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THE WASATCHIAN-BRIDGERIAN LAND MAMMAL AGE BOUNDARY (EARLY TO MIDDLE EOCENE) IN THE DESERTION POINT-LITTLE MUDDY AREA, SOUTHWESTERN GREEN RIVER BASIN, WYOMING

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JOHN-PAUL ZONNEVELD

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THE WASATCHIAN-BRIDGERIAN LAND MAMMAL AGE BOUNDARY (EARLY TO MIDDLE EOCENE) IN THE DESERTION POINT-LITTLE MUDDY AREA, SOUTHWESTERN GREEN RIVER BASIN, WYOMING

By

John-Paul Zonneveld

A THESIS

Submitted to Michigan State University in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

Department of Geological Sciences

ABSTRACT

THE WASATCHIAN-BRIDGERIAN LAND MAMMAL AGE BOUNDARY (EARLY TO MIDDLE EOCENE) IN THE DESERTION POINT-LITTLE MUDDY AREA, SOUTHWESTERN GREEN RIVER BASIN, WYOMING

By

John-Paul Zonneveld

A relatively diverse vertebrate assemblage is described from a continuous sedimentary sequence spanning the boundary between the Wasatchian and Bridgerian North American Land-Mammal Ages (early-middle Eocene). Two distinct faunas are separated by approximately eighty meters of unfossiliferous lacustrine sediments.

The Little Muddy local fauna is assigned to the Lostcabinian (Wa7) based primarily on the presence of Lambdotherium popoagacium and the co-occurrence of Esthonyx acutidens, Copelemur cf. C. australotutus and Cantius cf. C. frugivorous. For the first time, Ignacius graybullianus and Anemorhysis wortmani are identified from the Lostcabinian of the Green River Basin. The Desertion Point local fauna is assigned to the earliest Bridgerian (Br1), based on the cooccurrence of Palaeosyops cf. P. fontinalis, Hyrachyus, Selenaletes, Smilodectes mcgrewi, Notharctus robinsoni, Omonys carteri, and Washakius insignis.

This is the first time the Wasatchian-Bridgerian boundary has been delineated within the type area of these North American Land Mammal Ages. To my parents, Jacob and Nellie Zonneveld, for their continued support (and patience).

•

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LIST OF ABBREVIATIONS

Institutions:

ACM- Pratt Museum, Amherst College

AMNH- American Museum of Natural History

UM- University of Michigan, Museum of paleontology

USGS- United States Geological Survey

USNM- United States National Museum

UW- University of Wyoming

YPM- Yale Peabody Museum

Measurements, Specimens and Localities:

| AP- | anteroposterior | Tr- | transverse |
|------|----------------------|------|-------------------------|
| Tra- | transverse, anterior | Trp- | transverse, posterior |
| /X- | lower tooth | X/- | upper tooth |
| M- | molar | P- | premolar |
| C- | canine | I- | incisor |
| BB- | Bridger Basin | *- | measurement approximate |

m- specimen included in miscellaneous box

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INTRODUCTION

Hundreds of early and middle Eocene vertebrate fossil localities have been reported from the Tertiary basins of Wyoming, Colorado, New Mexico and Utah. In several of these, continuous depositional sequences spanning the earlymiddle Eocene boundary (Wasatchian-Bridgerian boundary) are known. Extensive faunas from these sequences have been reported in the Wind River and Huerfano basins (Guthrie, 1967; 1971; Robinson, 1966; Stucky, 1984a; 1984b) and less comprehensive faunas are known from the Washakie and Bighorn basins, (Gunnell <u>et al</u>., 1992; Turnbull, 1978) and the northeastern Green River Basin (West, 1969; 1970; 1973).

Although extensive faunas are known from southwestern Wyoming where the type areas of both the Wasatchian and Bridgerian Land Mammal Ages are known (e.g. Gazin, 1952; 1962; Wood, 1966; Pledge, 1969; McGrew and Sullivan, 1970; Gunnell and Bartels, in press), faunas spanning the Wasatchian-Bridgerian (Lostcabinian-Gardnerbuttean subage) boundary in this area have not been extensively reported.

A field research project was initiated by G.F. Gunnell in 1989 to investigate early Bridgerian vertebrate paleontology in the southwestern Green River Basin (Bridger

Basin). This field work not only tripled the previous collection of early Bridgerian fossils from the Bridger Basin (Gunnell and Bartels, in press), but, in 1992 a locality was discovered at the extreme western margin of this area, containing a small, but diagnostic, Wasatchian assemblage in the La Barge Member of the Wasatch Formation.

Subsequent field work has shown that an essentially continuous transitional depositional sequence exists between the La Barge Member to the west through the lower Bridger Formation to the east. This study documents the vertebrate paleontology across the Wasatchian-Bridgerian boundary in this sequence, and delineates for the first time the Wasatchian-Bridgerian boundary within the vicinity of the type areas of these North American Land-Mammal Ages. The boundary is located considerably lower in the Wasatch Formation than previously reported (i.e. Grande, 1984, Sullivan, 1980).

LOCATION AND DESCRIPTION

The study area is located in the southwestern corner of the Green River Basin, Wyoming (Figure 1). It lies equidistant between the towns of Opal and Carter, spanning the Lincoln\Uinta county line (figure 2). The study area is on the eastern limb of a large, gently dipping, north to south-trending anticline. Many of the localities are therefore on the western faces of small buttes and long

escarpments. The localities are typically separated by broad, shallow, alluvium-filled valleys. In parts of the study area, especially the northern portion, outcrops are uncommon, the best ones being found along its eastern, western and southern margins.

MATERIALS AND METHODS

The fossils of this study were collected during the summers of 1989 through 1993 by joint University of Michigan/Albion College/California State University at Sacramento field parties. All fossils are accessioned at the University of Michigan Museum of Paleontology (UM). Most specimens were obtained by surface collecting. Although a large quantity of excellent specimens have been recovered over five seasons, most localities are actually unfossiliferous compared to the classic higher Bridger beds.

Attempted screening for microvertebrates at several localities did not produce a significant number of vertebrate elements. A single locality, BB110, proved ideal for screening and produced many microvertebrates, including several taxa never before reported from the early Eocene of the Green River Basin.

Fossils were identified by comparison with existing collections, and from descriptions in the literature. Detailed stratigraphic sections were measured in the study area to determine the precise relationships of the fossil

localities. These sections are presented as Plate 2, and along with aerial photos, were used in the construction of the detailed geologic map presented as Plate 1, and to reconstruct the depositional environments of the various units.

PREVIOUS INVESTIGATIONS

The Bridger Basin of southwestern Wyoming has been the focus of paleontological field investigation since the first fossils were discovered in the early 1850s (West, 1976, 1990). Most of these studies have focused on either the fishes of the predominantly lacustrine Green River Formation or the mammals of the predominantly fluvial Bridger Formation. Field investigations in the Bridger Formation have concentrated on the highly fossiliferous middle Bridger Beds in the southern part of the basin and have largely ignored the comparatively fossil-poor lower and upper parts of the Bridger Formation (Bridger A and E). West and Hutchinson (1981) were the first to describe mammalian fossils from the uppermost beds of the Bridger Formation (Bridger E), confirming that these strata are Bridgerian in age and that no rocks of Uintan age crop out in the southern part of the Green River Basin.

Field workers from the University of Wyoming (Wood, 1966; Pledge, 1969; McGrew and Sullivan, 1970) were the first to report vertebrate fossils from the Bridgerian A

Figure 1. Map showing the Green River Basin of southwestern Wyoming and surrounding mountains.



Figure 1.



Figure 2. Location Map of study area.

(late Br1) of the Green River Basin. Gazin (1952, 1962) reported a number of excellent early Eocene vertebrate localities along the northern, eastern, and western edges of the Green River Basin. Although many of these localities have produced only small collections, several (e.g., La Barge and Knight Station) have provided large and diverse collections.

LITHOSTRATIGRAPHY

A generalized stratigraphic section is presented as Figure 3 to show the relationship of the various lithostratigraphic units that outcrop within the study area. A geologic map of the study area showing locations of measured stratigraphic sections and fossil localities is presented as Plate 1. Plate 2 is a correlation chart with graphic representations of measured sections. The stratigraphic relationship of the vertebrate fossil localities is shown in figure 18. Written sections with brief lithologic descriptions are provided in the appendix. BRIDGER FORMATION

The Bridger Formation was named by F.V. Hayden in 1869 for a series of light green, brown, and gray fluviatile sandstones and mudstones of middle Eocene age in the southwestern Green River Basin. Since Hayden's original description the formation has been found to extend to

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Figure 3. Generalized stratigraphic column of the Desertion Point-Little Muddy area.

include beds in northeastern Utah and northwestern Colorado (Koenig, 1960). The formation reaches thicknesses exceeding 650 meters in the south-central part of the Bridger Basin (Sullivan, 1980).

As noted above, Matthew (1909) separated the Bridger Formation into five units, Bridger A through E using a series of calcareous tuffs or "White Layers". Wood (1934), utilizing Matthew's marker beds, divided the formation into two members, the Blacks Fork Member (Bridger A and B), and the Twin Buttes Member (Bridger C and D). Although these terms are still in use by some authors as informal biostratigraphic units (i.e. West, 1973; McGrew and Sullivan, 1970), they have never received wide acceptance as lithostratigraphic units. Koenig (1960), using solely lithologic characteristics, suggested redividing the formation into lower, middle, and upper Bridger Formation. Koenig (1960) also subdivided the Lower Bridger into two units. The lowermost of these, the lower Bridger A, crops out within the study area.

WHISKEY BUTTE BED

Sullivan (1980), recognizing the need for revision of the lithostratigraphy of the Bridger Formation proposed the name Whiskey Butte Bed for a unit separated from the main body of the Bridger Formation by the Craven Creek Bed of the Laney Member of the Green River Formation. Within the field area, the Whiskey Butte Bed consists of light gray

mudstones, siltstones and litharenites. The Whiskey Butte Bed is a fluvial interval representing a regression of Lake Gosiute. It separates two tongues of the lacustrine Laney Member of the Green River Formation. The tongue of Bridger Formation present at the eastern end of the study area represents a more terrestrial interlude between two major transgressions of ancient Lake Gosiute. The Whiskey Butte Bed produces fossil vertebrates characteristic of the early Bridgerian (Bridgerian "A", Br1.2).

WASATCH FORMATION

The Wasatch Formation was described by F.V. Hayden (1873) for a sequence of brightly coloured fluviatile sandstones, conglomerates, and mudstones in Echo and Weber Canyons in northeastern Utah. Although the name Wasatch has been used for the early Eocene sediments of many of the intermontane basins of Wyoming, Utah, and Colorado, it should be restricted to the greater Green River Basin (including the Washakie Basin and the type area in Utah; West, 1973). The formation crops out extensively within the study area, intertonguing with various units of the comparatively drab Green River Formation.

LA BARGE MEMBER

The La Barge Member conformably underlies the Fontanelle Tongue of the Green River Formation both in the type area (Oriel, 1962) and within the study area. It is comprised of brightly coloured mudstones, gray

sublitharenites, and thin, tan, micrite lenses. The La Barge Member is approximately 150 meters thick in the type area and up to 500 meters thick in the more central portions of the basin. The La Barge Member rests unconformably on the Lower Cretaceous Gannet Group. Extensive faulting immediately west of the study area makes the precise thickness of the unit difficult to ascertain. The La Barge Member produces vertebrate fossils indicative of a Lostcabinian subage (Wa7, latest early Eocene).

NEW FORK TONGUE

The New Fork Tongue was described by Donovan (1950) for a series of variegated mudstones and poorly sorted conglomerates and sandstones near the confluence of the Green and New Fork Rivers. Bradley (1964) extended the geographic range of the unit south to include most of the upper layers of the Wasatch Formation along the western margin of the Green River Formation. The term is used here to designate several thick, cross-bedded, litharenites and sublitharenites that intertongue with the Fontanelle Tongue of the Green River Formation. Vertebrate fossils have not been collected from the New Fork Tongue within the study area.

UPPER MEMBER

This paper follows M'Gonigle and Dover (1992) in referring to the upper strata of the Wasatch Formation as the Upper Member. Within the study area the Upper Member

consists of series of bright red, white, purple and gray mudstones with occasional, thick channel sandstones and several minor sheet sandstones. Sullivan (1980) named these layers the Desertion Point Member replacing the term "upper tongue of the Wasatch Formation" used by Oriel (1962, p. 2162-2164) and other previous workers. The type locality, as designated by Sullivan (1980, p.13) is "near Desertion Point (sec. 26, T. 19 N., R. 115 W.) and eastward to Little Muddy Creek in the Mulkay Spring Ouadrangle. In this locality the member is about 250 feet (76 meters) in thickness". This is somewhat confusing since less than one meter of the Wasatch Formation crops out at the base of Desertion Point (see measured section 6, Plate 2). The strata exposed at Desertion Point are the lignites, shales, limestones and sandstones of the Lanev Member of the Green River Formation (approximately 25 meters thick). The closest substantial outcrop of Wasatch Formation is approximately 3 kilometres southwest of Desertion Point.

Within the study area the Upper Member of the Wasatch Formation consists of two units. The upper unit is marked by cycles of red, white, purple and gray mudstones and siltstones with occasional litharenitic channel sandstones. The lower unit consists of thick rust red mudstones and siltstones, with thin limestone and sandstone interbeds. The Upper Member produces vertebrate fossils indicative of the earliest Bridgerian (Gardnerbuttean, Br1.1).

GREEN RIVER FORMATION

The Green River Formation was named by F.V. Hayden (1869) for a thick sequence of lacustrine sediments of early to middle Eocene age west of Rock Springs, Wyoming. The formation consists of light gray, tan, and brown oil shales, oolitic limestones, mudstones and litharenites. The thickness of the formation varies from only a few meters thick at the edges to up to 600 meters thick in the centre of the Green River Basin. Within the study area and throughout the Green River Basin, units of the Green River Formation intertongue with both the Wasatch and Bridger formations. The three units which crop out within the study area are the Fontanelle Tongue, the Wilkins Peak Member, and the Laney Member.

FONTANELLE TONGUE

The Fontanelle Tongue of the Green River Formation was named by Donovan (1950, p. 63-64) to designate a series of "alternating buff-brown sandstones and green and gray mudstones that conformably overlie the Knight Member of the Wasatch". The base of the Fontanelle Tongue is marked by a thick, yellow, ostracod and gastropod-rich micrite that forms the cap of the prominent ridge that runs north-south along the western side of the study area. A thick series of poorly sorted, cross-bedded litharenites interpreted by M'Gonigle and Dover (1992) as part of the Wasatch Formation intertongues with the Fontanelle Tongue. The Fontanelle

Tongue conformably underlies the Wilkins Peak Member of the Green River Formation.

WILKINS PEAK MEMBER

Bradley (1959) introduced the name Wilkins Peak Member for strata in the Green River Basin that represent intermittent lacustrine beds deposited during a period of frequent vacillations in the level of Eocene Lake Gosiute. This regression gave rise to a greater abundance of evaporite minerals and carbonate rocks. Within the study area the Wilkins Peak Member consists of gray-green mudstones, thin, poorly sorted litharenites, and abundant, thin, algal limestones. This unit is conformably overlain by the Upper Member of the Wasatch Formation and conformably overlies the Fontanelle Tongue of the Green River Formation. A single specimen of **Eyrachyus** collected near the base of this unit is indicative of earliest Bridgerian deposition (Gardnerbuttean, Br1.1).

LANEY MEMBER

The Laney Member was designated by Schultz (1920) for a thick sequence of tan marlstones, brown oil shales, gray mudstones and thin algal limestones in the Washakie Basin. Bradley (1959) extended the unit to include beds formally assigned to the Morrow Creek Member in the Green River Basin. The Laney Member is the thickest unit of the Green River Formation marking a major incursion of Eocene Lake Gosiute throughout the area (Sullivan, 1980, Roehler, 1992).

Sullivan (1980) separated the basal portion of the Laney Member into two distinct, laterally persistent tongues, the lower, which outcrops within the study area, he named the Craven Creek Bed. The upper unit which he named the Cow Hollow Bed outcrops east of the study area. These tongues are separated from each other by the more fluviatile strata of the Whiskey Butte Bed of the Bridger Formation, but merge basinward where Eocene Lake Gosiute attained greater depths (Sullivan, 1980).

CRAVEN CREEK BED

The boundary between the Craven Creek Bed and the Upper Member of the Wasatch Formation within the study area is marked by a thin, although laterally persistent, lignitic, tuffaceous mudstone. This bed contains abundant plant debris in the form of broken leaves, stems and carbonized wood. Above this the Craven Creek Bed consists of brown oil-shales, gray to tan calcareous silty mudstones, gray litharenites, occasional dark brown lignites and a few interbedded algal limestones.

FOSSIL VERTEBRATE LOCALITIES

Fossil vertebrates have been recovered from 31 localities within the study area. These localities are distributed throughout the Wasatch, Green River, and Bridger formations. There are four localities in the Whiskey Butte Bed of the Bridger Formation, twelve in the Craven Creek Bed of the Laney Member of the Green River Formation, one in the Wilkens Peak Member of the Green River Formation, nine in the Upper Member of the Wasatch Formation, and five in the La Barge Member of the Wasatch Formation. Fossil vertebrates have not been collected from the Fontanelle Tongue of the Green River Formation and the New Fork Tongue of the Wasatch Formation within the study area. The geographic distribution of the fossil localities is shown in Figure 4. There is a general progression of older localities on the west to younger on the east. A brief description of each locality is provided below. The topographic quadrangles are all from the United States Geological Survey 7.5 minute series.

LOCALITIES

WASATCH FORMATION

UPPER MEMBER

- BB013: Red, white, gray, and pink beds beneath the dark brown lignitic layer, at the base of Desertion Ridge, the low escarpment extending north from Desertion Point. W1/2, SW1/4, Section 23, and NW1/4 NW1/4 Section 26, T. 19 N., R. 115 W., Lincoln County, Mulkay Springs Quadrangle.
- BB014: Low red buttes and flats northeast of large, red hill known as Big Dutch Butte. NE1/4, SW1/4, Section


Figure 4. Map of study area showing localities and biostratigraphic zonations.

4, T. 18 N., R. 115 W., Uinta County, Mulkay Springs Quadrangle.

- BB051: Three prominent red and white variegated buttes, 400m north of Dry Muddy Creek and 3.3km west of Little Round Mountain. SW1/4, SE1/4, Section 28 and NW1/4 NE1/4 Section 33 T. 20 N. R. 115 W., Lincoln County, Little Round Mountain Quadrangle.
- BB068: Red, white, gray, and pink beds beneath the dark brown lignitic layer, at base of Desertion Ridge. SE1/4, NW1/4, Section 23, T. 19 N., R. 115 W., Lincoln County, Mulkay Springs Quadrangle.
- BB075: White, gray, and tan beds beneath the dark brown lignitic layer, at base of Desertion Point. SE1/4, SW1/4, Section 26, T. 19 N., R. 115 W., Lincoln County, Mulkay Springs Quadrangle.
- BB096: White flats and low buttes at the base of the northeast end of the long, low, multi-coloured hill known locally as Wasatch Butte, 2km north of Little Muddy Creek. SE1/4, Section 4, T.18 N., R. 115 W., Uinta County, Mulkay Springs Quadrangle.

BB097: SW1/4, NE1/4, Section 9, T. 18 N., R. 115 W., Uinta County. Red, white, gray, and purple beds below prominent white layer, bottom half of the southeastern end of Wasatch Butte, 500m north of Little Muddy Creek, Uinta County, Mulkay Springs Quadrangle.

- BB103: White, gray, and pink beds outcropping along a small dry-wash, 2km west of northern end of Desertion Ridge. NE1/4, NW1/4, Section 22, T. 19. N., R. 115 W., Lincoln County, Mulkay Springs Quadrangle.
- BB104: Red, white, gray, and purple beds above the prominent white layer, top half of Wasatch Butte, 900m north of Little Muddy Creek. NW1/4, NE1/4, Section 9, T. 18 N., R. 115 W., Uinta County, Mulkay Springs Quadrangle.

LA BARGE MEMBER

- BB110: White, gray, purple, and red flats, 900m west of Cumberland Ridge, 1.75km north of Little Muddy Creek. NE1/4, SW1/4, Section 34, T. 19 N., R. 116 W., Lincoln County, Cumberland Gap Quadrangle.
- BB114: White and purple mudstones, and gray litharenite at small exposure, 100m south of the long escarpment near the western margin of the study area known locally as Cumberland Ridge, 1.75km north of Little Muddy Creek. Centre of eastern boundary of Section 34, T. 19 N., R. 116 W., Lincoln County, Cumberland Gap Quadrangle.
- BB115: White, red, and orange mudstones at the base of the north face of Cumberland Ridge. SW1/4, SW1/4, Section 26, T.19 N., R. 116 W., Lincoln County, Mulkay Springs Quadrangle.

- BB116: Lowest units along prominent variegated ridge. Includes all units beneath the orange mudstone at the south western corner of the western extension of Cumberland Ridge. SW1/4, NE1/4, Section 34, T. 19 N., R. 116 W., Lincoln County, Cumberland Gap Ouadrangle.
- BB118: Orange and yellow mudstones along the lower part of the western extension of Cumberland Ridge. SW1/4, NE1/4, Section 34, T .19 N., R. 116 W., Lincoln County, Cumberland Gap Quadrangle.

BRIDGER FORMATION

WHISKEY BUTTE BED

BB035: Gray and white mudstones and litharenites of Top Hat Butte, a small hat-shaped hill on Desertion Ridge. NW1/4, SE1/4, Section 23, T. 19 N., R. 115 W., Lincoln County, Hampton Quadrangle.

BB037: Gray and white beds on northeastern side of the long, low butte east of Top Hat Butte, top of Desertion Ridge. NE1/4, SE1/4, Section 23, T. 19 N., R. 115 W.,

Lincoln County, Hampton Quadrangle.

BB038: Gray and white beds on southeastern side of the long, low butte east of Top Hat Butte, top of Desertion Ridge. NE1/4, SE1/4, Section 23, T. 19 N., R. 115 W., Lincoln County, Hampton Quadrangle. BB044: Gray and white beds on southwestern side of the long, low butte east of Top Hat Butte, top of Desertion Ridge. NW1/4, SE1/4, Section 23, T. 19 N., R. 115 W., Lincoln County, Hampton Quadrangle.

GREEN RIVER FORMATION

LANEY MEMBER, CRAVEN CREEK BED

- BB012: White, gray, and tan beds above the dark brown lignitic ash layer, top half of Desertion Point. SE1/4, SW1/4, Section 26, T. 19 N., R. 115 W., Lincoln County, Mulkay Springs Quadrangle.
- BB013w: Low gray, green, and white butte 300m west of base of Desertion Ridge. SE1/4, SE1/4, Section 22, and NE1/4, NE1/4, Section 27, T. 19 N., R. 115 W., Lincoln County, Mulkay Springs Quadrangle.
- BB019: Gray and white beds south of the broad dry wash at the south end of Desertion Ridge. NE1/4, NW1/4, Section 2, T. 18 N., R. 115 W., Uinta County, Hampton and Mulkay Springs Quadrangles.
- BB036: Tan, green, and gray beds above the dark brown lignitic layer, top half of Desertion Ridge. W1/2, SW1/4, Section 23, and NW1/4, NW1/4, Section 26, T. 19 N., R. 115 W., Lincoln County, Mulkay Springs Quadrangle.

- BB069: White, gray, and tan beds above the dark brown lignitic layer, top half of Desertion Ridge. SE1/4, NW1/4, Section 23, T. 19 N., R. 115 W., Lincoln County, Mulkay Springs Quadrangle.
- BB070: White, gray, and tan beds along Desertion Ridge. SE1/4, SW1/4, Section 26, T. 19 N., R. 115 W., Lincoln County, Mulkay Springs Quadrangle.
- BB072: White, gray, and tan beds 900m south of Little Muddy Creek. NE1/4, NW1/4, Section 14, T. 18 N., R. 115 W., Uinta County, Hampton and Mulkay Springs Quadrangles.
- BB074: Brown, tan, gray, and white beds at southeastern end of Desertion Ridge. SE1/4, SE1/14, Section 26, and NE1/4, NE1/4, Section 35, T. 19 N., R. 115 W., Lincoln County, Hampton Quadrangle.
- BB076: White, gray, and tan beds along Desertion Ridge. SE1/4, NW1/4, Section 26, T. 19 N., R. 115 W., Lincoln County, Mulkay Springs Quadrangle.
- BB077: Tan, gray, and white beds along northern face of butte south of the broad wash at the southern end of Desertion Ridge. SW1/4, SE1/4, Section 35, T. 19 N., R. 115 W., Lincoln County, and NE1/4, NW1/4, Section 2, T. 18 N., R. 115 W., Uinta County, Hampton and Mulkay Springs Quadrangles.

- BB098: Brown, tan, gray, and white beds at southwestern end of Desertion Ridge. SW1/4, NE1/4, Section 35, T. 19 N., R. 115 W., Lincoln County, Mulkay Springs Quadrangle.
- BB109: Tan, gray, and white beds along cliff 3.6km south of Little Muddy Creek. SW1/4, NW1/4, Section 23, T. 18
 - N., R. 115 W., Uinta County, Mulkay Springs Quadrangle. WILKENS PEAK MEMBER
- BB117: Gray mudstone immediately above the poorly sorted litharenite on the western side of prominent point. SE1/4, NE1/4, Section 1, T. 19 N., R. 116. W., Uinta County, Mulkay Springs Quadrangle.

Kingdom Monera Division Cyanophyta stromatolitic cyanophytes Kingdom Animalia Phylum Arthropoda Class Crustacea Subclass Ostracoda Phylum Mollusca Class Gastropoda Order Mesogastropoda Family Viviparidae <u>Viviparus</u> trochiformis Family Pleuroceridae Goniobasis tenera Order Basommatophora Family Physidae Physa bridgerensis Family Planorbidae Biomphlaria sp. Order Stylomatophora Family Uropcoptidae Holospira cf. H. grangeri Family Bulimulidae Oreoconus cf. O. planispira Class Pelecypoda Ord., Fam., gen. et sp. indet. Phylum Chordata Class Osteichthyes Order Lepisosteiformes Family Lepisosteidae Lepisosteus cuneatus Lepisosteus sp. indet. Order Amiiformes Family Amiidae Amia sp. indet. Order Siluriformes Family Ictaluridae genus and species indet. Class Reptilia Order Testudines Family Baenidae Baena arenosa

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FAUNAL LIST

Family Emydidae Echmatemys wyomingensis E. septaria Echmatemys cf. E. cibollensis Echmatemys sp. indet. Family Trionychidae cf. **Platypeltis** sp. indet. Family Dermatemydidae Baptemys fluviatalis Baptemys sp. indet. Family Carettochelyidae Anosteira radulina Order Squamata Family Iguanidae Parasauromalus olseni Family Anguidae <u>Glyptosaurus</u> sylvestris Xestops cf. X. vagans **Xestops** sp. indet. Family Boidae Calamagras primus Indeterminate amphisbaenid Order Crocodilia Family Alligatoridae Allognathosuchus sp. indet. **Diplocynodon** sp. indet. Family Crocodylidae Crocodylus affinis new genus (?) and species Family Pristichampsidae Pristichampsus vorax Class Mammalia Infraclass Metatheria Order Marsupialia Family Didelphidae Peratherium innominatum P. comstocki Infraclass Eutheria Order Insectivora Family Apatemyidae cf. Apatemys sp. indet. Family Pantolestidae Palaeosinopa cf. P. lutreola Family Lepticidae Palaeictops bicuspis Family Dormaalidae Scenopagus edenensis S. priscus

Order Proprimates Family Paromomyidae Ignacius graybullianus Family Microsyopidae Microsyops elegans Microsyops cf. M. scottianus Microsyops sp. indet. Order Primates Family Adapidae Cantius cf. C. frugivorous Notharctus robinsoni Copelemur cf C. australotutus Smilodectes mcgrewi Smilodectes sp. indet. Family Omomyidae <u>Omomys</u> <u>carteri</u> Omomys cf. O. carteri Washakius insignis Anemorhysis near A. wortmani Order Creodontidae Family Hyaenodontidae genus and species indet. Order Carnivora Family Miacidae Miacis latidens Vulpavus profectus Family Viverravidae Viverravus gracilis Viverravus sp. indet. Order Condylartha Family Meniscotheriidae Meniscotherium chamense Meniscotherium sp. indet. Family Hyopsodontidae Hyopsodus cf. H. minisculus Hyopsodus cf. H. miticulus Hyopsodus cf. H. wortmani Order Taeniodonta Family Stylinodontidae genus et sp. indet. Order Tillodontia Family Esthonychidae Esthonyx acutidens Order Artiodactvla Family Dichobunidae Diacodexis secans Diacodexis sp. indet.

Order Perrisodactyla Family Equidae Orohippus pumilus **Orohippus** sp. indet Hyracotherium vasacciense Family Brontotheriidae Lambdotherium popoagacium Paleosyops cf. P. fontinalis Family Helaletidae Hyrachyus modestus Selenaletes sp. indet. Order Rodentia Family Sciuravidae <u>Sciuravus</u> nitidus Knightomys depressus Family Paramyidae Paramys cf. P. excavatus Leptotomus parvus Leptotomus sp. indet. Order Incertae sedis Family Metacheiromyidae Metacheiromys sp. indet. **Palaeanodon** sp. indet. Family Epoicotheriidae Tetrapassalus sp. indet.

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SYSTEMATIC PALEONTOLOGY

The following is a discussion of the fossils found within the thesis study area. While all fossils recovered are described, special attention is given to the vertebrates, and in particular to the mammals. In all cases the locality is given along with the specimen description. A box labled "miscellaneous" has been retained for each locality containing invertebrates and isolated vertebrate bones and bone fragments not identifiable to the family level. The intention is to document the changes in the composition of the vertebrate community within the study area during the early middle Eocene. Measurements made with dial callipers calibrated to 0.1mm are presented where appropriate.

Basic invertebrate classification follows the <u>Treatise</u> on <u>Invertebrate Paleontology</u> (Moore, 1961). Gastropod classification follows that of Henderson (1935), Taylor and Sohl, (1962), and Hanley (1974). Non-mammalian vertebrates were classified according to Carroll (1988) and King and Burke (1989). Mammalian classification on the ordinal and familial levels follows Simpson (1945) and McKenna (1975). Mammalian classification, particularly that of extinct taxa, has undergone considerable revision in the last several decades however, so a variety of sources were used for more

precise classification of the mammals from the study area. These are referenced in the discussion of each individual taxon. The known chronological ranges of the mammals discussed below were obtained from Woodburne (1987), and if necessary, were updated from newer sources referenced in the discussion. North American Eocene biostratigraphy is discussed briefly in the section following systematic paleontology. S1: <u>.</u>... ;: ;: 31 . Là <u>..</u> st. :: he 1 tr là 32 :9 e] fr ar Or. 21

Kingdom Monera Linnaeus, 1758

<u>Remarks</u>: Kingdom Monera contains the earliest and simplest forms of life on earth. All members of this group, the bacteria and the cyanobacteria, are single-celled, prokaryotic organisms.

Phylum Cyanophyta Steinke, 1931

Class indet.

<u>Remarks</u>: Colonial algal structures known as stromatolites are ubiquitous in the limestone layers of the Laney and Wilkens Peak members of the Green River Formation. Although many authors use the term stromatolite to indicate strictly marine organisms, others use it in reference to any colonial algal structure (Awramik, 1990). The term as used here follows the usage of Surdam and Wray (1976) and indicates an organosedimentary structure formed by sediment trapping within microbial communities in either a marine or lacustrine setting.

Fresh water stromatolites have long been known from the Green River Formation (Bradley, 1928; Surdam and Wray, 1976). Wood (1966) and Pledge (1969) reported large ellipsoidal algal pods, likely fresh water stromatolites from the low Bridger (Bridger A) beds northeast of the study area. Pledge (1969) reports that these algal pods developed on inundated stumps and fallen trees in the shallow water at the edge of Eocene Lake Gosiute. Grande (1984) reported algal pods (oncolites) that developed on the fossil

33 15 • â 01 ľ.; à: gastropod <u>Goniobasis</u> <u>tenera</u>. Stromatolites have not been reported from the Wasatch Formation which consists primarily of terrigenous fluvial deposits.

As indicated above Stromatolites are particularly well developed in the Laney Member along the Desertion Point escarpment, especially in two thin micritic limestones. Abundant intermittent stromatolite layers differentiates the Wilkens Peak Member from the underlying Fontanelle Tongue. In most cases the algal pods in the Laney Member form in concentric ellipsoidal structures that range in size from a few centimetres to a meter or more. Consistent with the observations of Pledge (1969), and Grande (1984) several of the smaller algal pods formed around gastropods, particularly **Goniobasis**, and many of the larger pods formed as encrustations around submerged logs. Unlike most of the stromatolites in the Laney Member, algal structures in the Wilkens Peak Member tend to be more stratiform constructions than concentric ellipsoids.

Stromatolites and other related algal structures are useful indicators of environment. Stromatolites indicate the presence of photosynthesizing microbes which require abundant light, suggesting shallow water and the proximity of the shore (Bradley, 1928). Awramik (1990) argues that not only do stromatolites form in shallow water, they can actually form under intermittent conditions of submersion.

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Stromatolites are also indicative of quiet, perhaps stagnant water and the absence of aquatic grazers (Awramik, 1990).

Kingdom Animalia Linneaus, 1758 Phylum Arthropoda Siebold and Stannius, 1845 Subphylum Mandibulata Clairville, 1798 Class Crustacea Pennant, 1777 Subclass Ostracoda, Latrielle, 1806 Family indet.

Remarks: Ostracods are common in limestone lenses in the Laney Member and Fontanelle Tongue of the Green River Formation, particularly in a thick gastropodal limestone on the western side of the study area. Swain (1964), Baer (1969), and Oriel and Tracey (1970) reported a large variety of ostracods from the lacustrine beds of the Green River Formation in both the Bridger and Fossil basins. The ostracods from the study area have not been studied in detail.

Phylum Mollusca Linneaus, 1758

Snails and bivalve fragments are common within the study area. These taxa have not been studied in detail, however several taxa have been identified. Grande (1984) gives a brief synopsis of the Green River molluscan fauna. Although the overall diversity reported by Grande (1984) is

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Class Gastropoda Cuvier, 1797 Order Mesogastropoda Theile, 1925 Family Viviparidae Montfort, 1810 Genus <u>Viviparus</u> Montfort, 1810

Age and Distribution: Cretaceous to recent of North America, Africa, Europe, and Asia.

<u>Remarks</u>: Extant members of the genus <u>Viviparus</u> have been found in a wide variety of environmental conditions. They are found in both lakes and rivers and in depths ranging from a few centimetres to nearly three meters. La Rocque (1960) felt that the presence of <u>Viviparus</u> is indicative only of an abundant food supply in the form of lower plants and decaying animal matter rather than a particular ecological niche. <u>Viviparus</u> requires clean, oxygenated water (Richardson, 1928), and is able to aestivate during drought (Hanley, 1974).

Viviparus trochiformis Meek and Hayden, 1856 <u>Material</u>: UM 98713m- complete shell, collected at BB073, June 28, 1991. UM 101101m- damaged shell, collected at BB110, August 5, 1993.

<u>Remarks</u>: **UM 98713m** is a large individual of <u>Viviparus</u> <u>trochiformis</u> measuring 39mm in length and 35mm in width, **UM 101101m** is approximately half the size. Both shells are dextral and rather thin with abundant fine, closely spaced

growth lines. **UM 98713m** is somewhat ovaline in crosssection due to post-depositional deformation.

Family Pleuroceridae

Genus **Goniobasis** Lea, 1862

Age and Distribution: Cretaceous to recent of North America, Africa, Europe, and Asia.

Remarks: Gastropods of the genus **Goniobasis** are one of the most common molluscan fossils found in the Eocene of western Wyoming. Extant species of **Goniobasis** are common throughout North America in a broad range of aquatic ecological niches. They are typically only found in permanent water situations (Hanley, 1974). Notably, some extant species show remarkable tolerance to fluctuations in environmental conditions such as salinity and turbidity (Goodrich, 1944). This is an important consideration in Eocene Lake Gosiute which fluctuated from fresh to very saline water at various times in its history (Surdam and Wolfbauer, 1975).

Goniobasis tenera Hall, 1845

<u>Material</u>: UM 95670m- shells of two individuals, collected at BB051, June 15, 1990. UM 98577m- four shells, collected at BB037, June 20, 1991. UM 98579m- three shells, collected at BB044, June 20, 1991. UM 100896m- two shells, collected at BB114, July 25, 1993. UM 101101m- 14 shells, collected at BB110, August 5, 1993.

Remarks: **Goniobasis tenera** is the most common gastropod collected within the study area, particularly within the Green River Formation Several layers in the thick basal limestone of the Fontanelle Tongue at the western edge of the field area are comprised predominantly of **G**. **tenera**. **G**. **tenera** specimens recovered from the study area display considerable morphological variation.

La Rocque (1960), studying G. tenera from the Flagstaff Formation (Late Palaeocene to Early Eocene) of central Utah, established that there were four main morphotypes (labled forms A-D) of **G**. tenera that were for the most part, separated from each other stratigraphically. Although specimen UM 95670m from the upper Wasatch Formation most closely resembles Form C of La Rocque (1960) there are some significant differences. The specimen has the well developed plications and prominent nodes on the centre of each whorl that Form C has but also possesses carinae over the entire body of each whorl similar to Form B, rather than only on the base as in Form C. The specimens from the La Barge Member of the Wasatch Formation and the Fontanelle Tongue of the Green River Formation are smooth, without any type of plications or nodes, and with only subtle carinae. This is most similar to Form D of La Rocque (1960). The specimens from the Bridger Formation (UM 98577m, UM 98579m), do not have nodes, possess strong plications, and have carinae that cover the entire whorl, similar to Form B.

