Twenty-first Annual Field Conference—1969
Wyoming Geological Association Guidebook

GEOLOGY AND VERTEBRATE PALEONTOLOGY OF THE NORTHEASTERN GREEN RIVER BASIN, WYOMING

by
Robert M. West[2]

INTRODUCTION

Most biostratigraphic work in the Green River Basin has been concentrated in the spectacular middle Eocene outcrops of the southern part of the basin. In recent years, however, more attention has been devoted to studies in the northern part, where much of the exposed rock is somewhat older than that in the south. This paper is a summary of a study concerned with correlation of lower and middle Eocene fluvial and lacustrine sediments at the northern end of the basin. The bases for the relationships projected here are twofold—physical stratigraphy and correlations based on vertebrate paleontology (essentially mammalian) of the units involved.

As used in this paper, the Green River Basin (Fig. 1) includes the modern drainage basin of the upper Green River north of the Uinta Mountains, excluding the Washakie, Great Divide (Red Desert), Hoback and Fossil Basins. This is essentially the usage of Love (1961), except for my exclusion of the Hoback Basin.

My work concentrated on the area indicated in Figure 2, called the New Fork–Big Sandy area after its major streams. A detailed geological map of the New Fork–Big Sandy area is shown on Plate I; the geographic localities mentioned in the text are indicated there. Nearby areas are also mentioned in order to place this study in the context of the known geologic and paleontologic framework of the northern Green River Basin.

Rock exposures in the New Fork–Big Sandy area are rather limited. The only areas of extensive outcrop are along the streams (Fig. 3) and at sharp relief changes bounding major elevations. Otherwise the country is gently rolling and covered by cactus, sagebrush and coarse grasses. Lush grass and more hydrophytic vegetation are present along the perennial streams.

GEOLOGIC SETTING

The mountains bounding the northern Green River Basin vary in lithic composition. This is reflected in the nature of the early Tertiary sedimentary rocks derived from them. The Overthrust Belt, on the western side, is made up primarily of Paleozoic and Mesozoic marine sedimentary rocks, while the Wind River Mountains, on the northeastern flank of the Green River Basin, are essentially all Precambrian igneous and metamorphic rocks. Although the Hoback Basin to the north is structurally continuous with the northern Green River Basin, it is here considered separately as it has undergone a somewhat different geologic history.

The Eocene sedimentary rocks of the northern Green River Basin are of two general origins—fluvial and lacustrine. An irregular lens of lacustrine sediment, the Green River Formation, occupies the center of the basin. Only a few tongues of this unit extend into the New Fork–Big Sandy area, and there is no development there of the complete and striking lacustrine sequence seen so well to the south, in the Rock Springs–Green River area. Marginal to the Green River Formation are two fluvial units, the Wasatch and Bridger Formations, which constitute most of the exposures in the New Fork–Big Sandy area. The Wasatch Formation also underlies the Green River Formation, flooring the basin in which the lake formed, and the Bridger Formation overlies the Green River Formation, as it filled in the basin at the termination of the lacustrine sequence. The edges of the basin show some unconformities, where the Eocene units lapped over older beds and where late Laramide and post-Laramide faulting disrupted the early Tertiary sequence. In the central part of the basin, Tertiary sedimentation appears to have been continuous well into the middle Eocene.

The Tertiary units of concern to this study represent sedimentation at and around the margins of the Eocene lake. Because of the presumably lush vegetation and abundance of food and water, the fauna of the area during the early and middle Eocene was abundant and varied. The fossil remains of this fauna provide valuable evidence for both temporal correlation of the units within and outside of the basin and for increased understanding of the environment, physical as well as biological, at that time.

The following discussion of the units and their included fossils refers only to the units as they occur in the New Fork–Big Sandy area unless stated otherwise. There are many differences within single units in various parts of this depositional basin, and into neighboring basins, so the interpretations of the physical stratigraphy are of primarily local value. The paleontologic evidence permits more regional correlations to be postulated.

[1]This is an abbreviated version, with some additions, of a portion of the writer's doctoral dissertation, 1968, at the University of Chicago, under the direction of Everett C. Olson.

[2]Research Associate, Department of Geological and Geophysical Sciences, Princeton University, Princeton, New Jersey; present address: Assistant Professor of Biology, Adelphi University, Garden City, New York.

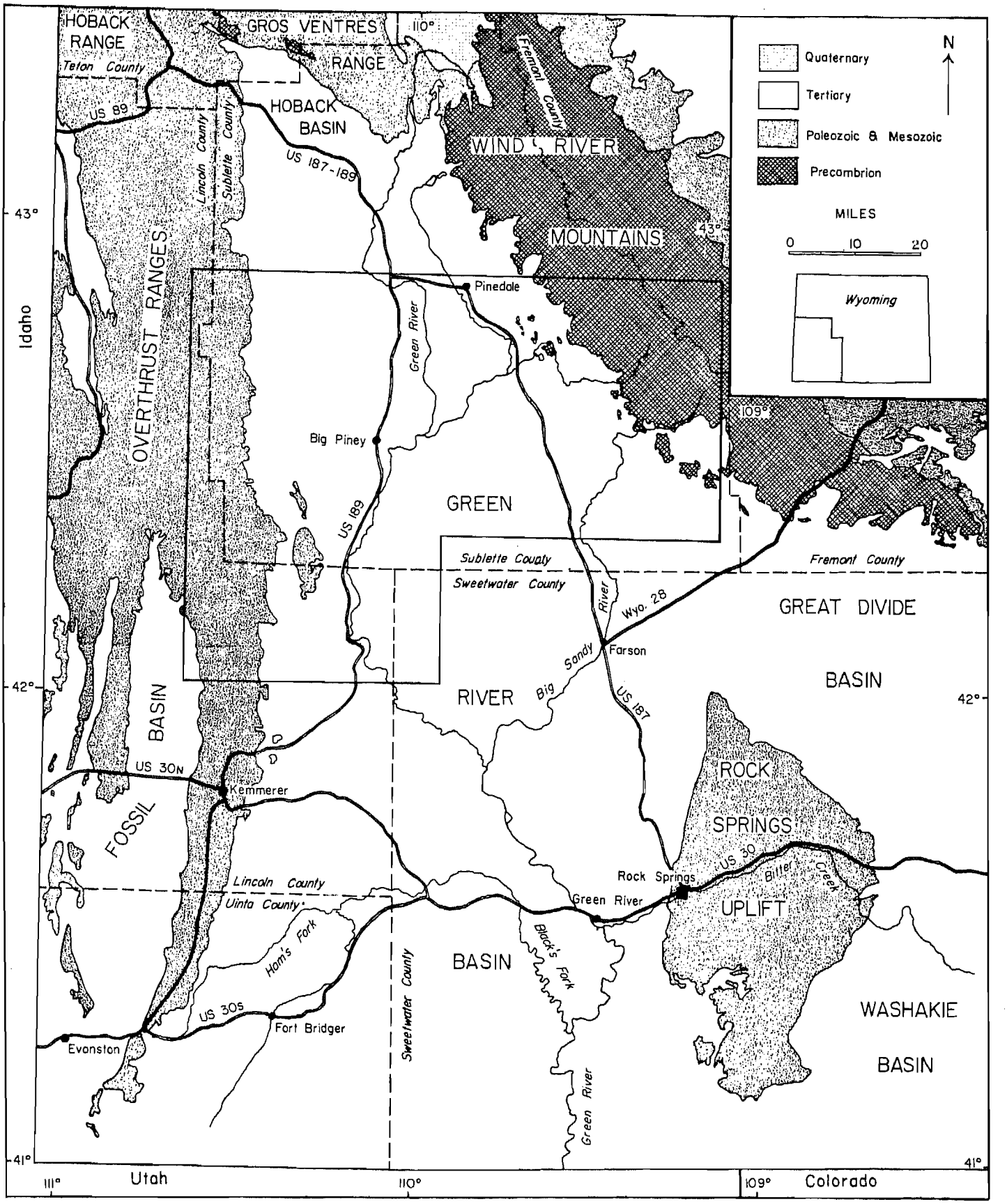
HOBACK RANGE
Teton County
US 89
GROS VENTRE RANGE
HOBACK BASIN
Lincoln County
Sublette County
US 187-189
Fremont County
WIND RIVER MOUNTAINS
110°
43°
Quaternary
Tertiary
Paleozoic & Mesozoic
Precambrian
N
MILES
0 10 20
Wyoming
Idaho
OVERTHRUST RANGES
Pinedale
Green River
Big Piney
109°
US 189
GREEN
Sublette County
Sweetwater County
Fremont County
River
Wyo. 28
GREAT DIVIDE
Farson
Big Sandy
US 187
BASIN
42°
RIVER
FOSSIL BASIN
US 30N
Kemmerer
ROCK SPRINGS
US 30
Rock Springs
Green River
Lincoln County
Uinta County
Ham's Fork
Black's Fork
Sweetwater County
BASIN
UPLIFT
Bitter Creek
US 30S
Fort Bridger
Evanston
WASHAKIE BASIN
Green River
41°
111°
Utah
110°
109°
Colorado

Fig. 1.

