HISTORY OF EARLY CENOZOIC VERTEBRATE PALEONTOLOGY IN THE BIGHORN BASIN

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Abstract.— The first fossil mammals from the Bighorn Basin were found by Wortman and described by Cope in 1880. These are early Wasatchian in age, and probably came from the southern part of the basin. During Wortman's 1881 expedition he collected mammalian faunas of both middle and late Wasatchian age in the central Bighorn Basin. The Clarkforkian fauna was first documented by Sinclair and Granger in 1911 and 1912 in the northern Bighorn and Clark's Fork basins. Sinclair and Jepsen found Puercan, Torrejonian, and Tiffanian faunas on the flanks of Polecat Bench in 1929. Knowledge of these Paleocene and early Eocene land mammal ages has been augmented considerably during the past fifty years, and recently middle Eocene and Oligocene faunas have been discovered on the margins of the Bighorn Basin as well. Unpublished field records complement published information in illuminating the life and times of paleontologists working in the Bighorn Basin during the past century.

INTRODUCTION

One hundred years of paleontological research on early Cenozoic faunas in the Bighorn Basin have yielded the most complete record of mammalian evolution through the Paleocene and early Eocene known anywhere in the world. In recent years a few scattered middle Eocene and Oligocene fossil localities have also been found on the margin of the Bighorn Basin. The history of paleontological field work in this area of Wyoming is interesting in part because field conditions were so different when the work began a century ago. It is also interesting because the field work involved several of the most important paleontological institutions in the country and many of the principal figures in the development of American vertebrate paleontology.

The history of paleontological research in the Bighorn Basin is important for another reason. By carefully retracing the steps of earlier collectors it is possible to duplicate their collections and determine, in some cases exactly, the stratigraphic level from which important type and referred specimens were collected. The purpose of this chapter is to outline the history of paleontological collecting in the Bighorn Basin, with particular attention to the modern biostratigrahic context of important early collections.

The three North American land mammal ages that are best represented in the Bighorn Basin are the Tiffanian (late Paleocene), the Clarkforkian (transitional Paleocene-Eocene), and the Wasatchian (early Eocene). The Tiffanian can be divided into five reasonably well defined biochrons based on *Plesiadapis,* and these are abbreviated Ti_1-Ti_5 from oldest to youngest (Gingerich, 1976, 1980). The Clarkforkian can similarly be divided into three biochrons Cf_1-Cf_3 based on *Plesiadapis* (Rose, 1979, 1980; present evidence indicates that earliest Cf_1 is actually very latest Tiffanian). The Wasatchian can be divided into five biochrons Wa_1-Wa_5 based on the evolution of

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Pelycodus (Gingerich, 1980). Reference will be made to these subdivisions whenever appropriate to lend precision to the following discussion. In addition, in discussing the history of the Clark's Fork Basin area, it will be convenient to refer to University of Michigan localities, which are prefaced UM.

WORTMAN AND COPE

Jacob L. Wortman made the first paleontological investigation of the early Cenozoic of the Bighorn Basin in 1880, while employed by Edward Drinker Cope. Wortman spent the early part of the 1880 field season collecting in Pliocene deposits along the Snake River in Idaho, and then moved to the Wind River Basin in Wyoming to explore Eocene sediments of Hayden's "Wind River group." Very little has been recorded of how Wortman chanced to cross into the Bighorn Basin, but his headquarters in the Wind River Basin in 1880 is known to have been at Fort Washakie (near the present city of Lander). Fort Washakie was, at that time, the last outfitting post for ranchers and miners entering the Bighorn Basin from the south. It is likely that Wortman learned of the extensive badlands developed in the central Bighorn Basin from men he met at Fort Washakie. In any case, Wortman's preliminary exploration of the Bighorn Basin appears to have been done on his own initiative after finishing his assigned work in the Wind River Basin.

During the 1870's, the Bighorn Basin was virtually enclosed by reserved Indian lands, with Crow Indians settled to the north along the Yellowstone River, Sioux to the east, Arapahoes and Cheyennes in the central part, and Shoshones occupying the southern Bighorn Basin and Wind River Basin. General Custer's last stand against the Sioux and Cheyennes on the Little Bighorn River of southern Montana in 1876 turned public sentiment against the Indians, leading to a severe military retaliation against them and ending their control over the Bighorn Basin. Miners made their first uncontested invasion into the Bighorn Basin in 1877, and cattlemen followed in 1878 and 1879. John W. Chapman's ranch on Pat O'Hara Creek, the modern Two Dot Ranch, was established in 1879, and Count Otto Franc von Lichtenstein brought his first herd of cattle to the Pitchfork Ranch on the upper Greybull River in the same year. Wortman's (1899) description of the Bighorn Basin in 1880 as "a wild, uninhabited region, save for the occasional visits of roving bands of hostile Indians" and his professed fear of "violence at the hands of savage Indians," written nearly twenty years after the fact, cannot be accurate characterizations. They are more logically viewed, in the context of their time, as aberrations of a Victorian "romantic" mentality. Wortman's writing in 1882 indicates that scarcity of water was his major concern.

Figure 1. Jacob L. Wortman as a young man at the American Museum of Natural History. Photograph courtesy of American Museum.

Wortman himself (Figure 1) was originally from Oregon, where he studied under Thomas Condon at the University of Oregon. He met Charles Sternberg while Sternberg was in Oregon during the winter of 1877-78 and Wortman first worked for Cope as a collector during the summer of 1878, accompanying

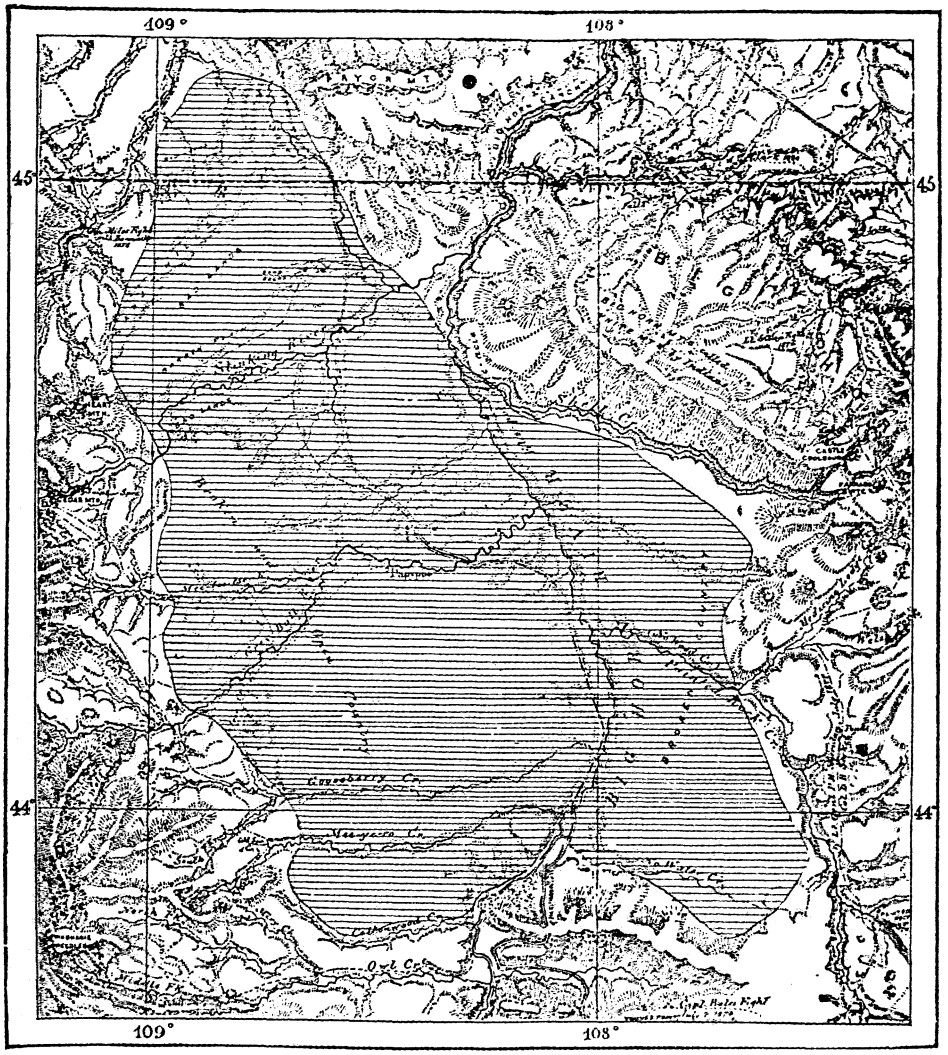

Figure 2. Jacob L. Wortman's map of the Bighorn Basin, based on his work in the basin in 1881. Cross-hatching indicates inferred extent of "Wasatch" deposits. Note one main road crossing the Bridger Mountains from the Wind River Basin in the south, then crossing the Bighorn River near the present town of Worland, the Greybull River near Otto, and the Stinking Water River near Byron, before going up Sage Creek toward Pryor Gap. Reproduced from Wortman (1882).