Similar to the specimens studied by La Rocque (1960) the three morphotypes come from stratigraphically distinct horizons and may indicate separate invasions of the species into the study area. Alternatively, the variance in morphotypes between the three formations may reflect the different habitats in which the units were deposited (Bartels, pers. comm.).

Order Pulmonata

Family Physidae Draparnaud, 1801 Genus **Physa** Draparnaud, 1801

Age and Distribution: Pennsylvanian to Recent of North America, Europe, Asia, and Africa.

<u>Remarks</u>: Modern members of the genus <u>Physa</u> are considered among the "hardiest" of the freshwater molluscs (La Rocque, 1960). They are generally found in very shallow water. <u>Physa</u> in association with other pulmonate gastropods such as <u>Biophlaria</u> may be indicative of the poorly drained marshy wetlands adjacent to Lake Gosiute (Hanley, 1977). Surdam and Wolfbauer (1975) note that the presence of <u>Physa</u>, a lung breathing gastropod indicates very shallow water and emergent vegetation. A single species of <u>Physa</u> has been found within the study area.

Physa bridgerensis Meek 1872

<u>Material</u>: **UM 98577m**- single shell, collected at BB037, June 20, 1991. **UM 98713m**- complete shell, collected at BB073, June 28, 1991. UM 101103m- single shell, collected at BB118, August 5, 1993.

<u>Remarks</u>: Consistent with specimens figured in Grande (1984), <u>Physa bridgerensis</u> from the study area are small, sinistral, pulmonate gastropods. They are smooth shelled with very fine, closely spaced growth lines. They are slightly oval in outline and have regularly increasing whorls.

Family Planoribidae Hubendick, 1955

Genus **Biomphlaria** White, 1876

Age and Distribution: Cretaceous to recent of Europe, North America, Asia, and Africa.

Biomphlaria sp. indet.

<u>Material</u>: UM 95602m- two shells, collected at BB036, June 5, 1990. UM 98577m- single shell, collected at BB037, June 20, 1991. UM98688- single shell, collected at BB070, June 28, 1991. UM 98713m- six shells, collected at BB073, June 28, 1991. UM 101026m- two shells, collected at BB038, August 1, 1993.

<u>Remarks</u>: **Biomphlaria** is a small, low-spired, thinshelled pulmonate gastropod. As mentioned above **Biomphlaria** in association with **Physa** is considered indicative of the lowlands contiguous to Lake Gosiute (Hanley, 1974).

Order Stylommatophora

<u>Remarks</u>: Two genera of stylommatophoran gastropods, <u>**Holospira**</u> and <u>**Oreoconus**</u>, have been recovered from the lowermost beds of the Wasatch Formation within the study area. Hanley (1976) attributed these molluscs to the hot, humid, forested, calcium-rich lowlands adjacent to Lake Gosiute.

Family Urocoptidae Pilsbry, 1902

Genus Holospira Martens, 1860

Age and Distribution: Palaeocene to Recent of western North America.

Holospira cf. H. grangeri Cockerell, 1914

Material: UM 101101m- Single shell, collected at BB110, August 5, 1993.

Remarks: Cockerell (1914) described the species from an incomplete shell approximately 10mm in length from the Palaeocene Torrejon Formation of New Mexico but did not designate a catalogue number for the type. Similar to the type, the solitary specimen referred to **Holospira** cf. **H**. **grangeri** is damaged and does not retain the aperture. **UN 101101m** is identical to the photographs in Mckenna et al (1962) and Cockerell (1914). It consists of ten whorls increasing in width. The specimen is approximately the size and shape of a blowfly larva and was initially mistaken for one. The whorls are a single continuous ribbon, not the individual lamellae characteristic of fly larvae. Abundant minute growth lines are apparent under high magnification. Extant **Holospira** are found in hot, arid, calcium rich environments (Pilsbry, 1946). Gingerich (1989) considered **Holospira** indicative of high, well-drained floodplains.

> Family Bulimulidae Zilch, 1959 Subfamily Oreohelcinae Pilsbry, 1946 Genus **Oreoconus** Taylor, 1962

<u>Age and Distribution</u>: Lower Eccene through lower Oligocene of western and central Wyoming.

Type Species: Oreoconus planispira Taylor, 1962

Oreoconus cf. **O**. **planispira**

<u>Holotype</u>: USNM 647848- single shell, collected from the Bridger Formation at Tabernacle Butte, Wyoming (Br2).

<u>Material</u>: **UM 101101m**- Single shell, collected at BB110, August 5, 1993.

<u>Remarks</u>: **Oreoconus planispira** is a medium sized, conical shelled, terrestrial gastropod. The species is poorly known. It is considered diagnostic of a terrestrial habitat since most specimens have been collected in association with other terrestrial gastropods (McKenna <u>et</u> <u>al.</u>, 1962; Hanley, 1974).

Class Pelycepoda Goldfuss, 1820

Ord., Fam., Gen. et sp. indet.

<u>Material</u>: **UM 98733m**- single valve, collected at BB012, June 29, 1991.

<u>Remarks</u>: Fragments of pelecypod valves are common at most localities along Desertion Point Ridge. A single

complete value of an indeterminate pelecypod was collected within the study area. This specimen does not match the description of any pelecypod described by Grande (1984), La Rocque (1960) or Hanley (1976, 1977).

> Phylum Chordata Haeckal, 1874 Subphylum Vertebrata Linnaeus, 1758 Class Osteichthyes Muller, 1846

Fish remains in the form of isolated skeletal elements are ubiquitous in the upper beds of the study area, particularly in the Laney Member of the Green River Formation. The lower, more terrigenous beds rarely contain fish material. Most of these fish remains are indeterminate fragments of teleosts and the scales and vertebrae of Lepisosteus and Amia.

> Superorder Holostei Muller, 1846 Order LEPISOSTEIFORMES Hay, 1929 Family Lepisosteidae Cuvier, 1825 Genus Lepisosteus Lacepede, 1803

Age and Distribution: **Lepisosteus** is known from the Late Cretaceous to Present. During the Cretaceous they were world-wide in distribution but today they are limited to North and Central America and Cuba. Using track analysis of the biogeographic distribution of the gar, Wiley (1976) gave a minimum age for the genus as middle Jurassic.

<u>Type Species</u>: **Lepisosteus gavialis** Jordan and Evermann, 1896.

Lepisosteus cuneatus (Cope, 1878)

<u>Holotype</u>: AMNH P.2517- Complete fish with crushed skull, from an unknown locality in the Manti Beds of the Green River Formation, Utah.

<u>Material</u>: UM 95602m- two parietals, collected at BB036, June 5, 1990. UM 98775m- four parietals and two dermopterotics, collected at BB069, June 30, 1991. UM 99659m- crushed skull including cleithra, basioccipital, part of the pterygoid, and a fragment of the opercular, collected at BB070, June 23, 1993.

<u>Remarks</u>: **Lepisosteus cuneatus** is present in most of the lacustrine and fluviatile deposits in the Eocene of North America. The various bones of the skull are covered by elongate enameloid tubercles. It differs from all extinct and extant species of **Lepisosteus** with the exception of **L**. **opertus** in having wide interconnecting enameloid ridges rather than thin discontinuous ridges on the parietals and dermopterotics (Wiley, 1976). **L**. **cuneatus** differs from **L**. **opertus** in having a reduced number of thicker interconnecting ridges (Wiley, 1976).

Lepisosteus sp. indet.

<u>Material</u>: Abundant vertebrae and scales have been recovered from the following localities: BB012, BB013, BB019, BB035, BB036, BB037, BB038, BB044, BB068, BB069, BB070, BB072, BB074, BB075, BB076, BB077, BB098, and BB109. A few isolated scales have been recovered from BB110, BB114, and BB118.

Remarks: Lepisosteus, the gar, is known from three species in the Green River Formation (Grande, 1984). Lepisosteus cuneatus (see above) is the only species known from Green River deposits outside of Fossil Basin and has been recovered from the study area (see below). Modern gars prefer swamps, bayous, shallow sluggish pools, backwaters of rivers and streams, and occasionally brackish lagoons (Page and Burr, 1991). They are primitive fish, and along with the bowfin (see below) are the only non-tropical airbreathing fish (Moyle and Cech, 1982). Lepisosteus is known from isolated vertebrae and scales from most localities on the eastern side of the study area, and from jaw fragments from several of these localities. Lepisosteus vertebrae are unique among fish in being procoelous rather than amphicoelous. This is thought to be related to the weight of the scaled armour the fish possess (Moyle and Cech, 1982). This armour protected gars from predation by everything except crocodilians (Grande, 1984). The thick ganoid scales that comprise this armour are easily identified by their elongate trapezoidal shape. The teeth are acrodont and needle-like.

Order Amioidea Huxley, 1861 Family Amiidae Cuvier, 1825

Genus Amia Linnaeus, 1766

Age and Distribution: Late Cretaceous to Present of North America and Europe.

Type Species: Amia calva Linneaus, 1766.

Amia sp. indet.

<u>Material</u>: Abundant vertebrae and scales have been recovered from the following localities: BB012, BB013, BB019, BB035, BB036, BB037, BB038, BB044, BB068, BB069, BB070, BB072, BB074, BB075, BB076, BB077, BB098, and BB109.

<u>Remarks</u>: **Amia**, the bowfin, is represented in the Green River Formation by two species, **Amia uintaensis** and **A**. **fragosa**. Both species are common throughout the formation. Along with the gar, bowfins are the only non-tropical airbreathing fish (Moyle and Cech, 1982). Modern bowfins are found in swamps, sloughs and shallow pools, usually near vegetation. The cycloid scales that comprise the armour of this primitive fish are easily identified by their roundedoff rectangular shape. The scales are usually slightly concave and are much thinner than those of the gar.

Superorder Teleostei Owen, 1847

Order indet.

<u>Material</u>: Abundant vertebrae, spines, ribs, and skull fragments have been recovered from the following localities:

BB012, BB013, BB019, BB035, BB036, BB037, BB038, BB044, BB068, BB069, BB070, BB072, BB074, BB075, BB076, BB077, BB098, and BB109.

<u>Remarks</u>: Although abundant teleost fossils have been recovered from the study area, they are, with the exception of the catfish spines described below, extremely fragmentary in nature. Most studies of the Green River fish fauna have been conducted in the richer strata of the Fossil and Uinta Basins. Grande (1984) reviewed the fish fauna of the Green River Formation. No new information on the teleosts of the Green River Formation can be added here.

Order SILURIFORMES

Family Ictaluridae

Genus and species indet.

Age and Distribution: Palaeocene to Recent, North America.

<u>Material</u>: **UM 95600m**- Base of dorsal spine, collected at BB013, June 29,1990. **UM 98735m**- Base of dorsal spine, collected at BB077, June 29, 1991.

<u>Remarks</u>: Two genera and three species of ictalurid catfish have been reported from the Green River Formation (Grande, 1984). The only easily identified elements are the long serrated dorsal and pectoral spines. Ictalurids are probably more common than the identified fossils might suggest since most other isolated skeletal elements of catfish look similar to those of other teleostean fish.

Class Reptilia Laurenti, 1768 Subclass Anapsida Osborn, 1918 Order TESTUDINES Batsch, 1788 Suborder Cryptodira Cope, 1869

<u>Remarks</u>: The remains of turtles are the most abundant tetrapod fossils within the study area. The majority of the specimens are fragmented carapaces and plastrons and are of limited use. Several excellent specimens have been recovered, however, largely consisting of complete carapaces and plastra. Few of these have any associated skeletal material and only a single fragmentary skull has been found.

> Superfamily Baenoidea Williams, 1950 Family Baenidae Cope, 1869 Subfamily Baeninae Williams, 1950 Genus **Baena** Leidy, 1870

Age and Distribution: Early to late Eocene (Wasatchian to Uintan) of Wyoming and Utah.

Type Species: Baena arenosa Leidy, 1870

Baena arenosa Leidy, 1870

<u>Holotype</u>: USNM 103- partial carapace, collected near the junction of the Big Sandy and Green Rivers, lowermost Bridger Formation (Br1). <u>Material</u>: UM 98663-fragmentary skull, complete mandibles, fore and hind limb elements, carapace and plastron fragments, collected at BB013, June 28, 1991. UM 98690- Complete plastron and partial carapace of large adult, collected at BB069, June 28, 1991. UM 98714carapace and plastron fragments with associated limb elements, collected at BB036, June 28, 1991. UM 98718carapace and plastron fragments, collected at BB013, June 29, 1991.

<u>Remarks</u>: **UM 98690** is a specimen of a relatively old turtle. All traces of the sutures between the various bones of the plastron are obliterated through co-ossification. No traces of the pattern of the epidermal covering remain. The other three specimens were much younger and smaller individuals and retain obscure suture lines.

The plastron of <u>Baena arenosa</u> is comparatively blunt at both ends. The posterior margins of the xiphiplastra are rounded and only slightly concave. The vertebral scutes are wide and rectangular. The carapace fragments are moderately thick. The skull is short and wide. The mandibles are robust, and possess a deep groove on the medial surface. The condylus mandibularis is rectangular and concave unlike the tear drop shaped bone in the closely related <u>Chisternon</u> (Gaffney, 1972).

Superfamily Testudinoidea Baur, 1893

Family Emydidae Lydekker, 1889

Genus Echmatemys Hay, 1906

<u>Age and Distribution</u>: Eocene (Wa0-Ui2) of North America.

Type Species: Echmatemys septaria Cope, 1873

Echmatemys septaria Cope, 1873

<u>Holotype</u>: The type is in the United States National Museum, and consists of carapace fragments and a complete plastron, collected in the Washakie Basin near South Bitter Creek, Wyoming.

<u>Material</u>: UM 95598- Nearly complete plastron, most of the carapace, some postcrania including a large claw, collected at BB013 on June 4, 1990. UM 98717- complete plastron and nearly complete carapace, collected at BB076, June 29, 1991. UM 98693- Complete plastron, carapace fragments, collected at BB013w, June 28, 1991. UM 98722partial plastron including right epiplastron, collected at BB074, June 29, 1991. UM 101024- right epiplastron, collected at BB037, August 1, 1993. UM 101028- right epiplastron, collected at BB036, August 1, 1993.

<u>Remarks</u>: <u>Echmatemys</u> <u>septaria</u> is the most common emydid turtle found within the field area. It differs from <u>E</u>. <u>wyomingensis</u> (see below) in having a narrow epiplastron with distinct tubercles set near the medial suture, a thick margin, and a deep epiplastral trough (figure 5) and

massive, medial bridge extensions on the hypoplastron. This turtle is indicative of lacustrine or near-lake fluvial environments (Bartels, 1993).

Echmatemys wyomingensis Leidy, 1869

<u>Holotype</u>: The type is in the collection of the Academy of Natural Science, Philadeplhia, and consists of an isolated left epiplastron, collected in the Bridger Basin, near Fort Bridger, Wyoming.

<u>Material</u>: **UM 95602m**- right xiphiplastron, collected at BB036, June 4, 1990. **UM 98717**- Complete carapace and plastron, collected at BB076, June 29, 1991.

<u>Remarks</u>: **Echmatemys wyomingensis** differs from **E**. **septaria** above in having a wider epiplastron with indistinct tubercles more distant from the medial suture, a thin margin, and a comparatively wide, short, and shallow epiplastral trough (figure 5). **E**. **wyomingensis** is considerably less common than **E**. **septaria** within the field area. The turtle is restricted to fluvial environments (Bartels, 1993).

Echmatemys cf. **E**. **cibollensis** (Cope, 1902) <u>Holotype</u>: USNM 2576- fragments of the plastron, collected from the Wasatch beds of New Mexico in the vicinity of the Gallinas River.

<u>Material</u>: **UM 101153**- carapace and plastron fragments including the epiplastron, collected by at BB097, August 5, 1993.
Remarks: This interesting species of Echmatemys is known from a single specimen within the study area. It is significantly different from the other two species of Echmatemys found within the study area. The tubercles on the epiplastra (Figure 5) are large, distinct and pointed, and set near the medial suture. The tubercle is much more pointed and elongate than in either E. septaria or E. wyomingensis. The ventral surface is indented beneath the tubercles unlike either of these species. The margin, although thin like in E. septaria, extends the entire length of the short medial suture. Like many modern terrestrial forms, the carapace and plastron are thick.

Echmatemys sp. indet.

<u>Material</u>: UM 98668m- carapace and plastron fragments, collected at BB013, June 25, 1991. UM 98704m- carapace and plastron fragments, collected at BB072, June 28, 1991. UM 98714- Fragments of the carapace and plastron, some limb elements, collected at BB036, June 28, 1991. UM 98715complete entoplastron, fragments of hyoplastron, and epiplastron, collected at BB070, June 29, 1991. UM 99635mcarapace and plastron fragments, collected at BB037, June 17, 1992.

<u>Remarks</u>: These specimens unfortunately do not retain any of the diagnostic characters which differentiate between <u>Echmatemys wyomingensis</u> and <u>E. septaria</u>. The thinner shell

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Figure 5.

Epiplastra of <u>Echmatemys</u> species from the study area. A. <u>E. wyomingensis</u> (UM 98717), B. <u>E. septaria</u> (UM 101024) C. <u>E. cibollensis</u> (UM 101153). Bars are one millimeter in length.



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Figure 5.

and less stream-lined plastral fragments make it unlikely that any of these specimens are referable to <u>E</u>. <u>cibollensis</u>.

Superfamily Trionychoidea Gray, 1870

Family Trionychidae Bell, 1828

cf. Genus Platypeltis Fitzinger, 18??

Age and Distribution: Cretaceous to Recent of Asia, $\mathbf{A} \mathbf{f} \mathbf{r}$ ica, North America, and Europe.

Type Species: Platypeltis ferox Schneider, 1783

cf. **Platypeltis** sp. indet.

<u>Material</u>: UM 98775m- most of the carapace and plastron, Collected at BB069, June 30, 1991. UM 100135- most of the Carapace and plastron, collected at BB074, July 25, 1992.

Remarks: This genus has been tentatively recognized on the basis of the pattern of the markings on the carapace. The markings are finer and more detailed than in the larger trionychid genera Amyda and Aspiderites. In addition, several carinae run the length of the carapace, a feature not usually seen in other trionychid genera. Both specimens are juveniles however. Bartels (pers. comm.) feels that the carinae may disappear and the markings may become more generalized with age.

Genus and Species indet.

<u>Material</u>: UM 95602m- seventh right costal, collected at BB036, June 5, 1990. UM 98668m- carapace fragments, collected at BB013, June 25, 1991. UM 98695m- carapace fragment, collected at BB013w, June 28, 1991. UM 98704carapace and plastron fragments (at least two species), collected at BB072, June 28, 1991. UM 98713m- carapace fragments, collected at BB073, June 29, 1991. UM 98716carapace and plastron fragments, collected at BB070, June 29, 1991. UM 98722m- carapace fragment, collected at BB074, June 29, 1991. UM 98725a- carapace and plastron fragments, collected at BB070, June 28, 1991. UM 99634mcarapace fragments, collected at BB097, June 17, 1992. UM 101015m- carapace fragment, collected at BB116, July 31, 1993. UM 101097m- carapace and plastron fragments (two or three species), collected at BB118, August 5, 1993.

<u>Remarks</u>: Although fragments of trionychid turtles are common in the upper beds of the study area, more complete specimens are rare. The plastron and carapace, and the individual elements of the plastron are connected only by ligaments facilitating rapid dispersal of the skeleton after degradation. The highly varied sculpture patterns on the surfaces of the carapace and plastron fragments in the study collection indicate the presence of several different taxa.

Family Dermatemydidae Gray, 1870

Genus **Baptemys** Leidy, 1870

Age and Distribution: Eocene (Wa?-Ui2) of North America.

Type Species: Baptemys wyomingensis Leidy, 1870

Baptemys fluviatilis Hay, 1908

<u>Holotype</u>: Hay (1908) described the species based on a specimen donated to the American Museum, from an uncertain level and locality, and did not give the holotype a catalogue number.

<u>Material</u>: **UM 99628**- Nearly complete carapace, and complete plastron and associated postcrania, collected at BB067. **UM 99928**- Complete plastron and carapace. Collected at BB013, .

Remarks: Hay (1908) recorded three species of **Baptemys**. **UM 99628** and **UM 99928** are most similar to the diagram and description of **B**. <u>fluviatalis</u> in having a small entoplastron, only two suprapygals, and a somewhat rounded xiphiplastra. **B**. <u>wyomingensis</u> is characterized by three suprapygals, a large entoplastron, and blunt xiphiplastra. **B**. <u>tricarinata</u> is characterized by having two suprapygals, a large entoplastron, acute xiphiplastra, and as the name suggests, three prominent ridges (or carinae) running the length of the carapace. In both specimens the articulation between the plastron and the carapace is well-fused, such that the sutures are difficult to define. The scute impressions are indistinct, indicating that both were older animals.

Baptemys sp. indet.

<u>Material</u>: **UM 95603**- plastron fragments, collected at BB013, June 5, 1990. **UM 95604m**- carapace and plastron

fragments, collected at BB013, June 5, 1990. UM 95613mcarapace fragments, collected at BB038, June 5, 1990. UM 95670m- carapace and plastron fragments, collected at BB051, June 15, 1990. UM 98696- carapace fragments, collected at BB070, June 28, 1991.

<u>Remarks</u>: The material referred here is too incomplete to assign to a particular **Baptemys** species. While all of the specimens are comprised of fragmented carapaces and plastrons, the neurals and peripherals included in the specimens are identical in all respects to similar elements in the two specimens referred to **Baptemys fluviatalis** (see above). In addition, the texture of the dorsal surface of the carapace fragments is unlike that of any other turtle from the field area.

Family Carettochelyidae Lydekker, 1887

Genus **Anosteira** Leidy, 1871

Type Species: Anosteira ornata Leidy, 1871

<u>Age and Distribution</u>: Middle Eocene (Br1-Br3) of Wyoming, lower Oligocene (Suevian) of England.

Anosteira ornata Leidy, 1871

<u>Holotype</u>: Original holotype lost; the neotype is USNM 4062, a partial carapace and plastron from the lower Bridger Formation near Fort Bridger, Wyoming.

<u>Material</u>: UM 95595a- sixth peripheral and a fragment of the epiplastron, collected at BB035, June 4, 1993. UM 95612a- ninth peripheral, collected at BB037, June 5, 1990.

UM 99635m- carapace fragment, collected at BB037, June 17, 1992. UM 101026- sixth peripheral, collected at BB038, August 1, 1993.

Remarks: Specimens of **Anosteira ornata** have been collected from three localities within the study area, all from the same level. Cope (1872) named **A**. **radulina**, the only other North American species, based on two peripherals found near the present study area. The species was diagnosed by it's much larger size than known specimens of **A**. **ornata**. Hay (1908) revised Cope's diagnosis, and based the species on the more rhomboid shape of the anterior peripherals. Bartels (pers. comm.) does not consider that the known material warrants two species of this poorly known genus.

Anosteira ornata is characterized by its uniquely textured carapace and plastron. The sculpturing is in the form of tiny, well defined tubercles rather than the broader ridges and pits of the Trionychidae. The specimens from within the study area are slightly larger than specimens of **A. ornata** and much smaller than those of **A. radulina** measured by Hay (1908). The shape of the individual peripherals matches those of **A. ornata** figured by Hay. Order SQUAMATA Oppel, 1811 Suborder Lacertilia Cuvier, 1842 Infraorder Iguania Cuvier, 1807 Family Iguanidae Gray, 1825 Genus **Parasauromalus** Gilmore, 1928

<u>Age and Distribution</u>: Middle Eocene (Br1-Br3?) of North America.

Type Species: Parasauromalus olseni Gilmore, 1928.

Parasauromalus olseni Gilmore, 1928.

<u>Holotype</u>: AMNH 1620- right dentary with five complete teeth, and the basal portion of eight others, collected from the Wind River Formation (early-middle Eocene), Alkali Creek, Fremont County, Wyoming.

<u>Material</u>: **UM 98657**- fragment of anterior portion of right dentary with three teeth, collected at BB013, June 25, 1991. **UM 98658**- fragment of right dentary with three complete teeth, collected at BB013, June 25, 1991.

<u>Remarks</u>: Consistent with the diagnosis of Gilmore (1928), **UM 98657** and **UM 98658** have pleurodont, laterally compressed teeth. **UM 98657** is a fragment of the anterior part of the dentary and has less distinctly tricuspid teeth than **UM 98658**. The crowns of the teeth are elongate, reflected slightly inward, and are somewhat "spoon-shaped". Infraorder Anguimorpha Furbringer, 1900

Superfamily Anguioidea Fitzinger, 1826

Family Anguidae Gray, 1825

Subfamily Glyptosaurinae Marsh, 1872

<u>Remarks</u>: Sullivan (1979) split the Glyptosaurinae into two tribes, the Glyptosaurini and the Melanosaurini, both of which are known from the study area.

Tribe Glyptosaurini Sullivan, 1979

Genus **Glyptosaurus** Marsh, 1871

Holotype: Glyptosaurus sylvestris Marsh, 1871

Age and Distribution: Late early Eocene (Wa6) through early Late Eocene (Ui2) of North America.

Glyptosaurus sylvestris Marsh, 1871

<u>Holotype</u>: USNM 16523- left frontal, collected from the middle Eocene Bridger Formation at Grizzly Buttes (Br2), Uinta County, Wyoming.

<u>Material</u>: **UM 98724**- right frontal, six vertebrae and additional vertebral fragments, limb fragments, collected at BB074, June 29, 1991.

<u>Remarks</u>: This was the first fossil anguid lizard genus to be described from North America. Marsh (1871) based his description of <u>Glyptosaurus sylvestris</u> on a variety of skeletal and cranial material including a "ventral shield...covered with small polished tubercles", "a left frontal", and a "fragment of jaw bearing three teeth" collected from the middle Bridger beds (Bridger B) near Grizzly Buttes, Wyoming (Marsh, 1871, p.456). Gilmore (1928) questioned the association of the other material and limited the type to the left frontal. The frontal is covered with primarily hexagonal osteoderms. Sullivan (1979) limited the species included in <u>Glyptosaurus</u> to <u>G</u>. sylvestris.

The right frontal of **UM 98724** is identical in most respects to the type described in Marsh (1871a) and other specimens in Gilmore (1928). It is covered with discrete hexagonal osteoderms. Consistent with the diagnosis of Sullivan (1979) the osteoderms are strongly fused to the underlying bone. Each osteoderm is covered with tiny raised tubercles arranged in a concentric pattern.

Glyptosaurus is the only large lizard known from the study area. Although the postcranial elements of the various glyptosaurines are not useful in generic identification, those associated with **UM 98724** do indicate the animal was large (30-50cm in total length), supporting the diagnosis of the specimen as **Glyptosaurus sylvestris**.

Glyptosaurini indet.

<u>Material</u>: UM 94890- one large vertebra, collected at BB019, June 29, 1989. UM 98574- isolated osteoscute, collected at BB037, June 20, 1991. UM 98691- isolated osteoscute, collected at BB013w, June 28, 1991. UM 98697associated vertebrae, collected at BB070, June 27, 1991. UM 98726m- isolated vertebrae and osteoscutes, collected at

BB074, June 29, 1993. UM 99634- isolated osteoscute, collected at BB097, June 19, 1992. UM 100898- one large vertebra, collected at BB115, July 25, 1993. UM 101011isolated osteoscute, collected at BB114, July 31, 1993. UM 101013- isolated osteoscute, collected at BB116, August 1, 1993. UM 101034m- eight large vertebrae, collected at BB013, August 1, 1993.

<u>Remarks</u>: Isolated postcranial elements have not been used in separating the various glyptosaurine taxa (see Sullivan, 1979; Gilmore, 1928). Osteoscutes with raised tubercles arranged in concentric rings are characteristic of most glyptosaurine lizards (Sullivan, 1979). The presence of <u>Glyptosaurus sylvestris</u> at the Desertion Point level (see below) suggests that other glyptosaurine specimens, especially those from the same level, may belong to this taxon.

Tribe Melanosaurini Sullivan, 1979

Genus **Xestops** Cope, 1873

Age and Distribution: Eocene of North America.

<u>Remarks</u>: The genus <u>Xestops</u> is indicated by the presence of isolated osteoscutes from several localities. The osteoscutes are covered with tiny tubercles and have a diagonal keel across their entire length. They are slightly thinner than in <u>Glyptosaurus</u>, and in complete specimens are bevelled on the anterior and lateral surfaces. This arrangement allows for free movement of the armour in three

directions (Hecht, 1959). The diagonal keel suggests an angular rather than straight arrangement of the osteoscutes as in <u>Glyptosaurus</u> (Hecht, 1959).

Xestops cf. X. vagans Marsh, 1873

<u>Holotype</u>: YPM 541- left and right dentaries, frontals, basal portion of right coronoid, fragment of Pterygoid with teeth, and numerous osteoscutes, collected from the Middle Eocene Bridger Formation at Grizzly Buttes (Br2), Uinta County, Wyoming.

<u>Material</u>: **UM 101167**- fragment of the right dentary with four teeth, a single caudal vertebra, and 58 osteoscutes, collected at BB110, August 5, 1993.

<u>Remarks</u>: UM 101167 is the remains of a tiny, possibly juvenile individual. The teeth are pleurodont and simple. Consistent with the description of Gilmore (1928), and that of the type (Marsh, 1872), the teeth are rodlike with obtuse crowns. The tips of the teeth are pigmented, possibly an artifact of preservation since other specimens referred to this species are unpigmented. The osteoscutes are typical **Xestops** osteoscutes (see above). The vertebra is abraded and is not diagnostic.

Type Species: Xestops vagans Marsh, 1873

<u>Xestops</u> sp. indet.

<u>Material</u>: UM 95612m- isolated osteoscute, collected at BB037, June 5, 1990. UM 98655- isolated osteoscute, collected at BB013, June 25, 1991. UM 98667- isolated osteoscute, collected at BB013, June 25, 1991. UM 98695isolated vertebrae and osteoscute, collected at BB013w, June 29, 1991. UM 98719- isolated osteoscute, collected at BB074, June 29, 1991. UM 98744- three osteoscutes, collected at BB069, June 30, 1991.

<u>Remarks</u>: Species of <u>Xestops</u> are difficult to identify from isolated vertebrae and osteoscutes. Although <u>Xestops</u> <u>vagans</u> is present in the study area, and is ubiquitous in the Bridgerian of the Bridger Basin, the material is insufficient to warrant specific identification.

Suborder Serpentes Linnaeus, 1758 Family Boidae

Subfamily Erycinae Hofstetter and Rage, 1972

<u>Remarks</u>: Hofstetter resurrected the subfamily Erycinae on the basis of the unique osteological characteristics of the caudal vertebrae (Hecht, 1959, Holman, 1979). This group of fossorial to semi-fossorial boids is thought to have originated in the "North America-Western European" geographic unit and migrated to Asia and Africa from there (Holman, 1979).

Genus Calamagras Cope, 1873

Age and Distribution: The genus **Calamagras** is known from the middle Eccene through the middle Miccene of North America and the lower Eccene of France.

Type Species: Calamagras murivorus Cope (1873)

<u>Holotype</u>: AMNH-1603- six articulated trunk vertebrate, collected in the middle Oligocene Oreodon beds at Cedar Creek, Colorado.

<u>Remarks</u>: Vertebrae of individuals of this genus are characterized by a comparatively short centrum, a short, stout neural spine, and a low, wide neural arch. The zygapophyses are joined by a low, short ridge, the glenoid fossa is suboval, and the condyle is moderately oblique (Gilmore, 1938).

The genus **Calamagras** is closely related to the North American genus **Ogmophis** and may in fact be congeneric (Rage, 1977; Holman, 1979; Gilmore, 1938). The only feature used to distinguish between the two genera is the neural spine which is short and thick in **Calamagras**, and thin and elongate in **Ogmophis** (Holman, 1979, Rage, 1977). Rage (1977) feels this criterion is invalid since the length of the neural spine of snake vertebrae varies throughout the vertebral column. This character does not vary appreciably in modern erycinine boids however (Holman, pers. comm.). and is considered here to be a diagnostic character.

Calamagras primus Hecht, 1959

<u>Holotype</u>: AMNH 3828- a single trunk vertebra, collected in the middle Eocene Bridger Formation near Tabernacle Butte in the northeastern Green River Basin, Wyoming.

<u>Material</u>: **UM 101211**- Two vertebrae, collected at BB037 on June 5, 1992.

<u>Remarks</u>: UM 101211 (Figure 6) is the only fossil snake specimen recovered from within the study area. The specimen agrees well with the description and illustrations of Hecht (1959) and Holman (1979) in having a relatively short, thick centrum with a low although distinct haemal keel, a trapezoidal neural canal, and a well-rounded, ovaloid condyle which extends directly posteriorly. The zygosphene is thin and high. The neural arch, although broken off, was thick at the base.

Suborder Amphisbaenia Gray, 1844

Family indet.

<u>Material</u>: **UM 101168**- Fused centra of the atlas and axis, collected at BB110, August 5, 1993.

<u>Remarks</u>: **UM 101168** is the only amphisbaenid specimen recovered from within the field area. This element has a single elongate dorsal keel, unlike the interrupted dorsal keel found in most lizards.



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Figure 6. Trunk vertebra of <u>Calamagras primus</u> (UM 101211). Bars are one millimeter in length. A. anterior view. B. dorsal view. C. lateral view. 67

Subclass Archosauria Cope, 1891

Order CROCODYLIA (Gmelin, 1789)

Suborder Eusuchia Mook, 1934

Family Alligatoridae (Cuvier, 1807)

Genus Allognathosuchus Mook, 1921

Age and Distribution: Palaeocene and Eocene of Europe and North America.

Type Species: Allognathosuchus polyodon (Cope, 1873)

Allognathosuchus sp. indet.

<u>Material</u>: UM 95595m- isolated tooth, collected at BB035, June 4, 1990. UM 95613m- isolated tooth, collected at BB038, June 5, 1990. UM 98695m- isolated tooth, collected at BB013w, June 28, 1991. UM 98735m- isolated tooth, collected at BB077, June 29, 1991. UM 100892- six teeth, collected at BB114, July 25, 1993.

<u>Remarks</u>: The teeth of <u>Allognathosuchus</u> are unique among crocodilians in the study area. They are somewhat onionshaped, slightly laterally compressed, and have tiny, slightly wavy striae running vertically from the flat occlusal surface to the base of the enamel (see figure 7). Case (1925) considered <u>Allognathosuchus</u> to be a molluscivore, but Bartels (1984) and Simpson (1930) argued for a varied diet.

Genus **Diplocynodon** Pomel, 1843

<u>Age and Distribution</u>: Eocene of North America, Eocene through Pliocene of Europe.

Type Species; Diplocynodon ratelli

Diplocynodon sp. indet.

<u>Material</u>: UM 95595m- isolated tooth, collected at BB035, June 4, 1990. UM 95613m- three teeth, collected at BB038, June 5, 1990. UM 98577m- two teeth, collected at BB037, June 20, 1991. UM 98713m- isolated tooth, collected at BB073, June 28, 1991. UM 98733m- associated osteoscutes, collected at BB012, June 29, 1991. UM 99638m- isolated tooth, collected at BB074, June 18, 1992.

Remarks: **Diplocynodon** is known from the study area by isolated teeth and osteoscutes. The teeth (Figure 7) are long and gracile, and possess thin ridges from apex to base. The teeth are similar to those of the extant crocodilian **Gavialis gangeticus** (the Gharial) and are suggestive of a piscivorous diet.

Diplocynodon is tentatively placed within the Alligatoridae, but may be more closely allied with caimans or crocodylids (Bartels, pers comm.).

Genus and Species indet.

<u>Material</u>: UM 95601- cranial and skeletal fragments, collected at BB036, June 5, 1990. UM 95612m- isolated osteoscute, collected at BB037, June 5, 1990. UM 98692skeletal fragments, collected at BB013w, June 28, 1991. UM 98707- isolated quadratojugal, collected at BB073, June 28, 1991. UM 98731m- associated osteoscutes, collected at

BBO76, June 29, 1991. **UM 98772**- skeletal fragments, collected at BB069, June 30, 1991.

<u>Remarks</u>: The osteoscutes of alligators are differentiated from those of other crocodilians by possessing sutures on both the lateral and the posterior surfaces rather than just on the lateral. Three genera of alligators have been reported from the Lower Bridger Formation of southwestern Wyoming. Two of these,

Allognathosuchus and Diplocynodon have been recovered from the study area (see below); the other, Procaimanoidia, has not yet been recovered from the study area although it has been reported from slightly higher strata adjoining the study area to the east (Gunnell and Bartels, in press). Unfortunately the postcrania of these three genera are difficult to distinguish.

Family Crocodylidae (Cuvier, 1807)

Genus Crocodylus Laurenti, 1768

Age and Distribution: Cretaceous to present of Asia, South America, North America, Europe, Australia, and Africa.

Type Species: Crocodylus niloticus Laurenti, 1768.

Crocodylus affinis Marsh, 1871

Holotype: YPM 1345- an almost complete skull and mandibles, collected from the middle Eocene Bridger Formation at Grizzly Buttes (Br2), Uinta County, Wyoming.

