Revised Stratigraphic Nomenclature for the Wasatch and Green River Formations of Eocene Age, Wyoming, Utah, and Colorado

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Revised Stratigraphic Nomenclature for the Wasatch and Green River Formations of Eocene Age, Wyoming, Utah, and Colorado

By HENRY W. ROEHLER

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

U.S. GEOLOGICAL SURVEY PROFESSIONAL PAPER 1506-B

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By HENRY W. ROEHLER

ABSTRACT

The nomenclature of the Eocene Wasatch and Green River Formations is revised in the greater Green River basin to correct major problems involving the definition and correlation of stratigraphic units. To implement these revisions, the names Alkali Creek Tongue of the Wasatch Formation, Farson Sandstone Member of the Green River Formation, and Scheggs and Rife Beds of the Tipton Shale Member of the Green River Formation are introduced. The nomenclature revisions are necessary to establish an acceptable stratigraphic framework that permits the accurate interpretation of the sedimentary and tectonic evolution of the basin and the origin and distribution of mineral resources.

INTRODUCTION

The greater Green River basin is an intermontane desert basin that occupies about 20,000 mi^2 of southwest Wyoming, northeast Utah, and northwest Colorado. It is bounded on the west by the Wyoming thrust belt, on the north by the Wind River Mountains and Sweetwater arch, on the east by the Rawlins uplift and Sierra Madre, and on the south by the Uinta Mountains. The basin is divided by the Rock Springs uplift into the Green River basin to the west and the Great Divide, Washakie, and Sand Wash basins to the east. Major structural features, towns and cities, and townships and ranges are indicated on a generalized index map, figure 1. A detailed description of the geologic and geographic setting of the greater Green River basin is given in chapter A of this volume.

Manuscript approved for publication September 26, 1989.

The stratigraphic nomenclature of the intertongued Wasatch and Green River Formations has undergone numerous revisions in the greater Green River basin since the formations were named by Hayden (1869). New tongue and member names have been added or abandoned and the boundaries of others redefined. Some of the most important nomenclature revisions are recorded in publications by Schultz (1920), Bradley (1926), Donavan (1950), Pipiringos (1955), and Bradley (1959). The Wasatch and Green River Formations cannot be satisfactorily studied in the greater Green River basin unless an acceptable stratigraphic framework is established that allows for the clear definition and basinwide correlation of lithostratigraphic and chronostratigraphic units. For that reason, I am revising the nomenclature to resolve two outstanding problems: the definition and correlation of (1) tongues and members of the Wasatch and Green River Formations along the western margins of the Green River basin, and (2) the Tipton Shale Member everywhere in the greater Green River basin. To implement these revisions, I am introducing the new names Alkali Creek Tongue of the Wasatch Formation, Farson Sandstone Member of the Green River Formation, and Scheggs and Rife Beds of the Tipton Shale Member of the Green River Formation. The continued use of the names New Fork Tongue, Desertion Point Tongue, and upper tongue of the Wasatch Formation, and Fontenelle Tongue, upper Tipton Shale Member, middle tongue, and upper tongue of the Green River Formation is discouraged.

