show considerable variation. The premolars tend to be slightly larger and less curved than the molars. Two of the molars are strongly curved. The mesostyles vary in height, being weaker in the M_3 and some badly worn teeth, but quite strong in most, with the tip rounded, pointed, or in one premolar, expanded as in most species of *Equus*. The parastyle is strong and either rounded or flattened at the tip. The protocone is anteroposteriorly shorter in the premolars than in the molars; however, it is distinctly grooved in only one tooth of the eight with the protocone preserved. The protocones are consistently much shorter anteroposteriorly than in Recent *Equus*, and than in *E. simplicidens* from Hagerman. The form of the protocones resembles most closely those of the type specimen of *E.* (*D.*) *francescana* (Frick, 1921, p. 322, Blancan, San Timoteo beds, California). The pli caballini is absent on one worn molar but is present on the other teeth; however, it tends to be small. The hypoconal groove is highly variable and may be absent in some individual teeth. The prefossette consistently has one or two pli protoconules, and a pli prefossette is present on five of nine teeth. Postfossette structure tends to be simpler; five of nine have no accessory crenulations, one has a pli hypostyle, and three have a pli postfossette.

Discussion—The usage of the name *Dolichohippus* for those North American horses previously placed in the subgenus *Plesippus* follows Skinner (in Skinner and Hibbard, 1972, p. 118).

The horse from the Ringold Formation is considered to belong in the *Dolichohippus* group because of the following characters: large size, great hypso-

TABLE 16

MEASUREMENTS[1] OF TEETH OF *Equus* FROM THE RINGOLD FORMATION

Specimen number	Tooth	AP[2]	T[3]	H[4]
41553	dP_2	33.9	13.7	11
	dP_3	--	14.0	14
	dP_4	30.1	14.2	16
	M_1	32.2	13.5	78
	M_2	32.0	11.8	67+
42321	P_3	31.3	17.0	63+
	P_4	28.6	15.6	64+
	M_1	27.1	14.7	69
45103	M_{1or2}	23.7	15.8	-
41991	P^{3or4}	31.0	24e	27
42331	P^{3or4}	28.1	26.1	43
42136	M^{1or2}	26.5	25.8	77
42324	M^{1or2}	30.6	21.3	69+
45033	M^1	21.4	25.0	28e
	M^2	24.1	25.3	26e
	M^3	27.4	23.3	23e
42323	M^3	30.8	26.3	14

---

[1] In millimeters.

[2] AP measured through middle of tooth parallel to occlusal plane and parallel to tooth row.

[3] T measured across mesostyle and protocone.

[4] H measured between lowest enamel and highest cusp on lingual side of lower teeth, labial side of upper teeth; necessarily approximate. Plus sign indicates a tooth on which the roots had not formed.

donty (maximum height of cheek teeth over 80 mm), presence (though not dominance) of elongated, grooved protocones, presence of pli caballinid, sharp metaconid-metastylid groove, and extension of median valley between flexids of lower molars.

The upper cheek teeth from the Ringold Formation match the illustrations of *E.* (*D.*) *francescana* (Frick 1921, figs. 1, 2, 3, and 4 of Folder 3) and UW specimens assignable to *E.* (*D.*) *proversus* (Merriam 1916) from the Tehama Formation of California (UW A3198) more closely than tthey match either specimens or illustrations (e.g. Gazin, 1936, fig. 21) *of E.* (D.) *simplicidens* from Hagerman, Idaho, the Broadwater quarries of Nebraska (Howe, 1970 p. 961, Text fig. 1), and other localities.

Merriam and Buwalda (1917) briefly described some horse teeth found in the Ringold Formation. Stratigraphically, their specimens were from just above the White Bluffs tuff; the site can be located from a published photograph, their Plate 13, figure 1. Their description suggests a more advanced horse than is indicated by the Burke Museum specimens.

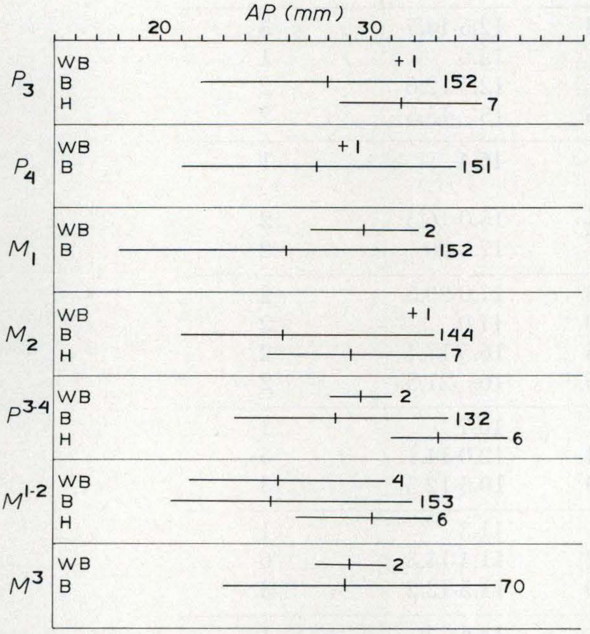

Figure 25. Ranges and means of anteroposterior tooth measurements of *Equus simplicidens* from the Broadwater Quarries (B), Nebraska (Howe, 1970), Hagerman (H), Idaho (Gazin, 1936), and of *E.* cf. *simplicidens* from the White Bluffs (WB), Washington. Horizontal lines indicates ranges, vertical lines indicate means; numbers at right of horizontal lines are numbers of specimens measured.

Merriam (1918) compared the White Bluffs teeth to *E. idahoensis* Merriam, from Idaho. Although the Idaho form is advanced (see descriptions by Shotwell, 1970) with respect to the Burke Museum specimens, Merriam's Ringold specimens seem to be more so. This record suggests that either more than one species of *Equus* is present in the Ringold Formation, or that the range of variation in the species is not adequately covered in the materials available to me.

Savage (1951, p. 217) believed that given a reasonable amount of variation within a species, most of the plesippine (=dolichohippine) species could be referred to the earliest-described species, *E.* (*D.*) *simplicidens* Cope (1893). This latter opinion has been accepted here, with the reservation that more complete statistical studies of the sort done on *Merychippus* by Downs (1961) may make a subdivision of the group possible.

Order ARTIODACTYLA

Family Tayassuidae

Genus *Platygonus* Le Conte, 1848

Platygonus pearcei Gazin, 1938

(Figure 27)

Material—UW A3024: UW 42000, mandible fragment with P_4-M_2. UW A3036: UW41942, /C fragment. UW A3037: UW 41972, molar fragment. UW A5136: UW 28734, M^1. UW A5137: UW 28733, molar fragment. UW A5927: UW 34966, M^1: UW 35231, P/? fragments. UW A6503: UW 35099, C/: UW 35115, /P: UW 35216, maxillary with P^2-M^3: UW 35246, /C. UW A6520: UW 40301, M/ fragment: UW 40302, M^1. UW A6571: UW 35257, /M fragment. UW A8807: UW 42161, M? fragment. UW A8809: UW 41516, M_2 fragment. UW A9292: UW 42327, M^3.

