EARLY CENOZOIC MAMMALIAN FAUNAS OF THE CLARK'S FORK BASIN-POLECAT BENCH AREA, NORTHWESTERN WYOMING

Philip D. Gingerich, Kenneth D. Rose,[1] and David W. Krause

Abstract.— A richly fossiliferous stratigraphic section including late Cretaceous, Paleocene, and early Eocene faunas is exposed along Polecat Bench and the southern margin of the Clark's Fork Basin. Lancian, early Puercan, and late Torrejonian faunas are known from three concentrations in 200 m of section on the east side of Polecat Bench: Dumbbell Hill, Mantua Quarry, and Rock Bench Quarry, respectively. Tiffanian faunas occur at 55 localities in about 800 m of section on the east, south, and west sides of Polecat Bench. Large faunal samples are known from Cedar Point Quarry (mid-Tiffanian) in the Foster Gulch area and Princeton Quarry (late Tiffanian) in the Clark's Fork Basin. Clarkforkian faunas occur at 135 localities in about 470 m of section on the south side of Polecat Bench and in the Clark's Fork Basin. Early and middle Wasatchian faunas occur at 105 localities in about 600 m of section in the southwestern part of the Clark's Fork Basin. The Tiffanian-Clarkforkian boundary is marked by the immigration of Rodentia, Tillodontia, *Coryphodon,* and *Haplomylus,* and the Clarkforkian-Wasatchian boundary is defined by the immigration of Artiodactyla, Perissodactyla, adapid and omomyid primates, and hyaenodontid creodonts. Faunal diversity was high in the Torrejonian, relatively low in the Tiffanian and Clarkforkian, and high again in the Wasatchian.

INTRODUCTION

One of the most complete stratigraphic sections spanning the Paleocene-Eocene boundary in continental sediments is in the Clark's Fork Basin-Polecat Bench area of the northern Bighorn Basin. Mammalian faunas from the Clark's Fork Basin were first described by W. J. Sinclair and W. Granger (Sinclair and Granger, 1912; Granger, 1914). They recognized a "Gray Bull" fauna and two new faunas, a "Clark Fork" fauna and a "Sand Coulee" fauna, each older than the typical Bighorn Basin "Wasatch" exposed along the Greybull River. In 1929, Sinclair and G. L. Jepsen discovered three quarries near Polecat Bench in beds stratigraphically below the Clark Fork and Sand Coulee beds. These were, from oldest to youngest, Mantua Quarry, Rock Bench Quarry, and Princeton Quarry. Later, Jepsen discovered latest Cretaceous mammals 120 m below the level of Mantua Quarry. As a result of Granger, Sinclair, and Jepsen's work, all of the latest Cretaceous to early Eocene North American land-mammal ages are represented in one stratigraphic section exposed along the south side of Polecat Bench and the southern margin of the Clark's Fork Basin. These are, from oldest to youngest, the Lancian, Puercan, Torrejonian, Tiffanian, Clarkforkian, and Wasatchian (Granger's "Sand

Museum of Paleontology, The University of Michigan, Ann Arbor, Michigan 48109. [1]*Present address:* Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.

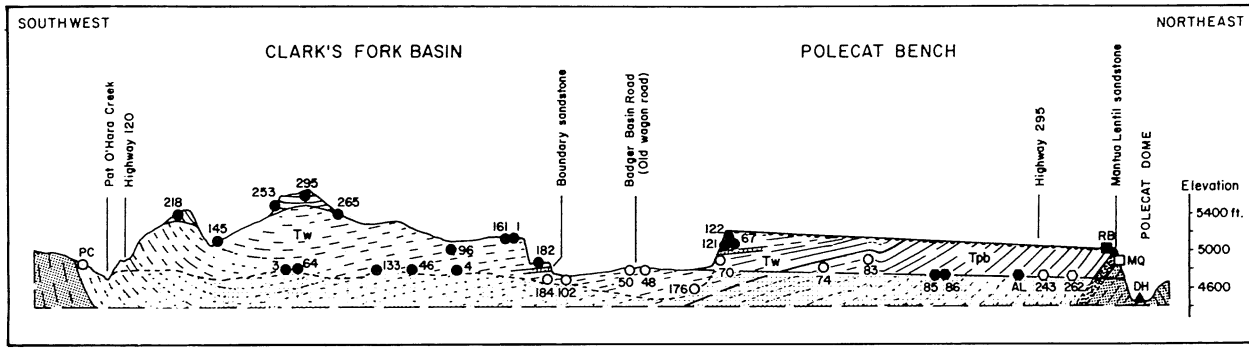


Figure 1. Diagrammatic geological cross-section of the Clark's Fork Basin-Polecat Bench area, showing the stratigraphic relationship of some of the principal fossil localities. Abbreviations, symbols, and horizontal scale as in Figure 2. Vertical scale exaggerated approximately x14.

Coulee beds" are now generally recognized as basal Wasatchian).

The total stratigraphic section exposed at the surface in the Clark's Fork Basin-Polecat Bench area and yielding latest Cretaceous, Paleocene, and early Eocene mammalian fossils is now known to be approximately 2,100 m thick. The combined thickness of the preserved Puercan and Torrejonian sediments on Polecat Bench is only about 80 m, compared with a combined thickness of Tiffanian, Clarkforkian, and Wasatchian sediments of approximately 1,900 m. Thus the Tiffanian-Clarkforkian-Wasatchian sequence spanning the Paleocene-Eocene boundary is particularly well represented.

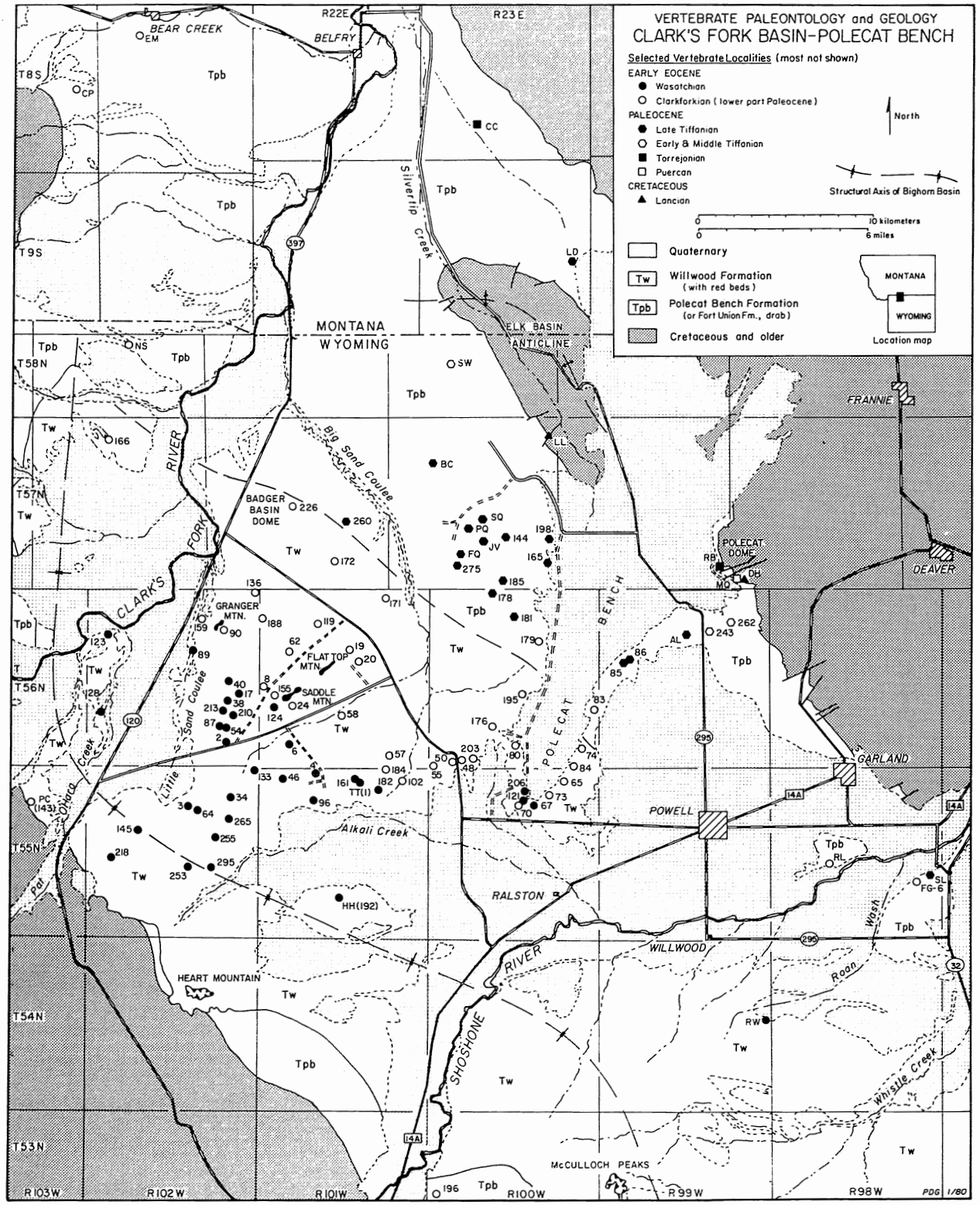
The University of Michigan began field work in the Clark's Fork Basin in 1975 in an attempt to document the poorly known fauna of Granger's Sand Coulee beds. Several very rich Clarkforkian localities with the index fossil *Plesiadapis cookei* were found during the first summer in supposed Sand Coulee beds. During the second summer Clarkforkian and basal Wasatchian localities were mapped, a sandstone unit separating them was located, and this boundary sandstone was traced across the Clark's Fork Basin. Work continues on the Wasatchian faunas of the Clark's Fork Basin, but we have expanded the scope of this project to try to understand faunal change through the entire section exposed on Polecat Bench and in the Clark's Fork Basin.

