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PALEONTOLOGY AND GEOLOGY OF THE BRIDGER FORMATION, SOUTHERN GREEN RIVER BASIN, SOUTHWESTERN WYOMING

PART 1. HISTORY OF FIELD WORK AND GEOLOGICAL SETTING

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Part 1. History of Field Work and Geological Setting

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Abstract

This paper is the first number in an irregular series which will discuss the results of a long-term paleontologic and biostratigraphic study of the middle Eocene Bridger Formation of southwestern Wyoming. The use of screen-washing has allowed the accumulation of large numbers of very small specimens from an area where larger and more complete fossils have been collected for over one hundred years. The new population samples should allow new insights into faunal structure, correlation and environmental interpretations.

Introduction

Investigation of middle Eocene vertebrate faunas from the Green River Basin (*sensu* Love, 1961) of southwestern Wyoming has been conducted by numerous institutions since the 1870's. Earlier work was devoted largely to surface collection and quarrying; the present investigation is devoted to the accumulation of population samples of smaller vertebrates as a complement to the older collections.

Numerous recent publications have dealt with middle Eocene mammals [Gazin on *Hyopsodus* (1968), Dawson on rodents (1968), Nelson on rodents (1974), West on apatemyids (1973b), Robinson on nyctitheres (1968)] and others are in progress (Lillegraven and McKenna, Krishtalka, Szalay). None of these studies, which deal with smaller mammals, has had the benefit of the large amount of material which has been recovered during the recent screen-washing work in the Bridger Formation. Therefore, even though the work is still in progress and is expected to continue for the next several years, it seems wise to begin to make available information on the accumulated collections.

This paper therefore initiates an irregular series of publications dealing with individual groups of organisms and discrete geological problems of the Bridger Formation and associated sedimentary units in the southern Green River Basin of Wyoming. Part 1 is a

general introduction to the field work and geologic setting of the region. Additional studies dealing with marsupials, condylarths, primates and biostratigraphic problems are in preparation. Although the specific sequence of appearance of the various parts cannot be predicted, the earlier contributions will be descriptive and systematic and the later ones more interpretive.

Prior to the initiation of this series, brief descriptions of two Bridger Formation taxa, an epoicothere (West, 1973c) and an insectivore (West, 1974), were published in the *Journal of Paleontology*.

History of Investigation

Collection and study of fossil vertebrates from the southern Green River Basin Bridger Formation began before the Civil War. The first descriptions were published by J. Leidy (1869; 1871); his papers stimulated O.C. Marsh to organize expeditions to Wyoming in the years from 1870-1873. Professional collectors in Marsh's employ continued collecting for Yale for another decade. This collecting resulted in a torrent of new taxa plus the famous feud with E.D. Cope. Cope actually collected in the Bridger Formation in 1872 and 1873, though his publications appeared through the 1880's. Much of the descriptive work of both Marsh and Cope is redundant, but nonetheless the Bridger fauna was recognized as different from those collected in other Rocky Mountain basins.

Leidy, just prior to his abandonment of paleontology because of the vituperative Cope-Marsh dispute, collected middle Eocene fossils for the Philadelphia Academy of Natural Sciences in 1872. The Academy of Natural Science collection contains several well-preserved uintatheres described by Leidy. Princeton University entered the crowded field in 1877 and 1878 when H.F. Osborn and W.B. Scott visited the Green River Basin and Scott returned alone in 1886. The Princeton collection has been little studied.

Unfortunately, during this frantic collecting, when the cream was skimmed off the Bridger badlands, little attention was paid to the stratigraphic position of fossil specimens, and adequate mapping was not available for accurate spotting of localities. Later workers (e.g., Robinson, 1957, and Wheeler, 1961) have had to "relocate" specimens on the basis of sketchy locality data and guesswork distance estimates which severely restrict the biostratigraphic utility of the collections. Nonetheless, these early collections do contain the holotypes of most presently-recognized Bridger species.