Stratigraphic position—Ringold Formation, 40 feet below to 45 feet above White Bluffs tuff, early Blancan.

Description—Gazin (1938) did not describe the dentition of *P. pearcei* from Hagerman in detail. The following description is intended to cover the White Bluffs material but will hold for the Hagerman sample except where noted. Three canines, one upper and two lower, have been damaged or badly eroded, but appear to have been similar in size to those of *Platygonus pearcei* Gazin (Hagerman, Idaho).

The upper premolars show progressive molariformity from front to rear, manifested in increasing rectangularity and size of the posterior cusps (metacone and hypocone) from P^2 to P^4. The upper teeth differ only slightly from specimens of *P. pearcei* in the collections of the University of

TABLE 17

MEASUREMENTS OF TEETH OF
Platygonus pearcei AND *P. bicalcaratus*
(MAXIMA AND MINIMA ONLY)

A= *P. pearcei*, White Bluffs, Ringold Formation, Washington.
B= *P. pearcei*, Hagerman, Idaho, UMMP collection and Gazin, 1938.
C= *P. bicalcaratus*, Keefe Canyon, Rexroad Formation, Hibbard and Riggs, 1949.
D= *P. bicalcaratus*, Blanco Formation, Texas, from Gidley, 1903.

Tooth	locality	AP	T	no. of specimens
P^2	A	10.8	9.7	1
	B	-	-	-
	C	9.5-11.8	7.5-11.0	3
	D	11 -11.5	10.5-12	2
P^3	A	11.4	11.2	1
	B	10.1e	10.8e	1
	C	10.8-11.8	9.8-12.4	3
	D	12 -13.5	12 -13	2
P^4	A	11.7	12.0	1
	B	10.2-11.2	12.8-13.2	2
	C	11.6-14.0	11.8-13.7	3
	D	12 -14	14	2
M^1	A	13.5-16.3	12.5-14.7	3
	B	14.8	12.6	1
	C	14.1-16.1	12.5-12.6	2
	D	16.5-17.5	15 -15.5	2
M^2	A	18.7	16.4	1
	B	-	.	-
	C	18.0-18.4	15.0-16.5	2
	D	19.5-20	17.5-20	2
M^3	A	23.1-30.5	17.0-20.5	2
	B	21.8-23.0	17.0	2
	C	21.0-21.5	16.5-17.4	2
	D	20 -25.5	16 -21.5	2
P_4	A	14.3	10.7	1
	B	11.5-15.4	12.0-14.1	6
	C	12.2-13.0	10.5-12.5	3
M_1	A	15.1	11.3	1
	B	15.1-16.2	11.4-14.3	6
	C	14.8-16.0	11.5-12.2	3
M_2	A	18.7	14.6	1
	B	17.3-21.5	13.3-17.5	4
	C	18.2-19.5	14.0-15.5	3

Michigan Museum of Paleontology, and are within the range of variation of that species.

P^2 is a rounded triangular tooth, widest posteriorly. There are two distinct cusps, a protocone and paracone, with a very small divided cusp in the position of a metacone. The paracone is slightly more anterior and higher. A heavy cingulum is present on all sides except the anterolabial.

P^3 is more quadrate than P^2, and is widest anteriorly. The protocone and paracone are large and subequal; the metacone and hypocone are distinct but much smaller, and the hypocone is set well in from the lingual side. The cingulum is strong, especially on the posterior border, but is absent on the lingual side of the protocone and the labial side of the paracone.

P^4 is distinctly rectangular, widest anteriorly, and is larger than P^3. The metacone is proportionately larger than in P^3, considerably larger than the hypocone. The cingulum is strong anteriorly and on the labial side of the metacone, but is weaker posteriorly than in P^3.

The posterior cusps on $P^{3\text{-}4}$ are apparently larger and more distinct than on specimens of *P. bicalcaratus* Cope from the Blanco Formation of Texas illustrated by Gidley (1903 fig. 1, 2).

M^1 is badly worn on the complete series. It shows that a cingulum was present on the labial side but not the lingual. Two isolated M^1's are available. UW 28734 is worn, though not as badly as in UW 35216. The cusps are subequal in size as in the other M^1's, and a cingulum is present on anterior, labial, and posterior sides. UW 40302 is unworn; on it the cingulum is strongest on the anterior side, present on labial and posterior sides, and is present but weak on the lingual side of the protocone. The cusps are well separated and do not form distinct cross-lophs when unworn. The enamel is lightly crenulated.