A map and cross-section of the Clark's Fork Basin-Polecat Bench area are presented in Figures 1 and 2, where some of the more important University of Michigan and Princeton University localities are shown. On the east side of Polecat Bench, Lancian, Puercan, and Torrejonian strata are exposed in the vicinity of Polecat Dome, an anticline representing a southeastward extension of the larger Elk Basin anticline and oil field. The thick sequence of strata above the Torrejonian Rock Bench Quarry (RB) level, representing the Tiffanian, Clarkforkian, and

Figure 2 [Opposite page]. Geological map of the Clark's Fork Basin-Polecat Bench area, showing the geographical distribution of the Polecat Bench and Willwood formations, and the location of some of the principal fossil vertebrate localities. University of Michigan localities in the Sand Coulee area are numbered on the map without the prefatory SC used in the text. Foster Gulch localities to the southeast are prefaced FG. Princeton University localities are abbreviated as follows:

AL, Airport Locality (SC-239, 246)
BC, Brice Canyon (SC-272)
CC, Cub Creek
CP, *Coryphodon proterus* type locality
DH, Dumbbell Hill
EM, Eagle Mine
FQ, Fritz Quarry
HH, Hackberry Hollow (SC-192)
JV, Jepsen Valley Quarry
LD, Long Draw Quarry
LL, *Leptoceratops* Locality
MQ, Mantua Quarry
NS, Noble Site
PC, Paint Creek (SC-143)
PQ, Princeton Quarry (SC-187)
RB, Rock Bench Quarry
RL, Ries Locality (FG-10)
RW, Roan Wash
SL, Sunday Locality (FG-4)
SQ Schaff Quarry
SW, Seaboard Well
TT, Twisty Turn Hollow (SC-1, 161)

SC-144 is the area where the Tiffanian *Hyracotherium* is said to have been found.


VERTEBRATE PALEONTOLOGY and GEOLOGY
CLARK'S FORK BASIN–POLECAT BENCH
Selected Vertebrate Localities (most not shown)
EARLY EOCENE
Wasatchian
Clarkforkian (lower part Paleocene)
PALEOCENE
Late Tiffanian
Early & Middle Tiffanian
Torrejonian
Puercan
CRETACEOUS
Lancian
North
Structural Axis of Bighorn Basin
10 kilometers
6 miles
Quaternary
Tw Willwood Formation (with red beds)
Tpb Polecat Bench Formation (or Fort Union Fm., drab)
Cretaceous and older
MONTANA
WYOMING
Location map
BEAR CREEK
BELFRY
Silvertip Creek
ELK BASIN ANTICLINE
MONTANA
WYOMING
FRANNIE
DEAVER
POLECAT DOME
POLECAT BENCH
CLARK'S FORK RIVER
Big Sand Coulee
BADGER BASIN DOME
GRANGER MTN.
FLAT TOP MTN.
SADDLE MTN.
Sand Coulee
Little Sand Coulee
Alkali Creek
Pat O'Hara Creek
HEART MOUNTAIN
RALSTON
POWELL
GARLAND
WILLWOOD
SHOSHONE RIVER
Roan Wash
Whistle Creek
McCULLOCH PEAKS
T8S
T9S
T58N
T57N
T56N
T55N
T54N
T53N
R103W
R102W
R101W
R100W
R99W
R98W
R22E
R23E
CC
LD
LL
BC
SQ
PQ
JV
FQ
RB
DH
MQ
AL
RL
RW
SL
FG-6
PC (143)
HH(192)
TT(1)
SW
NS
EM
CP
PDG 1/80

early-middle Wasatchian, is best exposed along the south side of Polecat Bench and the southern margin of the Clark's Fork Basin. Here the sediments are part of a monocline dipping gently to the southwest, with dips of up to 10-12°. Some 20 mi (32 km) southwest of Polecat Dome, in the structural axis of the Clark's Fork Basin, beds are flat-lying. West of the basin axis they dip steeply to the northeast. The Clark's Fork Basin is asymmetrical, with the structural axis running very near the western margin. Stratigraphically, the basin is also asymmetrical, and along the western margin Clarkforkian and Wasatchian age sediments rest directly on the Cretaceous. Intervening Paleocene sediments were probably never deposited along this western margin.

In the following sections of the paper we summarize what is known about Lancian, Puercan, Torrejonian, Tiffanian, Clarkforkian, and Wasatchian faunas of the Clark's Fork Basin-Polecat Bench area.

Abbreviations referring to specific localities are given in parentheses. These are explained in the captions to Figures 1 and 2.

LANCIAN FAUNA (LATE CRETACEOUS)

Mammalian fossils from "Lance equivalent" strata in the northern Bighorn Basin have not yet been described in detail. Jepsen (1931) first reported the discovery of an isolated mammalian tooth east of Red Lodge, Montana, in association with dinosaur bones, teeth, and egg shell fragments. Later, mammalian teeth were recovered by Princeton University field parties from a locality known as "Dumbbell Hill" (DH), on the east side of Polecat Bench. This collection was described by J. Dyer in 1948 in an unpublished senior thesis at Princeton University. Dyer's collection and a subsequent collection made by D. C. Parris of Princeton in 1971 include the taxa listed in Table 1. These confirm the Lancian age generally ascribed to "Lance equivalent" strata in this area. Ostrom (1978) described a partial skeleton of the ceratopsian dinosaur *Leptoceratops gracilis* from a locality (LL) 8.5 mi (14 km) northwest of Dumbbell Hill.

Table 1. Mammalian fauna of the Dumbell Hill locality, late Cretaceous. Identifications by R. E. Sloan and W. A. Clemens (see Clemens et al., 1979).

MULTITUBERCULATA
Cimolomys gracilis
Mesodma formosa
Cf. *Cimexomys* sp.
Cimolodon nitidus
MARSUPIALIA
Alphadon cf. *A. marshi*
PROTEUTHERIA
?Leptictoid insectivore

Table 2. Mammalian fauna of Mantua Quarry (Jepsen, 1930, 1940; Van Valen, 1978).

MULTITUBERCULATA
Mesodma ambigua
Stygimys gratus
PROTEUTHERIA
Procerberus sp.
CONDYLARTHRA
Oxyprimus galadrielae
Oxyprimus putorius
Ragnarok nordicum
Eoconodon copanus
Maiorana noctiluca
Mimatuta minuial
Earendil undomiel
Oxyacodon josephi

PUERCAN FAUNA (EARLY PALEOCENE)

The Mantua lentil is a massive sandstone about 40 meters thick at the base of the Polecat Bench Formation, directly overlying Lancian strata. A sample of over one hundred mammalian specimens, including skulls and jaws, was obtained from Mantua Quarry at the base of the sandstone by Jepsen and Princeton University field parties. The mammalian fauna has been described by Jepsen (1930, 1940) and Van Valen (1978), with additional citations of taxa by Russell (1967) and Sloan (1969). A faunal list is given in Table 2. Dinosaur bones and teeth occur in "Lance equivalent" strata only 6 ft (1.83 m) below the thin coal bed that directly underlies Mantua lentil (Jepsen, 1940).

