Description and Correlation of Eocene Rocks in Stratigraphic Reference Sections for the Green River and Washakie Basins, Southwest Wyoming

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By HENRY W. ROEHLER

GEOLOGY OF THE EOCENE WASATCH, GREEN RIVER, AND BRIDGER (WASHAKIE) FORMATIONS, GREATER GREEN RIVER BASIN, WYOMING, UTAH, AND COLORADO

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Includes analyses of Eocene rocks in the Washakie basin

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GEOLOGY OF THE EOCENE WASATCH, GREEN RIVER, AND BRIDGER (WASHAKIE) FORMATIONS, GREATER GREEN RIVER BASIN, WYOMING, UTAH, AND COLORADO

DESCRIPTION AND CORRELATION OF EOCENE ROCKS IN STRATIGRAPHIC REFERENCE SECTIONS FOR THE GREEN RIVER AND WASHAKIE BASINS, SOUTHWEST WYOMING

By HENRY W. ROEHLER

ABSTRACT

Stratigraphic reference sections of the Wasatch, Green River, and Bridger (Washakie) Formations were measured on outcrops in the Green River and Washakie basins adjacent to the Rock Springs uplift in southwest Wyoming. The Washakie basin reference section is 7,939 feet thick and consists of 708 beds that were measured, described, and sampled to evaluate the origin, composition, and paleontology of the rocks. The reference section in the Green River basin is 6,587 feet thick and consists of 624 beds that were measured and described but were not sampled; this section was measured to correlate rock units with those in the Washakie basin. Columnar sections that have been prepared combine information on the stratigraphic nomenclature, age, depositional environments, lithologies, and fossils of each bed in the reference sections.

Eocene strata in the Green River and Washakie basins have been correlated biostratigraphically, chronostratigraphically, and lithostratigraphically. The time boundaries of the lower, middle, and upper Eocene rocks in the reference sections are located partly from biostratigraphic investigations and partly from chronostratigraphic investigations. The time boundaries agree with North American land mammal ages, which were used in the report because of their historical precedence.

Major stratigraphic units and key marker beds correlated between the reference sections appeared remarkably similar in thickness and lithology, which suggests that most depositional events were contemporaneous in both basins. One major difference between the sections is that the upper 875 feet of upper Eocene rocks in the Washakie basin is missing by nondeposition or by post-Eocene erosion in the Green River basin.

Rocks sampled in the Washakie basin reference section were examined petrographically and were analyzed using heavy mineral separations, X-ray techniques, and assays. The mineralogy suggests that source rocks in the lower part of the Eocene were mostly of plutonic origin and that source rocks in the upper part of the Eocene were mostly of volcanic origin. Economically significant beds of oil shale and zeolite were identified by the analyses. Fossil pollen collected from 22 beds was used to identify plants that characterize five successive climates present in the Washakie basin during the Eocene Epoch.

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INTRODUCTION

Eocene rocks were measured and described in two reference sections located in the southeastern part of the Green River basin and in the southwestern part of the Washakie basin adjacent to the Rock Springs uplift in Sweetwater County in southwest Wyoming (fig. 1). The reference sections have a combined total thickness of more than 14,500 ft. They comprise complete sedimentary records of the Wasatch, Green River, and Bridger (Washakie) Formations for the basinal areas investigated. The name Bridger Formation is used for post-Green River Eocene rocks in the Green River basin, whereas Washakie Formation is used for post-Green River Eocene rocks in the Washakie basin. These rocks are referred to as Bridger (Washakie) Formation in the report. The sections are composites, as no continuous exposures are present that allow for the uninterrupted measurement of the rocks by single linear traverses. Segments of the composite sections are separated by as much as several miles, but they are tied together by persistent stratigraphic marker beds. The reference sections are illustrated graphically by columnar sections on plates 1 and 2; lithologies are noted in the detailed section descriptions beginning on page 44 of this report.

Lithostratigraphic units and principal marker beds are correlated between the Green River basin and Washakie basin reference sections. These correlations

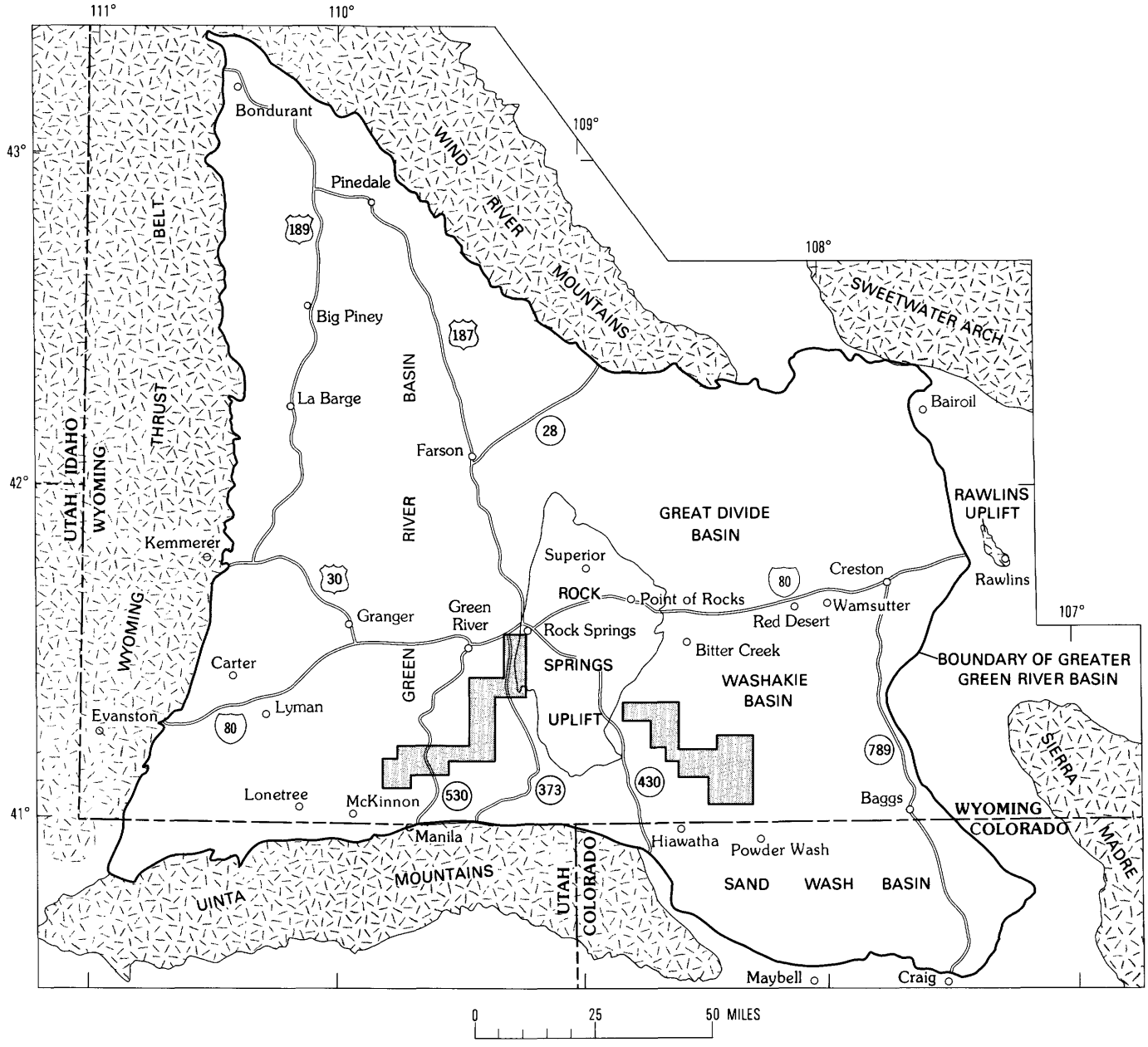


FIGURE 1.—General locations (shaded) of Eocene reference sections, Green River and Washakie basins. For detailed locations, see index maps on plates 1 and 2.

permit interpretations concerning the depositional history and areal extent of Eocene rocks across the eastern and western parts of the greater Green River basin (fig. 1) in areas that have not been precisely correlated previously. The beds measured and described in the Washakie basin reference section (pl. 2) were sampled and analyzed; the beds in the Green River basin reference section (pl. 1) were not sampled but were measured and described for correlation purposes. Economically significant deposits of oil shale and zeolites, and other minerals of potential economic value were located stratigraphically by the analyses of samples collected from the Washakie basin reference section. Fossil pollen from the Washakie basin section has aided in interpreting Eocene climates and depositional environments.

ACCESSIBILITY OF THE REFERENCE SECTIONS

The reference section in the Green River basin is accessible by Wyoming Highway 530 south of Green River, Wyo., and Wyoming Highway 373 southwest of Rock Springs, Wyo. The reference section in the Washakie basin is accessible by Wyoming Highway 430 southeast of Rock Springs, Wyo. Secondary gravel roads and unimproved trails branch from these paved highways and provide access to the outcrops that were measured. The general locations of the reference sections are shown in figure 1. More accurate geographic locations of segments of the measured sections and of nearby roads are shown on the index maps on plates 1 and 2.

FIELD DATES AND METHODOLOGY

The Green River basin Eocene reference section was measured in segments over a 27-year period using a 5-ft Jacob's staff and Abney level. The main body of the Wasatch Formation was measured in 1958 during oil and gas explorations involving the stratigraphy of Eocene rocks on the southwest flank of the Rock Springs uplift (Roehler, 1965, p. 143–144). The Niland Tongue of the Wasatch Formation and the Luman Tongue, Scheggs and Rife Beds of the Tipton Shale Member, and Wilkins Peak Member of the Green River Formation were measured between 1979 and 1981 during investigations of coal deposits in the Rock Springs coal field (Roehler, 1981, sheet 2). The Laney Member of the Green River Formation and the Bridger Formation were measured in 1985 to complete the upper part of the Eocene section in the Green River basin, so that it could be correlated to Eocene rocks in the Washakie basin.

The Washakie basin reference section was measured, described, and sampled in 1968 during investigations undertaken to evaluate oil shale resources. The section was measured using a 5-ft Jacob's staff and Abney level. Many of the bed numbers (listed at the left side of the columns on pl. 2) were chiseled into outcrops and then sprayed with yellow paint to provide a means for permanently identifying beds along the line of section. The geographic locations of many of the beds thus marked are shown on the Kinney Rim 30′×60′ geologic quadrangle map (Roehler, 1985). All beds in the Washakie basin section were sampled for X-ray diffraction analysis. Samples were also taken from beds at selected intervals in the section for petrographic, heavy mineral, X-ray fluorescence, oil shale assay, and palynomorph analyses.

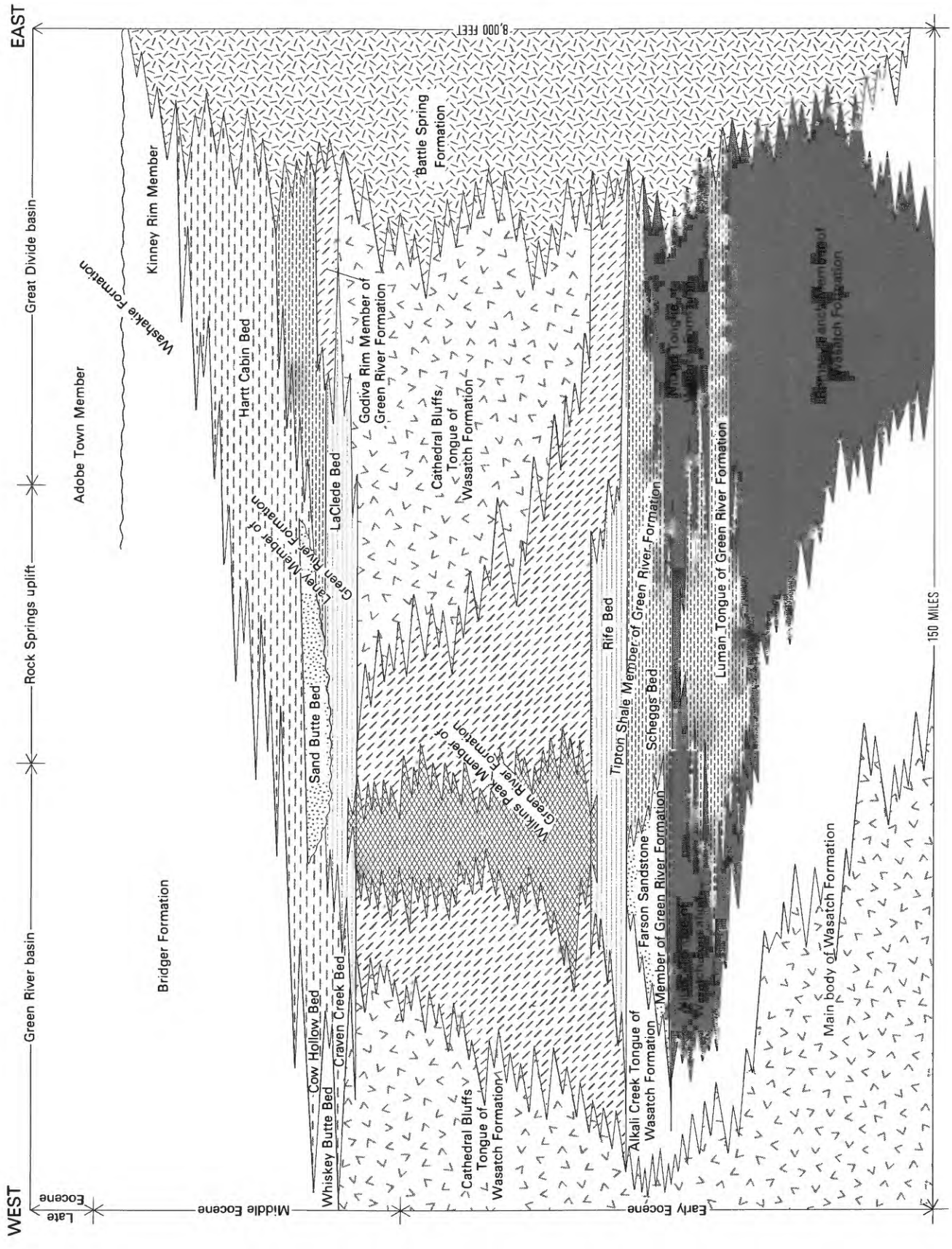
DEFINITION AND INTERTONGUING RELATIONSHIPS OF THE WASATCH, GREEN RIVER, AND BRIDGER (WASHAKIE) FORMATIONS

The Wasatch, Green River, and Bridger (Washakie) Formations are defined by their distinctive lithologies and fossils (Bradley, 1964, p. A18). The Wasatch and Bridger (Washakie) Formations are mostly composed of rocks of fluvial and paludal origin, whereas the Green River Formation is mostly composed of rocks of lacustrine origin. The Green River Formation was deposited in Eocene Lake Gosiute in topographically low parts of the ancestral greater Green River basin. The Green River Formation intertongues with and is laterally replaced by parts of the underlying Wasatch and overlying Bridger (Washakie) Formations around the margins of the basin, but it does not form a symmetrical central lens (fig. 2). The Battle Spring Formation is an arkosic fluvial facies equivalent to parts of the Wasatch, Green River, and Bridger (Washakie) Formations along the northeastern margin of the greater Green River basin.

The tongues and members of the Green River Formation are defined either by their distinctive lithologies that reflect the changing water salinities of Lake Gosiute, or by their intertonguing relationships with the Wasatch Formation (fig. 2). The salinity changes mostly correspond to lake expansions, contractions, and extinctions that were caused by Eocene climate changes. The tongues, members, and beds of the Green River Formation are superposed and in contact with each other in various parts of the basin to form a vertically contiguous stratigraphic unit, except for the Luman Tongue (fig. 2). The Luman is defined as a tongue of the Green River Formation, although no place is known in the basin where it is in contact with overlying parts of the formation.

DEPOSITIONAL ENVIRONMENTS

The depositional environments interpreted for the Eocene formations are from field observations. They are classified as fluvial, lacustrine, and paludal. Beds of airfall volcanic ash were also deposited at various stratigraphic levels. The fluvial environment is divided into three subenvironments characterized by lithofacies of flood-plain origin: (1) stream channel sandstone, (2) overbank splay sandstone and siltstone, and (3) interdistributary basin-fill siltstone, mudstone, and shale. The lacustrine environment is characterized by lithofacies divided into (1) freshwater sandstone (mostly shorelines), siltstone, organic limestone


EAST
WEST
8,000 FEET
150 MILES
Great Divide basin
Rock Springs uplift
Green River basin
Late Eocene
Middle Eocene
Early Eocene
Washakie Formation
Kinney Rim Member
Adobe Town Member
Bridger Formation
Hartt Cabin Bed
Cow Hollow Bed
Whiskey Butte Bed
Sand Butte Bed
Craven Creek Bed
Laney Member of Green River Formation
LaClede Bed
Godiva Rim Member of Green River Formation
Cathedral Bluffs Tongue of Wasatch Formation
Wilkins Peak Member of Green River Formation
Battle Spring Formation
Rife Bed
Tipton Shale Member of Green River Formation
Scheggs Bed
Farson Sandstone Member of Green River Formation
Alkali Creek Tongue of Wasatch Formation
Luman Tongue of Green River Formation
Main body of Wasatch Formation

(coquinas and stromatolites), inorganic limestone (partly oolites), shale, and oil shale; (2) saltwater or brackish-water sandstone, siltstone, organic limestone (mostly stromatolites), inorganic limestone, shale, and oil shale; (3) mudflat mudstone; and (4) freshwater pond limestone. The swamp (or paludal) environment is generally recognized by carbonaceous shale or coal and may include stream channel sandstone and splay sandstone and siltstone. The areal distribution of these environments and other subenvironments is illustrated and discussed at length in Chapter F of this volume.

LOCATION AND DESCRIPTION OF ROCKS COMPRISING THE GREEN RIVER BASIN EOCENE REFERENCE SECTION

Eocene rocks measured in the Green River basin reference section are 6,587 ft thick. The measured thicknesses (rounded to the nearest foot) for stratigraphic units are listed in table 1. Lithologies are described by numbered beds in the detailed section description (beginning on p. 44); they are illustrated graphically on plate 1.

WASATCH FORMATION

The Wasatch Formation has a combined total thickness of 1,718 ft in the Green River basin reference section, where it consists of one member and one tongue. The thicker lower member is called the main body of the formation. An overlying tongue, the Niland Tongue, is separated from the main body of the formation by the Luman Tongue of the Green River Formation (fig. 2).

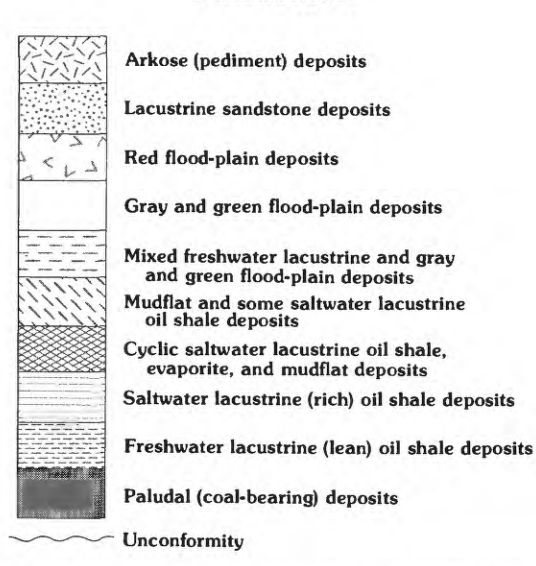


FIGURE 2 (above and facing page).—Generalized cross section showing stratigraphic nomenclature and depositional environments of Eocene rocks in greater Green River basin. Not to scale.

TABLE 1.—*Measured thicknesses, in feet, of Eocene stratigraphic units in Green River basin reference section*

Bridger Formation	2,106
Green River Formation:	
Laney Member:	
Hartt Cabin and Sand Butte Beds	1,040
LaClede Bed	259
Wilkins Peak Member	1,068
Tipton Shale Member:	
Rife Bed	69
Scheggs Bed	98
Luman Tongue	229
Wasatch Formation:	
Niland Tongue	482
Main body	1,236
Total thickness of Eocene rocks	6,587

MAIN BODY

The main body of the Wasatch Formation (beds 1–130, pl. 1) was measured along the south slopes of a gravel-covered terrace located west of Little Bitter Creek in S½SE¼ sec. 7, N½ sec. 17, and NE¼NE¼ sec. 18, T. 18 N., R. 105 W., 3 mi southwest of the city of Rock Springs. The main body measures 1,236 ft thick (rounded to the nearest foot) and is mostly composed of gray, green, and red mudstone and interbedded gray or tan sandstone and siltstone, all of fluvial (flood-plain) origin. The sandstone beds are either lenticular, trough-crossbedded stream channel deposits (beds 7, 38, 127, pl. 1), some of which contain conglomerate lenses or concretions, or extensive parallel-bedded splay deposits (bed 71, pl. 1). The mudstone usually weathers medium gray, and the sandstone mostly weathers gold brown.

NILAND TONGUE

The Niland Tongue (beds 182–216, pl. 1) was measured in south-center sec. 34, T. 17 N., R. 106 W., along the east end of a ridge that separates Little Firehole Canyon from Middle Firehole Canyon. The tongue measures 482 ft thick (rounded to the nearest foot) and was deposited in fluvial (flood-plain) environments similar to that of the main body of the formation. The Niland Tongue consists mostly of gray, green, and red

mudstone and interbedded gray or tan sandstone and siltstone. Thin beds of gray shale, gray dolomitic siltstone concretions, and brown carbonaceous shale are present at widely spaced vertical intervals through the tongue. Outcrops are generally variegated.

GREEN RIVER FORMATION

The Green River Formation in the Green River basin reference section has a combined total thickness of 2,763 ft. It is divided in ascending order into the Luman Tongue, Scheggs Bed of Tipton Shale Member, Rife Bed of Tipton Shale Member, Wilkins Peak Member, LaClede Bed of Laney Member, and undivided Sand Butte and Hartt Cabin Beds of the Laney Member (fig. 2).

LUMAN TONGUE

The Luman Tongue (beds 131–181, pl. 1) was measured on the north slopes of Middle Firehole Canyon in SE¼ sec. 34, T. 17 N., R. 106 W. The outcrops are found in small, deeply incised canyons separated by gently west dipping sandstone cap rocks. The Luman Tongue measures 229 ft thick (rounded to the nearest foot) and is composed of gray, green, and red mudstone and interbedded gray and red sandstone with minor thin beds of gray shale, gray-brown oil shale, brown carbonaceous shale, and coal. Outcrops weather drab gray and gray red. Where the reference section was measured, the tongue is composed of rocks that are laterally transitional from mostly lacustrine deposits that form the main body of the Luman Tongue to the south to entirely fluvial (flood-plain) deposits of the main body of the Wasatch Formation to the north. The coal beds in this transitional area were deposited along swampy lake margins. Some of the coal beds and adjacent carbonaceous shale beds (beds 131–136, 139–146, and 167–171, pl. 1) are radioactive. The origin and composition of similar radioactive beds in the overlying Niland Tongue of the Wasatch Formation were discussed by Leventhal and Finkelman (1987). Oil shale beds in the tongue contain abundant ostracodes, a few sandstone beds contain crustacean trace fossils, and some of the carbonaceous shale beds contain aquatic plant fragments.

SCHEGGS BED OF TIPTON SHALE MEMBER

The Scheggs Bed of the Tipton Shale Member (beds 217–235, pl. 1) was measured in the NE¼SW¼ sec. 34, T. 17 N., R. 106 W. across a low saddle developed along the ridge that separates Little Firehole Canyon from Middle Firehole Canyon. The bed crops out in smooth sage-covered slopes. It is 98 ft thick and consists of mostly brown fissile to papery oil shale with sparse thin gray or tan sandstone, siltstone, dolomite, limestone, and tuff beds. It is entirely of freshwater lacustrine origin. Outcrops of the bed weather drab brown, which contrasts sharply with overlying oil shales in the Rife Bed of the Tipton Shale Member of saline lacustrine origin that have a higher carbonate content and weather light gray. The Scheggs Bed has a mollusk-bearing shoreline sandstone at its base (bed 217, pl. 1), which contains the turreted gastropod, *Goniobasis tenera*, the large spired gastropod, *Viviparus* sp., and the large unionid pelecypod, *Lampsilis* sp. The basal fossiliferous sandstone is commonly used as a datum plane on stratigraphic cross sections. However, structure contour mapping along the west flank of the Rock Springs uplift has shown that the basal fossiliferous sandstone actually consists of several shoreline sandstones (for example, beds 217 and 221, pl. 1) that rise stratigraphically in steplike fashion from the deepest part of the lake basin (located south of the reference section) northward toward the lake margin (Roehler, unpub. data, 1961). The oil shale beds in the reference section contain numerous ostracodes and locally thin algal limestone.

RIFE BED OF TIPTON SHALE MEMBER

The Rife Bed of the Tipton Shale Member (beds 236–245, pl. 1) was measured on the north slopes of Middle Firehole Canyon in center S½ sec. 33, T. 17 N., R. 105 W., where it is 69 ft thick. It is composed of medium-brown to dark-brown, flaky, dolomitic oil shale, and very thin interbedded and interlaminated tan-brown dolomite and sparse thin gray tuff. Oil shale in the section weathers light gray to silver gray, dolomite beds weather orange, and tuff beds weather tan to rust brown. The bed generally forms a bench below less resistant rocks that make up the Wilkins Peak Member. The Rife Bed was deposited during a large, saltwater stage of Lake Gosiute. It is unfossiliferous in the reference section, but at nearby localities it contains thin beds of algal limestone and oolite.

WILKINS PEAK MEMBER

The lower part of the Wilkins Peak Member (beds 246–303, pl. 1) was measured in the NE¼SW¼ sec. 33, T. 17 N., R. 106 W., on the north slopes of Middle Firehole Canyon. The upper part of the member (beds

304–422, pl. 1) was measured on steep slopes along the east side of Flaming Gorge Reservoir in S½SW¼ sec. 31, T. 17 N., R. 106 W. and in NE¼NW¼ sec. 1, T. 16 N., R. 107 W. The member has a measured thickness of 1,068 ft (rounded to the nearest foot) and consists of interbedded tan to brown oil shale and clay shale, green mudstone, gray siltstone, tan to gray shale, and gray sandstone. A few thin beds of tan algal limestone, tan tuff, and brown clay pebble conglomerate are also present. Three laterally persistent tuff beds in the member (pl. 1) have been named the Firehole Bed, the main tuff marker bed (bed 392), and the layered tuff marker bed (bed 413). The member was deposited in central parts of the basin of Lake Gosiute during saltwater and evaporite stages. The oil shale, clay-shale, siltstone, sandstone, and mudstone beds comprise orderly vertical and horizontal successions of offshore, nearshore, shoreline, and backshore lithofacies, respectively, that are associated with climatic-related cyclic expansions and contractions of the lake waters. Mudstone beds near the middle and in the upper part of the member (pl. 1) contain abundant casts of shortite ($Na_2CO_3 \cdot CaCO_3$), an evaporite mineral. Economically important beds of the evaporite minerals trona and halite are present in central parts of the Green River basin 10–40 mi west of the reference section. Bed 303 (pl. 1) is an isolated occurrence of a fluvial channel sandstone that crossed a mudflat at the eastern margin of the lake during a contracted phase of the lake. Some water-worn and unidentifiable bone fragments were collected from bed 303. Disseminated plant material was found in beds 267 and 273, and insect fossils are fairly common in bed 416.

LACLEDE, SAND BUTTE, AND HARTT CABIN BEDS OF THE LANEY MEMBER

The Laney Member is divided in ascending order into the LaClede, Sand Butte, and Hartt Cabin Beds. The LaClede Bed was originally defined as the "Laney Shale Member" by Schultz (1920, p. 27–28). The upper boundary of the member as defined by Schultz has since been expanded to include the Sand Butte and Hartt Cabin Beds or their stratigraphic equivalents (fig. 2). The three beds that make up the Laney Member have a combined measured thickness of 1,299 ft (rounded to the nearest foot). The Hartt Cabin and Sand Butte Beds are not differentiated in the reference section because the outcrops across the contact of these beds are covered by soil and vegetation (bed 469, pl. 1).

The lower part of the Laney Member, including all of the LaClede Bed and the lower part of the Sand Butte Bed, was measured on the east slopes of Flaming Gorge Reservoir in NE¼NW¼ sec. 1, T. 16 N., R. 107 W. The remaining parts of the member, including the upper part of the Sand Butte Bed and all of the Hartt Cabin Bed, were measured on the west side of Flaming Gorge Reservoir. On the west side of the reservoir, the section begins at bed 462 (pl. 1) near the Squaw Hollow boat-launching ramp in NW¼SW¼ sec. 26, T. 14 N., R. 108 W. It continues westward across the center of secs. 27 and 28 to bed 471 (pl. 1) located west of Wyoming Highway 530 in the south-center sec. 29, T. 14 N., R. 108 W. From there the section moves several miles northward, using a persistent gray mudstone marker bed as a datum, to the north slopes of a flooded canyon on the west side of Flaming Gorge Reservoir in SW¼SE¼ sec. 8, T. 14 N., R. 108 W. The top of the Laney Member is placed on the top of bed 517 (pl. 1) in the NW¼NE¼ sec. 18, T. 14 N., R. 108 W. near where the section again crosses Wyoming Highway 530.

The LaClede Bed of the Laney Member (beds 424–460, pl. 1) is 259 ft thick. It consists of mostly brown oil shale and clay shale and minor thin interbedded gray siltstone, shale, and tuff. Beds 438–446 (pl. 1) of the LaClede Bed are oil shale, clay shale, and tuff beds that weather to a tan-brown groove in outcrops. The term buff marker was applied to these beds in the Washakie basin (Roehler, 1973a, p. E7). The LaClede Bed was deposited during a vertical succession of saltwater, brackish-water, and freshwater stages of Lake Gosiute. The lower contact of the bed is generally discernible in outcrops by a color change from gray-weathering rocks in the underlying Wilkins Peak Member to brown-weathering rocks in the LaClede Bed. The contact of the LaClede Bed and the overlying Sand Butte Bed is sharp and is defined by a regional unconformity that was first identified by Schultz (1920, p. 27). This unconformity was named the "Tower unconformity" by Roehler and Trudell (1981). The Sand Butte Bed (beds 461–469, pl. 1) is more than 225 ft thick and is mostly composed of tuffaceous sandstone, siltstone, and sandy mudstone that weathers to tan or brown cliffs, towers, or pinnacles. The Sand Butte Bed was formerly called the Tower Sandstone Lentil of the Laney Member of the Green River Formation, but that name was abandoned by Culbertson (1962, p. C54). The Sand Butte Bed is composed of shallow freshwater lacustrine and fluvial rocks deposited upon and adjacent to a minor middle Eocene uplift of the Rock Springs anticline. The Hartt Cabin Bed (from within bed 469 to 516, pl. 1) is probably more than 450 ft thick and comprises the top of the Laney Member. It is composed of thin interbedded tan, brown, gray, and green mudstone, shale, clay shale, carbonaceous shale, dolomite, sandstone, and

siltstone of shallow freshwater lacustrine origin that intertongue with fluvial (flood-plain) deposits of the laterally equivalent and overlying Bridger Formation (fig. 2). The Hartt Cabin Bed represents the final stages of deposition in Lake Gosiute in the Green River basin. No fossils were identified in the LaClede and Sand Butte Beds, but invertebrate, vertebrate, and plant fossils are abundant in the Hartt Cabin Bed (pl. 1).

BRIDGER FORMATION

The lower part of the Bridger Formation (beds 518–582, pl. 1) was measured across badlands in the Devils Playground on the northeast slopes of Black Mountain in SW¼ sec. 7 and N½ sec. 18, T. 14 N., R. 108 W. and S½ sec. 10, SW¼ sec. 11, SE¼SE¼ sec. 12, NE¼ sec. 13, and NW¼ sec. 15, T. 14 N., R. 109 W. The upper part of the Bridger Formation (beds 583–624, pl. 1) was measured on steep slopes at the southwest edge of Black Mountain in SW¼ sec. 36, T. 14 N., R. 110 W., and near the southwest corner of Twin Buttes in S½ and NE¼ sec. 12, T. 13 N., R. 110 W.

The Bridger Formation measures 2,106 ft thick (rounded to the nearest foot). It consists of a monotonously uniform sequence of interbedded gray and green mudstone and sandstone of fluvial (flood-plain) origin, and some thin interbeds of gray or tan limestone and brown clay shale of lacustrine origin and gray or white tuff of airfall volcanic ash origin. A few beds of red mudstone and gray conglomerate of flood-plain origin and brown carbonaceous shale of swamp origin are present in widely spaced vertical intervals. The formation cannot be subdivided into members, zones, or stratigraphic levels strictly on the basis of lithology. Faunal zonation supported by persistent stratigraphic marker beds has been used to subdivide the formation, but the boundaries of the faunal zones are vague and controversial, and some of the marker beds have been miscorrelated.

BISHOP CONGLOMERATE CAPPING TWIN BUTTES

The Twin Buttes are capped by 29 ft of gray-brown conglomerate (bed 625, pl. 1) composed of mostly well rounded and poorly sorted granules, pebbles, cobbles, and boulders of red quartzite, tan and white quartzite, and gray limestone in a coarse-grained sandstone matrix. The conglomerate rests unconformably on the Bridger Formation. The composition and stratigraphic position of the conglomerate indicate that it is an isolated remnant of the Bishop Conglomerate, which is considered to be Oligocene age.

TABLE 2.—*Measured thicknesses, in feet, of Eocene stratigraphic units in Washakie basin reference section*

Washakie Formation:	
Adobe Town Member	2,326
Kinney Rim Member	851
Green River Formation:	
Laney Member:	
Sand Butte Bed	850
LaClede Bed	470
Wilkins Peak Member	119
Tipton Shale Member:	
Rife Bed	120
Scheggs Bed	63
Luman Tongue	293
Wasatch Formation:	
Cathedral Bluffs Tongue	827
Niland Tongue	329
Main body	1,691
Total thickness of Eocene rocks	7,939

LOCATION AND DESCRIPTION OF ROCKS COMPRISING THE WASHAKIE BASIN EOCENE REFERENCE SECTION

Eocene rocks measured in the Washakie basin reference section are 7,939 ft thick. The thicknesses (rounded to the nearest foot) for stratigraphic units are listed in table 2. Lithologies are described by numbered beds in the detailed section description (beginning on p. 59); they are illustrated graphically on plate 2.

WASATCH FORMATION

The Wasatch Formation in the Washakie basin reference section is divided into the main body of the formation at the base and two overlying tongues, the Niland and Cathedral Bluffs. The Niland Tongue is separated from the underlying main body of the formation by the Luman Tongue of the Green River Formation, and the Cathedral Bluffs Tongue is separated from the underlying Niland Tongue by the Tipton Shale Member and Wilkins Peak Member of the Green River Formation (fig. 2).

MAIN BODY

The main body of the Wasatch Formation was measured along the south side of the Brady oil and gas field in T. 16 N., R. 101 W. The section begins at the base of Eocene rocks on the east slopes of Burley Draw in SE¼ sec. 19, continues eastward across badlands located in the S½ sec. 17, SW¼ sec. 16, N½ sec. 21, NW¼ sec. 22,

N½ sec. 35, and ends on the west slopes of a low bench capped by sandstones in the basal part of the Luman Tongue of the Green River Formation in west-center sec. 36. The location of the section is shown on the index map, plate 2; it is plotted in greater detail on the Kinney Rim 30′×60′ quadrangle map (Roehler, 1985).

The main body of the Wasatch Formation (beds 3–168, pl. 2) measures 1,691 ft thick (rounded to the nearest foot) and consists mostly of gray and green mudstone and gray sandstone and some thin interbedded tan or gray limestone, gray, black, green, or brown shale, red mudstone, gray siltstone, and gray or brown carbonaceous shale. The main body is primarily of fluvial (flood-plain) origin and consists of stream channel and splay sandstone and basin-fill mudstone. Thin pond limestone and carbonaceous swamp deposits are present at various intervals in the section and are abundant in the upper part. The overall section weathers drab medium gray. Numerous vertebrate, invertebrate, and trace fossils are present at the stratigraphic levels indicated in the columnar section, plate 2. Fossil identifications are listed in the complete section description, beginning on p. 59.

NILAND TONGUE

The Niland Tongue was measured on the lower west slopes of Kinney Rim west of Sand Butte in NE¼ sec. 36, T. 16 N., R. 101 W., center sec. 25, T. 16 N., R. 100½ W., and NW¼ sec. 30, T. 16 N., R. 100 W. The section parallels an east-west-trending road that climbs the west face of Kinney Rim and then continues eastward between Sand Butte and Pine Butte into the Washakie basin. The Niland Tongue crops out in a shallow, narrow, partly alluvium filled valley situated between ridges formed by resistant lacustrine sandstone beds in the underlying Luman Tongue and algal limestone beds in the overlying Rife Bed of the Tipton Shale Member.

The Niland Tongue (beds 205–248, pl. 2) measures 329 ft thick (rounded to the nearest foot) and is composed of interbedded deposits of lacustrine, fluvial, and swamp origin. The lower part of the tongue (beds 212–231, pl. 2) is chiefly fluvial (flood-plain) deposits consisting of stream channel and splay sandstone and basin-fill mudstone and some thin interbedded pond limestone. The upper part of the Niland Tongue (beds 232–248, pl. 2) is also mostly fluvial (flood-plain) deposits but contains several thin beds of carbonaceous shale (beds 232, 240, 245, and 248, pl. 2) that reflect swamp conditions present between and adjacent to small, shallow, freshwater lakes. Vertebrate, mollusk, and trace fossils are present at the stratigraphic levels indicated on plate 2.

CATHEDRAL BLUFFS TONGUE

The Cathedral Bluffs Tongue was measured between Sand Butte and Pine Butte on the west slopes of Kinney Rim (pl. 2). The lower part of the tongue (beds 295–356, pl. 2) was measured in NE¼ sec. 32 and NW¼ sec. 33, T. 16 N., R. 100 W., and the upper part of the tongue (beds 357–372, pl. 2) was measured in SE¼NE¼ sec. 21, T. 16 N., R. 100 W. The tongue measures 827 ft thick (rounded to the nearest foot) and is recognized in outcrops by its red banding.

The Cathedral Bluffs Tongue can be divided into three stratigraphic units in the Washakie basin reference section: (1) a lower dominantly gray and green mudstone unit (beds 295–322, pl. 2) consisting of thin interbedded red and maroon mudstone, tan and gray siltstone, gray sandstone, brown carbonaceous shale, and tan oolitic and algal limestone, (2) a middle dominantly red and maroon variegated mudstone unit (beds 323–334, pl. 2) containing thin interbedded gray, green, orange, and brown mudstone, and gray claystone and sandstone, and (3) an upper dominantly gray and green mudstone and shale unit (beds 335–372, pl. 2) with thin interbedded red mudstone, tan and gray sandstone and siltstone, brown carbonaceous shale, and tan and gray oolitic and algal limestone. The lower and upper units were deposited in mixed fluvial (flood-plain), lacustrine, and mudflat environments, and the middle unit was deposited entirely in a fluvial (flood-plain) environment. Vertebrate, trace, and wood fossils are abundant in the tongue. Mud cracks were observed in beds 308, 336, and 355 (pl. 2).

GREEN RIVER FORMATION

The Green River Formation in the Washakie basin reference section is 1,914 ft thick. It is divided in ascending order into the Luman Tongue, Scheggs Bed of the Tipton Shale Member, Rife Bed of the Tipton Shale Member, Wilkins Peak Member, LaClede Bed of the Laney Member, and Sand Butte Bed of the Laney Member (fig. 2). The Hartt Cabin Bed of the Laney Member is not present at the location where the reference section was measured, but it is present in other parts of the Washakie basin.

LUMAN TONGUE

The Luman Tongue was measured in N½ sec. 36, T. 16 N., R. 100 W. Outcrops in the lower part of the tongue (beds 169–197, pl. 2) weather drab gray brown and form small ledges on west-facing slopes. Outcrops

in the upper part of the tongue consist mostly of prominent ledge-forming lacustrine shoreline sandstones (beds 198–203, pl. 2) that are overlain by soft, nonresistant oil shales (bed 204, pl. 2). The shoreline sandstones form persistent ledges that can be correlated for miles along the lower west slopes of Kinney Rim.

The Luman Tongue measures 293 ft thick (rounded to the nearest foot) and is composed of brown to gray-brown oil shale, gray, partly mollusk bearing sandstone, gray and brown shale, dark-brown carbonaceous shale, and brown mollusk-bearing limestone. Freshwater mollusks are abundant throughout the tongue, and the assemblage is commonly characterized by the large prosobranch gastropods, *Goniobasis tenera* and *Viviparus* sp., and by the large unionid pelecypod, *Lampsilis* sp. Fish, ostracode, and trace fossils are also present (pl. 2).

SCHEGGS BED OF TIPTON SHALE MEMBER

The Scheggs Bed of the Tipton Shale Member was measured in NW¼ sec. 30, T. 16 N., R. 100 W. It crops out along smooth west-facing slopes below a ridge capped by algal limestones (beds 257, 259, pl. 2) in the overlying Rife Bed of the Tipton Shale Member. The contact of the Scheggs Bed with the Rife Bed is at the base of these ledge-forming algal limestones, which coincides with a color change in weathered outcrops from drab brown in the Scheggs Bed to chalky gray in the Rife Bed. The contact of the Scheggs Bed with the underlying Niland Tongue is at the base of the lowermost oil shale bed that overlies nonlacustrine barren shale and sandstone (pl. 2).

The Scheggs Bed (beds 249–256, pl. 2) measures 63 ft thick (rounded to the nearest foot) and consists mostly of brown to gray fissile to papery oil shale. Thin beds of sandstone and interbedded carbonaceous shale (beds 250–252, pl. 2) are present in the lower part. The sediments that compose the bed were deposited on the bottom and along the swampy margins of a large freshwater lake. Ostracodes are abundant in most of the oil shale beds, and mollusks, including *Goniobasis* sp., were identified in bed 252 (pl. 2).

RIFE BED OF TIPTON SHALE MEMBER

The Rife Bed of the Tipton Shale Member was measured across the N½ sec. 30, T. 16 N., R. 100 W., west of Sand Butte (pl. 2). The bed weathers chalky gray and forms slopes that rise in step fashion from west to east. The basal contact of the bed, as just discussed, is at the base of a ridge-forming algal limestone (bed 257, pl. 2). The upper contact is at the base of the lowermost green claystone (of the Wilkins Peak Member; bed 269, pl. 2) that overlies the thick oil shale beds (beds 266, 268, pl. 2) that comprise the bulk of the Rife Bed. Stratigraphic correlations of the Rife Bed and the Wilkins Peak Member in outcrops along the eastern and western margins of the Washakie basin (Roehler, 1981, 1989) reveal that the two units are partly intertongued.

The Rife Bed (beds 257–268, pl. 2) measures 120 ft thick (rounded to the nearest foot) in the reference section and consists of brown to dark-brown oil shale and thin interbedded tan algal limestone and dolomite. The sediments that formed the Rife Bed were deposited on the bottom and along the shorelines of a large saltwater lake. Excluding the algal limestone and a few ostracodes found in bed 261 (pl. 2), the Rife is barren of fossils.

WILKINS PEAK MEMBER

The Wilkins Peak Member was measured in NE¼ sec. 30, N½ sec. 29, and SW¼SE¼ sec. 19, T. 16 N., R. 100 W. along the slopes of Dripping Rock Draw west of Sand Butte. The member weathers chalky gray and crops out as a series of low benches capped by sandstone or algal limestone that rise eastward in upslope directions. Much of the member between these benches is covered by soil, sagebrush, and other desert vegetation. The Wilkins Peak Member intertongues with the Cathedral Bluffs Tongue of the Wasatch Formation, and the contact of these units is at the base of the lowermost bed with red coloration (bed 295, pl. 2) in the intertongued sequence.

The Wilkins Peak Member (beds 269–294, pl. 2) measures 119 ft thick (rounded to the nearest foot). It is composed of green claystone and mudstone and interbedded brown oil shale, gray sandstone, gray to tan limestone, algal limestone, and dolomite. The sediments of the member were mostly deposited in deep saltwater lakes and on mudflats adjacent to the lakes. Bed 276 (pl. 2) contains isolated concentrations of bird and fish bones in a ledge-forming sandstone. The bird bones were identified as belonging to a primitive flamingo (P.O. McGrew, oral commun., 1972). Bed 281 is a soft claystone which contains fossils of unidentified plant fragments, fish bones, and ostracodes.

LACLEDE BED OF LANEY MEMBER

The LaClede Bed, the basal oil shale unit of the Laney Member, was measured on the west slopes of Kinney Rim in NW¼NE¼ sec. 19, and SE¼ sec. 18,

T. 14 N., R. 99 W. The measured section parallels the south edge of a road that crosses Kinney Rim a few miles north of the Pioneer gas field. The LaClede Bed crops out as a series of cliffs and ledges that are interrupted by narrow, steep slopes. The bed is well exposed, but the contact with the underlying Cathedral Bluffs Tongue of the Wasatch Formation is partly obscured by slope wash. The LaClede Bed (beds 373–452, pl. 2) measures 470 ft thick (rounded to the nearest foot) and is composed mostly of brown to black oil shale and some thin interbedded gray sandstone, tan and gray limestone and shale, gray siltstone, brown clay shale, tan claystone and tuff, and gray analcimic tuff. Beds containing large amounts of tuff commonly form tan or buff grooves in outcrops (beds 388, 405, and 423, pl. 2). One of these grooves, the buff marker bed (bed 423), forms an easily recognized stratigraphic unit in outcrops along the west side of the Washakie basin (Roehler, 1973a, p. E7). The silver bench that underlies the buff marker bed is an informal name used to describe an interval of silver-gray-weathering rich oil shale beds (Trudell and others, 1973, fig. 5). The LaClede Bed was deposited in the largest of the Green River lakes (Lake Gosiute) during the hottest, wettest period of the Eocene. The lake was saline in the basal part of the LaClede Bed, but it freshened upward. It was probably a fresh body of water by the time of deposition of beds 444 and 448 (pl. 2), which contain gastropods and other unidentified mollusk shell fragments. Oolites, pisolites, insects, fish, and plant fragments are present in various other beds (pl. 2). The contact of the LaClede Bed with the overlying Sand Butte Bed is marked by the regional unconformity that was identified by Schultz (1920), Bradley (1964), Roehler (1973a), and Trudell and others (1973).

SAND BUTTE BED OF LANEY MEMBER

The Sand Butte Bed of the Laney Member (beds 453–514, pl. 2) was measured across the crest of Kinney Rim in SE¼ sec. 18, S½ sec. 17, S½ sec. 16, and N½SW¼ sec. 15, T. 14 N., R. 99 W. The bed crops out as a series of high-standing, steeply eastward dipping hogback ridges capped by resistant limestone and sandstone that are separated by less resistant mudstone and shale valleys. The elevations of the crests of the hogback ridges progressively decrease eastward down the east slopes of Kinney Rim. The Sand Butte Bed weathers mostly drab tan and gray. It measures 850 ft thick and consists of tan tuffaceous, partly mollusk bearing sandstone and siltstone, and thin interbedded gray, red, or brown sandstone and siltstone, brown oil shale, tan, white or gray tuff, tan, gray, or brown, partly fossiliferous limestone, gray, brown, or green mudstone, and gray conglomerate. The presence of freshwater mollusks in beds 455, 456, 475, 478, and 498 (pl. 2) indicates that the bed was deposited in shallow freshwater stages of Lake Gosiute. Wood, leaf, trace, ostracode, and fish fossils were identified in various beds as indicated on plate 2. Mudcracks are present near the top of bed 493. Other significant lithologies include a radioactive tuff, bed 492, and a persistent ridge-forming algal limestone, bed 514, that defines the contact of the Sand Butte Bed with the overlying Washakie Formation.

The Hartt Cabin Bed of the Laney Member, as discussed previously, is not present in the southwest part of the Washakie basin in the area where the reference section was measured. It is present in other parts of the basin where it intertongues with and grades laterally into the Sand Butte Bed of the Laney Member and the Kinney Rim Member of the Washakie Formation (Roehler, 1973a, 1985).

WASHAKIE FORMATION

The Washakie Formation in the Washakie basin is divided into a lower Kinney Rim Member (beds 515–568, pl. 2) and an upper Adobe Town Member (beds 569–708, pl. 2) by minor lithologic changes and a basinwide unconformity (Roehler, 1973a, p. 12). The unconformity is located at the base of a 25-ft-thick ridge-forming sandstone known informally as the lower brown sandstone, bed 569 (pl. 2).

The Kinney Rim and Adobe Town Members were mostly deposited in fluvial (flood-plain) environments during the influx of large quantities of airfall volcanic ash. The Kinney Rim Member measures 851 ft thick (rounded to the nearest foot) and is composed of gray, green, and some red mudstone and interbedded gray and gray-green sandstone, gray limestone and siltstone, and gray to white tuff. The Adobe Town Member measures 2,326 ft thick (rounded to the nearest foot) and is composed of gray, green, and red tuffaceous mudstone alternating with gray tuffaceous and arkosic sandstone and minor thin beds of green shale, gray and green tuff, and gray siltstone and conglomerate. The top of the Adobe Town Member is the top of Eocene rocks in the Washakie basin. Vertebrate, invertebrate, plant, and trace fossils are abundant in both the Kinney Rim and Adobe Town Members (pl. 2).

KINNEY RIM MEMBER

The Kinney Rim Member was measured on the lower east slopes of Kinney Rim across the S½ sec. 16 and

N½SW¼ sec. 15, T. 14 N., R. 99 W. The outcrops consist of tan and gray hogback ridges capped by resistant limestone and sandstone that are separated by less resistant mudstone and shale. The most distinctive stratigraphic marker beds in the section are bed 540, a white tuff, and beds 560–563, an interval of mostly red and gray banded mudstones and sandstones.

ADOBE TOWN MEMBER

The Adobe Town Member was measured in five segments. The basal part, beds 569–579 (pl. 2), was measured in N½SW¼ sec. 15, T. 14 N., R. 99 W. at the base of the east slopes of Kinney Rim. Beds 580–628 were measured in NW¼ sec. 29 and SW¼ sec. 20, T. 13 N., R. 98 W., between small unnamed tributaries of Shell Creek that flow eastward from Kinney Rim. Beds 629–675 were measured in NE¼NW¼ sec. 29, W½ sec. 19, and W½ sec. 17, T. 13 N., R. 97 W. across the headwaters of Skull Creek that forms the major drainage system between Cherokee Ridge near the south margin of the Washakie basin and Skull Creek Rim within the basin to the north. Beds 676–687 and 688–708 were measured in NW¼ sec. 30 and S½ sec. 31, T. 15 N., R. 97 W. along the west rim of a badland area known as Adobe Town.

PREVIOUS CORRELATIONS OF EOCENE ROCKS IN THE GREEN RIVER AND WASHAKIE BASINS

Eocene rocks have been correlated in the Green River and Washakie basins biostratigraphically, chronostratigraphically, and lithostratigraphically. The earliest correlations were biostratigraphic by the vertebrate paleontologists Matthew (1909), Granger (1909), and Osborn (1929), who attempted to establish time zones or stratigraphic horizons based on age-diagnostic fossil mammals. Similar, more recent, biostratigraphic correlations were made by Turnbull (1978). The work of Matthew, Granger, Osborn, and Turnbull was restricted to very fossiliferous middle and upper Eocene rocks. Additional biostratigraphic correlations involving early Eocene fossil mammals were attempted by Gazin (1962). Chronostratigraphic correlations have combined the faunal data assembled by Wood and others (1941) with the radiometric dating of biotites in tuffs by Evernden and others (1964). Lithostratigraphic correlations have been made by numerous authors, including Schultz (1920), Sears and Bradley (1925), Gazin (1959), McGrew and Roehler (1960), Bradley (1964), Roehler (1974), and Sullivan (1980). The various methods that have been employed to correlate Eocene rocks in the Green River and Washakie basins are discussed in following paragraphs.

BIOSTRATIGRAPHIC CORRELATIONS

The Bridger Formation in the Green River basin was divided by Matthew (1909) into five faunal zones, A, B, C, D, and E, that are defined by thin "white layer" marker beds consisting of either lacustrine limestone or tuff. The areal distribution and a cross-sectional profile of the five faunal zones envisioned by Matthew (1909, pl. 42) are shown in figure 3. The stratigraphy of the five faunal zones of Matthew was illustrated graphically (fig. 4) in a columnar section constructed years later by Osborn (1929, fig. 55, p. 80). Note that in Matthew's cross-sectional profile (fig. 3) the Bridger A-B levels are shown to wedge out eastward across the Green River basin upon a regional unconformity. Stratigraphic investigations by Bradley (1964, p. A18) have correctly demonstrated that the A–B levels intertongue eastward and are partly replaced from the base upwards by the Laney Member of the Green River Formation. Biostratigraphic work by Kistner (1973) provides conclusive evidence that parts of both the Bridger A and B levels are present east of Matthew's line of cross section along the west side of the Rock Springs uplift.