Sternberg to the John Day beds. In 1879 Wortman took charge of the John Day expedition, before moving to Idaho and Wyoming in 1880.

As a result of his 1880 exploration of the Wind River Basin, Wortman mailed to Cope a collection of some forty-five species of Eocene vertebrates, of which twenty-four were recognized as new. The first report on these was published in September, 1880 (Cope, 1880a). In December, Cope described a second smaller collection, erroneously stating that it had been made by Wortman from beds of the Wind River group (Cope 1880b). This smaller collection was actually the first to be made from the Bighorn Basin. It included the type specimens of *Esthonyx spatularius, Didymictis leptomylus,* and *"Hyopsodus"* [*Haplomylus*] *speirianus.* Cope (1885) later corrected his error and listed these as coming from the Bighorn Basin.

Wortman spent much of the summer of 1881 in the Bighorn Basin, and he was able to make a preliminary map showing the extent of "Wasatch" deposits (Figure 2) in addition to collecting specimens of some sixty-five species of fossil vertebrates, of which Cope recognized twenty-seven as new. Most of these were

described early in the following year (Cope, 1882a, b). Wortman's early expeditions into the Bighorn Basin were especially important because they provided the first extensive documentation of early and middle Wasatchian faunas (a collection of middle Wasatchian age had previously been made for O. C. Marsh from the vicinity of Bitter Creek in southern Wyoming, but only a small part of this was ever described).

Unfortunately no detailed locality or stratigraphic records were kept for the earliest collections made by Wortman, but it is possible in retrospect to assign many of these to stratigraphic interval based on circumstantial evidence and the experience of subsequent collecting. Wortman's map of the Bighorn Basin (Figure 2) also gives a clue to the source of his collections. On his first trip from Fort Washakie into the Bighorn Basin he must have crossed the Bridger Mountains via Birdseye Pass. The principal road through the Bighorn Basin in 1880 and 1881, as shown on Wortman's map, generally followed the old Jim Bridger trail. It came down Kirby Creek from the Bridger Mountains and Birdseye Pass, passed to the west of Cedar Mountain near the present site of Kirby, crossed No Water Creek near its mouth, and then followed the east side of the Bighorn River, crossing to the west side of the river near the present site of Worland. From here the road followed within a few miles of the Bighorn River until it reached the vicinity of Elk Creek, where it cut directly across the badlands to ford the Greybull River near the present town of Otto. From here the road passed west of Table Mountain, crossing Dry Creek near Bridger Butte. Then it headed northward down Coon Creek to cross the Shoshone River (formerly called the Stinking Water River) near the present town of Byron. The Jim Bridger trail diverged near Bridger Butte, crossing badlands on a more direct route toward the present town of Garland.

The three mammalian species described from Wortman's 1880 trip into the Bighorn Basin have subsequently only been found in lower Wasatchian deposits (Wa_1 and Wa_2). The first lower Wasatchian deposits that Wortman would have encountered coming into the Bighorn Basin from the south are in the Sand Creek facies of the Willwood Formation in the vicinity of Worland. Bown (1979) has recently studied the mammalian fauna from this area and found it to include abundant *Haplomylus speirianus,* a small species of *Esthonyx* like *E. spatularius,* and a small species of *Didymictis* like *D. leptomylus.* Gazin (1953, p. 23) noted that it seems probable that Wortman obtained all three specimens from about the same locality, inasmuch as a collector of Wortman's experience would have obtained much more material had he extended his examination over any appreciable area. If Wortman had proceeded as far as Elk Creek or the Greybull River it is almost certain that he would have made a much larger collection. Admittedly there is no direct evidence one way or the other, but it seems likely that Wortman's 1880 trip into the Bighorn Basin was little more than a brief trip across the Bridger Mountains to examine the first Wasatchian outcrops he encountered. He probably did not go any farther north than Worland, and probably never crossed to the west side of the Bighorn River.

Direct evidence on the source of the 1881 Bighorn Basin collections is also lacking, but again there is some circumstantial evidence. Wortman (1882) mentions that "the exploration of this region is most arduous and difficult. The great scarcity of water in these badland wastes makes it very inconvenient . . . the broken and mountainous character of the country forbids the use of wagons to such an extent that pack animals are indispensible." He also mentions that "blue" beds seemed to be the most productive for fossils, and that these fossils were often found (as the only known skull of *Tetonius* was) in small limestone nodules, sometimes with a hard layer of ferrous oxide investing them. Considering the need for water and at least initial access by road, it is likely that Wortman spent most of his time during the summer of 1881 collecting in the extensive badlands just south of where the main road through the basin crossed the Greybull River, i.e. in the vicinity of Dorsey Creek south of Otto. Fossils there are often found in nodules with a coating of ferrous oxide weathering out of "blue" beds, as Wortman described. That this area was the source of most of his collections is further corroborated by the account given of his next expedition to the Bighorn Basin ten years later: "Our immediate destination. . . . was the extensive exposures lying to the south of the Gray Bull River in the vicinity of its junction with the Big Horn. . . . On the south side of the Gray Bull from near its mouth to a point twenty miles up the river are to be found the best exposures of the Big Horn Wahsatch" (Wortman, 1892). Scott's intervening expedition of 1884 had also camped on the Greybull River in an unsuccessful attempt to duplicate Wortman's efforts (Scott, 1939; see below).

Wortman's 1881 collection from the Bighorn Basin included a number of new species, such as *Oligotomus* [*Ectocion*] *osbornianus, Anaptomorphus* [*Tetonius*] *homunculus,* and *Pantolestes* [*Cynodontomys*] *nuptus* that have subsequently been found

only in the middle Wasatchian (Wa_3), but it also included several new species characteristic of the early part of the late Wasatchian (Wa_4) as well: *Cynodontomys latidens, Mioclaenus* [*Bunophorus*] *etsagicus, Pachynolophus* [*Heptodon*] *posticus,* and *Hyopsodus powellianus* (Cope, 1882a, 1882b, 1885). Thus it is clear that Wortman collected some in both the upper part of Schankler's *Haplomylus-Ectocion* Range Zone and in the *Heptodon* Range Zone (Schankler, this volume). None of the new species described by Cope from these collections is confined to the intervening *Bunophorus* Interval Zone, but the presence of *Hyopsodus lemoinianus* suggests that this interval was probably sampled as well.

SCOTT'S EXPEDITION OF 1884

William Berryman Scott is best known for his work on faunas of the middle Eocene of southwestern Wyoming and Utah and the Oligocene of South Dakota, and for his early expeditions to Patagonia. Scott spent much of the summer of 1884 exploring the Bighorn Basin. He had seen the specimens collected by Wortman, including a nearly complete skeleton of *Phenacodus,* and set out to attempt to duplicate these. As Scott (1939, p. 161) himself admitted: "This was the only one of all the western trips . . . that was a complete failure from the collector's point of view; we obtained practically nothing." The problem seems to have been that, while they knew the collections had come from the vicinity of the Greybull River, they approached this area from the north and attempted to work too far upriver in the vicinity of Meeteetse Creek.