The collections from Mantua Quarry and from Leidy Quarry (in the southern part of the Bighorn Basin) represent a distinctive fauna, and Van Valen (1978) proposed a pre-Puercan land-mammal age, the Mantuan, to recognize their individuality. In our opinion the evidence is insufficient for recognition of a distinct stage or land-mammal age (see Savage, 1962; Tedford, 1970), and we therefore provisionally

regard these faunas as earliest Puercan in age. Puercan mammals are unknown from elsewhere in the Bighorn Basin.

TORREJONIAN FAUNA (MIDDLE PALEOCENE)

Torrejonian mammals are known from only two localities in the Clark's Fork Basin-Polecat Bench area: Rock Bench Quarry, and "Simons' 1955 locality" on Cub Creek. Both localities have yielded late Torrejonian mammals.

Rock Bench Quarry (RB) is one of the most productive and significant sites of middle Paleocene (Torrejonian) age anywhere in North America. While some of the lower vertebrates from the quarry have been described (e.g., Gilmore, 1942; Boreske, 1974; Krause, this volume; Bartels, this volume), the site is best known for its variety and abundance of fossil mammals. Jepsen (1930, 1940) and Russell (1967) presented the principal accounts of the mammalian fauna. Their faunal lists have since been expanded by Rose (1979).

Fossil vertebrates in the quarry are concentrated in a thin clay-gall conglomerate at the base of a thick channel sandstone. Since this is a water-laid deposit, we may assume that some hydraulic sorting has occurred. Remains of small and very small mammals predominate in the sample; however, many of the larger species of the time are also represented (for example, arctocyonid and phenacodontid condylarths, mesonychids, pantodonts, and taeniodonts). Hence size-sorting does not appear to be a serious bias in the sample. Sedimentary conditions at Rock Bench Quarry suggest rapid deposition of the bone-producing bed. The Rock Bench sample, then, should give us a reasonably accurate picture of mammalian life in northern Wyoming during the latter part of the middle Paleocene.

The composition of the mammalian fauna, based on minimum numbers of individuals, is depicted in Figure 3A. Dominating the fauna are several archaic groups: condylarths (particularly hyopsodontids and arctocyonids), multituberculates, and plesiadapiform primates. The assemblage is very similar to that of Gidley Quarry, a late Torrejonian locality in the Crazy Mountain Field, Montana (Simpson, 1937a). The most significant features of the composition of the Rock Bench fauna are its very high species richness (57 species)—the highest of any single Paleocene site yet analyzed—and its relatively even distribution of species abundance. The two most common species, the multituberculate *Ptilodus wyomingensis* and the primate *Plesiolestes problematicus,* each account for only about 10% of the fauna. These and other factors suggest that the sample from Rock Bench Quarry represents a diverse subtropical forest community.

Simons' locality on Cub Creek (CC), 5 mi (8 km) southeast of Belfry, Montana, appears to be temporally equivalent to Rock Bench Quarry, but it represents a very different depositional setting. Fossils here are found on the surface, weathering out of a Lebo-like greenish sandy shale. Only *Pronothodectes jepi* and *Stelocyon arctylos* have been described from this locality (Gingerich, 1976, 1978).

TIFFANIAN FAUNAS (LATE PALEOCENE)

Tiffanian mammals have been recovered from a total of 55 localities in the Clark's Fork Basin-Polecat Bench area. Abundant specimens of plesiadapid primates from here and elsewhere in the Rocky Mountain Interior permit the Tiffanian to be subdivided into five zones or biochrons, which are, from oldest to youngest, the *Plesiadapis praecursor, P. anceps, P. rex, P. churchilli,* and *P. simonsi* zones (Gingerich, 1976). The very latest Tiffanian belongs to a sixth zone based on a new species of *Plesiadapis* that is predominantly Clarkforkian in age (Rose, 1980). No mammalian taxa have been described from the *P. praecursor* Zone in the Clark's Fork Basin-Polecat Bench area and only a single dentary of *P. anceps* has been reported from the next highest zone (Gingerich, 1976). This specimen was recovered from locality SC-263 (just east of locality SC-262 in Figure 2) on the south side of Polecat Bench, approximately 115 m above the level of Rock Bench Quarry (175 m above the Cretaceous-Tertiary boundary at the base of our measured section).

Mammals from the *P. rex* Zone are known from several localities (e.g. SC-262, 243) on the south side of Polecat Bench between levels 280 m and 425 m. The most productive *P. rex* Zone locality is Cedar Point Quarry located in the Foster Gulch area approximately 20 mi (32 km) southeast of Polecat Bench. Cedar Point Quarry was found by Robert Witter and Albert Silberling, while working for Jepsen in the late 1940s. Since then, more than 2000 mammalian fossils have been collected at the site, making it one of the richest late Paleocene localities in the world. Although certain elements of the fauna have been studied (e.g. pantodonts, Simons, 1960; phenacodontids, West, 1976; apatemyids, West, 1973; carpolestids, Rose, 1975; plesiadapids, Gingerich, 1976), no summary of the total mammalian as-

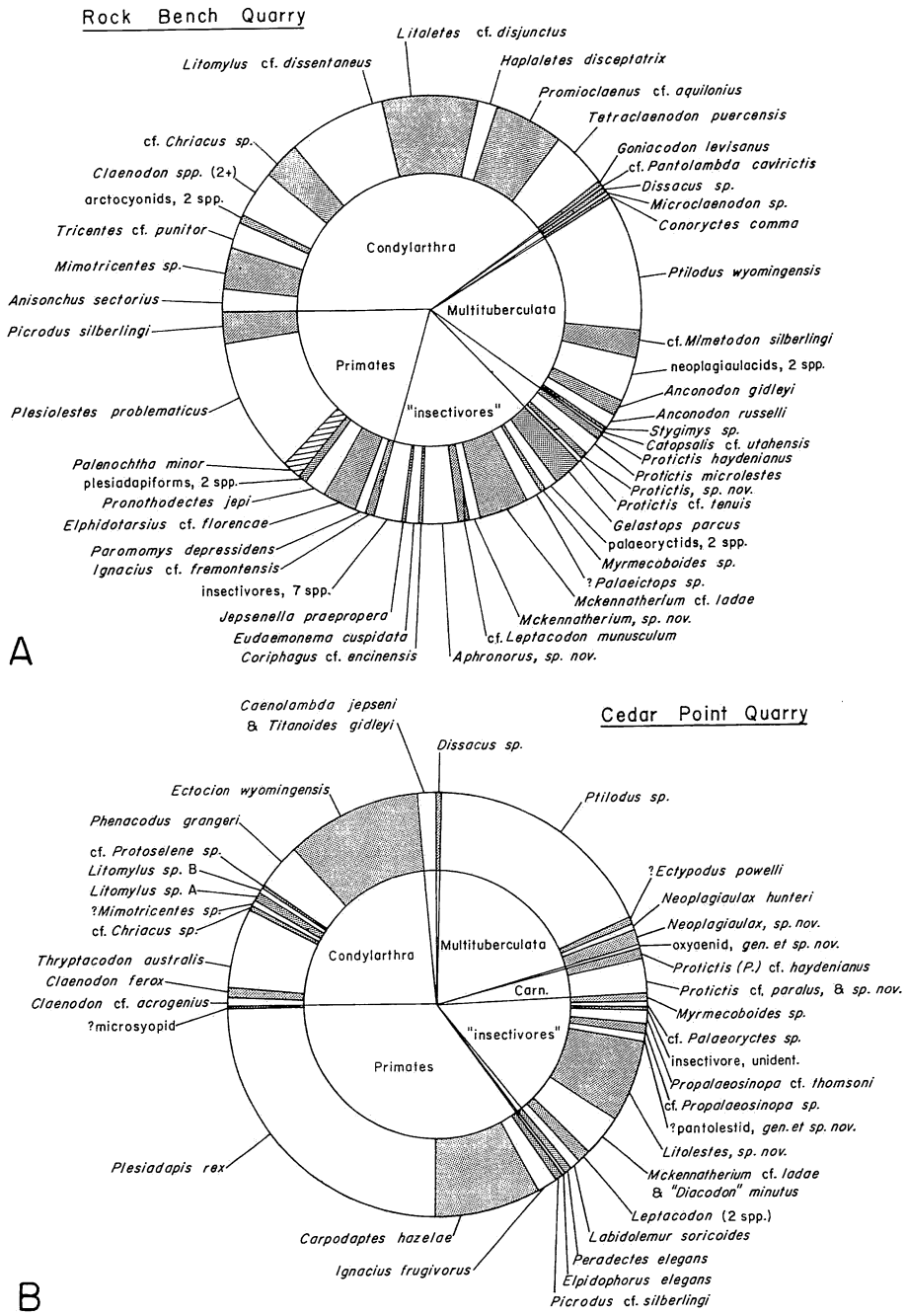


Figure 3. Pie diagrams comparing the mammalian fauna from the late Torrejonian Rock Bench Quarry (A) with that from the mid-Tiffanian Cedar Point Quarry (B). Rock Bench diagram is based on 1687 specimens representing a minimum of 496 individuals and a total of 57 species. Cedar Point diagram is based on 1988 specimens representing a minimum of 503 individuals and a total of 38 species. Note the greater species richness and equitability (evenness) of the Torrejonian Rock Bench Quarry sample compared to those of the Cedar Point Quarry sample. Both of these quarry samples are found in similar clay-gall conglomerate beds at the base of massive channel sandstones. Figures and calculations from Rose (1979).

semblage was available until recently (Rose, 1979; Figure 3B).