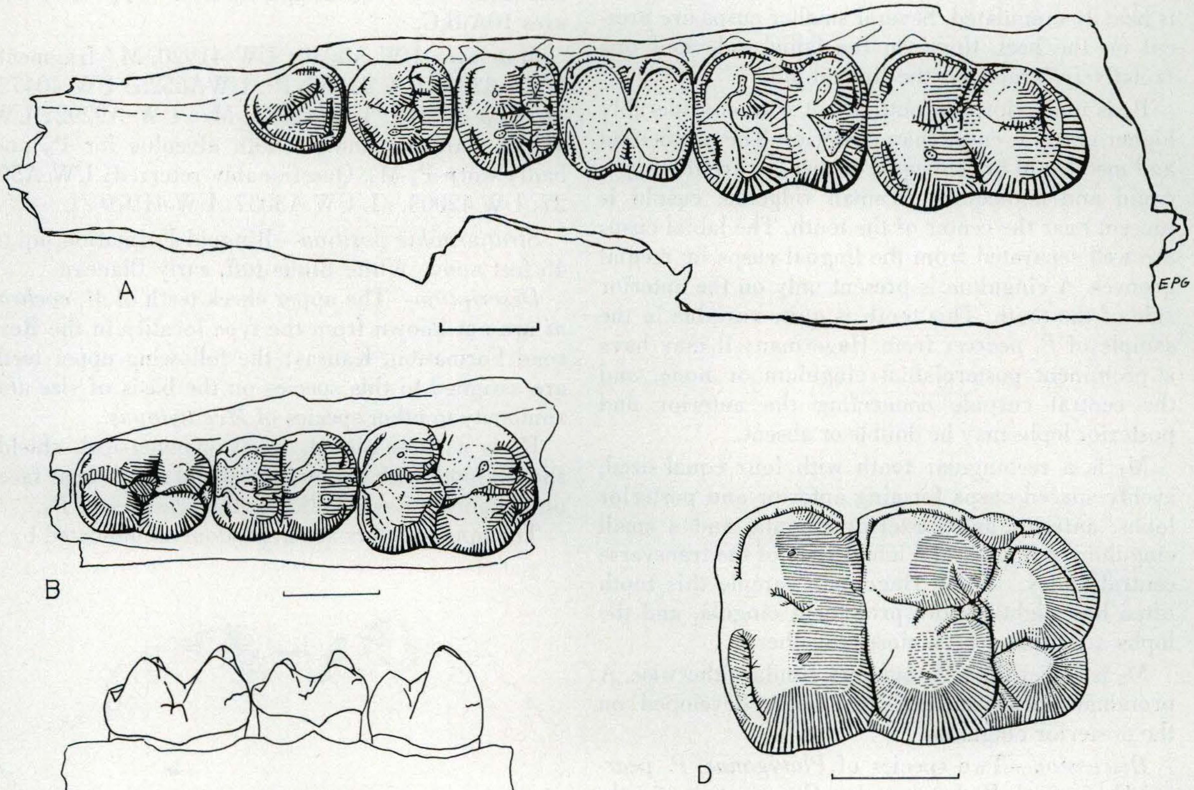

Figure 27. *Platygonus pearcei.* A. P^2-M^3, UW 35216, occlusal view. B. P_4-M_2 UW 42000, occlusal view. C. UW 42000, lateral view. D. M^3, UW 42327, occlusal view. Lines indicate one centimeter. Anterior to left in A, B, and D; to right in C.

M^2 is larger than M^1, with the cusps subequal in size but spaced further apart anteriorly than posteriorly. It is more lophodont than the unworn M^1. A cingulum is present around the labial half of the tooth and on the anterior side of the protocone.

M^3 is the largest molar. It tapers strongly towards the posterior end; the protocone and paracone are larger than metacone and hypocone. The posterior cusp or heel is part of a broad ridge or posterior cingulum which extends labiad and posterad from the posterior hypocone and connects with the labial cingulum. The labial and anterior cingula are similar to those of M^2. The enamel is crenulated where unworn. A second M^3 (UW 42327) is questionably referred to this species. It is larger than any reported M^3 of *Platygonus,* but could conceivably be a large variant of *P. pearcei.* The cusps are large and well separated, the cingulum is stronger than but in the same positions as in the smaller M^3, and the enamel is heavily crenulated. Several smaller cusps are present on the heel, three on the labial side and one (relatively large) on the lingual side.

P_4 is molariform in outline but with considerably higher anterior cusps than posterior. The protoconid and metaconid are subequal in size, as are the hypoconid and entoconid. A small ridgelike cuspid is present near the center of the tooth. The labial cusps are well separated from the lingual cusps by medial grooves. A cingulum is present only on the anterior side of the tooth. This tooth is quite variable in the sample of *P. pearcei* from Hagerman; it may have a prominent posterolabial cingulum or none, and the central cuspule connecting the anterior and posterior lophs may be double or absent.

M_1 is a rectangular tooth with four equal-sized, evenly spaced cusps forming anterior and posterior lophs, anterior and posterior cingula, and a small cingulum at lingual and labial ends of the transverse central valley. In the Hagerman sample this tooth often has slightly more prominent cingula, and the lophs are often a little closer together.

M_2 is larger than M_1 but very similar otherwise. A prominent posteromedial cuspule is developed on the posterior cingulum.

Discussion—Two species of *Platygonus, P. pearcei* Gazin and *P. bicalcaratus* Cope, are currently recognized from the Blancan of western North America. These two species are difficult to distinguish; they are almost the same size, and distinguishing characters which have been mentioned (Gazin, 1938) such as development of cingula, height and distinctness of lophs, and development of M_3^3 heels, are all variable. Woodburne (1968), using Gazin's illustrations, suggested that *P. pearcei* was a longer snouted species with more flaring zygomatic arches than *P. bicalcaratus;* unfortunately these characters are not determinable in the Ringold material. I have referred the Ringold specimens to *P. pearcei* because I could not adequately distinguish them from the latter, and because there are apparent differences between the Ringold specimens and published figures of topotypes of *P. bicalcaratus.* The great variability found by Simpson (1949) in a sample of *P. compressus* LeConte suggests that better criteria may be needed if it is to be shown that *P. pearcei* and *P. bicalcaratus* are distinct.

Family Camelidae Gray, 1821
Genus *Megatylopus* Matthew and Cook, 1909

Megatylopus cf. M. cochrani (Hibbard and Riggs), 1949
(Figure 28)

Hibbard, C. W., and Riggs, E. S., 1949, p. 854, Figures 10A,B,C,

Material—UW A3030: UW 41920, M/ fragment. UW A3339: UW 41557, P^4. UWA6525: UW 40475, M_1. UW A8812: UW 42221, M/. UW A9292: UW 42320, partial mandible with alveolus for P_3 and badly worn P_4-M_3. Questionably referred: UW A3027: UW 42003, /I. UW A3037: UW 41979 /I.

Stratigraphic position—Ringold Formation, up to 45 feet above White Bluffs tuff, early Blancan.

Description—The upper cheek teeth of *M. cochrani* are not known from the type locality in the Rexroad Formation, Kansas; the following upper teeth are assigned to this species on the basis of size and similarity to other species of *Megatylopus.*

P_4 is a three-rooted, fairly symmetrical, shield-shaped tooth with distinct styles and rib. A wear facet on the anterior side indicates the presence of P_3.

The upper molars are hypsodont as indicated by a fragmentary specimen. A strong mesostyle is pres-

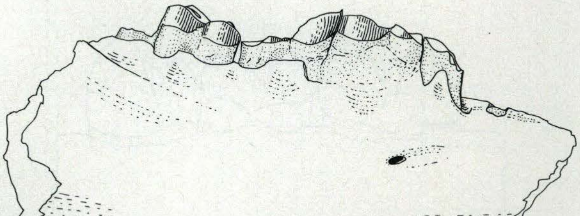

Figure 28. *Megatylopus* sp. cf. *M. cochrani,* mandible with alveolus of P_3 and badly worn P_4-M_3, UW 42320, lateral view. Line indicates one centimeter. Anterior to right.

ent, but ribs are weak. A worn upper molar (UW 42221) closely resembles the M^1 of *Megatylopus gigas* (Matthew and Cook, 1909), except for somewhat smaller size.

The lower dentition is represented by a single littleworn molar, probably M_1, and by a partial mandible with the single root of P_3 and badly worn and chipped P_4-M_3. The root of P_3 is separated from P_4 by a 12 mm diastema. The P_3 of the type specimen of *M. cochrani* is two-rooted.

The measurements of the lower dentition of the lower dentition of the Ringold specimens are close to measurements of *Megatylopus cochrani* (Hibbard and Riggs, 1949) from the Rexroad Formation of Kansas. The Ringold specimens are at the lower range of measurements of *Camelops hesternus* Leidy from Rancho la Brea (Webb, 1965 p. 50) which lacks P_3 entirely, and are apparently outside the range of variation of *M. gigas* (Mathew and Cook, 1909) and species of *Titanotylopus* (Meade, 1945). Although only one root can be seen for P_3 in the Ringold mandible, the preserved root is well separated from the anterior root of P_4. Since this was an old individual, P_3 could have been broken off and the posterior root resorbed before the animal died.