<u>Material</u>: **UM 95595m**- isolated tooth, collected at BB035, June 4, 1990. **UM 95612m**- isolated tooth, collected

at BB037, June 5, 1990. UM 98577m- two teeth, collected at BBO 37, June 20, 1991. UM 98579m- two teeth, collected at BBO 44, June 20, 1991. UM 98698m- tooth, vertebra, and osteoscute, collected at BB070, June 28, 1991. UM 98713misolated tooth, collected at BB073, June 28, 1991. UM 987 28- seven teeth, collected at BB075, June 29, 1991. UM 987 2 9m- Tooth fragment, collected at BB076, June 29, 1991. UM 98733m- isolated tooth, collected at BB012, June 29, 1991. UM 98735m- two teeth, collected at BB077, June 29, 1991. UM 98775m- two teeth and associated limb fragments, collected at BB069, June 30, 1991. UM 99638m- isolated tooth, collected at BB074, June 18, 1992. UM 99844misolated tooth, collected at BB036, July 16, 1992. UM **100896m**- teeth and osteoscutes, collected at BB114, July 25, 1993. UM 101170- two teeth, collected at BB110, August 5, 1993

Remarks: The teeth of <u>Crocodylus affinis</u> are among the most common crocodilian remains within the study area. The teeth are rather robust, only slightly laterally compressed, and possess relatively straight striae from the tip to the base. They are pointed, but quickly widen unlike the long slender teeth of <u>Diplocynodon</u> (figure 7). The teeth of <u>C</u>. **Affinis** are the most generalized teeth of any of the Bridger crocodilians. These teeth would be beneficial for crushing bones, less so for tearing flesh. <u>C</u>. **Affinis** probably

.... ŧ ::: 13 ar (:: Ta; 320 Ię: 120 preyed upon turtles, tetrapod herbivores and fish, perhaps even large gars.

New genus (?) and species

<u>Material</u>: **UM 95599**- Complete skull and associated postcrania, collected at BB013, June 28, 1991.

<u>Remarks</u>: Little can be said about this specimen as it is **still in preparation**. It's snout is substantially blumter than any of the described crocodilids from the field area. The dentition indicates a generalized diet, similar

to that of Crocodylus affinis

Family Pristichampsidae Kuhn, 1968

Genus Pristichampsus Gervais, 1853

Remarks: The taxonomic position of **Pristichampsus** is rather uncertain. The teeth, and certain of the skeletal elements are unlike those found in any other crocodilians (Troxell, 1925; Langston, 1975; Bartels, pers. comm.). While dental occlusion is intermediate between that found in Alligatoridae and that found in Crocodylidae (Langston, 1975), the skull is morphologically most similar to Crocodilids. Langston (1975) and many previous authors retained <u>Pristichampsus</u> in the Crocodylidae. This thesis follows Kuhn (1968) in recognizing family Pristichampsidae

Age and Distribution: Eccene of Europe and North

Type Species: Pristichampsus vorax Troxell, 1925

<u>:</u> fragmen Errati Steps: . Large g ttthe The tee slight) Serrat: The tee angle, Teport, lirth (represe

Pristichampsus Vorax Troxell, 1925

Holotype: YPM 249- crushed skull and mandibles, fragmented skeleton, collected from the "Greensand Formation" (lowest Bridger Formation) near Red Dog Butte (Br1) in the Bridger Basin, Wyoming.

<u>Material</u>: UM 98712- tooth fragment, vertebra, and an OSteoscute, collected at BB073, June 28, 1991. UM 98577mlarge single tooth, collected at BB037, June 20, 1993.

Remarks: **P**. **vorax** is the only ziphodont (dinosaurtoothed) crocodilian known from the Eocene of North America. The teeth are unique among Cenozoic crocodilians. They are slightly curved, laterally compressed, and possess tiny serrations on the anterior and posterior edges (figure 7). The teeth are set in the mandibles and the maxilla at an angle, and are pointed posteriorly. The "?carnosaur tooth" "Sported from the Bridger Formation at Opal Bench, 10 kms "Orth of the study area by Wood (1966, p.54) is undoubtedly "Spresentative of a large specimen of this enigmatic taxon.



Figure 7. Crocodilian teeth. A. <u>Allognathosuchus</u> (UM 100892). B. <u>Diplocynodon</u> (UM 98577m). C. <u>Crocodylus affinis</u> (UM 101012m). D. <u>Pristichampsus vorax</u> (UM 98577m). Bars are one millimeter in length. Class Mammalia Linneaus, 1758 Infraclass Metatheria Huxley, 1880 Order DIDELPHIMORPHIA Illiger, 1811 Superfamily Didelphoidea Gray, 1821 Family Didelphidae Gray, 1821 Subfamily Didelphinae Gray, 1821 Tribe Didelphini Crochet, 1979 Genus <u>Peratherium</u>, Aymard, 1850

Age and Distribution: Early Eocene (Wal) to late **Oligocene** (Arl) of western North America.

Type Species: P. comstocki Cope, 1884

Peratherium comstocki Cope, 1884

Holotype: AMNH 4252- left dentary fragment with M/2-M/3, from an unreported locality in the "badlands of the Wind River, Wyoming".

Material: UM 95611- left dentary fragment with /M1 Deceserved, collected at BB037, June 5, 1990.

Remarks: Peratherium comstocki is by far the largest North American species of Peratherium. UM 95611 is equivalent in size to specimens of P. comstocki from the Wind River Formation measured by Krishtalka and Stucky (1983). Measurements of UM 95611 are provided in Table 1. Consistent with their description, the tooth has a strong, although rather short, precingulum at the base of the protoconid, the largest of the cusps. The paraconid, the lowest of the trigonid cusps, is deflected anterodorsally.

The entoconid is large and conical and separated from the **flat tabular** hypoconulid by the entoconid notch, a gap in **the** postcristid.

Peratherium innominatum Simpson, 1928

Holotype: AMNH 11493- Partial left dentary containing /M1-/M3, collected at Millersville from the Lower Bridger Formation (Br1) in the Bridger Basin, Wyoming.

Material: UM 95610- fragment of left dentary containing /M1 and alveoli of /M2, collected at BB037, June 5, 1990.
UM 99919- talonid of right Mx/, collected at BB109, July 21, 1992. UM 101102- right M2/, collected at BB118, August 5, 1993.

Remarks: Three specimens have been referred to **Peratherium innominatum**. **UM 95610** comes from one of the **h**ighest localities in the section, while **UM 101102** comes **f**ion one of the lowest. **UM 99919** was recovered from one of **t**he intermediate beds in the section.

The teeth fall well below the size range of most **Peratherium** species including <u>P</u>. <u>comstocki</u>, also known from the study area (Table 1). The two exceptions are <u>P</u>.

brighti, and **P**. **innominatum**. Similar to described specimens of **P**. **innominatum** and unlike those of **P**. **knighti** (Krishtalka and Stucky, 1983), **UM 95610** possesses a low, posteriorly projecting hypoconulid. The hypoconulid is separated by a deep groove from a large entoconid. The entoconid and hypoconid are tall and pointed resulting in a very deep talonid basin, deeper than that exhibited in <u>P</u>. <u>knighti</u>. Dissimilar to the condition in <u>P</u>. <u>knighti</u> (Krishtalka and Stucky, 1983), UM 101102 has a very distinct ectoflexus. UM 99919, although rather incomplete, is very similar to UM 101102.

Previously Bown (1982) and Setoguchi (1973) allocated **Peratherium innominatum** to the genus **Peradectes**, a didelphid **Genus well known from higher Bridger Beds.** Krishtalka and **Stucky** (1983) returned <u>P. innominatum</u> to the genus **Peratherium** on the basis of the size of the entoconid of /M2 and /M3, and the presence of a deep, wide notch between the

entoconid and the hypoconulid (Krishtalka and Stucky, 1984).

TABLE 1

Measurements (in mm.) of Marsupialia

Peratherium

| | | <u>P. comstocki</u> | | | | <u>P</u> . | innominatum | | |
|-----|------------------|---------------------|-----------------------------------|------|----------|------------|-------------|-----------------------------------|--|
| /M1 | AP Tra Trp | UM | 95611 2.7 1.3 1.5 | | | | UM | 99919 1.9 0.8 0.7 | |
| | | | | M2 / | AP Tr | | UM | 101102 1.8 1.7 | |

Infraclass Eutheria Huxley, 1880 Order INSECTIVORA Illiger, 1811 Suborder Proteutheria Romer, 1966 Superfamily Apatemyoidea Matthew, 1909 Family Apatemyidae Matthew, 1909

Apatemys Marsh, 1872

Age and Distribution: Late Palaeocene (Cf1) through

Type Species: Apatemys bellulus Marsh, 1872

cf. Apatemys sp. indet.

Material: UM 101022- right /I1, collected by at BB037, August 1, 1993.

Remarks: Apatemyids, and **Apatemys** in particular are **Characterized** by enlarged lower incisors (Marsh, 1872; **Matthew**, 1915). **Apatemys** is the only apatemyid insectivore **Coported** from the study area or adjacent strata. **UM 101022 i** somewhat smaller than the type of **A**. **bellus** measured by **Marsh** (1872), and may belong to **A**. **bellulus**. Measurements **Of** specimen **UM 101022** are provided in Table 2.

Family Pantolestidae Cope, 1884

Genus Palaeosinopa Matthew, 1901

Age and Distribution: Late Palaeocene (Ti4) to middle Eocene (Br1) of North America, and possibly the early Eocene of eastern Asia.

Type Species: Palaeosinopa veterrima Matthew, 1901.

Palaeosinopa cf. P. lutreola Matthew, 1918

Holotype: AMNH 15100- fragment of right dentary with M2 and /M3, from the lower beds of the Willwood Formation Elk Creek, Bighorn Basin, Wyoming.

<u>Material</u>: **UM 101155**- right M2/ with abraded metastyle **ard** postcingulum, collected at BB110, August 5, 1993.

Remarks: UM 101155 is characterized by its prominent parastyle wing, extending far out from the paracone. The precingulum is slight, and only extends from the lingual side of the protocone to the paraconule. The metaconule is nearly imperceptible.

Although morphologically similar, the tooth is considerably smaller than specimens of <u>Palaeosinopa</u> <u>veterrima</u> and <u>P. incerta</u> figured in Bown and Schankler (1982). The specimen is possibly referable to <u>P. lutreola</u> however this species is known from the lower dentition only (Van Valen, 1967). Measurements of specimen UM 101155 are provided in Table 2.

> Family Lepticidae Gill, 1872 Subfamily Lepticinae Gill, 1872

Palaeictops Matthew, 1899

Age and Distribution: Early to late Eocene (Wa3-Ui2) of Western North America.

Type Species: Palaeictops bicuspis (Cope, 1880)

Palaeictops bicuspis (Cope, 1880)

<u>Holotype</u>: AMNH 4802- crushed skull and mandibles with nearly complete dentition, collected from the Lost Cabin beds (Wa7) of the Wind River Basin, Wyoming.

Material: UM 101166- left /M2, collected at BB110, August 5, 1993.

<u>Remarks</u>: UM 101166 (Figure 8) is the only leptictid identified from within the study area. Although the trigonid is wider than the talonid, the talonid basin is much larger and deeper than the trigonid basin. The hypoconulid extends posteriorly from the postcristid. The paraconid is centrally placed and projects farther anteriorly than in the closely related <u>Palaeictops bridgeri</u>. The paralophid descends quite low between the paraconid and the protoconid unlike the even ridge present in <u>P</u>. <u>bridgeri</u>.

The tooth is considerably larger than specimens of \underline{P} . **tauri-cinerei** reported by Jepsen (1930), and specimens of \underline{P} . **pinevensis** reported by Gazin (1962) and Guthrie (1967). It is smaller than the few known specimens of \underline{P} . **multicuspis** reported by Guthrie (1971), and slightly smaller than the type of \underline{P} . **bridgeri** described by Simpson (1959). **UM 101155** is similar in size and morphology to the smallest specimens of \underline{P} . **bicuspis** reported by Guthrie (1967). Measurements of specimen **UM 101155** are provided in Table 2.



Α.



в.

Figure 8. <u>Palaeictops bicuspis</u>. A. Occlusal view of /M2 (UM 101166) B. Labial view of /M2 (UM 101166). Bar is one millimeter in length. Suborder Erinaceota Van Valen, 1967

Superfamily Erinaceoidea Fischer von Waldheim, 1817

Family Dormaliidae

Genus **Scenopagus** McKenna and Simpson, 1959

Type Species: Scenopagus edenensis (McGrew, 1959)

Age and Distribution: Early to late Eocene (Wa1-Ui1) of North America.

Scenopagus edenensis (McGrew, 1959)

<u>Holotype</u>: AMNH 55685- fragment right mandible with /M1-/M3, collected from the Morrow Creek Member (Br1) of the Green River Formation, Eden Valley, Wyoming.

<u>Material</u>: **UM 101019**- fragment of left dentary with /M2, collected at BB037, August 1, 1993.

Remarks: McGrew (1959) originally referred **§**.

edenensis to the genus <u>Diacodon</u>. Later that same year and with material from the same area McKenna and Simpson (1959) described a new genus, <u>S. mcgrewi</u>. In 1962, McKenna et al referred <u>D. edenensis</u> to the genus <u>Scenopagus</u> recognizing the priority of <u>S. edenensis</u> over <u>S. mcgrewi</u>.

Judging from the amount of wear, **UM 101019** is a specimen of relatively old individual of <u>S</u>. <u>edenensis</u>. Consistent with the description of McGrew (1959), the trigonid is inclined forward and is slightly wider than the talonid. The trigonid basin is tiny compared to the large talonid. The ridge between the hypoconid and the base of the protoconid is quite prominent. The tooth is much larger than specimens of <u>S</u>. **priscus** measured by Robinson (1966). It is similar in size to the type of <u>S</u>. **edenensis** (McGrew, 1959) and with specimens reported by Robinson (1966) and West (1973). Measurements of specimen **UM 101019** are provided in Table 2.

Scenopagus priscus (Marsh, 1872)

<u>Holotype</u>: YPM 15309- left dentary with /M2 and alveoli of /P4, /M1, and /M3, from the middle Eocene Bridger Formation (Br2) near the Henry's Fork River, Wyoming.

<u>Material</u>: **UM 95608**- fragment of right dentary with /M1-/M2, collected at BB037, June 5, 1990. **UM 95609**fragment of left dentary with /P1-/P3, and both dental foramina, collected at BB037, June 5, 1990.

<u>Remarks</u>: Robinson (1966) reassigned <u>Nyctitherium</u> **priscus** to the genus <u>Scenopagus</u> based on its similarities to <u>S. edenensis</u> and its dissimilarity to <u>N. velox</u>. Two specimens from the study area have been referred to

Scenopagus priscus.

The two molars of **UM 95608** are very nearly equal in size. On both teeth, the hypoconulid extends posteriorly from the postcristid. The trigonid and talonid of /M1 are approximately equal in size, while the trigonid is slightly narrower than the talonid in /M2. The trigonid is directed slightly anteriorly.

Anterior premolars in <u>Scenopagus</u> have not been described for some species and are difficult to refer to a
Table 2

Measurements (in mm.) of Insectivora

Apatemys sp. indet.

| | UM | 101022 |
|-----|----|--------|
| /I1 | AP | 1.6 |
| | Tr | 1.2 |

Palaeosinopa cf. P. lutreola

| | UM | 101155 |
|-----|----|--------|
| M2/ | AP | 2.4 |
| | Tr | 4.6 |

Palaeictops bicuspis

| | UM 1 | 01166 |
|-----|------|-------|
| /M2 | AP | 2.8 |
| | Tra | 1.9 |
| | Trp | 1.7 |

<u>Scenopagus</u>

| <u>s</u> . e | denensis | <u>s</u> . | <u>priscus</u> |
|--------------|----------|------------|----------------|
|--------------|----------|------------|----------------|

| | | UM 101019 | UM 95609 |
|------------|-------------------------------|----------------------|--|
| /P1 | AP | - | 0.7 |
| | Tr | - | 0.3 |
| /P2 | AP | - | 1.2 |
| | Tr | - | 0.4 |
| /P3 | AP | - | 1.1 |
| | Tr | - | 0.5 |
| | | | |
| | | | UM 95608 |
| /M1 | AP | _ | UM 95608 1.8 |
| /M1 | AP Tra | - | UM 95608 1.8 1.5 |
| /M1 | AP Tra Trp | - - | UM 95608 1.8 1.5 1.3 |
| /M1 /M2 | AP Tra Trp AP | - - 2.1 | UM 95608 1.8 1.5 1.3 1.6 |
| /M1 /M2 | AP Tra Trp AP Tra | - - 2.1 1.7 | UM 95608 1.8 1.5 1.3 1.6 1.2 |

particular form. **UM 95609** falls well below the expected size range of <u>S</u>. <u>edenensis</u> and is close to that of <u>S</u>. <u>priscus</u>.

The two specimens are consistent with specimens of <u>S</u>. **priscus** and much smaller than specimens of <u>S</u>. <u>edenensis</u> described by Robinson (1966) and West (1973). Measurements of specimens **UM 95608** and **UM 95609** are provided in Table 2.

Insectivore indet.

<u>Material</u>: **UM 101014**- left astragalus, collected at BB116, July 28, 1993. **UM 101160**- fragment of edentulous right dentary with alveoli of /P4-/M1, collected at BB110, August 5, 1993. **UM 101161**- fragment of right dentary with roots of /M1, collected at BB110, August 5, 1993. **UM 101164**- fragment of upper molar, collected at BB110, August 5, 1993.

Order PROPRIMATES Gingerich, 1989 Suborder Plesiadapiformes Simons and Tattersall, 1972

<u>Remarks</u>: The plesiadapiforms are the earliest group of primate-like animals known. Although plesiadapiforms have traditionally been included in the Order Primates, the relationship of the plesiadapiform primates to early Eocene primates of modern aspect has always been somewhat conjectural. Gunnell (1989) established that plesiadapiforms are more closely related to plagiomenids (archaic dermopterans) than to true primates. Gingerich

.... • Sty :: ; gray (1989) proposed the name Proprimates to include two Superfamilies (Microsyopidae and Plesiadapoidea), separating them from the more advanced primates and recognizing that this is likely a paraphyletic grouping.

Superfamily Plesiadapoidea Trouessart, 1879

Family Paromomyidae (Simpson, 1940)

Tribe Paromomyini Simpson, 1940

Genus Ignacius Matthew and Granger, 1921

<u>Age and Distribution</u>: Middle Palaeocene (To3) to late Eocene (Ui2) of the Rocky Mountain Region of North America.

<u>Type Species</u>: **Ignacius frugivorous** Matthew and Granger, 1921.

Ignacius graybullianus Bown and Rose, 1976

<u>Holotype</u>: YPM 26004- fragment of right maxilla containing P4/ to M2/, lower Willwood formation, Big Horn County, Wyoming.

Material: UM 101154- right M2/, collected at BB110, August 5, 1993.

<u>Remarks</u>: UM 101154 (Figure 9) is identical in size to the type of <u>Ignacius graybullianus</u> described and figured in Bown and Rose (1976). Similar to all of the specimens studied by Bown and Rose (1976) the posterolingual corner of the tooth is much less rounded than in <u>I</u>. <u>frugivorous</u>. Although the tip of the parastyle wing has been sheared off, it appears to have been larger than in the type of <u>I</u>. graybullianus. In addition, the tooth possesses a more developed lingual precingulum than the type. The tooth is slightly wider labially than lingually, giving it a less squared appearance than in the type.

Although there are some minor morphological differences, they are not considered substantive enough to warrant allocation to a new species without the study of additional material. Measurements of specimen **UM 101154** are provided in Table 3.

Superfamily Microsyopoidea Osborn and Wortman, 1892

Family Microsyopidae Osborn and Wortman, 1892 Subfamily Microsyopinae Osborn and Wortman, 1892

Remarks: The upper cheek teeth of early microsyopines are characterized by the complete lack of a stylar shelf. The cusps of the cheek teeth are low, the talonid basin is comparatively deep. They typically have a single pair of enlarged upper and at least one pair of enlarged lower incisors. A small diastema, usually not exceeding the first cheek tooth in length, exists between the enlarged incisors and the cheek teeth. The incisors often display considerable wear on the medial surface, a product of a rather unique method of mastication (Gunnell, 1989) (see below). A single microsyopine incisor is generally considered sufficient for identification to the subfamily level.



Frigure 9. Ignacius graybullianus. Occlusal view of M2/(UM 101154). Bar is one millimeter in length.

Genus Microsyops Leidy, 1872

Are and Distribution: Known primarily from the early and middle Eccene of Wyoming, Colorado, and New Mexico. The genus is first known from the latest Palaeocene (Cf2) of the Bighorn Basin (Woodburne, 1987) and last known from a single specimen from the middle Eccene (Ui2) Friars Formation in California.

Type Species: Microsyops elegans Marsh, 1871

Microsyops elegans Marsh, 1871

<u>Holotype</u>: YPM 11794- left dentary containing /P4-/M2, collected from lower Bridger beds, Bridger Basin, Wyoming. Specific locality data is unavailable.

<u>Material</u>: **UM 99843**- Cranial material including a skull roof with parietals, frontals, the occipital complex, and

3 -• : • 13 1 1 2 21 11 20 the right petrosal; a right maxilla including P4/, M1/, and the labial half of M2/; a right dentary including /P3 through /M1, sheared /I3, intermandibular suture, masseteric fossia, and mandibular condyle; fragments of a left dentary including labial half of /P4, mental foramen, and the mandibular condyle. Several rib fragments fit the expected size range for microsyopids and may belong to the same individual as the cranium, collected at BB036, July 16, 1992. UM 101032- left /M1, collected at BB013, August 1, 1993.

Remarks: Most specimens of Microsyops elegans are from the lower Bridger beds (Br1-Br2) of southwestern Wyoming (Szalay, 1969). The /P4 of UM 99843 has a broad talonid basin and a centrally placed hypoconulid similar to Microsyops scottianus, M. elegans, M. knightensis, and to later specimens of M. latidens, however, the measurements of /P4 and /M1 fall considerably above the size range of M. latidens. Additionally, the protoconid of both /P4 and /M1 does not extend as high above the talonid as those of specimens of M. latidens studied by Szalay (1969).

The cheek teeth of **UM 99843**, particularly /M1, /M2, and /P3 fall well below the size range of <u>Microsyops scottianus</u> but are within the size range of both <u>M</u>. <u>elegans</u> and <u>M</u>. <u>knightensis</u>. Gunnell (1989) indicates that these two species could be considered conspecific since only a few minor differences are present. Most importantly, **UM 99843** appears

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to have the more strongly dilambdodont upper molars of \underline{M} . elegans, and has more slender mandibles than \underline{M} . <u>knightensis</u>.

The skull of <u>Microsyops</u> is known from three described specimens, two skulls and a skull fragment (Szalay, 1969, Gunnell, pers. comm, 1992). Of these three specimens, only one, AMNH 55286 has the otic region intact. UM 99843 therefore comprises the most complete cranial material of <u>M</u>. elegans known.

Microsyopid postcranial osteology is even less well known. The only definite postcranial element of a microsyopid is a proximal tibia associated with upper teeth of <u>M</u>. <u>elegans</u> from the lower Bridger beds. UM 99843 includes several rib fragments that were found in close association with the teeth and skull fragments and fit the expected size range of microsyopids. Two metatarsals and a calcaneum were catalogued with the specimen but are not included here since they are much too large to have come from a microsyopid. Measurements of specimens UM 99843 and UM 101032 are provided in Table 3.

Microsyops scottianus Cope, 1881

Holotype: AMNH 4748- left mandible with /P4 and part of /M2. Collected from the Lost Cabin Member of the Wind River Formation, Wind River Basin, Wyoming.

Microsyops cf. M. scottianus Cope, 1881

<u>Material</u>: **UM 100888**- left dP4/, collected at BB114, July 25, 1993.

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<u>Remarks</u>: UM 100888 is larger than P4/ in <u>Microsyops</u> <u>**mightensis** and <u>Microsyops latidens</u> and is slightly smaller than <u>M</u>. <u>elegans</u> described in Gunnell (1989). This specimen is <u>tentatively</u> referred to <u>M</u>. <u>scottianus</u>, primarily on the bas is of size, since morphological variation in deciduous premolars is not considered diagnostic. Measurements of UM 100888 are provided in Table 3.</u>

Microsyops sp. indet.

Material: UM 99636- Edentulous left mandible Consisting of the ramus of the dentary from /I3 socket to /P3 socket; intermandibular symphysis present, collected at BBO74, June 18, 1992. UM 99720- Fragment of upper left Cheek tooth (probably P3/), collected at BB074, June 29, 1991.

Remarks: Although all of the teeth are broken off of **OM** 99636, enough of the socket and root exist to indicate **the** presence of an enlarged lower incisor, an important **character** in microsyopines. As is also characteristic of **microsyopines**, the specimen has an unfused mandibular **symp**hysis. It is thought that the mandibles were movable during mastication, as is evidenced by the wear facets on the medial surface of the enlarged lower incisors (Szalay, 1969).

Specimen UM 99636 is somewhat dissimilar to most Microsyops mandibles in having two mental foramina on the labial side of the ramus rather than the usual single one. The first of these foramina is located below the diastema between the enlarged lower incisor and /P2, the second is located in the usual position under and slightly forward of /P3. A third foramen is located below, and slightly caudal to /M1.

Other closely related taxa such as <u>Craseops</u> and **Arctodontomys** have twin mental foramina. <u>Microsyops</u> is the only microsyopine known from the late Wasatchian (Wa7) or early Bridgerian (Br1) of western North America. The only species of <u>Microsyops</u> known to have multiple mental foramina is the middle Eocene <u>M. kratos</u>, known from a single specimen from California, which has two foramina under dP3 (Gunnell, 1989).

UM 98720, although worn and incomplete, has several key characteristics of the genus <u>Microsyops</u> (e.g., a small but pronounced metaconule lingual to the metacone and a mesostyle between the paracone and metacone). <u>Microsyops</u> elegans is the only species of the genus known from the lower Bridger beds of Wyoming (Szalay, 1969), but the referred specimens are not complete enough to identify to the specific level.

TABLE 3

Measurements (in mm.) of Proprimates

Ignacius graybullianus

| | | UM 101154 | |
|-----|----|------------------|---|
| M2/ | AP | 2. | 2 |
| | Tr | 2. | 7 |

Microsyops elegans

_ •

| | | UM 99843 | UM 98664 | UM 101032 |
|-----|----|-----------------|----------|------------------|
| M1/ | AP | 3.9 | - | - |
| | Tr | 4.3 | - | - |
| /P3 | Ap | 2.4 | - | - |
| | Tr | 1.6 | - | - |
| /P4 | Ap | 3.8 | - | - |
| | Tr | 2.5 | - | - |
| /M1 | AP | 4.0 | - | 4.1 |
| | Tr | 2.4 | - | 2.9 |
| /M2 | AP | - | 4.2 | - |
| | Tr | - | 3.1 | - |

Order PRIMATES Linneaus, 1758 Suborder Haplorhini Pocock, 1918 Infraorder Adapiformes Szalay and Delson, 1979 Family Adapidae Trousseart, 1879 Subfamily Notharctinae Trousseart, 1879 <u>Remarks</u>: Four of the five notharctine genera have been recovered from within the field area. Two of these, **Smilodectes** and Notharctus are first known from the early

Bridgerian. The other two, <u>Copelemur</u> and <u>Cantius</u> are last known from the late Wasatchian.

Tribe Notharctini (Trouessart, 1879) <u>Remarks</u>: Beard (1988) resurrected the tribe **Notharctini and established the tribe Copelemurini (see below**) to distinguish the two monophyletic groups within the **Notharctinae**.

Genus Cantius Simons, 1962

Age and Distribution: Early Eocene (Wa0 to Wa4, Neustrian) of Europe and North America.

Type Species: Cantius angulatus Cope, 1875

Remarks: The early Eocene notharctine **Cantius** is the earliest known lemuriform primate (Rose, 1981, Rose and Walker, 1985) and is considered ancestral to other Eocene notharctines such as **Notharctus** and **Smilodectes** (Rose and Walker, 1985, Gingerich and Simons, 1977, Szalay and Delson, 1979). Most adapids from the early Eocene of North America are known from scant material and for many years all were included in a single genus, <u>Pelycodus</u> (Rose and Walker, 1985, Szalay and Delson, 1979). Gingerich and Simons (1977) established the genus <u>Copelemur</u> to include several species with markedly different molar morphology than <u>Pelycodus</u>. Gingerich and Haskin (1981) limited <u>Pelycodus</u> to the type species, <u>P. jarrovii</u>, since the dentition of <u>P. jarrovii</u> is substantially different than that of other, previously included taxa, and reinstated the genus <u>Cantius</u> (Simons, 1962) to include all other species that had previously been referred to <u>Pelycodus</u>.

<u>Cantius</u> frugivorous (Cope, 1875)

Holotype: unnumbered fragment of right dentary with /M2 and /M3 from the San Jose Formation (Wa3-Wa4), San Juan Basin, New Mexico, now lost. The neotype is CM 37448- right dentary fragment with /M2 and /M3 from the "Alamagre locality 2", New Mexico.

Cantius cf. C. frugivorous

<u>Material</u>: UM 100021- left M2/, collected at BB110, July 27, 1992. UM 100025- right /M1, collected at BB110, July 27, 1992. UM 100026- right M3/, collected at BB110, July 27, 1992. UM 101096- right /M3, collected at BB114, July 31, 1993. UM 101162- left /M2, collected at BB110, August 5, 1993.

<u>Remarks</u>: Five individual teeth, all from the same locality are referred to <u>Cantius frugivorous</u> (Figure 10). Variations in degree of tooth wear and in size make it

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improbable that any of the specimens come from the same individual. The specimens fit closely in size and morphology with the emended diagnosis of Beard (1988) and the descriptions of **Pelycodus frugivorous** and **P. trigonadus** in Matthew (1915). The specimens are considerably smaller than the corresponding teeth of C. abditus and C. venticolis reported by Gingerich and Haskin (1977). The /M3 is much more slender than specimens of C. mckennai and C. angulatus. Consistent with the emended diagnosis of Beard (1988), the paraconid of /M1 is distally emplaced, and the trigonid has rather inflated cusps. The M2/ is almost rectangular in outline, the lingual side only slightly larger than the labial. This is in close agreement to the diagram of the type of C. frugivorous in Matthew (1915). Measurements of Cantius cf. C. frugivorous from the study area are presented in Table 4a.

Genus Notharctus Leidy, 1870

Age and Distribution: Middle to late Eocene (Br1-Br3) of the Green River Basin, Wyoming. Other possible **Notharctus** specimens have been collected from the Huerfano beds of southwestern Colorado, and the Washakie Basin of southern Wyoming.

Type Species: Notharctus tenebrosus Leidy, 1870

Notharctus robinsoni Gingerich, 1979

<u>Holotype</u>: UW 3007, left mandible with P/4 to M/3, fragment of right mandible with P/3, and isolated lower



Figure 10. <u>Cantius</u> cf. <u>C</u>. <u>frugivorous</u>. Occlusal view of /M2 (UM 101162). Bar is one millimeter in length.



Figure 11. <u>Notharctus robinsoni</u>. Occlusal view of /M3 (UM 98576). Bar is one millimeter in length. incisors and canine, from the lower part of the Bridger Formation (Br1), north of Opal, Wyoming.

<u>Material</u>: UM 95507- fragment of right dentary with /P3-/M1, left /M1, collected at BB037, June 5,1990. UM 98576fragment of left dentary containing /M3, collected at BB037, June 20, 1991. UM 95634- fragment of left dentary containing /M1-/M2, fragment of right dentary containing /P4, collected at BB044, June 9, 1990. UM 99917- right lower /P4, collected at BB109, July 20, 1992.

<u>Remarks</u>: <u>Notharctus</u> <u>robinsoni</u> (Figure 11), known only from the early Bridgerian (Br1), is larger than the middle Bridgerian (Br2) N. tenebrosus and smaller than the middle Bridgerian (Br2) N. pugnax and middle to late Bridgerian (Br2-Br3) N. robustior (Gingerich, 1979). Consistent with specimens reported by Beard (1988) and Gingerich (1979), the entoconid notch is well-developed and the paraconids of the molars are very large, much larger than in specimens of **Smilodectes** and **Copelemur** from the field area. Even the smallest of the specimens is substantially larger than any specimens of **Cantius** from the field area or described in Beard (1988) or Gingerich and Simons (1977). All four specimens from the field area fit well within the size range of Notharctus robinsoni reported by Gingerich (1979). Specimens from the study area confirm the presence of Notharctug in the early Bridgerian and are some of the oldest specimens of the genus yet identified. Measurements

: 3 ¥ Ξ U, 5 2 of **Notharctus robinsoni** from the field area are presented in Table 4a.

Tribe Copelemurini Beard, 1988 Genus <u>Copelemur</u> Gingerich and Simons, 1977 <u>Age and Distribution</u>: Early Eccene (Wa0-Wa7) of the Rocky Mountain region of North America.

Type Species: Copelemur tutus (Cope, 1877)

Copelemur australotutus Beard, 1988

Holotype: USNM 22261- left dentary with alveoli for P/1, fragment of P/2, and P/3-M/1, from the Wasatch Formation on the slopes of Fossil Butte, Fossil Basin, Wyoming.

Copelemur cf. C. australotutus Beard, 1988

<u>Material</u>: **UM 100895**- talonid of left /M3, collected at BB114, July 25, 1993. **UM 101009**- fragment of left dentary with alveoli for /M1, and associated left /M2, collected at BB116, July 29, 1993.

Remarks: **Copelemur australotutus** was only known from the type specimen. Beard (1988) provisionally referred USNM 411883, an isolated left M/2 to the species since it is of the appropriate size and is intermediate in morphology between <u>C</u>. **tutus** and <u>C</u>. **praetutus**. Similar to this tooth, **UM 101009** (Figure 12) has a tiny mesoinferiorly displaced paraconid, and a distally placed entoconid. **UM 101009** is less worn than the specimen described by Beard, preserving



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Figure 12. <u>Copelemur</u> cf. <u>C</u>. <u>australotutus</u>. A. Occlusal view of /M2 (UM 101009). B. Lingual view of /M2 (UM 101009). Bars are one millimeter in length. the well developed paracristid and the labial cingulid. The tooth is significantly larger than the type of <u>C</u>. <u>praetutus</u> described by Gingerich and Haskin (1977) and additional specimens reported by Beard (1988). It is much smaller than the neotype of <u>C</u>. <u>tutus</u> figured in Beard (1988). Measurements of <u>Copelemur</u> cf. <u>C</u>. <u>australotutus</u> from the study area are presented in Table 4a.

Genus Smilodectes Wortman, 1903

Age and Distribution: Middle Eocene (Br1-Br3) of North America.

Type Species: Smilodectes gracilis Marsh, 1871

Smilodectes mcgrewi Gingerich, 1979

Holotype: UW 5021- left mandible with /P3 to /M3, lower part of the Bridger Formation (Br1), near the junction of the Big Sandy and Green Rivers, Sweetwater County, Wyoming.

<u>Material</u>: **UM 95506**, left dentary with /M1-/M2, right dentary with posterior root of /M1 and base of /M2, collected at BB037, June 5, 1990.

<u>Remarks</u>: <u>Smilodectes mcgrewi</u> is the earliest species of <u>Smilodectes</u> known. Although UM 95506 is close in size to other early and middle Bridgerian notharctines, it differs in dental morphology. The paraconids of both molars are reduced, unlike the large cuspule found in <u>Cantius</u> and <u>Notharctus</u>. /M1 is more elongate, thinner, and less robust than in the specimen of <u>Copelemur</u> from the field area and in measurements in Beard (1988).

à 9 ¢ 1 2. F.c al 밙 Ľa The primary difference between <u>S</u>. <u>mcgrewi</u> and the middle Bridgerian (Br2) <u>S</u>. <u>gracilis</u> is the larger size of <u>S</u>. <u>mcgrewi</u>. Gingerich (1979) noted that the observed size range of the type sample of <u>S</u>. <u>mcgrewi</u> is more than three standard deviations larger than the observed range of a sample of <u>S</u>. <u>gracilis</u> from its type locality. UM 95506 fits well within the expected size range of <u>S</u>. <u>mcgrewi</u>. UM 95506 was recovered well below the type locality of <u>S</u>. <u>mcgrewi</u> and represents one of the oldest records of <u>Smilodectes</u> yet identified. Measurements of specimen UM 95506 are presented in Table 4a.

<u>Smilodectes</u> sp. indet.

<u>Material</u>: **UM 98723**- fragment of right dentary with broken P/4, sheared off M/1 and P/3, and alveoli for P/1, P/2, and /C, intermandibular symphysis complete, collected at BB074, June 29, 1991.

Remarks: Although the only tooth preserved with UM 98723 is damaged, enough remains of the specimen is to confidently assign it to <u>Smilodectes</u>. The alveoli between the sheared /P3 and the alveolus for the enlarged canine indicate that both /P1 and /P2 were single rooted, whereas in <u>Notharctus</u> /P2 is double rooted (Gingerich, 1979; Robinson, 1957). In addition, while the mandibular rami of all species of <u>Notharctus</u> are at least partially fused, those of <u>Smilodectes</u> are unfused (Gingerich, 1979). The mandibular symphysis of UM 98723 is unfused. Although UM

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98723 is not identifiable to the specific level, the presence of <u>S</u>. <u>mcgrewi</u> at the same stratigraphic interval (see below) makes it probable that the specimen belongs to this taxon.

Notharctinae Indet.

<u>Material</u>: **UM 99631**, right distal tibia, collected at BB014, June 20, 1992. **UM 101025**- left pisiform, collected at BB038, August 1, 1993. **UM 101093**- distal phalanx, collected at BB110, August 4, 1993.