As at Rock Bench, fossils at Cedar Point occur in a thin clay-gall conglomerate at the base of a channel sandstone. Deposition was probably rapid, and size-sorting probably occurred but does not appear to have been a serious factor. The assemblage at Cedar Point Quarry shows dramatic differences from that at Rock Bench—contrasts that cannot be attributed merely to evolutionary changes within lineages. Species richness is only two-thirds as great as that at Rock Bench Quarry, and two of the 38 species at Cedar Point Quarry far outrank all others in relative abundance (the primate *Plesiadapis rex* accounts for 25% of the mammalian population, and the multituberculate *Ptilodus* sp. is 18%). Diversity among multituberculates, primates, and arctocyonids, and the relative abundance of hyopsodontids show marked declines compared to the Rock Bench assemblage (see Table 3).

Table 3. Comparison of the Rock Bench, Cedar Point, and Princeton Quarry mammalian assemblages (Rose, 1979).*

	ROCK BENCH (Torr.)	CEDAR POINT (M. Tiff.)	PRINCETON (L. Tiff.)
Sample size/MNI	1687/497	1988/503	546/185
Number of species	57	38	36
Multituberculata	18% (8)	20% (4)	13% (8)
Primates (all)	20% (8)	36% (4)	26% (4)
Plesiadapidae	2% (1)	25% (1)	10% (1)
Arctocyonidae	13% (8)	8% (5)	5% (3)
Phenacodontidae	4% (1)	14% (2)	4% (2)
Hyopsodontidae	22% (4)	1% (3)	15% (1)

*MNI = Minimum number of individuals necessary to account for all specimens of teeth and jaws. Percentage of the fauna represented by each taxon is based on MNI. Number of species present in each group is shown in parentheses.

Mammals of the *P. churchilli* Zone are known principally from the Airport Locality (AL) and other localities on Polecat Bench between the 495 m and 550 m levels. Long Draw Quarry (LD) is north of Elk Basin. Croc Tooth Quarry, Divide Quarry, and Lower Sand Draw, all in the Foster Gulch area southeast of Polecat Bench, also correlate with this interval. None of these quarries have yet been exploited to their full potential.

Numerous localities, including several quarries, have yielded mammalian fossils assigned to the *P. simonsi* Zone, which includes levels from about 650 m to 850 m in the Polecat Bench section. The best known of these localities is Princeton Quarry (PQ). Princeton Quarry, cited as "Silver Coulee Quarry" by some authors, was the first (and most productive) of several late Tiffanian quarries to be found on the west side of Polecat Bench. Within a few miles of Princeton Quarry are Fritz (FQ), Schaff (SQ), and Jepsen Valley (JV) quarries (all at about the same level as Princeton Quarry), and UM locality SC-165 (stratigraphically somewhat higher).

The concentration of fossil vertebrates at Princeton Quarry occurs in a "fine grained gray-green sandstone" (Jepsen, 1940), in contrast to the coarse channel sandstones at Rock Bench and Cedar Point quarries. Although there is little evidence of water transport of the bones (well-preserved and articulated specimens have been found), the larger mammals of the time are rare or absent in the quarry, suggesting that the sample is biased toward small animals.

The principal discussions of the Princeton Quarry mammalian fauna were presented by Jepsen (1930, 1940), Jepsen and Woodburne (1969), and Rose (1979). Reptiles and amphibians from the quarry and sites at equivalent levels have been described by Gilmore (1942), Estes (1975), Krause (this volume), and Bartels (this volume). The Princeton Quarry assemblage is dominated by small mammals, chiefly multituberculates, insectivores, primates, and a hyopsodontid (*Phenacodaptes,* the most common element in the fauna), suggesting that the quarry sample does not provide an accurate picture of the whole late Tiffanian mammalian community (see Table 4). About ten species of relatively large mammals occur in close proximity to the quarry (but not at the quarry itself—see Table 4). Nonetheless, the Princeton Quarry fauna probably does offer a very good census of small mammals of the time.

Other noteworthy localities that have produced mammalian fossils of the *P. simonsi* Zone are Michigan and Princeton localities SC-85, SC-86, SC-198 (Fossil Hollow), SC-144 (Horse Pasture), and Brice Canyon (BC) in the vicinity of Polecat Bench. The Sunday localities (SL) and Middle Sand Draw in the Foster Gulch area are also in this zone.

CLARKFORKIAN FAUNAS (PALEOCENE-EOCENE)

The Clark's Fork Basin is the type area of the Clarkforkian Land-Mammal Age, and it remains the

Table 4. Mammalian fauna of Princeton Quarry* (Rose, 1979).

	Total/MNI	Frequency (MNI)
MULTITUBERCULATA		
Neoliotomus conventus	4/1	.005
Microcosmodon conus	7/4	.022
Pentacosmodon pronus	2/1	.005
Prochetodon cavus	12/3	.016
Neoplagiaulax hazeni	4/1	.005
Mimetodon churchilli	2/1	.005
Parectypodus laytoni	9/5	.027
Ectypodus powelli	10/8	.043
MARSUPIALIA		
Peradectes elegans	4/3	.016
?Peratherium sp.	1/1	.005
PROTEUTHERIA		
Cf. *Palaeoryctes* sp.	11/4	.022
Prodiacodon cf. *concordiarcensis*	2/1	.005
?Palaeictops sp.	3/3	.016
Unuchinia sp.	3/2	.011
LIPOTYPHLA		
Leptacodon packi	8/5	.027
Litolestes ignotus	25/14	.076
"Diacodon" minutus	43/17	.092
Adapisoricid or nyctithere, unident.	11/6	.032
Apternodus-like sp. A	1/1	.005
Apternodus-like sp. B	1/1	.005
PRIMATES		
Micromomys silvercouleei	1/1	.005
Plesiadapis fodinatus	112/19	.103
Carpolestes dubius	48/13	.070
Phenacolemur pagei	51/17	.092
CONDYLARTHRA		
Cf. *Tricentes* sp.	14/5	.027
Thryptacodon sp.	3/2	.011
Claenodon sp.	1/1	.005
Phenacodus sp.	3/1	.005
Ectocion osbornianus	15/5	.027
Phenacodaptes sabulosus	103/27	.146
Dissacus cf. *navajovius*	5/2	.011
CARNIVORA		
Didymictis, sp. nov.?	5/1	.005
Cf. *Viverravus*, sp. nov.	12/4	.022
Viverravine, sp. A	2/2	.011
Viverravine, sp. B	1/1	.005
PALAEANODONTA		
Propalaeanodon schaffi	2/2	.011
Totals	541/185	.996

*NOTE: The following additional taxa have been found in the vicinity of Princeton Quarry, but not at the quarry itself:

CONDYLARTHRA
Anacodon? nexus
Phenacodus cf. *vortmani*
PANTODONTA
Haplolambda quinni
Leptolambda schmidti
Titanoides primaevus
Gen. and sp. nov.
DINOCERATA
Probathyopsis sp.
TAENIODONTA
Cf. *Lampadophorus* sp.
NOTOUNGULATA
Arctostylops cf. *steini*
CREODONTA
Cf. *Oxyaena* sp.
?Dipsalodon matthewi
Dipsalodon sp. nov.

only area where the entire Clarkforkian sequence is preserved and is richly fossiliferous. Based on the studies of Matthew and Granger (1915-1918), Jepsen (1930, 1940), and Simpson (1973b), the Clarkforkian was proposed as a North American Provincial Age by H. Wood et al. (1941). Collections of Clarkforkian age were meager, however, and for years doubts about the validity of the Clarkforkian persisted (e.g. R. Wood, 1967; A. Wood, 1977). Our work in the Clark's Fork Basin during the last five field seasons has provided evidence affirming the validity of the Clarkforkian and permitting this age to be precisely defined (Gingerich and Rose, 1977; Rose, 1978, 1979, 1980).