Discussion—Differentiation of the species of *Megatylopus* depends largely on the degree of reduction of the third premolars (Webb, 1965, p. 44), which are not, except for alveoli, preserved in the Ringold Formation sample. The close similarity to *M. cochrani* in size suggests a close affinity.

Family Camelidae

Genus *Hemiauchenia* Gervais and Ameghino, 1880

Hemiauchenia sp.

Material—UW A3027: UW 42004, M_3. UW A3036: UW 41939, M^3 fragment. UW A3037: UW 41965, C or P. UW A3339: UW 41555, mandible with M_1 and partial DP_4, $M_{2\text{-}3}$: UW 41556, /M fragment. UW A3339?: UW 41554, mandible fragment with DP_4, M_1. UW A6503: UW 35154, DP_4; UW 35147, M_3: UW 40392, M_1. UW A6571: UW 42985, mandible fragment with DP_4 and partial M_1. UW A8812: UW 40468, /I. UW A9292: UW 42325, $M^{1\text{-}2}$. UW A9305: UW 42147, M_3.

Stratigraphic position—Ringold Formation, up to 45 feet above White Bluffs tuff, early Blancan.

Description—M^1 and M^2 are very similar in size, and rib and style development to a specimen of *Hemiauchenia blancoensis* (Meade), (KU 7503) from the Rexroad Formation of Kansas, Keefe Canyon locality (Hibbard and Riggs, 1949): styles are strong, and ribs, though low and rounded, are distinct. The Ringold specimen is chipped on the labial side of both upper teeth, so that further details are not available.

The mandible (UW 45101) is long and slender.

TABLE 18
MEASUREMENTS OF THE TEETH OF *Megatylopus* FROM THE RINGOLD FORMATION

				Megatylopus cochrani, holotype*	
Tooth	Specimen number	AP	T	AP	T
P^4	UW 41557	20.9	14.5		
M/	UW 42221	33.4	30.7		
M_1	UW 40475	36.0	16.4		
P_4	UW 42320	19.4	14.0	21.8	15.0
M_1	"	33.0	22.2	32.6	24.0
M_2	"	38.6	24.8	39.8	26.3
M_3	"	53.2	23.3	52.0	21.7
P_3-M_3	"	163e		166.2	

	UW 42320	*M. cochrani*, holotype
Depth of mandible (inside) below anterior P_4	60.7	62.2
Depth of mandible (inside) below anterior M_3	74.3	80.7

* KU 7644, after Hibbard and Riggs, 1949

TABLE 19

Measurements of Teeth of *Hemiauchenia* from the Ringold Formation

Specimen number	Tooth	AP	T
41555	dP_4	-	13.7
	M_1	27.5	12.3
	M_2	-	10.2
41554	dP_4	29.5	10.9
	M_1	30.6	11.8
42985	dP_4	35.9	9.6
35154	dP_4	-	9.7
45101	M_1	18.5	13.3
	M_2	27.2	16.1
	M_3	40.9	14.6
40392	M_1	-	13.8
42004	M_3	36.6	14.7
35147	M_3	38.0	15.0
42147	M_3	36.4	13.7

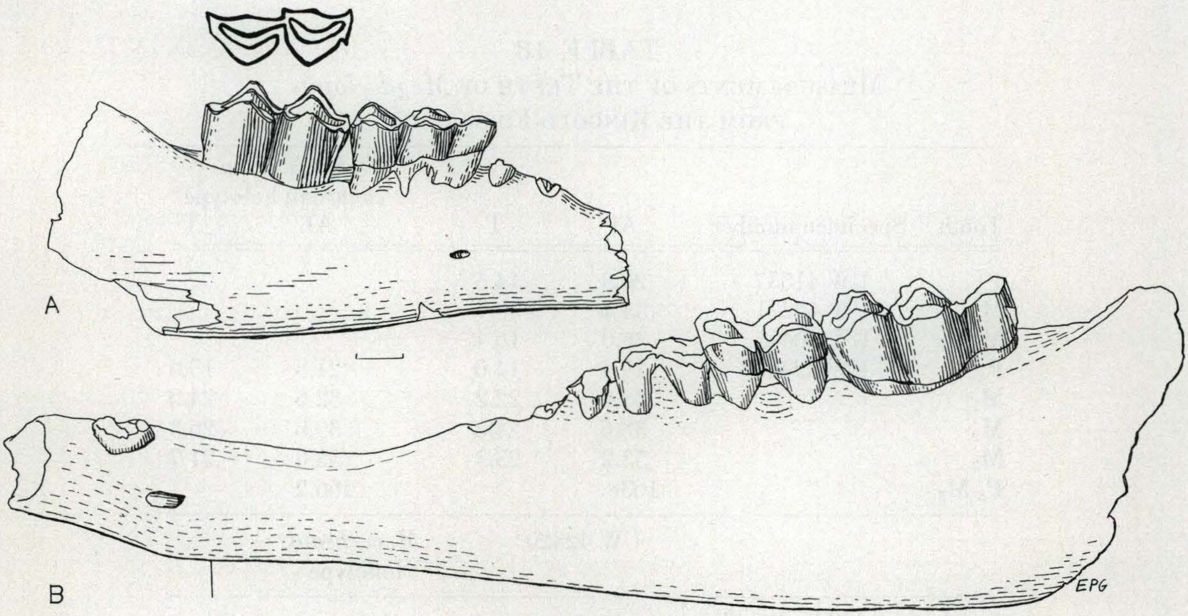

Figure 29. *Hemiauchenia* sp.. A. Mandible with dP_4 and M_1, UW 41554, lateral view, and occlusal view of M_1. B. Mandible with partial P_1, alveoli for P_3, badly worn P_4-M_3, UW 45101, lateral view. Lines indicate one centimeter. Anterior to right in A, to left in B.