The upper three faunal zones of the Bridger Formation, C, D, and E, are identified in the Green River basin reference section (pl. 1) by two of the white layer marker beds named by Matthew (1909). The lowermost of these layers, the Burnt Fork white layer, consists of a gray ledge-forming limestone (bed 549, pl. 1) that weathers to a wide bench in outcrops along the northern margins of Black Mountain in sec. 10, T. 14 N., R. 109 W. As indicated by Matthew (1909), the Burnt Fork white layer is situated near the middle of Bridger C. The Burnt Fork white layer corresponds to the Sage Creek white layer as defined and mapped by Bradley (1964, p. A51, pl. 1).

The upper white layer of Matthew (1909) is stratigraphically higher than the Burnt Fork (Sage Creek) white layer and is the uppermost recognizable marker bed in the reference section (pl. 1). It consists of a gray silty tuff (bed 595, pl. 1) that encircles the upper parts of Twin Buttes and Black Mountain in T. 13–14 N., R. 109–110 W. The upper white layer is the only distinctive stratigraphic unit in a thick interval composed mostly of homogeneous mudstone, and it was consequently used as an arbitrary boundary separating the middle and upper Eocene in the reference section (pl. 1).

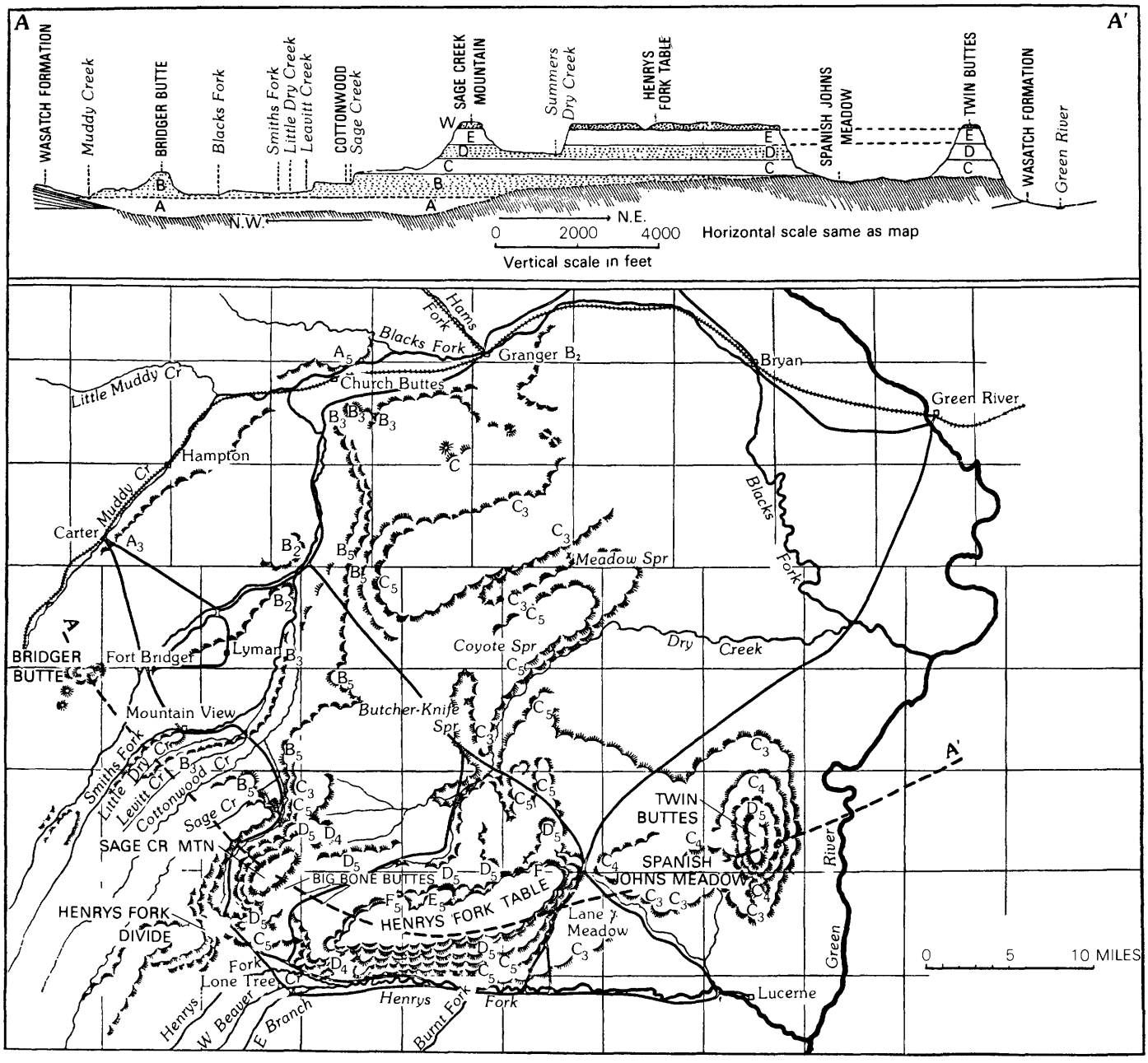


FIGURE 3.—Cross-sectional profile and map of Bridger A, B, C, D, and E faunal zones in Green River basin, Wyoming. Linework from Matthew (1909).

Bradley's (1964, pl. 1) Sage Creek white layer (bed 549, pl. 1) is the only marker bed that can be mapped continuously across the southern part of the Green River basin. The remaining white layers are local in extent. According to Koenig (1960, p. 165) and West (1976, p. 5), many of the white layer marker beds have been incorrectly correlated. Bradley's (1964) Sage Creek white layer was used in the reference section (pl. 1) to informally divide the Bridger Formation into a lower part, 540 ft thick, and an upper part, 1,565 ft thick. The lower and upper parts as thus defined are approximate equivalents of the informal biostratigraphic terms Blacks Fork member and Twin Buttes member of the Bridger Formation as defined by Wood and others (1941).

The Washakie Formation in the Washakie basin was divided biostratigraphically by Granger (1909) into a lower part, Washakie A or *Uintatherium* zone, and an upper part, Washakie B or *Eobasileus* zone (fig. 5). Granger's Washakie A included the stratigraphic

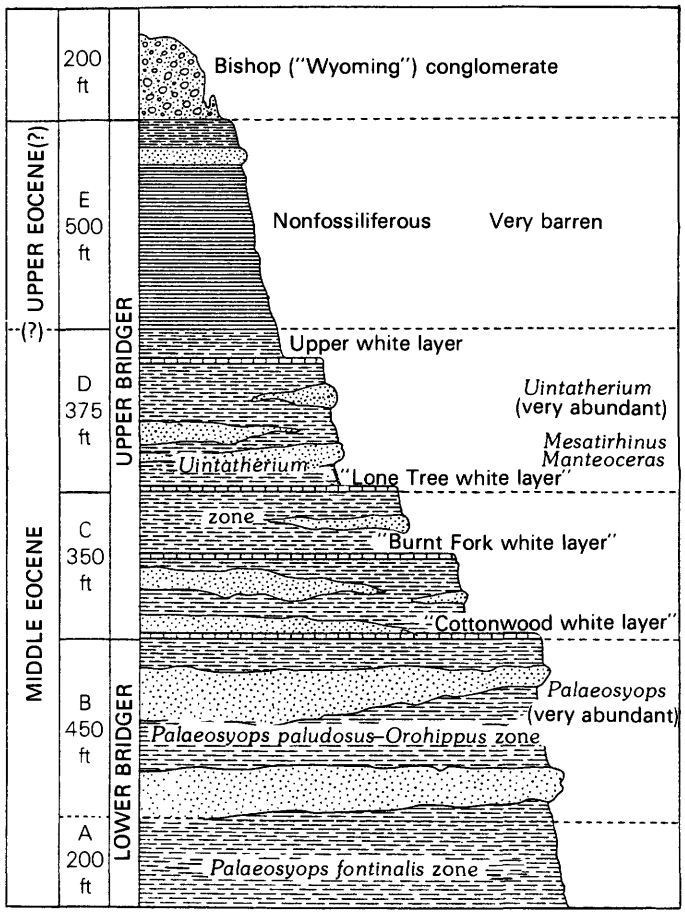


FIGURE 4.—Columnar section of the Bridger Formation in Green River basin showing faunal zones A-E and stratigraphic positions of white layer marker beds. Linework from Osborn (1929).

interval from the base of his bed 1 (fig. 5), the lower brown sandstone (bed 569, pl. 2), upward to his bed 11 (beds 620–622, pl. 2). Granger's Washakie B included the section from his bed 11 upward to his bed 22 (fig. 5), which is equivalent to beds 623–676 (pl. 2). Bed 22 comprises the uppermost Eocene rocks that are exposed in Granger's measured section on Haystack Mountain in the north-central part of the basin. Granger's measured section (fig. 5) does not include the upper and lower parts of the Washakie Formation as it was redefined by Roehler (1973b). Nearly 300 ft of the formation (beds 677–708, pl. 2) overlies the level of Granger's bed 22 at Skull Creek Rim, 15–20 mi southwest of Haystack Mountain. An additional 900 ft of the Washakie Formation (beds 515–568, pl. 2) underlies Granger's bed 1 (fig. 5). Granger apparently ignored the fact that King (1877, p. 214) had previously reported the presence of strata equivalent to the Washakie Formation below his bed 1 on the east slopes of Kinney Rim in the southwestern part of the basin. King (1877, p. 216) also noted that the beds at the top of Haystack Mountain were not the uppermost Eocene rocks (Washakie Formation) in the Washakie basin. The beds measured by Granger on Haystack Mountain (fig. 5, probably by altimeter) range from 25 to 60 percent less in thickness than the thicknesses of the beds shown by Roehler (1973b, pl. 2, measured by Jacob's staff and Abney level) for the same section.

The differences in the stratigraphic positions of the mammalian genera by which faunal zones were identified in the Green River and Washakie basins were described by Granger (1909, p. 22). Granger concluded that the genera from Washakie A in the Washakie basin are nearly identical to those of Bridger C and D in the Green River basin, which are middle Eocene age (compare figs. 4 and 5). The genera from Washakie B, however, were distinct from those of Washakie A and Bridger C and D. They closely resembled the genera from Uinta A and B in the Uinta basin in northeast Utah (Osborn, 1929, p. 91), which are late Eocene age. The uppermost Eocene rocks of Osborn (1929) in the Green River basin are Bridger E (beds 604–624, pl. 1), and these rocks, although unfossiliferous and undated, occupy the approximate stratigraphic position of the lower part of the upper Eocene rocks in the Washakie basin (beds 629–645, pl. 2).

Turnbull (1978) collected fossil mammals from 77 localities in the Washakie Formation in the Washakie basin over a period of 20 years beginning in 1956. From

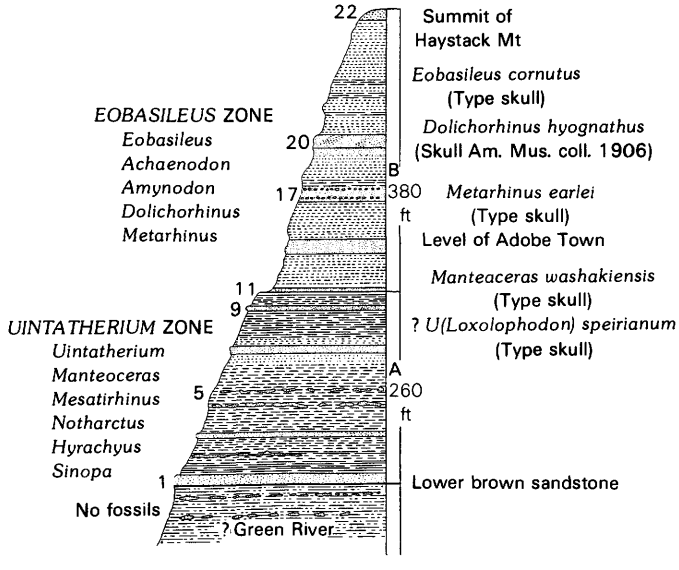


FIGURE 5.—Columnar section of the Washakie Formation at Haystack Mountain in the Washakie basin showing numbered beds in faunal divisions A and B. Linework from Granger (1909).

preliminary fossil identifications, he divided the formation into four parts using the same stratigraphic nomenclature and bed numbers that are used in this report. Turnbull's (1978, p. 573–579) four parts in ascending sequence are (1) the Kinney Rim Member, beds 515–568; (2) the lower 878 ft of the Adobe Town Member, beds 569–628; (3) the middle 1,101 ft of the Adobe Town Member, beds 629–675; and (4) the upper 341 ft of the Adobe Town Member, beds 676–708. Turnbull (1978, p. 577) equated the Kinney Rim Member to Bridger A and B in the Green River basin, and the lower part of the Adobe Town Member to Bridger C and D in the Green River basin. He equated the middle Adobe Town Member to Uinta A and B in the Uinta basin, and the upper part of the Adobe Town Member to Uinta C and D in the Uinta basin.

CHRONOSTRATIGRAPHIC CORRELATIONS

The boundaries and ages of the lower, middle, and upper Eocene rocks shown on the reference sections, plates 1 and 2, were determined by a combined faunal and radiometric age-dating method. The criteria for establishing the timelines were initially based on the stratigraphic occurrence of index fossils and the first and last appearance of fossil mammals (Wood and others, 1941, p. 8). The work of Wood and others (1941) resulted in the faunal division of continental Eocene rocks into lower, middle, and upper parts named the Wasatchian, Bridgerian, and Uintan provincial ages, respectively. Evernden and others (1964, p. 165) later determined the physical ages (in millions of years before present) for these provincial ages by analyzing potassium-argon in biotite from tuff beds at various levels in the Eocene sections. By this method "North American land mammal ages" were established. The North American land mammal ages do not correspond to the European ages (Ypresian, Lutetian, Bartonian, and Priabonian), to the numerical time scales established worldwide for Eocene chronostratigraphic units (Salvador, 1985), or to the boundaries of lithostratigraphic units in the Green River basin and Washakie basin reference sections (this report).

The accuracy of the faunal and radiometric age-dating method has been seriously questioned in recent years. Opinions differ concerning unsubstantiated morphological and temporal factors and the effects of local paleoecology on mammalian evolution. Also, attempts by Mauger (1977) using potassium-argon to date 12 tuffs that form persistent stratigraphic marker beds in the Green River and Washakie basins proved unsuccessful. The ages he determined for the marker beds ranged from 34 to 153 million years, and many were chronologically out of order. Some of the biotites were altered and degraded, and it was difficult to separate those of volcanic origin from those of extraneous detrital origin.

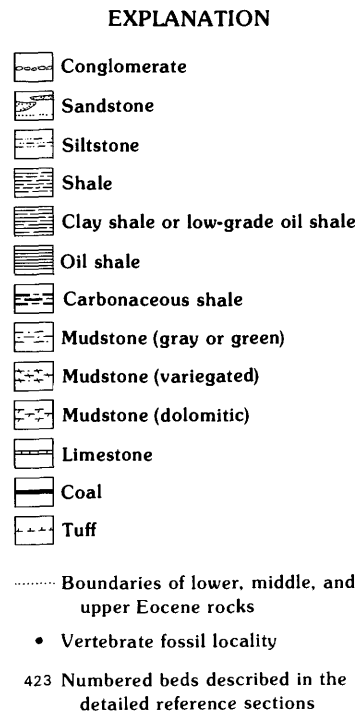
Although the faunal and radiometric method of correlating and dating is probably inappropriate for determining the age of Eocene rocks in the greater Green River basin, I have nonetheless used it in this report because of its historical precedence. Note, however, that the chronostratigraphic terms lower, middle, and upper Eocene are used in preference to the synchronous faunal terms Wasatchian, Bridgerian, and Uintan provincial ages.

LITHOSTRATIGRAPHIC CORRELATIONS

Eocene lithostratigraphic units were not accurately correlated across the greater Green River basin area until the work of Schultz (1920). Schultz (1920, p. 27–30) named the Tipton Shale and Laney Members of the Green River Formation and the Cathedral Bluffs Tongue of the Wasatch Formation, and he correlated these and other Eocene strata from the west side of the Rock Springs uplift (the Green River basin) to the east side of the Rock Springs uplift (the Washakie basin). Later, Sears and Bradley (1925, fig. 10, p. 99) correlated the same units from a section measured near Green River, Wyo., to sections measured 70–90 mi to the southeast at Lookout Mountain and near the Little Snake River in northwest Colorado. Gazin (1959, fig. 1, p. 134) prepared one of the first correlation charts that showed the approximate relationships of Eocene stratigraphic units, ages, and faunal horizons in basins adjacent to the Uinta Mountains. McGrew and Roehler (1960, p. 156) subsequently prepared a similar correlation chart for Eocene formations in southwest Wyoming. In an appraisal of Eocene rocks, Bradley (1964, fig. 6, p. A18) drew a simple diagrammatic section of the greater Green River basin on which he correlated the members and tongues of the Wasatch, Green River, and Bridger Formations. An interbasin correlation of Eocene stratigraphic units was published by Roehler (1974, fig. 4, p. 63) for the Green River and Washakie basins in southwest Wyoming, the Sand Wash and Piceance Creek basins in northwest Colorado, and the Uinta basin in northeast Utah (a modified version of this correlation appears in Chapter E of this volume). A detailed report covering the intertonguing relations, age, thickness, environments of deposition, and areal distribution of lithofacies of Eocene rocks in southwest Wyoming was published by Sullivan (1980).

CORRELATION OF THE GREEN RIVER AND WASHAKIE BASIN REFERENCE SECTIONS

Eocene strata in the Green River and Washakie basin reference sections show remarkably similar thicknesses and lithologies. These relationships are discernible on a generalized correlation diagram, figure 6. The correlations in figure 6 are based on the composition and stratigraphic position of persistent marker beds and the boundaries of major lithologic units that distinguish depositional events that occurred contemporaneously in both basins. The age or timing of many of these events is corroborated by the evidence of vertebrate fossils. More precise correlations than those of figure 6 are possible using plates 1 and 2 and the bed descriptions in the detailed reference sections herein. Note that the Eocene section is about 1,350 ft thicker in the Washakie basin reference section than it is in the Green River basin reference section, and that the upper 875 ft of rocks in the Washakie basin is missing by nondeposition or erosion in the Green River basin.



ANALYSIS OF EOCENE ROCKS IN THE WASHAKIE BASIN REFERENCE SECTION

PETROGRAPHY

The petrography of the Washakie Formation was examined by Johannsen (1914) from 31 rock samples collected in the field by H.F. Osborn. Johannsen used the measured section of Granger (fig. 5, this report) to locate the stratigraphic positions of the samples. Johannsen (1914, p. 210–211) concluded from his investigations that the middle and upper Eocene rocks in the Washakie basin were composed chiefly of tuff. He believed that the tuff was primarily an eruptive dacite, but that it could have been an andesite with sedimentary quartz grains. A volcanic origin for the rocks in the Washakie Formation was determined at about the same time by Sinclair (1909, p. 26), who described the tuff as andesitic.

A few comments can be made here concerning the petrography of Eocene rocks in the Washakie basin. The rocks from the base of the main body of the Wasatch Formation upward in section to the middle of the Sand Butte Bed of the Laney Member of the Green River Formation are derived mainly from plutonic source rocks. The rocks overlying the middle of the Sand Butte Bed of the Laney Member are derived mainly from volcanic rocks (fig. 6). Most of the plutonic and volcanic material in these rocks was reworked by fluvial processes prior to burial, and much of it has been diagenetically altered. Mineral grains such as quartz exhibit only slight rounding, suggesting that the sediments composing the plutonic source rocks were transported only short distances before deposition. The volcanic rocks are mostly eruptive andesites from source areas outside the greater Green River basin. Pebbles of extrusive porphyritic andesite were found in a few conglomerates in the Adobe Town Member in the Washakie basin. They were found in bed 636 (pl. 2) in sec. 20, T. 13 N., R. 97 W. (composed 90 percent of andesite pebbles), in an unidentified bed in the northeastern part of the basin in sec. 21, T. 15 N., R. 99 W. (composed 5 percent of andesite pebbles), and in an unidentified bed in the southwestern part of the basin in sec. 18, T. 14 N., R. 98 W. (composed 55 percent of andesite pebbles). The andesite pebbles are well rounded (many are egg shaped) and appear to have been transported by streams for long distances (as much as 200 mi from the Absaroka volcanic field in northwest Wyoming). Many of the limestones in the Green River Formation, particularly those deposited in the salt waters of Lake Gosiute during deposition of the Rife Bed of the Tipton Shale Member, Wilkins Peak Member, and LaClede Bed of the Laney Member, are partly or completely altered to dolomite. Evaporites are present in these same

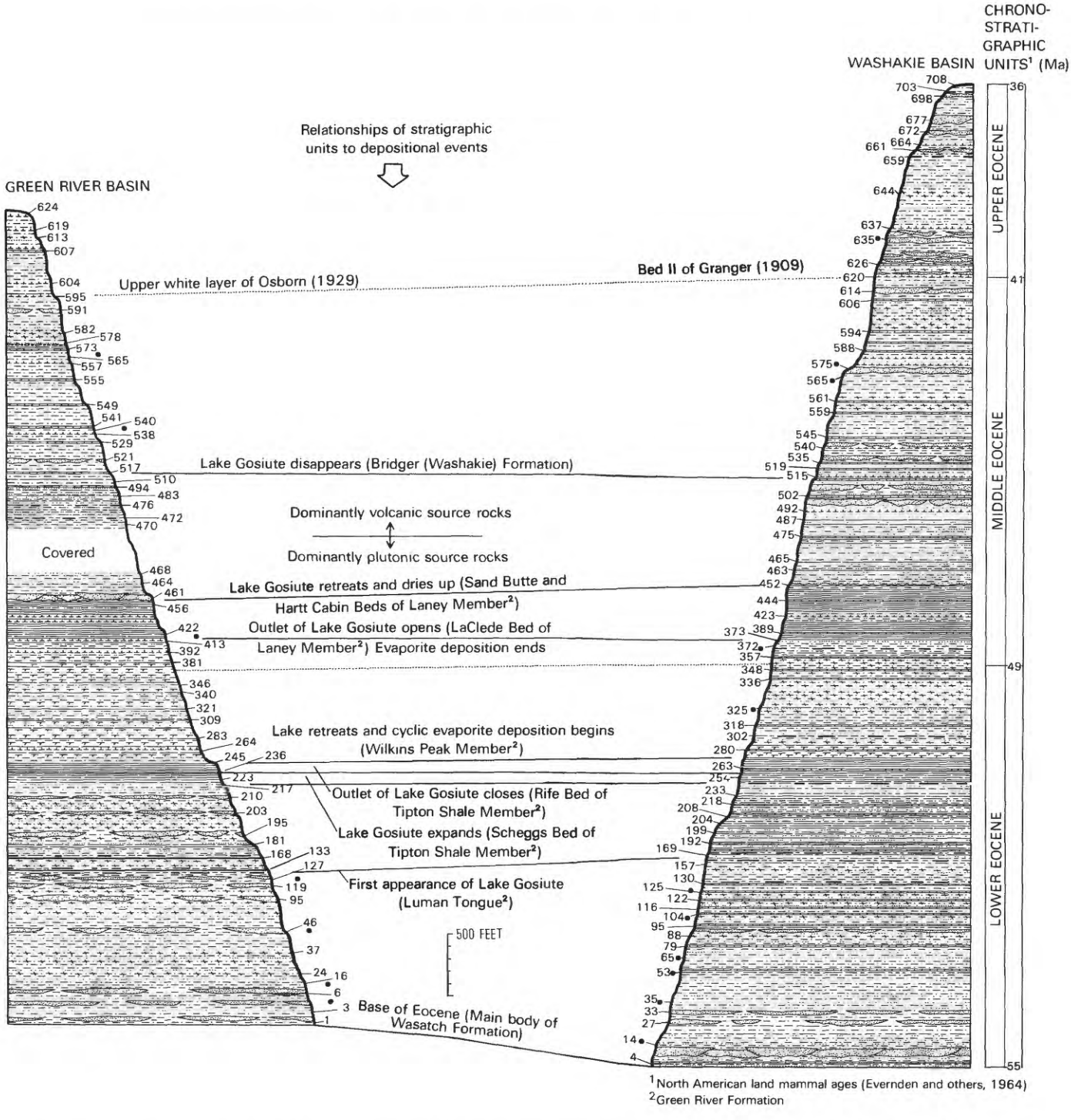


FIGURE 6 (above and facing page).—Correlation of stratigraphic units, stratigraphic marker beds, and timelines of Eocene rocks in reference sections measured in the Green River and Washakie basins in southwest Wyoming. Numbered beds are described in the detailed reference sections.

members of the Green River Formation, but their distribution is restricted to the Green River basin west of the Rock Springs uplift (fig. 5).

Sixty samples of Eocene rocks in the Washakie basin reference section were thin sectioned and examined petrographically. Thirteen of these thin sections, that

characterize basic rock types and depositional environments, are illustrated in photomicrographs (figs. 7–19). The photomicrographs were taken by transmitted light and have original magnifications ×35.

NONOPAQUE HEAVY MINERALS

The system used to classify nonopaque heavy minerals in this report is based on the work of Sato and Denson (1967). Mineral identifications and 100 grain counts were made for the author by W.A. Chisholm.

Nonopaque heavy minerals were identified in 44 spot samples of sandstones collected along the outcrops of Eocene rocks in the Washakie basin (Roehler, 1970). The sandstones are quartzose and generally contain 2–3 percent heavy minerals. The samples were prepared using standard laboratory procedures. The whole-rock sample was first cleaned, crushed, and sieved. The very fine grained fraction was retained for separations. The light and heavy minerals were then separated using bromoform (tribrom-methane, $CHBr_3$), specific gravity 2.87. Magnetic grains were removed with a magnet, and the remaining grains were cleaned by ultrasonic vibrator. Finally, the nonopaque grains were mounted on glass slides and identified by petrographic microscope. One hundred grains, constituting percentages, were identified for each slide.

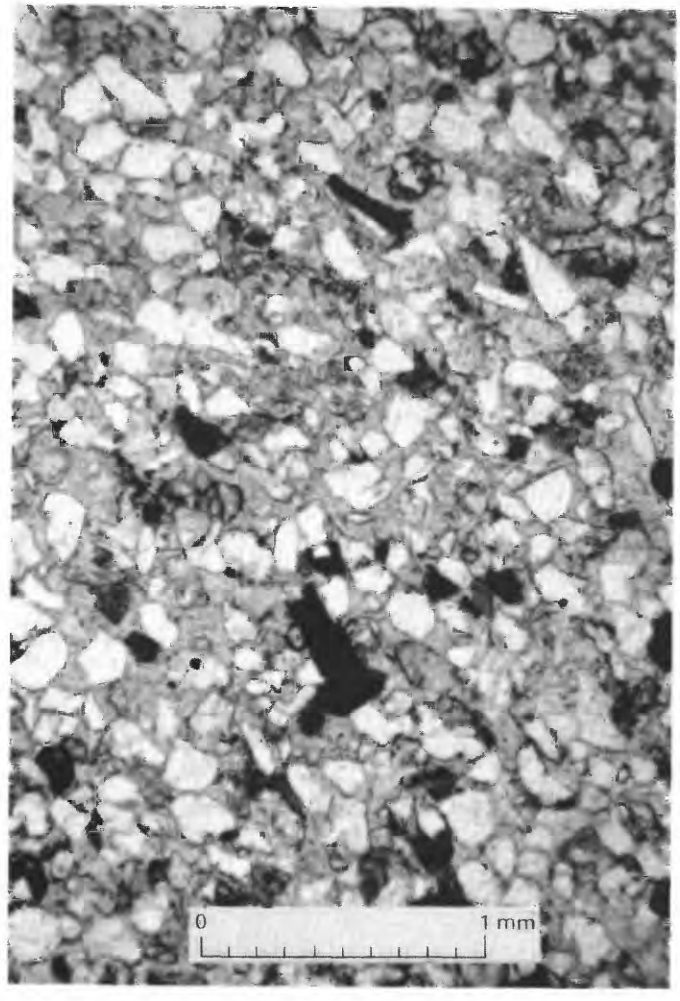


FIGURE 7.—Very fine grained flood-plain (stream channel) sandstone near base of main body of the Wasatch Formation (bed 9, pl. 2). Composed mostly of clear, angular quartz grains in clay matrix. Dark grains are mostly rock fragments.

The nonopaque heavy minerals in the Washakie basin reference section are divisible into three distinct suites: (1) minerals of plutonic and metamorphic origin composed mostly of garnet with minor green, green-brown hornblende, epidote, zircon, tourmaline, staurolite, green-brown biotite, brown biotite, green biotite, red-brown biotite, and chlorite (beds 9–244, table 3); (2) minerals of different plutonic origin composed mostly of green-brown biotite, brown biotite, and garnet with minor or trace amounts of oxyhornblende, green, green-brown hornblende, blue-green hornblende, epidote, zircon, sphene, tourmaline, green biotite, and red-brown biotite (beds 274–467, table 3); and (3) minerals of volcanic origin composed mostly of augite, green, green-brown hornblende, and blue-green hornblende with varying amounts of garnet and minor or trace amounts of oxyhornblende, epidote, zircon, sphene, tourmaline, green-brown biotite, brown biotite, green biotite, and red-brown biotite (beds 480–707, table 3). Looked for but not found were hypersthene, zoisite, sillimanite, kyanite, andalusite, monazite, allanite, diopside, and apatite.

The source rock terranes for the three nonopaque heavy mineral suites are apparent from the dominant one to three minerals in each suite. Mineral suites 1 and 2 reflect the progressive erosion of sedimentary, metamorphic, and igneous rocks, respectively, that were exposed across the uplifted crests of mountain ranges adjacent to the greater Green River basin during the Laramide orogeny. Suite 1 is probably derived from the reworked older sedimentary and metamorphic roof rocks of these ranges. Suite 2 is derived mostly from the breached igneous (mostly granitic) cores of the mountains. Suite 3 is composed of volcanic rocks (airfall ash) derived from the Absaroka volcanic field in northwest Wyoming.

Suites 1 and 2 attest to the magnitude of the Laramide mountain-building events that took place during the Eocene at the outer fringes of the greater Green River basin. The introduction of huge quantities of airfall volcanic ash during the period of deposition of suite 3 corresponds to the time of, and is undoubtedly responsible for, the final contractions and disappearance of Lake Gosiute. The intense volcanism of this period caused the basin climate to become cooler and drier, and the influx of the volcanic ash filled and choked the shallow remnants of the lake.

TABLE 3.—*Nonopaque heavy minerals from Eocene sandstones in Washakie basin, Wyoming*

[From Roehler (1970). Numbers are percentages of 100 grain counts; leaders (---), mineral not identified]

Stratigraphic unit	Bed No.	Nonopaque heavy minerals																
		Augite	Oxyhornblende	Green, green-brown hornblende	Blue-green hornblende	Garnet	Epidote	Zircon	Sphene	Rutile	Tourmaline	Staurolite	Green-brown biotite	Brown biotite	Green biotite	Red-brown biotite	Chlorite	
Adobe Town Member of Washakie Formation	707	43	4	52	---	1	---	---	---	---	---	---	---	---	---	---	---	Suite 3
	698	9	9	78	---	---	---	1	---	---	---	---	---	2	---	1	---	
	677	38	6	48	6	2	---	---	---	---	---	---	---	---	---	---	---	
	676	41	4	53	2	---	---	---	---	---	---	---	---	---	---	---	---	
	661	51	2	43	4	---	---	---	---	---	---	---	---	---	---	---	---	
	655	35	2	56	5	2	---	---	---	---	---	---	---	---	---	---	---	
	646	---	1	73	19	5	1	---	1	---	---	---	---	---	---	---	---	
	643	1	1	78	8	9	---	1	2	---	---	---	---	---	---	---	---	
	638	79	1	16	2	1	---	1	---	---	---	---	---	---	---	---	---	
	635	87	---	13	---	---	---	---	---	---	---	---	---	---	---	---	---	
	628	11	5	76	8	---	---	---	---	---	---	---	---	---	---	---	---	
	618	8	---	22	4	58	---	4	---	---	1	---	---	3	---	---	---	
	614	42	10	42	3	2	---	---	---	---	---	---	---	---	1	---	---	
	593	34	1	41	19	2	---	---	---	---	---	---	---	2	---	1	---	
	582	9	1	65	13	8	---	1	2	---	---	---	---	1	---	---	---	
Kinney Rim Member of Washakie Formation	566	14	---	59	16	3	---	2	---	---	---	---	4	2	---	---	---	
	562	12	---	76	8	3	---	1	---	---	---	---	---	---	---	---	---	
	552	1	---	69	26	2	---	1	---	---	---	---	---	1	---	---	---	
	533	3	---	65	17	5	2	---	---	---	---	---	---	7	---	1	---	
Laney Member of Green River Formation	508	8	1	61	22	4	---	---	---	---	---	---	---	4	---	---	---	
	493	43	2	42	10	2	---	---	---	---	---	---	---	1	---	---	---	
	480	---	---	38	24	33	---	---	1	---	---	---	2	2	---	---	---	
Cathedral Bluffs Tongue of Wasatch Formation	467	---	1	1	---	55	1	1	1	---	---	---	---	39	---	1	---	Suite 2
	458	---	---	---	---	29	1	1	---	---	---	---	---	69	---	---	---	
	346	---	---	---	---	1	---	---	---	---	---	---	57	42	---	---	---	
	325	---	---	---	2	76	---	12	---	---	6	---	4	---	---	---	---	
	298	---	---	5	---	---	---	---	---	---	---	---	34	58	3	---	---	
Wilkins Peak Mbr. of G. R. Fm.	274	---	---	---	---	1	---	---	---	---	---	---	14	83	1	1	---	
Niland Tongue of Wasatch Formation	244	---	---	---	---	83	1	13	---	1	---	---	2	---	---	---	---	Suite 1
	206	---	---	---	---	81	---	14	---	3	---	---	---	1	---	---	1	
Tipton Shale Mbr. of G. R. Fm.	191	---	---	---	---	88	---	3	---	---	---	---	3	3	---	3	---	
Main body of Wasatch Formation	157	---	---	---	---	90	1	6	---	1	1	---	---	1	---	---	---	
	142	---	---	---	---	81	2	10	---	2	1	---	2	2	---	---	---	
	124	---	---	2	---	87	1	2	---	1	3	---	1	2	1	---	---	
	110	---	---	2	---	89	---	3	---	---	3	---	---	2	1	---	---	
	91	---	---	1	---	68	---	10	---	2	2	---	4	13	---	---	---	
	81	---	---	---	---	88	---	7	---	1	---	---	2	2	---	---	---	
	59	---	---	---	---	83	---	4	---	---	2	---	7	2	---	---	2	
	37	---	---	---	---	95	---	4	---	---	1	---	---	---	---	---	---	
	33	---	---	---	---	88	---	9	---	2	---	---	1	---	---	---	---	
	23	---	---	---	---	92	---	2	---	2	---	1	2	1	---	---	---	
	15	---	---	---	---	86	---	11	---	1	1	---	---	---	---	---	1	
	9	---	---	---	---	85	---	9	---	4	---	---	---	---	---	---	2	

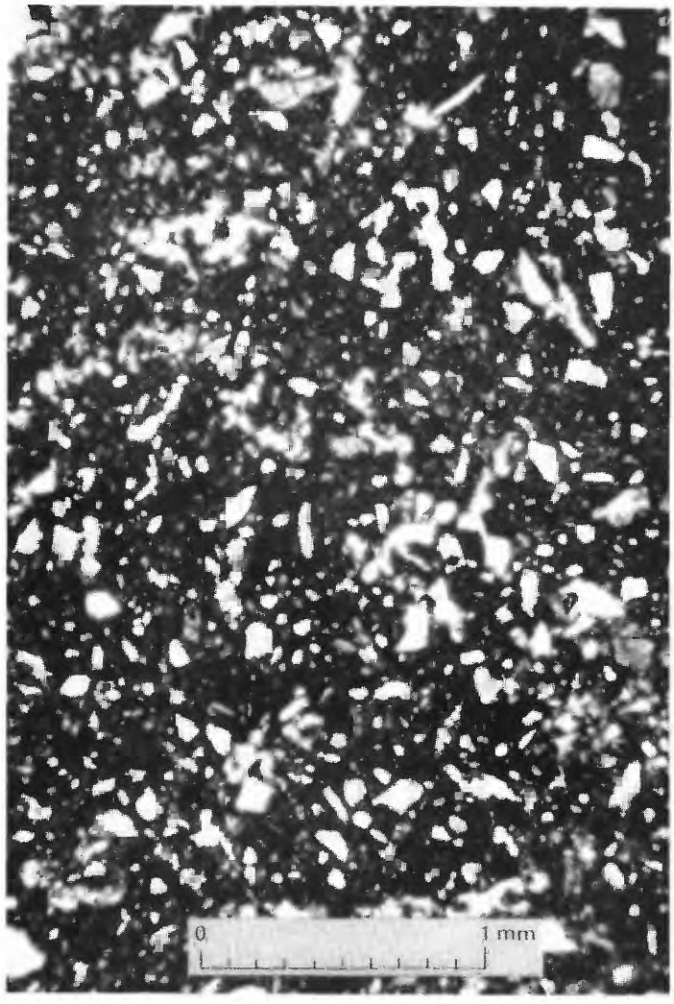


FIGURE 8.—Freshwater lacustrine (pond) limestone in flood-plain deposits near middle of main body of the Wasatch Formation (bed 79, pl. 2). Composed of white, fine-grained calcite in a dark-gray, limy clay matrix.

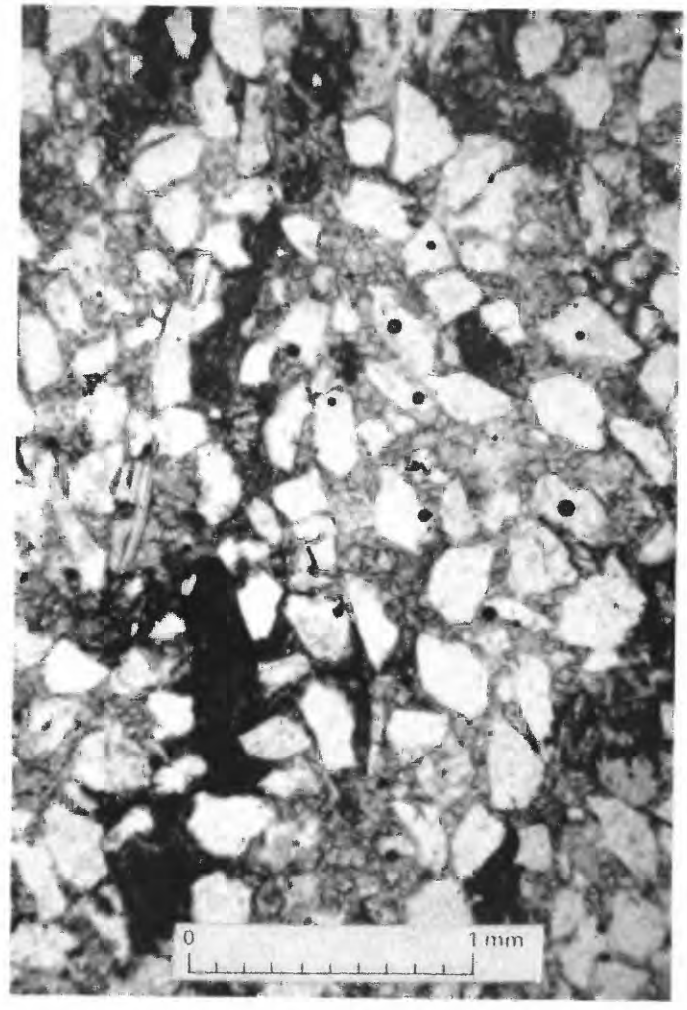


FIGURE 9.—Fine-grained freshwater lacustrine (shoreline) sandstone in lower part of the Niland Tongue of the Wasatch Formation (bed 206, pl. 2). Composed mostly of angular to subangular quartz grains with calcite cement. Dark grains are rock fragments and biotite.

X-RAY DIFFRACTION

The 708 beds comprising the Eocene reference section in the Washakie basin were sampled for X-ray diffraction analysis to determine the distribution of clay, zeolite, and other minerals of scientific interest or economic importance. The whole-rock samples were powdered, pelletized, and X-rayed using nickel-filtered CuKα radiation. Minerals were identified by comparison with standard X-ray diffractogram patterns.

The occurrence and probable origin of nine selected minerals in the reference section—chlorite, kaolinite, illite, montmorillonite, magnesium smectite, potassium feldspar, analcime, clinoptilolite, and mordenite—are discussed and are illustrated in figures 20–28. Other minerals examined and found to be ubiquitous, and which are not discussed, include calcite, dolomite, and sodium feldspar. Figures 20–28 constitute mineral profiles prepared by combining all of the peak heights of the X-ray diffractograms for each mineral in single illustrations. The stratigraphic positions of the mineral concentrations are identified by bed numbers; bed lithologies are described in the detailed reference section, beginning on page 59. The geographic locations of the mineral concentrations in the Washakie basin can be found by examining the geologic map of the Kinney Rim 30×60 minute quadrangle, Wyoming and Colorado (Roehler, 1985), on which many of the numbered beds in the reference section have been mapped.

CHLORITE

The chlorite group of minerals, including clinochlore, penninite, and prochlorite, comprise basic magnesium-

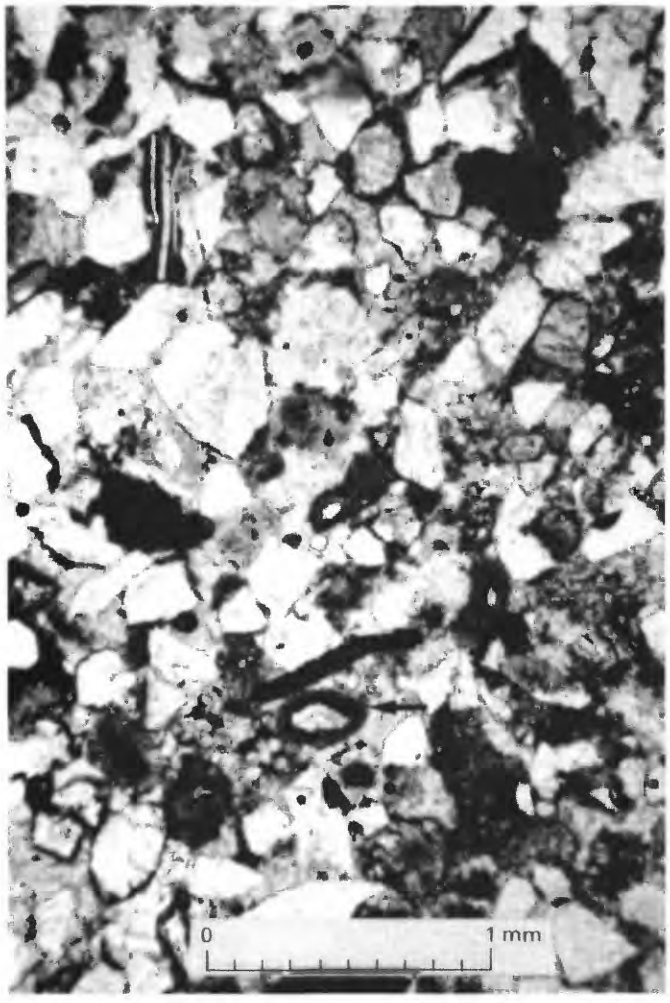


FIGURE 10.—Very fine to fine grained, poorly sorted sandstone from a mudflat sequence in the Wilkins Peak Member of the Green River Formation (bed 292, pl. 2). Composed mostly of angular to subangular quartz grains with calcite cement. Dark grains are mostly rock fragments and biotite. Note that some quartz grains have carbonate overgrowths (arrow).

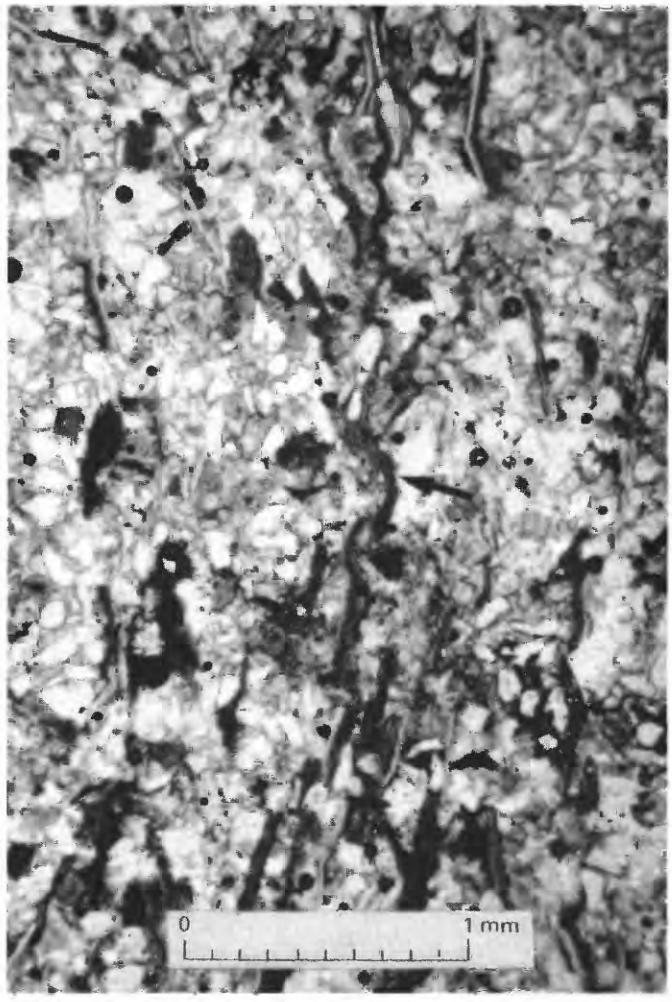


FIGURE 11.—Very fine grained sandstone in a flood-plain splay in upper part of the Cathedral Bluffs Tongue of the Wasatch Formation (bed 346, pl. 2). Composed of clear angular to subangular quartz grains with calcareous clay and some hematite cement. Thin, dark, wavy grains near center are current-oriented biotite (arrow). Orientation is perpendicular to bedding plane.

iron aluminosilicate minerals that are generally green in color and similar in habit to mica (Rogers and Kerr, 1942). Chlorite may form by the alteration of pyroxenes, amphiboles, biotite, and garnet, and is commonly associated with metamorphic rocks. It is also a common constituent of argillaceous sediments, where it occurs as both detrital and authigenic grains.

The chlorite identified by X-ray diffractograms (fig. 20) is restricted to lower Eocene rocks of the Wasatch Formation that are of freshwater fluvial (flood-plain) origin. These rocks correspond to the interval of suite 1 of the nonopaque heavy mineral assemblage (table 3). Suite 1, as discussed previously, is believed to have been derived from the reworked sedimentary and metamorphic roof rocks of nearby mountain ranges, which supports a conclusion that the chlorite is mostly detrital. Chlorite occasionally contains small amounts of manganese and chromium (Deer and others, 1962), but as it forms a minor constituent of the Eocene rocks, it probably has no economic importance.

KAOLINITE

Kaolinite, a hydrous aluminosilicate, is a common white clay mineral formed by the weathering of silicic igneous and metamorphic rocks, particularly feldspars in these rocks. Acid water conditions are favorable for kaolinite formation and preservation.

The kaolinite identified by X-ray diffraction analysis of rocks in the Washakie basin reference section is restricted to beds of freshwater origin in the Wasatch Formation and in parts of the Green River and

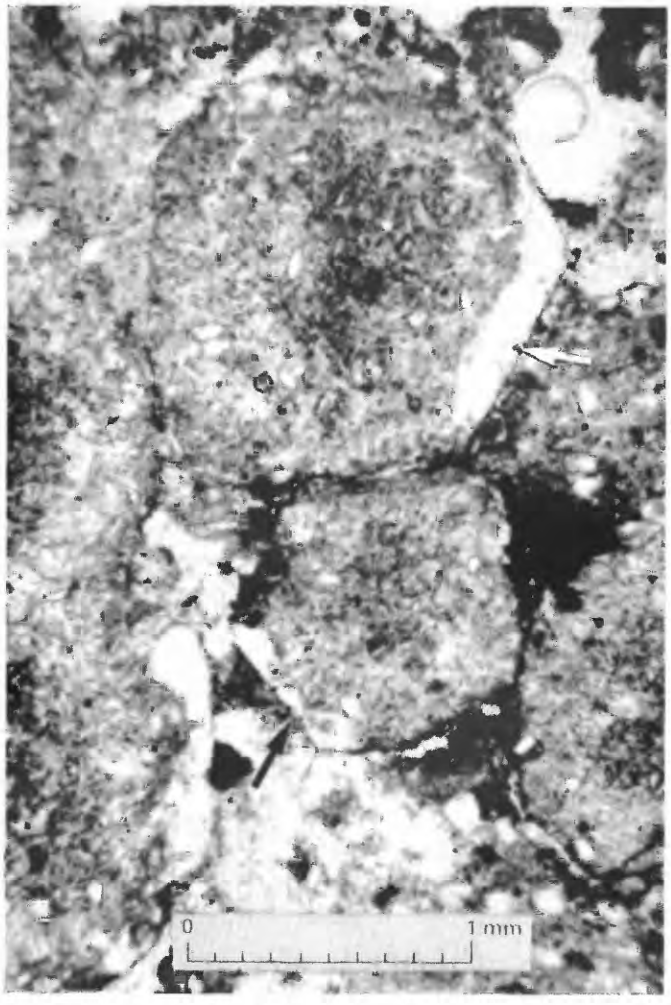


FIGURE 12.—Analcime in zeolitic tuff bed in the LaClede Bed of the Laney Member of the Green River Formation (bed 433, pl. 2). Crystals are well-formed trapezohedrons. Crystal faces are indicated by arrows. Dark interstitial material is kerogen.

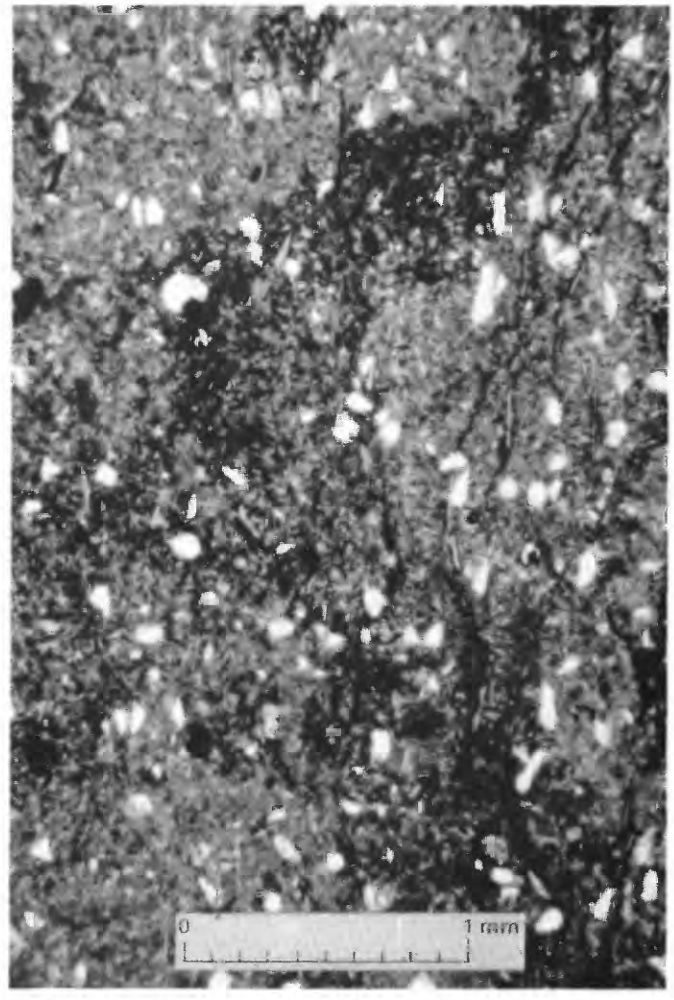


FIGURE 13.—Low-grade oil shale in the LaClede Bed of the Laney Member of the Green River Formation (bed 447, pl. 2). Scattered very fine grained quartz is present in the shale matrix. Needle-like inclusions are unidentified.

Washakie Formations (fig. 21). It occurs in normal sedimentary rocks where it probably formed by the weathering of granitic material eroded from the cores of nearby mountain ranges. No thick beds of kaolinite were identified in the reference section, and the mineral is not considered to have economic importance in the basin.

ILLITE

Illite is a colorless, white, or yellow potassium aluminum silicate clay mineral closely related to the micas. It is the dominant clay mineral in many shales and mudstones and generally forms by the degradation of micas and feldspars.

Illite is ubiquitous in the Washakie basin reference section (fig. 22), but it is most abundant in rocks of early Eocene age comprising the Wasatch Formation and the lower tongues and members of the Green River Formation. These rocks are mostly of freshwater origin, and as was the case with chlorite and kaolinite (discussed previously), the illite was probably derived from the weathering of granitic material eroded from the cores of nearby mountain ranges. The mineral has no economic importance in the Washakie basin.

