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GEOLOGY AND MAMMALIAN PALEONTOLOGY OF THE NEW FORK-BIG SANDY AREA, SUBLETTE COUNTY, WYOMING

ROBERT M. WEST

MARCH 23, 1973

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GEOLOGY AND MAMMALIAN PALEONTOLOGY OF THE NEW FORK-BIG SANDY AREA, SUBLETTE COUNTY, WYOMING

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INTRODUCTION

General Geography

The New Fork-Big Sandy area, about 430 sq. miles in extent, is located in the northeastern Green River Basin of Wyoming (fig. 1). It is entirely east of the Green River, and is crossed by two major tributaries of the upper Green River, the New Fork River and the Big Sandy River. To the east are the Wind River Mountains, while lower country bounds the area in the other directions. Pinedale, the Sublette County seat, is 6 miles north of the northwest corner, Big Piney about 10 miles west of the southwestern corner, and Farson about 27 miles south of the southern boundary.

Most of the area is made up of gently rolling plains with an average elevation in excess of 7,000 ft. Occasional badlands areas occur, usually at the infrequent sharp changes in relief. The maximum relief is along the streams and at the edge of the Mesa, a flat elevation at the northwestern edge of the New Fork-Big Sandy area. Granitic knobs, such as Fremont Butte, with an elevation of 7,875 ft., form prominent highs. The Paleozoic rocks of Steele Butte project to 7,408 ft., and Ross Butte, in the southwestern corner, is 7,475 ft. in elevation. The locations of these features are noted on the geological map of the New Fork-Big Sandy area (fig. 2).

The New Fork and Big Sandy Rivers meander extensively. A major tributary of the New Fork, the East Fork River, flows generally northwestward across the area, receiving water from Muddy, Cotton, Silver, and Scab Creeks.

This part of the Green River Basin has a pleasant summer climate, with daily high temperatures in the high seventies and low eighties, and nighttime lows in the forties and fifties. The average total annual precipitation is about 9.5 in. The growing season is short, averaging 60 to 80 days between killing frosts. The last spring freeze usually occurs about mid-June, and the first fall freeze in late August. The short duration of the growing season limits most forms of agriculture. Land unsuited for growing hay is devoted to range for cattle and sheep.

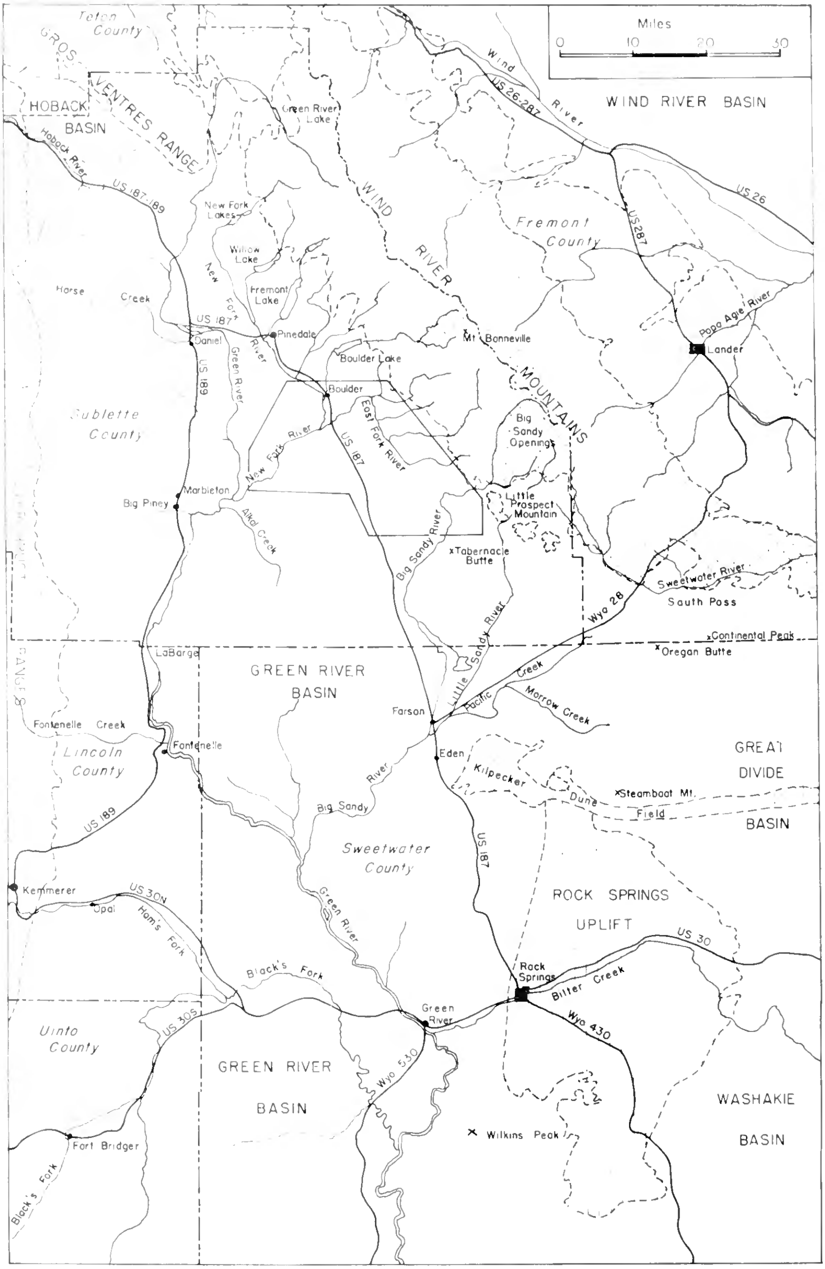


FIG. 1. Index map of southwestern Wyoming. The areas of Tertiary exposure are unshaded, except for the sand dune area, indicated by dots. The areas of pre-Tertiary rocks are represented as follows: crosshatching—Precambrian; horizontal lines—Paleozoic and Mesozoic; vertical lines—Cretaceous only. The New Fork-Big Sandy area is outlined.

Vehicle access to most of the area is good. U. S. 187 bisects the area north-south, Wyoming State Secondary Highway 1801 goes west from U. S. 187 across the southwestern part of the area toward U. S. 189 and Marbleton and Big Piney, and Wyoming State Secondary Highway 1804 is paved for 20 miles east and south of Boulder, almost to the Big Sandy Junction. This then continues south as a graded dirt road, the "Lander Cutoff Road," across the Big Sandy River at Buckskin Crossing. At that point it turns eastward and follows the flank of the mountains to join Wyoming State Highway 28 near South Pass and the Sweetwater River. A western branch goes almost due south from Buckskin Crossing, past Elk Mountain, and meets Wyoming 28 a few miles east of Farson.

In addition to the numbered paved roads and their continuations, there are several primary graded dirt roads, maintained by Sublette County. A fine network of trails permits pickup truck access to most of the New Fork-Big Sandy area.

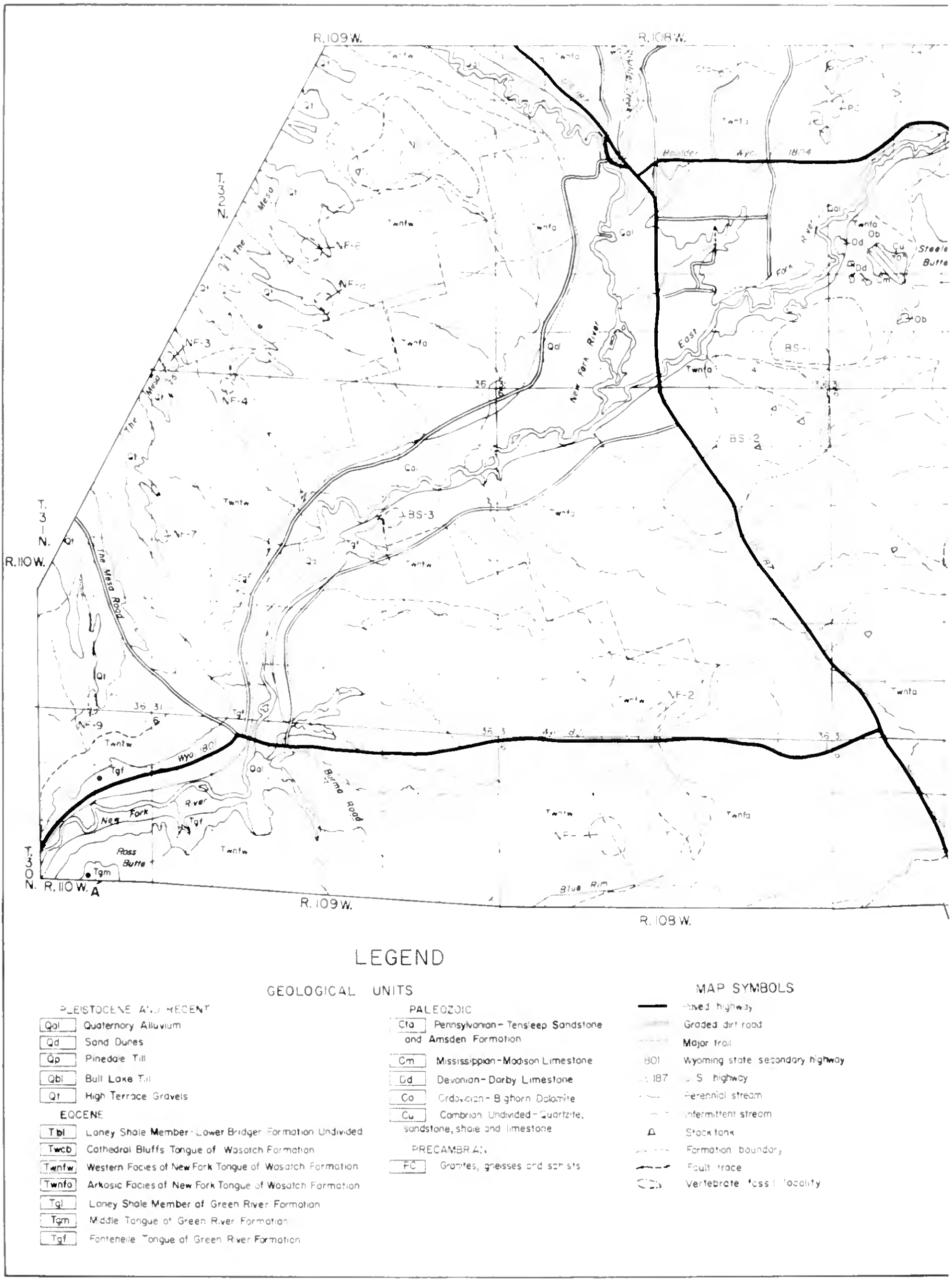
History of Investigation

In June, 1832 John Ball (1835, p. 3), accompanying William Sublette's Rocky Mountain Fur Company supply caravan, wrote of his impressions of entry into the Green River Basin via South Pass:

> Standing on the dividing ridge between the Great Oceans at an elevation . . . of about ten thousand feet, you look down East upon the granite mountains already passed, and then to the N.W. upon the snowy Wind-river mountain, rising probably, five thousand feet above the place where you stand. To the South on the height of the land, stretches an immense prairie as far as the limits of vision, with little variation of surfaces, on which are feeding herds of buffaloes; and far to the West, extends north and south, a range of mountains of apparently great elevation.

He then picked his way northwestward along the flank of the Wind River Mountains among the "granite boulders, which showed conclusively the character of that mountain" (Ball, 1835, p. 3). This is the earliest description of any geological features of the Green River Basin area.

On August 7, 1842, Captain John G. Fremont crossed South Pass and headed northwest. He stopped on the Big Sandy on August 9, noting the "parti-colored sand, exhibited in escarpments fifty to eighty feet high" (Fremont, 1845, p. 61). He camped that evening along the East Fork at the base of what is now called Fremont Butte, spent a week in the high country, returned to the East Fork camp on August 17, and recrossed South Pass on August 19. Fre-


R. 109 W.
R. 108 W.
T. 32 N.
T. 31 N.
R. 110 W.
T. 30 N.
R. 110 W.
A
The Mesa
The Mesa Road
New Fork River
East Fork River
Boulder
Steele Butte
Ross Butte
Blue Rim
Burma Road
NF-3
NF-4
NF-2
NF-9
BS-1
BS-2
BS-3
Qal
Twnfw
Twnfo
Tgf
Tgm
LEGEND
GEOLOGICAL UNITS
PLEISTOCENE AND RECENT
Qal Quaternary Alluvium
Qd Sand Dunes
Qp Pinedale Till
Qbl Bull Lake Till
Qt High Terrace Gravels
EOCENE
Tbl Laney Shale Member - Lower Bridger Formation Undivided
Twcb Cathedral Bluffs Tongue of Wasatch Formation
Twnfw Western Facies of New Fork Tongue of Wasatch Formation
Twnfo Arkosic Facies of New Fork Tongue of Wasatch Formation
Tgl Laney Shale Member of Green River Formation
Tgm Middle Tongue of Green River Formation
Tgf Fontenelle Tongue of Green River Formation
PALEOZOIC
Cta Pennsylvanian - Tensleep Sandstone and Amsden Formation
Cm Mississippian - Madison Limestone
Dd Devonian - Darby Limestone
Co Ordovician - Bighorn Dolomite
Cu Cambrian Undivided - Quartzite, sandstone, shale and limestone
PRECAMBRIAN
PC Granites, gneisses and schists
MAP SYMBOLS
Paved highway
Graded dirt road
Major trail
801 Wyoming state secondary highway
187 U.S. highway
Perennial stream
Intermittent stream
Stock tank
Formation boundary
Fault trace
Vertebrate fossil locality

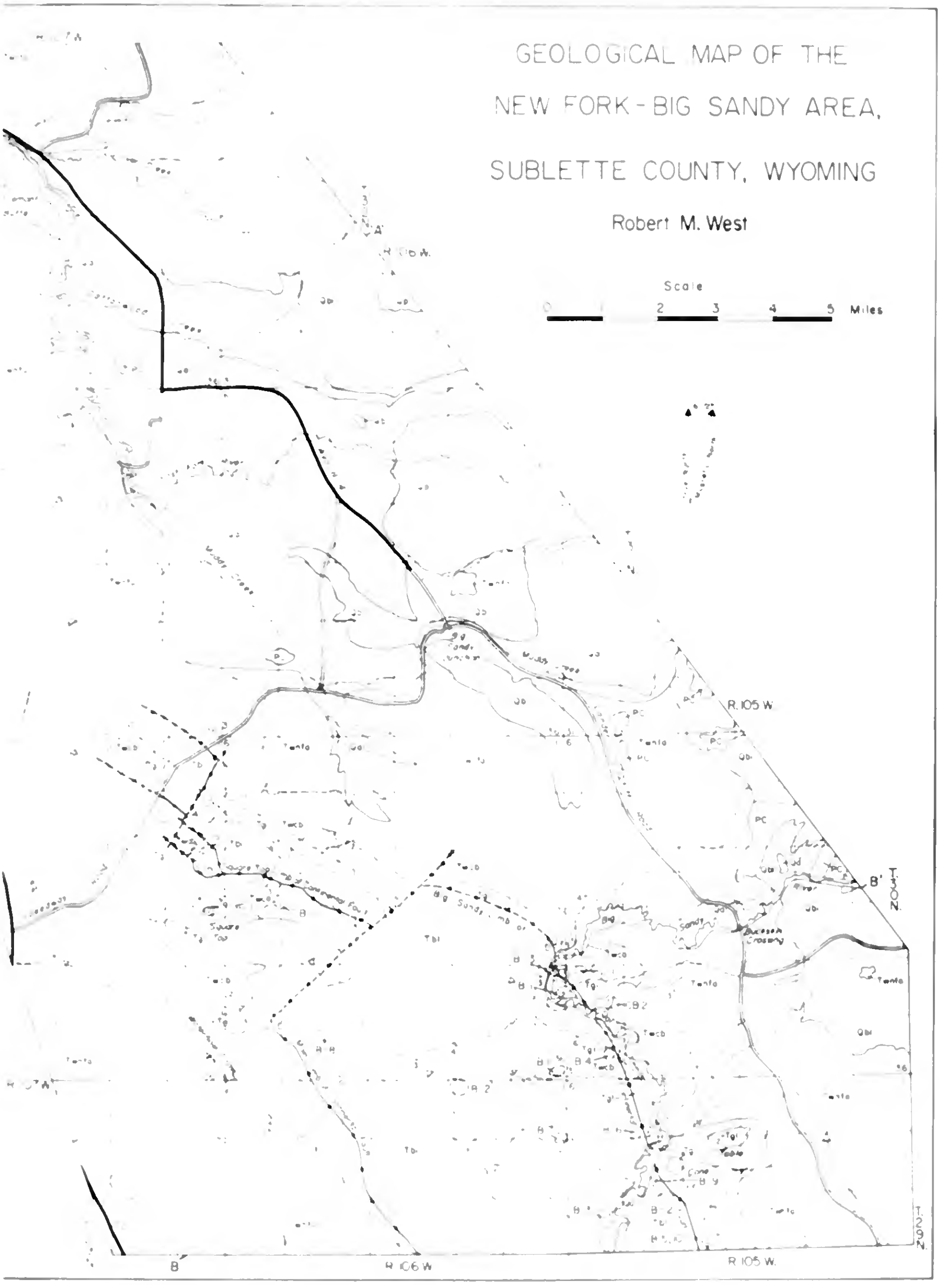


FIG. 2. Geological map of the New Fork-Big Sandy area.

mont observed the geology as well as the flora and fauna, and made special mention of the highly weathered granite in the Fremont Butte vicinity.

Fremont visited the basin again in 1843, travelling to Ft. Bridger. At this time he collected a number of gastropods which were described by James Hall in Fremont's 1845 report.

A number of pre-Civil War surveys were conducted pertaining to the various immigrant trails and resultant wagon roads, but these reports paid no attention to the local geology. A typical one of these is F. W. Lander's 1859 "Preliminary report . . . upon . . . explorations west of the South Pass, for a suitable location for the Fort Kearney, South Pass, and Honey Lake wagon road." During this period scientific work began in the southern part of the basin, especially near Ft. Bridger. The first Green River fossil fish was collected in 1856 by Dr. John Evans and described by Joseph Leidy in 1857.

After the Civil War, both the government and the Union Pacific Railroad encouraged systematic exploration. The territorial surveys, directed by Powell, Hayden and King, produced a wealth of information. Most of the work was focused along the Union Pacific right-of-way, but the Hayden Surveys of 1877–1878 concentrated on the area between latitude 41°45′N and 43°N, which included the northern half of the basin.

Hayden's 1877 survey included the geology of the "Green River Division" by A. C. Peale, and the "Sweetwater Division" by F. M. Endlich. Peale's division covered all but the eastern edge of the Green River basin. He observed the vast amounts of Tertiary sediments in the northern Green River Basin, and established a fine framework for future studies. Endlich barely crossed South Pass, and only briefly visited the areas of the Big and Little Sandy Rivers. E. D. Cope collected vertebrates in conjunction with the southern portion of the Hayden Survey, continuing the legendary feud with O. C. Marsh.

One of the best of the other government surveys was Comstock (1874), which covered the area between Ft. Bridger and South Pass, as well as the eastern side of the Wind River Mountains and the Yellowstone region. Other groups working in the Green River Basin at this time included both Yale and Princeton in the Ft. Bridger vicinity. Cope continued his collecting work after the termination of his connection with the government surveys.

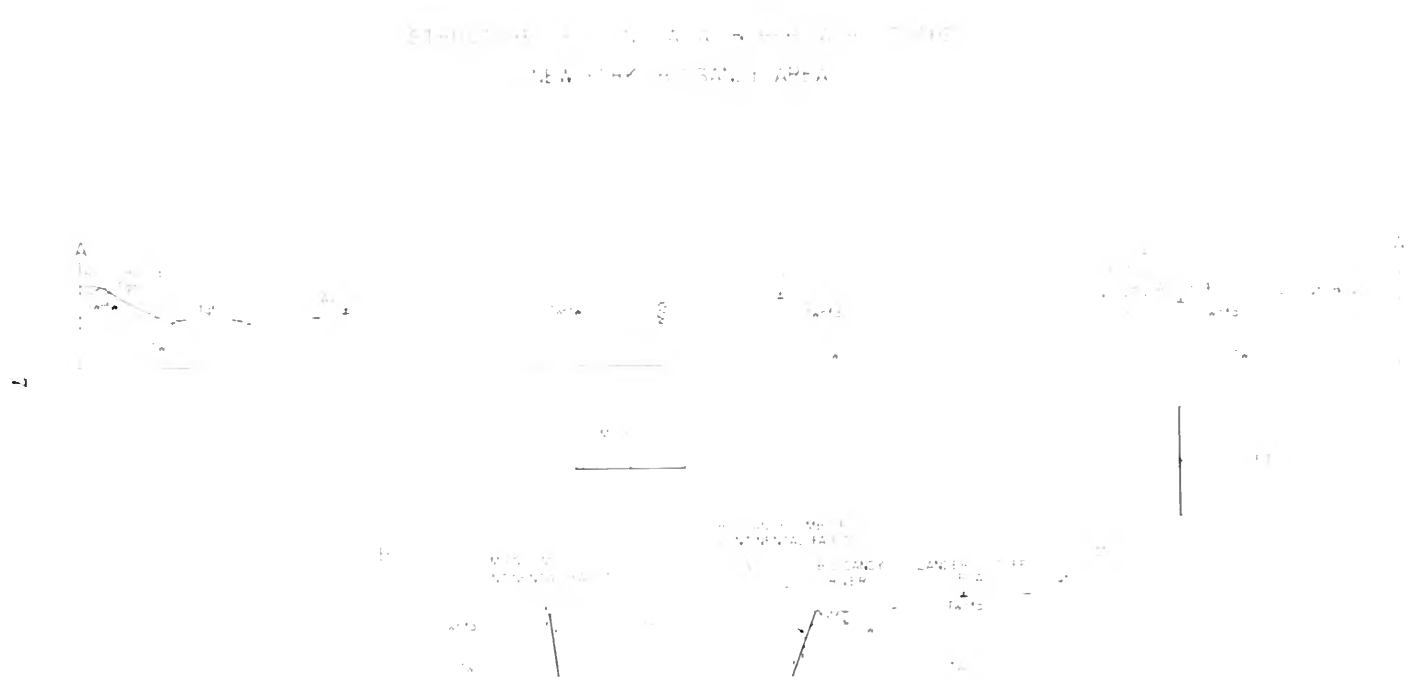


FIG. 3. Structure sections A-A′ and B-B′ across the New Fork-Big Sandy area.

Detailed stratigraphic work commenced shortly after the turn of the century, initiated by A. C. Veatch's fine paper on the Evanston-Kemmerer area in 1907. A. R. Schultz (1914) continued Veatch's work, and also surveyed the Rock Springs Uplift area (1909, 1910, 1920). In the early twenties W. H. Bradley began his long and successful career as a student of the Green River Basin. His 1964 U.S. Geological Survey Professional Paper 494-A brings together his knowledge and experience in the basin and adjacent areas.

More recent work has been concentrated on the establishment of areal stratigraphic relations and paleontologic faunal studies. Work pertinent to the study of the northern part of the basin (fig. 4) began with R. L. Nace (1939) in the Oregon Buttes area near South Pass. This work was carried northwestward by J. R. Berman (1950) at Tabernacle Butte and Elk Mountain and J. M. Hummel (1955) along Pacific Creek. These latter two papers were summarized by P. O. McGrew and others in 1959, with the addition of the description of Bridgerian faunas. In 1964 H. D. Zeller and E. V. Stephens of the U. S. Geological Survey published a series of quadrangle maps covering the area to the south and west of South Pass, and a synthesis of their work appeared in 1969. H. B. Stewart, Jr., of Princeton University, wrote a senior thesis in 1945 dealing with a small area southeast of the New Fork-Big Sandy area, later discussed by Bradley (1964).

To the west, A. J. Bertagnolli mapped in the LaBarge area in 1941. J. H. Donovan worked a large area along the Green River, extending north of Big Piney, in 1950. Both S. S. Oriel and N. C. Privravsky of the U. S. Geological Survey mapped smaller areas in 1963, Oriel at Fort Hill and Privravsky west of Big Piney, and Oriel published on the Fort Hill Quadrangle in 1969.

Until about 20 years ago, paleontologic work was concentrated in the spectacularly productive beds in the southern part of the Green River Basin. C. L. Gazin of the U.S. National Museum opened up the northern end of the basin by discovering two levels of early Eocene fossils along the northwest side of the basin, north as far as 12 miles north of Big Piney (Gazin, 1952, 1962). McGrew et al. (1959) included a report on middle to late Bridgerian faunas from Berman's area at Tabernacle Butte, and M. C. McKenna and G. G. Simpson (1959), Simpson (1959), McKenna, P. Robinson, and D. W. Taylor (1962), and R. M. West and E. G. Atkins (1970) have reported additions to the later fauna.

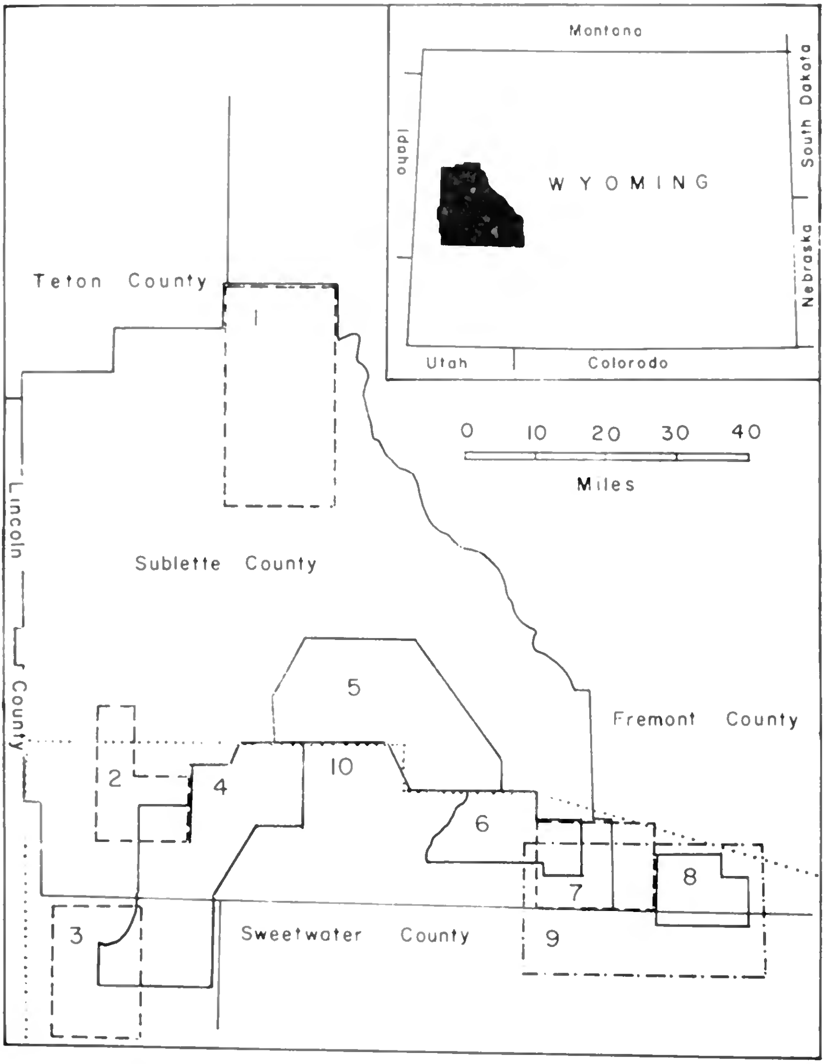


FIG. 4. Mapped portions of the northern Green River Basin. **1**—Richmond, 1945; **2**—Privravsky, 1963; **3**—Oriel, 1963, 1969; **4**—Donovan, 1950; **5**—New Fork-Big Sandy area; **6**—McGrew et al., 1959; **7**—Hummel, 1955; **8**—Nace, 1939; **9**—Zeller and Stephens, 1964; **10**—(dotted line) northern boundary of Bradley, 1964.

To the north, J. A. Dorr, Jr. (1952, 1958) has worked out the detailed stratigraphy of the Hoback Basin, and has studied Eocene mammals from the Pass Peak Formation (Dorr, 1969). Recent work (Steidtmann, 1969) has extended south of the Hoback Rim into the area where the Hoback and Green River Basin units merge. In 1945 G. Richmond mapped a structurally complex area at the northwest end of the Wind River Mountains.

Love (1950) described the Paleozoic units near Boulder, while the stratigraphy and paleontology of the Tertiary rocks within the New Fork-Big Sandy area have been discussed in five preliminary papers by me (West, 1968, 1969a, b, c, 1970).

The paleontological possibilities of the New Fork-Big Sandy areas were first recognized by Dr. Paul O. McGrew in September, 1956 when he found the Fault locality along the Big Sandy River. He visited it several times, but was unable to carry out any systematic exploration of the exposures along the Big Sandy. In 1965 he suggested to me that I use his locality as a starting point in my work.

I visited the area for two weeks in August, 1965, and found intriguing geology and vertebrate fossils. The entire summers of 1966 and 1967 were then devoted to geologic and paleontologic field work in the New Fork-Big Sandy area.

Methodology

The areal geology was mapped initially on U.S. Geological Survey 7½ min. advance proof quadrangle sheets, U.S. Forest Service planimetric maps, and aerial photographs. For the purposes of synthesis, the geology was transferred to a base adapted from the 1967 edition of the Sublette County Highway Map published by the State of Wyoming. Sections were measured by means of a Brunton compass and steel tape.

I found a number of fossil localities (in addition to McGrew's initial find), 25 of which have produced identifiable fossil mammals. All areas of badlands exposures have been investigated, on hands and knees when necessary. In several places I was able to apply the washing technique outlined by Black and Dawson (1966, p. 300). An estimated 24,000 lbs. (dry weight) of sediment was processed through burlap bags during the two full summers of field work.

The rock units present in the New Fork-Big Sandy area were studied in outcrop and hand sample; no petrographic or sieve analyses were conducted. Gross sedimentary structure and texture were noted. This information, along with that obtained from the areal stratigraphic relationships, was applied to the interpretation of depositional environments and sequences.

The fossil material has been identified as well as is possible with fragmental specimens. Direct comparisons were made with material at the U.S. National Museum, Princeton University, the American Museum of Natural History, Yale University, and the Carnegie Museum, as well as Field Museum of Natural History. The materials collected by McGrew during his visits to Fault locality prior to my study were loaned to me for incorporation with my fauna. These are designated by the prefix UW before the catalog number, while my material, deposited at Field Museum, has been given the prefix PM.

Measurements of fossil teeth were made both with dial calipers calibrated to .01 mm. and with an eyepiece micrometer in a binocular dissecting microscope.

Acknowledgements

The three summers in Wyoming were greatly facilitated by travel funds granted by Dr. E. C. Olson and the Committee on Paleozoölogy (Evolutionary Biology) of the University of Chicago. The 1968 trip to the eastern museums was supported by the Hinds Fund of the Division of Biological Sciences. Dr. Olson allowed me use of the Committee on Paleozoölogy pickup truck for the 1966 field season.

Many people in Wyoming aided the field effort, including Mr. and Mrs. John Arambel of Midland Land and Livestock, Rock Springs; Mr. and Mrs. Leonard Priebe of Boulder; and Mr. and Mrs. Perry Binning of Pinedale.

Dr. Steven S. Oriel of the U.S. Geological Survey, Denver; Dr. John A. Dorr, Jr., of the University of Michigan; and Dr. James Steidtmann, now of the University of Wyoming; and I spent several days during the summer of 1967 conferring on common problems of the Green River and Hoback Basins. Dr. W. B. Clapham, Jr., now of Case-Western Reserve University, analyzed a pollen sample, and Dr. William P. MacLean III, now of the College of the Virgin Islands, helped by identifying the lower tetrapod fauna.

During my museum visits I was cordially received and assisted by Drs. C. Lewis Gazin, U.S. National Museum; Glenn L. Jepsen, Princeton University; Malcolm C. McKenna, Frederick S. Szalay, and Giles T. MacIntyre, American Museum of Natural History;

A. W. Crompton, Yale Peabody Museum; and Mary R. Dawson, Carnegie Museum.

Dr. Paul O. McGrew of the University of Wyoming, who initially suggested the project, has offered helpful advice throughout, and visited the New Fork-Big Sandy area in August, 1967. Drs. Leigh Van Valen and Leonard B. Radinsky of the Committee on Evolutionary Biology of the University of Chicago were of great assistance in the overall consideration of early Tertiary faunas. Drs. Ralph G. Johnson and Alfred M. Zeigler, also of the Committee on Evolutionary Biology, offered encouragement and assistance on the technical matters involved in manuscript preparation. My University of Chicago advisor, Dr. Everett C. Olson, now of the University of California, Los Angeles, must be sincerely thanked for his encouragement and help in so many facets of my graduate education at the University of Chicago.

Lastly, I thank my wife, Jean, for her inspiration and patience. She helped with the field work all three summers, and became a competent fossil collector in the process.

The last two years of work on this project were carried out during the tenure of a two-year National Science Foundation Graduate Fellowship.

GENERAL GEOLOGY

The northern Green River Basin is a faulted Laramide downwarp filled by Paleocene and Eocene sediments derived largely from the lithologically variable bounding mountains (see fig. 1). The Overthrust Belt along the western side is made up primarily of Paleozoic and Mesozoic marine sedimentary rocks. To the northeast, the Wind River Mountains are essentially all Precambrian igneous and metamorphic rocks. Far to the north the Gros Ventre Mountains contain both Paleozoic and Mesozoic sedimentary units. Most of the Tertiary sediments exposed in the northern Green River Basin are of Eocene age.

The Eocene sedimentary rocks are of both fluvial and lacustrine origin. The center of the basin is filled with an irregular lens of lacustrine sediment, the Green River Formation, which is bounded beneath and laterally by the fluvial lower Eocene Wasatch Formation and laterally and above by the fluvial middle Eocene Bridger Formation. The Wasatch Formation is represented, in the northern Green River Basin, by the New Fork Tongue and the Cathedral Bluffs Tongue. The older New Fork Tongue is divided, within the New Fork-Big Sandy area, into the arkosic facies along the Wind River Mountains and the western facies farther toward the Overthrust Ranges. The Cathedral Bluffs Tongue overlies the arkosic facies at several localities in the eastern part of the area. Bridger Formation sediments are exposed only in the southeastern part of the New Fork-Big Sandy area, in a graben controlled by the Continental Fault. Three Green River Formation subunits are present: the Fontenelle and middle tongues lie below and above the western facies of the New Fork Tongue in the western part of the area, and the Laney Shale Member interdigitates with and overlies the Cathedral Bluffs Tongue along the Big Sandy River.

Each of these sedimentary units will be discussed in detail below, so no further description is presented here.

Pleistocene glacial deposits obscure much of the earlier material along the flank of the Wind River Mountains, and the modern topography has been strongly affected by glacial runoff.

FIG. 5. Precambrian inlier to the north of Fremont Butte in NW ¼ sec. 7, T. 32 N., R. 107 W.

Pre-Tertiary.—Precambrian and Paleozoic rocks are present in the eastern part of the New Fork-Big Sandy area. No Mesozoic units have been located; their absence is largely structurally controlled.

Many of the Precambrian exposures are inliers surrounded by Eocene and/or Pleistocene sediments (fig. 5). The most prominent is Fremont Butte, 5 miles east of Boulder. Other exposures of Precambrian rocks are near the Big Sandy River. The lack of distortion of the surficial Eocene at these localities indicates that the Precambrian material was thrust into position and eroded to approximately the present configuration prior to late-early Eocene time. In many places this unconformity between the Precambrian and the Eocene cannot be seen because of the heavy Pleistocene debris cover.

The Precambrian within the New Fork-Big Sandy area isgranitic with some separation into gneissic bands. The exposures are too limited for any large-scale trends to be detected, but de Laguna (1938, cited in Holmes and Moss, 1955, p. 632) recognized two zones in the Precambrian between the Big Sandy Openings and Mt. Bonneville.

Fragments of Precambrian rocks occur in the Eocene sediments immediately adjacent to the Wind River Mountains, and are also included in the various Pleistocene deposits along the mountain front.

The Paleozoic inliers in the Boulder vicinity have been studied by J. D. Love (1950, pp. 25–27). The largest Paleozoic exposure is Steele Butte (fig. 6), a prominent knob about 1 mile southwest of Fremont Butte, which includes units of Cambrian, Ordovician, Devonian, and Mississippian age. Four small exposures one-quarter mile west of Steele Butte are at least partly Devonian in age, on the basis of their marine fossil content. Two miles north-northwest of Steele Butte two low hills of Cambrian rocks are close enough to a Precambrian inlier for an approximate contact to be located. Several miles north of Boulder are several small exposures of Pennsylvanian and Permian age.

FIG. 6. Steele Butte viewed from the south. The beds are dipping to the southwest at about 70°. Cambrian sediment is exposed at the right side of the picture, and Mississippian at the left. See Figure 27 for a cross-section of Steele Butte.

Southeast of the New Fork-Big Sandy area along the flank of the Wind River Mountains there are no surface exposures of either Paleozoic or Mesozoic units. To the northwest, the entire Paleozoic section, lacking only the Silurian, and a virtually complete Mesozoic section, is present near the Green River Lakes.

Pleistocene.—A considerable volume of Pleistocene material occupies the eastern part of the New Fork-Big Sandy area. Glacial till surrounds and overlaps some Precambrian knobs and obscures much of the Precambrian-Eocene unconformity.

At least five glacial advances are recorded on the southwestern flank of the Wind River Mountains, remains of two of which are found within the New Fork-Big Sandy area. The oldest advance, the Buffalo, is not present in the area. The next two, the Bull Lake and Pinedale advances, are well documented within the area. The last two advances, the Temple Lake and Little Ice Age, occurred only high in the mountains. Terraces were formed by the meltwater runoff after each of these advances. Holmes and Moss (1955) have related most of these terraces to moraines, especially in the valley of the Big Sandy River.

Of considerable interest are a series of granitic gravel and cobble terrace veneers. A thick layer of this material caps the Mesa, and Holmes and Moss (1955, p. 633) believed that it "antedate(s) the oldest till in the area, but may represent earlier glacial stages." Ross Butte, only 3 miles from the Mesa, has practically no capping cobble veneer. This suggests that the pre-Buffalo advance did not extend as far as Ross Butte. Cobbles also blanket the land surface around and to the west of Square Top. This zone is not flat like the Mesa top, and the cobble layer is only a few feet thick. No physical correlation can be made between these two areas to ascertain any possible temporal relationships.

The oldest till definitely identified within the New Fork-Big Sandy area represents the Bull Lake glacial advance. Bull Lake deposits make up the irregular land surface near the Big Sandy River southeast of Buckskin Crossing, and almost all the hills in the vicinity of Big Sandy Junction. Bull Lake material is distinguished from the younger Pinedale by its more advanced weathering state.

The Pinedale moraine, characteristically irregular and boulder-strewn, is well developed around Boulder Lake north of the New Fork-Big Sandy area, and also in the vicinity of Silver and Cottonwood Creeks. The slight weathering of the Pinedale Till is reflected in the almost total lack of clay minerals.

An area of recognizable sand dunes is located on the north side of the Big Sandy River about 1 mile upstream of Buckskin Crossing. Holmes and Moss reported stabilized sand sheets 1–3 ft. thick along the East Fork River near Boulder. The sand was originally derived from sandy flats on the Bull Lake and Pinedale outwash plains, and accumulated to the leeward (east) as influenced by the prevailing Pleistocene winds. Far to the south, east of Eden, the Kilpecker dune field extends some 60 miles into the Red Desert.

EOCENE STRATIGRAPHY

The classic interpretation of Eocene sedimentation in the Green River Basin is that so well expounded by Bradley (1964), and shown in Figure 7. His basic thesis involves a symmetrical basin; that is, it expanded and contracted in all directions essentially simultaneously and with essentially equal expression. Among the assumptions based on this model is the temporal equivalence of lake-bounding Wasatch Formation units, including the New Fork Tongue and the Cathedral Bluffs Tongue.

In general, Bradley's model fits well the known stratigraphic picture of the Green River Basin. However, in peripheral areas along the margins of the lacustrine Green River Formation sequence this neat picture does not hold true uniformly (fig. 8). Within the New Fork-Big Sandy area it is apparent that the New Fork Tongue and the Cathedral Bluffs Tongue (as here interpreted) of the Wasatch Formation are not temporal equivalents; likewise, lacustrine units such as the Fontenelle Tongue of the Green River Formation are absent in some places. This latter condition reflects, at least in part, the limits of lacustrine expansion, but it also suggests that local situations in various parts of the Green River Basin, such as the New Fork-Big Sandy area, add unexpected complexities to Bradley's reconstruction. Ensuing discussions point out the relationships of the various early and middle Eocene units as they are developed in the northern Green River Basin.

WASATCH FORMATION

The Wasatch Formation is generally considered to include sediments deposited throughout early Eocene time. The type section (Hayden, 1869, p. 90) is a series of conglomeratic exposures in Echo and Weber Canyons, Utah. The name has been, frequently with very little justification, extended to include many early Eocene intermontane basin sediments. Logically the Wasatch Formation should be restricted to the early Eocene sediments of the Green River Basin, the depositional sequence including the type section.

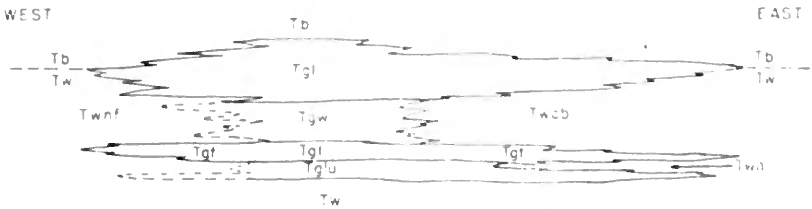


FIG. 7. Bradley's (1964, p. A18, fig. 6) reconstruction of the probable sedimentary relationships of the Green River Formation and the bounding early and middle Eocene fluvial units. Key: Tw—Wasatch Formation; Twn—Niland Tongue of Wasatch Formation; Twcb—Cathedral Bluffs Tongue of Wasatch Formation; Twnf—New Fork Tongue of Wasatch Formation; Tb—Bridger Formation; Tglu—Lumen Tongue of Green River Formation; Tgt—Tipton Shale Member and Tongue of Green River Formation; Tgf—Fontenelle Tongue of Green River Formation; Tgw—Wilkins Peak Member of Green River Formation; Tgl—Laney Shale Member of Green River Formation.

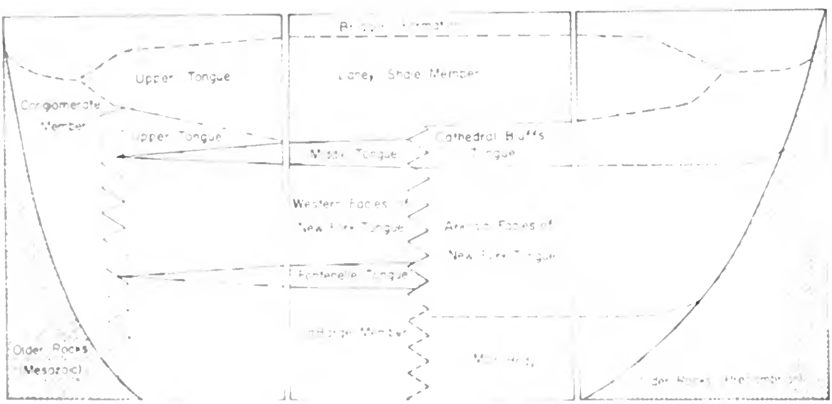


FIG. 8. Digrammatic cross-section of stratigraphic relationships at the northern end of the Green River Basin. The center segment represents the New Fork-Big Sandy area; the left (west) segment is adapted and slightly expanded from Oriel, 1962, p. 2,163; and the right (east) segment is based upon estimates of the probable situation beneath the glacial debris along the flank of the Wind River Mountains. The various units of the Wasatch Formation are indicated by the unshaded areas; the various units of the Green River Formation by horizontal lines; and the Bridger Formation by dots. The older rocks are Mesozoic units of the Wyoming Ranges on the west and the Precambrian core of the Wind River Mountains on the east. Compare the relative developments and positions of the sedimentary units with Bradley's interpretation shown in Figure 7.

Wasatch Formation sediments are usually variegated mudstones, predominantly grayish with variable amounts of red (Bradley, 1964, p. A21). Coals and sandstone lenses are locally important, and conglomerates frequently indicate rapid deposition along the flanks of mountain ranges. The maximum thickness of the unit is in excess of 4,000 ft. (Bradley, 1964, p. A22).

A number of mappable tongues of the upper Wasatch Formation interfinger with the lacustrine Green River Formation. Several of these, as discussed below, occur in the New Fork-Big Sandy area.

New Fork Tongue

Donovan (1950, p. 64) described the New Fork Tongue of the Wasatch Formation as a sequence of variegated clay shales, arkosic conglomerates, and cross-laminated sandstones, with the type area near the confluence of the Green and New Fork Rivers. Bradley (1964, p. A27) extended Donovan's New Fork Tongue 80 miles farther southwest, and Oriel (1961, p. 107) included some fluvial beds in the New Fork Tongue which Donovan had originally placed in the Fontenelle Tongue of the Green River Formation. This study extends the exposure area of the New Fork Tongue into the northeastern part of the Green River Basin, along the flank of the Wind River Mountains.

Arkosic Facies

The informal term "arkosic facies of the New Fork Tongue" is introduced here to designate a thick sequence of multi-colored sandy mudstones along the western flank of the Wind River Mountains. A typical exposure of this sequence is on the south bank of the Big Sandy River in the center of sec. 21, T. 30 N., R. 105 W., where 175 ft. of sediment are present in a high face. These sediments are referred to simply as Wasatch Formation on the 1955 Geologic Map of Wyoming, as well as by Love (1950). Nace (1939, p. 17) regarded these banded mudstones as the Cathedral Bluffs Tongue of the Wasatch Formation. McGrew et al. (1959) called them Wasatch Formation, although Berman (1950) considered the possibility of the upper portion belonging to the Cathedral Bluffs Tongue. The present study has led to the conclusion that the variegated beds are older than the Cathedral Bluffs Tongue, and are assigned an informal name for the purposes of reference and correlation.

Exposures.—The arkosic facies of the New Fork Tongue is the lowermost Wasatch unit exposed in the New Fork-Big Sandy area,

FIG. 9. Arkosic facies of the New Fork Tongue of the Wasatch Formation exposed along the East Fork River in SW 1/4 sec. 11, T. 31 N., R. 107 W. Note the irregular color bandings.

and is by far the most extensive. Excellent exposures of this unit are present in stream cuts along the Big Sandy and East Fork Rivers, and on a long slope south of the East Fork near U.S. 187.

The total thickness of the arkosic facies is unknown, as the surface exposures are only a part of the total thickness. About 175 ft. of exposed arkosic facies have been measured along the Big Sandy, and approximately 300 ft. are exposed on the slope south of the East Fork River. McGrew et al. (1959, p. 128) estimated a total exposed Wasatch Formation (largely the arkosic facies of this paper) thickness of several hundred feet in the Tabernacle Butte area. Five-thousand-seven-hundred-forty feet of Wasatch Formation sediments were penetrated above the Paleocene Fort Union Formation by the 1949 Pacific Creek Deep Test, Superior Oil Co. No. 1 Unit, sec. 27, T. 27 N., R. 103 W. (Jenkins, 1955a, pp. 153–154), although the lower portion of this well passed through materials beneath the arkosic facies.

Lithologies.—The arkosic facies of the New Fork Tongue is primarily a sandy mudstone colored in shades of green, gray, red, brown, purple, yellow, and tan, generally more vivid than the colors of the western facies. A considerable amount of mottling, especially the appearance of greenish blebs in red, purple, and gray sediments, is probably due to reduction by vegetable matter. The colors are displayed in laterally discontinuous horizontal bands (fig. 9) several inches to tens of feet thick. The hand sample texture of the banded sediments ranges from relatively pure siltstone to coarse conglomerate, with particles ranging in size up to several millimeters in diameter. Few levels are calcareous to any extent.

The sandy mudstones are generally poorly sorted, with the larger particles of quartz and feldspar haphazardly distributed throughout. These large particles vary from quite angular to rounded. None of the sandy mudstones show any lamination. The more pure sandstones are generally gray to tan, composed primarily of quartz with feldspar and mica less common. The sandstones break in a platy fashion and some of the more indurated levels show cross-stratification and graded bedding. Calcareous cements are present in some of the sandstone levels.

Conglomerates in the arkosic facies are indurated to varying degrees. The cement is sometimes calcareous, but other times is simply fine siliceous sand. Although some conglomerates occur very close to the exposed Precambrian, no lithology approaches that of the diamictite facies of the western side of the basin (Tracey et al., 1961, pp. 149–150) or the heavy conglomerate on the north side of the Uinta Mountains.

Several granular limestones, suggestive of ponds and sloughs, are present. They contain particles of quartz and calcite in a calcareous matrix and occur irregularly in the arkosic facies.

Relationships.—In the southern part of the New Fork-Big Sandy area the top of the arkosic facies can be located at a moderately abrupt change from variegated, banded sandy mudstones to the drab green and brown sandy mudstones of the overlying Cathedral Bluffs Tongue. The contact is readily apparent near the big bend in the Sandy River (SW 1/4 T. 30 N., R. 105 W.), while it is less clear in the Square Top region. Outcrops of the Cathedral Bluffs Tongue are limited, so the contact can be observed only locally.

The basal relationships are less clear, since the bottom of the arkosic facies is presently undefined. Below it is a fluvial unit which can be called either the LaBarge Member or the Main Body of the Wasatch Formation. Main Body is used here, with the suggestion that is probably synchronous with the LaBarge Member, although derived from a different source area. Hummel (1955) used the term Main Body in reference to the entire undifferentiated Wasatch Formation in the Pacific Creek area, part of which is equivalent to the arkosic facies.

