PALEONTOLOGY AND GEOLOGY OF THE BADWATER CREEK AREA, CENTRAL WYOMING

Part 1. History of Field Work and Geological Setting

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INTRODUCTION

In 1962 the Section of Vertebrate Fossils of Carnegie Museum began the exploration of Tertiary deposits and the collection of Tertiary fossils along Badwater Creek in the northeastern part of the Wind River Basin, Natrona and Fremont counties, Wyoming. Field work and study of the collections will probably occupy several more years, but the significance of the materials and information obtained so far seems to warrant publication of results as individual groups of the faunas and various aspects of the geology are studied. Part 1 of this series is a general introduction to the field work and setting of the faunas. Part 2 describes the only known late Eocene multituberculate. Part 3 describes a new species of apatemyid.

SCOPE OF THE SERIES

In recent years there has been an increased interest in the evolutionary changes in various mammalian groups during the late Eocene, an interval lasting from about forty-five to about thirty-six million years ago. This interest led to such work as Gazin (1955, 1958) on artiodactyls and primates, Radinsky (1963) on tapiroids, Dawson (1966) on rodents, and to many studies on late Eocene faunas now in progress in both North America and Eurasia. As Simpson (1965) has remarked, "Paleontology is necessarily a slow science, costly in labour and time in each phase from discovery through collection and laboratory preparation to comparison, identification, and analysis." Nevertheless, as many colleagues are working on similar problems, the authors feel it is perhaps unwise to delay presenting information as it becomes available, even though they believe their knowledge is incomplete. The present series of papers has accordingly been initiated.

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The papers in this series on the paleontology and geology of the Badwater Creek area will include a number of parts. Although the authors cannot predict the order in which studies will be completed, the first reports will probably be descriptive and systematic treatments of the vertebrate groups present in the various faunas. When the composition of each fauna is well established, analysis of entire assemblages, including invertebrates, from the various localities will be possible. Geological work including more detailed mapping and sedimentation studies is also planned.

HISTORY OF INVESTIGATION

Our interest in the late Eocene and thus in the Badwater area stems from a series of informal discussions during 1960 and 1961 on problems of small mammal evolution and the dearth of information on this subject for the late Eocene and early Oligocene. A recent evaluation of previously known information on this period (Black and Dawson, 1966) has demonstrated how critical in mammalian history the late Eocene was, not only for small mammals but for eutherians in general.

The first result of these discussions was an endeavor to assess the potential of the then known late Eocene vertebrate localities for further work using a washing technique (McKenna, 1962) for recovering micro-mammalian remains. One of the most promising localities appeared to be in the area along Badwater Creek in the northeastern Wind River Basin. Wood, Seton, and Hares (1936) were the first to collect vertebrates in this region and to recognize the late Eocene age of the fossils. The mammalian specimens discovered were *Amynodon advenus* and cf. *Telmatherium cultridens*. After this initial discovery little attention was given to the area by vertebrate paleontologists until Tourtelot (1946, 1953, 1957) began geological investigations for the U. S. Geological Survey. In the course of his work vertebrate material was discovered at a number of localities along Badwater Creek and also farther to the west along Dry Creek in Fremont County.

Partly as a result of Tourtelot's discoveries, the Third Annual Field Conference of the Society of Vertebrate Paleontology included the Badwater Creek—Lysite Mountain area in its itinerary. In the Guidebook