MONTMORILLONITE

Montmorillonite is a white, yellow, or green, hydrous sodium aluminum magnesium silicate mineral, which is one of the swelling clays. It is the principal constituent of bentonite and is primarily formed by the alteration of vitric tuffs in depositional environments where considerable magnesium is present (Deer and others, 1962).

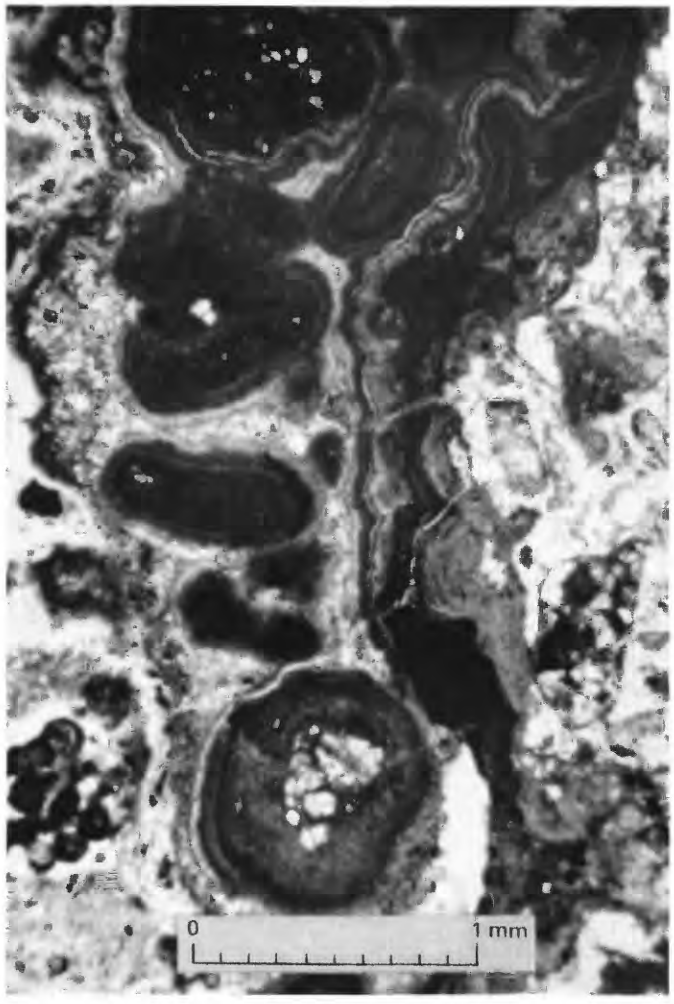


FIGURE 14.—Freshwater lacustrine algal limestone (stromatolite) from flock of sheep marker bed in the Sand Butte Bed of the Laney Member of the Green River Formation (bed 502, pl. 2). The algal colonies have secondary overgrowths of calcite. Orientation of photo is perpendicular to bedding plane.

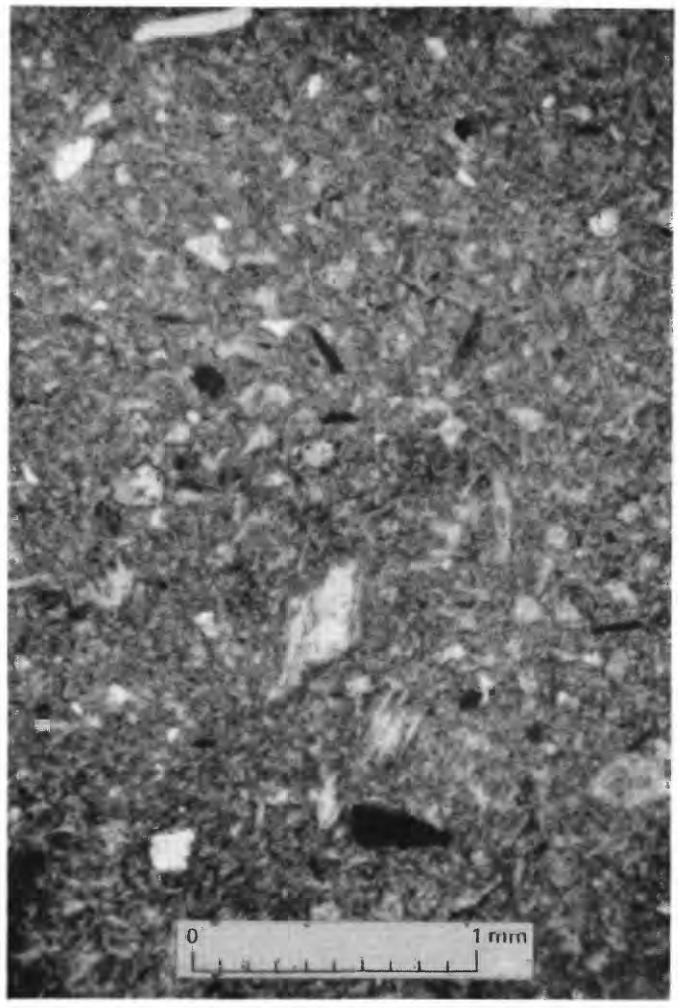


FIGURE 15.—Vitric tuff altered to clinoptilolite in sandstone overlying the lower brown sandstone near base of the Adobe Town Member of the Washakie Formation (bed 572, pl. 2). Vitroclastic texture is visible.

Montmorillonite is present throughout the Washakie basin reference section, mostly in beds deposited in freshwater (figs. 5, 23). The mineral is not known to be concentrated in any single bed with sufficient thickness to have economic importance.

MAGNESIUM SMECTITE

A magnesium smectite mineral identified in the Washakie basin reference section is either stevensite or saponite (C.G. Whitney, oral commun., 1988). Both stevensite and saponite are variously colored complex hydrous magnesium trioctahedral minerals. Smectite is common in shales and mudstones and is commonly found in sedimentary rocks in closed basins (Dyni, 1976, p. 10). Stevensite was found by Bradley and Fahey (1962) in outcrops of the Wilkins Peak Member along White Mountain on the west flank of the Rock Springs uplift.

Magnesium smectite in the Washakie basin reference section is concentrated between beds 452 and 565 (pl. 2) and is also present in a number of overlying beds (fig. 24). The smectite is found in rocks composed mostly of reworked tuffs deposited in freshwater fluvial and lacustrine environments. It is probably authigenic and was derived from the degradation of ferromagnesian minerals (such as biotite and hornblende). As noted by Dyni (1976, p. 12), the trioctahedral smectites serve as chemical traps for large amounts of lithium, zinc, and copper. However, qualitative analysis of these rocks by X-ray fluorescence (discussed later) does not indicate high concentrations of zinc or copper; lithium was not analyzed.

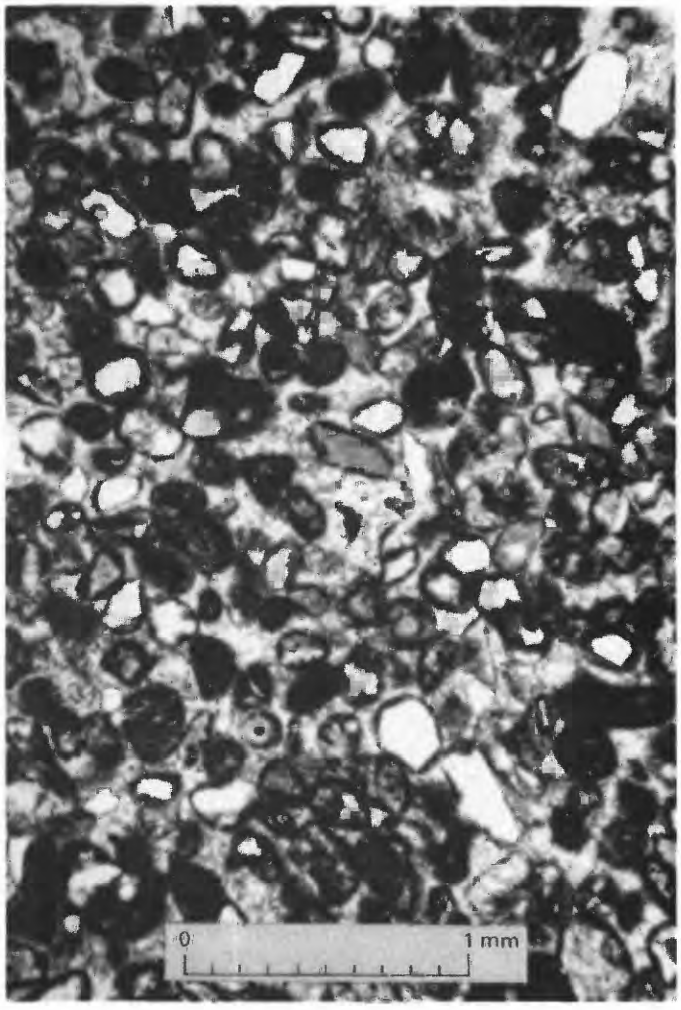


FIGURE 16.—Oolite in the Adobe Town Member of the Washakie Formation (bed 630, pl. 2). Consists mostly of sand grains with secondary quartz overgrowths, cemented by calcite. Probably of lacustrine origin.

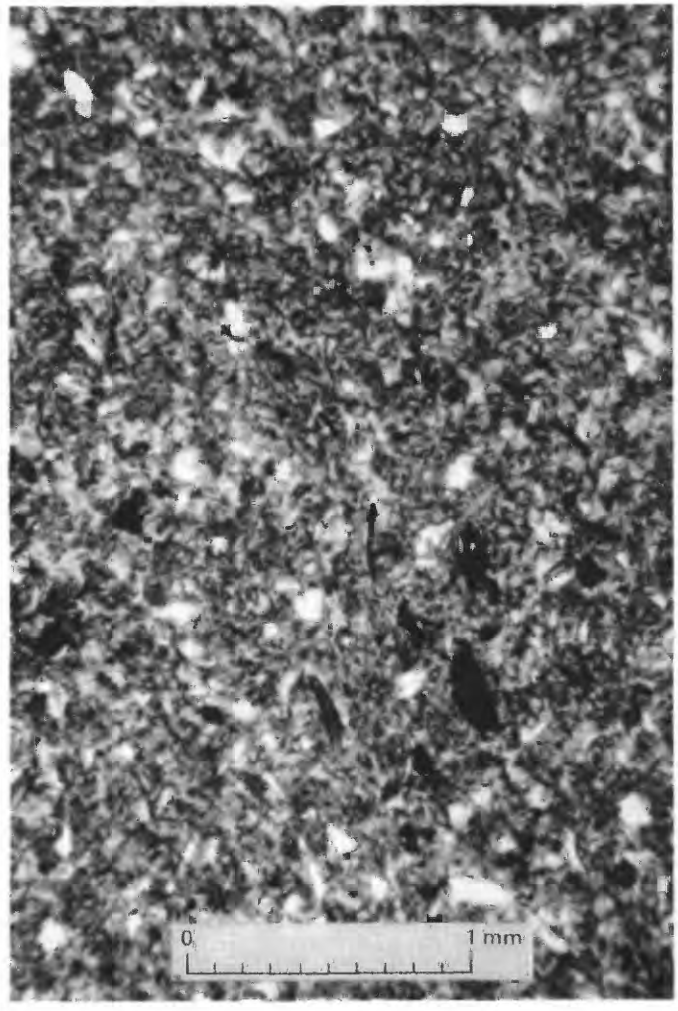


FIGURE 17.—Vitric tuff partly altered to clinoptilolite. From the white glass tuff marker bed in the Adobe Town Member of the Washakie Formation (bed 637, pl. 2). Vitric matrix is still visible.

POTASSIUM FELDSPAR

The potassium feldspars are common rock-forming minerals composed of potassium aluminosilicate. They primarily form by crystallization of igneous rocks, but are also present as authigenic minerals formed by the alteration of vitric tuffs. Authigenic potassium feldspars in the Green River Formation have been described as sodium free, monoclinic, and formed by replacement of analcime (Parker and Surdam, 1971, p. 69). As the potassium feldspars in the Washakie basin are widely distributed and occur in tuffaceous and nontuffaceous rocks deposited in both freshwater and saltwater, they appear to be partly detrital and partly authigenic in origin. Their origin cannot be determined by X-ray diffraction. The mineral probably has no economic value in the Washakie basin.

ANALCIME

Analcime, a member of the zeolite family, is a hydrous sodium aluminosilicate mineral. Analcime occurs in a thick interval of Eocene rocks in the Washakie basin, where it is the product of the authigenic alteration of vitric tuff. Zeolites in the basin were first reported by Johannsen (1914, p. 214–219) and later by Bradley (1928, 1945). Evidence that the zeolites are zonally distributed was presented by Roehler (1972).

Analcime forms in freshwater and saltwater deposits (Hay, 1966, p. 80) and is present in rocks of fluvial and lacustrine origin in the Washakie basin (figs. 5, 26). It is present in large amounts in the Wilkins Peak Member and in most of the LaClede Bed of the Laney Member of the Green River Formation, stratigraphic units that were deposited in saline, alkaline waters of Lake Gosiute. The analcime in these units is believed

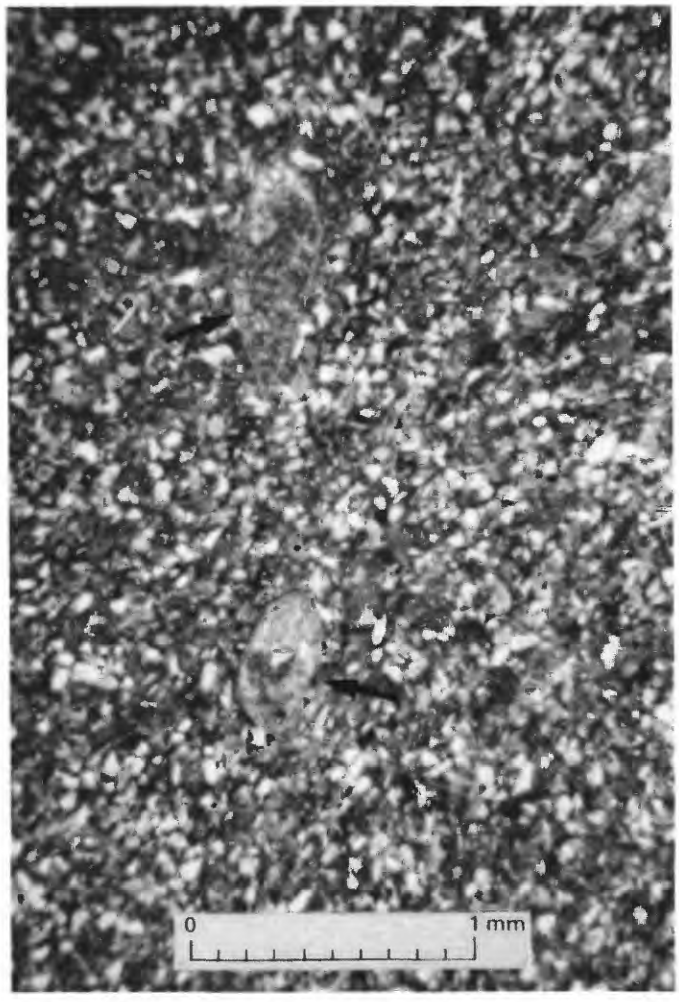


FIGURE 18.—Siltstone from flood-plain splay in the Adobe Town Member of the Washakie Formation (bed 649, pl. 2). Composed of quartz grains in limy clay matrix. Arrows point to unidentified trace fossils.

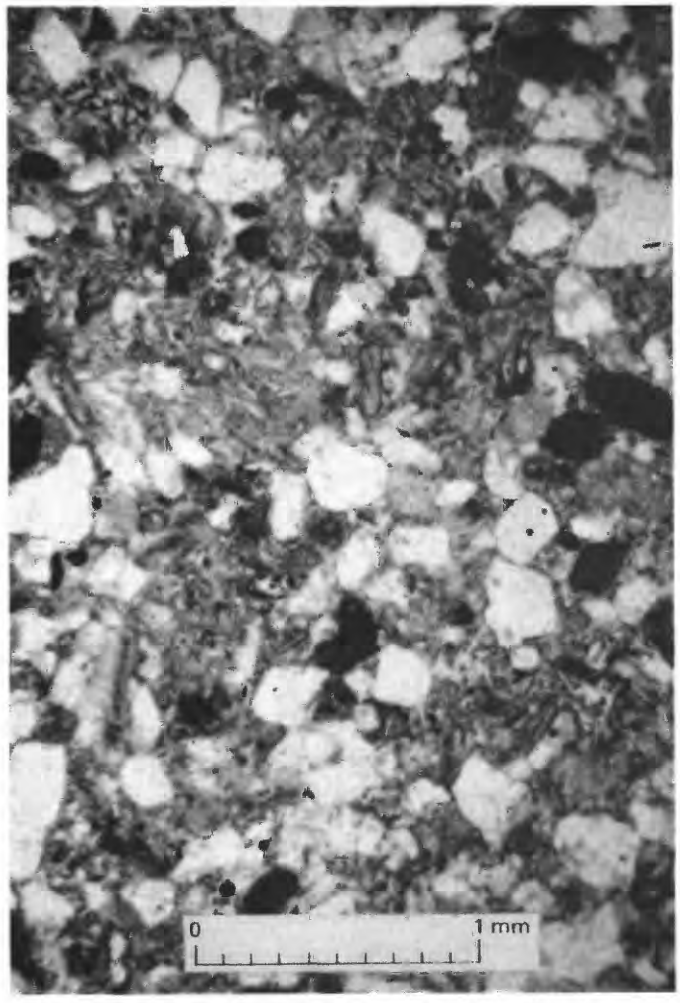


FIGURE 19.—Tuffaceous flood-plain (stream channel) sandstone in the Adobe Town Member of the Washakie Formation (bed 677, pl. 2). Fine to medium poorly sorted, subangular quartz, heavy mineral, and rock fragment grains in groundmass of partly altered tuff.

to have formed from unreworked volcanic ash that fell directly into the lake waters. It commonly occurs as gray, vitreous, megascopic trapezohedral crystals (fig. 12). Lesser amounts of analcime are present in the Sand Butte Bed of the Laney Member and in the Washakie Formation in rocks of shallow freshwater lacustrine and fluvial origin, where the volcanic ash was reworked and disseminated in sandstone, siltstone, mudstone, and shale. The analcime in these beds is microscopic and was identified by X-ray diffraction (fig. 26). The economic importance of the analcime deposits in the Washakie basin has not been determined.

CLINOPTILOLITE

Clinoptilolite, a hydrous calcium sodium potassium aluminum silicate zeolite mineral, occurs in substantial amounts in the Washakie basin. Although zeolites, as a family of minerals, were identified in the Washakie basin by Johannsen (1914), the mineral clinoptilolite was not identified there until the investigations of Parker and Surdam (1971, p. 70, fig. 1). The geographic location and stratigraphic position of a minable clinoptilolite deposit in the basin were reported by Roehler (1973c, p. 55).

Parker and Surdam (1971, p. 72, fig. 3) stated that clinoptilolite forms either from saline alkaline solutions containing vitric materials or from montmorillonite as a precursor. They interpreted the alteration in relation to the paleosalinities and paleoalkalinities of Lake Gosiute. Minato and Utada (1969, p. 127) believed that depth of burial is equally important, because the pH, salinity, and cation content of connate waters commonly change with increasing depth of

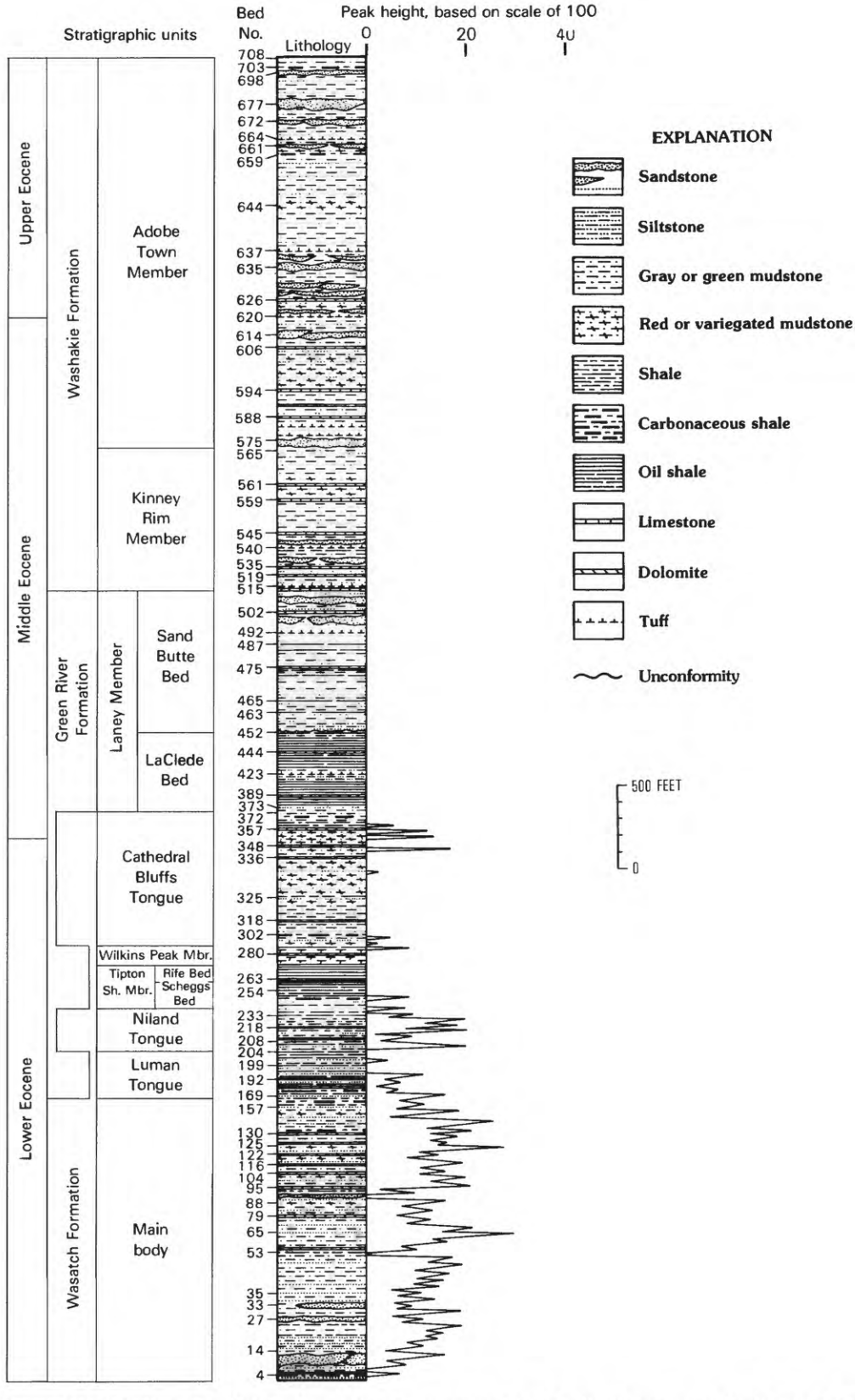


FIGURE 20.—Stratigraphic distribution and relative amount of chlorite in Eocene rocks in Washakie basin reference section based on peak heights from X-ray diffractograms.

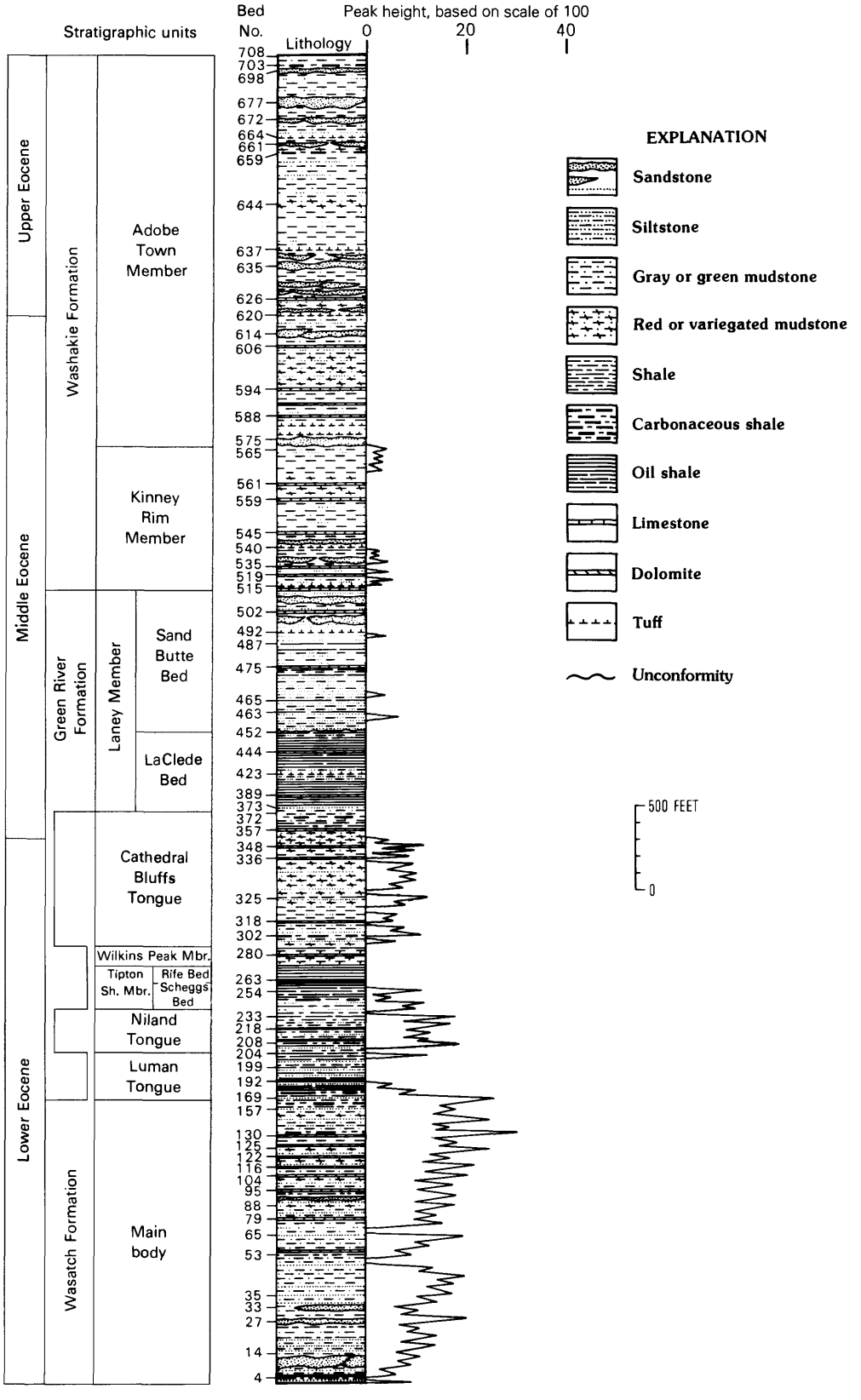


FIGURE 21.—Stratigraphic distribution and relative amount of kaolinite in Eocene rocks in Washakie basin reference section based on peak heights from X-ray diffractograms.

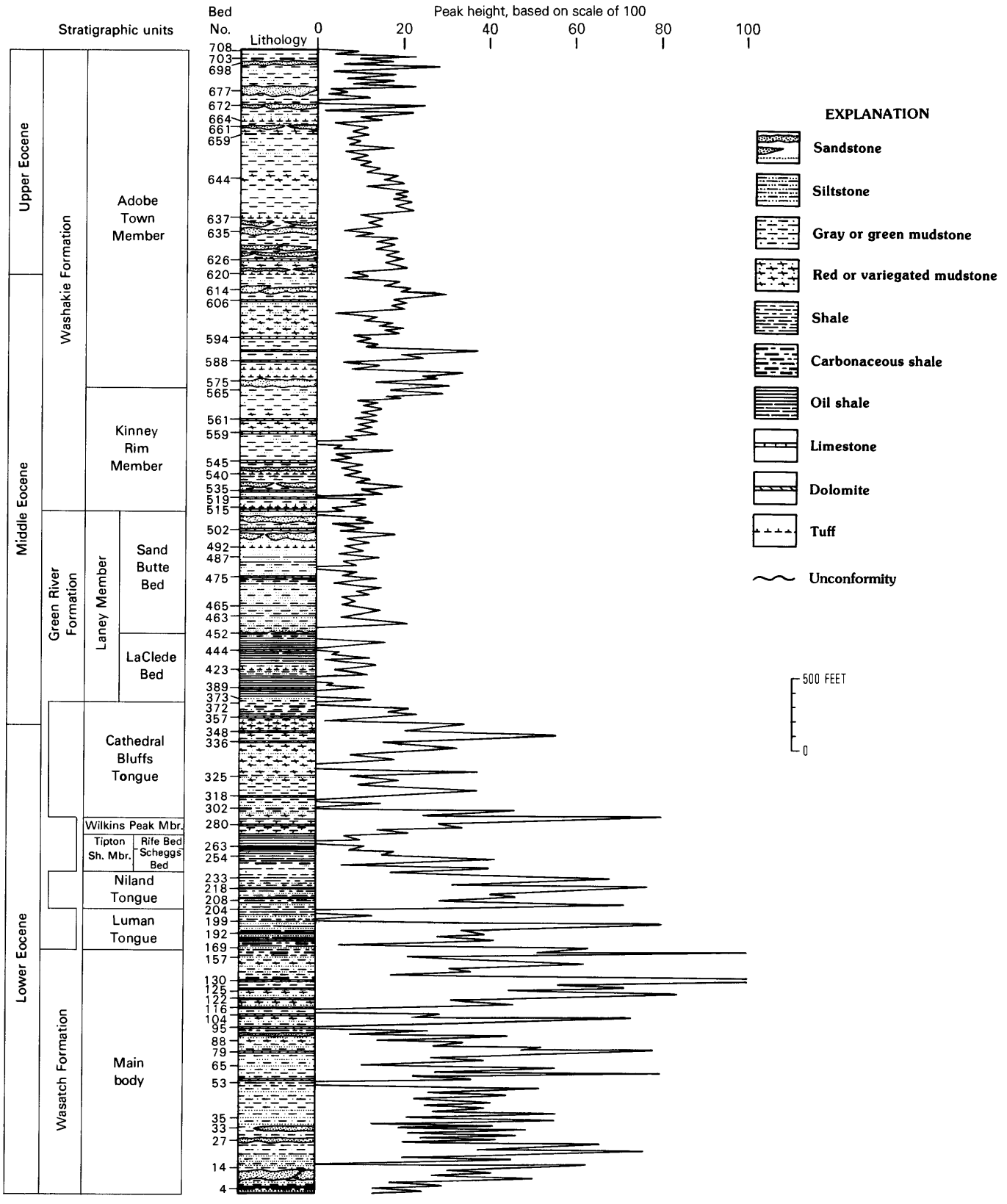


FIGURE 22.—Stratigraphic distribution and relative amount of illite in Eocene rocks in Washakie basin reference section based on peak heights from X-ray diffractograms.

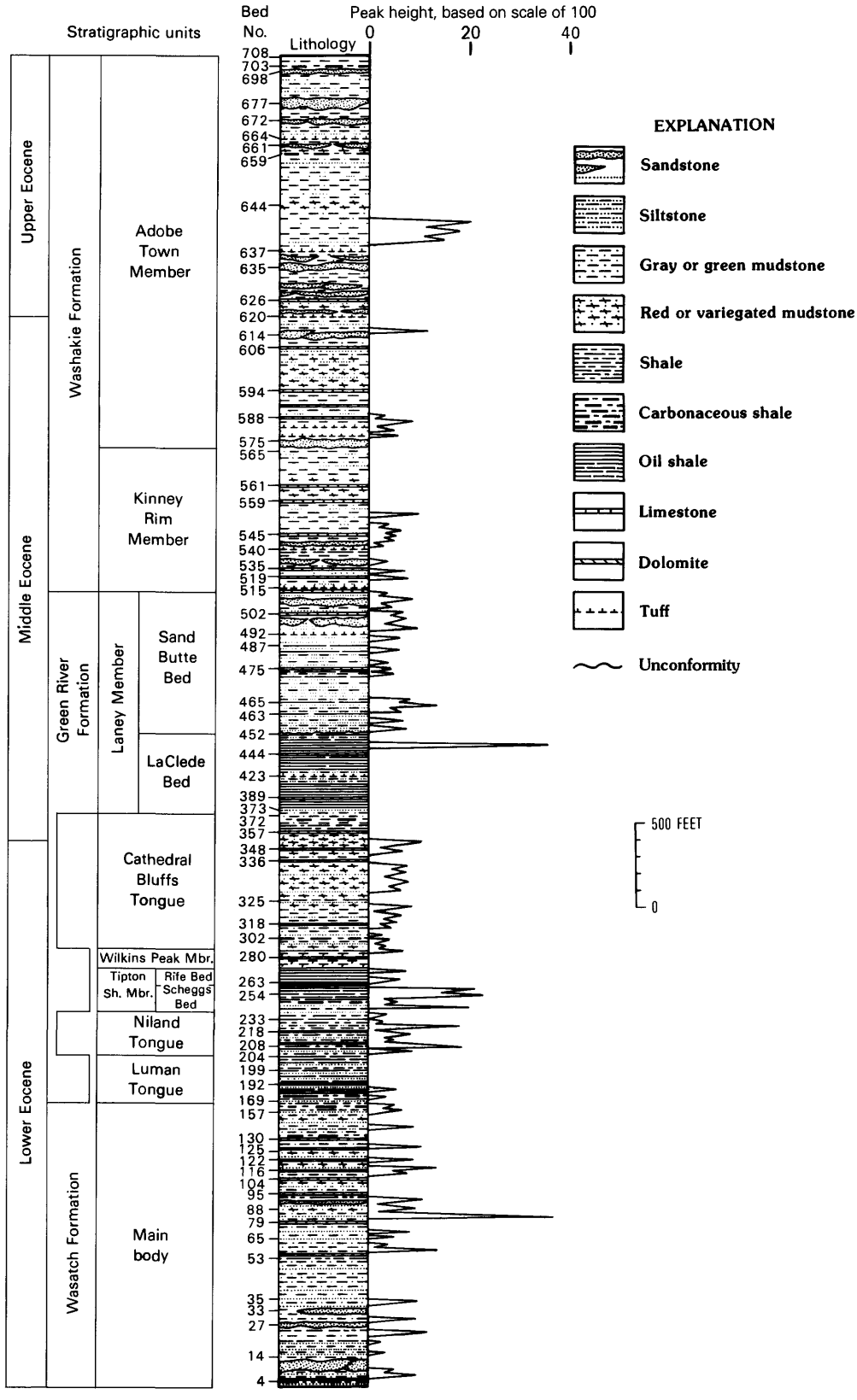


FIGURE 23.—Stratigraphic distribution and relative amount of montmorillonite in Eocene rocks in Washakie basin reference section based on peak heights from X-ray diffractograms.

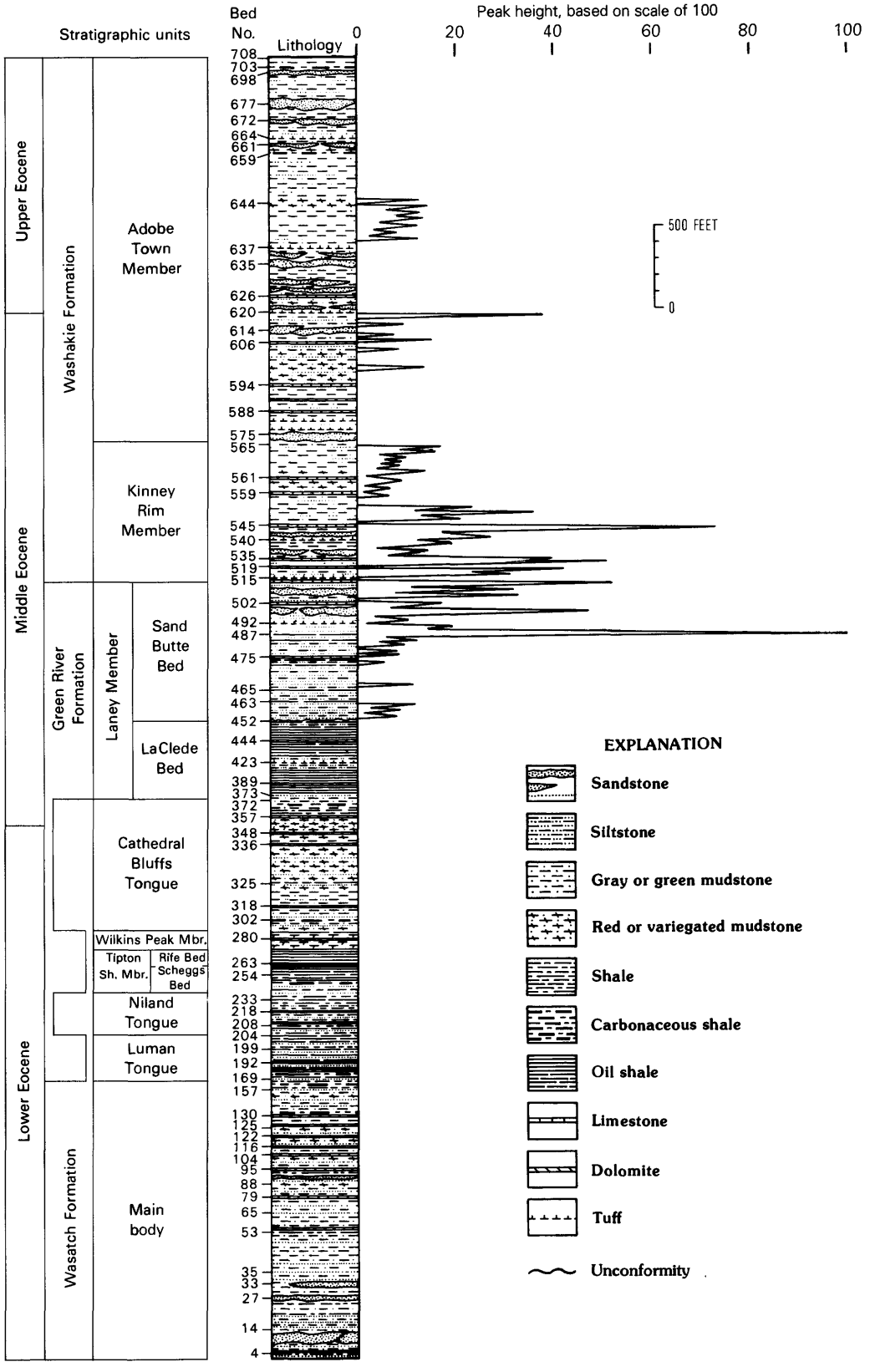


FIGURE 24.—Stratigraphic distribution and relative amount of magnesium smectite in Eocene rocks in Washakie basin reference section based on peak heights from X-ray diffractograms.

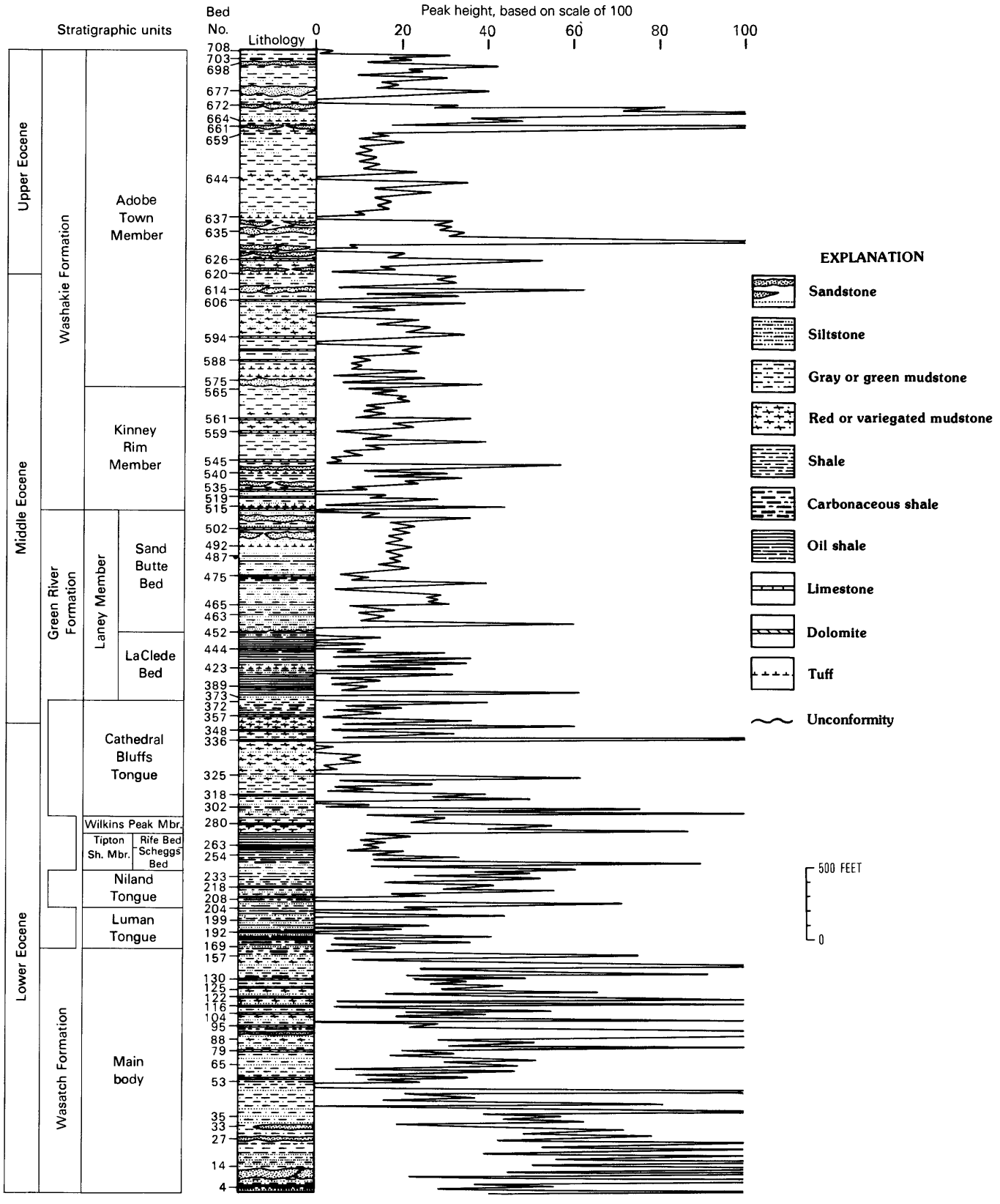


FIGURE 25.—Stratigraphic distribution and relative amount of potassium feldspar in Eocene rocks in Washakie basin reference section based on peak heights from X-ray diffractograms.

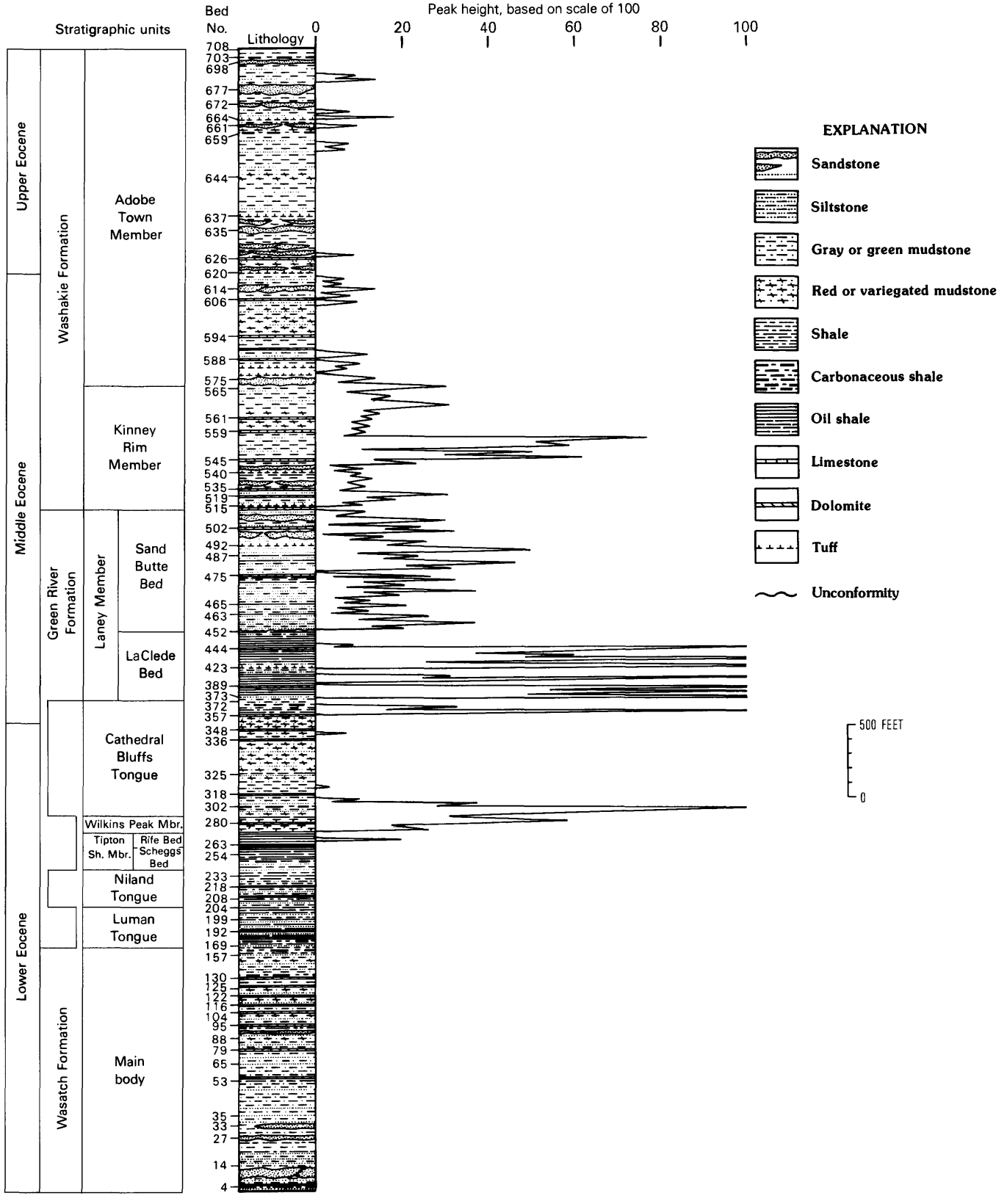


FIGURE 26.—Stratigraphic distribution and relative amount of analcime in Eocene rocks in Washakie basin reference section based on peak heights from X-ray diffractograms.

burial. The clinoptilolite in the Laney Member of the Green River Formation and in the Washakie Formation (fig. 27) was deposited during freshwater stages of Lake Gosiute and in freshwaters on flood plains that developed after the lake had disappeared.

According to Minato and Utada (1969, p. 132–133), zeolite minerals are used as agents for moisture adsorption and deodorization, as an additive to aid in the retention of fertilizer on agricultural lands, and for papermaking. Mercer (1969, p. 209) stated that clinoptilolite, as an agent for the removal of ammonium nitrogen from wastewaters, will have major use in control of water pollution. Beds containing large amounts of minable clinoptilolite are concentrated in two stratigraphic intervals in the Adobe Town Member of the Washakie Formation, beds 566–589 (279 ft thick) and beds 603–618 (184 ft thick). Bed 579 in the lower of the two intervals is called the robins-egg-blue marker. This bed ranges from less than 10 ft to more than 100 ft thick and is composed more than 50 percent of clinoptilolite. It is estimated to contain at least 5 billion tons of clinoptilolite (Roehler, 1973c, p. 55). Clinoptilolite appears to be an easily exploited, inexhaustible resource in the Washakie basin.

MORDENITE

Mordenite, another member of the zeolite group, is a hydrous calcium sodium aluminum silicate mineral with chemistry similar to clinoptilolite. Mordenite is a high-silica type of zeolite (Minato and Utada, 1969, p. 130). It generally contains more sodium than potassium, and this chemical parameter commonly distinguishes it from clinoptilolite (Sheppard, 1971, p. 301–302). Clinoptilolite and mordenite commonly coexist and are difficult to differentiate, but X-ray diffraction techniques are adequate for this purpose. Mordenite forms by the alteration of tuffaceous rocks and is characterized by relict vitroclastic textures (Goodwin and Surdam, 1967, p. 307).

Mordenite forms under less saline, alkaline conditions than does analcime, and in the Washakie basin reference section it occurs only in rocks deposited in freshwater (figs. 5, 28). Mordenite is present in small amounts in a number of beds in the LaClede and Sand Butte Beds of the Laney Member of the Green River Formation, and it is a common mineral throughout the Washakie Formation. The low peak heights on X-ray diffractograms (fig. 28) indicate that the mineral is probably not sufficiently concentrated to have economic importance, except for those beds where it coexists with clinoptilolite and analcime.

X-RAY FLUORESCENCE

Twenty-one spot samples of rocks from the Washakie basin reference section were analyzed by X-ray fluorescence (table 4) to determine the occurrence and relative amounts of 18 selected elements. The analyses are qualitative scans, and the data are shown as raw counts. No anomalously high concentrations of elements are revealed by the data.

OIL SHALE ASSAYS

Oil shale deposits in the Washakie basin were first reported by Winchester (1923). The stratigraphy of the oil shale-bearing units was later investigated by Roehler (1969). An evaluation of oil shale resources from data collected from cores of the Green River Formation in the southwest part of the basin was published by Trudell and others (1973). Oil shale outcrops were mapped, and resource estimates for selected beds in the basin listed by Roehler (1973c).

Oil shale in Eocene rocks in the Washakie basin is concentrated in the Luman Tongue, Scheggs Bed of the Tipton Shale Member, Rife Bed of the Tipton Shale Member, and LaClede Bed of the Laney Member of the Green River Formation. A few thin oil shale beds are also present in the Niland Tongue of the Wasatch Formation and Sand Butte Bed of the Laney Member of the Green River Formation (pl. 2). The term oil shale in this report refers to all types of kerogenaceous rocks regardless of their composition or the amount of oil they will yield by assay. The term "rich oil shale" is used to identify beds that will yield more than 15 gallons of oil per ton of rock by assay, and the term "lean oil shale" is used to identify beds that will yield less than 15 gallons of oil per ton of rock by assay.

Two lithologically distinct types of kerogenaceous rocks are present—shales and dolomites. The kerogenaceous shales are generally of freshwater origin, tan to brown, commonly varved, generally papery, and very fossiliferous. They comprise most of the lean oil shale beds in the section. The outcrops of these beds commonly weather drab brown to drab gray brown and form smooth unbroken slopes. The shales consist chiefly of quartz, feldspar, and clay. The carbonate content is generally less than 6 percent. The kerogenaceous dolomites (also called kerogenaceous marlstones, mudstones, or clay shales) are mostly of saltwater origin, dark brown to black, hard, dense, and seldom fossiliferous. They comprise most of the rich oil shale beds in the section. The outcrops of these beds commonly weather light gray to silver gray and form slopes broken into benches by resistant beds of

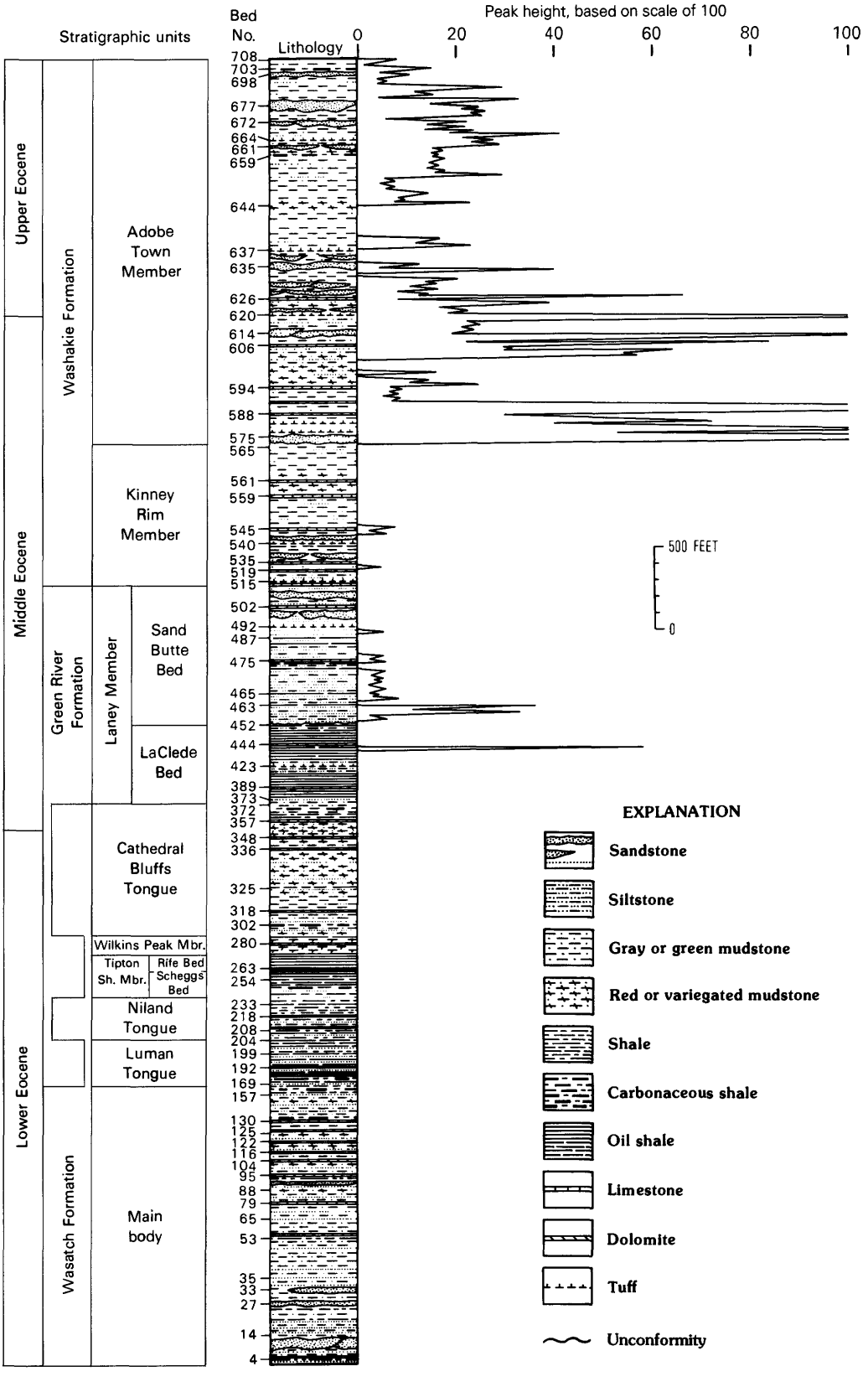


FIGURE 27.—Stratigraphic distribution and relative amount of clinoptilolite in Eocene rocks in Washakie basin reference section based on peak heights from X-ray diffractograms.