At the turn of the 20th Century the American Museum of Natural History augmented its recently-purchased Cope collection through the field efforts of J. Wortman in 1893 and W. Granger, W. Sinclair and W.D. Matthew from 1903 to 1906. The major result of this was Matthew's 1909 monographic study of Bridger stratigraphy and the carnivores and insectivores (as then understood). In that paper he published the first descriptive stratigraphy of the

Bridger Formation (including a map with a strange cartographic aberration which offset the southwestern corner of the map six miles westward, distorting topographic features in the Lonetree vicinity) and divided the formation into five alphabetically-designated lithostratigraphic units, defined by the positions of presumably horizontally-continuous white layers. With only minor modifications (Wood, 1934, and Bradley, 1964) this has continued to be the basic framework for study of Bridger stratigraphy and paleontology.

The next episode in the history of the study of the Bridger Formation began in 1930 with the U.S. National Museum began collecting there, first under the direction of J. Gidley and later of C.L. Gazin. Between 1930 and 1968 Smithsonian parties scoured the basin, amassing a large and well-documented collection; numerous papers by Gazin are based largely on this material.

P.O. McGrew and R. Sullivan attacked the biostratigraphic problem of the reality and uniqueness of the Bridger A of Matthew during a field program in the late 1960's (McGrew and Sullivan, 1970).

Because of the ready access to some well-known Bridger localities, such as those near Lonetree, numerous small collections have been made. R. Alf's student groups from Webb school, California, collected Bridger fossils every summer for many years (much of this material is now deposited at the University of California — Riverside), and many universities and museums accumulated small reference and teaching collections.

The work of the present writer in the southern Green River Basin began in 1970. Specimens collected between 1970 and 1972 are part of the collection of the American Museum of Natural History, and those collected since belong to the Milwaukee Public Museum. This most recent work is the first to utilize washing techniques in the Bridger Formation, so my collection contains a much better representation of the smaller taxa which were overlooked by earlier surface collectors. On the other hand, the earlier collections contain far more complete material; erosion of Bridger sediments certainly is not exposing fossils as rapidly as paleontologists are collecting them.

In summary, the major research collections of southern Green River Basin Bridger Formation vertebrates are at the Yale Peabody Museum, the American Museum of Natural History, the U.S. National Museum of Natural History, and the Milwaukee Public Museum; lesser collections, but nonetheless of research calibre, are at Princeton University and the Academy of Natural Sciences.

General Geology

The Green River Basin is an asymmetrical faulted Laramide downwarp filled by Paleocene and Eocene fluvial and lacustrine sediments (figure 1). The lacustrine Green River Formation com-

prises an irregular central lens, bounded beneath and laterally by the fluvial early Eocene Wasatch Formation and laterally and above by the fluvial middle Eocene Bridger Formation.

The oldest Tertiary rocks in the southern part of the basin are exposed along the eastern and western flanks of the basin where rocks of the Paleocene Fort Union and early Eocene Wasatch Formations overlie steeply dipping Cretaceous units of the Rock Springs Uplift and the southern extension of the Wyoming and Salt River Ranges, respectively.

Basinward from the fluvial early Eocene exposures are various members of the lacustrine Green River Formation, and the fluvial Bridger Formation occupies most of the middle of the basin. Flat elevations of the Bridger Formation are erosionally truncated and capped with coarse grained sediments mapped as either the Brown's Park Formation or the Bishop Conglomerate, both presumably of Miocene age. The absence of fossils or other age information from these conglomeratic caprocks in the southern Green River Basin renders the identifications questionable.

The thickest part of the Bridger Formation is at the southern end of the basin (Bradley, 1964, p. 53) where the thickness is estimated at 2,285 feet west of Sage Creek Mountain about five miles north of Lonetree. The sequence thins northward, and the exposed surface drops downward stratigraphically, until the Bridger is altogether absent from the underlying Green River and Wasatch Formations.

The Bridger Formation is structurally simple, as it is made up of essentially horizontally bedded mudstone and sandstone. A minor northwest-southeast trending syncline in the western part of the exposure area is recognized only with difficulty.

The sediment includes clastic particles derived from the surrounding Laramide uplifts, minor chemical precipitates of local origin, and large quantities of volcanic material which probably originated in the Yellowstone-Absaroka region (Smedes and Protska, 1972). The proportion of the volcanic material increases upward in the section, indicative of either a greater intensity of volcanic activity in later middle Eocene time or a pronounced shift in the pattern of dispersal of airborne volcanic sediments at that time. Depositional environments include substantial streams, flood plains, ponds, and swamps.