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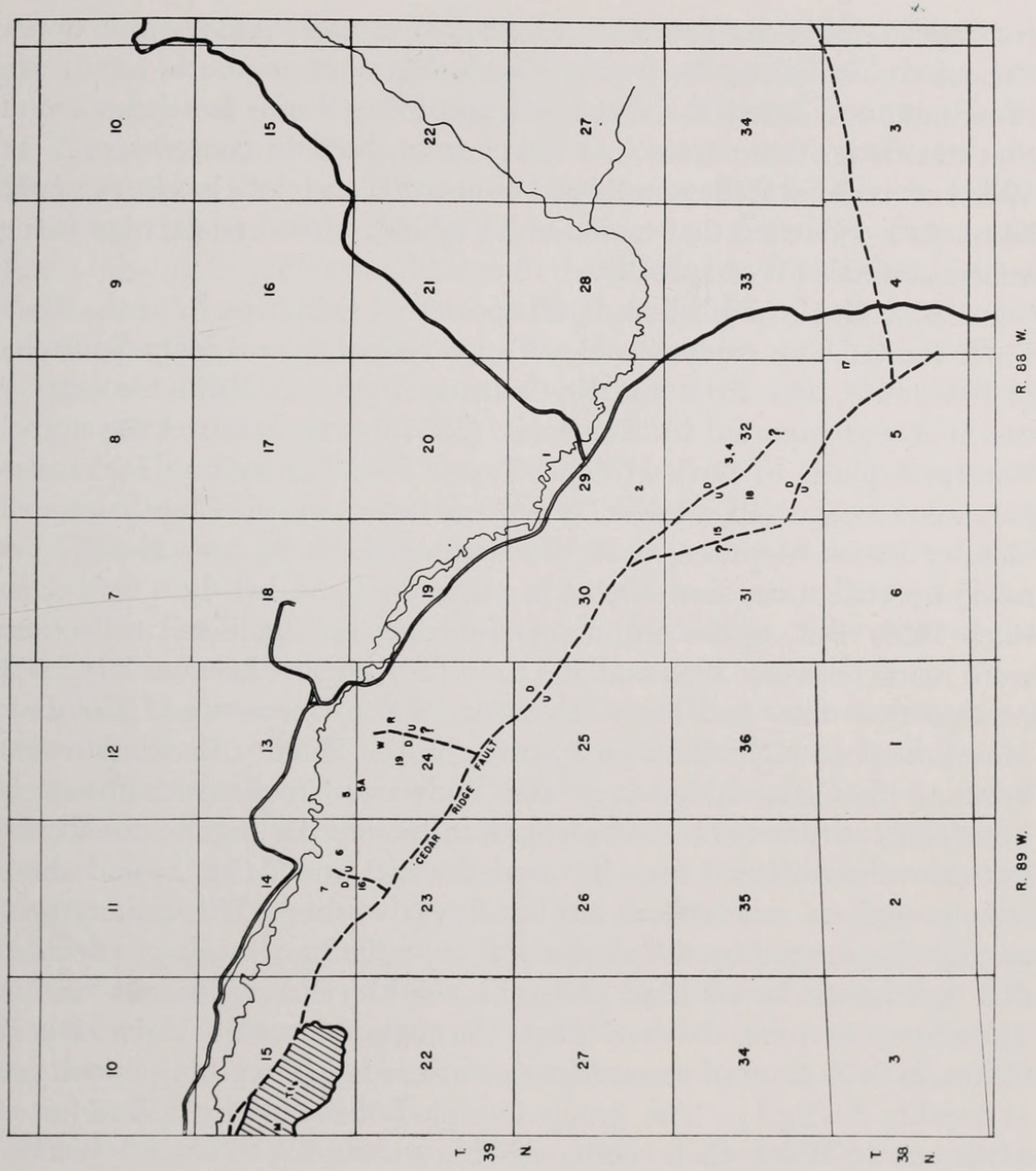
Figure 1. Sketch map showing position of Tourtelot's and the authors' localities along Badwater Creek in Natrona Co., Wyoming. Nos. 1-7, 15-16 used by Tourtelot (1957). Nos. 5A, 17-19, and W (Wood), M (Malcolm), and R (rodent) refer to localities discovered since 1962.


CEDAR RIDGE FAULT
R. 88 W.
R. 89 W.
T. 39 N.
T. 38 N.

for the Conference, Tourtelot (1948) discussed "middle and upper Eocene rocks" along Badwater Creek and farther north on Lysite Mountain, and listed the vertebrate and invertebrate fossils known at that time from these areas. At the close of the field conference, A. E. Wood of Amherst College returned to one of Tourtelot's localities where he made a collection that included 14 species of mammals, nine being micromammals (Wood, 1949).