TABLE 4.—*Qualitative X-ray fluorescence of selected whole rock samples from the Washakie basin Eocene reference section*

[nd, not determined]

Stratigraphic unit	Bed No.	X-ray fluorescence (counts per second)																	
		Mg	Al	Si	S	K	Ca	Ti	Cr	Mn	Fe	Ni	Cu	Zn	Rb	Sr	Y	Zr	Ba
Adobe Town Member of Washakie Formation	698	12	362	3,747	12	2,746	2,546	282	27	140	19,380	200	160	140	110	4,100	nd	nd	68
	664	8	307	3,255	104	1,950	950	365	20	185	24,350	130	120	190	150	1,500	nd	nd	95
	649	30	250	2,370	60	3,080	13,384	406	25	1,110	30,880	145	160	210	200	1,100	nd	nd	54
	639	32	298	3,036	105	3,535	3,435	606	67	860	57,870	190	140	250	250	750	nd	nd	47
	633	14	205	4,752	24	3,154	1,454	336	52	203	26,825	190	110	120	125	1,250	nd	nd	937
	615	26	348	3,246	25	4,440	1,640	507	31	268	54,870	205	200	270	300	650	200	500	48
	579	17	310	4,046	11	3,247	1,947	374	31	110	32,860	170	170	210	250	3,800	nd	nd	109
Kinney Rim Member of Washakie Formation	562	75	260	2,740	0	3,160	18,360	314	15	1,610	23,870	175	160	160	170	1,350	nd	nd	45
	540	10	277	3,740	0	4,738	3,438	506	36	265	36,870	190	180	220	200	1,100	nd	nd	59
Sand Butte Bed of Laney Mbr. of Green River Formation	502	0	0	540	0	300	64,500	16	0	422	11,310	80	110	0	0	3,540	nd	nd	23
	466	14	290	3,426	0	10,424	5,424	517	45	510	31,370	160	110	220	380	330	150	500	37
LaClede Bed of Laney Mbr.	437	90	70	1,320	110	580	22,320	70	20	922	17,390	100	140	80	0	3,150	nd	nd	34
Cathedral Bluffs Tongue of Wasatch Formation	331	22	350	2,450	158	3,150	1,950	819	45	602	78,000	185	200	390	370	5,700	nd	nd	69
	320	60	360	2,090	180	3,305	10,405	572	45	697	64,000	140	145	360	305	1,800	nd	nd	37
Rife Bed of Tipton Sh. Member	266	45	310	2,310	0	3,110	8,010	546	39	612	62,000	180	180	345	280	1,400	0	500	41
Niland T. of Wasatch Fm.	217	26	405	3,442	25	5,036	11,836	723	52	400	64,000	210	190	350	350	300	150	500	70
Luman Tongue of Green River Formation	203	0	0	400	0	500	61,550	40	0	392	8,405	90	75	50	0	750	nd	nd	10
	190	22	274	3,340	0	3,340	3,240	587	48	515	46,000	170	180	240	270	200	150	800	45
Main body of Wasatch Formation	125	34	352	3,318	0	4,120	6,320	625	50	705	57,805	140	190	280	300	500	200	700	nd
	33	18	245	4,443	16	2,840	3,240	566	33	355	38,820	70	140	130	200	600	200	2,100	nd
	6	22	274	3,140	0	4,440	3,240	627	42	270	56,880	190	180	0	350	325	0	800	44

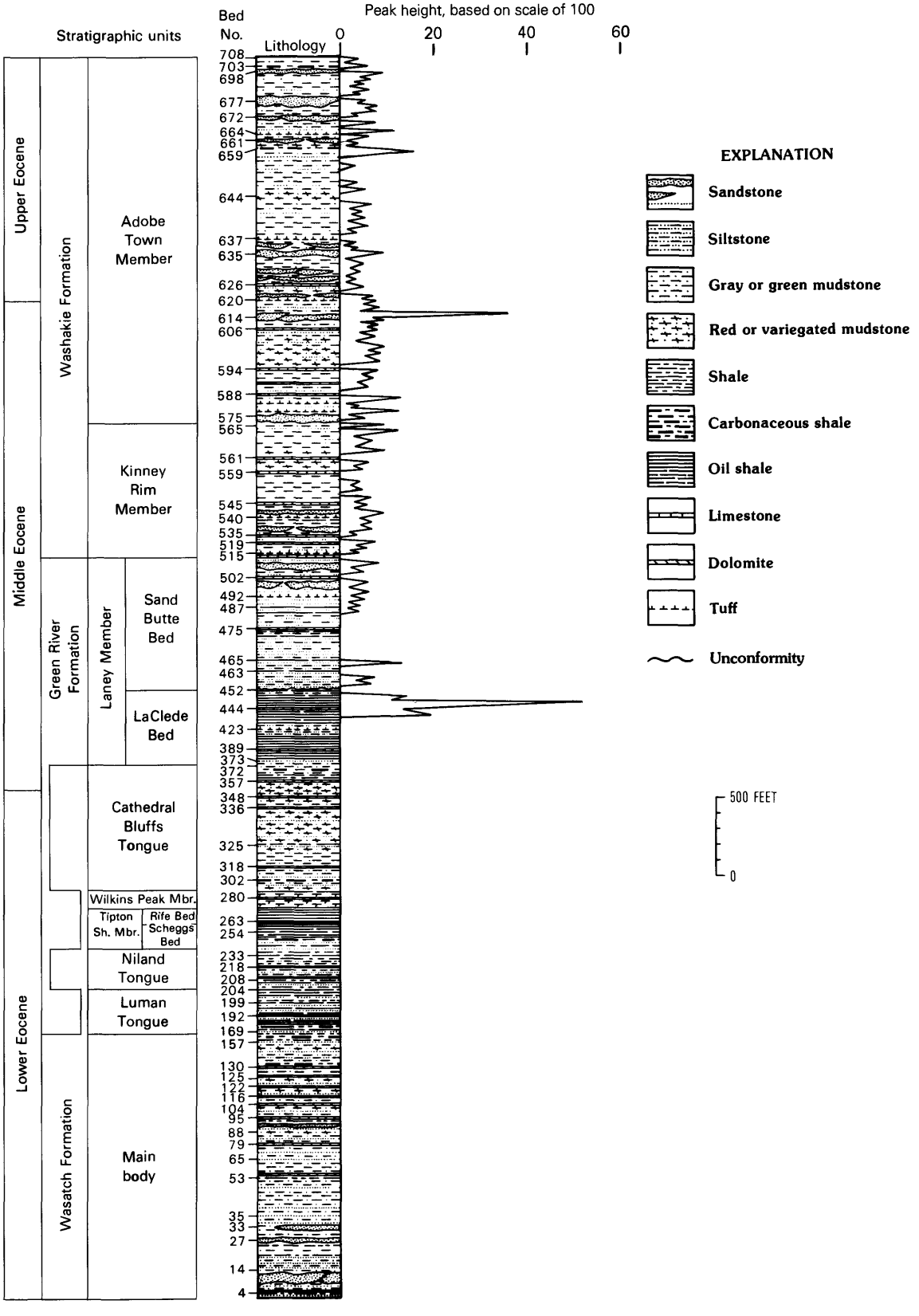


FIGURE 28.—Stratigraphic distribution and relative amount of mordenite in Eocene rocks in Washakie basin reference section based on peak heights from X-ray diffractograms.

extremely rich oil shale, algal limestone, oolitic limestone, and sandstone. The beds are dominantly carbonates (generally 40–50 percent), with lesser amounts of quartz, clay, and zeolite.

The oil shale samples collected for assay during measurement of the Washakie basin reference section are channel samples. The amount of oil in these weathered samples has been reduced from about 5 to 25 percent by oxidation and biogenic degradation as a result of surface exposure. Because of this weathering, the oil shale assays from the reference section are compared to assays of unweathered core samples from the nearby U.S. Bureau of Mines Washakie basin Coreholes No. 1, located in sec. 17, T. 14 N., R. 99 W., and No. 1A, located in sec. 24, T. 14 N., R. 100 W. Oil yields of the outcrop and core samples were determined by the Fischer retort method, whereby the kerogen (insoluble organic material) in the rocks is converted by distillation into a low-quality crude oil. The samples were assayed at the U.S. Bureau of Mines Laramie Energy Research Center, Laramie, Wyo.

LUMAN TONGUE

One thick bed of lean oil shale is present at the top of the Luman Tongue, and several thin beds of lean oil shale are spaced through the middle and lower parts of the tongue (fig. 29). The oil shale beds in the tongue consist of kerogenaceous shale of freshwater lacustrine origin. The oil shale beds along the Luman outcrops were so badly weathered that samples were not collected for Fischer assay. Instead, visual estimates of oil yields (based on color) were recorded for each bed in the field, and these estimates are illustrated in figure 29. The estimates suggest that few, if any, of the beds will have oil yields in excess of 15 gal/ton. The estimated oil yields in the Luman Tongue agree with the assays of cores from the tongue from the U.S. Bureau of Mines Washakie basin Corehole No. 1A, located in sec. 24, T. 14 N., R. 100 W. (Trudell and others, 1973, p. 147–148).

SCHEGGS BED OF TIPTON SHALE MEMBER

The lean oil shale beds that make up the Scheggs Bed of the Tipton Shale Member (fig. 30) are similar in composition and appearance to the oil shale beds in the underlying Luman Tongue. The oil shales in the Scheggs Bed are similarly deeply weathered along outcrops, and the samples collected for assay consequently have lower than normal oil yields. Few of the unweathered oil shale beds in the member are expected to yield more than 15 gal/ton by assay. In the Washakie basin Corehole No. 1A, located in sec. 24, T. 14 N., R. 100 W., the highest recorded oil yield was 12.0 gal/ton for a bed 1 ft thick near the top of the member (Trudell and others, 1973, p. 147).

RIFE BED OF TIPTON SHALE MEMBER

The Rife Bed of the Tipton Shale Member is composed mostly of thick beds of lean oil shale with some thin interbedded rich oil shale. The upper few feet of bed 266 (fig. 30) assayed 19.1 gal/ton, which is the richest interval assayed in the member. The Rife Bed in the U.S. Bureau of Mines Washakie basin Corehole No. 1A, located in sec. 24, T. 14 N., R. 100 W., has a 3.1-ft-thick bed at the top of the member that averaged 25.4 gal/ton; 14 underlying beds, from less than 1 to slightly more than 4 ft thick, yielded slightly more than 15 gal/ton (Trudell and others, 1973, p. 145–146).

WILKINS PEAK MEMBER

The Wilkins Peak Member in the reference section is a mixture of saltwater lacustrine and mudflat deposits that contain traces of kerogen, except for bed 289 (fig. 30), which assayed 6.3 gal/ton. The Wilkins Peak Member thickens southward from 119 ft in secs. 29 and 30, T. 16 N., R. 100 W., where the reference section was measured, to 214 ft in the U.S. Bureau of Mines Washakie basin Corehole No. 1, located in sec. 17, T. 14 N., R. 99 W. The oil shale beds in the corehole assayed less than 15 gal/ton, except for one bed less than 1 ft thick in the upper part of the member that assayed 22.7 gal/ton (Trudell and others, 1973, p. 143).

LANEY MEMBER

The Sand Butte Bed of the Laney Member contains five thin beds of oil shale (beds 463, 465, 470, 474, and 482, pl. 2) that by visual estimates will yield less than 15 gal/ton of oil by assay. These beds are entirely of freshwater lacustrine origin. The Sand Butte Bed unconformably overlies a thick section of rich oil shales that are present in the LaClede Bed of the Laney Member (fig. 31; pl. 2). The oil shale beds in the lower and middle parts of the LaClede Bed (beds 373–443, fig. 31) are mostly kerogenaceous dolomites of saltwater lacustrine origin, and the oil shale beds in the upper part of the LaClede Bed (beds 444–452, fig. 31) are mostly kerogenaceous shales of freshwater lacustrine origin. The oil shales between beds 390 and 443 (fig. 31), adjacent to the buff marker, are without doubt the thickest, richest oil shale section in the Washakie

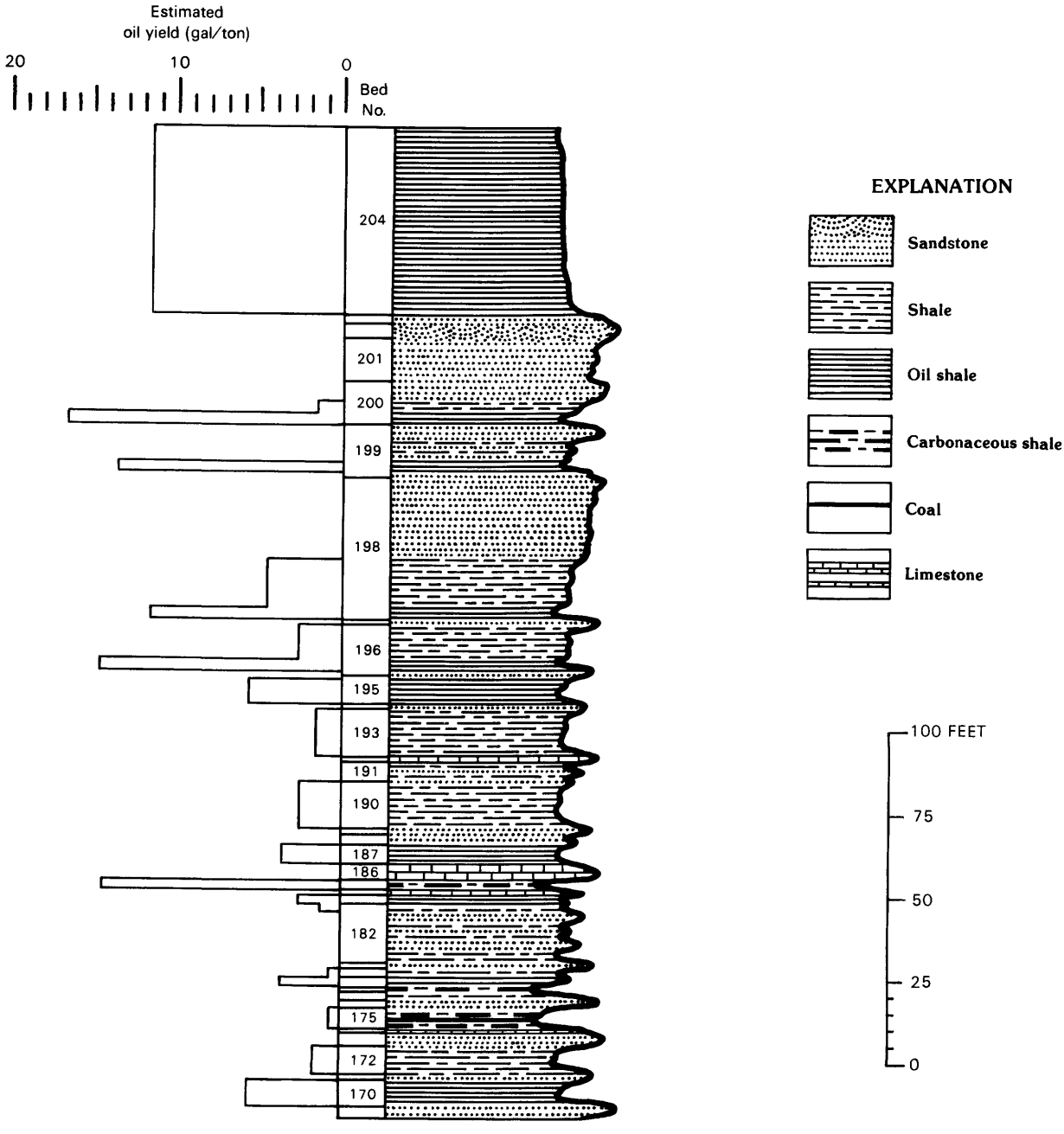


FIGURE 29.—Estimated oil yields of weathered oil shale from outcrops in the Luman Tongue of the Green River Formation in Washakie basin reference section.

basin. Most of the oil shale beds in this section will yield more than 15 gal/ton by assay, many will exceed 25 gal/ton by assay, and a few thin beds in the vicinity of the reference section have assayed more than 40 gal/ton (Roehler, unpub. data). Assays from the U.S. Bureau of Mines Washakie basin Corehole No. 1, located in sec. 17, T. 14 N., R. 99 W., indicate that the section between beds 390 and 443 may contain as much as 200 million barrels of shale oil per square mile in the southwestern part of the Washakie basin (Roehler, 1973c, p. 49, table 2).

PALYNOMORPHS

Twenty-two spot samples of gray to black carbonaceous shale, shale, and mudstone from widely spaced vertical intervals in the Washakie basin reference section were collected for palynological identifications. The stratigraphic positions of the samples and their assigned paleobotany locality numbers are shown on table 5. The samples were prepared in the U.S. Geological Survey paleontology and stratigraphy laboratory, Denver, Colo., and the taxa were identified by E.B. Leopold (written commun., 1976).

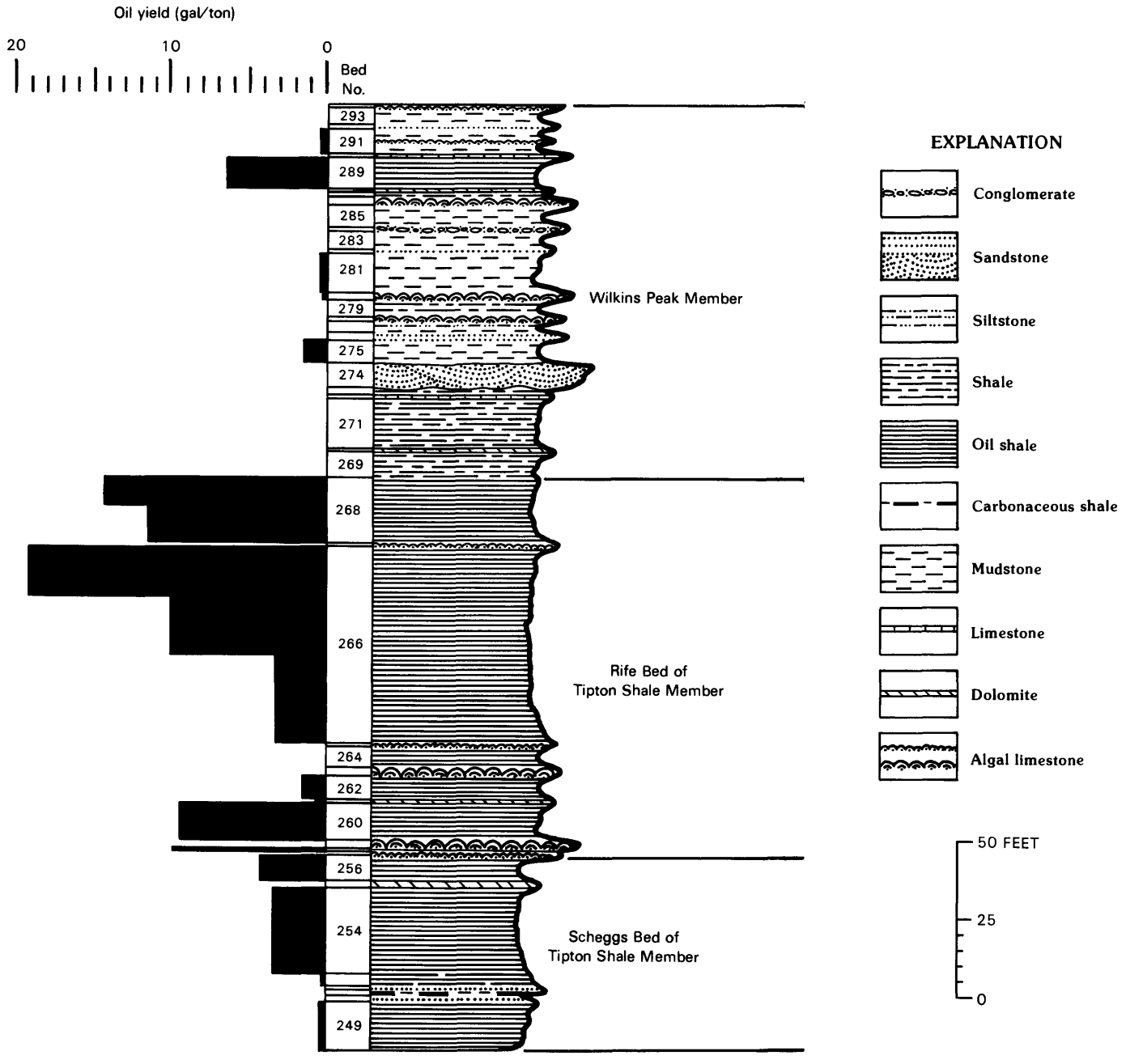


FIGURE 30.—Oil yields by Fischer assay of weathered oil shale from outcrop samples of the Scheggs and Rife Beds of the Tipton Shale Member, and Wilkins Peak Member of the Green River Formation in the Washakie basin reference section.

The palynomorphs indicate that distinctly different groups of plants were present that reflect different climates for the Washakie basin area during the Eocene Epoch (Leopold and MacGinitie, 1972, p. 169–172). In terms of precipitation and temperature, the Eocene climates were moist and warm (warm temperate) during the early Eocene, moist and hot (semiarid) and then dry and hot (arid) during the late early and early middle Eocene, wet and hot (subtropical) during the middle middle Eocene, and dry and cool (cool temperate) during the late middle and late Eocene. Within these basic climates, each from 2 to 10 million years long, were lesser and commonly cyclic climate changes of 15–25 thousand years duration (Chapter F, this volume). The climate changes are apparent not only from the palynologic data but also by distinct changes in the composition and areal distribution of lithofacies. The relationships of the climates to the depositional environments are explained in detail in Chapter F of this volume.

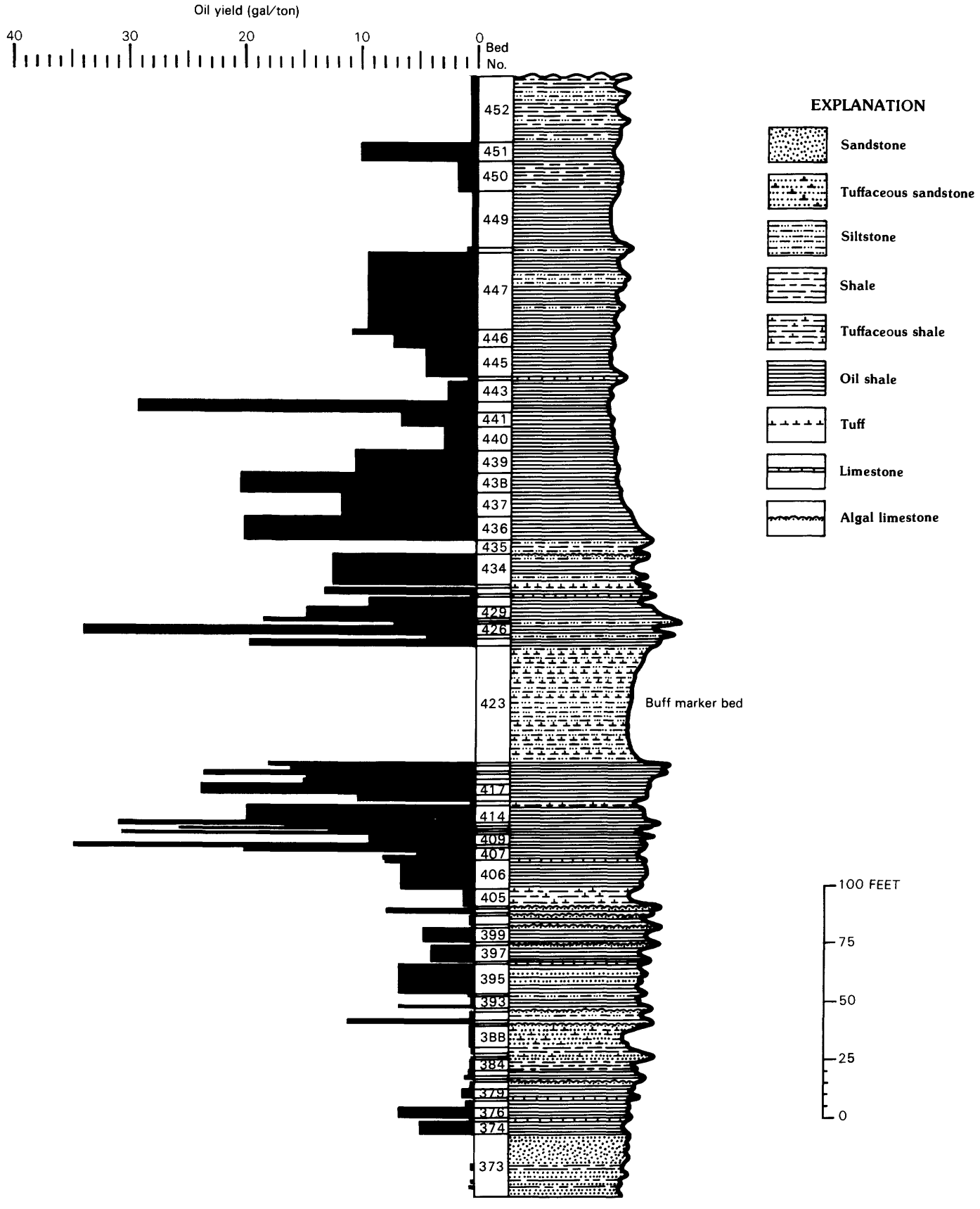


FIGURE 31.—Oil yields by Fischer assay of weathered oil shale from outcrop samples of the LaClede Bed of the Laney Member of the Green River Formation in Washakie basin reference section.

TABLE 5.—*Palynomorphs identified by E.B. Leopold in Eocene rocks, Washakie basin reference section*

[Identification, written commun., 1976; Abn., abundant]

	Eocene																					
	Early								Middle								Late					
	Main body Was.			Luman T.	Niland T.		Cath. Bluffs T.		Laney Mbr.								Washakie Fm.					
USGS paleobotany locality No.	D4303	D4304	D4306	D4307	D4308	D4309	D4310	D4311	D4475	D4476	D4477	D4478	D4312	D4479	D4313	D4314	D4316	D4318	D4319	D4320	D4321	D4322
Bed No.	55	108	167	175	217	248	302	353	370	440	446	449	451	461	465	482	585	652	659	701B	701A	703
Monolete, smooth	X			X			X						X						X			
Palmae types	X	X	X			X	X	X	X			X		X	X							
cf. *Engelhardtia*	X	X				X			X											X		
Eucommia	X?	X?				X		X	X									X		X	X	
Platycarya	X	36%	Abn.	50%		35%		Rare					Rare									
Sparganium-Potamogeton		X		X														Abn.	X	Abn.	X	
Carya		X	X	X?		X			X			X	X		X						X	
Chenopodiaceae		X			X			X		X							X					
Tiliaceae cf. *Triumfetta*		X				X								X								
Betulaceoipollenites w/3 polar scars		X				X		X	X									X				
Pterocarya		X?											X								X	
cf. Bombaceae		X																				
cf. *Platanus*		X						X	X					X					X	X	X	
cf. Rosaceae		X																X				
Pistillipollenites mcgregorii		X				X	X							X								
Ulmus-Zelkova				X		X		X	X			X	X	X	X	X		X	X	X	X	
Tiliaepollenites, smooth				X		X		X	X				X	X								
Pinus					X	X		X					Abn.	X		X	X	X	X	X		
Schizaeaceae undet.						X																
cf. *Hemiptelia*						X																
cf. Taxodiaceae						X		X				X	X						X	X		
Meliaceae cf. *Cedrela*						X																
cf. *Castanea*						X			X													
Trema						X		X					X									
cf. *Ostrya-Carpinus* p4						X																
cf. *Picrodendron*						X		X														
Ericales						X																
Tricolpites cf. *angululuminosus*						X																
Alnus						X							X	X					X	X		
Cardiospermum						X																
Arecipites (Liliales)						X		X												X		
cf. *Lygodium kaulfussi*								X					X	X						X?	X	
cf. *Cycas*								X									X					
Tricolpites (pl. 40, fig. 9, Leopold, 1974)								X														
Alangium cf. *barghoornianus*													X									
Juglans													X						X		X	
Ilex													X									
cf. *Comptonia*									X				X									
cf. *Cedrus*													X						X			
Pediastrum										X			Abn.							Abn.		
Sarcobatus (contam.?)														X				X?				
Artemisia (contam.?)																		X?				
Picea									X					X					X		X	
Ephedra cf. *nevadensis*																			X	X	X	

TABLE 5.—*Palynomorphs identified by E.B. Leopold in Eocene rocks, Washakie basin reference section*—Continued

	Eocene																				
	Early								Middle									Late			
	Main body Was.			Luman T.	Niland T.		Cath. Bluffs T.		Laney Mbr.									Washakie Fm.			
USGS paleobotany locality No.	D4303	D4304	D4306	D4307	D4308	D4309	D4310	D4311	D4475	D4476	D4477	D4478	D4312	D4479	D4313	D4314	D4316	D4318	D4319	D4320	D4321	D4322
Bed No.	55	108	167	175	217	248	302	353	370	440	446	449	451	461	465	482	585	652	659	701B	701A	703
Scirpus																			X			
cf. *Impatiens*																			X			
Caesalpinia																			X			
cf. *Quercus*																				X		
cf. *Lemna*														X						X	X	
Botryococcus																				X		
cf. *Celtis*																					X	
cf. *Salix*														X							X	
Onagraceae																					X	
cf. *Circumflexipollis*																			X			
Tricolpites cf. *parvistriatus*																			X			
cf. *Pseudotsuga*														X								X
cf. *Castanopsis*									X													
cf. *Glyptostrobus*									X													
cf. *Platanus* (as above)									X													
cf. *Peraphyllum* (type)									X													
Tristriopollenites glandulosus									X													
Elaeagnus (type)									X													
Lygodium, smooth types									X													
Ovoidites									X													
Ulmaceae											X											
Maceopolipollenites												X										
Pterocarya														X								
Myriophyllum ambigulpites														X								
Carpinus ancipites														X								
Abietipites antiquus (*Tsuga*)														X								
cf. *Rhoipites bradleyi*														X								

REFERENCE SECTION OF EOCENE ROCKS IN THE GREEN RIVER BASIN

[Measured by H.W. Roehler, using a 5-ft Jacob's staff and Abney level, between 1958 and 1985, at various correlated localities in Sweetwater County, southwest Wyoming (pl. 1)]

	Thickness (Feet)
Bishop Conglomerate:	
625. Conglomerate, gray-brown, composed of granules, pebbles, cobbles, and boulders of well-rounded, poorly sorted red quartzite, tan and white quartzite and gray limestone in a coarse-grained sandstone matrix; clasts are matrix supported; caps Twin Buttes	29.0
Unconformity.	
Bridger Formation:	
624. Tuff, white, and interbedded mudstone, medium-gray, tuffaceous, soft; airfall ash and flood-plain (basin-fill) deposits	45.0
623. Tuff, white, sandy, with very thin interbedded mudstone, gray, tuffaceous; some siliceous layers; one isolated specimen of *Australorbis* sp. in a white tuff airfall ash; flood-plain (basin-fill) and shallow freshwater lacustrine deposits.	9.7
622. Mudstone, gray-green, blocky, hard; some tuff layers; flood-plain (basin-fill) deposits	98.0
621. Sandstone, gray, fine-grained, tuffaceous, firm; flood-plain (splay) deposit	0.6
620. Shale, black, carbonaceous; swamp deposits	0.3
619. Mudstone, gray-green, blocky, soft; flood-plain (basin-fill) deposit	1.7
618. Tuff, white, crumbly, blocky; airfall ash deposit	1.9
617. Mudstone, gray-green, tuffaceous, soft; flood-plain (basin-fill) deposit	4.5
616. Tuff, light-gray, sandy, blocky, hard; airfall ash deposit	1.8
615. Sandstone, gray-green, fine-grained, tuffaceous, massive; some worm burrows; a thin, narrow, flood-plain (stream channel) deposit	3.0
614. Mudstone, gray-green, blocky, soft, and interbedded sandstone, gray-green, fine-grained; in parallel beds; flood-plain (splay and basin-fill) deposits	35.6
613. Mudstone, gray-green, some light-pink banding, blocky, soft; flood-plain (basin-fill) deposit	9.0
612. Mudstone, gray-green, blocky, soft; flood-plain (basin-fill) deposit	13.0
611. Sandstone, gray, fine-grained, tuffaceous; in parallel beds; flood-plain (splay) deposit	12.0
610. Mudstone, gray-green, blocky, soft, tuffaceous; 0.9-ft-thick tuff with black siliceous laminae 30 ft above the base; flood-plain (basin-fill) and airfall ash deposits	65.0
609. Tuff, white, silty, hard; airfall ash deposit	2.8
608. Mudstone, gray, tuffaceous, soft; flood-plain (basin-fill) deposit	2.2
607. Limestone, light-gray-tan, tuffaceous, hard; in parallel layers 2.8 ft thick (top) and 4.3 ft thick (bottom). Upper layer has abundant siliceous root fillings; bottom layer has irregularly shaped nodular chert inclusions up to 0.5 ft long. Chert has distinct brown and black concentric banding; tuffaceous freshwater pond deposit	7.1
606. Mudstone, gray-green, blocky, and numerous 1–2 ft-thick interbedded sandstones, gray-green, fine-grained, and tuff, light-gray, sandy; in parallel beds; flood-plain (basin-fill and splay) deposits	119.0
605. Mudstone, gray-green, blocky, tuffaceous, and a few interbedded sandstones, gray, fine-grained, tuffaceous, hard, and tuff, light-gray, sandy, hard; in parallel beds; flood-plain (basin-fill) and airfall ash deposits	155.0
604. Tuff, light-gray, sandy; massive; airfall ash deposit	2.4
603. Mudstone, gray, gray-green; blocky, firm, tuffaceous; two very thin interbedded sandstones, gray-green, fine-grained; flood-plain (basin-fill) deposits	25.3
602. Tuff, light-gray, silty, hard; airfall ash deposit	0.2
601. Mudstone, gray-green, blocky, and some interbedded sandstone, gray-green; in parallel beds; one tuff bed 0.9 ft thick, sandy, light-gray, about 25 ft below the top; flood-plain (basin-fill) and airfall ash deposits	65.4
600. Shale, black, carbonaceous; abundant turtle scutes; swamp deposit	0.2
599. Mudstone, gray, sandy, tuffaceous; flood-plain (basin-fill) deposit	1.0
598. Siltstone, tan, sandy, tuffaceous; flood-plain (basin-fill) deposit	0.5
597. Mudstone, gray-green, blocky, firm; flood-plain (basin-fill) deposit	3.4
596. Clay shale, brown, flaky; scattered fish bones; upper 0.5 ft is kerogenaceous; freshwater lacustrine deposit	1.7
595. Tuff, gray, silty, massive; abundant siliceous root fillings; airfall ash deposit. The upper white layer of Osborn (1929, p. 86)	3.6
594. Mudstone, gray, tuffaceous, blocky, firm; flood-plain (basin-fill) deposit	11.1
593. Sandstone, gray to gray-green, fine- to medium-grained, poorly sorted, biotitic, tuffaceous; scattered black, green, and red grains; in thin, even, parallel beds; flood-plain (splay) deposit.	10.8
592. Mudstone, gray, gray-green, and some interbedded sandstone, gray, fine-grained; in parallel beds; flood-plain (basin-fill and splay) deposits.	75.2
591. Sandstone, apple-green, gray-green, fine- to coarse-grained, poorly sorted, abundant dark and varicolored grains; low-angle trough cross-beds; flood-plain (stream channel) deposit	29.5
590. Mudstone, gray-green, and interbedded sandstone, gray-green, fine-grained, argillaceous; in parallel beds; flood-plain (basin-fill and splay) deposits	35.0
589. Sandstone, apple-green, fine-grained, fairly well sorted, very argillaceous, massive; in parallel beds; flood-plain (splay) deposit	6.9
588. Mudstone, gray, gray-green, and interbedded sandstone, gray-green, fine-grained; in parallel beds; abundant mammal bones; flood-plain (basin-fill and splay) deposits	21.8
587. Sandstone, gray, fine-grained, fairly well sorted; abundant dark grains; weathers brown; a small, lenticular, flood-plain (stream channel) deposit	2.2
586. Mudstone, gray-green, and interbedded sandstone, gray-green, fine-grained; in parallel beds; flood-plain (basin-fill and splay) deposit.	16.1

Reference section of Eocene rocks in the Green River basin—Continued

Bridger Formation—Continued

606.—Continued

Reference section of Eocene rocks in the Green River basin—Continued

	Thickness Feet
Bridger Formation—Continued	
585. Sandstone, gray, very fine to fine-grained; in thin lenticular beds; abundant worm borings; flood-plain (stream channel) deposit	4.6
584. Mudstone, gray, gray-green, and interbedded sandstone, gray-green, very argillaceous; in parallel, nonresistant beds; flood-plain (basin-fill and splay) deposits	50.6
583. Mudstone, gray-green, pink, red, black, variegated, blocky, hard; flood-plain (basin-fill) deposit	8.1
582. Mudstone, brick-red, and interbedded narrow lenses of sandstone, red, fine-grained, up to 3 ft thick; flood-plain (basin-fill and stream channel) deposits. Red marker beds	29.0
581. Mudstone, apple-green, gray-green, pink-red, banded; flood-plain (basin-fill) deposit	24.5
580. Mudstone, gray-green, blocky, firm; flood-plain (basin-fill) deposit	45.0
579. Sandstone, gray-green, fine- to medium-grained, soft, loose; flood-plain (stream channel) deposit	10.1
578. Conglomerate, gray-green; composed of rounded pebbles of black, gray, and red chert and gray sandstone in a very coarse grained sandstone matrix; some fossil wood; the base of a flood-plain (stream channel) deposit	5.5
577. Mudstone, gray-green, clayey, soft; flood-plain (basin-fill) deposit	3.2
576. Clay shale, brown, silty, dolomitic, flaky to platy; freshwater lacustrine deposit; kerogenaceous.	2.0
575. Siltstone, tan, limy, hard; freshwater lacustrine deposit	0.8
574. Mudstone, gray-green, soft; flood-plain (basin-fill) deposit	23.2
573. Limestone, tan, silty, hard; abundant ostracodes; some large pelecypod shell fragments; some unidentified gastropod shell fragments and well-preserved *Valvata* sp., abundant siliceous root fillings; part of the bench where the unit crops out is covered by a 0.5-ft-thick lens of algal limestone, brown, perforate-type, that forms a local mat; freshwater lacustrine deposits	2.8
572. Tuff, light-gray, hard; airfall ash deposit	1.6
571. Mudstone, gray-green, soft; two blocky tuff layers in the lower part; flood-plain (basin-fill) and airfall ash deposits	31.0
570. Siltstone, light-gray, very tuffaceous, hard; airfall ash deposit	2.3
569. Mudstone, gray-green, blocky, soft; flood-plain (basin-fill) deposit	6.4
568. Tuff, tan, blocky, very hard; airfall ash deposit	1.0
567. Mudstone, gray-green, blocky, soft; flood-plain (basin-fill deposit)	24.3
566. Siltstone, tan, limy; abundant siliceous root fillings; freshwater pond deposit	0.9
565. Mudstone, gray-green, blocky, soft; scattered mammal bone fragments; flood-plain (basin-fill) deposit	18.9
564. Siltstone, tan, limy, hard; freshwater pond deposit	0.3
563. Mudstone, gray-green, soft; flood-plain (basin-fill) deposit	6.8

Reference section of Eocene rocks in the Green River basin—Continued

	Thickness Feet
Bridger Formation—Continued	
562. Clay shale, brown, dolomitic, flaky to platy; some layers grade into oil shale, brown, flaky, dolomitic; kerogenaceous; scattered plant impressions; freshwater lacustrine deposit	2.8
561. Mudstone, gray-brown, soft; flood-plain (basin-fill) deposit	2.7
560. Sandstone, gray-green, fine- to coarse-grained, poorly sorted, subangular; abundant colored grains, lenticular; in trough crossbeds; thickens north of the line of section; flood-plain (stream channel) deposit	6.5
559. Mudstone, gray-green, soft; flood-plain (basin-fill) deposit	5.5
558. Limestone, tan-brown, platy, hard; freshwater lacustrine deposit	0.8
557. Tuff, tan-gray, limy, hard, massive; airfall ash deposit	1.1
556. Mudstone, gray-green, blocky, firm; flood-plain (basin-fill deposit	131.4
555. Limestone, tan-gray, silty, hard; a few ostracodes; some unidentified mollusk shell impressions; some siliceous root fillings; weathers to a brown ledge; freshwater lacustrine deposit	0.8
554. Mudstone, gray-green, blocky, firm; flood-plain (basin-fill) deposit	29.5
553. Sandstone, gray-green, fine- to medium-grained, poorly sorted, subangular; abundant colored grains, in trough crossbeds; lenticular flood-plain (stream channel) deposit	15.6
552. Mudstone, gray-green, blocky; abundant turtle carapaces the lower 10 ft; flood-plain (basin-fill) deposit	60.0
551. Limestone, tan-gray, sandy, hard; layer of siliceous, dark-gray algal limestone at the top; fish bones; leaf impressions; freshwater lacustrine deposit	2.1
550. Mudstone, gray-green, blocky, firm; flood-plain (basin-fill) deposit	103.8
549. Limestone, gray, very sandy, hard; unidentified small gastropods; some fairly large thin-shelled pelecypod shell fragments; abundant siliceous root fillings; a few small algal heads at the top, some of which surround tree trunk impressions or form irregularly shaped mounds up to a few feet wide; weathers to brown ledge; freshwater lacustrine deposit. The Sage Creek white layer of Bradley (1964, p. A80) or Burnt Fork white layer of Osborn (1929)	2.0
548. Mudstone, gray-green, blocky, firm; flood-plain (basin-fill) deposit	14.5
547. Limestone, tan-gray, platy, hard; abundant ostracodes, at the top and bottom of interval; mudstone, gray, in the middle; freshwater lacustrine deposit	2.3
546. Mudstone, gray-green, blocky; flood-plain (basin-fill) deposit	9.6
545. Limestone, tan-gray, hard; abundant ostracodes; weathers to brown ledge; freshwater lacustrine deposit	1.9

Reference section of Eocene rocks in the Green River basin—Continued

	Thickness Feet
Bridger Formation—Continued	
544. Mudstone, gray-green with some green bands, blocky, firm; weathers to steep, smooth slopes; flood- plain (basin-fill) deposit	109.0
543. Shale, brown, carbonaceous, flaky; swamp deposit	0.3
542. Mudstone, gray-green with some green bands and some brownish bands, blocky, firm; the lower 10 ft has abundant turtle carapaces; some fossil wood (conifer?); a few barite nodules as much as 0.2 ft in diameter; flood-plain (basin-fill) deposit	30.6
541. Limestone, tan-gray, platy, hard; weathers to a very persistent brown ledge at the base of steep badland slopes; freshwater lacustrine deposit	2.8
540. Mudstone, gray-green, blocky; sandy the lower 3.0 ft; flood-plain (basin-fill) deposit	39.2
The approximate stratigraphic horizon of the Church Buttes fossil locality, located 200 ft southeast of the section corner 3, 4, 9, 10 in T. 15 N., R. 112 W., about 200 ft below the Sage Creek white layer. Fossil mammal identifications by C.L. Gazin.	
Scenopagus sp.	
Notharctus tenebrosus	
Paramys delicatior	
Viverravus gracilis	
Hyopsodus paulus	
Orohippus sp.	
Helohyus plicodon	
539. Siltstone, gray, slightly limy, hard; flood-plain (basin-fill) deposit	1.6
538. Tuffaceous limestone, tan-gray, blocky, hard, ledge-forming; freshwater lacustrine deposit	1.1
537. Mudstone, gray-green, blocky, flood-plain (basin-fill) deposit	18.9
536. Tuff, light-gray, blocky; some small biotite grains; ledge forming; airfall ash deposit	1.2
535. Mudstone, gray-green; flood-plain (basin-fill) deposit	3.0
534. Sandstone, gray-green, fine- to medium-grained, poorly sorted; abundant colored grains; in small-scale trough crossbeds; mostly soft and loose; flood-plain (stream channel) deposit	13.2
533. Mudstone, gray-green at the top and bottom, bright-green in the middle, tuffaceous, blocky, firm; flood-plain (basin-fill) deposit	19.1
532. Limestone, gray, sandy, blocky, firm; weathers to brown ledge; freshwater lacustrine deposit	1.9
531. Mudstone, gray-green, blocky; one very thin layer of clay shale, gray, platy, 2.0 ft above the base; flood-plain (basin-fill) and freshwater lacustrine deposits	18.3
530. Clay shale, brown, dolomitic, flaky to platy, hard; abundant ostracodes; kerogenaceous; freshwater lacustrine deposit. Top of white marker bed	2.0
529. Siltstone, gray, dolomitic, tuffaceous, hard; in parallel beds up to 0.5 ft thick; some interbedded shaly layers; freshwater lacustrine deposit. Base of white marker bed	1.4

Reference section of Eocene rocks in the Green River basin—Continued

	Thickness Feet
Bridger Formation—Continued	
528. Mudstone, gray-green, black, hard; sandy the lower 3.0 ft; flood-plain (basin-fill) deposit	35.2
527. Sandstone, tan, very fine grained, limy; thin layer of green shale in the middle; some clay pebbles in the lower part; flood-plain (basin-fill) deposit	0.9
526. Mudstone, gray-green, blocky, firm; flood-plain (basin-fill) deposit	9.1
525. Algal limestone, tan, hard, dolomitic; grades upward into thin parallel-bedded dolomite, tan-brown, very hard; weathers to ledge; freshwater lacustrine deposit	1.8
524. Mudstone, gray-green, blocky, hard; with several 0.5–2.0-ft-thick, lenticular, parallel, interbedded sandstones, gray-green, fine-grained; flood-plain (basin-fill and splay) deposits	83.1
523. Sandstone, gray-green, fine-grained; in parallel beds; flood-plain (splay) deposit	1.4
522. Mudstone, gray-green, blocky, firm; flood-plain (basin-fill) deposit	11.5
521. Sandstone, gray-green, fine- to very coarse grained; conglomeratic at the base with well-rounded pebbles of bright-green clay; scoured base; trough crossbedded; one turtle scute; flood-plain (stream channel) deposit	23.5
520. Mudstone, medium-gray, blocky, firm, and some very thin interbedded sandstone, gray, very fine grained; in lenticular, parallel beds; flood-plain (basin-fill and splay) deposit	11.0
519. Sandstone, gray-green, fine-grained, fairly well sorted, subangular; in parallel beds, flood-plain (splay) deposit	4.6
518. Mudstone, gray-green, blocky, soft, with very thin interbedded lenticular sandstone, light- to medium-gray, fine-grained, firm; flood-plain (basin-fill and splay) deposits	64.5
Total thickness of Bridger Formation	2,105.5
Laney Member of Green River Formation:	
Hartt Cabin and Sand Butte Beds:	
517. Dolomite, light-gray, blocky, hard; freshwater pond deposit	1.6
516. Mudstone, brown, gray, arenaceous, soft; weathers tan and is the uppermost thick, freshwater lacustrine deposit in the section	34.1
515. Dolomite, tan, brown, platy, hard; freshwater pond deposit	2.6
514. Mudstone, tan-brown, sandy, argillaceous, soft; appears to be a freshwater lacustrine deposit.	16.0
513. Coquinal sandy dolomite, hard, crumbly; abundant *Goniobasis* sp., some *Valvata* sp., miscellaneous unidentified shell fragments; freshwater lacustrine (shoreline) deposit	0.5
512. Mudstone, brown, soft; appears to be a freshwater lacustrine deposit	2.7
511. Dolomite, light-gray, platy, hard; freshwater pond deposit	0.5
510. Shale, brown, flaky; kerogenaceous; freshwater lacustrine deposit	1.0
509. Dolomite, tan-brown, hard, platy; some *Goniobasis* sp., and *Viviparus* sp.; freshwater lacustrine deposit	0.4

Reference section of Eocene rocks in the Green River basin—Continued

	Thickness Feet
Laney Member of Green River Formation—Continued	
Hartt Cabin and Sand Butte Beds—Continued	
508. Mudstone, gray-green, brown, sandy; one dolomitic layer near the middle; flood-plain (basin-fill) and freshwater pond deposits	6.1
507. Sandstone, tan-gray, fine-grained to very coarse grained, poorly sorted, subangular to rounded, dolomitic; some turtle scutes; flood-plain (splay) deposit	1.8
506. Mudstone, interbedded brown and gray, sandy, soft; flood-plain (basin-fill) deposit	9.7
505. Dolomite, green-brown, platy, hard; some root casts; freshwater pond deposit	0.6
504. Mudstone, gray-green, brown in the upper part, sandy laminae; becomes green dolomite the upper 1.0 ft; flood-plain (basin-fill) deposit	4.7
503. Dolomite, green-brown, platy, hard; some root casts; freshwater pond deposit	0.7
502. Mudstone, green, flaky; flood-plain (basin-fill) deposit	1.5
501. Sandstone, dark-gray-green, fine- to medium-grained, poorly sorted, subangular; composed mostly of dark grains; massive; flood-plain deposit	14.9
500. Siltstone, light-gray, very dolomitic, hard; scattered isolated coarse sand grains; some *Goniobasis* sp., *Valvata* sp., and fish bones; freshwater pond deposit	0.4
499. Mudstone, gray-green, blocky, hard, very dolomitic the top 1.0 ft; flood-plain (basin-fill) deposit	6.5
498. Siltstone, brown, argillaceous, and interbedded sandstone, brown, very fine grained; in thin, even, parallel beds; freshwater lacustrine (shoreline) deposit	5.1
497. Mudstone, gray-green, blocky, hard; becomes very dolomitic upwards and nearly dolomite at the top; flood-plain (basin-fill) deposit	2.5
496. Siltstone, brown, argillaceous, and interbedded and interlaminated sandstone, brown, very fine grained; in thin, even beds and laminae; freshwater lacustrine (shoreline) deposit	9.0
495. Clay shale, gray, dolomitic, platy, hard; freshwater lacustrine deposit	1.8
494. Coquinal sandstone, gray, very fine grained, limy, hard in thin, subparallel beds; contains *Goniobasis* sp., and unidentified Unionid clams; freshwater lacustrine (shoreline) deposit. Coquina bench marker bed	4.3
493. Sandstone, brown, very fine grained, calcareous, in parallel beds with planar crossbeds, and some interbedded siltstone, brown, argillaceous, soft; shallow freshwater lacustrine (shoreline) deposit	8.0
492. Clay shale, gray, dolomitic, laminated, hard, and some interbedded siltstone, brown, argillaceous, soft; in thin, parallel beds; freshwater lacustrine deposit	4.3
491. Siltstone, brown, argillaceous, soft, and interbedded sandstone, tan-brown, very fine grained; in thin, even, parallel beds; freshwater lacustrine deposit	9.5

Reference section of Eocene rocks in the Green River basin—Continued

	Thickness Feet
Laney Member of Green River Formation—Continued	
Hartt Cabin and Sand Butte Beds—Continued	
490. Clay shale, gray, very dolomitic, very hard; abundant small, oval impressions as much as ¼ inch long that appear to be seed pods; freshwater lacustrine deposit	2.7
489. Siltstone, brown, argillaceous, soft, and some interbedded sandstone, tan, very fine grained; becomes sandy upwards; in thin, even, parallel beds; freshwater lacustrine deposit	24.1
488. Siltstone, brown, argillaceous, soft, and thin interbedded siltstone, gray, dolomitic, laminated, and some sandstone, brown, very fine grained; in thin, even, parallel beds; freshwater lacustrine deposit	11.0
487. Sandstone, brown, very fine grained, subangular, poorly sorted; very small scale trough crossbeds; a small narrow, lenticular, freshwater lacustrine (channel) deposit	2.7
486. Siltstone, brown, argillaceous, and interbedded siltstone, gray, dolomitic, hard; in thin laminations; freshwater lacustrine deposit	7.8
485. Siltstone, gray, argillaceous, dolomitic, hard; in thin, parallel laminations; freshwater lacustrine deposit	3.0
484. Mudstone, gray, soft, shaly; flood-plain (basin-fill) deposit	4.5
483. Clay shale, brown, flaky, silty; scattered plant fragments; kerogenaceous; freshwater lacustrine deposit	2.3
482. Coquinal sandstone, brown, very fine grained, limy; abundant *Goniobasis* sp., some Unionid clams; fish bones; turtle scutes; a few aquatic plant fragments; freshwater lacustrine deposit	0.4
481. Siltstone, tan-brown, argillaceous, soft, and some interbedded sandstone, brown, very fine grained, and laminae and very thin beds of clay shale, gray, dolomitic, hard; in parallel beds; freshwater lacustrine deposits	24.8
480. Clay shale, gray, dolomitic, hard, and interbedded siltstone, tan-brown, argillaceous, soft; freshwater lacustrine deposits	2.5
479. Sandstone, tan, brown, very fine grained, subangular, poorly sorted; becomes a coquinal sandstone the top 1.0 ft; abundant *Goniobasis* sp., some Unionid clams; abundant fish bones; turtle scutes; freshwater lacustrine (shoreline) deposit	3.9
478. Clay shale, gray, dolomitic, in thin, even, parallel, laminated beds, and interbedded siltstone, tan-brown, argillaceous, soft; one turtle scute; freshwater lacustrine deposits	17.6
477. Sandstone, tan-brown, very fine grained, silty, very argillaceous; in parallel to subparallel beds with a few 0.3–0.5-ft-thick interbedded clay shales, gray, brown carbonaceous laminae, aquatic plant fragments; freshwater lacustrine deposits	21.7
476. Clay shale, gray, dolomitic, in even, parallel laminae, and interlaminated shale, brown, black, carbonaceous; abundant ribbonlike aquatic plant fragments (cattails?); freshwater lacustrine (shoreline) and swamp deposits	0.8

Reference section of Eocene rocks in the Green River basin—Continued

	Thickness Feet
Laney Member of Green River Formation—Continued	
Hartt Cabin and Sand Butte Beds—Continued	
475. Siltstone, tan-brown, argillaceous, sandy; in parallel to subparallel beds up to a few feet thick; with numerous very thin interbedded and interlaminated clay shale, gray, dolomitic, in thin, even laminae; one turtle scute; a muddy, freshwater lacustrine (shoreline) deposit	75.9
474. Clay shale, gray, dolomitic, carbonaceous laminae; ribbonlike aquatic plant impressions (cattails?); freshwater lacustrine deposit	0.8
473. Siltstone, tan-gray, dolomitic, hard, in subparallel beds, with some layers of shale, tan-brown, very silty; freshwater lacustrine deposit	4.1
472. Siltstone, tan, dolomitic; in subparallel beds up to 2.0 ft thick; 0.2-ft-thick layers of shale, black, carbonaceous, aquatic plant fragments, 4.4 and 6.5 ft below the top; swampy freshwater lacustrine (shoreline) deposit	14.0
471. Poorly exposed. Top of this interval is at level of State Highway 530. Equivalent outcrops are tan-brown to rust-brown argillaceous sandstone and tan siltstone about 1,500 ft north of the measured section. The interval appears to be lacustrine, except for about 20 ft of gray mudstone below road level, which is probably flood plain	31.6
470. Siltstone, rust-brown, argillaceous, slightly tuffaceous, soft; outcrop forms an isolated butte; freshwater lacustrine	55.0
469. Covered. In outcrops to the north of the measured section, the interval is freshwater lacustrine tan-brown sandstone and interbedded tan, arenaceous mudstone and siltstone	360.0
468. Poorly exposed. Ledgy sandstones are interbedded with siltstone and mudstone; freshwater lacustrine deposits	32.0
467. Poorly exposed. Sandstone, tan-brown, very fine to medium-grained, poorly sorted, subangular, tuffaceous, and interbedded mudstone, gray-brown, arenaceous; freshwater lacustrine deposits	48.0
466. Siltstone, tan, laminated; freshwater lacustrine deposit	7.0
465. Sandstone, tan, brown, very fine to medium-grained, poorly sorted, angular, micaceous, tuffaceous; some coarse-grained sandstone in trough crossbeds; freshwater lacustrine (channel) deposit	16.4
464. Siltstone, tan; in thin, varvelike laminae; weathers to tan plates; freshwater lacustrine deposit	16.0
463. Sandstone, tan-brown, very fine to medium-grained, poorly sorted, angular, micaceous; abundant dark grains; in small-scale trough crossbeds; freshwater lacustrine (channel) deposit	8.5
462. Sandstone, tan-brown, very fine grained, argillaceous, soft, and interbedded mudstone, gray, arenaceous, hard; flood-plain (basin-fill) deposits	49.0
461. Sandstone, gray, very fine grained, silty, tuffaceous, dolomitic; very silty the lower 15.0 ft; coarser grained beds increase in number upwards; in very thin, flat, massive beds; some crossbedding in the upper part; flood-plain (stream channel and splay) deposits	41.0
Total thickness of Hartt Cabin and Sand Butte Beds of Laney Member of Green River Formation	1,039.9
Unconformity.	
LaClede Bed:	
460. Shale, gray, fissile, very silty; freshwater or brackish-water lacustrine deposit	4.3
459. Siltstone, gray, very dolomitic, very tuffaceous; freshwater or brackish-water lacustrine deposit	0.9
458. Oil shale, brown, flaky; EOY 13 gpt[1]; freshwater or brackish-water lacustrine deposit	4.7
457. Tuff, gray, analcimic; airfall ash deposit	0.3
456. Oil shale, brown, flaky, silty in part, and a few interlaminated siltstones, brown; EOY 12 gpt; freshwater or brackish-water lacustrine deposits	35.9
455. Siltstone, tan, very tuffaceous; crosses bedding planes vertically; a siltstone dike	1.3
454. Oil shale, brown, silty, flaky; EOY 5 gpt; freshwater or brackish-water lacustrine deposit	9.8
453. Siltstone, gray, dolomitic; in very thin, parallel beds; freshwater or brackish-water lacustrine deposit	0.6
452. Oil shale, brown, papery to flaky, soft; EOY 12 gpt; freshwater or brackish-water lacustrine deposit	27.8
451. Clay shale, tan, silty, EOY 5 gpt, and a few laminations of oil shale, dark-brown, EOY 25 gpt; freshwater or brackish-water lacustrine deposits	14.2
450. Oil shale, brown, fissile, silty; EOY 10 gpt; freshwater or brackish-water lacustrine deposits	8.6
449. Oil shale, dark-brown; weathers silver; EOY 30 gpt; brackish-water lacustrine deposit	0.6
448. Oil shale, dark-brown; EOY 18 gpt; brackish-water lacustrine deposit	2.9
447. Oil shale, brown, flaky; EOY 15 gpt; brackish-water lacustrine deposit	4.9
446. Tuff, tan; airfall ash deposit. Top of buff marker bed	0.3
445. Oil shale, brown, flaky; EOY 12 gpt; brackish-water lacustrine deposit	2.8
444. Tuff, tan, shaly; looks varved; airfall ash deposit.	2.8
443. Shale, light-brown, silty, fissile; freshwater or brackish-water lacustrine deposit	1.8
442. Shale, tan, silty, tuffaceous; freshwater or brackish-water lacustrine deposit	5.6
441. Oil shale, brown, flaky, hard; EOY 10 gpt, some thin layers EOY 20 gpt; brackish-water lacustrine deposit	7.5

[1]EOY, estimated oil yield; gpt, gallons per ton.