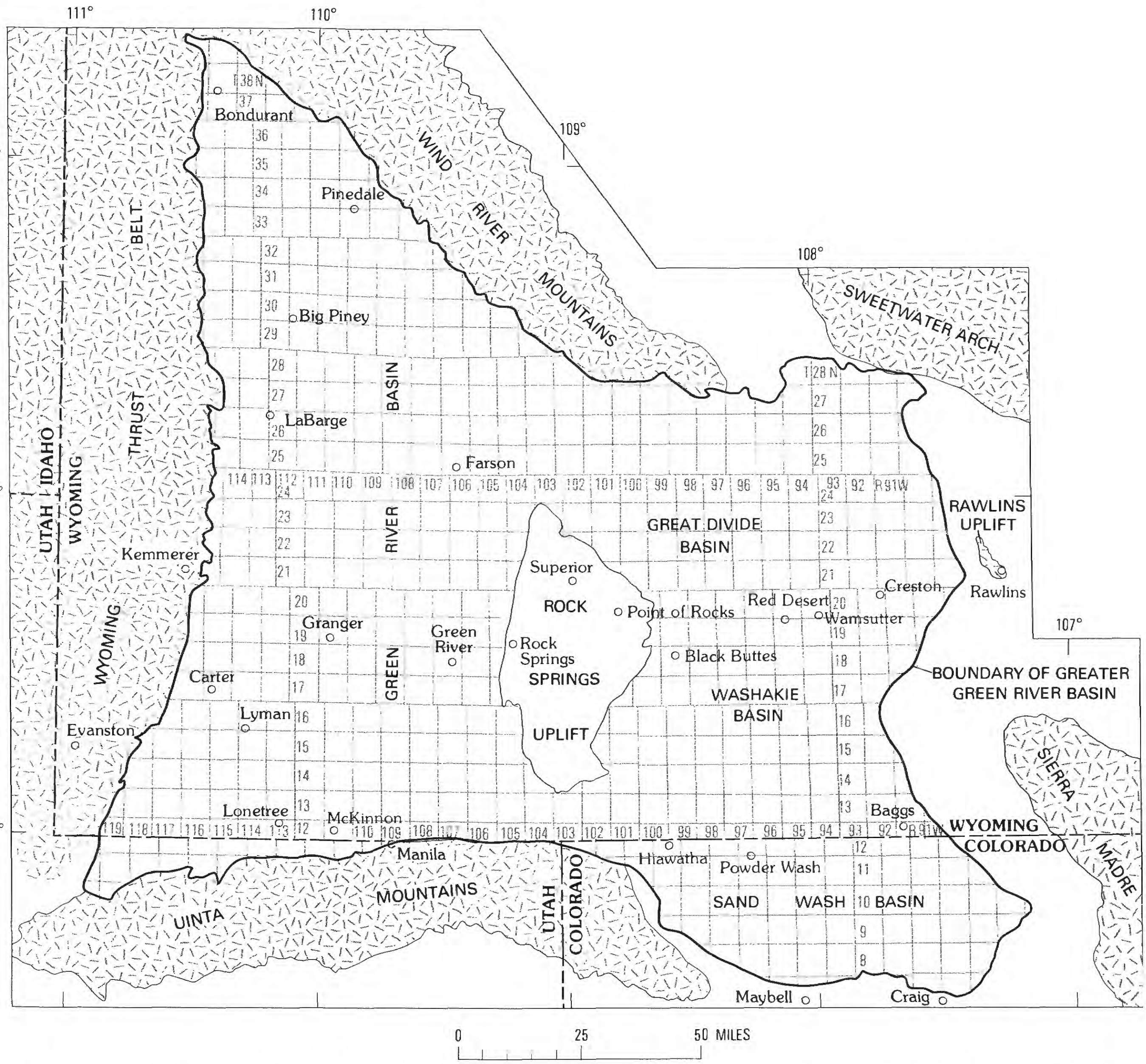


FIGURE 1.—Generalized index map of greater Green River basin showing locations of major structural features, towns and cities, and townships and ranges.

NOMENCLATURE OF THE INTERTONGUED WASATCH AND GREEN RIVER FORMATIONS ALONG THE WESTERN MARGINS OF THE GREEN RIVER BASIN

HISTORY

The Wasatch and Green River Formations were divided into tongues and members along the western margins of the Green River basin by Donavan (1950). Variegated clay and arkosic sandstone that underlie the lowest member of the Green River Formation were placed by him in the Knight Member (main body) of the Wasatch Formation, which had been previously named by Veatch (1907). Donavan applied the name Fontenelle Member (or Tongue) of the Green River Formation to a 246-ft-thick sequence of alternating buff-brown sandstone and green and gray mudstone that conformably overlies the Knight Member south of Fontenelle Creek in sec. 13, T. 24 N., R. 115 W. (Donavan, 1950, p. 21, 40–41). A 300-ft-thick sequence of variegated clay, shale, sandstone and arkosic conglomerate overlying the Fontenelle Tongue near the Green River–New Fork River junction in sec. 35, T. 30 N., R. 110 W. was named the New Fork Tongue of the Wasatch Formation (Donavan, 1950, p. 23–24). Lacustrine limestone, siltstone, shale, and oil shale overlying the New Fork Tongue were assigned to the Laney Member of the Green River Formation that had been named earlier by Schultz (1920). The nomenclature applied by Donavan is shown on a correlation diagram, figure 2. Donavan (1950) mapped the tongues and members of the Wasatch and Green River Formations from T. 30 N., R. 110 W. at the north, southward to T. 22 N., R. 114 W., a distance of about 75 mi.