Scott's party traveled as far as Miles City, Montana, on the Northern Pacific railroad, outfitting at Fort Keogh across the Tongue River. On July 1st the expedition set out on horseback from Fort Keogh along the Yellowstone River, arriving at Fort Custer on July 5th. Here they rested for several days, visiting the scene of Custer's last stand, which had taken place only eight years earlier. By July 20th they were in Pryor Gap, and they reached Sage Creek on the 21st. On July 23rd they "had a terrible march of considerably more than 30 miles through the Stinking Water Desert, a hot plain that burns one's face to look at and is utterly without grass and water" (Scott, manuscript autobiography). Robert V. Witter (pers. comm.) identifies this "Stinking Water desert" as Polecat Bench, which Scott's party must have crossed. The freight and stagecoach road from Billings into the Bighorn Basin that they were following paralleled the south side of Polecat Bench before dropping off the end of the bench to cross the "Stinking Water" River at Corbett. Scott's group attempted to collect fossils near Corbett for one day, but had poor success. From Corbett the trail passed east of present-day Cody and then continued southward to Meeteetse. Camp was pitched at a comfortable site near the Greybull River, below the mouth of Meeteetse Creek. Scott's group attempted to collect in this area of poor exposures, some twenty miles west of the productive areas explored by Wortman, and consequently the results were disappointing. The entire collection, consisting of four catalogued specimens of *Coryphodon, Didymictis, Lambdotherium,* and *Hyracotherium* respectively, fit into one cigar box. The only finds worthy of note were the *Didymictis,* a partial skeleton later described by Scott (1887), and the *Lambdotherium,* first record of this genus in the Bighorn Basin (albeit long unpublished; Sinclair and Granger, 1911). The latter presumably came from the head of Fifteen Mile Creek in Buffalo Basin, across the divide on the east side of the Greybull River, because these are the nearest *Lambdotherium*-bearing beds.

WORTMAN AND OSBORN

Wortman was hired by the American Museum of Natural History in 1891 to direct their field program in vertebrate paleontology, and he was immediately sent to the Bighorn Basin and Wind River Basin to make new collections similar to those made ten years earlier for Cope (Osborn, 1926). Fortunately, a reasonably detailed narrative of the 1891 expedition was published along with descriptions of the fossils (Wortman, 1892). By this time the Northern Pacific railroad had reached Red Lodge, Montana, and Wortman traveled from New York to Red Lodge by rail. Here he hired a team and wagon, riding horses, and one assistant to serve as teamster, cook, and collector combined. The expedition set out from Red Lodge for the extensive exposures previously prospected by Wortman south of the Greybull River. They followed the Meeteetse Trail across the Clark's Fork Basin, emerging from the head of Big Sand Coulee where the highway does today, and crossed the Stinking Water River on the new bridge at Corbett. From Corbett they traveled south of the McCullough Peaks down Dry Creek to join the Bridger Trail near Bridger Butte. The Greybull River was impassable due to high water, so Wortman and his assistant passed their time collecting on the divide between Dry Creek and the Greybull River in the vicinity of YU Bench and/or Table Mountain. The greater part of the summer was spent on the south side of the Greybull River in the vicinity of Dorsey

Figure 3. Mode of transport employed by Jacob L. Wortman, Barnum Brown, and Elmer S. Riggs on American Museum of Natural History expedition in the Bighorn Basin in 1896. Driver shown is either Riggs or Brown, in badlands near the Greybull River. Photograph courtesy of American Museum.

Creek and possibly Elk Creek. Prospecting farther from the Greybull was also attempted, the assistant being employed to ferry water from the river, and in this way Wortman managed to prospect in Buffalo Basin south of Sheep Mountain and Tatman Mountain. The final twenty days of the expedition were spent revisiting the Wind River Basin for a brief reconnaissance there.

The 1891 expedition was very successful, perhaps the most extraordinary find being the complete upper and lower dentition of *Palaeonictis,* a creodont previously known only from Europe (Osborn, 1892). Osborn also described *Dissacus* [*Hapalodectes*] *leptognathus* and *Pachyaena gigantea* based on these collections. The *Palaeonictis* and much of the skeleton of an *Oxyaena* were collected by a form of underwater washing invented on the spot by Wortman. He washed in a flat pan as a placer miner would, rather than through screens as one does today, but his results were equally successful. Even so, the *Oxyaena* skeleton collected in 1891 remained incomplete until Cope's collection was purchased by the American Museum in 1895 and W. D. Matthew discovered that many of the missing pieces of the same individual had previously been collected by Wortman in 1881! The complete specimen was described by Wortman (1899).

Wortman made a number of important geological observations during the 1891 expeditions, estimating the thickness of Wasatchian sediments in the Bighorn Basin to be between 2500 and 4000 feet, and describing the apparent unconformity between the Wasatchian and underlying "Cretaceous" sediments near Corbett Bridge. Wortman searched for evidence of "Puerco" deposits between the Cretaceous and Wasatchian, but failed to find any. Wortman correctly inferred that the sediments of the Clark's Fork Basin are continuous with those in the Bighorn Basin, and collected "enough material to settle the age of

these beds without question . . . the remains are all mammalian, and the species represented are characteristically those of the Wasatch," not the Cretaceous as previously thought. Assuming Wortman collected near the Meeteetse Trail as he passed through the Clark's Fork Basin, the fossils he collected were almost certainly Clarkforkian and not Wasatchian in age, but none of these remains has ever been described.

Wortman revisited the central Bighorn Basin in 1896 (Figure 3) as part of a more extensive expedition prospecting in the Wind River, Uinta, and San Juan basins. He was accompanied by two fledgling paleontology students, Barnum Brown and Elmer S. Riggs, of the University of Kansas. Both went on to distinguished careers in vertebrate paleontology, Brown at the American Museum and Riggs at the Field Museum in Chicago. One of the few species based on collections obtained in 1896 is *Pachyaena intermedia* Wortman (1899). Matthew and Granger (1915) indicate that Wortman visited the Clark's Fork Basin as well in 1896, but again nothing was ever published of this collection. Many of the leading vertebrate paleontologists of this time, including Wortman and Osborn, are shown in Figure 4.

Figure 4. Leading figures in early American vertebrate paleontology, at *Diplodocus* quarry on Sheep Creek, Wyoming, 1899. Man squatting in foreground is J. L. Wortman; others, from left to right, are: W. J. Holland, H. F. Osborn, W. D. Matthew, W. Granger, and R. S. Lull. Osborn, Granger, and Wortman were directly responsible for much early Cenozoic paleontological exploration in the Bighorn Basin. Photograph courtesy of Division of Vertebrate Paleontology, Peabody Museum, Yale University.

LOOMIS' EXPEDITION OF 1904

The next scientific party to study the early Cenozoic vertebrate paleontology of the Bighorn Basin was led by Frederick B. Loomis of Amherst College in Massachusetts. In 1904 Loomis and two students went by train to Rapid City, South Dakota. From Rapid City they drove a team and wagon 450 miles across the Powder River Basin and Big Horn Mountains to the vicinity of the Greybull River. As reported in a local Massachusetts newspaper at the time, Loomis initially believed the Wasatchian in the Bighorn Basin to represent a thick series of lake sediments, deposited "about 1.5 million years ago." The total lack of water and grass in the badlands forced Loomis' party to camp along the Greybull River, making daily forays into the badlands eight to ten miles to the south. There each man worked in a different direction from the wagon in order to cover as much ground as possible. According to the newspaper account, Loomis considered the greater part of a *Hyracotherium* skeleton to be one of their most important finds. To insure finding all of the pieces "the earth in the immediate vicinity was scraped up and hauled in sacks to the river, where it was washed through screens and 100 or more further fragments recovered." Thus screen washing, as employed in paleontology today, has apparently had a number of independent origins.