The arkosic facies probably lies conformably over the unexposed Main Body in the New Fork-Big Sandy area. Berg (1961, p. 78) indicated complete conformity through the Eocene, but he worked on too gross a scale to recognize small unconformities. The arkosic facies is unconformable against the Precambrian, as may be seen at Little Prospect Mountain in sec. 32, T. 30 N., R. 105 W., and at Fremont Butte. Horizontal beds of the arkosic facies meet the steeply dipping Paleozoics of Steele Butte and associated knobs (secs. 19, 20, 29, and 30, T. 32 N., R. 105 W.) as well.

The arkosic facies merges laterally westward with both the Fontenelle Tongue of the Green River Formation and the western facies of the New Fork Tongue. These facies changes are often hard to locate because of the scattered outcrops and great deal of interfingering between these units. One wedge of the arkosic facies, characterized by its color and coarseness, can be traced westward within the western facies along the Blue Rim almost to Ross Butte.

Paleontology.— The arkosic facies produces vertebrate fossils indicative of the early Eocene Lost Cabin faunal zone, with perissodactyls and condylarths most abundant. The comparatively small proportion of small mammals is probably a collecting artifact. Fish and aquatic reptiles indicate the presence of aquatic zones.

WESTERN FACIES

Exposures.—The Mesa, bounded by the Green River valley on the west and the New Fork River valley on the south and east, is composed entirely of western facies sediments with a thin veneer of later material on top. Exposures at Ross Butte, Ross Ridge, and the Blue Rim, in the southwestern corner of the New Fork-Big Sandy area, are continuous with the type locality of the New Fork Tongue.

The top of the western facies is present only at Ross Butte where it is approximately 340 ft. thick. Near the Burma Road, the western facies is about 370 ft. thick, and is split near the top by a 94 ft. thick westward wedge of arkosic facies sediment. At the very northern edge of the New Fork-Big Sandy area, in sec. 2, T. 32 N., R. 109

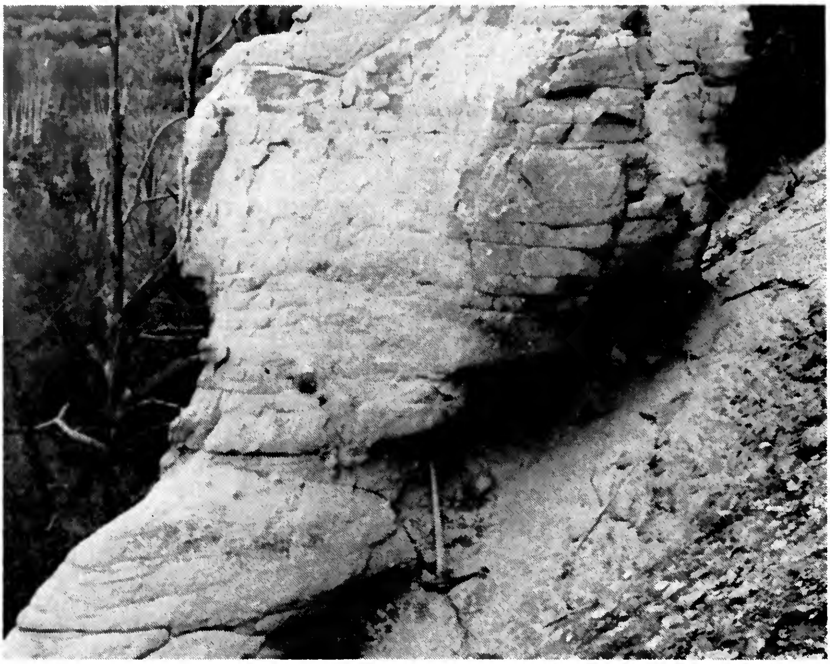


FIG. 10. Outcrop of fine yellow sandstone on the bluff overlooking the New Fork River in sec. 1, T. 32 N., R. 109 W., northwest of Boulder. Note the development of syngenetic concretions.

W., 410 ft. of western facies sediment are present. In the valley of the New Fork River, the basal blue sandy mudstone of the western facies stands out against the massive buff sandstone of the upper Fontenelle Tongue of the Green River Formation.

Lithologies.—Much of the western facies sediment is fluvial sandy mudstone, but in outcrop and hand sample there appears to be more sandy material than in the arkosic facies or the Cathedral Bluffs Tongue. This greater proportion of sand in the western facies may indicate a marginal lacustrine environment, in contrast to the largely subaerial deposition of the arkosic facies. The western facies is more uniform in grain size than the arkosic facies, and may be further distinguished by its more pastel coloration.

Sands and sandstones range from conglomeratic to very fine, grading into siltstones. Coarse sandstone is present on the northeastern part of the Mesa, where there are excellent exposures of river channel deposits interbedded with massive fine-grained yellow sandstone (fig. 10). Syngenetic concretions of very hard sandstone are scattered throughout, as are zones of coarse sandstone with included organic debris and angular blocks of siltstone. The yellow sandstone is composed of quartz, biotite mica, and feldspar and varies considerably in $CaCO_3$ content. The finer sandstone often shows foreset beds, while the coarser material lacks orientation. Two miles to the west of the New Fork River the higher coarse sandstone has strongly developed foresets which indicate varying directions of generally southward flow, and suggest development of a braided or meandering regime in the stream. Hand samples of this sandstone contain ferromagnesian minerals as well as quartz and a small amount of feldspar, suggestive of a contribution from the north and east to this part of the New Fork Tongue. Interbedded with the lenticular yellow sandstones of this sequence are zones of green to gray-brown mudstones, often quite calcareous.

Above and lateral to the heavy yellow sandstones are gray and brown fine-grained mudstones and siltstones, distinctive in their whitish weathering. These are bedded, and some levels are shaley.

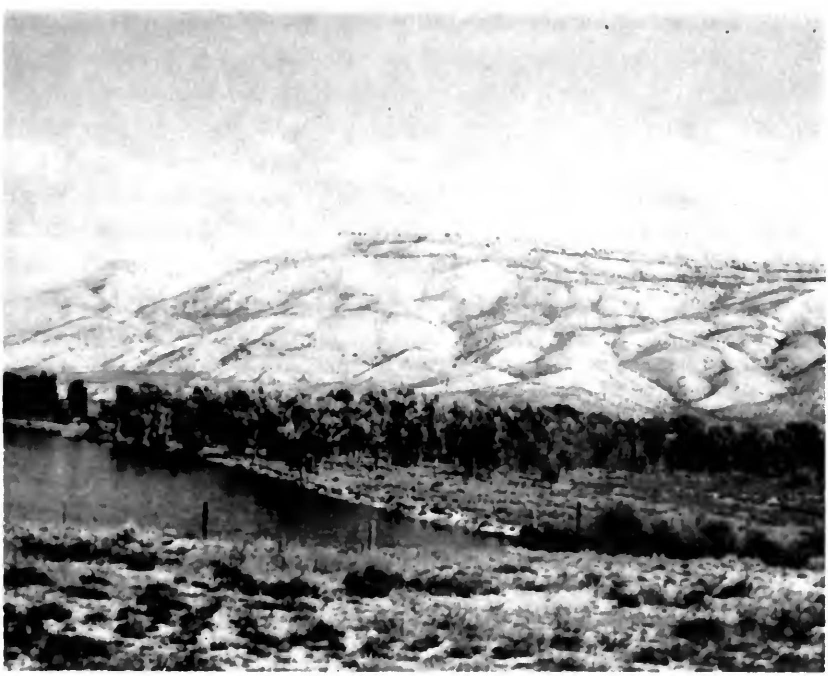


FIG. 11. Exposures of the New Fork Tongue of the Wasatch Formation on the north side of Ross Butte. The New Fork River is in the foreground. Ross Butte is capped by the middle tongue of the Green River Formation.

They have little feldspar, much quartz and mica, and some undetermined ferromagnesians. At the western edge of the Mesa almost the entire western facies is composed of gray-weathering sandy mudstones and siltstones. Irregular red zones appear there and are more common southward and westward.

Elsewhere within the New Fork-Big Sandy area the sandstones of the western facies of the New Fork Tongue are fine-grained and seem low in feldspar. The relative amounts of quartz and micas vary, and other ferromagnesians and carbonates are present. Most of these finer sandstones are calcareous and the particles are reasonably rounded. They tend to be laterally extensive beds rather than lenticular channels.

The New Fork Tongue mudstones and siltstones at Ross Butte (fig. 11) and to the south and east along Ross Ridge and the west end of Blue Rim are various shades of red, purple, and green and are commonly fine-grained. A good example of this material can be seen in the Alkali Draw vicinity (SW $\frac{1}{4}$ T. 30 N., R. 109 W.). Along the Blue Rim this fine-grained siltstone and sand can be seen to merge laterally with sandy mudstones of the arkosic facies.

Relationships.—The western facies of the New Fork Tongue of the Wasatch Formation is overlain by the Middle Tongue of the Green River Formation, and, in turn, overlies the Fontenelle Tongue of the Green River Formation. Westward these two lacustrine units wedge out, and the western facies becomes a part of the thick lateral fluvial sequence (fig. 8).

The western facies merges eastward into the more vividly colored, coarser arkosic facies of the Wasatch Formation. The Blue Rim area shows this intertonguing and facies change quite well. Along the eastern edge of the Mesa the transition is somewhat obscured by the large sandstone deposit and the New Fork River valley. The stream probably drained into the expanded Lake Gosiute while the Fontenelle Tongue was being deposited during early New Fork Tongue deposition, and later on into the more restricted lake of the Wilkins Peak and Middle Tongue stage. The yellow sandstone deposit suggests a lakeward delta, the southern end of which is no longer present.

Paleontology.—Vertebrate fossils are common in a number of localities in the western facies of the New Fork Tongue within the New Fork-Big Sandy area. These fossils are useful in the determination of the stratigraphic placement of the western facies. The fauna is suggestive of a rather well-vegetated area, with abundant large browsing animals present. In most respects this fauna is similar to the assemblages recovered from the temporally equivalent arkosic facies.

Cathedral Bluffs Tongue

A. R. Schultz in 1920 (p. 28) designated a red and green claystone sequence along the Laney Rim on the north side of the Washakie Basin (approximately T. 19 N., R. 95, 96 W.) as the type area for the "Cathedral Bluffs redbed member of the Green River Formation." Sears and Bradley moved the Cathedral Bluffs Member to the Wasatch Formation in 1924 (pp. 98–99), and it since has been extended geographically (Nace, 1939; Pipiringos, 1962; West, 1969b, c). A more detailed discussion of the Cathedral Bluffs Tongue may be found in West, 1969c.

Exposures.—Sediment assignable to the Cathedral Bluffs Tongue of the Wasatch Formation appears in the southeastern portion of the New Fork-Big Sandy area. The best exposures are along the Big Sandy River east of the Big Sandy Limb of the Continental Fault, and in the Square Top area, where it is present south and west of the Square Top Limb of the Continental Fault.

Complete sections of the Cathedral Bluffs Tongue are present at several locations within the area. On the north flank of Table the Cathedral Bluffs Tongue has been measured at 60.5 ft. in thickness. It is between 106 and 125 ft. thick along the Big Sandy upstream of the Big Sandy Limb of the Continental Fault, and is 65 ft. thick just east of Square Top.

The maximum development of the Cathedral Bluffs Tongue is in the Washakie Basin, near the type area, where it is 1,200 to 1,500 ft. thick (Schultz, 1920, p. 29), 1,750 ft. thick along the Kinney Rim in northern Colorado (Nightingdale, 1930, p. 1,021), and 2,340 ft. thick based on subsurface data from sec. 35, T. 15 N., R. 99 W. (Love, 1964, pl. 1).

Lithologies.—Cathedral Bluffs Tongue sediments within the New Fork-Big Sandy area, with few exceptions, are drab and uniform. Most of the sediment is poorly sorted, poorly cemented gray-green to brown sandy mudstone. In hand sample the large particles appear to be primarily quartz, with feldspar, biotite mica, and a very small amount of muscovite mica present. The fine-grained matrix is often calcareous, in contrast to the underlying arkosic

FIG. 12. Green fossil locality, in an intraformational mudstone conglomerate deposit in the Cathedral Bluffs Tongue of the Wasatch Formation near the Square Top Limb of the Continental Fault. The truck is parked near the small area which has produced vertebrate fossil material. The lighter-colored outcrop areas are zones of blue-white tuffaceous mudstone.

facies. Figure 12 illustrates the usual outcrop appearance of the Cathedral Bluffs Tongue.

Some levels are made up of intraformational mudstone conglomerate, composed of somewhat calcareous, laminated siltstone held together by less calcareous, coarser mudstone. This reflects water activity followed by redeposition of the disrupted material.

The lack of bright coloration of the mudstone is probably due in large part to the environment of deposition, as this drab material was probably deposited in paludal or stagnant backwater situations. The backwater provided a reducing environment rather than the oxidizing environment required for the development of the bright colors.

Coarser beds appear as both extensive layers and lenticular channel deposits. The poorly cemented sandy beds, dull gray-green to white in color, are composed mainly of quartz and feldspar. The particles are larger than the large grains in the sandy mudstones and somewhat less rounded. These beds also vary in the amount of $CaCO_3$ present. The arkosic channels are well cemented and quite calcareous. The smaller sand-sized grains are often subangular, while the larger pebbles are quite rounded. These pebbles frequently are composed of granitic materials, and several samples contain some pink rhyolite. The rhyolite, along with the occasional glass sherds seen in the Cathedral Bluffs Tongue mudstones, probably originated in acidic igneous activity to the north, while the other materials were derived from the Wind River Mountains.

Tuffaceous sandstones and siltstones crop out at Green locality in SW ¼ sec. 17, T. 30 N., R. 106 W. The tuffaceous siltstone is white and has little coarse material with recognizable particles of biotite and glass sherds. The sandy tuff includes sand-sized particles of mica, rhyolite, and spicular glass sherds in addition to the normal products of fluvial deposition.

The overall nature of the Cathedral Bluffs Tongue in the New Fork-Big Sandy area is considerably different from other recognized and described Cathedral Bluffs localities (West, 1969c, pp. 190–194). In its type area in the Washakie Basin the Cathedral Bluffs consists of "red or vari-colored conglomeratic sandstone, shale, and clay" (Schultz, 1920, p. 281). This variegated nature of the Cathedral Bluffs Tongue extends north of the Washakie Basin through the Great Divide Basin to the southeastern end of the Wind River Range as described by Hummel in 1957, although he did not differentiate the Cathedral Bluffs Tongue from the Main Body of the Wasatch Formation. Excellent exposures of this facies of the Cathedral Bluffs Tongue are located along Wyoming Highway 28 in the southwestern corner of Fremont County in T. 27 N., R. 102 W.

The brilliantly colored Cathedral Bluffs Tongue changes to drab gray-green to brown sandy mudstone northwestward from the Great Divide Basin. At Bush Rim (SE ¼ T. 25 N., R. 102 W.) the Cathedral Bluffs Tongue is mostly brightly variegated with some drab levels high in the section. Westward toward Rock Cabin Creek (W ¼ T. 25 N., R. 102 W.) the upper Cathedral Bluffs Tongue becomes progressively more drab and the lower variegated portion thins abruptly. Northward into the Tabernacle Butte area the lower variegated portion disappears entirely, leaving only drab sediment in the Cathedral Bluffs Tongue. Unfortunately, outcrops are not continuous across this interval, so this correlation is based upon infrequent observations of poor exposures. McGrew et al. (1959, p.

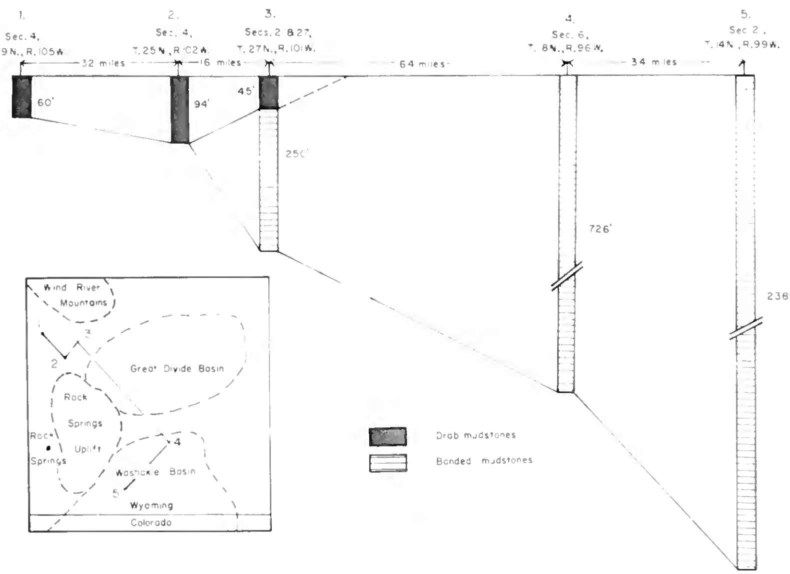


FIG. 13. Fence diagram illustrating the areal changes in the nature of the Cathedral Bluffs Tongue of the Wasatch Formation between the Washakie Basin and the New Fork-Big Sandy area.

Section 1—Surface section in the New Fork-Big Sandy area;
Section 2—Surface section, Bradley, 1926, p. 131;
Section 3—Surface section, Nace, 1939;
Section 4—Laney Rim surface section, Love, 1964, pl. 1;
Section 5—Cabot Carbon and Continental Oil Cos.,
Cathedral Reservoir Unit 1, Love, 1964, pl. 1.

128) noted the presence of drab sediments of Cathedral Bluffs affinities, as their Morrow Creek (Laney Shale Member) north of Tabernacle Butte "changes rapidly to green and gray, arkosic, tuffaceous clay, containing lenses of sandstone and arkose." Figure 13 illustrates the variation in the Cathedral Bluffs Tongue from the Washakie Basin to the New Fork-Big Sandy area.

In 1964 Bradley mapped all this surface fluvial material between Bush Rim and the northern edge of his map (south of the New Fork-Big Sandy area) as the Main Body of the Wasatch Formation. It is shown here that at least the upper part of this can be separated as a facies of the Cathedral Bluffs Tongue of the Wasatch Formation.

Relationships.—The Cathedral Bluffs Tongue lies conformably over the arkosic facies of the New Fork Tongue wherever the contact can be seen within the New Fork-Big Sandy area. The distinction between the units is quite apparent due to the difference in coloration and the increase in volcanic material indicated by rhyolite pebbles and glass sherds seen in hand sample in the Cathedral Bluffs Tongue. Laterally the Cathedral Bluffs Tongue probably interfingers with the Middle Tongue of the Green River Formation, although this contact is not present within the New Fork-Big Sandy area. In 1926 Bradley noted variegated Cathedral Bluffs Tongue in S $\frac{1}{2}$ T. 24 N., R. 104 W. merging into what is now called Wilkins Peak Member. It is overlain by and interfingers with the Laney Shale Member of the Green River Formation as the upper portion of the Cathedral Bluffs Tongue is contemporaneous with the last Lake Gosiute expansion. These relationships indicate that within the New Fork-Big Sandy area the Cathedral Bluffs Tongue is stratigraphically higher than both facies of the New Fork Tongue.

Supporting evidence for this relationship of the Cathedral Bluffs Tongue and the New Fork Tongue is present elsewhere in the Green River Basin. W. C. Culbertson (1966, p. 79) stated:

> . . . the New Fork Tongue of the Eocene Wasatch Formation in the northwestern part of the Green River Basin in Lincoln County is neither a rock-stratigraphic nor a time equivalent of the Cathedral Bluffs Tongue of the Wasatch in the Great Divide and Washakie Basins. The New Fork Tongue . . . can be traced basinward into . . . the middle of the lacustrine Tipton Shale Member of the Green River Formation. The Cathedral Bluffs Tongue is the fluviatile equivalent of the upper three-fourths of the predominantly lacustrine Wilkins Peak Member of the Green River Formation.

The paleontologic evidence for non-contemporaneity of the New Fork Tongue and the Cathedral Bluffs Tongue within the New Fork-Big Sandy area is strong. The mammalian fauna found in the western facies of the New Fork Tongue includes such typical late Wasatchian Lost Cabin genera as *Lambdotherium*, *Hyracotherium*, and *Meniscotherium*. These genera are also found in the arkosic facies with the addition of *Coryphodon*, another late Wasatchian genus. The Cathedral Bluffs Tongue in the New Fork-Big Sandy area has produced genera most closely allied to the middle Eocene Bridgerian faunas, including *Orohippus*, *Sciuravus*, and *Hyopsodus minusculus*. This faunal difference indicates a temporal gap between the times of deposition of the New Fork and Cathedral Bluffs Tongues in the northern Green River Basin. On the other hand, Gazin (1965a) believed that the fauna from the Washakie Basin Cathedral Bluffs Tongue indicates a late Wasatchian age. This particular matter is discussed later in this paper, under the heading "Faunal Correlations."

The independence of these two units lithologically, temporally, and faunally affirms the validity of both names. Some workers (Lawrence, 1963; Textoris, 1963; Stuart, 1965) have stated that the units were identical and that one name or the other was superfluous and should be eliminated. Both the Cathedral Bluffs Tongue and the New Fork Tongue of the Wasatch Formation must be retained as valid stratigraphic terms.

Paleontology.—Prior to this study no vertebrate fossil localities had been reported from the Cathedral Bluffs Tongue in the Green River Basin proper. I found two vertebrate localities, one of which has produced a small mammalian fauna of early Bridgerian temporal affinities. The second locality has yielded only a single tooth which can be tentatively identified. Several small collections, to be discussed below, have been made from Cathedral Bluffs Tongue sediments in both the Great Divide and Washakie Basins.

Bridger Formation

F. V. Hayden named the Bridger Formation in 1873 for middle and upper(?) Eocene exposures in the central part of the southern Green River Basin. Outliers of Bridger Formation have since been found in the northern Green River Basin (Nace, 1939; McGrew et al., 1959) and beds of late Bridgerian age are well known in the Washakie Basin. The Bridger Formation is now considered to be restricted to middle Eocene deposits in the Green River Basin.

Bridger sediments include, in addition to clastics, a considerable amount of pyroclastic material, indicating the increasing amount of vulcanism in the mountains in middle Eocene. The clastic units of the Bridger Formation are generally similar to those of the Wasatch Formation, although a number of extensive, thin limestone and marlstone units support resistant benches and serve as extremely useful stratigraphic marker units.

Upper Laney Shale Member of the Green River Formation and Lower Bridger Formation Combined

The Bridger Formation is the highest pre-Pleistocene unit present in the New Fork-Big Sandy area. The upper part of the Laney Shale Member of the Green River Formation is here included with the basal Bridger Formation, as they represent continuous sedimentation with little, if any, definable separation. This combined level will be referred to as the "lower Bridger Formation."

Exposures.—The lower Bridger Formation outcrop pattern is structurally controlled as movement along the Continental Fault brought the lower Bridger Formation sediments into their present relationship with the lower Eocene units. No lower Bridger Formation material is present in the northern and western two-thirds of the area, away from the fault system.

The total original thickness of the Bridger Formation is not known. The maximum measured thickness is about 2,285 ft. near Lonetree, Wyoming (Bradley, 1964, p. 53), but this exposure is truncated by the younger Bishop Conglomerate and the original top is not present. The Bridger thins northward. On the east side of Oregon Butte (W 1/2 sec. 2, T 26 N., R. 101 W.) Nace (1939, pp. 37-39) measured 755.5-763.5 ft. of upper and lower Bridger Formation combined. In the Tabernacle Butte area (McGrew et al., 1959, p. 128) 357 ft. of upper Bridger Formation sediment is present. About 300 ft. of lower Bridger Formation is exposed in the New Fork-Big Sandy area, giving a total of more than 650 ft. of Bridger Formation sediment in the northern Green River Basin.

Lithologies.—The lower Bridger Formation is variable within the New Fork-Big Sandy area. This range of lithologies indicates a large amount of local environmental variation.

Conglomeratic lenses, remnants of wandering stream channels, are relatively common. Resistant sandstones are plainly visible as elevations, while others occur as lenses or irregular beds in dissected areas and stream cuts. Most are not calcareous, or only slightly so, and are composed almost entirely of quartz with variable amounts of feldspar and little biotite mica or other ferromagnesians. Little evidence of current action is apparent, as few of these deposits display current cross-bedding, graded bedding, or well-developed laminations.

The finer clastic sediments make up the bulk of the lower Bridger Formation in the New Fork-Big Sandy area (fig. 14). The colors tend to be more pastel than those of the fluvial Wasatchian sediment. Buff and brown are the most common colors and the overall range is from white to gray, green, and pink. The materials recognizable in hand sample are crystalline quartz, orthoclase feldspar, and mica, as well as particles of rhyolite and other acidic volcanics. The darker levels contain a greater proportion of ferromagnesian minerals, especially biotite mica and hornblende. There is little evidence of current action.

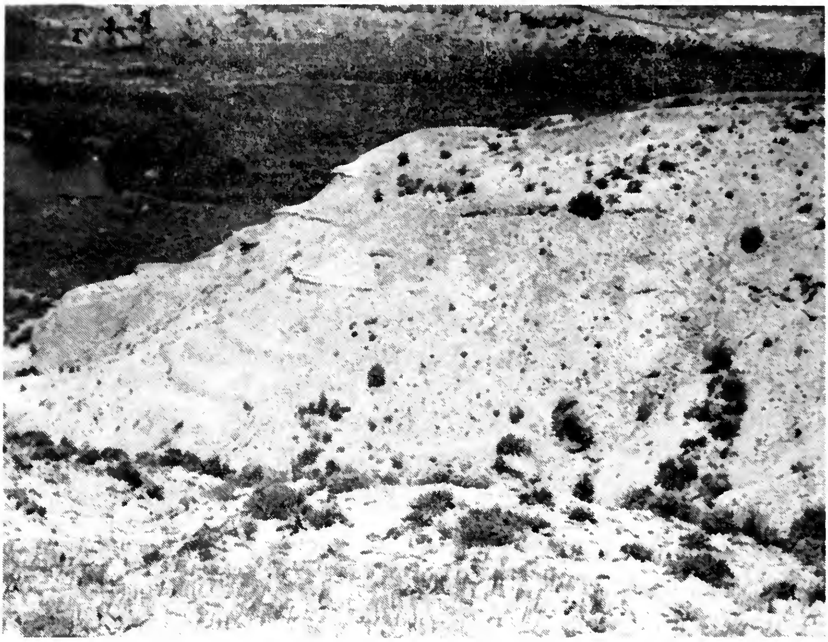


FIG. 14. Typical exposure of the lower Bridger Formation along the Big Sandy River. The ledges are more calcareous and more resistant than the interbedded mudstone.

Gray-green to brown sandy mudstones and intraformational mudstone conglomerate are abundant. Most of this sediment is blocky to rubbly in appearance, but some levels are almost shaley. The amount of calcium carbonate varies without apparent pattern. Recognizable grains in hand sample include quartz, biotite, and muscovite mica, ferromagnesians, rhyolite, granite fragments, and sherds of volcanic glass. The abundance of volcanic derivatives is indicated by the presence of bentonite, detected by its characteristic hygroscopic action.

Dense buff to dark gray siltstone makes up the remainder of the clastic sediments. These contain virtually no particles identifiable in hand sample, and vary considerably in the degree of calcareousness. Many are laminated, and some are almost fissile.

Some tuffs are present, marked by their light blue-white weathering. Plant impressions were found in a tuff bed in the NW 1/4 sec. 4, T. 29 N., R. 106 W. The lower Bridger Formation continues the trend established in the underlying Laney Shale Member of the Green River Formation and becomes more tuffaceous upward.

Calcium carbonate is present in the form of crystal veins. Such veins are common at Hawk locality (SW 1/4, NE 1/4 sec. 18, T. 29 N., R. 106 W.), while wider veins with poorly formed geodes of crystalline calcite occur in NE 1/4 sec. 31, T. 30 N., R. 106 W. Crystals derived from weathered calcite geodes occur in the Fish Hill area (SW 1/4 sec. 5, T. 29 N., R. 105 W.). Gypsum crystals have been found in NW 1/4 sec. 4, T. 29 N., R. 106 W., possibly indicating some aridity and evaporation of sulfate-rich lake and pond waters.

The last expansion of Lake Gosiute, represented by the Laney Shale Member of the Green River Formation, did not terminate abruptly, but ended slowly under various conditions at various places. Lacustrine sedimentation gradually gave way to more subaerial deposition in the Bridger Formation.

At the same time as the lacustrine condition was disappearing, a greater amount of airborn pyroclastic debris came in from nearby active volcanic areas, probably the Yellowstone-Absaroka Plateau of northwestern Wyoming (Love, 1939, pp. 109-110). Thus, with time, the Bridger Formation fluvial deposits came to be dominated by pyroclastics. Such deposits are well exposed on the flanks of Tabernacle Butte south of the study area.

Relationships.—Although the sediment here assigned to the lower Bridger Formation is geographically isolated from the type region of the Bridger Formation, it is lithologically and faunally similar. The New Fork-Big Sandy area lower Bridger Formation is stratigraphically below the upper Bridger Formation described by McGrew et al. (1959) in the Tabernacle Butte area, and conformably overlies the Laney Shale Member of the Green River Formation within the New Fork-Big Sandy area. The composition of the included fauna also indicates a younger age than that of the Wasatchian units.

The lower Bridger Formation exposure area is bounded almost everywhere by branches of the Continental Fault system. The dips within this downdropped block are mostly to the west and southwest, although areas near the fault zones show fault-distorted dips which reflect the relative movement of the sediments. The stratigraphically highest lower Bridger Formation sediment within the New Fork-Big Sandy area is near the middle of the lower Bridger Formation exposure area. Unfortunately, the fault system obscures the Laney-Bridger transition zone.

Paleontology.—The lower Bridger Formation in the New Fork-Big Sandy area produces a diverse fauna, representative of the lower part of the formation, Bridger B. No amphibians have been recovered, although a variety of reptiles are common. Birds are represented in the collection by a single vertebra. The mammalian fauna is dominated by the smaller forms, especially primates and rodents. Comparatively few large mammals have been found. Sediment from four localities has been washed, and this technique has greatly increased the relative numbers of small animals represented in the assemblage.

Green River Formation

The Green River Formation is the lens of lacustrine sediment occupying the center of the Green River Basin. Temporally it transgresses early and middle Eocene time, interfingering laterally with both the Wasatch and Bridger Formations. Its marginal fluctuations represent the successive advances and retreats of the lake, while the composition of the sediments in the continuous central portion reflect great variations in salinity associated with the size changes. The tongues of the Green River Formation are based upon the expansions and lateral relationships to the bounding fluvial sediments.

Only the upper part of the Green River Formation is present in the New Fork-Big Sandy area. None of the lacustrine units are developed across the entire area; this adds to the complexity of interpretation of the relationships along the northern end of the basin.

Fontenelle Tongue

The Fontenelle Tongue of the Green River Formation was proposed by Donovan (1950, p. 63) to designate a sequence of "alternating buff-brown sandstones and green and gray mudstones, which conformably overlies the Knight member of the Wasatch." The type locality is about one-half mile south of Fontenelle Creek in sec. 13, T. 24 N., R. 115 W. Oriel (1961, p. 151) has since separated mudstones of the lower portion of the New Fork Tongue of the Wasatch Formation from the original upper Fontenelle Tongue, so the Fontenelle Tongue is now a primarily lacustrine unit (see Donovan, 1950, p. 63). Oriel's rearrangement places the New Fork Tongue between the Fontenelle Tongue and higher lacustrine units, while Donovan's original interpretation placed Laney Shale sediment directly on top of Fontenelle Tongue material. Although Donovan stated that the Fontenelle Tongue disappears in the south-

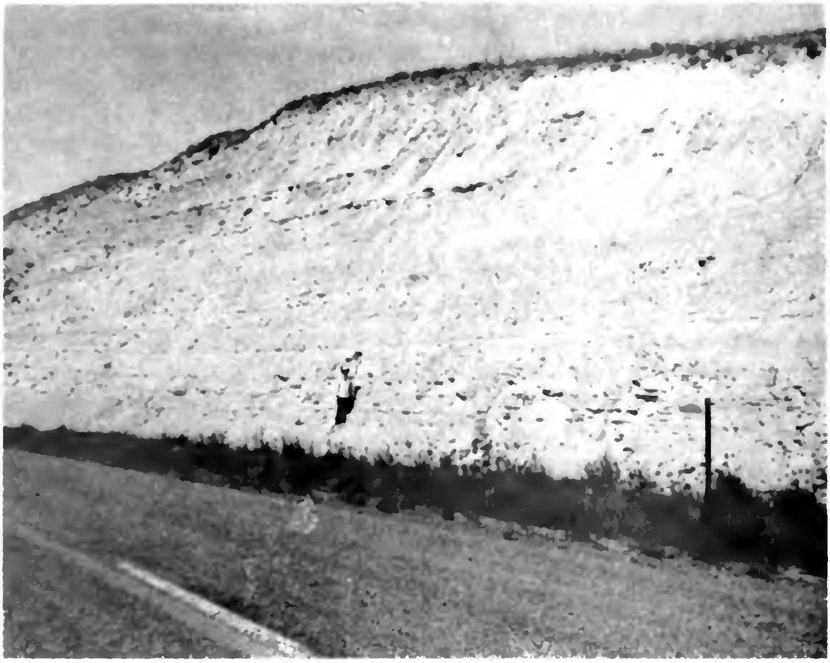


FIG. 15. Fontenelle Tongue of the Green River Formation exposed in a large roadcut along Wyoming State Secondary Highway 1801 in sec. 11, T. 30 N., R. 110 W.

west corner of T. 30 N., R. 110 W., it is apparent from this study that it persists for about 10 miles to the northeast of the point indicated on his map.

Exposures.—The Fontenelle Tongue is exposed within the New Fork-Big Sandy area only along the New Fork River. The top is placed at the top of the highest heavy buff sandstone underlying the bright blue-gray to blue-green mudstone of the basal western facies of the New Fork Tongue of the Wasatch Formation. The base is not exposed within the New Fork-Big Sandy area.

The maximum thickness exposed within the New Fork-Big Sandy area is approximately 90 ft. in a prominent cut along Wyoming Highway 1801 in sec. 11, T. 30 N., R. 110 W (fig. 15). This is nearly the total thickness, as the underlying Wasatch Formation is exposed nearby to the west. According to Bradley (1964, p. A34), the Fontenelle varies from a feather edge to 250 ft. in thickness.

Lithologies.—The Fontenelle Tongue is composed of well-laminated buff to gray fine calcareous sandstone, fine gray muddy limestone, poorly indurated fine yellow sand, and calcareous gray blocky mudstones and shales. Some sandy ostracodal limestone is present low in the unit. Black chert grit in the sandstone and mudstone suggest derivation from the Paleozoic and Mesozoic units to the west. The angular to subrounded sand grains are sorted into thin laminae, suggesting deposition below wave base. The sediment is coarser toward the top of the tongue, with current ripple marks and long cut-and-fill structures evident. This reflects a gradual transition to a more fluvial environment. Exposures along the New Fork River show yellow, buff, and brown sandstone lenses cut down into the much finer laminated sandstones and apparently having a greater feldspar component.

Relationships.—In the middle of T. 31 N., R. 109 W. the lacustrine Fontenelle Tongue merges laterally, along a fluctuating shoreline, with fluvial sandy mudstones of the arkosic facies of the New Fork Tongue of the Wasatch Formation. This transition can be seen in a poor outcrop on the south bank of the New Fork River in Sec. 15, T. 31 N., R. 109 W.

The Fontenelle Tongue has been considered the lateral equivalent of the Tipton Tongue, which is not developed in the New Fork-Big Sandy area. Roehler (1968) has shown that the upper part of the Tipton Tongue discussed by Bradley (1959) should be assigned to the Wilkins Peak Member of the Green River Formation. The faunal ages of the New Fork Tongue and Cathedral Bluffs Tongue in the New Fork-Big Sandy area suggest that the Fontenelle may be significantly older than the Tipton Tongue-Wilkins Peak Member sequence to the south.

In the New Fork-Big Sandy area the Fontenelle usually dips slightly southeast (basinward). It dips southwest along the west flank of the Pinedale Anticline, in T. 30 N., R. 109 W., and is absent on the east flank of the anticline because of the lateral merger into the Wasatch Formation.

Paleontology.—The Fontenelle Tongue has not produced any fossil vertebrates. Fresh-water ostracodes occur, and some layers contain plant remains as carbonized zones and impressions. Localities outside the area, however, contain invertebrate faunas (Oriel, 1969, p. M19).

Middle Tongue

Oriel (1961) referred to a lacustrine level along the western margin of the northern Green River Basin as the middle tongue of the

Green River Formation. These beds were initially mapped as Laney Shale Member by Donovan (1950). Bradley (1959) determined that the type Laney Shale Member in the Washakie Basin was not correlative with what had been called Laney Shale Member in the Green River Basin. He reassigned the name Laney Shale Member to higher beds in the Green River Basin and gave the name Wilkins Peak Member to what had previously been called Laney Shale Member there. The Wilkins Peak Member of the Green River Formation, with its type section on Wilkins Peak in the southern part of T. 16 N., R. 106 W., represents a contracted stage of Lake Gosiute, replete with evaporite minerals. The beds discussed by Oriel may represent the initial post-Wilkins Peak northward expansion of the lake, preceding the far more extensive Laney Shale expansion.

Exposures.—The middle tongue is present on top of Ross Butte (SW ¼ sec. 13, and SE ¼ sec. 14, T. 30 N., R. 110 W.) and caps Ross Ridge and the west end of Blue Rim. No more than 100 ft. of middle tongue is present on top of Ross Butte, and there is much

FIG. 16. Middle tongue of the Green River Formation exposed on top of Ross Butte. The hammer is resting upon an algal limestone unit, which is overlain by a thin-bedded calcareous sandstone.

less on the lower rises to the south and east. Elsewhere within the area it has been removed by erosion. A small amount of the middle tongue is present northwest of the New Fork-Big Sandy area, on top of Grindstone Butte in sec. 13, T. 33 M., R. 111 W. (Oriel, pers. comm., 1967).

Lithologies.—The middle tongue of the Green River Formation is composed of gray-white algal limestone, platy buff calcareous sandstone, and massive buff limestone (fig. 16). The unit is resistant, providing a cap on the ridges. As studied in hand sample, the sandstones are composed mostly of subangular to subrounded particles with calcareous cementing material.

Relationships.—The middle tongue overlies the New Fork Tongue of the Wasatch Formation with a sharp contact of limestone over green sandy mudstone. The top is not present within the New Fork-Big Sandy area, but Oriel (1961, p. B151; 1969, p. M17) mentioned an upper tongue of the Wasatch Formation overlying the middle tongue of the Green River Formation in the Fort Hill area.

To the west of the area, the middle tongue merges laterally into fluvial Wasatch Formation beds (Donovan, 1950, p. 64). Eastward, the Cathedral Bluffs Tongue of the Wasatch Formation presumably occupies the same relative stratigraphic position. The middle tongue may well be a northward expansion of lacustrine deposition immediately following the Wilkins Peak contracted stage, although continuous exposures do not exist for verification.

Paleontology.—Much of the material in the middle tongue of the Green River Formation in the New Fork-Big Sandy area is algal in origin. No vertebrates have come from the small exposures considered in this study, nor have any invertebrates been seen, with the possible exception of some larval arthropod cases. Donovan (1950, p. 65) found fragmental fish and insects, and Oriel (1969, pp. M20–M21) found plant remains and insect cases in the upper zone of the middle tongue.

Laney Shale Member

In 1920 A. R. Schultz proposed the name Laney Shale Member of the Green River Formation for lacustrine beds exposed along the Laney Rim on the north side of the Washakie Basin. Bradley, in 1959, equated the Washakie Basin Laney Shale Member with the Morrow Creek Member of the Green River Basin, and substituted Wilkins Peak Member for what had been known as Laney Shale Member in the Green River Basin.

Exposures.—The Laney Shale Member, the most extensive lacustrine unit in the area, caps several prominent hills near Speedway Road, including Square Top in the NE 1/4 sec. 24, T. 30 N., R. 107 W., and appears along the upthrown side of the Big Sandy Limb of the Continental Fault. Exposures along the Big Sandy River provide the most nearly complete Laney Shale Member section in the New Fork-Big Sandy area.

The base of the Laney Shale Member is readily defineable as that level at which "structured" or bedded and laminated shales and sandstones appear, while the top merges imperceptibly into the overlying Bridger Formation. This transitional upper part of the Laney Shale Member is included with the Lower Bridger Formation, and the lower, readily differentiable Laney Shale Member is treated separately here.

Incomplete measured sections of the Laney Shale Member are 137.6 ft. thick on the southwest flank of Cone (E 1/4 sec. 8, T. 29 N., R. 105 W.) and 50.5 ft. thick on the west flank of Square Top (NE 1/4 sec. 24, T. 30 N., R. 107 W.). McGrew et al. (1959, p. 128) measured 156 ft. of Laney Shale Member (then called Morrow Creek) near Tabernacle Butte, just south of the New Fork-Big Sandy area, and Bradley (1926, p. 131) recorded 324 ft. of "Morrow Creek" in sec. 17, T. 23 N., R. 102 W., near Steamboat Mountain in northern Sweetwater County. The maximum thickness of the Laney Shale Member within the New Fork-Big Sandy area may be as much as 200 ft. More than 600 ft. of Laney Shale Member sediments are present to the south, near Rock Springs.

Lithologies.—Shale and fine shaley sand are common in the Laney Shale Member and range in color from almost black to gray-white, brown, and buff. When observed with a hand lens, much of the shale has sizeable amounts of fine sand sized particles, usually composed of quartz and feldspar as well as biotite and muscovite micas. "Paper shales" appear at two elevations in the southeastern part of the New Fork-Big Sandy area: Cone (E 1/2 sec. 8, T. 29 N., R. 105 W.) and Table (S 1/2 sec. 4, SW 1/4 sec. 3 and N 1/2 sec. 9, T. 29 N., R. 105 W.).

Laney Shale Member sandstones and poorly indurated sands are gray, gray-brown, brown, buff, and yellow. They are generally rather fine-grained, and most are at least incipiently bedded. Some are quite marly, with $CaCO_3$ abundant in the cement, while others are siliceous or clayey. The resistant sandstones frequently form small ledges. The sandstones in the Laney Shale Member tend to be more tuffaceous than those of the lower lacustrine units. An excellent exposure of several tuffaceous Laney sandstones is present just east of the Big Sandy Limb of the Continental Fault in SW ¼ sec. 24, T. 30 N., R. 106 W. These sandy zones are suggestive of beaches along the fluctuating Laney shoreline.

The tops of both Table and Cone are supported by a hard siliceous conglomerate bed. In hand sample this poorly sorted conglomerate contains loosely packed angular to subrounded quartz and plagioclase and microcline feldspar grains. Ferromagnesian minerals are much less common than in the finer, softer sandstone. The conglomerate is cut randomly by siliceous veins.

Gray to brown sandy mudstones are usually reasonably well consolidated, although not particularly resistant. The fine matrix makes up the bulk of the rock along with a varying amount of sand-sized particles of quartz and feldspar. Some layers are extremely marly, and aquatic fossils frequently occur in these.

Several buff to white, resistant limestones occur on Square Top and nearby elevations. They range from massive to granular and porous, and are rich in aquatic fossils—algae, ostracodes, and molluscs. Rapid facies changes from this organic limestone occur at several places on Square Top, reflecting rather abrupt environmental changes.

Relationships.—In the New Fork-Big Sandy area the Laney Shale Member is bounded above and below by fluvial beds, but farther toward the center of the basin it is the top of a continuous lacustrine sequence, overlying the Wilkins Peak Member of the Green River Formation. The Laney Shale Member, while generally overlying the Cathedral Bluffs Tongue of the Wasatch Formation, is in part contemporaneous with it. In the SW ¼ sec. 30, T. 30 N., R. 105 W., brown shales and fine sandstones of the Laney Shale Member interfinger laterally with greenish sandy mudstone of the Cathedral Bluffs Tongue.

Paleontology.—The Laney Shale Member is much more fossiliferous than other lacustrine units within the New Fork-Big Sandy area. Plants, invertebrates, and vertebrates have been recovered and fossil material is scattered throughout the unit. Pollen and spores from the carbonaceous shale on Cone have been examined and are indicative of a swamp environment (W. B. Clapham, Jr., pers. comm., 1967).

Invertebrates found in the Laney Shale Member include abundant gastropods and pelecypods as well as ostracodes. The gastropods are both terrestrial (*Helix*, sensu Shrimer and Shrock, 1944, p. 521) and shallow water (*Viviparus*, *Goniobasis*, and *Planorbina* sensu McKenna et al., 1962, pp. 6–10). The systematics of these gastropods is debated by malacologists. Those who work with modern forms (Hyman, 1967, p. 623) have determined that there are no indigenous members of the family Helicidae in North America. Paleontologists such as La Rocque (1960, pp. 44–45) prefer to retain a very large and poorly defined species group for *Helix*. The pelecypods of the Laney Shale Member are less distinct, but appear to be unionids.

Vertebrate fossils from the Laney include garpike (*Lepisosteus*) scales, fish spines, and miscellaneous vertebrae, crocodile teeth, fragments of turtle shell, lizard fragments, and a small amount of unidentifiable mammalian bone scrap. The aquatic fauna also occurs in the bounding fluvial units, as most of these animals were also able to live in streams and ponds on the alluvial plain lateral to the lake.

Summary of Depositional History

A. Figure 17. Marginal uplift and regional downwarping, both absolute and relative, around the Green River Basin. Deposition of Paleocene sediments, which may be related to the Hoback Formation. Movement along the Wind River Thrust Fault to the east (Berg, 1962). Paleocene.

B. Figure 18. Development of the overthrust area to the west. Continued movement along the Wind River Thrust. Chappo and LaBarge members of the Wasatch Formation deposited on the west, undifferentiated Main Body on the east (Berg, 1962; Oriel, 1962). Early and Middle Wasatchian.

C. Figure 19. Movement on thrust faults virtually complete. First development of Green River Formation lacustrine deposits as the Fontenelle Tongue. Arkosic facies of New Fork Tongue fluvial material being deposited on the east. Late Wasatchian.

D. Figure 20. Fluvial material of the western facies of the New Fork Tongue covers Fontenelle Tongue on the west. Continued deposition of arkosic facies on east. Late Wasatchian.

E. Figure 21. Middle Tongue of Green River Formation shows a second lacustrine sequence in the New Fork-Big Sandy area.

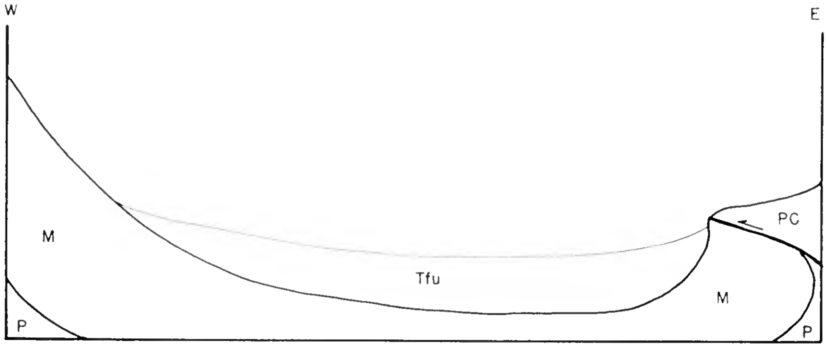


Fig. 17.

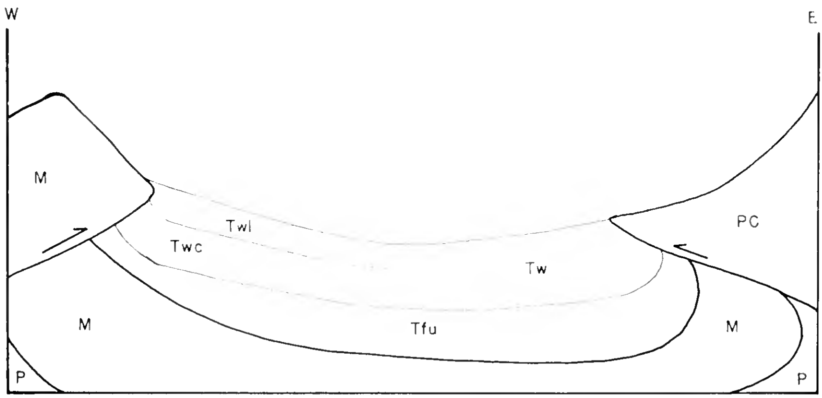


Fig. 18.

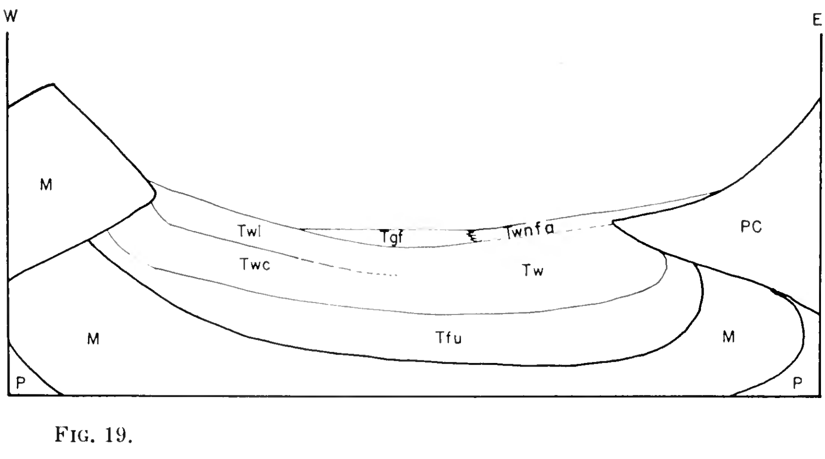


Fig. 19.