Reference section of Eocene rocks in the Green River basin—Continued

	Thickness Feet
Laney Member of Green River Formation—Continued	
LaClede Bed—Continued	5.6
440. Oil shale, dark-brown, dolomitic, hard; EOY 18 gpt; brackish-water lacustrine deposit	1.0
439. Oil shale, dark-brown, flaky, dolomitic; EOY 15 gpt, with very thin layers EOY 20 gpt; brackish-water lacustrine deposit	22.2
438. Tuff, tan, shaly; airfall ash deposit. Bottom of buff marker bed	9.7
437. Clay shale, brown, dolomitic, platy; EOY 6 gpt; freshwater or brackish-water lacustrine deposit	2.0
436. Siltstone, light-gray, dolomitic, platy, hard; in very thin, parallel beds; lacustrine (shoreline) deposit	5.6
435. Oil shale, brown, papery, and finely interlaminated siltstone, gray, brown, dolomitic, hard; EOY 12 gpt; freshwater or brackish-water lacustrine deposits	14.5
434. Siltstone, gray, dolomitic; in very thin, parallel beds; freshwater or brackish-water lacustrine deposit	0.9
433. Oil shale, tan, brown, papery, with a few layers of rich oil shale less than 0.3 ft thick; silty the lower 2.0 ft; a few laminae of siltstone, brown; EOY 12–25 gpt; brackish-water lacustrine deposits	32.0
432. Tuff, tan; airfall ash deposit	0.3
431. Oil shale, brown, papery; EOY 11 gpt; freshwater or brackish-water lacustrine deposit	2.4
430. Oil shale, brown, flaky; EOY 15 gpt; freshwater or brackish-water lacustrine deposit	0.9
429. Shale, gray, fissile, very silty; lacustrine deposit.	3.9
428. Oil shale, dark-brown, flaky; EOY 15 gpt; freshwater or brackish-water lacustrine deposit	0.3
427. Clay shale, brown, platy, dolomitic; EOY 8 gpt; freshwater or brackish-water lacustrine deposit	20.5
426. Mudstone, gray-green, blocky; mudflat deposit	3.0
425. Clay shale, brown, flaky; EOY 8 gpt; brackish-water lacustrine deposit	1.8
424. Oil shale, dark-brown, flaky; EOY 19 gpt; brackish-water lacustrine deposit	0.1
Total thickness of LaClede Bed of Laney Member of Green River Formation	258.7
Wilkins Peak Member of Green River Formation:	
423. Clay shale, brown, dolomitic, flaky; EOY 8 gpt; saltwater lacustrine deposit	1.0
422. Clay shale, brown at the base, gray at the top, silty; one 0.05-ft-thick analcimic tuff 2.0 ft below the top; scattered salt casts; saltwater lacustrine deposit	18.4
This bed is situated at the stratigraphic position of mudstone beds containing mammal fossils on Parnell Creek in NW¼NE¼NE¼ sec. 29, T. 25 N., R. 101 W. Collected by H.W. Roehler and P.O. McGrew in 1957.	
Cynodontomys sp.	
Thisbemys plicatus	
Leptotomus parvus	
Paramys wortmani	
Paramys copei	

Reference section of Eocene rocks in the Green River basin—Continued

	Thickness Feet
Wilkins Peak Member of Green River Formation—Continued	
421. Siltstone, gray, dolomitic, platy; in very thin parallel beds; saltwater lacustrine (shoreline) deposits	4.8
420. Clay shale, brown at the base, gray at the top, platy, dolomitic, some finely disseminated carbonaceous material; EOY 10 gpt, at the base; saltwater lacustrine deposit	7.5
419. Oil shale, dark-brown; weathers silver; EOY 25 gpt; saltwater lacustrine deposit	0.4
418. Clay shale, brown, silty, and some very thin interbedded siltstone, gray, dolomitic, platy; saltwater lacustrine deposit	9.4
417. Dolomite, medium-gray, blocky, hard; mudflat deposit	0.8
416. Clay shale, brown; abundant salt casts, scattered insect fossils; and some very thin interbedded siltstone, gray, platy, with salt casts; saltwater lacustrine deposit	7.7
415. Siltstone, light-gray, platy, dolomitic; abundant salt casts; saltwater lacustrine (shoreline) deposit	1.9
414. Clay shale, brown, dolomitic; scattered salt casts; saltwater lacustrine deposit	3.4
413. Tuff, tan, banded; airfall ash deposit. Layered tuff marker bed	0.3
412. Oil shale, brown, flaky; EOY 15 gpt; saltwater lacustrine deposit	0.6
411. Clay shale, brown, dolomitic, blocky; scattered salt casts; saltwater lacustrine deposit	1.3
410. Siltstone, light-gray, dolomitic, platy, hard; salt casts; saltwater lacustrine (shoreline) deposit.	3.4
409. Oil shale, brown, silty; some thin pods and lenses of high-grade oil shale; EOY 8–20 gpt; saltwater lacustrine deposit	2.2
408. Mudstone, gray-brown, blocky; mudflat deposit .	4.8
407. Siltstone, gray, dolomitic, hard; some salt casts; saltwater lacustrine (shoreline) deposit	0.8
406. Oil shale, brown, flaky; saltwater lacustrine deposit	0.6
405. Mudstone, dark-gray-green, silty, blocky; slightly radioactive from 5 to 10 ft above the base; mudflat deposit	16.5
404. Sandstone, gray, very fine grained, calcareous; 60 percent quartz grains, abundant mica and dark rock fragments; current rippled with current direction east to west; mudflat (channel) deposit	13.0
403. Mudstone, olive-brown, blocky; slightly radioactive the upper 3.0 ft; mudflat deposit	9.7
402. Clay shale, brown, dolomitic, platy; abundant salt casts; saltwater lacustrine deposit	2.6
401. Oil shale, dark-brown; weathers silver; EOY 30 gpt; saltwater lacustrine deposit	1.1
400. Siltstone, gray, platy, hard; in very thin wave-rippled beds; saltwater lacustrine (shoreline) deposit	2.3
399. Siltstone, gray, dolomitic, hard, and some very thin interbedded mudstone, gray; mudflat deposit	8.4
398. Clay shale, brown, platy; a few scattered salt casts; EOY 15 gpt; saltwater lacustrine deposit	11.6
397. Tuff, tan; abundant salt casts; airfall ash deposit.	0.1

Reference section of Eocene rocks in the Green River basin—Continued

	Thickness Feet
Wilkins Peak Member of Green River Formation—Continued	
396. Siltstone, gray, platy, dolomitic, hard; abundant salt casts; saltwater lacustrine (shoreline) deposit	0.6
395. Mudstone, gray; abundant salt casts; mudflat deposit	7.7
394. Siltstone, gray, platy; abundant salt casts, saltwater lacustrine (shoreline) deposit	0.8
393. Clay shale, brown, platy; some salt casts; saltwater lacustrine deposit	6.5
392. Tuff, tan; airfall ash deposit. Main tuff marker bed	0.9
391. Siltstone, light-gray, dolomitic, platy, hard; abundant salt casts; saltwater lacustrine (shoreline) deposit	0.8
390. Mudstone, gray-green, silty, blocky, abundant salt casts, and a few interlaminated siltstones, gray, platy; mudflat and saltwater lacustrine deposits	50.9
389. Siltstone, gray, dolomitic, platy; abundant salt casts; saltwater lacustrine (shoreline) deposit.	2.5
388. Mudstone, gray-green, and some thin interbedded siltstone, gray, platy; abundant salt casts; mudflat and saltwater lacustrine deposits	10.7
387. Siltstone, gray, dolomitic, platy, hard; abundant salt casts; saltwater lacustrine (shoreline) deposit	4.4
386. Mudstone, gray-green, blocky; abundant salt casts; mudflat deposit	18.2
385. Clay shale, brown; abundant salt casts; EOY 12 gpt; saltwater lacustrine deposit	2.0
384. Mudstone, gray-green; abundant salt casts; mudflat deposit	1.6
383. Siltstone, light-gray, dolomitic, hard, platy; abundant salt casts; saltwater lacustrine (shoreline) deposit	2.8
382. Mudstone, gray-brown; abundant salt casts; mudflat deposit	1.0
381. Oil shale, dark-brown; weathers silver; EOY 30 gpt; saltwater lacustrine deposit	1.2
380. Siltstone, light-gray, dolomitic, platy; in thin, parallel, wave-rippled beds; abundant salt casts; saltwater lacustrine (shoreline) deposit.	7.2
379. Shale, tan, silty, fissile; EOY 5 gpt; saltwater lacustrine deposit	0.4
378. Mudstone, gray, shaly, hard; mudflat deposit	1.5
377. Siltstone, gray, calcareous; current rippled; saltwater lacustrine (shoreline) deposit	5.4
376. Mudstone, gray-green, silty, blocky; mudflat deposit	4.7
375. Siltstone, gray, dolomitic, platy, hard; in very thin parallel beds; saltwater lacustrine (shoreline) deposit	1.4
374. Algal limestone, tan; in a thin, wavy bed; saltwater lacustrine (shoreline) deposit	0.2
373. Mudstone, gray-green, silty; some radioactivity; mudflat deposit	4.8
372. Mudstone, gray, very dolomitic, very hard, blocky; mudflat deposit	2.2
371. Siltstone, light-gray, dolomitic, platy; abundant salt casts, including long-bladed pseudomorphs of trona; evaporite deposit	2.8

Reference section of Eocene rocks in the Green River basin—Continued

	Thickness Feet
Wilkins Peak Member of Green River Formation—Continued	
370. Shale, brown, silty, soft; EOY 5 gpt; salt casts; saltwater lacustrine deposit	1.0
369. Mudstone, gray-green, silty; a few salt casts; mudflat deposit	4.5
368. Siltstone, gray, dolomitic, platy; abundant salt casts; saltwater lacustrine (shoreline) deposit.	1.8
367. Mudstone, gray, silty, blocky; mudflat deposit	1.7
366. Clay shale, brown, silty; some finely disseminated carbonaceous material; a few salt casts; saltwater lacustrine deposit	1.0
365. Siltstone, light-gray, dolomitic, platy; abundant salt casts; saltwater lacustrine (shoreline) deposit	4.3
364. Mudstone, gray-green; abundant salt casts; mudflat deposit	4.5
363. Siltstone, light-gray, dolomitic, hard; some salt casts; saltwater lacustrine (shoreline) deposit.	4.6
362. Siltstone, light-gray; abundant small, rounded, flattened clay pebbles (flat clay pebble conglomerate); mudflat deposit	0.8
361. Siltstone, light-gray; in very thin parallel beds; abundant small clusters of salt casts; saltwater lacustrine (shoreline) deposit	1.1
360. Mudstone, dark-green, very dolomitic, very hard; mudflat deposit	0.6
359. Siltstone, dark-gray-green, silty to sandy, dolomitic; saltwater lacustrine (shoreline) deposit	1.7
358. Mudstone, dark-gray-green, silty, dolomitic, and a few very thin beds and laminae of siltstone, dark-gray-green; 3.0 ft in the middle of the interval is slightly radioactive; mudflat and saltwater lacustrine (shoreline) deposits	38.3
357. Siltstone, light-gray, dolomitic, platy, hard; in very thin parallel beds; saltwater lacustrine (shoreline) deposits	0.8
356. Siltstone, light-gray, platy, hard, and interbedded clay shale, tan, silty; saltwater lacustrine deposit	4.6
355. Siltstone, light-gray, dolomitic, platy, hard; in very thin, parallel beds; abundant salt casts; saltwater lacustrine (shoreline) deposit	7.1
354. Mudstone, gray-green, silty; some salt casts; mudflat deposit	6.7
353. Siltstone, light-gray, dolomitic, platy; in very thin parallel beds; saltwater lacustrine (shoreline) deposit	0.8
352. Mudstone, gray-green, gray-brown, dolomitic, hard; mudflat deposit	20.8
351. Siltstone, light-gray, dolomitic, platy, hard; in very thin parallel beds; saltwater lacustrine (shoreline) deposit	2.0
350. Mudstone, dark-gray-green, silty, blocky; mudflat deposit	19.0
349. Siltstone, light-gray, dolomitic, platy, and finely interbedded mudstone, gray, dolomitic, hard, and some clay shale, tan-brown; EOY 5 gpt; mudflat and saltwater lacustrine deposits	14.6

Reference section of Eocene rocks in the Green River basin—Continued

	Thickness Feet
Wilkins Peak Member of Green River Formation—Continued	
348. Siltstone, light-gray, dolomitic, platy, hard; in very thin parallel beds; saltwater lacustrine (shoreline) deposit	4.0
347. Clay shale, dark-brown, dolomitic, flaky; EOY 15 gpt; saltwater lacustrine deposit	0.9
346. Mudstone, dark-olive-gray, sandy, and very thin interbedded sandstone, gray, very fine grained, calcareous, current-rippled; mudflat deposit	29.4
345. Mudstone, olive-gray, dolomitic, silty, blocky; slightly radioactive in the lower 2.0 ft; mudflat deposit	7.8
344. Siltstone, light-gray, dolomitic, platy; in thin parallel beds; saltwater lacustrine (shoreline) deposit	1.9
343. Mudstone, gray-green, silty, blocky; mudflat deposit	6.5
342. Siltstone, gray, tan, dolomitic, platy, hard; saltwater lacustrine (shoreline) deposit	6.1
341. Mudstone, gray, silty; mudflat deposit	6.0
340. Clay shale, brown, platy, dolomitic; saltwater lacustrine deposit	1.5
339. Mudstone, olive-gray, and interbedded sandstone, olive-gray, very fine grained, current-rippled; sandstone at the top and bottom; mudflat deposit	7.7
338. Mudstone, olive-gray, silty, dolomitic, blocky; mudflat deposit	9.5
337. Mudstone, olive-gray, and interbedded sandstone, gray, very fine grained, current-rippled; mudflat deposit. Mudstone interval from 5 to 10 ft below the top is very radioactive	34.7
336. Mudstone, olive-gray, silty; very radioactive; mudflat deposit	5.0
335. Siltstone, light-gray, dolomitic, in thin parallel beds at the top, middle, and bottom, and interbedded mudstone, gray, blocky; saltwater lacustrine (shoreline) and mudflat deposits	4.0
334. Sandstone, gray, very fine grained, calcareous; current rippled with current direction east to west; mudflat deposit	4.2
333. Mudstone, dark-gray-green, silty, blocky; slightly radioactive the top 1.0 ft; mudflat deposit	9.3
332. Siltstone, light-gray, in thin parallel beds; abundant salt casts; saltwater lacustrine (shoreline) deposit	5.0
331. Mudstone, gray-green, silty; abundant salt casts; mudflat deposit	5.0
330. Siltstone, gray; in thin parallel beds; abundant salt casts; saltwater lacustrine (shoreline) deposit	3.0
329. Mudstone, gray, silty; abundant layers containing salt casts; mudflat deposit	4.0
328. Shale, gray-green, flaky; slightly radioactive; mudflat deposit	1.0
327. Shale, tan, very silty; saltwater lacustrine deposit	2.4
326. Siltstone, light-gray, dolomitic, platy, hard; saltwater lacustrine (shoreline) deposit	3.2

Reference section of Eocene rocks in the Green River basin—Continued

	Thickness Feet
Wilkins Peak Member of Green River Formation—Continued	
325. Sandstone, gray, very fine grained, calcareous, current-rippled, and interbedded mudstone, gray, sandy; mudflat deposit	9.5
324. Mudstone, dark-gray-green, dolomitic, blocky; mudflat deposit	7.7
323. Silty evaporite solution zone; mostly calcite after evaporite minerals; evaporite deposit	1.2
322. Mudstone, gray, dolomitic; abundant salt casts; mudflat deposit	10.7
321. Clay shale, medium to very dark brown, dolomitic; EOY 8–18 gpt; saltwater lacustrine deposit	1.6
320. Clay shale, brown, dolomitic; EOY 6 gpt; saltwater lacustrine deposit	8.0
319. Siltstone, light-gray, dolomitic, platy, hard; saltwater lacustrine (shoreline) deposit	2.3
318. Clay shale, brown, dolomitic, flaky, brittle, and some very thin interbedded siltstone, gray, dolomitic, platy, hard; EOY 7 gpt; saltwater lacustrine deposit	12.9
317. Siltstone, light-gray, dolomitic, platy, hard, and some interlaminated clay shale, brown, silty; saltwater lacustrine deposit	10.5
316. Siltstone, medium-gray, dolomitic, platy, hard, and some interlaminated clay shale, brown, silty; saltwater lacustrine deposit	3.7
315. Sandstone, gray, very fine grained, calcareous, current-rippled; about 65 percent quartz grains, abundant dark grains; and some thin interbedded mudstone, olive, dolomitic, sandy, blocky; mudflat deposit	25.0
314. Mudstone, olive-gray, sandy, blocky; moderately radioactive; mudflat deposit	5.6
313. Siltstone, gray, current-rippled, and interlaminated and finely interbedded mudstone, olive, silty; mudflat deposit	3.4
312. Mudstone, olive-gray, silty, blocky; mudflat deposit	8.0
311. Clay shale, brown, silty, dolomitic, and interlaminated siltstone, gray, at the top; saltwater lacustrine deposit	2.8
310. Mudstone, gray, dolomitic, hard; mudflat deposit	4.4
309. Clay shale, brown, silty, very dolomitic; EOY 10–15 gpt; saltwater lacustrine deposit	15.9
308. Siltstone, gray, dolomitic, hard, and interlaminated shale, gray, very silty; saltwater lacustrine deposit	2.0
307. Sandstone, gray, very fine grained, and interlaminated mudstone, gray, dolomitic, sandy, shaly; saltwater lacustrine deposit	1.6
306. Sandstone, gray, very fine grained, dolomitic, hard; current rippled; saltwater lacustrine deposit	3.2
305. Mudstone, gray, very dolomitic, very hard; mudflat deposit	1.1
304. Sandstone, gray, very fine grained, current-rippled, and very thin interbedded and interlaminated mudstone, gray, silty; mudflat deposit	9.8

Reference section of Eocene rocks in the Green River basin—Continued

	Thickness Feet
Wilkins Peak Member of Green River Formation—Continued	
303. Sandstone, gray, very fine to fine-grained, poorly sorted; large grains of muscovite; composed of 75 percent quartz grains and 25 percent rock fragments; small-scale, fairly high angle trough crossbeds with current ripples; some lag gravels composed of clay pebbles; some water-worn bone fragments; dominant current direction is from east to west; mudflat (channel) deposit	14.0
302. Mudstone, gray, dolomitic, hard; mudflat deposit	2.7
301. Siltstone, gray, dolomitic, platy, hard; mudflat deposit	0.4
300. Mudstone, gray-green, silty, dolomitic, blocky; mudflat deposit	16.4
299. Clay shale, tan, flaky, very silty; saltwater lacustrine deposit	2.2
298. Siltstone, gray, dolomitic, hard; saltwater lacustrine deposit	0.2
297. Clay shale, tan, very silty, dolomitic, hard; EOY 2 gpt; saltwater lacustrine deposit	7.7
296. Clay shale, brown, flaky; EOY 9 gpt; saltwater lacustrine deposit	2.0
295. Siltstone, gray; a conglomerate composed of very small, rounded, flattened clay pebbles; mudflat deposit	0.3
294. Mudstone, medium-gray, very dolomitic, very hard; mudflat deposit	12.1
293. Sandstone, gray, very fine grained, dolomitic, hard; current rippled with foresets that dip mostly southwest; becomes interbedded with siltstone, gray-green, dolomitic, hard; mostly siltstone the top 10 ft; mudflat deposit	18.0
292. Mudstone, gray-green, silty, blocky; mudflat deposit	30.6
291. Siltstone, gray, dolomitic, platy, hard; in very thin, parallel beds; saltwater lacustrine (shoreline) deposit	2.1
290. Mudstone, gray, silty; mudflat deposit	4.0
289. Clay shale, brown, flaky; EOY 6 gpt; saltwater lacustrine deposit	3.0
288. Siltstone, gray, dolomitic, hard; in very thin wave-rippled beds; saltwater lacustrine (shoreline) deposit	2.6
287. Mudstone, gray-green, silty; mudflat deposit	3.5
286. Clay shale, brown, dolomitic, silty; EOY 7 gpt; saltwater lacustrine deposit	1.3
285. Siltstone, gray, dolomitic, hard; in very thin, parallel beds; saltwater lacustrine (shoreline) deposit	0.6
284. Shale, gray, dolomitic, hard; looks varved; saltwater lacustrine deposit	3.2
283. Clay shale, brown, flaky, dolomitic; EOY 9 gpt; saltwater lacustrine deposit	2.1
282. Mudstone, gray, silty, blocky; mudflat deposit	1.3
281. Clay shale, brown, flaky, silty; saltwater lacustrine deposit	5.0
280. Siltstone, gray, dolomitic, platy, hard; in very thin parallel beds; saltwater lacustrine (shoreline) deposit	3.9
279. Shale, medium-gray, very silty; mudflat deposit.	4.3

Reference section of Eocene rocks in the Green River basin—Continued

	Thickness Feet
Wilkins Peak Member of Green River Formation—Continued	
278. Siltstone, gray, dolomitic, shaly; saltwater lacustrine (shoreline) deposit	1.1
277. Mudstone, gray, dolomitic, shaly; mudflat deposit	1.6
276. Shale, medium-gray, very silty; grades upward into siltstone, gray, in very thin parallel beds; mudflat and saltwater lacustrine (shoreline) deposits	5.3
275. Mudstone, gray, very dolomitic, very hard; mudflat deposit	6.5
274. Siltstone, gray, dolomitic, platy, hard; in very thin parallel beds; saltwater lacustrine (shoreline) deposit	0.7
273. Shale, tan, fissile, dolomitic; finely disseminated plant material; saltwater lacustrine deposit	2.1
272. Siltstone, gray, dolomitic, platy, hard; in very thin parallel beds; saltwater lacustrine (shoreline) deposit	1.3
271. Mudstone, gray, gray-green, very dolomitic, very hard, blocky; mudflat deposit	13.0
270. Siltstone, gray, dolomitic, platy, hard; saltwater lacustrine (shoreline) deposit	1.0
269. Mudstone, gray-green, silty; mudflat deposit	15.1
268. Mudstone, gray, very shaly; mudflat deposit	3.0
267. Clay shale, brown, dolomitic, platy; finely disseminated plant material; saltwater lacustrine deposit	4.4
266. Mudstone, gray, very shaly, silty; mudflat deposit	7.6
265. Clay shale, brown, dolomitic, platy; EOY 8 gpt; saltwater lacustrine deposit	5.0
264. Tuff, tan; weathers to a brown ledge; airfall ash deposit. Firehole Bed; tuff marker bed	0.5
263. Clay shale, tan, and finely interlaminated siltstone, gray, dolomitic, hard; saltwater lacustrine deposit	2.0
262. Siltstone, gray, dolomitic, platy; in very thin parallel beds; saltwater lacustrine (shoreline) deposit	1.5
261. Shale, gray, very silty, fissile; in very thin plates; saltwater lacustrine deposit	1.7
260. Clay shale, gray at the base, brown at the top, dolomitic, platy; EOY 8 gpt; saltwater lacustrine deposit	4.7
259. Mudstone, gray-green, silty, blocky; mudflat deposit	9.0
258. Clay shale, brown, dolomitic, platy; EOY 8 gpt; saltwater lacustrine deposit	3.2
257. Siltstone, gray, dolomitic, platy, hard; in very thin parallel beds; saltwater lacustrine (shoreline) deposit	1.9
256. Mudstone, gray-green, blocky, soft; mudflat deposit	13.8
255. Siltstone, gray, dolomitic; saltwater lacustrine deposit	0.3
254. Clay shale, brown, dolomitic; EOY 8 gpt; saltwater lacustrine deposit	1.5
253. Siltstone, gray, dolomitic, hard; in very thin parallel beds with lenticular pods of dolomite, gray; saltwater lacustrine (shoreline) deposit.	3.4
252. Mudstone, dark-gray-green, blocky, silty; mudflat deposit	11.8

Reference section of Eocene rocks in the Green River basin—Continued

	Thickness Feet
Wilkins Peak Member of Green River Formation—Continued	
251. Clay shale, tan, very silty, platy; saltwater lacustrine deposit	1.0
250. Clay shale, brown, silty; EOY 5 gpt; saltwater lacustrine deposit	3.2
249. Clay shale, tan, brown, silty, and thin interbedded and interlaminated siltstone, gray, dolomitic, hard; in current-rippled beds with east-to-west current direction; mudflat and saltwater lacustrine deposits	16.6
248. Siltstone, gray, dolomitic, hard; in very thin parallel current-rippled beds; some shaly laminae; mudflat deposit	36.0
247. Clay shale, brown, dolomitic, silty, platy; EOY 8 gpt; saltwater lacustrine deposit	6.4
246. Siltstone, gray, dolomitic, hard; in parallel to subparallel, current-rippled beds; saltwater lacustrine (shoreline) deposit	5.1
Total thickness of Wilkins Peak Member of Green River Formation	1,068.9
Tipton Shale Member of Green River Formation:	
Rife Bed:	
245. Oil shale, brown, dolomitic, flaky; EOY 15 gpt; saltwater lacustrine deposit	6.4
244. Oil shale, dark-brown; weathers light gray and silver; EOY 22 gpt; saltwater lacustrine deposit	4.4
243. Oil shale, brown, dolomitic, flaky; EOY 17 gpt; saltwater lacustrine deposit	10.0
242. Oil shale, brown, flaky; numerous layers weather silver; EOY 16–30 gpt with 30 gpt in irregularly spaced, thin layers; saltwater lacustrine deposit	21.5
241. Oil shale, brown, flaky; a few small, lenticular pods and laminae of dolomite, tan-brown, hard; EOY 15 gpt; saltwater lacustrine deposit.	22.1
240. Tuff, tan; airfall ash deposit	0.5
239. Oil shale, brown, flaky; EOY 15 gpt; saltwater lacustrine deposit	2.7
238. Tuff, tan, silty; in very thin parallel beds; airfall ash deposit	0.4
237. Oil shale, brown, flaky; EOY 15 gpt; saltwater lacustrine deposit	0.5
236. Tuff, tan; airfall ash deposit	0.7
Total thickness of Rife Bed of Tipton Shale Member of Green River Formation	69.2
Scheggs Bed:	
235. Oil shale, brown, flaky; a few silty layers; EOY 15 gpt; freshwater lacustrine deposit	29.4
234. Siltstone, gray, tuffaceous; freshwater lacustrine deposit	0.2
233. Oil shale, brown, flaky; three thin, lenticular, podlike layers of dolomite, tan; EOY 15 gpt; freshwater lacustrine deposit	4.7
232. Dolomite, gray, hard; freshwater lacustrine deposit	0.1
231. Oil shale, brown, flaky; EOY 14 gpt; freshwater lacustrine deposit	0.1
230. Dolomite, gray, hard; freshwater lacustrine deposit	0.1

Reference section of Eocene rocks in the Green River basin—Continued

	Thickness Feet
Tipton Shale Member of Green River Formation—Continued	
Scheggs Bed—Continued	
229. Oil shale, brown, flaky; EOY 12 gpt; freshwater lacustrine deposit	4.8
228. Dolomite, gray, hard; freshwater lacustrine deposit	0.3
227. Oil shale, brown, flaky; weathers gray; EOY 15 gpt; freshwater lacustrine deposit	1.9
226. Siltstone, tan, tuffaceous; in very thin, parallel beds; freshwater lacustrine deposit	0.4
225. Oil shale, brown, flaky; EOY 15 gpt; freshwater lacustrine deposit	6.3
224. Algal limestone, tan; wavy laminations; freshwater lacustrine (shoreline) deposit	0.2
223. Oil shale, brown, flaky, and a few pods and laminae of ostracodal limestone, and dolomite, tan; EOY 15 gpt; freshwater lacustrine deposit.	11.5
222. Oil shale, brown, flaky; abundant ostracodes; EOY 15 gpt; freshwater lacustrine deposit	15.9
221. Coquinal sandstone, gray, very fine grained, crumbly, thin-bedded; abundant *Goniobasis* sp., and some *Viviparus* sp. and *Lampsilis* sp.; freshwater lacustrine (shoreline) deposit	1.6
220. Oil shale, brown, papery, soft; abundant ostracodes and mollusk shell fragments; EOY 12 gpt; freshwater lacustrine deposit	17.2
219. Shale, dark-brown, carbonaceous; shoreline swamp deposit	1.5
218. Coal; shoreline swamp deposit	0.4
217. Sandstone, dark-gray, very fine to medium-grained, carbonaceous, micaceous; abundant mollusks, including *Australorbis* sp.; freshwater lacustrine (shoreline) deposit	1.2
Total thickness of Scheggs Bed of Tipton Shale Member of Green River Formation	97.8
Niland Tongue of Wasatch Formation:	
216. Mudstone, gray, silty; flood-plain (basin-fill) deposit	35.0
215. Sandstone, gray, very fine to fine-grained, micaceous, calcareous; flood-plain (splay) deposit	2.1
214. Mudstone, gray, and some interbedded sandstone, gray, fine-grained, soft, loose; flood-plain (basin-fill and splay) deposits	23.0
213. Mudstone, gray, silty; flood-plain (basin-fill) deposit	25.0
212. Sandstone, gray, very fine to fine-grained; in parallel beds; flood-plain (splay) deposit	1.2
211. Mudstone, gray, silty; flood-plain (basin-fill) deposit	6.3
210. Sandstone, gray, very fine to medium-grained, poorly sorted, micaceous, soft, loose	12.0
209. Mudstone, gray, silty; flood-plain (basin-fill) deposit	2.0
208. Sandstone, gray, very fine to medium-grained, calcareous; parallel, current-rippled beds; flood-plain (splay) deposit	1.7
207. Mudstone, gray, silty; flood-plain (basin-fill) deposit	11.6
206. Shale, dark-brown, carbonaceous; swamp deposit	0.4
205. Mudstone, gray, silty; one 0.5-ft-thick bed of sandstone, gray, very fine grained, 5.0 ft above the base; flood-plain (basin-fill and splay) deposit	20.2

Reference section of Eocene rocks in the Green River basin—Continued

		Thickness Feet
	Niland Tongue of Wasatch Formation—Continued	
204.	Mudstone, variegated red, maroon, orange, and gray, silty to sandy, and several 0.5- to 3.0-ft-thick interbedded sandstones, gray, very fine to medium-grained, calcareous, in parallel to subparallel burrowed beds; flood-plain (basin-fill and splay) deposit	72.5
203.	Sandstone, gray, red, very fine to medium-grained, poorly sorted, subangular; abundant muscovite and biotite; lenticular; trough cross-bedded; scoured base; 65 percent quartz grains; flood-plain (stream channel) deposit	12.3
202.	Mudstone, variegated red, maroon, gray, and orange, silty, and several 0.5- to 4.0-ft-thick interbedded sandstones, gray, very fine to medium-grained; in subparallel beds; flood-plain (basin-fill and splay) deposit	105.6
201.	Sandstone, gray, red, very fine to medium-grained, subangular, micaceous; the lower 1.5 ft is very silty and contains burrows; flood-plain (splay) deposit	4.0
200.	Mudstone, gray, silty; flood-plain (basin-fill) deposit	6.9
199.	Sandstone, gray, very fine to medium-grained, poorly sorted, subangular; trough crossbedded; flood-plain (stream channel) deposit	4.5
198.	Mudstone, variegated gray, green, maroon, and red, sandy; mostly red near the middle; flood-plain (basin-fill and splay) deposit	37.3
197.	Sandstone, gray, very fine to coarse-grained, poorly sorted, subangular; in subparallel beds; flood-plain (splay) deposit	1.7
196.	Mudstone, gray, red, silty; flood-plain (basin- fill) deposit	6.5
195.	Sandstone, orange, gray, very fine to very coarse grained, poorly sorted, subangular, micaceous; irregular, small trough crossbeds; flood-plain (stream channel) deposit	29.0
194.	Sandstone, gray, red, very fine to medium-grained, poorly sorted, subangular; in subparallel beds; flood-plain (splay) deposit	6.3
193.	Siltstone, gray, red, limy, hard; flood-plain (splay) deposit	1.0
192.	Shale, gray, silty, fissile; flood-plain (basin-fill) deposit	3.0
191.	Sandstone, red, very fine to medium-grained, poorly sorted, subangular; in subparallel beds; flood-plain (splay) deposit	5.8
190.	Mudstone, gray, silty; flood-plain (basin-fill) deposit	4.0
189.	Sandstone, gray, very fine to medium-grained, soft, loose; flood-plain (splay) deposit	1.8
188.	Mudstone, gray, silty; flood-plain (basin-fill) deposit	5.2
187.	Siltstone, gray, dolomitic, hard; concretionary zone; flood-plain deposit	0.5
186.	Mudstone, medium-gray, silty; flood-plain (basin-fill) deposit	1.4
185.	Sandstone, gray, very fine to medium-grained, poorly sorted, subangular, micaceous, soft, loose	4.3
184.	Mudstone, medium-gray, sandy; flood-plain (basin-fill) deposit	8.5

Reference section of Eocene rocks in the Green River basin—Continued

		Thickness Feet
	Niland Tongue of Wasatch Formation—Continued	
183.	Sandstone, gray, very fine to medium-grained, poorly sorted, subangular, micaceous; in subparallel beds; flood-plain (splay) deposit	14.0
182.	Shale, gray, fissile, silty; flood-plain (basin-fill) deposit	5.3
	Total thickness of Niland Tongue of Wasatch Formation	481.9
	Luman Tongue of Green River Formation:	
181.	Shale, gray, fissile, silty; abundant ostracodes; no kerogen; freshwater lacustrine deposit	5.0
180.	Oil shale, gray-brown, fissile, soft; abundant ostracodes; EOY 8 gpt; freshwater lacustrine deposit	2.8
179.	Ostracodal sandstone, gray, very fine grained, limy; in very thin, parallel, wave-rippled laminae; freshwater lacustrine (shoreline) deposit.	2.7
178.	Mudstone, gray, blocky, silty, and two 0.5-ft-thick interbedded sandstones, gray, very fine grained; in parallel beds; flood-plain (basin-fill and splay) deposits	30.2
177.	Mudstone, gray, sandy, and interbedded sandstone, gray, very fine to medium-grained, in current- rippled beds; flood-plain (basin-fill and splay) deposits	15.6
176.	Sandstone, red, very fine to coarse-grained, poorly sorted, subangular; scoured base; small- to large-scale trough crossbeds; flood-plain (stream channel) deposit	14.0
175.	Mudstone, gray, sandy; flood-plain (basin-fill) deposit	8.2
174.	Sandstone, gray, very fine to fine-grained, calcareous; in thin, parallel, current-rippled beds with foresets that dip west; flood-plain (splay) deposit	1.1
173.	Mudstone, gray, sandy, and two very thin interbedded sandstones, gray, very fine to fine-grained, calcareous; in subparallel beds; flood-plain (splay and basin-fill) deposits	12.4
172.	Sandstone, gray, very fine to medium-grained, poorly sorted, subangular, micaceous, soft, loose	12.5
171.	Shale, medium-gray, fissile; abundant aquatic plant fragments; swamp deposit	0.7
170.	Shale, brown, carbonaceous; swamp deposit	0.2
169.	Shale, medium-gray, fissile; flood-plain (basin-fill) deposit	0.8
168.	Coal, 0.2 ft thick Sandstone, dark-gray, very fine grained, very carbonaceous, 0.1 ft thick Coal, 0.9 ft thick; moderately radioactive Mudstone, gray-brown, limonitic; moderately radioactive, 0.4 ft thick Coal, 0.8 ft thick Shale, brown, carbonaceous, 0.4 ft thick Coal, 0.7 ft thick Total thickness of bed 168; swamp deposits	3.5
167.	Shale, dark-brown, carbonaceous, silty; swamp deposit	0.3
166.	Mudstone, medium-gray, limonitic at the top; flood-plain (basin-fill) deposit	4.5

Reference section of Eocene rocks in the Green River basin—Continued

	Thickness Feet
Luman Tongue of Green River Formation—Continued	
165. Sandstone, gray, very fine to medium-grained, poorly sorted, subangular, micaceous; in parallel beds; flood-plain (splay) deposit	2.9
164. Mudstone, gray, red, sandy; flood-plain (basin-fill) deposit	5.8
163. Sandstone, gray, red, very fine to medium-grained, micaceous; vertical burrows; current rippled with current direction east to west; flood-plain (splay) deposit	3.2
162. Mudstone, gray, red, sandy; flood-plain (basin-fill) deposit	10.8
161. Sandstone, gray, very fine to fine-grained; in parallel beds; flood-plain (splay) deposit	1.3
160. Mudstone, gray, red, sandy; flood-plain (basin-fill) deposit	4.0
159. Sandstone, red, gray, very fine to fine-grained, poorly sorted, subangular; abundant small, vertical, smooth-walled burrows; trough cross-bedded; flood-plain (stream channel) deposit	6.5
158. Mudstone, gray, red, silty to sandy; very sandy the top 2.0 ft; flood-plain (basin-fill) deposit	6.6
157. Sandstone, gray, red, very fine to medium-grained, poorly sorted, subangular, micaceous; scoured base; trough crossbedded; flood-plain (stream channel) deposit	6.8
156. Mudstone, gray and red mottled, sandy; flood-plain (basin-fill) deposit	2.6
155. Sandstone, gray, red, very fine to fine-grained, calcareous; in thin, parallel beds with vertical burrows; and very thin interbedded mudstone, gray and red; flood-plain (splay) deposit	2.3
154. Mudstone, red, gray, sandy; flood-plain (basin-fill) deposit	4.1
153. Sandstone, gray, red, very fine to medium-grained, poorly sorted, subangular, micaceous; scoured base; trough crossbedded; flood-plain (stream channel) deposit	6.6
152. Mudstone, gray at the base, gray and red at the top, banded, silty to sandy; flood-plain (basin-fill) deposit	21.4
151. Sandstone, gray, very fine to medium-grained, poorly sorted, subangular, micaceous, soft, loose	3.6
150. Sandstone, gray, very fine to fine-grained, calcareous, micaceous, soft; small-scale trough crossbeds; some current ripples; flood-plain (splay) deposit	4.4
149. Mudstone, gray, blocky; flood-plain (basin-fill) deposit	1.0
148. Shale, dark-brown, carbonaceous, sandy; swamp deposit	0.4
147. Coquinal sandstone, gray, crumbly; contains abundant *Goniobasis* sp., and some *Viviparus* sp., and *Lampsilis* sp.; freshwater lacustrine deposit	0.4
146. Mudstone, gray, sandy; abundant *Goniobasis tenera*; freshwater lacustrine deposit	0.5
145. Shale, brown, carbonaceous; swamp deposit	0.5
144. Coal; very radioactive; swamp deposit	0.2
143. Shale, dark-brown, carbonaceous; swamp deposit	0.2
142. Mudstone, medium-gray, blocky; rooted; swamp deposit	0.9

Reference section of Eocene rocks in the Green River basin—Continued

	Thickness Feet
Luman Tongue of Green River Formation—Continued	
141. Coal, 1.7 ft thick Sandstone, dark-brown, carbonaceous, shaly, very fine grained, 0.1 ft thick Coal, 0.3 ft thick Total thickness of bed 141; swamp deposits	2.1
140. Shale, dark-brown, carbonaceous, very sandy; swamp deposit	0.2
139. Shale, gray, fissile; becomes sandy and carbonaceous the top 1.0 ft; swamp deposit	2.3
138. Sandstone, gray, very fine to medium-grained, poorly sorted, subangular, soft, loose; flood-plain (splay) deposit	3.5
137. Shale, gray, fissile, silty, sandy at the top; flood-plain (basin-fill) deposit	2.4
136. Shale, dark-brown, carbonaceous; moderately radioactive; swamp deposit	0.7
135. Shale, gray, silty; swamp deposit	2.4
134. Shale, dark-brown, carbonaceous; swamp deposit	0.2
133. Coal; slightly radioactive; swamp deposit	0.9
132. Shale, dark-brown, carbonaceous; swamp deposit	0.3
131. Mudstone, medium-gray, blocky; swamp deposit.	2.8
Total thickness of Luman Tongue of Green River Formation	229.3
Main body of Wasatch Formation:	
130. Mudstone, gray-green, soft; flood-plain (basin-fill) deposit	23.2
129. Sandstone, gray, calcareous; burrowed; flood-plain (splay) deposit	2.4
128. Mudstone, gray-green, soft; flood-plain (basin-fill) deposit	8.0
127. Sandstone, gold, very fine to very coarse grained, micaceous; 1.5-ft-thick clay pebble conglomerate in a brown sandstone matrix at the base; the upper 1.0 ft is gray, calcareous, and hard; flood-plain (stream channel) deposit	22.0
Fossil locality 359 located in NW¼NW¼NE¼ sec. 18, T. 18 N., R. 105 W. Fossil mammals identified by C.L. Gazin. *Cynodontomys latidens* *Hyopsodus powellianus* *Hyopsodus mentalis* *Hyracotherium* sp.	
Invertebrates identified by H.W. Roehler. "Helix" *Lampsilis* sp.	
126. Mudstone, gray-green, soft; some *Lampsilis* sp.; flood-plain (basin-fill) deposits	3.5
125. Sandstone, gold-gray, fine- to coarse-grained, lenses of clay pebble conglomerate; garpike scales; unidentified Unionid clam; bone fragments; flood-plain (stream channel) deposit	7.6
124. Mudstone, gray-green; flood-plain (basin-fill) deposit	14.6
123. Sandstone, gold, very fine to coarse-grained, soft; flood-plain (stream channel) deposit	12.0
122. Mudstone, gray-green; flood-plain (basin-fill) deposit	2.3
121. Mudstone, maroon-red and gray-green, mottled; flood-plain (basin-fill) deposit	5.1

Reference section of Eocene rocks in the Green River basin—Continued

		Thickness Feet
Main body of Wasatch Formation—Continued		
120.	Mudstone, gray-green, soft; flood-plain (basin-fill) deposit	5.7
119.	Sandstone, gold, very fine to coarse-grained, micaceous; trough crossbedded; calcareous and gray the top 1.0 ft; flood-plain (stream channel) deposit	11.5
118.	Mudstone, gray, green; flood-plain (basin-fill) deposit	4.1
117.	Mudstone, maroon-red and gray-green, mottled; flood-plain (basin-fill) deposit	2.4
116.	Mudstone, gray-green; flood-plain (basin-fill) deposit	3.8
115.	Mudstone, maroon-red and gray-green, mottled; flood-plain (basin-fill) deposit	3.7
114.	Mudstone, gray-green; flood-plain (basin-fill) deposit	1.7
113.	Sandstone, gold, gray at the top and bottom, calcareous at the top and bottom; in parallel beds; flood-plain (splay) deposit	4.2
112.	Mudstone, gray-green, soft; flood-plain (basin-fill) deposit	19.0
111.	Sandstone, brown, very fine grained, calcareous; abundant burrows; flood-plain (splay) deposit.	1.1
110.	Mudstone, gray, soft; flood-plain (basin-fill) deposit	2.7
109.	Sandstone, gray, very fine grained, calcareous; burrowed; flood-plain (splay) deposit	2.0
108.	Sandstone, gold, very fine to coarse-grained; trough crossbedded; flood-plain (stream channel) deposit	9.5
107.	Sandstone, gray, very fine to fine-grained; some U-shaped burrows at the base; trough cross-bedded with current ripples; flood-plain (stream channel) deposit	3.4
106.	Mudstone, gray-green, soft; flood-plain (basin-fill) deposit	5.7
105.	Sandstone, brown, gold, very fine grained; parallel beds; flood-plain (splay) deposit	4.3
104.	Mudstone, gray-green; flood-plain (basin-fill) deposit	1.6
103.	Mudstone, maroon-red and gray-green, mottled; flood-plain (basin-fill) deposit	0.6
102.	Mudstone, gray-green; flood-plain (basin-fill) deposit	1.5
101.	Mudstone, maroon-red and gray-green, mottled; flood-plain (basin-fill) deposit	1.6
100.	Mudstone, gray-green, soft; flood-plain (basin-fill) deposit	5.0
99.	Sandstone, gray, very fine grained; in undulating, parallel beds; flood-plain (splay) deposit.	1.0
98.	Mudstone, gray-green, soft; flood-plain (basin-fill) deposit	2.3
97.	Mudstone, maroon-red and gray-green, mottled, soft; flood-plain (basin-fill) deposit	4.4
96.	Mudstone, gray-green, soft; flood-plain (basin-fill) deposit	3.2
95.	Sandstone, gold, very fine to coarse-grained; trough crossbedded; scoured base; sparse, thin lenses of clay pebbles; thickens north of the line of section; flood-plain (stream channel) deposit	17.0

Reference section of Eocene rocks in the Green River basin—Continued

		Thickness Feet
Main body of Wasatch Formation—Continued		
94.	Mudstone, gray-green, soft; flood-plain (basin-fill) deposit	0.8
93.	Mudstone, maroon-red and gray-green, mottled; flood-plain (basin-fill) deposit	4.4
92.	Mudstone, gray-green, soft; flood-plain (basin-fill) deposit	1.7
91.	Sandstone, very fine grained, very silty; parallel, current-rippled beds; flood-plain (splay) deposit	4.1
90.	Mudstone, gray-green; flood-plain (basin-fill) deposit	0.5
89.	Mudstone, maroon-red and green, mottled; flood-plain (basin-fill) deposit	2.0
88.	Mudstone, gray-green, soft; flood-plain (basin-fill) deposit	8.1
87.	Sandstone, gray, very fine to coarse-grained, very micaceous; crossbedded; lenticular; flood-plain (stream channel) deposit	8.0
86.	Mudstone, gray-green; flood-plain (basin-fill) deposit	0.4
85.	Mudstone, maroon-red and green, mottled; flood-plain (basin-fill) deposit	0.9
84.	Mudstone, dark-green, soft; flood-plain (basin-fill) deposit	0.7
83.	Sandstone, gold-gray, gray and calcareous at the top and bottom; burrowed at the top and bottom; in parallel beds; flood-plain (splay) deposit	5.9
82.	Mudstone, gray-green, soft; flood-plain (basin-fill) deposit	3.9
81.	Mudstone, maroon-red and green, mottled; flood-plain (basin-fill) deposit	4.5
80.	Mudstone, gray-green; flood-plain (basin-fill) deposit	4.6
79.	Sandstone, gray-brown, very fine grained; extensively burrowed; parallel bedded; flood-plain (splay) deposit	1.8
78.	Mudstone, gray-green; flood-plain (basin-fill) deposit	2.4
77.	Mudstone, maroon-red and green, mottled; flood-plain (basin-fill) deposit	4.7
76.	Mudstone, gray-green; flood-plain (basin-fill) deposits	7.5
75.	Sandstone, gold-gray, very fine to fine-grained, micaceous, calcareous and burrowed the top 1.0 ft; in parallel beds; flood-plain (splay) deposit	6.8
74.	Mudstone, gray-green, soft; flood-plain (basin-fill) deposit	1.7
73.	Mudstone, maroon-red and green, mottled, blocky, soft; flood-plain (basin-fill) deposit	2.6
72.	Mudstone, dark-green, gray-green, soft; flood-plain (basin-fill) deposit	6.9
71.	Sandstone, gray at the top and bottom, gold in the middle, calcareous at the top and bottom; abundant crustacean burrows about 0.1 ft wide with corn cob texture; in parallel beds; flood-plain (splay) deposit	9.0
70.	Mudstone, gray, gray-green, silty laminae; flood-plain (basin-fill) deposit	8.0
69.	Sandstone, brown, hard; burrowed; flood-plain (splay) deposit	0.4

Reference section of Eocene rocks in the Green River basin—Continued

		Thickness Feet
Main body of Wasatch Formation—Continued		
68.	Mudstone, gray-green, soft; flood-plain (basin-fill) deposit	1.3
67.	Siltstone, gray, soft; current rippled; flood-plain (splay) deposit	3.5
66.	Mudstone, gray-green, silty, firm; flood-plain (basin-fill) deposit	7.8
65.	Mudstone, maroon-red and gray-green, mottled; flood-plain (basin-fill) deposit	0.6
64.	Mudstone, gray-green, soft, top and bottom, and siltstone, gray, soft, in the middle; flood-plain (basin-fill) deposits	4.0
63.	Sandstone, gray, very fine grained; in subparallel beds, flood-plain (splay) deposits	1.7
62.	Mudstone, gray-green, soft; flood-plain (basin-fill) deposit	3.4
61.	Mudstone, maroon-red and gray-green, mottled, blocky, soft; flood-plain (basin-fill) deposit	6.8
60.	Mudstone, gray-green, soft; flood-plain (basin-fill) deposits	1.5
59.	Sandstone, gold-gray, very fine grained; in parallel beds; flood-plain (splay) deposit	9.4
58.	Sandstone, gold-gray, very fine grained; in current-rippled beds; flood-plain (splay) deposit	2.1
57.	Mudstone, gray, soft; flood-plain (basin-fill) deposits	21.6
56.	Sandstone, gold-gray, very fine to medium-grained, micaceous; in parallel beds; flood-plain (splay) deposit	5.4
55.	Sandstone, gray-brown, very fine to fine-grained; in current-rippled beds; flood-plain (splay) deposit	1.4
54.	Mudstone, gray, soft; flood-plain (basin-fill) deposit	17.2
53.	Sandstone, gray-brown, fine-grained; in parallel beds; flood-plain (splay) deposit	2.5
52.	Sandstone, gold-gray, very fine to fine-grained; trough crossbedded; lenticular; flood-plain (stream channel) deposit	6.5
51.	Mudstone, medium-gray, soft; flood-plain (basin-fill) deposit	14.3
50.	Sandstone, gold-gray, very fine to fine-grained; large grains of mica; in parallel beds; flood-plain (splay) deposit	4.4
49.	Mudstone, medium-gray, silty, soft; flood-plain deposit	12.6
48.	Sandstone, gold-gray, very fine to medium-grained; trough crossbedded; scoured base; lenticular; flood-plain (stream channel) deposit	5.2
47.	Mudstone, gray, very sandy; flood-plain (basin-fill) deposit	3.6
46.	Sandstone, gold-gray, very fine to medium-grained; trough crossbedded; lenticular; flood-plain (stream channel) deposit	10.4
	Fossil locality 459 located in NE¼NE¼SE¼ sec. 32, T. 19 N., R. 105 W. Fossil mammals identified by C.L. Gazin.	
	Palaeictops tauri-cinerei	
	Cynodontomys sp.	
	Pelycodus sp.	
	Hyopsodus sp.	
	Hyracotherium sp.	