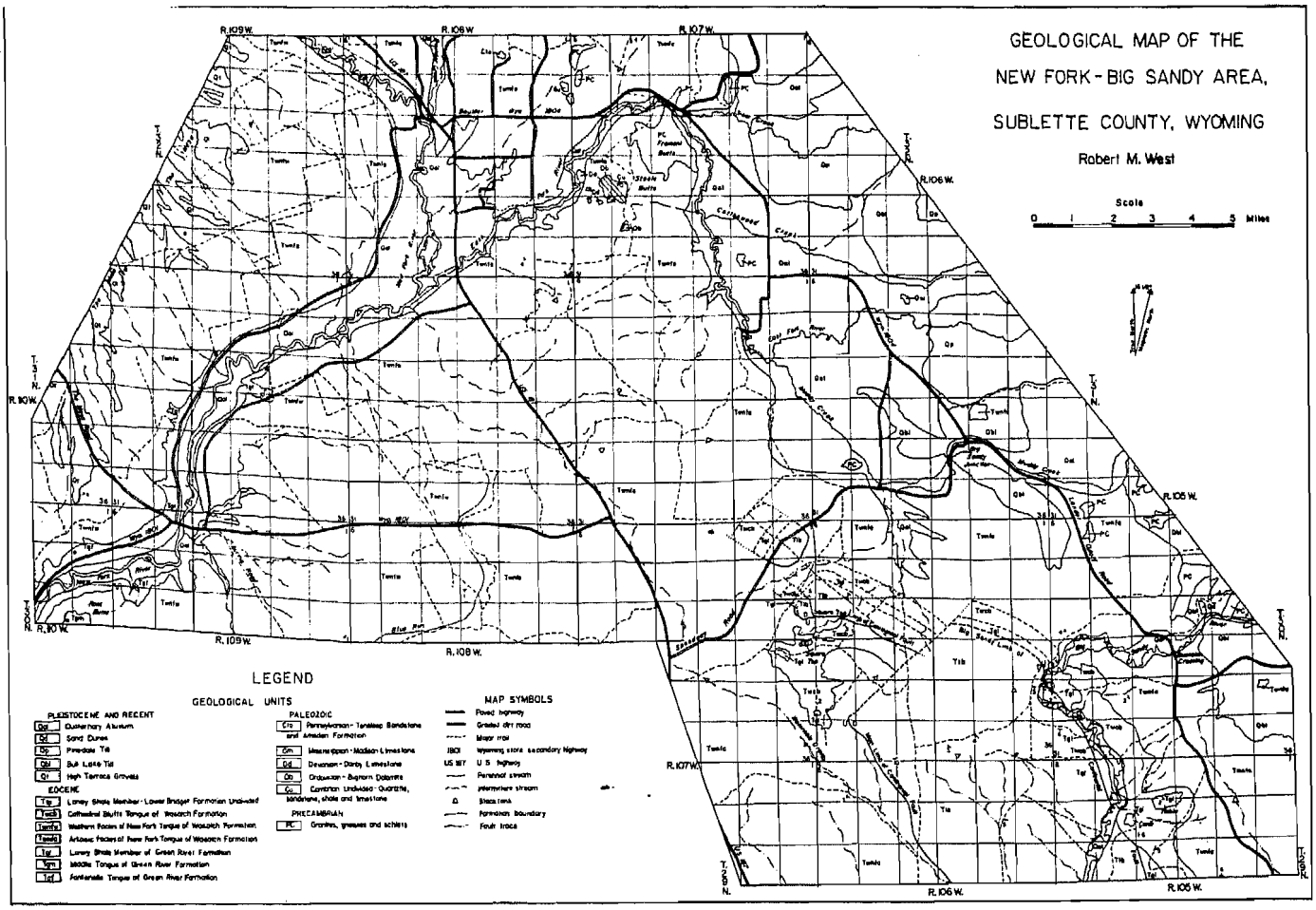

Plate I. Geologic map of the New Fork–Big Sandy area.

STRATIGRAPHY

Pre-Tertiary

Precambrian and Paleozoic rocks are exposed in the eastern part of the New Fork–Big Sandy area; the absence of Mesozoic units is in all probability structurally controlled by the fault system along the border of the Wind River Mountains. The outcrops are inliers surrounded by Eocene and/or Pleistocene deposits. Most prominent among these are the large Precambrian mass of Fremont Butte and the nearby smaller inlier of Paleozoic rocks called Steele Butte (see geological map, Plate 1).

Precambrian rocks within the New Fork–Big Sandy area (Fig. 4) are granitic in composition, with some differentiation into gneissic bands. The few exposures in the study area do not permit detection of the regional trends reported to be present in the granitic mountains (de Laguna, 1938, cited in Holmes and Moss, 1955, p. 632). Granitic minerals are abundant in most of the Eocene sedimentary rocks immediately adjacent to the Wind River Mountain front, strongly indicating local provenance for the sediment.

Exposures of Paleozoic rocks are less common than those of Precambrian rocks in the New Fork–Big Sandy area. Steele Butte (Fig. 5), the prominent knob one mile southwest of Fremont Butte, is made up of about 2,800 feet of steeply dipping strata, ranging in age from Cambrian to Mississippian (Love, 1950), but with no Silurian present. The rocks are largely limestone, dolomite, shale and sandstone of marine origin. West of Steele Butte are four small exposures which are at least partly Devonian in age. Outside the New Fork–Big Sandy area, several miles north of Boulder, are several small exposures of Pennsylvanian and Permian rocks. The total thickness of the Paleozoic sequence is about 3,200 feet, although this was not measured in a single locality (Love, 1950). The nearest well-developed Paleozoic section bounding the Green River Basin is at the northern end of the Wind River Mountains, in the area mapped by Richmond (1945). To the south, no Paleozoic or Mesozoic rocks occur along the western side of the Wind River Mountains (Fig. 1).

Eocene

Green River Formation

The lacustrine lens of the Green River Formation has been divided into a number of units of varying thickness, composition and distribution (Bradley, 1964; Oriel, 1962; Roehler, 1968). Three tongues of this sequence are present in the New Fork–Big Sandy area; two can be well related to the main part of the formation, while the third may be more localized. The relative ages of these lacustrine units are determined from the

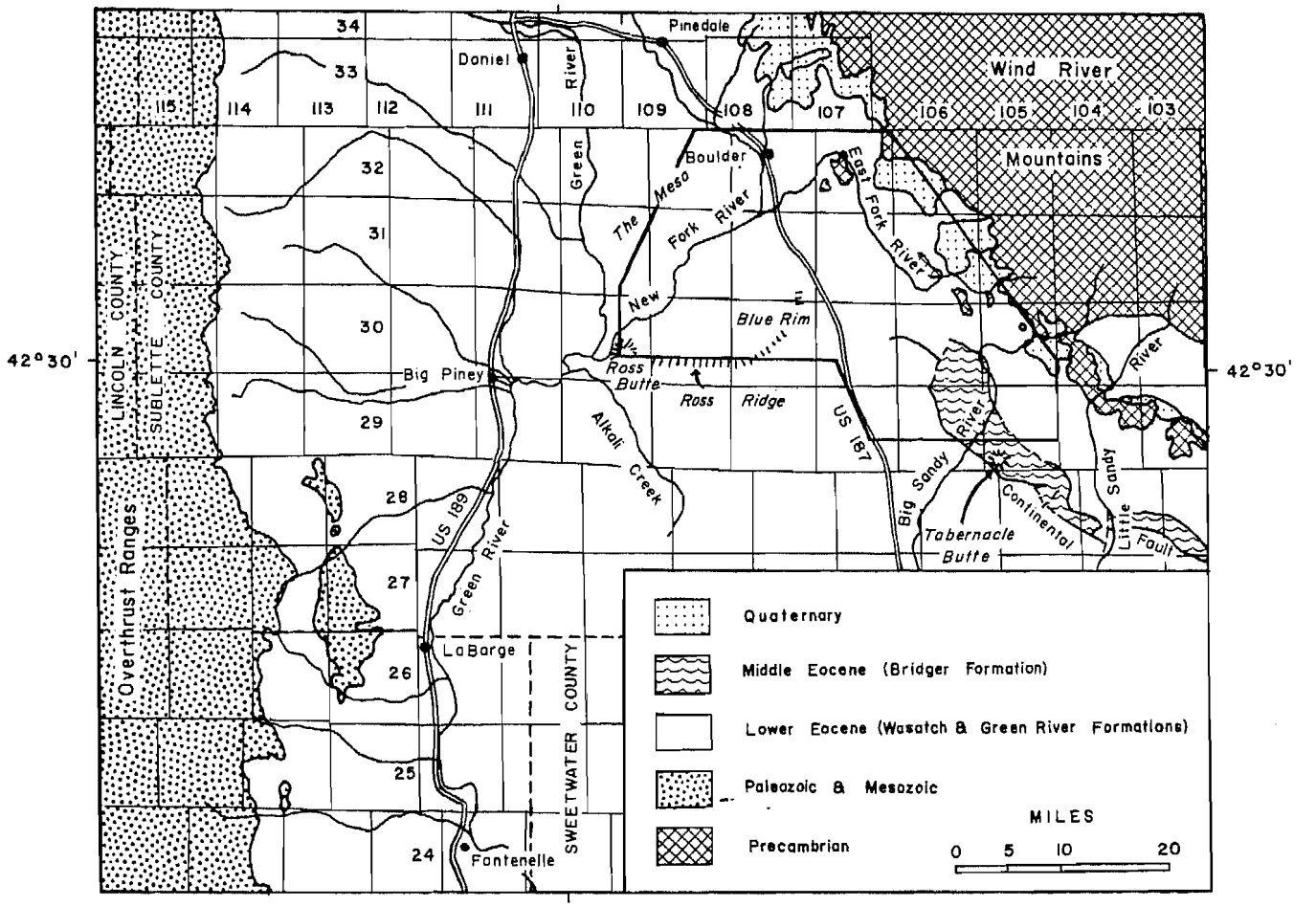

Fig. 2.—Index map of the northern Green River Basin. The area covered by the detailed geological map of the New Fork–Big Sandy area (Plate I) is outlined.

ages of the adjacent fluvial units which contain suites of fossil mammals.