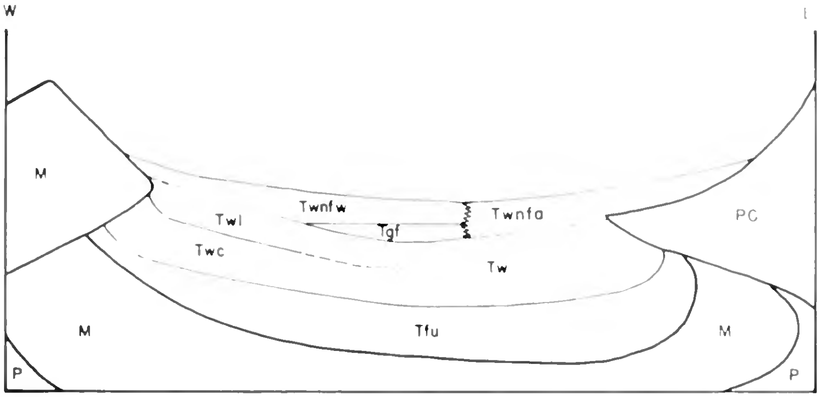


FIG. 20.

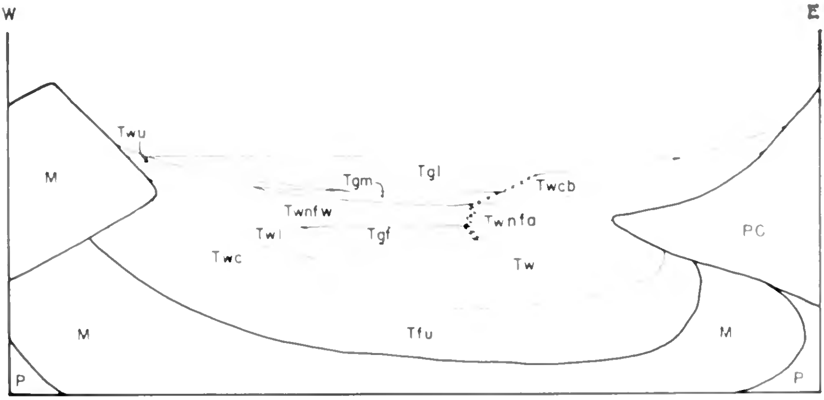


FIG. 21.

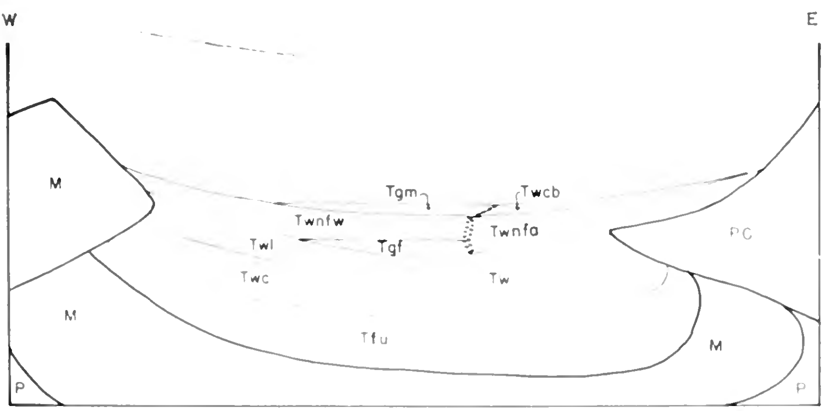


FIG. 22.

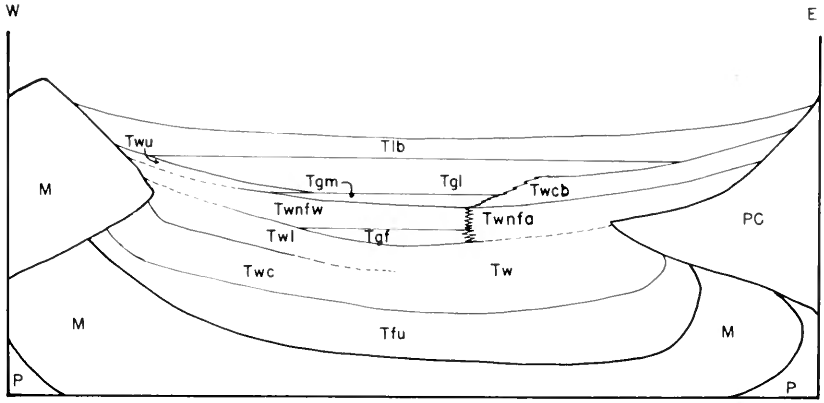


Fig. 23.

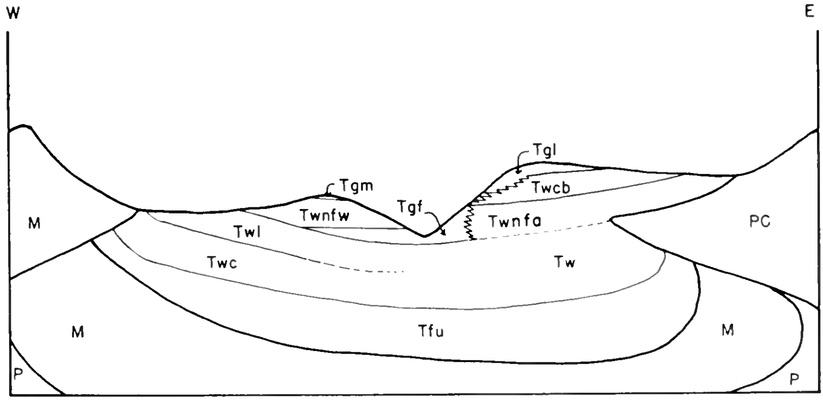


Fig. 24.

Cathedral Bluffs Tongue of the Wastach is lateral to the Middle Tongue of the Green River on the east. Early Bridgerian.

F. Figure 22. The large lacustrine unit, the Laney Shale Member of the Green River Formation, covers much of the basin. This overlaps the small Upper Tongue of the Wasatch on the west (Oriel, 1969). Early Bridgerian.

G. Figure. 23. Fluvial Bridger Formation fills the basin after the disappearance of Lake Gosiute. Bridgerian.

H. Figure 24. Present topography, with faulting omitted, displays two sets of units, eastern and western, with the Bridger Formation eroded away completely.

Key to Figures 17 through 24

PC—Precambrian undifferentiated
P—Paleozoic undifferentiated
M—Mesozoic undifferentiated
Tfu—Paleocene Fort Union Formation (or Hoback Formation) undifferentiated
Tw—Main Body of the Wasatch Formation
Twc—Chappo Member of the Wasatch Formation
Twl—LaBarge Member of the Wasatch Formation
Twnfa—Arkosic Facies of the New Fork Tongue of the Wasatch Formation
Twnfw—Western Facies of the New Fork Tongue of the Wasatch Formation
Twcb—Cathedral Bluffs Tongue of the Wasatch Formation
Twu—Upper Tongue of the Wasatch Formation
Tgf—Fontenelle Tongue of the Green River Formation
Tgm—Middle Tongue of the Green River Formation
Tgl—Laney Shale Member of the Green River Formation
Tlb—Upper Laney Shale Member of the Green River Formation and Lower Bridger Formation, undivided

STRUCTURAL GEOLOGY

The Laramide Orogeny and related events formed the present structural Green River Basin. Precambrian to Cretaceous rocks were folded, faulted, and uplifted into the present basin-bounding elevations: the Wyoming Overthrust Ranges to the west, the Uinta Mountains to the south, the Rock Springs Uplift to the southeast, the Wind River Mountains to the northeast, and the Gros Ventre Range to the north. Post-Laramide movement within the New Fork-Big Sandy area occurred along a thrust fault zone and a complex normal fault system as shown on Figure 25.

Wind River Thrust Fault

Considerable evidence points to the existence of a major thrust fault zone along the southwestern front of the Wind River Moun-

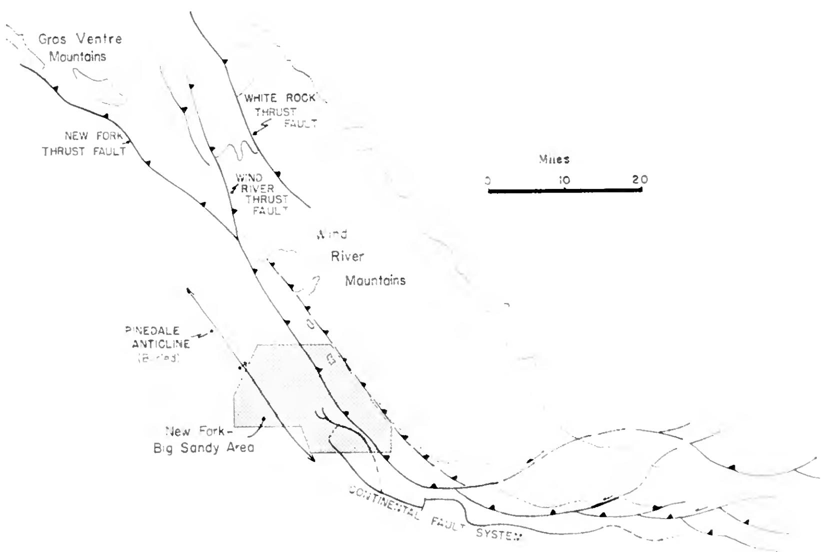


FIG. 25. Structural map of the western and southern flanks of the Wind River Mountains, showing the major structural trends and their relationships to the New Fork-Big Sandy area. Adapted from Love et al., 1955, and Berg, 1961.

tains (fig. 25). North of the New Fork-Big Sandy area Richmond (1945) mapped two large thrusts; the largest, called the Wind River Thrust Fault, has a horizontal displacement of as much as 7 miles with a throw of 10,000 ft. at Flattop Mountain (center T. 36 N., R. 109 W.). Seven miles east of the Wind River Thrust is the White Rock Thrust Fault, with a throw of 3,000 ft. Berg (1961, p. 74) utilized data from the core of Gulf 1 Unit (sec. 5, T. 36 N., R. 110 W.) to locate the concealed New Fork Thrust Fault, estimated to have a throw of up to 25,000 ft. All three of these large thrusts decrease in magnitude to the northwest, swing westward, and merge with the structures of the Gros Ventre Mountains.

Southeast of the New Fork-Big Sandy area the large thrust fault has been delineated by several wells (Berg, 1962, p. 75; Zeller and Stephens, 1969, p. 27). The fault zone trends more easterly and may extend as far east as the southern flank of the Granite Mountains before losing its identity.

Berg (1961, 1962) recorded the Wind River Thrust Fault by a seismic survey and several cores taken near the Big Sandy River in T. 29 N., R. 105, 106 W. This indicated the presence of a large wedge of crystalline Precambrian material thrust out over Paleozoic, Mesozoic, and early Tertiary sediments, and in turn lapped over by Eocene sediments. The schematic cross-section (fig. 26) illustrates

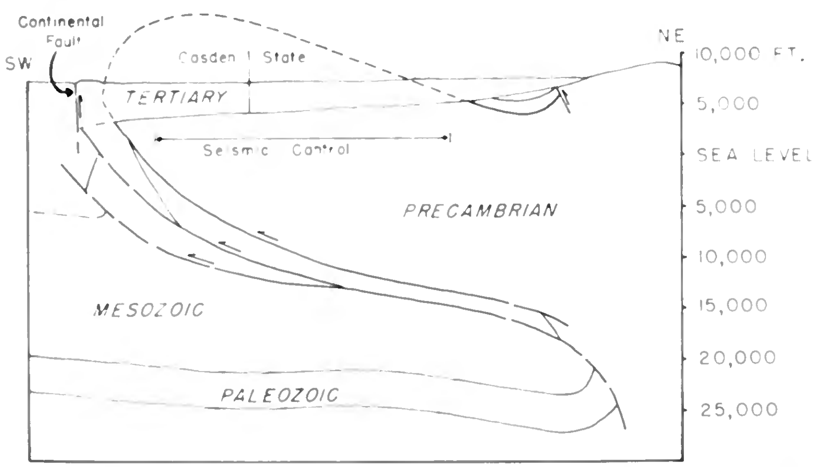


FIG. 26. Structure section through the thrust wedge of the Wind River Thrust Fault in the southeast corner of the New Fork-Big Sandy area. Cosden 1 State is located in sec. 16, T. 29 N., R. 105 W. The presence of the small area of sedimentary rocks bounded on the northeast by a small fault is based on gravity data only. Vertical and horizontal scales are equal. Adapted from Berg, 1961, p. 73.

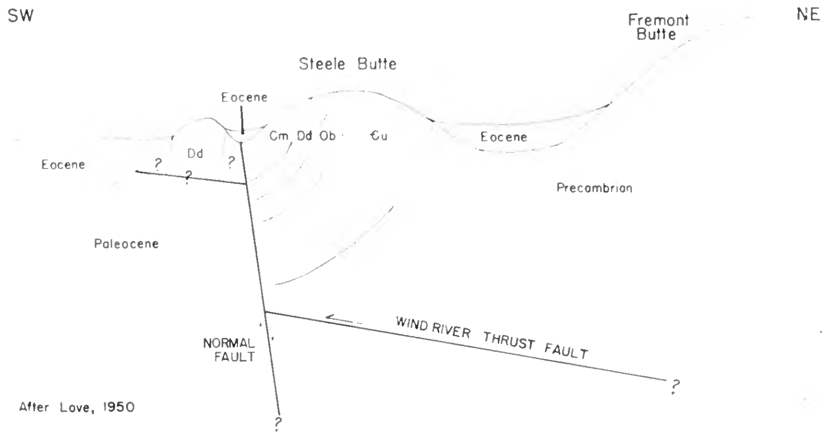


FIG. 27. Structure section of the Paleozoic inlier at Steele Butte. Cu—Cambrian undifferentiated; Ob—Ordovician, Bighorn Dolomite; Dd—Devonian, Darby Formation; Cm—Carboniferous (Mississippian), Madison Limestone. This section is approximately two miles in length. Adapted from Love, 1950.

this structure. The Cosden 1 State drill hole (sec. 16, T. 29 N., R. 105 W.) passed through 3,100 ft. of "Wasatch" above the crystalline Precambrian rocks. Seismic evidence indicated to Berg that a sheet of sediment 1,000 to 2,500 ft. thick lies below the granitic thrust wedge. This sheet is probably composed of Paleozoic and Mesozoic rocks overridden by the thrust wedge, dragged along with it and overturned. At the toe of the thrust wedge the dip is about 50° NE; this decreases to about 10° NE near the middle of the wedge and then steepens sharply into the root zone. At this locality the thrust fault has a vertical displacement of 30,000 ft. and a horizontal displacement of 48,000 ft., although the vertical displacement may have originally been greater, prior to erosion on the surface of the thrust wedge.

The Wind River Thrust was active through a considerable period of time. Cores show that in late Paleocene time coarse detritus from Paleozoic and Mesozoic units poured westward into the basin where they interfingered with basinal fluvial mudstones and sandstones of the Hoback Formation (Berg, 1961, p. 78). Higher, the debris reflects a more granitic source, as the sedimentary rocks were eroded away to the granite of the thrust sheet. Quartz and feldspar are more abundant in the upper Paleocene sediments. The thrust continued its movement throughout the Paleocene and possibly into the early Eocene time. By middle Wasatchian time, however, its movement had ceased and crystalline-derived detritus covered over the fault trace. The presence of only depositional and compactional basinward dips indicate that significant relative uplift of the Wind River Mountains had also ceased. This does not mean, however, that there was no more regional uplift; there is a considerable body of evidence that all of western Wyoming has risen several thousand feet since middle Eocene time.

The peculiar exposures of Paleozoic rocks in the Steele Butte vicinity are related to movement along the Wind River Thrust Fault. Love (1950, p. 27) believed that a normal fault moved later than the major thrust fault, bringing Devonian rocks down to the level of the early Paleozoic units, which are resting on the distorted tip of the thrust wedge (fig. 27). He suggested that this activity may be related to some post-Oligocene movement described by Nace (1939) near Oregon Butte along the Continental Fault. The lack of disturbance of the Eocene between Steele Butte and the small Devonian outcrops leads me to believe that if some faulting occurred there, it took place soon after the major Wind River Thrust Fault.

Continental Fault

The Continental Fault was initially traced by Nace (1939) in the Oregon Butte-Continental Peak Region. McGrew et al. (1959) traced the fault as far as the Big Sandy River to the west, and the 1955 Geologic Map of Wyoming showed it eastward to the vicinity of Pickett Lake. I have traced the Continental Fault and its subsidiary limbs for an additional 7 miles to the northwest of the Big Sandy River. Waterhole Draw follows the course of the main limb of the Continental Fault for about 3 miles northwest of the Big Sandy River; the fault then swings more northerly. The herein named Big Sandy Limb of the Continental Fault (figs. 25, 28) may be traced readily in stream cuts for about 4½ miles from sec. 24, T. 30 N., R. 106 W. to sec. 8, T. 29 N., R. 105 W. A few useful outcrops south of Table and Cone allow this limb to be followed into sec. 16, T. 29 N., R. 105 W. Southeast of this point the country is featureless for several miles; a fault with the same relative movement was mapped by Berman (1950) as far as sec. 2, T. 28 N., R. 105 W., about five miles southeast of the nearest exposure of the Big Sandy Limb. Northwest of the river-cut exposures the Big Sandy Limb disappears into the sagebrush. Some trends can be detected on aerial photos; these may reflect the course of the fault although nothing is visible on the ground.

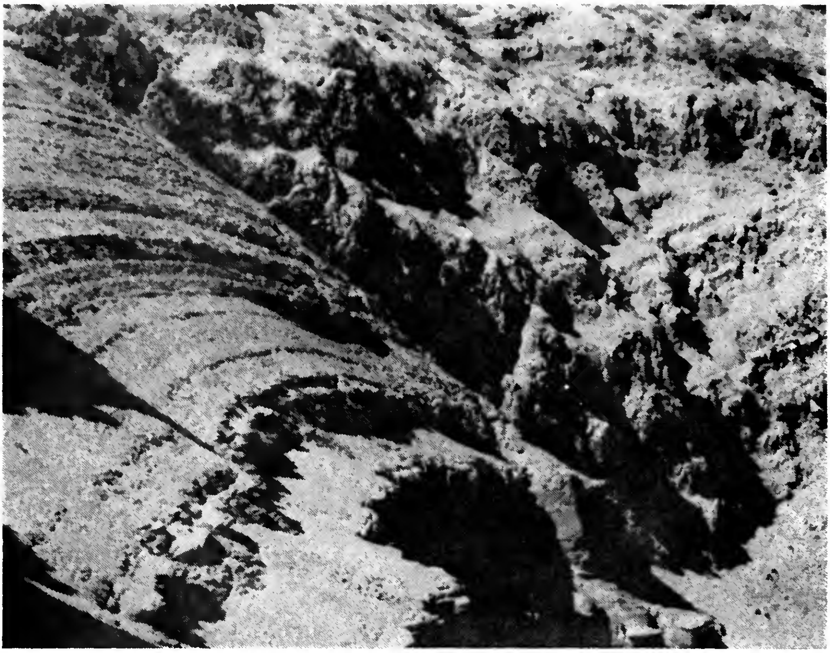


FIG. 28. Fine shaley sandstones and shales of the Laney Shale Member of the Green River Formation at the Big Sandy Limb of the Continental Fault in SW ¼ sec. 24, T. 30 N., R. 106 W. Sediments of the Bridger Formation are on the right (downthrown) side of the fault.

Northwest of the Big Sandy Limb and the main extension of the Continental Fault is another subsidiary fracture here named the Square Top Limb of the Continental Fault after the prominent elevation Square Top. It is best exposed in N ½ NE ¼ sec. 13, T. 30 N., R. 107 W., on the north side of a small hill, while the only other exposure is in a dry tank in SW ¼ NE ¼ sec. 18, T. 30 N., R. 106 W. At its western end the Square Top Limb breaks into at least two NNW-trending branches. Lower Bridger Formation sediment exposed between these is contorted, with SE dips of 15° quite common. Northeast of the Square Top Limb the lower Bridger Formation dips up to 8° SW.

These three limbs of the Continental Fault trend toward each other in a flat area in NW ¼ SW ¼ T. 30 N., R. 106 W. Presumably, they meet as shown on the geological map and isolate the area of the lower Bridger Formation exposures.

There has been considerable movement along the eastern portion of the Continental Fault. Nace (1939, pp. 45–46) gave a minimum of 1,450 ft. and a maximum of 1,830 ft. for the throw at Oregon Buttes. In the Tabernacle Butte area (McGrew et al., 1959, p. 129) the throw is 250 to 300 ft. No measurements could be made within the New Fork-Big Sandy area because of poor exposures and lack of correlative horizons on either side of the fault. Estimates based on the approximate thicknesses of the units cut by the fault give a throw of about 250 ft. along the Big Sandy River and a similar amount where maximum displacement occurs along the Square Top Limb. The amount of displacement decreases northwestward.

The fault plane of the Big Sandy Limb generally dips 50° to 60° to the southwest. The main limb of the Continental Fault in a cut near Waterhole Draw dips 65° to 75° to the north, with the north side downdropped (McGrew et al., 1959, p. 129). The Square Top Limb has the same sense of movement as the main portion of the fault, but measurements of the dip of the fault plane could not be taken.

The overall effect of the Continental Fault system was to drop middle Eocene Bridger Formation sediments down to the level of the early Eocene Wasatch and Green River Formations and thus allow them to escape erosion and remain as an indicator of the former extent of Bridger deposition. The lower Bridger Formation material mapped along the Square Top Limb of the Continental Fault is the farthest north yet reported. Thirteen fossil mammal localities are in the downdropped lower Bridger Formation, so the structural situation is paleontologically fortunate.

Since the faulting within the New Fork-Big Sandy area cuts the Bridger Formation, at least some movement occurred in post-Bridgerian time. Zeller and Stephens (1969, pl. 1) showed the Continental Fault cutting beds of the Miocene South Pass Formation in sec. 3, T. 27 N., R. 102 W., so the final movement cannot be any older than Miocene and may be as recent as mid-Pliocene (Love, 1954, p. 1,311). McGrew (pers. comm., Aug. 12, 1967) has seen Eocene fault scarps in the Elk Mountain vicinity which indicate that the Continental Fault system was active then as well.

Berg (1961, p. 73) interpreted the Continental Fault system as a "late normal collapse along the toe of the (major) thrust wedge." He regarded the correlation between the subsurface position of the thrust wedge and the surface expression of the Continental Fault as good evidence for this interpretation. Zeller and Stephens (1969, pl. 1) showed the Continental Fault on the mountainward side of the Wind River Thrust Fault, resulting from a normal fault within the thrust wedge. There is general agreement that the Continental Fault is genetically related to the Wind River Thrust Fault, but the precise relationship is as yet unclear. Additional evidence pertaining to the location of the thrust might also be provided by the normal fault just west of Steele Butte proposed by Love in 1950.

Pinedale Anticline

The Pinedale Anticline extends 45 miles parallel to the Wind River Mountains from T. 35, N., R. 110 W., to T. 29 N., R. 106 W. (fig. 25). It is approximately symmetrical, 6 miles wide, with a closure of more than 1,500 ft. (Jenkins, 1955b, p. 155). It is poorly indicated along the south bank of the New Fork River in T. 31 N., R. 109 W., where the Fontenelle Tongue of the Green River Formation reverses its dip along the west flank of the anticline. As this is the location of the facies change into sediments of the arkosic facies of the New Fork Tongue, a similar change in attitude cannot be seen on the east flank where bedded lacustrine sediments are not present. Both facies of the New Fork Tongue appear unaffected by the anticline, which thus is not a mappable surface structure. The Fontenelle Tongue is the highest unit to be visibly affected by the anticline; if the New Fork Tongue was at all distorted by the Pinedale Anticline it cannot be detected in available outcrops.

Drilling and seismic work have revealed the structure of the Pinedale Anticline to a much greater extent than is visible on the surface (Berg, 1961, p. 71). Thousands of feet of relatively young sediment are involved in the anticline which does not appear to be present in the Precambrian basement.

OCCURRENCE OF FOSSIL MATERIAL

Collecting

The initial collection at every locality was a surface collection. Promising areas in all units were searched by systematic walking. If the resultant collection was large enough and the area seemed rich enough, washing was attempted. The Cathedral Bluffs Tongue fauna was collected primarily by washing, and four Bridger Formation localities were extensively washed. No localities suitable for quarrying operations were encountered.

Preservation

Fossils from all levels are usually well-preserved although fragmentary. This durability of the fossil material is the main reason for the success of the washing technique. Were the fossils fragile it would be next to impossible to recover any identifiable material from the washed concentrate.

Most material is fragmentary; few jaws have as many as three teeth, and only three reasonably complete skulls were found during all the collecting.

Some of the smaller broken specimens were undoubtedly fractured during the washing procedure. Much fragmentation, however, occurred prior to and during deposition and burial and many specimens undoubtedly fragmented during recent erosional processes. Abraded fractures are sometimes visible, but the amount of friction during washing is certainly inadequate to significantly abrade a freshly broken surface.

Deterioration of the bone by pre-burial dessication is a result of post-mortem exposure to the elements prior to being covered by sediment. During this interval it is also possible that scavengers may have disarticulated the carcass, scattering the elements so that only one or a few were in a position to be preserved and later collected. Severe deterioration of the carcass left only the most resistant elements, the teeth, available for preservation.

Fossil Production

The western facies of New Fork Tongue of the Wasatch Formation produces fossils from the green-to-gray mudstone zones adjacent to the yellow channel sandstones at seven localities along the southeastern face of the Mesa. Two other localities are in fine blue-green sandy zones along the Blue Rim. These, and the localities mentioned below, are indicated on the geological map.

Fossils are not as concentrated in the arkosic facies. The two localities in the arkosic facies are large in areal extent. The finer sandy mudstones, not necessarily adjacent to channel sandstones, are the most productive zones. Aside from the two localities in the northern part of the New Fork-Big Sandy area, the arkosic facies is virtually barren.

The Cathedral Bluffs Tongue of the Wasatch Formation is poorly fossiliferous. Bone has been found in only two places within the New Fork-Big Sandy area. A fragmentary stylinodontine tooth and nearly a dozen edentulous mammal jaws were found near the Big Sandy River, while the remainder of the Cathedral Bluffs Tongue in that area has yielded only well-worn unidentifiable scraps of bone. A small surface collection led to the development of a washing locality, which has yielded 65 specimens, near the Square Top Limb of the Continental Fault. Both of these Cathedral Bluffs Tongue localities are in greenish intraformational mudstone conglomerate.

Remains of aquatic animals are well distributed through the Laney Shale Member exposures. Unidentifiable fragments of teleost fish and turtles are common, along with the omnipresent *Lepisosteus* scales. The darker, more carbonaceous, shales of the Laney Shale Member contain more fossil material than do the light brown sandy shales.

The lower Bridger Formation is the most productive unit in the New Fork-Big Sandy area. The 13 localities in the lower Bridger Formation are sharply delineated, as they are small areas with relatively abundant fossil material, while the same levels a few yards away produce nothing, with little or no physical difference in the sediments across such a transition.

VERTEBRATE FAUNAL LIST

Class Osteichthyes
  Order Semionotoidea
    Family Lepisosteidae
      Lepisosteus sp.
  Undetermined teleosts

Class Reptilia
  Order Chelonia
    Family Testudinidae
      Undetermined genera and species
    Family Trionychidae
      Trionyx sp.
  Order Squamata (as determined by W. P. MacLean III)
   Suborder Lacertilia
    Family Iguanidae
      Undescribed genus and species
    Family Agamidae
      Tinosaurus sp.
    Family Teiidae
      Undetermined genus and species
    Family Amphisbaenidae
      Lestophis sp.
    Family Anguidae
      Glyptosaurus (three species)
      Xestops sp.
      Dimetopisaurus sp.
      Saniva sp.
      Undetermined genus and species
   Suborder Ophidia
    Family Boidae
      Ogmophis n. sp.
      Dunnophis microechinus
      Calamagras primus
      Boavus sp.

?Paraepicrates brevispondylus
Coniophis carinatus
Order Crocodilia
Undetermined Gavialidae
Class Aves
Undetermined genus and species
Class Mammalia—See *Systematics* and Table 1.

FOSSIL MAMMAL AND REPTILE LOCALITIES IN THE NEW FORK-BIG SANDY AREA

Fossil mammals have been recovered from 26 localities in four stratigraphic units. There are two localities in the arkosic facies of the New Fork Tongue of the Wasatch Formation, nine in the western facies of the New Fork Tongue of the Wasatch Formation, two in the Cathedral Bluffs Tongue of the Wasatch Formation, and 13 in the lower part of the Bridger Formation. Reptiles have been found at two additional localities. These localities are described below.

The reptilian fauna has been provisionally studied by W. P. MacLean. The lizards and snakes occur in the same localities with the mammals, and apparently lived in the same environments as the various mammals.

The various localities have the following relative positions:

YOUNG (Later)	
	Bridger Formation
	B-2, B-7, B-11, B-8
	B-3, B-5, B-10
	B-1, B-4, B-6, B-9, B-12, B-13
Laney Shale Member	Cathedral Bluffs Tongue
L-1	CB-1, CB-2
Western Facies of the New Fork Tongue	
	Arkosic Facies of the New Fork Tongue
NF-1, NF-2	
NF-3, NF-4, NF-6, NF-7, NF-8, NF-9	BS-1, BS-2
OLD (Earlier)	BS-3

LOCALITIES

Bridger Formation

B-1. Fault (Big Sandy of the University of Wyoming). SE ¼ NE ¼ sec. 25, T. 30 N., R. 106 W., and NW ¼ SW ¼ sec. 30, T. 30 N., R. 105 W. Middle of high bluffs on east side of Big Sandy

River. One 10 ft. layer of sandy mudstone, brownish and gray-green, about 15 ft. below a prominent chippy, buff-white siltstone which carries plant impressions. One-third mile long on east side of the river; small amount of fossil material at corresponding level on the west side. Approximately 7,700 lbs. of matrix washed. Fauna: 470 specimens of 37 mammalian species.

B-2. White Hills. NW ¼ sec. 2, T. 29 N., R. 106 W. Five foot layer of tuffaceous sandy mudstone, buff to white, in a series of terraces to the south of the access road.

Small amount of fossil material on north side of access road. Fauna: 41 specimens representing 14 mammalian species.

B-3. Hawk. SW ¼ NE ¼ sec. 18, 29 N., R. 105 W. Large draw on northwest bank of Big Sandy River. Fossils found on flat just above a big rivercut, and at about the same level across the first draw upstream. Also a small area with mammalian material near the head of the main draw. Some $CaCO_3$ veins present here. Access to this area by abandoned seismograph trail. Approximately 1,900 lbs. of sediment washed. Fauna: 91 specimens representing 20 mammalian species.

B-4. Tree Road. N ½ SE ¼ sec. 31, T. 30 N., R. 105 W. Just west of Big Sandy Limb of Continental Fault on west side of Big Sandy River. Buff-brown sandy mudstone about 50 ft. below a heavy channel arkose on south-facing surface. Some material on south side of first ridge to the south. Road at base of locality. Approximately 4,250 lbs. of sediment washed. Fauna: 84 specimens representing 16 mammalian species.

B-5. Wash. NE ¼ sec. 19, T. 29 N., R. 105 W. Actually south of area. Flat breaks on northeast side of long draw, first to the south of an intermittently-flowing stream. Fossils found primarily on one interstream divide—very little on other divides at same level. Sandy mudstone with some shaley and blocky sandy mudstone. Approximately 2,550 lbs. of sediment washed. Fauna: 44 specimens representing 10 mammalian species.

B-6. Fish Hill. SW ¼ sec. 5, T. 29 N., R. 105 W. East-facing broken area just to west of Big Sandy Limb of Continental Fault. Light-colored sandy mudstone with $CaCO_3$ crystals weathering out. Some material on small knobs and hillside; remainder is slightly lower on washed-over areas. Fauna: 7 specimens representing 4 mammalian species.

B-7. Little White Butte. SE ¼ SE ¼ sec. 1, NE ¼ NE ¼ sec. 12, T. 29 N., R. 106 W. Light colored sandy mudstone and tuffaceous light sandstone on prominent knob just east of road on west side of Big Sandy River. Fossils around knob itself, and in brown sandy area slightly to southeast which is about 25 ft. lower. Approximately 350 lbs. of sediment washed. Fauna: 8 specimens representing 5 mammalian species.

B-8. 1375 #8. SW ¼ NE ¼ sec. 32, T. 30 N., R. 106 W. Low breaks facing north on north side of small elevation. Fossils in very blocky, rubbly, gray mudstone. Fauna: 12 specimens representing 7 mammalian species.

B-9. Jean's Quarry. NE ¼ SW ¼ sec. 8, T. 29 N., R. 105 W. Breaks in steep draw overlooking Big Sandy River. Just west of Big Sandy Limb of Continental Fault. Fauna: 4 specimens representing 3 mammalian species.

B-10. S ½ sec. 20, T. 29 N., R. 105 W. Just east of Wash Locality, and also out of the New Fork-Big Sandy area. Buff sandy mudstone in north-south draw to south of major drainage. Fauna: 3 specimens representing 2 mammalian species.

B-11. SW ¼ sec. 36, T. 30 N., R. 106 W. Low exposures of sandy mudstone below arkose several hundred yards north of road to Fish Hill. North of fence line. Fauna: 2 specimens representing 2 mammalian species.

B-12. West of Cone. NE ¼ sec. 17, T. 29 N., R. 105 W. Breaks facing west overlooking large meander of Big Sandy River. West of Big Limb of Continental Fault. Access road on top of bank overlooking this locality. Fauna: 1 specimen of mammal.

B-13. Sandstone Point. N ½ NE ¼ sec. 25, T. 30 N., R. 106 W. Prominent tongue of sandstone directed ESE, just to west of Big Sandy Limb of Continental Fault. Fossils from flats near top of exposure. Access road about one-quarter mile to the west. Approximately 200 lbs. of sediment washed. Fauna: 5 specimens representing 5 mammalian species.

Laney Shale Member of Green River Formation

L-1. Scale Canyon. NW ¼ sec. 30, T. 30 N., R. 105 W. Long draw directed WSW. Fossils, especially fish fragments, found in dark fissile shales and interbedded marly sandstones of the Laney Shale. Fauna: lower vertebrates only.

Cathedral Bluffs Tongue of Wasatch Formation

CB-1. Green. SW ¼ sec. 17, T. 30 N., R. 106 W. Located on a north facing slope, just south of Square Top Limb of Continental Fault. Above a blue-white tuffaceous zone. East of access road which crosses low, wide Cathedral Bluffs exposure. Fossils come from a gray-green intraformational sandy mudstone conglomerate. Approximately 6,200 lbs. of sediment washed. Fauna: 65 specimens representing 15 mammalian species.

CB-2. Fence X Road. SE ¼ sec. 30, T. 30 N., R. 105 W. On south side of a long draw directed east on the east side of the Big Sandy River. One poorly productive zone about halfway up the slope, in an intraformational sandy mudstone conglomerate near some arkosic zones. Marginal Laney a few hundred yards to the northwest. Fauna: 1 specimen representing a mammalian species.

Arkosic Facies of New Fork Tongue of Wasatch Formation

BS-1. Steele Butte Breaks. Sec. 30, and N ½ sec. 31, T. 32 N., R. 107 W., and S ½ sec. 25, and N ½ sec. 36, T. 32 N., R. 108 W. Large sequence of colored breaks overlooking East Fork River about 1½ miles southeast of Steele Butte. Fossils produced throughout the locality, but concentrated in the middle in generally darker, finer-grained sediments. Fossils found through 200 ft. of vertical section. Fauna: 115 specimens representing 22 mammalian species.

BS-2. East Fork Rim. Sec. 1, N ½ sec. 12, N ½ sec. 11, S ½ sec. 10, NE ¼ sec. 15, and sec. 2, T. 31 N., R. 108 W. and S ½ sec. 36, sec. 35, and SE ¼ sec. 34, T. 32 N., R. 108 W. Large area of colored breaks overlooking East Fork River to the west and south of Steele Butte Breaks. Generally high on the rim, but abundant material found in long, low draw which opens in sec. 34, T. 32 N., R. 108 W. Material found throughout locality. U.S. Highway 187 cuts across western side. Fossils found through 200 ft. of vertical section. Fauna: 124 specimens representing 23 mammalian species.

BS-3. NW ¼ sec. 14, T. 31 N., R. 109 W. Small broken area facing northwest over the New Fork River, just to the east of the facies change from the Fontenelle into the arkosic facies. Access road on west side. Fauna: lower vertebrates only.

Western Facies of New Fork Tongue of Wasatch Formation

NF-1. Blue Rim. NW ¼ NW ¼ sec. 16, SW ¼ sec. 9, and SE ¼ sec. 8, T. 30 N., R. 108 W. At base of Blue Rim where crossed by oil company road. Just below tongue of arkosic facies which can be easily identified by color and texture. Fossils produced from muddy blue-green poorly consolidated sandstone. Fauna: 43 specimens representing 13 mammalian species.

NF-2. Piney Cutoff. SW 1/4 sec. 34, SE 1/4 sec. 33, T. 31 N., R. 108 W., and NE 1/4 NE 1/4 sec. 4, T. 30 N., R. 108 W. At base of Blue Rim where it is crossed by Wyoming State Secondary 1801 in well-dissected area to north of highway. Fossils found in muddy blue-green poorly consolidated sandstone. Fauna: 14 specimens representing 9 mammalian species.

NF-3. Blue Saddle. NW 1/4 SW 1/4 sec. 31, T. 32 N., R. 109 W. Saddle on side of hill north of access road. Fossil production from bluish sandy mudstone. Approximately 800 lbs. of sediment washed. Fauna: 6 specimens representing 4 mammalian species.

NF-4. Unnamed. NW 1/4 sec. 5, T. 31 N., R. 109 W. On hillside on northeast side of deep draw to southeast of Blue Saddle. Very steep slope, best approached from top. Best level in a coarse blue to gray sandy mudstone. Approximately 500 lbs. of sediment washed. Fauna: 17 specimens representing 6 mammalian species.

NF-5. Two Buttes. SE 1/4 sec. 13, NW 1/4 sec. 13, N 1/2 sec. 14, NE 1/4 sec. 15, and sec. 11, T. 32 N., R. 109 W. Long valley with hill called Two Buttes in the middle. Fossil production sporadic from marginal exposures. Fossils come from yellow sandstones and adjacent gray-green mudstones. Fauna: 37 specimens representing 13 mammalian species.

NF-6. Twnf-H. SE 1/4 sec. 21, T. 32 N., R. 109 W. Breaks on nose on southwest-facing slope in greenish mudstone near yellow sandstone. Fauna: 2 specimens representing 2 mammalian species.

NF-7. Twnf-E. SW 1/4 sec. 18, T. 31 N., R. 109 W. Low east-facing breaks. Fossils from gray-green sandy mudstones near small calcareous pond deposit. Fauna: 1 specimen of mammal.

NF-8. Twnf-C. SE 1/4 sec. 28, T. 32 N., R. 109 W. Breaks low on a very high face. Fossils found in gray-green mudstone surrounding several yellow sandstones. Road crosses east end of locality. Fauna: 6 specimens representing 3 mammalian species.

NF-9. Twnf-D. SW 1/4 SW 1/4 sec. 36, T. 31 N., R. 110 W., and NW 1/4 NW 1/4 sec. 1, T. 30 N., R. 110 W. Fossils found in a poorly indurated yellow-orange sandy zone halfway down the slope of a very high southwestern-facing exposure. Fauna: 3 specimens representing 2 mammalian species.

The remains of lower vertebrates are present at all of these localities, as well as many other places in the New Fork-Big Sandy area. No record was kept of the occurrence of turtles because of their abundance and generally fragmentary nature.

Mammalian Faunal Composition

1,208 identifiable specimens representing at least 75 species of 51 genera of mammals have been recovered from the 26 localities in the New Fork-Big Sandy area. The Bridger Formation localities account for 772 specimens of 45 species of 33 genera, the Cathedral Bluffs Tongue localities for 66 specimens of 16 species and 12 genera, and 370 specimens of 33 species and 26 genera have been recovered from the upper Wasatch Formation localities in the New Fork Tongue and Big Sandy facies.

Both the calculated minimum number of individuals and number of specimens assignable to each taxon at each locality is indicated in Table 1 and summarized in Table 2. These minimum numbers were determined by the age-spread minimum as discussed briefly by Van Valen and Sloan (1965, p. 745) and at greater length by Schram and Turnbull (1970). This involves consideration of the wear shown by each tooth as well as its position in the dentition.

The collections made within the New Fork-Big Sandy area, at all the productive horizons, are from mechanical assemblages created during the deposition of the Eocene sediments. The moving water gathered together organic debris from many places and deposited it when carrying capacities dropped. It is essential that the artificiality of the assemblage be recognized. Any determination of the population composition of the life assemblages from which the recovered individuals were drawn must take this into consideration, as well as the possible biases discussed in detail by Clark (1967, pp. 114–120).

TABLE 1. Faunal composition at all mammalian localities within the New Fork–Big Sandy area. Numerator–Total number of specimens; Denominator–Minimum number of individuals.

	B-1 Fault	B-2 White Hills	B-3 Hawk	B-4 Tree Road	B-5 Wash	B-6 Fish Hill	B-7 Little White Butte	B-8 1375 No. 8	B-9 Jean's Quarry	B-10 S 1/2 sec. 20	B-11 SW 1/4 sec. 36	B-12 West of Cone	B-13 Sandstone Point	CB-1 Green	CB-2 Fence X Road	BS-1 Steele Butte Breaks	BS-2 East Fork Rim	NF-1 Blue Rim	NF-2 Piney Cutoff	NF-3 Blue Saddle	NF-4 Unnamed	NF-5 Two Buttes	NF-6 Twnf-H	NF-7 Twnf-E	NF-8 Twnf-C	NF-9 Twnf-D
Marsupiala																										
Peratherium sp.	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
P. innominatum	5/2	..	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
P. cf. *P. marsupium*	8/4	..	1/1	..	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Insectivora																										
Palaeictops cf. *P. pineyensis*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1/1	..	..	..	..	..	..	..	..	..
Apatemys bellulus	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Centetodon cf. *C. pulcher*	..	..	..	3/2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Myolestes cf. *M. dasypelix*	2/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Scenopagus edenensis	24/4	1/1	1/1	1/1	..	..	..	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Scenopagus priscus	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Creotarsinae incertae sedis	4/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

TABLE 1. Faunal composition at all mammalian localities within the New Fork–Big Sandy area. Numerator–Total number of specimens; Denominator–Minimum number of individuals–*continued*

	B-1 Fault	B-2 White Hills	B-3 Hawk	B-4 Tree Road	B-5 Wash	B-6 Fish Hill	B-7 Little White Butte	B-8 1375 No. 8	B-9 Jean's Quarry	B-10 S 1/2 sec. 20	B-11 SW 1/4 sec. 36	B-12 West of Cone	B-13 Sandstone Point	CB-1 Green	CB-2 Fence X Road	BS-1 Steele Butte Breaks	BS-2 East Fork Rim	NF-1 Blue Rim	NF-2 Piney Cutoff	NF-3 Blue Saddle	NF-4 Unnamed	NF-5 Two Buttes	NF-6 Twnf-H	NF-7 Twnf-E	NF-8 Twnf-C	NF-9 Twnf-D
Insectivora *(cont.)*																										
Nyctitherium sp.	5/3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Creodonta																										
Didelphodus altidens	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Oxyaena forcipata	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1/1	..	..	..	..	..	..	..	..	..	..
O. sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2/2	..	..	..	..	..	..	..	..	..	..
Oxyaenid	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1/1	..	..	..	..	..	..	..	..	..
?*Prototomus* sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1/1	..	..	..	..	..	1/1	..	..	..	..
?*Proviverra* sp.	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Tritemnodon sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1/1	..	..	..	..	..	..	..	..	..	..
Thinocyon cf. *T. velox*	..	..	..	3/2	..	..	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

TABLE 1. Faunal composition at all mammalian localities within the New Fork – Big Sandy area. Numerator – Total number of specimens; Denominator – Minimum number of individuals – *continued*

	B-1 Fault	B-2 White Hills	B-3 Hawk	B-4 Tree Road	B-5 Wash	B-6 Fish Hill	B-7 Little White Butte	B-8 1375 No. 8	B-9 Jean's Quarry	B-10 S 1/2 sec. 20	B-11 SW 1/4 sec. 36	B-12 West of Cone	B-13 Sandstone Point	CB-1 Green	CB-2 Fence X Road	BS-1 Steele Butte Breaks	BS-2 East Fork Rim	NF-1 Blue Rim	NF-2 Piney Cutoff	NF-3 Blue Saddle	NF-4 Unnamed	NF-5 Two Buttes	NF-6 Twnf-H	NF-7 Twnf-E	NF-8 Twnf-C	NF-9 Twnf-D
Carnivora																										
Didymictis altidens	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1/1	1/1	..	..	..	1/1	1/1	..	..	..	..
Viverravus gracilis	2/1	..	..	..	..	..	..	..	..	..	..	..	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..
V. sp.	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Miacis latidens	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2/2	..	1/1	..	..	..	..	..	..	..
Vulpavus sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1/1	..	..	..	..	..	..	..	..	..
Primates																										
Notharctus cf. *N. nunienus*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1/1	3/2	2/2	..	..	..	1/1	..	..	1/1	1/1
N. tenebrosus	8/3	..	1/1	..	1/1	..	..	1/1	..	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Smilodectes gracilis	12/3	..	2/2	4/1	1/1	..	1/1	1/1	2/1	..	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Omomys carteri	26/5	1/1	4/3	4/3	2/1	..	..	..	..	..	..	..	..	7/4	..	..	..	..	..	..	..	..	..	..	..	..
O. cf. *O. carteri*	..	..	1/1	..	..	..	..	..	..	..	..	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..

TABLE 1. Faunal composition at all mammalian localities within the New Fork–Big Sandy area. Numerator–Total number of specimens; Denominator–Minimum number of individuals–*continued*

	B-1 Fault	B-2 White Hills	B-3 Hawk	B-4 Tree Road	B-5 Wash	B-6 Fish Hill	B-7 Little White Butte	B-8 1375 No. 8	B-9 Jean's Quarry	B-10 S 1/2 sec. 20	B-11 SW 1/4 sec. 36	B-12 West of Cone	B-13 Sandstone Point	CB-1 Green	CB-2 Fence X Road	BS-1 Steele Butte Breaks	BS-2 East Fork Rim	NF-1 Blue Rim	NF-2 Piney Cutoff	NF-3 Blue Saddle	NF-4 Unnamed	NF-5 Two Buttes	NF-6 Twnf-H	NF-7 Twnf-E	NF-8 Twnf-C	NF-9 Twnf-D
Primates *(cont.)*																										
O. cf. *O. sheai*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1/1	..	..	..	..	..	..	..	..
Washakius insignis	14/3	3/2	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
W. near *W. insignis*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1/1	..	..	..	..	..	..	..	..	..
Anaptomorphus aemulus	1/1	..	2/2	2/1	1/1	..	..	..	..	..	..	..	..	1/1	..	..	..	..	..	..	..	..	..	..	..	..
Microsyops scottianus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3/1	2/1	2/1	..	..	1/1	1/1	1/1	..	..	..
M. elegans	65/9	9/3	6/3	15/5	1/1	..	3/1	1/1	1/1	..	..	..	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..
M. sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	8/3	..	..	..	..	..	..	..	..	..	..	..	..
Rodentia																										
Sciuravus nitidus	147/21	7/2	17/5	34/9	30/8	1/1	2/2	6/4	..	..	1/1	..	1/1	5/2	..	..	..	..	..	..	..	..	..	..	..	..
S. sp.	..	..	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Sciuravid	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1/1	1/1	..	..	..	..	..

TABLE 1. Faunal composition at all mammalian localities within the New Fork–Big Sandy area. Numerator–Total number of specimens; Denominator–Minimum number of individuals *continued*

	B-1 Fault	B-2 White Hills	B-3 Hawk	B-4 Tree Road	B-5 Wash	B-6 Fish Hill	B-7 Little White Butte	B-8 1375 No. 8	B-9 Jean's Quarry	B-10 S 1/2 sec. 20	B-11 SW 1/4 sec. 36	B-12 West of Cone	B-13 Sandstone Point	CB-1 Green	CB-2 Fence X Road	BS-1 Steele Butte Breaks	BS-2 East Fork Rim	NF-1 Blue Rim	NF-2 Piney Cutoff	NF-3 Blue Saddle	NF-4 Unnamed	NF-5 Two Buttes	NF-6 Twnf-H	NF-7 Twnf-E	NF-8 Twnf-C	NF-9 Twnf-D
Rodentia *(cont.)*																										
Tillomys cf. *T. parvidens*	..	..	..	..	..	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Taxymys lucaris	4/2	..	..	..	..	..	..	..	..	..	..	..	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..
Knightomys cf. *K. senior*	..	..	..	..	..	..	..	..	..	..	..	..	..	1/1	..	..	..	..	..	..	..	..	..	..	..	..
K. sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	3/2	..	..	..	..	..	..	..	..	..	..	..	..
Paramys delicatus	6/1	1/1	4/1	..	..	..	..	..	..	2/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
P. excavatus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1/1	..	..	..	..	..	..	..	..
P. near *P. excavatus*	..	1/1	..	..	..	..	..	..	..	..	..	..	..	8/2	..	..	..	..	..	..	..	..	..	..	..	..
"*Paramys*" group	42/9	7/3	6/2	3/1	..	2/1	..	..	..	..	..	..	..	5/3	..	1/1	2/2	1/1	..	..	..	..	..	..	..	..
P. wyomingensis	5/1	..	5/2	1/1	..	..	..	1/1	..	..	..	..	..	2/1	..	..	..	..	..	..	..	..	..	..	..	..
Reithroparamys huerfanensis	2/2	1/1	..	..	..	..	..	..	..	..	..	..	..	1/1	..	..	..	..	..	..	..	..	..	..	..	..