Clarkforkian faunas occur in an interval about 470 m thick in the uppermost Polecat Bench Formation and lower Willwood Formation. The formational boundary is time-transgressive and does not coincide with any faunal boundary. In Badger Basin west of Polecat Bench, most of the earliest Clarkforkian sites appear to be in Willwood sediments, whereas on the south side of Polecat Bench, Willwood sedimentation did not begin until the middle Clarkforkian. The University of Michigan presently has 135 Clarkforkian vertebrate localities in the Clark's Fork Basin and along Polecat Bench, most of them in the Willwood Formation.

We define the lower boundary of the Clarkforkian by the first occurrence of Rodentia *(Paramys),* Tillodontia *(Esthonyx),* the pantodont *Coryphodon,* and the condylarth *Haplomylus,* all of which first appear at essentially the same time within our present powers of resolution (Rose, 1979, 1980). Wood et al. (1941) believed that the first appearance of *Ectocion, Oxyaena, Esthonyx,* and cf. *Coryphodon* characterized the Clarkforkian, but the first two genera are now known from Tiffanian sediments. They also listed the first occurrence of Rodentia in the Tiffanian, but this was undoubtedly based on specimens of *Paramys atavus* from Bear Creek (EM), now known to be of Clarkforkian age. The end of the Clarkforkian—that is, the beginning of the Wasatchian—may be defined in the Bighorn Basin by the first appearance of Artiodactyla *(Diacodexis),* Perissodactyla *(Hyracotherium),* adapid and omomyid primates *(Pelycodus, Tetonoides),* and hyaenodontid creodonts *(Arfia),* which first appeared at the same time as immigrants. These taxa mark the beginning of Wasatchian time throughout the northern Western Interior, but *Hyracotherium* is known from two possible Clarkforkian sites in the southern part of North America (Morris, 1968; Schiebout, 1974; an intensive collecting effort in the late Tiffanian around

Figure 4. Clarkforkian-Wasatchian boundary in the Willwood Formation on the south side of Saddle Mountain in the Clark's Fork Basin. Dashed line shows the base of the boundary sandstone ("Clark Fork sheet sandstone" of Kraus, this volume), which forms the large, nearly flat dip slope at the left of the photograph and in the foreground. Sediments above this boundary sandstone are Wasatchian in age. Two Clarkforkian localities, SC-24 and SC-25, are shown below the boundary sandstone. View looking to northeast.

Princeton Quarry and SC-144 has failed to corroborate the present of *Hyracotherium* in late Tiffanian faunas as reported by Jepsen and Woodburne, 1969, and we suspect locality information with the single specimen in question to be in error). The abundant condylarth *Hyopsodus* is another good indicator of Wasatchian age, but it is also known (very rarely) from the late Clarkforkian (Rose, 1979).

Through much of the Clark's Fork Basin, the Clarkforkian-Wasatchian boundary coincides with a widespread sheet sandstone complex (Figure 4, see also Kraus, this volume). Faunas found just below the sandstone are Clarkforkian, while those from immediately above it are Wasatchian. At the southern end of Polecat Bench (Figure 5) this sandstone thins and disappears, and Wasatchian mammals occur at localities SC-67 and SC-121 above Clarkforkian mammals at SC-70, SC-71, and SC-107 with no evidence of a stratigraphic or sedimentological discontinuity.

In addition to defining the boundaries of the Clarkforkian, it is possible to characterize this land-mammal age in terms of the most common mammalian fossils found and by taxa that appear to be confined to the Clarkforkian. In the past, the common primate *Plesiadapis cookei* has been regarded as a Clarkforkian index fossil, and this remains so, although we now know that it is restricted to the middle Clarkforkian. Other taxa that are at present known only from the Clarkforkian include the primate *Carpolestes nigridens,* the condylarths *Aletodon gunnelli, Apheliscus nitidus,* and a new species of *Haplomylus,* the tillodonts *Esthonyx xenicus* and *E. ancylion,* the multituberculate *Microcosmodon rosei,* and the rodent *Paramys atavus.* Particularly characteristic of Clarkforkian faunas, although not restricted to that age, are the condylarths *Phenacodus primaevus, P. vortmani,* and *Ectocion osbornianus,* the uintathere *Probathyopsis praecursor,* the carnivore *Didymictis proteus,* the multituberculate *Neoliotomus conventus,* and several species of oxyaenid creodonts (see Rose, 1979, and Krause, 1980, for additional discussion). The composition of the middle Clarkforkian fauna is depicted in Figure 6A.

Seventy species of mammals have been recorded from the Clarkforkian of the Clark's Fork Basin (Rose, 1979), and they reveal that this was truly a time of transition in mammalian faunas. Clarkforkian faunas are dominated by archaic mammals of Paleocene aspect, but they also include (for the first time) several forms that are characteristic of Wasatchian faunas. Among the latter are miacine carnivores and the genera *Plagiomene, Microsyops, Niptomomys, Palaeonictis,* and *Palaeanodon,* as well as the four taxa that define the beginning of the Clarkforkian.

Three faunal zones can be recognized in the Clark's Fork Basin, corresponding approximately to early, middle, and late Clarkforkian. They are based primarily on the stratigraphic ranges of species of *Plesiadapis.* Species of the primate *Phenacolemur* and the tillodont *Esthonyx* are also particularly useful

Figure 5. Clarkforkian-Wasatchian boundary at the south end of Polecat Bench. Dashed line shows the base of the boundary sandstone. Bright red-banded sediments just above this sandstone (SC–121) and higher (SC–122) yield a Wasatchian fauna. Drab beds below the boundary sandstone here (SC–70, SC–71) yield a Clarkforkian fauna. Entire sequence is in the Willwood Formation. View looking to north.

in recognizing the zones. The lowest zone, which corresponds to the upper part of the range of a new species of *Plesiadapis* (not yet described), occurs in Badger Basin (e.g., locality SC-226) and along Polecat Bench (SC-179 on the west side, SC-83 on the southeast side). Middle Clarkforkian sites (*Plesiadapis cookei* Zone) occur in the center of the Clark's Fork Basin (e.g. SC-19, SC-62, SC-136, SC-183), and along Polecat Bench (e.g. SC-74, SC-110, SC-195) south of early Clarkforkian sites. Two quarries have been located in this zone: SC-188, the most productive Clarkforkian microsite, and SC-195, which has yielded several well-preserved skulls and partially articulated mammalian skeletons. The original Clarkforkian locality discovered by Sinclair and Granger, locality SC-196 in Rough Gulch west of the McCullough Peaks, belongs to this zone (Gingerich, (1976). A large collection of middle Clarkforkian mammals has also been obtained from the Paint Creek locality (SC-143). Late Clarkforkian sites (*Phenacodus-Ectocion* Zone) occur in a northwest-southeast band west of middle Clarkforkian sites in the Clark's Fork Basin and at the southern end of Polecat Bench. Some of the most productive localities are around Granger Mountain (SC-90) and in the head of Big Sand Coulee (vicinity of SC-102).

The question of the age of the Clarkforkian has been controversial, and it has been complicated by several factors, not the least of which has been a general misconception that faunal, formational, and temporal boundaries coincide in the Clark's Fork Basin. Evidence now available suggests that the Clarkforkian straddles the Paleocene-Eocene boundary, with the early Clarkforkian best considered latest Paleocene and the middle and late Clarkforkian best considered earliest Eocene (see Rose, 1979, 1980, for detailed discussion).

WASATCHIAN FAUNAS (EARLY EOCENE)

Wasatchian faunas are known from 105 localities in the southwestern part of the Clark's Fork Basin. These localities occur in a stratigraphic section 600 m thick representing the early and middle Wasatchian. The Clark's Fork Basin is the type locality for the "Sand Coulee beds" of Granger (1914) and the "Sandcouleean" subdivision of the Wasatchian Land-Mammal Age. Wasatchian strata yielding a typical Graybullian mammalian fauna occur in the Clark's Fork Basin immediately above "Sand Coulee beds," but Lysitean and Lostcabinian faunas are not present in the Clark's Fork Basin.