Fontenelle Tongue—This lacustrine unit is exposed along the New Fork River in the southwestern part of the New Fork–Big Sandy area. A long roadcut on Wyoming State Secondary 1801 (sec. 11, T. 30 N., R. 110 W.) (Fig. 6), continued on the lower slope between the road and the New Fork River, displays about 90 feet of Fontenelle Tongue sediment. The top of the unit may be seen along the New Fork River upstream of this cut, where the bright blue-gray to blue-green mudstone of the basal western facies of the New Fork Tongue of the Wasatch Formation overlies the buff sandstone of the Fontenelle Tongue. The bottom is not present in the study area, but is visible a few miles to the west along Wyoming 1801, where the bright sandy mudstones of the LaBarge Member of the Wasatch Formation underlie the Fontenelle Tongue.

The Fontenelle Tongue is composed of well-laminated buff to gray fine-grained calcareous sandstone, gray limestone, poorly indurated fine-grained yellow sand and calcareous gray blocky mudstones and shales. Some ostracodal limestone is present low in the unit. The sediments are coarser-grained near the top of the unit, and there are increased indications of current activity, including some prominent long cut and fill structures. Some feldspar is present in this coarser-grained sandstone, suggesting partial derivation of the sediment from the granitic Wind River Mountains, perhaps by way of the stream system so markedly displayed in the western facies of the New Fork Tongue.

The Fontenelle Tongue is probably a partial lateral equivalent of the Tipton Shale Member of the Green River Formation, which is well exposed to the south and southeast

Fig. 3.—View of the valley of the Big Sandy River, showing outcrops along the stream. The Wind River Mountains are in the background.

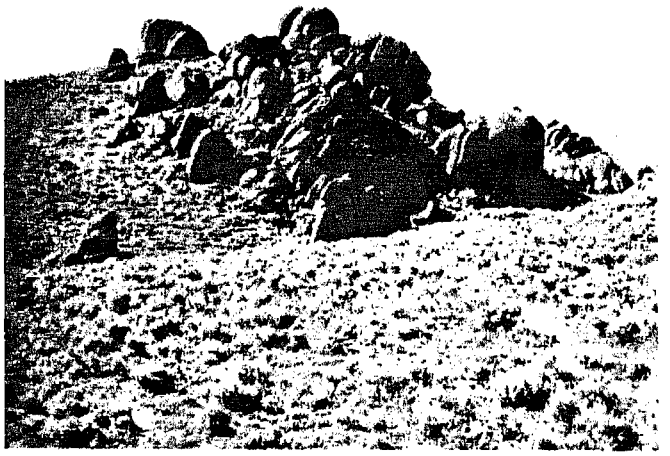

Fig. 4.—Inlier of Precambrian granite in sec. 6, T. 32 N., R. 107 W.

(Roehler, 1968). Exact correlation of the two units is unlikely, however, as evidenced by the relative ages of the overlying fluvial units. These two lacustrine tongues are probably representative of expansions of the lake in response to slightly different tectonic situations in various parts of the basin. Immediately to the east, the Fontenelle Tongue merges into the fluvial sandy mudstones of the arkosic facies of the New Fork Tongue of the Wasatch Formation, a transition which may be seen in a poor outcrop on the south bank of the New Fork River in sec. 15, T. 31 N., R. 109 W. The Fontenelle Tongue overlies the LaBarge Member of the Wasatch Formation and underlies the western facies of the New Fork Tongue of the Wasatch Formation.

The environment indicated by the Fontenelle Tongue is a shallow lactustrine situation which gradually became more fluvial with the lateral and vertical transitions into the New Fork Tongue. Occasional stringers of fluvial and lacustrine materials indicate the presence of a fluctuating shoreline.

No fossil vertebrates have been found in the Fontenelle Tongue. Ostracodes are present at some levels, and other invertebrates and poorly preserved plant remains have also been found. These are inadequate for any direct biological correlation of the tongue.

Middle Tongue—A second lacustrine tongue is present in the southwestern part of the New Fork–Big Sandy area. This unit, the middle tongue of the Green River Formation (terminology of Oriel, 1961), is exposed on Ross Butte (SW¼ sec. 13, and SE¼ sec. 14, T. 30 N., R. 110 W.) and caps Ross Ridge and the western end of Blue Rim. The former presence of middle tongue between Ross Butte and Grindstone Butte (sec. 13, T. 33 N., R. 111 W.), to the northwest of the study area, is suggested by "logs" of algal material in debris on some intervening New Fork Tongue outcrops.

The middle tongue is composed of gray-white, relatively pure algal limestone, platy buff calcareous sandstone, and massive buff limestone (Fig. 7). Both limestones are very resistant, providing caps on the ridges. There is up to 100 feet of middle tongue in the New Fork–Big Sandy area, and the top is probably missing; there are no sediments on top of the middle tongue on any of the elevations it caps.

Fig. 6.—Long exposure of fine-grained sandstones of the Fontenelle Tongue along Wyoming 1801.

The lower contact of the middle tongue with the western facies of the New Fork Tongue of the Wasatch Formation is a clearly marked change from the green sandy mudstone of the New Fork Tongue to the limestone of the middle tongue. No upper contact is present in the New Fork–Big Sandy area, but Oriel (1961, p. 151) mentioned a tongue of Wasatch Formation sediment overlying the middle tongue to the southwest. Laterally the middle tongue merges westward into fluvial New Fork Tongue sediments, eastward probably into the lower Cathedral Bluffs Tongue of the Wasatch Formation, and toward the center of the basin the Wilkins Peak Member of the Green River Formation presumably occupies the same relative position.

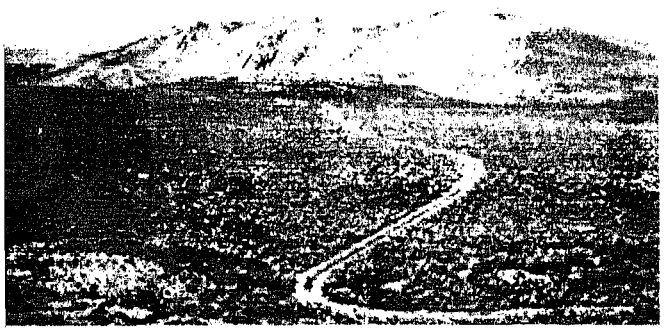

Fig. 5.—View of Steele Butte from the southeast. The inclined strata dip southwest at about 70°.

Fig. 7.—Middle tongue of the Green River Formation near the top of Ross Ridge, just south of the New Fork–Big Sandy area. Note the contrast between the algal limestone and the sandstone.

A near-shore lacustrine environment is suggested by the algal limestone and interbedded sandstone. The algal development was quite extensive, probably extending at least 20 miles north of Ross Butte.

Although the stratigraphic evidence suggests that the middle tongue and the Wilkins Peak Member were deposited at essentially the same time, they represent different environments. The Wilkins Peak Member is characterized by massive evaporite deposits in the central Green River Basin, although there is more organic material in the unit in the Washakie Basin (Roehler, 1968), while algal deposits typify the middle tongue in the northern Green River Basin. The middle tongue may represent a localized lacustrine development northwest of the limits of the Wilkins Peak Member lake, and the two bodies of water may not have been physically connected.

No fossil vertebrates have been found in the middle tongue in the New Fork–Big Sandy area, and, with the exception of the algal limestone, organic material of any recognizable sort is rare. To the south, Donovan (1950, p. 65) found fragmental fish and insects, and Oriel (pers. comm., Aug. 1967) has found fine plant remains in the upper part of the middle tongue in the Fort Hill area.

Laney Shale Member—The final expansion of the Eocene lacustrine sequence is represented by the Laney Shale Member of the Green River Formation. It is present in the southeastern part of the New Fork–Big Sandy area; elsewhere in the area beds of Laney and equivalent age have been removed by erosion. The Laney Shale Member caps several prominent hills south of Speedway Road, and appears along the upthrown side of the Big Sandy Limb of the Continental Fault. The thickness varies in response to the Eocene shoreline position and previous topography, with the measured range in the New Fork–Big Sandy area from 50.5 feet in the NE¼ sec. 24, T. 30 N., R. 107 W., to 127.6 feet in the E½ sec. 8, T. 29 N., R. 105 W. The total thickness is probably about 200 feet.

The base of the Laney Shale Member is readily defined as that level at which "structured" or bedded and laminated shale and sandstone appear. The top merges imperceptibly into the fluvial Bridger Formation, rendering extremely difficult the designation of a formation boundary. Thus the upper part of the Laney Shale Member, much more fluvial in nature than the lower part, is here included with the lower Bridger Formation, and the lower, readily discernible lacustrine beds are discussed separately. Figure 8 shows the difference between lower Laney Shale Member and typical Bridger Formation sediment.

The Laney Shale Member, in the restricted sense, is made up largely of shale and fine-grained shaley sandstones ranging in color from almost black to gray-white, brown and buff. Much of the shale has a significant component of sand-sized particles, although "paper shales" are developed in some places. The sandstone levels are generally more resistant than are the shale beds, and they form small ledges on the exposed slopes. These sandstones become more tuffaceous toward the top of the unit. Several tuffaceous zones appear in E½ sec. 8, T. 29 N., R. 105 W., and an excellent exposure of several tuffaceous sandstones is present just east of the Big Sandy Limb of the Continental Fault in NE¼ sec. 25, T. 30 N., R. 106 W.

A conglomerate bed of granitic composition with a siliceous groundmass caps the two elevations in the southeastern part of the area. Limestones are developed at some localities in the Square Top vicinity (sec. 24, T. 30 N., R. 107 W.). These are rich in aquatic fossils-algae, ostracodes and molluscs—but are not of large areal extent.

The Laney Shale Member in the New Fork–Big Sandy area is bounded below and laterally by the Cathedral Bluffs Tongue and laterally and above by the Bridger Formation. A poorly exposed interfingering of Laney shale and fine sandstone and Cathedral Bluffs mudstone may be seen in SW¼ sec. 30, T. 30 N., R. 106 W.