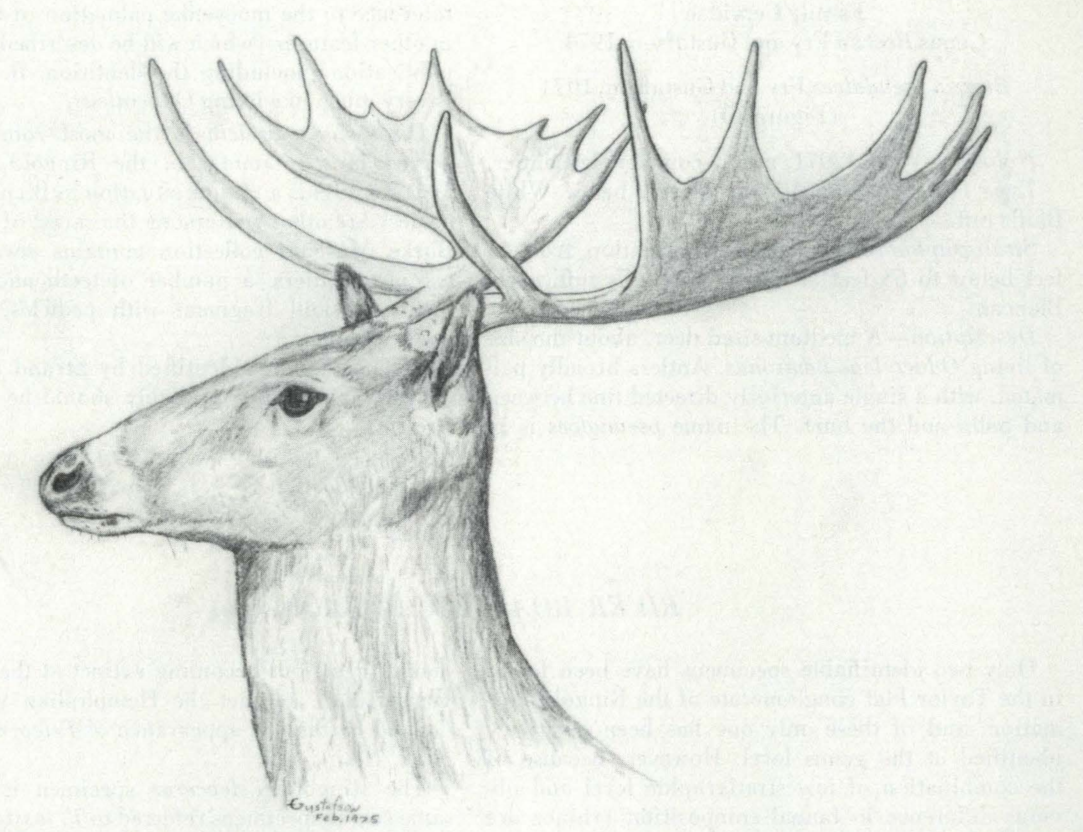

Figure 30. *Bretzia pseudalces* Fry and Gustafson, restoration.

The anterior part of the mandible is considerably longer than seen in *H. blancoensis* (distance from anterior root of P_4 to posterior border of symphysis= 71 mm versus 46 to 56 mm in Keefe Canyon *H. blancoensis*). It is not as elongate as in *H. mirifica* Simpson (distance from anterior border of P_4 to posterior alveolus of P_1=81 mm versus 99 mm in *H. mirifica* [Pleistocene, Florida] reported by Hibbard and Dalquest, 1962). The teeth are close in size and form to *H. blancoensis*, and are larger than in *H. macrocephala* (Cope) from the Pleistocene of Texas.

DP_4 is a three-lobed tooth with only very low, rounded ribs and small styles on the posterolingual corners of the anterior and middle lobes. It is similar in form to DP_4 of *H. blancoensis*.

The permanent premolar crowns are not preserved. P_3 was two-rooted and probably rather large; P_4 was somewhat larger but smaller than M_1.

Both labial and lingual anterior styles are present in M_1, though both styles would be greatly reduced when the tooth was more worn. A strong steplike style occupies the posterolingual corner of the anterior lobe, so that the anterior lobe is placed further linguad than the posterior lobe. Development of all styles is similar to that seen in *H. blancoensis.* The anterior hypolophid does not connect to the metalophid at the stage of wear represented by UW 41554. Ribs are low but distinct.

The only M_2 available is badly worn. A remnant of an anterolabial style can be seen.

The four M_3's are all badly worn. The anterolabial style is present. The posterior lobe is set labiad from the line of the paralophid and metalophid, but the angle of offset is variable; also the development of a steplike posterolingual style on the metalophid is variable. Characters of M_3 are like those of *H. blancoensis* at a similar stage of wear.

Discussion—The Ringold *Hemiauchenia* would be easily placed in *H. blancoensis* except for the longer anterior mandible. Additional specimens will be needed to demonstrate whether this character is constant or not in the Ringold Formation.

The synonomy of *Tanupolama* with *Hemiauchenia* follows Webb (1974).

Family Cervidae
Genus *Bretzia* Fry and Gustafson, 1974

Bretzia pseudalces Fry and Gustafson, 1974
(Figure 30)

Holotype—UW 42971, nearly complete left antler.

Type locality—UW A9577, 44 feet below White Bluffs tuff.

Stratigraphic range—Ringold Formation, from 44 feet below to 65 feet above White Bluffs tuff, early Blancan.

Description—A medium-sized deer, about the size of living *Odocoileus hemionus*. Antlers broadly palmated, with a single anteriorly directed tine between and palm and the burr. The name *pseudalces* is in reference to the mooselike palmation of the antlers; in other features (which will be described in a future publication) including the dentition, *B. pseudalces* is very much like living *Odocoileus*.

Discussion—*Bretzia* is the most commonly preserved large mammal in the Ringold Formation This represents a unique situation in Blancan faunas, as deer are otherwise among the rarest of forms. The Burke Museum collection contains several nearly complete antlers, a number of teeth and jaw fragments, a skull fragment with pedicles, and other assorted bones.

The metapodial identified by Strand and Hough (1952) as *Rangifer* probably should be referred to *Bretzia*.

RIVER ROAD LOCAL FAUNA

Only two identifiable specimens have been found in the Taylor Flat conglomerate of the Ringold Formation, and of these only one has been positively identified at the genus level. However, because of the combination of low stratigraphic level and obvious difference in faunal composition (rhinos are conspicuous by their absence, despite the availability of many hundreds of specimens, in the upper Ringold Formation), I consider a separate name to be justified for this fauna.

Class MAMMALIA
Order PERISSODACTYLA
Family Rhinocerotidae
Genus *Teleoceras* Hatcher, 1894

Teleoceras sp.
(Figure 31)

Material—Left mandibular ramus with symphysis, incisors, P_3-M_3, collected December 27, 1974 near south end of Taylor Flat. UW C71: UW 52685.

Stratigraphic position—Ringold Formation, Taylor Flat conglomerate, about 70 feet below top of conglomerate, near line of section C of figure 4, late (?) Hemphillian.

Discussion—The late discovery of this specimen and the press of other duties have allowed only a preliminary identification to be made. Neverthless some mention must be made here because of its biostratigraphic importance. *Teleoceras* is a characteristic pre-Blancan genus, ranging from the Barstovian (middle Miocene) through the Hemphillian mammalian ages, but becoming extinct at the end of the Hemphillian. In fact the Hemphillian was in part defined by the last appearance of *Teleoceras* (Wood *et al.*, 1941).