In 1956, Gazin published on 28 species of mammals from the Badwater fauna. This study was based upon collections made by Tourtelot in 1944, 1945, and 1948, and by Gazin in 1946 and 1953. Geology of the area was reported by Tourtelot (1957), who referred the upper Eocene deposits to Love's (1939) Tepee Trail Formation. Two members were recognized, a lower "green and brown member" and an upper Hendry Ranch Member. A. E. Wood returned to the area in 1957 but made no collections and Gazin has worked there briefly a few times since 1956. But, to the authors' knowledge, no significant collections were made between 1953 and the time they began their work in 1962. At that time they and Peter Robinson of the University of Colorado Museum spent eight days prospecting in the Hendry Ranch Member between the Cedar Ridge fault and Badwater Creek, visiting most of Tourtelot's vertebrate fossil-bearing localities in the region. Small collections were obtained from his localities 5, 6, and 7 (fig. 1) and about forty pounds of matrix from locality 6 was washed. The authors were greatly encouraged by the results of this preliminary work and decided that a large-scale washing program would yield significant results. Therefore, in June, 1963, a joint Carnegie Museum—University of Colorado field crew of some dozen members began washing operations at locality 5 (fig.1). The group modified the washing technique of McKenna (1962) to their needs, washing and drying the highly bentonitic matrix in relatively tightly woven burlap sacks that would retain teeth less than 0.5 mm. in length. Preliminary sorting of concentrates indicated a loss, when screens were used, of some thirty to forty per cent of the isolated teeth and bones occuring in the deposit. This fraction was retained when washing was done in finely woven burlap sacks. The fraction retained consisted of isolated rodent and insectivore teeth of several species plus isolated teeth of one marsupial, one primate, and one multituberculate.

Further prospecting led to discovery of locality 5A, and during the 1963 season about twenty tons of matrix from localities 5 and 5A were processed. It was during this field season that the first late Eocene

multituberculate tooth was found (Robinson, *et. al.*, 1964) while prospecting at locality 5. It was also during the summer of 1963 that a late Paleocene fauna was discovered just east of the Natrona-Fremont County line and south of Badwater Creek in what is now considered the Shotgun Butte Member of the Fort Union Formation (Keefer, 1964).

Prospecting in 1963 and 1964 led to discovery of several other vertebrate-bearing localities in addition to those listed by Tourtelot. Two of these, nos. 17 and 18, have yielded materials which suggest a fauna possibly of late Lost Cabinian age. The locality from which A. E. Wood (1949) obtained his collection was also prospected. This is not Tourtelot's locality 15, as reported, and is here termed "Wood locality." Tourtelot's locality 15 is in the NE½sec. 31, T. 39N., R. 89W., while the Wood locality is in NE¼NW¼sec. 24, T. 39N., R. 89W. In 1964 20 tons of matrix from locality 6 and the Wood locality were processed as were 2 tons of matrix from the late Paleocene county line locality [named "Malcolm's locality" (fig. 1) after Malcolm C. McKenna, discoverer of the first fossil mammals there.].

During the summer of 1963 a fourth faunal horizon was discovered in tan sandy silts which unconformably overlie the Tepee Trail Formation in the vicinity of the Wood locality and of localities 5, 6, and 7. This horizon was not worked extensively until 1965 when a small productive lens, locality 19, was discovered near the Wood locality but stratigraphically considerably above it. Preliminary analysis of this fauna indicates a late Oligocene or earliest Miocene age (included are *Palaeolagus, Eumys, Prosciurus, Proheteromys, Pseudotheridomys* (?), *Peratherium,* and an insectivore). In 1965 one month was spent working this and the previously known localities, and about a ton of matrix from locality 17 was washed.