The environment represented by the Laney Shale Member is a marginal lacustrine situation, though with larger swampy

Fig. 8.—Exposure of Laney Shale Member (on left) and lower Bridger Formation sediment in sec. 25, T. 30 N., R. 106 W. The Continental Fault has brought these strata into this relationship.

areas than either the Fontenelle or middle tongues. It is the most fossilferous of the lacustrine units in the New Fork–Big Sandy area, as remains of plants, invertebrates and vertebrates, have been recovered from a number of localities. Invertebrates include abundant gastropods (both terrestrial, *Helix*, and shallow water aquatic, *Viviparus, Goniobasis* and *Planorbina*) and pelecypods (unionids), frequently in cochina beds. Vertebrate fossils include garpike (*Lepisosteus*) scales, teleost fish spines and vertebrae, crocodile teeth, fragments of turtle shell, lizard and snake osteoderms and vertebrae, and a small amount of unidentifiable mammalian bone scrap. Remains of the aquatic members of this assemblage are also found in the fluvial units, as most also lived in the streams and ponds on the alluvial plain.

Wasatch Formation

The Wasatch Formation is, like the Green River Formation, divided into a number of tongues and members (Bradley, 1964; Donovan, 1950; Oriel, 1962). Two tongues, of different ages as shown by their mammalian fossil suites, are present in the New Fork–Big Sandy area. They are the New Fork Tongue, late Wasatchian in age, and the Cathedral Bluffs Tongue, probably of earliest Bridgerian age.

New Fork Tongue–The New Fork Tongue in the northern Green River Basin is divided, on lithologic grounds, into two facies. The western facies includes the beds called simply New Fork Tongue by Bradley (1964), Donovan (1950), and Gazin (1952, 1962). The arkosic facies of the New Fork Tongue consists of strata of equivalent and slightly older age along the northeastern edge of the basin.

Arkosic facies: The arkosic facies, a sequence of multicolored sandy mudstones, is exposed in a belt ten to 15 miles wide between U. S. Highway 187 and the Wind River Mountains, as shown on the geological map. Typical exposures of this sequence are in high outcrops on the south side of the Big Sandy River in the center of sec. 21, T. 30 N., R. 105 W., and on the slope south of the East Fork River along U. S. 187. Much of the unit is covered by glacial debris, especially near the mountains.

The total thickness of the arkosic facies of the New Fork Tongue has not been determined, as no definable base is known. Up to 300 feet of arkosic facies strata is exposed south of the East Fork River, and 175 feet along the Big Sandy River at the reference section mentioned above.

The variegated strata include discontinuous bands of green, gray, red, brown, purple, yellow and tan sandy mudstones, ranging in texture from siltstone to relatively coarse-grained conglomerate. There is little lamination in the mudstones; some light-colored sandstones show cross-stratifications and graded bedding. Figure 9 shows a vertical exposure of arkosic facies sediment which displays the lateral discontinuity of the color bands.

There is no coarse-grained conglomerate unit close to the mountain front such as that assigned to the diamictite facies by Tracey *et al.* (1961) in the Fossil Basin, the Battle Spring Conglomerate mapped by Pipiringos (1962) in the Great Divide Basin, or the conglomerate facies of the Wasatch Formation on the western side of the Green River Basin discussed by Oriel (1962). Channel deposits containing well-rounded granitoid clasts and petrified wood are present, frequently several miles from the mountain front. The general trend of these channels is to the southwest, at right angles to the mountain system.

Fig. 9.–Arkosic facies of the New Fork Tongue exposed along the East Fork River in sec. 11, T. 31 N., R. 107 W., showing discontinuous color bands.

The variegated arkosic facies of the New Fork Tongue is conformably overlain by the drab-colored Cathedral Bluffs Tongue. This contact is readily seen along the Big Sandy River in SW¼ T. 30 N., R. 105 W. The base is undefined, although it is apparent that the arkosic facies grades downward into the main body of the Wasatch Formation. Eastward the arkosic facies lies unconformably on the Precambrian of the Wind River Mountains and the small inliers, and surrounds the Paleozoic outcrops of Steele Butte and associated exposures. Westward the arkosic facies merges into the Fontenelle Tongue of the Green River Formation and the western facies of the New Fork Tongue.

Fossil remains, especially of mammals, are common in the arkosic facies of the New Fork Tongue in a few places. Turtles, crocodiles, lizards, snakes, various fish and gastropods are also represented by fossil material. Two localities between Steele Butte and U. S. 187 have produced 30 identified mammalian taxa, as follows:

Insectivora:	*Paleictops* cf. *P. pineyensis*
Creodonta:	*Oxyaena forcipata*
	Oxyaena sp.
	oxyaenid
Carnivora:	*?Prototomus* sp.
	Tritemnodon sp.
	Didymictis altidens
	Miacis cf. *M. latidens*
	Vulpavus sp.
Primates:	*Notharctus* cf. *N. nunienus*
	Washakius aff. *W. insignis*
	Microsyops scottianus

Rodentia:	"*Paramys*" group
Tillodontia:	*Esthonyx acutidens*
Taeniodonta:	stylinodontine
Dinocerata:	*Bathyopsis fissidens*
Pantodonta:	*Coryphodon* sp.
Condylarthra:	*Hyopsodus miticulus*
	Hyopsodus wortmani
	Meniscotherium chamense
	Meniscotherium robustum
	Phenacodus wortmani
Perissodactyla:	*Hyracotherium vasacciense*
	Hyracotherium craspedotum
	Lambdotherium popoagicum
	Eotitanops borealis
	Heptodon posticus
	Heptodon calciculus
	Hyrachyus modestus
Artiodactyla:	*Diacodexis* cf. *D. secans*

The presence of *Oxyaena, Esthonyx, Coryphodon, Meniscotherium, Phenacodus, Hyracotherium, Lambdotherium* and *Heptodon* is indicative of the late early Eocene, Lost Cabin faunal zone. This fauna corresponds well with that from the type area of the Lost Cabin Member of the Wind River Formation in the north-central Wind River Basin.

Western facies: The western facies of the New Fork Tongue extends along the western side of the Green River Basin for about 80 miles south of the New Fork–Big Sandy area (Bradley, 1964, p. 27). Within the New Fork–Big Sandy area it makes up most of the Mesa (T. 31-32 N., R. 109-110 W.) and is well exposed along Ross Ridge and Ross Butte (T. 30 N., R. 109-110 W.) (Fig. 10). The type section (Donovan, 1950, p. 64) is a few miles west of the study area at the junction of the New Fork and Green Rivers. Within the study area it ranges in thickness from 340 feet to over 400 feet.

Fig. 10.—Pastel and sediments of the western facies of the New Fork Tongue on the northeastern slope of Ross Butte; the New Fork River is in the foreground.

The western facies is made up of variegated sandy mudstones, generally paler in color and finer-grained than those of the arkosic facies. There is a well-exposed series of massive yellow sandstone channel deposits in the western facies on the high bluff above the New Fork River just west of Boulder. A few miles to the west (sec. 11, T. 32 N., R. 109 W.) a coarse-grained sandstone at the top of this channel deposit shows excellent foreset beds (Fig. 11). It is likely that many of the smaller channel sandstones found elsewhere in the western facies in the Mesa area represent tributaries of this large stream system.

Fig. 11. Large channel deposit in the western facies of the New Fork Tongue (sec. 11, T. 32 N., R. 109 W.) showing a well-developed sequence of foreset beds.

The composition of the sandy mudstones of the western facies differs from that of the arkosic facies in that there is much less feldspar present and the sediment is more calcareous. This reflects the primary origin of the western facies sediment from the marine sedimentary rocks to the west, while the arkosic facies sediment was derived largely from the granitic Wind River Mountains. Some granitic material is present in the channel sandstones, suggesting that the drainage area of the stream system included some granitic areas as well as the sedimentary areas to the northwest.

The bluish and greenish mudstones of the western facies of the New Fork Tongue overlie the yellow sandstones of the Fontenelle Tongue of the Green River Formation. The middle tongue of the Green River Formation, where present, overlies the western facies of the New Fork Tongue in the New Fork–Big Sandy area. Westward the western facies loses its identity in the conglomerate facies of the Wasatch Formation along the basin margin (Oriel, 1962, p. 2170-2171), and eastward it merges into the upper part of the arkosic facies.

Fossils have been found at several localities in the western facies of the New Fork Tongue within the New Fork–Big Sandy area, and have been previously reported from additional localities to the south and west (Gazin, 1952, 1962, 1965). In addition to the remains of mammals, the usual representatives

of fish, aquatic reptiles, lizards, snakes and invertebrates have been found. The following 22 mammalian taxa have been identified:

Carnivora:	*?Prototomus* sp.
	Tritemnodon sp.
	Didymictis altidens
	Miacis cf. *M. latidens*
Primates:	*Notharctus* cf. *N. nunienus*
	Omomys cf. *O. sheai*
	Microsyops scottianus
Rodentia:	sciuravid
	"*Paramys*" group
Tillodontia:	stylinodontine
Condylarthra:	*Hyopsodus miticulus*
	Hyopsodus wortmani
	Meniscotherium chamense
	Meniscotherium robustum
	Phenacodus wortmani
	Phenacodus primaevus
	Phenacodus sp.
Perissodactyla:	*Hyracotherium vasacciense*
	Hyracotherium craspedotum
	Lambdotherium popoagicum
	Heptodon calciculus
Artiodactyla:	*Diacodexis* cf. *D. secans*

This assemblage is virtually identical to that from the arkosic facies, although there are some differences in proportional representation, as shown in Figure 12. The only important Lost Cabin taxon absent from the western facies assemblage is *Coryphodon*; this is probably explainable on ecologic grounds. Several less common genera, including *Oxyaena*, *Esthonyx*, *Bathyopsis* and *Eotitanops* have not yet been found in the western facies in the New Fork–Big Sandy area, but *Esthonyx* and *Bathyopsis* have been reported by Gazin (1962, p. 9-11) from elsewhere in the western facies.