Matthew's (1909) subdivisions of the Bridger Formation were based on the presence of several prominent laterally-extensive white layers (figure 2). They are readily differentiated from the mudstones and sandstones by their light coloration and usual resistance to weathering. The white layers, with large amounts of calcium carbonate and abundant aquatic fossils were probably deposited in broad shallow lakes, making them essentially isochrons and therefore excellent datum horizons.

The most easily followed of the white layers is the Sage Creek

White Layer which separates the Bridger B below from the Bridger C above. This particular white layer was intensively studied by S. Gustav (1974), who followed it across the entire basin, as Bradley (1964) had mapped it. The Lonetree White Layer, at the base of Matthew's Bridger D, is prominent in the southwestern part of the Basin, north of Lonetree, but cannot be followed as far east as Twin Buttes. The prominent white layer in the saddle between the two hills at Twin Buttes is not the Lonetree White Layer, differing in both lithology and position. Thus, Matthew's Bridger C-D differentiation cannot be made uniformly through the exposure area of the upper part of the formation. This lends support to H.E. Wood's 1934 suggestion that the formation is best divided into a lower (Blacks Fork Member) and an upper (Twin Buttes Member) lithostratigraphic unit, separated by the Sage Creek White Layer. Wood considered these two members to also be biostratigraphic units, containing recognizably different mammals. K. Koenig (1960) also noted difficulties with all but the Sage Creek White Layer as persistent markers, and proposed a tripartite subdivision of the Bridger Formation. To my knowledge, no subsequent author has adopted his suggestion.

The other named white layers of Matthew (Cottonwood, Burntfork and Upper) apparently are of still more local extent and thus cannot be used for basinwide correlations. The mere fact that they were named, however, emphasizes the geographic area of concentration of the early collectors; this can be confirmed by reading the specimen labels at Yale and the American Museum.

Present Work

The current work is devoted to intensive collection of suites of fossil vertebrates from numerous localities through the thickness of the Bridger Formation in the southern part of the Green River Basin (zones B through D of Matthew). A primary purpose is to obtain reasonably complete faunal samples by use of quarrying and wet-screening techniques (McKenna, 1962). It is hoped that these samples, treated in conjunction with the excellent collections of larger and more complete organisms at Yale, the American Museum and the Smithsonian, will permit adequate analysis of the course of faunal change through Bridgerian time in Wyoming.

The search for washing sites in the Bridger Formation began in 1970, after Bridger rock suitable for screen-washing had been found in the northern part of the basin in 1965 (West, 1973a). During the 1970 season the phenomonally productive Sage Creek locality was opened high in Matthew's Bridger B (about 80 feet below the Sage Creek White Layer). It was found that the Bridger D sediment immediately above the Lonetree White Layer north of Lonetree washes poorly, but does produce microvertebrates. Finally, a fossil-