Collections of 1963, 1964, and 1965 now total several thousand specimens including mollusks, reptiles, and mammals. There still remains a backlog of unsorted concentrate which represents approximately one-third again as much as the total processed to date. Of the mammalian specimens so far obtained, roughly 90 per cent are isolated teeth. A sufficient number of jaw and maxillary fragments have been recovered, however, to warrant some hope that quarrying will produce additional associations, and quarrying operations are planned for future field work.

Thus far our work (Robinson, *et al.*, 1964) has added between twenty-eight and thirty species to the previously recognized 28 (Table 1) that were discussed by Gazin (1956). Of the additions, 18 genera are new to the North American late Eocene. Some of the preliminary

determinations of the 1964 report (Robinson, *et al.*) and the fauna listed in Table 1 will undoubtedly be modified by later work as more complete material is obtained. However, it is now obvious that the late Eocene faunas recovered from the Hendry Ranch Member of the Tepee Trail Formation are the most varied and the richest of any North American late Eocene faunas known. In addition, the other newly discovered faunal horizons north of Cedar Ridge along Badwater Creek are of significance both faunally and geologically.

General Geological Setting

The area from which the numerous Badwater faunas have been obtained is located in the northeastern part of the Wind River Basin along the southern edge of the Big Horn Mountains and the southeastern end of the Owl Creek Mountains in Fremont and Natrona Counties, Wyoming. All but one of the localities considered here lies to the south of Badwater Creek between the creek and the Cedar Ridge fault (fig. 1). To quote from Tourtelot (1957: 1-2), "The younger Eocene strata consist of resedimented andesitic volcanic rocks and form a narrow belt adjacent to the mountains, and in part within them. These volcanic-rich strata are separated from the Wind River formation of early Eocene age on the south by a normal fault of large displacement."

Tourtelot recognized two members of the Tepee Trail Formation, a lower "green and brown" member and above this the Hendry Ranch Member. The rocks of the Hendry Ranch Member were considered by Tourtelot to be generally finer grained than those of the green and brown member. The green and brown member is characterized as being (Tourtelot, 1957: 7), "rich in volcanic material and zones of conglomerate . . . and hard tuff (?) embedded in a coarse-grained matrix of similar volcanic material." Siliceous fresh-water limestones are prominent in the upper part of the green and brown member. The Hendry Ranch Member is described as being made up of gray and greenish-gray claystone and siltstone and tan siltstone rich in volcanic material.

At the western end of Cedar Ridge, Tourtelot recognized a small area of vertical to overturned beds of the Fort Union Formation. These are now (Keefer, 1964) considered to be part of the Shotgun Butte Member of the Fort Union Formation. Vertebrate fossils have been recovered from these strata [Malcolm's (M) locality, fig. 1].

All other localities worked by the authors since 1962 are in the Tepee Trail Formation. Tourtelot regarded the Tepee Trail strata as deposits

of both middle and late Eocene time. Two faunas, those from localities 17 and 18, are of a late early Eocene aspect. *Phenacodus,* a genus unknown after Lost Cabinian time, occurs in both. Unfortunately, neither locality has yet produced sufficient material of other groups for an accurate age determination.

Localities 1, 2, 3, 4, 17, and 18 all occur in the green and brown member as shown by Tourtelot (1957), fig. 2). No vertebrate specimens have been recovered from 1, 2, 3, or 4 that would suggest an age assignment different from that of the Hendry Ranch faunas. However, very little diagnostic material has been obtained from localities 1, 2, 3, and 4 as yet.

All other localities are in the Hendry Ranch Member as mapped by Tourtelot. These include localities 5, 5A, 6, 7, 16, 19, R, and W. Faunas from these localities, except 16 and 19, are essentially the same although some minor differences in composition are suggested. Localities 16 and 19 are in the silts considered by Tourtelot (1957: 13) to be the uppermost portion of the Hendry Ranch Member. Field work in 1964 and 1965 disclosed that these tan silts unconformably overlie the gray and greenish-gray strata of the Hendry Ranch Member and that they contain a fauna of much later aspect. Mammals recovered from both localities 16 and 19 indicate a late Oligocene to earliest Miocene age for these rocks.