The Ringold *Teleoceras* specimen is about the same size as specimens referred to *T. fossiger* (Cope), but the genus is badly in need of revision and a specific designation would be premature. The Burke Museum collection includes a partial skull and mandible of *Teleoceras* from the Westend Blowout local fauna and a M_3 from the McKay Reservoir local fauna, both Hemphillian of Oregon. The latter specimens are almost identical in form to the equivalent parts of the mandible from the Taylor Flat conglomerate. The diastema is short as is typical of *Teleoceras*, and there is no sign of P_{1}-$_{2}$. The animal was an adult, with all molars worn, though none of the teeth are worn to the roots. The anterior part of P_4 is raised above the molar occlusal plane, and P_3 seems to have been tilted forward; these suggest that the upper premolars were damaged or otherwise wearing abnormally. The coronoid process has the anterad lean commonly seen in *Teleoceras*.

There are no published analyses of evolutionary trends in *Teleoceras*. Some Clarendonian individuals possess P_2, but older individuals from sediments of the same age have lost this tooth (Webb, 1969), and may have no sign of the alveolus. The stratigraphic superposition of a fauna of early Blancan age and the similarity to specimens of known Hemphillian age are evidence of a Hemphillian age for the River Road local fauna. I tentatively consider the Taylor Flat conglomerate to be late Hemphillian.

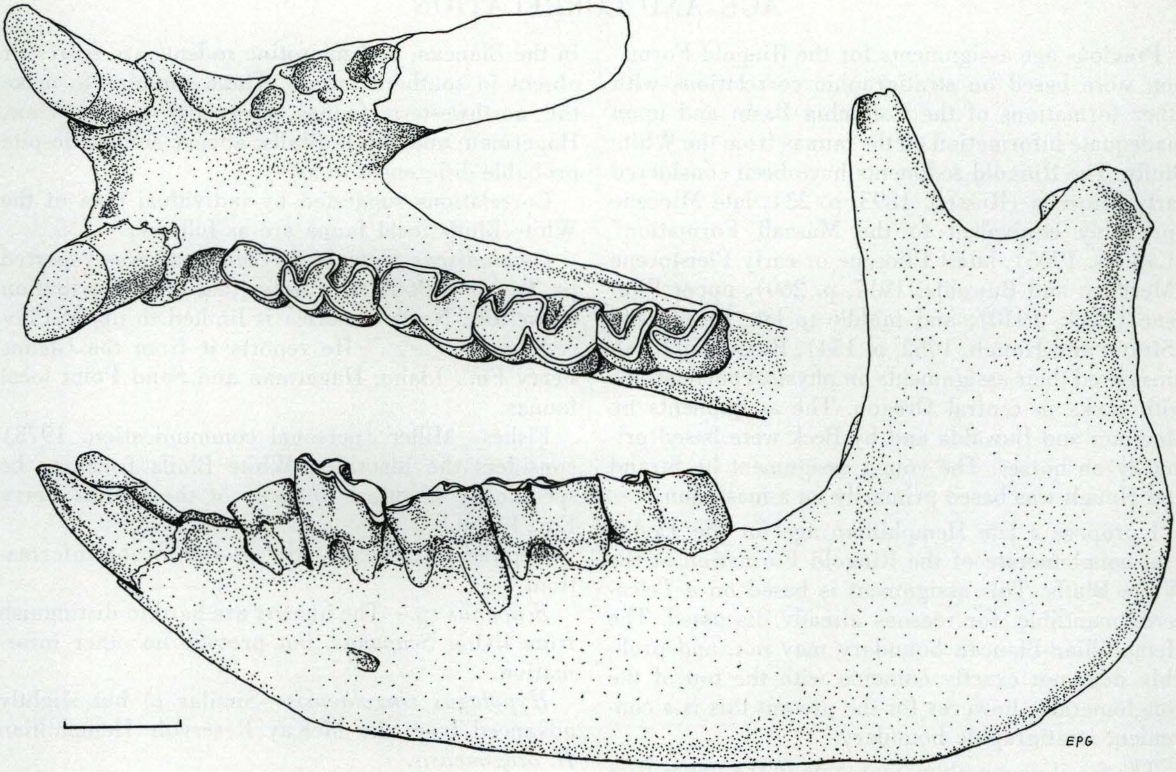

Figure 31. *Teleoceras* sp., mandible from Taylor Flat conglomerate, UW 52685. Occlusal and left lateral views. Scale line equals 5 centimeters.

Order ARTIODACTYLA
Family Camelidae
?*Megatylopus* sp.

Material—UW A8817: proximal portion of radioulna.

Stratigraphic position—Ringold Formation, Taylor Flat conglomerate, 20 feet below top of conglomerate, late (?) Hemphillian.

Discussion—This bone is similar in morphology to the radioulna of *Camelops* and its size is reasonable for members of the genus *Megatylopus* which is found in the overlying White Bluffs local fauna and which was probably ancestral to *Camelops* (Webb, 1965).

AGE AND CORRELATION

Previous age assignments for the Ringold Formation were based on stratigraphic correlations with other formations of the Columbia Basin and upon inadequate information on the faunas from the White Bluffs. The Ringold sediments have been considered early Miocene (Russell, 1893, p. 23), late Miocene "probably equivalent to the Mascall Formation" (Calkins, 1905), latest Pliocene or early Pleistocene (Merriam and Buwalda, 1917, p. 260), upper Pliocene (Beck, 1940), and middle to late Pleistocene (Strand and Hough, 1952, p. 154). Russell and Calkins based their assignments on physical correlations with rocks in central Oregon. The assignments by Merriam and Buwalda and by Beck were based primarily on horses. The young assignment by Strand and Hough was based primarily on a mastodon.

I propose a late Hemphillian age for the Taylor Flat conglomerate of the Ringold Formation at the White Bluffs. This assignment is based on a *Teleoceras* mandible, for reasons already discussed. The Hemphillian-Blancan boundary may not, and probably does not exactly coincide with the top of the conglomerate; however for the present this is a convenient stratigraphic boundary.

The fossil mammalian aggregate in the upper Ringold Formation at the White Bluffs represents a North American Mammal Age of early Blancan (Pliocene). The Blancan age is based on the presence of *Equus* (*Dolichohippus*), *Ophiomys*, *Borophagus*, *Trigonictis*, and *Nekrolagus*; on the association of these with other genera, particularly *Platygonus*, *Megatylopus*, and large *Dipoides*; and on the absence of genera characteristic of Hemphillian age (rhinoceroses, *Neohipparion*, *Prosthenops*, *Plesiogulo*, *Microtoscoptes*) or of Irvingtonian age (*Equus* (*Equus*), *Lepus*, *Microtus*, *Mammuthus*).

Correlation within the Blancan is currently undergoing revision on the basis of combined radiometric and paleomagnetic data (Lindsay, Johnson, and Opdyke, 1975) which when properly combined with biostratigraphic information will eventually provide a much finer-scale correlation.