TABLE 1. Faunal composition at all mammalian localities within the New Fork–Big Sandy area. Numerator–Total number of specimens; Denominator–minimum number of individuals–*continued*

	B-1 Fault	B-2 White Hills	B-3 Hawk	B-4 Tree Road	B-5 Wash	B-6 Fish Hill	B-7 Little White Butte	B-8 1375 No. 8	B-9 Jean's Quarry	B-10 S 1/2 sec. 20	B-11 SW 1/4 sec. 36	B-12 West of Cone	B-13 Sandstone Point	CB-1 Green	CB-2 Fence X Road	BS-1 Steele Butte Breaks	BS-2 East Fork Rim	NF-1 Blue Rim	NF-2 Piney Cutoff	NF-3 Blue Saddle	NF-4 Unnamed	NF-5 Two Buttes	NF-6 Twnf-H	NF-7 Twnf-E	NF-8 Twnf-C	NF-9 Twnf-D
Rodentia *(cont.)*																										
R. delicatissimus	. .	$\frac{1}{1}$	. .	$\frac{1}{1}$	. .	. .	. .	. .	$\frac{1}{1}$	. .	. .	. .	. .	$\frac{1}{1}$	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
R. near *R. delicatissimus*	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	$\frac{1}{1}$	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Pseudotomus robustus	. .	. .	. .	$\frac{1}{1}$	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Microparamys minutus	$\frac{3}{1}$	. .	. .	$\frac{4}{1}$	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
M. sp. A.	$\frac{1}{1}$	. .	. .	$\frac{2}{1}$	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
M. sp. B.	. .	. .	. .	. .	$\frac{3}{1}$	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Tillodontia																										
Esthonyx acutidens	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	$\frac{2}{1}$	. .	. .	. .	. .	. .	. .	. .	. .	. .
Taeniodonta																										
Stylinodontine	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	$\frac{1}{1}$	$\frac{2}{1}$	$\frac{2}{1}$	$\frac{1}{1}$	$\frac{1}{1}$	. .	. .	. .	. .	. .	. .	. .
Dinocerata																										
Bathyopsis fissidens	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	$\frac{2}{1}$	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .

TABLE 1. Faunal composition at all mammalian localities within the New Fork – Big Sandy area. Numerator – Total number of specimens; Denominator – Minimum number of individuals – *continued*

	B-1 Fault	B-2 White Hills	B-3 Hawk	B-4 Tree Road	B-5 Wash	B-6 Fish Hill	B-7 Little White Butte	B-8 1375 No. 8	B-9 Jean's Quarry	B-10 S 1/2 sec. 20	B-11 SW 1/4 sec. 36	B-12 West of Cone	B-13 Sandstone Point	CB-1 Green	CB-2 Fence X Road	BS-1 Steele Butte Breaks	BS-2 East Fork Rim	NF-1 Blue Rim	NF-2 Piney Cutoff	NF-3 Blue Saddle	NF-4 Unnamed	NF-5 Two Buttes	NF-6 Twnf-H	NF-7 Twnf-E	NF-8 Twnf-C	NF-9 Twnf-D
Pantodonta																										
Coryphodon sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	13/4	14/4	..	..	..	..	..	..	..	..	..
Condylarthra																										
Hyopsodus miticulus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2/1	4/2	2/1	2/1	1/1	..	4/2	..	..	..	..
H. wortmani	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1/1	2/1	..	1/1	..	..	..	..	..	..	..
H. minusculus	46/12	4/1	32/9	4/2	3/2	3/2	1/1	1/1	..	..	..	..	..	17/4	..	..	..	..	..	..	..	..	..	..	..	..
H. paulus	1/1	..	..	..	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Meniscotherium chamense	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4/2	17/5	12/4	1/1	3/1	10/4	1/1	..	1/1	..	2/2
M. robustum	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2/2	2/1	3/3	1/1	..	..	..	..	..	..
Phenacodus vortmani	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2/2	..	2/1	..	..	..	1/1	..	..	..	..
P. primaevus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1/1	..	..	..	..
P. sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1/1	..	..	..	..	..	..	..

TABLE 1. Faunal composition at all mammalian localities within the New Fork–Big Sandy area. Numerator–Total number of specimens; Denominator–Minimum number of individuals.

	B-1 Fault	B-2 White Hills	B-3 Hawk	B-4 Tree Road	B-5 Wash	B-6 Fish Hill	B-7 Little White Butte	B-8 1375 No. 8	B-9 Jean's Quarry	B-10 S 1/2 sec. 20	B-11 SW 1/4 sec. 36	B-12 West of Cone	B-13 Sandstone Point	CB-1 Green	CB-2 Fence X Road	BS-1 Steele Butte Breaks	BS-2 East Fork Rim	NF-1 Blue Rim	NF-2 Piney Cutoff	NF-3 Blue Saddle	NF-4 Unnamed	NF-5 Two Buttes	NF-6 Twnf-H	NF-7 Twnf-E	NF-8 Twnf-C	NF-9 Twnf-D
Perissodactyla																										
Hyracotherium vasacciense	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	30/4	32/5	9/3	3/2	..	3/2	16/3	..	..	4/3	..
H. craspedotum	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6/5	7/4	..	..	1/1	..	1/1	..	..	..	..
Orohippus cf. *O. pumilus*	9/4	1/1	1/1	2/2	..	..	..	..	..	..	..	..	..	2/1	..	..	..	..	..	..	..	..	..	..	..	..
Lambdotherium popoagicum	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	35/7	22/6	7/2	1/1	..	1/1	5/3	..	..	1/1	..
Eotitanops borealis	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1/1	..	..	..	..	..	..	..	..	..
Palaeosyops fontinalis	1/1	..	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Heptodon posticus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3/1	1/1	..	..	..	..	..	..	..	..	..
H. calciculus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2/1	3/1	..	..	..	..	1/1	..	..	..	..
Hyrachyus modestus	1/1	..	1/1	..	..	..	..	..	..	..	..	..	1/1	2/1	..	1/1	..	..	..	..	..	..	..	..	..	..
Tapiroid	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

TABLE 1. Faunal composition at all mammalian localities within the New Fork – Big Sandy area. Numerator – Total number of specimens; Denominator – Minimum number of individuals.

	B-1 Fault	B-2 White Hills	B-3 Hawk	B-4 Tree Road	B-5 Wash	B-6 Fish Hill	B-7 Little White Butte	B-8 1375 No. 8	B-9 Jean's Quarry	B-10 S 1/2 sec. 20	B-11 SW 1/4 sec. 36	B-12 West of Cone	B-13 Sandstone Point	CB-1 Green	CB-2 Fence X Road	BS-1 Steele Butte Breaks	BS-2 East Fork Rim	NF-1 Blue Rim	NF-2 Piney Cutoff	NF-3 Blue Saddle	NF-4 Unnamed	NF-5 Two Buttes	NF-6 Twnf-H	NF-7 Twnf-E	NF-8 Twnf-C	NF-9 Twnf-D
Artiodactyla																										
Diacodexis cf. *D. secans*	..	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	1/1	1/1	..	..	..	..	2/2	1/1	..	..	..
Antiacodon pygmaeus	16/4	2/1	3/2	..	..	..	..	..	..	..	..	..	..	1/1	..	..	..	..	..	..	..	..	..	..	..	..
Microsus sp.	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Helohyus cf. *H. plicodon*	1/1	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Artiodactyl incertae sedis	1/1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTALS	470/111	41/21	91/41	84/34	44/18	7/5	8/6	12/10	4/3	3/2	2/2	1/1	5/5	65/29	1/1	115/41	124/47	43/20	14/12	6/4	17/10	37/20	2/2	1/1	6/5	3/3

TABLE 2. Summary of faunal composition at the four stratigraphic levels of fossil production within the New Fork–Big Sandy area. Numerator–Number of specimens; Denominator–Minimum number of individuals

	Bridger Fm.	Cathedral Bluffs	Wasatch Fm. Arkosic Facies	Western Facies
Peratherium sp.	1/1	..	..	..
P. innominatum	6/3	..	..	..
P. cf. *P. marsupium*	10/6	..	..	..
Palaeictops cf. *P. pineyensis*	..	..	1/1	..
Apatemys bellulus	1/1	..	..	..
Centetodon cf. *C. pulcher*	3/2	..	..	..
Myolestes cf. *M. dasypelix*	2/1	..	..	..
Scenopagus edenensis	28/8	..	..	..
S. priscus	1/1	..	..	..
Creotarsinae incertaè sedis	4/1	..	..	..
Nyctitherium sp.	5/3	..	..	..
Didelphodus altidens	1/1	..	..	..
Oxyaena forcipata	..	..	1/1	..
O. sp.	..	..	2/2	..
Oxyaenid	..	..	1/1	..
?*Prototomus* sp.	..	..	1/1	1/1
?*Proviverra* sp.	1/1	..	..	..
Tritemnodon sp.	..	..	1/1	1/1
Thinocyon cf. *T. velox*	4/3	..	..	..
Didymictis altidens	..	..	2/2	2/2
Viverravus gracilis	3/2	..	..	..
V. sp.	1/1	..	..	..
Miacis latidens	..	..	2/2	1/1

TABLE 2. Summary of faunal composition at the four stratigraphic levels of fossil production within the New Fork–Big Sandy area. Numerator–Number of specimens; Denominator–Minimum number of individuals–*continued*

	Bridger Fm.	Cathedral Bluffs	Wasatch Fm. Arkosic Facies	Western Facies
Vulpavus sp.	..	..	1/1	..
Notharctus cf. *N. nunienus*	..	..	4/3	5/5
N. tenebrosus	12/7	..	..	..
Smilodectes gracilis	24/11	..	..	..
Omomys carteri	37/13	7/4	..	..
O. cf. *O. carteri*	2/2	..	..	..
O. cf. *O. sheai*	..	..	..	1/1
Washakius insignis	18/6	..	..	..
W. near *W. insignis*	..	..	1/1	..
Anaptomorphus aemulus	6/5	1/1	..	..
Microsyops scottianus	..	..	5/2	5/4
M. elegans	102/25	..	..	..
M. sp.	..	8/3	..	..
Sciuravus nitidus	246/54	5/2	..	..
S. sp.	1/1	..	..	..
Sciuravid	..	..	..	2/2
Tillomys cf. *T. parvidens*	1/1	..	..	..
Taxymys lucaris	5/3	..	..	..
Knightomys cf. *K. senior*	..	1/1	..	..
K. sp.	..	3/2	..	..
Paramys delicatus	13/4	..	..	..
P. excavatus	..	..	..	1/1
P. near *P. excavatus*	1/1	8/2	..	..

TABLE 2. Summary of faunal composition at the four stratigraphic levels of fossil production within the New Fork–Big Sandy area. Numerator–Number of specimens; Denominator–Minimum number of individuals–*continued*

	Bridger Fm.	Cathedral Bluffs	Wasatch Fm. Arkosic Facies	Western Facies
P. group	60/16	5/3	3/3	1/1
P. wyomingensis	12/5	2/1	..	..
Reithroparamys huerfanensis	3/3	1/1	..	..
R. delicatissimus	3/3	1/1	..	..
R. near *R. delicatissimus*	..	1/1	..	..
Pseudotomus robustus	1/1	..	..	..
Microparamys minutus	7/2	..	..	..
M. sp. A.	3/2	..	..	..
M. sp. B.	3/1	..	..	..
Esthonyx acutidens	..	..	2/1	..
Stylinodontine		1/1	4/2	2/2
Bathyopsis fissidens	..	..	2/1	..
Coryphodon sp.	..	..	27/8	..
Hyopsodus miticulus	..	..	6/3	9/5
H. wortmani	..	..	3/2	1/1
H. minusculus	94/30	17/4	..	..
H. paulus	2/2	..	..	..
Meniscotherium chamense	..	..	21/7	30/14
M. robustum	..	..	2/2	6/5
Phenacodus vortmani	..	..	2/2	3/2
P. primaevus	..	..	..	1/1
P. sp.	..	..	..	1/1
Hyracotherium vasacciense	..	..	64/9	35/13

TABLE 2. Summary of faunal composition at the four stratigraphic levels of fossil production within the New Fork–Big Sandy area. Numerator–Number of specimens; Denominator–Minimum number of individuals–*continued*

	Bridger Fm.	Cathedral Bluffs	Wasatch Fm. Arkosic Facies	Western Facies
H. craspedotum	..	..	13/9	2/2
Orohippus cf. *O. pumilus*	13/8	2/1	..	..
Lambdotherium popoagicum	..	..	57/13	15/8
Eotitanops borealis	..	..	1/1	..
Palaeosyops fontinalis	2/2	..	..	..
Heptodon posticus	..	..	4/2	..
H. calciculus	..	..	5/2	1/1
Hyrachyus modestus	3/3	2/1	1/1	..
Tapiroid	1/1	..	..	..
Diacodexis cf. *D. secans*	1/1	..	2/2	3/3
Antiacodon pygmaeus	21/7	1/1	..	..
Microsus sp.	1/1	..	..	..
Helohyus cf. *H. plicodon*	2/2	..	..	..
Artiodactyl incertae sedis	1/1	..	..	..
TOTALS	772/259	66/30	241/88	129/77

SYSTEMATICS

The following is a discussion of the fossil mammals found in the New Fork-Big Sandy area. The locality data indicates the levels at which the particular specimens were found.

This discussion is not intended as a review and revision of the late Wasatchian and early Bridgerian faunas of the northern Green River Basin. Rather it is a presentation of fossil mammals recovered over a brief span of time from a restricted area. The intention is to delineate the faunas from the various levels which are used as evidence in the stratigraphic synthesis.

Measurements are presented for all specimens which are sufficiently complete. Coefficient of variation and standard deviation and their errors are computed when there are six or more specimens of a single tooth available. In cases of two to five specimens only the mean and observed range are recorded. Frequently it was impossible to distinguish between first and second molars; these are then tabulated in a separate column.

Article 36 of the International Code of Zoological Nomenclature is followed in determining authorship of the suprageneric names. Asterisks (*) alongside numbers in the lists of materials indicate specimens that are illustrated.

Abbreviations:

Museums

PM—Field Museum of Natural History, Chicago
UW—University of Wyoming, Laramie
AMNH—American Museum of Natural History, New York
USNM—U. S. National Museum, Washington

Standard abbreviations are used for tooth position and number
Measurements

Wtrig—width of lower molar across trigonid
Wtal—width of lower molar across talonid

N—number of specimens
OR—observed range
M—mean
V—coefficient of variation
SD—standard deviation

Order Marsupicarnivora
Superfamily Didelphoidea Gray, 1821
Family Didelphidae Gray, 1821
Peratherium Aymard, 1850

Peratherium sp. Plate Ia.

Material.—Fault: 1 UW 1538.*

Discussion.—One very large *Peratherium* M_3 was found at Fault locality. A specific reference to *P. comstocki*, a large Graybull didelphid, would be insecure because of possible differences in the upper molars. UW 1538, the largest *Peratherium* specimen in the study collection, is 3.7 mm. long, 2.1 mm. wide across the trigonid, and 2.3 mm. wide across the talonid.

Peratherium innominatum Simpson, 1938. Plate Ib, c, d.

Material.—Fault: 5 (Jaws: PM 15861, RP^3-M^2; PM 15862*, LM^3-M^4; PM 15320*, LM_1-M_2 or M_2-M_3), PM 15322, 15343.

Hawk: 1 (Jaw: PM 15866*, RM^1-M^2).

Discussion.—*Peratherium innominatum*, known from throughout the Bridgerian, is the smallest Eocene didelphid. Aside from its small size, it is comparable in detail to other didelphids.

TABLE 3. Measurements in millimeters of teeth of *Peratherium innominatum*.

		N	OR	M
P^3	L	1	1.2	
	W	1	0.7	
M^1	L	2	1.6–1.7	1.65
	W	2	1.4–1.6	1.5
M^2	L	1	1.7	
	W	2	1.5–1.7	1.6
M^3	L	1	1.4	
	W	1	1.7	
M^4	L	1	1.1	
	W	1	1.3	
M_2	L	1	1.7	
	Wtrig	1	1.0	
	Wtal	1	1.1	
	L	4	1.4–1.7	1.55
M_{1-3}	Wtrig	4	0.8–1.0	.92
	Wtal	3	0.9–1.0	.93

Peratherium cf. **P. marsupium** (Troxell, 1923). Plate Ie.

Material.—Fault: 8 (Jaws: PM 15864*, LM^2-M^4; PM 15865, RM^2-M^3), PM 15010, 15321, 15323, 15853, 15863, 21181.

Wash: 1 PM 15324.

Hawk: 1 PM 21124.

Discussion.—These ten specimens fall into a size range intermediate between *P. marsupium* and *P. knighti*. They are referred to Bridgerian *P. marsupium* for the following reasons: protoconule and metaconule of M^2 and M^3 are not well developed; although the stylar cusps are low, all five are present and definitive, whereas only three are present in *P. knighti;* and the size is somewhat closer to *P. marsupium* as measured by McGrew et al. (1959, p. 148).

TABLE 4. Measurements in millimeters of teeth of *Peratherium* cf. *P. marsupium.*

		N	OR	M	SD	V
M^2	L	3	2.0–2.5	2.3		
	W	3	2.1–2.7	2.47		
M^3	L	2	2.2–2.5	2.35		
	W	2	2.9			
M^{1-3}	L	6	2.2–2.5	2.38±.05	.12±.03	5.04±1.13
	W	3	2.0–3.0	2.47		
M_{1-3}	L	1	1.9			
	Wtrig	1	1.0			
	Wtal	1	1.2			

Order Insectivora

Suborder Proteutheria Romer, 1966

Superfamily Tupaioidea Gray, 1825

Family Leptictidae Gill, 1872

Subfamily Leptictinae Gill, 1872

Palaeictops Matthew, 1899

Palaeictops cf. **P. pineyenesis** (Gazin, 1952). Plate If.

Material.—East Fork Rim: 1 PM 15565.*

Discussion.—This single P_3 is similar to that of *P. pineyensis* from the LaBarge local fauna illustrated by Gazin (1962). The well-defined anterior capsule is characteristic, as are the overall size and elongate shape. *P. tauri-cinerei* (Jepsen, 1930, pp. 124–126, pl. III) also displays this morphology of P_3, but this species is much smaller than *P. pineyensis*. The size of PM 15565, 3.7 mm. long and 1.5 mm. wide, fits well with Guthrie's (1967, p. 11) measurements of Lysite *P. pineyensis*.

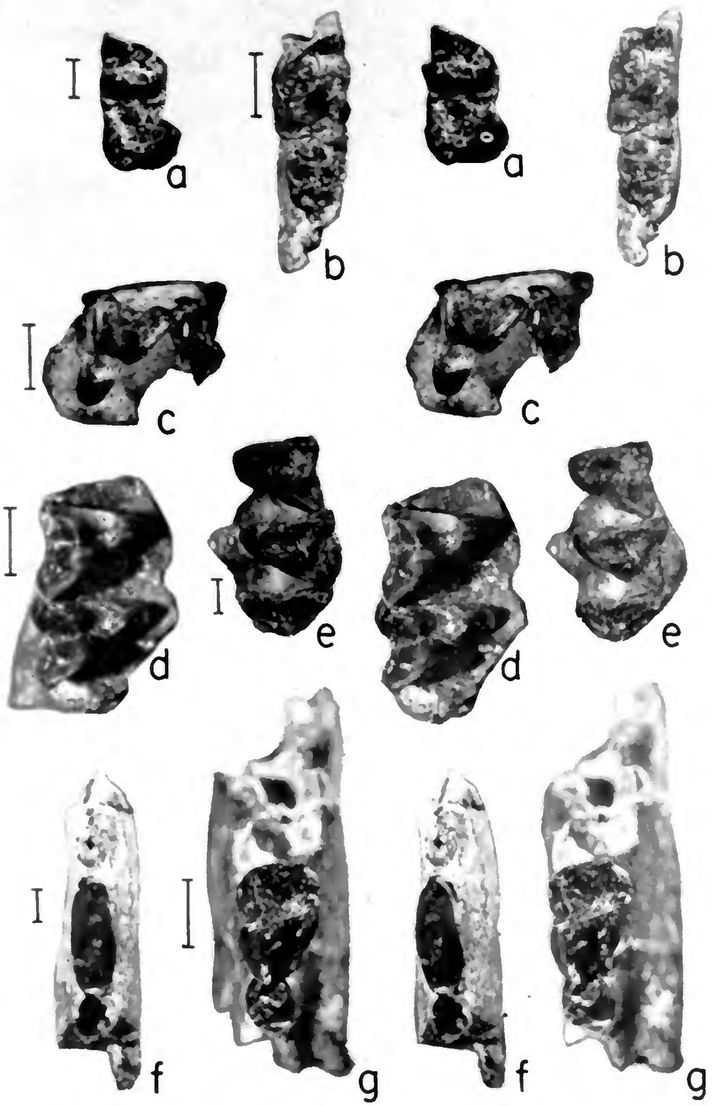


PLATE I. Marsupials and insectivores. All specimens illustrated as stereopairs. The line beside the left member of each pair represents 1 mm. **a.** *Peratherium* sp., UW 1538, RM_{1-3}. **b.** *Peratherium innominatum*, PM 15320, LM_{1-3}. **c.** *Peratherium innominatum*, PM 15862, LM^2-M^3. **d.** *Peratherium innominatum*, PM 15866, RM^1-M^2. **e.** *Peratherium marsupium*, PM 15864, LM^2-M^4. **f.** *Palaeictops* cf. *P. pineyensis*, PM 15565, LP_4. **g.** *Apatemys bellulus*, PM 15060, RM_1.

Superfamily Apatemyoidea Matthew, 1909

Family Apatemyidae Matthew, 1909

Until recently, many authors placed the Apatemyidae in the primates (summarized by McKenna, 1963, pp. 2–11). Jepsen (1934, p. 305) agreed with Matthew's (1909, pp. 543–544) suggestion that they belong in the Insectivora. Van Valen (1967) placed the Apatemyidae in the Proteutheria (named by Romer in 1966 after the discussion by McKenna, 1960a), as is done here, and Szalay (1968, pp. 24–25) remarked on certain parallelisms between apatemyids and prosimian primates. I am at present preparing a review of the Eocene members of this family.

Apatemys Marsh, 1872

Apatemys bellulus Marsh, 1872. Plate Ig.

Material.—Fault: 1 PM 15060.*

Discussion.—*Apatemys* is represented by this single jaw fragment referable to *A. bellulus*. M_1 is approximately the same size (L—1.8 mm., Wtrig—0.9 mm., Wtal—1.2 mm.) as the *A. bellulus* material tabulated by Robinson (1966, p. 37), although PM 15060 is slightly narrower. Breakage gives the trigonid a falsely triangular shape. The protoconid and metaconid are approximately equal in size. An elevated hypoconid is visible on the posteroexternal corner of the talonid marginal crest; the area of the entoconid is missing. P_4 is partially preserved, and is reduced and single rooted, as in referred specimens of *A. bellulus* (Matthew, 1909, pp. 544–545).

Suborder Erinaceota Van Valen, 1967

Superfamily Erinaceoidea Fischer von Waldheim, 1817

Family Adapisoricidae Schlosser, 1887

Van Valen (1967, p. 272) regarded this basal group of the Erinaceota as significantly different from the Erinaceidae, thus warranting a familial separation.

Subfamily Geolabidinae McKenna, 1960b

Centetodon Marsh, 1872

Centetodon cf. **C. pulcher** Marsh, 1872. Plate IIa.

Material.—Tree Road: 3 PM 15834-5, 15836.*

Discussion.—The overall form of the teeth, all lower fourth premolars, especially the single large cusp on the talonid, compares favorably with McKenna's (1960b, pp. 148–149) description of *Hypacodon praecursor*, synonymized with *Centetodon pulcher* by McKenna et al. (1962, p. 22). The type specimen is from an unknown level in the Bridger Formation. Several variations, primarily that these teeth are more antero-posteriorly shortened and the paraconid is higher than indicated in McKenna's illustrations, necessitate a tentative specific identification.

TABLE 5. Measurements in millimeters of P_4 of *Centetodon* cf. *C. pulcher*.

		N	OR	M
P_4	L	3	2.0–2.2	2.1
	Wtrig	3	1.1–1.3	1.2
	Wtal	3	1.1–1.2	1.17

Myolestes Matthew, 1909

Myolestes cf. **M. dasypelix** Matthew, 1909. Plate IIb.

Material.—Fault: 2 UW 1567, PM 15822.*

Discussion.—UW 1567 is slightly smaller than PM 15822, but both are in the size range of *M. dasypelix* (McKenna, 1960b, p. 147). *Myolestes* lower molars are characterized by a strong protoconid and metaconid, lingually directed paraconid ridge, and a strong hypoconid. The entoconid and hypoconulid are close together and are joined by a ridge. This species is known from throughout the Bridger Formation, and was reported from the Lost Cabin by Guthrie (1967).

TABLE 6. Measurements in millimeters of M_{1-2} of *Myolestes* cf. *M. dasypelix*.

		N	OR	M
M_{1-2}	L	2	1.3–1.5	1.4
	Wtrig	2	0.8–0.9	0.85
	Wtal	2	0.7–0.8	0.75

Subfamily Creotarsinae Hay, 1930

Scenopagus McKenna and Simpson, 1959

This genus was initially recognized by McKenna and Simpson in material collected at Tabernacle Butte and called *Scenopagus mcgrewi*. McGrew et al. (1959, pp. 148–151) had earlier referred a lower jaw to *Diacodon edenensis*. In 1962 McKenna et al. (pp. 26–27) referred *edenensis* to *Scenopagus*, with priority over *mcgrewi*. Since the initial discovery of this genus at Tabernacle Butte, Robinson

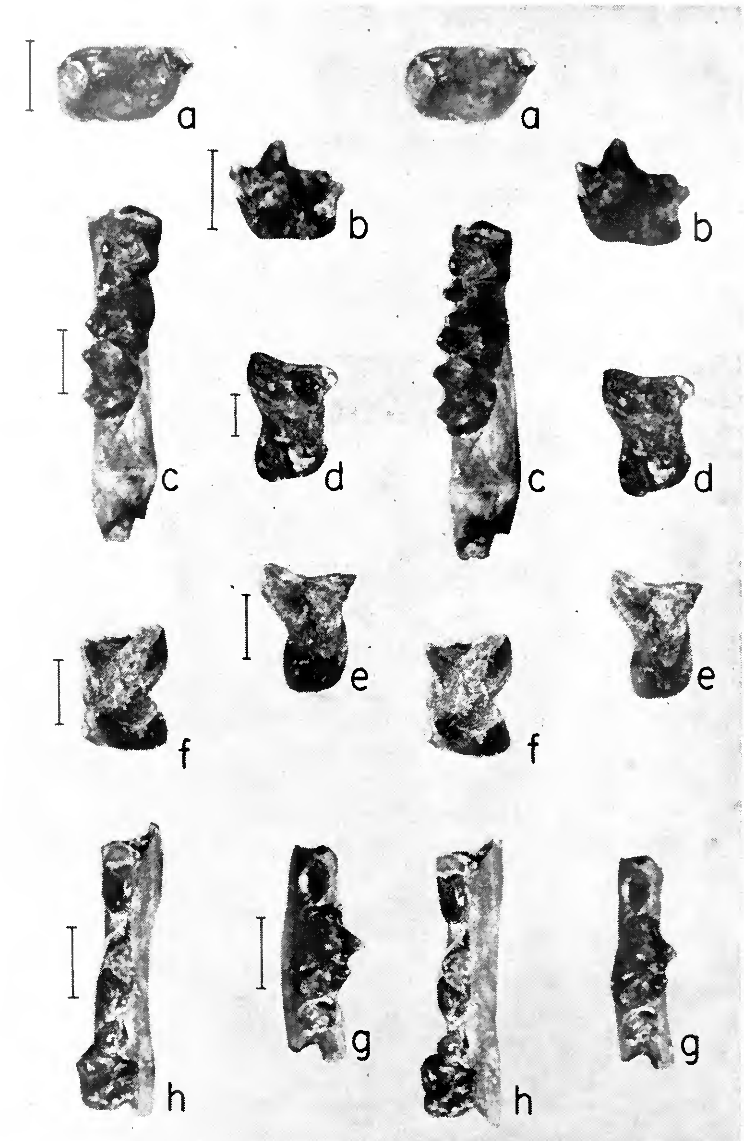


PLATE II. Insectivores. All specimens illustrated as stereopairs. The line beside the left member of each pair represents 1 mm. **a.** *Centetodon* cf. *C. pulcher*, PM15836, RP_4. **b.** *Myolestes* cf. *M. dasypelix*, PM 15822, LM_{1-2}. **c.** *Scenopagus edenensis*, PM 15067, RM_1-M_3. **d.** *Scenopagus edenensis*, PM 15846, RM^2. **e.** *Scenopagus priscus*, PM 15827, RM^2. **f.** Creotarsinae, incertae sedis, PM 15830, LM^{1-2}. **g.** *Nyctitherium* sp., PM 15810, LP_4. **h.** *Nyctitherium* sp., PM 15821, LP_2-P_4.

(1966) has reported it in the latest Wasatchian of the Huerfano Basin of Colorado, and Black (1967) from the late Eocene Badwater fauna of the Wind River Basin, as well as from the late Eocene Climbing Arrow Formation of southwestern Montana. It is by far the most abundant insectivore genus in the fauna from the lower Bridger Formation of the New Fork-Big Sandy area.

Scenopagus edenensis (McGrew, 1959). Plate IIc, d.

Material.—Fault: 24 (Jaws: PM 15052, RM_2-M_3; PM 15805, RM_1-M_2), UW 1513, PM 15053, 15058, 15064, 15070, 15088, 15807-9, 15811, 15813, 15817, 15819, 15825, 15828-9, 15831-2, 15841-3, 21179.

White Hills: 1 (Jaw: PM 15067*, RM_1-M_3).

Hawk: 1 PM 21180.

Tree Road: 1 PM 15830.

1375 #8: 1 PM 15846*.

Discussion.—Material here assigned to *Scenopagus edenensis* agrees well with that illustrated by McGraw (1959), McKenna and Simpson (1959), and Robinson (1966). This species, known to range through the Bridgerian, is the most common insectivore in the study collection.

TABLE 7. Measurements in millimeters and statistics of teeth of *Scenopagus edenensis*.

		N	OR	M	SD	V
P^3	L	1	1.6			
	W	1	1.3			
P^4	L	1	2.1			
	W	1	2.8			
M^1	L	1	2.3			
	W	1	2.7			
M^2	L	5	2.0–2.2	2.12		
	W	5	3.0–3.3	3.1		
M^{1-2}	L	1	2.0			
	W	1	2.9			
M^3	L	1	2.0			
	W	1	3.1			
M_1	L	4	2.3–2.4	2.35		
	Wtrig	5	1.5–1.6	1.54		
	Wtal	5	1.4–1.6	1.52		
M_2	L	6	2.1–2.4	2.23 ± .04	.10 ± .03	4.48 ± 1.29
	Wtrig	6	1.6–1.8	1.72 ± .32	.08 ± .22	4.50 ± 1.30
	Wtal	6	1.6–1.8	1.67 ± .32	.08 ± .22	4.64 ± 1.34
M_{1-2}	L	2	2.1–2.2	2.15		
	Wtrig	2	1.3–1.7	1.5		
	Wtal	2	1.4–1.5	1.45		
M_3	L	4	2.2–2.5	2.32		
	Wtrig	4	1.3–1.6	1.48		
	Wtal	4	1.3–1.6	1.45		

Scenopagus priscus (Marsh, 1872). Plate IIe.

Material.—Fault: 1 PM 15827*.

Discussion.—Robinson (1966, pp. 29–30) referred *Nyctitherium priscum* Marsh to *Scenopagus.* This is a smaller species than *S. edenensis,* with the same dental morphology, and like *S. edenensis,* ranges through the Bridgerian. The single specimen in the study collection, an M^2, is 1.5 mm. long and 2.0 mm. wide. Both species are represented by single specimens in the Huerfano collection, while *S. priscus* is obviously uncommon in the Bridger B collection from the New Fork-Big Sandy area.

Creotarsinae incertae sedis. Plate IIf.

Material.—Fault: 4 PM 15065, 15806, 15826, 15830*.

Discussion.—These four specimens may be assigned to either *Talpavus* or *Entomolestes.* These two genera are very similar to each other as well as to several other creotarsines. Robinson (McKenna et al., 1962) revived the genus *Talpavus* Marsh which had been included in *Nyctitherium* by Matthew in 1909, and considered *Talpavus* and *Nyctitherium* to belong to two different families (Robinson, 1968a, p. 4). *Entomolestes* is believed to be more advanced than *Talpavus* on the basis of its single-rooted anterior incisors (if *E. nitens* is included in *Scenopagus*). He also pointed out that the best distinction between these two genera for the purposes of identification is the expanded paraconid on the lower molars of *Entomolestes,* in contrast with the more narrow, compressed paraconid of *Talpavus.*

The indeterminate creotarsine molars in the study collection are about the same size as those of *Scenopagus priscus,* although the upper teeth are stouter. The hypocone is joined to the protocone anterobucally, and the conules are larger than in nyctitheres. The cingula are more strongly developed than in the closely related *Scenopagus.* The single lower molar, M_3 in PM 15065, is not definitive in the matter of paraconid development, so a positive identification is not possible.

TABLE 8. Measurements in millimeters of teeth of Creotarsinae, incertae sedis.

		N	OR	M
M^{1-2}	L	2	1.2–1.5	1.35
	W	1	1.9	
M_{1-2}	L	1	1.6	
	Wtrig	1	1.0	
	Wtal	1	0.9	
M_3	L	1	1.6	
	Wtrig	1	0.9	
	Wtal	1	0.7	

Family Nyctitheriidae Simpson, 1928

The status of this family is the current subject of intensive study. Robinson (1968b) believed that a reasonably coherent family can be assembled around *Nyctitherium*, and McKenna (1968), utilizing Robinson's unpublished conclusions, added the genus *Leptacodon* to the Nyctitheriidae. Van Valen (1967, p. 262) did not feel that the nyctitheres are so independent, and placed them as a subfamily of the Adapiscoricidae.

Nyctitherium Marsh, 1872

Nyctitherium sp. Plate IIg, h.

Material.—Fault: 5 PM 15810*, 15816, 15818, 15820, 15821*.

Discussion.—This poorly preserved material may be either of two Bridgerian species, *Nyctitherium serotinum* or *N. velox* (P. Robinson, pers. comm., 1968). Unfortunately, the poor quality of the material and the lack of adequate molars limits the accuracy of the identification.

Distinctive features of these specimens include double-rooted P_2 and P_3 in front of the complex P_4. The mental foramen is located below P_3 in three specimens, but seems to be located beneath P_4 in PM 15816, a specimen with a single badly fractured tooth which may not be part of this group.

P_4 has a trigonid with a low paraconid ridge in front of the high metaconid and protoconid. The talonid is rather distinctive, as the cristid obliqua is directed toward the posterior surface of the metaconid, making the area of the talonid basin quite small. Both entoconid and hypoconulid are present, and the individual talonid cones are not connected by a crest as in *Myolestes*.

Order Creodonta

Superfamily Palaeoryctoidea Simpson, 1931

Family Palaeoryctidae Simpson, 1931

Subfamily Didelphodontinae Matthew, 1918

Didelphodus Cope, 1882

Didelphodus altidens (Marsh, 1872). Plate IIIa.

Material.—Fault: 1 PM 15852*.

Discussion.—*Didelphodus altidens* is a long-ranging species, present from the Lost Cabin through the Bridgerian. It has primitive

TABLE 9. Measurements in millimeters of teeth of *Nyctitherium* sp.

		N	OR	M
P_3	L	1	1.1	
	W	1	0.5	
P_4	L	4	1.4–1.6	1.48
	Wtrig	3	0.7–0.9	0.8
	Wtal	4	0.7–0.9	0.83
M_1	L	1	1.4	
	Wtrig			
	Wtal	1	0.9	

upper molars, compressed anteroposteriorly, with a wide stylar shelf and a prominent ectoflexus separating the two stylar lobes. The single tooth present in the study collection, a RM^1, is in good condition except for a small missing area at the mesostyle. It is 3.4 mm. in length and 5.0 mm. in width.

Superfamily Oxyaenoidea Cope, 1877

Family Oxyaenidae Cope, 1877

Oxyaena Cope, 1874

Oxyaena forcipata Cope, 1874. Plate IIIb, c.

Material.—Steele Butte Breaks: 1 (Skull: PM 15081*, including $R\&LP^2$-M^2, $R\&LP_3$-M_2)

Discussion.—*Oxyaena forcipata* is a large species, well known through the Wasatchian (Denison, 1938, p. 169). Guthrie (1967, pp. 16–17) discussed the Wasatchian species of *Oxyaena*, and concluded that only *O. forcipata* was present in the Lysite and Lost Cabin faunas of Wyoming, and Robinson (1966, p. 47) recognized *O. lupina* in the late Wasatchian of the Huerfano Basin in Colorado. PM 15081 is considerably larger than the *O. forcipata* from the Lysite, as well as larger than the type specimen of *O. ultima* from the Lost Cabin Member. The M_1/M_2 length ratio criterion proposed by Denison (1938, p. 197) for *O. forcipata* ranges from .77 to .86; PM 15081 has a ratio of .81.

TABLE 10. Measurements in millimeters of teeth of *Oxyaena forcipata*, PM 15081.

	P_3		P_4		M_1		M_2	
	L	W	L	W	L	W	L	W
R	17.7	10.5	21.2	12.4	18.2	10.8	22.3	13.0
L	16.8	10.0	20.6	11.6	18.9	11.0	23.4	13.2

	P^2		P^3		P^4		M^1		M^2	
	L	W	L	W	L	W	L	W	L	W
R	13.8	9.3	21.9	14.6	22.6	21.5	23.8	18.2	18.9	8.1
L	13.5	9.4	21.1	15.2	22.9	21.5	26.5	17.4	19.0	6.0

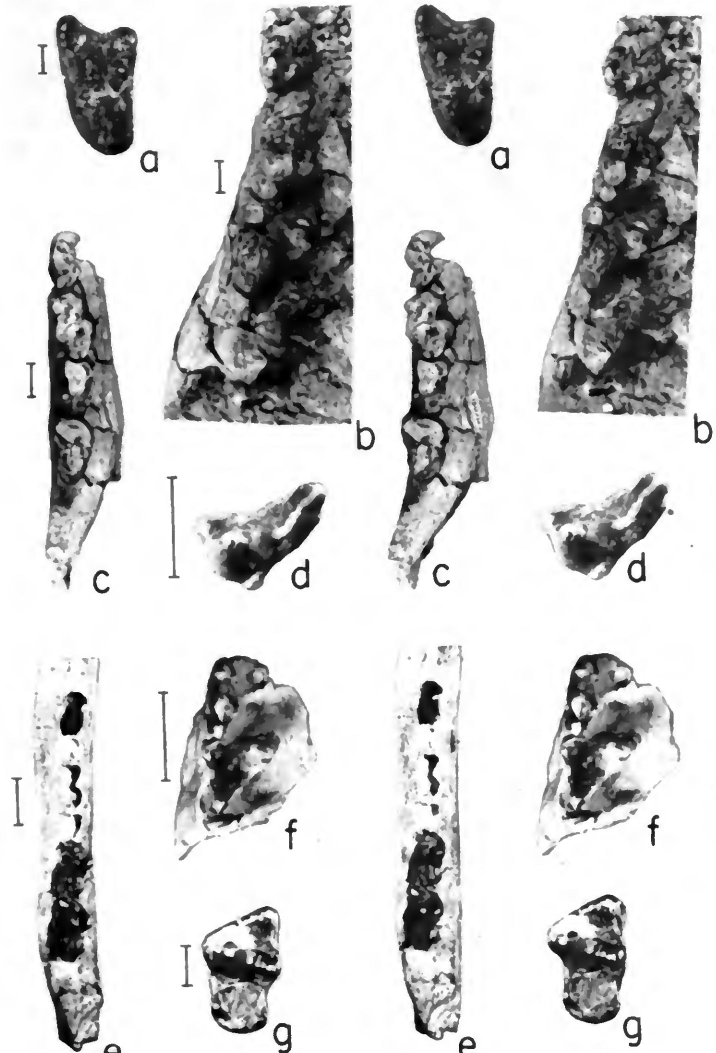


PLATE III. Creodonts and carnivores. All specimens illustrated as stereopairs. The line beside the left member of each pair serves as the scale: for **a**, the line represents the length of 1 mm.; for **b** and **c** it represents 10 mm.; and for **d** through **g** it represents 5 mm. **a**. *Didelphodus altidens*, PM 15852, RM^1. **b**. *Oxyaena forcipata*, PM 15081, RP$_3$-M$_2$. **c**. *Oxyaena forcipata*, PM 15081, RP^3-M^2. **d**. *Tritemnodon* sp., PM 15607, LM^2. **e**. *Thinocyon* cf. *T. velox*, PM 15858, RP$_2$M$_1$M$_2$ **f**. *Thinocyon* cf. *T. velox*, PM 15083, RP^4-M^1. **g**. *Didymictis altidens*, PM 15563, RM$_1$.

Oxyaena sp.

Material.—Steele Butte Breaks: 2 PM 15080, 15082.

Discussion.—Two specimens, both consisting only of premolars, are referable to *Oxyaena*, but they are considerably smaller than *O. forcipata*. Perhaps a smaller species, such as *O. lupina*, is present in the upper Wasatch fauna from the Green River Basin. Alternatively, these three specimens (including PM 15081) of *Oxyaena* may cover virtually the entire size range of a single variable species. Gazin has not reported any *Oxyaena* material from the New Fork Tongue; these specimens plus PM 15081 are the first record of upper Lost Cabin zone *Oxyaena* in the northern Green River Basin.

TABLE 11. Measurements in millimeters of teeth of *Oxyaena* sp.

		PM 15080		PM 15082
		R	L	
P^3	L	10.1	10.1	14.3
	W	6.8	6.9	10.9
P^4	L	14.0		17.1
	W	11.0		13.0

Oxyaenid

Material.—East Fork Rim: 1 PM 21228.

Discussion.—This partial P_3 is small for a late Wasatchian oxyaenid, too small for *Oxyaena*. It may belong to *Ambloctonus* (Matthew, 1915a, pp. 59–63; Denison, 1938, p. 191), but the material is inadequate for more than a suggestion of this assignment. The overall shape is indicative of *Ambloctonus*, as the talonid is broad, wider than the anterior portion of the tooth. This tooth is 11.4 mm. long and 8.5 mm. wide.

Family Hyaenodontidae Leidy, 1869

Subfamily Hyaenodontinae Leidy, 1869

Tribe Proviverrini Van Valen, 1966

Prototomus Cope, 1874

?**Prototomus** sp.

Material.—Steele Butte Breaks: 1 PM 15606.

Two Buttes: 1 PM 15624.

Discussion.—Van Valen (1965, p. 639) rejected the genus *Sinopa*, placing the various species in *Proviverra* Rutimeyer, *Prototomus* Cope, *Tritemnodon* Marsh, and the new genus *Arfia*. *Prototomus* is the most primitive genus and includes most of the Wasatchian species previously assigned to *Sinopa* (Matthew, 1915a, p. 72). *Prototomus* was regarded by Van Valen as the stem genus for the family Hyaenodontidae.

PM 15606 is a fragmental upper molar, resembling *Prototomus* in overall aspect. PM 15624 is a lower molar trigonid, possibly also of *Prototomus* by comparison with other, more complete specimens.

Proviverra Rütimeyer, 1862

?Proviverra sp.

Material.—Fault: 1 PM 15849.

Discussion.—This specimen is the labial portion of an upper molar, showing the external shelf, paracone, and metacone. These external cones are too far apart for *Prototomus*, and seem to fit the criteria for *Proviverra*, which has Bridgerian species. The specimen is so incomplete, however, that specific identification is impossible, and the generic assignment has to be tentative.

Tritemnodon Matthew, 1906

Tritemnodon sp. Plate IIId.

Material.—Steele Butte Breaks: 1 PM 15607*.

Blue Rim: 1 PM 15571.

Discussion.—The M^2 from Steele Butte Breaks is heavily worn and missing the protocone. Nonetheless, the large stylar shelf and the elongate metastyle, combined with the closely appressed metacone and paracone, are indicative of *Tritemnodon*. The specimen is close in size to late Wasatchian *T. agilis*, but is somewhat smaller. There is a heavy wear facet along the posterior metastyle-metacone crest.

Subfamily Limnocyoninae Wortman, 1902
Tribe Limnocyonini Wortman, 1902
Thinocyon Marsh, 1872

Thinocyon cf. **T. velox** Marsh, 1872. Plate IIIe, f.

Material.—Tree Road: 3 (Jaws: PM 15858*, RP_3, M_1-M_2; PM 15860, RP_4, M_1), PM 15859.

Little White Butte: 1 (Jaw: PM 15083*, RP^4-M^1).

Discussion.—The maxillary fragment (PM 15083) is referable to *Thinocyon velox,* the single lower Bridger Formation species discussed by Matthew. It is small compared with Matthew's (1909, p. 458) measurements, but a great deal of size variability is recognized in this species. The two lower jaws are quite different in size—PM 15860 is smaller than PM 15858, and fits well with Matthew's illustrated *T. velox.* The location of the mental foramen below P_3 can be seen in both of these specimens. The isolated molar trigonid, PM 15859, is assigned to this taxon because of its similarity to the M_2 trigonid on PM 15858.

TABLE 12. Measurements in millimeters of teeth of *Thinocyon* cf. *T. velox.*

		N	OR	M
P^4	L	1	4.1	
	W			
M^1	L	1	4.2	
	W	1	4.1	
P_1	L	1	2.6	
	W	1	1.1	
P_2	L	1	4.6	
	W			
M_1	L	2	5.3–6.4	5.85
	Wtrig	2	3.3–3.7	3.5
	Wtal	2	2.5–3.2	2.85
M_2	L	1	7.2	
	Wtrig	1	4.0	
	Wtal	1	3.0	

Order Carnivora

Suborder Fissipedia Blumenbach, 1871

Family Miacidae Cope, 1880

Subfamily Viverravinae Matthew, 1909

Didymictis Cope, 1875

Didymictis altidens Cope, 1880. Plates IIIg, IVa.

Material.—Steele Butte Breaks: 1 (Jaw: PM 15563*, R&LM_1-M_2).

East Fork Rim: 1 PM 15589.

Unnamed: 1 PM 15570*.

Two Buttes: 1 (Jaw fragments: PM 15572, LP_2-P_4, RP_2, P_4).

Discussion.—These four specimens represent a large species of *Didymictis.* It is likely that they are individuals of *Didymictis altidens,* a species which apparently increased in size through the later Wasatchian (Gazin, 1962, p. 57, found that *D. altidens* from

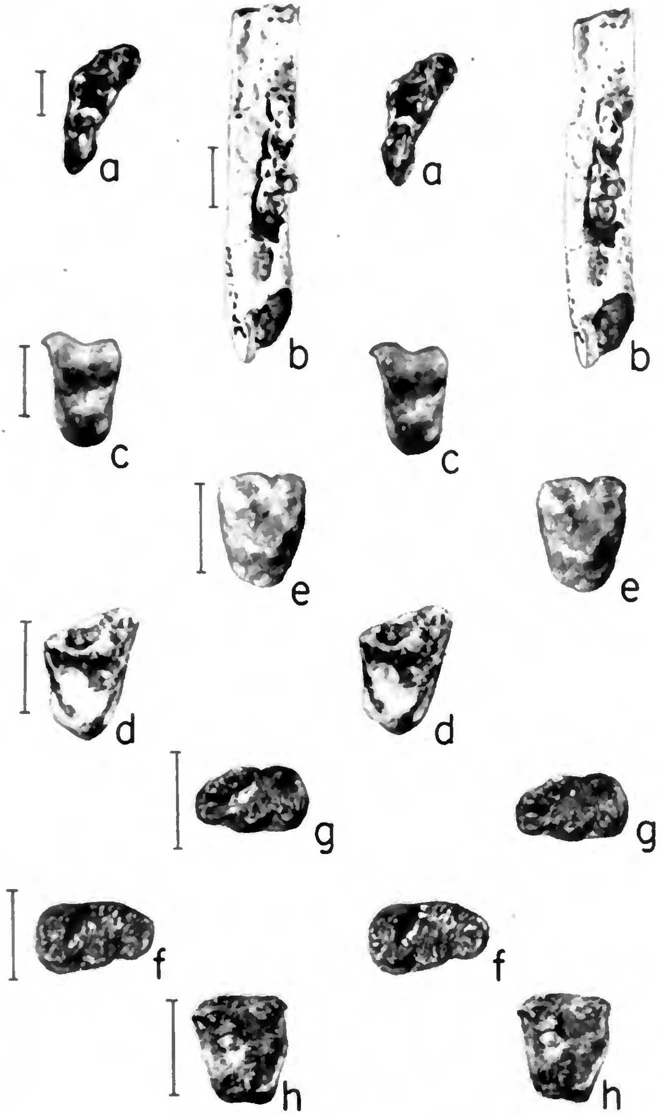


PLATE IV. Carnivores and primates. All specimens illustrated as stereopairs. The line beside the left member of each pair represents 5 mm. **a.** *Didymictis altidens*, PM 15570, LM^1. **b.** *Viverravus gracilis*, PM 15085, RP_4-M_1. **c.** *Miacis latidens*, PM 15566, LM^1. **d.** *Vulpavus* sp., PM 15564, RM^2. **e.** *Notharctus* cf. *N. nunienus*, PM 15541, RM^2. **f.** *Notharctus* cf. *N. nunienus*, PM 15547, LM_3. **g.** *Notharctus tenebrosus*, PM 15040, RM_3. **h.** *Smilodectes gracilis*, UW 1514, RM^1.