The nomenclature of the Wasatch and Green River Formations applied by Donavan (1950) was modified by Oriel (1961). Most of Oriel's work centered in the Fort Hill quadrangle located southwest of La Barge, Wyo., where he recognized two tongues of the Wasatch Formation and three tongues of the Green River Formation. Oriel retained the names main body of the Wasatch Formation (divided locally into the La Barge and Chappo Members), Fontenelle Tongue, and New Fork Tongue. However, he restricted use of the name Fontenelle Tongue to the basal 50–60 ft of strata assigned to the tongue by Donavan (Oriel, 1961, p. B151). The stratigraphic units overlying Oriel's redefined Fontenelle Tongue were called the New Fork Tongue and upper tongue of the Wasatch Formation and the middle and upper tongues of the Green River Formation (fig. 2). Oriel (1961, p. B151) described the New Fork Tongue as a 250-ft-thick sequence of green and gray mudstone with numerous lenses of yellow, buff, and brown sandstone. In his middle tongue of the Green River Formation he combined two "readily distinguishable" units: "a lower white unit composed mainly of white-weathering low-grade oil shale and white to gray limestone, and an upper buff to brown, locally pink, gray or white limestone, marlstone, mudstone, siltstone, and sandstone unit" (Oriel, 1961, p. B151). The name upper tongue of the Wasatch Formation was given to a 200-ft-thick wedge of fluvial gray mudstone and yellow to brown sandstone overlying the middle tongue of the Green River Formation. The upper tongue of the Green River Formation was described as tan, yellow to brown and gray limestone, marlstone, mudstone, siltstone, and sandstone containing ostracodes, gastropods, and algae, situated between the upper tongue of the Wasatch Formation and the overlying Bridger Formation.

Lawrence (1963) used the earlier nomenclature established by Oriel (1961). He divided the Wasatch Formation into the main body at the base with two overlying tongues, the New Fork Tongue and upper tongue (fig. 2). The Green River Formation was divided into the Fontenelle Tongue at the base and the overlying middle and upper tongues. The stratigraphic relationships envisioned by Lawrence along the west margins of the basin are shown in figure 3. Lawrence (1963, p. 154) believed that the New Fork Tongue was underlain by the Fontenelle Tongue and overlain by the middle tongue of the Green River Formation. However, in the southern part of the area near Carter, Wyo., the New Fork Tongue was believed to wedge out, and the middle tongue of the Green River Formation there was thought to rest upon the Fontenelle Tongue (note the dashed contact in fig. 3). Lawrence also believed that the middle tongue of the Green River Formation was underlain by the New Fork Tongue and overlain by the upper tongue of the Wasatch Formation, except in the vicinity of Big Piney, Wyo., to the north, where the upper tongue of the Wasatch Formation wedges out and the middle and upper tongues of the Green River Formation converge (fig. 3). Lawrence (1963, p. 154) assumed that part or all of the middle tongue of the Green River Formation was equivalent to the Wilkins Peak Member of the Green River Formation.

The stratigraphy of Eocene rocks in southwest Wyoming was reviewed by Sullivan (1980). The stratigraphic units recognized by him along the western margins of the Green River basin generally correspond to those identified earlier by Lawrence (1963), but he modified most of the nomenclature assignments (fig. 2). He thought the name Fontenelle Tongue of the Green River Formation should be discarded. He reassigned rocks formerly called Fontenelle Tongue by Lawrence to the Tipton Shale Member of the Green River Formation, the middle tongue of the Green River Formation to the Wilkins Peak Member of the Green River Formation, the upper tongue of the Wasatch Formation to a newly named Desertion Point Tongue of the Wasatch Formation, and the upper tongue of the Green River Formation to the Laney Member of the Green River Formation (Sullivan, 1980, figs. 10, 24).