After working along the Greybull River and Fifteen Mile Creek for three weeks, Loomis' party left the Bighorn Basin to continue their work in the Wind River Basin. Loomis made a number of contributions to Wasatchian paleontology based upon his Bighorn Basin collections. Perhaps most important was his reinterpretation of the Bighorn Wasatchian deposits as fluvial rather than lacustrine in origin (Loomis, 1907). Judging from both the *Pelycodus* and *Lambdatherium* Loomis collected, his "Tatman Mountain lower level" is in the *Pelycodus trigonodus* Zone (Wa_3) and his "Tatman Mountain higher level" is in the *Pelycodus jarrovii* Zone (Wa_5) of the Wasatchian (*Pelycodus* revised in Gingerich and Simons, 1977).

FISHER AND THE SHOSHONE RECLAMATION PROJECT

In 1906, Cassius A. Fisher published the first extensive treatment of the geology and hydrology of the Bighorn Basin, including a geological map of the entire Bighorn Basin. Impetus for this work was un-

Figure 5. American Museum of Natural History field party in camp in 1910 in the central Bighorn Basin, probably along Dorsey Creek or the Greybull River. Men are, from left to right: William Stein, Walter Granger, William J. Sinclair (of Princeton University), and George Olsen. Photograph courtesy of American Museum.

doubtedly authorization of the Shoshone Reclamation Project by President Roosevelt in 1904. As a result of this ambitious project, some 150 square miles of desert are now productive farmland (Churchill, 1979). Fisher (1906) mapped the present Polecat Bench or Fort Union Formation (Paleocene) as part of the Cretaceous Laramie Group, but he correctly interpreted the Wasatchian deposits as being largely fluvial in origin. His map was used extensively by Sinclair and Granger in their subsequent paleontological explorations of the Bighorn Basin.

SINCLAIR AND GRANGER

One of the most productive phases of research on Cenozoic vertebrate paleontology in the Bighorn Basin began in 1910 when the American Museum of Natural History sent a full expedition into the central basin under the direction of William J. Sinclair and Walter Granger (Figure 5). In 1910 they worked from various camps between the towns of Basin and St. Joe on the south side of the Greybull River. Collections were made from levels near the base of the Wasatchian on Antelope and Elk Creek to the top of Tatman Mountain. Sinclair and Granger concentrated on the interval below Loomis' lower level on Tatman Mountain, and they succeeded in recognizing three "more or less well defined" fossiliferous zones. The lowest, Zone 1, was described as being exposed on Elk Creek Anticline. Zone 2 was higher than Zone 1, and exposed along upper Elk Creek and the lower part of Dorsey Creek. Zone 3 was above Zone 2 and exposed in badlands south of St. Joe, i.e. on upper Dorsey Creek.

In their report on the 1910 expedition, Sinclair and Granger (1911) outlined the stratigraphy of Wasatchian deposits in the Bighorn Basin. They also discussed the origin of the red beds common in these sediments, suggesting that the red beds developed from "blue" beds [gray beds] by concentration and oxidation of iron compounds at the surface during periods of dryer climate than existed during deposition of the blue clays. Sinclair and Granger noticed also that vertebrate fossils are particularly abundant in red clays or at the contact of red and blue strata. These views are not very different from current ideas regarding the origin of both red beds and fossiliferous horizons, although it is clear that Sinclair and Granger attributed the origin of red beds to climatic change rather

than normal soil-forming processes in a stable climate. Also, we now know that fossils are usually found in "blue" beds associated with red beds, not actually in the red beds themselves (Bown, 1979; Winkler, this volume).

Sinclair and Granger continued field research in the Bighorn Basin during the summer of 1911. In July they worked in the central basin on Five and Ten Mile Creeks, east of the Bighorn River north of Worland, and then in the upper Fifteen Mile Creek area near Parker Spring. In a letter to W. D. Matthew dated August 2, Granger reports that they obtained "many hundred individuals—and all apparently from the Lysite." Having documented the presence of Lysite equivalent faunas in the Bighorn Basin, Sinclair and Granger then concentrated efforts on finding a distinctive fauna in drab beds of Fisher's "Laramie group" below red-banded Wasatchian beds on the southwest slope of the McCullough Peaks (in Rough Gulch, UM locality SC–196). A similar fauna was found on the bluff north of Ralston (Polecat Bench) and in the head of Big Sand Coulee, and Sinclair and Granger (1912) concluded that if these faunas proved to be older than the typical Wasatchian, the beds should be distinguished as the "Ralston" beds or formation.

Granger collected in the Bighorn Basin in 1912 with William Stein. They arrived late in August, having spent the better part of the summer in New Mexico, and immediately set to work exploring the "Ralston" beds. According to Granger and Stein's field catalogue, September 4th and 5th were spent on the end of Polecat Bench; September 6th, 7th, and 8th were spent in the head of Big Sand Coulee; and September 12th was spent first in Badger Basin on the east side of the Clark's Fork River and then near Sugarloaf Butte on the west side of the Clark's Fork River. After losing several days to a snowstorm, they set up camp on the Hopkins Ranch at the mouth of Pat O'Hara Creek and explored from there. On September 18th a good concentration of Wasatchian mammals was found in red beds three miles southeast of the camp on Pat O'Hara Creek. This locality, almost certainly UM locality SC–40, furnished the largest "Sand Coulee" fauna. Granger appears to have been particularly intrigued by a nice specimen of "*Ptilodus*" he found here—this later became the holotype of *Eucosmodon* [*Neoliotomus*] *ultimus* Granger and Simpson (1928). *Pelycodus ralstoni* Matthew, *Diatryma ajax* Schufeldt, and a number of other new species were first described from specimens found at this locality.

September 19th was spent collecting near camp. Then on September 20th and 21st Stein collected three miles east of camp, near Granger Mountain (UM locality SC–90), and obtained a good collection of "Ralston" mammals, while Granger continued work on the "Sand Coulee" locality. Both then worked the latter through September 25th. September 27th, 28th and 29th were spent collecting five miles southeast of the mouth of Pat O'Hara Creek, probably in the vicinity of UM localities SC–2, SC–54, and SC–87. One curious find here was a pair of phalanges initially identified by Granger in the field and by Matthew and Osborn at the American Museum as belonging to a theropod dinosaur—later they were correctly referred to the giant flightless bird *Diatryma* by Shufeldt (1913). October 2nd was spent on the east side of Polecat Bench, collecting "on Fisher's contact line" between the Laramie and Wasatch (UM locality SC–74). Another early storm ended exploration of the Clark's Fork Basin–Polecat Bench area, "rain, sleet, and snow—over a foot of the latter" is probably all that prevented Granger and Stein from finding the first Tiffanian mammals to the east along Polecat Bench.

This American Museum phase of field work in the Bighorn Basin was essentially completed in 1913 by William Stein and an assistant, Philip L. Turner. Stein was by this time a naturalized German immigrant, ranching on a small scale on Dorsey Creek south of Otto, Wyoming. Turner was a young Easterner who was paid a three month salary totaling $75, out of which he was required to pay his own transportation from New York to Wyoming and back. On a budget like this it is not surprising that Stein and Turner wrote often to Granger complaining that they were short of money.

Stein and Turner spent the early part of the summer of 1913 on Five Mile and Ten Mile Creeks, before heading for Coon and Whistle Creeks east of the McCullough Peaks in August. Here they were not very successful, and soon moved on to the Clark's Fork Basin. They camped for 10 days in the head of Big Sand Coulee, about a mile west of an Irish sheepherder's camp. Unfortunately, no more precise locality data are given. Near this camp, on September 4, Stein found the first specimen of a notoungulate to be discovered outside of South America. It was catalogued as No. 79 "Rodent(?) Jaw (upper beds), Head of Big Sand Coulee." Matthew (1915c) inexplicably described this specimen, the holotype of *Arctostylops steini*, as coming from Gray Bull beds of the Clark's Fork Basin. The only other specimen found that day, the holotype of *Probathyopsis praecursor* Simpson (1929c), was also found by Stein

and bears an identical locality record. It was recognized, even by Matthew (letter to Stein, 1913), as coming from the Clarkforkian. All subsequent finds of *Arctostylops steini* and *Probathyopsis praecursor* have been in late Tiffanian or Clarkforkian strata, and Matthew's attribution of *Arctostylops* to a Wasatchian horizon is almost certainly in error.