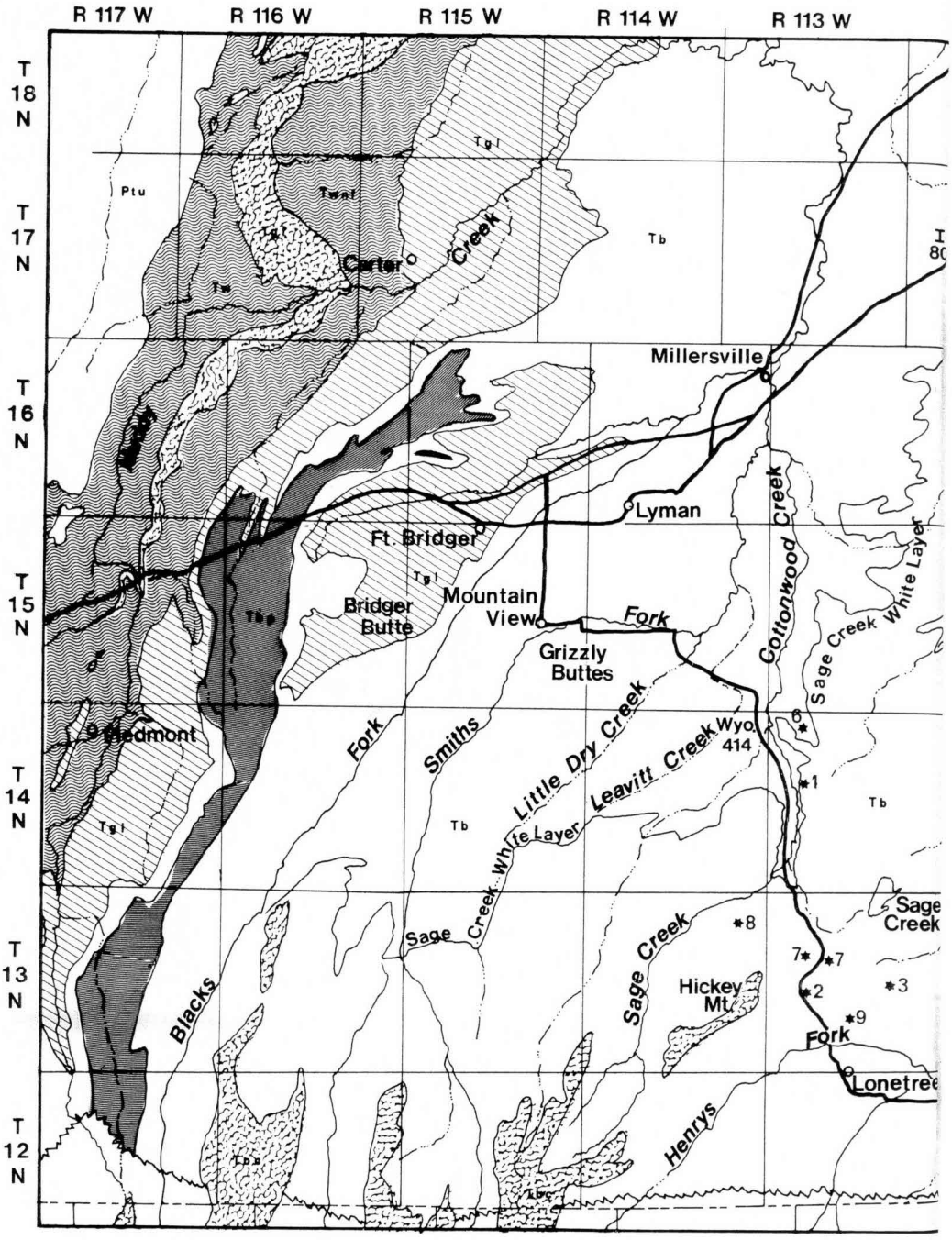