Remarks: The postcranial anatomy of notharctines is well-known, largely because of nearly complete specimens of the middle Eocene genera Notharctus and Smilodectes. The postcranial anatomy of Notharctus and Smilodectes do not differ greatly (Szalay and Delson, 1979). Rose and Walker (1984) found that the skeleton of the early Eocene Cantius is very similar to its descendant Notharctus. Only fragmentary postcranial remains are known of the early Eocene genera Pelycodus and Copelemur, however, enough has been found to suggest that they do not differ markedly from the other notharctines (Szalay and Delson, 1979). The skeleton of notharctine primates bears close resemblance to extant lemuriform genera such as Lemur and Lepilemur (Szalay and Delson, 1979; Rose, 1985).

UM 99631 comes from an area and stratigraphic horizon where very few other fossils and no other notharctines have been found. The specimen fits the size range of all of the

TABLE 4a

Measurements (in mm.) of Adapid Primates

| | <u>Cantius</u> | frugivorous | <u>C</u> (| opeler | mur | <u>australotutus</u> |
|------|----------------|------------------|------------|--------|------|----------------------|
| | | UM 100021 | | σ | M 1(| 01009 |
| M2/ | AP | 4.3 | /M2 | AP | 4.6 | 5 |
| | Tr | 6.7 | | Tra | 3.0 | 5 |
| | | UM 100026 | | Trp | 3.8 | 3 |
| M3 / | AP | 4.0 | | σ | M 1(| 00895 |
| | Tr | 6.1 | | Ap | - | |
| | | UM 100025 | | Tra | 4.6 | 5 |
| /M1 | AP | 4.8 | | Trp | - | |
| | Tra | 3.4 | | | | |
| | Trp | 3.5 | <u>S1</u> | nilod | ecte | <u>es mcgrewi</u> |
| | | UM 101162 | | | | |
| /M2 | AP | 4.8* | | σ | M 9! | 5606 |
| | Tra | 3.4* | /M2 | AP | 4.4 | 1 |
| | Trp | 3.7 | | Tra | 3.3 | 3 |
| | | UM 101096 | | Trp | 3.6 | 5 |
| /M3 | AP | 5.5 | /M3 | AP | 5.4 | 1 |
| | Tra | 3.0 | | Tra | 3.8 | 3 |
| | Trp | 2.4 | | Trp | 4.3 | L |

Notharctus robinsoni

| | | UM 95607 | UM 95634 | UM 99917 |
|-----|-----|-----------------|----------|-----------------|
| /P3 | AP | 4.1 | - | - |
| | Tr | 3.2 | - | - |
| /P4 | AP | - | 5.1 | 5.2 |
| | Tr | - | 3.7 | 3.8 |
| /M1 | AP | 5.5-5.9 | 5.6 | - |
| | Tra | 3.7-3.8 | 3.7 | - |
| | Trp | 4.2-4.3 | 4.1 | - |
| /M2 | AP | - | 5.8 | - |
| | Tra | - | 3.8 | - |
| | Trp | - | 4.2 | - |
| | | UM 98576 | | |
| /M3 | AP | 6.4 | | |
| | Tra | 3.3 | | |
| | Trp | 3.0 | | |

notharctine taxa identified from the study area.

UM 101025 comes from one of the stratigraphically highest localities in the field area. Other faunal elements from this horizon indicate an early Bridgerian age making it likely that the specimen is representative of either

<u>Smilodectes</u> or <u>Notharctus</u>.

UM 101093 comes from the lowest locality within the study area. Although only <u>Cantius</u> has been identified from this locality, both <u>Copelemur</u> and <u>Cantius</u> have been found at this level. The small size of the specimen suggests that it may be referable to <u>Cantius</u>, but it could represent a small individual of <u>Copelemur</u>.

Infraorder Tarsiiformes Gregory, 1915 Family Omomyidae Gazin, 1958 Subfamily Omomyinae Trouesseart, 1879 Tribe Omomyini Trouesseart, 1879 Subtribe Omomyina Trousseart, 1879 Genus <u>Omomys</u> Leidy, 1869

Age and Distribution: Early to middle Eocene (Br1-Ui2) of Wyoming and Utah.

Type Species: Omomys carteri Leidy, 1869.

Omomys carteri Leidy, 1869

<u>Holotype</u>: ANS 10335- ramus of right dentary with P3, P4, and M2 from the lower Bridger Beds (BR2), near Fort Bridger, Wyoming.

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<u>Material</u>: **UM 99658**, fragment of right maxilla containing complete P3/ and M2/, lingual half of P4/, and labial half of M2/, Collected at BB070, June 23, 1992.

Remarks: Although two of the teeth in UM 99658 have been damaged, the specimen is complete enough to assign it to Q. <u>carteri</u>. Consistent with the diagnosis of Szalay (1976), the cingulum forms a continuous ridge around the molars and is particularly heavy on the lingual side. The hypocone of M1/ is less pronounced than in the diagram of Szalay (1976), probably due to the high degree of wear of UM 99658. P3/ has a very tall, robust paracone consistent with Szalay's diagnosis. <u>Omomys carteri</u> is the largest species of <u>Omomys</u> and the only one that matches the size of UM 99658. Measurements of specimen UM 99658 are presented in Table 4b.

Omomys cf. O. carteri

Material: UM 101037- fragment of right mandible with
/M2, /M3, and posterior root of /M1.

<u>Remarks</u>: UM 101037 (Figure 13) is too large to be either Omomys minutus or O. <u>lloydi</u>. Although it is similar in size and general morphology to O. <u>carteri</u>, there are several important differences. The most visible way in which it differs from O. <u>carteri</u> is in the smoother enamel of the talonid basins of /M2 and /M3, and the much shallower trigonid basin on /M2. UM 101037 was collected at the contact between the Wasatch and Bridger Formations (early

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Figure 13. <u>Omomys</u> cf. <u>0</u>. <u>carteri</u>, Occlusal view of right dentary with /M2 and /M3 (UM 101038). Bar is one millimeter in length.



Figure 14. <u>Anemorhysis</u> near <u>A. wortmani</u>. Occlusal view of /M1 (UM 101159). Bar is one millimeter in length. Br1) and is one of the oldest identified specimen of <u>Omomys</u>, possibly accounting for its less complex appearance. Measurements of <u>Omomys carteri</u> from the study area are presented in Table 4b.

Tribe Washakini Szalay, 1976

Genus Washakius Leidy, 1873

Type Species: Washakius insignis Leidy, 1873.

Age and Distribution: Middle to late Eocene (Br1-Ui1) of North America.

Washakius insignis Leidy, 1873

<u>Holotype</u>: ANS 10332- right dentary with M2 and M3, from the lower Bridger Formation (Bridger B), Bridger Basin, Wyoming,

<u>Material</u>: **UM 98575**- fragment of the right dentary containing /P3, roots of /P4, alveoli of /C and /P2, and mandibular symphysis, collected at BB037, June 20, 1991.

<u>Remarks</u>: Consistent with Szalay's (1976) diagnosis of <u>Washakius insignis</u>, /P3 of UM 98575 has a prominent parastyle. The anterior portion of the mandible is anteroposteriorly compressed with a vertically emplaced /C and /P2, not elongated with an anteriorly projecting /C and /P2 as in the omomyines. The mandibular symphysis is more vertical than in <u>Omomys carteri</u>. The two alveoli anterior to /P3 are equal in size indicating similarly sized /C and /P2. Measurements of specimen UM 98575 are provided in Table 4b. Subfamily Anaptomorphinae Cope, 1883

Tribe Trogolemurini Szalay, 1976

Genus Anemorhysis Gazin, 1958

Age and Distribution: Early to middle Eocene (Wa3-Br1) of North America.

Type Species: Anemorhysis sublettensis Gazin, 1952

Anemorhysis wortmani Bown and Rose, 1984 Holotype: USGS 6554- right dentary with P/3-M/2, roots of I/1 and M/3, and alveoli of I/2 and C, from Upper

Anemorhysis near A. wortmani Bown and Rose, 1984 Material: UM 101159- right /M1, collected at BB110, August 5, 1993.

Willwood Formation (Wa6), Washakie County, Wyoming.

Remarks: UM 101159 (Figure 14) differs from Anemorhysis pearcei described by Gazin (1962) in being longer and thinner. It is longer and much more slender than A. sublettensis. Although similar in length to specimens of A. pattersoni and A. wortmani described by Bown and Rose (1987) and A. natronensis described by Beard et al. (1992), it is much thinner. The specimen has a better-developed buccal cingulum than the type of A. pattersoni figured in Bown and Rose (1984). The hypoconulid is better-developed and more posterior in position than in any of the described species of Anemorhysis. The talonid is much narrower than the trigonid and is more triangular in outline than in A. sublettensis (Szalay, 1976), A. pearcei (Gazin, 1962), A. **<u>pattersoni</u>** (Bown and Rose, 1984) or <u>**A**</u>. <u>**natronensis**</u> (Beard et al., 1992).

Although **UM 101159** is similar in most respects to $\underline{\mathbf{A}}$. **wortmani** there are some critical differences and it is not definitely assignable to this taxon. Although this specimen may represent a new species of **Anemorhysis**, more material is needed before this can be established. Measurements of specimen **UM 101159** are provided in Figure 4b.

Omomyidae indet.

<u>Material</u>: **UM 101036**- left /C, collected at BB074, August 1, 1993. **UM 101110**- fragment of right mandible with talonid of /M3, collected at BB037, August 1, 1993.

<u>Remarks</u>: The canines of omomyids tend to be slightly reduced and have a slight cingulum. This tooth is similar in most omomyid genera and is therefore of little use in generic identification. While /M3 is generally a useful tooth in omomyid identification, the trigonid of **UM 101110** has been sheared off and the talonid is very worn. Despite the fact that <u>Washakius</u> has been recovered from the same locality, the specimen fits the size range of several omomyid taxa and is not identifiable past the family level.

TABLE 4b

Measurements (in mm.) of Omomyid Primates

| <u>Washakius</u> insignis | Anemorhysis sublettensis |
|----------------------------------|--|
| UM 98575 P/3 AP 1.6 Tr 1.4 | UM 101159 /M2 AP 1.9 Tra 1.1 Trp 1.4 |

<u>Omomys</u> <u>carteri</u>

| UM 99658 | | | UM 1010 | | |
|-----------------|----|------|---------|-----|-----|
| P3/ | AP | 2.0 | /M2 | AP | 2.2 |
| | Tr | 2.3 | | Tra | 1.9 |
| P4/ | AP | 2.1* | | Trp | 2.0 |
| | Tr | 2.7* | /M3 | AP | 2.4 |
| M1/ | AP | 2.2 | | Tra | 1.8 |
| | Tr | 2.8 | | Trp | 1.5 |
| M2 / | AP | 2.4 | | | |
| | Tr | 3.0* | | | |

Order CREODONTA

Family Hyaenadontidae

Genus et sp. indet.

<u>Material</u>: **UM 98991**- left astragalus, collected at BB013W, June 28, 1991. **UM 100022**- left astragalus, collected at BB110, July 27, 1992.

<u>Remarks</u>: UM 98991 is the astragalus of a very large hyaenadontid. It has a narrow trochlear tibial facet with a shallow groove, a narrow neck, and a robust, rounded capitulum. The fibular facet is long, pronounced, and prominent, and protrudes laterally from the body of the astragalus. The groove beneath and behind the trochlea containing the ventral astragalar foramen is rather narrow, and very deep. The specimen is considerably larger and the trochlear groove is not as deep as in <u>Mesonyx</u>. The neck is somewhat more slender than that in figures of <u>Sinopa</u> in Matthew (1909), but is very similar in size.

UM 100022 is the astragalus of a much smaller individual. Although part of the trochlear tibial facet is broken off, it appears that it was narrow with a very shallow groove. The neck is exceedingly short and the capitulum is unpronounced. The fibular facet is prominent but short and rectangular, and does not extend laterally from the main body of the astragalus. The groove beneath and behind the trochlea is shallow. There does not appear

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to have been a ventral astragalar foramen. The specimen is smaller than any described by Matthew (1909).

Order CARNIVORA Vicq d'Azyr, 1792 Suborder Fissipedia von Waldheim, 1813 Family Miacidae

Genus Miacis Cope, 1872

Age and Distribution: Early Eocene (Wal) through early Oligocene (Chl) of North America. Eocene (Neustrian-Headonian) of Europe, and upper Eocene of Asia.

Type Species: Miacis parvivorus Cope, 1872.

Miacis latidens Matthew, 1915

<u>Holotype</u>: AMNH 14766- right dentary with /M2-/M3, and alveoli of /P1-/M1, and part of left maxilla with M1/-M2/, collected from the Lost Cabin beds of the Wind River Basin.

<u>Material</u>: **UM 100028**- right M1/, collected at BB110, July 27, 1992.

<u>Remarks</u>: As is common of fossils from BB110, the lowest locality in the section, **UM 100028** (Figure 15) shows signs of considerable abrasion and wear. The irregular pattern of nicks and scrapes, both on the sides and on the crown of the tooth indicate that most of this wear is due to transport.

UM 100028 fits the size range of three early to middle Eccene species of <u>Miacis</u> described in Matthew (1909, 1915), Gazin (1962) and Gingerich (1983), <u>M. exiguus</u>, <u>M</u>. **parvivorous**, and <u>M</u>. <u>latidens</u>. The small cuspule on the lingual cingulum found on the molars of <u>M</u>. <u>parvivorous</u> is absent on **UM 100028**. The lingual side of the tooth is wider and blunter, and the parastyle wing is blunter and does not extend as far posteriorly as that in <u>M</u>. <u>exiguus</u>, and <u>M</u>. <u>parvivorous</u>. While **UM 100028** has a slightly thicker lingual cingulum than the type specimen of <u>M</u>. <u>latidens</u>, it is identical in all other ways. Measurements of specimen **UM** 100028 are provided in Table 5.



Figure 15. <u>Miacis latidens</u>. Occlusal view of M1/ (UM 100028). Bar is one millimeter in length.
Genus **Vulpavus** Marsh, 1871

Age and Distribution: Early to middle Eocene (Wa2-Br1) of North America.

Type Species: Vulpavus palustris Marsh, 1871

<u>Vulpavus profectus</u> Matthew, 1909 <u>Holotype</u>: AMNH 12626- complete skull, both lower mandibles, complete fore and hind limbs, collected from the middle Bridger (Br2) at Grizzly Buttes, Wyoming.

<u>Material</u>: **UM 101100**- upper left M1/ with broken metastyle wing, collected at BB110, August 6, 1993.

Remarks: Similar to the type specimen of **Vulpavus palustris** (Matthew, 1909), the metastyle wing of **UM 101100** has been broken off. The specimen is approximately thirty percent smaller than the type of **V**. **palustris** and twenty percent smaller than the type of **V**. **hargeri** figured in Wortman (1901). In addition to being slightly larger than specimens of **V**. **canavus** figured by Guthrie (1971), the specimen has a broader lingual cingulum on the parastyle wing, and a more prominent paraconule. Although the type consists of lower dentition, Gazin (1952) described **Y**. **asius** as having teeth significantly smaller than those of **Y**. **canavus** and of the same approximate size as **Y**. **australis**. The specimen is larger and more slender anteroposteriorly than the type of **Y**. **ovatus** described by Matthew (1909)

The specimen is only slightly smaller than the type of **Vulpavus profectus** described and figured in Matthew (1909)

and has been referred to this species. Morphologically it is very similar to the type. The hypocone is large and located in a more posterior position than in other members of the genus. It continues into cingular ridges along the posterior side and the anterolingual portion of the tooth. The protocone is connected to a minuscule paraconule and an indistinct metaconule. Measurements of specimen **UM 101100** are provided in Table 5.

Family Viverravidae

Genus Viverravus Marsh, 1872

Age and Distribution: Late Palaeocene (Ti5) through middle Eocene (Ui2) of North America. Problematic specimens from the upper Eocene (Headonian) of Europe, and lower Oligocene of Asia.

Type Species: Viverravus gracilis Marsh, 1872

Viverravus gracilis Marsh, 1872

<u>Holotype</u>: Complete set of lower jaws, and a single upper molar. Collected from the lower Bridger beds (Br2) at Grizzly Buttes, Uinta County, Wyoming.

Material: UM 101017- left M1/, collected at BB037, August 1, 1993.

<u>Remarks</u>: In addition to being slightly larger, the lingual side of **UM 101017** is thinner and less blunt, and the parastyle wing is less pronounced than in specimens of <u>Viverravus minutus</u> figured in Matthew (1909). It is less than half the size of the type of the lower Bridger **Viverravus sicarius** figured in Matthew (1909) and reported by Robinson (1966). The specimen fits Robinson's (1966) description of **Viverravus gracilis** in having a well developed hypocone forming a broad cingular shelf, and in having a heavy anterior lingual cingulum. The anterior lingual cingulum is less developed and the hypocone is absent in **Viverravus acutus**. The specimen is slightly smaller than the closely allied **Viverravus dawkinsianus**. Measurements of specimen **UM 101017** are provided in Table 5.

Viverravus sp. indet.

<u>Material</u>: **UM 100023**- anterior half of left P3/, collected at BB110, July 27, 1992.

Remarks: UM 100023 is unfortunately not complete enough to assign specifically. The cusps are extremely high and sharp, with a ridge running down the medial section of the paracone towards the anterior cuspule. The anterior accessory cuspule is better developed than in the lower Bridgerian <u>Viverravus sicarius</u>. The tooth is too large to be <u>Y</u>. <u>gracilis</u> or <u>Y</u>. <u>dawkinsianus</u>, and too small to be <u>Y</u>. <u>sicarius</u> or <u>Y</u>. <u>acutus</u>. It is most similar in size to <u>Y</u>. <u>minutus</u> described by Matthew (1909) or <u>Y</u>. <u>lutosus</u> described by Gazin (1952) however the upper dentition of both these species is poorly known. Measurements of specimen UM 100023 are provided in Table 5. Fissipedia indet.

<u>Material</u>: **UM 98775m**, claw, collected at BB069, June 30, 1991.

<u>Remarks</u>: Carnivores are rare in the higher beds within the study area. The two exceptions to this are **UM 98775**, a single claw, and **UM 101017**, a single viverravid tooth (see below).

TABLE 5

Measurements (in mm.) of Carnivora

| <u>Miacis</u> <u>latidens</u> | <u>Vulpavus</u> profectus |
|------------------------------------|------------------------------|
| UM 100028 | UM 101100 |
| M1/ AP 4.8 | M1/ AP 6.2 |
| Tr 7.9 | Tr 8.1 |
| <u>Viverravus</u> sp. indet | . <u>Viverravus</u> gracilis |
| UM 100023 | UM 101017 |
| P3/ AP 4.8 | * M1/ AP 4.8 |
| Tr 2.2 | tr 3.5 |
| | |

Order CONDYLARTHA Cope, 1881

Family Meniscotheriidae Cope 1882

<u>Remarks</u>: The Meniscotheriidae were highly specialized condylarths with precociously advanced dentitions. The cheek teeth are lophodont, and the molars are highly molariform (Gazin, 1965). Although the selenodont pattern of their cheek teeth resembles that of artiodactyls they are not implicated in the ancestry of any modern ungulate groups (Carroll, 1988). Found in various locations throughout the North American west and in Europe, they are most abundant in the early Eocene of the San Juan and Green River Basins and adjacent areas.

Subfamily Meniscotheriinae Cope, 1882

Genus Meniscotherium Cope, 1874

Age and Distribution: Late Palaeocene to Early Eocene (Cf3-Wa7) of western North America, particularly the Rocky Mountain interior.

Type Species: Meniscotherium chamense Cope, 1874

<u>Remarks</u>: The premolars of <u>Meniscotherium</u> are relatively molariform resulting in a tooth row comparatively homogenous in both size and shape. Both the upper and lower cheek teeth of <u>Meniscotherium</u> are characterized by a more selenodont occlusal surface than the molars of contemporaneous condylarths. <u>Meniscotherium</u> is the most distinctly herbivorous condylarth (Gazin, 1965).

Gazin (1965) was the first to study <u>Meniscotherium</u> in depth since Cope described the family in 1882. Gazin (1965) felt that of the five described species only three were valid. Gazin (1965) considered <u>Meniscotherium</u> <u>semicingulatum</u> undefinable since it was based on a single deciduous lower premolar. <u>Meniscotherium priscum</u> was synonomyzed with <u>M. tapiactis</u> since the development of the metastylid is variable, and this was the sole basis for the species. The three accepted species are <u>M. chamense</u>, <u>M</u>. tapiactis, and <u>M. robustum</u>. Although the types of the three species of <u>Meniscotherium</u> come from widely separated areas, they are all known from the middle to late Wasatchian of the Green River Basin.

Meniscotherium chamense Cope, 1874

<u>Holotype</u>: AMNH 4425- portions of both lower mandibles with /P3-/M3 intact, San Jose Formation (Wa3-6) in the San Juan Basin, New Mexico.

<u>Material</u>: **UM 100027**- right M1/, right I3/, and right proximal radius, collected at BB110, July 27, 1992.

<u>Remarks</u>: The incisor included with UM 100027 is a typical condylarthan incisor and of little help in identification. The proximal radius included with UM 100027 has a broken, slender shaft and a highly expanded, rather rectangular articular surface, consistent with the description of Gazin (1965). This is typical of all three species of <u>Meniscotherium</u> and is of little help in specific identification. The M1/ included with UM 100027 retains the characteristic unworn, high crescentic cusps associated with a younger individual.

The tooth is longitudinally more slender than figures of <u>M</u>. robustum but similar to figures of <u>M</u>. tapiacitis and <u>M</u>. chamense in Gazin (1962, 1965). The tooth also has an anteroposteriorly compressed lingual portion similar to specimens of <u>M</u>. chamense described by Gazin (1962). The tooth is much more slender transversely, and much less lophodont than M1/ of <u>M</u>. robustum illustrated by Gazin (1965) and West (1973). Consistent with the condition of illustrated specimens of <u>M</u>. <u>chamense</u> in Gazin (1965) and by West (1973) the protoloph and metaloph of M1/ differ only slightly in size whereas the protoloph is a much smaller cusp than the metaloph in M1/ of <u>Meniscotherium robustum</u>. Although morphologically similar, <u>UM 100027</u> is approximately 25% larger than <u>M</u>. <u>tapiactis</u>. The specimen is most similar in size and morphology to <u>Meniscotherium</u> <u>chamense</u> illustrated by Gazin (1965). Measurements of specimen <u>UM 100027</u> are provided in Table 6.

Meniscotherium sp. indet.

<u>Material</u>: **UM 100894**- several fragmentary teeth, collected at BB114, July 25, 1993.

<u>Remarks</u>: The teeth of specimen **UM 100894** display the high degree of selenodonty characteristic of <u>Meniscotherium</u>, however none of the fragments are complete enough to make a specific assignation.

Family Hyopsodontidae Trouessart, 1879

Subfamily Hyopsodontinae Trouessart, 1879

Genus **Hyopsodus** Leidy, 1870 Age and Distribution: Early to late Eocene (Cf3-Du) of western North America.

Type Species: Hyopsodus paulus Leidy, 1870.

<u>Remarks</u>: Although **<u>Byopsodus</u>** is one of the most common mammalian genera in the Eocene deposits of Wyoming, and while it is particularly common in the higher Bridger beds,

it is represented by only five specimens from within the study area. Although four of these were collected at a single locality, BB110, the lowest locality within the study area, differences in size (Table 6) indicate that two species are present. The fifth comes from considerably higher up in the section, but still from within the Wasatch Formation. McGrew and Sullivan (1970), working in slightly younger units adjacent to the study area, reported only a single specimen of **Hyopsodus**.

The phylogenetic relationships of **<u>Byopsodus</u>** species have proven difficult to define. Gazin (1968) was the first to study **Evopsodus** in depth. He found that, although known from abundant specimens, the various species are difficult to separate on the basis of dental morphology. There is verv little difference in tooth structure between early specimens of Hyopsodus and later ones. Matthew (1909) noted that while the teeth of the various Bridger species show little advance over the Wasatch or Wind River species, there is a trend towards more complex premolar crowns and more crowded tooth roots. Gazin (1968) did not observe this increasing complexity, noting only that the P2/ of the Bridger specimens looks more like the P3/ of the Wasatchian specimens, and the P3/ of the Bridger looks like the P4/ of the Wasatchian. He did find that later Eocene (Uintan) specimens trend towards more lophodont molars. This trend, however, is not observed in early or middle Eocene

specimens. As a result, the various species of Wasatchian and Bridgerian **Eyopsodus** are virtually indistinguishable from each other except for size. (West, 1973, 1979, Gazin, 1968).

Hyopsodus minisculus Cope, 1874

<u>Holotype</u>: ANS 10259- left maxilla with M1/ to M3/, collected from the Blacks Fork Member of the Bridger Formation (Br2), near Fort Bridger, Wyoming.

Hyopsodus cf. H. minisculus Cope, 1874

<u>Material</u>: **UM 98665**- fragment of left dentary containing /M2 and the roots of /M1, collected at BB013, June 25, 1991.

<u>Remarks</u>: As mentioned above size is considered the best criterion for differentiating species of <u>**Byopsodus**</u>. The specimen was compared to five early to middle Eocene species of <u>**Byopsodus**</u> in Gazin (1952; 1962; 1968), Matthew (1909, 1915) and West (1973). Based on size the specimens are referred to <u>**Byopsodus**</u> <u>minisculus</u>. Measurements of specimen UM 98665 are provided in Table 6.

Hyopsodus miticulus Cope, 1874

<u>Holotype</u>: USNM- left ramus of mandible with /M1 to /M3, type missing since before 1907, "Wasatchian early Eocene, San Jose Formation, San Juan Basin, New Mexico."

Hyopsodus cf. H. miticulus

<u>Material</u>: **UM 100020**- right /P4, collected at BB110, July 27, 1992. **UM 100030**- left /M1, collected at BB110, July 27, 1992.

<u>Remarks</u>: Two specimens fell well under the size range of <u>**Byopsodus wortmani**</u> and best fit the size range of the Wasatchian species <u>**H**</u>. <u>miticulus</u>. Measurements of specimens **UM 100020** and **UM 100030** are provided in Table 6.

Hyopsodus wortmani Osborn, 1902

Holotype: AM 4716- portions of both maxillae, premaxillae, and both rami of mandible with I2/, P3/-M3/, and /P3-/M3 represented, collected from the late Wasatchian of the Wind River Basin, Wyoming.

Hyopsodus cf. H.wortmani Osborn, 1902

<u>Material</u>: **UM 101150**- labial half of right M2/, collected at BB114 (wash), August 5, 1993. **UM 101156**- right M2/, collected at BB110 (wash), August 19, 1993. **UM 101157**right /M1 collected at BB110 (wash), August 19, 1993.

<u>Remarks</u>: Three specimens of **Hyopsodus** from the lowest two localities within the field area fell well below the size range of <u>H</u>. <u>minisculus</u> and best fit the size range of <u>H</u>. <u>wortmani</u>. Measurements of specimens **UM 101156** and **UM 101157** are provided in Table 6.

Order TAENIODONTIA Cope, 1876

Family Stylinodontidae Marsh, 1875

<u>Remarks</u>: Stylinodonts were among the most highly specialized mammals of the Early Cenozoic. Features such as rootless, ever-growing teeth, and large well-developed claws

TABLE 6

Measurements (in mm.) of Condylartha

| <u>Meniscotherium</u> <u>chamense</u> | | Hyop | sodus | <u>wortma</u> | ni | | |
|---------------------------------------|------|-------|-------|---------------|-------------|-------|--|
| | UM 1 | 00027 | | | UM 1 | 01156 | |
| I3/ | AP | 2.7 | | M2/ | AP | 3.2 | |
| | Tr | 3.9 | | | Tr | 4.3 | |
| M1/ | AP | 11.5 | | | UM 1 | 01157 | |
| | Tr | 6.3 | | /M1 | AP | 3.1 | |
| | | | | | Tra | 2.0 | |
| | | | | | Trp | 2.3 | |
| | | | | | | | |

Hyopsodus miticulus

| | UM | 100020 | | UM | 100030 |
|-----|----|--------|-----|-----|--------|
| /P4 | AP | 3.9 | /M1 | AP | 3.4 |
| | Tr | 2.5 | | Tra | a 2.5 |
| | | | | Trr | 2.7 |

Hyopsodus minisculus

| | UM | 98665 |
|-----|-----|-------|
| /M2 | AP | 3.5 |
| | Tra | 2.6 |
| | Trp | 2.8 |

suggest the animals dug their food, probably roots, from the ground. The phylogenetic relationships of stylinodonts remain somewhat conjectural.

Stylinodontidae, gen. et sp. indet.

<u>Material</u>: **UM 99844m**- Right terminal phalanx, probably from the pes, tip broken off, collected at BB036, July 16, 1992.

<u>Remarks</u>: UM 99844m is the only record of a stylinodont from within the study area. The specimen is a large, robust claw 30.3mm in length, and 12.5mm in width at the proximal end, and is similar to the description and photograph of the undetermined stylinodont described by Gazin (1952). It tapers towards the distal end of which approximately 5mm is broken off. The articular surface is broad and deep, within only a slight keel. Although <u>Stylinodon</u> is the only known genus of stylinodont known from the middle Eocene of the Green River Basin, not enough material is present to definitively assign the specimen past the level of family.

Order TILLODONTIA Marsh, 1875

Family Esthonychidae Cope, 1883 Subfamily Esthonychinae Zittel and Schossler, 1911

<u>Remarks</u>: Subfamily Esthonychinae differs from other esthonychids by its large second lower incisor with enamel only on the anterior, labial, and lingual sides.

Genus Esthonyx Cope, 1874

Type Species: Esthonyx bisulcatus Cope, 1874

Age and Distribution: Late Palaeocene (Cf1) through early middle Eocene (Br1) of North America and Asia, and early Eocene of Europe (Sparnacian or Cuisan).

Esthonyx acutidens Cope, 1881

Holotype: AMNH 4807- left /M1 and /M2, collected from the Lost Cabin beds (Wa7) of the Wind River Basin, Wyoming.

<u>Material</u>: **UM 100896**- bone and tooth fragments including lower right /I1, posterior half of lower left /P4, lingual half of lower left /M2, collected at BB115, July 25, 1993.

Remarks: UN 100896 represents an older individual of Esthonyx. All three teeth are worn down. Although the specimen is similar in size to three species of Esthonyx, only one species, Esthonyx acutidens, has been reported from the Green River Basin. Fragments of the lower mandibles associated with the teeth indicate that the mandibular rami were likely fused, consistent with the diagnosis of the Esthonyx spatularis - E. bisulcatus - E.acutidens lineage given by Gingerich and Gunnell (1979). The /M2 of UM 100896 is approximately 30% larger than the type of Esthonyx spatularis. The /I1 of UM 100896, although well worn, is much thicker than that of Esthonyx bisulcatus figured in Gazin (1953). Although the anterior half of /P4 is missing, the tooth is complete enough to show that it is much larger than either Esthonyx spatularis or E. bisulcatis, and

slightly larger than the type of <u>E</u>. <u>acutidens</u>. All three teeth are similar in size to specimens of <u>Esthonyx acutidens</u> measured by Stucky and Krishtalka (1983). Measurements of specimen **UM 100896** are provided in Table 7.

TABLE 7

Measurements (in mm.) of Tillodontia

Esthonyx acutidens

| | UM | 100896 |
|-----|-----|--------|
| /I1 | AP | 3.2 |
| | Tr | 3.6 |
| /P4 | Ap | - |
| | Tr | 6.3 |
| /M2 | AP | 8.8 |
| | Tra | 6.8 |
| | Trp | - |

Order ARTIODACTYLA Owen, 1848

Suborder Bunodonta Kowalevsky, 1873

Family Diacodexeidae (Gazin, 1955)

Subfamily Diacodexeinae Gazin, 1955

Genus **Diacodexis** Cope, 1882

Age and Distribution: Early to middle Eocene (Wal-Br3)

of western North America, early Eccene of Europe.

Type Species: Diacodexis secans Cope, 1881

Diacodexis secans Cope, 1881

Age and Distribution: Early to middle Eocene (Wa0-Br2) of western North America.

<u>Material</u>: **UM 100024**- left /P4, collected at BB110, July 27, 1992. **UM 101092**- left /P3, collected at BB110, August 4, 1993.

<u>Remarks</u>: The premolars of lower Eocene artiodactyls are not highly distinctive teeth. **UM 100024** and **UM 101092** are relatively low cusped and rather worn teeth. The specimens agree well in both size and morphology with specimens of <u>Diacodexis secans</u> described by Krishtalka and Stucky (1985, 1986), and Robinson (1966). The paraconid of both teeth is a small, but distinct, cuspule on the anterior side of the protoconid. In both cases the protoconid is the major cusp and is well separated from the hypoconid.

Both UM 100024 and UM 101092 fall well below the size range of <u>Bunophorus</u> (Stucky and Krishtalka, 1990) and well above that of <u>Diacodexis chacensis</u> (Robinson, 1966; Sinclair 1914). Although both teeth are similar in size to specimens of <u>Antiacodon pygmaeus</u> measured by West (1973, 1984) and Robinson (1966), they differ in other aspects. Most significantly, both specimens lack the distinct metaconid seen in specimens of <u>A. pygmaeus</u> from the Bridger Basin (West, 1984). Measurements of specimens UM 100024 and UM 101092 are provided in Table 8.

Diacodexis sp. indet.

<u>Material</u>: **UM 101099** left astragalus, collected at BB110, August 5, 1993.

Remarks: All artiodactyls recovered from the study area have been referred to the genus **Diacodexis**, the most primitive known artiodactyl. **Diacodexis** is considered to be ancestral to all other artiodactyls and many of the features that characterize modern artiodactyls are already present (Krishtalka and Stucky, 1985; Carroll, 1988). The most important of these features is the unique double-trochleated arrangement of the astragalus. While the general pattern of the astragalus of **Diacodexis** is reminiscent of primitive condylarths there are some large morphological and functional differences (Schaeffer, 1947).

The astragalus of **Diacodexis** is more slender and less robust than those of contemporaneous artiodactyls of similar size (Rose, 1982, 1985). Specimen **UM 101099** was compared to specimens and diagrams of all comparably-sized lower and middle Eocene artiodactyls and fits the description of Rose (1982, 1985).

TABLE 8

Measurements (in mm.) of Artiodactyla

Diacodexis secans

| | UM 1 | .00024 | | 101092 |
|-----|-------------|--------|--------|------------|
| /P4 | AP | 4.9 | /P3 AB | 5.3 |
| | Tr | 2.5 | Tr | 2.8 |

Order PERISSODACTYLA Owen, 1848

Suborder Hippomorpha Wood, 1937

Superfamily Equoidea Gray, 1821

Family Equidae Gray, 1821

Genus Orohippus Marsh, 1872

Age and Distribution: Middle Eocene (Br1-Br2) of western north America, primarily the Green River Basin

Type Species: Orohippus pumilus Marsh, 1871

Orohippus pumilus Marsh, 1871

<u>Holotype</u>: YPM 11336- fragment of the right maxilla with P3/ to M2/ and roots of P1/ and P2/, from the Bridger Formation at Marsh's Fork Wyoming (Br2).

cf. Orohippus pumilus Marsh, 1871

<u>Material</u>: **UM 94980**- left dentary with /P3 and /M1, roots of /P2, /M2, and /M3, collected at BB019, June 29, 1989.

Remarks: Of the five species of **Orohippus**, only two, **Q**. **pumilus** and **Q**. **major** have been found in the early Bridgerian (Br1). **UM 94980** fits well within the size range of **Orohippus pumilus** and is much smaller than **Q**. **major** (Kitts, 1957). Although the specimen is of comparable size with **Hyracotherium vasacciense**, known from the lower units of the study area, /P3 appears to have a minuscule entoconid, a feature not found in **Hyracotherium**. The tooth is slightly abraded in the area around the entoconid making this feature difficult to discern. Kitts (1957) considered **O**. **pumilus** to be the direct descendant of **Hyracotherium vasacciense** and the progenitor of all other species of **Orohippus**. Measurements of specimen **UM 94980** are provided in Table 9.

Orohippus sp. indet.

<u>Material</u>: **UM 98727**- right astragalus, collected at BB075, June 29, 1991.

Remarks: The astragali of **Orohippus** and all subsequent equids are differentiated from **Hyracotherium** by having trochlear crests inclined at an angle, rather than parallel to the long axis of the foot (Kitts, 1957). In addition, the medial trochlear crest extends to the navicular facet. In **Hyracotherium** the neck is slightly longer and the medial trochlear crest does not touch the navicular facet (Gunnell, pers. comm.). The navicular facet of **UM 98727** is central in position beneath the main body of the astragalus rather than medially emplaced as in diagrams of **Hyracotherium** in Radinsky (1966a) and Kitts (1956).

Genus Hyracotherium Owen, 1840

<u>Age and Distribution</u>: Early to middle Eocene (Wa0-Wa7) of Europe and North America.