Granger (1914) distinguished the Sand Coulee beds from underlying Clark Fork beds by the presence of *Eohippus* [*Hyracotherium*], Artiodactyla, Rodentia, and Primates. He distinguished Sand Coulee beds from overlying Gray Bull beds by the absence of *"Systemodon"* [large *Homogalax*], presence of a multituberculate [*Neoliotomus ultimus*], and by "the generally more primitive character of such genera as are common to both horizons." Granger listed several areas of red-banded exposures in the Clark's Fork Basin as yielding a Sand Coulee fauna, but practically all of the species later described from this interval, including *Neoliotomus ultimus,* were collected three

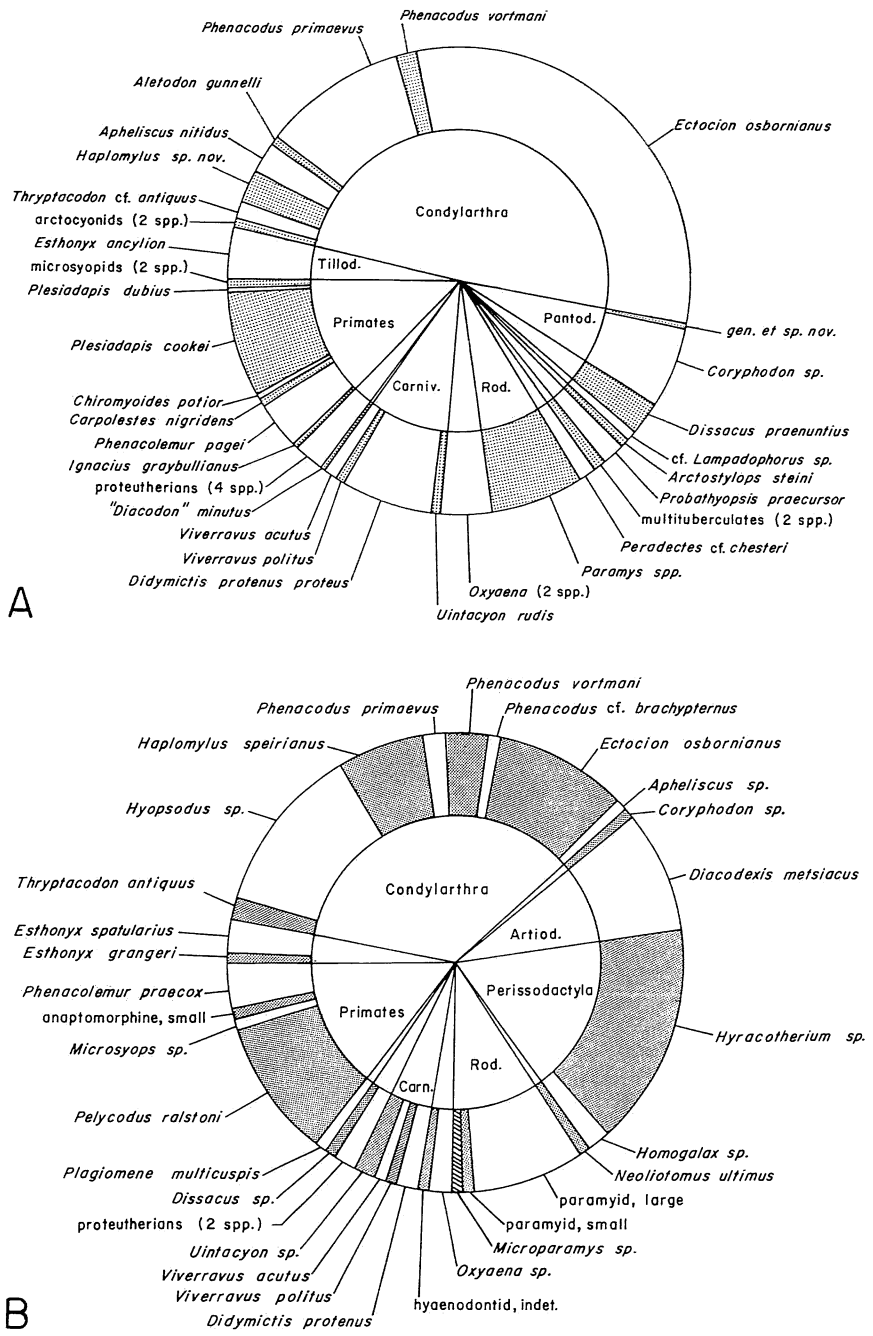


Figure 6. Pie diagrams comparing the mammalian faunas from selected localities in the *Plesiadapsis cookei* zone of the Clarkforkian (A) with one well-sampled locality in the Wasatchian (B). Both samples are based on surface collections only (with no extensive quarrying or screen-washing). The Clarkforkian diagram is based on 793 specimens from 20 localities representing a minimum of 338 individuals and a total of 39 species. The Wasatchian diagram is based on 398 specimens representing a minimum of 129 individuals and a total of 32 species, all from one locality (SC–4). Note the greater equitability (evenness) of the Wasatchian sample, where no species dominates the fauna like *Ectocion osbornianus* does in the Clarkforkian. Figures and calculations from Rose (1979).

miles southeast of the mouth of Pat O'Hara Creek (in the vicinity of SC-40). A new small species of *Homogalax* (not the larger *"Systemodon"*) does occur in the basal Wasatchian at locality SC-40 and elsewhere (in fact Granger collected some fragmentary specimens of this himself). In our collections, *Neoliotomus ultimus* occurs only in the lower 160 m of the Wasatchian section. *Pelycodus ralstoni, Esthonyx spatularius, Esthonyx grangeri, Didymictis leptomylus,* a new small species of *Arfia,* and the new small species of *Homogalax* are among the more primitive species characteristic of the Sand Coulee beds.

We are not yet in a position to restrict or extend Granger's definition of the Sand Coulee subdivision of the Wasatchian, but this interval does appear to contain a fauna more primitive than that of the typical *"Systemodon"*-bearing Graybull beds. Sand Coulee faunas occur on the southwest end of Polecat Bench (Figure 5), and along a northwest-trending belt including localities SC-182, SC-4, SC-6, SC-40, SC-89, and SC-123 at the mouth of Pat O'Hara Creek. The Roan Wash locality (RW) southeast of the settlement at Willwood is also in this interval. The relative abundance of mammalian taxa from one of these localities (SC-4) is depicted in Figure 6B.

Large *Homogalax ("Systemodon")* does occur in the Clark's Fork Basin Wasatchian section, beginning 180 m above the base of the Wasatchian, and extending to the highest levels exposed, some 600 m above the base of the Wasatchian. *Tetonius* has a similar distribution. Thus the uppermost 420 m of the Clark's Fork Basin section appears to be faunally equivalent to typical "Gray Bull beds" exposed in the central Bighorn Basin.

Five sequential species of the adapid primate *Pelycodus* can be recognized in the Wasatchian, and these provide a useful zonation (Gingerich, 1980). The species are, from oldest to youngest, *P. ralstoni, P. mckennai, P. trigonodus, P. abditus,* and *P. jarrovii. Pelycodus ralstoni* is confined to the lowest 130 m of the Clark's Fork Basin Wasatchian. Its descendant *P. mckennai* is found from 135 m to 425 m above the base of the Wasatchian. *P. trigonodus* is derived from *P. mckennai,* and it occurs from 430 m to the highest levels at about 600 m above the base of the Wasatchian. These three species are sequential parts of a chronocline. Boundaries between the successive species are arbitrary but *Pelycodus* does change significantly through time in both size and morphology, making it useful in biochronolgy. *Pelycodus abditus,* which occurs in the very highest Gray Bull and Lysite equivalent beds of the central Bighorn Basin and the Lysite of the Wind River Basin, has not been found in the Clark's Fork Basin.

Judging from faunal comparisons, the highest stratigraphic levels in the Wasatchian of the Clark's Fork Basin (localities SC-253, 295) are equivalent to the "middle Gray Bull" of authors in the central Bighorn Basin (upper *Haplomylus-Ectocion* Range-Zone of Schankler, this volume). *Bunophorus etsagicus* of Schankler's overlying *Bunophorus* Interval-Zone has not been found in the Clark's Fork Basin. Locality SC-128 on Pat O'Hara Creek and the Hackberry Hollow locality (HH, SC-192) in the Eaglenest Basin south of Alkali Creek correlate faunally with levels approximately 400 m above the base of the Wasatchian. Higher stratigraphic levels may occur at the top of the McCullough Peaks, but this has not yet been investigated.