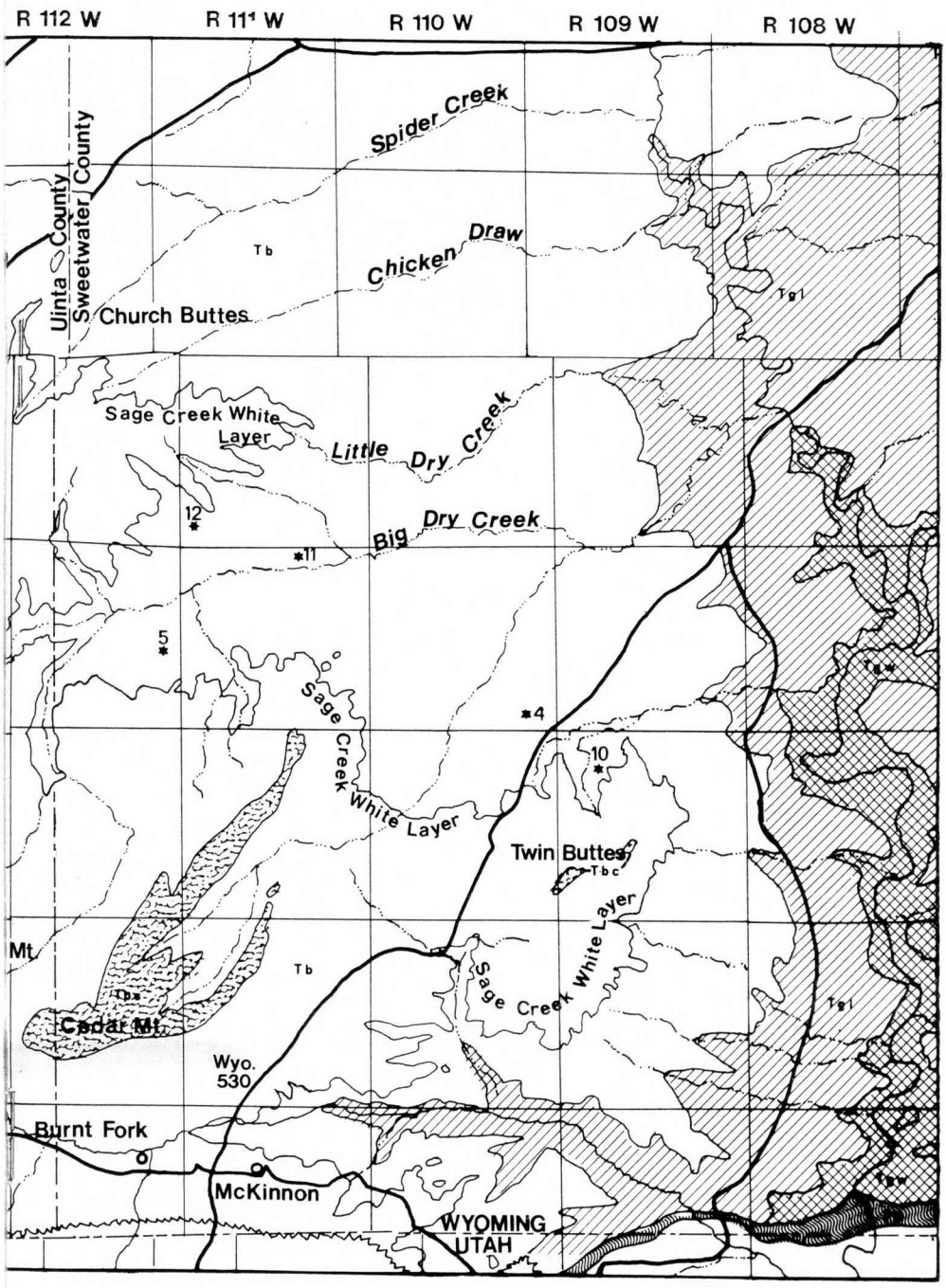