TABLE 13. Measurements in millimeters of teeth of *Didymictis altidens.*

		N	OR	M
P^4	L	1	16.9	
	W	1	11.4	
M^1	L	1	8.6	
	W	1	10.7	
P_2	L	1	9.6	
	W	1	4.0	
P_3	L	1	11.8	
	W	1	5.7	
P_4	L	1	16.0	
	W	1	7.5	
M_1	L	1	15.9	
	Wtrig	1	9.6	
	Wtal	1	8.2	
M_2	L	2	9.1–10.4	9.75
	Wtrig	2	5.8– 6.0	5.9
	Wtal	2	4.9– 5.6	5.25

the New Fork Tongue is significantly larger than that from the LaBarge horizon).

Viverravus Cope, 1872

Viverravus gracilis Cope, 1872. Plate IVb.

Material.—Fault: 2 (Jaw: PM 15086, RP_4-M_1) UW 1553.

Sandstone Point: 1 (Jaw PM 15085, RP_4-M_1).

Discussion.—PM 15085 shows alveoli for only one tooth behind M_1, suggesting that these specimens are *Viverravus* rather than *Didymictis.* The size corresponds well to *V. gracilis,* a relatively common Bridgerian species, as can be seen in the measurements presented by Robinson (1966, p. 50). The lower molars of *Viverravus* differ from those of *Didymictis* in the wide separation between the paraconid and metaconid in *Viverravus.*

TABLE 14. Measurements in millimeters of teeth of *Viverravus gracilis.*

		N	OR	M
P_4	L	2	5.0–5.2	5.1
	Wtrig	2	2.4–2.5	2.45
M_1	L	2	5.7–6.1	5.9
	Wtrig	2	3.1–3.3	3.2
	Wtal	2	2.5–2.8	2.65

Viverravus sp.

Material.—Fault: 1 PM 15854.

Discussion.—This single left P_4 is probably referable to *Viverravus,* although it is not *V. gracilis.* Although the tooth shows the same morphology as *V. gracilis,* it is somewhat shorter and much more slender, being 4.8 mm. long and 1.8 mm. wide. It is impossible to make a specific assignment on such material.

Subfamily Miacinae Trouessart, 1885

Miacis Cope, 1872

Miacis latidens Matthew, 1915. Plate IVc.

Material.—East Fork Rim: 2 PM 15566*, 15568.

Piney Cutoff: 1 PM 15629.

Discussion.—*Miacis latidens* is represented by two upper first molars from East Fork Rim, complete PM 15566 and fragmentary PM 15568. They show the typical extended parastyle, large paracone, and lack of hypocone. PM 15566 is 5.8 mm. long and 8.5 mm. wide. A third M^1, PM 15629, is a fragment including the paracone, metacone, and stylar area; it compares well with the other two specimens. *M. latidens* is a Lost Cabin species.

Vulpavus Marsh, 1871

Vulpavus sp. Plate IVd.

Material.—East Fork Rim: 1 PM 15564*.

Discussion.—This heavily worn M^2 appears most similar to *V. asius*, described by Gazin (1962, p. 60) from the New Fork Tongue. It has a narrow stylar shelf with an enlarged parastylar area. The parastyle is much larger than the metastyle, and a protoconule is present. A slight bulge on the postero-internal corner of the tooth may represent an incipient hypocone. The tooth is 5.5 mm. long and 7.6 mm. wide.

Order Primates

Suborder Prosimii Illiger, 1811

Superfamily Lemuroidea Gray, 1821

Family Adapidae Trouessart, 1879

There is some question as to whether the North American and European genera here included in the family Adapidae should be divided into two families, the Adapidae for the European genera and the Notharctidae for the North American genera. Gazin (1958, p. 31), argued for two families, and was hesitantly followed by McKenna (1967). I follow Simons (1963, p. 88), who placed all the genera in the single family Adapidae. Russell et al. (1967) considered the European early Eocene primate *Cantius* to be a notharctid, thus giving that family representatives on both sides of the North Atlantic. In all other respects they recognized two separate families.

Subfamily Notharctinae Trouessart, 1879

Notharctus Leidy, 1870

In 1957 Robinson reviewed middle Eocene *Notharctus* and delineated three basically size-determined species. In 1958 Gazin referred the smallest of Robinson's Bridgerian species to *Smilodectes gracilis,* leaving the larger species *N. tenebrosus* of the Bridger B (and possibly C and D) and *N. robustus* of the Bridger C and D as described by Robinson.

Notharctus cf. **N. nunienus** (Cope, 1881). Plate IVe, f.

Material.—Steele Butte Breaks: 1 PM 15544.

East Fork Rim: 3 PM 15546, 15547*, 15548.

Blue Rim: 2 PM 15537–8.

Two Buttes: 1 PM 15532.

Twnf-C: 1 PM 15541*.

Twnf-D: 1 PM 15573.

Discussion.—Comparison of the nine specimens listed above to Gazin's material (1962, p. 30) and the approximate measurements given by Granger and Gregory (1917, pp. 843–846) indicates that these specimens fall into the size range of *Notharctus nunienus,* a typical Lost Cabin species. The M_3, PM 15547, has the characteristic cristid obliqua conformation mentioned by Robinson (1957) for the Bridgerian species of *Notharctus.*

TABLE 15. Measurements in millimeters of teeth of *Notharctus* cf. *N. nunienus.*

		N	OR	M
P^4	L	1	3.2	
	W	1	4.3	
M^{1-2}	L	3	4.5–5.2	4.9
	W	3	5.3–6.9	6.23
	L	4	4.8–5.0	4.88
M_{1-2}	Wtrig	4	3.5–4.4	3.95
	Wtal	4	3.9–4.5	4.12
M_3	L	1	6.9	
	Wtrig	1	4.0	
	Wtal	1	3.8	

Notharctus tenebrosus Leidy, 1870. Plate IVg.

Material.—Fault: 8 UW 1734, PM 15040*, 15310, 15675, 15677, 15682, 15686, 15696.

Hawk: 1 PM 15712.

Wash: 1 PM 15327.

1375 #8: 1 PM 15746.

S½ sec. 20: 1 PM 15044.

Discussion.—*Notharctus tenebrosus* is the smaller of the two Bridgerian species placed in *Notharctus* by Gazin. Robinson mentioned differences other than size that distinguish *N. tenebrosus* from the *Smilodectus gracilis,* including the large hypoconid on P_3 and the cristid obliqua of M_3 joining a ridge extending backward from the protoconid. The two M_3's of *N. tenebrosus,* PM 15040 and UW 1734, show the characteristic hook in the cristid obliqua.

TABLE 16. Measurements in millimeters of teeth of *Notharctus tenebrosus.*

		N	OR	M
P^3	L	1	3.5	
	W	1	3.9	
M^3	L	2	5.3–5.7	5.5
	W	2	7.0–7.1	7.05
P_4	L	1	5.3	
	W	1	4.1	
M_1	L	1	6.2	
	Wtrig	1	4.3	
	Wtal	1	4.8	
M_{1-2}	L	5	5.8–6.4	6.0
	Wtrig	5	3.7–4.9	4.1
	Wtal	5	4.2–5.1	4.6
M_3	L	2	5.6–6.0	5.8
	Wtrig	2	3.3–3.4	3.35
	Wtal	2	3.1–3.6	3.35

Smilodectes Wortman, 1903

Smilodectes gracilis (Marsh, 1871). Plates IVh, Va.

Material.—Fault: 12 UW 1514*, 1527, 1541, 1548, 1570, PM 15005, 15062, 15256, 15329, 15335–6, 15697.

Hawk: 2 PM 15314, 15783.

Tree Road: 4 (Jaw: PM 15731, RP^2–P^4), PM 15737, 15740, 15743.

Wash: 1 PM 15326.

Little White Butte: 1 PM 15078.

1375 #8: 1 (Jaw: PM 15045, RM_1–M_3).

Jean's Quarry: 2 (Jaws: PM 15749*, LM_1–M_2; PM 15750, RP_2–P_4).

SW ¼ sec. 36: 1 PM 15752.

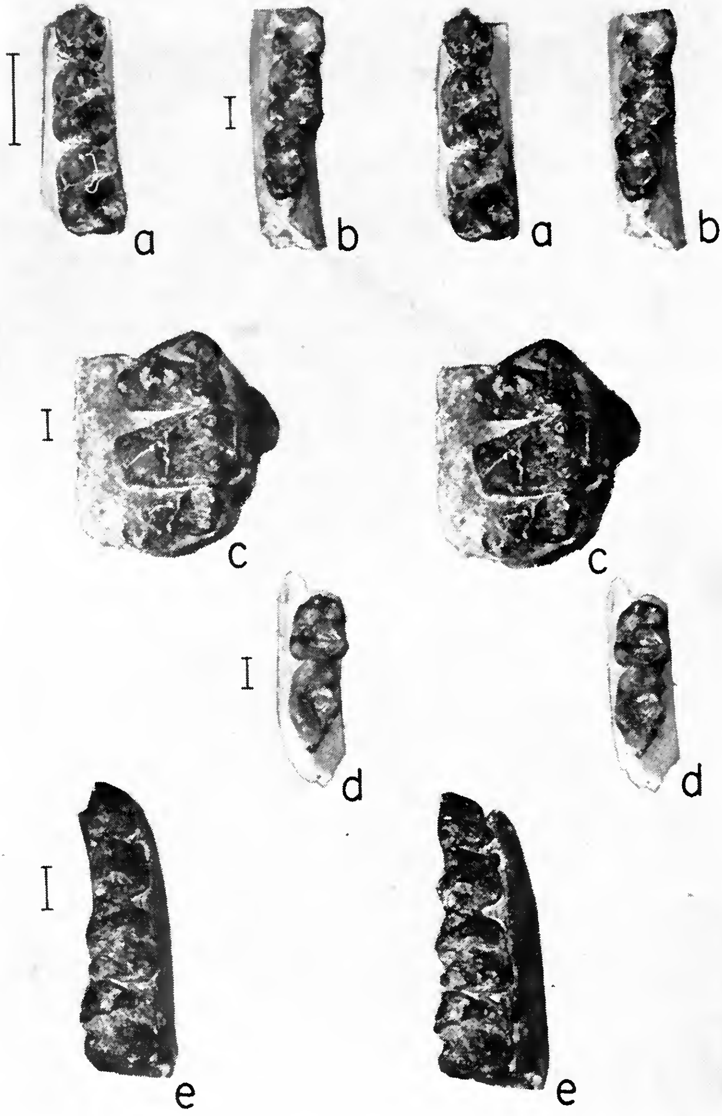


PLATE V. Primates. All specimens illustrated as stereopairs. The line beside the left member of each pair serves as the scale: for **a** the line represents 5 mm., and for **b** through **e** it represents 1 mm. **a.** *Smilodectes gracilis,* PM 15749, LM_1-M_2. **b.** *Omomys carteri,* UW 1320, RM_1-M_3. **c.** *Anaptomorphus aemulus,* PM 15661, LM^1-M^3. **d.** *Omomys* cf. *O. sheai,* PM 15337, RM_2-M_3. **e.** *Washakius insignis,* PM 15019, RP_3-M_2.

Discussion.—*Smilodectes gracilis*, common in the Bridgerian collection, is distinguished from the slightly larger *Notharctus tenebrosus* on the basis of size, rectangular shape of M^3, and configuration of the cristid obliqua on M_3. Gazin's 1958 discussion of the middle and upper Eocene primates considers cranial differences between the two genera; cranial material is lacking in the study collection and thus is not useful here. *Smilodectes gracilis* is typical of the Bridger B, and is rare in the upper Bridger beds (P. Robinson, pers. comm., Dec. 20, 1968).

TABLE 17. Measurements in millimeters and statistics of teeth of *Smilodectes gracilis*.

		N	OR	M	SD	V
P^3	L	5	2.5–2.8	2.58		
	W	5	2.7–3.5	2.98		
P^4	L	3	2.5–3.1	2.7		
	W	3	2.2–3.8	3.17		
M^{1-2}	L	2	4.3–4.7	4.5		
	W	2	5.3–6.0	5.65		
M^3	L	3	3.5–4.0	3.73		
	W	3	4.0–5.1	4.67		
P_2	L	1	1.9			
	W	1	1.3			
P_3	L	1	2.5			
	W	1	1.9			
P_4	L	2	2.8			
	W	2	2.1–2.3	2.2		
M_1	L	1	4.6			
	Wtrig	1	3.0			
	Wtal	1	3.3			
M_2	L	2	4.7–5.0	4.85		
	Wtrig	2	3.2–3.7	3.45		
	Wtal	2	3.5–3.9	3.7		
M_{1-2}	L	6	4.8–5.4	5.07 ± .10	.24 ± .05	4.83 ± 1.08
	Wtrig	6	2.1–4.2	3.45 ± .32	.79 ± .18	22.90 ± 5.12
	Wtal	6	3.2–4.4	3.83 ± .18	.42 ± .09	11.22 ± 2.51
M_3	L	1	6.0			
	Wtrig	1	3.1			
	Wtal	2	2.8–3.1	2.95		

Superfamily Omomyoidea Trouessart, 1879
Family Omomyidae Trouessart, 1879
Omomys Leidy, 1869

Omomys carteri Leidy, 1869. Plate Vb.

Material.—Fault: 25 (Jaws: UW 1320*, RM_2–M_3; UW 1518, RP_3–M_1), UW 1565, PM 15001–2, 15009, 15011, 15022, 15024, 15026, 15028, 15032, 15034, 15663–4, 15669, 15673, 15678–9, 15689, 15692, 15699–700, 15759, 15805.

White Hills: 1 PM 15299.

Hawk: 4 PM 15713–5, 15719.

Tree Road: 4 PM 15724–5, 15736, 15745.

Wash: 2 PM 15721–2.

Green: 7 (Jaw: PM 15641, RP_3–P_4), PM 15531, 15637–8, 15640, 15643, 15645.

Discussion.—*Omomys carteri* is a common Bridgerian species, with generalized, variable teeth. Weak conules and a lack of a mesostyle characterize the upper molars, although a small mesostyle bulge is infrequently present. The two-rooted, elongate P_3 and P_4 are present in UW 1518. The lower molars are simple teeth with prominent paraconids and deeply basined talonids.

In 1958 Gazin named *O. lloydi* on material from the Powder Wash locality in the Green River Formation of the Uinta Basin. The basic differences between *O. lloydi* and *O. carteri* are absolute size and relative size of M_3. Some specimens of *O. carteri* from the New Fork-Big Sandy area are small enough to be in the *O. lloydi* size range, but there is no indication in the size-frequency distribution that two different species are present.

TABLE 18. Measurements in millimeters and statistics of teeth of *Omomys carteri*.

		N	OR	M	SD	V
P^4	L	3	1.9–2.2	2.1		
	W	3	2.5–3.3	2.97		
M^1	L	7	2.5–3.2	2.64±.10	.26±.07	9.81±2.62
	W	4	3.1–3.3	3.25		
M^2	L	2	2.2–2.6	2.4		
	W	2	3.4–4.1	3.75		
M^3	L	4	1.6–2.2	1.9		
	W	4	2.5–3.3	2.95		
P_3	L	3	1.4–2.2	1.93		
	W	3	1.3–1.5	1.4		
P_4	L	8	2.1–3.0	2.61±.11	.32±.08	12.18±3.04
	Wtrig	8	1.7–2.1	1.91±.06	.18±.04	9.58±2.40
	Wtal	2	1.9–2.2	2.05		
M_1	L	5	2.4–2.6	2.5		
	Wtrig	6	1.5–1.9	1.72±.07	.18±.05	10.70±3.09
	Wtal	6	1.6–2.3	1.87±.10	.24±.07	12.89±3.72
M_2	L	12	2.1–2.7	2.45±.05	.17±.03	7.07±1.44
	Wtrig	12	1.7–2.1	1.88±.04	.15±.03	7.87±1.61
	Wtal	12	1.8–2.2	2.04±.03	.11±.02	5.37±1.10
M_3	L	4	2.5–2.8	2.72		
	Wtrig	4	1.5–1.9	1.68		
	Wtal	4	1.5–1.8	1.65		

Omomys cf. **O. carteri** Leidy, 1869

Material.—Hawk: 1 (Jaw: PM 15710, LM^1–M^2).

West of Cone: 1 (Jaw: PM 15084, RM^1–M^3).

Discussion.—One badly broken maxillary fragment from the West of Cone locality and a better one from Hawk probably can be referred to *O. carteri.* The buccal sides of all the teeth on PM 15084 are missing, but the lingual parts show the poorly developed cuspules and internal cingulum of *O. carteri.* This individual seems small, but with such a large portion of each tooth missing it is difficult to determine the original size of the teeth.

The molars of PM 15710 are relatively large, in contrast to most individuals of *O. carteri,* in which both M^1 and M^3 are relatively smaller than M^2. However, with the great amount of variations observed in *Omomys,* it is likely that this specimen also belongs in *O. carteri.*

TABLE 19. Measurements in millimeters of teeth of *Omomys* cf. *O. carteri.*

		N	OR	M
M^1	L	2	1.8–2.1	1.95
	W	2	2.3–3.0	2.65
M^2	L	2	1.7–1.9	1.8
	W	2	2.7–3.1	2.9
M^3	L	1	1.3	
	W	1	2.1	

Omomys cf. O. sheai Gazin, 1962. Plate Vd.

Material.—Blue Rim: 1 (Jaw PM 15536*, RM_2–M_3).

Discussion.—In 1962 (pp. 31–32) Gazin described a new species, *Omomys sheai,* from the LaBarge local fauna. *O. sheai* is smaller than the common Bridgerian *O. carteri* (especially in M_2), and is larger than the Lysite species *O. minutus.* Gazin's single specimen, USNM 22384, shows a long M_3 relative to M_2. PM 15536 shows this relationship of M_3 to M_2, as well as the slight basining of the trigonid mentioned by Gazin. An anterior shelf, possibly homologous to the normal paralophid, is present on the lower molars of PM 15536. A slight crest is also developed posterior to this, in the normal position of the paralophid. This crest extends forward from the anterior face of the paraconid before curving toward the protoconid, so it makes up a larger proportion of the trigonid than in *O. carteri.*

TABLE 20. Measurements in millimeters of teeth of PM 15536 *Omomys* cf. *O. sheai.*

	M_2	M_3
Length	2.2	2.8
Width trigonid	1.7	1.5
Width talonid	1.9	1.7

Washakius Leidy, 1873

Washakius insignis Leidy, 1873. Plates Ve, VIa.

Material.—Fault:14 (Jaws: PM 15019*, RP_3–M_2; PM 15027*, LP^3–M^3; PM 15055, RM_1–M_2; PM 15057, RP^2–P^3; PM 15687, RP_3–P_4), UW 1533, PM 15004, 15036–9, 15061, 15670, 15674.

White Hills: 3 PM 15068, 15703, 15707.

Hawk: 1 PM 15072.

Discussion.—Several dental specializations give *Washakius* a distinctive appearance, although it is closely related to *Omomys*. The upper dentition of *Washakius insignis* is characterized by enlarged protoconules and metaconules on the molars, as well as prominent hypocones developed on the posterointernal cingula. PM 15038 shows another distinctive feature of *Washakius*, the twinned metaconule. P_3 and P_4 have antero- and posterolingual crests from the primary cusp. The paraconid of M_1 is lingual in position, and all the lower molars show development of a metastylid on the posterior slope of the metaconid. M_3 has an anteroposteriorly compressed trigonid and a very large hypoconulid.

TABLE 21. Measurements in millimeters of teeth of *Washakius insignis*.

		N	OR	M
P^3	L	3	1.7–1.9	1.8
	W	3	2.1–2.2	2.17
P^4	L	3	1.8–2.0	1.87
	W	3	2.3–2.5	2.43
M^1	L	2	2.2–2.9	2.55
	W	2	2.1–3.0	2.55
M^2	L	2	2.1	
	W	2	3.2–3.4	3.3
M^{1-2}	L	1	2.1	
	W	1	2.7	
M^3	L	1	1.8	
	W	1	2.8	
P_3	L	2	1.5	
	W	2	1.3	
P_4	L	3	1.7–2.1	1.87
	W	3	1.6–1.8	1.67
M_1	L	3	2.1–2.2	2.13
	Wtrig	3	1.6–1.8	1.7
	Wtal	3	1.8–2.0	1.87
M_2	L	5	2.1–2.4	2.22
	Wtrig	5	1.8–1.9	1.88
	Wtal	5	1.8–2.0	1.94
M_{1-2}	L	1	2.3	
	Wtrig	1	1.6	
	Wtal	1	1.8	
M_3	L	1	3.0	
	Wtrig	1	1.6	
	Wtal	1	1.8	

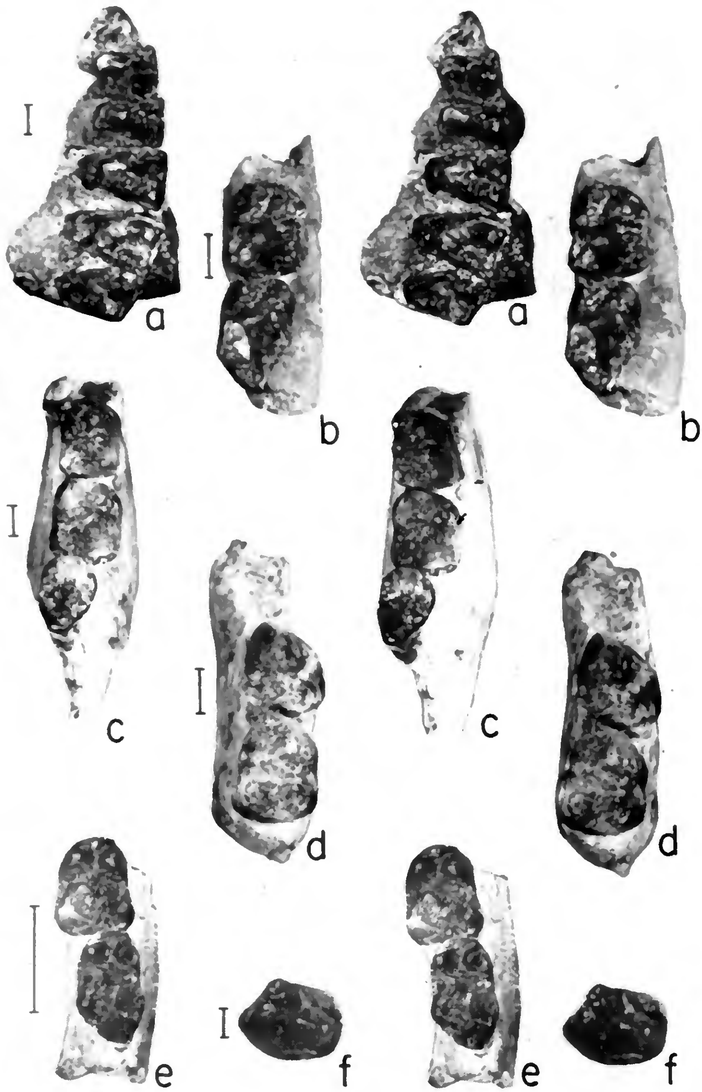


PLATE VI. Primates. All specimens illustrated as stereopairs. The line beside the left member of each pair serves as the scale: for **a** through **d** and **f** the line represents 1 mm.; for **e** it represents 5 mm. **a.** *Washakius insignis*, PM 15027, LP^3-M^3. **b.** *Washakius* near *W. insignis*, PM 15551, RM_2-M_3. **c.** *Anaptomorphus aemulus*, PM 15041, RM^1-M^2. **d.** *Anaptomorphus aemulus*, PM 15684, RP_4-M_1. **e.** *Microsyops scottianus*, PM 15535, LM_3-M_3. **f.** *Microsyops scottianus*, PM 15539, LP_4.

Washakius, near **W. insignis** Leidy, 1873. Plate VIb.

Material.—East Fork Rim: 1 (Jaw: PM 15551*, RM_2–M_3).

Discussion.—One specimen of *Washakius*, similar in size to *W. insignis*, has been recovered from the arkosic facies of the New Fork Tongue. In both M_2 and M_3 there is greater fusion of paraconid and metaconid than in molars of Bridgerian *W. insignis*, and the trigonid basin opens forward more prominently. The hypoconulid is slightly lower in M_2, and in M_3 it is narrower than in the Bridgerian specimens. However, these differences are minor in the face of many similarities, so it seems reasonable to refer PM 15551 to *Washakius insignis*, and extend its range back to the late Wasatchian.

TABLE 22. Measurements in millimeters of teeth of *Washakius* near *W. insignis*, PM 15551.

	M_2	M_3
Length	2.1	2.6
Width trigonid	1.8	1.7
Width talonid	1.9	1.7

Family Anaptomorphidae Cope, 1883

Subfamily Anaptomorphinae Cope, 1883

Anaptomorphus Cope, 1872

Anaptomorphus aemulus Cope, 1872. Plates Vc, VIc, d.

Material.—Fault: 2 (Jaws: PM 15684*, RP_4–M_2; PM 15661*, LM^1–M^3).

Hawk: 2 (Jaw: PM 15041*, RM_1–M_3), PM 15717.

Tree Road: 2 (Jaw: PM 15739, LM_2–M_3), PM 15735.

Wash: 1 PM 15043.

Green: 1 PM 15882.

Discussion.—The eight specimens of *Anaptomorphus aemulus* are a large assemblage of this uncommon early Bridgerian species. Gazin, at the writing of his 1958 paper on the middle and upper Eocene primates, knew of only the type specimen; Szalay has additional material which will be included in his review of the Eocene prosimii.

M_1 and M_2 are characterized as omomyid-like (Gazin 1958, pp. 74–75), but with a less well-defined paraconid on M_2, short and poorly excavated talonid basins, and a generally rather bulbous appearance. P_4 is short and broad, standing considerably higher than the trigonid of M_1 and showing antero- and posterointernal crests off the main cusp as in *Omomys*.

M_3 is considerably narrower than M_2 and about as long. A paraconid bulge is present, joined to the metaconid, and slightly more medial. The protoconid is not connected by a crest to either internal conid. There is no trigonid basin. The anterior end of the trigoid is a flat shelf and the posterior end opens into the talonid basin. The small entoconid is connected to the hypoconulid. The hypoconulid, though small, is larger than the entoconid and is not extended into a true heel.

PM 15661, M^1–M^3, is referred to *A. aemulus* (Szalay, pers. comm., 1970), and is the first record of upper molars for the species. M^1 is smaller than M^2, and both have a prominent, cuspless, external cingular shelf. Low bulbous conules lie between the protocone and the paracone and metacone. The protocone is large, and on M^2 sends a strong crest anteroexternally toward the anterior cingulum. There is no hypocone on any of the molars. M^3 is small with a much narrower cingular shelf than in the anterior molars. While M^1 and M^2 are almost rectangular in outline, M^3 is distinctly triangular.

TABLE 23. Measurements in millimeters of teeth of *Anaptomorphus aemulus*.

		N	OR	M
P_4	L	1	2.2	
	Wtrig	1	2.2	
	Wtal	1	2.0	
M_1	L	5	2.5–2.8	2.6
	Wtrig	5	1.9–2.2	2.08
	Wtal	5	2.3–2.6	2.4
M_2	L	2	2.7	
	Wtrig	3	2.0–2.3	2.17
	Wtal	3	2.0–2.5	2.3
M_3	L	2	2.6–2.8	2.7
	Wtrig	1	1.9	
	Wtal	1	1.7	

Family Microsyopidae Osborn and Wortman, 1892

McKenna (1960a, pp. 76–79) revived the family Microsyopidae to include *Cynodontomys*, *Microsyops*, and *Craseops* of North America, genera frequently previously included in the insectivore family Mixodectidae. Szalay (1969) reviewed the Microsyopidae, and presented a summary (pp. 310–311) of the evidence for the primate affinities of the Microsyopidae.

Microsyops Leidy, 1872

Microsyops includes what were formerly the separate genera *Cynodontomys* and *Microsyops* (Szalay, 1968, p. 26; 1969, pp. 248–249).

They had long been recognized as two parts of a continuum, with the generic boundary drawn essentially at the temporal boundary between the Wasatchian and Bridgerian zones. I follow Szalay in recognizing the Wasatchian and Bridgerian species as representatives of a single long-lived genus.

Microsyops cf. **M. scottianus** (Cope, 1881). Plate VIe, f.

Material.—Steele Butte Breaks: 3 (Jaw: PM 15545, RM_2–M_3), PM 15603–4.

East Fork Rim: 2 PM 15550, 15555.

Blue Rim: 2 (Jaw: PM 15535*, LM_2–M_3), PM 15539*.

Unnamed: 1 PM 15561.

Two Buttes: 1 PM 15558.

Twnf-H: 1 PM 15540.

Discussion.—One species of *Microsyops* is present at six of the upper Wasatch localities. This material is near the size range of both *M. scottianus* and *M. latidens*. The single P_4 present in the study collection, PM 15539, is primitive and somewhat similar to *M. latidens*. However, because of the overall robustness of the teeth I feel it is better to refer these specimens to *Microsyops* cf. *M. scottianus*, a common element in middle and late Wasatchian faunas.

Microsyops elegans (Marsh, 1871). Plate VIIa, b.

Material.—Fault: 65 (Jaws: UW 1555, RM_2–M_3; PM 15654, LP^3–P^4; PM 15660*, RM^2–M^3; PM 15662, LP^3–P^4), UW P2, P3, 1510, 1517, 1522, 1524, 1529, 1530, 1535, 1544, 1551, 1557–8, 1560, 1719, 1723, 1726, 1739, PM 15003, 15006–7, 15013–8, 15023, 15025, 15030–1, 15033, 15035, 15051, 15063, 15074–6, 15087, 15331, 15334, 15338, 15656, 15658, 15665–8, 15671–2, 15681, 15683, 15685, 15688, 15690, 15695, 15698, 15756–7, 15840, 15949.

White Hills: 9 PM 15046–9, 15066, 15704–5, 15708, 21083.

Hawk: 6 (Jaw: PM 15718, RP_3–P_4), PM 15071, 15073, 15709, 15716, 15720.

Tree Road: 15 (Jaw: PM 15730*, LP^4–M^1), PM 15723, 15726–9, 15733–4, 15738, 15741–2, 15744, 15797, 21129, 21161.

Wash: 1 PM 21226.

Little White Butte: 3 PM 15042, 15069, 15077.

1375 #8: 1 PM 15747.

Jean's Quarry: 1 PM 15751.

TABLE 24. Measurements in millimeters of teeth of *Microsyops scottianus*

		N	OR	M
M^1	L	3	3.8–4.8	4.27
	W	3	4.4–5.4	4.9
M^3	L	1	4.0	
	W	1	5.0	
P_4	L	1	3.9	
	Wtrig	1	2.7	
	Wtal	1	2.9	
M_2	L	3	3.9–4.2	4.03
	Wtrig	3	2.5–3.1	2.77
	Wtal	3	2.9–3.7	3.2
	L	2	4.6–5.1	4.85
M_3	Wtrig	2	2.6–2.9	2.75
	Wtal	2	3.0–3.1	3.05

Sandstone Point: 1 PM 21225.

Discussion.—This is the most abundant primate in the study collection. The fourth premolars of *Microsyops elegans*, both upper and lower, are smaller and slightly more molariform than those of *M. scottianus*. The two external cusps of P^4 are equal in height, and the protoconid and metaconid are equal in P_4 of *M. elegans*. The talonid is characterized by the proximity of the entoconid and hypoconulid. The canines are distinctive blade-like teeth with minor marginal serrations. *M. elegans* is a common early Bridgerian species.

TABLE 25. Measurements in millimeters and statistics of teeth of *Microsyops elegans*.

		N	OR	M	SD	V
P^3	L	1	3.0			
	W	2	2.7–2.9	2.8		
P^4	L	12	2.8–3.7	3.4 ±.08	.29±.06	8.59±1.75
	W	12	3.0–4.0	3.72±.08	.27±.06	7.36±1.50
M^1	L	19	3.2–4.1	3.63±.06	.24±.04	6.70±1.09
	W	19	3.2–4.7	4.28±.08	.36±.06	8.36±1.36
M^2	L	8	3.5–4.5	3.92±.13	.38±.10	9.64±2.41
	W	8	4.3–5.7	4.79±.17	.49±.12	10.15±2.54
M^{1-2}	L	1	4.2			
	W	1	5.0			
M^3	L	8	2.8–3.8	3.31±.11	.32±.08	9.52±2.38
	W	8	3.2–4.8	3.85±.16	.46±.12	11.97±2.99
P_3	L	1	2.0			
	W	1	1.6			
P_4	L	10	3.0–3.7	3.47±.06	.20±.04	5.76±1.29
	Wtrig	9	1.8–2.6	2.23±.08	.25±.06	11.16±2.63
	Wtal	10	1.9–2.5	2.34±.05	.17±.04	7.31±1.64
M_1	L	16	3.2–4.0	3.71±.06	.24±.04	6.37±1.12
	Wtrig	13	2.2–2.7	2.41±.05	.17±.03	7.10±1.39
	Wtal	16	2.3–3.2	2.79±.06	.26±.04	9.14±1.61
M_2	L	13	3.4–4.0	3.70±.06	.20±.04	5.51±1.08
	Wtrig	13	2.1–2.7	2.35±.07	.24±.05	10.05±1.97
	Wtal	13	2.3–3.0	2.72±.06	.23±.04	8.61±1.69
M_3	L	3	4.2–4.3	4.23		
	Wtrig	2	2.3–2.4	2.35		
	Wtal	3	2.7			

Microsyops sp. Plate VIIc, d.

Material.—Green: 8 PM 15636, 15639, 15644*, 15646, 15647*, 15648, 21217, 21221.

Discussion.—These specimens represent a robust species of *Microsyops,* considerably larger than either *M.* cf. *M. scottianus* of the late Wasatchian fauna or *M. elegans* of the early Bridgerian fauna. Szalay (1969, pp. 263–267) discussed the very large late Wasatchian species *M. lundeliusi;* this species is probably too large to include the material from the Cathedral Bluffs Tongue.

TABLE 26. Measurements in millimeters of teeth of *Microsyops* sp.

	P^4		M^1		M^2		P_4			M_3		
	L	W	L	W	L	W	L	Wtrig	Wtal	L	Wtrig	Wtal
N	1	1	1	1	1	1	1	1	1	1	1	1
OR	3.9	4.3	4.0	4.2	3.8	4.3	4.4	2.2	3.4	5.2	3.1	3.2

The P^4 metacone and paracone are not equal in height, a feature of *M. scottianus.* P_4 has a nearly equal protoconid and metaconid, similar to *M. elegans.* It is possible that these teeth belong to two or more taxa, although this is unlikely. It is difficult to tell whether this represents a distinct species of *Microsyops,* a large variant of *M. scottianus,* or a very large variant of *M. elegans.*

Order Rodentia
Suborder Protrogomorpha Zittel, 1893
Superfamily Ischyromyoidea Wood, 1937
Family Sciuravidae Miller and Gidley, 1918
Sciuravus Marsh, 1871

Sciuravus nitidus Marsh, 1871. Plate VIIe, f.

Material.—Fault: 147 (Jaws: UW P4, RP^4–M^1; UW P5, RP^4–M^2; UW 1325, LM_2–M_3; UW 1511, RP^4–M^1; UW 1571, RP^4–M^1; UW 1575, RP^4–M^2; UW 1576, LP^3–P^4; UW 1548, RP^4–M^1; UW 1585, RP^4–M^1; PM 15094, RM^2–M^3; PM 15110, LM_2–M_3; PM 15910, LM_1–M_2; PM 15912, RP^3–M^1; PM 15921, RM_1–M_2; PM 21049, RP^4–M^3; PM 21051, RM_2–M_3; PM 21062, RM_1–M_2, PM 21064, LP^3–P^4), UW P6–8, 1326–7, 1335–6, 1338, 1509, 1512, 1546, 1568, 1572–4, 1581, 1587, PM 15090–3, 15095, 15096–8, 15100–9, 15111–8, 15120, 15122, 15124–8, 15130–3, 15136, 15140–3, 15145, 15150, 15900, 15902–5, 15907–8, 15911, 15913–5, 15919–20, 15923–33, 15937, 15939–43, 15945–8, 15950–1, 15953–5, 15957–8, 15961–4, 15969–70, 15972–3, 15976–9, 21043, 21048, 21052a, 21053, 21056, 21058–9, 21061, 21065–6, 21068, 21196–7, 21198, 21200.

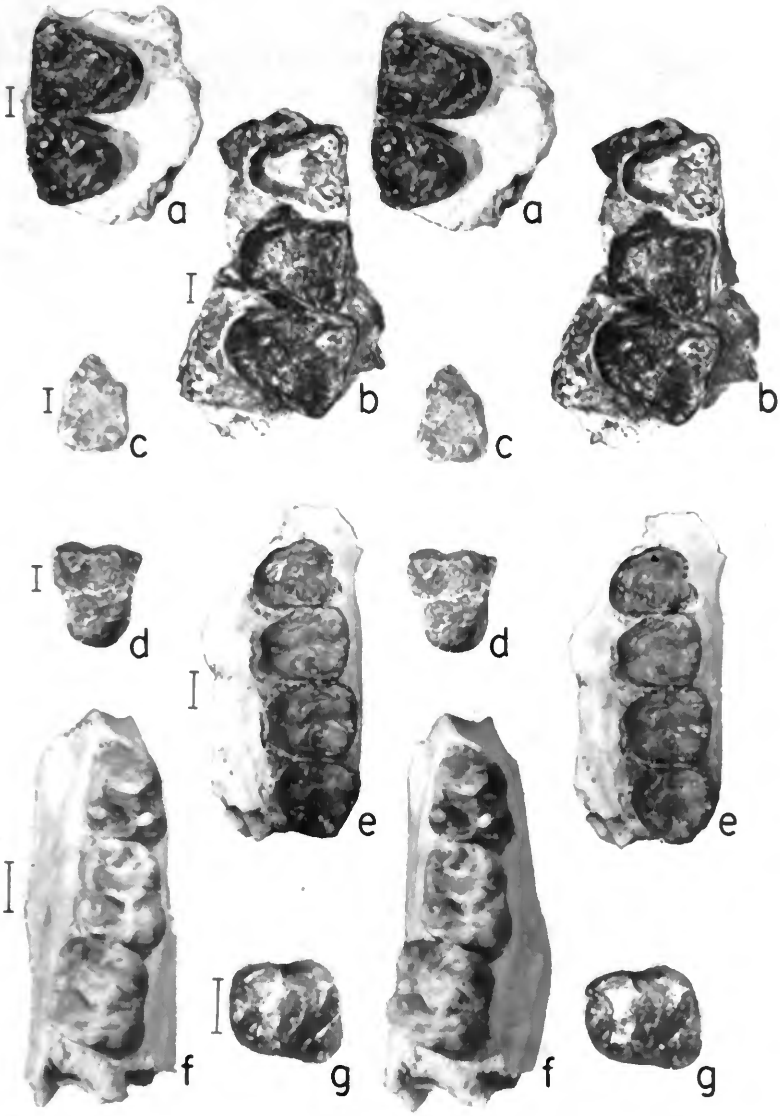


PLATE VII. Primates and rodents. All specimens illustrated as stereopairs. The line beside the left member of each pair represents 1 mm. **a.** *Microsyops elegans*, PM 15660, RM^{2}-M^{3}. **b.** *Microsyops elegans*, PM 15730, LP^{4}-M^{1}. **c.** *Microsyops* sp., PM 15644, LP$_{4}$. **d.** *Microsyops* sp., PM 15647, RP^{4}. **e.** *Sciuravus nitidus*, PM 21079, LP^{4}-M^{3}. **f.** *Sciuravus nitidus*, PM 21144, RP$_{4}$-M$_{2}$. **g.** *Sciuravus* sp., PM 15170, LM$_{1-2}$.

White Hills: 7 (Jaws: PM 15156, RM_1–M_2, LM_1; PM_1 21079*, LP^4–M^3), PM 15159, 21075, 21077–8, 21082.

Hawk: 17 (Jaw: PM 21106, RM_1–M_2) PM 15169, 15172, 21084–5, 21087, 21089, 21091–2, 21098, 21101–2, 21104, 21107–8, 21110, 21113.

Tree Road: 34 (Jaws: PM 21135, RM^1–M^2; PM 21144*, RP_4–M_2; PM 21146, RM_1–M_2), PM 21133–4, 21137–8, 21140, 21146a, 21147–52, 21154–6, 21159–60, 21162–8, 21170, 21174–5, 21177–8.

Wash: 30 PM 15176–92, 15194, 15196, 15342, 21114–9, 21121–3.

Fish Hill: 1 PM 21130.

Little White Butte: 2 PM 15166, 15175.

1375 #8:6 (Jaw: PM 21071, LP_4–M_2), PM 15152–4, 21070, 21073.

SW ¼ sec. 36: 1 PM 21126.

Sandstone Point: 1 PM 15173.

Green: 5 PM 21202, 21204, 21208–9, 21213.

Discussion.—*Sciuravus nitidus* is the most abundant species in the fauna from the lower Bridger Formation localities in the New Fork-Big Sandy area. The teeth of these specimens agree with

TABLE 27. Measurements in millimeters and statistics of teeth of *Sciuravus nitidus*.

		N	OR	M	SD	V
P^3	L	3	0.7–1.2	1.0		
	W	3	1.0–1.2	1.1		
P^4	L	22	1.6–2.0	1.80±.02	.11±.02	6.06±0.91
	W	22	1.8–2.4	2.15±.03	.16±.02	7.30±1.10
M^1	L	13	2.1–2.3	2.16±.02	.06±.01	2.94±0.58
	W	13	1.9–2.5	2.22±.05	.17±.03	7.79±1.53
M^2	L	6	2.1–2.2	2.18±.02	.05±.01	2.16±0.62
	W	6	2.3–2.4	2.33±.02	.05±.01	2.02±0.58
M^{1-2}	L	72	1.8–2.5	2.20±.01	.12±.01	5.59±0.47
	W	71	1.9–2.7	2.25±.03	.26±.02	11.60±0.97
M^3	L	22	1.9–2.4	2.19±.02	.13±.02	5.94±0.90
	W	22	1.9–2.3	2.15±.03	.14±.02	6.17±0.93
P_4	L	15	1.8–2.4	2.05±.04	.16±.03	8.00±1.46
	Wtrig	15	1.1–1.7	1.39±.05	.20±.04	14.53±2.65
	Wtal	15	1.3–2.0	1.69±.06	.22±.04	12.84±2.34
M_1	L	11	2.0–2.4	2.25±.04	.12±.03	5.56±1.21
	Wtrig	11	1.5–1.9	1.75±.05	.16±.03	9.03±1.97
	Wtal	11	1.5–2.1	1.96±.06	.19±.04	9.82±2.14
M_2	L	11	2.1–2.5	2.14±.03	.11±.02	5.12±1.09
	Wtrig	11	1.8–2.2	2.04±.03	.10±.02	5.14±1.10
	Wtal	11	1.9–2.3	2.17±.04	.12±.02	5.39±1.15
M_{1-2}	L	61	2.0–2.5	2.29±.02	.18±.02	7.82±0.71
	Wtrig	61	1.6–2.1	1.89±.02	.17±.02	8.84±0.80
	Wtal	61	1.7–2.3	2.05±.02	.15±.01	7.41±0.67
M_3	L	30	2.1–3.0	2.56±.04	.20±.02	7.62±0.98
	Wtrig	30	1.7–2.3	2.03±.02	.14±.02	7.14±0.92
	Wtal	30	1.7–2.3	1.96±.03	.18±.02	8.98±1.16

the descriptions of Wilson (1938, pp. 129–133) and Wood (1959, pp. 165–168). *S. nitidus* is well known throughout the Bridgerian.

Considerable variability is present in the lower dentition, especially in the development of the ectolophid and mesoconulid. The posterior parts of both upper and lower third molars do not show well-developed cusp and loph patterns, but rather are unpredictably variable areas with considerable cresting.

Sciuravus sp. Plate VIIg.

Material.—Hawk: 1 PM 15170*.

Discussion.—This single tooth, LP_4, is approximately the same size as the correlative tooth in *S. nitidus*, with the length being 2.0 mm., the trigonid width 1.6 mm., and the talonid width 1.7 mm. It differs in having a much more prominent hypoconulid, virtually no ectolophid connecting the metaconulid with the protoconid and hypoconid, and a very low anterior cingulum so there is no definitive trigonid basin. The talonid basin is proportionally larger than in *S. nitidus*. It is improbable that the range of variation of *S. nitidus* extends to include this specimen.

Sciuravids. Plate VIII a, b.

Material.—Unnamed: 1 PM 15529*.

Two Buttes: 1 PM 15526*.

Discussion.—These two specimens from the New Fork Tongue demonstrate the presence of sciuravids in the later Wasatchian fauna of the New Fork-Big Sandy area. It is difficult to draw conclusions from them, as PM 15526 is a LP_4 and PM 15529 is a LM^3, neither a particularly informative tooth. Both are the general size of *S. wilsoni* (Gazin, 1961; 1962, pp. 49–50).

Tillomys Marsh, 1872

Tillomys cf. **T. parvidens** (Marsh, 1872). Plate VIIIc.

Material.—Fish Hill: 1 (Jaw: PM 21128*, LM_1–M_3).

TABLE 28. Measurements in millimeters of teeth of "sciuravids."

		PM 15529	PM 15526
M^3	Length	1.8	
	Width	1.8	
P_4	Length		2.0
	Trigonid Width		1.3
	Talonid Width		1.5

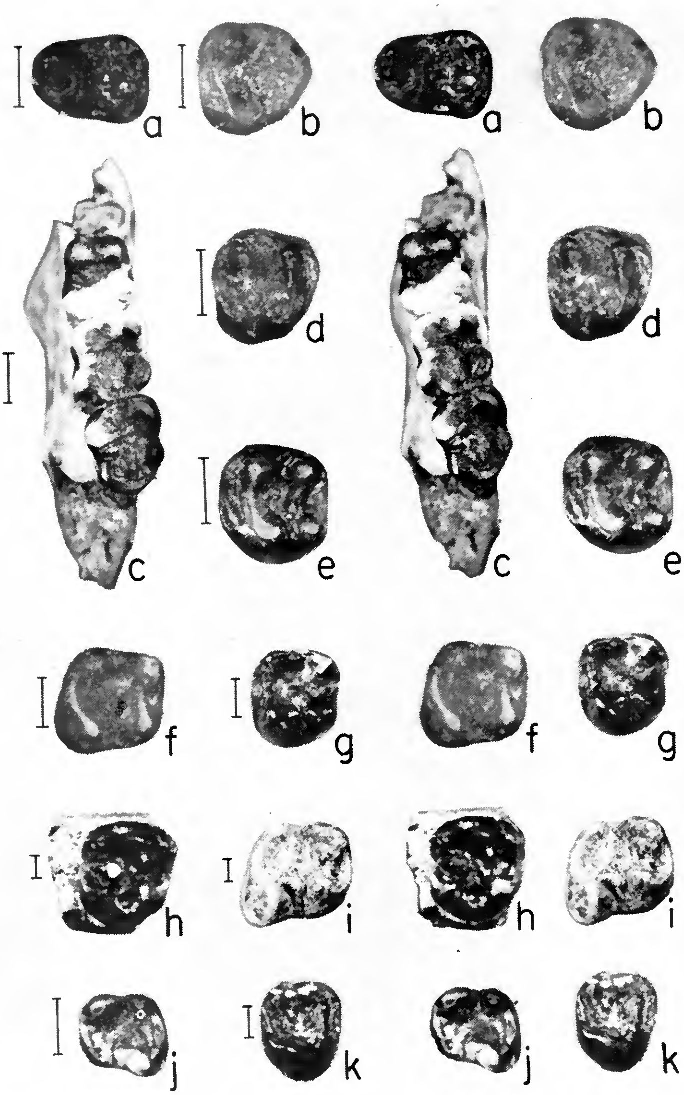


PLATE VIII. Rodents. All specimens illustrated as stereopairs. The line beside the left member of each pair represents 1 mm. **a.** Sciuravid, PM 15526, LP_4. **b.** Sciuravid, PM 15529, LM^3. **c.** *Tillomys parvidens*, PM 21128, LM_1-M_3. **d.** *Taxymys lucaris*, PM 15123, RM^{1-2}. **e.** *Knightomys* cf. *K. senior*, PM 15895, LM^{1-2}. **f.** *Knightomys* sp., PM 15524, RM_{1-2}. **g.** *Knightomys* sp., PM 15889, LM^{1-2}. **h.** *Paramys delicatus*, PM 15337, RM^{1-2}. **i.** *Paramys delicatus*, PM 21097, RM_2. **j.** *Paramys excavatus*, PM 15528, LM_1. **k.** *Paramys* near *P. excavatus*, PM 21076, RP^4.

Discussion.—PM 21128 is heavily worn, so much of the detail of the tooth surfaces is unavailable. It is about 20 per cent smaller than *S. nitidus* and about 10 per cent smaller than the *Tillomys senex* material described by Wood (1959, pp. 168–169). The transversely elongate mesoconid, posteriorly prolonged metaconid, and shape of the posteroloph are characteristic of *Tillomys* (Wilson, 1938; Wood, 1959).

TABLE 29. Measurements in millimeters of teeth of *Tillomys* cf. *T. parvidens*, PM 21128.

	M_1	M_2	M_3
Length	1.8	1.8	2.0
Trigonid Width	1.3	1.7	1.7
Talonid Width	1.6	1.7	1.5

There is a similarity to the upper Bridger *T. senex* in the complete anterior cingulum. On the other hand, the size and nature of the metaconid and mesoconid indicate a similarity to early Bridgerian *T. parvidens*. The affinities are probably with the latter species, although the amount of detail obscured by wear makes this assignment tentative.