FUTURE WORK

Field work in the future will be devoted to recovery of larger collections from the late early Eocene and the late (?) Oligocene localities; to development of quarries at localities W, 5, 5A, 6, and 7 in the hope of securing more complete materials; and to work in the Dry Creek area to the west.

Various groups such as insectivores, primates, and rodents are now being studied and reports on individual elements of the faunas should be completed soon. Analysis of faunal variations among localities within the Hendry Ranch Member will be made. Certain differences are already apparent in gross aspect indicating possibly differing ecological conditions within this limited area of deposition.

Geological studies will continue during the summer of 1966. The Tertiary structural history of this region is much more complex than heretofore realized and this must be unraveled. Petrographic studies will be made of rock samples from each vertebrate producing locality. These may shed some light on differing depositional environments which

would influence animal distribution. Finally, an attempt will be made to relate Tepee Trail sediments along Badwater Creek to those to the north and west toward and into the type area of the Formation (Love, 1939).

ACKNOWLEDGEMENTS

Genera of Marsupialia, Insectivora, Dermoptera, and Primates listed in Table 1 were supplied by Peter Robinson of the University of Colorado Museum, who is studying these elements of the Badwater faunas. The authors would also like to thank him for his help during the 1962 and 1963 field seasons. Work was supported by NSF grants GB-1266 and GB-4089 and by grants from the Childs Frick Corporation and the Gulf Oil Corporation.

TABLE 1

Late Eocene mammals, Hendry Ranch Member, Tepee Trail Formation, as now known from localities 5, 5A, 6, 7, Rodent (R), and Wood (W), shown in figure 1.

Multituberculata
- Ptilodontidae
  - *Parectypodus**

Marsupialia
- Didelphidae
  - *Peratherium*
  - *Nanodelphys**

Mammalia *inc. sed.*
- *Thylacaelurus*

Insectivora
- Leptictidae
  - leptictid sp.
- Pantolestidae
  - pantolestid sp.*
- Apatemyidae
  - *Apatemys* 2 spp.
- Nyctitheriidae
  - ?*Nyctitherium**
  - ?*Micropternodus**
  - *Geolabis**
- Erinaceidae
  - ?*Scenopagus*
  - ?*Entomolestes**
  - *Ankylodon**
  - ?*Proterixoides**
- Soricidae
  - *Domnina**
- Talpidae
  - ?talpid sp.*
- Apternodontidae
  - ?*Apternodus**
  - *Oligoryctes**

Dermoptera
- Plagiomenidae
  - plagiomenid*

Primates
- Omomyidae
  - *Chumashius*
  - *Macrotarsius**
- Anaptomorphidae
  - *Uintasorex**
  - ?*Anaptomorphus**
- Paromomyidae
  - paromomyid sp.*

Lagomorpha
- Leporidae
  - *Mytonolagus*

Rodentia
- Paramyidae
  - *Ischyrotomus*

Leptotomus
Rapamys
Microparamys
?*Plesispermophilus**
Cylindrodontidae
?*Pseudocylindrodon**
Sciuravidae
Sciuravus
sciuravid sp.*
Eomyidae
eomyid sp.*
Rodentia *inc. sed.*
1 sp.
Carnivora
Limnocyonidae
?*Limnocyon*
Miacidae
Miacis
Tapocyon
Condylarthra
Hyopsodontidae
Hyopsodus
Perissodactyla
Equidae
Epihippus
Brontotheriidae
brontotheriid sp.
Eomoropidae
?*Grangeria**
Helaletidae
Dilophodon
Colodon
Hyracodontidae
Prothyracodon
?*Epitriplopus*
Amynodontidae
Amynodon
Artiodactyla
Dichobunidae
?*Pentacemylus*
*Apriculus**
?*Auxontodon*
?*Hylomeryx*
Agriochoeridae
Protoreodon
Diplobunops
Leptomerycidae
Leptotragulus
Leptoreodon
Oromerycidae
*Malaquiferus**

*Indicates this is the first record for the taxon in the late Eocene.

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