Figure 1. Geologic map of the southern Green River Basin, showing areas and localities of paleontologic interest. Localities mentioned in the text (indicated by stars): 1 — Sage Creek; 2 — Henry's Fork Divide; 3 — Behunin; 4 — East Hill; 5 — Trap/Hutch Quarry; 6 — Reservoir; 7 — LSV; 8 — Stuck Truck; 9 — 28FW; 10 — George's Gorge; 11 — *Notharctus* Knob; 12 — Wight. Geologic units: pTu — Pre-Ter-



tiary undifferentiated; Tw — Wasatch Formation; Twnf — New Fork Tongue of the Wasatch Formation; Tgf — Fontenelle Tongue of the Green River Formation; Tgl — Laney Shale Member of the Green River Formation; Tgw — Wilkins Peak Member of the Green River Formation; Tb — Bridger Formation; Tbp — Brown's Park Formation; Tbc — Bishop Conglomerate. After Bradley, 1964, Plate 1.

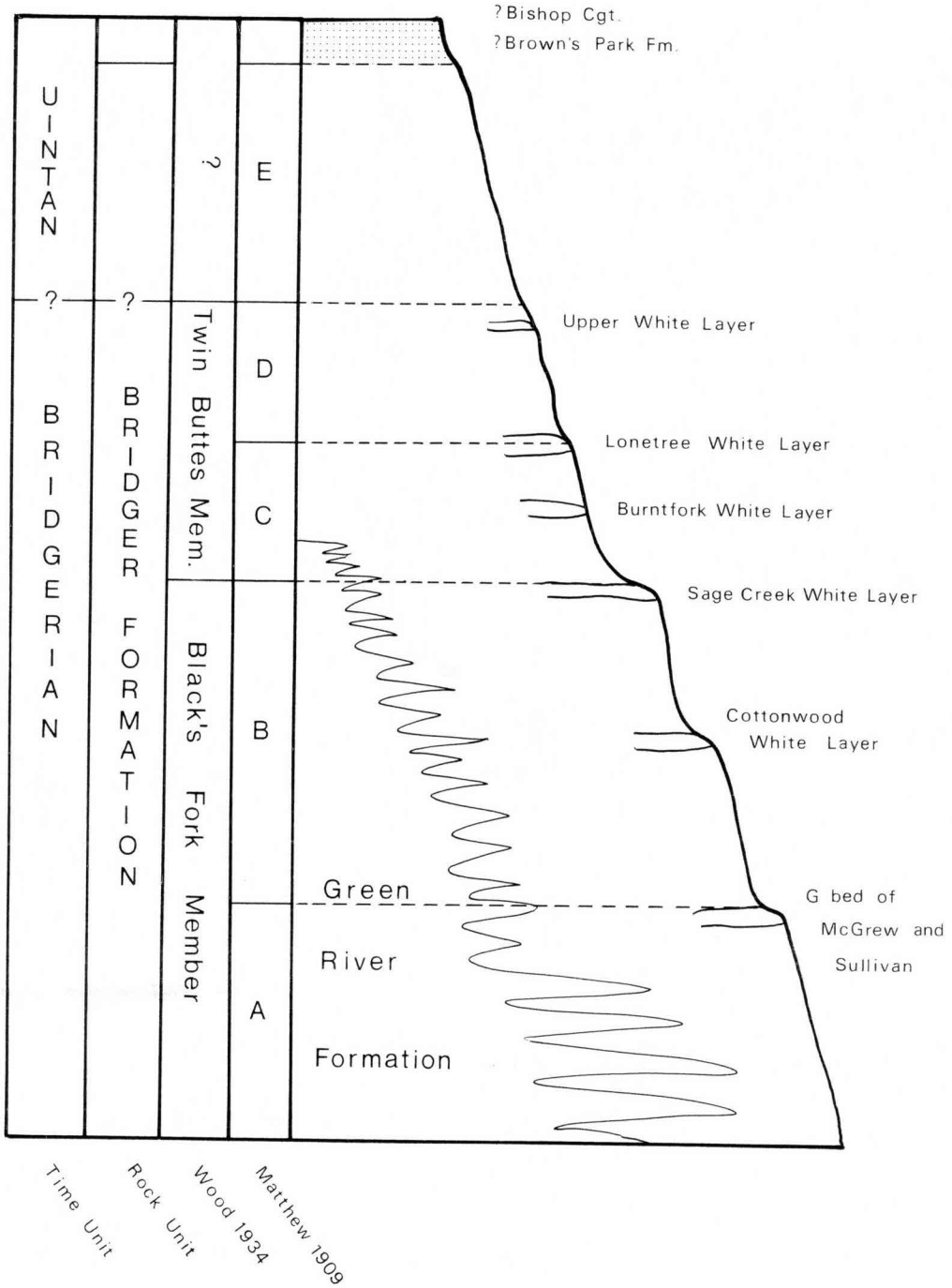


Figure 2. Diagrammatic section of the Bridger Formation in the southern Green River Basin, showing the assorted named units.

iferous tuffaceous sandstone channel (Behunin locality) in the Bridger D was located and rapidly worked out.

Two highly productive Bridger B wash localities, East Hill and Trap-Hutch Quarry, along with a less productive one (Reservoir), were opened in 1971. All have approximately the same relationship to the Sage Creek White Layer as does Sage Creek locality. A series of quarries were excavated at Henry's Fork Divide, demonstrating the presence there of at least seven fossiliferous intervals in the eight feet of sediment immediately above the marly Lonetree White Layer.

The most significant development of the 1972 season was the discovery of an exceedingly fossiliferous interval in the Bridger C in Marsh's Big Bone Buttes area (Sage Creek Basin of other authors). Five discrete sites, LSV-A, LSV-B, LSV-C, LSV-F, and LSV-O were found and worked. LSV-C is now worked out, but the others, especially LSV-A and LSV-O, continue to produce well and are laterally extensive. Another Bridger C locality, Stuck Truck, was found in and immediately above a marly mudstone on the northern base of Hickey Mountain. Section 28 FW locality, in the Bridger D, was opened, and Trap 72, George's Gorge and *Notharctus* Knob, all in the Bridger B, were discovered. During this season the southern Green River Basin was visited by the Field Conference on Tertiary Biostratigraphy of Southern and Western Wyoming and a preliminary paper was prepared for the guidebook used on that field trip (West, 1972).

The brief 1974 season produced one more Bridger B locality, Wight locality, and 1975 was devoted to extensive washing at Trap 72, East Hill, Stuck Truck and LSV localities. Unusually wet weather hampered washing activities during 1975.