Reference section of Eocene rocks in the Green River basin—Continued

		Thickness Feet
Main body of Wasatch Formation—Continued		
45.	Mudstone, medium- to dark-gray, silty, soft; flood-plain (basin-fill) deposit	10.3
44.	Sandstone, gray-gold, very fine to medium-grained; trough crossbedded; lenticular; flood-plain (stream channel) deposit	8.5
43.	Mudstone, gray, silty; unidentified bone fragments; flood-plain (basin-fill) deposit	9.0
42.	Sandstone, gold-gray, very fine to medium-grained; very large ironstone concretions; large-scale trough crossbeds; lenticular; flood-plain (stream channel) deposit	22.5
41.	Mudstone, gray, sandy, soft; flood-plain (basin-fill) deposits	18.0
40.	Sandstone, gold-gray, very fine to coarse-grained, poorly sorted; large round ironstone concretions as much as 4 ft in diameter; trough crossbedded; lenticular; scoured base; flood-plain (stream channel) deposit	49.0
39.	Mudstone, gray, soft; flood-plain (basin-fill) deposit	17.0
38.	Sandstone, gold-gray, very fine to coarse-grained; trough crossbedded; flood-plain (stream channel) deposit	32.4
37.	Mudstone, medium-gray, red, variegated, silty, firm; flood-plain (basin-fill) deposit	24.0
36.	Sandstone, gold-brown, fine-grained, soft, friable, dark streaks composed of large biotite grains, large grains of muscovite, some black and red grains; rounded calcareous concretions; trough crossbedded; flood-plain (stream channel) deposits	7.5
35.	Mudstone, medium-gray, soft; one very thin bed of sandstone, gray, fine-grained, calcareous, hard, near the middle; flood-plain (basin-fill and splay) deposits	12.0
34.	Sandstone, gold-brown, fine-grained, soft, friable, micaceous; dark-brown calcareous concretions the top 2 ft in parallel beds; flood-plain (splay) deposit	4.5
33.	Mudstone, medium-gray, blocky, sandy, and a few 1- to 3-ft-thick lenses of sandstone, dark-gray, calcareous, hard; weathers brown; flood-plain and flood-plain (splay) deposits	40.5
32.	Sandstone, gold-brown, very fine to fine-grained, soft, friable, calcareous; in parallel beds; flood-plain (splay) deposit	6.0
31.	Mudstone, medium-gray, blocky; sandy layers; flood-plain (basin-fill) deposit	40.0
30.	Sandstone, gold-brown, fine-grained, soft; brown calcareous concretions; in parallel beds; flood-plain (splay) deposit	3.5
29.	Mudstone, medium- to dark-gray, bands of red-brown, soft; flood-plain (basin-fill) deposit	9.5
28.	Sandstone, gold-brown, fine-grained, soft, friable; abundant red and black grains, biotitic, large grains of muscovite; large, round, dark-brown calcareous concretions; trough cross-bedded; flood-plain (stream channel) deposit	5.0
27.	Mudstone, medium- to dark-gray, soft; flood-plain (basin-fill) deposit	13.0

Reference section of Eocene rocks in the Green River basin—Continued

		Thickness Feet
Main body of Wasatch Formation—Continued		
26.	Sandstone, gold-brown, fine-grained, soft, friable; abundant red and black grains, large biotite and muscovite grains; large, rounded, dark-brown calcareous concretions; in parallel beds; flood-plain (splay) deposit	4.5
25.	Sandstone, gray, fine- to medium-grained, hard, calcareous, biotitic; abundant red and black grains; trough crossbedded; flood-plain (splay channel) deposit	1.0
24.	Mudstone, medium-gray, gray-green, some red bands, silty, blocky, firm; abundant turtle scutes; flood-plain (basin-fill) deposit	16.0
23.	Sandstone, gold-brown, fine-grained, soft, friable; capped by large dark-brown calcareous concretions; flood-plain (splay) deposit	4.5
22.	Mudstone, medium-gray, fissile, silty, firm; flood-plain (basin-fill) deposit	4.0
21.	Sandstone, gold-brown, gray, fine-grained, soft, friable, poorly sorted; in parallel beds; flood-plain (splay) deposit	3.5
20.	Mudstone, medium-gray, firm; flood-plain (basin-fill) deposit	6.0
19.	Sandstone, gold-brown to gray, fine-grained, soft, friable, poorly sorted; abundant biotite and muscovite grains; contains dark-brown, rounded ironstone concretions as much as 4 ft in diameter; flood-plain (splay) deposit	4.5
18.	Mudstone, medium-gray, brown, firm; becomes sandy the top 3 ft; flood-plain (basin-fill) deposit	27.0
17.	Siltstone, gray; grades upward into sandstone, gray, very fine grained, calcareous, crossbedded with shaly interbeds; flood-plain (splay) deposit	6.5
16.	Mudstone, medium- to dark-gray, silty, blocky, firm; very fossiliferous the bottom 12 ft; flood-plain (basin-fill) deposit	27.5
	Three hundred feet south of the line of section, the lower part of the interval grades into a stream channel sandstone with conglomerate lenses at the base. Fossil locality 2a59 is located in these conglomerates in N½SW¼ SE¼ sec. 17, T. 18 N., R. 104 W. Fossil mammals identified by C.L. Gazin.	
	Diacodon sp. *Didelphodus* sp. *Paleosinopa* sp. *Haplomylus speirianus* *Hyopsodus* sp. *Hyracotherium* sp.	
15.	Sandstone, gold-brown, some layers of gray, very fine to fine-grained, soft, friable, partly calcareous, large mica grains; scattered 3- to 4-ft-thick rounded, brown, calcareous concretions; massive; flood-plain (splay) deposit	5.0
14.	Mudstone, medium-gray, silty to sandy, firm; flood-plain (basin-fill) deposit	10.5
13.	Sandstone, gray, very fine grained, calcareous, hard; in subparallel beds; flood-plain (splay) deposit	2.0
12.	Mudstone, medium-gray, silty, blocky, soft; flood-plain (basin-fill) deposit	3.5
11.	Sandstone, gold-brown to gray, very fine grained, poorly sorted, soft, friable; large muscovite and biotite grains; massive; flood-plain (splay) deposit	2.5
10.	Mudstone, medium-gray, silty, soft; flood-plain (basin-fill) deposit	2.0
9.	Sandstone, gold-brown, very fine to fine-grained, soft, friable; large muscovite and biotite grains, some black grains; massive; flood-plain (splay) deposit	4.0
8.	Mudstone, medium-gray, silty, blocky, soft; becomes very sandy the top 2 ft; flood-plain (basin-fill) deposit	9.5
7.	Sandstone, gold-brown, fine-grained, well-sorted, soft, friable; some black and red grains; scattered dark-brown, calcareous concretions as much as 4 ft in diameter; trough crossbedded; flood-plain (stream channel) deposit	37.0
6.	Conglomerate, dark-brown; composed of small pebbles of gray claystone and sandstone in a light-gray, fine-grained sandstone matrix; flood-plain (stream channel) deposit	1.5
	Fossil locality 259. Locality is located in SW¼ SE¼ sec. 17, T. 18 N., R. 105 W. Fossil mammals identified by C.L. Gazin.	
	Undetermined multituberculate *Esthonyx bisulcatus* *Viverravus* sp. *Haplomylus speirianus* *Hyopsodus* sp. *Meniscotherium priscum* *Hyracotherium* sp.	
5.	Mudstone, medium-gray, sandy laminae, soft; flood-plain (basin-fill) deposit	55.0
4.	Sandstone, gold-brown, fine-grained, well-sorted, subangular, soft, friable; abundant black grains, some red and green grains; scattered dark-brown calcareous concretions as much as 4 ft in diameter; trough crossbedded; flood-plain (stream channel) deposit	16.0
3.	Mudstone, medium-gray, firm, and a few very thin lenses of sandstone, brown, fine-grained, firm; flood-plain (basin-fill and splay) deposits.	119.0
2.	Sandstone, gold-brown, medium-grained, subrounded, soft, friable; abundant black grains, large grains of muscovite and biotite; trough crossbedded; flood-plain (stream channel) deposit	20.5
1.	Mudstone, medium-gray, dark-gray, firm; flood-plain (basin-fill) deposit	38.0
	Total thickness of main body of Wasatch Formation	1,236.4

REFERENCE SECTION OF EOCENE ROCKS IN THE WASHAKIE BASIN

[Measured, sampled, and described by H.W. Roehler in 1968, using a 5-ft Jacob's staff and Abney level, at various correlated localities in Sweetwater County, southwest Wyoming (pl. 2)]

Reference section of Eocene rocks in the Washakie basin

		Thickness Feet
	Washakie Formation:	
	Adobe Town Member:	
708.	Mudstone, green, silty, blocky, firm; flood-plain (basin-fill) deposit	13.0
707.	Sandstone, gray, fine-grained to very coarse grained, poorly sorted, subangular; abundant colored grains, argillaceous, calcareous streaks; trough crossbedded; weathers to nearly vertical slopes; scattered fish bones and turtle scutes; flood-plain (stream channel) deposit	16.9
706.	Mudstone, green, blocky, silty, hard; grades upwards into sandstone, gray, fine-grained, argillaceous, soft; flood-plain (basin-fill) deposit	5.0
705.	Sandstone, gray, fine-grained to very coarse grained, poorly sorted, subangular, firm, friable, limonitic, argillaceous; trough crossbedded; scattered fish bones and turtle scutes; flood-plain (stream channel) deposit	4.3
704.	Mudstone, green, some thin black layers, silty, blocky, hard, and some interbedded sandstone, gray-green, very fine grained, argillaceous, firm, friable; flood-plain (basin-fill and splay) deposits	15.4
703.	Siltstone, gray-brown, shaly, limonitic, carbonaceous, firm; weathers rust brown; swamp deposit	2.7
702.	Mudstone, green, silty, firm, gypsiferous; flood-plain (basin-fill) deposit	6.5
701.	Shale, dark-brown, sandy, carbonaceous, firm; weathers rust brown, swamp deposit	0.5
700.	Sandstone, gray, fine-grained, very soft, very friable, limonitic; flood-plain (splay) deposit	0.6
699.	Mudstone, mostly green, some very thin dark-gray to black layers, silty to sandy, hard, gypsiferous; flood-plain (basin-fill) deposit	17.5
698.	Sandstone, gray, fine-grained, fairly well sorted, subangular; colored grains, calcareous and hard in part, soft and friable in part; weathers to steep slope; scattered bone fragments; flood-plain (stream channel) deposit	15.8
697.	Mudstone, medium-gray-green, very silty, blocky, hard; biotite grains; several whole turtle carapaces are weathered from the base; flood-plain (basin-fill) deposits	2.0
696.	Mudstone, dark-green at base, thin black layer at center, thin red layer at top, silty, blocky, hard; abundant turtle scutes; flood-plain (basin-fill) deposits	1.5
695.	Sandstone, gray, fine-grained, fairly well sorted, subangular, firm, finely interbedded with mudstone, dark-green, silty, blocky, hard; abundant turtle bones and scutes; flood-plain (splay and basin-fill) deposits	6.4
694.	Mudstone, dark-green, some dark-gray streaks, silty, blocky, hard; flood-plain (basin-fill) deposit	9.0
693.	Sandstone, gray, fine-grained, fairly well sorted, subangular, firm, friable; thin argillaceous streaks near the center; weathers to nearly vertical, smooth slope; flood-plain (splay) deposit	3.4

Reference section of Eocene rocks in the Washakie basin—Continued

		Thickness Feet
	Washakie Formation—Continued	
	Adobe Town Member—Continued	
692.	Mudstone, dark-green; thin streaks dark gray in lower part, some reddish streaks in the upper part; silty, blocky, hard, with three very thin interbeds of argillaceous sandstone; flood-plain (basin-fill) deposits	9.1
691.	Sandstone, gray, very fine grained, fairly well sorted, subangular, firm, argillaceous; muscovite grains; weathers to nearly vertical slopes; abundant turtle and crocodile bones and scutes; scattered large crocodile teeth and coprolites; flood-plain (splay) deposit	2.7
690.	Mudstone, green, silty to sandy, blocky, hard; 0.2-ft-thick carbonaceous zone 1.0 ft above base; flood-plain (basin-fill) and swamp deposits	5.7
689.	Sandstone, gray, very fine to medium-grained, poorly sorted, subangular, calcareous, firm; abundant colored grains; weathers to small steplike ledges; top of unit has very abundant turtle bones and scutes; flood-plain (splay) deposit	2.5
688.	Mudstone, green, silty, blocky, hard, with two very sandy streaks 6 ft above the base and 6 ft below the top; calcareous concretionary zone 3.0 ft above the base weathers to brown, rounded balls; flood-plain (basin-fill) deposits.	18.8
687.	Sandstone, gray, fine-grained to very coarse grained, poorly sorted, subangular to subrounded; abundant colored grains, arkosic, calcareous in part, firm; trough crossbedded; very calcareous and parallel bedded the top 0.7 ft; weathers rust brown; abundant turtle scutes; flood-plain (stream channel) deposit	24.6
686.	Mudstone, dark-green, dark-gray-green, some reddish tints in the upper 1.0 ft, silty, blocky, hard, and some interbedded sandstone, gray, argillaceous; abundant turtle scutes; flood-plain (basin-fill) deposits	16.0
685.	Mudstone, dark-green, orange-red the upper 1.0 ft, silty, blocky, gypsiferous, firm; weathers to rounded, mud-cracked slopes; flood-plain (basin-fill) deposit	4.2
684.	Sandstone, gray-green, very fine to fine-grained, very argillaceous, very calcareous; contains tan, limy inclusions that look like root impressions; flood-plain (splay) deposit	1.6
683.	Sandstone, gray, fine- to medium-grained, poorly sorted, subangular, abundant colored grains, firm, friable; weathers to steep slope; flood-plain (stream channel) deposit	11.9
682.	Mudstone, green, silty, blocky, hard, and a very thin lens of sandstone, gray-green, fine- to medium-grained; abundant colored grains, 0.8 ft above the base; flood-plain (basin-fill) deposits	10.2
681.	Sandstone, gray-green, fine- to medium-grained, poorly sorted, subangular; abundant colored grains, firm, friable; flood-plain (splay) deposit.	2.8
680.	Mudstone, green, silty, blocky, hard; flood-plain (basin-fill) deposit	4.9

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Washakie Formation—Continued	
Adobe Town Member—Continued	
679. Sandstone, gray with tints of green, fine- to coarse-grained, poorly sorted, subangular; abundant colored grains, hard, very calcareous at the top; trough crossbedded at the base, parallel bedded at the top; flood-plain (stream channel) deposit	7.8
678. Mudstone, green, very sandy, argillaceous, firm, becomes very sandy at the top; weathers to sloping bench above underlying sandstone; flood-plain (basin-fill) deposit	10.0
677. Sandstone, gray-green, very fine to medium-grained, fairly well sorted, subangular, tuffaceous, calcareous, firm; trough crossbedded; weathers to nearly vertical sided badlands; flood-plain (stream channel) deposit	71.8
676. Sandstone, gray-green, very fine grained, fairly well sorted, very argillaceous to clayey, hard, and numerous 0.2- to 0.8-ft-thick narrow lenses of sandstone, gray, gray-green, fine-grained, fairly well sorted, subangular, abundant black and red grains, calcareous, firm; weathers to badlands with nearly vertical slopes; flood-plain (splay) deposits	15.9
675. Mudstone, gray-green, green, silty, blocky, hard; flood-plain (basin-fill) deposits	15.5
674. Sandstone, gray-green, fine-grained to very coarse grained, poorly sorted, subangular; abundant green feldspar grains, very argillaceous to upper 9.0 ft; trough crossbedded; flood-plain (stream channel) deposit	17.0
673. Mudstone, apple-green, silty, blocky, hard; flood-plain (basin-fill) deposit	15.0
672. Sandstone, green, fine-grained to very coarse grained, poorly sorted, subangular; abundant colored grains; lenticular; trough crossbedded; flood-plain (stream channel) deposit	22.5
671. Mudstone, green, sandy, blocky, hard, and interbedded sandstone, gray-green, fine- to coarse-grained, poorly sorted, hard; flood-plain (basin-fill) deposits	5.0
670. Sandstone, gray, fine-grained to very coarse grained, poorly sorted, subangular, firm, friable, some green clay pebbles; lenticular; trough crossbedded; flood-plain (stream channel) deposit	8.0
669. Mudstone, green, sandy, blocky, firm, and interlaminated and thin interbedded sandstone, gray-green, medium-grained, subangular, hard; scattered turtle bones; flood-plain (basin-fill) deposits	6.8
668. Sandstone, gray-green, fine-grained to very coarse grained, poorly sorted, subangular, calcareous, some green clay pebbles, hard; weathers gray brown; flood-plain (splay) deposit	2.0
667. Sandstone, green, fine- to coarse-grained, poorly sorted, subangular, argillaceous, firm, friable, and interbedded mudstone, green, sandy, blocky, hard; flood-plain (splay and basin-fill) deposits	21.2
666. Sandstone, gray, fine-grained to very coarse grained, conglomeratic layers, poorly sorted, subangular; abundant green feldspar;	

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Washakie Formation—Continued	
Adobe Town Member—Continued	
666.—Continued	
weathers rust brown; lenticular; trough crossbedded; flood-plain (stream channel) deposit	14.0
665. Mudstone, green, silty, blocky, hard, and interbedded sandstone, gray-green, fine- to coarse-grained, poorly sorted, argillaceous, soft; flood-plain (basin-fill and splay) deposits	26.0
664. Tuff, white, finely bedded; no visible biotite grains; forms a white band and marker bed in outcrops; airfall ash deposit	8.6
663. Sandstone, green, fine-grained to very coarse grained, poorly sorted, very argillaceous, and interbedded sandstone, gray, very coarse grained, calcareous; trough crossbedded; flood-plain (stream channel) deposit	17.5
662. Mudstone, green, silty, blocky, hard, partly very sandy; flood-plain (basin-fill) deposit	4.5
661. Sandstone, gray, medium-grained to very coarse grained, poorly sorted, subangular, conglomeratic, and thin interbedded sandstone, gray, fine-grained, fairly well sorted, very argillaceous, firm; weathers to nearly vertical badland slopes; flood-plain (stream channel) deposit	19.5
660. Mudstone, green, some very thin red tints, silty to sandy, firm, and some interbedded sandstone, gray-green, fine-grained, very argillaceous, firm; weathers to steep badland slopes; flood-plain (basin-fill) deposits. Probably equivalent to the top of bed 21 of Granger (1909)	27.5
659. Mudstone, gray, silty, gypsiferous, soft, and some thin interbedded siltstone, gray, carbonaceous, calcareous, thin-bedded, hard; weathers yellow brown; swampy flood-plain (basin-fill) deposits	8.0
658. Mudstone, green, silty to sandy, soft, and interbedded sandstone, gray, fine-grained, argillaceous, very soft; some very thin calcareous ledges; weathers to smooth slope; flood-plain (basin-fill and splay) deposits	35.0
657. Mudstone, brown, gypsiferous, very soft; weathers yellow brown; flood-plain (basin-fill) deposit	10.3
656. Mudstone, dark-green, silty, blocky, hard, sandy at the base, and some 0.5- to 1.0-ft-thick interbedded sandstones, gray, fine-grained to very coarse grained, poorly sorted, calcareous, hard, and some thin interbedded sandstones, gray, fine-grained, argillaceous, firm; weathers to smooth slopes; flood-plain (basin-fill and splay) deposits	68.0
655. Sandstone, gray, fine-grained, fairly well sorted; abundant colored grains, calcareous, hard, limonitic; lenticular, trough crossbedded; weathers rust gray; flood-plain (stream channel) deposit	4.0
654. Mudstone, gray, gray-green, silty, blocky, firm, and interbedded sandstone, gray, fine-grained, poorly sorted, soft to hard, in part calcareous; some of the sandstone forms ledges in otherwise smooth badland slopes; flood-plain (basin-fill) deposits	58.5

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Washakie Formation—Continued	
Adobe Town Member—Continued	
653. Shale, dark-green, fissile, soft, gypsiferous; weathers to yellow-brown smooth slope; flood-plain (basin-fill) deposits	5.4
652. Mudstone, dark-green, silty, soft, and interbedded sandstone, gray, fine-grained, very soft and unconsolidated in the upper one-half of the interval; small calcite cones 2.0 ft above the base; weathers to smooth slope; flood-plain (basin-fill and splay) deposits	12.9
651. Mudstone, gray, silty, blocky, hard; weathers to yellow-brown, smooth, rounded badland slopes; flood-plain (basin-fill) deposits	8.2
650. Mudstone, gray, very silty to sandy, soft, and interlaminated and thin interbedded sandstone, gray, very fine to fine-grained, very soft, unconsolidated; abundant milky calcite laminae in the upper part; weathers to smooth badland slopes; flood-plain (basin-fill and splay) deposits	23.0
649. Siltstone, gray, argillaceous, firm; in thin parallel beds; weathers to prominent yellow band in outcrops; flood-plain (splay) deposit	5.0
648. Sandstone, gray, green, fine-grained, loose, unconsolidated, and interbedded mudstone, gray-green, very silty to sandy, blocky, hard; flood-plain (splay and basin-fill) deposits	24.8
647. Sandstone, brown, fine-grained, fairly well sorted, loose, unconsolidated, very limonitic, gypsiferous (loose pieces of satin spar); weathers to prominent yellow band in outcrops; flood-plain (splay) deposit	5.3
646. Sandstone, gray, fine-grained, fairly well sorted, calcareous, hard; weathers brown; caps dip slope; flood-plain (splay) deposit	0.3
645. Sandstone, gray, gray-green, fine-grained to very coarse grained, poorly sorted, subangular, dark grains, very soft, argillaceous, forms smooth slopes, and interbedded mudstone, gray, silty, blocky, firm; flood-plain (splay and basin-fill) deposits	37.5
644. Mudstone, variegated apple-green and brick-red, silty, blocky, firm, with some 0.5- to 1.5-ft-thick interbedded sandstones, gray, fine- to coarse-grained, poorly sorted, subangular, thin-bedded; sandstones weather dark brown; flood-plain (basin-fill and splay) deposits. Constitutes the upper or rose-red marker bed.	47.3
Probable level of *Eobasileus cornutus* collected by E.D. Cope (Granger, 1909, p. 19).	
643. Sandstone, gray, fine-grained to very coarse grained, poorly sorted, subangular, firm, friable, silty, argillaceous in part; trough crossbedded with some convoluted bedding; flood-plain (stream channel) deposit	13.4
642. Shale, dark-gray-green, soapy, clayey, blocky, hard; flood-plain (basin-fill) deposit	10.0

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Washakie Formation—Continued	
Adobe Town Member—Continued	
642—Continued:	
Stratigraphic level of locality 12–70 of W.D. Turnbull (1978).	
Titanothere	
641. Siltstone, gray, argillaceous, hard, carbonaceous; scattered plant fragments; one perfect leaf; swampy flood-plain (basin-fill) deposit	5.0
640. Sandstone, gray, gray-green, mostly fine grained, silty, hard, thin parallel bedding, and thin interbedded mudstone, green, very silty, blocky, hard; flood-plain (splay and basin-fill) deposit	26.5
639. Mudstone, gray-green, green, very silty, blocky, hard, and interlaminated and thin interbedded sandstone, gray, gray-green, fine- to coarse-grained, poorly sorted, subangular, firm to hard; abundant colored grains; flood-plain (basin-fill and splay) deposits	124.0
Locality 270 of H.W. Roehler.	
Titanothere	
638. Sandstone, gray, fine-grained to very coarse grained, poorly sorted, subangular; abundant colored grains, very argillaceous streaks, trough crossbedded; becomes interbedded with mudstone, gray, very silty, blocky, hard, in the upper part; bone fragments and one complete turtle carapace; scattered wood fragments; flood-plain (stream channel and basin-fill) deposits	64.8
637. Tuff, white, soft to very hard; scattered biotite grains; weathers to brilliant chalk-white marker bed; airfall ash deposit. White glass tuff marker bed	8.1
636. Mudstone, gray, silty, blocky, hard, and interbedded sandstone, green, fine- to coarse-grained, poorly sorted, subangular, soft and friable; abundant colored grains; trough crossbedded; sandstones are thin, narrow flood-plain (stream channel) deposits; the lower part of the unit (about 15 ft above the base) contains chocolate-brown weathered, limy, hematitic, sandstone concretions; 0.4-ft-thick lens of conglomerate composed of small, well-rounded, varicolored pebbles of porphyritic andesite in a coarse-grained sandstone matrix, 15.0 ft below the top; abundant turtle carapaces	62.0
Locality 470 of H.W. Roehler.	
Titanothere	
Level of *Dolichorhinus hyognathus* collected by Granger (1909, p. 19).	
635. Sandstone, green, fine- to coarse-grained, poorly sorted, subangular, firm, friable; abundant colored grains; lenticular; trough crossbedded; flood-plain (stream channel) deposits	28.3
634. Mudstone, gray, silty, blocky, hard, and some interbedded sandstone, light-gray, fine-grained, soft, friable, the upper 3.0 ft; flood-plain (basin-fill) deposits	10.0

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Washakie Formation—Continued	
Adobe Town Member—Continued	
633. Sandstone, dark-green, medium-grained to very coarse grained, conglomeratic at the base, poorly sorted, subangular, soft, friable; abundant green feldspar grains; trough crossbedded; flood-plain (stream channel) deposit; contains abundant silicified wood, including many tree trunks; abundant large mammal bone and tooth fragments, including weathered ramus about the right size for titanothere; weathers green to olive green in overall color and spans the entire width of outcrops in this area. Bed 17 of Granger (1909)	17.0
Locality 868 of H.W. Roehler.	
Fostercooperi grandus *Metarhinus earlei* *Limnocyon* sp. *Manteoceras* cf. *washakiensis* *Paleosyops* sp. *Hyrachyus* sp.	
632. Sandstone, gray-green, fine-grained, poorly sorted, very soft, mostly unconsolidated, with small white irregularly shaped calcite(?) concretions	3.0
631. Mudstone, green, gray-green, silty, fissile, some blocky, firm, and interbedded sandstone, gray, fine-grained, poorly sorted, argillaceous, very soft; weathers to nonresistant slopes; flood-plain (basin-fill and splay) deposits	49.0
630. Sandstone, gray, fine-grained, limy, very hard; grades upwards into limestone, gray, with black, oolitic, siliceous lenses; weathers dark brown; caps dip slope; freshwater lacustrine (shoreline) deposits	1.5
629. Sandstone, green, fine-grained to very coarse grained, poorly sorted, subangular; abundant colored grains; trough crossbedded, lenticular; and interbedded mudstone, gray-green, silty to very sandy, hard; scattered poorly preserved fossil leaves in the lower 2.0 ft; one fossil tree trunk 41.0 ft above the base; flood-plain (stream channel and basin-fill) deposits	94.0
628. Sandstone, gray, fine- to medium-grained, poorly sorted, subangular, hematitic, thin-bedded; weathers rust; flood-plain (splay) deposit	0.6
627. Shale, medium-gray, clayey, blocky, soft; flood-plain (basin-fill) deposit	6.8
626. Limestone, tan-gray, finely crystalline, hard, dense, very thin bedded, platy; weathers to yellow band in outcrops; freshwater lacustrine deposit	0.9
625. Sandstone, gray, very fine to fine-grained, poorly sorted, subangular, limonitic; abundant colored grains; massive at the base and thin bedded at the top; weathers brown; flood-plain (splay) deposit	5.0

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Washakie Formation—Continued	
Adobe Town Member—Continued	
624. Mudstone, mostly gray green, several dark-red beds, silty, blocky, hard, and a few laminae of very fine grained sandstone; interval weathers to pastel shades of green and red; flood-plain (basin-fill) deposit	66.0
Miacis sp. collected by W.D. Turnbull (1978)	
623. Mudstone, gray, gray-green, silty, blocky, hard, and some thin interbedded lenticular sandstone, gray-green, fine- to medium-grained, poorly sorted, calcareous, hard; flood-plain (basin-fill) deposits	34.0
622. Limestone, tan, finely crystalline, very silty, blocky, hard; freshwater lacustrine deposit	0.6
621. Mudstone, gray, silty, blocky, firm; flood-plain (basin-fill) deposit	3.5
620. Tuff, tan, very limy, very silty, hard, finely laminated; weathers brown; caps hogback ridge; airfall ash deposit	0.7
619. Mudstone, green, very sandy, blocky, firm, partly grades into argillaceous sandstone; not well exposed; flood-plain (basin-fill) deposit	43.1
618. Sandstone, dark-apple-green, fine-grained to very coarse grained, poorly sorted, subangular, soft, friable; thin lenses contain abundant clay pebbles; trough crossbedded; base of unit is a 0.3-ft-thick lens of black placer sandstone; abundant very large mammal bones; flood-plain (stream channel) deposit	18.0
617. Sandstone, light-gray, very fine to fine-grained, poorly sorted, biotitic, argillaceous, calcareous, thin-bedded; freshwater lacustrine deposit	3.0
616. Sandstone, green, fine-grained to very coarse grained, poorly sorted, subangular, conglomerate lenses at the base, calcareous, firm; trough crossbedded; occasional large isolated algal heads up to 4.0 ft in diameter; freshwater lacustrine (shoreline) deposit	9.0
615. Mudstone, gray-green, silty, blocky, hard, and some very thin interbedded sandstone, gray, fine- to medium-grained, firm, friable; flood-plain (basin-fill and splay) deposits	13.0
614. Sandstone, gray to apple-green, fine-grained to very coarse grained, poorly sorted, subangular, firm, friable; conglomerate lenses at the base; abundant colored grains; trough crossbedded; lenticular; flood-plain (stream channel) deposit; abundant turtle and large mammal bones. Beds 610–614 form a prominent north-dipping scarp with badlands developed along its face	41.0
613. Mudstone, gray-green, silty, blocky, hard; flood-plain (basin-fill) deposits	6.7
612. Sandstone, gray-green, fine- to coarse-grained, poorly sorted, subangular, firm, friable; lenticular; trough crossbedded; flood-plain (stream channel) deposit	11.2
611. Mudstone, gray, very sandy, thin-bedded, hard; flood-plain (basin-fill) deposit	4.1

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Washakie Formation—Continued	
Adobe Town Member—Continued	
610. Sandstone, light-gray-green, fine- to coarse-grained, poorly sorted, subangular, firm, friable; abundant colored grains; lenticular; trough crossbedded; abundant bone fragments; one humerus about 1 ft long is embedded in the outcrop; flood-plain (stream channel) deposit .	14.0
609. Mudstone, gray-green, silty, blocky, hard, becomes very sandy at the top; abundant turtle scutes and mammal bone fragments; flood-plain (basin-fill) deposit	5.5
608. Sandstone, gray-green, fine- to medium-grained, poorly sorted, subangular, firm and friable at the base, becomes calcareous the top 1.0 ft; abundant colored grains; top part weathers brown and caps small hogback; contains small, poorly preserved *Goniobasis* sp., *Viviparus* sp., and *Australorbis* sp.; freshwater lacustrine (shoreline) deposit	3.9
607. Mudstone, gray-green, very sandy, very thin bedded, firm; flood-plain (basin-fill) deposit	7.7
606. Coquinal limestone, gray, sandy, hard; contains *Goniobasis* sp., very large *Gyraulus militaris*(?), and abundant turtle scutes and fish bones; freshwater lacustrine (shoreline) deposit	0.2
605. Mudstone, green, sandy, blocky, hard; flood-plain (basin-fill) deposit	8.4
604. Sandstone, light-gray, fine- to coarse-grained, poorly sorted, subangular, very argillaceous, firm, friable; abundant colored grains; trough crossbedded; weathers to nearly vertical slope; flood-plain (stream channel) deposit	15.3
603. Mudstone, dark-gray-green at the base, grading upward into green and some red near the center, silty, blocky, hard; two very thin interbeds of gray-green sandstone; two whole turtles weathering out; flood-plain (basin-fill and splay) deposits; top of the middle red marker beds	22.9
602. Limestone, tan-brown, silty, hard; scattered algal limestone colonies as large as 5 ft in diameter, mostly on the upper surface; freshwater lacustrine deposit	0.8
601. Mudstone, green, silty, blocky, firm; flood-plain (basin-fill) deposit	4.9
600. Limestone, tan-gray, very finely crystalline, silty, very hard; weathers light chocolate brown; caps hogback ridge; freshwater lacustrine deposit	1.0
599. Mudstone, green, some layers of red, sandy, blocky, hard, and interbedded sandstone, gray-green, very fine to medium-grained, poorly sorted, subangular, argillaceous, hard; colored grains; flood-plain (basin-fill and splay) deposits	27.7
598. Mudstone, dark-brick-red to orange-red, very sandy, hard, and interbedded sandstone, green, red, argillaceous, hard; unit weathers to red band in outcrops; abundant turtle scutes; flood-plain (basin-fill) deposit	19.0
Vertebrate locality 7–69 of W.D. Turnbull (1978).	

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Washakie Formation—Continued	
Adobe Town Member—Continued	
597. Mudstone, mostly apple green, some thin bands of red, very silty, hard; several whole turtles; weather to bright-green band in outcrops; flood-plain (basin-fill) deposit	10.7
596. Mudstone, mostly layered pastel shades of maroon and green, very sandy, soft, and some interbedded sandstone, gray, green, very fine to medium-grained, poorly sorted, subangular, very argillaceous; abundant colored grains; lenticular; abundant turtle scutes and small mammal bones; flood-plain (basin-fill and splay) deposits; base is bottom of middle red marker beds	58.0
595. Sandstone, gray-green, very fine to medium-grained, poorly sorted, subangular, argillaceous, firm, and interbedded mudstone, mostly gray green, occasionally brown, maroon, and green, very sandy, firm; scattered turtle scutes; weathers to pastel shades; flood-plain (splay and basin-fill) deposits	90.6
Locality 468 of H.W. Roehler.	
Hyopsodus sp.	
594. Limestone, tan-brown, finely crystalline, silty, very hard; weathers brown; freshwater lacustrine deposit	2.5
593. Sandstone, gray-green, very fine to medium-grained, poorly sorted, subangular, soft, friable, argillaceous; abundant colored grains; flood-plain (splay) deposit	6.0
592. Limestone, medium-gray-brown, finely crystalline, silty, platy, hard; weathers dark brown; caps last ridge to south of red-bed sequence; freshwater lacustrine deposit	4.3
591. Sandstone, gray-green, fine- to medium-grained, poorly sorted, biotitic, very shaly, soft, and some thin interbedded shale, gray, fissile, firm, and some thin interbedded mudstone, gray-green, sandy, blocky, hard; mammal bone fragments; flood-plain (splay and basin-fill) deposits	65.3
590. Limestone, gray-brown, finely crystalline, silty, very hard, dense; weathers brown, caps very resistant ridge; freshwater lacustrine deposit .	1.5
589. Sandstone, gray-green, fine-grained, poorly sorted, shaly, with layers very shaly near the middle, and some very thin interbedded sandstone, gray, calcareous; flood-plain (stream channel) deposit	67.5
588. Limestone, tan-gray, finely crystalline, silty, hard, dense, thin-bedded; weathers yellow brown; freshwater lacustrine deposit	5.8
587. Mudstone, dark-olive-green, silty, blocky, firm, at the base, and interbedded in the upper part with siltstone, gray, limy, hard, and sandstone, gray-green, partly blue green and tuffaceous, calcareous, firm; flood-plain (basin-fill and splay) deposits	32.0
586. Sandstone, light-gray, fine-grained, very tuffaceous, firm, friable; weathers to resistant gray-white band in outcrops; mostly reworked air-fall volcanic ash deposit	7.0

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Washakie Formation—Continued	
Adobe Town Member—Continued	
585. Shale, tan, fissile, soft; freshwater lacustrine deposit	6.0
584. Sandstone, gray-green, fine-grained, very soft, shaly, nonresistant, and thin interbedded siltstone, light-gray, calcareous, tuffaceous, blocky, hard; flood-plain deposit; bed 2 of Granger (1909)	20.0
583. Sandstone, light-gray, fine- to coarse-grained, poorly sorted, very limy at the base; grades upward into limestone, tan-gray, silty, very hard; forms brown-weathering ledge that caps hogback; freshwater lacustrine deposit	3.7
582. Sandstone, gray-green, fine-grained, subangular, fairly well sorted, biotitic; abundant colored grains; grades laterally to light-blue-green, very tuffaceous sandstone; flood-plain (stream channel) deposit	6.5
581. Siltstone, light-gray, limy, hard, thin-bedded, capped by thin laminae of limestone, gray-brown, finely crystalline, platy, hard, dense; freshwater lacustrine deposit	2.5
580. Limestone, gray-brown, finely crystalline, hard, dense, platy, thin-bedded at the top, becomes very silty the top 1.0 ft; abundant worm trails; freshwater lacustrine deposit	1.7
579. Sandstone, light-blue-green, very tuffaceous, hard; weathers to prominent marker bed in outcrops; airfall ash deposit. The robins-egg-blue marker bed	6.3
Bradley (1945, 1964) placed the top of the Laney Member of the Green River Formation at the robins-egg-blue marker bed. The bed is located approximately 75 ft above the base of Washakie A of Granger (1909).	
578. Tuff, yellow-gray, blocky, hard; airfall ash deposit	0.5
577. Sandstone, light-gray-green, fine-grained, fairly well sorted, very tuffaceous, calcareous, hard; very large unidentified fossil mammal leg bones; flood-plain (splay) deposit	9.9
576. Tuff, yellow-gray, blocky, hard; small molds of *Australorbis* sp.; airfall ash deposit	2.4
575. Sandstone, light-gray-green, fine-grained, fairly well sorted, very tuffaceous, calcareous, hard; flood-plain (stream channel) deposit	20.4
Stratigraphic level of fossil mammals collected by W.D. Turnbull in 1958 in SE¼ sec. 22, T. 16 N., R. 95 W.	
Stylinodon sp.	
Tinoceras grande	
574. Tuff, gray-brown, hard; airfall ash deposit	0.6
573. Siltstone, gray-green, very tuffaceous, thin-bedded, very hard; flood-plain (splay) deposit	9.4
572. Tuff, gray with greenish cast, silty, very hard; airfall ash deposit	7.4
571. Sandstone, light-gray-green, fine-grained, fairly well sorted, calcareous, firm, very tuffaceous the bottom 1.5 ft; abundant colored grains; flood-plain (splay) deposit	10.8
570. Tuff, light-greenish-gray, blocky, hard; airfall ash deposit	0.7
569. Sandstone, light-gray-green, fine-grained, fairly well sorted, abundant colored grains, calcareous, blocky, very hard, ridge-forming, and mudstone, green, sandy, blocky, hard; flood-plain (basin-fill and splay) deposits. The lower brown sandstone	25.3
Total thickness of Adobe Town Member of Washakie Formation	2,325.5
Unconformity.	
Washakie Formation:	
Kinney Rim Member:	
568. Sandstone, light-gray-green, fine-grained, fairly well sorted, calcareous, firm; abundant colored grains; flood-plain (splay) deposit	10.0
Locality 370 of H.W. Roehler.	
Microsyops cf. *schlosseri*	
Hyrachyus sp.	
567. Mudstone, green, gray-green, very tuffaceous in part, silty, blocky, soft, and some 0.5- to 1.5-ft-thick interbedded sandstone, gray-green, fine-grained, fairly well sorted, calcareous, firm; abundant colored grains; flood-plain (basin-fill and splay) deposits	19.9
566. Sandstone, gray-green, fine-grained, fairly well sorted, calcareous, firm; abundant colored grains; lenticular; flood-plain (stream channel) deposit	2.7
565. Mudstone, apple-green, sandy, firm, and some interbedded 0.5- to 1.0-ft-thick lenses of sandstone, gray with greenish cast, fine-grained, fairly well sorted, calcareous, firm; unidentified bone fragments; flood-plain (basin-fill and splay) deposits	89.5
Stratigraphic level of fossil mammal locality 558 of H.W. Roehler located in SE¼SE¼NE¼ sec. 6, T. 15 N., R. 94 W.	
Hemiacodon gracilis	
564. Sandstone, gray, with greenish cast, fine-grained, fairly well sorted, subangular; firm; abundant colored grains, flood-plain (splay) deposit	1.0
563. Mudstone, red, maroon, gray, very sandy, soft, and a few 0.5- to 1.0-ft-thick interbedded sandstones, dark-gray-red, some gray, very fine grained, calcareous, firm; flood-plain (basin-fill and splay) deposits. Top of the lower red marker beds	76.0
562. Sandstone, gray with greenish cast, fine-grained, fairly well sorted, subangular, firm; abundant colored grains; trough crossbedded; flood-plain (stream channel) deposits	15.0
561. Limestone, tan-gray, finely crystalline, silty, very hard, dense; weathers dark brown; freshwater lacustrine deposit	3.0
560. Mudstone, maroon, dark-orange-red, apple-green, some bands of gray, silty, blocky, soft, and some interbedded 0.5- to 1.0-ft-thick lenses of sandstone, dark-gray-red, very fine grained, calcareous, firm; flood-plain (basin-fill and splay) deposits. Base of lower red marker beds	91.5

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Washakie Formation—Continued	
Kinney Rim Member—Continued	
559. Algal limestone, gray, hard, silty; flattened, rounded platy heads; freshwater lacustrine deposit	2.1
558. Mudstone, medium-gray, silty, blocky, soft; flood-plain (basin-fill) deposit	18.5
557. Sandstone, light-gray, very fine grained, micaceous, calcareous, hard; flood-plain (splay) deposit	3.0
556. Mudstone, gray, gray-green, silty, blocky, soft, and some thin interbedded siltstone, light-gray, limy, hard; not well exposed; flood-plain (basin-fill and splay) deposits	47.9
555. Limestone, light-gray-brown, very finely crystalline, silty, hard, dense, platy; freshwater lacustrine deposit	2.5
554. Mudstone, dark-green, gray-green, blocky, soft, and interbedded sandstone, light-gray, very fine grained, calcareous, hard; flood-plain (basin-fill and splay) deposits	17.7
553. Limestone, light-brown-gray, very silty, hard, dense, platy; weathers brown; freshwater lacustrine deposit	2.3
552. Sandstone, gray, fine-grained, fairly well sorted, subangular, soft, friable, nonresistant; abundant colored grains; flood-plain (splay) deposit.	6.9
551. Mudstone, dark-green, green-gray, blocky, soft; flood-plain (basin-fill) deposit	10.0
550. Sandstone, light-gray, very fine grained, fairly well sorted, micaceous, calcareous, hard; flood-plain (splay) deposit	3.0
549. Mudstone, dark-olive-green, silty, blocky, soft, and interbedded sandstone, light-gray, very fine grained, calcareous, hard; poorly exposed on soil- and sage-covered dip slope; flood-plain (basin-fill and splay) deposits	49.0
548. Siltstone, light-gray, limy, very tuffaceous, hard; flood-plain deposit	2.5
547. Sandstone, light-gray, very fine grained, very calcareous, hard, and interbedded mudstone, olive-green, silty, blocky, firm, and siltstone, light-gray, very limy, very hard; not well exposed; flood-plain (splay and basin-fill) deposits	31.2
546. Mudstone, dark-olive-green, silty, blocky; flood-plain (basin-fill) deposit	22.5
545. Limestone, tan, finely crystalline, hard, dense; freshwater lacustrine deposit	3.0
544. Sandstone, gray, very fine grained, calcareous, hard; flood-plain (splay) deposit	2.5
543. Mudstone, gray-green, silty, blocky, soft, and thin interbedded sandstone, gray, very fine grained, calcareous, hard; flood-plain (basin-fill and splay) deposits	26.0
542. Sandstone, gray, fine- to coarse-grained, poorly sorted, subangular, calcareous, soft to hard; some clay-pebble conglomerate lenses; trough crossbedded; nonresistant; flood-plain (stream channel) deposit	27.0
541. Sandstone, gray, very fine to fine-grained, calcareous, firm, and some thin interbedded mudstone, olive-green, sandy, blocky, firm; flood-plain (splay and basin-fill) deposits	10.8

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Washakie Formation—Continued	
Kinney Rim Member—Continued	
540. Tuff, white-tan, silty, hard; airfall ash deposit. White tuff marker bed.	7.0
539. Shale, gray-brown, flaky, firm; freshwater lacustrine deposit	6.0
538. Sandstone, gray, very fine to medium-grained, poorly sorted, subangular, micaceous, colored grains, and interbedded mudstone, olive-green, very sandy; lower part of unit is composed of very limy sandstone; flood-plain (splay and basin-fill) deposits	36.5
537. Sandstone, gray, very fine to medium-grained, poorly sorted, subangular, micaceous; colored grains; scattered clay pebbles and some conglomerate lenses; trough crossbedded; weathers to rust-brown ledge; flood-plain (stream channel) deposit	13.0
536. Mudstone, dark-olive-green, silty, blocky, firm; flood-plain (basin-fill) deposit	2.0
535. Limestone, tan-gray, finely crystalline, very sandy, very hard; freshwater lacustrine deposit	1.3
534. Mudstone, dark-olive-green, silty, blocky, firm; flood-plain (basin-fill) deposit	16.0
533. Sandstone, gray, fine- to medium-grained, poorly sorted, subangular, firm, friable; trough crossbedded; some conglomerate lenses; gray siltstone and mudstone clay pebbles near the base; weathers to rust-brown ledge; flood-plain (stream channel) deposit	23.0
Vertebrate locality 11–70 of Turnbull (1978).	
Titanothere sp. undet.	
Uintathere sp. undet.	
532. Mudstone, dark-olive-green and gray, silty, blocky, firm, and some thin interbedded lenses of sandstone, light-gray, very fine grained, calcareous, hard; flood-plain (basin-fill and splay) deposits	19.0
531. Limestone, brown, finely crystalline, sandy, hard, dense; weathers to white band in outcrops; freshwater lacustrine deposit	0.6
530. Mudstone, dark-olive-green and gray, silty, blocky, firm; abundant mammal bones and teeth; flood-plain (basin-fill) deposit	4.3
529. Limestone, brown, finely crystalline, sandy, hard, dense; freshwater lacustrine deposit	0.4
528. Mudstone, dark-olive-green and gray, silty, blocky, firm; flood-plain (basin-fill) deposit	6.8
527. Covered	43.0
526. Sandstone, light-gray, very fine to fine-grained, poorly sorted, subangular, calcareous, hard; colored grains; flood-plain (splay) deposit	2.5
525. Limestone, tan-gray, brown, finely crystalline, silty, hard, dense; freshwater lacustrine deposit	1.0
524. Mudstone, dark-olive-green and gray, silty to sandy, blocky, firm; flood-plain (basin-fill) deposit	7.0
523. Limestone, tan-gray, very finely crystalline, hard, dense, silty; freshwater lacustrine deposit	1.2