There was initially some skepticism over whether the notoungulate had really been found in Wyoming and on December 2, 1913, Matthew wrote to Stein about this:

> "Now some of the paleontologists will not be willing to believe in this find if they can help it, and they may suggest that you found the specimen when you were with Loomis in Patagonia and it got mixed in accidentally with your Wasatch collection. It is just possible that you might have picked it up in Patagonia, wrapped it in cotton and tucked it in some out of the way pocket of your coat, and then missed it when you came to turn in your finds at camp there. It might then stay in that pocket when you brought the coat back, and if you were wearing the same coat in the Bighorn Basin, you might find it when you came to turn out your finds at night, and not remembering it, have supposed you had found it in the Wasatch beds. . . ."

Stein replied from Otto on December 8:

> "In regard to the specimen No. 79 it was find by me as stated on label and in record book by Mr. Turner. I even remember the place. I find the two end pieces side by side but the mittle [sic.] part was missing but after looking around a few minute and uttering some very strong word I was able to locate it a few feet below the others in a crack. . . . The little jaw in question is find from Clark's Fork Basin pure and simple and not misplaced specimen from Patagonia by me."

This was sufficient to convince Matthew of the authenticity of the find, and he proceeded to publish it. A few years later American Museum parties found similar notoungulates in Mongolia, corroborating their occurrence outside of South America, and in recent years several additional Clarkforkian specimens have been found in the head of Big Sand Coulee by UM expeditions.

Granger (1914) reviewed and revised the biostratigraphic nomenclature relating to early Cenozoic faunas in the Bighorn Basin. His conclusions are essentially those expressed in Figure 6. The fauna of the Clark Fork beds (= "Ralston" beds) was a completely new one, which Granger correctly distinguished from later faunas by its lack of perissodactyls, artiodactyls, and modern primates. The Sand Coulee fauna was distinguished from the overlying Gray Bull fauna by the absence of "*Systemodon*" and by "the generally more primitive character of such genera as are common to both horizons." The Gray Bull beds were delimited from overlying Lysite beds by the presence of "*Systemodon*" and absence of *Heptodon*. Lysite beds were characterized by the presence of *Heptodon* but not *Lambdatherium*, and finally the Lost Cabin interval was differentiated from lower intervals by the presence of *Lambdatherium*. This sequence has subsequently become widely used in the literature on early mammals as a succession of faunal zones: Clarkforkian, Sandcouleean, Graybullian, etc. It is a measure of the quality of Granger's original field observations and collections that the faunal zones he proposed have withstood nearly seventy years of subsequent research on Bighorn Basin faunas. Other zonation schemes have been proposed to supplement Granger's, and his sequence has been refined, but the basic succession he described remains unchanged.

Many papers have been published on early Eocene faunas based on the American Museum collections from the Bighorn Basin. Principal among these are Sinclair (1914), Matthew (1915a,b,c, 1918), Granger (1915), Granger and Simpson (1928), Simpson (1929c, 1937). Stein made a small collection on Elk Creek and in the Clark's Fork Basin for the American Museum in 1916, but it contained nothing noteworthy.

CASE'S EXPEDITION OF 1924

The first University of Michigan collection of fossil vertebrates from the Bighorn Basin was made in 1924 by Ermine Cowles Case, assisted by A. S. Warthin and W. H. Buettner. They spent several days in July collecting in the lower level of Tatman Mountain badlands as part of a general survey of the Cretaceous and early Tertiary faunas of South Dakota, Wyoming, and Montana. Only one specimen considered worthy of publication was found in the Bighorn Basin. This was the holotype of *Allognathosuchus wartheni*, described by Case (1925). Another notable find, in view of the rarity of birds in early Cenozoic collections, was the distal end of the femur of a large *Paragrus*-like bird (which was, until recently, labelled *Phenacodus*!).

SIEGFRIEDT AND SIMPSON

In November 1926, J. C. F. Siegfriedt, a medical doctor in Bear Creek, Montana, discovered a mammalian molar in gangue from one of the nearby late Paleocene coal mines. Siegfriedt studied the tooth,

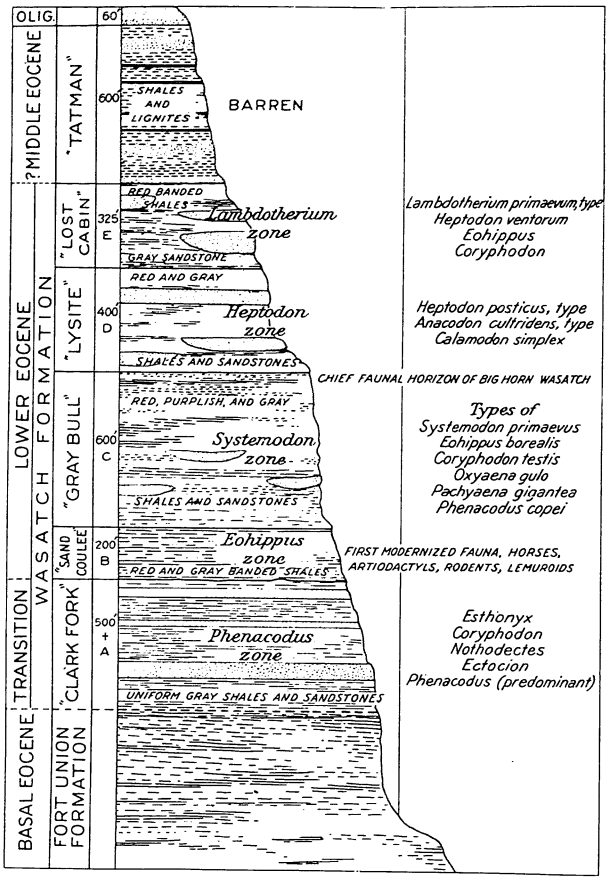

Figure 6. Composite stratigraphic section of Paleocene ("Basal Eocene") and Eocene deposits of the Bighorn and Clark's Fork basins, showing faunal zones as perceived by Granger at the conclusion of American Museum work in the Bighorn Basin in 1918. Figure from Osborn (1929).

concluding that it was human, and further proposed that Bear Creek was the site of the Garden of Eden. This received considerable notice in the local press and within a short time Henry Fairfield Osborn at the American Museum was in contact with Siegfriedt regarding the discovery. Siegfriedt had by this time found more fossils, and he sent the first collection of these to New York in May of 1927. Barnum Brown of the American Museum visited Bear Creek in 1927, as did J. LeRoy Kay of the Carnegie Museum in Pittsburgh. Then Rachel A. Husband (later Nichols) of the American Museum spent the summer of 1928 collecting from the spoil heaps of the Eagle Mine, assisted by the superintendent of the mine, Mr. J. F. Lobdell. George Gaylord Simpson published three papers on the Bear Creek fauna (1928, 1929a, 1929b), bringing it to the attention of the scientific community. As a result of all this activity a 1929 issue of the Carbon County News, published in nearby Red Lodge, echoed Siegfriedt's original claim noting: "it may possibly be found that the ancestors of most mammal life may have originated, not in Asia or Europe, but in North America, and that the Garden of Eden was actually located in the foothills of the Rocky Mountains, with Bear Creek, Montana, figuring as at least the porter's lodge or one of the suburbs." Within a short time Siegfriedt was Mayor of Red Lodge!