Biostratigraphic correlations with Great Plains and southern faunas suffer because of regional and latitudinal effects. The White Bluffs local fauna lacks such common southern and plains forms as *Nannippus*, glyptodonts, *Geomys*, *Ogmodontomys*, and *Sigmodon*. Thus I cannot use the major faunal datum planes set up by Johnson, Opdyke, and Lindsay (1975) in Blancan deposits of the San Pedro Valley, Arizona, which were based on *Nannippus* and *Sigmodon*. On the other hand, *Scapanus*, *Ammospermophilus*, *Thomomys*, and *Castor* are all western forms in the Blancan, and microtine rodents are scarce or absent in southern faunas. These combine to make the northwestern faunas, especially Grand View, Hagerman, and White Bluffs, appear similar despite probable differences in age.

Correlations suggested by individual taxa of the White Bluffs local fauna are as follows;

Omalodiscus pattersoni—This snail was reported by Taylor (1966) who states that "the distribution in western North America is limited to upper Pliocene rocks . . . ." He reports it from the Glenns Ferry Fm., Idaho, Hagerman and Sand Point local faunas.

Fishes—Miller (personal communication, 1973) considers the identified White Bluffs fishes to be specifically identical to those of the Glenns Ferry Fm., Idaho.

Reptiles—These provide no significant information.

Scapanus sp.—The humeri are hard to distinguish from living *Scapanus*, but provide no other information.

Hypolagus ringoldensis—Similar to but slightly advanced from the McKay Reservoir Hemphillian *H. oregonensis*.

Nekrolagus cf. *N. progressus*—Similar to specimens from the Rexroad Formation, Kansas.

Paenemarmota or *Marmota* sp.—Most similar to *M. sawrockensis* from the late Hemphillian Sawrock Canyon local fauna; smaller than (and perhaps therefore earlier than?) specimens from Hagerman and Rexroad local faunas.

Spermophilus? russelli—"primitive" in appearance, and possibly matched by specimens from Hagerman.

Ammospermophilus hanfordi—Provides no significant information.

Thomomys cf. *T. gidleyi*—Similar to the Hagerman species.

Castor californicus—Specimens of very similar beavers are known from California, Hagerman, and (though assigned a different specific name by Shotwell, 1970) Grand View local fauna of Idaho.

Dipoides rexroadensis—Similar-size *Dipoides* are known from Hagerman and Rexroad local faunas. A slightly larger upper molar from the late Blancan Sand Draw local fauna of Nebraska was assigned to this species by Hibbard (1972).

Peromyscus nosher—A modern-looking species, similar to *P. hagermanensis* but not very informative.

Neotoma cf. *N. quadriplicatus*—Most similar to specimens from Fox Canyon fauna of the lower part of the Rexroad Formation, Kansas. This species has not been reported from later Blancan localities.

Ophiomys mcknighti—This species is more primitive than *O. taylori* from Hagerman, and is not greatly advanced beyond *Promimomys* from the Hemphillian of Oregon.

Megalonyx rohrmanni—This species may appear at both Hagerman and Grand View, Idaho.

Canis davisi—This canid is common in the late Hemphillian faunas of Oregon, but has not been reported from other Blancan faunas.

Borophagus sp.—This genus is found generally in both early and late Blancan faunas.

Ursus cf. *U. abstrusus*—Otherwise known only from the Hagerman local fauna.

Trigonictis cooki—Known from both Hagerman and Grand View local faunas.

Felis sp.—Provides no significant information.

Machairodontinae—Provides no significant information.

Mammut americanum—If correctly identified, this species provides the strongest evidence for later Blancan (or Pleistocene) age; however, the mammutids of the Blancan are poorly known.

Equus (*Dolichohippus*) cf. *E. simplicidens*—Evidence from the horses is contradictory. Merriam and Buwalda (1917) found "advanced" specimens of *Equus* in the White Bluffs; however, specimens in the Burke Museum collection are uniformly primitive in appearance.

Platygonus pearcei—All other identified specimens of this species are from Hagerman, but *P. pearcei* is questionably distinct from *P. bicalcaratus*, known from several other Blancan localities.

Megatylopus cf. *M. cochrani*—Species reported only from the Rexroad Formation, Kansas, though *Megatylopus* is reported from Cita Canyon, Texas, and Hagerman. The genus is more widespread in the Hemphillian.

Hemiauchenia sp.—Not well enough known to provide significant information.

Bretzia pseudalces—This genus is reported only from the White Bluffs. Deer from other Blancan localities have not ben sufficiently described to allow positive identification.

From the above listing it is evident that the affinities of this fauna are, first, to the Hagerman local fauna; second, to other western Blancan faunas, including Grand View; and third, to the Rexroad Formation faunas (Rexroad, Fox Canyon, and Sawrock Canyon local faunas) of Kansas. Several of the taxa have close relatives in Hemphillian faunas, especially those of northern Oregon. It would be difficult to justify a late Blancan age assignment for the White Bluffs local fauna. Keeping in mind the very small samples available for most of the taxa from the Ringold Formation, I would tentatively correlate the White Bluffs local fauna with the faunas of he middle and lower part of the Rexroad Formation, Kansas, very early Blancan, and place it earlier than the Hagerman local fauna of Idaho.

Author's note.—Specimens of *Ophiomys mcknighti* from Alturas, California, underlie a basalt dated at 4.9± 0.5 million years (C. A. Repenning, personal communication, 1977). If the date is correct and the Ringold Formation specimens of *O. mcknighti* are of about the same age, the White Bluffs local fauna would be about 1.5 million years older than the Hagerman local fauna.

PALEOENVIRONMENT

Fauna—The most striking feature of the White Bluffs fauna is the high relative abundance of larger mammals with dentitions adapted for browsing rather than grazing. This preponderance is illustrated by figure 32 which graphs the number of localities at which a particular form was found. The number of localities is probably nearly the same as the minimum number of individuals because of the large number of localities from which specimens were recorded and the small number of specimens from most localities.

The most common large mammal is *Bretzia pseudalces*, a deer about the size of the Recent mule deer (*Odocoileus hemionus*) but with wide palmated antlers. It was presumably a browser; modern deer prefer areas where brushy cover is available.

The adaptive features of *Platygonus*, the second most common form, have recently been studied by Guilday, Hamilton, and McGrady (1971). A variety of evidence, including the elongated antorbital portion of the skull and elongation of the legs, was considered to be indicative of adaptation to an open forest habitat; this conclusion is supported by the tooth structure, which (p. 307) "would seem to be adapted to browsing, much more so than in the Old World *Sus*, although it is still essentially that of a modified omnivore."