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Washakie Formation—Continued	
Kinney Rim Member—Continued	
522. Mudstone, dark-olive-green, some mottled black, silty to sandy, blocky, firm; becomes clayey at the top; flood-plain (basin-fill) deposit	11.6
521. Limestone, tan-gray, very finely crystalline, silty, hard, dense; freshwater lacustrine deposit	1.0
520. Mudstone, dark-olive-green and gray, very sandy, blocky, firm, almost a sandstone, and thin interbedded and interlaminated sandstone, gray, very fine grained, calcareous, hard; flood-plain (basin-fill and splay) deposits	8.0
519. Limestone, tan, very finely crystalline, silty, hard, dense, platy; freshwater lacustrine deposit	1.4
518. Mudstone, dark-olive-green and gray, silty to sandy, blocky, firm, and some 1.0- to 1.5-ft-thick interbedded sandstone, gray, very fine grained, and siltstone, gray, calcareous, firm; flood-plain (basin-fill and splay) deposits	40.3
517. Sandstone, gray, very fine to fine-grained, fairly well sorted, subangular, calcareous, firm to soft, nonresistant; flood-plain (stream channel) deposit	31.0
516. Mudstone, gray, gray-green, silty, blocky, firm; flood-plain (basin-fill) deposit	8.0
515. Tuff, light-gray, very limy, almost a limestone, silty, hard, dense, platy; freshwater lacustrine and airfall ash deposit	5.0
Total thickness of Kinney Rim Member of Washakie Formation	850.9
Green River Formation:	
Laney Member:	
Sand Butte Bed:	
514. Algal limestone, gray, silty, hard, in rounded brain-type colonies up to 1.5 ft in diameter, and limestone, gray, very finely crystalline, silty, platy, hard, between the algal colonies; ridge forming; fresh-water lacustrine deposit. Cathedral limestone marker bed	4.1
513. Mudstone, dark-olive-gray and green, silty to sandy, blocky, firm; flood-plain (basin-fill) deposit	17.8
512. Sandstone, gray, very fine grained, some fine-grained, poorly sorted, subangular, soft to very hard, partly friable; very calcareous layers; flood-plain (splay) deposit	16.7
511. Mudstone, gray-brown, silty to very sandy, blocky, firm; flood-plain (basin-fill) deposit	4.0
510. Limestone, tan-gray, very finely crystalline, silty, platy, hard; freshwater lacustrine deposit	1.1
509. Sandstone, light-gray, very fine grained, very argillaceous, biotitic, calcareous, hard; flood-plain (splay) deposit	4.0
508. Sandstone, gray, fine-grained to very coarse grained, poorly sorted, subangular, biotitic, calcareous, firm, with scattered pebbles, and a few lenses of conglomerate comprising	

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Green River Formation—Continued	
Laney Member—Continued	
Sand Butte Bed—Continued	
508.—Continued rounded, flattened gray mudstone and siltstone clasts; trough crossbedded; flood-plain (stream channel) deposit	41.9
507. Conglomerate, gray; composed of gray, sandy mudstone pebbles up to 0.2 ft in diameter in a matrix of sandstone, gray, coarse-grained, poorly sorted, biotitic, very calcareous, hard; abundant poorly preserved fossil wood fragments; flood-plain (stream channel) deposit	3.0
506. Sandstone, medium-gray, very fine grained, fairly well sorted, subangular, very calcareous; colored grains; trough crossbedded; nonresistant; flood-plain (stream channel) deposit	5.0
505. Mudstone, medium-gray, silty to sandy, blocky, firm, becomes very sandy at the top; flood-plain (basin-fill) deposit	2.5
504. Sandstone, medium-gray, very fine grained, fairly well sorted, subangular, very calcareous, hard; colored grains; weathers to ledge; flood-plain (splay) deposit	2.5
503. Sandstone, gray, very fine to fine-grained, fairly well sorted, micaceous, abundant colored grains, firm, friable, nonresistant, and thin interbedded mudstone, dark-gray-green, silty to sandy, blocky, firm; flood-plain (splay and basin-fill) deposits	28.0
502. Algal limestone, light-gray, very finely crystalline, hard, dense; peculiar spongy texture; weathers to prominent gray ledge; freshwater lacustrine deposit. The flock of sheep limestone marker bed	4.9
501. Sandstone, light-gray, very fine to very coarse grained, poorly sorted, subangular, soft, friable; abundant colored grains; trough crossbedded; conglomerate lens near the base contains gray clay pebbles up to 1 in. diameter; abundant fossil wood fragments; flood-plain (stream channel) deposits	56.0
500. Sandstone, light-gray, mostly very fine grained, some fine-grained, calcareous, firm, and interbedded mudstone, dark-gray-green, sandy, soft; flood-plain (splay and basin-fill) deposits	20.0
499. Siltstone, light-gray, calcareous, argillaceous, hard; freshwater lacustrine deposit	1.0
498. Limestone, gray, sandy, hard; scattered fish bones and mollusk fragments including *Goniobasis* sp.; freshwater lacustrine deposit	0.3
497. Algal limestone, tan, composed of small, platy, rounded colonies up to 1.0 ft in diameter; freshwater lacustrine deposit	0.4
496. Sandstone, gray, very fine grained, soft, friable, nonresistant; freshwater(?) lacustrine (shoreline) deposit	7.8
495. Sandstone, gray, fine- to coarse-grained, poorly sorted, subangular, soft, friable; abundant colored grains; becomes calcareous the top 3.0 ft; weathers gold brown; stream channel deposit	18.5

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Green River Formation—Continued	
Laney Member—Continued	
Sand Butte Bed—Continued	
494. Limestone, medium-gray, silty, hard; weathers to ledge; freshwater lacustrine deposit	1.5
493. Sandstone, gray-brown, fine- to medium-grained, subangular, soft, friable, tuffaceous; some calcareous lenses, abundant colored grains; mudcracks near the top; weathers to nonresistant, low-angle slopes; some mammal bones and teeth; stream channel deposit.	23.8
492. Tuff, tan-gray, silty, hard; radioactive tuff bed; airfall ash deposit	1.5
491. Siltstone, tan, gray, tuffaceous, calcareous, firm, and some interbedded sandstone, gray, very fine grained to fine-grained, calcareous, tuffaceous, hard; freshwater lacustrine deposit	49.3
490. Mudstone, gray-green, silty, blocky, soft to firm; flood-plain (basin-fill) deposit	2.8
489. Sandstone, gray, very fine to fine-grained, poorly sorted, subangular, soft, friable, calcareous; colored grains; becomes very silty the top 1.0 ft; freshwater lacustrine deposit.	9.1
488. Sandstone, gray, very fine grained, poorly sorted, tuffaceous, calcareous, hard; red, green, and black grains; freshwater lacustrine deposit	1.0
487. Mudstone, gray-brown, blocky, firm; low kerogen content; freshwater lacustrine deposit	10.5
486. Tuff, white, hard; airfall ash deposit	0.4
485. Sandstone, gray, very fine grained, slightly calcareous, fairly well sorted, firm, and interbedded siltstone, gray, calcareous, tuffaceous, firm; freshwater lacustrine deposit	14.5
484. Sandstone, gray, very fine grained, very limy, very hard; weathers gray brown; freshwater lacustrine deposit	1.3
483. Siltstone, tan-gray, tuffaceous, calcareous, hard, and some thin interbedded sandstone, light-gray, very fine grained to fine-grained, tuffaceous, calcareous, hard; freshwater lacustrine deposit	21.6
482. Oil shale, brown, flaky, firm, some silty, some very limy; freshwater lacustrine deposit; EOY 5 gpt	5.0
481. Siltstone, gray, hard, tuffaceous, calcareous; abundant clay pebbles; weathered blocks form talus slope; freshwater lacustrine deposit	7.5
480. Sandstone, light-gray, very fine grained, poorly sorted, silty, tuffaceous, calcareous, hard; weathers rust brown; freshwater lacustrine deposit	6.5
479. Siltstone, light-gray, tuffaceous, calcareous, hard, scattered plant impressions, and thin interbedded sandstone, light-gray, very fine grained, calcareous, hard; freshwater lacustrine deposit	38.0
478. Coquinal sandstone, gray, fine- to medium-grained, very limy, very hard; contains *Goniobasis* sp. and *Lampsilis* sp.; freshwater lacustrine (shoreline) deposit	1.0

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Green River Formation—Continued	
Laney Member—Continued	
Sand Butte Bed—Continued	
477. Siltstone, pink to maroon-red, tuffaceous, calcareous, hard; freshwater lacustrine deposit.	2.5
476. Siltstone, gray, maroon-red, brown, tuffaceous, calcareous, hard, and interlaminated and interbedded sandstone, light-gray, tan, very fine to medium-grained, poorly sorted, subangular, tuffaceous, calcareous, firm; freshwater lacustrine deposit	35.5
475. Coquinal limestone, gray, shaly, hard; contains poorly preserved *Goniobasis* sp., *Lampsilis* sp., and *Viviparus* sp. shells; freshwater lacustrine (shoreline) deposit	0.4
474. Limestone, tan, brown, silty, hard, abundant ostracodes, and thin interbedded and interlaminated shale, brown, silty, blocky, hard, very low kerogen content; freshwater lacustrine deposit; EOY 5 gpt	9.8
473. Siltstone, tan, gray, some maroon-red-tinted, tuffaceous, calcareous, hard, some shale partings, and interlaminated and thin interbedded sandstone, gray, some red-tinted, very fine grained, tuffaceous, calcareous, hard; some beds have mud-cracked upper surfaces; freshwater lacustrine deposit	19.0
472. Sandstone, tan-gray, very fine to medium-grained, poorly sorted, subangular, calcareous, firm; abundant black, gray, and red grains; weathers to ledge; freshwater lacustrine deposit	4.8
471. Siltstone, gray, some red-maroon, calcareous, tuffaceous, hard, thin-bedded, platy; some green shale partings; partly grading into laminae and thin beds of very fine grained sandstone; scattered aquatic plant impressions; freshwater lacustrine deposit	8.0
470. Oil shale, dark-brown, silty, hard; abundant ostracodes; becomes very silty the top 1.5 ft; freshwater lacustrine deposit	5.4
469. Sandstone, gray, red, brown, very fine to fine-grained, fairly well sorted, subangular, very calcareous, hard, abundant green shale partings, and some interbedded siltstone, brown, gray, tuffaceous, calcareous, hard; freshwater lacustrine deposit	10.0
468. Sandstone, gray, green, very fine grained, poorly sorted, very calcareous, very hard, shaly-streaked; abundant worm trails; weathers to ledge; freshwater lacustrine deposit	3.0
467. Sandstone, light-gray, brown, some red-streaked, fine- to coarse-grained, poorly sorted, subangular, argillaceous; abundant black, gray, green, and red grains; weathers to a series of trough-crossbedded ledges; and some interbedded siltstone, gray, very tuffaceous, calcareous, firm; unit weathers to rust-brown overall color; freshwater lacustrine deposit	131.0
466. Siltstone, tan, argillaceous, tuffaceous, firm, and interlaminated sandstone, light-gray,	

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Green River Formation—Continued	
Laney Member—Continued	
Sand Butte Bed—Continued	
466.—Continued	
very fine grained, tuffaceous, calcareous, firm; level of andesite-pebble conglomerate in northwest Washakie basin; freshwater lacustrine deposit	9.0
465. Oil shale, brown, flaky, soft; abundant ostracodes, freshwater lacustrine deposit; EOY 10 gpt	7.5
464. Siltstone, gray, tan, some red-tinted, argillaceous, tuffaceous, some shaly lenses, and interlaminated and thin interbedded sandstone, light-gray, very fine grained, calcareous, tuffaceous, firm, poorly exposed; freshwater lacustrine deposit	65.5
463. Oil shale, tan-brown, fissile to flaky, soft; abundant ostracodes, freshwater lacustrine deposit; EOY 3 gpt	13.3
462. Sandstone, light-gray, fine- to coarse-grained, poorly sorted, subangular, tuffaceous, calcareous, hard; weathers to smooth slope; scattered very poorly preserved twigs and wood, mostly replaced by hematite and limonite; freshwater lacustrine deposit	2.0
461. Sandstone, light-gray, very fine grained, subangular, tuffaceous, hard, and interbedded siltstone, light-gray, tuffaceous, firm; 2.0-ft-thick bed of shale, dark-gray, fissile, soft, 5.0 ft below the top; freshwater lacustrine deposit	18.4
460. Sandstone, light-gray, very fine grained, subangular, poorly sorted, calcareous, tuffaceous, firm	3.2
459. Siltstone, light-gray, tuffaceous, hard, and some interlaminated sandstone, gray, fine-grained to very fine grained; freshwater lacustrine deposit	9.6
458. Sandstone, light-gray, fine- to coarse-grained, subangular to subrounded, poorly sorted, calcareous, tuffaceous; abundant colored grains; exhibits fairly large scale, low-angle trough crossbedding that dips steeply eastward; weathers rust brown; stream channel deposit	4.5
457. Siltstone, light-gray, argillaceous, tuffaceous, firm; disseminated plant fragments; freshwater lacustrine deposit	1.9
456. Sandstone, light-gray, fine- to coarse-grained, poorly sorted, subangular to subrounded, calcareous, hematitic, nonresistant; abundant colored grains; weathers to a rust-brown, low-angle, smooth slope; top of the unit contains abundant *Goniobasis* sp.; freshwater lacustrine (shoreline) deposit	4.2
455. Siltstone, light-gray, argillaceous, tuffaceous, firm, and some interlaminated sandstone, light-gray, very fine grained, argillaceous, firm; one loose slab on the surface contains casts of *Goniobasis* sp.; freshwater lacustrine (shoreline) deposit	7.7
454. Sandstone, light-gray, fine- to coarse-grained, poorly sorted, subangular to subrounded, calcareous, firm; abundant black, red, and green grains; weathers rust brown; freshwater lacustrine deposit	19.2
453. Siltstone, gray, tuffaceous, firm, thin-bedded, platy in part, and interlaminated and thin interbedded sandstone, light-gray, very fine grained, argillaceous, tuffaceous, firm, friable; disseminated small plant fragments; freshwater lacustrine deposit	19.8
Total thickness of Sand Butte Bed of Laney Member of Green River Formation	850.0
Unconformity.	
Green River Formation:	
Laney Member:	
LaClede Bed:	
452. Siltstone, gray, tuffaceous, platy, firm, and interbedded clay shale, brown, silty, blocky, firm; one thin bed of brown, papery oil shale 7.0 ft above the base; freshwater lacustrine deposit	28.0
451. Oil shale, brown, flaky, some papery, silty in part; a few laminae of aragonite; freshwater lacustrine deposit	8.0
450. Clay-shale, medium-yellow-brown, silty, flaky, firm; freshwater lacustrine deposit	12.9
449. Oil shale, brown, papery, soft; freshwater lacustrine deposit	24.0
448. Siltstone, gray, tuffaceous, firm; freshwater lacustrine deposit; scattered mollusk shell fragments. Fischer assay, 0.8 gpt	1.9
447. Oil shale, brown, papery, soft, and interbedded siltstone, tan, tuffaceous, calcareous, platy, hard; not well exposed; freshwater lacustrine deposit	33.0
446. Oil shale, medium- to dark-brown, some tan, papery to flaky; freshwater lacustrine deposit. Fischer assay, 10.7 gpt (top), 7.1 gpt (bottom)	7.2
445. Oil shale, brown, flaky, brittle; very thin bed of aragonite 2.0 ft above the base; freshwater lacustrine deposit. Fischer assay, 4.5 gpt	13.0
444. Limestone, tan, finely crystalline, silty, hard, dense, platy; contains scattered ostracodes and some *Gyraulus militaris*; freshwater lacustrine deposit. Fischer assay, trace. The *Gyraulus* marker bed	0.8
443. Oil shale, brown, silty, flaky; abundant ostracodes; scattered insect remains; saltwater(?) lacustrine deposit. Fischer assay, 2.4 gpt	9.4
442. Oil shale, dark-brown, flaky, brittle; weathers to small bench; saltwater lacustrine deposit. Fischer assay, 29.1 gpt	4.7
441. Oil shale, tan, flaky, silty, brittle; saltwater lacustrine deposit. Fischer assay, 6.5 gpt	6.0
440. Oil shale, tan, papery, firm; abundant ostracodes; scattered plant remains; one complete deciduous leaf; saltwater lacustrine deposit. Fischer assay, 2.9 gpt	10.0
439. Oil shale, brown, papery, soft; low kerogen content the top 4.0 ft; saltwater lacustrine deposit. Fischer assay, 10.5 gpt	10.0

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Green River Formation—Continued	
Laney Member—Continued	
LaClede Bed—Continued	
438. Oil shale, brown, flaky, firm; saltwater lacustrine deposit. Fischer assay, 20.2 gpt	8.0
437. Oil shale, dark-brown, flaky, some papery, soft; becomes light brown with low kerogen content the top 3.0 ft; saltwater lacustrine deposit. Fischer assay, 11.7 gpt	10.0
436. Oil shale, brown, flaky, brittle, saltwater lacustrine deposit. Fischer assay, 20.0 gpt	10.0
435. Siltstone, gray, tuffaceous, calcareous, firm, and interbedded shale, gray, very silty, brittle, firm; saltwater lacustrine deposit. Fischer assay, no oil	6.0
434. Oil shale, brown, papery, soft, and some interlaminated tuffaceous siltstone, near the base; 0.2-ft-thick bed of algal limestone, tan, gray, onion-skin-type, at the top; saltwater lacustrine deposit. Fischer assay, 12.3 gpt	13.0
433. Analcime, gray, very coarsely crystalline, hard, blocky; dodecahedron crystals as much as 2 mm in diameter; airfall ash deposit. Fischer assay, trace. The analcite marker bed	0.3
432. Oil shale, brown, papery, soft; saltwater lacustrine deposit. Fischer assay, 13.0 gpt	2.6
431. Ostracodal limestone, tan-brown, tuffaceous, thin-bedded, platy, hard; saltwater lacustrine deposit. Fischer assay, trace	1.0
430. Oil shale, brown, papery, soft, with 0.08-ft-thick bed of analcime, dark-gray, silty, blocky, hard, at the base; saltwater lacustrine deposit. Fischer assay, 9.2 gpt	4.08
429. Oil shale, dark-brown, flaky, firm; several thin laminae of analcime; saltwater lacustrine deposit. Fischer assay, 14.6 gpt	4.8
428. Oil shale, dark-brown, flaky, firm; saltwater lacustrine deposit. Fischer assay, 18.2 gpt	1.4
427. Siltstone, tan, tuffaceous, blocky, firm, weathers to groove in outcrops; saltwater lacustrine deposit. Fischer assay, 7.0 gpt	0.6
426. Oil shale, black, hard, dense, some flaky; saltwater lacustrine deposit. Fischer assay, 33.9 gpt	4.7
425. Siltstone, gray, tuffaceous, calcareous, thin-bedded, hard, and interbedded oil shale, tan, silty, brittle, hard; saltwater lacustrine deposit. Fischer assay, 4.1 gpt	1.6
424. Oil shale, dark-brown, flaky, brittle, firm; saltwater lacustrine deposit. Fischer assay, 19.7 gpt	3.2
423. Siltstone, tan, gray, very tuffaceous, with laminae of tuff, tan, thin-bedded; weathers to prominent tan to rust-brown grooved marker bed in cliff face; saltwater lacustrine deposit. Fischer assay, trace. The buff marker bed	50.9
422. Oil shale, dark-brown to black; two laminae of oil shale weather silver gray in the lower 0.3 ft of the bed; saltwater lacustrine deposit. Fischer assay, 17.8 gpt. Top of silver bench.	0.8
421. Oil shale, brown, papery, firm, and occasional thin laminae of analcime and calcite; 0.05-ft-thick bed of analcime, dark-gray, 1.1 ft above the base; saltwater lacustrine deposit. Fischer assay, 15.9 gpt	2.6
420. Oil shale, dark-brown, some black, flaky to hard, dense; consists of five laminae of black oil shale (about 30 percent) in dark-brown oil shale; saltwater lacustrine deposit. Fischer assay, 23.3 gpt	0.7
419. Oil shale, brown, papery to flaky, firm; one lamina of oil shale, black, 0.05 ft thick, at base of unit; some thin laminae of analcime; bed contains scattered irregularly shaped pods of algal limestone that exhibit vertical growth patterns; saltwater lacustrine deposit. Fischer assay, 14.5 gpt	2.4
418. Oil shale, black, dolomitic, hard; weathers drab gray; saltwater lacustrine deposit. Fischer assay, 14.8 gpt	2.1
417. Oil shale, dark-brown, thin laminae of black, papery to flaky; weathers silver gray; 0.1 ft of oil shale, black, at the base of the bed; 0.8 ft of oil shale, black, 1.1 ft above the base of the bed; saltwater lacustrine deposit. Fischer assay, 23.7 gpt	4.3
416. Oil shale, brown, papery, soft; saltwater lacustrine deposit. Fischer assay, 10.1 gpt	2.5
415. Claystone, tan, silty, tuffaceous, blocky, firm; weathers to groove in cliff face; saltwater lacustrine deposit. Fischer assay, 0.3 gpt	1.9
414. Oil shale, dark-brown, fissile, papery, soft; saltwater lacustrine deposit. Fischer assay, 19.8 gpt	7.3
413. Oil shale, dark-brown and black interlaminated, fissile, partly hard and dense; the black oil shale weathers silver blue; saltwater lacustrine deposit. Fischer assay, 30.7 gpt	0.4
412. Oil shale, dark-brown, fissile to papery; the upper 0.6 ft consists of dark-brown oil shale with laminae of black; weathers silver blue; saltwater lacustrine deposit. Fischer assay, 16.2 gpt (top 0.8 ft), 25.5 gpt (bottom 0.6 ft).	1.4
411. Oil shale, dark-brown, papery, soft; saltwater lacustrine deposit. Fischer assay, 12.7 gpt	1.3
410. Oil shale, black, dense; weathers silver gray; constitutes the lowermost of three persistent silver-blue-weathering oil shale beds along Kinney Rim; saltwater lacustrine deposit. Fischer assay, 31.4 gpt	0.5
409. Oil shale, brown, papery, brittle; some laminae of analcime, some with interstitial dead oil staining; saltwater lacustrine deposit. Fischer assay, 9.1 gpt	4.8
408. Oil shale, black, hard, weathers silver blue, and interbedded oil shale, dark-chocolate-brown, papery; saltwater lacustrine deposit. Fischer assay, 34.7 gpt	1.0

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Green River Formation—Continued	
Laney Member—Continued	
LaClede Bed—Continued	
407. Oil shale, brown, papery, soft; occasional laminae of tan silty shale; sparse laminae of black oil shale toward the top; saltwater lacustrine deposit	5.9
406. Oil shale, brown, papery, soft, with 0.3-ft-thick bed of analcime and brown ostracodal limestone containing dead oil, at the top; saltwater lacustrine deposit. Fischer assay, 6.4 gpt (oil shale), 7.8 gpt (limestone)	12.0
405. Claystone, tan, silty, shaly, blocky, firm, tuffaceous; weathers to groove in cliff face; contains well-preserved fish fossils; saltwater lacustrine deposit. Fischer assay, 1.0 gpt	6.7
404. Algal limestone, onion-skin-type; consists of two thin beds with silty shale in the middle; saltwater lacustrine deposit. Fischer assay, trace	0.4
403. Oil shale, brown, papery, brittle, firm; saltwater lacustrine deposit. Fischer assay, 7.7 gpt	1.9
402. Algal limestone, tan, thin wavy bedding; oolitic at the top; saltwater lacustrine deposit. Fischer assay, trace	0.6
401. Oil shale, brown, papery, firm; some laminae of white calcite(?); numerous analcime laminae; saltwater lacustrine deposit. Fischer assay, trace	4.2
400. Algal limestone, tan, irregularly bedded brain-type and onion-skin-type mixed; weathers to persistent ledge; saltwater lacustrine deposit. Fischer assay, trace	0.9
399. Oil shale, brown, papery, soft, and a few thin laminae of analcime; abundant ostracodes; saltwater lacustrine deposit. Fischer assay, 4.5 gpt	6.0
398. Algal limestone, tan, onion-skin-type; weathers to scales and concave plates; saltwater lacustrine deposit. Fischer assay, trace	0.8
397. Oil shale, brown, fissile, papery, brittle, firm, and some laminae of analcime; saltwater lacustrine deposit. Fischer assay, 3.8 gpt	7.9
396. Oolitic limestone, tan, thin-bedded, hard; middle part of bed contains pisolites; upper part looks like algae; saltwater lacustrine deposit. Fischer assay, no oil	0.3
395. Oil shale, brown, papery to flaky, brittle, firm, and some laminae of sandstone, gray, fine-grained, partly containing dead oil, and sparse thin laminae of analcime; saltwater lacustrine deposit. Fischer assay, 6.7 gpt	12.8
394. Siltstone, gray, very limy, tuffaceous, hard, parallel-bedded; scattered ostracodes; brown dead oil saturation at the top; saltwater lacustrine deposit. Fischer assay, trace	0.2
393. Oil shale, medium- to dark-brown, papery, firm; saltwater lacustrine deposit. Fischer assay, 20.1 gpt (base), 6.6 gpt (upper 5.0 ft). Base of silver bench	5.3
392. Algal limestone, tan, parallel-bedded, brain-type; saltwater lacustrine deposit. Fischer assay, no oil	0.2
391. Siltstone, gray, sandy, soft; some very sandy layers; shaly at the top; saltwater lacustrine deposit. Fischer assay, trace	4.0
390. Oil shale, brown, papery, soft; saltwater lacustrine deposit. Fischer assay, 10.9 gpt	1.0
389. Algal limestone, tan, comprises a domal, isolated head 7.0 ft in diameter; grades laterally into oil shale containing thin pods of algal limestone; saltwater lacustrine deposit. Fischer assay, trace	1.3
388. Sandstone, gray, very fine grained, very micaceous, tuffaceous in thin calcareous laminae; weathers rust brown; weathers to groove in cliff face; saltwater lacustrine deposit. Fischer assay, trace	9.4
387. Shale, steel-gray, silty, slightly dolomitic, firm; saltwater lacustrine deposit. Fischer assay, trace	2.7
386. Sandstone, gray, very fine grained, shaly, very micaceous, tuffaceous, soft, noncalcareous; weathers rust brown; saltwater lacustrine deposit. Fischer assay, no oil	1.6
385. Sandstone, light-gray, very fine grained, fairly well sorted, calcareous, hard; sparse red and black grains; parallel bedded; saltwater lacustrine deposit. Fischer assay, trace	0.6
384. Shale, tan, brown, very silty, blocky to fissile, some hard, limy laminae; saltwater lacustrine deposit. Fischer assay, trace	4.4
383. Oil shale, brown, papery, soft; saltwater lacustrine deposit. Fischer assay, 0.4 gpt	2.5
382. Oil shale, brown, papery, soft, and interlaminated ostracodal limestone, tan, platy, hard, and laminae of quartzite, gray, very hard; abundant fish bones; saltwater lacustrine deposit. Fischer assay, 0.8 gpt	1.2
381. Algal limestone, gray, irregularly bedded brain-type; saltwater lacustrine deposit. Fischer assay, no oil	0.2
380. Oil shale, brown, silty, blocky, firm; some fissure fillings of white satin spar; saltwater lacustrine deposit. Fischer assay, trace	3.3
379. Oil shale, brown, papery; some fissure fillings of white satin spar, some laminae of gray quartzite; saltwater lacustrine deposit. Fischer assay, 1.0 gpt	4.0
378. Oolitic limestone, tan, very sandy, hard, laminated; scattered, disarticulated fish bones; saltwater lacustrine deposit. Fischer assay, no oil	0.9
377. Oil shale, brown, papery, soft, and occasional laminae of aragonite; saltwater lacustrine deposit. Fischer assay, 0.7 gpt	3.6
376. Oil shale, brown, papery, soft; saltwater lacustrine deposit. Fischer assay, 6.6 gpt	4.0

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Green River Formation—Continued	
Laney Member—Continued	
LaClede Bed—Continued	
375. Limestone, tan, very silty, laminated, hard, in the lower 1.0 ft; overlain by algal limestone, parallel bed of brain-type, 0.2 ft thick; saltwater lacustrine deposit. Fischer assay, trace.	1.2
374. Oil shale, brown, papery, soft; some laminae and very small veinlets of aragonite; saltwater lacustrine deposit. Fischer assay, 4.8 gpt	5.8
373. Sandstone, gray, very fine grained, fairly well sorted, limonitic, some muscovite, soft, and interlaminated siltstone, gray, soft, and occasional thin beds of shale, dark-gray, fissile, firm; saltwater lacustrine deposit. Fischer assay, trace	26.6
Total thickness of LaClede Bed of Laney Member of Green River Formation	469.5
Wasatch Formation:	
Cathedral Bluffs Tongue:	
372. Mudstone, dark-green, dark-gray-green, silty to sandy; flood-plain (basin-fill) deposit	40.0
Stratigraphic level of mammal locality discovered by H.W. Roehler and P.O. McGrew in 1958, NW¼SW¼NW¼ sec. 8, T. 15 N., R. 93 W.	
Sciuravus nitidus	
371. Shale, dark-brown, silty, carbonaceous, firm, some coaly streaks at the top; swamp deposit.	2.0
370. Mudstone, dark-green, silty, sandy, flaky in part, blocky in part, firm; flood-plain (basin-fill) deposit	22.8
369. Siltstone, tan, limy, hard; flood-plain (basin-fill) deposit	0.1
368. Shale, dark-green, blocky, soft; flood-plain (basin-fill) deposit	1.3
367. Siltstone, medium-gray, limy, hard; abundant worm borings filled with tan siltstone; flood-plain (splay) deposit	1.0
366. Mudstone, dark-apple-green, silty, sandy, hard; flood-plain (basin-fill) deposit	1.8
365. Limestone, tan, oolitic, with small algal fragments, and other fragments of tan limestone; occasional small disarticulated fish bones and other vertebrate bone fragments; saltwater lacustrine (shoreline) deposit	0.4
364. Mudstone, dark-green, dolomitic, silty to sandy, blocky, firm; flood-plain (basin-fill) deposit	3.1
363. Siltstone, light-gray, limy, tuffaceous, firm; weathers to small, angular, blocky fragments; flood-plain (splay) deposit	0.6
362. Mudstone, dark-green, sandy, blocky, firm; flood-plain (basin-fill) deposit	1.9
361. Shale, dark-gray-green, flaky to blocky, firm; flood-plain (basin-fill) deposit	2.1
360. Shale, dark-green, dark-gray-green, blocky, soft; deeply weathered; flood-plain (basin-fill) deposit	39.0
359. Siltstone, tan, tuffaceous, hard; flood-plain (splay) deposit	0.5
358. Shale, dark-green, blocky, soft; flood-plain (basin-fill) deposit	0.1

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Wasatch Formation—Continued	
Cathedral Bluffs Tongue—Continued	
357. Limestone, tan-gray, finely crystalline, silty, hard; scattered ostracodes; contains small concretions of unknown mineral composition; saltwater lacustrine deposit	0.6
356. Shale, dark-green, blocky, soft; flood-plain (basin-fill) deposit	4.4
355. Siltstone, tan, limy, hard; weathers to yellow ledge; has mudcracked upper surface; flood-plain (basin-fill) deposit	1.8
354. Mudstone, nearly all red, some thin bands mottled gray-red, silty, blocky, hard, and occasional thin laminae of sandstone, gray, micaceous, thin-bedded; unit forms the uppermost red band in outcrops of the Cathedral Bluffs Tongue between Sand Butte and Pine Butte; flood-plain (basin-fill and splay) deposits	37.4
353. Mudstone, dark-gray-green, silty, blocky, gypsiferous, hard, and occasional thin laminae of siltstone and sandstone; flood-plain (basin-fill and splay) deposits	25.0
352. Sandstone, light-gray, very fine grained, subangular, micaceous, very calcareous; small-scale trough crossbedding; weathers to small brown ledge; flood-plain (splay channel) deposit	0.9
351. Mudstone, layers of black, dark-green, dark-gray-green, brown, maroon, silty, blocky, soft; weathers mostly gray; flood-plain (basin-fill) deposit	20.0
350. Oolitic limestone, light-gray, 0.2 ft thick at the base; mudstone, maroon-gray, 0.5 ft thick in the middle; oolitic limestone, light-gray, 0.1 ft thick at the top; saltwater lacustrine (shoreline) and flood-plain (basin-fill) deposits.	0.8
349. Mudstone, beds of gray, brown, maroon, green, silty, blocky, firm, occasional silty and sandy laminae; outcrops are mostly gray and banded; abundant turtle scutes; flood-plain (basin-fill) deposits	6.6
348. Algal limestone, gray, in small, rounded, flowery heads; upper surface suggests vertical growth in bottom muds; saltwater lacustrine (shoreline) deposit	1.2
347. Mudstone, dark-gray-green, one thin horizon of gray-maroon, silty, blocky, hard, and interlaminated and interbedded sandstone, light-gray, very fine grained, fairly well sorted, argillaceous, micaceous, thin-bedded; abundant worm trails and bone fragments; unidentified small white globules; flood-plain (basin-fill and splay) deposits	16.2
346. Sandstone, light-gray, very fine grained, calcareous, thin-bedded, ripple-marked; weathers to small ledge; flood-plain (splay) deposit	1.1
345. Mudstone, dark-gray-green, silty, blocky, soft; 0.5-ft-thick lenticular bed of siltstone, gray, limy, near the middle; flood-plain (basin-fill and splay) deposits	11.4
344. Sandstone, light-gray, very fine grained, biotitic, calcareous, hard, thin-bedded, ripple-marked; flood-plain (splay) deposit	0.8

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Wasatch Formation—Continued	
Cathedral Bluffs Tongue—Continued	
343. Mudstone, dark-gray-green, maroon, silty, blocky, soft, and interlaminated siltstone, light-gray, limy, hard; flood-plain (basin-fill and splay) deposits	9.9
342. Mudstone, dark-gray-green, silty, blocky, hard; flood-plain (basin-fill) deposit	4.1
341. Sandstone, light-gray, very fine grained, biotitic, calcareous, thin-bedded, ripple-marked; shaly near the middle; abundant worm borings; flood-plain (splay) deposit	1.1
340. Mudstone, dark-gray-green, silty, blocky, firm; scattered turtle scutes; flood-plain (basin-fill) deposit	1.3
339. Sandstone, light-gray, very fine grained, biotitic, calcareous, thin-bedded, ripple-marked; abundant worm borings; weathers to resistant ledge; flood-plain (splay) deposit	0.4
338. Mudstone, dark-gray-green, silty, blocky, firm; flood-plain (basin-fill) deposit	11.5
337. Mudstone, dark-gray-green, silty, blocky, soft; reddish tints in the upper 3.0 ft; one thin lenticular bed of sandstone, gray, about 3.0 ft above the base; flood-plain (basin-fill and splay) deposits	15.0
336. Limestone, tan, very finely crystalline, hard, dense, and thin laminae of algal limestone at the base; mud-cracked upper surface; abundant worm borings in the upper part; saltwater lacustrine deposits	0.7
335. Mudstone, medium-gray, sandy, hard; flood-plain (basin-fill) deposit	4.3
334. Mudstone, mostly red, some gray with red tints, silty, blocky, soft to hard; unit forms the uppermost thick, massive red unit of Cathedral Bluffs Tongue locally; flood-plain (basin-fill) deposit	16.8
333. Mudstone, mostly gray with tints of maroon, silty, blocky, soft, gypsiferous at the base; very sandy layer the upper 0.5 ft; flood-plain (basin-fill) deposit	11.9
332. Sandstone, light-gray, very fine grained, subangular, biotitic, firm, friable, thin-bedded; flood-plain (splay) deposit	1.5
331. Mudstone, mostly red, numerous beds of orange, brown, maroon, and some thin gray, silty, blocky, soft; some algae-covered twigs in the lower part; flood-plain (basin-fill) deposit	68.3
330. Mudstone, mostly red with some interbedded gray with mottled reddish tints, silty, blocky, soft; four 0.1- to 0.2-ft-thick beds of white satin spar in the lower 3.5 ft, and five similar beds of white satin spar (gypsum) in the upper 8.0 ft; abundant algae-covered twigs in the lower part; flood-plain (basin-fill) deposit	32.5
329. Mudstone, mainly dark brick red, some interbedded gray with red tints, silty to sandy, blocky, soft; some loose algal fragments on the outcrop; flood-plain (basin-fill) deposit	61.0
Stratigraphic level of vertebrate locality 268 of H.W. Roehler.	
Hyracotherium sp.	

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Wasatch Formation—Continued	
Cathedral Bluffs Tongue—Continued	
328. Mudstone, mainly gray, some orange tints at the top and bottom, one thin bed of black, silty, blocky, firm; abundant fossil wood and occasional loose algal fragments at the base; flood-plain (basin-fill) deposit	15.5
327. Mudstone, mainly maroon and red, blocky, soft, some interbedded gray, silty to sandy; flood-plain (basin-fill) deposit	27.8
326. Shale, dark-gray, gypsiferous, soft; deeply weathered; flood-plain (basin-fill) deposit	7.0
325. Sandstone, light-gray, very fine grained, biotitic, poorly sorted, very soft; scattered black grains; friable at the base, becomes calcareous the top 1.5 ft; weathers to a low white ledge at the base of a red butte in SW¼SW¼ sec. 28, T. 16 N., R. 100 W.; flood-plain (splay) deposit	4.0
324. Shale, gray, clayey, gypsiferous, soft; flood-plain (basin-fill) deposit	10.0
323. Mudstone, maroon, red, blocky, soft; flood-plain (basin-fill) deposit	19.0
322. Mudstone, dark-gray-green, dark-green, gypsiferous, blocky, soft; very silty and sandy layers; scattered turtle scutes; flood-plain (basin-fill) deposit	17.0
321. Siltstone, light-gray, limy, hard; flood-plain (splay) deposit	0.6
320. Mudstone, dark-gray-green, silty, blocky, gypsiferous, firm; three very thin (0.3- to 0.5-ft-thick) beds of tan, limy siltstone at the base; flood-plain (basin-fill and splay) deposits	49.0
319. Mudstone; black at the base, thin bed of brown above; upper two-thirds of unit is dark gray green, blocky, soft; abundant turtle scutes near the middle; flood-plain (basin-fill) deposit	33.0
318. Algal limestone, tan, toadstool-type, hard; weathers to dark-brown, concave plates; saltwater lacustrine (shoreline) deposit	1.8
317. Mudstone, dark-gray, dark-gray-green, some reddish tints toward the base, silty, blocky, soft; four laminae of gray siltstone in the lower part; one 0.2-ft-thick bed of gray sandstone, 10.0 ft below the top; flood-plain (basin-fill and splay) deposits	34.5
316. Sandstone, light-gray, brown, very fine grained, very limonitic, calcareous, hard; trough cross-bedded; flood-plain (stream channel) deposit	1.0
315. Mudstone, dark-gray, silty, blocky, firm; very thin sandy lenses; thin lenses of limonitic siltstone; flood-plain (basin-fill) deposit	5.5
314. Sandstone, brown, very fine grained, fairly well sorted, very limonitic, hard; weathers to thin rust band in outcrops; flood-plain (splay) deposit	0.3
313. Mudstone, red at the base, gray at the top, silty, blocky, soft; flood-plain (basin-fill) deposit	2.7
312. Siltstone, light-gray, limy, hard, thin-bedded; abundant worm borings; flood-plain (splay) deposit	0.6
311. Mudstone, gray, soft, blocky; deeply weathered; flood-plain (basin-fill) deposit	5.6

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Wasatch Formation—Continued	
Cathedral Bluffs Tongue—Continued	
310. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, micaceous, calcareous, hard, very hematitic; in small lenses; flood-plain (splay) deposit	0.6
309. Mudstone, dark-gray, dark-gray-green, silty, blocky, soft; one thick band of maroon near the middle; one very thin bed of sandstone, light-gray, very fine grained, calcareous, hard, lenticular, toward the base; 1.0-ft-thick red sandy mudstone at the top; flood-plain (basin-fill) deposits	23.6
308. Sandstone, light-gray, very fine grained, poorly sorted, subangular, calcareous; argillaceous streaks; abundant fish bones; mud-cracked upper surface; saltwater lacustrine (shoreline) deposit	0.9
307. Mudstone, dark-gray-green, blocky, soft; one large algal head 4.0 ft in diameter, at the base; one thin bed of siltstone, gray, hard, near the middle; one 0.4-ft-thick bed of sandstone, light-gray, very fine grained, very micaceous, partly trough crossbedded, 10.0 ft below the top; mudflat and saltwater lacustrine (shoreline) deposits	16.7
306. Oolite, tan, limy, hard; very small oolites; abundant clay-pebble inclusions; weathers dark brown; worm borings at the top; saltwater lacustrine (shoreline) deposit	0.7
305. Shale, dark-gray, gypsiferous, soft; deeply weathered; flood-plain (basin-fill) deposit	3.1
304. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, micaceous, calcareous, hard; flood-plain (splay) deposit	1.4
303. Mudstone, gray, green, silty, fissile to blocky, soft, and a few thin laminae of siltstone, gray, limy, hard, and limestone, gray, hard, dense; flood-plain (basin-fill and splay) and shallow saltwater lacustrine deposits	13.5
302. Shale, dark-brown, fissile, carbonaceous to coaly, soft; swamp deposit	2.5
301. Mudstone, dark-gray, dark-gray-green, brown, black, mostly blocky, soft; one very thin bed of gray siltstone near the middle; flood-plain (basin-fill) deposits	12.7
300. Sandstone, light-gray, very fine grained, fairly well sorted, calcareous, hard, thin-bedded; flood-plain (splay) deposit	1.6
299. Mudstone, dark-gray-green at the base, gray and brown at the top, silty, blocky, firm; becomes sandy at the top; flood-plain (basin-fill) deposit	14.0
298. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, very micaceous, calcareous, firm; small-scale trough crossbeds; flood-plain (stream channel) deposit	2.8
297. Mudstone, dark-gray, brown, dark-gray-green, silty, blocky, firm, and laminae and very thin beds of gray siltstone and sandstone; flood-plain (basin-fill and splay) deposits	7.3
296. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, micaceous; small-scale trough crossbeds; ripple marked; flood-plain (stream channel) deposit	3.0

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Wasatch Formation—Continued	
Cathedral Bluffs Tongue—Continued	
295. Mudstone, gray, brown, somber reddish tints, fissile to blocky, silty, firm; flood-plain (basin-fill) deposit	26.5
Total thickness of Cathedral Bluffs Tongue of Wasatch Formation	827.4
Green River Formation:	
Wilkins Peak Member:	
294. Algal limestone, tan, gray, hard; saltwater lacustrine (shoreline) deposit	0.6
293. Mudstone, dark-green and dark-gray-green laminated, blocky, firm, silty to sandy; mudflat deposit	5.9
292. Sandstone, light-gray, very fine to fine-grained, calcareous, hard; ripple marked; weathers to small ledge; saltwater lacustrine deposit	1.0
291. Mudstone, dark-gray-brown, dark-gray-green, blocky, dolomitic, firm, and one lamina of algal limestone near the middle; saltwater lacustrine deposit	8.3
290. Limestone, gray, sugary, hard; exhibits peculiar stringy texture on weathered surfaces; saltwater lacustrine deposit	0.4
289. Oil shale, dark-brown at the base; becomes gray-brown at the top, flaky, dolomitic, firm; saltwater lacustrine deposit	10.8
288. Dolomite, tan-gray, finely crystalline, hard, dense; saltwater lacustrine deposit	0.2
287. Shale, dark-green, blocky, firm; mudflat deposit.	1.3
286. Algal limestone, tan, toadstool-type; caps high ridge in SW¼SW¼SW¼ sec. 20, T. 16 N., R. 100 W.; saltwater lacustrine (shoreline) deposit	2.6
285. Mudstone, dark-gray-green, silty, firm; mudflat deposit	8.5
284. Conglomeratic sandstone, light-gray, very fine grained, argillaceous, silty, calcareous, thin-bedded, limonitic; abundant flattened clay pebbles; mudflat deposit	0.4
283. Mudstone, dark-green, silty, firm, and thin interbedded sandstone, gray-green, argillaceous, soft; mudflat deposit	7.0
282. Sandstone, light-gray, very fine grained, silty to argillaceous, calcareous, hard; mudflat deposit	0.3
281. Mudstone, dark-gray, dark-gray-green, blocky, firm; scattered plant fragments at the top; abundant fish bones and ostracodes; mudflat and saltwater lacustrine deposits	13.0
280. Algal limestone, tan, toadstool-type; weathers to small, rounded, concave sheets; saltwater lacustrine (shoreline) deposit	2.3
279. Shale, dark-green, blocky, firm; mudflat deposit.	5.4
278. Algal limestone, tan, toadstool-type; saltwater lacustrine (shoreline) deposit	1.5
277. Mudstone, dark-green, dark-gray-green, fissile to blocky, and some interlaminated siltstone, gray; mudflat deposit	3.7
276. Sandstone, light-gray, very fine grained, silty, partly argillaceous, calcareous, hard, thin-bedded; abundant black fish bones; abundant scattered bird bones; saltwater lacustrine (shoreline) deposit	2.3

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Green River Formation—Continued	
Wilkins Peak Member—Continued	
275. Mudstone, dark-green, fissile, silty, firm; mudflat deposit	7.5
274. Sandstone, light-gray, very fine grained, fairly well sorted, micaceous, soft to hard; thin, hard, calcareous laminae; trough crossbedded; ripple marked; mudflat (stream channel) deposit	7.7
273. Shale, dark-green, blocky, firm; mudflat deposit.	2.8
272. Limestone, dark-gray, finely crystalline, very hard, dense, silty at the top; weathers to yellow-brown ledge; saltwater lacustrine deposit	0.5
271. Shale, mostly dark green, some dark-gray-green, blocky, firm; mudflat deposit	16.2
270. Dolomite, tan, finely crystalline, hard, dense; weathers into yellow-brown, flattened, rounded lenses; saltwater lacustrine deposit	0.4
269. Claystone, green, blocky, firm; one small brown carbonaceous leaf fragment; mudflat deposit	8.0
Total thickness of Wilkins Peak Member of Green River Formation	118.6
Tipton Shale Member:	
Rife Bed:	
268. Oil shale, brown, dark-brown toward the top, flaky at the base, very fissile to papery, firm; saltwater lacustrine deposit. Fischer assays, 11.4 and 14.1 gpt	21.0
267. Algal limestone, tan, hard; a massive reef of colonies that are hummocky in cross section; saltwater lacustrine (shoreline) deposit	0.9
266. Oil shale, dark-brown, very fissile, papery, brittle, firm to soft; saltwater lacustrine deposit. Fischer assay, 3.9 and 19.1 gpt (top)	63.1
265. Algal limestone, tan, mostly small brain-type colonies up to 1.0 ft in diameter; saltwater lacustrine (shoreline) deposit	1.0
264. Oil shale, dark-brown, papery, brittle, firm; saltwater lacustrine deposit. Fischer assay, 12.9 gpt	6.4
263. Algal limestone, tan, massive heads of brain-type; caps ridge; bed can be traced in outcrops about 20 miles to the northeast and about 15 miles to the south; saltwater lacustrine (shoreline) deposit	2.7
262. Oil shale, brown, papery, soft; saltwater lacustrine deposit	8.1
261. Dolomite, tan, finely crystalline, hard, dense; some ostracodes; saltwater lacustrine deposit	0.5
260. Oil shale, brown, papery, soft; saltwater lacustrine deposit. Fischer assay, 9.4 gpt	12.5
259. Algal limestone, tan, large rounded heads up to 1.0 ft in diameter; saltwater lacustrine (shoreline) deposit	2.4
258. Oil shale, brown, papery to flaky, soft; saltwater lacustrine deposit. Fischer assay, 9.8 gpt	1.0
257. Algal limestone, tan, silty, in pea size, rounded colonies; saltwater lacustrine	0.9
Total thickness of Rife Bed of Tipton Shale Member of Green River Formation	120.5

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Scheggs Bed: The upper contact is placed where gray-weathering shales that characterize the Rife Bed change to brown-weathering oil shales that characterize the Scheggs Bed. The color change marks the closing of the outlet of Lake Gosiute.	
Scheggs Bed:	
256. Oil shale, brown, papery, soft; abundant ostracodes; freshwater lacustrine deposit. Fischer assay, 4.2 gpt	8.0
255. Dolomite, tan, very silty, hard; weathers yellow; freshwater lacustrine deposit	2.4
254. Oil shale, brown, papery, soft; abundant ostracodes; freshwater lacustrine deposit. Fischer assay, 3.3 gpt	27.3
253. Coquinal shale, brown, gray, limy, silty, crumbly, soft; abundant shell fragments; freshwater lacustrine deposit	3.3
252. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, micaceous, calcareous; scattered *Goniobasis* sp., and other mollusks; freshwater lacustrine (shoreline) deposit	1.0
251. Shale, dark-brown, fissile, carbonaceous, soft; swamp deposit	1.8
250. Sandstone, light-gray, very fine grained, very soft; mostly loose grains; freshwater lacustrine (shoreline deposit)	2.0
249. Oil shale, dark-gray, silty, sandy, blocky, firm; freshwater lacustrine deposit	17.0
Total thickness of Scheggs Bed of Tipton Shale Member of Green River Formation	62.8
Total thickness of Tipton Shale Member of Green River Formation	183.3
Wasatch Formation:	
Niland Tongue:	
248. Shale, dark-brown, black, fissile, carbonaceous, firm; swamp deposit	2.0
247. Shale, dark-gray-green, silty, blocky, soft; flood-plain (basin-fill) deposit	12.5
246. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, micaceous, limonitic; lenticular, trough crossbedded; flood-plain (stream channel) deposit	2.5
245. Shale, dark-brown, black, fissile, carbonaceous to coaly, soft to firm; swamp deposit	5.0
244. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, micaceous, limonitic, calcareous, ripple-marked; trough crossbedded; abundant crustacean borings in the lower part; scattered fish bones; abundant *Goniobasis* sp. and *Lampsilis* sp., the top 0.5 ft; flood-plain (stream channel) deposit	22.0
243. Shale, dark-gray, dark-gray-green, fissile to blocky, soft, and some thin interbedded siltstone, gray, limy, hard; flood-plain (basin-fill) deposits	9.0
242. Sandstone, light-gray, very fine grained, silty, soft; friable at the base, becomes calcareous and hard at the top; trough crossbedded; flood-plain (stream channel) deposit	3.2

Reference section of Eocene rocks in the Washakie basin—Continued

		Thickness Feet
Wasatch Formation—Continued		
Niland Tongue—Continued		
241.	Shale, dark-gray, dark-gray-green, silty, blocky, soft, and one thin bed of sandstone, light-gray, very fine grained, near the middle; flood-plain (basin-fill) deposits	15.0
240.	Shale, dark-brown, black, fissile, carbonaceous, firm, coaly at the top; swamp deposit	2.0
239.	Shale, dark-gray-green, silty, blocky, firm; one layer contains small, tan limestone nodules; abundant turtle scutes; flood-plain (basin-fill) deposit	5.2
238.	Sandstone, light-gray, very fine grained, fairly well sorted, subangular, soft; abundant colored grains; friable at the base, becomes calcareous and hard at the top; weathers to small ledge; flood-plain (splay) deposit	4.3
237.	Shale, dark-gray, dark-gray-green, silty, blocky, soft, and interbedded sandstone, light-gray, very fine grained, fairly well sorted, subangular, micaceous, calcareous, firm; flood-plain (basin-fill and splay) deposits	18.5
236.	Sandstone, light-gray, very fine grained, fairly well sorted, subangular, micaceous, firm; weathers to small ledge; flood-plain (splay) deposit	5.0
235.	Shale, dark-gray-green, silty, blocky, soft, and interbedded sandstone, light-gray, very fine grained, fairly well sorted, micaceous, calcareous, hard; abundant colored grains; flood-plain (basin-fill and splay) deposits	10.7
234.	Sandstone, light-gray, very fine grained, fairly well sorted, micaceous, calcareous, hard; abundant colored grains; ripple marked, trough crossbedded; flood-plain (stream channel) deposits	1.5
233.	Oil shale, brown, very fissile, soft; abundant weathered white shell fragments including *Goniobasis* sp., *Lampsilis* sp., and *Viviparus* sp.; weathers to brown band in outcrops in NE¼NE¼SE¼ sec. 25, T. 16 N., R. 101 W.; freshwater lacustrine deposit, EOY 8 gpt	3.1
232.	Shale, dark-brown, black, carbonaceous, soft, coaly at the top; swamp deposit	0.5
231.	Shale, dark-gray, fissile, silty, soft; flood-plain (basin-fill) deposit	5.2
230.	Sandstone, light-gray, very fine grained, very soft; flood-plain (splay) deposit	2.3
229.	Shale, dark-gray, fissile, silty, soft; flood-plain (basin-fill) deposit	4.0
228.	Limestone, tan-yellow, finely crystalline, hard, dense, silty; fractures into small, angular, yellow blocks; freshwater lacustrine (pond) deposit	1.5
227.	Shale, dark-gray, silty, fissile, soft, and thin interbedded sandstone, light-gray, very fine grained, very soft; flood-plain (basin-fill and splay) deposits	8.1
226.	Siltstone, gray, limy, hard; weathers to small, tan-yellow, angular blocks; freshwater lacustrine (pond) deposit	0.9
225.	Shale, dark-gray, blocky, soft; flood-plain (basin-fill) deposit	1.0
224.	Siltstone, gray, limy, hard; flood-plain deposit	1.0