In a more serious vein, Simpson (1929b) concluded that the Bear Creek fauna was late Paleocene in age, equivalent to both the Clark Fork fauna of Wyoming and the Tiffany fauna of southern Colorado. Jepsen (1937) first described a rodent, *Paramys atavus*, from the Bear Creek fauna, correctly noting that it was at that time the oldest record of Rodentia known anywhere. Jepsen believed the age of the Bear Creek fauna to be Tiffanian, but more recent work has shown it to be Clarkforkian, probably early Clarkforkian (Cf_1; Rose, 1979). Robert V. Witter collected additional fossil vertebrates from the Bear Creek mines for Princeton University in 1948. This collection included two specimens of the champsosaurid *Simoedosaurus* recently described by Sigogneau-Russell and Baird (1978). The most recent collection from Bear Creek was made in 1958 by Peter Robinson, J. T. Gregory, and James Hopson for Yale University.

SINCLAIR AND JEPSEN

Paleontological field work was curtailed during World War I, and the first subsequent expedition to the Bighorn Basin did not take place until 1927. Then William J. Sinclair, accompanied by two students, Glenn L. Jepsen and T. C. von Storch, drove from Rapid City, South Dakota, to the Bighorn Basin, arriving at William Stein's ranch on Dorsey Creek on June 27. On June 29 they moved to the nearby Wardell Ranch. Sinclair and his assistants then spent nearly two months exploring the Dorsey Creek badlands south of the Greybull River, the area previously prospected by Wortman, by Loomis, and by Granger. They were rewarded by several extraordinary finds, among them the *Omorhamphus* [*Diatryma*] described by Sinclair (1928), with its intermingled micromammalian fauna including the holotype of *Parectypodus* [*Ectypodus*] *tardus* (Jepsen, 1930a). A nearly complete skeleton of *Palaeonictis* was also found on this expedition (Sinclair and Jepsen, 1929).

Figure 7. Glenn L. Jepsen (left) and LeMoyne Cook excavating a specimen of *Phenacodus* in the Bighorn Basin during the 1928 Princeton University expedition. Photograph courtesy of Department of Geological and Geophysical Sciences, Princeton University.

In 1928 Jepsen led the Princeton expedition, accompanied by two other students, LeMoyne Cook and Joseph Page (Figure 7). Their first camp was in the Clark's Fork Basin, at the head of the west fork of Big Sand Coulee (Figure 8). This camp was set up on June 27th very near the section corner adjacent to UM locality SC–2, a locality they found to be very productive. This was also, as mentioned above, probably one of Granger and Stein's localities as well. Jepsen and crew remained here until July 13th. Most of the time was probably spent prospecting in the vicinity of the camp, but they also ranged five miles northward on July 10th to the vicinity of UM locality SC–136, and on July 12th they must have hiked some three miles southward to the vicinity of UM locality SC–265 because they recorded finding the section corner near that locality. July 12th is particularly significant because it is the day the holotype and only specimen of *Paleomoropus jepseni* was found. In describing this, Radinsky (1964) quoted the specimen label stating that it was found in "Section 9, T. 55 N., R. 102 W." in "lower Gray Bull beds." Neither of these designations can be true, since there are virtually no exposed Wasatchian sediments in Section 9 and, even if there were, all faunas from this area are upper Graybullian (Wa_3) in age. The original field

Figure 8. Princeton University camp in the Clark's Fork Basin: year is 1928, and the automobile is a Ford Model T. Jepsen (1928) indicates that nearly one hundred specimens were collected at this locality in 1928. This is presumably Jepsen's Camp #1, near UM localities 2 and 54. Photograph courtesy of Department of Geological and Geophysical Sciences, Princeton University.

label says simply "2½ mi. S. Camp #1." Since it is clear that some if not all of the group climbed to the corner between Sections 11, 12, 13, and 14, it is possible that the *Paleomoropus* specimen came from a level as high as UM locality SC-265. Whatever the precise level, the specimen is clearly from the middle Wasatchian, and not the early Wasatchian as described.

Jepsen (1930a) made much of finding *Homogalax* (*Systemodon*) in Sand Coulee beds, but it is clear from his labels and published discussion that he often used Sand Coulee in a geographical sense rather than the stratigraphical sense intended by Granger. A species of *Homogalax* does occur in Sand Coulee beds (Wa_1) but this is a smaller species than that referred to "*Systemodon*", which has not been found in beds older than early Graybullian (Wa_2).

On July 13th, Jepsen moved to his Camp #2 near UM locality SC-80 on the west side of Polecat Bench. From this camp the crew worked along Polecat Bench and in the head of Big Sand Coulee, where they found the holotype of *Probathyopsis successor* at a locality said to be in Gray Bull beds (but now known to be Clarkforkian). On July 27th they moved to Camp #3 near an abandoned coal mine just east of UM localities SC-262, 263, and 264 on the southeast side of Polecat Bench. A specimen of *Plesiadapsis rex* was found by Cook "½ mile southwest of Camp #3," probably in UM locality SC-262. The holotype of *Titanoides gidleyi* Jepsen (1930b) was found one mile southwest of this camp near UM locality SC-261, which is also in the *Plesiadapis rex* Zone (Ti_3). Dinosaur remains were discovered in the lowest beds of Polecat Dome. After a week of prospecting from Camp #3 Jepsen and crew packed their fossils and headed back to Princeton, stopping briefly to collect on Elk Creek in the central Bighorn Basin (where the holotype of *Parectypodus simpsoni* Jepsen, 1930a, was found) and on Cottonwood Creek in the Wind River Basin.

Jepsen's expedition of 1928 proved the feasibility of finding fossils in beds stratigraphically below the typical Clarkforkian documented by Granger in the Clark's Fork Basin. Consequently, Sinclair returned to this area with Jepsen and three undergraduate students, James W. Cooke, Sven Dorf, and Joseph F. Page, in 1929 (Figure 9). Their first camp was set up on June 29th at the west edge of Polecat Bench, near Fossil Hollow (UM locality SC-198), a site Jepsen had visited on his last day in the Polecat Bench area the year before. Sinclair kept a detailed field catalogue that sheds considerable light on the collections made in 1929. The first two weeks were spent prospecting near camp, mostly along the west edge of Polecat Bench. On July 11th the first specimens were collected at what later became the very productive Princeton Quarry. Piecing together several lines of evidence, it appears that discovery of the first specimen from this locality (premolars of *Neoliotomus*) resulted from a fortuitous, if uncomfortable, encounter Page had with a tick. However the actual concentration of jaws and teeth at Princeton Quarry was not recognized until July 22nd, when two days were spent quarrying here.

On July 29th a nice collection of Clarkforkian mammals was made in Sand Coulee, near UM locality SC-136, including the holotype of *Plesiadapis cookei*. The Paint Creek locality (UM locality SC-143), yielding *Neoliotomus conventus* Jepsen (1930a), was discovered on August 2nd in brightly colored strata on the west side of the Clark's Fork Basin. As with the holotype of *Probathyopsis successor*, the Clarkforkian fossils from Paint Creek were incorrectly considered to be Sand Coulee or Graybull in age because they came from red-banded strata. Jepsen (1940) explicitly stated that red beds occur well down in the Clark Fork beds, but he continued to concentrate collecting efforts only on drab sediments, with the result that many rich and important Clarkforkian localities in red-banded strata were not discovered until recently.

The Torrejonian Rock Bench Quarry on the east side of Polecat Bench was discovered on August 6th, when a number of jaws, including the holotype of *Plesiolestes* [*Palaechthon*] *problematicus* Jepsen (1930b), were collected. On August 13th the first Puercan mammal, described as *Eoconodon*, was discovered one half mile east of the coal mine at the 1928 Camp #3. The Mantua Quarry itself was found at the same stratigraphic level on August 14th about a mile to the northwest. The first fossil discovered here was the holotype of *Loxolophus nordicus* Jepsen (1930b). The following day several blocks of matrix were hastily removed from the Mantua Quarry, and Sinclair, Jepsen, and crew headed back to Princeton. In little more than a month of field work this crew had succeeded in finding what became three extremely productive Puercan, Torrejonian, and Tiffanian quarries, and demonstrated their relationship to underlying Cretaceous and overlying Eocene faunas.