Type Species: Hyracotherium leporinum Owen, 1840

<u>Remarks</u>: Early Eocene equid systematics have undergone substantial revision since the first specimen of <u>Hyracotherium</u> was found in 1838. Granger (1908) revised the genus <u>Hyracotherium</u>, recognizing eleven species. Kitts (1956), with substantially more material, recognized three

North American species. Although he did not formally study any European specimens, he felt that specific separation of these from North American specimens would be difficult. Wortman (1896) synonymized <u>Hyracotherium vasacciense</u>, H. index, H. cuspidatum, H. venticolum and H. angustidens. Kitts (1956) revised this, separating H. vasacciense and H. **index** into one species (<u>**H**</u>. **vasacciense**), and the remainder into a second ($\underline{\mathbf{H}}$. <u>angustidens</u>), largely on the basis of stratigraphic position. The types of the \underline{H} . vasacciense group are all from the late Wasatchian of southwestern Wyoming, those of the **<u>H</u>**. **angustidens** group are from various early Wasatchian localities in Wyoming and adjacent states. Rather than separate these animals into a larger number of formal species, Kitts used the term "subspecies" to distinguish groups of specimens with overlapping morphological characters. This thesis follows the classification of Kitts (1956).

<u>Hyracotherium</u> <u>vasacciense</u> (Cope, 1872)

Holotype: AMNH 4658- left M/2, from the lower Eocene Knight Formation, near Evanston, Wyoming.

<u>Material</u>: UM 100890- right /M3, left /M3, right M2/, and associated tooth fragments, collected at BB114, July 25, 1993. UM 101158- upper Mx/, collected at BB110 (wash), August 5, 1993.

<u>Remarks</u>: All of the teeth that comprise specimen **UM** 100890, with the exception the left /M3, are damaged to some

extent. The diagnosis of the specimen therefore is based primarily on this tooth. The heel is slender and elongate, unlike the short structure found in **Orohippus**. The tooth is broader than in <u>**H**</u>. angustidens and its synonyms reported by Kitts (1956). Hyracotherium vasacciense is most easily differentiated from H. craspedotum by its much smaller size. The specimen is substantially smaller than specimens of \mathbf{H} . craspedotum reported by Kitts (1956) and Guthrie (1971), and figured by Gazin (1962). Contrary to Kitts (1956), Guthrie (1971) recognized <u>H</u>. index as a valid species, independent from <u>H</u>. <u>vasacciense</u>. Specimen **UM 100890** is substantially larger than the single specimen of $\underline{\mathbf{H}}$. **index** reported by Guthrie (1971). Specimen UM 100890 is closest in size to specimens of **<u>Hyracotherium</u> y**. **vasacciense** from the La Barge sample described by Kitts (1956). Measurements of specimen UM 100890 are provided in Table 9.

Equidae, gen. et sp. indet.

<u>Material</u>: **UM 98666**- fragment of right Mx/, possibly M2, collected at BB013, June 25, 1991. **UM 98656**postcranial material including a left distal femur, left and right distal tibiae, a right humeral head, seven caudal vertebrae, three distal metacarpals, and a left calcaneum, collected at BB013, June 25, 1991.

<u>Remarks</u>: Two closely related genera of equids are known from the early and middle Eocene of Wyoming. Kitts (1956, 1957) studied both <u>Orohippus</u> and <u>Hyracotherium</u> in depth and observed that, in many respects, the postcranial anatomy of the two genera is similar. Certain bones, particularly those of the pes, have proven useful for identification (see above). With additional study it may become apparent that it is easier to separate early specimens of **Orohippus** from late specimens of **Byracotherium** using the shape and orientation of certain of the hind limb elements than with the dentition. The most commonly used criterion in separating the two is morphology of the teeth. **Orohippus** is considered to be the Bridgerian successor to **Byracotherium** (Kitts, 1956; 1957) As the two genera are considered to be members of an evolutionary continuum, the critical dental characteristics may vary considerably.

UM 98666 is a portion of an upper right cheek tooth, probably an M2/. The criteria used by Kitts (1956, 1957) to differentiate the two genera are absent on this specimen. UM 98656 fits the size range of both early Eocene equids, Evracotherium and Orohippus, and likely belongs to one of these two genera. The distal tibiae fit perfectly with both Evracotherium and Orohippus astragali in the University of Michigan collection. Although the specimen falls within the size range of <u>Seleneletes</u> there are several morphological differences. The astragalar groove of the tibia is deeper than that of a distal tibia found associated with Seleneletes material from the same locality. In addition the

bone is more rounded in cross section than the homologous bone in **Seleneletes**.

Superfamily Brontotherioidea Hay, 1902 Family Brontotheriidae Marsh, 1873 Subfamily Lambdotheriinae Osborn Genus Lambdotherium Cope, 1889

Age and distribution: Early Eccene (Wa4-Wa7) of North America.

Type Species: Lambdotherium popoagacium (Cope, 1880)

Lambdotherium popoagacium (Cope, 1880)

<u>Holotype</u>: Right P/4-M/3, from the Lostcabinian of the Wind River Basin, Wyoming.

<u>Material</u>: **UM 100891**- associated teeth including left /P2, left /P4, right /M1, left P4/, and left M1/, collected at BB114, July 25, 1993.

Remarks: Bonillas (1936) synonymized all other described species with Lambdotherium popoagacium. Prior to this the main criterion for specific separation was the degree of molarization of the premolars. All described species occurred within a narrow stratigraphic interval and most graded one into another without any clear divisions. Previous to this revision, a complete dentition belonging to a single individual had never been described, and it became clear that the upper and lower dentition of the specimen Bonillas studied (CIT 1743) had characters of several different species.

UM 100891 (Figure 16) is similar in all aspects to the specimen described by Bonillas (1936) and specimens figured by Osborn (1929). The /P2 is a rather simple tooth, and is very worn making the cusp pattern difficult to discern. The /P4 is a high-cusped tooth and is almost completely molariform. While a true entoconid is absent, the posterior cingulum is thick and pronounced. Osborn (1929) using progressive molarization of the lower premolars, considered Lambdotherium popoagacium to be the intermediate species in an evolutionary continuum. Based on the lower premolars, UM 100891 fits the description of Lambdotherium popagacium of both Osborn (1929), and Bonillas (1936). Although the ectoloph has been damaged, M1/ is easily identified as a molar of Lambdotherium popoagacium. A thin low cingulum encircles the crown. The four main cusps are approximately equal in height. The protoconule, although smaller than the other cusps, is rather large, and consistent with Bonillas' description, is crescentic, its base curling slightly around the base of the enlarged paracone. Measurements of specimen **UM 100891** are provided in Table 9.

Subfamily Palaeosyopinae Steinman and Doderlein, 1890

Genus Palaeosyops Leidy, 1870

Age and Distribution: Middle Eocene (Br1-Br3) of North America. Early Eocene of Asia.



Α.



в.

Figure 16. Lambdotherium popoagacium. A. Occlusal view of /P4 (UM 100891). B. Labial view of /P4 (UM 100891). Bar is one millimeter in length. Type Species: Palaeosyops paludosus Leidy, 1870.

Palaeosyops fontinalis Leidy, 1870

Holotype: AMNH 5107- fragmentary skull including the left nasal, both squamosals, both parietals and right maxilla containing dP4/, M1/ and M/2, collected from the lower Bridger formation (Br1), near the confluence of the Big Sandy and Green Rivers, central Green River basin, Wyoming.

Palaeosyops cf. P. fontinalis Leidy, 1870

<u>Material</u>: **UM 98732**- trigonid of left /dP4, collected at BB012, June 29, 1991. **UM 99815**- fragments of Mx/, collected at BB096, July 15, 1992.

Remarks: Palaeosyops fontinalis and Eotitanops borealis are the only two large brontotheres known from the Early and Middle Eocene of the Green River Basin. Palaeosyops is likely derived from Eotitanops (West, 1973). Gazin (1952) considered Palaeosyops and Eotitanops congeneric. Although their teeth are morphologically similar, West (1973) and Robinson (1966) consider them two distinct genera, based primarily on their substantial difference in size.

Based on size, UM 98732 is referred to <u>Palaeosyops</u> <u>fontinalis</u> rather than the smaller <u>Eotitanops borealis</u>. Gazin (1952) noted that the deciduous teeth of <u>Lambdotherium</u>, a taxon closely related to <u>Palaeosyops</u>, are identical except for size to their permanent counterparts. The trigonid of **UM 98732**, a deciduous premolar is preserved in its entirety, and is slightly larger than any permanent /P4 of <u>P</u>. <u>fontinalis</u> measured by Robinson (1966), and is far larger than /P4 of <u>Eotitanops borealis</u>. Although the specimen is fragmentary, the size of **UM 98732** is also indicative of <u>Palaeosyops</u> cf. <u>P</u>. <u>fontinalis</u>. Measurements of <u>Palaeosyops</u> cf. <u>P</u>. <u>fontinalis</u>. Measurements of <u>Palaeosyops</u> cf. <u>P</u>. <u>fontinalis</u> from the study area are provided in Table 9.

> Suborder Ceratomorpha Wood, 1937 Superfamily Tapiroidea Gill, 1872 Family Helaletidae Osborn, 1892 Genus **Selenaletes** Radinsky, 1966

Age and Distribution: Middle Eocene (Gardnerbuttean, early Br1) of Wyoming. Few specimens of <u>Selenaletes</u> have been described. To date, all described specimens have been lower cheek teeth. Locality and stratigraphy data is poor for the holotype and the hypodigm described by Radinsky (1966b). The holotype and two other specimens were found in a drawer of Bighorn Basin specimens in a box containing <u>Heptodon calciculus</u>, a species known only from the Lysitean and Lostcabinian (Wa6-7) (Radinsky, 1966b). Guthrie (1971) reported <u>Selenaletes</u> from the Lost Cabin Member of the Wind River Formation but did not indicate which horizon his specimens came from. Stucky (1984a) restricted <u>Selenaletes</u> scopaeus to the <u>Palaeosyops borealis</u> zone (Gardnerbuttean, early Br1) within the Wind River Basin. Specimens of **Selenaletes** from the study area are the first specimens reported from outside of the Wind River Basin.

Type Species: Selenaletes scopaeus Radinsky, 1966.

Selenaletes sp. indet.

<u>Material</u>: **UM 94877**- edentulous left mandible, collected at BB013, June 25, 1989. **UM 94913**- left dentary with /M2 and /M3, fragments of right dentary containing roots of /P2 through /M3, right distal tibia, collected at BB013, June 25, 1989. **UM 95597**- right dentary with /M2, collected at BB013, June 4, 1990. **UM 98661**- left M3/, collected at BB013, June 25, 1991.

Remarks: Selenaletes scopaeus, the only described species of Selenaletes, is one of the smallest known helaletid ceratomorphs. Morphologically it is very similar to many other helaletids known from the late Wasatchian and early Bridgerian of the Bridger Basin. Aside from minor differences in individual tooth shape, the most important distinguishing characteristic between the forms is size. Teeth of Selenaletes are approximately 30% smaller than those of Heptodon calciculus, the smallest species of Heptodon, and 20% smaller than Dilophodon leotanus, the smallest species of Dilophodon (Radinsky, 1963, 1966b).

Emry (1989, 1990) recently described a tiny helaletid ceratomorph from the Bridgerian of the Elderberry Canyon Local Fauna in Nevada. Teeth of this animal, <u>Fouchia</u> elvensis, are approximately 10% smaller than those of

Selenaletes scopaeus. Fouchia elyensis is the smallest known ceratomorph. The teeth of **Selenaletes** have slightly higher crowns, and more advanced bilophodonty than those of Fouchia (Emry, 1990). In <u>Selenaletes</u> the anteroposterior length of /M3 is less than that of /M2 yielding a /M2:/M3ratio of 1.0 (Radinsky, 1966b). In Fouchia the length of /M3 is longer than that of /M2 yielding a /M2:/M3 ratio of 0.85 (Emry, 1990). The Bridger specimens, and in particular UM 94913 (Figure 17) follow the trend in Fouchia rather than that in Selenaletes with a /M2:/M3 ratio of 0.80 in specimen UM 94913 and 0.89 in UM 95597 (/M3 alveolar length). These specimens may well occupy an intermediate position between Fouchia and Selenaletes since the relative smaller size of /M3 is considered a diagnostic character in Selenaletes scopaeus (Radinsky, 1966b). The specimens from the study area are likely representative of a new species of this poorly known genus. Measurements of specimens of **Seleneletes** from the study area are presented in Table 9.

Subfamily Hyrachyinae Osborn, 1892

<u>Remarks</u>: This study follows the classification of Radinsky (1967). Radinsky removed the family Hyrachyidae from Superfamily Rhinocerotoidea, and placed it as a subfamily in Superfamily Tapiroidea, Family Helaletidae.

Genus **Hyrachyus** Leidy, 1871

Age and Distribution: Middle Eccene (Br1-Ui2) of North America and Europe.



Α.



Β.

Figure 17. **Seleneletes** sp. indet. A. Occlusal view of left dentary with /M2 and /M3 (**UM 94913**). B. Labial view of left dentary with /M2 and M/3 (**UM 94913**). bar is one millimeter in length. Type Species: Hyrachyus modestus Leidy, 1871.

Remarks: **Eyrachyus** is one of the most common mammalian genera in the middle Eocene of western North America. Radinsky (1967) was the first to study the hyrachyids in depth since Wood's monograph in 1934, where 12 species in four genera of hyrachyids were recognized. Seven of these species (four from the Bridger Formation) were placed in the genus **Eyrachyus**. Wood (1934) separated these into three lineages or evolutionary grades, primarily on the basis of size. Radinsky (1967), utilizing a much larger sample reduced the number of genera to one and the number of species to two.

Radinsky (1967) concurred with Wood (1934) that size is the only useful criterion for separating Bridgerian species of **<u>Hyrachyus</u>**. Measurements of specimens of <u>**Hyrachyus**</u> from the study area are presented in Table 9.

Hyrachyus modestus (Leidy, 1871)

<u>Holotype</u>: USNM 661- isolated dP3/ or dP4/ from the lower Bridger Formation (Br2) of the Bridger Basin of Wyoming. There is some dispute about the type specimen since Leidy (1871) originally designated this specimen as the type of **Lophiodon modestus** and described the genus **Hyrachyus** the same year, based on another specimen. Wood (1934) and Radinsky (1967) concur that USNM 661 is the proper type specimen.

<u>Material</u>: UM 95635- cheek tooth fragments, collected at BB044, June 9, 1990. UM 98734- fragments of right maxilla containing P2/-P3/, M2/, fragments of M3/, and the roots of I1/ to I3/, collected at BB077, June 29, 1991. UM 101023- associated postcranial elements including left astragalus, left calcaneum, and left patella, collected at BB037, August 1, 1993. UM 101035- associated postcranial elements including left navicular, left ectocuneiform, and the distal end of the left second metatarsal, collected at BB074, August 1, 1993. UM 101075- fragmentary left dentary including part of the descending ramus, and /M3, isolated /P3, left astragalus, collected at BB117, August 3, 1993.

<u>Remarks</u>: **UM 95635** is assigned to <u>**Evrachvus**</u> on the basis of the large folded lophs of enamel characteristic of the species. The only other animal of the similar size is the brontothere <u>**Palaeosyops**</u>. The enamel folds of **UM 95635** are considerably higher, sharper and tighter than are those of **Palaeosyops**.

As mentioned above, size is considered the only valid criterion for separating species of **<u>Hyrachyus</u>**. Consistent with Wood's (1934) diagnosis of **<u>Hyrachyus</u>**, the protoloph of P2/ and P3/ of **UM 98734** is considerably more robust and prominent than is the metaloph. The ectoloph and metaloph are connected by a ridge that is only slightly lower than the cusps themselves, whereas the protoloph is separated from the metaloph and the ectoloph by a deep depression.

Although UM 98734 is larger than most specimens of \underline{H} . modestus described by Radinsky (1967). Radinsky did report three exceptionally large \underline{H} . modestus specimens from lower Bridger beds, and West (1973) reported a comparably large specimen of \underline{H} . modestus from the New Fork Tongue of the Wasatch Formation. Radinsky felt that size difference does not warrant the recognition of two species of early Bridgerian <u>Hyrachyus</u>. As more specimens of <u>Hyrachyus</u> are discovered from late Wasatchian and early Bridgerian deposits it may become apparent a second species is present.

Specimen UM 101075 is a very large specimen of **Evrachvus modestus**, It is larger than any specimens reported by Robinson (1966) from the upper Huerfano Formation (Br1), by Radinsky (1967) from the Bridger B through D beds (Br2-Br3), or the single specimen from the Lost Cabin Member reported by Guthrie (1971). Measurements of specimens UM 98734 and UM 101075 are reported in Table 9.

Fam., gen. et sp. indet.

Material: UM 98578- postcranial material including left humeral head, left femoral head, terminal phalanx, distal metacarpal, proximal metatarsal, distal fibula, left proximal radius, left lateral cuneiform and five vertebral fragments, collected at BB044, June 20, 1991. UM 99661mtwo terminal phalanx, one distal metacarpal, one proximal metacarpal, collected at BB103, June 23, 1992. UM 101101m-

trochlea of right astragalus, collected at BB110, July 27, 1992.

Remarks: **UM 98578** is the remains of a very small perissodactyl. The terminal phalange is only 8mm long. The specimen may be either a small equid species, or possibly represents some of the first postcranial remains known from the diminutive hyrachyid Seleneletes. UM 99661m is too large to belong to any of the early or middle Eocene equid taxa and too small to belong to **Palaeosyops fontinalis**. It is unlikely representative of Lambdotherium, an important Lostcabinian (Wa7) taxon, since a specimen of the Bridgerian taxa Hyrachyus was identified from a lower level. It is most likely representative of either Hyrachyus, or Palaeosyops **borealis**. UM 101101m likely belongs to either a large specimen of **Hyracotherium** or a small specimen of Lambdotherium. It is too incomplete for further identification.

> Order RODENTIA Vicq d'Azyr, 1792 Suborder Protrogomorpha Zittel, 1893 Superfamily Ischromyoidea Wood, 1937 Family Sciuravidae Miller and Gidley, 1918

Age and Distribution: Early Eccene (Wa4) to late Eccene (Uil) of North America.

Genus **Sciuravus** Marsh, 1871

Type Species: Sciuravus nitidus Marsh, 1871.

TABLE 9

Measurements (in mm.) of Perrisodactyla

| cf. | <u>Orohir</u> | <u>pus pumi</u> | lus |
|-----|---------------|-----------------|-----|
| | UM 94 | 890 | |
| /P3 | AP | 6.5 | |
| | Tr | 4.1 | |
| /M1 | AP | 7.1 | |
| | Tra | 4.9 | |
| | Trp | 5.1 | |

| Hyra | cothe UM 1 | rium sp. 01158 | indet. |
|------|------------------|----------------------------------|-------------|
| M2/ | AP Tr | 7.2* 8.9* | |
| Hyra | UM 1 | <u>rium vas</u> 00890 | acciense |
| M2/ | AP Tr | 6.9 8.8* | |
| /M3 | AP Tra Trp | 9.7-10.4 5.8- 6.2 5.2- 5.8 | 4 1 3 |

| Lambo | loti | nerium ; | popagacium |
|-------|------|----------|------------|
| | Um | 100891 | |
| /P2 | AP | 7.7 | |
| | Tr | 4.9 | |
| /P4 | AP | 9.7 | |
| | Tr | 6.6 | |
| P4/ | AP | 9.0 | |
| | Tr | - | |
| M1/ | AP | 12.7 | |
| | Tr | 15.0 | |

| /M3 | AP Tra | 9.7-3 5.8- | 10.4 6.1 |
|------|----------------------|---------------|-------------|
| | Trp | 5.2- | 5.8 |
| Pala | eosyo | DS | |
| cf. | <u>P</u> . <u>fo</u> | ntina | lis |
| | UM 9 | 8732 | |
| /dP4 | AP | 22.0 | 5* |
| | Tr | 15.3 | 1 |

<u>Seleneletes</u> sp. nov.

| | UM 9 | 4913 | UM | 95597 |
|-----|-------------|-------|--------|-------|
| /M2 | AP | 7.2 | /M2 AP | 8.1 |
| | Tra | 5.6 | Tra | a 5.5 |
| | Trp | 5.9 | Tr | p 5.7 |
| /M3 | AP | 8.9 | UM | 98661 |
| | Tra | 5.8 | M3/ AP | 8.5 |
| | Trp | 5.7 | Tr | 9.1 |
| | UM 1 | 01029 | | |
| /P3 | AP | 4.7 | | |
| | Tr | 3.9 | | |
| /P4 | AP | - | | |
| | Tr | 4.4 | | |

<u>Hyrachyus</u> modestus

| | UM | 98734 | | UM | 101075 |
|-----|----|-------|-----|-----|--------|
| P2/ | AP | 10.7 | P/3 | AP | 14.0 |
| | Tr | 13.7 | | Tr. | 8.8 |
| P3/ | AP | 13.7 | M/3 | AP | 23.8 |
| | Tr | 16.5 | | Tra | 15.9 |
| M2/ | AP | 18.4 | | Trp | 14.1 |
| | Tr | 20.6 | | - | |
| M3/ | AP | 19.0* | | | |
| | Tr | 23.0* | | | |

Sciuravus nitidus Marsh, 1871

<u>Holotype</u>: YPM 13333- fragment of left maxillary with M1/-M3/, collected from the lower Bridger Formation (Br2) at Grizzly Buttes, Wyoming.

Material: UM 98659, Fragment of left maxilla containing chipped /P4 and complete /M1, collected at BB013, June 25, 1991. UM 98662, Fragment of left maxilla containing /P3 through /M1, collected at BB013, June 25, 1991. UM 99637- fragment of right dentary containing /M1 through /M3, collected at BB074, June 18, 1992. UM 99918right Mx/ and associated postcrania, collected at BB109, July 20, 1992. UM 101018- left M2/, collected at BB037, August 1, 1993. UM 101031- fragment of left maxilla with P4/ and M1/, collected at BB013, August 1, 1993. UM 101033left /M1, collected at BB013, August 1, 1993.

Remarks: The specimens agree quite closely with the illustrations and descriptions of <u>Sciuravus nitidus</u> given by Wilson (1938) and West (1973). The anterior cingula are well-defined and rather cuspate, a tiny cusp, the metastylid is present near the base of the internal surface of the metaconid. The entoconid of /P4 is less pronounced than the other cusps on the tooth. The posterior cingulum of /M3 is heavier than in the other molars. Tooth measurements of all <u>Sciuravus</u> teeth recovered from the study area are presented in Table 10. The specimens are all well within the size ranges for <u>Sciuravus nitidus</u> reported by West (1973). Korth
(1984) feels that West may have included specimens of the smaller <u>S</u>. <u>wilsoni</u> in his sample since West included specimens collected from the Cathedral Bluffs Tongue of the Wasatch formation. All three specimens exceed the sizes for <u>S</u>. <u>wilsoni</u> reported by Gazin (1962).

Genus Knightomys Gazin, 1961

Type Species: Knightomys senior (Gazin, 1952)

Age and Distribution: Early to middle Eocene (Wal-Br1) of Wyoming, Colorado, and New Mexico.

Knightomys depressus (Loomis, 1907)

<u>Holotype</u>: ACM 432- partial skull with right M1/ to M3/ from the Lysite Member (Wa6) of the Wind River Formation, Wyoming.

<u>Material</u>: **UM 101095**- right M2/, collected at BB110, August 4, 1993. **UM 101098**- right /M3, collected at BB110, August 4, 1993. **UM 101163**- left /M3, collected at BB110, August 20, 1993.

<u>Remarks</u>: Loomis (1907), using several isolated teeth, originally included the species in the genus <u>Sciuravus</u>. Wood (1965) recognized that the skull of the animal was identical to that of the closely related genus <u>Knightomys</u> described by Gazin (1961). Although both genera are found within the study area, their ranges are distinct.

Three isolated teeth, one M2/ and two /M3s have been referred to **Knightomys depressus**. Although all three were collected from the same locality, the variance in tooth wear

. . . . :::: 2::: <u>;</u>::: mi Iet: the iar(viti TILS 2205 size Zeso .ar from tutt. Post away 1011(makes it likely that they are from three different individuals. The metaconid of /M3 is the largest cusp, the other cusps are all relatively the same height, the anterior cingulum is separated from the protoconid and the metaconid. Consistent with the description of Korth (1984) the posterolingual lophid of the mesoconid of /M3 is elongate, and extends back to the posterolophid. A prominent metalophid extends labially from the protoconid, almost to the base of the metaconid. The hypolophid is a slight, barely perceptible ridge on the base of the talonid basin.

The M1/ is essentially square in outline. Consistent with diagrams in Korth (1984), a prominent anterior cingulum runs in an arc from the paracone to the protocone. The protocone is the largest cusp. The other cusps are equal in size, and approximately half as large as the protocone. The mesocone is an independent cuspule rising from the posterior flank of the metacone. The metaconule extends anteriorly from the hypocone towards the centre of the tooth before cutting sharply back to the base of the paracone. The posterior cingulum is reduced in size and is almost worn away. Measurements of specimens **UM 101095**, **UM 101098** and **UM 101163** are presented in Figure 10.

Family Ischyromyidae Alston, 1876 Subfamily Paramyinae Simpson, 1945 Tribe Paramyini Korth, 1984 Genus **Paramys** Leidy, 1871

Age and Distribution: Late Palaeocene (Ti6) to Late Eocene of North America, early Eocene (Neustrian) of Belgium and France.

Type Species: Paramys delicatus Leidy, 1871

Paramys excavatus Loomis, 1907

Holotype: ACM 327- fragment of right dentary with /P4-/M3, collected from the Lysite beds (Wa6) of the Wind River Formation, near Bridger Creek, Wyoming.

Paramys cf. P. excavatus Loomis, 1907

<u>Material</u>: **UM 100889**- right /M1, collected at BB114, July 25, 1993.

<u>Remarks</u>: The metaconid is the largest cusp on the tooth, towering over a tiny trigonid basin and a deep, broad talonid basin. The other cusps are much lower, the entoconid barely higher than the posterior cingulum. A tiny cuspule, the mesoconid, rises from the labial side of the talonid basin. The enamel of the talonid basin is slightly crenulated.

Wood (1962) split <u>Paramys</u> <u>excavatus</u> into four subspecies. Korth (1984) revised this diagnosis restricting the species to <u>P</u>. <u>e</u>. <u>excavatus</u> of Wood (1962). Two of the other subspecies, <u>P</u>. <u>e</u> <u>taurus</u> and <u>P</u>. <u>e</u>. <u>obliquidens</u> were incorporated into a new species, **Paramys** taurus. The fourth subspecies **Paramys e. gardneri** was incorporated into **Thisbemys perditus** Wood, 1962.

UM 100889 agrees well with the type description of Loomis (1907) and the emended diagnosis of Wood (1962) of Paramys excavatus. Although the specimen is closer in size to Paramys excavatus gardneri than any of the other subspecies of <u>P</u>. excavatus described by Wood (1962), morphologically it is closer to <u>P</u>. <u>e</u>. excavatus. The slight crenulations on the surface of the tooth are not considered important enough to warrant inclusion in <u>Thisbemys plicatus</u>. Measurements of this specimen are presented in Table 10.

Genus Leptotomus Matthew, 1910

Age and Distribution: Early middle Eocene (Br1) to early Oligocene (Ch1) of western North America.

Type Species: Leptotomus leptodus Cope, 1873

Remarks: Leptotomus and Paramys are very closely related forms with many characters in common. Matthew (1910) originally established Leptotomus as a subgenus of Paramys. Subsequent workers however have largely ignored this classification. Burke (1934) using specimens obtained from the Duchesne River in Utah, and Wilson (1940) using specimens from the Eocene of California, were the first to accept Leptotomus as a valid genus. Despite the striking similarities between Leptotomus and Paramys, Leptotomus is the most easily differentiated of the paramyid rodents. The lower incisors are oval in cross-section, the apex pointing anteriorly. The enamel, therefore, is on the narrowest side of the tooth, extending onto the lateral surface, almost to the posterior side. This is the reverse of the situation in **Paramys** and the other paramyid rodents, where the enamelled anterior side of the incisor is considerably wider than the posterior side. The cheek teeth of **Leptotomus** are rounder, simpler and have fewer irregularities than those of the other paramyid rodents. The crenulations characteristic of molars of **Paramys** are absent in **Leptotomus** and a ridge, absent in other paramyids, runs from the entoconid across the talonid basin.

Leptotomus parvus Wood, 1959

<u>Material</u>: **UM 98710**- fragment of the right dentary containing /M2 and /M3, incisor groove present, collected at BB073, June 28, 1990. **UM 101030**- fragment of left dentary extending from midway through /M1 to the middle of the ramus including the massentaric fossa, contains /M2-/M3 and the posterior half of /M1, collected at BB013, August 1, 1993.

<u>Remarks</u>: UM 101030 agrees quite closely in size and morphology with the type of <u>Leptotomus parvus</u> described in Wood (1959) and additional specimens reported by Wood (1962). <u>Leptotomus parvus</u> is one of the smaller species of <u>Leptotomus</u>, being only slightly larger than the diminutive <u>L. scuiroides</u> and <u>L. huerfanensis</u>. UM 98710 is closest in size to this <u>Leptotomus parvus</u> than any of the other species of **Leptotomus** measured by Wood (1966). Measurements of specimens **UM 98710** and **UM 101030** are presented in Table 10.

Leptotomus sp. indet.

<u>Material</u>: **UM 99660**- fragment of left maxilla with /P3 and most of /P4, collected at BB103, June 23, 1992.

Remarks: Wood (1962) proposed three informal species groups within Leptotomus. The specimens collected from the study area fall into the smallest species group, consisting of Leptotomus huerfanensis, L. parvus, L. bridgerensis, L. mytonensis, and L. kayi. Wood (1962) felt that with the possible exception of L. huerfanensis this sequence represented a continuous evolutionary series. Based on geography and chronology it is likely that UM 99660 is either Leptotomus huerfanensis or L. parvus, however the specimen is not complete enough to identify to the species level. Measurements of specimen UM 99660 are presented in Table 10.

Fam. gen. et sp. indet.

<u>Material</u>: UM 98577m- isolated incisor, collected at BB037, June 20, 1991. UM 98726- two isolated incisors, collected at BB074, June 29, 1991. UM 101031- two isolated incisors, collected at BB110, July 27, 1992. UM 101101isolated incisor, collected at BB110, August 5, 1993. UM 101015- isolated incisor, collected at BB116, July 31, 1993. UM 101164- /Mx, collected at BB110, August 5, 1993.

Table 10

Measurements (in mm.) of Rodentia

<u>Sciuravus</u> nitidus

| | UM | 98662 | UM | 98659 |
|-----|----|--------|--------|--------|
| P3/ | AP | 0.9 | /P4 AP | 1.8 |
| | Tr | 1.1 | Tr | 2.0 |
| P4/ | AP | 1.5 | /M1 AP | 2.0 |
| | Tr | 2.1 | Tr | 2.1 |
| M1/ | AP | 1.7 | UM | 99637 |
| | Tr | 2.2 | /M1 AP | 2.1 |
| | UM | 99918 | Tr | 2.0 |
| M2/ | AP | 2.1 | /M2 AP | 2.2 |
| | Tr | 2.3 | Tr | 2.2 |
| | UM | 101018 | /M3 AP | 2.7 |
| M2/ | AP | 2.1 | Tr | 2.2 |
| | Tr | 2.3 | UM | 101031 |
| | UM | 101033 | P4/ AP | 1.7 |
| /M1 | AP | 2.0 | Tr | 2.0 |
| | Tr | 2.3 | M1/ AP | 2.1 |
| | | | Tr | 2.3 |
| | | | | |

Knightomys depressus

| M2/ | UM AP Tr | 101095 2.0 2.1 |
|--------------|-----------------------|-----------------------------|
| /M3 | UM AP Tr | 101098 2.2 1.8 |
| / M 3 | UM AP Tr | 101163 2.5 1.9 |

Paramys cf. P. excavatus

| | UM 1 | 00889 |
|-----|----------------|-------|
| /M1 | Ap | 3.2 |
| | Tra | 2.7 |
| | \mathtt{Trp} | 3.1 |

4

| | Tr | 2.3 | | | |
|------------------------------|----|-------|--|--|--|
| Leptotomus sp. indet. | | | | | |
| | UM | 99660 | | | |
| P3/ | AP | 2.2 | | | |
| | Tr | 2.1 | | | |
| P4/ | AP | 3.7 | | | |
| | Tr | 3.9 | | | |

L. cf. L. huerfanensis

| | UM | 98710 |
|-----|----|-------|
| /M2 | AP | 3.5 |
| | Tr | 3.3 |
| /M3 | AP | 4.1 |
| | Tr | 3.3 |

L. Parvus

| | UM | 101030 |
|-----|----|--------|
| /M1 | AP | 3.9* |
| | Tr | 3.6 |
| /M2 | AP | 3.8 |
| | Tr | 3.6 |
| /M3 | AP | 4.6 |
| | Tr | 3.6 |

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Order Incertae Sedis

Suborder Palaeanodonta Matthew, 1918

Remarks: Palaeanodonts are an early Tertiary group of "edentates" of uncertain origin and affinity. Matthew (1918) contended that the Suborder Palaeanodonta was ancestral to living xenarthrans. Simpson (1931) also argued for a close relationship with both the Xenarthra and the Pholidota, but recognized that they are too highly specialized to be directly ancestral. Additional evidence is needed before the precise relationships of the various edentate groups is sorted out.

Family Metacheiromyidae Wortman, 1903

Genus Metacheiromys Wortman, 1903

Age and Distribution: Middle Eccene (Br1-3) of North America, particularly the Bridger Basin of Wyoming.

Type Species: Metacheiromys marshi Wortman, 1903

Metacheiromys sp. indet.

<u>Material</u>: **UM 98573**- third metacarpal, collected at BB037, June 20, 1991. **UM 101037**- ramus and caudal portion of mandibular body of left dentary, collected at BB074, August 1, 1993.

<u>Remarks</u>: As is typical of the posterior portion of jaws of <u>Metacheiromys</u>, specimen UM 101037 does not contain any teeth or alveoli. UM 98573 is typical of the metacarpals of metacheiromyids. Metacarpal III is stouter and longer than the other metacarpals. It is not notched

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ventrally like the other metacarpals. Based on size, both specimens are most likely referable to **Metacheiromys dasypus**, however not enough material is present for a definitive identification.

Age and Distribution: Late Palaeocene (Cf2) to early Eocene (Wa7) of North America and Asia.

Genus Palaeanodon Matthew, 1918

Type Species: Palaeanodon ignavus Matthew, 1918.

<u>Palaeanodon</u> sp. indet.

<u>Material</u>: **UM 100019**- left third metacarpal, collected at BB110, July 27, 1992. **UM 101094**- left third metacarpal, collected at BB110, August 4, 1993.

<u>Remarks</u>: The genus <u>Palaeanodon</u> is represented in the study area by two left third metacarpals. Based on size alone, the specimens are most likely referable to <u>Palaeanodon ignavus</u>, however, the material is insufficient for a specific identification.

Family Epoicotheriidae Simpson, 1927

<u>Remarks</u>: Like palaeanodonts, epoicotheres are uniquely adapted to a digging lifestyle. Specializations of the skull and skeleton indicate they were probably subterranean burrowers (Rose and Emry, 1983).

Genus Tetrapassalus Simpson, 1959

Age and Distribution: Middle Eocene (Br1-Br3) of North America.

Type Species: Tetrapassalus mckennai Simpson, 1959

Tetrapassalus sp.

<u>Material</u>: **UM 99920**- right partial humerus and ulna, collected at BB109, July 21, 1992.

<u>Remarks</u>: The humerus of palaeanodonts is one of the most important diagnostic elements. The humerus of **UM 99920** is shorter and squatter than the humerus of metacheiromyid palaeanodonts. The specimen is smaller than most other epoicotheres, and best fits the size range of <u>Tetrapassalus</u>.

EOCENE BIOSTRATIGRAPHY

Wood <u>et al</u>. (1941) proposed a standardized set of Provincial Land Mammal Ages to subdivide the Cenozoic of North America using characteristic groups of fossil mammals. Eighteen ages defined by characteristic suites of mammals were established, spanning the length of the Cenozoic. These units have served as standards in the attempt to correlate various faunas of similar age scattered across North America. Unfortunately the provincial ages of Wood et al. (1941) were named after lithostratigraphic units. As the faunas of the various ages have become better known, it has become apparent that the land mammal ages are rarely precisely contemporaneous with the lithostratigraphic unit for which the ages were named.

Presently the Eocene Epoch consists of four ages and part of a fifth as defined by Gunnell et al. (1993): Wasatchian, Bridgerian, Uintan, Duchesnean and the early Chadronian. The present paper deals with the strata and faunas spanning the Wasatchian-Bridgerian boundary of southwestern Wyoming, and details two boundaries; the biochronologic Wasatchian-Bridgerian (=Lostcabinian-Gardnerbuttean) boundary, and the lithostratigraphic Wasatch-Green River-Bridger formational boundary. As is shown in Figure 12, the two are not correlative within the study area.

The Wasatchian and Bridgerian Land Mammal Ages have been further subdivided into a series of zones ("subages"). Table 11 presents the Eocene biostratigraphic terminology used in this thesis. As more and larger Palaeogene fossil mammal assemblages are discovered, the relationships between the various subages in the Tertiary Basins of the Rocky Mountain area shall become better understood. In recent years Eocene faunas have become better known and correspondingly the Land-Mammal Age system particularly the Bridgerian has undergone substantial revision.

WASATCHIAN LAND MAMMAL AGE

Hayden (1869) first used the name Wasatch as an informal reference to a series of formations in northeastern Utah and southwestern Wyoming. Granger (1914) subdivided the Wasatchian of the Big Horn Basin into four units: Sand Couleean, Graybullian, Lysitean, and Lostcabinian. This paper utilizes the terminology of Gingerich (1989), who redivided the Wasatchian into eight biostratigraphic zones (Wa0-Wa7). These zones correspond for the most part to Granger's units. This study is concerned primarily with Lysitean (Wa6) and the Lostcabinian (Wa7).