Blancan faunas vary considerably in relative abundances of large herbivorous mammals. Three examples are listed in Table 20; the fauna from the Keefe Canyon locality of the Rexroad Formation, Kansas (Hibbard and Riggs, 1949), the Grand View

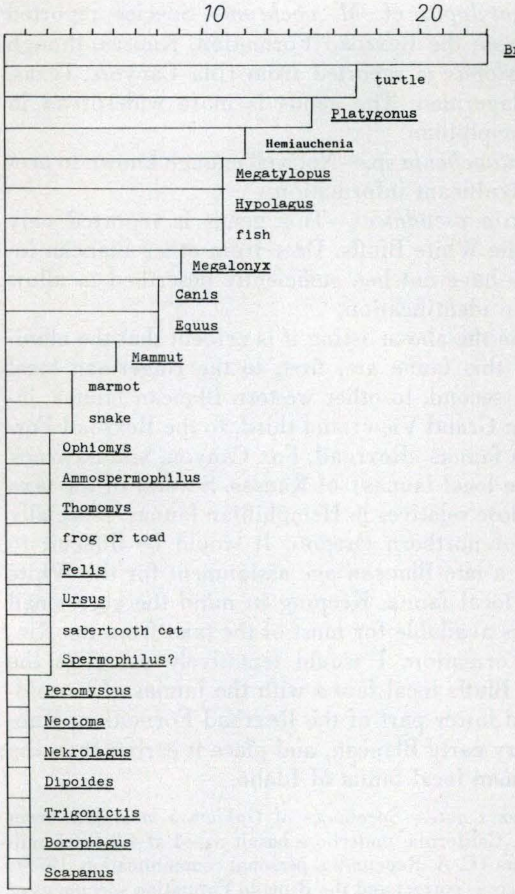

Figure 32. Relative abundance of vertebrates in the White Bluffs local fauna, Ringold Formation, Washington. Length of bar indicates number of localities at which a taxon was found. Census of Burke Museum collection made in June, 1972; it includes identified teeth and postcranial material, some of which was not listed in the systematics section.

fauna from several localities in the upper Glenns Ferry Formation, Idaho (Shotwell, 1970), and the White Bluffs fauna.

The White Bluffs local fauna lacks *Stegomastodon* and *Titanotylopus* (*sensu* Webb, 1965), both members of Hibbard's (1972, p. 134) "Savannah Valley Communities" and present in both of the other faunas: it also lacks antilocaprids, which are present in the Grand View local fauna. Both the Idaho and Kansas faunas are typical of Blancan faunas in general in their high abundance of *Equus* and low abundance or absence of cervids and *Megalonyx*.

The White Bluffs fauna in contrast includes abundant cervids and *Megalonyx; Equus* is relatively scarce. *Hemiauchenia* is abundant in all three faunas, as is *Platygonus*; however, *Platygonus* is relatively more abundant in the White Bluffs and Keefe Canyon samples than in the Grand View sample. *Megatylopus* is also present in the Keefe Canyon and White Bluffs faunas, but is not seen at Grand View.

Differences in these faunas of large mammals probably reflect local abundances of vegetation types rather than geographical differences. The most sensitive "indicators" of vegetation types are presumably the more specialized browsers and grazers, primarily cervids, *Megalonyx*, *Mammut*, *Equus*, and antilocaprids; the first three of these are probably indicative of dense woodland, the latter two of open grassland. Other forms, such as the camels and *Platygonus* probably ranged through the open woodland-savannah habitats. With these "indicators" in mind, it appears that woodland habitats were most prevalent on the Ringold floodplain, and less prevalent but present near the Keefe Canyon and Grand View depositional sites. Open grassland was most prevalent near the Grand View deposits and least prevalent on the Ringold floodplain.

The mammals may be allocated to the following communities (modified after Shotwell, 1958, fig. 13, and Hibbard, 1972, p. 134):

Stream-Bank and Lake Bank Communities: *Dipoides rexroadensis*, *Castor californicus*.

Marsh and Semiaquatic Communities: *Ophiomys mcknighti*.

Woodland Communities: *Hypolagus ringoldensis*, *Scapanus* sp., (?) *Peromyscus nosher*, *Megalonyx rohrmanni*, *Mammut americanum*, *Ursus* cf. *U. abstrusus*, (?) *Trigonictis cooki*, *Bretzia pseudalces*.

Open Woodland-Savannah Communities: *Nekrolagus* cf. *progressus*, *Paenemarmota* or *Marmota* sp., *Spermophilus? russelli*, *Thomomys* cf. *T. gidleyi*, *Neotoma*, *Felis* sp., *Platygonus pearcei*, *Megatylopus* cf. *M. cochrani*.

Open grassland Communities: *Equus* cf. *E. simpplicidens*.

Not allocated: *Ammospermophilus hanfordi*, *Canis davisi*, *Machairodontinae*, *Hemiauchena* sp.

These are very preliminary allocations; many of these animals certainly ranged through several habitats, and some may have lived in rather different habitats from those occupied by their Recent counterparts.

The lower vertebrates, including pond turtles, frogs or toads, and snakes, as well as catfish and sunfish, are suggestive of the presence of quiet water (oxbow lakes?) and marshes.

There are no areas along the present Columbia River that could support the White Bluffs faunas. This absence of suitable habitat seems to be largely

TABLE 20

RELATIVE ABUNDANCE[1] OF LARGE MAMMALS

	Keefe Canyon[2] Rexroad Formation		Grand View[3] Glenns Ferry Formation		White Bluffs Ringold Formation	
1.	*Titanotylopus*	21	*Equus*	30+	*Bretzia*	22
2.	*Hemiauchenia*	14	*Hemiauchenia*	7	*Platygonus*	14
3.	*Equus*	10+	*Stegomastodon*	6	*Hemiauchenia*	11
4.	*Platygonus*	8+	*Platygonus*	3	*Megatylopus*	10
5.	*Mammut*	2	*Titanotylopus*	3	*Megalonyx*	8
6.	*Megatylopus*	1	Cervid	3	*Equus*	7
7.	*Megalonyx*	1	*Megalonyx*	2	*Mammut*	5
8.	*Stegomastodon*	1	*Mammut*	2		
9.			*Antilocaprid*	2		

[1] Numbers given are approximate minimum numbers of individuals for Keefe Canyon and Grand View, and are numbers of localities for White Bluffs (see fig. 23).

[2] Hibbard and Riggs, 1949

[3] Shotwell, 1970

due to the absence of broad flood plains as well as to the lack of rainfall. The nearest areas which could conceivably support such a fauna today are along the Yakima River near Yakima and for about thirty miles downstream, where some floodplain woodland is developed. The large mammal fauna is depauperate at present (except for deer and domestic mammals), probably due to late Pleistocene extinctions and heavy use by humans. This area receives little more rainfall than the Pasco Basin (less than 10 inches yearly) yet supports even some drought-sensitive animals such as the mole *Scapanus*. Columbia Basin areas with slightly higher rainfall (about 15 inches yearly) support very productive grasses and in historic times were famous as excellent grazing land for horses. The faunas of the Ringold Formation near the streams may have been relatively independent of rainfall, as long as permanent streams were present and the floodplain water table remained relatively high. Somewhat greater rainfall may have been present in the central Columbia Basin during the Pliocene, perhaps because the Cascade Mountains rainshadow was not as effective. However, the Pliocene rainfall could have been only about 5 to 7 inches greater yearly and yet have allowed the vegetational changes necessary to support a large and varied fauna on the Columbia Plateau.

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