PM 21128 is a fragmentary jaw, and a few features of the mandible are visible. The masseteric fossa ends below the posterior end of M_1, while the scar extends forward below M_1. No foramina are visible beneath the molars.

Taxymys Marsh, 1872

Taxymys lucaris Marsh, 1872. Plate VIIId.

Material.—Fault: 4 UW 1586, PM 15099, 15123*, 15960.

Sandstone Point: 1 PM 21227.

Discussion.—This small sciuravid is distinguishable from *Sciuravus nitidus* by its small size, very strong cresting on the upper molars, small hypocone, closer connections between conules and paracone and metacone, lower anterior cingulum, and transversely straighter lophs. *Taxymys lucaris* has been found previously only at upper Bridger localities, so its appearance at these lower Bridger localities extends its temporal range.

TABLE 30. Measurements in millimeters of teeth of *Taxymys lucaris*.

		N	OR	M
M^{1-2}	L	4	1.7–2.8	1.75
	W	4	1.8–1.9	1.82
M^3	L	1	2.0	
	W	1	2.0	

Taxymys (known only from upper teeth) and *Tillomys* (known only from lower teeth) are similar in size and are both sciuravids. It is possible that they are in reality a single genus. Until upper and lower teeth are found in unequivocal association, however, I continue to regard them as separate genera.

Knightomys Gazin, 1961

Knightomys cf. **K. senior** Gazin, 1961. Plate VIIIe.

Material.—Green: 1 PM 15895*.

Discussion.—In the absence of published descriptions of the upper dentition of this species, PM 15895, a first or second upper molar, is compared with the Lysitian species *Knightomys depressus* (Wood, 1965, pp. 127–132). PM 15895 shows *Knightomys* generic characters such as small size, good separation of protocone and hypocone, convex lophs, and no mesocone. In contrast to *K. depressus,* PM 15895 has no ectoloph, and has an obliquely oriented mesostyle. The tooth is slightly longer than wide, being 1.7 mm. in length and 1.6 mm. in width, another difference from *K. depressus.*

This specimen can be tentatively placed in *K. senior* on the basis of size, cusp separation, and stratigraphic occurrence. If the assignment is correct, this is the first record of an upper tooth of *Knightomys senior.*

Knightomys sp. Plate VIIIf, g.

Material.—Green: 3 PM 15524*, 15887, 15889*.

Discussion.—These three *Knightomys* specimens are much larger than the material referred to *K.* senior. The lower molar, PM 15524, has a very small trigonid basin, deep and closed in all directions. A small bulge represents the hypoconulid, which is virtually continuous with the hypoconid. The entoconid is isolated, though it sends a weak crest toward the posterior side of the hypoconid. The metaconid is large and somewhat extended anteroposteriorly. A low mesoconid is present, lacking connections to either the protoconid or the hypoconid.

In the upper molars the posterior cingulum is much stronger than the metaloph, which is interrupted between the metaconule and the metacone. The metaconule of PM 15889 gives off a low ridge toward the protoloph, which ends in the central basin. The protoloph is stronger than the anterior cingulum, and the protoconule is only a slight bulge. The well-formed hypocone is smaller than the proto-

TABLE 31. Measurements in millimeters of teeth of *Knightomys* sp.

		PM 15524	PM 15887	PM 15889
M^{1-2}	Length		2.1	2.1
	Width		2.2	2.3
M_{1-2}	Length	2.2		
	Trigonid Width	2.1		
	Talonid Width	2.3		

cone and is separated from it by a deep groove. There is no connection between the protocone and metaconule.

This species seems to be intermediate in development between *Knightomys* and *Tillomys*, and is probably closer to *Knightomys*. It is placed in *Knightomys* as an indeterminate species.

Family Ischyromyidae Alston, 1876

Black (1968) placed the Oligocene genus *Ischyromys* in the family called the Paramyidae by Wood, thus reviving the familial name Ischyromyidae used earlier (see Simpson, 1945).

Subfamily Paramyinae Simpson, 1945

Paramys Leidy, 1871

Paramys delicatus Leidy, 1871. Plate VIIIh, i.

Material.—Fault: 6 PM 15134, 15337*, 15339–40, 15916, 15918.

White Hills: 1 PM 15162.

Hawk: 4 PM 15168, 21095, 21097*, 21103.

S ½ sec. 20: PM 15164–5.

Discussion.—*Paramys delicatus* is a medium to somewhat large Bridgerian ischyromyid. It is separable from other ischyromyids

TABLE 32. Measurements in millimeters of teeth of *Paramys delicatus*.

		N	OR	M
P^4	L	1	3.7	
	W	1	4.8	
M^1	L	1	4.1	
	W	1	4.6	
M^2	L	1	4.1	
	W	1	4.7	
P_4	L	4	4.0–4.3	4.1
	Wtrig	4	2.8–3.2	3.08
	Wtal	4	3.3–4.1	3.75
M_{1-2}	L	3	4.5–4.6	4.53
	Wtrig	3	3.9	3.9
	Wtal	3	4.2–4.3	4.27
M_3	L	3	5.3–5.9	5.63
	Wtrig	3	4.1–4.2	4.17
	Wtal	3	4.0–4.2	4.1

on a size-frequency distribution, although other taxa may overlap the small end of its size range. *P. delicatus* is distinctly smaller than *Pseudotomus* and *Ischyrotomus* (if these are separable).

The diagnosis by Wood (1962, pp. 30–33) adequately describes *Paramys delicatus*. A great deal of variability is present in the surface crenulation, especially in unworn and slightly worn teeth.

Paramys excavatus Loomis, 1907. Plate VIIIj.

Material.—Blue Rim: 1 PM 15528*.

Discussion.—PM 15528, the single specimen definitely assigned to early and middle Eocene *Paramys excavatus*, is a LM_1. *P. excavatus* is one of the smaller species of *Paramys*, and is generally primitive in the lack of enamel crenulations. This tooth has a large metaconid, small posteriorly opening trigonid basin, and is 2.6 mm. long, 2.2 mm. wide across the trigonid, and 2.4 mm. wide across the talonid. These measurements place it in the size range of Wood's subspecies *P. e. excavatus* from the Lysite and Lost Cabin zones. This is the only ischyromyid from the upper Wasatch in the study collection that falls into this size range.

Paramys, near **P. excavatus** Loomis, 1907. Plate VIIIk.

Material.—White Hills: 1 PM 21076*.

Green: 8 PM 15888, 15898, 21201, 21205-7, 21219, 21222.

Discussion.—These nine specimens fall into the *Paramys excavatus* size range, but are not definitely assignable to this taxon. The P^4, PM 21076, fits Wood's 1962 description of P^4 of either *P. excavatus* or *P. copei*. The lower teeth from the Cathedral Bluffs Tongue are less certainly *P. excavatus*, largely because of the greatly reduced

TABLE 33. Measurements in millimeters of teeth of *Paramys* near *P. excavatus*.

		N	OR	M
P^4	L	1	2.4	
	W	1	2.8	
P_4	L	2	2.7–3.0	2.85
	Wtrig	2	1.4–1.6	1.5
	Wtal	2	2.4–2.5	2.45
M_{1-2}	L	3	2.9–3.2	3.03
	Wtrig	3	2.6–2.9	2.73
	Wtal	3	2.7–2.9	2.8
M_2	L	1	2.8	
	Wtrig	1	2.8	
	Wtal	1	2.7	
M_3	L	2	3.1–3.4	3.25
	Wtrig	2	2.7–3.0	2.85
	Wtal	2	2.6–2.8	2.7

TABLE 34. Measurements in millimeters and statistics of teeth of *Paramys wyomingensis*.

		N	OR	M	SD	V
P^4	L	2	2.9			
	W	2	2.4-2.6	2.5		
M^{1-2}	L	7	2.1-2.6	2.3 ±.06	.16±.04	7.13±1.91
	W	7	2.1-2.7	2.46±.09	.24±.06	9.72±2.60
P_4	L	2	1.9-2.3	2.1		
	Wtrig	2	1.5-1.6	1.55		
	Wtal	2	1.7-1.9	1.8		
M_{1-2}	L	1	2.3			
	Wtrig	1	2.0			
	Wtal	1	2.0			
M_3	L	2	2.5			
	Wtrig	2	1.9-2.0	1.95		
	Wtal	2	1.9			

mesoconid and ectolophid. *P. copei* is also a small species, and these rather indeterminate teeth might also be placed in that species.

Paramys wyomingensis (Wood, 1959). Plate IXc, d.

Material.—Fault: 5 UW 2363, PM 15936, 15966, 21041, 21044.

Hawk: 5 PM 15171, 21086, 21090, 21093-4.

Tree Road: 1 PM 21173.

1375 #8: 1 PM 21072.

Green: 2 PM 15890*, 21214*.

Discussion.—Wood described this species as *Microparamys wyomingensis* in 1959 (p. 163) on three teeth from the upper Bridger Formation at Tabernacle Butte. West (1969a) determined that the species should be assigned to *Paramys* on the basis of the large size relative to most microparamyines, the large parastyle on P^4 and the distinct round metaconule on the cheek teeth. The lower molars referred to *Paramys wyomingensis* are placed in this group because of their size, although this is an uncertain association. This occurrence in the Cathedral Bluffs Tongue extends the range of the species through all of Bridgerian time.

"**Paramys**" group. Plate IXa, b.

Material.—Fault: 42 (Jaws: UW 2361*, RP_4-M_3; UW 2364, RP^4-M^1; UW 2365*, RM^1-M^2; PM 15975, RP_4-M_1; PM 21042, LM^1-M^2), UW 1538-9, 1552, 1577-80, 1582-3, 2362, PM 15119, 15121, 15129, 15135, 15138, 15146-8, 15151, 15901, 15906, 15909, 15917, 15935, 15944, 15952, 15968, 15971, 15974, 15980, 21046, 21050, 21054-5, 21063, 21067, 21069.

White Hills: 7 PM 15157-8, 15160-1, 21074 21080-1.

TABLE 35. Measurements in millimeters of teeth of "*Paramys*" group.

		N	OR	M
P^4	L	5	3.1–3.6	3.28
	W	5	3.8–4.7	4.06
M^1	L	4	3.1–3.5	3.32
	W	4	3.1–4.0	3.60
M^2	L	3	3.2–3.6	3.43
	W	3	3.7–4.2	3.97
M^{1-2}	L	16	3.0–3.9	3.38
	W	16	3.5–4.6	3.78
M^3	L	3	3.1–4.4	3.80
	W	3	3.2–3.9	3.53
P_4	L	6	3.0–4.0	3.48
	Wtrig	6	2.0–2.9	2.57
	Wtal	6	2.3–3.7	3.03
M_1	L	4	3.6–4.1	3.82
	Wtrig	4	3.0–3.2	3.12
	Wtal	4	3.3–3.5	3.4
M_2	L	19	3.5–4.3	3.83
	Wtrig	19	2.9–3.8	3.41
	Wtal	17	2.8–3.9	3.51
M_{1-2}	L	2	3.6	
	Wtrig	2	3.0–3.2	3.1
	Wtal	2	3.4–3.5	3.45
M_3	L	16	4.0–4.8	4.34
	Wtrig	15	3.1–3.6	3.37
	Wtal	16	3.1–3.5	3.27

Hawk: 6 (Jaw: PM 15167, RM_1-M_3), PM 21088, 21096, 21105, 21109, 21111.

Tree Road: 3 PM 21132, 21136, 21172.

Fish Hill: 2 PM 21127, 21129.

Green: 5 PM 15525, 15883, 15891, 15894, 15897.

Steele Butte Breaks: 1 PM 15174.

East Fork Rim: 2 PM 15522-3.

Blue Rim: 1 PM 15527.

Discussion.—This is an artificial group, as it includes material which might be placed in *Paramys delicatior, Thisbemys plicatus*, and perhaps *Paramys copei*. However, with the material on hand, I cannot separate any seemingly consistent groups from this large assemblage of medium-sized ischyromyids. Variability is continuous, without any coherent groupings. The variables include amount of surface enamel crenulation, depth of the valley between the metaconid and the entoconid, individuality of the entoconid and hypoconid, shape of the mesostyle, degree of development of the hypocone, and degree of development of the conules.

Wood (1962) had large numbers of specimens when he divided the ischryomyid rodents into several taxa. It is probable that at

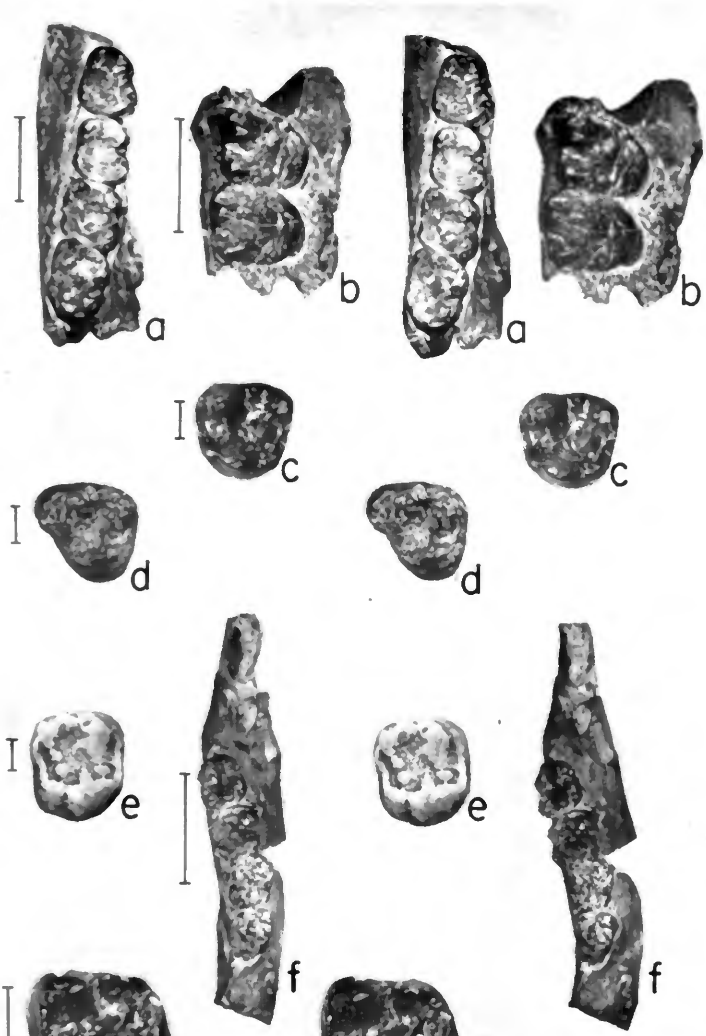


PLATE IX. Rodents. All specimens illustrated as stereopairs. The line besides the left member of each pair serves as the scale; for **a**, **b**, and **f** it represents 5 mm., and for **c** through **e** and **g** it represents 1 mm. **a**. "*Paramys*" group, UW 2361, RP$_4$-M$_3$. **b**. "*Paramys*" group, UW 2365, RM^1-M^2. **c**. *Paramys wyomingensis*, PM 15890, LM$^{1-2}$. **d**. *Paramys wyomingensis*, PM 21214, LP^4. **e**. *Reithroparamys delicatissimus*, PM 15163, RM^1. **f**. *Reithroparamys huerfanensis*, UW 1328, LP$_4$-M$_2$. **g**. *Reithroparamys* near *R. delicatissimus*, PM 15893, LM$_{1-2}$.

least some of those taxa are present in "*Paramys*" group, although I cannot recognize them.

Subfamily Reithroparamyinae Wood, 1962

Reithroparamys Matthew, 1920

Reithroparamys huerfanensis Wood, 1962. Plate IXf.

Material.—Fault: 2 (Jaw: UW 1328*, LP_4-M_3), PM 21047.

White Hills: 1 (Jaw: PM 15155, RM_1-M_3).

Green: 1 PM 21215.

Discussion.—Lower molars of *Reithroparamys huerfanensis* are characterized by a ridge from the entoconid into the talonid basin. The masseteric fossa and scar terminate below M_1, rather than below the posterior molars as in other species of *Reithroparamys*. Both dentaries show this configuration of the masseteric fossa. UW 1328 is about 25 per cent smaller than the type specimen (Wood 1962, p. 137), from the Huerfano B.

TABLE 36. Measurements in millimeters of teeth of *Reithroparamys huerfanensis*.

		N	OR	M
P_4	L	1	1.9	
	Wtrig	1	1.5	
	Wtal	1	1.8	
M_1	L	2	2.2–2.5	2.35
	Wtrig	2	1.7–2.2	1.95
	Wtal	2	1.9–2.4	2.15
M_2	L	3	2.3–2.8	2.57
	Wtrig	3	2.1–2.7	2.37
	Wtal	3	2.2–2.7	2.43
M_{1-2}	L	1	2.1	
	Wtrig	1	2.0	
	Wtal	1	2.1	
M_3	L	2	2.4–3.1	2.75
	Wtrig	2	2.0–2.7	2.35
	Wtal	2	1.8–2.5	2.15

Reithroparamys delicatissimus (Leidy, 1873). Plate IXe.

Material.—White Hills: 1 PM 15163*.

Tree Road: 1 PM 21139.

Jean's Quarry: 1 (Jaw: PM 21125, LM_2-M_3).

Green: 1 PM 15885.

Discussion.—*Reithroparamys delicatissimus,* known from the entire Bridgerian, is differentiated from *R. huerfanensis* by its somewhat larger size (about 30 per cent greater) and the posterior position of the masseteric fossa. Molars of both species have an entoconid crest

TABLE 37. Measurements in millimeters of teeth of *Reithroparamys delicatissimus*.

		N	OR	M
M^1	L	1	3.1	
	W	1	3.5	
M^{1-2}	L	1	2.9	
	W	1	3.2	
M_2	L	2	2.7–3.0	2.85
	Wtrig	2	2.6–2.8	2.7
	Wtal	2	2.8–3.1	2.95
M_3	L	1	2.9	
	Wtrig	1	2.6	
	Wtal	1	2.5	

extending into the talonid basin. PM 21125 has heavily worn teeth; size is the major criterion for the taxonomic assignment. PM 15163, an upper molar, shows the double metaconule typical of *Reithroparamys*.

Reithroparamys, near R. delicatissimus (Leidy, 1873). Plate IXg.

Material.—Green: 1 PM 15893*.

Discussion.—The overall appearance of this lower molar is similar to that of *R. delicatissimus*, with a few somewhat primitive features: the metaloph is interrupted, the ectoloph shows very little development of a mesoconid, and the hypoloph is broken just posterior to the hypocone. The specimen is small, but still within the *Reithroparamys* range. This tooth is 2.7 mm. long and 2.4 mm. wide across both trigonid and talonid.

Subfamily Manitshinae Simpson, 1941

Pseudotomus Cope, 1872

Pseudotomus robustus (Marsh, 1872). Plate Xa, b.

Material.—Tree Road: 1 PM 15965*, one individual with complete upper and lower dentitions, parts of the skull and skeleton.

Discussion.—The dentition of *Pseudotomus robustus* is well described by Wood (1962, pp. 171–179, 182–186). The large size is the most striking feature of this Bridgerian genus. PM 15695 is about 20 per cent larger than Wood's *P. robustus* material, and corresponds well to his description. With the small amount of *P. robustus* material currently available, there is no justification for any specific separation based on a size variation of this magnitude.

Pseudotomus is similar to the slightly smaller *Ischyrotomus* and Wood indicated that several lower Bridger species could easily be referred to either genus. Wood (1962, p. 186) utilized the shape of

TABLE 38. Measurements in millimeters of teeth of *Pseudotomus robustus*, PM 15965.

	P^3		P^4		M^1		M^2		M^3	
	L	W	L	W	L	W	L	W	L	W
R	2.8	3.3	5.8	6.5	6.5	6.9	6.1	6.6	7.0	6.0
L	2.7	3.1	5.7	6.4	6.4	7.0	6.2	6.6	6.9	6.2

	P_4			M_1			M_2			M_3		
	L	Wtrig	Wtal	L	Wtrig	Wtal	L	Wtrig	Wtal	L	Wtrig	Wtal
R	5.8	4.7	5.7	6.0	5.4	5.4	6.0	6.1	5.8	7.4	5.8	5.4
L	5.9	4.9	5.8	5.9	5.6	5.5	6.2	6.0	5.8	7.5	5.7	5.6

the incisors as one means for separating the two genera in the early Bridgerian. Based on this criterion, as well as the large size, PM 15695 is *Pseudotomus robustus*. It is likely that some of the large rodent incisors found at other localities belong to *Pseudotomus* and that it is a more common genus than is indicated here.

Subfamily Microparamyinae Wood, 1962

Microparamys Wood, 1959

Microparamys minutus (Wilson, 1937). Plate Xc, d.

Material.—Fault: 3 PM 15137*, 15144, 21060.

Tree Road: 4 PM 21156a*, 21158, 21171, 21176.

Discussion.—These small ischyromyids have a distinct V-shaped arrangement of strong lophs on the upper molars. This is well displayed on PM 21156a, the only upper tooth of *M. minutus* in the study collection. The hypocone is present as a bulge on the posterior cingulum. A mesostyle is present, and there is a slight expansion on the lophs in the positions of the conules.

The lower molars are typically ischyromyid. They have strong trigonid basins, with antero-external drainage anterior to the protoconid. There is a distinct enlargement of the hypoconulid. Both the hypoconid and the protoconid have weak connections to the mesoconid.

M. minutus is known from throughout the Bridgerian.

TABLE 39. Measurements in millimeters of teeth of *Microparamys minutus*.

		N	OR	M
M^{1-2}	L	1	1.2	
	W	1	1.4	
P_4	L	1	1.3	
	Wtrig	1	0.9	
	Wtal	1	1.1	
M_{1-2}	L	5	1.2–1.3	1.28
	Wtrig	5	1.0–1.4	1.18
	Wtal	5	1.1–1.5	1.30

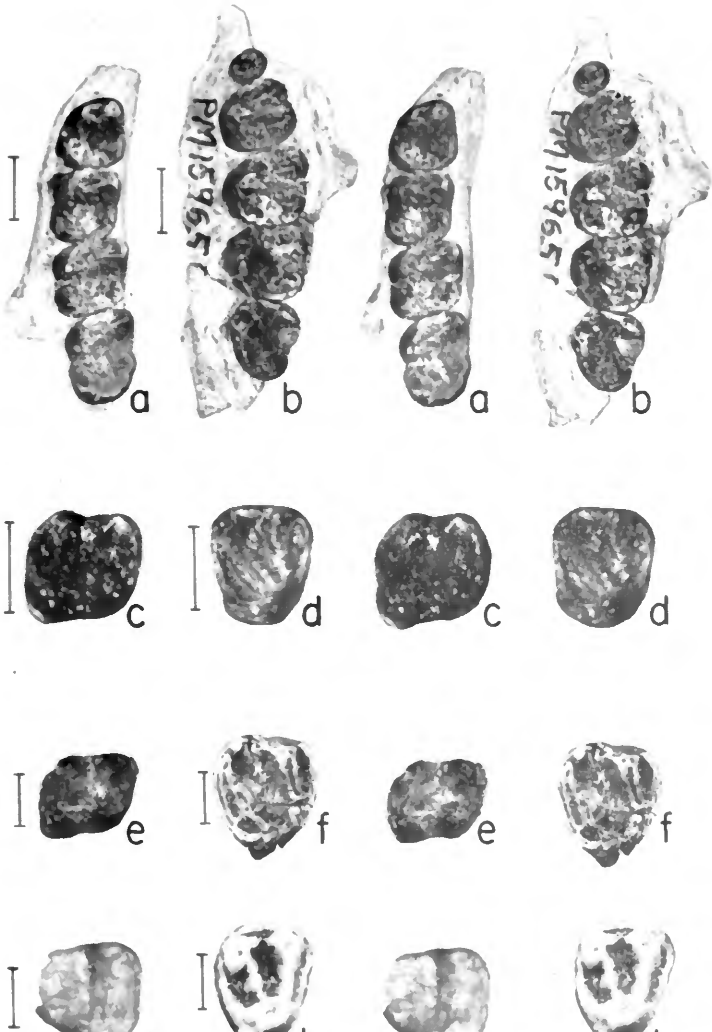


PLATE X. Rodents. All specimens illustrated as stereopairs. The line beside the left member of each pair serves as the scale: for **a** and **b** the line represents 5 mm., and for **c** through **h** it represents 1 mm. **a.** *Pseudotomus robustus*, PM 15965, LP_4-M_3. **b.** *Pseudotomus robustus*, PM 15965, LP^3-M^3. **c.** *Microparamys minutus*, PM 15137, RM_{1-2}. **d.** *Microparamys minutus*, PM 21156a, RM^{1-2}. **e.** *Microparamys* sp. A, PM 15139, RM_{1-2}. **f.** *Microparamys* sp. A, PM 21131, RM^{1-2}. **g.** *Microparamys* sp. B, PM 15193, RM^3. **h.** *Microparamys* sp. B, PM 15195, RM^{1-2}.

Microparamys sp. A. Plate Xe, f.

Material.—Fault: 1 PM 15139*.

Tree Road: 2 PM 21131*, 21143.

Discussion.—This is a large microparamyine species, larger than either *M. lysitensis* or *M. cathedralis*, the largest early and middle Eocene species discussed by Wood (1962, p. 163). PM 15139, a very worn specimen, is placed here on the basis of size and overall shape. PM 21143, a P_4, is a robust tooth with somewhat inflated cones and a well-developed hypoconulid. The most distinctive tooth assigned to this taxon is PM 21131, an upper molar. It has the typical *Microparamys* strong V-shaped lophs, but shows a prominent interruption in the metaloph near the protocone. Both anterior and posterior cingula are strong, with small accessory cuspules on the posterior cingulum. There is no hypocone, and the mesostyle is weak. A protoconule is present, but the metaconule is absent.

Microparamys sp. A is a distinctive species, but no suggestions can be made of its relationships with other species until better material is available.

TABLE 40. Measurements in millimeters of teeth of *Microparamys* sp. A.

		PM 15139	PM 21131	PM 21143
M^{1-2}	Length		2.1	
	Width		2.4	
P_4	Length			2.2
	Width Trigonid			1.5
	Width Talonid			1.8
M_{1-2}	Length	2.1		
	Width Trigonid	1.7		
	Width Talonid	1.9		

Microparamys sp. B. Plate Xg, h.

Material.—Wash: 3 PM 15193*, 15195*, 21120.

Discussion.—This species (if the material represents a single taxon) is intermediate in size between *Microparamys* sp. A and *Microparamys minutus*. PM 21120, M^1 or M^2, is quite worn, but shows the presence of a rudimentary hypocone and complete lophs with the metaloph lower than the protoloph. PM 15195, much less worn, has a somewhat divided metaloph and a much stronger protoloph than metaloph. M^3 (PM 15193) is typical of *Microparamys*, with a strong protoloph and anterior cingulum. It also has a mesostyle, lacking on either of the anterior molars. PM 15193 is not certainly related to PM 15195 and PM 21120, despite the similar size.

TABLE 41. Measurements in millimeters of teeth of *Microparamys* sp. B.

		PM 15193	PM 15195	PM 21120
M^{1-2}	Length		1.8	1.6
	Width		2.2	1.9
M^3	Length	1.8		
	Width	1.7		

Assignments of these teeth to *Microparamys cathedralis*, the other known microparamyine of this size, would be conjectural because the upper teeth of *M. cathedralis* are as yet unknown. The size is the only present reason for a relationship.

Order Tillodontia

Family Esthonychidae Cope, 1883

Subfamily Esthonychinae Cope, 1883

Esthonyx Cope, 1874

Esthonyx acutidens Cope, 1881. Plate XIa, b.

Material.—East Fork Rim: 2 PM 15567*, 15574*.

Discussion.—The only complete lower tooth, RM_3 of PM 15574, has the elongate hypoconulid characteristic of Lost Cabin *Esthonyx acutidens*, and is the same size as AMNH 14783 (Gazin, 1953, p. 28). The lingual portion of LM^2 shows a hypocone and anterior cingulum. A weathered RM^3, along with fragments of other teeth and bone, makes up PM 15567. Although much of the detail of the tooth has been lost due to weathering, the pronounced ectoflexus, small pre- and postcingula, and large parastyle are apparent.

TABLE 42. Measurements in millimeters of teeth of *Esthonyx acutidens*.

		PM 15567	PM 15574
M^3	Length	7.4	
	Width	13.4	
M_3	Length		12.4
	Trigonid Width		6.5
	Talonid Width		5.4

Order Taeniodonta

Family Stylinodontidae Marsh, 1875

Subfamily Stylinodontinae Marsh, 1875

Stylinodontine. Plate XIc.

Material.—Fence X Road: 1 PM 15198.

Steele Butte Breaks: 2 PM 15199, 15602.

East Fork Rim: 2 PM 15200, 15590*.

Blue Rim: 1 PM 15610.

Piney Cutoff: 1 PM 15625.

Discussion.—All the materials consist of fragmentary teeth, showing the enamel distribution pattern characteristic of Eocene stylinodontines. No further identification is possible.

Order Dinocerata
Family Uintatheriidae Flower, 1876
Bathyopsis Cope, 1881

Bathyopsis fissidens Cope, 1881. Plate XId.

Material.—Steele Butte Breaks: 2 PM 15197*, 15608.

Discussion.—Of the two lower molars of *Bathyopsis fissidens* in the study collection, only PM 15197 is reasonably complete and measureable; it is 17.3 mm. long, 13.6 mm. wide across the trigonid, and 12.4 mm. wide across the talonid. PM 15197 is longer than M_1 of Cope's type specimen of *B. fissidens* (he failed to publish the measurements of M_2), but is not large enough to place it in *B. middleswarti*. The cf. *B. fissidens* found by Gazin (1952, pp. 64–65) in the New Fork Tongue, USNM 19990, is also larger than Cope's type, AMNH 4820.

The notable feature of *Bathyopsis* is the peculiar lophodont structure of the teeth, with a vestigial paraconid and paraconid ridge, a heavy portoconid-metaconid crest with the metastylid closely joined to the postero-buccal surface of the metaconid, a hypoconid crest extending antero-internally from the hypoconid, and a convex posterior talonid crest at the rear of the tooth, presumably made up of the hypoconulid and entoconid.

Order Pantodonta
Superfamily Coryphodontoidea Marsh, 1876
Family Coryphodontidae Marsh, 1876
Coryphodon Owen, 1846

Coryphodon sp. Plate XIe, f.

Material.—Steele Butte Breaks: 13 PM 15262*, 15263-6, 15592, 15593, 21182, 21189, 21191-4.

East Fork Rim: 14 PM 15267-70, 15587, 15591, 21183-8, 21190, 21195.

Discussion.—There are at present 28 named species of *Coryphodon,* most proposed by Cope. Simons (1960) revised the Paleo-

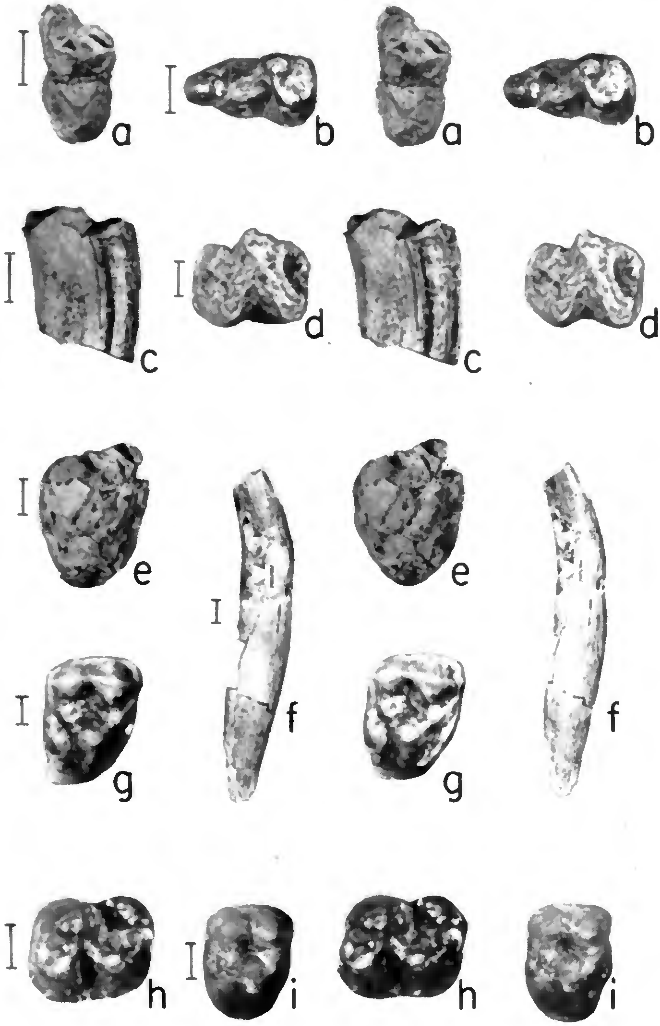


PLATE XI. Tillodonts, taeniodont, dinoceratan, pantodonts, and condylarths. All specimens illustrated as stereopairs. The line beside the left member of each pair serves as the scale: for **a**, **b**, and **d** it represents 5 mm., for **c**, **e**, and **f** it represents 10 mm., and for **g**, **h**, and **i** it represents 1 mm. **a.** *Esthonyx acutidens*, PM 15567, RM^2. **b.** *Esthonyx acutidens*, PM 15574, RM_3. **c.** Stylinodontine, PM 15590, C. **d.** *Bathyopsis fissidens*, PM 15197, RM^{1-2}. **e.** *Coryphodon* sp., PM 15592, RM^2. **f.** *Coryphodon* sp., PM 15262, C. **g.** *Hyopsodus miticulus*, PM 15514, RM^1. **h.** *Hyopsodus miticulus*, PM 15543, LM_{1-2}. **i.** *Hyopsodus wortmani*, PM 15511, RM^2.

cene Pantodonta, but stopped short of *Coryphodon*. The genus is in a state of taxonomic confusion, and is in need of a careful review. The genus is common in the Wasatchian, but is not known to have survived into the Bridgerian.

TABLE 43. Measurements in millimeters of teeth of *Coryphodon*, PM 15592.

P^1	Length	20.0
	Width	15.0
M^2	Length	33.0
	Width	41.6

The material available in the study collection is not suitable for specific identifications. The large incisors are the most frequently encountered elements, but these are not diagnostic. Accumulations of tooth fragments can be assigned only to the genus *Coryphodon* on their general aspect. In addition to the specimens listed above, numerous miscellaneous postcranial fragments are so large that they are probably *Coryphodon*.

Order Condylarthra

Family Hyopsodontidae Trouessart, 1879

Subfamily Hyopsodontinae Trouessart, 1879

Hyopsodus Leidy, 1870

Gazin (1968) has recently reviewed the morphology, systematics, and paleoecology of *Hyopsodus*, long a problem to mammalian paleontologists. I use his classification (op. cit., pp. 13–30) for the specific names applied to specimens in the study collection.

Gazin used parameters such as size and variability to differentiate sympatric species of *Hyopsodus*. Features such as the molarization of the premolars and incipient hypsodonty are also sometimes useful criteria. On the whole, however, it is difficult to distinguish the various species on the basis of isolated teeth and partial jaws.

Hyopsodus is the smallest and most abundant condylarth in the study collection, and is the only condylarth to be positively identified in both upper Wasatch Formation and lower Bridger Formation deposits in the New Fork-Big Sandy area. *Hyopsodus* is more abundant in the Bridgerian than in the Wasatchian in the New Fork-Big Sandy area. It is the most common genus in many Bridgerian surface collections, although it is outnumbered by *Sciuravus* in the New Fork-Big Sandy area, a result of the washing process.

Hyopsodus miticulus (Cope, 1874). Plate XIg, h.

Material.—Steele Butte Breaks: 2 PM 15305-6.

East Fork Rim: 4 PM 15542, 15543*, 15549, 15552.

Blue Rim: 2 PM 15520-1.

Piney Cutoff: 2 PM 15518, 15627.

Blue Saddle: 1 PM 15512.

Two Buttes: 4 PM 15513, 15514*, 15515-6.

Discussion.—*Hyopsodus miticulus* is the larger and more abundant of the two species of *Hyopsodus* present in the late Wasatchian levels of the New Fork-Big Sandy area. The specimens are all isolated teeth, so Gazin's criterion of premolar spacing cannot be utilized. All three lower molars of *H. miticulus* in the study collection have a small metastylid on the posterior side of the metaconid, seen well on PM 15543.

Gazin (1968, pp. 14, 17–18) included the material he called. *H. mentalis* in 1962 (p. 64) within *H. miticulus*, so this species is well represented in the earlier New Fork Tongue collection.

TABLE 44. Measurements in millimeters of teeth of *Hyopsodus miticulus*.

		N	OR	M
M^1	L	1	3.8	
	W	1	5.0	
M^2	L	3	3.6–3.9	3.77
	W	2	5.2–5.3	5.25
M^{1-2}	L	3	3.7–3.8	3.77
	W	2	4.5–5.4	4.95
M^3	L	1	3.4	
	W	1	4.9	
P_4	L	1	4.2	
	Wtrig	1	2.7	
	Wtal	1	3.0	
M_2	L	2	4.1–4.2	4.15
	Wtrig	2	3.6–3.8	3.70
	Wtal	2	3.6–3.9	3.75
M_{1-2}	L	2	4.2–4.4	4.30
	Wtrig	3	3.1–3.6	3.37
	Wtal	2	3.5–3.7	3.60

Hyopsodus wortmani Osborn, 1902. Plates XIi, XIIa.

Material.—Steele Butte Breaks: 1 PM 15511.

East Fork Rim: 2 PM 15301, 15533.

Piney Cutoff: 1 PM 15519*.

Discussion.—This species is about two-thirds the size of *H. miticulus* and is much less common in the study collection. This same relative frequency of occurrence was noted by Gazin (1952, p. 8) in his early collection from the LaBarge local fauna. However,

TABLE 45. Measurements in millimeters of teeth of *Hyopsodus wortmani*.

		N	OR	M
M^1	L	2	2.5–2.7	2.6
	W	2	3.0–3.2	3.1
P_3	L	1	2.6	
	Wtrig	1	1.7	
	Wtal	1	1.8	
P_4	L	1	3.2	
	Wtrig	1	2.3	
	Wtal	1	2.4	
M_2	L	1	3.7	
	Wtrig	1	3.0	
	Wtal	1	2.9	

his (1962, p. 64) later material from the New Fork Tongue showed *H. wortmani* to be more abundant than *H. miticulus* by a factor of 10: 6 in a small collection. The variations in proportions between Gazin's New Fork Tongue collection and mine are probably due primarily to small collection bias.

The single lower molar of *H. wortmani*, PM 15519, does not have a metastylid as noted in *H. miticulus*, but the small sample reduces the significance of the observation.

Hyopsodus minusculus Leidy, 1873. Plate XIIb, c.

Material.—Fault: 46 (Jaws: UW 1526, RM_1-M_2; UW 1569, LP^3-P^4; PM 15008, LP_4, M_2-M_3), UW 1322, 1523, 1525, 1528, 1531-2, 1534, 1536-7, 1554, 1563-4, 1719, 1722, PM 15029, 15054, 15271-8, 15280-3, 15312, 15560, 15642, 15694, 15748, 15753, 15755, 15758, 15760, 15762-3, 15765, 15938, 21052, 21223.

White Hills: 4 PM 15298, 15702, 15786-7.

Hawk: 32 (Jaws: PM 15767, RM_2-M_3; PM 15775*, RP_4-M_2; PM 15780*, LP^4–M^1), PM 15284–97, 15297, 15313, 15766, 15769–70, 15772-4, 15776-8, 15781-2, 15784-5, 21099.

Tree Road: 4 PM 15794-5, 15796, 15732.

Wash: 3 PM 15309, 15316, 15788.

Fish Hill: 3 PM 15790-2.

Little White Butte: 1 PM 15300.

1375# 8: 1 PM 15789.

Green: 17 PM 15530, 15651-3, 15799, 15800-4, 21203, 21210-2, 21216, 21218, 21220.

Discussion.—*Hyopsodus minusculus* is the smaller of the two early Bridgerian species, approximating *H. wortmani* of the late Wasatchian in size. It is virtually ubiquitous in the lower Bridger Formation collections in the New Fork-Big Sandy area. The lower

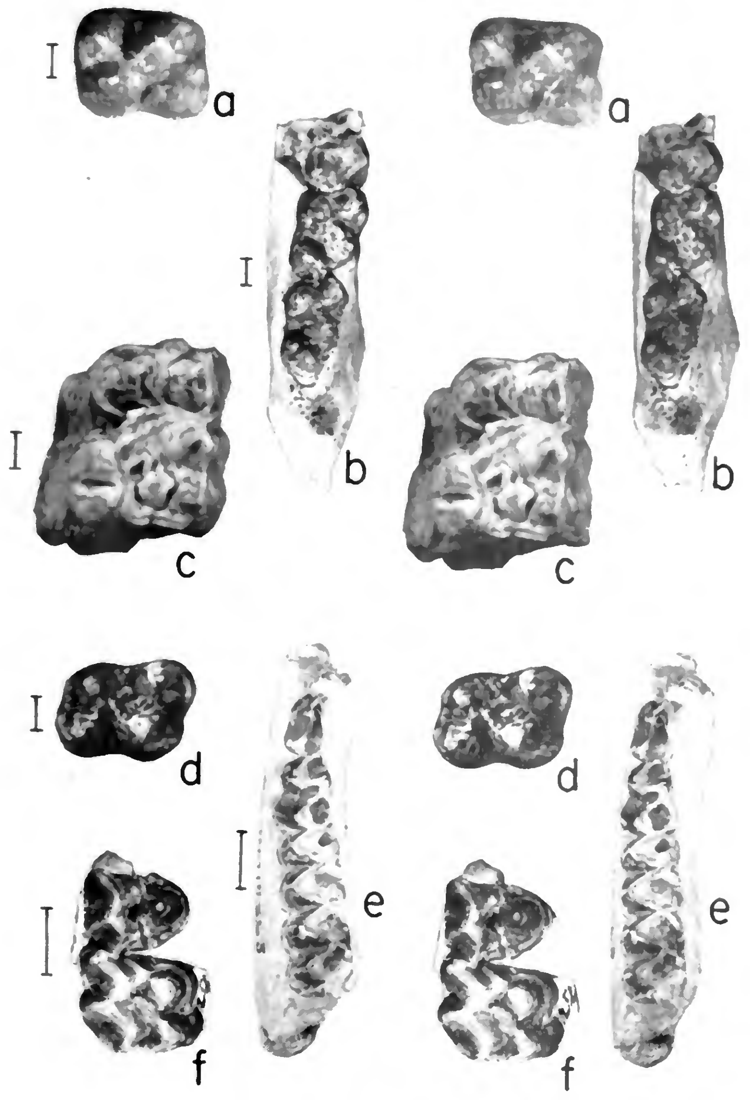


PLATE XII. Condylarths. All specimens illustrated as stereopairs. The line beside the left member of each pair serves as the scale: for **a** through **d** it represents 1 mm., and for **e** and **f** it represents 5 mm. **a.** *Hyopsodus wortmani*, PM 15519, RM_2. **b.** *Hyopsodus minusculus*, PM 15775, RM_2-M_3. **c.** *Hyopsodus minusculus*, PM 15780, LP^4-M^1. **d.** *Hyopsodus paulus*, PM 15308, LM_1. **e.** *Meniscotherium chamense*, PM 15353, LP_3-M_2. **f.** *Meniscotherium chamense*, PM 15307, RP^4-M^1.

TABLE 46. Measurements in millimeters and statistics of teeth of *Hyopsodus minusculus*.

		N	OR	M	SD	V
P^3	L	3	2.2–2.8	2.53		
	W	3	2.9–3.2	3.0		
P^4	L	7	2.0–2.7	2.47±.09	.23±.06	9.47±2.53
	W	7	3.5–4.1	3.87±.07	.19±.05	4.96±1.33
M^1	L	19	2.6–3.7	3.26±.07	.29±.05	8.96±1.45
	W	19	3.3–5.0	4.06±.11	.46±.07	11.38±1.85
M^2	L	25	2.3–4.0	3.43±.06	.28±.04	8.10±1.14
	W	24	3.7–5.0	4.38±.08	.40±.06	9.22±1.33
M^{1-2}	L	4	3.5–3.6	3.58		
	W	3	4.2–4.5	4.37		
M^3	L	16	2.7–3.3	3.01±.05	.20±.04	6.58±1.16
	W	16	3.5–4.5	4.08±.08	.30±.05	7.37±1.30
P_4	L	2	2.7			
	W	2	2.0			
M_1	L	9	3.2–3.6	3.40±.05	.14±.03	4.18±0.98
	Wtrig	9	2.4–2.7	2.51±.04	.12±.03	4.66±1.10
	Wtal	9	2.5–2.9	2.68±.04	.13±.03	4.86±1.15
M_2	L	13	3.2–4.0	3.49±.06	.23±.04	6.53±1.28
	Wtrig	13	2.3–3.0	2.71±.06	.21±.04	7.75±1.52
	Wtal	13	2.4–3.0	2.72±.05	.19±.04	7.06±1.38
M^{1-2}	L	12	3.4–4.2	3.73±.07	.24±.05	6.41±1.31
	Wtrig	10	2.3–3.5	2.92±.03	.11±.02	3.80±0.85
	Wtal	10	2.5–3.4	2.91±.08	.25±.06	8.49±1.90
M_3	L	6	3.6–4.4	4.02±.11	.26±.08	6.57±1.90
	Wtrig	6	2.2–3.0	2.62±.11	.26±.08	10.00±2.89
	Wtal	6	1.9–2.6	2.27±.09	.22±.06	9.78±2.83

molars have the metastylid noted in *H. miticulus*. This lower Bridger species also shows the development of an entostylid on the anterior face of the entoconid, not seen in the Wasatchian material. Specimens from Green locality in the Cathedral Bluffs Tongue lack this small cuspule. The Cathedral Bluffs Tongue material differs from the Wasatchian *H. wortmani*, though, in having a metastylid.

Hyopsodus paulus Leidy, 1870. Plate XIId.

Material.—Fault: 1 UW 1745.

Wash: 1 PM 15308*.

Discussion.—*Hyopsodus paulus*, poorly represented in the study collection, is a larger, more robust species than *H. minusculus* from the same level. The single lower molar, PM 15308, has a small metastylid and no entostylid.

The frequency of occurrence of this species is just about the opposite of that noted by Gazin (1968, pp. 24–26) in his large Bridger B surface collection from the southern margin of the Green River Basin. There the *Hyopsodus* sample is made up primarily of *H. paulus*. Farther north, near the junction of Ham's Fork and Black's Fork, *H. paulus* and *H. minusculus* are about equally abun-

TABLE 47. Measurements in millimeters of teeth of *Hyopsodus paulus*.

		UW 1745	PM 15308
M^3	Length	3.7	
	Width	5.2	
M_1	Length		4.2
	Width Trigonid		2.9
	Width talonid		3.0

dant. In the New Fork-Big Sandy area, at the same faunal level much farther north, the smaller species is much more abundant than the larger *H. paulus*.

Family Meniscotheriidae Cope, 1882
Subfamily Meniscotheriinae Cope, 1882
Meniscotherium Cope, 1874

Gazin (1965b) reduced the number of valid species of *Meniscotherium* to three (two of which are present in the study collection). He pointed out the apparent ecologic sensitivity of *Meniscotherium;* this reduces the value of the genus as a biostratigraphic indicator.

Meniscotherium chamense Cope, 1884. Plate XIIe, f.

Material.—Steele Butte Breaks: 4 (Jaw: PM 15307*, RP^4-M^2, LM^1-M^2), PM 15487–9.

East Fork Rim: 17 (Jaws: PM 15472, LP^3, RM^1; PM 15473, LM^2, R&LM_2; PM 15475, RM^1-M^2, LM^3), PM 15302–4, 15317, 15474, 15476–81, 15483–4, 15586.

Blue Rim: 12 (Jaws: PM 15391, LC, P_3-M_3; PM 15399, RM_1-M_3), PM 15388–9, 15394, 15503, 15505–6, 15611–14.

Piney Cutoff: 1 PM 15352.

Blue Saddle: 3 (Jaw: PM 15500, RM_1, LM_1, LM^3), PM 15499, 15635.

Unnamed: 10 (Jaw: PM 15353*, LP_3-M_2), PM 15359, 15490–7

Two Buttes: 1 (Jaw: PM 15501, LM^1-M^3).

Twnf-E: 1 PM 15633.

Twnf-D: 2 PM 15630, 15632.

Discussion.—*Meniscotherium chamense* is an abundant species in the western facies of New Fork Tongue, and is also common in the arkosic facies. It is the moderate-sized species of the genus, and ranges from middle to late Wasatchian. Like all species of *Meniscotherium*, it is not known to extend into the Bridgerian.

TABLE 48. Measurements in millimeters and statistics of teeth of *Meniscotherium chamense*.

		N	OR	M	SD	V
P^3	L	2	5.9– 6.0	5.95		
	W	2	5.9– 6.7	6.30		
P^4	L	4	6.6– 7.5	6.95		
	W	4	7.9– 8.9	8.50		
M^1	L	6	7.5– 8.9	8.27±.20	.48±.14	5.76±1.66
	W	4	8.0–11.0	9.92		
M^2	L	2	9.0– 9.6	9.30		
	W	1	10.4			
M^3	L	6	8.2– 9.5	9.00±.22	.54±.16	6.06±1.75
	W	3	10.0–10.9	10.57		
P_2	L	1	5.1			
	W	1	3.5			
P_3	L	2	5.9– 6.0	5.95		
	Wtrig	2	3.2– 3.5	3.35		
	Wtal	2	3.9			
P_4	L	3	7.1– 7.4	7.27		
	Wtrig	3	4.5– 5.1	4.83		
	Wtal	3	5.2– 5.7	5.50		
M_1	L	10	7.5– 8.1	7.81±.06	.19±.04	2.47±0.55
	Wtrig	10	4.6– 6.5	5.38±.15	.47±.10	8.75±1.96
	Wtal	10	5.0– 7.0	5.86±.16	.51±.11	8.67±1.94
M_2	L	5	8.2– 9.3	8.82		
	Wtrig	5	4.6– 6.9	5.92		
	Wtal	7	5.4– 6.9	6.33±.19	.50±.13	7.91±2.11
M_{1-2}	L					
	Wtrig	1	5.9			
	Wtal					
M_3	L	3	9.1– 9.9	9.53		
	Wtrig	3	5.3– 6.2	5.70		
	Wtal	3	5.0– 5.6	5.27		

Meniscotherium robustum Thorpe, 1920. Plate XIIIa.