The 1928 and 1929 collections formed the basis of Jepsen's doctoral dissertation (Jepsen, 1930b). In addition to the mammals described by Jepsen from the Clark's Fork Basin-Polecat Bench area, these expeditions documented a remarkable diversity of

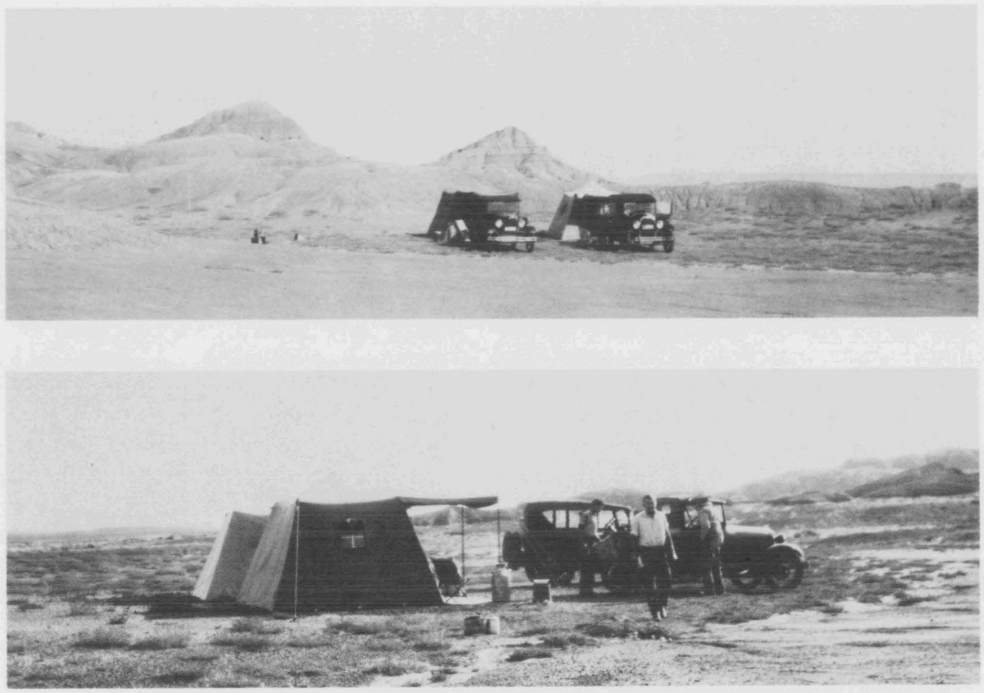

Figure 9. Princeton University camp in the McCullough Peaks in 1929, during a break from prospecting in the Paleocene. *Top:* view looking northwest, showing two Model A Fords, one a touring car and the other a pickup. Note Polecat Bench on the skyline at right. *Bottom:* view looking east. Gentleman at right in hat is William J. Sinclair. Others are students James W. Cooke, Joseph R. Page, or Sven Dorf. Photographs courtesy of Department of Geological and Geophysical Sciences, Princeton University.

land snails in the Clarkforkian and early Wasatchian, differing from the underlying Tiffanian fauna dominated by aquatic forms (Russell, 1931). During the 1930's Jepsen continued to work the Puercan, Torrejonian, and Tiffanian quarries, which yielded a rich collection of fossil vertebrates. Jepsen (1940) described the multituberculates and proposed a new formation, the Polecat Bench Formation, to include, essentially, the Paleocene sediments of the northern Bighorn Basin. This terminology has not been universally accepted because it has never been thoroughly and adequately documented, and the drab early Cenozoic sediments are sometimes still included in the Fort Union Formation.

During the 1930's Jepsen became acquainted with Frederick and Thelma Churchill, a farming couple living near Powell, Wyoming. The Churchill family has continued to play an important role in Bighorn Basin vertebrate paleontology for nearly fifty years. During his lifetime, Frederick discovered many important Paleocene and Eocene fossil localities, among them the late Tiffanian Fritz Quarry and the early Wasatchian Bone Hill locality.

LATER PRINCETON UNIVERSITY EXPEDITIONS

In 1937, Franklyn B. Van Houten began major projects on the Wasatchian stratigraphy and faunas of the Bighorn Basin, which resulted in two important publications (Van Houten, 1944, 1945), and differentiation of the red-banded early Eocene sediments of the basin as the Willwood Formation.

Field work was curtailed during World Was II, but the years following the war were also productive. Robert V. Witter and Albert C. Silberling were employed by Princeton during this period. Silberling was at that time a veteran of some fifty years of paleontological prospecting in the Crazy Mountain Field in Montana, having first accompanied a Princeton party working there in 1901 when he was sixteen years old. Witter was younger and less experienced but proved equally capable as a collector. Together they initiated work in the Foster Gulch area in the large expanse of badlands between the towns of Powell, Lovell, Greybull, and Emblem. Among the most important sites discovered by Witter and Silberling

were the Tiffanian Cedar Point (Ti_3), Jepsen (Ti_3), Croc Tooth (Ti_4), and Divide (Ti_4) Quarries, and the late Tiffanian or Clarkforkian Little Dry Creek locality near Greybull. In 1948 Witter succeeded in obtaining a new collection of early Clarkforkian fossil vertebrates from the Foster, Burns, Brophy, and Smith coal mines near Bear Creek, Montana. Minchen Chow, Frank Goto, Marshall Lambert, Ernest Lundelius, William J. Morris, and Elwyn L. Simons also worked with Princeton parties in the Bighorn Basin during the late 1940's and early 1950's.

In 1955, Simons discovered a Torrejonian locality on Cub Creek southeast of Belfry, Montana. This locality yielded several good specimens, among them the holotype of *Stelocyon arctylos* Gingerich (1978). Simons continued exploration of the Bighorn Basin in 1960, assisted by Farish A. Jenkins and Leonard B. Radinsky. They discovered several important sites in the southern Bighorn Basin, among these the Wasatchian Sand Creek-No Water Creek area later worked by Bown (1979), the Puercan (?) Gooseberry Creek locality some 15 miles south of Meeteetse along Highway 120, and the Puercan Leidy Quarry east of Kirby. Simons also found the Sunday locality and a specimen of "Sunday beast" in 1960. Professor Jepsen was away at the time; and according to Simons these were both named to remind Jepsen of how the crew had spent their sabbath. In Jepsen's later years his idea of a day of rest was a day away from the Paleocene, often a "picnic" in more fossiliferous Wasatchian deposits.

During the 1960's Princeton parties working in the Bighorn Basin included Michael Archer, Henry Bunn, Robert Chaffee, Farish Jenkins, Marshall, Brice, and Russell Lambert, David Parris, Wayne Pennington, Robert Rainey, Kenneth Rose, Charles Schaff, Wallace Ulrich, Robert West, Craig Wood, Roger Wood, and a number of others. I first worked for Jepsen in 1967, completing an undergraduate thesis on pollen stratigraphy in the Polecat Bench Formation (Gingerich, 1968). During the summer of 1967 my brother Steven and I, at Jepsen's suggestion, made the first accurate determination of the thickness of the Polecat Bench Formation along the south side of Polecat Bench. After a week spent making a complex series of measurements with plane table and alidade, analyzed by computer at Princeton, we concluded that the thickness of the Polecat Bench Formation was 3,817 feet (1,163 m) from the base of the Mantua lentil to the lowest red bed on the south side of Polecat Bench. Jepsen (1940) had given the thickness of the formation as 3,500 feet (1,067 m), within 10% of our figure. He was pleased and little amused that our figure matched his so closely, since in his calculation he had assumed an average strike and dip and then simply driven his automobile along the south edge of Polecat Bench using its odometer to measure the distance traversed!