BRIDGERIAN LAND MAMMAL AGE

Matthew (1909) subdivided the Bridger Formation into five units (Bridger A through E). The units were separated lithologically by a series of "white layers", comparatively thick and widespread calcareous ash layers. Although these

were technically lithostratigraphic zonations, Matthew (1909) and many subsequent authors utilized these units as informal biostratigraphic zonations. Wood (1934) felt that while fossil abundance differed greatly between Bridger A and Bridger B deposits, the fauna was basically the same. He combined Bridger A and B into a single unit, the Black's Fork Member, and combined Bridger C and D into the Twin Buttes Member. He did not recognize the Bridger E as a distinct unit. To alleviate confusion, this paper distinguishes between Bridger A, a lithostratigraphic unit and Bridgerian A, a biostratigraphic unit.

Robinson (1966) discovered a new fauna in the Huerfano Valley of Colorado, intermediate in age between Lostcabinian and Bridger A and proposed a new Wasatchian subage, the Gardnerbuttean. Stucky (1984a) reported a similar assemblage from the Wind River Basin. Stucky (1984a) and Krishtalka <u>et al</u>. (1987) included it in the Bridgerian Land-Mammal Age since the fauna has a stronger similarity to Bridgerian than to Lostcabinian faunas. Most recently, Gunnell et al. (1992) proposed revision of the Bridgerian Land-Mammal Age into three subages. These are Br1 (Gardnerbuttean and "Bridgerian A"), Br2 ("Bridgerian B") and Br3 ("Bridgerian C", "Bridgerian D" and "Bridgerian E"). To alleviate confusion and to distinguish between upper and lower Br1, two zones are established. These are Br1.1, (Gardnerbuttean), and Br1.2, (Bridgerian A).

Table 11. North American Early to Middle Eocene Continental Biostratigraphy. Ma indicates millions of years before present and is approximate.

| | <u>NO</u> | RTH AMERICAN LA | ND | <u>Alternate Zone</u> |
|------------------|-----------|-----------------|--------|-----------------------------|
| EPOCH | MA | MAMMAL AGE | ZONE | Terminology |
| | 47.5 | Uintan | Ui1 | Early Uintan |
| | 48.0 | | | |
| | 48.5 | | Br3 | Late Bridgerian |
| | | Bridgerian | Br2 | Middle Bridgerian |
| Е | 49.0 | | | |
| 0 | 49.5 | | Br1 | Early Bridgerian (Br1.2) |
| C | 50.0 | | | Gardnerbuttean |
| C | 50.5 | | | (511:1) |
| E | 51.0 | Wasatchian | | |
| N | 51.5 | | Wa7 | Lostcabinian |
| E | 52.0 | | | |
| | 53.5 | | Wa6 | Lysitean |
| | 54.0 | | | |
| | 54.5 | | tuto E | |
| | 55.0 | | Wab | Late Graybullian |
| | 55.5 | | Wa4 | Middle Graybullian |
| | 56.0 | | | |
| | 56.5 | | Wa3 | Early Graybullian |
| | 57.0 | | Wa1 | Late Sandcouleean |
| | 57.0 | | Wa0 | Early Sandcouleean |
| <u> </u> | 57.5 | | | |
| P A T | 58.0 | Clarkforkian | Cf3 | Late Clarkforkian |
| E | 58.5 | | Cf2 | Middle Clarkforkian |
| C E N E | 59.0 | | Cf1 | Early Clarkforkian |

AGE AND CORRELATION OF THE

LITTLE MUDDY-DESERTION POINT FAUNAS

Most of the vertebrate fossils collected within the study area come from two distinct faunas. The lower assemblage, the Little Muddy local fauna is vertically separated from the upper assemblage, the Desertion Point local fauna by approximately eighty meters of lacustrine sediments. The complete interval above contains, from oldest to youngest, the upper part of the La Barge Member of the Wasatch Formation, the Fontanelle Tongue and lower part of the Wilkins Peak Member of the Green River Formation, and the New Fork Tongue of the Wasatch Formation which bisects the Fontanelle Tongue. Table 12 provides a synopsis of the chronologic ranges of the mammalian taxa from the Desertion Point-Little Muddy area.

Table 12. Chronologic ranges of mammalian taxa within the Little Muddy-Desertion Point area. The lines indicate the known stratigraphic range of each taxon, X's indicate the horizons within the study area from which species have been recovered and ?'s denote questionable occurrences.

| <u>Wa6 Wa7 Br1.1 Br</u> | <u>1.2</u> |
|-------------------------------|------------|
| | v |
| <u>Peratherium</u> X | A |
| P. comstocki | X |
| P. innominatumXXX | X |
| PalaeosinopaXX | |
| P.lutreola ? ?-X-< | |
| PalaeictopsXXX | |
| P.bicuspisX-< | |
| Scenopagus | x |
| <u>S</u> . <u>edenensis</u> > | X |
| <u>S. priscus</u> > | X- |
| ApatemysXX | |
| IgnaciusXX | |
| <u>I. graybullianus</u> X | |

Table 12 (cont'd). WASATCHIAN BRIDGERIAN <u>Wa6</u><u>Wa7</u> <u>Br1.1</u> <u>Br1.2</u> ----X----X-----X---Microsyops ?-X--M. elegans >-X-? M. scottianus ----X-< Cantius ----X-< <u>C</u>.<u>frugivorous</u> ----X-< Copelemur C. australotutus ----X-< -----X-----< Anemorhysis ----< X A. wortmani >----X--Smilodectes >----X--<u>S. mcgrewi</u> >----X--Notharctus >----X--N. robinsoni >-X--Omomys >-X--<u>O. carteri</u> >----X--Washakius >-X--<u>W. insignis</u> Miacis M. latidens >----X-< ----X-----<u>Vulpavus</u> -----X------V. profectus -----X----X----X---Viverravus >----X--<u>V. gracilis</u> -----X-< Meniscotherium ----X-< M. chamense -----X-----X-----X---<u>Hyopsodus</u> >----X--H. minisculus Х H. miticulus >-X-< <u>H. wortmani</u> ----X-< -----< Esthonyx >-X----< E. acutidens **Diacodexis** D. secans <u>Hyracotherium</u> ----? ----X-< H. vasacciense >----X--Orohippus >----X--O. pumilus Lambdotherium >-X-< >-X-< L. popoagacium >-X----X--Palaeosyops P. fontinalis >-X----X-->-X----X--<u>Hyrachyus</u> >-X----X--H. modestus >-X--Seleneletes Knightomys ----X-< K. depressus >----X-< -----X-----Paramys

P. excavatus

-----X-----X------

| | Table | 12 (cont | 'd). | | |
|---------------------------|-------|------------|--------------|--------------|--------------|
| | | WASAT | CHIAN | BRIDG | ERIAN |
| | | <u>Wa6</u> | <u>_Wa7_</u> | <u>Br1.1</u> | <u>Br1.2</u> |
| <u>Sciuravus</u> | | | > | | X |
| <u>S</u> . <u>nitidus</u> | | | | > | X |
| Leptotomus | | | | >-X | X |
| L. parvus | | | | | >-X |
| <u>Palaeanodon</u> | | | X-< | | |
| <u>Metacheiromys</u> | | | | | Х |
| <u>Tetrapassalus</u> | | | | | Х |
| | | | | | |

LITTLE MUDDY LOCAL FAUNA

The little Muddy Local fauna is contained by the La Barge Member of the Wasatch Formation, the lowest stratigraphic interval within the study area. Table 13 presents the vertebrate taxa collected from this level. The stratigraphic relationship of the localities are presented along with the measured sections as Plate 1

TABLE 13

Faunal List of the Little Muddy Local Fauna.

| Level | Locality | Taxon |
|-------|----------|---|
| III | 115, 118 | Lepisosteus sp. indet. Glyptosaurini indet. <u>Peratherium innominatum</u> <u>Esthonyx</u> <u>acutidens</u> |
| II | 114, 116 | Lepisosteus sp. indet. Allognathosuchus sp. indet. Trionychidae indet. Glyptosaurini indet. Microsyops cf. M. scottianus Cantius cf. C. frugivorous Copelemur cf. C. australotutus Meniscotherium sp. Hyopsodus cf. H. wortmani Hyracotherium vasacciense Lambdotherium popoagacium Paramys cf. P. excavatus |

Table 13 (cont'd).

| Level | Locality | Taxon |
|-------|----------|--|
| I | 110 | Lepisosteus sp. indet. Trionychidae indet. Glyptosaurini indet. Xestops cf. X. vagans Amphisbaenia indet. Palaeosinopa cf. P. lutreola Palaeictops bicuspis Ignacius graybullianus Cantius cf. C. frugivorous Anemorhysis cf. A sublettensis Miacis latidens Vulpavus profectus Viverravus sp. Meniscotherium chamense Hyopsodus, cf. H. minisculus Hyopsodus cf. D. secans Hyracotherium vasacciense Knightomys depressus Palaeanodon sp. |

LITTLE MUDDY LOCAL FAUNA, LEVEL I

The lowest horizon containing the Little Muddy local fauna has been designated level I. Fifteen mammalian taxa have been identified from the locality at this level making it the most diverse locality within the study area.

Several of the taxa from level I (Viverravus, Vulpavus profectus, and Diacodexis) are characteristic of both the Wasatchian and the Bridgerian (Stucky, 1984a). The remaining are Wasatchian taxa. <u>Meniscotherium chamense</u> is known primarily from the upper Lysitean of the Piceance Creek and San Juan basins of Colorado, and the Lostcabinian of the Wind River and Green River basins of Wyoming (Gazin, 1965). <u>Knightomys depressus</u> is known from the Lysitean

through the Lostcabinian (Korth, 1984) and possibly the middle Bridgerian (Gunnell et al., 1992).

Miacis latidens is with a few exceptions, limited to the Lostcabinian. Guthrie (1967) reported three specimens of <u>M</u>. <u>latidens</u> from the Lysitean of the Wind River Formation, and Matthew (1915) reported a single tooth from the Graybullian of the Bighorn Basin. <u>M</u>. <u>latidens</u> is only known from the Lostcabinian (Wa7) within the Green River Basin (i.e. West, 1973; Gazin, 1952; 1962).

Two species of Hyopsodus were identified from this level. **Hyopsodus wortmani** is limited to the Lysitean (Wa6) and Lostcabinian (Wa7) (Gazin, 1968; West, 1973; 1979). Hyopsodus miticulus is known only from the Wasatchian (West, 1973; 1979). **Palaeanodon** and **Hyracotherium** are known throughout the Wasatchian (Stucky, 1984a). Several isolated teeth referred to Cantius frugivorous were identified from this horizon. This notharctine primate is known primarily from the middle Wasatchian (Graybullian) of western North America (Beard, 1988). Palaeictops bicuspis is known throughout the Wasatchian, and is a particularly common insectivore in the Wind River Lostcabinian (Guthrie, 1971). **Palaeosinopa lutreola** is known primarily from the Graybullian (Wa3-5) of the Bighorn Basin (Bown and Schankler, 1982). Specimens previously referred to this species by Guthrie (1971) fall out of the size range of this taxon and are likely referable to **P**. **incerta** or **P**.

didelphoides (Bown and Schankler, 1982). **Anemorhysis wortmani** is unknown outside of the Graybullian of the Bighorn Basin (Bown and Rose, 1984) possibly due to its extreme rarity. **Ignacius graybullianus**, the only early Eocene member of the genus, is also known only from the Graybullian of the Bighorn Basin (Bown and Rose, 1976).

Based primarily on the presence of <u>Miacis latidens</u> and <u>Meniscotherium chamense</u>, the Little Muddy local fauna, level I is tentatively referred to the Lostcabinian. While it is recognized that these taxa are known from older deposits elsewhere, within the Green River Basin they are known only from Lostcabinian strata. Additional field work may reveal that this level is actually Lysitean in age. The age and geographic range of <u>Palaeosinopa</u> cf. <u>P. lutreola</u>,

Anemorhysis wortmani and Ignacius graybullianus are extended to include the Lostcabinian (or possibly Lysitean) of the southwestern Green River Basin.

LITTLE MUDDY LOCAL FAUNA, LEVEL II

The only common elements between levels I and II (see below) are <u>Cantius</u> cf. <u>C</u>. <u>frugivorous</u>, <u>Meniscotherium</u>, and <u>Hyracotherium vasacciense</u>, taxa previously known from the middle to late Wasatchian (Beard, 1988; Kitts, 1956; Stucky, 1984b). The most diagnostic taxon in level II is <u>Lambdotherium popoagacium</u>, a species long considered the index fossil for the Lostcabinian (Granger, 1914; Stucky, 1984a; 1984b). <u>Paramys excavatus</u> is known only from the Lysitean (Wa6) and Lostcabinian (Korth, 1992). Two specimens of **<u>Copelemur</u>** cf. <u>C</u>. <u>australotutus</u> have been identified from this level. Beard (1988) erected this species on two specimens collected in the vicinity of Fossil Butte in southwestern Wyoming. There is some conjecture as to the precise age of these strata, although they are considered Wasatchian (Gazin, 1962; Beard, 1988). A single /M3 of **Cantius** cf. **C. frugivorous**, a Graybullian (Wa3-5) taxon (see above), was collected from locality BB114. Fragments of Meniscotherium teeth were scattered over a large portion of Locality BB114. Meniscotherium is common from the Late Palaeocene (Cf2) of the Bighorn Basin and Alberta, to the Lostcabinian of the Washakie, Wind River, and Green River basins (Gazin, 1965; Stucky, 1984b). Microsyops scottianus is known from the Lostcabinian (Wa7) and possibly, the Gardnerbuttean (Br1.1; Gunnell, 1989).

Level II is similar in most respects to the La Barge fauna of Gazin (1952, 1962). It correlates with the **Lambdotherium** Range Zone of Stucky (1984a), the Wapiti II fauna of Gunnell <u>et al</u>. (1992), the Lost Cabin beds of the Bighorn Basin of Schankler (1980), and the lower Huerfano of Robinson (1966). The occurrence of **Cantius** cf. <u>C</u>.

frugivorous with **Lambdotherium** suggests that this taxon survived longer in the Green River Basin than elsewhere in western North America. Level II is clearly Lostcabinian (Wa7) in age. LITTLE MUDDY LOCAL FAUNA, LEVEL III

Two mammalian taxa have been identified from Little Muddy level III. **Peratherium innominatum** is known from the early Wasatchian through the Duchesnean of the Rocky Mountain region (Krishtalka and Stucky, 1983). **Esthonyx acutidens** is, with the exception of a single specimen from the Gardnerbuttean of the Huerfano Basin (Mckenna, 1976), known only from the Lostcabinian (Gingerich and Gunnell, 1979). All **E**. **acutidens** identified within the Green River Basin has been reported from Lostcabinian localities (West, 1973; Gazin, 1962). Based on this, Little Muddy local fauna level III is tentatively referred to the Lostcabinian.

DESERTION POINT LOCAL FAUNA

The Desertion Point local fauna was collected from the Whiskey Butte Bed of the Bridger Formation, the Craven Creek Bed of the Laney Member of the Green River Formation, and the upper portion of the Upper Member of the Wasatch Formation. Table 14 presents the vertebrate taxa collected from this level. The stratigraphic relationship of the localities is presented along with the measured sections as Plate 1.

DESERTION POINT LOCAL FAUNA LEVEL I

Similar to the Wapiti IV local fauna of Gunnell et al. (1992), level I is comprised of a single species, **<u>Hyrachyus</u>**

TABLE 14

Faunal List of the Desertion Point Local Fauna.

| Level | Locality | Taxon |
|-------|----------------|---|
| V | 35, 37, 38, 44 | Lepisosteus sp. indet. Amia sp. indet. Echmatemys sp. indet. Echmatemys septaria Anosteira ornata Alligatoridae indet. Allognathosuchus sp. indet. Diplocynodon sp. indet. Diplocynodon sp. indet. Crocodylus affinis Pristichampsus Glyptosaurini indet. Xestops sp. indet. Calamagras primus Peratherium comstocki P. innominatum cf. Apatemys sp. indet. Scenopagus edenensis S. priscus Notharctus robinsoni Smilodectes mcgrewi Washakius insignis Viverravus gracilis Byrachyus modestus Sciuravus nitidus Metacheiromys |

•

Table 14 (cont'd).

| Level | Locality | Taxon |
|-------|---|---|
| IV | 12, 19, 36 69, 70, 74 76, 77, 109 | Lepisosteus cuneatus Lepisosteus sp. indet. Amia sp. indet. Ictaluridae sp. indet. Baena arenosa Echmatemys septaria Echmatemys septaria Echmatemys sp. indet. Cf. Platypeltis sp. indet. Baptemys fluviatalis Baptemys sp. indet. Alligatoridae indet. Alligatoridae indet. Alligathosuchus sp. indet. Diplocynodon sp. indet. Crocodylus affinis Pristichampsus Glyptosaurini indet. Glyptosaurini indet. Glyptosaurus sylvestris Xestops sp. indet. Peratherium innominatum Microsyops elegans Smilodectes sp. Notharctus robinsoni Omomys cf. Q. carteri cf. Orohippus pumilus Palaeosyops cf. P. fontinalis Hyrachyus modestus Sciuravus nitidus; Metacheiromys sp. Tetrapassalus sp. |

Table 14 (cont'd).

| Level | Locality | | Taxon |
|-------|-----------------------|----------------------------------|---|
| III | 13, 13w, 75 | | Lepisosteus cuneatus Lepisosteus sp. indet. Amia sp. indet. Ictaluridae indet. Baena arenosa Echmatemys septaria Echmatemys sp. indet. Baptemys fluviatalis Baptemys sp. indet. Allognathosuchus sp. indet. Crocodylidae indet. Crocodylidae indet. Crocodylus affinis Parasauromalus olseni Glyptosaurini indet. Xestops. sp. indet. Microsyops elegans Eyopsodus cf. H. minisculus Orohippus sp. Seleneletes sp. Sciuravus nitidus Leptotomus parvus |
| II | 14, 51, 9 97, 103, | 96 <u>1</u> 104 <u>F</u> G | Lepisosteus sp. indet. Echmatemys cf. E. cibollensis Baptemys sp. indet. Glyptosaurini indet. Palaeosyops cf. P. fontinalis Leptotomus sp. |
| I | 117 | E | <u>Byrachyus</u> <u>modestus</u> |

modestus. **Evrachyus** is known from the earliest Bridgerian to well into the Uintan (Radinsky, 1967; Stucky, 1984b; Woodburne, 1987). West (1973) reported both **Evrachyus** and **Lambdotherium** from a single locality that spans over sixty meters of stratigraphic section. It is uncertain if the two taxa came from the same horizon. Until conclusive evidence of overlap in the ranges of **Lambdotherium** and **Evrachyus** is provided, **Evrachyus** can be retained as a diagnostic Bridgerian taxon. Level I is interpreted as Gardnerbuttean based on the presence of **Evrachyus modestus**, and its stratigraphic position (see Level III below). DESERTION POINT LOCAL FAUNA, LEVEL II

Two mammalian taxa have been identified from Level II, Leptotomus sp., and Palaeosyops cf. P. fontinalis. P. fontinalis is indicative of an early Bridgerian (Br1) designation (Gunnell and Bartels, in press; Gunnell et al., 1992). Leptotomus is first recognized from the Gardnerbuttean (Korth, 1984; Stucky, 1984b).

Echmatemys is a common element in Desertion Point local fauna levels III through V. The two species known from these levels, **E**. **septaria**, and **E**. **wyomingensis** are unknown from the lower levels, including II. A single specimen of the poorly known emydid **Echmatemys** cf. **E**. **cibollensis** was collected from level II. This taxon is not present however in the substantial collection of lower vertebrates collected from higher levels within the study area. Further study may confirm that the presence of <u>E</u>. <u>cibollensis</u> is indicative of pre-Bridgerian A deposition. Level II is interpreted as early Gardnerbuttean based on the fauna of the overlying level III (see below).

DESERTION POINT LOCAL FAUNA, LEVEL III

Six mammalian taxa have identified from level III. All are indicative of the early Bridgerian. <u>Sciuravus nitidus</u> first appears in the Gardnerbuttean and is common throughout the Bridgerian (West, 1973). <u>Microsyops elegans</u> is known from the middle Bridgerian of southwestern Wyoming (Gunnell, 1989). A single specimen from the Gardnerbuttean of the Willwood Formation of Wapiti Valley (Gunnell et al., 1992) and several specimens from the Bridger A and B of the Aycross Formation of Hot Springs and Park County (Bown, 1982; Gunnell, 1989; Gunnell et al. 1992) have been referred to M. elegans.

The taxa from this level are indicative of the early Bridgerian (Br1). It is difficult to assign this level to either the Bridgerian A or to the Gardnerbuttean with the available information. <u>Selenaletes</u> is poorly known, the only specimens of known provenance outside the study area were collected from the Gardnerbuttean (Br1.1) <u>Palaeosyops</u> borealis Zone of Stucky (1984a; 1984b). <u>Evopsodus</u> minisculus and <u>Orohippus</u> are common Bridgerian taxa. <u>Orohippus</u> is also known from the late Wasatchian (Korth and Evander, 1982; Stucky, 1984a; 1984b). <u>Leptotomus parvus</u> is

known from the upper Huerfano Formation (Gardnerbuttean; Robinson, 1966) and is common throughout the middle Bridgerian of the Green River Basin.

Based primarily on the presence of **Seleneletes**, Level III is interpreted as Gardnerbuttean (Br1.1). The geographic range of **Seleneletes** is extended to include the southwestern Green River Basin.

DESERTION POINT LOCAL FAUNA, LEVEL IV

Omomys carteri and **Washakius insignis** are first known from the Bridger A of the southwestern Green River Basin (Gunnell, pers. comm.), and range through the end of the Bridgerian in this area. **Notharctus robinsoni** is known only from the early Bridgerian of the Green River, Huerfano, and possibly the Bighorn basins (Gingerich, 1979). **Orohippus pumilus** is known from the lower (McGrew and Sullivan, 1970) and middle Bridgerian (Gazin, 1976) of the Bridger Basin, and from the Gardnerbuttean Aycross Formation of the Wind River Basin (Stucky, 1984b). **Tetrapassalus** is known from the middle Bridgerian of the Bridger Basin (Stucky, 1984a). **Smilodectes** is known throughout the Bridgerian of North America.

Based primarily on the co-occurrence of **Notharctus robinsoni** and **Omomys carteri**, level IV is interpreted as Bridger A (Br1.2). The known range of **Tetrapassalus** is extended to include the early Bridgerian.

DESERTION POINT LOCAL FAUNA, LEVEL V

Level V is the highest interval within the study area. Seven mammalian taxa not found in any of the lower intervals have been identified from level V. Two species of Scenopagus, S. priscus, and S. edenensis are found at this level. Both of these species are known from the Bridgerian A (Br1.1) of the northeastern Green River Basin (West, 1973), the Gardnerbuttean (Br1.2) of the Huerfano Basin (Robinson, 1966), and the middle Bridgerian (Br2) of the southern and eastern Green River Basin (McGrew, 1959). **Viverravus gracilis** is a common taxon in the early and middle Eccene of the Rocky Mountain region (West, 1973). **Peratherium** comstocki is common throughout the early and middle Eocene of Wyoming, Colorado, New Mexico, and Texas (Krishtalka and Stucky, 1983). Smilodectes mcgrewi is known from the Gardnerbuttean of the Huerfano Basin and the Bridgerian A of the Green River Basin (Gingerich, 1979). Metacheiromys is known from the early and middle Bridgerian (Br1-Br2) of the southwestern Green River Basin (Gunnell and Bartels, in press; Stucky, 1984a). Washakius insignis is known primarily from Bridgerian A (Br1.2) and Bridgerian B (Br2) within the Green River Basin (Gunnell, in prep.). Based primarily on the co-occurrence of **Smilodectes** mcgrewi, Washakius insignis, and Scenopagus, Level V is referred to Bridgerian A (Br1.2).

STRUCTURAL AND SEDIMENTARY HISTORY

The Green River Basin (Figure 1) is bounded by Laramide uplifts and mountain systems to the south east and north. The basin is filled with approximately 3,000 meters of Tertiary strata (Blackstone, 1955; Sullivan, 1980). Laramide tectonism commenced in the Late Cretaceous, and although some movement continued through the end of the Eocene (Chadronean), it was effectively completed in the Early Eocene (Wasatchian, Lillegraven, 1992). The west margin of the study area is formed by the Wyoming Overthrust Belt, a complex of thrust fault mountains. Initial movement began in the early Mesozoic (Rubey, 1955) with major deformation continuing (locally) into the early middle Eocene (Andermann, 1955).

Formation of the Green River Basin commenced in the Late Cretaceous with initial downwarping initiated by Laramide tectonism and augmented by sedimentary loading from the Overthrust Belt (Shuster and Steidtmann, 1988). Subsidence continued well into the Tertiary (West, 1976).

The sedimentary history of the early to late Eocene of the Green River Basin centres around the multiple regressions and transgressions of Eocene Lake Gosiute, a large shallow lake that occupied the centre of the basin. The deposits of this lake, now represented by the Green River Formation, is one of the largest accumulations of lacustrine sedimentary rocks in the world (Grande, 1984).

Lake Gosiute is currently thought to have been a playa lake complex (Surdam and Wolfbauer, 1975). Lake Gosiute was set in the centre of a large, relatively flat intermontane plain. The abundance of fine-grained material extending from the center to the periphery of the basin indicates that "the original dip (gradient) probably did not exceed 1 or 2 feet per mile except in a rather narrow belt adjacent to the mountains" (Bradley, 1964 p. A16). Minor fluctuations in water depth would therefore have resulted in the extensive inundation of the lowlands adjacent to the lake.

In periods of drought the lake became quite restricted and likely very saline (Surdam and Wolfbauer, 1975; Grande, 1984). The lake was eutrophic (characterized by abundant organic material and a seasonal oxygen deficiency in the lowest layers, usually shallow) as is evidenced by the abundant organic mudstones, oilshales and periodically extensive algal limestones produced at different stages in its history (Surdam and Wolfbauer 1975).

Lake Gosiute likely began as a system of small lakes, swamps and ponds on the subsiding Wasatch Plain (Surdam and Wolfbauer, 1975). Expansion of the lake throughout most of the Bridger Basin is signified by the Luman Tongue of the Green River Formation, which does not crop out within the study area. A major regression of the lake is represented by the fluviatile red-bed deposits of the La Barge Member of the Wasatch Formation. Figure 18 shows the relationship of

Figure 18. Correlation chart of lithostratigraphy, fossil vertebrate localities, faunal levels, and biostratigraphy. DPLF denotes Desertion Point local fauna, LMLF denotes Little Muddy local fauna.


Figure 18

the lithostratigraphy, biostratigraphy, and fossil vertebrate localities within the study area. The sediment that comprises the La Barge Member is derived from active faulting in the Overthrust Belt west of the study area (Lawrence, 1965). The Little Muddy local fauna (see above, Table 13) is found entirely within the La Barge Member.

The thick gastropodal limestone at the base of the Fontanelle Tongue represents another major transgression of Lake Gosiute. The absence of stromatolites in this unit may indicate that the transgression was rapid (Lawrence, 1965). The abundance of <u>Goniobasis tenera</u> in this layer may indicate that much of unit was deposited in the littoral zone (Hanley, 1976). Fragmented elements of fish are also common in this layer. Surdam and Wolfbauer (1975) consider the Fontanelle Tongue representative of a maximum stand of Lake Gosiute.

The overlying Wilkins Peak Member is characterized by organic rich mudstones interbedded with algal limestones. At this time the lake vacillated from freshwater to hypersaline conditions as is indicated by the abundant interbedded stromatolitic limestones and organic shales (Surdam and Wolfbauer, 1975). Hypersaline water and the absence of aquatic grazers are essential for the preservation of cryptalgal structures (Logan et al., 1974; Surdam and Wolfbauer, 1975). Chemically enriched water may

explain the absence of fossil vertebrates, even fish, within most of this layer.

Periodically, during the deposition of the Wilkins Peak Member, the lake retreated far enough for the study area to be exposed. This is evidenced by mudcracks in many of the shales overlying the stromatolitic layers (Surdam and Wolfbauer, 1975). The presence of **Hyrachyus modestus**, a tapiroid perissodactyl, at locality BB117 near the base of the Wilkins Peak Member is additional evidence that the study area was exposed at this time.

Evrachvus is also indicative of Bridgerian deposition. The presence of a Bridgerian index taxon in strata immediately above, and Wasatchian taxa below the lacustrine beds of the Fontanelle Tongue indicates that the Wasatchian-Bridgerian boundary is obscured within the Bridger Basin by a major transgression of Lake Gosiute. This single specimen of **Evrachvus** along with several unidentifiable turtle fragments constitutes Desertion Point local fauna level I. The presence of diagnostic Bridgerian taxa over 200 meters below the base of the Bridger Formation clearly shows that the Wasatchian-Bridgerian biostratigraphic boundary is not correlative with the Wasatch-Bridger lithostartigraphic boundary in the southwestern Green River Basin, the type area of both of these Land Mammal Ages.

Major tectonic activity in both the Overthrust Belt to the west and in the Wind River Mountains to the northeast

supplied the sediment for the litharenites of the New Fork Tongue which interbed with the lacustrine strata of the Wilkens Peak Member (Lawrence, 1965). The intertongueing of the fluvial beds of the New Fork Tongue and the lacustrine beds of the Wilkens Peak Member may indicate that the New Fork Tongue represents a delta (Lawrence, 1965).

Renewed tectonic activity of the Uinta Mountains to the south resulted in the deposition of the fluviatile beds of the Upper Member of the Wasatch Formation (Lawrence, 1965). The interbedded red-gray fluviatile deposits of the Wasatch Formation may indicate periodic inundation followed by desiccation and an interval of non-deposition, allowing for <u>in situ</u> oxidation of the iron-rich sediments (Braunagel and Stanley, 1977; Roehler, 1965). Shorter periods of desiccation and non-deposition resulted in the predominance of mottled red mudstones with thin, discontinuous algal limestones and thick channel sandstones in the lower part of the Upper Member indicating a terrigenous environment more proximal to the shore of Lake Gosiute than in the upper part. Only a few vertebrate fossils have been recovered from the lower part of the Upper Member of the Wasatch Formation. Of these fossils, only a single specimen of Echmatemys cf. E. cibollensis has been identified. All other fossils, mammals and reptiles alike, are characterized by a high degree of post-depositional corrosion. Desertion

Point local fauna level II was collected from the lower **Half of the Upper Member of the Wasatch Formation**.

The less mottled, more colourful mudstones of the upper part of the Upper Member were deposited in a better drained fluvial environment. While few fossils have been identified from most of these layers, they are typically much better preserved than specimens from the lower part of this unit. The mudstones at the top of the Upper Member of the Wasatch Formation have produced a small but diverse and diagnostic assemblage of fossil vertebrates designated Desertion Point l ocal fauna level III (Table 14).

The upper boundary of the Upper Member of the Wasatch Formation signals another transgression of Lake Gosiute. These deposits have been termed the Craven Creek Bed of the Laney Member of the Green River Formation (Sullivan, 1980). Within the study area, this transgression coincides with a major deposit of ash, likely from the Absaroka volcanic field in the northwest corner of Wyoming. This ash deposit buried large amounts of organic material preventing rotting, and resulting in the tuffaceous lignitic mudstone which marks the upper boundary of the Wasatch Formation within the field area. Many of the specimens incorporated into Desertion Point local fauna level IV were collected at the top of this tuffaceous lignite. The interbedded lignites, grad e oil shales and cross-bedded channel sandstones

indicate that the Craven Creek Bed is a mixture of lacustrine, paludal, and fluviatile deposition (Roehler, **1965**). The presence of both fluvial taxa such as glyptosaurine lizards, Anosteira, Allognathosuchus, and perhaps **Baptemys fluviatalis** and lake to lake-margin taxa Such as Crocodylus, Baena arenosa, and possibly Amyda from this layer also suggest frequent environmental turnover. The last major event in the study area was the regression of **I**_ake Gosiute, resulting in deposition of the fluviatile deposits of the Whiskey Butte Bed of the Bridger Formation. As is indicated by the light gray to gray-green mudstones and siltstones, the Whiskey Butte Bed was deposited in the 1 owlands adjacent to the lake. The greenish tinge in most of the mudstones is indicative of the reduction of iron in poorly drained conditions (Roehler, 1965). Desertion Point **local** fauna level V was collected from the Whiskey Butte bed.

PALEOENVIRONMENTS AND PALEOECOLOGY

The following comprises a brief interpretation of the **pale**ocology and paleoenvironments of the various lithologies **with**in the study area. Interpretations of paleogene **pale**oenvironments generally utilize floral remains rather **than** terrestrial vertebrates since many plant genera and **fami**lies present in the Paleogene are still alive today

while vertebrate (particularly mammalian) generic and **familial turnover rates are comparatively rapid**.

PALEOBOTANY AND GENERAL PALEOECOLOGY

Although the paleobotany of the Green River Formation of Utah and Colorado is well known, collections from the Green River Basin (ex. Hayden, 1871; Lesquereaux, 1878; 1883; Newberry, 1883; 1898, and Knowlton, 1923) have little Stratigraphic or geographic control. These collections do rot appear markedly different in composition than collections from the Uinta Basin (MacGinite, 1969). Plant macrofossils from the study area are limited to fragments of permineralized wood, carbonized root traces in many of the mudstones, fragmented plant debris in the lignitic ash layer at the base of the Craven Creek Bed of the Laney Member of the Green River Formation, and a single hackberry seed (Genus <u>Celtis</u>) from the La Barge Member of the Wasatch Formation.

Based on floral analysis of the Green River Formation in the Uinta Basin of northeastern Utah and northwestern Colorado, MacGinite (1969) suggested a warm temperate to subtropical environment with savannah type vegetation conditions proximal to the lake and subhumid shrub to open forest conditions at slightly higher altitudes. Precipitation was highly seasonal with abundant rainfall in the spring and drought conditions in the fall (MacGinite, 1969). Annual precipitation was 24-34 inches (60-85cm) at

lake level, and 38 inches (95cm) in the surrounding uplands
(Bradley, 1963). Based primarily on the distribution of
Eccene volcanic ash deposits, prevalent wind direction is
thought to have been from the north (Clark et al, 1967).

The size of Eocene Lake Gosiute would have had a strong effect on the climate of the Green River Basin. During high stands of the lake, it is probable that the local climate was comparatively equitable, with more moderate high and low temperatures, and higher humidity. When the lake was more restricted in size, annual temperatures reached greater extremes and humidity was lower. It is uncertain to what extent this climatic variance affected faunal composition.

PALEOECOLOGY- LITTLE MUDDY LOCAL FAUNA

The La Barge Member of the Wasatch Formation was deposited in drier times than the overlying strata within the study area. Lake Gosiute was restricted to the centre of the Green River Basin, far to the east of the study area. The Little Muddy local fauna, derived exclusively from this layer, was dominated by adapid primates and condylarths.

While adapid primates are comparably common throughout the study area, condylarths are almost nonexistent in the overlying Wasatch and Green River formations. Two condylarthan genera have been identified from the La Barge Member. Most authors (ex. Gazin , 1965; Simpson, 1948) conditionation (ex. Gazin , 1965; Simpson, 1948) condition (ex. Gazin , 1968) condition (ex. Gazin (ex. Gazin , 1968) condition (ex. Gazin (ex. Gazin) condition (ex. Gazin (ex. Gazin) condition (ex. Gazin) cond

consider **Hyopsodus** diagnostic of any particular environment, it appears that this small condylarth may have some paleoecologic significance. **<u>Hyopsodus</u>** is among the most common mammalian taxa collected from the Bridgerian B (Br2) of the southwestern Green River Basin (West, 1979), and from the late Wasatchian of the western Green River Basin (Gazin, **1**952; 1962). While it remains an important constituent during the Bridgerian A (Br1.2) of this area (Gunnell and Bartels , in press), it is less evenly distributed than in earlier and later times (Gunnell, pers. comm.). Although the exact environmental or ecologic reason is uncertain, preliminary comparison of localities where it is common and those where it is not may indicate a preference for drier **locales** such as open forest or savannah (Gunnell, pers. **comm.**). This is consistent with the conclusions of Pledge (1969) and analysis of the distribution of **Hyopsodus** within the study area. The artiodactyl Diacodexis, and the perissodactyls Lambdotherium and Hyracotherium comprise the **balance** of the ungulate taxa. The comparative scarcity of $\mathbf{perissodactyls}$ and plethora of condylarths, in both overall abundance and taxonomic diversity, in the Little Muddy local faura may reflect incompatible habitat preference. The condylarths preferred drier, more open country; the peri sodactyls favoured the swampy woodlands adjacent to the shores of Lake Gosiute and the myriad streams and ponds on its periphery.

The Little Muddy local fauna is also characterized by an abundance of arboreal and semi-arboreal taxa such as the insectivores <u>Palaeosinopa</u> and <u>Palaeictops</u>, the marsupial <u>Peratherium</u>, the proprimates <u>Ignacius</u> and <u>Microsyops</u>, and the primates <u>Cantius</u>, <u>Copelemur</u>, and <u>Anemorhysis</u>. Fossorial taxa such as the edentate <u>Palaeanodon</u>, the tillodont <u>Esthonyx</u>, and an indeterminate amphisbaenid are also present.