Material.—East Fork Rim: 2 (Jaw: PM 15482, R&LP_4-M_1), PM 15486.

Blue Rim: 2 PM 15504, 15396.

Piney Cutoff: 3 (Jaws: PM 15350*, LM_1-M_3; PM 15351, RP_3-P_4, LM_{1-2}; PM 15502, LP^4-M^1).

Blue Saddle: 1 PM 15365.

Discussion.—This species is less abundant than *M. chamense*, being represented by only eight specimens. They are rather small for *M. robustum*, but the size-frequency distribution for all specimens of *Meniscotherium* shows two definite groups, with the larger designated as *M. robustum*.

The occurrence of *M. robustum* in the New Fork Tongue extends the range of the species upward. Gazin (1962, p. 68) noted the presence of *M. robustum* only in beds below the Tipton and Fontenelle Tongues of the Green River Formation.

TABLE 49. Measurements in millimeters of teeth of *Meniscotherium robustum*.

		N	OR	M
P^4	L	2	7.5– 8.0	7.75
	W	2	8.8– 9.2	9.00
M^1	L	1	9.7	
	W	1	10.6	
M^3	L	1	9.8	
	W	1	12.0	
P_3	L	1	6.5	
	W	1	4.0	
P_4	L	2	8.0– 8.8	8.40
	Wtrig	2	5.3– 5.4	5.35
	Wtal	1	5.9	
M_1	L	3	9.4–10.0	9.67
	Wtrig	3	5.9– 6.2	6.03
	Wtal	3	6.1– 6.4	6.23
M_2	L	2	10.0	
	Wtrig	2	6.2– 7.0	6.60
	Wtal	2	6.4– 6.9	6.65
M_3	L	1	11.0	
	Wtrig	1	6.0	
	Wtal	1	5.7	

Family Phenacodontidae Cope, 1881

Phenacodus Cope, 1873

The largest condylarth in the study collection is *Phenacodus*, represented by two species. Gazin's extensive collecting in both the western facies of the New Fork Tongue and the LaBarge level has produced no specimens of *Phenacodus*, and the genus has not been found in the post-Lost Cabin Cathedral Bluffs Tongue in the Washakie Basin. West and Atkins (1970) reported the occurrence of *P. primaevus* in the upper Bridger Formation at Tabernacle Butte, so the genus is no longer restricted to Tiffanian and Wasatchian beds in

TABLE 50. Measurements in millimeters of teeth of *Phenacodus vortmani*.

		N	OR	M
M^2	L	1	8.1	
	W	1	11.2	
M^3	L	1	7.0	
	W	1	9.3	
M_1	L	1	7.3	
	Wtrig	1	5.7	
	Wtal	1	6.3	
M_2	L	1	7.6	
	Wtrig	1	6.9	
	Wtal	1	7.0	
M_{1-2}	L	2	7.6–7.8	7.70
	Wtrig	3	5.8–6.7	6.40
	Wtal	2	6.4–7.0	6.70
M_3	L	1	8.3	
	Wtrig	1	6.4	
	Wtal	1	5.5	

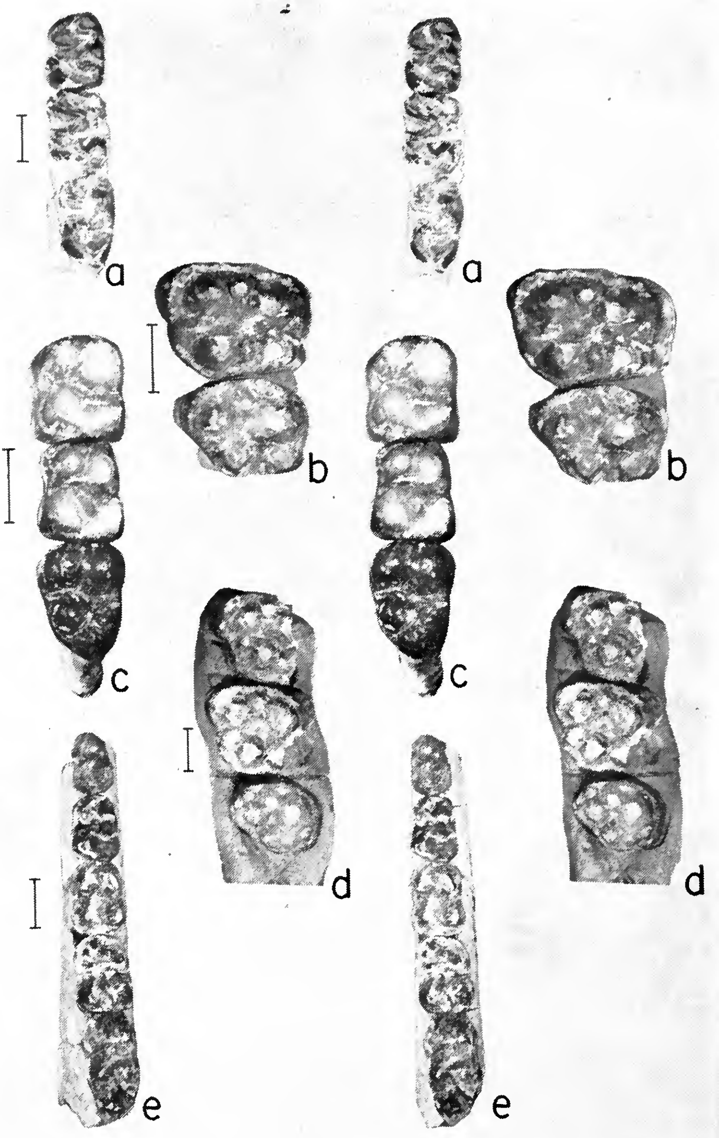


PLATE XIII. Condylarths and perissodactyl. All specimens illustrated as stereopairs. The line beside the left member of each pair represents 5 mm. **a.** *Meniscotherium robustum*, PM 15350, LM_1-M_3. **b.** *Phenacodus vortmani*, PM 15956, RM^2M^3. **c.** *Phenacodus vortmani*, PM 15510, RM_1-M_3. **d.** *Phenacodus primaevus*, PM 15507, $RM^1M^2M^3$. **e.** *Hyracotherium vasacciense*, PM 15447, LP_3-M_3.

North America. Guthrie (pers. comm., 1970) reports the same two species in the type area of the Lost Cabin fauna that I have found in the Lost Cabin level of the New Fork-Big Sandy area.

Phenacodus vortmani Cope, 1880. Plate XIIIb, c.

Material.—Steele Butte Breaks: 2 (Jaw: PM 15510*, RM_1-M_3), PM 15605.

Blue Rim: 2 PM 15508–9.

Two Buttes: 1 (Jaw: PM 15956*, RM^2-M^3).

Discussion.—*Phenacodus vortmani* is represented by five specimens, which fall into the size range of *P. vortmani* from the Lost Cabin as tabulated by Robinson (1966, pp. 53–54). The species ranges through the Wasatchian.

Phenacodus primaevus Cope, 1873. Plate XIIId.

Material.—Two Buttes: 1 (Jaw: PM 15507*, RM^1, M^2, M^3).

Discussion.—The single specimen of *Phenacodus primaevus* is about 25 per cent larger than the *P. vortmani* material discussed above. These worn teeth are the first evidence of *P. primaevus* in the New Fork Tongue.

TABLE 51. Measurements in millimeters of teeth of *Phenacodus primaevus*, PM 15507.

	P^3	M^2	M^3
Length	11.0	10.6	10.8
Width	8.0	14.0	12.3

Phenacodus sp.

Material.—Piney Cutoff: 1 PM 15575.

Discussion.—This fragmental upper molar displays the rounded shape and low cusps of *Phenacodus*, but it is too incomplete for specific assignment. It is large, and is probably *P. primaevus*.

Order Perissodactyla

Suborder Hippomorpha Wood, 1937

Superfamily Equoidea Gray, 1821

Family Equidae Gray 1821

Hyracotherium Owen, 1840

Hyracotherium flourished during the Wasatchian and evolved into the Bridgerian *Orohippus*. Late Wasatchian *Hyracotherium* is characterized by incipient molarization of the third and fourth premolars, lophodont upper molars with conules still prominent, and the lack of a mesostyle.

Kitts (1956) reviewed *Hyracotherium* from North America, leaving only *H. angustidens*, *H. vasacciense*, and *H. craspedotum* as valid species. Guthrie (1967, pp. 41–42) revived the species *H. index* for small individuals from the Lysite zone.

Kitts assigned statistical subspecies to *H. vasacciense*, but the systematics of *Hyracotherium* discussed here will consider only species.

Hyracotherium vasacciense Cope, 1872. Plates XIIIe, XIVa.

Material.—Steele Butte Breaks: 30 PM 15206, 15206a, 15207–9 15211–9, 15319, 15403–6, 15408–13, 15430, 15471, 15594, 15598–9.

East Fork Rim: 32 (Jaws: PM 15417, LP_2, P_4; PM 15454, RP_2, M_3), PM 15238, 15240, 15247, 15250, 15252, 15415–6, 15419, 15441, 15443–6, 15448–53, 15455–6, 15458, 15485, 15576, 15579–83, 15585.

TABLE 52. Measurements in millimeters and statistics of teeth of *Hyracotherium vasacciense.*

		N	OR	M	SD	V
P^3	L	1	6.5			
	W	1	7.4			
P^4	L	5	6.9– 7.5	7.32		
	W	5	7.8– 8.8	8.26		
M^1	L	17	7.6– 8.4	8.00±.06	.24±.04	2.95±0.51
	W	16	8.3–10.5	9.26±.14	.58±.10	6.30±1.11
M^2	L	12	7.4– 9.1	8.33±.14	.47±.10	5.63±1.15
	W	11	9.5–11.3	10.22±.15	.49±.10	4.79±1.02
M^{1-2}	L	2	8.4– 8.9	8.65		
	W	1	10.2			
M^3	L	16	6.8– 8.7	7.87±.13	.52±.09	6.60±1.17
	W	16	7.9–10.2	9.18±.17	.68±.12	7.46±1.32
P_3	L	10	5.9– 7.9	6.98±.20	.65±.14	9.33±2.09
	Wtrig	7	3.6– 5.0	4.34±.19	.51±.14	11.75±3.14
	Wtal	8	4.1– 4.9	4.50±.17	.47±.12	10.36±2.59
P_4	L	9	6.8– 8.5	7.63±.22	.65±.15	8.57±2.02
	Wtrig	8	3.9– 5.7	4.92±.21	.59±.15	11.91±2.98
	Wtal	7	4.6– 6.0	5.14±.25	.67±.18	13.02±3.48
M_1	L	7	7.1– 9.0	8.11±.28	.75±.20	9.25±2.47
	Wtrig	7	4.7– 6.1	5.34±.18	.49±.13	9.23±2.47
	Wtal	5	4.8– 6.1	5.38		
M_2	L	2	8.5– 9.3	8.9		
	Wtrig	2	6.0– 6.4	6.2		
	Wtal	2	6.6– 7.1	6.85		
M_{1-2}	L	2	8.3– 8.5	8.4		
	Wtrig	2	5.6– 6.2	5.9		
	Wtal	2	5.6– 6.4	6.0		
M_3	L	6	10.6–12.3	11.42±.24	.58±.17	5.12±1.48
	Wtrig	6	5.5– 6.1	5.83±.09	.23±.07	3.98±1.15
	Wtal	6	5.1– 6.0	5.62±.15	.37±.11	6.60±1.91

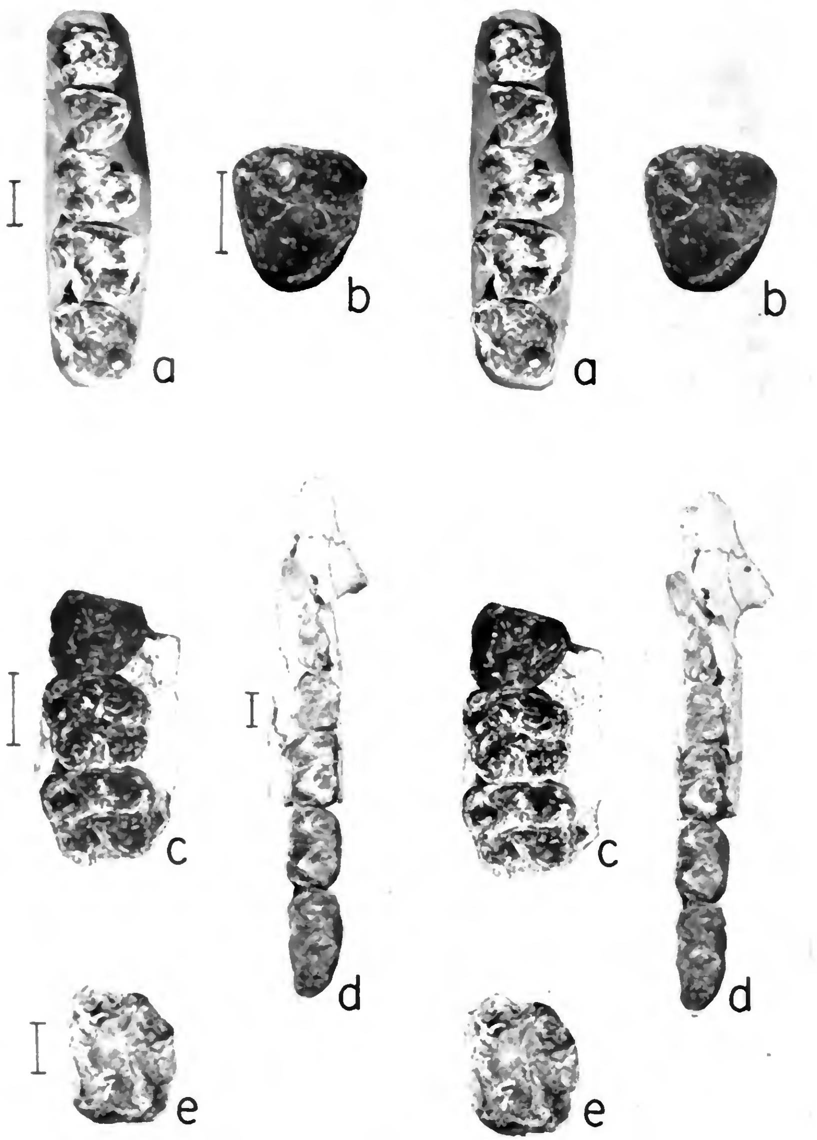


PLATE XIV. Perissodactyls. All specimens illustrated as stereopairs. The line beside the left member of each pair represents 5 mm. **a.** *Hyracotherium vasacciense*, PM 15385, RP³-M². **b.** *Hyracotherium craspedotum*, PM 15407, LP⁴. **c.** *Orohippus* cf. *O. pumilus*, UW 1316, RP⁴-M². **d.** *Lambdotherium popoagicum*, PM 15201, LP₂-M₃. **e.** *Lambdotherium popoagicum*, PM 15434, LM³.

Blue Rim: 9 (Jaws: PM 15385*, RP_3-M_3, LP^4-M^3; PM 15392 RM^2-M^3), PM 15398, 15400, 15615–6, 15618–9, 15634.

Piney Cutoff: 3 PM 15347, 15349, 15628.

Unnamed: 3 PM 15355–6, 15498.

Two Buttes: 16 (Jaws: PM 15371, RM^1, LM^2; PM 15447*, LP_3-M_3), PM 15367–70, 15373, 15376, 15378–81, 15517, 15533, 15622–3.

Twnf–C: (Jaw: PM 15360, LP_3-P_4, RM^3), PM 15362–3.

Discussion.—*Hyracotherium vasacciense*, a middle and late Wasatchian species, is by far the more abundant of the two species present in the study collection. Differentiation between this species and *H. craspedotum* is made essentially on the basis of size, with attention devoted to the molarization of P^3 when it can be positively associated.

Hyracotherium craspedotum Cope, 1880. Plate XIVb.

Material.—Steele Butte Breaks: 6 PM 15204–5, 15210, 15229, 15407*, 15414.

East Fork Rim: 7 PM 15239, 15418, 15436, 15442, 15457, 15578, 15584.

Blue Saddle: 1 PM 15366.

Two Buttes: 1 (Jaw: PM 15384, RP_4-M_1).

Discussion.—*Hyracotherium craspedotum* is about 20 per cent larger than *H. vasacciense* and is not nearly so well represented in the study collection. Gazin (1962, pp. 73–75) recorded both species from the New Fork Tongue, and found *H. vasacciense* to be more abundant by a factor of 3:1. *H. craspedotum* is more common in the arkosic facies of the New Fork Tongue than in the western facies, although only 15 specimens have been found, and it is far outnumbered by *H. vasacciense* in both units.

Orohippus Marsh, 1872

Orohippus cf. **O. pumilus** (Marsh, 1871). Plate XIVc.

Material.—Fault: 9 UW 1561–2, 1316*, P9, PM 15254–5, 15258, 15873–4.

White Hills: 1 PM 15259.

Hawk: 1 PM 15878.

Tree Road: 2 PM 15879, 15881.

Green: 2 PM 15344–5.

TABLE 53. Measurements in millimeters of teeth of *Hyracotherium craspedotum*

		N	OR	M
P^4	L	5	8.0– 8.7	8.42
	W	5	8.9–10.7	10.2
M^2	L	1	9.9	
	W	1	12.1	
M^{1-2}	L	1	9.5	
	W	1	12.5	
M^3	L	1	9.6	
	W	1	11.5	
P_3	L	2	8.5– 8.6	8.55
	Wtrig	2	5.0– 6.4	5.7
	Wtal	2	5.4– 5.5	5.45
P_4	L	1	8.7	
	Wtrig	1	5.8	
	Wtal	1	6.5	

Discussion.—*Orohippus* is the Bridgerian descendent of *Hyracotherium*. It is much less common in the early Bridgerian than *Hyracotherium* is in the late Wasatchian. Progressive features that distinguish *Orohippus* from *Hyracotherium*, considering, of course, that the two genera are portions of a continuum, include the presence of a mesostyle on the upper molars and a hypocone on P^3 and P^4 of *Orohippus*. Kitts (1957) reviewed *Orohippus* and reduced the 12 named species to five valid ones, one of which is present in the study collection.

Most of the equid material from the various Bridgerian localities satisfies the criteria listed above for separation from *Hyracotherium*. A P^4 with a good hypocone is shown on PM 15258, and a molar with

TABLE 54. Measurements in millimeters of teeth of *Orohippus* cf. *O. pumilus*.

		N	OR	M
P^4	L	3	6.4–6.9	6.6
	W	3	7.0–7.5	7.3
M^1	L	4	7.0–7.5	7.32
	W	4	6.7–8.1	7.82
M^2	L	2	7.5–7.6	7.55
	W	2	8.7–9.7	9.2
M^{1-2}	L	1	7.8	
	W	1	8.0	
M^3	L	2	7.0–8.5	7.75
	W	2	7.0–7.8	7.4
P_3	L	2	6.0–7.0	6.5
	Wtrig	2	3.9–4.0	3.95
	Wtal	2	3.8–4.0	3.9
P_4	L	2	6.2–7.0	6.6
	Wtrig	2	4.5–4.6	4.55
	Wtal	2	4.5	
M_1	L	1	7.1	
	Wtrig	1	4.9	
	Wtal	1	5.2	
M_3	L	1	11.0	
	Wtrig	1	5.0	
	Wtal	1	4.5	

a mesostyle by PM 15344. The mesostyles are poorly developed on most of these specimens, and only barely visible on some. However, this is a feature which is progressively better developed through the Bridgerian, and individuals occurring higher in the Bridger Formation show it more prominently. An inspection of the *Orohippus* material at the American Museum of Natural History showed the Bridger B specimens to be variable in this feature, while specimens from the Bridger C and D have it well developed almost invariably.

TABLE 55. Measurements in millimeters and statistics of teeth of *Lambdotherium popoagicum*.

		N	OR	M	SD	V
P^4	L	3	8.8–9.5	9.13		
	W	2	11.4–12.0	11.7		
M^2	L	10	11.1–13.5	12.1 ±.26	.82±.18	6.74±1.51
	W	10	13.0–16.8	15.12±.44	1.38±.31	9.09±2.03
M^{1-2}	L	3	10.3–12.5	11.53		
	W	2	13.8–15.0	14.4		
M^3	L	10	10.2–11.8	11.28±.15	.47±.10	4.19±0.94
	W	10	14.0–16.0	14.62±.19	.60±.13	4.08±0.91
P_3	L	4	8.6–9.9	9.12		
	Wtrig	4	4.6–5.8	5.12		
	Wtal	3	4.8–6.6	5.50		
P_4	L	8	8.2–10.8	9.42±.18	.73±.26	7.76±1.94
	Wtrig	8	5.8–7.0	6.31±.11	.43±.15	6.80±1.70
	Wtal	8	5.9–7.0	6.50±.10	.41±.14	6.37±1.59
M_1	L	7	10.9–14.5	12.00±.24	.64±.17	5.29±1.41
	Wtrig	7	6.0–10.0	7.87±.50	1.32±.35	16.77±4.48
	Wtal	7	7.2–10.0	8.07±.36	.96±.26	11.88±3.18
M_2	L	6	11.4–12.6	12.03±.20	.50±.14	4.16±1.20
	Wtrig	6	8.1–8.7	8.35±.12	.29±.08	3.42±0.99
	Wtal	6	7.8–8.9	8.27±.16	.38±.11	4.56±1.32
M_{1-2}	L	3	11.2–13.0	11.9		
	Wtrig	3	7.5–8.5	8.1		
	Wtal	2	7.8–8.6	8.2		
M_3	L	10	14.3–18.0	6.22±.36	1.13±.25	6.97±1.56
	Wtrig	10	7.6–9.3	8.60±.16	.51±.11	5.98±1.34
	Wtal	11	7.1–8.5	7.80±.16	.52±.11	6.73±1.43

Superfamily Brontotherioidea Hay, 1902

Family Brontotheriidae Marsh, 1873

Subfamily Lambdotheriinae Hay, 1902

Lambdotherium Cope, 1880

Lambdotherium popoagicum (Cope, 1880). Plate XIVd, e.

Material.—Steele Butte Breaks: 35 (Jaws: PM 15201*, LP_2-M_3; PM 15203, RP_4, M_2-M_3, LM_3), PM 15202, 15220–8, 15230–3, 15402, 15420–9, 15431–3, 15466, 15595–7, 15600.

East Fork Rim: 22 (Jaws: PM 15241, RP_4-M_1; PM 15439, R& LP_3-M_3; PM 15463, RP_3-P_4), PM 15243-6, 15249, 15251, 15253, 15434*, 15435, 15437-8, 15440, 15459-62, 15464-5, 21230.

Blue Rim: 7 PM 15386, 15390, 15393, 15395, 15397, 15401, 15617.

Piney Cutoff: 1 PM 15348.

Unnamed: 1 PM 15354.

Two Buttes: 5 (Jaws: PM 15382, RM_1-M_2; PM 15383, R&LM_3), PM 15372, 15377, 15620.

Twnf-C: 1 PM 15361.

Discussion.—*Lambdotherium popoagicum* is a medium-sized cursorial perissodactyl, more generalized than its larger, horned Oligocene successors. It is as abundant as *Hyracotherium* in the later Wasatchian, and disappears without persisting into the early Bridgerian fauna. Neither direct ancestor nor descendent are known.

Subfamily Palaeosyopinae Steinman and Döderlein, 1890

Eotitanops Osborn, 1907

Eotitanops borealis (Cope, 1880). Plate XVa.

Material.—East Fork Rim: 1 PM 15609*.

Discussion.—*Eotitanops* is known from throughout the Lost Cabin faunal zone, although only one individual was found in the New Fork-Big Sandy area. The W-shaped ectoloph and conical internal cusps are indicative of its position in the titanothere lineage. The protoconule is developed, but there is no trace of a metaconule. Since the material in the study collection consists of only two upper molars, both of which are too small to be *Palaeosyops* (Robinson, 1966, p. 66), there is no way to compare the lower molars with Robinson's or Osborn's (1929, p. 290) descriptions.

TABLE 56. Measurements in millimeters of teeth of *Eotitanops borealis*, PM 15609.

	M^1	M^2
Length	18.8	21.9
Width	21.1	24.0

Palaeosyops Leidy, 1870

Palaeosyops fontinalis Cope, 1882. Plate XVb.

Material.—Fault: 1 UW P10.

Hawk: 1 PM 15876*.

Discussion.—*Palaeosyops* of the early Bridgerian is recognized as a genus separate from, and probably derived from, *Eotitanops*. It is morphologically similar to *E. borealis*, differing only in the larger size. The M^2 of *P. fontinalis* in the study collection, PM 15876, is 27.0 mm. long, half again as large as *E. borealis*. Robinson (1966, p. 66) recognized the similarity, although he differentiated the two genera, as I do here, with reservations. Gazin pointed out the arbitrariness of the generic distinction when in 1952 (p. 76) he suggested the assignment of a Washakie Basin Cathedral Bluffs palaeosyopine to *Eotitanops* based on his interpretation of a Wasatchian aspect to the rest of the fauna from the locality.

Suborder Ceratomorpha Wood, 1937

Superfamily Tapiroidea Gill, 1872

Family Helaletidae Osborn, 1892

Radinsky (1963, 1967) has recently revised the family, and his suggestions on the systematics are followed here.

Heptodon Cope, 1882

Heptodon is the characteristic helaletid tapiroid of the middle to late Wasatchian. It occurs in the Lost Cabin equivalent faunas in the study collection, represented by two species, but is not persistent into the known Bridgerian faunas.

Heptodon posticus (Cope, 1882). Plate XVc, d.

Material.—Steele Butte Breaks: 3 PM 15234, 15235*, 15467.

East Fork Rim: 1 PM 15469*.

Discussion.—*Heptodon posticus* is the largest species of *Heptodon*. It is much less common than *H. calciculus* in the Wind River Basin Lost Cabin zone; the single specimen known from the Bighorn Basin Lost Cabin equivalent fauna is *H. posticus* (Radinsky, 1963, p. 38). Gazin has not found any *H. posticus* in his New Fork Tongue localities and all four of the specimens in the study collection are from the arkosic facies of the New Fork Tongue.

Heptodon calciculus (Cope, 1880). Plate XVe.

Material.—Steele Butte Breaks: 2 PM 15236, 15470.

East Fork Rim: 3 (Jaw: PM 15468*, RP_3-M_1), PM 15242, 15248.

Two Buttes: 1 PM 15621.

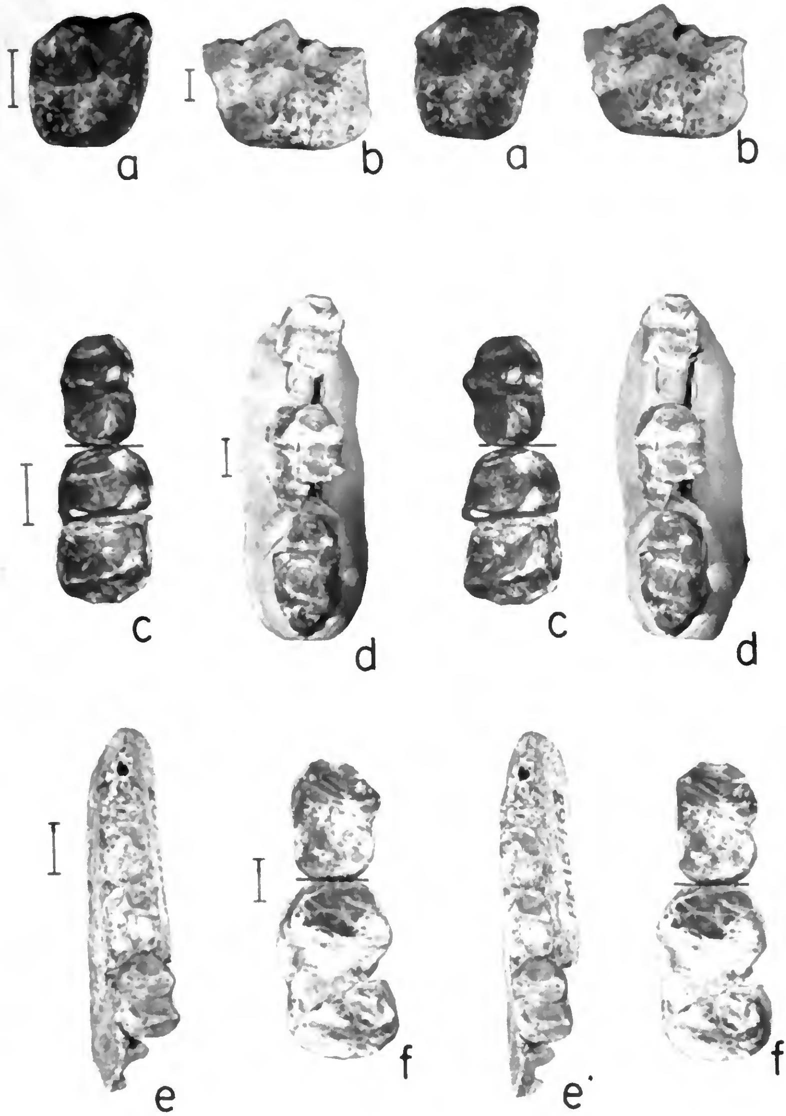


PLATE XV. Perissodactyls. All specimens illustrated as stereopairs. The line beside the left member of each pair serves as the scale: for **a** it represents 10 mm., and for **b** through **f** it represents 5 mm. **a.** *Eotitanops borealis*, PM 15609, LM^2. **b.** *Palaeosyops fontinalis*, PM 15876, LM^2. **c.** *Heptodon posticus*, PM 15235, RP_4M_2. **d.** *Heptodon posticus*, PM 15469, LM_1-M_3. **e.** *Heptodon calciculus*, PM 15468, RP_3-M_1. **f.** *Hyrachyus modestus*, PM 15261, LP_4M_2.

TABLE 57. Measurements in millimeters of teeth of *Heptodon posticus*.

		N	OR	M
M^3	L	1	11.0	
	W	1	14.0	
P_3	L	1	8.4	
	Wtrig	1	5.0	
	Wtal	1	5.0	
P_4	L	1	9.3	
	Wtrig	1	6.2	
	Wtal	1	6.4	
M_1	L			
	Wtrig	1	9.0	
	Wtal			
M_2	L	2	13.3–14.5	13.9
	Wtrig	2	8.0– 9.0	8.5
	Wtal	1	8.3	
M_{1-2}	L			
	Wtrig	1	8.0	
	Wtal			
M_3	L	1	16.4	
	Wtrig	1	8.0	
	Wtal	1	8.1	

Discussion.—*Heptodon calciculus*, the smaller species of *Heptodon* present in the study collection, is also uncommon. Gazin (1962, pp. 78–80) found it in the New Fork Tongue, calling it *H. ventorum*, a species which Radinsky (1963, p. 34) synonymized with *H. calciculus*. Gazin (1962, p. 79) proposed reference of some larger individuals from his New Fork Tongue collection to *H. ventorum* mut. *posticus*, but the material in my collection allows a clear differentiation between *H. posticus* and *H. calciculus* in the fauna from the western facies of the New Fork Tongue.

TABLE 58. Measurements in millimeters of teeth of *Heptodon calciculus*.

		N	OR	M
M^1	L	1	10.0	
	W	1	11.5	
M^{1-2}	L	1	10.0	
	W	1	11.0	
P_3	L	1	6.9	
	Wtrig	1	4.4	
	Wtal	1	4.2	
P_4	L	1	7.1	
	Wtrig	1	4.9	
	Wtal	1	4.8	
M_1	L	1	8.5	
	Wtrig	1	5.8	
	Wtal	1	5.9	
M_{1-2}	L	1	11.5	
	Wtrig	1	7.2	
	Wtal	1	7.2	
M_3	L	2	14.6–14.8	14.7
	Wtrig	2	7.3– 7.9	7.6
	Wtal	2	7.1– 7.2	7.15

Subfamily Hyrachyinae Osborn, 1892

Radinsky (1967), as a part of his re-examination of the early Tertiary perissodactyls, recently reviewed the genus *Hyrachyus* from North America and Europe. He (1967, p. 21) reduced the Hyrachyidae to a subfamily and transferred it from the Rhinocerotoidea to the Tapiroidea, placing it in the Helaletidae. He felt that the hyrachyines are traceable to and not much different from the earliest *Heptodon* (early or middle Wasatchian), and that *Hyrachyus* thus belongs in the tapiroid line.

Hyrachyus Leidy, 1871

Hyrachyus modestus (Leidy, 1871). Plates XVf, XVI a.

Material.—Fault: 1 PM 15872.

Hawk: 1 (Skull: PM 15261*, LP^2-P^3, RP^2-P^4, LP_3, P_4, M_2).

Sandstone Point: 1 (Jaw: PM 15260, LM^1-M^2).

Green: 2 PM 15346, 15569.

Steele Butte Breaks: 1 PM 15237.

Discussion.—This is the largest non-brontotheriid perissodactyl present in the study collection. Aside from a moderately well-preserved skull from Hawk locality (PM 15261), it is represented only by fragmentary teeth. When the ectoloph of an upper molar is present, as in PM 15260, *Hyrachyus* is readily identifiable at the generic level.

TABLE 59. Measurements in millimeters of teeth of *Hyrachyus modestus*.

		N	OR	M
P^3	L	2	10.5–12.7	11.6
	W	2	16.2	
P^4	L	1	15.5	
	W	1	18.7	
M^1	L	2	19.8–20.0	19.9
	W	1	18.0	
M^2	L	2	22.5–25.0	23.75
	W	1	23.3	
M^{1-2}	L	1	15.8	
	W	1	22.0	
M^3	L	1	19.0	
	W	1	22.8	
P_3	L	1	12.5	
	Wtrig	1	8.0	
	Wtal	1	8.2	
P_4	L	1	14.0	
	Wtrig	1	9.7	
	Wtal	1	9.5	
M_{1-2}	L	1	20.7	
	Wtrig	1	12.7	
	Wtal	1	12.5	

Radinsky's (1967) study stressed that the only valid criterion for separation of Bridgerian species of *Hyrachyus* is size, and that in the late Wasatchian *H. modestus* is the only species present. *H. modestus* is present in both Wasatchian and Bridgerian faunas in the study collection.

The skull is large, with an M^1-M^3 length of 61.3 mm. Radinsky (1967, p. 3) mentioned two unusually large specimens of *H. modestus* with M^1-M^3 lengths of 63 and 65 mm., so PM 15261 falls readily within the observed range of this species.

Indeterminate Tapiroid

Material.—Fault: 1 PM 15257.

Discussion.—This fragmental tooth has the lophodont structure with transverse crests typical of tapiroids. It may be a representative of the Bridgerian *Helaletes*, but the material is inadequate for even a familial identification. The tooth has an estimated length of 15 mm. and a talonid width of 6.7 mm.

Order Artiodactyla
Suborder Suiformes Jaeckel, 1911
Infraorder Palaeodonta Matthew, 1929
Family Dichobunidae Gill, 1872
Subfamily Diacodexinae sensu Gazin, 1955
Diacodexis Cope, 1882

Diacodexis cf. **D. secans** (Cope, 1881). Plate XVIb, c.

Material.—White Hills: 1 PM 15706*.

Steele Butte Breaks: 1 PM 15554.

East Fork Rim: 1 PM 15556.

Two Buttes: 2 PM 15557*, 15559.

Twnf-H: 1 PM 15560.

Discussion.—All the study collection upper Wasatch *Diacodexis* material is larger than the *D. chacensis* measured by Robinson (1966, p. 69), and falls close to the range of *D. secans* (op. cit., p. 70). The poor hypocone development and large conules on all the upper molars are characteristic of *Diacodexis*.

PM 15706, from White Hills locality, is the only specimen from the lower Bridger Formation assigned to *Diacodexis*. There is a close similarity to the late Wasatchian *D. secans* specimens. This occur-

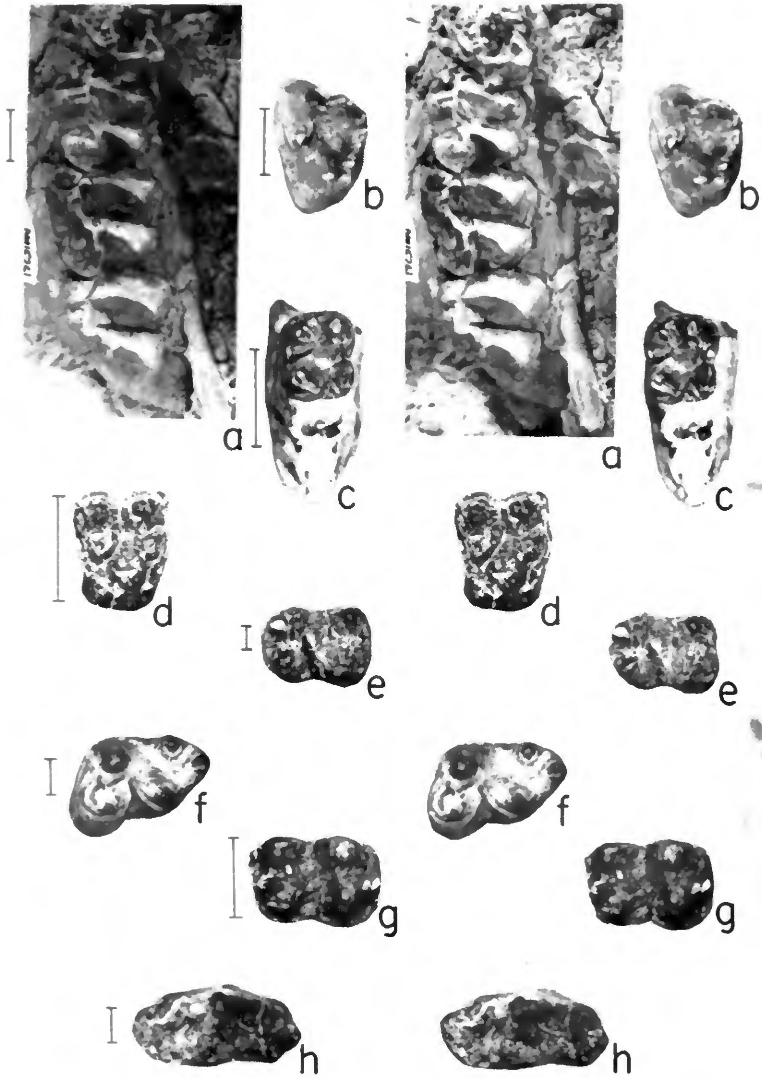


PLATE XVI. Perissodactyl and artiodactyls. All specimens illustrated as stereopairs. The line beside the left member of each pair serves as the scale: for **a** it represents the length of 10 mm., for **b** through **d** and **g** it represents 5 mm., and for **e**, **f**, and **h** it represents 1 mm. **a.** *Hyrachyus modestus*, PM 15261, RM^1-M^3. **b.** *Diacodexis* cf. *D. secans*, PM 15557, LM^3. **c.** *Diacodexis* cf. *D. secans*, PM 15706, LM_{1-2}. **d.** *Antiacodon pygmaeus*, PM 15655, RM^1. **e.** *Antiacodon pygmaeus*, PM 15676, LM_{1-2}. **f.** *Microsus* sp., PM 15012, LM_3. **g.** *Helohyus* cf. *H. plicodon*, PM 15875, RM_3. **h.** Artiodactyl, incertae sedis, PM 15847, RP_4.

TABLE 60. Measurements in millimeters of teeth of *Diacodexis* cf. *D. secans*.

		N	OR	M
M^1	L	1	4.1	
	W	1	5.1	
M^2	L	2	4.2–4.5	4.35
	W	2	5.6–5.8	5.7
M^3	L	2	4.6–4.7	4.65
	W	2	5.2–6.0	5.6
M_{1-2}	L	1	4.5	
	Wtrig	1	3.9	
	Wtal	1	3.7	

rence is stratigraphically high for *Diacodexis*, as it is primarily a Wasatchian genus.

Subfamily Homacodontinae Peterson, 1919

Antiacodon Marsh, 1872

Antiacodon pygmaeus (Cope, 1872). Plate XVId, e.

Material.—Fault: 16 (Jaw: UW 1519, LP_4-M_1), UW P1, 1516, 1520, 1545, 1556, 1721, PM 15279, 15330, 15332, 15655*, 15657, 15659, 15676*, 15691, 15693.

White Hills: 2 PM 15325, 15701.

Hawk: 3 PM 15711, 15768, 15771.

Green: 1 PM 15798.

Discussion.—This is the only artiodactyl in the study collection that is frequently encountered, and even it does not occur at all the well-represented localities. It is distinctive because of the reduced metaconid, close to the paraconid, the presence of a small hypocone

TABLE 61. Measurements in millimeters and statistics of teeth of *Antiacodon pygmaeus*.

		N	OR	M	SD	V
M^1	L	2	4.3–4.5	4.4		
	W	2	5.8–5.9	5.85		
M^2	L	3	4.5–4.7	4.6		
	W	3	5.8–6.3	6.03		
M^3	L	5	4.1–4.5	4.3		
	W	5	4.4–6.0	5.24		
P_4	L	1	5.0			
	W	1	3.6			
M_1	L	6	4.5–5.1	4.73±.08	.20±.06	4.11±1.19
	Wtrig	5	2.7–3.4	3.1		
	Wtal	5	3.1–3.7	3.48		
M_2	L	4	4.7–4.9	4.82		
	Wtrig	4	3.1–3.6	3.38		
	Wtal	4	3.4–4.2	3.85		
M_3	L	2	5.2–5.3	5.25		
	Wtrig	2	3.3–3.5	3.4		
	Wtal	3	3.2–3.7	3.43		

on M^1 and M^2, and an incipient to small mesostyle on all the upper molars. The material in the study collection falls within the size range of *Antiacodon pygmaeus* from the Bridger Formation (Robinson, 1966, p. 71), which is about 6 per cent smaller than the *A. pygmaeus* from the Huerfano B level. PM 15332 is a peculiar upper molar, as it shows a well-developed extra cuspule on the internal side of the protocone.

Microsus Leidy, 1870

Microsus sp. Plate XVIf.

Material.—Fault: 1 PM 15012*.

Discussion.—This single lower third molar is referable to Bridgerian *Microsus* on the basis of the lack of a paraconid and the relatively high cusps. It is larger than *M. cuspidatus* (Sinclair, 1914, pp. 288–289). *Microsus* is known too poorly for any further identification. The tooth is 3.7 mm. long, 2.4 mm. wide across the trigonid, and 2.0 mm. wide across the talonid.

Subfamily Helohyinae Marsh, 1877

Helohyus Marsh, 1872

Helohyus cf. H. plicodon Marsh, 1872. Plate XVIg.

Material.—Fault: 1 PM 15871.

White Hills: 1 PM 15875*.

Discussion.—Two incomplete third lower molars form the sample of *Helohyus* cf. *H. plicodon*, a species known through the Bridgerian. Both are lacking the hypoconulid, but the area of breakage where the hypoconulid joined the main portion of the tooth is small, so presumably the hypoconulid was also small. This, combined with the overall size and robustness of the tooth, suggests *H. plicodon* as the most reasonable assignment (Sinclair, 1914, pp. 281–283).

TABLE 62. Measurements in millimeters of teeth of *Helohyus* cf. *H. plicodon*.

		PM 15871	PM 15875
M_3	Length	9.5	9.7
	Trigonid Width	5.0	5.7
	Talonid Width	5.0	5.5

Artiodactyl? incertae sedis. Plate XVIh.

Material.—Fault: 1 PM 15847*.

Discussion.—This is a peculiar and interesting tooth, possibly referable to the Artiodactyla. It is probably a right P_4, with a high protoconid and a lower metaconid. The paraconid is low and bicusped. The talonid is low and short, with a slight posterior crest. The tooth is 5.2 mm. long and 2.4 mm. wide.

An additional possibility is that this specimen may be a somewhat aberrant premolar of *Phenacodus,* the condylarth genus recently reported from upper Bridger Formation beds at Tabernacle Butte (West and Atkins, 1970).

GEOCHRONOLOGY

Table 63 provides a summary of the geochronologic positions of the various identified species from the New Fork-Big Sandy area. The lines indicate the known stratigraphic range of each species, and the x's indicate the horizons within the New Fork-Big Sandy area from which the species have been recovered. The Cathedral Bluffs materials from the Washakie and Great Divide Basins are not shown; as pointed out in West (1969c) the precise identification of many of those specimens is uncertain. Nonetheless, Table 63, pp. 154–155, enables the reader to see readily the relationships between the New Fork-Big Sandy area faunas and the early and middle Eocene standards.

	WASATCHIAN				BRIDGERIAN	
	Graybull	Lysite	Lost Cabin	Cathedral Bluffs	Block's Fork (?A, B)	Twin Buttes (C, D)
Perotherium cf. *P. innominatum*					—X—	—
P. marsupium					—X—	—
Palaeictops pineyensis		—	—X—			
Apatemys bellulus					—X—	—
Centetodon cf. *C. pulcher*					—X—	—
Myolestes cf. *M. dasypelix*			—		—X—	—
Scenopagus edenensis					—X—	—
S. priscus					—X—	—
Didelphodus altidens			—		—X—	—
Oxyaena forcipata		—	—X—			
Thinocyon cf. *T. velox*					—X—	
Didymictis altidens		—	—X—			
Viverravus gracilis			—		—X—	
Miacis latidens			—X—			
Notharctus cf. *N. nunienus*			—X—			
N. tenebrosus					—X—	
Smilodectes gracilis					—X—	—
Omomys carteri				X	—X—	—
O. sheai			—X—			
Washakius insignis			X		—X—	—
Anaptomorphus aemulus				X	—X—	
Microsyops scottianus			—X—			
M. elegans					—X—	
Sciuravus nitidus				X	—X—	—
Tillomys parvidens					—X—	
Taxymys lucaris					X	—
Knightomys cf. *K. senior*			—	X		
Paramys delicatus					—X—	
P. excavatus	—	—	—X—		—	—
P. wyomingensis				X	—X—	—

	WASATCHIAN				BRIDGERIAN	
	Graybull	Lysite	Lost Cabin	Cathedral Bluffs	Black's Fork (?A,B)	Twin Buttes (C,D)
Reithroparamys huerfanensis				X	—X—	
R. delicatissimus				X	—	—
Pseudotomus robustus					—X—	—
Microparamys minutus					—X—	—
Esthonyx acutidens			—X—			
Bathyopsis fissidens			—X—			
Hyopsodus miticulus			—X—			
H. wortmani		—	—X—			
H. minusculus				X	—X—	
H. paulus					—X—	
Meniscotherium chamense		—	—X—			
M. robustum		—	—X—			
Phenacodus wortmani	—	—	—X—			
P. primaevus	—	—	—X—			—
Hyracotherium vasacciense		—	—X—			
H. craspedotum		—	—X—			
Orohippus cf. O. pumilus				X	—X—	
Lambdotherium popoagicum			—X—			
Eotitanops borealis			—X—			
Palaeosyops fontinalis					—X—	
Heptodon posticus		—	—X—			
H. calciculus		—	—X—			
Hyrachyus modestus			—X—		—X—	
Diacodexis cf. D. secans	—	—	—X—		X	
Antiacodon pygmaeus				X	—X—	—
Helohyus cf. H. plicodon					—X—	—

FAUNAL CORRELATIONS

The intermontane basins of Wyoming, Colorado, and Utah contain a number of early and middle Eocene fossil-producing horizons. This period of time has been divided into a number of faunal zones: the early Eocene Wasatchian age includes the Graybull, Lysite, and Lost Cabin zones, and the middle Eocene Bridgerian age the Bridger A and B (Black's Fork) and Bridger C and D (Twin Buttes) zones. The late Wasatchian and early Bridgerian zones are of interest here. Figure 29 shows the presumed relationships between faunal levels in the New Fork-Big Sandy area and those in the above mentioned basins.

Large animals are probably better than small ones for faunal correlations. First, they are more likely to range more extensively and to occupy available environments more rapidly than smaller animals, increasing the likelihood that they will be present in temporally equivalent localities in widely scattered areas. Secondly, due to their size and visibility, they are more frequently recovered, even in rather cursory prospecting. Smaller animals are badly under-represented or lacking in many surface collections because they are inconspicuous and are found often only by washing or quarrying. Larger forms, including perissodactyls, artiodactyls, condylarths, pantodonts, and dinoceratans form the primary basis for the faunal evaluation to follow, with evidence from the smaller mammals used when available.