Approximately half the time during each of these seasons was devoted to surface prospecting, both for larger, scattered fossils and for additional washing sites. As a result, a substantial macrofauna collection has been accumulated, but the quality of the material for the most part does not approach that of the fossils collected by earlier workers.

Future Work

The questions generated by the Bridger Formation work thus far accomplished greatly exceed the answers produced. The great expanses of badlands in the southern Green River Basin have not yet been examined completely for potential washing sites; systematic prospecting therefore will continue. Additional wash sites as well as larger specimens will result from this activity. The recent expansion of petroleum drilling and seismic work south of the well-established Church Buttes gas field has opened to easy vehicular access substantial areas of badlands in the central part of the basin, making it practical to work wash sites there.

Efforts will be made to expand the vertical distribution of wash sites. To date, most of the Bridger B localities are very high in the unit and probably represent very little time: They are also environmentally similar, as the fossiliferous horizons are a few inches to a few feet above marlstone ledges at Sage Creek, East Hill and George's Gorge. Bridger C and Bridger D localities are likewise restricted. Adequate paleoenvironmental interpretations require far more extensive distribution, both through the section and with respect to lithology. Petrographic studies of fossiliferous rocks will also contribute to the adequacy of these interpretations.

Recent radiometric dating of Eocene rocks in the intermountain region (McKenna *et al,* 1973) suggests that Bridgerian time (defined as the period of deposition of the Bridger Formation) was shorter than previously assumed; it may have lasted only a bit more than one million years. If the known Bridgerian fossil assemblages must be accommodated within such a relatively short time span, it may well be that some of the differences between faunas derived from different levels within the formation may be ecologically determined rather than simply the result of evolution *in situ.* The likelihood of this possibility is enhanced by the lithic variations among the classic collecting areas. This matter will not be resolved until extensive samples have been obtained from various depositional situations through the thickness of the Bridger Formation. If paleoenvironmental variations prove to be the primary reason for faunal distinctions, the utility of the concept of "a" Blacks Fork Member fauna and "a" Twin Buttes Member fauna in the sense of Wood (1934) will have to be reconsidered.

Correlations of white layers through the Bridger Formation and with events recorded in the Green River Formation must also be investigated. The Lonetree White Layer was mapped in 1975, and Gustav (1974) conducted a detailed study of the Sage Creek White Layer. The other white layers will be investigated in a similar fashion. Recent studies on the Green River Formation (Surdam and Wolfbauer, 1975) may produce insights into the genesis of the more restricted lacustrine deposits within the Bridger Formation.

Prospecting and collecting efforts will continue in early Tertiary regions adjacent to the outcrop area of the Bridger Formation.

Systematic studies of the assorted animal groups will be conducted. Some are already in progress and will appear as subsequent numbers in this series. Not only will these make available basic taxonomic and systematic information, especially on the smaller forms, but they will also contribute to the paleoenvironmental studies. Furthermore, faunal studies will assist in understanding events of the middle Eocene elsewhere in the mountain region (southern Absarokas, northeastern Utah, greater Washakie Basin), in the rest of North America (southwestern Texas, Oregon, northern Canada) and in western Europe.

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Literature Cited

Bradley, W.H., 1964. Geology of Green River Formation and associated Eocene rocks in southwestern Wyoming and adjacent parts of Colorado and Utah. U.S. Geol. Suv. Prof. Paper 496-A:1-86.

Dawson, M.R., 1968. Middle Eocene rodents (Mammalia) from northeastern Utah. Ann. Carn. Mus. 39:327-370.

Gazin, C.L., 1968. A study of the Eocene condylarthran mammal *Hyopsodus*. Smiths. Misc. Coll. 153(4):1-90.

Gilmore, C.W., 1931. Fossil hunting in the Bridger Basin of Wyoming. Explorations and field work of the Smithsonian Institution in 1930:13-20.

Gustav, S., 1974. The sedimentology and paleogeography of the Bridger Formation, (Eocene) of southwestern Wyoming. MS dissertation, University of Mass.:1-82.

Knight, S.H., 1955. Review of early geological explorations of the Green River Basin area, 1812-1879. Wyo. Geol. Assoc. Guidebook, Tenth Ann. Field Conf.:10-17.