A single hackberry seed (Genus <u>Celtis</u>) was recovered from Little Muddy local fauna level I. <u>Celtis</u> prospers in dry conditions and is intolerant of shade (Taggart, pers. comm.), suggesting an open forest or savannalike environment The occurrence of the gastropods <u>Oreoconus</u> and <u>Holospira</u> indicate standing water in the form of marshes and small **ponds** (Hanley, 1976). Abundant remains of trionychid turtles, especially <u>Aspiderites</u>, glyptosaurine lizards and teeth of the alligator <u>Allognathosuchus</u> are indicative of a **fluviatile** environment (Bartels, 1993).

Overall, the Little Muddy local fauna occupied a warm, comparably dry setting, distal to the shores of Lake Gosiute. Extensive open forests were present on a welldrained substrate as is evidenced by the presence of diverse fossorial and arboreal taxa and abundant fragments of Permineralized wood.

PALEOECOLOGY- DESERTION POINT LOCAL FAUNA

As indicated above, few fossils have been collected from the thick sequence of sediments separating the La Barge Member of the Wasatch Formation in the west, and the upper part of the Upper Member of the Wasatch Formation in the east. The Fontenelle Tongue and Wilkens Peak Member of the Green River Formation represent frequent, minor lake incursions (see above), indicating a net increase average annual rainfall. The lower part of the Upper Member of the Wasatch Formation was characterized by a dominance of terrigenous conditions, although sedimentation was more frequent and the substrate less well-drained than in the La Barge Member and the upper part of the Upper Member of the Wasatch Formation. Little can be said about the local environment at this time.

The upper part of the Upper Member, the Craven Creek Bed of the Green River Formation, and the Whiskey Butte Bed of the Bridger Formation represent frequent vacillation between terrigenous and lacustrine dominated conditions. The abundance of aquatic and amphibious taxa from the upper layers of the Upper Member of the Wasatch Formation and the Craven Creek Bed of the Laney Member of the Green River Formation indicates the close proximity of the shoreline of Lake Gosiute. Turtles and crocodiles are represented by many large, diverse forms. Fish are common and also reached large sizes. Although only three taxa have been identified,

it is possible, indeed likely, that many forms existed since teleosts are difficult to identify with only fragmentary remains.

Most of the turtle specimens collected within the study area were comprised solely of carapace and plastron elements. Few specimens, even those with articulated shells, possessed any associated limb or cranial material. Most likely, with subsidence of **rigor mortis** and the relaxation of striated skeletal muscle, the head and the limbs were extended out from the body. As decomposition continued, small scavengers were attracted and initiated mechanical destruction of the corpse. Birds and most other carrion-eaters were limited to portions that could be removed through the front or back openings of the shell. Although bird fossils have not yet been identified from the study area, Grande (1984) reported several fine specimens $f_{\mathbf{r}}$ om fossil quarries in the Green River Formation elsewhere in the Green River Basin, and indicated that footprints of a quatic waterfowl are not uncommon. Scavenging arthropods **1 i k**ely completed the removal of soft tissue, in most cases without seriously damaging the carapace or plastron. Scavengers turning dead individuals on their backs for easier access to shell openings may explain why most turtles were found lying plastron up.

The presence of abundant pulmonate gastropods such as **Physea**, and **Biomphlaria**, are indicative of poorly drained

marshy wetlands (Hanley, 1977). Fossorial taxa such as the edentates Metacheiromys and Tetrapassalus and arboreal taxa such as the primates Omomys, Notharctus, and Smilodectes, the proprimate Microsyops, and the marsupial Peratherium along with abundant specimens of the anguid lizard Glyptosaurus combined with the plethora of large aquatic and amphibious taxa indicate well-developed forests in close proximity to Lake Gosiute. Abundant localized lignitic and organic mudstone deposits interspersed with a plethora of small channel sandstones indicates a frequently flooded, heavily forested environment, with abundant swamps, ponds, and streams on the lowlands at the edge of Lake Gosiute.

The lower Bridger Formation represents a return to predominantly terrigenous conditions, This is confirmed by the abundance of terrestrial taxa such as edentates

(<u>Metacheiromys</u>), insectivores (<u>Scenopagus</u> and <u>Apatemys</u>), marsupials (<u>Peratherium</u>), primates (<u>Notharctus</u>, <u>Smilodectes</u>, and <u>Washakius</u>), and squamates (<u>Xestops</u> and the boid <u>Calamagras</u>). Comparatively short lake incursions allowed for the invasion of aquatic taxa such as <u>Lepisosteus</u> and <u>amia</u>, and amphibious taxa such as the larger crocodilians.

The co-occurrence of the insectivores <u>Scenopagus</u> (two Species), and <u>Apatemys</u>, the marsupial <u>Peratherium</u> (two Species), the primates <u>Notharctus</u>, <u>Smilodectes</u>, and <u>Washakius</u>, the only snake from the study area, <u>Calamagras</u> <u>Primus</u>, and the lizard <u>Xestops</u> are indicative of a

terrestrial habitat. The presence of <u>Baena arenosa</u>, and possibly <u>Amyda</u> are also suggestive of the lowlands proximal to Lake Gosiute. Abundant fossil logs indicate welldeveloped forests in the lowlands. This fits well with Gunnell and Bartels' (in press) interpretation of a humid, closed, heavily forested environment with abundant swamps, small ponds and meandering streams proximal to the shore of Lake Gosiute.

Overall, the Desertion Point local fauna occupied a warm, comparably moist environment, proximal to the shores of Eocene Lake Gosiute. Interbedded lignites, channel sands, and lacustrine muds along with a mixture of aquatic, amphibious and terrigenous taxa indicate frequent environmental turnover caused by minor fluctuations in the level of Lake Gosiute. Abundant fossilized logs at the base of the Bridger Formation indicate extensive forests in the lowlands adjacent to the lake.

DISCUSSION AND SUMMARY

The Wasatchian-Bridgerian boundary is best known from the Huerfano Basin (Robinson, 1966), the Wind River Basin (Stucky, 1984a; 1984b), the Bighorn Basin (Bown, 1982; Gunnell et al. 1992) and the northeastern Green River Basin (West, 1973; West and Dawson, 1973). In most cases, the boundary is marked by a transition zone, combining characteristic taxa of both the latest Wasatchian (Wa7) and the earliest Bridgerian (Br1).

The present study has shown that within the Southwestern Green River Basin the Wasatchian-Bridgerian boundary is represented by about eighty meters of essentially unfossiliferous lacustrine sediments that reflect the intrusion and recession of Eocene Lake Gosiute. This interval saw considerable change in the vertebrate fauna of the area. The following paragraphs incorporate these new data with previous studies of the region.

Stucky (1984b) established two distinct faunal zones above and below the boundary. The lowest, the Lambdotherium range zone is Lostcabinian in age. The upper he termed the **Palaeosyops** (=**Eotitanops**) borealis range zone (also marked by the appearance of **<u>Hyrachyus</u>**). In the Wind River and Huerfano basins these two faunas do not overlap. West (1973) reported Hyrachyus and Lambdotherium from one 1 Ocality, and Palaeosyops borealis and Lambdotherium from another locality in the northwestern Green River Basin. **Bo**th localities represent approximately 60 meters of s tratigraphic section however and it is not known where in **the** section any of the fossils were collected. Additional evidence is needed before <u>Hyrachyus</u> and <u>Palaeosyops</u> can be **Considered** contemporaneous taxa of <u>Lambdotherium</u>. The Wapiti II local fauna of Gunnell et al. (1992) contains both Landotherium and Ectitanops borealis and is the only place

where these two animals are known to co-exist. This may indicate that either the Wapiti II local fauna is slightly Younger than Lostcabinian localities elsewhere or that basin margin faunas differ from central basin faunas (Gunnell <u>et</u> <u>al</u>., 1992). Within the field area, specimens of <u>Lambdotherium</u> and <u>Byrachyus</u> were collected from localities separated by more than 100 meters of stratigraphic section. <u>Palaeosyops</u> is first known from approximately 120 meters above <u>Byrachyus</u>.

Unlike the classic Gardnerbuttean (Br1.1) in the Huerfano Basin (Robinson, 1966) and the <u>Palaeosyops borealis</u> assemblage zone of the Wind River Basin (Stucky, 1984b), strata assigned to the Gardnerbuttean within the study area are characterized by an absence of Wasatchian forms. Analogous to the Gardnerbuttean fauna described by West (1973), the Desertion Point Gardnerbuttean resembles a depauperate Bridgerian fauna rather than a mix of Wasatchian and Bridgerian forms. The difference between the Gardnerbuttean of the Green River Basin and that of the Bighorn, Wind River and Huerfano Basins is largely due to its depositional history.

The early Tertiary sedimentary history of the Bighorn, Wind River and Huerfano basins is dominated by floodplain, stream, alluvial fan, and occasionally volcaniclastic deposits (Gingerich, 1989; Gunnell et al. 1992; Robinson, 1966; Stucky, 1984b). The Palaeogene of the Green River Basin was dominated by transgressions and regressions of an extensive lake system known as Lake Gosiute. This lake System periodically inundated most of the available terrestrial habit within the basin. The Green River Basin, therefore, frequently needed to be repopulated by terrestrial plants and animals.

Rather than a transitional fauna, the Wasatchian-Bridgerian boundary is marked by a 80 meter hiatus representing a major transgression of fossil Lake Gosiute. This transgression is marked by the thick lacustrine deposits of the Fontanelle Tongue of the Green River Formation. The subsidence of the lake is marked by the deposition of the Wilkins Peak Member. By the time the lake had subsided to the minimum represented by the terrigenous beds of the Upper Member of the Wasatch Formation, most Wasatchian forms had become extinct, and the area was

The Wasatchian-Bridgerian boundary is a time of significant faunal change, particularly among mammals, at both the generic and ordinal level. Out of a total of 34 mammalian genera represented within the study area, only four: <u>Peratherium, Microsyops, Viverravus</u>, and <u>Eyopsodus</u> are shared in common between the Little Muddy and the Desertion Point local faunas. Table 15 presents a breakdown of the mammals within the study area and their relative abundance

Table 15

Percent composition of the Little Muddy local Fauna. The minimum number of individuals is used in calculating ordinal Dercentages. The number in parentheses indicates the total number of specimens.

| | Minimum number | Per cent of |
|---|----------------|-------------|
| | of individuals | total fauna |
| M arsupalia | 1 | 2.9 |
| Peratherium innominatum | 1 | |
| Insectivora | 5 | 14.7 |
| Palaeosinopa cf. <u>P. lutre</u> | 51a 1 | |
| Palaeictops bicuspis | 1 | |
| Proprimates | 2(3) | 5.9 |
| Ignacius graybullianus | 1 | |
| Microsyops sp. indet. | 1 | |
| Primates | 6(9) | 17.7 |
| Cantius cf. C. frugivorous | s 2(5) | |
| Copelemur cf. C. australot | tutus 2 | |
| Anemorhysis cf. A. sublett | tensis 1 | |
| Creodonta | 1 | 2.9 |
| Carnivora | 3 | 8.8 |
| <u>Miacis latidens</u> | 1 | |
| Vulpavus profectus | 1 | |
| Viverravus sp. indet. | 1 | |
| Condylartha | 5(8) | 14.8 |
| Meniscotherium chamense | 1 | |
| Meniscotherium sp. indet. | 1 | |
| Hyopsodus miticulus | 1(3) | |
| Hyopsodus wortmani | 2(3) | |
| Ti llodontia | 1 | 2.9 |
| <u>Esthonyx</u> <u>acutidens</u> | 1 | |
| Artiodactyla | 1(3) | 2.9 |
| Diacodexis cf. D. secans | 1(2) | |
| Perrisodactyla | 3(5) | 8.8 |
| Hyracotherium vasacciense | 1(2) | |
| Lambdotherium popoagacium | 1(2) | |
| Rodentia | 4(8) | 11.9 |
| <u>Knightomys</u> <u>depressus</u> | 1(3) | |
| Paramys cf. P. excavatus | 1 | |
| Incertae sedis | 2 | 5.8 |
| <u>Palaeanodon</u> sp. indet. | 2 | |
| | | . <u> </u> |
| Totals | s 34 (51) | 100.0 |

Table 16.

Percent composition of the Desertion Point local Fauna. The minimum number of individuals is used in calculating ordinal percentages. The number in parentheses indicates the total number of specimens.

| | Minimum number | Per cent of |
|--|-----------------|-------------|
| | of individuals | total fauna |
| Marsupalia | 3 | 6.1 |
| <u>Peratherium comstocki</u> | 1 | |
| <u>P. innominatum</u> | 2 | |
| Insectivora | 3(4) | 6.1 |
| Apatemys | 1 | |
| <u>Scenopagus</u> <u>edenensis</u> | 1 | |
| <u>S</u> . priscus | 1(2) | |
| Proprimates | 3(4) | 6.1 |
| <u>Microsyops</u> <u>elegans</u> | 2 | |
| Microsyops sp. indet. | 1(2) | |
| Primates | 8(11) | 16.3 |
| <u>Notharctus</u> <u>robinsoni</u> | 3(4) | |
| <u>Smilodectes mcgrewi</u> | 1 | |
| <u>Omomys carteri</u> | 2 | |
| <u>Washakius insignis</u> | 1 | |
| Creodonta | 1 | 2.0 |
| Carnivora | 2 | 4.1 |
| <u>Viverravus</u> gracilis | 1 | |
| Condylartha | 1 | 2.0 |
| <u>Hyopsodus</u> <u>miticulus</u> | 1 | |
| Taeniodontia | 1 | 2.0 |
| Perrisodactyla | 14(20) | 28.7 |
| <u> Orohippus pumilus</u> | 1 | |
| Orchippus sp. indet. | 1 | |
| <u>Palaeosyops</u> cf. <u>P</u> . <u>fonti</u> | nalis 2 | |
| <u>Hyrachyus</u> <u>modestus</u> | 4 | |
| <u>Seleneletes</u> sp. nov. | 3(5) | |
| Rodentia | 10(12) | 20.5 |
| <u>Sciuravus</u> <u>nitidus</u> | 5(7) | |
| Leptotomus cf. L . Huerfa | nensis 1 | |
| L. parvus | 1 | |
| -ncertae Sedis | 3 | 6.1 |
| <u>Metacheiromys</u> sp. indet. | 2 | |
| <u>Tetrapassalus</u> sp. indet. | 1 | |
| | | |
| Tota | ls 49 (61) | 99.9 |

in the two faunal zones. The total sample is too small for a statistically significant analysis, but some interesting trends are apparent.

While no primate genera are shared between the Wasatchian and Bridgerian within the study area, generic diversity and overall abundance remain relatively constant. Perissodactyls comprise almost one third of the Desertion Point local fauna, and less than a tenth of the Little Muddy local fauna. Conversely, only a single condylarth has been identified from the Desertion Point local fauna, while they comprise approximately 15% of the Little Muddy local fauna.

The most noticeable difference between the two faunas is the larger number of reptilian taxa in the Desertion Point local fauna. The predominance of lower vertebrates in the Desertion Point local fauna may well have stronger Cologic than biostratigraphic implications. The abundant meandering streams and minor incursions of Lake Gosiute Characteristic of the Laney Member of the Green River Formation and the lower Bridger Formation provided a variety of environments conducive to a large, diverse, reptilian fauna.

Reptiles and amphibians are usually not considered in early Tertiary biostratigraphic studies. While the mammalian faunas of the Huerfano, Wind River, Bighorn, and Green River Basins have undergone almost continuous study for the last century, the lower vertebrates have rarely been

discussed. Many localities throughout the Green River Basin Such as Desertion Point local fauna levels III and IV Contain abundant reptile remains and only a few mammals. Studies of both lower vertebrates and mammals will be essential if the biostratigraphy of the Green River Basin is to be completely understood. Most of the reptilian taxa found within the study area are found through much of the Palaeogene. Nevertheless, a single species of emydid, absent from higher levels was collected from Desertion Point local fauna level II. <u>Echmatemys</u> cf. <u>E. cibollensis</u> noted above may be indicative of pre-Bridger A deposition.

While the study area has yielded two distinct, biostratigraphically diagnostic assemblages, the diversity of both faunas is low compared to those of the Wind River and Huerfano Basins. Additional field work needs to be done to augment the sample of fossil vertebrates from the late Early and early Middle Eocene of the southwestern Green River Basin. In addition, areas need to be sought where transitional faunas are preserved. Sedimentological evidence indicates that if these faunas are preserved, they should be sought along the margins of the basin, in regions which escaped inundation by Eocene lake Gosiute.

The palaeobotany of the Wasatch, Bridger and Green River Formations needs to be studied. This information may Provide important information about the paleoecology of the Green River Basin that is not available from other sources.

Investigation of the stable isotope geochemistry of Carbonate nodules and organic material within paleosols across the boundary may shed light on paleoclimatic trends from the early to the middle Eocene. Taphonomic studies would clarify many of the differences between the Little Muddy and Desertion Point local faunas. The collection of fossil vertebrates derived from the various stratigraphic units within the study area shows that preservation is highly variable, not only in the quality of individual fossils, but also in taxonomic diversity between horizons, the type of individual skeletal elements preserved, and in the proportions of large, medium and small taxa present (Zonneveld, 1994). Many of the differences between the two faunas are based on taphonomic and paleoecologic factors Father than community succession.

From the study area to the northwest to Twin Buttes in the foothills of the Uinta Mountains to the southeast, an almost continuous stratigraphic sequence is now known in the Bridger Basin temporally extending from the late early Eocene (Wa7) to the late middle Eocene (Br3). Magnetostratigraphic dating correlated with biostratigraphic information would help calibrate North American Chronostratigraphy with European and Asian.

An impetus for future work in the area is that most area rly Tertiary biostratigraphic studies ignore the potential importance of amphibians and reptiles. The fact that lower

vertebrates are much more common from the upper levels than from the lower levels likely has stronger ecologic than biostratigraphic implications. As noted above however, there are differences in the reptilian taxa present at different levels. Additional study of the lower vertebrates is needed before their biostratigraphic significance can be ascertained.

CONCLUSION

For the first time, the Wasatchian-Bridgerian Land Mammal Age boundary has been identified within the vicinity $\odot f$ their type areas. This boundary is represented by approximately 80 meters of stratigraphic section between two distinct faunas within the Desertion Point-Little Muddy area **in** the southwestern Bridger Basin, southwestern Wyoming. As \mathbf{t} he Early Eocene drew to a close, Lake Gosiute expanded, inundating most of the Green River Basin. This transgression deposited the thick sequence of lacustrine Sediments that comprises the Fontanelle Tongue of the Green River Formation and separates the Desertion Point and Little \mathbf{M} uddy local faunas. As the waters receded, the valley was \mathbf{r} epopulated with a fauna markedly different from that which **Dr**eceded the invasion of the lake. The biostratigraphic Wasatchian-Bridgerian boundary does not coincide with the Lithostratigraphic Wasatch-Bridger boundary in southwestern $\mathcal{W}_{\mathcal{Y}}$ oming (see Figure 18), the type area of both of these

Land-Mammal Ages. The Wasatchian-Bridgerian boundary is Located approximately 200 meters below the base of the Bridger formation within the study area.

Elements within the Little Muddy local fauna are indicative of late Wasatchian deposition, particularly the Lostcabinian index fossil Lambdotherium popoagacium, but also Meniscotherium chamense, Miacis latidens, and Evopsodus cf. H. wortmani. The time range of Cantius cf. C. frugivorous is extended to include the Lostcabinian; that of Copelemur cf. C. australotutus is confirmed as latest Wasatchian. The chronologic and geographic ranges of Anemorhysis wortmani and Ignacius graybullianus are extended to include the Lostcabinian of the Green River Basin.

Elements from the Desertion Point local fauna are indicative of the early Bridgerian. Desertion Point local fauna level I through III are interpreted as earliest Bridgerian (Gardnerbuttean) based on the co-occurrence of **Byrachyus**, **Seleneletes**, and **Palaeosyops**. Desertion Point local fauna levels IV and V are interpreted as late Early Bridgerian based on the presence of <u>Smilodectes mcgrewi</u>, **Notharctus robinsoni**, <u>Washakius insignis</u>, <u>Omomys carteri</u>, and <u>Scenopagus</u> along with <u>Palaeosyops fontenellis</u> and **Byrachyus modestus**. The known time range of <u>Tetrapassulus</u> is extended to the early Bridgerian. APPENDIX

APPENDIX

MEASURED STRATIGRAPHIC SECTIONS

Stratigraphic sections were measured using Jacob Staff, Brunton Compass, and metric tape-measure. Brief descriptions of each section are supplied below. The precise location of each measured section is presented in **Pl** ate 1. A graphical correlation of all measured sections within the study area is supplied as Plate 2.

Grain size measurements are as follows:

, •

| | | phi | | М | i11: | imetr | es |
|------|------|-----|------|----|------|-------|-------|
| mud | 14.0 | to | 9.0 | 1 | ess | than | .004 |
| silt | 9.0 | to | 4.0 | | 004 | to | .063 |
| vfL= | 4.0 | to | 3.5 | • | 063 | to | .094 |
| vfU= | 3.5 | to | 3.0 | | 094 | to | .125 |
| fL= | 3.0 | to | 2.5 | | 125 | to | .188 |
| fU= | 2.5 | to | 2.0 | | 188 | to | .250 |
| mL= | 2.0 | to | 1.5 | • | 250 | to | .375 |
| mU= | 1.5 | to | 1.0 | • | 375 | to | .500 |
| cL= | 1.0 | to | 0.5 | • | 500 | to | .750 |
| cU= | 0.5 | to | 0.0 | • | 750 | to | 1.000 |
| vcL= | 0.0 | to | -0.5 | 1. | 000 | to | 1.500 |
| vcU= | -0.5 | to | -1.0 | 1. | 500 | to | 2.000 |

Measured Section 1, Camp Section

Mulkay Springs Quadrangle, T. 19 N., R. 115 W., Section 23, SW1/4, NW1/4. The west face of the third ridge south of the Desertion Point escarpment. From the base of the escarpment to the main break in slope. Through fossil localities BB068 and BB069.

| Unit | <u>Thickness</u> | Description |
|--------------------|------------------|---|
| \mathbf{Cr} aven | buried s | equence. |
| Creek | 1.10m | Siltstone, gray. |
| Bed | 0.80m | Litharenite, gray, coarsens up from |
| Laney | | mL to mU, moderate sorting, subrounded. |
| Member, | 1.50m | Mudstone, gray, silty. |
| 6 | 0.45m | Sublitharenite, gray, fL, moderate |
| Sreen | | sorting, subrounded. |
| River | 0.54m | Mudstone, light gray, trace silt. |
| Formation | 0.96m | Siltstone, yellowish-gray, sandy, |

| | 0.50m | weathers to brown. Lignitic mudstone, brown, abundant ash and organic debris, contains lenses of selenite and gypsum, poorly preserved plant debris, and abundant sulphur seams, weathers brown. |
|---|-------|--|
| | 1.65m | Claystone, yellowish gray, weathers vellow. |
| | 0.70m | Mudstone, light gray, silty. |
| | 1.65m | Sublitharenite, fL, subrounded, moderate sorting, weathers rusty red. |
| | 0.20m | Mudstone, gray, sandy. |
| | 0.28m | Sublitharenite, gray, fU, subrounded, moderate sorting, weathers rusty red. |
| | 2.04m | Mudstone, whitish gray, trace silt, darkens in colour downwards to a greenish gray ry HCL |
| | 0.68m | Mudstone, pinkish gray, coarsens down to sandy at base, does not |
| $\mathbf{U}_{\mathbf{p}}$ per Me mber | 0.39m | Sublitharenite, gray, mL, subrounded, moderate sorting, rx HCL, weathers rusty red. |
| Wasatch | 0.20m | Mudstone, olive green, some silt. |
| Formation | 0.79m | Mudstone, tan brown, some silt, grades up to a mottled green and brown, rx HCL. |
| | 0.40+ | Mudstone, olive green, some silt, somewhat mottled, rx HCL, iron stains and gypsum in fractures. buried sequence |

Measured Section 2, New Crocodilian Section

Mulkay Springs Quadrangle, T. 19 N., R. 115 W., Section 23, SW1/4, SW1/4. Up the axis of the prominent ridge due east of BB013W. From the valley floor to the boundary lignite. Through fossil localities BB013 and BB036.

| <u>Unit</u> | Measurement | Description |
|-------------------|-------------|---|
| | | OI SECTION Mudatana ubita hand |
| | 0.20m | Mudstone, white, hard. |
| Creek | 0.10m | Lignitic Mudstone, gray-brown, |
| Bea | | weathers dark brown, abundant plant |
| | 1 25 | <u>debris, nigh ash content.</u> |
| | 1.35m | Mudstone, dark gray, some silt, |
| | 0.70- | Diotite Hakes abundant. |
| | 0.70m | Sublitharenite, gray to rusty red, |
| | | rines upwards from mL/10 to VIU, |
| T T | 0 0 7 | Moderately sorted, subrounded. |
| Opper | 0.3/m | Mudstone, gray, silty, sandy, fines |
| Member, | 0.40- | up to a slity mudstone. |
| Se7 - ach ch | 0.42m | Sublitharenite, gray, subrounded, |
| | | well solled, lines upwards to a |
| P Ormation | | trage at base |
| | 0 52m | Ciltatono dark grav dark grav |
| | 0.521 | mudalasta common random poorly |
| | | nuderasts conmon, random poorry |
| | | top 2 cm organic rich |
| | 0 5/m | Mudstone light gray silty |
| | 0.541 | muscone, light gray, silly, mottled in places coarsens up from |
| | | a mudstone trace silt mudslasts |
| | | abundant |
| | 0 50m | Mudstone light gray-brown |
| | 0.50 | abundant purple and red flecks |
| | | (oxidation residues) abundant dark |
| | | gray mudclasts. |
| | 0.35m | Siltstone, grav, sandy, abundant |
| | | lithic fragments. |
| | 0.59m | Litharenite, gray, mL, moderately |
| | | sorted, subrounded, weathers rust |
| | | red. |
| | 0.59m | Mudstone, gray, silty. |
| | 0.45m | Mudstone, light gray, trace silt. |
| | 0.10m | Mudstone, tan-gray. |
| | 0.17m | Mudstone, gray-brown, abundant |
| | | concentric carbonate nodules. |
| | 0.10m | Siltstone, gray, muddy, mudclasts |
| | | abundant, fish bits and brown |
| | | pellets as above also present. |
| | 0.71m | Mudstone, gray, silty, pellets as |
| | | above, coarsens upwards slightly, |
| | | mudclasts throughout. |

| | 0.70m | Sublitharenite, fL, subrounded, poorly sorted, mudclasts and red chert shards common |
|----------------------|-------|---|
| | 0.35m | Mudstone, greenish gray, trace silt, abundant mudclasts and biotite flakes, pink/purple mottling 15cm above base. |
| | 0.18m | Siltstone, light green-gray, lithic fragments and mudclasts common. |
| | 0.40m | Mudstone, gray, trace silt, mudclasts common throughout, although less so near top. |
| Upper Member, | 0.26m | Mudstone, maroon, gray/green mottling, trace silt, mudclasts common. |
| Wasatch Formation | 0.34m | Mudstone, tan-gray, silty, mudclasts common. |
| | 0.28m | Mudstone, pink, some silt at base, less at top, tiny gray mudclasts common throughout. |
| | 0.86m | <pre>tan/gray mudstone, some silt, laminated, mudclasts abundant, lithic fragments present although not common, mudclasts larger and pinker towards base.</pre> |
| | 0.10m | Sublitharenite, mL to fU, subrounded, well sorted, weathers red, soft sedimentary deformation at base, this unit interfingers and probes into the lower unit |
| | 0.57m | Mudstone, mottled green, gray, brown, and pink, silty at base, fines upwards, very abundant mudclasts, bedded, rx HCL, pink mudstone lense 0.20m from base. |
| | 0.20m | Mudstone, purple, fines upwards, base is silty and mottled with green. |
| | 1.62m | Mudstone, gray, sandy. |
| | 3.24m | Litharenite, gray, vfL to cU, extremely variable in grain size, shape and sorting, finer grained towards middle of unit, cross- bedded. |
| | 0.21m | Mudstone, light gray, silty. |
| | 0.04m | Sublitherenite, gray poorly sorted, subangular. |
| | 0.02m | Mudstone, gray. |
| | 0.06m | Sublitharenite, poorly sorted, subangular to subrounded. |
| | 0.06m | Mudstone, gray. |

| Upper Member, | 0.09m | Mudstone, mottled red, gray, green, and maroon. |
|----------------------|-------|---|
| | 0.31m | Mudstone, gray. |
| Wasatch Formation | 0.40m | Siltstone, gray, sandy, wedge shaped cross-bedding. |
| | 0.15m | Mudstone, alternating red and gray lenses, some silt. |
| | 1.01m | Mudstone, gray, trace silt, grades up into a sandier layer with a few mudclasts (gray), and into a reworked mess of sandier material surrounding large rip-up clasts, sand is angular and poorly sorted, a zone of red mudclasts 0.20m from top of unit, above this the mudclasts decrease in size and number, and the unit gets muddier and less sandy, Crocodile and turtle specimen found in this layer. |

Measured Section 3, Lost Butte Section Mulkay Springs Quadrangle, T. 19 N., R. 115 W., Section 22, SE1/4, SE1/4. From the valley floor to the top of the small butte 250m west of the Desertion Point Escarpment. Through fossil locality BB013W.

| <u>Thickness</u> | | Description |
|------------------|--|--|
| | top (| of Butte |
| 0.58m | | Mudstone, gray, trace silt, trace |
| | | sand, fines upwards slightly. |
| 1.75m | | Litharenite, gray-brown, mL, |
| | | subangular to subrounded, poorly |
| | | sorted, silty near top, |
| a 4a | | crossbedded, mudclasts present. |
| 0.42m | | Mudstone, gray, yellowish near top, |
| 0.00- | | trace silt. |
| 0.90m | | Mudstone, brown, sandy, silty, |
| | | lines upwards, gray mudclasts |
| | | abundant, especially at top and |
| | | of foggil figh and rontilo |
| | | abundant ooids present |
| 0.06m | | Micrite vellow-gray sandy |
| 0.25m | | Sublitherenite white to grav |
| 0.2511 | | moderate sorting fll subangular to |
| | | subrounded grains weathers rust |
| | | red |
| 0.60m | | Siltstone, grav. |
| 0.98m | | Mudstone, grav, trace silt. |
| 0.20m | | Sublitharenite, grav, mL, moderate |
| | | sorting, subrounded, crossbedded. |
| | Base | of butte. |
| | Thickness 0.58m 1.75m 0.42m 0.90m 0.90m 0.25m 0.60m 0.98m 0.20m | Thickness 0.58m 1.75m 0.42m 0.90m 0.06m 0.25m 0.60m 0.98m 0.20m Base |

Measured Section 4, Microsyops Skull Section Mulkay Spring Quadrangle, R. 115 W., T. 19 N. Section 26, NE1/4, NW1/4. The ridge at the centre of the valley due north of fossil locality BB076. From the base of the valley to the last break in slope below the top of the escarpment. Through fossil localities BB013 and BB036.

| <u>Unit</u> | <u>Thickness</u> | Description Top of butto |
|-------------|------------------|---|
| | 0.25- | Top of Dutte. |
| | 0.35m | Micrite, light yellow, some sandy |
| | 0.04. | regions, possible insect fossils. |
| | 0.04m | Asn layer, white. |
| | 0.81m | Mudstone, interpedded gray and |
| | | gray-green. |
| | 1.13m | Mudstone, gray. |
| | 0.70m | Mudstone white. |
| | 0.20m | Mudstone, olive green, greyer towards top. |
| | 0.10m | Micrite, white to yellow, sand and |
| | | biotite laminae (possibly ash) |
| | | common, abundant gar and amia |
| | | scales. |
| Craven | 0.48m | Siltstone, grav, sandy, fossils |
| Creek | | (mostly fish) common as are ooliths |
| Bed. | | and mudclasts. |
| , | 0.22m | Micrite, light vellow, oolitic. |
| Lanev | 0.25m | Litharenite, poorly sorted, silty, |
| Member. | | mudclasts and vertebrate fossils |
| | | (mostly fish bits) common. |
| Green | 0 20m | Micrite, vellow-white, sand and |
| River | 0.2011 | mudclasts common. |
| Formation | 0 10m | Sublitharenite grav. mL. moderate |
| rormación | 0.2011 | sorting subrounded |
| | 0 70m | Mudstone dark brown organic rich |
| | 0.701 | 10cm from base thin orange layer |
| | | with abundant gynsum |
| | 0 68m | Litharenite gray mL to cll |
| | 0.001 | subangular to angular poorly |
| | | sorted abundant mudclasts |
| | | crossbedded |
| | 1 60m | buried sequence |
| | 0.20m | Litherenite grav mi to di |
| | 0.2011 | subargular to argular poorly |
| | | subangular to angular, poorly |
| | | areashedded |
| | 0.20- | crossbedded. |
| | U.29m 1 45- | Juiled Sequence |
| | 1.40M | aubangular to argular maarle |
| | | subangular to angular, poorly |
| | | sorted, abundant MUQCIASES, |
| | | crosspeaaea. |

| | 0.51m | Mudstone, gray, abundant organic rich lenses |
|-----------|---------|---|
| | 0.22m | Litharenite, light gray, mU to vcU, |
| | | angular to subrounded, poorly sorted, abundant mudclasts, |
| | | weathers to rust red, cross-bedded. |
| | 0.04m | Mudstone, gray, some silt, abundant |
| | | gray mudclasts. |
| | 0.04m | Litharenite, gray, fU to mL, poor |
| | | to moderate sorting, subrounded, |
| | 0.25m | Mudatone grav-tan some silt grav |
| | 0.351 | mudclasts abundant near base, rust |
| | | coloured lenses common. |
| | 1.50m | buried sequence |
| | 0.45m | Mudstone, gray, mudclasts common, organic rich. |
| | 0.08m | Mudstone, gray, sandy. |
| | 0.33m | Mudstone, gray, sandy at base, |
| | | mudclasts common near top, also |
| | | some sand clasts present, both |
| | | gastropods and bivalves common. |
| Craven | 0.57m | Siltstone, gray, sandy, coarsens up |
| Creek | | to a litharenite, gray, fL, |
| Bed. | | moderate sorting, subrounded. |
| , | 0.22m | Mudstone, gray, some sand, some |
| Lanev | •• | silt, mudclasts common, coarsens |
| Member. | | upwards slightly. |
| , | 0.32m | Siltstone, grav-tan, sandy, fines |
| Green | 0.02. | upwards slightly. |
| River | 1.75m | Sublitharenite, mL, subrounded, |
| Formation | 2., , 5 | moderately sorted, cross-bedded. |
| | 0.64m | Mudstone, gray, sandy, gray |
| | 0.01 | mudclasts abundant, mudclasts more |
| | | abundant base, bivalve pelecypods |
| | | present but poorly preserved. |
| | 1 34m | Mudstone, grav, silty, sandy, |
| | 2.51 | biotite flakes and mudclasts |
| | | abundant, sandier towards top. |
| | 0 66m | Mudstone, gray, siltier towards |
| | 0.00 | top. |
| | 0 10m | Mudstone, white, calcareous, |
| | 1 94m | Mudstone, light grav, some sand, |
| | 2.9 1 | some silt, mudclasts present, more |
| | | abundant towards bottom, fines up |
| | | slightly, abundant fish bits. |
| | 0.70m | Mudstone, green-grav, abundant |
| | | large, elongate, horizontal |
| | | mudclasts, abundant organic debris. |
| | | and abundant rounded. elongate |
| | | brownish pellet-like inclusions. |
| | | - |

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100 A

| | | probably ooliths near top, fish |
|--------------------|---------------|---|
| | 0 22- | Dits also common. Mignite vellev stremetelitis |
| | 0.33m | Micrite, yellow, stromatolitic. |
| | 0.10m | sorting, subrounded. |
| | 0.44m | Mudstone, light gray, contains |
| | 0.75m | Siltstone, gray, sandy, sand lenses and fish debris common. |
| Craven Creek | 0.65m | Mudstone, white, abundant fish bits. |
| Bed, | 2.53m | Mudstone, gray-tan, sand and silt lenses, fish bits common. |
| Laney Member. | 0.03m | Sublitharenite, fL, poorly sorted, rounded. |
| | 0.07m | Micrite, stromatolite pods thick in |
| River Formation | 1.22m | Mudstone, gray, some silt, fish debris common. |
| | 0.18m | Mudstone, white, hard. |
| | 0.17m | Lignitic mudstone, dark brown to gray and yellow, abundant plant debris, high ash content. |
| | 0.88m | Mudstone, dark gray, some silt, abundant biotite flakes. |
| | 1.65m | Litharenite, gray, fL to mL, poorly sorted, abundant greenish |
| | | <pre>mudclasts, vertebrate fossils very abundant, fish, turtle, crocodilian, cross-bedded.</pre> |
| | 0.56m Base | Siltstone, gray, muddy, top 25cm has abundant sandy regions, sandier and less muddy towards the top. of butte. |

Measured Section 5, Desertion Point Upper Section Mulkay Springs Quadrangle, T. 19 N., R. 115 W. Section 26, SE1/4, SW 1/4. From the top to the base of the escarpment at the southern end of Desertion Point. Through fossil localities BB075 and BB012.