New Fork Tongue

Late Wasatchian faunas are compared with the Wind River Basin Lost Cabin fauna, proposed by Sinclair and Granger (1911, pp. 105–106). This fauna comes primarily from a relatively thin horizon, 40–50 ft. thick, about 200 ft. above the base of the Lost Cabin Member. Keefer (1965, pp. 69–70) presented partial measured sections for the Lost Cabin Member of the Wind River Formation, giving it a firm stratigraphic status. The base of the Lost Cabin Member is placed at the level of the first occurrence of the primitive brontothere *Lambdotherium*, the basis for the original description of

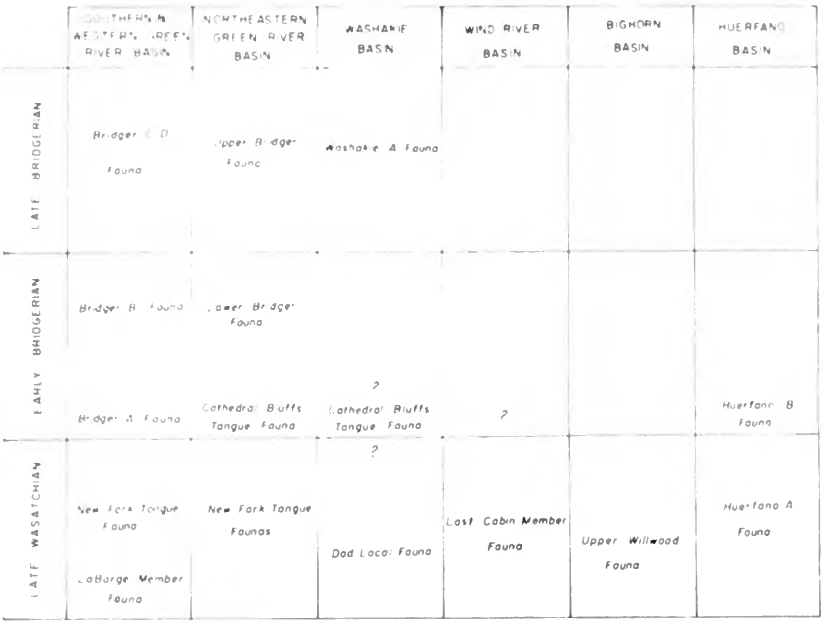


FIG. 29. Relationships between faunal horizons of the New Fork-Big Sandy area and those of nearby productive basins.

the unit as the "*Lambdotherium* beds," and presumably that genus did not survive the time represented by the Lost Cabin Member sediments. Other mammals characteristic of the Lost Cabin fauna include *Eotitanops, Coryphodon, Bathyopsis fissidens, Phenacodus vortmani, P. primaevus, Meniscotherium chamense, Hyracotherium vasacciense,* and *Diacodexis.* Most of these taxa did not persist into the Bridgerian.

The late Wasatchian fauna from the New Fork-Big Sandy area (that found in the New Fork Tongue) is similar to the fauna from the Lost Cabin Member. Every taxon enumerated above is present in the arkosic facies, and only *Coryphodon* and *Bathyopsis fissidens* are missing from the fauna of the western facies. These two temporally equivalent facies show lithologic differences due to sediment provenance and minor environmental differences. Distinctions between their mammalian faunal compositions are shown in Figures 30 and 31.

Coryphodon, the virtually ubiquitous pantodont of the Lost Cabin zone, is well represented in the arkosic facies (9 per cent of 88 individuals), while neither Gazin nor I have found it in the western

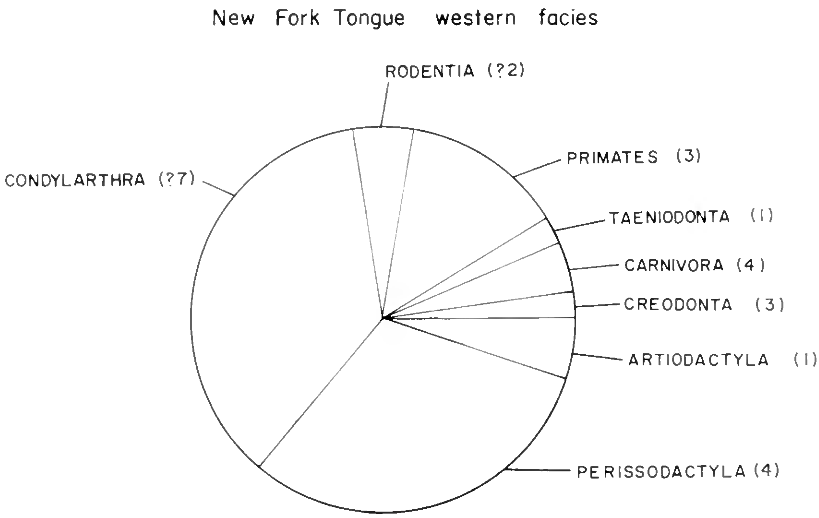


FIG. 30. Ordinal composition of the fauna collected from the various western facies of the New Fork Tongue localities in the New Fork-Big Sandy area. The number in parentheses indicates the number of species identified in each order.

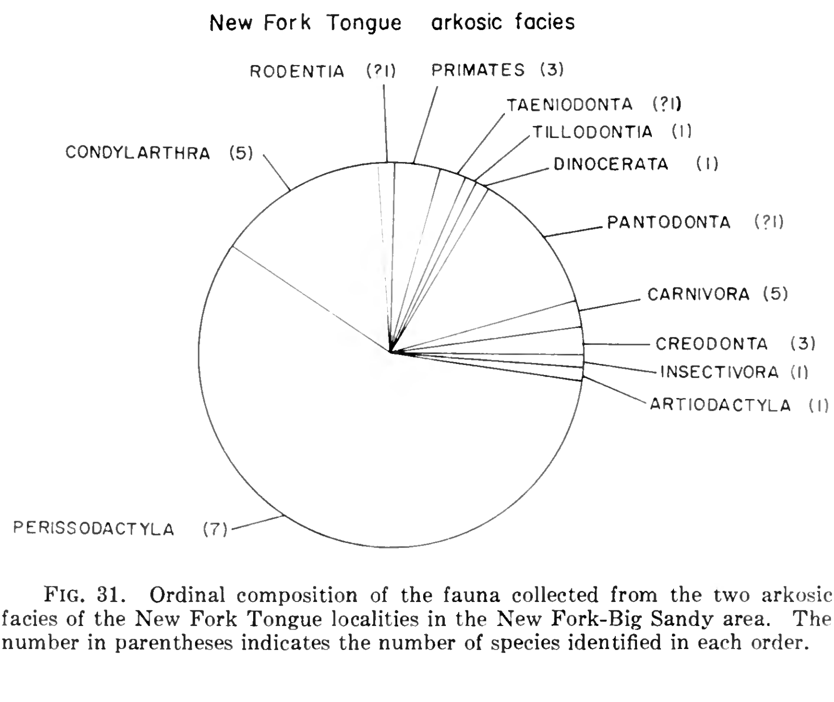


FIG. 31. Ordinal composition of the fauna collected from the two arkosic facies of the New Fork Tongue localities in the New Fork-Big Sandy area. The number in parentheses indicates the number of species identified in each order.

facies. It is such a large animal that, were it present, it would be difficult to miss, even if the remains were badly disarticulated and fragmented. Gazin (1962, p. 70) proposed that the absence of *Coryphodon* in the New Fork Tongue was due to its extinction at the end of the Fontenelle Tongue expansion of Lake Gosiute. The presence of *Coryphodon* in the arkosic facies disproves that suggestion, and it is probable that the absence of *Coryphodon* to the west is due to ecological factors. Gazin (1965, pp. 13–20) has discussed the environmental sensitivity of *Meniscotherium*; the basic incompatibility of *Meniscotherium* and *Phenacodus* is also shown in the Lost Cabin equivalent faunas of the New Fork-Big Sandy area, as *Meniscotherium* is common while *Phenacodus* is quite rare.

Most of the other differences between the faunules from the New Fork Tongue are probably due to small collection bias. Neither unit has yet produced a large number of specimens, so there are probably many elements of each fauna which have not yet been sampled.

Cathedral Bluffs Tongue

There is a temporal gap of uncertain duration between the time represented by the Lost Cabin fauna and that represented by the Green River Basin Bridger B fauna, the next higher well-defined assemblage. In the Wind River Basin this time may be represented partially by the poorly fossiliferous upper 750 ft. of the Lost Cabin Member, which might include some sediments of Bridgerian age. Matthew (1909, p. 296), when dividing the middle Eocene Bridger Formation in the southern Green River Basin, placed the poorly fossiliferous A horizon in this position.

Robinson (1966) described two late Wasatchian faunas from the Huerfano Basin, and placed the latest, from the Huerfano B beds, in the Lost Cabin-Bridger interval. Composition of the Huerfano B fauna suggests that it is actually of Wasatchian age, probably late Lost Cabin, and should not be considered equivalent to Bridger A. C. Wood (1966) collected a small fauna from sediments of Bridger lithology near Opal, Wyoming, and referred these to the Bridger A. Wood's fauna closely resembles that from the Cathedral Bluffs Tongue in the New Fork-Big Sandy area, despite the discrepancies resulting from the small size of both collections.

The fauna recovered from the Cathedral Bluffs Tongue in the New Fork-Big Sandy area is notable for the presence of a number of Bridgerian elements, including *Sciuravus nitidus*, *Omomys carteri*, *Orohippus* cf. *O. pumilus*, *Antiacodon pygmaeus*, and *Hyopsodus minusculus*. Such characteristic Lost Cabin mammals as *Lambdotherium*, *Hyracotherium*, *Coryphodon*, *Meniscotherium*, *Phenacodus*, and the Wasatchian species of *Hyopsodus* are absent. Reliance upon absences in the fossil record for correlative purposes is an inherently unsafe practice, as it involves considerations of preservation and collecting bias and facies differences as well as time. Nonetheless, the simultaneous absence of so many common Lost Cabin taxa must be considered in the context of the presence of numerous common Bridgerian forms.

Orohippus cf. *O. pumilus* is quite primitive as indicated by the poor development of the molar mesostyles. Unfortunately, no fourth premolars have yet been found in the Cathedral Bluffs Tongue, so positive assignment of this material is not possible. The Cathedral Bluffs species of *Hyopsodus* is closest to *H. minusculus*, but has some stylid features resembling the Wasatchian species. *Microsyops* sp. may be intermediate between Wasatchian *M. scottianus* and Bridgerian *M. elegans*. This combination of presence of Bridgerian taxa, some of which are relatively primitive, and the absence of Lost Cabin faunal elements is evidence for a post-Lost Cabin, probably very early Bridgerian, age for the Cathedral Bluffs Tongue in the New Fork-Big Sandy area. On a simple superpositional basis, it is certainly younger than the New Fork Tongue.

The collection is informative despite its small size and restricted number of taxa. Aside from several specimens found on the surface prior to washing, the animals and fragments representing them are small. The faunal list from Green locality shows a preponderance of rodents, primates, and condylarths (fig. 32). More intensive collecting at this locality should significantly increase the numbers of taxa known from this part of the Cathedral Bluffs Tongue and, hopefully, solidify the temporal interpretation.

South of the New Fork-Big Sandy area the Cathedral Bluffs Tongue is considerably thicker (fig. 13). Morris (1954, p. 199) felt that in the northern Washakie Basin the Cathedral Bluffs Tongue ". . . may be placed between the Lost Cabin level and the Bridger B, perhaps being represented by the rarely fossiliferous sediments of the Bridger A." Gazin (1959) reworked Morris's fauna and concluded that the Washakie Basin Cathedral Bluffs Tongue represents late Wasatchian time, faunally equivalent to the Lost Cabin Member of the Wind River Formation and the New Fork Tongue of the Wasatch Formation.

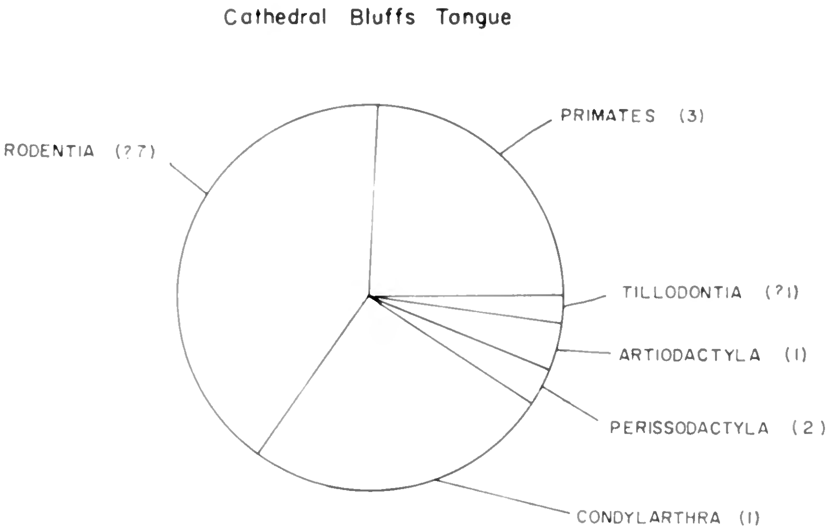


FIG. 32. Ordinal composition of the fauna collected from the two Cathedral Bluffs Tongue localities in the New Fork-Big Sandy area. The number in parentheses indicates the number of species indentified in each order.

My (West, 1969c) review of Morris's specimens leads to essentially the same conclusion as that reached by Morris. The absence of most typical Lost Cabin taxa (*Coryphodon*, *Lamdotherium*, *Meniscotherium*, *Exthonyx*, and *Phenacodus*, among the common larger Wasatchian mammals, are not present), combined with the indeterminate nature of the rest of the small collection, are more suggestive of a post-Lost Cabin age than of the Lost Cabin zone itself.

Also in the Washakie Basin, west of Dad, McGrew (McGrew and Roehler, 1960, p. 158) found a single *Sciuravus nitidus* tooth in the upper part of the Cathedral Bluffs Tongue, suggestive of a possible Bridgerian age for that part of the unit. Several miles south of Oregon Buttes (T. 25N., R. 101 W.), in a green zone near the top of the Cathedral Bluffs Tongue, a rodent fauna was found which A.E. Wood believed to be intermediate in age between Lost Cabin and early Bridgerian (McGrew and Roehler, 1960, p. 158). Nace (1939, pp. 26–27) found a tillodont tooth in the Cathedral Bluffs Tongue in the Northwestern part of the Red Desert which indicated a middle Eocene age to G. G. Simpson (pers. comm., cited by Nace, 1939, p. 26), late Wasatchian to Gazin (1959), and as *Trogosus* sp., either Wasatchian or Bridgerian to Robinson (cited in Zeller and Stephens, 1969, p. 16).

This faunal evidence suggests that the Cathedral Bluffs Tongue of the Wasatch Formation may well be closely allied to the Bridger A horizon of the southern and central Green River Basin, and possibly to the Aycross Formation of the Wind River Basin. The paucity of paleontologic data prevents uey close correlations. The small collection from the Cathedral Bluffs Tongue in the New Fork-Big Sandy area is the largest collection yet made from the unit. Far more collecting is necessary before the position of the Cathedral Bluffs Tongue is established beyond doubt throughout its exposure area.

In addition to the lack of fossils, the possible confusing contribution of facies differences must be considered. It is obvious that the New Fork-Big Sandy area Cathedral Bluffs Tongue was deposited under different conditions than was the Cathedral Bluffs Tongue to the southeast. This environmental difference may well have contributed to faunal differences. However, I feel that the lack of relationship to almost the entire Lost Cabin fauna, and the resemblance to the typical Bridger B fauna, is evidence for the post-Lost Cabin age of the Cathedral Bluffs Tongue in the New Fork-Big Sandy area, despite the facies difference.

This facies difference may also be used as the basis for separating the drab Cathedral Bluffs Tongue as a unit separate from the variegated Cathedral Bluffs Tongue. This action may be necessary in the future, but for the present it is less confusing to regard the paludal beds as a facies of the Cathedral Bluffs Tongue.

A potential correlative aid in this problem is the use of essentially simultaneously-deposited volcanic debris to relate separated units. The middle and upper portions of the Wind River Formation in the northwestern Wind River Basin contain tuffaceous sediment (Keefer, 1957, pp. 188–192), indicative of the initiation of volcanic activity during the late Wasatchian. The middle Eocene Aycross Formation is markedly tuffaceous, much like the Bridger Formation of the same age in the Green River Basin. No correlations can be based on the mere presence of the volcanic material, as it has not yet been analyzed and compared. Future investigations of the tuffaceous zones may provide a non-paleontological correlation between the Green River and the Wind River Basins.

Bridger Formation

The Bridger Formation, which overlies the Wasatch and Green River Formations in the Green River Basin, is the focal point for correlation of the intermontane basin middle Eocene faunas.

Middle Eocene beds are not known to be present in the central and eastern Wind River Basin (Tourtelot, 1957; Keefer, 1965), as the upper Eocene Tepee Trail Formation unconformably overlies the Wind River Formation where most of the Lost Cabin member collecting areas are located. At the northwest end of the Wind River Basin the middle Eocene Aycross Formation (Love, 1939, p. 66) is present at higher elevations, but as pointed out by Black (1967, p. 46), it has not yet been adequately prospected.

In the southern Green River Basin the Bridger Formation was divided into five horizons, A, B, C, D, and E by Matthew (1909, pp. 295–304). These horizons are lithologically separable through part of their exposure area by several "white layers" composed of light-colored hard marlstone or water-laid tuff. Their two distinct faunas are the sole feature distinguishing upper and lower portions in the absence of the white layers. H. E. Wood (1934, pp. 241–242) utilized

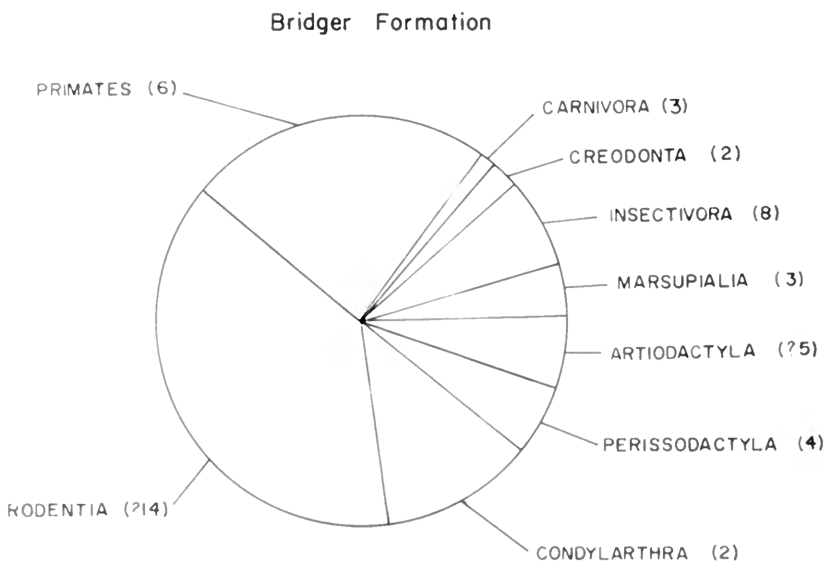


Fig. 33. Ordinal composition of the fauna collected from the various lower Bridger Formation localities in the New Fork-Big Sandy area. The number in parentheses indicates the number of species identified in each order.

this faunal zonation to designate two biostratigraphic units within the Bridger Formation, combining Matthew's A and B zones into the Black's Fork Member and C and D into the Twin Buttes Member because of doubt that it was actually Bridgerian in age.

Matthew (1909, pp. 298–302) listed the following characteristic Bridger B taxa: *Orohippus pumilus, Palaeosyops fontinalis, Sarcolemur* (=*Antiacodon*) *pygmaeus, Hyposodus paulus,* and *Hyposodus minusculus.* The material collected from the various lower Bridger Formation localities within the New Fork-Big Sandy area includes the taxa listed above, as well as the additional common Bridgerian elements *Sciuravus nitidus, Smilodectes gracilis,* and *Microsyops elegans.* It is clear that the lower Bridger Formation beds in the New Fork-Big Sandy area are producing a typical Bridger B fauna.

The composition of the lower Bridger Formation fauna from the New Fork-Big Sandy area is skewed toward the smaller forms as a result of extensive washing as well as the naturally higher numbers smaller animals. This composition is shown in Figure 33. The lower Bridger localities in the New Fork-Big Sandy area produced 60 per cent primates and rodents, and 12 per cent *Hyopsodus. Sciuravus* is the most abundant genus in the lower Bridger Formation collection, making up 19 per cent of the individuals at Fault locality, the largest of the localities.

CONCLUSIONS

1. The lower part of the Bridger Formation is mapped to the northwest of the Big Sandy River. This is the northernmost known area of Bridger Formation exposure.

2. The Cathedral Bluffs Tongue of the Wasatch Formation is mapped to the northwest, approximately 35 miles from the nearest previously mapped area. Within the New Fork-Big Sandy area it has a rather unusual lithology and probably represents a paludal or marginal lacustrine environment. The sediments are mostly greenish to brownish intraformational mudstone conglomerates in contrast to the more brightly colored Wasatchian sediments below and the buff to white Bridgerian sediments above. To the southeast of the New Fork-Big Sandy area, the Cathedral Bluffs Tongue is thicker and variegated.

3. The Laney Shale Member of the Green River Formation is found overlying and interfingering with the Cathedral Bluffs Tongue of the Wasatch Formation in the New Fork-Big Sandy area, thus extending its known outcrop area to the north.

4. The Fontenelle Tongue of the Green River Formation outcrops along the New Fork River for about 8 miles upstream of Ross Butte, where it merges laterally into the arkosic facies of the Wasatch Formation.

5. The New Fork Tongue of the Wasatch Formation is mapped to the east of its previously-known exposures, and is here referred to as the western facies of the New Fork Tongue. It interfingers with the arkosic facies of the New Fork Tongue of the Wasatch Formation in the Blue Rim. The New Fork Tongue also makes up most of the elevation commonly called the "Mesa" in the northwestern part of the New Fork-Big Sandy area.

6. The arkosic facies of the New Fork Tongue of the Wasatch Formation is informally defined to designate a zone of sandy mudstones and arkoses which are temporal equivalents of the western facies of New Fork and Fontenelle Tongues, and which occur near

Boulder as well as along the Big Sandy River. This unit is distinct from the overlying Cathedral Bluffs Tongue of the Wasatch Formation lithologically as well as faunally.

7. The Continental Fault system, previously traced only to the east of the Big Sandy River, is followed to the northwest. The Continental Fault system controls the outcrop pattern of the Bridger Formation in the New Fork-Big Sandy area.

8. A significant temporal difference is noted in the New Fork-Big Sandy area between the New Fork and Cathedral Bluffs Tongues of the Wasatch Formation. The New Fork Tongue is stratigraphically lower and faunally earlier than the Cathedral Bluffs Tongue.

9. Mammals have been found at 26 localities within the New Fork-Big Sandy area, 13 in the lower Bridger Formation, two in the Cathedral Bluffs Tongue, two in the arkosic facies of the New Fork Tongue, and nine in the western facies of the New Fork Tongue. Various reptiles and fish also occur at most of these localities. Remains of aquatic organisms, vertebrates and invertebrates as well as plants, have been found in the various lacustrine units.

10. Faunal evidence, based on the presence of *Lambdotherium*, *Hyracotherium*, *Meniscotherium* (despite its ecologic limitations), *Coryphodon*, *Heptodon*, and *Phenacodus* and certain species of *Hyopsodus*, *Notharctus*, and *Microsyops* indicate a late Wasatchian, Lost Cabin age for both facies of the New Fork Tongue.

11. A small collection from the Cathedral Bluffs Tongue contains Bridgerian genera, including *Orohippus*, *Antiacodon*, *Omomys*, and Bridgerian species of *Sciuravus* and *Hyopsodus*, although some of the individuals seem more primitive than those usually present in the Bridger B fauna. This evidence, together with the lack of many typical Lost Cabin taxa, suggests a post-Lost Cabin and possibly very early Bridgerian age for the Cathedral Bluffs Tongue of the Wasatch Formation within the New Fork-Big Sandy area. Faunal evidence for the age of Cathedral Bluffs Tongue beds in the Great Divide and Washakie Basins is inadequate, but suggests a post-Lost Cabin age for at least the upper part of the unit. It is possible that faunally older beds occur low in the Cathedral Bluffs Tongue in that region.

12. The lower Bridger Formation beds within the New Fork-Big Sandy area have produced such mammals as *Orohippus*, *Smilodectes*, *Palaeosyops*, *Antiacodon*, and certain species of *Hyopsodus*, *Notharctus*, and *Sciuravus*. These, as well as the rest of the assemblage,

indicate that the fauna is equivalent to the early Bridgerian (Bridger B) fauna from the southern and central parts of the Green River Basin.

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APPENDIX

MEASURED SECTIONS

Section 1

Arkosic facies of the New Fork Tongue of the Wasatch Formation along the Big Sandy River, center sec. 21, T. 30 N., R. 105 W.

	Thickness (feet)
Arkosic facies (in part):	
17. Overgrown zone with brush and rubble. Faint red and blue bands	40.0
16. Mudstone, mottled red and blue-gray, coarse sandy; some rusty zones	4.0
15. Sandstone, green, gray-green and gray-brown; three pebbly arkose layers	15.0
14. Siltstone and fine sandstone, mottled red and blue-gray; poorly consolidated	3.0
13. Sandstone, mottled yellow-orange and blue, fine; poorly consolidated; not constant in thickness, with some almost totally blue lenses	6.5
12. Siltstone, mottled red and blue-gray, coarse	3.0
11. Sandstone, gray-green, fine; large number of light-colored pebbles; slight ledge-former	3.0
10. Mudstone, mottled red and blue-gray; sandy; some rusty zones	6.5
9. Mudstone, gray-green, pebbly; varies in thickness	3.5
8. Sandstone, bright yellow-orange, arkosic; well consolidated in places; increasingly gray-green toward the bottom; large pebbles common; several layers of green shaley material scattered throughout	15.0

	Thickness (feet)
7. Sand, light gray-green; unconsolidated; some light-colored pebbles	2.5
6. Mudstone, mottled red and blue-gray, sandy	4.5
5. Mudstone, mottled red-orange and blue-gray, sandy	7.0
4. Mudstone, mottled red and blue-gray, sandy	1.5
3. Mudstone, pebbly blue-gray, sandy	1.5
2. Mudstone, mottled red and blue-gray, sandy; more pebbly toward the base	8.0
1. To the base of the outcrop, at river level, an alternation of color bands, essentially mottled red and blue-gray mudstones and blue-green mudstones. Thickness of individual layers varies	50.0+
Total measured thickness	175.0 feet

Section 2

Arkosic facies of the New Fork Tongue of the Wasatch Formation in a cut along the Big Sandy River in NE 1/4 SE 1/4 sec. 21, T. 30 N., R. 105 W.

	Thickness (feet)
Big Sandy facies (in part):	
10. Upper debris-covered zone	40.0
9. Sand, gray, fine-grained; poorly consolidated; contains some larger pebbles	5.5
8. Mudstone, mottled red and blue-gray, sandy	10.0
7. Sandstone, blue with large orange lenses, coarse; poorly consolidated	6.0
6. Mudstone, mottled red and blue-gray, sandy	2.0
5. Mudstone, light blue-gray, pebbly and sandy	2.5
4. Mudstone, mottled red-orange and blue-gray, sandy; numerous pebbles	8.5
3. Mudstone, mottled red-orange and blue-gray with blue-gray dominant; some large pebbles	3.0
2. Mudstone, mottled red and blue-gray, sandy; resistant	9.0

	Thickness (feet)
1. To the base of the outcrop, at river level, a continuation of the red and blue-gray mottled sandy mudstones	25.0
Total measured thickness	111.5 feet

Section 3

New Fork Tongue of the Wasatch Formation and Fontenelle Tongue of the Green River Formation along the south bank of the New Fork River in S ½ sec. 21, T. 31 N., R. 109 W.

New Fork Tongue (in part):	Thickness (feet)
29. Covered zone	5.0
28. Mudstone, gray-green; calcareous	4.0
27. Sandstone, brown	2.0
26. Mudstone, gray-green, blocky	4.5
25. Sandstone, gray-brown; calcareous, somewhat bedded; ledge-former	1.0
24. Sandstone, gray-brown, fine-grained; laminated	0.5
23. Mudstone, gray, sandy	4.0
22. Mudstone, blue-green, sandy; calcareous, blocky; more drab downward	3.0
21. Mudstone, brown, sandy	5.0
20. Sandstone, brown; calcareous; minor ledge-former	0.5
19. Mudstone, dark green, sandy; slightly calcareous; becomes harder toward the base	3.0
18. Mudstone, greenish-brown, sandy; somewhat calcareous; becomes browner and sandier downward	1.5
17. Covered interval	13.5
16. Sandstone, brown, fine-grained; well-bedded channel deposit; quite calcareous	1.5
15. Sandstone, orange-brown; some well-indurated zones	4.0
14. Mudstone, gray-brown, sandy	1.0
13. Sandstone, orange-brown	1.0

		Thickness (feet)
12.	Mudstone, light blue-gray, sandy; some sandy resistant zones	4.5

Fontenelle Tongue (in part):

11.	Sandstone, yellow-brown, fine; very calcareous; top portion better bedded than lower; lower portion less calcareous and less resistant	9.5
10.	Mudstone, gray-green, sandy; well laminated, some very shaley zones	2.0
9.	Sandstone, orange-brown; current laminations.	10.0
8.	Mudstone, brown, sandy; not calcareous	0.2
7.	Sandstone, orange-brown	1.0
6.	Mudstone, brown, sandy; somewhat bedded	0.2
5.	Sandstone, orange-brown; calcareous, very finely bedded	8.0
4.	Mudstone, gray, blocky; calcareous, some shaley zones	2.5
3.	Sandstone, red-brown; very hard	0.2
2.	Sandstone, brown, fine-grained; finely bedded, calcareous	3.0
1.	Covered to water level of New Fork River	6.0
	Total measured thickness	102.0 feet

Section 4

Middle Tongue of the Green River Formation, New Fork Tongue of the Wasatch Formation and lens of the arkosic facies of the New Fork Tongue of the Wasatch Formation at Burma Road, SW ¼ sec. 23, T. 30 N., R. 109 W.

Middle Tongue (in part):		Thickness (feet)
31.	Limestone, buff; massive, with some organic zones	5.0
30.	Sandstone, buff; marly, bedded	1.0
29.	Limestone, buff-white, algal	3.0

		Thickness (feet)
Western Facies of the New Fork Tongue:		
28.	Mudstone, dark olive green, fragmental; marly.	10.5
27.	Sandstone, light gray-green, coarse-grained; marly, poorly sorted; forms a prominent ledge.	1.0
26.	Mudstone, dark green, sandy; slightly calcareous.	5.0
25.	Mudstone, dark gray-green, sandy; slightly calcareous.	2.0
24.	Mudstone, gray-brown, sandy; platy.	0.5
23.	Mudstone, dark green, arkosic.	3.0
22.	Conglomerate, yellow-green, fine-grained; poorly sorted, marly, some feldspar particles.	7.0
21.	Mudstone, yellow-green, sandy.	4.0
20.	Mudstone, purple and green mottled.	3.0
19.	Mudstone, green, reworked (platy fragments held together by calcareous cement).	3.0
18.	Mudstone, green, sandy.	2.5
17.	Conglomerate, gray, fine-grained.	1.5
16.	Mudstone, yellow-green; some feldspar.	13.0
15.	Mudstone, purple-gray, fragmental; somewhat marly.	2.0
Arkosic facies:		
14.	Mudstone, purple-green, arkosic.	5.0
13.	Mudstone, green, arkosic; some sandy zones.	9.0
12.	Mudstone, yellow-green, sandy; little feldspar.	2.0
11.	Mudstone, green, arkosic; interbedded with purplish layers and some less arkosic zones.	50.0
10.	Sandstone, light yellow-green, fine-grained; some reddish oxidized zones.	2.0
9.	Mudstone, mottled red and purple, sandy, arkosic, with greener arkosic zones.	8.0
8.	Mudstone, mottled red and purple, arkosic; green zones more arkosic.	10.0
7.	Mudstone, olive-green, arkosic.	3.0

	Thickness (feet)
Western Facies of the New Fork Tongue:	
6. Mudstone, green, sandy; more olive-green and coarser downward	5.0
5. Covered interval; soil reddish with float from overlying units	15.0
4. Mudstone, green, sandy; small amount of feldspar	5.0
3. Mudstone, purple; platy	1.0
2. Mudstone, purple-gray, and limestone, gray, vesicular; interbedded	1.0
1. To base of exposure, the colors and lithologies change rapidly and the color bands have no lateral continuity. Included in this interval are the following: mudstone, gray-green, arkosic; mudstone, mottled purple and gold, fine-grained; sandstone, gray-green, fine-grained; mudstone, purple, gray and green mottled, somewhat arkosic; mudstone, blue, purple and gold mottled, fine-grained; conglomerate, brown, arkosic; mudstone, purple and green mottled; sandstone, green and purple; calcite dikes, thin, randomly oriented; limestones, discontinuous algal zones; sand, mint green, fine-grained; sandstone, buff, medium-grained, marly	85.0
Total measured thickness	268.0 feet

Section 5

Western Facies of the New Fork Tongue of the Wasatch Formation at the edge of the Mesa in SW ¼ SE ¼ sec. 28, T. 32 N., R. 109 W.

	Thickness (feet)
43. Debris cap	14.0
Western Facies of the New Fork Tongue (in part):	
42. Sandstone, brown, fine-grained; more greenish near top; some well-indurated zones form irregular ledges	36.0

	Thickness (feet)
41. Mudstone, blue-gray, blocky; calcareous, somewhat laminated	4.5
40. Sand, gray; some indurated zones show platy weathering	3.0
39. Mudstone, blue-gray, sandy; somewhat laminated, sandier downward	2.5
38. Mudstone, gray-brown, shaley; becomes sandier downward	1.0
37. Sandstone, gray, fine-grained; some indurated ledge-forming zones	4.5
36. Mudstone, gray, blocky; very calcareous, forms a conspicuous ledge	4.0
35. Sandstone, orange-brown; some indurated zones near the top	23.0
34. Limestone, blue-gray	0.2
33. Sandstone, orange-brown	2.0
32. Mudstone, blue-gray; somewhat laminated	8.0
31. Sandstone, gray; calcareous	2.5
30. Mudstone, gray-brown, sandy	2.0
29. Mudstone, gray-green; somewhat laminated	2.5
28. Sandstone, gray; well laminated, calcareous; prominent ledge-former	3.0
27. Mudstone, gray-green; laminated	2.5
26. Sandstone, orange-brown	4.0
25. Sandstone, orange-brown; fine-bedded	6.0
24. Mudstone, gray-brown, sandy	7.0
23. Mudstone, gray-brown; laminated	1.5
22. Sandstone, gray to brown	1.0
21. Mudstone, gray; well laminated	4.0
20. Shale, gray-brown, sandy; algal zones	0.5
19. Mudstone, brown, shaley; laminated	1.0
18. Mudstone, gray-green; somewhat laminated	4.5
17. Mudstone, gray-orange, sandy	1.0
16. Mudstone, brown, coarse; laminated	0.5

		Thickness (feet)
15.	Sandstone, orange-brown	1.0
14.	Sandstone, gray; platy	0.5
13.	Mudstone, blue-gray	2.5
12.	Shale, brown; well laminated	0.5
11.	Sandstone, gray-orange; heavily oxidized at base	2.0
10.	Mudstone, blue-gray; laminated	1.0
9.	Sandstone, gray; laminated	1.5
8.	Blue-gray mudstone	1.0
7.	Sandstone, gray-brown	2.0
6.	Mudstone, brown to gray	0.5
5.	Sandstone, gray; ledge-former; more orange toward the base	4.0
4.	Sandstone, gray-orange	11.0
3.	Mudstone, greenish-brown	0.5
2.	Mudstone, dark green, sandy; slightly browner toward base; contains bone fragments and *Lepisosteus* scales	5.0
1.	Sandstone, gray and coarse-grained in upper two feet, bright yellow and finer grained in lower portion; some bone fragments	15.0+
	Total measured thickness	188.5+ feet

Section 6

Western Facies of the New Fork Tongue of the Wasatch Formation along the edge of the Mesa in NE ¼ sec. 3, T. 32 N., R. 109 W.

		Thickness (feet)
32.	Debris cover	26.0
	Western Facies of the New Fork Tongue (in part):	
31.	Mudstone, gray, fine-grained, sandy; unconsolidated	11.0
30.	Sandstone, gray-brown, fine-grained; unconsolidated	3.5
29.	Mudstone, gray, sandy; unconsolidated	2.5

		Thickness (feet)
28.	Sandstone, gray-brown, fine-grained; unconsolidated	1.0
27.	Mudstone, gray, sandy	3.0
26.	Sandstone, brown to gray; finer toward base	5.0
25.	Mudstone, gray-brown, sandy	1.5
24.	Sandstone, gray-brown; some orange zones	6.0
23.	Sandstone, gray; well indurated	1.0
22.	Mudstone, gray, sandy	2.0
21.	Sandstone, brown; well indurated	4.0
20.	Mudstone, gray, sandy	7.0
19.	Sandstone, gray-brown	2.0
18.	Mudstone, gray, sandy; more shaley downward	29.0
17.	Mudstone, brown, sandy	1.0
16.	Mudstone, gray, blocky; some pinkish reduced zones; sandier downward	4.0
15.	Mudstone, gray, blocky and sandy; some sandstone ledges	2.0
14.	Sandstone, brown-purple; channel deposit	2.0
13.	Mudstone, gray, sandy; shaley in places	10.5
12.	Sandstone, brown; finer toward bottom	5.0
11.	Sandstone, gray; well indurated	3.0
10.	Sandstone, yellow-brown	3.0
9.	Shale, blue-gray; browner and sandier toward base; laminated	6.0
8.	Sandstone, orange-brown	1.0
7.	Sandstone, gray; indurated, some bedding	1.0
6.	Sandstone, brown; some channel bedding; plant remains accompany oxidation to vivid reds, oranges and browns	8.0
5.	Sandstone, gray-brown, heavy and coarse-grained; channel deposit; prominent ledge-former	7.0
4.	Sandstone, brown; indurated	10.0
3.	Mudstone, gray-brown, sandy	2.0
2.	Sandstone, gray-brown; ledge-former	6.0

	Thickness (feet)
1. Covered to base of slope	30.0
Total measured thickness	219.0 feet

Section 7

Western Facies of the New Fork Tongue of the Wasatch Formation along the edge of the Mesa in NW ¼ sec. 5, T. 31 N., R. 109 W.

	Thickness (feet)
30. Debris cover	30.0
Western Facies of the New Fork Tongue (in part):	
29. Mudstone, gray-green, chippy	16.5
28. Mudstone, gray, fine-grained	1.0
27. Mudstone, red-brown, chippy	2.0
26. Mudstone, gray-green, chippy	4.0
25. Sandstone, gray-green; somewhat platy	9.0
24. Mudstone, gray-brown, sandy; becomes finer-grained and more laminated toward bottom	4.0
23. Mudstone, red-brown, laminated	1.5
22. Mudstone, gray-green; somewhat laminated	0.5
21. Mudstone, gray-brown, sandy	0.5
20. Sandstone, gray; somewhat platy, more mudstone toward bottom	2.0
19. Mudstone, gray-green, sandy; reddish mottlings and some shaley zones; fossil mammals present	7.0
18. Sandstone, orange-brown; somewhat platy	1.5
17. Mudstone, gray-green, sandy; reddish mottlings	2.0
16. Sandstone, gray-green, fine-grained; platy	4.5
15. Mudstone, gray-green, chippy and sandy	0.5
14. Sandstone, brown; ledge-former	11.0
13. Mudstone, green, fine-grained; laminated	1.0
12. Mudstone, reddish-brown, sandy; blocky, with more green toward the bottom	5.5

		Thickness (feet)
11.	Mudstone, gray-brown, sandy; sandier downward.	3.0
10.	Shale, gray-green.	1.0
9.	Sandstone, brown; calcareous, ledge-former.	1.5
8.	Mudstone, gray-green, sandy.	8.0
7.	Sandstone, brown; laminated, ledge-former.	6.0
6.	Mudstone, gray-brown, sandy; well laminated.	3.0
5.	Mudstone, gray-green; blocky to laminated, some sandy zones.	3.0
4.	Mudstone, greenish-brown, sandy.	13.0
3.	Mudstone, gray-green, sandy.	1.0
2.	Sandstone, gray-brown; platy, muddier toward the bottom.	8.5
1.	Covered to base of slope.	85.0
	Total measured thickness	237.0 feet

Section 8

Western Facies of the New Fork Tongue of the Wasatch Formation along the edge of the Mesa in SW ¼ SW ¼ sec. 36, T. 31 N., R. 110 W. and NW ¼ NW ¼ sec. 1, T. 30 N., R. 110 W.

		Thickness (feet)
15.	Debris cover.	32.0
Western Facies of the New Fork Tongue (in part):		
14.	Mudstone, red and green mottled.	2.0
13.	Mudstone, green and maroon-gray mottled, sandy; small amount of dark red.	14.0
12.	Mudstone, reddish-brown, mottled red and green, mottled gray-green-red, and lavender gray, sandy.	24.0
11.	Mudstone, khaki green; calcareous.	5.0
10.	Limestone, light gray-green; weathers white; slight ledge-former.	6.5
9.	Mudstone, gray-green, sandy and blocky.	15.0
8.	Sandstone, orange; mammalian bones as well as reptiles and *Lepisosteus*.	29.0

		Thickness (feet)
7.	Mudstone, blue-gray, sandy	2.0
6.	Sandstone, brown-green, fine-grained; some well-indurated zones	3.0
5.	Mudstone, gray-green, sandy	13.0
4.	Sandstone, light gray-green, fine-grained	4.0
3.	Mudstone, gray-green, sandy; some calcareous zones	10.0
2.	Sandstone, gray-brown, fine-grained	2.0
1.	Mudstone, gray-green, sandy; some fragmentary fossil bone present	25.0+
	Total measured thickness	182.0+ feet

Section 9

Laney Shale Member of the Green River Formation on the southwest side of Cone, center sec. 8, T. 29 N., R. 105 W.

Laney Shale Member (in part):

		Thickness (feet)
26.	Top debris, quartzitic sandstone, gray-red, coarse; slight bedding	2.0
25.	Sandstone, buff, coarse to medium-grained with fragments up to 4 mm. in diameter; micaceous, some prominent chalcedony veins, slight bedding	3.0
24.	Sandstone, brown to orange, coarse	4.0
23.	Conglomerate, brown, fine-grained; poorly indurated, micaceous ledge-former	2.0
22.	Sandstone, gray-brown, fine-grained	1.0
21.	Mudstone, gray-brown; weathers tan to rusty.	5.0
20.	Sandstone, brown, medium-grained; fairly well indurated, weathers tan, ledge-former	9.0
19.	Mudstone, gray-brown, sandy; vaguely bedded.	10.0
18.	Shale, gray-brown; fissile, weathers tan; merges into gray-brown sandy mudstone	25.0

		Thickness (feet)
17.	Sandstone, gray-brown, fine-grained; very calcareous, contains some concretionary material; forms a small ledge	1.5
16.	Mudstone, gray-brown, shaley; contains lenses of brownish sandy material; forms a steep slope.	8.0
15.	Sandstone, gray, very fine-grained; poorly indurated	0.1
14.	Mudstone, gray-brown, shaley; sandy lenses	8.0
13.	Shale, dark brown; weathers light gray	7.0
12.	Shale, gray; well laminated; forms a prominent white debris band	3.0
11.	Mudstone, brown, sandy; slight bedding	15.0
10.	Sandstone, gray, fine-grained; marly	2.5
9.	Shale, brown, sandy	5.0
8.	Shale, gray-brown; thinly laminated, contains abundant gastropods	8.0
7.	Mudstone, dark brown, sandy; contains abundant gastropods and some pelecypods	2.5
6.	Shale, gray; well laminated	1.5
5.	Mudstone, brown, sandy	3.0
4.	Shale, gray-brown; well laminated	1.0
3.	Sandstone, brown	0.5
2.	Shale, gray-brown, and mudstone, gray-brown; well laminated toward base; rusty lenses	6.0
1.	Mudstone, gray-brown, sandy; to base in grass-covered Laney Shale Member or Cathedral Bluffs Tongue	5.0+
	Total measured thickness	137.6+ feet

Section 10

Laney Shale Member of the Green River Formation and Cathedral Bluffs Tongue of the Wasatch Formation on the southwest flank of Square Top in NE 1/4 sec. 24, T. 30 N., R. 106 W.

		Thickness (feet)
Laney Shale Member (in part):		
20.	Limestone, buff, organic; contains abundant gastropods; merges laterally into bedded sandstone	2.0
19.	Sandstone, dark brown, fine-grained; well bedded, marly, some cross-bedding	1.0
18.	Shale, gray to brown; papery, calcareous	14.0
17.	Sandstone, brown, fine-grained; poorly bedded.	3.0
16.	Shale, brown, fine-grained; calcareous, contains some bedded calcite	6.0
15.	Sandstone, brown, fine-grained; calcareous	3.0
14.	Shale, gray; papery weathering, calcareous	4.0
13.	Sandstone, dark brown, fine-grained	2.0
12.	Shale, gray-brown; calcareous	5.5
11.	Sandstone, light brown; platy	3.0
10.	Sandstone, gray, fine-grained; somewhat calcareous, blockier toward the base	2.0
9.	Sandstone, brown, fine-grained; calcareous, platy to blocky	4.0
8.	Mudstone, light gray-brown, sandy; calcareous.	1.0
Cathedral Bluffs Tongue:		
7.	Mudstone, gray, fine-grained; chippy	1.0
6.	Sandstone, brown, fine-grained	2.0
5.	Mudstone, gray-brown, fine-grained; chippy	3.0
4.	Sandstone, brown, fine-grained; unbedded	1.5
3.	Mudstone, gray, fine-grained; calcareous	1.0
2.	Mudstone, brown, sandy; at least one indurated sand layer	10.0
1.	Covered to approximate top of Big Sandy facies. Covered interval is muddier than units 2–7 and is generally gray-brown to gray-green in color	50.0+
	Total measured thickness	119.0+ feet

Section 11

Interbedded Laney Shale Member of the Green River Formation and Cathedral Bluffs Tongue of the Wasatch Formation at Mystery Gulch, SW 1/4 sec. 30, T. 30 N., R. 105 W.

	Thickness (feet)
10. Siltstone, brown, fine-grained	11.5
9. Sandstone, gray-brown, fine-grained	0.2
8. Siltstone, brown, fine-grained; alternates with shale, dark brown to gray; well laminated	38.0
7. Sandstone, brown, coarse; ledge-former, with vague bedding	1.0
6. Sandstone, red, yellow and dark blue-gray, fine-grained	10.0
5. Mudstone, dark blue-gray, sandy; somewhat laminated near top and blockier near bottom	11.0
4. Sandstone, gray to orange, coarse-grained; locally well indurated	6.0
3. Mudstone, gray-green, sandy; unbedded	5.0
2. Mudstone, gray-brown to brown, sandy	13.0
1. Mudstone, gray-brown, sandy; to base of slope in sagebrush-covered area	10.0+
Total measured thickness	105.7+ feet

Section 12

Laney Shale Member of the Green River Formation and Cathedral Bluffs Tongue and arkosic facies of the New Fork Tongue of the Wasatch Formation on the north side of Table in SE 1/4 sec. 4, T. 29 N., R. 105 W.

	Thickness (feet)
Laney Shale Member (in part):	
3. Sandstone, siltstone and shale, brown and buff.	
Cathedral Bluffs Tongue:	
2. Mudstone, drab gray-green, sandy; includes pebbles of igneous origin; some arkosic levels almost gravelly; vague color banding, mostly in shades of gray-green due to arkose content; quite uniform	60.5

	Thickness (feet)
Arkosic facies (in part):	
1. Mudstones, brightly banded, sandy..........	
Total measured thickness	60.5 feet

Section 13

Laney Shale Member of the Green River Formation and Cathedral Bluffs Tongue and arkosic facies of the New Fork Tongue of the Wasatch Formation along the south bank of the Big Sandy River in S ½ sec. 19, T. 30 N., R. 105 W.

	Thickness (feet)
Laney Shale Member (in part):	
5. Covered interval with shaley float...........	6.0
Cathedral Bluffs Tongue:	
4. Mudstone, green to brown; sandy; some well-laminated shaley zones and some heavily oxidized zones; upper portion shalier.........	10.5
3. Sandstone, buff to yellow, coarse; merges downward into brown sandy mudstone; well-indurated gray arkosic channel sandstones present in this level...............................	10.0
2. Mudstone, drab gray-green, sandy; vague color bands of purplish and yellowish mudstones along with light gray-green arkosic beds. Several arkosic sandstone lenses. The base is a three-foot thick cobbly zone...............	106.0
Arkosic facies (in part):	
1. Mudstones, brightly banded, sandy; to river level....................................	10.0
Total measured thickness	142.5 feet

Section 14

Bridger Formation at Big Sandy Fault locality, SE ¼ NE ¼ sec. 25, T. 30 N., R. 106 W.

	Thickness (feet)
14. Covered interval.........................	16.5

	Thickness (feet)
Bridger Formation (in part):	
13. Mudstone, gray; chippy, with clay pellets, ledge-former	4.5
12. Mudstone, brown, sandy; some bedding, grayer and more shaley toward base; some vertebrate remains found, but no mammals	35.0
11. Shale, light gray; well bedded, with rusty weathering; conspicuous impressions of vegetable remains, fish scales and assorted organic debris; good ledge-former	3.0
10. Mudstone, green to gray-brown, soft sandy	5.5
9. Mudstone, dark brown, coarse-grained	8.0
8. Mudstone, gray-brown, sandy; somewhat bedded; contains a small amount of fossil vertebrate material	3.0
7. Mudstone, brown, sandy; poorly laminated, with irregular nodular material at base; contains a large amount of fossil vertebrate material	4.0
6. Mudstone, green to gray-green, sandy; chippy to somewhat shaley with some nodules; excellent producer of fossil vertebrates	4.5
5. Mudstone, light brown, sandy; conspicuous nodular zones near middle of unit; forms a steep slope below the nodular zone	30.5
4. Mudstone, dark brown, sandy	11.3
3. Mudstone, light gray-brown, sandy	1.0
2. Shale, light gray; chippy, forms a conspicuous white line on the outcrop	0.2
1. Mudstone, brown, sandy; has some hard, massive zones and irregular greenish zones; forms occasional ledges; to water level	45.0
Total measured thickness	168.0 feet

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