Both facies of the New Fork Tongue represent sedimentation under alluvial plain conditions lateral to the Eocene lake. Channels are present in both, although more prominently developed in the western facies. The pale coloration of much of the western facies sediment is suggestive of a reducing, partially subaqueous situation much of the time, while the arkosic facies seems to have been deposited under more oxidizing conditions. The abundance of browsing mammals attests to the lushness of the late early Eocene vegetation, very little of which has been preserved.

Cathedral Bluffs Tongue–Directly overlying the arkosic facies of the New Fork Tongue in the southeastern part of the New Fork–Big Sandy area is a sequence of drab gray-green tuffaceous sandy mudstones which are referred to as the Cathedral Bluffs Tongue of the Wasatch Formation. This unit is best exposed along the Big Sandy River and near the northwestern terminus of the Continental Fault system. It ranges in thickness from 60 to 125 feet within the New Fork–Big Sandy area.

The Cathedral Bluffs Tongue, as developed in the New Fork–Big Sandy area, is composed of poorly cemented, poorly sorted, gray-green to brown calcareous sandy mudstone and gray-green arkose, with a high proportion of granitic particles. The unit is more tuffaceous than the underlying arkosic facies of the New Fork Tongue, a compositional feature indicated in outcrop by both "popcorn" weathering features of the mudstone and by some prominent bluish bands of almost pure tuff.

The interpretation of these sediments as belonging to the Cathedral Bluffs Tongue involves both physical and biologic correlations from well-exposed, though poorly fossiliferous, Cathedral Bluffs Tongue exposures in the Great Divide and Washakie Basins. This correlation is discussed in detail elsewhere (West, in press).

There is no lacustrine unit underlying the Cathedral Bluffs Tongue in the New Fork–Big Sandy area. Farther south and southeast the Wilkins Peak Member (as redefined by Roehler, 1968) is directly beneath the Cathedral Bluffs Tongue. Zeller and Stephens (1969, p. 16) utilized the presence of an underlying lacustrine unit as a criterion for the identification of the Cathedral Bluffs Tongue to the southeast of the New Fork–Big Sandy area. The Cathedral Bluffs Tongue is overlain by the Laney Shale Member of the Green River Formation, which is also its partial lateral equivalent in the New Fork–Big Sandy area. The lower part of the Cathedral Bluffs Tongue is probably laterally equivalent to the middle tongue of the Green River Formation to the west, although the actual relationship is not visible. The Cathedral Bluffs Tongue is eroded eastward, but likely originally lapped onto the Precambrian rocks of the Wind River Mountains.

Fossil evidence for the determination of the age of the Cathedral Bluffs Tongue is scanty. Two localities within the New Fork–Big Sandy area allow an estimate of its age in that region, but determinations for the unit to the south and southeast remain inadequate. The assemblage collected in the study area includes the following mammalian taxa:

Primates:	*Omomys carteri*
	Anaptomorphus aemulus
	Microsyops sp.
Rodentia:	*Sciuravus nitidus*
	Knightomys cf. *K. senior*
	Paramys aff. *P. excavatus*
	"*Paramys*" group
	Paramys wyomingensis
	Reithroparamys huerfanensis
	Reithroparamys aff. *R. delicatissimus*
Tillodontia:	stylinodontine
Condylarthra:	*Hyopsodus minusculus*
Perissodactyla:	*Orohippus* cf. *O. pumilus*
	Hyrachyus modestus
Artiodactyla:	*Antiacodon pygmaeus*

This fauna is much more similar to that from the Bridger B zone than from the Lost Cabin zone (Fig. 14, and compare with Fig. 12). The assemblage may be tentatively assigned to the Bridger A, the poorly fossiliferous early Bridgerian zone

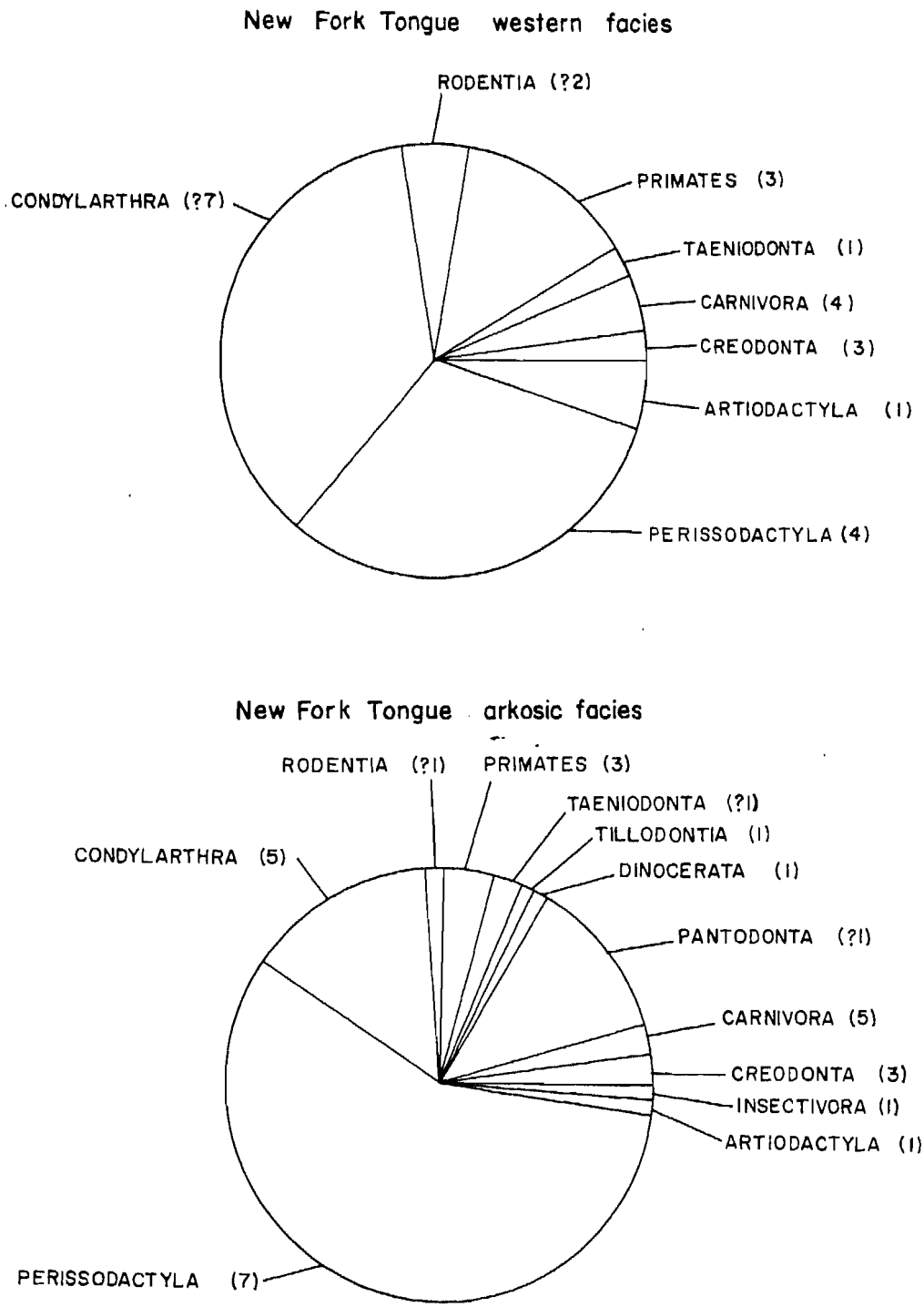

Fig. 12.—Comparison of compositions, at the ordinal level, of the mammalian assemblages from the western facies and the arkosic facies of the New Fork Tongue in the New Fork–Big Sandy area. The circles are divided according to the percentage of the minimum number of individuals in each order. The number in parentheses following each name indicates the number of species present; if it is preceded by a question mark, there actually may be more species than indicated.

designated by Matthew (1909, p. 295-296). The lack of essentially all typical Lost Cabin taxa, including *Oxyaena, Coryphodon, Lambdotherium, Meniscotherium, Phenacodus* and *Hyracotherium*, combined with the presence of the typical early Bridgerian forms–*Omomys, Sciuravus, Hyopsodus, Orohippus* and *Antiacodon*–strongly supports that assignment. Gazin (1952, 1962, 1965) has suggested a Lost Cabin Wasatchian age for the Cathedral Bluffs Tongue in the Washakie and Great Divide Basins, while Nace (1939), Morris (1954) and McGrew and Roehler (1965), as well as the present writer (West, in press), have offered the possibility of a very early Bridgerian age for those sediments. It is apparent that more paleontologic data must be amassed before the age of the Cathedral Bluffs Tongue will be verified.

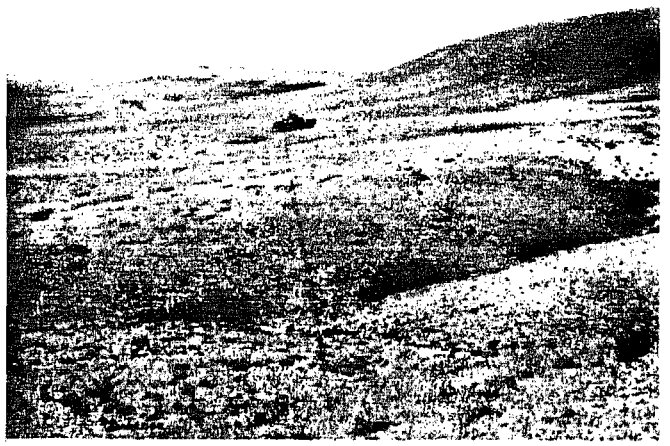

Fig. 13.—Fossiliferous exposure of drab-colored sediments of the Cathedral Bluffs Tongue in sec. 17, T. 30 N., R. 106 W. The truck is parked at the place where the Cathedral Bluffs mammalian assemblage was collected.