Koenig, K., 1960. Bridger Formation in the Bridger Basin, Wyoming. Wyoming Geol. Assoc. Guidebook, Fifteenth Annual Field Conference:163-168.

Lanham, Url, 1973. The Bone Hunters. Columbia Univ. Press. 285p.

Leidy, J., 1869. Notice of some extinct vertebrates from Wyoming and Dakota. Proc. Acad. Nat. Sci. Phila. 21:63-67.

Leidy, J., 1871. On the fossil vertebrates of the early Tertiary Formation of Wyoming. Geol. Surv. Terr. 4:353-372.

Love, J.D., 1961. Definition of Green River, Great Divide, and Washakie Basins, southwestern Wyoming. Bull. Amer. Assoc. Pet. Geol. 45:1749-1755.

Matthew, W.D., 1909. The Carnivora and Insectivora of the Bridger Basin, middle Eocene. Mem. Amer. Mus. Nat. Hist. 9(6):289-567.

McGrew, P.O. and R. Sullivan, 1970. The stratigraphy and paleontology of Bridger A. Univ. Wyo. Cont. to Geol. 9(2):66-85.

McKenna, M.C., 1962. Collecting small fossils by washing and screening. Curator 3:221-235.

McKenna, M.C., D.E. Russell, R.M. West, C.C. Black, W.D. Turnbull, M.R. Dawson and J.A. Lillegraven, 1973. K/Ar recalibration of Eocene North American land-mammal "ages" and European ages. Geol. Soc. Amer., Abstracts with Programs 5 (7):733.

Nelson, M.E., 1974. Middle Eocene rodents (Mammalia) from southwestern Wyoming. Univ. Wyo. Cont. to Geol. 13(1):1-10.

Osborn, H.F., 1931. Cope: Master naturalist. Princeton Univ. Press. 740p.

Robinson, P., 1957. The species of *Notharctus* from the middle Eocene. Postilla 28:1-27.

Robinson, P., 1968. Nyctitheriidae (Mammalia, Insectivora) from the Bridger Formation of Wyoming. Univ. Wyo. Cont. to Geol. 7:129-138.

Robinson, P., 1970. The Tertiary deposits of the Rocky Mountains — a summary and discussion of unsolved problems. Univ. Wyo. Cont. to Geol. 9(2):86-97

Schuchert, C. and C.M. LeVene, 1940. O.C. Marsh: pioneer in paleontology. Yale Univ. Press. 541p.

Scott, W.B. 1939. Some memories of a paleontologist. Princeton Univ. Press. 336p.

Smedes, H.W. and H.J. Prostka, 1972. Stratigraphic framework of the Absaroka Volcanic Super group in the Yellowstone National Park region. U.S. Geol. Surv. Prof. Paper. 729-C:1-33.

Surdam, R.C. and C.A. Wolfbauer, 1975. Green River Formation, Wyoming: a playa-lake complex. Bull. Geol. Soc. Amer. 86:335-345.

West, R.M., 1969. Biostratigraphy of fluvial sediments of the upper Wasatch Formation in the northern Green River Basin, Wyoming. Univ. Wyo. Cont. to Geol. 8(2, pt. 2):184-196.

West, R.M., 1973a. Geology and mammalian paleontology of the New Fork — Big Sandy area, Sublette County, Wyoming. Feldiana: Geology. 29:1-193.

West, R.M. 1973b. Review of the North American Eocene and Oligocene Apatemyidae (Mammalia, Insectivora). Spec. Publ., The Museum, Texas Tech. Univ. 3:1-42.

West, R.M., 1973c. An early middle Eocene epoicotheriid (Mammalia) from southwestern Wyoming. Jour. Paleo. 47(5):929-931.

West, R.M., 1974. New North American middle Eocene nyctithere (Mammalia, Insectivora). Jour. Paleo. 48(5):983-987.

West, R.M. and M.R. Dawson, 1975. Eocene fossil Mammalia from the Sand Wash Basin, northwestern Colorado. Ann. Carnegie Mus. 45(1):231-253.

Wheeler, W.H., 1961. Revision of the uintatheres. Peabody Mus. Bull. 14:1-93.

Wood, H.E., 1934. Revision of the Hyrachyidae. Bull. Amer. Mus. Nat. Hist. 67(5):181-295.