FAUNAL DIVERSITY

Rose (1979) has analyzed mammalian faunal diversity in the Torrejonian, Tiffanian, Clarkforkian, and Wasatchian in the Clark's Fork Basin-Polecat Bench area. As noted above in the discussion relating to Tiffanian faunas, the Rock Bench Quarry (Torrejonian) and Cedar Point Quarry (Tiffanian) are very similar lithologically and appear to represent the same depositional setting, yet these localities differ markedly in species richness and equitability. Cedar Point Quarry contains 38 species, compared with 57 present at Rock Bench Quarry (Table 3). *Plesiadapis* and *Ptilodus* dominate the fauna at Cedar Point (Figure 3B), whereas numbers of taxa are relatively evenly distributed in the Rock Bench fauna (Figure 3A).

It is more difficult to compare Clarkforkian and Wasatchian faunal assemblages directly with those at Rock Bench Quarry and Cedar Point Quarry because they come from different depositional environments and they were collected in different ways. Nevertheless, some generalizations can be made regarding species richness and equitability in the Clarkforkian and Wasatchian. Middle Clarkforkian faunas typically include about 39 species (Figure 6A) and this number increases only slightly in the late Clarkforkian (Rose, 1979). Equitability in the middle and late Clarkforkian resembles that in the Tiffanian because of the dominance of *Ectocion* in Clarkforkian faunas (Figure 6A). Early Wasatchian faunas typically include about 50 species if they have been sampled by a combination of surface collecting and screen-washing techniques (Rose, 1979). These faunas usually display a much higher level of equitability,

with no species comprising more than about 15-16% of the fauna.

Faunal diversity is a measure of both species richness and faunal equitability or evenness that can be calculated in a number of ways depending on how these two factors are combined. As the figures cited here would suggest, mammalian faunal diversity was high in the Torrejonian, relatively low in the Tiffanian and Clarkforkian, and high again in the Wasatchian (see Rose, 1979, for a full analysis and documentation). Such low diversity as that observed in Tiffanian and Clarkforkian mammalian faunas is often associated with stress or unpredictability in the environment (Hutchinson, 1961; Goulden, 1969). Paleobotanical evidence indicates that temperatures and climatic equability were lower in the Tiffanian and Clarkforkian than at any other time during the Paleocene or early Eocene (Hickey, 1977, and this volume; Wolfe, 1978). These differences are also reflected in the diversity of mammalian faunal assemblages. Thus there is a substantial evidence that a change in climate and/or ecology took place between the late Torrejonian and middle Tiffanian and again in the Clarkforkian and early Wasatchian.

FUTURE WORK

The Clarkforkian-Wasatchian boundary is now one of the best documented episodes of faunal turnover in Cenozoic mammals, but much remains to be learned about faunal evolution in the early Cenozoic. Other episodes of turnover remain to be documented, and most of the intervening periods of relative faunal stability are not yet thoroughly studied. The relatively thin Puercan and Torrejonian sections exposed on Polecat Bench preclude extensive analysis of faunal evolution in these intervals in the northern Bighorn Basin. However thick Tiffanian sections, exposed on the flanks of Polecat Bench and along strike to the southeast in the Foster Gulch area, invite a more intensive analysis of the Tiffanian than has been attempted to date. There is some indication of a significant episode of faunal turnover between the middle and late Tiffanian that requires study. The Tiffanian-Clarkforkian turnover is not as fully documented as we would like because fossils are rare in this stratigraphic interval (although the major features of this turnover are now clear, Rose, 1979). Finally, preliminary indications are that a significant episode of faunal turnover occurred about 180 m above the base of the Wasatchian in the Clark's Fork Basin, and this remains to be analyzed thoroughly. Continued interdisciplinary study of faunas, floras, sedimentology, and stratigraphy in the Clark's Fork Basin-Polecat Bench area promises to contribute to a better understanding of evolution across the Paleocene-Eocene boundary.

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APPENDIX

ROAD LOG -- POLECAT BENCH & CLARK'S FORK BASIN AREA

Mileage Cumul.	Increm.	
0.0	0.0	Begin at Post Office in Powell, Wyoming. Drive one block west and turn right (north) onto Wyoming Highway 295 leading out of Powell toward Elk Basin. As you leave Powell, the long low bluff stretching from due west to northeast along the skyline is Polecat Bench. It is capped by a river gravel deposited during the Pleistocene before the surrounding softer sediments were eroded away. Now Polecat Bench stands above the Shoshone and Clark's Fork river basins on both sides because it is protected by the gravel cap. Latest Cretaceous sediments outcrop on the east side of Polecat Bench out of view to the northeast. Most of the southwesterly dipping strata visible from the highway are in the drab Polecat Bench Formation, which includes a remarkably complete sequence of Paleocene faunas (Puercan, Torrejonian, Tiffanian, and early Clarkforkian). Near the southwest end of Polecat Bench red beds first appear, and these are the lowest part of the Willwood Formation of early Eocene age (Clarkforkian and Wasatchian).
6.6	6.6	University of Michigan locality SC-243 is 0.2 miles east of the highway at this point. It is (was) a large anthill developed on a bed of clay gall conglomerate that contained several hundred teeth, including a good sample of *Plesiadapis rex* (middle Tiffanian).
6.9	0.3	Approximately 0.5 miles west of the highway is the Princeton Airport Locality, yielding *Plesiadapis churchilli* (early late Tiffanian). The transitional interval between the middle and late Tiffanian is in a magnetozone of normal polarity interpreted as magnetic anomaly 26 (Butler, Lindsay, and Gingerich, this volume).
8.0	1.1	Top of Polecat Bench. Road leading to Powell Airport branches to left. Continue straight ahead.
8.5	0.5	Turn off of Wyoming Highway 295 onto the graded road heading east (right turn). This road leads to the small oil field in Polecat Dome, a southeastern extension of the much larger Elk Basin oil field.
10.2	1.7	Fence and cattle guard. This is where the track leading to Rock Bench Quarry leaves the Polecat Dome road. Proceed straight ahead to Polecat Dome.
10.9	0.7	Begin descent into Polecat Dome. Lignite bed exposed on right side of road as you descend into Polecat Dome is the Mantua lignite thought to mark the Cretaceous-Tertiary boundary. Dinosaur remains have been found within a short distance below this, and Mantua Quarry yielding early Paleocene (Puercan) mammals is just above the level of this lignite.
11.4	0.5	STOP 1: Park near the storage tanks and oil well. Talus from the Mantua Quarry, discovered in 1929 by Sinclair and Jepsen's expedition, is visible below the heavy sandstone (the Mantua Lentil sandstone) about 0.5 miles directly to the west across Polecat Dome. Dumbbell Hill, a Lancian mammal-bearing locality, is the small dumbbell-shaped hill at the bottom of Polecat Dome. Rock Bench Quarry is out of sight about one mile west-northwest of here, on the north flank of the graben north of Mantua Quarry. Turn around and return up the road we just came down.
11.9	0.5	Again note the Mantua lignite, this time on your left, as we emerge onto the top of Polecat Bench.
12.6	0.7	Fence and cattle guard we crossed earlier. Cross the guard and turn right (north), driving along the track on the west side of the fence.
13.8	1.2	Head of valley with small stock tank. Turn right off of track, driving across Polecat Bench on the north side of the valley.
14.1	0.3	STOP 2: Edge of Polecat Bench above Rock Bench Quarry, discovered in 1929 by Sinclair and Jepsen. Take a few minutes to walk down to