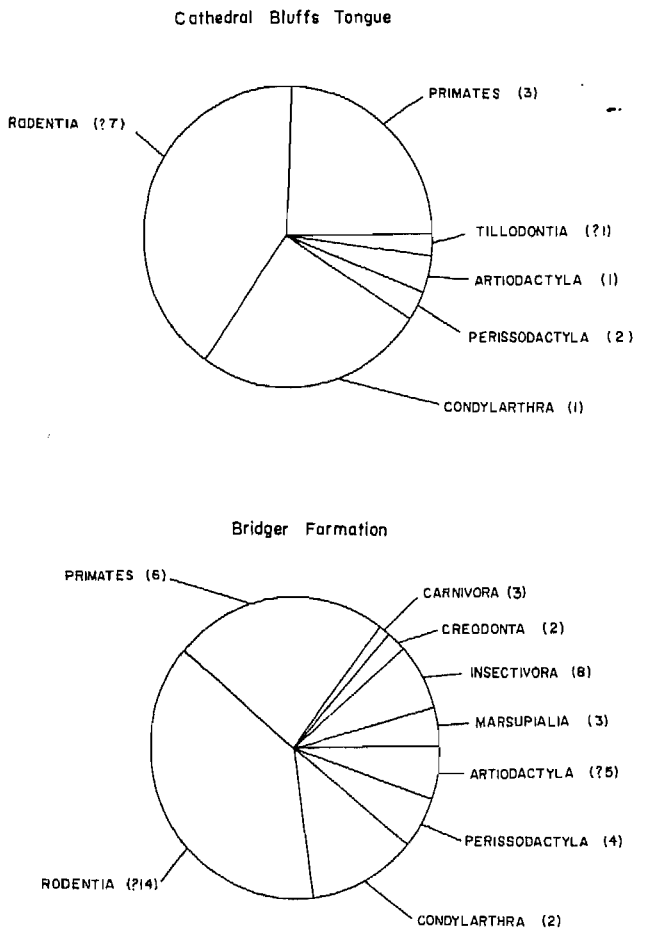

Fig. 14.—Comparison of compositions, at the ordinal level, of the mammalian assemblages from the Cathedral Bluffs Tongue of the Wasatch Formation and the lower Bridger Formation in the New Fork–Big Sandy area. See Fig. 12 for key.

Bridger Formation

The Bridger Formation is the youngest dated Tertiary unit within or near the New Fork–Big Sandy area. It outcrops in the southeastern part of the area, with its pattern largely controlled by the Continental Fault system. About 300 feet of lower Bridger Formation occurs in the New Fork–Big Sandy area, while just to the south of the study area McGrew *et al.* (1959, p. 129) measured an additional 357 feet of upper Bridger Formation sediment at Tabernacle Butte.

Lower Bridger Formation—The lower Bridger Formation (Fig. 15) is a fluvial deposit, with much sediment of volcanic origin. Thus it continues the trend toward increased amounts of tuffaceous material established earlier in the Laney Shale Member and the Cathedral Bluffs Tongue.

There is a considerable range of lithologies in the lower Bridger Formation. Most of the unit is composed of fine-

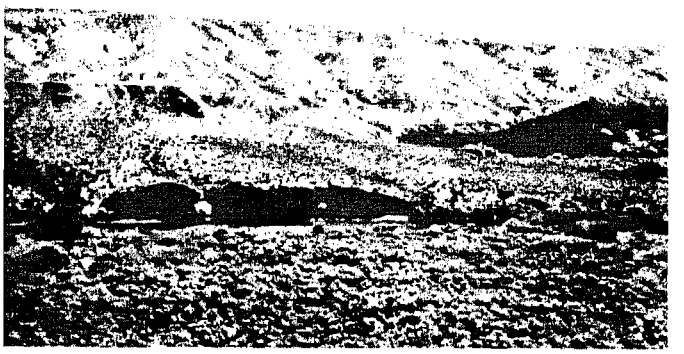

Fig. 15.—Large exposure of lower Bridger Formation sediment in sec. 25, T. 30 N., R. 106 W. This locality has produced a large vertebrate fossil assemblage.

grained clastic sediment, colored mainly pastel shades of buff and brown. Clasts of both volcanic and igneous origin are present. More tuffaceous levels are usually distinguishable by their light blue coloration and low density. No pure precipitated limestones were found, but several pond deposits are made up of fine clastic particles cemented by carbonate. A number of conglomeratic lenses are present; they appear either as resistant elevations or as lenses or irregular beds in dissected areas and stream cuts. There is little evidence of current action in these, as few display current cross-bedding or well-developed laminations.

The lower Bridger Formation lies conformably on top of the Laney Shale Member of the Green River Formation. No specific point of distinction between the two units can be defined, as they merge gradually. The upper boundary of the lower Bridger Formation is a similar situation, as no demarcation exists between it and the overlying upper Bridger Formation. Because of the peculiar outcrop pattern of the Bridger Formation, no information is available on its relationships with fluvial Wasatch Formation beds toward the mountains. Likewise, the isolation of the Bridger Formation in the

northeastern Green River Basin permits only generalized lithostratigraphic correlation with the major area of Bridger Formation exposure to the south.

The lower Bridger Formation in the New Fork–Big Sandy area produces a fossil mammal fauna which is representative of the early Bridgerian Bridger B zone of Matthew (1909). In addition to the mammals found at 13 localities, there is a great variety of remains of fish, reptiles, birds and invertebrates. The mammalian fauna is as follows:

Marsupialia:	*Peratherium* sp.
	Peratherium innominatum
	Peratherium marsupium
Insectivora:	*Centetodon* cf. *C. pulcher*
	Myolestes cf. *M. dasypelix*
	Scenopagus edenensis
	Scenopagus priscus
	creotarsine
	Nyctitherium sp.
	Didelphodus altidens
	Apatemys bellulus
Creodonta:	*?Proviverra* sp.
	Thinocyon cf. *T. velox*
Carnivora:	*Viverravus gracilis*
	Viverravus sp.
	Miacis latidens
Primates:	*Notharctus tenebrosus*
	Smilodectes gracilis
	Omomys carteri
	Washakius insignis
	Anaptomorphus aemulus
	Microsyops elegans
Rodentia:	*Sciuravus nitidus*
	Sciuravus sp.
	Tillomys cf. *T. parvidens*
	Taxymys lucaris
	Paramys delicatus
	"*Paramys*" group
	Paramys wyomingensis
	Reithroparamys huerfanensis
	Reithroparamys delicatissimus
	Pseudotomus robustus
	Microparamys minutus
	Microparamys sp. A.
	Microparamys sp. B.
Condylarthra:	*Hyopsodus minusculus*
	Hyopsodus paulus
Perissodactyla:	*Orohippus* cf. *O. pumilus*
	Palaeosyops fontinalis
	Hyrachyus modestus
	tapiroid
Artiodactyla:	*Diacodexis* cf. *D. secans*
	Antiacodon pygmaeus
	Microsus sp.
	Helohyus cf. *H. plicodon*
	indeterminate artiodactyl (?)

Upper Bridger Formation–Although no upper Bridger Formation sediments are present in the New Fork–Big Sandy area, they make up the prominent hills, Tabernacle Butte and Elk Mountain, south of the area (Fig. 2). These sediments are stratigraphically continuous with the lower Bridger Formation of the New Fork–Big Sandy area, and are much more tuffaceous. The sediment is largely white to gray soft tuffaceous sandstone, with irregular beds of pastel yellow, pink and buff mudstone (McGrew *et al.*, 1959, p. 129) (Fig. 16).

The upper Bridger Formation represents the top of the datable Tertiary section as present in the northeastern Green

Fig. 16.–Tuffaceous upper Bridger Formation sediments exposed at Tabernacle Butte.

River Basin. Tabernacle Butte and Elk Mountain are capped by a "Post-Bridger Conglomerate", composed primarily of granitic and basic igneous rocks, cemented by a sandy matrix which is frequently tuffaceous. No age determination is possible for the unit (McGrew *et al.*, 1959, p. 129).

The fossil fauna recovered from a number of localities at Tabernacle Butte and Elk Mountain is clearly of late Bridgerian age. Since McGrew *et al.* published the first faunal list in 1959, considerable work has both added to and modified that mammalian assemblage. In order to complete the paleontologic picture of the northeastern Green River Basin, a recently revised faunal list (West and Atkins, in press) is reproduced here:

Marsupialia:	*Peratherium* cf. *P. innominatum*
	Peratherium knighti
	Peratherium sp.
Insectivora:	*Palaeictops bridgeri*
	Nyctitherium velox
	Talpavus cf. *T. nitidus*
	Centetodon pulcher
	Centetodon (?) *bacchanalis*
	Geolabis cf. *G. marginalis*
	Scenopagus edenensis
	Didelphodus altidens
	undescribed apternodontine
	Apatemys sp.