| <u>Unit</u> | <u>Thickness</u> | Description Top of butte. |
|-------------|------------------|-------------------------------------|
| | 0.30m | Micrite, white-gray, trace sand. |
| | 5.77m | Mudstone, gray, silty. |
| | 1.05m | Sublitharenite, gray, mL, well- |
| | | sorted, rounded. |
| | 0.40m | Mudstone, grav, silty. |
| | 0.85m | Sublitharenite, grav, mL, well |
| | | sorted, rounded. |
| | 0.21m | Mudstone, gray, some silt. |
| | 2.46m | Sublitharenite, grav, mL, well |
| | | sorted, rounded. |
| Craven | 1.48m | Mudstone, gray-brown, silty, some |
| Creek | | sand. |
| Bed, | 0.90m | Mudstone, gray, some silt. |
| | 0.10m | Micrite, light gray, weathers rust |
| Laney | | red. |
| Member, | 1.10m | Lignitic mudstone, brown and |
| | | yellow, black, broken up bits of |
| Green | | carbonized plant material common, |
| River | | selenite and gypsum in fractures. |
| Formation | 0.80m | Mudstone, gray. |
| | 0.56m | Sublitharenite, gray, mL, well |
| | | sorted, rounded. |
| | 0.85m | Mudstone, gray-brown, some silt. |
| | 0.79m | Sublitharenite, gray, fU, well- |
| | | sorted, rounded. |
| | 3.45m | buried sequence |
| | 1.15m | Silty mudstone, gray-green. |
| | 2.60m | Buried sequence. |
| | 3.95m | Litharenite, sorting, angularity, |
| | | and grain size varies widely |
| | | throughout the unit, cross-bedded. |
| | 0.27m | Mudstone, gray-green, silty, |
| | | biotite flakes common. |
| | 0.40m | Mudstone, white, some silt, mottled |
| | | appearance, mud clasts present. |
| | 0.30m | Mudstone, green-gray, silty, |
| | | biotite flecks abundant. |
| | | Buried sequence |

Measured Section 6, Desertion Point Lower Section Mulkay Springs Quadrangle, T. 19 N., R. 115 W. Section 26, SE1/4, SW 1/4. From the break in slope to the base of the escarpment at the northern end of Desertion Point. Through fossil locality BB070.

| <u>Unit</u> | <u>Thickness</u> | <u>Description</u> |
|-------------|------------------|--|
| | | Buried sequence |
| | 0.80m | Mudstone, gray, mottled, mudclasts, |
| | | and fish scales common. |
| | 1.45m | Mudstone, yellow-gray, silty. |
| | 0.65m | Sublitharenite, gray, mL, well |
| | | sorted, rounded. |
| | 0.56m | Mudstone, gray-green, silty, |
| | | biotite flakes common. |
| Craven | 0.78m | Siltstone, gray, sandy. biotite |
| Creek | | flakes common. |
| Bed, | 1.01m | Mudstone, yellow-gray, trace silt, |
| | | yellow concretions and biotite |
| Laney | | flakes common. |
| Member, | 0.80m | Siltstone, gray. |
| | 0.20m | Litharenite, gray, mU, poorly |
| Green | | sorted, subrounded. |
| River | 0.50m | Siltstone, gray, sandy. |
| Formation | 1.75m | Mudstone, gray, some silt towards |
| | | the top. |
| | 0.40m | Sublitharenite, gray, mL, well- |
| | | sorted, subrounded. |
| | 1.45m | Mudstone, white-gray, silty, Amia |
| | | scales, and bivalves common. |
| | 1.35m | Sublitharenite, gray, mU, well- |
| | | sorted, subrounded, fossiliferous, |
| | | teleost bones, bivalve molluscs. |
| | 0.80m | Siltstone, gray, some sand, grades |
| | | up into a silty mudstone. |
| Upper | 0.20m | Siltstone, gray-green. |
| Member, | | buried sequence. |

Wasatch Formation
Measured Section 7, Dead Antelope Draw. Mulkay Springs Quadrangle, T. 18 N., R. 115 W. Section 2, NE1/4, NW1/4. From the base to the top of the prominent escarpment. Through Fossil Locality BB077.

| <u>Unit</u> | <u>Thickness</u> | Description |
|-------------|------------------|-------------------------------------|
| | 0.10m | Lignitic mudstone, brown, abundant |
| | | plant material. |
| | 10.92m | Buried sequence |
| | 2.15m | Mudstone, gray, silty, lignitic |
| | | layer 0.75m from top. |
| | 1.25m | Litharenite, gray, fL, poorly |
| | | sorted, contains large lithic |
| | | fragments, subrounded to |
| | | subangular. |
| | 1.27m | Mudstone, gray-brown, some silt, |
| | | abundant organic material towards |
| | | top. |
| | 0 10m | Mudstone, grav-green, weathers into |
| | 0.1011 | hard white chips |
| | 1 07 | Mudstone white-gray some silt |
| Craven | 0.28m | Mudstone vellow-gray organic |
| Creek | 0.2011 | rich silty sand lenses near the |
| Bed | | bottom abundant mudclasts |
| Dea, | | abundant fossils |
| Laney | 1 21m | Siltstone gray coarsens unwards |
| Member | 1.2111 | slichtly |
| Menwer, | 0 12m | Mudstone grav some silt |
| Croon | 0.42m | Tilloid light brown graing are |
| Green | 0.101 | woll rounded neer conting |
| River | | weil-founded, poor sorting, |
| FOIMALION | | possibly mud oords, weathers to |
| | 0.70m | Mudatono arou aomo ailt |
| | 0.781 | Mudstone, gray, some silt, |
| | | Sandstone lense 0.20m from base, |
| | 0 1 4- | 0.02m thick. |
| | 0.14m | Sublitharenite, gray, iU, well- |
| | | sorted, subrounded, lossils of |
| | 0 5 0 | lower vertebrates present. |
| | 0.58m | Mudstone, gray, some silt, fines |
| | | upwards slightly, sand lenses near |
| | 0 1 0 | base. |
| | 0.18m | Sublitharenite, gray, silty, fU, |
| | | poorly sorted, subrounded, |
| | | fossiliterous (fish bits). |
| | 0.73m | Mudstone, mottled gray, slightly |
| | | silty towards top, sand lense 0.20m |
| | | trom base, lower vertebrate |
| | | tossils. |
| | 0.10m | Litharenite, fU, poorly sorted, |
| | | subrounded. |

| | 1.01m | Siltstone, gray, interbedded silty and muddy layers, fossils abundant, |
|----------------------------------|-------|--|
| | | contains crocodilians, turtles, |
| | | fish, rarely mammals. |
| Craven | 0.21m | Sublitharenite, fU, moderate |
| Creek | | sorting, subrounded, weathers rust |
| Bed, | | red. |
| | 1.40m | Mudstone, white-gray, abundant |
| Laney | | biotite flakes, no fossils observed |
| Member, | | in most of the unit, the top 0.08m |
| | | of the unit increasingly silty, a |
| Green | | hard muddy layer totally devoid of |
| River | | silt 0.60m from top, above this is |
| Formation | | a 0.05m thick pinkish mudstone |
| | | layer that contains abundant fish |
| | | bits. |
| | 0.96m | Mudstone, gray, slightly silty |
| | | towards top, abundant mudclasts, |
| | | bivalve mollusc at base. |
| | 0.16m | Mudstone, tan, organic rich, |
| | | laminated, gypsum layer at base, |
| | | grades into above. |
| | 0.32m | Mudstone, gray, gypsum layer at |
| | | base. |
| | 0.04m | Lignitic mudstone, gray-brown, |
| | | silty, organic rich, gastropods |
| | | present. |
| Upper | 0.93m | Siltstone, gray, sandy, fines up to |
| Member, | | silty mudstone, mudclasts common, |
| T . T = 1 - | | organic bits also common especially |
| wasatch | | near the top, worm burrows common |
| rormation | | at Dase. |
| | | Buried sequence |

12.64

Measured Section 8, The Lost Locality. Mulkay Springs Quadrangle, T. 19 N., R. 115 W., Section 22, NE1/4, NW1/4, From the base of the wash to the top of the hill. Through fossil locality BB103.

| $\underline{\mathbf{U}}$ nit | <u>Thickness</u> | Description |
|------------------------------|------------------|-------------------------------------|
| | | Buried sequence |
| | 0.40m | Mudstone, gray, trace silt. |
| | 0.91m | Mudstone, light purple, tiny gray |
| | | mudclasts present. |
| | 0.14m | Mudstone, gray. |
| | 0.75m | Mudstone, gray mottled with pink, |
| | | red mudclasts common. |
| | 0.39m | Mudstone, mottled gray, purple, |
| | | rust, maroon, trace silt. |
| | 0.35m | Mudstone, gray, greenish towards |
| | | top, some silt. |
| | 0.89m | Siltstone, gray. |
| | 0.14m | Mudstone, gray to pinkish gray |
| | | trace silt, abundant gray |
| | | mudclasts. |
| | 0.02m | Sublitharenite, gray, mL, moderate |
| | 0.16 | sorting, subrounded. |
| | 0.16m | Micrite, gray, abundant mudclasts, |
| | 0.26. | sandy towards top. |
| Upper | 0.36m | Mudstone, gray, some silt, abundant |
| member, | 0.04- | Mudatana brown mudalasta |
| Tulo a o trab | 0.04m | Audstone, brown, mudclasts |
| Formation | 0.07m | Mudstone grav trace silt |
| FORMACION | 0.071 | abundant marcon muddlasts |
| | 0.14m | Micrite gray contains mudclasts |
| | 0.14m | Mudstone gray some silt mottled |
| | 0.55m | reddish at base abundant elongate |
| | | horizontal mudclasts at base |
| | | darkens towards top purple and red |
| | | mudclasts at top. |
| | 0.22m | Mudstone, light reddish mottled |
| | ••==== | purplish brown, trace silt, tiny |
| | | brown mudclasts present. |
| | 0.30m | Mudstone, light brown, silty. |
| | 0.16m | Sublitharenite, light gray, fL, |
| | | subrounded, moderate sorting. |
| | 0.22m | Mudstone, light brown, trace silt, |
| | | darker brown and no silt at top. |
| | 0.58m | Mudstone, purple-brown, trace silt, |
| | | maroon, gray and brown mudclasts, |
| | | darker at top, mudclasts less |
| | | abundant near top. |
| | 0.42m | Mudstone, dark gray-green, trace |
| | | silt, lightens upwards. |
| | | base of wash. |

Measured Section 9, Wasatch Butte Section A Mulkay Spring Quadrangle, T. 18 N., R. 115 W., Section 9, SW1/4, NE1/4. From base to top of Hill 6547, 600 meters north of the Little Muddy Creek. Through Fossil Locality BB097.

| Unit | <u>Thickness</u> | Description |
|-----------|------------------|-------------------------------------|
| | | top of butte |
| | 0.40m | Mudstone, gray, silty, pink near |
| | | the top. |
| | 0.75m | Mudstone, pink, some silt, greyer |
| | | at base. |
| | 0.17m | Mudstone, gray, silty. |
| | 0.15m | Mudstone, pink, trace silt. |
| | 0.21m | Mudstone, gray, trace silt. |
| | 2.09m | Mudstone, orange-pink. |
| | 0.12m | Mudstone, gray, some silt. |
| | 0.35m | Mudstone, red. |
| | 0.15m | Siltstone, gray. |
| | 0.18m | Mudstone, red, trace silt. |
| | 0.35m | Siltstone, gray, coarsens up to |
| | | gray fL sandstone, poorly sorted, |
| | | subangular. |
| | 0.67m | Mudstone, purple, rust red near |
| | | top, trace silt. |
| Upper | 1.11m | Mudstone, light brown-orange, trace |
| Member, | | silt, gray mottling 0.30m from |
| | | base. |
| Wasatch | 0.96m | Sublitharenite, gray, mU to fU |
| Formation | | subrounded, fines upwards, moderate |
| | | sorting. |
| | 0.96m | Mudstone, orange brown to pink, |
| | | coarsens up to silty mudstone, top |
| | | 3cm gray. |
| | 0.40m | Mudstone, brown, bottom 0.10m dark |
| | | brown, top 0.10m light brown. |
| • | 0.15m | Mudstone, purple-gray. |
| | 0.61m | Mudstone, purple, darkens upwards, |
| | | top 0.10m mottled gray. |
| | 3.76m | Mudstone, white gray, silty, fines |
| | | up to a mudstone, trace silt. |
| | 0.74m | Mudstone, white-gray, trace silt. |
| | 0.35m | Mudstone, purple, silty, abundant |
| | | biotite flakes. |
| | 0.72m | Sublitharenite, gray, fU, moderate |
| | | sorting, top 0.02m silty, abundant |
| | | red mudclasts, worm burrows and |
| | 0 50 | Dioturbation common. |
| | 0.59m | Mudstone, pink, red mudclasts |
| | | common towards base, purple |
| | | mudclasts and sand filled worm |
| | | burrows common throughout. |

| | 0.18m | Litharenite, gray, fL, poorly |
|------------|--------|--------------------------------------|
| | | rod mudalacts also abundant |
| | 0.71m | Mudatana nurnla-rad tan 0 15m |
| | 0./11 | mudstone, purpre-rea, top 0.15m |
| | | mudelagte ingroses in abundance |
| | | mudclasts increase in abundance |
| | 0.00 | upwards. |
| | 0.20m | Mudstone, gray, silty, fines upwards |
| | 0 1 0 | slightly. |
| | 0.10m | Sublitharenite, gray, iU, poorly |
| | 0 51 | sorted, angular. |
| | 0.51m | Mudstone, red, trace silt, coarsens |
| | | upwards slightly, no silt at top, |
| | 0.00 | trace blotite. |
| | 0.63m | Mudstone, gray, silty. |
| | 0.72m | Mudstone, purple, some silt, |
| | | biotite flakes present, contains |
| | | abundant red mudclasts, |
| | | increasingly mottled gray towards |
| | | the top. |
| T T | 0.22m | Sublitharenite, gray, mL, well- |
| Opper | | sorted, subrounded. |
| member, | 0.14m | Mudstone, purple-red. |
| Wasatch | 0.39m | Mudstone green-gray, biotite |
| | | present, mottled purple/red towards |
| r Ormation | 0.01 | top. |
| | 0.21m | Mudstone, purple-red, trace silt, |
| | | increasingly mottled rust red-gray |
| | | towards top, slight coarsening |
| | 0.04 | upwards. |
| | 0.24m | Mudstone, gray, some silt, abundant |
| | | biotite flakes, possibly high ash |
| | 0.16- | Content. |
| | 0.16m | Mudstone, red, darkens upwards to |
| | 0.02 | Maroon. |
| | 0.03m | Mudstone, red, trace silt. |
| | 0.16m | Mudstone, purple-red, silty. |
| | 0.20m | Mudstone, maroon to red, some silt. |
| | 0.1/m | Mudstone, red, silty, sandy. |
| | 0.03m | mudstone, mottled fust fed, gray, |
| | 0.34m | Mudatona mattled groon and blue |
| | 0.34m | Mudstone, mottled green and blue. |
| | 0.04m | Sublitheronito grav m |
| | Z.I.5m | subrounded medium corting |
| | 1 65m | Mudstone mottled number marcon |
| | T.0.01 | rust red grey- rimmed yellow |
| | | tust red, grey- rimmed yerrow, |
| | | forgila groupdiling and turtle |
| | | TOSSIIS, CLOCOULLIAN AND LULLE. |

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| Upper | 0.24m | | Sublitharenite, gray, fU, well |
|-----------|-------|------|-----------------------------------|
| Member, | | | rounded, well-sorted. |
| | 1.22m | | Mudstone, mottled yellow, purple, |
| Wasatch | | | gray, maroon, rust red, some silt |
| Formation | | | near the top. |
| | | Base | of Butte. |

| Measured | Section 10 | , Wasatch Butte Section B |
|-----------|------------|--|
| | Mulkay Sp: | rings Quadrangle, T. 18 N., R. 115 W., |
| | from Sect | ion 4, SW1/4, SE1/4 to Section 9, NW1/4, |
| | NE1/4. F: | rom the top to the bottom of the |
| | prominent | ridge at the centre of Wasatch Butte. |
| Unit | Thickness | Description |
| <u>×</u> | | Buried sequence |
| | 0 60m | Sublitharenite, mL, poorly sorted. |
| | 0.001 | subangular |
| | 1 40m | Mudstone greenish grav trace |
| | 1.4011 | silt trace sand |
| | 0 80m | Mudstone grav fines unwards from |
| | 0.0011 | trace cilt at bace greenich near |
| | | trace sill at base, greenish hear |
| | 0.07- | Colishe white somegad mainsails. |
| | 2.2/m | Caliche, white, composed primarily |
| | | of calcareous nodules. |
| | 0.76m | Mudstone, purple, trace silt. |
| | 0.31m | Mudstone, red, some silt. |
| | 0.15m | Mudstone, gray-green, sandy. |
| | 0.34m | Sublitharenite, fL, moderately |
| | | sorted, subrounded. |
| | 0.10m | Siltstone, purple, sandy, mottled |
| | | gray at base. |
| | 0.71m | Sublitharenite, fL, moderately |
| | | sorted, subrounded. |
| Upper | 0.17m | Mudstone, red. |
| Member, | 0.22m | Mudstone, purple-gray, trace silt. |
| Wasatch | 0.24m | Sublitharenite, gray, mL, moderate |
| Formation | 1 | sorting, subangular grains. |
| | 0.20m | Mudstone, purple, silty. |
| | 0.27m | Siltstone, sandy, greenish gray. |
| | 0.53m | Mudstone, brownish pink, some silt. |
| | 0.30m | Mudstone, light purple, silty at |
| | | base, trace silt at top. |
| | 0.38m | Sublitharenite, mL, poorly sorted. |
| | 0.00 | subangular abundant mudclasts |
| | 0 18m | Siltstone gray coarsens unwards |
| | 0.2011 | to a sandy siltstone |
| | 0 08m | Mudstone pink trace silt |
| | 0.0011 | according prink, trace silt, |
| | | mudatono ton fou continutuos eno |
| | | mudstone, top iew centimetres are |
| | 1 00 | mottled. |
| | 1.20m | Siltstone, mottled pink and gray, |
| | | biotite common, some mudclasts near |
| | | bottom, fines and greys upwards to |
| | | a gray silty mudstone. |
| | 0.29m | Mudstone, reddish purple, silty. |
| | 1.68m | Siltstone, sandy, gray, top pink. |
| | 0.69m | Siltstone, gray, muddy, coarsens up |
| | | into above unit. |
| | 0.15m | Mudstone, gray-green, trace silt. |
| | | Buried sequence |

Measured Section 11, Wasatch Butte Section C. Mulkay Spring Quadrangle, T.18 N. R. 115 W., Section 4, SE1/4, SE1/4. From top to base of escarpment at the northern end of Wasatch Butte.

| Unit | <u>Thickness</u> | | Description |
|-----------|------------------|------|---|
| | | Тор | of Butte. |
| | 0.81m | | mudstone, gray, some sand. |
| | 0.84m | | mudstone, rust red, some sand. |
| | 0.81m | | litharenite, gray, mL to mU, poorly sorted, subangular, abundant. |
| Upper | 0.25m | | mudstone, rust red, sandy. |
| Member, | 0.25m | | mudstone, gray, coarsens upwards |
| | | | rapidly to a very sandy mudstone, |
| Wasatch | | | to a mL sandstone, moderate to poor |
| Formation | | | sorting, subrounded to subangular. |
| | 1.00m | | mudstone, red, some silt, tiny gray |
| | | | mudclasts, some mottling, lense of |
| | | | greenish gray mudstone with |
| | | | abundant mica at 1.41m. |
| | 0.38m | | mudstone, grey, sandy, purple |
| | | | mudclasts abundant near bottom, |
| | | | fines up to a mudstone, some silt. |
| | 0. 14 m | | mudstone, purplish brown, sandy. |
| | 0.10m | | mudstone, gray, sandy, purple |
| | | | mudclasts, and purplish mottling |
| | | | throughout. |
| | 0.36m | | mudstone, purple-gray, sandy, many |
| | | | of the sand grains are dark, some |
| | | | gray mudclasts. |
| | | Buri | ied sequence |

Measured Section 12, Wasatch Butte Section D Mulkay Spring Quadrangle, T. 18 N., R. 115 W., Section 4, SE1/4, SE1/4. From base to top of ridge due north of Wasatch Butte Section C.

| <u>Unit</u> | <u>Thickness</u> | <u>Description</u> |
|-------------|------------------|-------------------------------------|
| | | Buried sequence |
| | 0.04m | Mudstone, purple. |
| | 0.44m | Mudstone, gray, some regions |
| | | mottled pink, purple, and red. |
| | 0.22m | Mudstone, mottled purple, maroon, |
| | | pink, weathers purple. |
| | 0.79m | Sublitharenite, gray, fU to mL, |
| Upper | | moderately sorted, subangular, |
| Member, | | fines up to a siltstone 0.20m from |
| | | base, and a mudstone 0.45m from |
| Wasatch | | base. |
| Formation | 1.51m | Mudstone, gray, some silt, red and |
| | | brown lenses. |
| | 0.42m | Mudstone, gray, silty, coarsens up |
| | | to a gray siltstone. |
| | 0.41m | Mudstone, pink, trace silt. |
| | 0.75m | Siltstone, gray, sandy, fines up to |
| | | a gray silty mudstone, some sand, |
| | | mudclasts brown near bottom, gray |
| | | near the top. |
| | 1.15m | Sublitharenite, gray, fU, well- |
| | | sorted, subrounded. |
| | | Buried sequence |
| | | - |

Measured Section 13, Cumberland Gap Section. Cumberland Gap Quadrangle, T. 19 N., R. 116 W., Section 34, SE 1/4, NE 1/4. From the base to the top of the tall escarpment north of Little Muddy Creek, and east of Ziller Ranch. Through Fossil Locality BB118.

| Unit | <u>Thickness</u> | Description | |
|------------|------------------|--|---------------|
| | 2 70m | Op of Bulle Migrito tan abundant octa | roada |
| | 5.7011 | and gastropode of the gopus | .ocous |
| | : | Conjobacia thick hodding t | , |
| Tongue, | | top of unit, thinner bedding | ig with |
| Green | | abundant light grav mudstor | ne lenses |
| River | | towards base, mudstones cor | ntain gar |
| Formation | | scales and fish spines. | |
| | 4 10m | Mudstone, green-grav, silty | , grades |
| | 1.101 | into a highly calcareous m | dstone |
| | | at base laminated | |
| La Barge | 0 15m | Micrite tan | |
| Member | 1 60m | Mudstone brown gray and m | aroon |
| - CILDEL , | 1.00m | lenses laminated | aroon |
| Wasatch | 0 98m | Sublitharenite grav ml to | - FIT |
| Formation | 0.50m | Mudstone red brown trace | , ro. silt |
| | 1.25m | Sublitherenite gray red a | siic. |
| | 1.2.511 | mudalacta and mudatone long | nd gray |
| | | acomponent throughout finds un | ,es word |
| | | from mi to ufil worthorg re | A |
| | 7 22- | Mudatone uppiggated appu | u. |
| | /.22m | Mudstone, variegated gray, | rea, |
| | 0 0 0 0 | purple, gray-green, trace s | |
| | 2.33m | Sublitharenite, gray, mL to | , mU, |
| | 0 FF | biotite flakes abundant. | - |
| | 0.55m | Mudstone, mottled red and g | ray, |
| | | abundant blotite and rust r | ea |
| | ~ | inclusions. | |
| | 0.44m | Sublitharenite, silty, mI, | coarsens |
| | | upwards. | - |
| | 0.30m | Mudstone, red, silty, trace | sand. |
| | 0.30m | Mudstone, gray, silty, trac | e sand. |
| | 0.80m | Mudstone, red with yellow a | ind gray |
| | | mottling, silty, trace sand | 1. |
| | 1.22m | Sublitharenite, gray, mL. | |
| | 0.67m | Mudstone, mottled yellow re | ed and |
| | | gray, silty at base. | _ |
| | 0.63m | Siltstone, gray, some yello | w and |
| | | pink mottling. | |
| | 0.15m | Mudstone, red, trace silt. | |
| | 0.10m | Litharenite, gray, mL to mL | ۶. |
| | 1.08m | Mudstone, gray, silty, abur | ıdant |
| | | biotite flakes. | |
| | 0.90m | Litharenite, gray, cL. | |
| | 0.40m | Mudstone, gray-green, trace | e silt. |
| | 0.10m | Mudstone, purple, trace sil | Lt. |

| | 2.18m | Mudstone, mottled red and yellow, |
|---------------------|----------------|--|
| | 0.90m | Siltstone, gray, sandy, biotite present, coarsens upwards to |
| | | sublitharenite, fL. |
| | 0.24m | Mudstone, red, silty. |
| | 0.64m | Sublitharenite, gray, silty, mL, biotite flakes and red mudclasts |
| | 1.42m | Mudstone, red, mottled gray in places, thin gray interbeds |
| | 1 3/m | Litherenite gray mL to mU |
| | 2.15m | Mudstone red with white gray |
| • | 2.15m | and mottled purple lenses. |
| La Barge Member, | 1.35m | Mudstone, gray, silty, sandy, coarser at base, biotite flakes and red mudclasts common. |
| Wasatch | 0.30m | Mudstone, red, trace silt. |
| Formation | 0.40m | Siltstone, gray, sandy, gray mudclasts present throughout. |
| | 1.35m | Mudstone, red, trace silt, siltier at base. |
| | 0.40m | Mudstone, gray, trace silt, red |
| | 0.95m | Sublitharenite, gray, fU to mL, weathers red |
| | 2.00m | Mudstone, variegated, red, purple, yellow, and gray, silty, hard, |
| | 0.50m | Sublitherenite grav fil |
| | 1 25m | Mudstone variegated primarily |
| | 1.23. | red, also purple, yellow, and gray, silty, hard, fractured. |
| | 1.20m | Sublitharenite, gray, fU. |
| | 1.51m | Siltstone, mottled purple and vellow, sandy, fines upwards. |
| | 0.50m | Sublitharenite, gray, fL, thin red mudstone interbeds. |
| | 0.50m | Mudstone, red, some sand, greyer and sandier towards top |
| | 0. 49 m | Siltstone, mottled red and yellow |
| | 0.28m | Litharenite, dark gray to yellow, angular rock fragments, abundant red mudclasts, and red and yellow |
| | 0.21m | mudstone interbeds. Mudstone, red and gray lenses, |
| | 0.00- | trace sand. |
| | 0.98m | Siltstone, yellow-gray, some sand. |
| | 0.4/m 0.63m | Mudstone, yellow-gray. |
| | 0.0311 | mudstone, mottled red and gray. |

| | 0.90m | | Mudstone, yellow with red and gray mottling. |
|-----------|----------------|------|--|
| | 0.28m | | Mudstone, gray, mammalian caudal vertebra, insectivore astragalus, gar vertebra and scales recovered from unit. |
| La Barge | 0. 4 4m | | Mudstone, red. |
| Member, | 0.82m | | Siltstone, gray, trace sand, some mud. |
| Wasatch | 0.30m | | Mudstone, red, trace silt. |
| Formation | 1.50m | | Siltstone, gray at top blends to red at base, trace sand, trace mud. |
| | 0.20m | | Mudstone, red, silty. |
| | 1.30m | | Siltstone, reddish gray, sandy, abundant biotite flakes. |
| | 0.24m | | Mudstone, red, some silt. |
| | 1.24m | | Litharenite, gray, mU. |
| | 0.21m | | Mudstone, gray, trace silt. |
| | 0.55m | | Mudstone, red mottled with gray and yellow, trace silt. |
| | | Base | of butte |
| | | | |

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Measured Section 14, Kizmi Butte Section. Mulkay Springs Quadrangle, T. 18 N., R. 115 W., Section 8, NE 1/4, SE 1/4. From base to top of Kizmi Butte.

| <u>Unit</u> | <u>Thickness</u> | Description |
|-------------|------------------|-------------------------------------|
| | | Top of butte |
| | 0.25m | Micrite, concentric algal pods |
| | | 0.02m to 0.30m in diameter. |
| | 1.01m | Siltstone, gray, some sand. |
| | 0. 4 9m | Mudstone, red, silty. |
| | 0.40m | Micrite, concentric algal pods |
| | | 0.02m to 0.30m in diameter. |
| | 0.30m | Mudstone, grav, silty, some sand. |
| | 0.74m | Mudstone, purple-red, silty, some |
| | ••• | sand. |
| | 1 35m | Litharenite, gray, mL, subrounded. |
| | 1.55% | moderate sorting, thickness |
| | | variable |
| | 3 0.0m | Mudstone red some silt |
| | 1 10m | Litherenite gray mL subrounded |
| | 1.101 | moderate conting thicknood |
| | | moderate sorting, thickness |
| | 0.20- | Somewhat Variable. |
| | 0.20m | Mudstone, red, some silt. |
| | 0.51m | sparite, white, no lossils |
| | 0 05 | apparent. |
| Upper | 0.05m | Mudstone, red, trace silt. |
| Member, | 1.08m | Litharenite, gray, mL to ru, |
| | | subrounded, moderate sorting. |
| Wasatch | 0.40m | Mudstone, red, trace silt. |
| Formation | 0.30m | Litharenite, gray, mL to fU, |
| | | subrounded, moderate sorting. |
| | 1.45m | Mudstone, red, trace silt, trace |
| | | sand. |
| | 0.15m | Siltstone, gray, trace sand. |
| | 0.40m | Mudstone, red, trace silt, trace |
| | | sand. |
| | 0.32m | Litharenite, gray, fL to fU, |
| | | subrounded, moderate sorting. |
| | 0.23m | Siltstone, gray, trace sand. |
| | 0.20m | Sparite, light gray, no fossils |
| | | apparent. |
| | 0.65m | Mudstone, red, trace silt, trace |
| | | sand. |
| | 0.60m | Litharenite, gray, fL, subrounded, |
| | | moderate sorting. |
| | 0.70m | Mudstone, light gray, highly |
| | | calcareous, trace silt. |
| | 0.60m | Mudstone, red with white bands, |
| | | some silt. |
| | 0.10m | Litharenite, gray, fL, subrounded. |
| | | moderate sorting. |
| Upper | 12.48m | Mudstone, red, thin white lenses in |
| * * | | |

| Member, | | | places, some silt. |
|-----------|-------|------|-------------------------------------|
| | 0.18m | | Sparite, white, no fossils |
| Wasatch | | | apparent. |
| Formation | 5.16m | | Mudstone, red, some silt. |
| | 0.04m | | Litharenite, gray, fL to fU, |
| | | | subrounded, moderate sorting. |
| | 0.38m | | Mudstone, red, some silt. |
| New Fork | 5.50m | | Litharenite, gray, mU to cL, poorly |
| Tongue, | | | sorted, cross-bedded, unit |
| | | | thickness variable. |
| Wasatch | | Base | of butte. |
| Formation | | | |

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Measured Section 15, Big Dutch Butte Section. Mulkay Springs Quadrangle, T. 18 N., R. 115 W., Section 5, SW 1/4, SE 1/4, SE 1/4 to Section 8, NW 1/4, NE 1/4, NE 1/4. From base to top of Big Dutch Butte.

| <u>Unit</u> | <u>Thickness</u> | | Description |
|-------------|------------------|------|-------------------------------------|
| | | Top | of butte |
| | 5.00m | | Litharenite, gray, mU, moderate |
| | | | sorting, subrounded to subangular, |
| | | | lenticular cross-bedding, grain |
| | | | size sorting, and thickness of unit |
| | | | highly variable. |
| | 0.50m | | Lithic conglomerate, poorly sorted, |
| | | | subangular to rounded, abundant |
| | | | yellowish mudclasts, reptile bones |
| | | | including turtle carapace fragments |
| | | | and crocodile limb elements common |
| | | | in places. |
| Upper | 4.55m | | Litharenite, gray, mL to cU, |
| Member, | | | moderately sorted, subrounded, |
| | | | 0.01m to 0.10m conglomeratic lenses |
| Wasatch | | | throughout, lenticular cross |
| Formation | | | bedding. |
| | 0.95m | | Mudclast conglomerate, gray, cU, |
| | | | grain size and sorting variable, |
| | | | mudclasts parallel to, bedding. |
| | 1.84m | | Mudstone, red, mottled gray and tan |
| | | | in places, silty, some sand. |
| | 0. 4 0m | | Litharenite, gray, mL, subrounded, |
| | | | moderate sorting. |
| | 4.23m | | mudstone, red, some silt. |
| | 0. 41 m | | Litharenite, gray, mL, subrounded, |
| | | | moderate sorting. |
| | 0.95m | | Mudstone, red, trace silt. |
| | 3.10m | | Mudstone, purple-gray, trace silt. |
| | 0.36m | | Mudstone, light gray, some silt. |
| | 1.05m | | Mudstone, red, some silt. |
| | 0.53m | | Litharenite, fU to mL, moderate |
| | | | sorting, subrounded. |
| | 0.85m | | Mudstone, red, some silt. |
| | 0.50m | | Litharenite, gray, fU to mL, |
| | | | subrounded, moderate sorting. |
| | 0.53m | | Mudstone, light gray, purple lense |
| | | | in middle, some silt. |
| | | Base | e of butte. |

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| Measured Mulk Sect Poin | Section 16, ay Springs ion 6, Sw1, t. Through | Eagle Point Section. Quadrangle, T. 19 N., R. 115. W., 4, SW1/4. From base to top of Eagle Fossil Locality BB117. |
|----------------------------------|--|--|
| <u>Unit</u> | <u>Thickness</u> | Description Top of ridge |
| New Fork | 2.75m | Litharenite, mU to vcU, poorly |
| Tonque | | sorted, conglomeratic lenses |
| 1011940 | | common, thickness variable but |
| Wasatch | | laterally persistent, lenticular |
| Formation | | cross-bedding. |
| | 0.10m | Micrite, oncolitic. |
| | 8.50m | Sublitharenite to Quartz arenite, |
| | | white to gray, mL to cL, moderate |
| | | sorting, thickness variable but |
| | | laterally persistent, lenticular |
| <u></u> | | cross-bedding. |
| | 2.00m | Mudstone, dark gray, trace silt. |
| | 0.60m | Sublitharenite, gray, fU to mL, |
| | 0 50 | well-sorted, subrounded. |
| | 2.50m | Mudstone, dark gray, trace silt. |
| | 0.30m | Sublitharenite, IU, moderately |
| Williams | 0 95- | Sortea, Subroundea. Mudatono dark gray gilty |
| NIIKINS | 0.85m | Migrite light vellow |
| Member | 0.2011 | stromatolitic |
| Member, | 0 90m | Mudstone, dark grav, silty |
| Green | 0.20m | Micrite, light vellow. |
| River | 0.12.01 | stromatolitic. |
| Formation | 1.07m | Mudstone, dark gray, silty. |
| | 0.45m | Sublitharenite, light gray, fU, |
| | | moderate sorting, subrounded. |
| | 1.30m | Mudstone, dark gray, some silt. |
| | 0.38m | Micrite, light yellow, |
| | | stromatolitic. |
| | 2.80m | Mudstone, dark gray-green, lighter |
| | | in colour towards top, almost tan, |
| | | some silt, trace sand. |
| | 0.20m | Micrite, white, stromatolitic in |
| | 1 45 | places. |
| | 1.45M | mudstone, dark gray-green, trace cilt |
| | 0 15m | Micrite white stromatolitic in |
| | 0.1.711 | places. |
| | 1.30m | Mudstone, grav-green, trace silt. |
| | 0.15m | Micrite, white, highly |
| | | stromatolitic |
| | 4.20m | Mudstone, tan to gray, emydid |

turtle and <u>**Byrachyus**</u> <u>modestus</u> jaw found near base. -----

| | 0.51m | Litharenite, gray, mU at top, |
|------------|-------|------------------------------------|
| Fontenelle | | conglomeratic at base, fines |
| Tongue, | | upwards, poor to moderate sorting, |
| _ | | subrounded, thickness variable. |
| Green | 0.29m | Mudstone, gray, trace silt. |
| River | 0.71m | Micrite, light yellow, |
| Formation | | stromatolitic in places. |
| | 5.50m | Mudstone, light gray at top, green |
| | | gray at base, some silt. |
| | 0.39m | Micrite, reddish gray. |
| | 6.10m | Mudstone, gray, trace silt. |
| | 0.35m | Micrite, white, stromatolitic in |
| | •••• | places. |
| | 9.05m | Mudstone, gray, trace silt. |
| | | |

Buried sequence approximately 25m in thickness.

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| New Fork | | |
|------------|-------|--|
| Tongue | 5.90m | Litharenite, gray, unit thickness, grain size and grain shape highly |
| Wasatch | | variable, conglomeratic lenses |
| Formation | | common, lenticular cross-bedding. |
| | 0.10m | Mudstone, gray, calcareous, trace silt, highly bioturbated. |
| | 0.75m | Litharenite, gray, unit thickness, grain size and grain shape highly variable, conglomeratic lenses common, lenticular cross-bedding. |
| | 1.00m | Sparite, yellow, fossils not |
| Fontenelle | | apparent, very oolitic in places. |
| Tongue, | 0.15m | Siltstone, green-gray, some mud. |
| | 0.45m | Sublitharenite, light gray, mL to |
| Green | | fU, well-sorted, cross-bedded. |
| River | 0.90m | Mudstone, red to maroon. |
| Formation | 1.40m | Mudstone, gray, silty. |
| | 1.10m | Litharenite, gray, mL, moderately sorted, subrounded. |
| | 2.88m | Mudstone, gray, silty, some sand. |
| | 0.65m | Litharenite, gray, mL, moderate sorting, subrounded. |
| | 0.97m | Mudstone, gray, silty, trace sand. |
| | 0.10m | Micrite, yellow, oolitic/ ostracodal at top, crystalline at |
| | | base. |
| | 0.70m | Siltstone, gray, trace sand. |
| | 0.90m | Mudstone, gray, some silt. |
| | 0.30m | Litharenite, gray, mL, moderate sorting, subrounded. |
| | Buri | ed Sequence. |

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SUPPLEMENTARY MATERIAL