Glenn Lowell Jepsen retired from the Princeton faculty in 1971 and passed away in 1974, having devoted nearly two-thirds of his life to research on early Cenozoic faunas of the Bighorn Basin. It is worth noting that most of the contributors to this volume owe their interest in the Clark's Fork and Bighorn basins directly or indirectly to Jepsen.

GILMORE, WILSON, KAY, AND OTHERS

During the summer of 1930, Theodore E. White and Norman Hartweg spent several days in the Bighorn Basin with William Stein collecting for the University of Michigan. They worked "twenty miles west of Basin," where they obtained a small collection consisting mostly of *Hyracotherium, Homogalax,* and *Phenacodus.* Edward L. Troxell of Trinity College (Connecticut) also worked in the Bighorn Basin in 1930, on Elk Creek, where he found a nearly complete skeleton of *Diatryma* (Troxell, 1931). Troxell continued field work in the Bighorn Basin in 1931.

Charles W. Gilmore, George F. Sternberg, and M. V. Walker carried out an extensive survey of the central Bighorn Basin for the U.S. National Museum in 1931, concentrating especially on the south fork of Elk Creek. On their first day of collecting Gilmore's crew located a nearly complete skeleton of *Coryphodon,* only to find out later while visiting Troxell's camp that it was of a specimen Troxell himself was in the process of collecting. Gilmore released all claims, noting in his field book that "some people get all the breaks." Gilmore's party found five fragmentary specimens of *Diatryma* near the mouth of the south fork of Elk Creek, which together with Troxell's eight specimens and the one found by Stein (Matthew and Granger, 1917) all came from a narrow strip not more than two miles wide along the eastern margin of exposures of the Willwood Formation. Walker found a partial skeleton of *Pachyaena* "five miles south of Otto." Then, eight miles northwest of Worland, Sternberg found the skull of a "rare edentate," the taeniodont *Ectoganus* later described by Gazin (1936). Gilmore (1932) published a brief illustrated account of the 1931 expedition. In 1935, Gilmore and Sternberg returned to the Bighorn Basin again for one month of collecting and this time they were rewarded by finding a complete *Coryphodon* skeleton to replace the one taken out from under their noses by Troxell (Gilmore, 1936).

Robert W. Wilson first worked in the Bighorn Basin for a brief time in 1934, with a party of three assistants. They were fortunate in finding a good locality yielding about one hundred jaws in the Dry Creek basin. These specimens were originally deposited at Cal Tech, and have since been transferred to the Los Angeles County Museum. In 1940, Wilson again collected in the Bighorn Basin, for the University of Colorado, being accompanied part of the time by G. E. Lewis of Yale University. Wilson later made a larger collection for the University of Kansas in 1949, mostly on the south fork of Elk Creek. This 1949 collection included the holotype of *Microsyops wilsoni* described by Szalay (1967), the *Pelycodus* mandible with a small supernumerary M_3 following the normal M_3 described by Wilson (1955), and, from the Dry Creek basin locality, a beautiful mandible of *Anacodon* and a highly fragmented nest of bird (?) eggs.

Albert E. Wood made a small collection of mammals from the Clark's Fork Basin in 1948, the most important find being the holotype of *Franimys amherstensis* (Wood, 1962).

In 1952, J. Leroy Kay and John A. Dorr spent thirteen days collecting in the Bighorn Basin for the Carnegie Museum in Pittsburgh. According to Dorr, they headed into the badlands west of Basin on a new seismograph road. The road was so rough and progress so slow that Dorr rode on the fender of the truck while Kay drove. After two miles or so of this, Dorr spotted bone from his perch on the fender. They stopped to prospect and soon found a 1 meter by 2 meter concentration of multituberculate, insectivore, condylarth, perissodactyl, and carnivore teeth, jaws, and skulls in a silty mudstone near the edge of a coarser channel sandstone. This site, Burrough's Pocket, was located at the head of Antelope Creek. Kay and Dorr ultimately removed a 300 kg block of matrix that was shipped back to Carnegie intact for later preparation.

Rohrer and Gazin (1965) published a brief discussion of Graybullian and Lysitean fossil vertebrates and invertebrates collected from 62 localities in connection with a geological mapping project in the vicinity of Tatman Mountain. In 1967, Dwight W. Taylor completed an extensive report on early Cenozoic mollusks, including those of the Bighorn Basin (U.S. Geol. Surv., Open-File report 75-331).

Additional collections of fossil mammals from the Bighorn Basin are housed at the Royal Ontario Museum, the University of Nebraska State Museum, the Raymond Alf Museum, the University of California Museum of Paleontology, Berkeley, the University of California, Riverside, and the University of Alberta. I have no doubt overlooked some smaller collections.

RECENT WORK

Elwyn L. Simons and Leonard Radinsky began the first intensive effort to collect fossil mammals from restricted stratigraphic intervals in the central Bighorn Basin in 1961. The Yale University program was continued through 1976 by Simons, and subsequently by David Schankler and Scott Wing (this volume). All collections are at Yale, except for those made in 1974 by a joint Yale-Michigan team. The latter collections were divided—the primates being housed at Yale, with the remainder of the fauna at the University of Michigan. In 1973, Thomas M. Bown of the University of Wyoming began an intensive survey of the lower Willwood Formation in the Sand Creek-No Water Creek area of the southeastern Bighorn Basin. Results of this study were recently published (Bown, 1979; also, this volume).

Following the summer of joint work with Simons in 1974 in the central Bighorn Basin, I began a University of Michigan project to study the typical Sand Coulee beds in the Clark's Fork Basin. In the process of sampling to find the base of the Wasatchian, we discovered many good localities yielding the formerly rare *Plesiadapis cookei,* a Clarkforkian index fossil, and after the second season of field work, we were able to trace the Clarkforkian-Wasatchian boundary from one side of the Clark's Fork Basin to the other. Kenneth D. Rose (1979) recently completed a monograph on the Clarkforkian mammalian fauna, and related Wasatchian and Tiffanian projects are in progress (Gingerich, Rose, and Krause, this volume). Charles R. Schaff at Harvard University has also continued work on the late Tiffanian faunas in the vicinity of Princeton and Schaff quarries in the Clark's Fork Basin.

A long-term project on the early Cenozoic floras of the Clark's Fork Basin and vicinity is in progress by Leo J. Hickey of the Smithsonian Institution (see report in this volume), and by Erling Dorf of Princeton University. John H. Hanley of the U.S. Geological Survey also initiated a project on early Cenozoic mollusks in the Clark's Fork and Bighorn basins several years ago. All of these studies promise to improve our understanding of early Cenozoic paleoecology greatly.

Post-Wasatchian sediments of the Bighorn Basin have been relatively little studied until recently. In

1962, Elwyn L. Simons received word from Lee Wentworth, a resident of Meeteetse, of fossil mammals occurring near Foster Reservoir on the flank of Carter Montain. Later that summer, James Mead and Peter Parks climbed to the upper levels of Carter Mountain and discovered additional mammal-bearing localities. All of these Carter Mountain localities appear to be Bridgerian in age. Several years ago David C. Parris of Princeton University succeeded in finding teeth of Bridgerian aspect in the Tatman Formation on Tatman Mountain. In 1977, Thomas W. Bown, now of the U.S. Geological Survey, and Jason A. Lillegraven and Jeffrey G. Eaton of the University of Wyoming began work on middle Eocene volcaniclastics along the southwestern margin of the Bighorn Basin (Bown, 1979; Eaton, this volume). Malcolm C. McKenna (this volume) summarizes what is known about Oligocene faunas in the vicinity of the Bighorn Basin and surrounding mountain ranges.

CONCLUSION

The first century of paleontological research in the Bighorn Basin has proven this to be one of the richest areas in the world for study of the early Cenozoic. Yet, in a sense, the work of integrating results of diverse approaches to earth history here has just begun. As the second century begins, we can expect the many complimentary studies now underway to yield a more coherent picture of early Cenozoic faunal and floral coevolution.

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