Chiroptera:	undescribed genus and species
Primates:	*Washakius insignis*
	Microsyops cf. *M. annectens*
	Uintasorex parvulus
Edentata:	*Tetrapassalus mckennai*
Rodentia:	*Sciuravus nitidus*
	Taxymys lucaris
	Tillomys senex
	Paramys delicatior
	Paramys aff. *P. excavatus*
	Paramys wyomingensis
	Leptotomus sp.
	Reithroparamys delicatissimus
Dinocerata:	*Uintatherium* sp.
Condylarthra:	*Hyopsodus lepidus*
	Phenacodus primaevus
Perissodactyla:	*Orohippus* large species
	Orohippus small species
	Telmatherium cultridens
	Manteoceras manteoceras
	Hyrachyus cf. *H. eximius*
Artiodactyla:	*Helohyus validus*
	Neodiacodexis emryi (nomen nudum Atkins *in* West and Atkins, in press)

Pleistocene

Pleistocene deposits of several varieties cover the Eocene beds in numerous places in the New Fork–Big Sandy area. An excellent study by Holmes and Moss (1955) documented the areas and ages of till deposits and related the various prominent terraces along the Big Sandy River and elsewhere to various glacial events.

At least five ice advances are recorded on the southwestern flank of the Wind River Mountains, and remains of two are present in the New Fork–Big Sandy area. The older, the Bull Lake advance, left the irregular land surface near the Big Sandy River south of Buckskin Crossing and almost all the hills in the vicinity of the Big Sandy Junction. The younger Pinedale moraine, more irregular and boulder-strewn than the Bull Lake moraine, is well-developed around Boulder Lake (north of the New Fork–Big Sandy area), and also in the vicinity of Cottonwood and Silver Creeks.

Cobble veneers cap several elevations. Most prominent of these is the two to five foot layer on top of the Mesa. Although no till covers this cobble layer, Holmes and Moss (1955, p. 633) believed that it may be older than any till preserved in the area. This layer is not present on top of Ross Butte, only three miles from the Mesa, so the early advance did not get that far. Another, less regular, cobble zone occurs around Square Top. These two zones are completely discontinuous and no correlation is presently possible.

Some small areas of wind-blown sand are present in the New Fork–Big Sandy area. An area of recognizable dunes is located on the north side of the Big Sandy River about one mile upstream of Buckskin Crossing, and Holmes and Moss (1955, p. 644-645) reported stabilized sand sheets one to three feet thick along the East Fork River near Boulder. This sand was originally derived from sandy flats on the outwash plains and accumulated to the leeward (east) as influenced by the prevailing winds.

STRUCTURAL FEATURES OF THE NORTHEASTERN GREEN RIVER BASIN

The major structural control in the northeastern Green River Basin during the late Cretaceous and early Tertiary was exerted by the now-covered Wind River Thrust Fault, behind which the Wind River Mountains arose. This fracture presumably runs the length of the range, from the series of exposed faults mapped by Richmond (1945) at the northwestern end of the range to the southeastern end and perhaps beyond as far east as the Granite Mountains. It has been studied by geophysical techniques, and its configuration is now generally understood (Berg, 1961).

The only exposed fault in the New Fork–Big Sandy area is the Continental Fault, so named by Nace (1939) near Continental Peak. This 50 to 80 mile long normal fault terminates in a number of small branches in the southeastern part of the New Fork–Big Sandy area.

The course of the Continental Fault is generally demarcated in the New Fork–Big Sandy area by the outcrop pattern of the Bridger Formation. These younger rocks occupy the downdropped graben block between subsidiary limbs of the fault system. Within the New Fork–Big Sandy area the fault is divisible into three traceable branches (see geological map). The main limb, the continuation of that discussed by McGrew *et al.* (1959, p. 129) can be followed three miles northwest of the Big Sandy River up Waterhole Draw, and then trends slightly more northward. The Big Sandy Limb is well exposed at a number of stream cuts, the best of which is in sec. 24, T. 30 N., R. 106 W. (Fig. 8). It cannot be related with confidence to any particular small fault near Elk Mountain because of the intervening featureless stretch. The Square Top Limb is at the northwestern terminus of the fault system. It is more difficult to locate, but may be seen on the north side of a small hill in N½, NE¼ sec. 13, T. 30 N., R. 107 W.

The maximum movement along the Continental Fault in the New Fork–Big Sandy area is about 250 feet, and this decreases to the northwest. Movement did not cease until at least mid-Pliocene (Love, 1954, p. 1311-1312), and some Eocene movement is indicated by contemporaneous fault scarps (McGrew, pers. comm., Aug., 1967).

Berg (1961, p. 73) interpreted the Continental Fault system as a "late normal collapse along the toe of the (major) thrust wedge," and noted a correlation between the position of the thrust wedge and the surface expression of the Continental Fault. Zeller and Stephens (1969, pl. 1) showed the Continental Fault on the mountainward side of the Wind River Thrust near Continental Peak as a result of a small fault within the thrust wedge; this suggests that the Continental Fault may not be an accurate expression of the Wind River Thrust for its entire length. An additional location of the

thrust plate might also be provided by the presumed normal fault west of Steele Butte postulated by Love (1950, p. 27) to account for the position of the small exposures of Devonian rocks west of the butte.

The overall effect of the Continental Fault in the New Fork–Big Sandy area has been to drop middle Eocene Bridger Formation sediments down to the level of the early Eocene Wasatch and Green River Formation beds. This allowed the younger material to escape total erosion and remain as an indicator of the former extent of Bridger Formation sedimentation in the northeastern Green River Basin. The lower Bridger Formation sediment mapped along the Square Top Limb is the farthest north yet recorded. As 13 fossil mammal sites are located in the downdropped Bridger Formation in the New Fork–Big Sandy area, and many more around Tabernacle Butte, the structural situation is paleontologically fortunate.

The Pinedale Anticline, a minor structure in the Tertiary, extends some 45 miles parallel to the Wind River Mountains from T. 35 N., R. 110 W. to T. 29 N., R. 106 W. It is approximately symmetrical, six miles wide, with a closure of more than 1500 feet (Jenkins, 1955, p. 155). Jenkins' report discussed the economic potential of the anticline; no field has yet been developed.

The New Fork River cuts the anticline, and minor "draping" may be noted in the Fontenelle Tongue of the Green River Formation. Higher beds, the New Fork Tongue, show no effects of the buried structure. Drilling has revealed that this anticline involves several thousand feet of sediment above the Precambrian (Berg, 1961, p. 71).

REGIONAL PALEONTOLOGICAL CORRELATION

The several faunal levels now known to be present in the northern Green River Basin provide a basis for biostratigraphic correlations with other areas in the intermountain region (Fig. 17).

The faunas from the New Fork Tongue are essentially identical to those from the lower part of the Lost Cabin Member of the Wind River Formation in the Wind River Basin. This Lost Cabin fauna is also well known from the lower part

	SOUTHERN & WESTERN GREEN RIVER BASIN	NORTHEASTERN GREEN RIVER BASIN	WASHAKIE BASIN	WIND RIVER BASIN	BIGHORN BASIN	HUERFANO BASIN
LATE BRIDGERIAN	Bridger C-D Fauna	Upper Bridger Fauna	Washakie A Fauna			
EARLY BRIDGERIAN	Bridger B Fauna Bridger A Fauna	Lower Bridger Fauna Cathedral Bluffs Tongue Fauna	? Cathedral Bluffs Tongue Fauna	?		Huerfano B Fauna
LATE WASATCHIAN	New Fork Tongue Fauna LaBarge Member Fauna	New Fork Tongue Faunas	? Dad Local Fauna	Lost Cabin Member Fauna	Upper Willwood Fauna	Huerfano A Fauna

Fig. 17.–Correlation chart of lower and middle Eocene faunas.

of the Huerfano Formation of south-central Colorado (Robinson, 1966).

The Cathedral Bluffs Tongue fauna indicates a very early Bridgerian age for that unit in the northeastern Green River Basin. Exposures of the unit elsewhere, including its type area in the northern Washakie Basin, have produced less diagnostic fossils and cannot be placed so well chronologically. The Cathedral Bluffs Tongue of the Wasatch Formation in the northeastern Green River Basin is probably correlative with the Bridger A of the south-central Green River Basin. It may also correlate with the upper part of the Huerfano Formation (separated as the "Gardnerbuttean substage" by Robinson, 1966, p. 15), and possibly with some insufficiently understood beds in the Badwater area of the Wind River Basin (Black and Dawson, 1966; West and Atkins, in press).

The fauna from the lower Bridger Formation is similar to that from the Bridger B elsewhere in the Green River Basin, and the upper Bridger Formation fauna at Tabernacle Butte certainly is related to that from the Bridger C-D farther south. Late Bridgerian faunas are also found in the Washakie Basin.

A caution must be added to this discussion of faunal correlations. While it is an accepted principle among invertebrate paleontologists that considerably different faunas exist simultaneously under different environmental conditions, and that faunal successions frequently represent only successive environments (as in a transgressing marine situation), the problems of facies differences have not yet been adequately considered by many vertebrate paleontologists. This problem is aggravated by the lack of diversity among readily-preserved terrestrial environments and by the discontinuous nature of basin sedimentation. Thus a "peculiar" assemblage is often treated as an evolutionary unit rather than as representative of a hitherto unsampled environment. Although the evolutionary "stages" of Tertiary mammals are probably generally accurate indicators of relative chronologic position, there still might be facies (environmental) differences controlling some morphologic features presently attributed to temporal change. The correlations made above depend on present understanding of mammalian evolution and ecology, and these should be subject to continual re-analysis as more and better information becomes available.

SUMMARY OF POST-CRETACEOUS GEOLOGIC HISTORY

Figure 18

Late Cretaceous–Early Eocene

Uplift of marginal mountain ranges. Activity along zones of overthrusts.

Paleocene

Marginal faults, especially the Wind River Thrust, continued to be active. Deposition of fluvial material into the basin, perhaps continuous with the Hoback Formation at this time.

Eocene

Early and Middle Wasatchian

Chappo Member and main body of the Wasatch

Formation deposited. Commencement of lacustrine sequence to the south. Wind River Thrust still active. Western overthrusts active.

Late Wasatchian

Movement on thrust faults essentially terminated. Lacustrine deposition (Fontenelle Tongue) in the northern Green River Basin covered over the LaBarge Member. Additional fluvial strata, the New Fork Tongue, covered the lacustrine beds as the lake receded.