		the quarry and examine the lithology of the sandstone and the clay gall conglomerate at its base. The bone-producing layer here, as at many of the other fossil quarries in the Polecat Bench Formation, is the clay gall conglomerate. Return to vehicles and backtrack to the graded road.
15.6	1.5	Graded road at cattle guard. Turn right.
17.3	1.7	Wyoming Highway 295. Turn right (north) and proceed toward Elk Basin.
19.6	2.3	Junction with road to South Elk Basin oil field. Turn left (west) and drive through oil field.
22.6	3.0	Road curves to north. Badlands on your left are all late Tiffanian. This is the area where the alleged late Tiffanian *Hyracotherium* described by Jepsen is said to have been found.
26.1	3.5	Junction with road to Husky cracking plant. Turn left and descend into Sand Coulee. Stay on main graded road.
27.3	1.2	Turn south just before cracking plant.
28.2	0.9	STOP 3: Princeton Quarry is about 0.2 miles east of the road at this point. Horizon is still productive although the quarry itself, discovered by Sinclair and Jepsen in 1929, is worked out. Spend 20 minutes examining lithologies and prospecting for fossils. Note that the productive bed here is a soft gray mudstone. Charles Schaff found a very nice palate of *Arctostylops* here several years ago. This is UM locality SC-187.
33.8	5.6	Backtrack to curve in road near South Elk Basin oil field. Drive south on the track along the west edge of Polecat Bench.
34.3	0.5	STOP 4: Fossil Hollow (SC-198). Valley to right is an old Princeton locality first visited by Jepsen on his last day in the field in 1928. He and Sinclair worked here at the beginning of the 1929 field season.
35.8	1.5	Late Tiffanian locality SC-165, including a good concentration of small jaws, is in the valley on the right. Continue to south.
37.8	2.0	Junction with power line track. SC-179 of early Clarkforkian age is at the base of Polecat Bench to the west of this point. Continue to south.
39.7	1.9	Track joins from northeast. Continue toward southwest. Krause Quarry (SC-110/195, middle Clarkforkian *Plesiadapis cookei* Zone) is just west of here, near the base of Polecat Bench. This quarry has yielded a number of very well preserved skulls, including those of *Dissacus* and *Oxyaena*.
41.7	2.0	Track drops over the edge of Polecat Bench here. Do not follow this but turn right and drive out on the point to the west ("Miles" triangulation point).
42.2	0.5	STOP 5: Panoramic view of the Clark's Fork Basin. Heart Mountain and Ralston Flats are to the southwest. The Absaroka and Beartooth mountains are to the west. Yellowstone Park is on the plateau behind these mountains. Area just below is drained by Big Sand Coulee. Here we are standing on the Clarkforkian-Wasatchian boundary sandstone. SC-176 at the base of the escarpment below is where the holotype skull of *Esthonyx ancylion* was found. This locality is in the late Clarkforkian *Phenacodus-Ectocion* Zone. American Museum of Natural History Clarkforkian localities in the head of Big Sand Coulee on "both sides of the wagon road where it drops down to the Big Sand Coulee" are 1-2 miles southwest of here, also in the *Phenacodus-Ectocion* Zone. Backtrack southeast along the edge of the bench.
42.7	0.5	Junction of several tracks. Continue driving to southwest along the edge of Polecat Bench.
44.7	2.0	Pipeline road off southwest end of Polecat Bench. As you descend, earliest Wasatchian ("Sand Coulee") localities SC-206 and SC-69 are in the bright red beds on your left.
46.7	2.0	Lane Nine. Turn left on paved road

toward Powell, Wyoming.

47.6 0.9 Junction with Road 16. Turn left (north) on dirt track.

48.3 0.7 STOP 6: Clarkforkian-Wasatchian boundary on southwest end of Polecat Bench (Figure 5). Localities SC-70 and SC-71 are in the drab beds immediately below the boundary here, and SC-121 is just above the boundary in the bright red beds. This is one of Granger's type areas of the "Sand Coulee" fauna.
Backtrack to Lane Nine.

49.0 0.7 Lane Nine. Turn right (west).

51.0 2.0 Junction with Badger Basin highway. Turn right (north).

53.4 2.4 Descend into the Clark's Fork Basin in the head of Big Sand Coulee. Badlands on both sides of highway are late Clarkforkian.

53.7 0.3 Old wagon road travelled by Wortman in 1891 and Granger and Stein in 1912 is visible on the right.

57.1 3.4 Little Sand Coulee Road diverges on the left. Continue straight ahead on the Badger Basin highway.

58.4 1.3 Locality SC-116 yielding a middle Clarkforkian fauna, including *Arctostylops steini* is on the left. On the right, about two miles to the northeast, are a number of early Clarkforkian localities.

59.8 1.4 Husky Refinery. Turn left on oil field road.

60.8 1.0 Type locality of *Franimys amherstensis* is in middle Clarkforkian beds along strike 0.5 miles to the northwest of here.

62.0 1.2 Locality SC-62 is on the right. *Plesiadapis cookei* has been found on the north side of this locality, in the lowest beds, but not higher.

63.5 1.5 STOP 7: Clarkforkian-Wasatchian boundary sandstone. Thick sheet sandstone above peppermint-striped beds marks the Clarkforkian-Wasatchian boundary. Peppermint-striped beds yield a *Phenacodus-Ectocion* Zone late Clarkforkian fauna.

65.0 1.5 Leave main track and take side track to the west.

65.4 0.4 STOP 8: Locality SC-210. This early Wasatchian site has been intensively analyzed taphonomically (see Winkler, this volume). All fossils seem to be weathering out of one of the five orange-gray or red-gray paleosol couplets.
Return to main track.

65.8 0.4 Main track. Turn right and continue to the southwest.

66.2 0.4 Gate. Wasatchian locality SC-7 is just to the west of this gate.

66.9 0.7 Little Sand Coulee Road. Wasatchian locality SC-2 is just to the west. Jepsen camped here in 1928 and made a moderately large collection of mammalian fossils. In recent years this locality and others in the vicinity have yielded a large fauna including *Pelycodus mckennai*. Beds along the west end of the escarpment two miles south of here yield *Pelycodus trigonodus*.
Turn left (east) on Little Sand Coulee Road.

68.9 2.0 STOP 9: Saddle Mountain is on our left. Note extent of Clarkforkian-Wasatchian boundary sheet sandstone forming dip slope in the foreground (see Figure 4).

72.2 3.3 Turn left on track, driving north.

73.0 0.8 STOP 10: Locality SC-20. This is one of the localities that has yielded numerous specimens of *Plesiadapis cookei*. In addition, Leo Hickey has a good fossil plant locality nearby (Hickey, this volume).
Return to Little Sand Coulee Road.

73.8 0.8 Little Sand Coulee Road. Turn left (east).

75.2 1.4 Badger Basin Highway. Turn right, climbing out of the Clark's Fork Basin at the head of Big Sand Coulee.

81.3 6.1 Lane Nine. Turn left (east) toward Powell. Polecat Bench is on our left.

88.8 7.5 Road Ten. Turn right (south).

89.4 0.6 U.S. Highway 14 (Alt.). Turn left (east).

90.4 1.0 Enter Powell. Turn right (south)

		across the railroad tracks, joining Wyoming Highway 295, and proceed south to Willwood corner.
94.2	3.8	Willwood corner. Turn left (east) and continue on Wyoming 295. Badlands on the right are Wasatchian in age.
100.0	5.8	Cross Roan Wash and the old Jim Bridger Trail.
101.0	1.0	Cross under powerline. A new middle Clarkforkian quarry in a clay gall conglomerate (FG-6) is located 1.7 miles north of here. One mile east of FG-6 is the Princeton Sunday Locality of late Tiffanian age.
102.7	1.7	Junction with Wyoming Highway 32. Turn right (south) onto Wyoming 32. The vast area of badlands extending 10 - 12 miles east of Wyoming 32 is a southeastern extension of Tiffanian, Clarkforkian, and Wasatchian beds exposed on Polecat Bench. This area includes Cedar Point Quarry, Croc Tooth Quarry, Foster Gulch Well, Bone Hill, and other very productive late Paleocene and early Eocene localities. This area was formerly prospected by Princeton University parties in the late 1940's and late 1960's. Intensive work by University of Michigan parties was initiated in 1979.
109.5	6.8	Cross Coon Creek. Yale-Michigan localities 415 and 418 are on the left.
112.7	3.2	Yale-Michigan locality 417 is on the right.
117.7	5.0	Cross Dry Creek.
118.3	0.6	Intersection with U.S. Highway 14. Turn right (west).
118.9	0.6	Junction with Burlington-Otto road. Turn left.
122.9	4.0	Burlington, Wyoming. The peak straight ahead is Sheep Mountain, and the longer, flat-topped mountain to the west of it is Tatman Mountain capped by the middle Eocene Tatman Formation.
132.9	10.0	Otto, Wyoming. This is one of the oldest towns in the Bighorn Basin. Formerly located closer to the Greybull River, this is the area where the Jim Bridger Trail and the first wagon road through the Bighorn Basin crossed the Greybull River. The badlands to the south of here along Dorsey Creek were first collected by Wortman in 1881 and have subsequently been extensively prospected by many other expeditions. There are several extremely productive Yale-Michigan localities in this area, YM-421 being the richest.
144.9	12.0	Arrive in Basin, Wyoming. Continue with Central Bighorn Basin road log (Schankler, this volume).