Reference section of Eocene rocks in the Washakie basin—Continued

		Thickness Feet
Wasatch Formation—Continued		
Niland Tongue—Continued		
223.	Shale, dark-gray, dark-gray-green, blocky, firm; some very thin silty to sandy lenses; flood-plain (basin-fill) deposit	11.9
222.	Siltstone, medium-gray, very limy, hard; weathers to resistant ledge; flood-plain (splay) deposit	2.2
221.	Sandstone, light-gray, very fine grained, fairly well sorted, subangular, calcareous, firm; flood-plain (stream channel) deposit	8.5
220.	Shale, brown, gray, silty, blocky, soft; flood-plain (basin-fill) deposit	15.0
219.	Sandstone, light-gray, very fine grained, fairly well sorted, subangular, calcareous, firm; becomes silty and limy the top 1.0 ft, trough crossbedded; flood-plain (stream channel) deposit	6.0
218.	Limestone, tan-gray, finely crystalline, hard, dense; blocky fracture pattern; freshwater lacustrine (pond) deposit	2.0
217.	Shale, dark-gray, dark-gray-green, blocky, soft; some gastropod shell fragments; flood-plain (basin-fill) deposit	15.4
	Stratigraphic level of fossil mammal locality 358 of McGrew and Roehler located in SE¼NE¼ NE¼ sec. 8, T. 18 N., R. 98 W. *Lambdotherium* sp. *Meniscotherium* sp. *Notharctus limosus* *Heptodon* sp. *Esthonyx* sp. *Hyracotherium* sp. *Hyopsodus miticulus*	
216.	Sandstone, light-gray, very fine grained, fairly well sorted, subangular, calcareous, massively bedded; flood-plain (splay) deposit	13.6
215.	Shale, medium-gray, very silty, blocky, firm; flood-plain (basin-fill) deposit	5.8
214.	Sandstone, light-gray, very fine grained, fairly well sorted, subangular, calcareous, firm; becomes silty and limy the top 1.0 ft; trough crossbedded; flood-plain (stream channel) deposit	12.7
213.	Shale, medium-gray-green, fissile, soft; flood-plain (basin-fill) deposit	11.6
212.	Coquinal limestone, tan-gray, finely crystalline, silty, hard, dense; contains poorly preserved *Goniobasis* sp., *Viviparus* sp., and *Lampsilis* sp.; weathers to cap rock on ridge located in SE¼SE¼ sec. 25, T. 17 N., R. 101 W.; freshwater lacustrine (shoreline) deposit	1.5
211.	Sandstone, light-gray, very fine grained, fairly well sorted, subangular, calcareous, hard at the base, soft and friable at the top; abundant colored grains; trough crossbedded; flood-plain (stream channel) deposit	20.0
210.	Shale, dark-gray-green, fissile to blocky, soft; flood-plain (basin-fill) deposit	3.5
209.	Limestone, gray-brown, finely crystalline, hard, dense; abundant yellow calcite fracture fillings; weathers to small, angular blocks; freshwater lacustrine (pond) deposit	1.0

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Wasatch Formation—Continued	
Niland Tongue—Continued	
208. Oil shale, brown, flaky to papery, soft; abundant ostracodes; freshwater lacustrine deposit; EOY 5 gpt	12.5
207. Sandstone, light-gray, very fine grained, fairly well sorted, angular to subangular, micaceous, very soft, very friable; weathers to smooth slope; freshwater lacustrine (shoreline) deposit	14.0
206. Sandstone, light-gray, very fine grained, fairly well sorted, angular to subangular, micaceous, calcareous at the top, trough crossbedded; freshwater lacustrine (shoreline) deposit	10.3
205. Shale, dark-gray-green, silty, blocky, soft; becomes sandy the top 5.0 ft; flood-plain (basin-fill) deposit	15.0
Total thickness of Niland Tongue of Wasatch Formation	329.3
Green River Formation:	
Luman Tongue:	
204. Oil shale, brown, flaky, soft; freshwater lacustrine deposit; EOY 12 gpt	56.3
203. Sandstone, gray, very fine grained; hard the top 1.3 ft, shaly and soft at the base; abundant *Goniobasis* sp. and some *Viviparus* sp. at the top; freshwater lacustrine (shoreline) deposit	2.8
202. Sandstone, gray, very fine grained, fairly well sorted, calcareous; abundant colored grains; trough crossbedded; flood-plain (stream channel) deposit	4.5
201. Sandstone, gray, very fine grained, argillaceous, soft, nonresistant; 2.0 ft of shale, gray, sandy, soft, at the base; freshwater lacustrine (shoreline) deposit	12.5
200. Coquinal sandstone, gray, limy, crumbly, hard; abundant *Goniobasis* sp. and *Lampsilis* sp.; freshwater lacustrine (shoreline) deposit	5.2
Shale, gray, fissile, slightly silty, soft; freshwater lacustrine deposit	4.2
Oil shale, dark-brown, flaky, soft, freshwater lacustrine deposit; EOY 15 gpt	3.1
199. Coquinal sandstone, gray, crumbly, hard; well-preserved *Goniobasis* sp., *Viviparus* sp., and *Lampsilis* sp.; freshwater lacustrine (shoreline) deposit	0.9
Sandstone, gray, very fine grained; soft in the lower half, calcareous and hard in the upper half; upper part is ripple marked; weathers to ledge; freshwater lacustrine (shoreline) deposit	3.5
Shale, brown, very sandy, soft, and interlaminated sandstone, gray, very fine grained, calcareous, soft, ripple-marked; freshwater lacustrine deposit	5.6
Oil shale, brown, silty, soft; abundant ostracodes; freshwater lacustrine deposit	4.0
Coquinal sandstone, gray, very fine grained, limy, hard; abundant *Goniobasis* sp., *Viviparus* sp., and *Lampsilis* sp.; freshwater lacustrine (shoreline) deposit	1.5
198. Sandstone, gray, very fine grained, calcareous, hard; weathers to ripple-marked ledge; freshwater lacustrine deposit	3.9

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Green River Formation—Continued	
Luman Tongue—Continued	
198.—Continued	
Sandstone, gray, very fine grained, very soft; argillaceous, nonresistant; freshwater lacustrine deposit	20.3
Shale, gray, very sandy, soft; freshwater lacustrine deposit	15.0
Oil shale, dark-brown, papery, soft; freshwater lacustrine deposit; EOY 12 gpt	4.0
197. Coquinal sandstone, gray, very fine grained, crumbly, soft; abundant *Goniobasis* sp., *Lampsilis* sp., and *Viviparus* sp.; freshwater lacustrine (shoreline) deposit	1.1
196. Shale, gray, fissile, very sandy, soft; freshwater lacustrine deposit	2.7
Shale, gray, fissile, clayey, soft; freshwater lacustrine deposit	8.0
Oil shale, dark-brown, papery, soft; abundant ostracodes; freshwater lacustrine deposit; EOY 12 gpt	2.0
Coquinal sandstone, gray, very fine grained, crumbly, hard; abundant *Goniobasis* sp., *Lampsilis* sp., and *Viviparus* sp.; freshwater lacustrine (shoreline) deposit	1.9
195. Oil shale, brown, flaky, soft; abundant ostracodes; scattered white weathered shell fragments; freshwater lacustrine deposit; EOY 5 gpt	8.4
194. Sandstone, gray, very fine grained, calcareous, hard; freshwater lacustrine deposit	0.8
193. Shale, medium- to dark-gray, fissile, silty, soft; freshwater lacustrine deposit	15.1
192. Coquinal limestone, brown, silty, crumbly, hard; contains *Goniobasis* sp., *Viviparus* sp., and *Lampsilis* sp.; freshwater lacustrine (shoreline) deposit	1.0
191. Sandstone, brown, gray, very fine grained, calcareous, ripple-marked, and interbedded shale, gray-green, very silty, blocky; freshwater lacustrine deposit	6.0
190. Shale, gray, silty, blocky, firm; freshwater lacustrine deposit	14.6
189. Sandstone, light-gray, very fine grained, fairly well sorted, calcareous, hard, thin-bedded; worm borings and trails on upper surface; freshwater lacustrine deposit	1.2
188. Sandstone, light-gray, very fine grained, calcareous, dirty, thin-bedded, and interbedded shale, gray, very silty, blocky, firm; freshwater lacustrine deposit	3.1
187. Oil shale, brown, fissile to papery, soft; abundant white, weathered shell fragments, including *Goniobasis* sp.; freshwater lacustrine (shoreline) deposit	5.5
186. Coquinal limestone, brown, silty, crumbly, firm; contains *Goniobasis* sp., *Viviparus* sp., and *Lampsilis* sp.; unit forms the top of a conspicuous brown band near the top of slopes in SW¼NW¼NW¼ sec. 36, T. 16 N., R. 101 W.; freshwater lacustrine (shoreline) deposit	5.0
185. Shale, dark-brown to black, fissile, carbonaceous, brittle, firm; swamp deposit	2.5

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness Feet
Green River Formation—Continued	
Luman Tongue—Continued	
184. Coquinal limestone, brown, silty, crumbly, firm; contains *Goniobasis* sp., *Viviparus* sp., and *Lampsilis* sp.; freshwater lacustrine (shoreline) deposit	1.5
183. Oil shale, dark-brown, papery, soft; contains abundant ostracodes, *Musculium* sp., and *Gyraulus militaris*; freshwater lacustrine deposit	2.8
182. Shale, dark-gray-green, silty, soft, and interbedded sandstone, light-gray, very fine grained, micaceous, very soft; weathers to smooth slope; freshwater lacustrine deposit	18.0
181. Sandstone, light-gray, very fine grained, well-sorted, calcareous; ripple marked; abundant fishbones; freshwater lacustrine deposit	1.4
180. Shale, dark-gray-green, silty, blocky, firm; freshwater lacustrine deposit	2.5
179. Oil shale, brown, papery, soft, coquinal; contains *Goniobasis* sp., *Viviparus* sp., and *Lampsilis* sp.; freshwater lacustrine (shoreline) deposit	3.0
178. Shale, dark-brown, carbonaceous, fissile, firm; coaly streak the top 0.3 ft; swamp deposit	1.3
177. Shale, gray, very silty, blocky, firm; freshwater lacustrine deposit	2.3
176. Sandstone, light-gray, very fine grained, very calcareous, hard; ripple marked; freshwater lacustrine deposit	2.5
175. Shale, dark-brown, silty, very carbonaceous, firm; one thin layer of lignitic coal; swamp deposit	6.0
174. Limestone, gray, silty, finely crystalline, hard, dense; weathers to small angular blocks; freshwater lacustrine (pond) deposit	1.0
173. Sandstone, light-gray, very fine grained, very calcareous, hard; ripple marked; flood-plain (splay) deposit	3.6
172. Shale, dark-gray-green, silty, fissile to blocky, soft; flood-plain (basin-fill) deposit	8.4
171. Sandstone, light-gray, very fine grained, very calcareous, hard; ripple marked; flood-plain (splay) deposit	1.0
170. Oil shale, dark-gray-brown, very fissile, to flaky, soft; freshwater lacustrine deposit	8.2
169. Sandstone, light-gray, very fine grained, well-sorted, very calcareous; scattered dark grains; ripple marked; contains poorly preserved *Goniobasis* sp., *Viviparus* sp., and *Lampsilis* sp.; weathers to persistent bench about halfway up steep slope; freshwater lacustrine (shoreline) deposit	3.2
Total thickness of Luman Tongue of Green River Formation	292.9
Wasatch Formation:	
Main body:	
168. Shale, dark-gray, fissile, soft, and one very thin carbonaceous layer near the base; one very thin layer of light-gray siltstone, 5.0 ft above the base; one very thin layer of sandstone, light-gray, very fine grained, calcareous, firm, about 4.0 ft below the top; flood-plain and swamp deposits	27.3

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness Feet
Wasatch Formation—Continued	
Main body—Continued	
167. Shale, dark-brown, fissile, very carbonaceous, limonitic, firm; swamp deposit	2.5
166. Sandstone, light-gray, very fine grained, micaceous, very soft; flood-plain (splay) deposit	1.7
165. Shale, dark-gray, very silty at the base, blocky, soft; flood-plain (basin-fill) deposit	4.0
164. Sandstone, light-gray, very fine grained, well-sorted, calcareous, dirty; ripple marked; abundant worm borings; flood-plain (splay) deposit	2.8
163. Shale, gray, very silty, very gypsiferous, soft; flood-plain (basin-fill) deposit	4.0
162. Limestone, tan-gray, thin-bedded, very silty, hard, dense; weathers to highly fractured ledge; freshwater lacustrine (pond) deposit	2.1
161. Sandstone, light-gray, very fine grained, fairly well sorted, micaceous, calcareous, hard; becomes very shaly and grades upwards into dark- gray shale at the top; flood-plain (splay) deposit	5.0
160. Shale, dark-gray-green, blocky, soft; flood-plain (basin-fill) deposit	1.3
159. Sandstone, light-gray, very fine grained, fairly well sorted, micaceous, very soft; weathers to smooth slope; flood-plain (splay) deposit	5.8
158. Shale, dark-gray, fissile, limonitic, gypsiferous, soft; flood-plain (basin-fill) deposit	1.0
157. Sandstone, light-gray, very fine grained, fairly well sorted, micaceous, very soft; weathers to smooth slope; flood-plain deposit	9.0
156. Mudstone, dark-gray-green, silty, blocky, soft; flood-plain (basin-fill) deposit	1.9
155. Sandstone, light-gray, very fine grained, fairly well sorted, micaceous; abundant dark grains; small ripple marks at the base, becomes soft and silty in the middle, limy and hard at the top; weathers to smooth slope; flood-plain (splay) deposit	13.1
154. Shale, dark-brown, carbonaceous at the base, soft; becomes dark gray and very fissile at the top; swamp and flood-plain deposits	5.9
153. Mudstone, dark-gray-green, very silty, blocky, soft; flood-plain (basin-fill) deposit	1.9
152. Sandstone, light-gray, very fine grained, fairly well sorted, micaceous, calcareous, hard; abundant dark grains; flood-plain (splay) deposit	2.5
151. Mudstone, dark-gray, dark-gray-green, one thin bed of maroon at the top, silty, very sandy at the base, firm; flood-plain (basin-fill) deposit	25.0
150. Sandstone, light-gray, very fine grained, fairly well sorted, micaceous, calcareous, hard; abundant dark grains; flood-plain (splay) deposit	1.2
149. Mudstone, gray, silty, blocky, firm; flood-plain (basin-fill) deposit	2.3
148. Sandstone, light-gray, very fine grained, fairly well sorted, micaceous, soft, friable; flood-plain (splay) deposit	2.6
147. Mudstone, dark-gray, silty, blocky, firm; flood-plain (basin-fill) deposit	5.4

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Wasatch Formation—Continued	
Main body—Continued	
146. Sandstone, light-gray, very fine grained, fairly well sorted, micaceous, calcareous, dirty, hard; flood-plain (splay) deposit	3.8
145. Mudstone, dark-gray, blocky, soft; flood-plain (basin-fill) deposit	8.0
144. Sandstone, light-gray, fine-grained, fairly well sorted, micaceous, calcareous, dirty, hard; flood-plain (splay) deposit	2.4
143. Mudstone, dark-gray-green, silty, blocky, soft, silty to sandy laminae; flood-plain (basin-fill) deposit	17.5
142. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, micaceous, calcareous; weathers to small ledge; flood-plain (splay) deposit	5.9
141. Mudstone, dark-gray-green, blocky, soft; becomes very silty toward the top; and three 0.3- to 0.5-ft-thick lenses of interbedded siltstone, light-gray, limy, hard; flood-plain (basin-fill and splay) deposits	9.8
140. Siltstone, light-gray, limy, hard; weathers to crumbly blocks; flood-plain (splay) deposit	2.9
139. Mudstone, dark-gray-green, silty, blocky, soft; abundant turtle and crocodile bones and scutes; flood-plain (basin-fill) deposits	6.7
138. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, micaceous, soft, friable; calcareous the top 1.0 ft; weathers to massive ledge covered by talus blocks; flood-plain (splay) deposit	4.7
137. Mudstone, medium-gray, blocky, soft; flood-plain (basin-fill) deposit	9.0
136. Siltstone, light-gray, limy, crumbly, hard; flood-plain (splay) deposit	1.2
135. Mudstone, gray, very silty, blocky, firm; flood-plain (basin-fill) deposit	11.3
134. Sandstone, light-gray, very fine grained, micaceous, slightly calcareous, thin-bedded, soft; flood-plain (splay) deposit	1.8
133. Mudstone, gray, gray-green, fissile, limonitic, firm; flood-plain (basin-fill) deposit	7.4
132. Shale, dark-brown, fissile, carbonaceous, limonitic, gypsiferous, soft; swamp deposit	5.0
131. Mudstone, gray-green, blocky, silty, soft; flood-plain (basin-fill) deposit	1.5
130. Limestone, medium-gray-brown, finely crystalline, hard, dense; fractures are filled with milky calcite; concretionary zone	0.9
129. Mudstone, gray, gray-green, one thin bed of red, very silty in part, fissile to blocky, soft, and one 0.5-ft-thick lens of sandstone, light-gray, very fine grained, very biotitic, calcareous, firm, in the lower part; flood-plain (basin-fill) deposits.	47.4
128. Limestone, tan-gray, finely crystalline, very hard, dense; contains abundant *Physa pleromatis* and some *Gyraulus* sp.; abundant turtle bones and scutes; freshwater lacustrine (pond) deposit	2.2
127. Mudstone, dark-green, clayey, blocky, soft; flood-plain (basin-fill) deposit	1.3
126. Limestone, medium-gray, silty, hard, dense, fossiliferous; abundant ostracodes; freshwater lacustrine (pond) deposit	1.0
125. Mudstone, green, gray, red, variegated, silty, blocky, soft; a red bed in the upper part forms a persistent red band in outcrops; flood-plain (basin-fill) deposit	58.0
Vertebrate fossil locality 6–60 is located 2 miles south of the line of section, in SW¼NE¼SE¼ sec. 4, T. 15 N., R. 101 W. in the lower part of bed 125:	
Hyopsodus wortmani	
124. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, calcareous at the top; trough crossbedded; flood-plain (stream channel) deposit	2.7
123. Mudstone, dark-gray-green, silty to sandy, soft; flood-plain (basin-fill) deposit	9.0
122. Limestone, gray-brown, silty, hard, dense, fossiliferous; contains *Gyraulus militaris*, *Gyraulus aequalis*, and *Physa pleromatis*; freshwater lacustrine (pond) deposit	1.1
121. Mudstone, green, brown, gray, silty, blocky, soft; flood-plain (basin-fill) deposit	8.4
120. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, soft, friable, calcareous; hard the top 1.0 ft; in small-scale trough crossbeds; flood-plain (stream channel) deposit	4.6
119. Mudstone, dark-gray-green, maroon, variegated, silty, blocky, firm; flood-plain (basin-fill) deposit	22.0
118. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, micaceous, soft, calcareous and hard at the top; caps ridge in center of NE¼NW¼ sec. 35, T. 16 N., R. 101 W.; flood-plain (stream channel) deposit	7.0
117. Mudstone, dark-gray, dark-gray-green, silty, blocky, firm; flood-plain (basin-fill) deposit	8.5
116. Limestone, medium-gray, silty, hard, dense; freshwater lacustrine (pond) deposit	0.6
115. Mudstone, dark-gray-green, maroon, variegated, blocky, soft; flood-plain (basin-fill) deposit	1.9
114. Siltstone, light-gray, limy, hard; small, white calcite? inclusions; flood-plain deposit	0.9
113. Mudstone, dark-gray-green, sandy, blocky, soft; flood-plain (basin-fill) deposit	1.0
112. Sandstone, light-gray, very fine grained, calcareous, hard; abundant worm borings at the top; flood-plain (splay) deposit	3.3
111. Mudstone, dark-gray-green, some maroon, silty, blocky, soft, and one thin lens of gray, shaly limestone at the center; flood-plain and freshwater lacustrine (pond) deposits	10.1
110. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, micaceous, soft, friable; abundant red and black grains, massively trough crossbedded; weathers to gold-brown ledge; flood-plain (basin-fill) deposit	11.5

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Wasatch Formation—Continued	
Main body—Continued	
109. Mudstone, dark-gray, dark-gray-green, silty, blocky, firm, and two 0.5- to 1.0-ft-thick lenses of siltstone, gray, sandy, calcareous, hard, and sandstone, light-gray, very fine grained, calcareous, firm; flood-plain (basin-fill and splay) deposits	23.5
108. Shale, dark-brown, some gray, fissile, carbonaceous, limonitic, soft, some very sandy; swamp deposits	3.0
107. Siltstone, light-gray, limy, shaly, hard; flood-plain (splay) deposit	1.4
106. Mudstone, dark-gray-green, silty, blocky, firm; flood-plain (basin-fill) deposit	15.5
105. Shale, tan-brown, silty, flaky, soft; very fossiliferous; abundant crocodile, turtle, fish, and mammal fragments; flood-plain (basin-fill) deposit	1.6
104. Limestone, medium-gray, finely crystalline, silty, hard, crumbly; abundant mollusk and vertebrate fossils; freshwater lacustrine (pond) deposit	1.4
Vertebrate locality 560 located in NW¼SE¼NW¼ sec. 35, T. 16 N., R. 101 W.	
Mollusks: *Physa pleromatis*	
Physa bridgerensis	
Helix sp.	
Australorbis sp.	
Gyraulus sp.	
Fish: Garpike scales and vertebrae	
Reptiles: *Glyptosaurus* sp.	
Crocodile	
Turtle	
Mammals: *Notharctus* cf. *limosus*	
Undet. primate	
Hyopsodus wortmani	
Meniscotherium cf. *robustum*	
Poss. *Coryphodon* sp.	
Hyracotherium sp.	
Diacodexis sp.	
103. Mudstone, medium-gray, dark-gray-green, red, brown variegated, blocky, soft; abundant bone and tooth fragments including garpike scales, crocodile bones, scutes, and teeth, turtle scutes, and mammal teeth and bones; flood-plain (basin-fill) deposit	25.4
102. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, micaceous, calcareous, small-scale trough crossbedding; flood-plain (fluvial channel) deposit	2.5
Stratigraphic level of vertebrate locality 7–60 located in SW¼SW¼SW¼ sec. 4, T. 15 N., R. 101 W.	
Mammals: *Cynodontomys* sp.	
cf. *Pelycodus*, poss. *P. jarrovii*	
Hyracotherium sp.	
101. Shale, dark-gray, fissile, soft, some silty laminae; flood-plain (basin-fill) deposit	6.5
100. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, micaceous, noncalcareous, shaly, soft; flood-plain (splay) deposit	5.0

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Wasatch Formation—Continued	
Main body—Continued	
99. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, micaceous, calcareous, firm to hard; abundant worm borings; flood-plain (splay) deposit	0.9
98. Mudstone, dark-gray-green, blocky, soft; one very silty bed 0.6 ft thick, 4.0 ft below the top; flood-plain (basin-fill) deposit	8.5
97. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, micaceous; some dark grains; weathers to massive tan-brown ledge; flood-plain (stream channel) deposit	10.3
96. Mudstone, dark-gray, dark-gray-green, blocky, soft; flood-plain (basin-fill) deposit	12.7
95. Limestone, gray-brown, finely crystalline, hard, dense, fossiliferous; contains *Physa pleromatis*, *Gyraulus militaris*, *Goniobasis* sp., *Australorbis* sp., abundant ostracodes, and a few large coprolites; freshwater lacustrine (pond) deposit	1.2
94. Sandstone, light-tan-gray, very fine grained, fairly well sorted, limy, hard; contains very small *Physa pleromatis* and very small *Goniobasis* sp.; freshwater lacustrine (pond) deposit	1.5
93. Shale, brown, fissile, soft; abundant ostracodes and mollusk shell fragments including *Gyraulus* sp.; scattered disseminated carbonaceous material; freshwater lacustrine (pond) deposit.	0.3
92. Shale, dark-gray, black, fissile, soft; flood-plain (basin-fill) deposit	28.6
91. Sandstone, light-gray, very fine to fine-grained, fairly well sorted, subangular, soft, friable; large grains of biotite and muscovite, some red and black grains; festoon crossbedding; weathers to massive gold-brown ledge in SW¼NW¼NW¼ sec. 35, T. 16 N., R. 101 W.; flood-plain (stream channel) deposit	35.5
90. Shale, dark-gray, blocky, clayey, soft; flood-plain (basin-fill) deposit	14.5
89. Sandstone, light-gray, very fine grained, fairly well sorted, calcareous, firm; flood-plain (splay) deposit	1.0
88. Mudstone, dark-gray, dark-gray-green, one thin horizon of maroon-red, blocky, clayey, soft, and three interbedded 0.5- to 1.0-ft-thick lenses of sandstone, light-gray, very fine grained, fairly well sorted, angular to subangular, micaceous, soft; flood-plain (basin-fill and splay) deposits.	20.2
87. Sandstone, light-gray, very fine grained, fairly well sorted, angular to subangular, micaceous, soft, friable, calcareous at the base; trough crossbedded; flood-plain (stream channel) deposit	22.9
86. Mudstone, dark-gray, dark-gray-green, silty to sandy, fissile to blocky, firm; flood-plain (basin-fill) deposit	6.2
85. Sandstone, light-gray, very fine grained, angular to subangular, fairly well sorted, micaceous, soft, friable, calcareous the top 1.0 ft; abundant crustacean borings at the top; weathers gold brown; flood-plain (splay) deposit	4.5

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Wasatch Formation—Continued	
Main body—Continued	
84. Mudstone, dark-gray-green, very silty, firm, and interbedded sandstone, light-gray, very fine grained, very calcareous, hard; flood-plain (basin-fill and splay) deposits	5.8
83. Sandstone, light-gray, very fine grained, angular to subangular, fairly well sorted; abundant biotite and muscovite grains, scattered colored grains, calcareous the top 0.5 ft; abundant worm borings; flood-plain (splay) deposit	2.3
82. Shale, dark-gray with brown cast, fissile, firm; flood-plain (basin-fill) deposit	9.6
81. Sandstone, light-gray, very fine grained, angular to subangular, fairly well sorted, soft, friable; abundant muscovite and biotite grains, some red and black grains, calcareous the top 1.0 ft; weathers to massive gold-brown ledge; flood-plain (splay) deposit	4.9
80. Mudstone, dark-gray, dark-gray-green, clayey, blocky, firm; flood-plain (basin-fill) deposit	8.8
79. Limestone, medium-tan-gray, finely crystalline, silty, very hard, dense; freshwater lacustrine (pond) deposit	0.3
78. Mudstone, dark-gray-green, very silty, blocky, firm; flood-plain (basin-fill) deposit	2.9
77. Sandstone, light-gray, very fine grained, micaceous, calcareous, firm; abundant worm borings; flood-plain (splay) deposit	0.7
76. Mudstone, dark-gray-green, clayey, blocky, soft; flood-plain (basin-fill) deposit	6.0
75. Sandstone, light-gray, very fine grained, micaceous, calcareous, firm; flood-plain (splay) deposit	1.4
74. Shale, dark-gray-green, fissile, soft; flood-plain (basin-fill) deposit	2.0
73. Sandstone, light-gray, very fine grained, micaceous, calcareous, firm; flood-plain (splay) deposit	1.3
72. Mudstone, dark-gray, dark-gray-green, clayey, blocky, soft; flood-plain (basin-fill) deposit	13.5
71. Sandstone, light-gray, very fine grained, fairly well sorted, calcareous, hard; large grains of muscovite and biotite; weathers to massive tan-brown ledge at the south point of a north-south-trending cedar-covered ridge in SE¼SE¼SW¼ sec. 27, T. 16 N., R. 101 W.; flood-plain (stream channel) deposit	10.1
70. Mudstone, dark-gray-green, some mottled maroon, clayey, blocky, firm; flood-plain (basin-fill) deposit	9.0
69. Siltstone, gray, limy, hard, biotite; flood-plain (splay) deposit	3.3
68. Shale, dark-gray, clayey, blocky, soft; flood-plain (basin-fill) deposit	8.3
67. Sandstone, light-gray, very fine grained, well-sorted, hard; sparse red and black grains; calcareous at the top and bottom, shaly and soft near the middle; flood-plain deposits	6.0
66. Shale, dark-gray, dark-gray-green, silty in part, fissile, some blocky, firm, and one 0.7-ft-thick	

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Wasatch Formation—Continued	
Main body—Continued	
66.—Continued	
bed of sandstone, light-gray, very fine grained, calcareous, micaceous, hard; abundant worm borings, about 10.0 ft above the base; flood-plain (basin-fill) deposits	28.4
65. Sandstone, light-gray, very fine to medium-grained, poorly sorted to fairly well sorted, calcareous, hard; trough crossbedded; abundant black grains; interbedded lenses of conglomerate contain bone fragments; caps north-south-trending cedar-covered ridge in NE¼SW¼NW¼ sec. 27, T. 16 N., R. 101 W.; flood-plain (stream channel) deposit	5.0
Stratigraphic level of vertebrate locality 260 located in SE¼NW¼NW¼ sec. 8, T. 15 N., R. 101 W.	
Mammals: *Cynodontomys* cf. *angustidens* *Pelycodus* cf. *trigonodus* cf. *Diacodexis* sp.	
64. Mudstone, dark-gray to dark-gray-green, silty, blocky, soft, and several thin interbedded lenses of sandstone, light-gray, very fine grained, micaceous, calcareous, hard, and siltstone, light-gray, limy, hard; flood-plain (basin-fill and splay) deposits	33.0
63. Siltstone, light-gray, very limy, hard; flood- plain deposit	0.4
62. Mudstone, dark-gray, dark-gray-green, silty, some very sandy layers, blocky, soft; flood-plain (basin-fill) deposit	20.3
61. Sandstone, light-gray, very fine grained, fairly well sorted, micaceous, soft; weathers to smooth slope; flood-plain deposit	6.0
60. Mudstone, dark-gray, some sandy layers, blocky, soft; flood-plain (basin-fill) deposit	31.0
59. Sandstone, light-gray, very fine grained, fairly well sorted, micaceous, calcareous; abundant crustacean borings at the top; flood-plain (splay) deposit	2.5
58. Mudstone, dark-gray-green, silty, blocky, soft; flood-plain (basin-fill) deposit	6.3
57. Limestone, medium-gray, silty, crumbly, hard; contains *Physa pleromatis*, *Australorbis* sp., *Gyraulus militaris*, and *Helix* sp.; freshwater lacustrine (pond) deposit	1.2
56. Mudstone, dark-gray, dark-gray-green, silty, blocky, firm, and three 0.5- to 1.5-ft-thick interbedded lenses of sandstone, light-gray, very fine grained, silty, calcareous, hard; flood-plain (basin-fill and splay) deposits	31.1
55. Shale, dark-brown, dark-gray, fissile, very carbonaceous, firm; swamp deposit	1.1
54. Shale, gray, silty, blocky, soft, limonitic; weathers to prominent rust band in outcrops; flood-plain deposit	1.0
53. Shale, dark-gray, almost black, blocky, firm; flood-plain (basin-fill) deposit; stratigraphic level of vertebrate locality 360 located in SW¼NW¼NW¼ sec. 22, T. 16 N., R. 101 W.	3.0

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Wasatch Formation—Continued	
Main body—Continued	
53.—Continued	
Mammals: *cf. Palaeosinopa lutreola* *Cynodontomys* cf. *angustidens* Undet. Insectivora *Pelycodus* cf. *trigonodus* Omomyid primate cf. *Tetonius homunculus* Creodont, poss. *Sinopa iverrina* cf. *Miacis exiguus* *Haplomylus speirianus* *Hyopsodus miticulus* or *H. simplex* *Hyracotherium* sp. *Diacodexis* cf. *metsiacus*	
52. Limestone, tan-gray, very silty, hard; crumbles into small, blocky fragments; freshwater lacustrine (pond) deposit	0.5
51. Mudstone, medium- to dark-gray, dark-gray-green, fissile to blocky, partly silty, firm; flood-plain (basin-fill) deposit	14.5
50. Sandstone, light-gray, very fine grained, fairly well sorted, angular to subangular, micaceous, soft, friable; weathers to soft, sandy slope; flood-plain (stream channel) deposit	17.5
49. Covered. Probably dark gray to dark-gray-green mudstone	35.0
48. Sandstone, light-gray, very fine grained, angular to subangular, fairly well sorted, micaceous, soft, friable; some red and black grains; calcareous the top 1.0 ft; weathers gold brown to brown; caps ridge; flood-plain (stream channel) deposit	6.5
47. Mudstone, dark-gray, dark-gray-green, blocky, soft; flood-plain (basin-fill) deposit	8.0
46. Sandstone, light-gray, very fine grained, fairly well sorted, micaceous, massive; becomes silty and very calcareous the top 2.0 ft; crustacean borings the top 1.0 ft; flood-plain (splay) deposit	5.9
45. Mudstone, dark-gray, dark-gray-green, fissile, some silty, firm; flood-plain (basin-fill) deposit.	15.3
44. Mudstone, dark-gray, with green tints, clayey, blocky, soft; flood-plain (basin-fill) deposit	5.0
43. Siltstone, light-gray, very limy, hard; weathers to persistent brown ledge; flood-plain (splay) deposit	1.4
42. Mudstone, medium-gray-green, silty, fissile, soft; flood-plain (basin-fill) deposit	1.3
41. Siltstone, gray, limy, hard; scattered muscovite and biotite grains; flood-plain (splay) deposit..	1.5
40. Mudstone, dark-gray, clayey, blocky, soft; flood-plain (basin-fill) deposit	9.7
39. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, micaceous, friable, soft; flood-plain (splay) deposit	2.5
38. Mudstone, dark-gray to dark-gray-green, fissile, firm, and a few very thin interbedded lenses of sandstone, light-gray, very fine grained, fairly well sorted, calcareous, firm; interval is poorly exposed; flood-plain (basin-fill and splay) deposits	32.5

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Wasatch Formation—Continued	
Main body—Continued	
37. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, micaceous, soft, friable; flood-plain (stream channel) deposit	10.0
36. Mudstone, medium- to dark-gray to gray-green, silty in part, fissile to blocky, firm, and several 1.0- to 2.0-ft-thick interbedded lenses of sandstone, light-gray, very fine grained, calcareous, firm; not well exposed; flood-plain (basin-fill and splay) deposits	55.0
Stratigraphic level of vertebrate locality 968 located in the upper 5.0 ft of bed 36 in NE¼ NW¼NW¼ sec. 28, T. 16 N., R. 101 W. Reptile and fish *Hyracotherium* sp. *Diacodexis* cf. *metsiacus* Undet. tooth frags.	
35. Sandstone, light-gray, very fine grained, fairly well sorted, calcareous, firm; abundant worm borings; flood-plain (splay) deposit	3.2
Vertebrate locality 960 located in SE¼SW¼ SW¼ sec. 21, T. 16 N., R. 101 W. cf. *Didymictis protenus* Creodont, possibly *Viverravus* sp. *Hyopsodus* sp. *Hyracotherium* sp.	
34. Mudstone, dark-gray, dark-gray-green, silty in part, some fissile, some blocky, firm, some sandy layers, and two 0.8- to 1.0-ft-thick interbedded lenses of sandstone, light-gray, very fine grained, calcareous, hard; abundant worm borings; flood-plain (basin-fill and splay) deposits	63.4
33. Sandstone, light-gray, very fine to fine-grained, fairly well sorted, subangular, soft, friable; large grains of biotite and muscovite; some red and black grains; large-scale, low-angle trough crossbedding; weathers to massive gold-brown bench; flood-plain (stream channel) deposit	20.5
32. Mudstone, dark-gray, fissile, clayey, firm, and interbedded 0.8-ft-thick lens of sandstone, light-gray, very fine grained, calcareous, hard; abundant worm borings; flood-plain deposits...	9.0
31. Sandstone, light-gray, very fine grained, subangular, well-sorted, soft, friable; large grains of biotite and muscovite, some black, white, and red grains; calcareous the top 1.0 ft; massively bedded; flood-plain (splay) deposit	3.5
30. Mudstone, dark-gray, dark-gray-green, silty layers, fissile to blocky, soft, and three interbedded 1.0- to 1.5-ft-thick lenses of sandstone, light-gray, very fine grained, calcareous, firm; some worm borings; flood-plain (basin-fill and splay) deposits	26.6
29. Sandstone, light-gray, very fine to fine-grained, subangular, fairly well sorted, soft, friable; large muscovite grains; weathers gold brown; flood-plain (splay) deposit	4.0
28. Mudstone, dark-gray, dark-gray-green, silty in part, blocky, soft; flood-plain (basin-fill) deposit	20.0

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Wasatch Formation—Continued	
Main body—Continued	
27. Sandstone, light-gray, very fine to fine-grained, subangular, fairly well sorted, soft, friable; large muscovite grains; weathers to gold-brown, massive ledge; top of unit contains large unidentified mammal bone and tooth fragments; flood-plain (stream channel) deposit	19.0
26. Mudstone, medium- to dark-gray, blocky, clayey, soft, silty in part, and two very thin layers that contain tan, limy nodules; flood-plain (basin-fill) deposits	11.6
25. Sandstone, light-gray, very fine to fine-grained, subangular, soft, friable; large grains of muscovite and biotite; weathers gold brown; flood-plain (stream channel) deposits	5.9
24. Shale, medium- to dark-gray, one layer nearly black, fissile, silty in part, soft; flood-plain (basin-fill) deposits	9.0
23. Sandstone, light-gray, very fine to fine-grained, fairly well sorted, subangular, soft, friable; large grains of muscovite and biotite; weathers to gold-brown ledge; flood-plain (stream channel) deposit	6.0
22. Mudstone, dark-gray to dark-gray-green, fissile to blocky, partly silty, soft, and four 1.0- to 2.0-ft-thick interbedded lenses of sandstone, light-gray, very fine grained, calcareous, micaceous, firm; abundant worm borings; flood-plain (basin-fill and splay) deposits	53.0
21. Sandstone, light-gray, very fine grained, fairly well sorted, subangular; abundant large grains of muscovite and biotite, some red and black grains; becomes calcareous with worm borings the top 1.0 ft; flood-plain (stream channel) deposit	7.7
20. Shale, dark-gray, blocky, soft; a thin layer of limy nodules at the base; flood-plain (basin-fill) deposits	7.5
19. Sandstone, light-gray, very fine grained, fairly well sorted, subangular; abundant large grains of muscovite and biotite, some red and black grains; weathers to massive, gold-brown ledge; flood-plain (stream channel) deposit	5.0
18. Mudstone, dark-gray-green, clayey, blocky, soft, some loose selenite crystals, and three 0.9- to 1.0-ft-thick lenses of sandstone, light-gray, very fine grained, fairly well sorted, calcareous, firm; abundant crustacean borings; flood-plain (basin-fill and splay) deposits	29.5
17. Sandstone, light-gray, very fine to fine-grained, fairly well sorted, subangular, micaceous, soft; weathers gold brown; flood-plain (stream channel) deposit	7.7
16. Mudstone, dark-gray-green, clayey, blocky, soft; becomes sandy the top 4.0 ft; flood-plain (basin-fill) deposits	10.7
15. Sandstone, light-gray, very fine to fine-grained, fairly well sorted, subangular, micaceous, soft; weathers to gold-brown ledge; flood-plain (stream channel) deposit	15.1

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness (Feet)
Wasatch Formation—Continued	
Main body—Continued	
14. Sandstone, light-gray, very fine to fine-grained, fairly well sorted, subangular, very soft, very friable; abundant large grains of muscovite and biotite; weathers gold brown; scattered *Gyraulus militaris* on the surface; flood-plain (stream channel) deposit	4.0
Vertebrate locality 860 located in NW¼SW¼ SW¼ sec. 20, T. 16 N., R. 101 W.:	
Primitive sciuravid and paramyid rodents cf. *Didymictis protenus* Undet. Creodonts *Haplomylus speirianus* *Hyopsodus* cf. *miticulus* *Meniscotherium* cf. *priscum* *Hyracotherium* sp. *Tetonius homunculus* *Diacodexis* cf. *metsiacus*	
13. Sandstone, light-gray, very fine to fine-grained, fairly well sorted, subangular, soft, friable; abundant large grains of muscovite and biotite; weathers to gold-brown, massive bench; base of the unit has an ant hill composed of about 95 percent mammal bones and tooth fragments; flood-plain (stream channel) deposit	18.7
12. Shale, dark-gray, fissile, soft; flood-plain (basin-fill) deposit	3.0
11. Siltstone, gray, limy, hard; flood-plain (splay) deposit	1.2
10. Mudstone, dark-gray to dark-gray-green, blocky, silty, soft; flood-plain (basin-fill) deposit	5.1
9. Sandstone, light-gray, very fine to fine-grained, fairly well sorted, subangular, soft, friable; large muscovite and biotite grains; scattered red and black grains; lenses of clay pebble conglomerate throughout; large-scale trough crossbedding in lower part and festoon cross-bedding at the top; weathers gold brown; flood-plain (stream channel) deposit	86.0
8. Mudstone, dark-gray-green, clayey, blocky, soft; flood-plain (basin-fill) deposit	8.8
7. Sandstone, light-gray, very fine to fine-grained, subangular, fairly well sorted, firm, friable; large grains of muscovite and biotite; weathers to light-tan-brown ledge; flood-plain (splay) deposit	4.0
6. Mudstone, medium-gray, blocky, soft, becomes very silty the top 8.0 ft; flood-plain deposits	28.9
5. Limestone, tan-gray, very silty, crumbly, hard; contains a few *Oreohelix* sp., and other mollusk fragments; freshwater lacustrine (pond) deposit	2.4
4. Shale, gray-brown, sandy, soft; abundant limy nodules near the top; flood-plain (basin-fill) deposits	7.6
Vertebrate locality 460 *Hyracotherium* sp.	

Reference section of Eocene rocks in the Washakie basin—Continued

	Thickness Feet
Wasatch Formation—Continued	
Main body—Continued	
3. Sandstone, light-gray, very fine grained, well-sorted, subangular, slightly calcareous at the top, firm, friable; abundant large muscovite grains, scattered black grains; flood-plain (stream channel) deposit	10.1
Total thickness of main body of Wasatch Formation	1,691.5
Fort Union Formation:	
Contact with the overlying Wasatch Formation is on the lower east slopes of Burley Draw in east-center of NE¼SW¼ sec. 19, T. 16 N. R. 101 W. The Fort Union Formation was deposited in flood-plain and swamp environments, and outcrops weather rust and gray. The Fort Union Formation contains abundant beds of carbonaceous shale and coal—the Wasatch Formation in this area does not.	
2. Covered by Quaternary alluvium in the valley of Burley Draw; appears to be gray, sandy shale.	20.0
1. Sandstone, light-gray, very fine to fine-grained, subangular, fairly well sorted, biotitic, slightly calcareous, firm; some black and red grains	1.5
Total measured thickness of Fort Union Formation	21.5

REFERENCES CITED

Bradley, W.H., 1928, Zeolites in the Green River Formation: Science, v. 67, p. 73–74.

_____ 1945, Geology of the Washakie basin, Sweetwater and Carbon Counties, Wyoming, and Moffat County, Colorado: U.S. Geological Survey Preliminary Oil and Gas Investigations Map 32, scale 1 inch=3 miles.

_____ 1964, Geology of Green River and associated Eocene rocks in southwestern Wyoming and adjacent parts of Colorado and Utah: U.S. Geological Survey Professional Paper 496–A, 86 p.

Bradley, W.H., and Fahey, J.J., 1962, Occurrence of stevensite in the Green River Formation of Wyoming: The American Mineralogist, v. 47, nos. 7–8, p. 996–998.

Culbertson, W.C., 1962, Laney Shale Member and Tower Sandstone Lentil of the Green River Formation, Green River Area, Wyoming: U.S. Geological Survey Professional Paper 450–C, p. C54–C57.

Deer, W.A., Howie, R.A., and Zussman, J., 1962, Chlorite, *in* Rock-forming minerals: London, William Clowes and Sons, p. 131–158.

Dyni, J.R., 1976, Trioctahedral smectite in the Green River Formation, Duchesne County, Utah: U.S. Geological Survey Professional Paper 967, 14 p.

Evernden, J.F., Savage, D.E., Curtis, G.H., and James, G.T., 1964, Potassium-argon dates and the Cenozoic mammalian chronology of North America: American Journal of Science, v. 262, no. 2, p. 145–198.

Gazin, C.L., 1959, Paleontological exploration and dating of the early Tertiary deposits in basins adjacent to the Uinta Mountains, *in* Williams, N.C., ed., Intermountain Association of Petroleum Geologists Guidebook, 10th Annual Field Conference, Wasatch and Uinta Mountains: Salt Lake City, Utah, p. 131–138.

_____ 1962, A further study of the lower Eocene mammalian faunas of southwestern Wyoming: Smithsonian Miscellaneous Collections, v. 144, no. 1, 98 p.

Goodwin, J.H., and Surdam, R.C., 1967, Zeolitization of tuffaceous rocks of the Green River Formation, Wyoming: Science, v. 157, no. 3786, p. 307–308.

Granger, Walter, 1909, Faunal horizons of the Washakie Formation of southern Wyoming: American Museum of Natural History Bulletin, v. 26, art. 3, p. 13–23.

Hay, R.L., 1966, Zeolites and zeolitic reactions in sedimentary rocks: Geological Society of America Special Paper 85, 130 p.

Johannsen, Albert, 1914, Petrographic analysis of the Bridger, Washakie, and other Eocene formations of the Rocky Mountains: American Museum of Natural History Bulletin, v. 33, art. 16, p. 209–222.

King, Clarence, 1877, Report of the U.S. Geological Exploration of the 40th Parallel, volume II, Descriptive geology: p. 202–229.

Kistner, F.B., 1973, Stratigraphy of the lower part of the Bridger Formation in the Big Island–Blue Rim Area, Sweetwater County, Wyoming: Laramie, Wyo., University of Wyoming M.A. thesis, 86 p.

Koenig, K.J., 1960, Bridger Formation in the Bridger basin, Wyoming, *in* McGookey, D.P., and Miller, D.N., Jr., eds., Wyoming Geological Association Guidebook, 15th Annual Field Conference, Overthrust belt of southwestern Wyoming and adjacent areas: Casper, Wyo., p. 163–168.

Leopold, E.B., and MacGinitie, H.D., 1972, Development and affinities of Tertiary floras in the Rocky Mountains, *in* Floristics and paleofloristics of Asia and Eastern North America: Amsterdam, Netherlands, Elsevier, p. 147–200.

Leventhal, J.S., and Finkelman, R.B., 1987, Uranium in the Vermillion Creek core samples, chapter J *in* Roehler, H.W., and Martin, P.L., eds., Geological investigations of the Vermillion Creek Coal Bed in the Eocene Niland Tongue of the Wasatch Formation, Sweetwater County, Wyoming: U.S. Geological Survey Professional Paper 1314, p. 171–178.

Matthew, W.D., 1909, The Carnivora and Insectivora of the Bridger basin, Middle Eocene: American Museum of Natural History Memoirs, v. 9, pt. 6, p. 291–567.

Mauger, R.L., 1977, K-Ar ages of biotites from tuffs in Eocene rocks of the Green River, Washakie, and Uinta basins, Utah, Wyoming, and Colorado: University of Wyoming Contributions to Geology, v. 15, no. 1, p. 17–41.

McGrew, P.O., and Roehler, H.W., 1960, Correlation of Tertiary units in southwestern Wyoming, *in* McGookey, D.P., and Miller, D.N., Jr., eds., Wyoming Geological Association Guidebook, 15th Annual Field Conference, Overthrust belt of southwestern Wyoming and adjacent areas: Casper, Wyo., p. 156–158.

Mercer, B.W., 1969, Clinoptilolite in water-pollution control: The Ore Bin, v. 31, no. 11, p. 209–213.

Minato, Hideo, and Utada, Minoru, 1969, Zeolite, *in* The clays of Japan: Japan Geological Survey, p. 121–134.

Osborn, H.F., 1929, The titanotheres of ancient Wyoming, Dakota, and Nebraska: U.S. Geological Survey Monograph 55, v. 1, 701 p.

Parker, R.B., and Surdam, R.C., 1971, A summary of authigenic silicates in tuffaceous rocks of the Green River Formation, *in* University of Wyoming Contributions to Geology, Trona Issue: v. 10, no. 1, p. 69–72.

Roehler, H.W., 1965, Early Tertiary depositional environments in the Rock Springs uplift area, *in* DeVoto, R.H., and Bitter, R.K., Wyoming Geological Association Guidebook, 19th Annual Field Conference, Sedimentation of Late Cretaceous and Tertiary outcrops, Rock Springs uplift: Casper, Wyo., p. 140–150.

_____ 1969, Stratigraphy and oil-shale deposits of Eocene rocks in the Washakie basin, Wyoming, *in* Barlow, J.A., Jr., ed., Wyoming Geological Association Guidebook, 21st Field Conference, Symposium on Tertiary rocks of Wyoming: Casper, Wyo., p. 197–206.

_____ 1970, Nonopaque heavy minerals from sandstone of Eocene age in the Washakie basin, Wyoming: U.S. Geological Survey Professional Paper 700–D, p. D181–D187.

_____ 1972, Zonal distribution of montmorillonite and zeolites in the Laney Shale Member of the Green River Formation in the Washakie basin, Wyoming: U.S. Geological Survey Professional Paper 800–B, p. B121–B124.

_____ 1973a, Stratigraphic divisions and geologic history of the Laney Member of the Green River Formation in the Washakie basin in southwestern Wyoming: U.S. Geological Survey Bulletin 1372–E, 28 p.

_____ 1973b, Stratigraphy of the Washakie Formation in the Washakie basin, Wyoming: U.S. Geological Survey Bulletin 1369, 40 p.

_____ 1973c, Mineral resources in the Washakie basin, Wyoming and Sand Wash basin, Colorado, *in* Schell, E.M., ed., Wyoming Geological Association Guidebook, 25th Field Conference, Symposium and core seminar on the geology and mineral resources of the greater Green River basin: Casper, Wyo., p. 47–56.

_____ 1974, Depositional environments of rocks in the Piceance Creek basin, Colorado, *in* Murray, D.K., ed., Rocky Mountain Association of Geologists Guidebook, 25th Field Conference, Energy Resources of the Piceance Creek basin: Denver, Colo., p. 57–64.

_____ 1981, Correlation of Eocene rocks in measured sections in the southeast and west parts of the Rock Springs coal field, Wyoming: U.S. Geological Survey Oil and Gas Investigations Chart OC–111, 2 sheets.

_____ 1985, Geological map of the Kinney Rim 30×60 minute quadrangle, Wyoming and Colorado: U.S. Geological Survey Miscellaneous Investigations Map I–1615, scale 1:100,000.

_____ 1989, Cross section of the intertongued Wasatch and Green River Formations across the central part of the Sand Wash basin, Colorado, and the eastern part of the Washakie basin, Wyoming: U.S. Geological Survey Miscellaneous Field Investigations Map MF–2106.

Roehler, H.W., and Trudell, L.G., 1981, Surface-subsurface correlations of the Eocene Green River Formation, on the west flank of the Rock Springs uplift, Sweetwater County, Wyoming: U.S. Geological Survey Miscellaneous Field Investigations Map MF–1308.

Rogers, A.F., and Kerr, P.F., 1942, Optical mineralogy: New York, McGraw-Hill, 390 p.

Salvador, Amos, 1985, Chronostratigraphic and geochronometric scales in COSUNA stratigraphic correlation charts of the United States: American Association of Petroleum Geologists Bulletin, v. 69, no. 2, p. 181–189.

Sato, Yoshiaki, and Denson, N.M., 1967, Volcanism and tectonism as reflected by the distribution of nonopaque heavy minerals in some Tertiary rocks of Wyoming and adjacent States, *in* Geological Survey research 1967: U.S. Geological Survey Professional Paper 575–C, p. C42–C54.

Schultz, A.R., 1920, Oil possibilities in and around Baxter basin, in the Rock Springs uplift, Sweetwater County, Wyoming: U.S. Geological Survey Bulletin 702, 107 p.

Sears, J.D., and Bradley, W.H., 1925, Relations of the Wasatch and Green River Formations in northwestern Colorado and southern Wyoming, with notes on oil shale in the Green River Formation: U.S. Geological Survey Professional Paper 132, p. 93–107.

Sheppard, R.A., 1971, Zeolites in sedimentary deposits of the United States—A review: American Chemical Society, Advances in Chemistry Series, no. 101, p. 279–310.

Sinclair, W.J., 1909, The Washakie, a volcanic ash formation: American Museum of Natural History, v. 26, art. 4, p. 25–27.

Sullivan, Raymond, 1980, A stratigraphic evaluation of the Eocene rocks of southwestern Wyoming: Geological Survey of Wyoming Report of Investigations 20, 50 p.

Trudell, L.G., Roehler, H.W., and Smith, J.W., 1973, Geology of Eocene rocks and oil yields of Green River oil shales on part of Kinney Rim, Washakie basin, Wyoming: U.S. Bureau of Mines Report of Investigations RI–7775, 151 p.

Turnbull, W.D., 1978, The mammalian faunas of the Washakie Formation, Eocene age, of southern Wyoming, Part I, Introduction: Fieldiana Geology, Field Museum of Natural History, v. 33, no. 30, p. 569–601.

West, R.M., 1976, Paleontology and geology of the Bridger Formation, southern Green River basin, southwestern Wyoming, Part 1, History of field work and geological setting: Milwaukee Public Museum Contributions in Biology and Geology 7, p. 1–12.

Winchester, D.E., 1923, Oil shale of the Rocky Mountain region: U.S. Geological Survey Bulletin 729, 204 p.

Wood, H.E., 2nd, Chaney, R.W., Clark, John, Colbert, E.H., Jepsen, G.L., Reeside, J.B., Jr., and Stock, Chester, 1941, Nomenclature and correlation of the North American continental Tertiary: Geological Society of America Bulletin, v. 52, no. 1, p. 1–48.

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