Earliest Bridgerian

Second expansion of the lacustrine sequence resulted in the middle tongue of the Green River Formation, which may or may not have been continuous with the Wilkins Peak Member. Continued deposition of Wasatch Formation as Cathedral Bluffs Tongue along flank of Wind River Mountains; perhaps an equivalent upper tongue of the Wasatch was present on the west. Volcanic activity began to the northwest. Final lacustrine expansion began, and lower part of Laney Shale Member was deposited lateral to the Cathedral Bluffs Tongue.

Early Bridgerian

Last great lacustrine expansion receded, leaving the Laney Shale Member. Volcanic activity continued, and Bridger Formation began to fill in the basin.

Bridgerian

Basin continued to fill with fluvial material. Volcanic component of Bridger Formation sediment increased. Probable beginning of movement along the Continental Fault system.

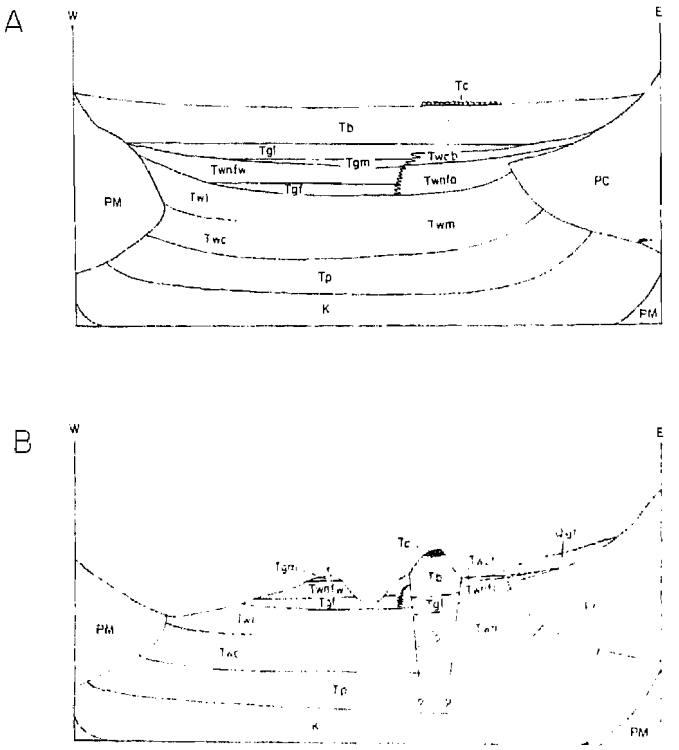

Fig. 18.—Schematic cross-sections of the northern Green River Basin. A. Probable situation in mid-Tertiary, after the deposition of the Post-Bridger Conglomerate. B. Present situation, taking into consideration movement on the Continental Fault, erosion, and Pleistocene deposition. Abbreviations: PC—Precambrian; P-M—Paleozoic and Mesozoic undifferentiated; K—Cretaceous; Tp—Paleocene (?) Ft. Union Formation; Twm-main body of Wasatch Formation; Twc—Chappo Member of Wasatch Formation; Twl—LaBarge Member of Wasatch Formation; Twnfw—western facies of New Fork Tongue of Wasatch Formation; Twnfa—Arkosic facies of New Fork Tongue of Wasatch Formation; Twcb—Cathedral Bluffs Tongue of Wasatch Formation; Tgf—Fontenelle Tongue of Green River Formation; Tgm—Middle tongue of Green River Formation; Tgl—Laney Shale Member of Green River Formation; Tb—Bridger Formation; Tc—Post-Bridger Conglomerate; Qgt—glacial till and moraine deposits.

Late Eocene–Pleistocene

Continued structural readjustment along the Continental Fault system resulted in the downdropping of large areas of Bridger Formation sediment. Continental Fault continued active as late as mid-Pliocene. Deposition of "Post-Bridger Conglomerate" occurred at an unknown time. Regional uplift, and beginning of erosional cycle which removed much of the Eocene sediment.

Pleistocene

Sequence of glacial advances and recessions left a series of moraines over the Eocene sediment and produced terraces along the drainages. Continued irregular excavation of Eocene sediments.

Recent

Some streams cut through Pleistocene deposits, leaving isolated patches of Pleistocene material on top of Eocene sediments. Presently little stream erosion, due to climate and low gradients, although the land surface is being generally degraded.

REFERENCES

BERG, ROBERT R., 1961, Laramide tectonics of the Wind River Mountains: Wyo. Geol. Assoc. Guidebook 16th Field Conf., p. 70-80.

BLACK, CRAIG C., and MARY R. DAWSON, 1966, Paleontology and geology of the Badwater Creek area, central Wyoming, Part 1, History of work and geological setting: Ann. Carnegie Mus., v. 30, art. 13, p. 297-307.

BRADLEY, WILMOT H., 1964, Geology of the Green River Formation and associated Eocene rocks in southwestern Wyoming and adjacent parts of Colorado and Utah: U. S. Geol. Survey Prof. Paper 496-A, p. 1-86.

DONOVAN, J. H., 1950, Intertonguing of Green River and Wasatch Formations in part of Sublette and Lincoln Counties, Wyoming: Wyoming Geol. Assoc. Guidebook, 5th Field Conf., p. 59-67.

GAZIN, C. LEWIS, 1952, The lower Eocene Knight Formation of western Wyoming and its mammalian faunas: Smithsonian Misc. Coll., v. 117, no. 18, p. 1-82.

———, 1962, A further study of the lower Eocene mammalian faunas of southwestern Wyoming: Smithsonian Misc. Coll., v. 144, no. 1, p. 1-98.

———— 1965, Early Eocene mammalian faunas and their environment in the vicinity of the Rock Springs Uplift, Wyoming: Wyoming Geol. Assoc. Guidebook, 19th Field Conf., p. 171-180.

HOLMES, G. WILLIAM, and JOHN H. MOSS, 1955, Pleistocene geology of the southwestern Wind River Mountains, Wyoming: Bull. Geol. Soc. Amer., v. 66, p. 629-654.

JENKINS, CARL E., 1955, Pinedale Anticline, Sublette County: Wyoming Geol. Assoc. Guidebook, 10th Field Conf., p. 155-156.

LOVE, J. DAVID, 1950, Paleozoic rocks of the southwest flank of the Wind River Mountains near Pinedale: Wyoming Geol. Assoc. Guidebook, 5th Field Conf., p. 25-27.

———, 1954, Periods of folding and faulting during late Cretaceous and Tertiary time in Wyoming (abs.): Bull. Amer. Assoc. Petroleum Geol., v. 38, p. 1311-1312.

———, 1961, Definition of Green River, Great Divide and Washakie Basins, southwestern Wyoming: Bull. Amer. Assoc. Petroleum Geol., v. 45, p. 1749-1755.

McGREW, PAUL O., JACK E. BERMAN, MAX K. HECHT, JOHN M. HUMMEL, GEORGE G. SIMPSON and ALBERT E. WOOD, 1959, The geology and paleontology of the Elk Mountain and Tabernacle Butte Area, Wyoming: Bull. Amer. Mus. Nat. Hist., v. 117, art. 3, p. 117-176.

McGREW, PAUL O., and HENRY W. ROEHLER, 1960, Correlation of Tertiary units in southwestern Wyoming: Wyo. Geol. Assoc. Guidebook, 15th Field Conf., p. 156-158.

MATTHEW, WILLIAM D., 1909, The Carnivora and Insectivora of the Bridger Basin, Middle Eocene: Mem. Amer. Mus. Nat. Hist., v. 9, p. 195-203.

MORRIS, WILLIAM J., 1954, An Eocene fauna from the Cathedral Bluffs Tongue of the Washakie Basin, Wyoming: Journal Paleo., v. 28, p. 195-203.

NACE, R. L., 1939, Geology of the northwest part of the Red Desert, Sweetwater and Fremont Counties, Wyoming: Geol. Survey Wyo. Bull. 21, p. 1-51.

ORIEL, STEVEN S., 1961, Tongues of the Wasatch and Green River Formations, Fort Hill area, Wyoming: U.S. Geol. Survey Prof. Paper 424-B, p. 151-152.

———— 1962, Main body of Wasatch Formation near LaBarge, Wyoming: Bulletin Amer. Assoc. Petroleum Geol., v. 46, p. 2161-2173.

RICHMOND, GERALD M., 1945, Geology of the northwest end of the Wind River Mountains, Sublette County, Wyoming: U.S. Geol. Survey Oil and Gas Invest. Prelim. Map 31.

ROBINSON, PETER, 1966, Fossil Mammalia of the Huerfano Formation, Eocene of Colorado: Peabody Mus. Nat. Hist. Bull. 21, p. 1-85.

ROEHLER, HENRY W., 1968, Redefinition of the Tipton Shale Member of Green River Formation of Wyoming: Bull. Amer. Assoc. Petroleum Geol., v. 52, p. 2249-2256.

WEST, ROBERT M., 1968, Geology and paleontology of a portion of the northern Green River Basin, Wyoming: Unpublished Ph.D. dissertation, University of Chicago.

———, in press, Biostratigraphy of fluvial sediments of the upper Wasatch Formation in the northern Green River Basin, Wyoming: Univ. Wyo. Contrib. to Geology.

———, and EDWARD G. ATKINS, in press, Additional middle Eocene (Bridgerian) mammals from Tabernacle Butte, Sublette County, Wyoming: Amer. Mus. Novitates.

ZELLER, HOWARD D., and E. VERNON STEPHENS, 1969, Geology of the Oregon Buttes area, Sweetwater, Sublette and Fremont Counties, southwestern Wyoming: U.S. Geol. Survey Bull. 1256, p. 1-60.