PROPOSED REVISIONS

The nomenclature employed by Donavan (1950), Oriel (1961), and Lawrence (1963) for the intertongued Wasatch and Green River Formations along the western margins of the Green River basin has long troubled me. The fluvial tongues of the Wasatch Formation there did not correlate to their stratigraphic counterparts in the eastern Green River basin, and lake sequences

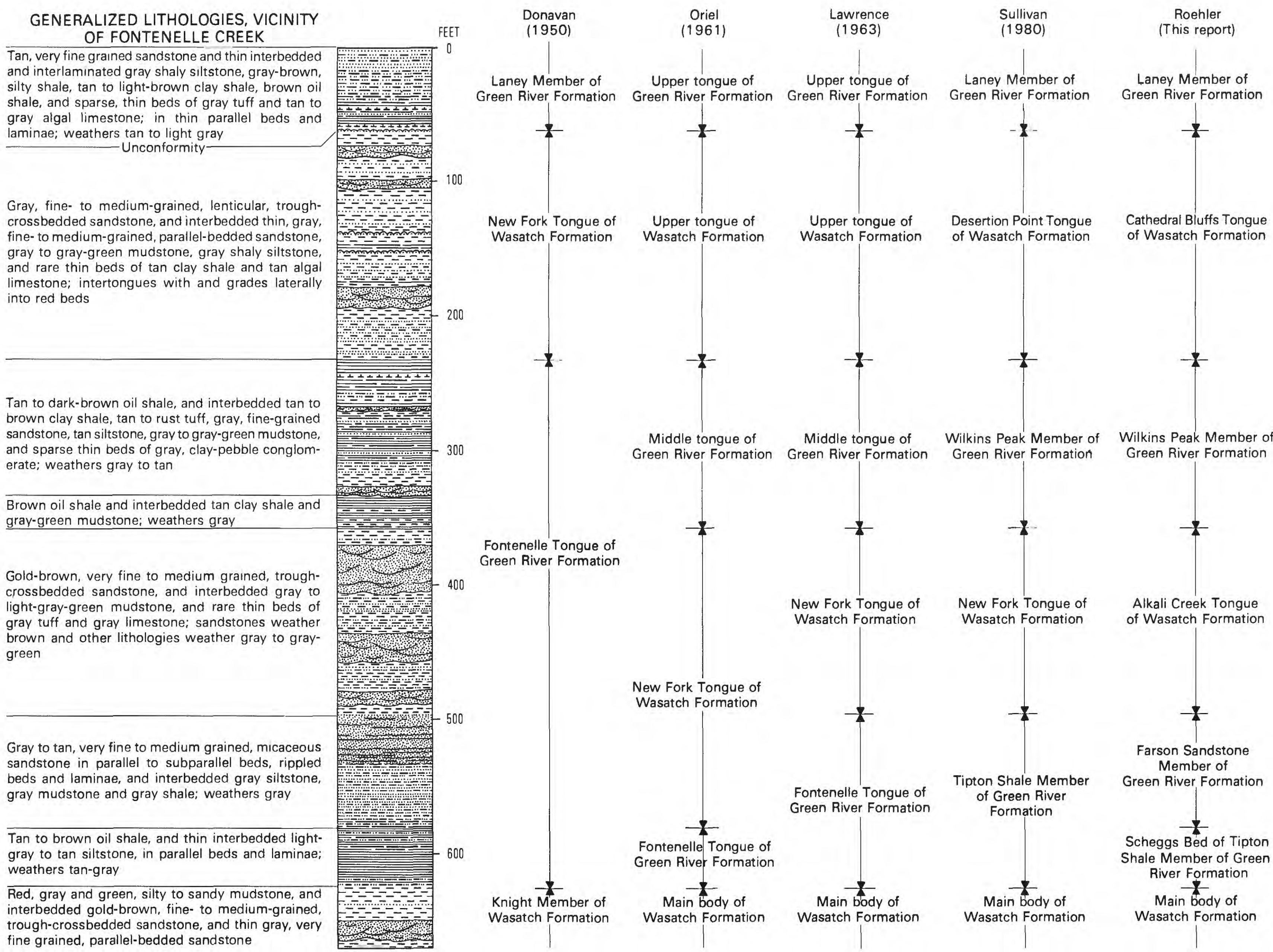


FIGURE 2.—Nomenclature of the Wasatch and Green River Formations along western margins of Green River basin.

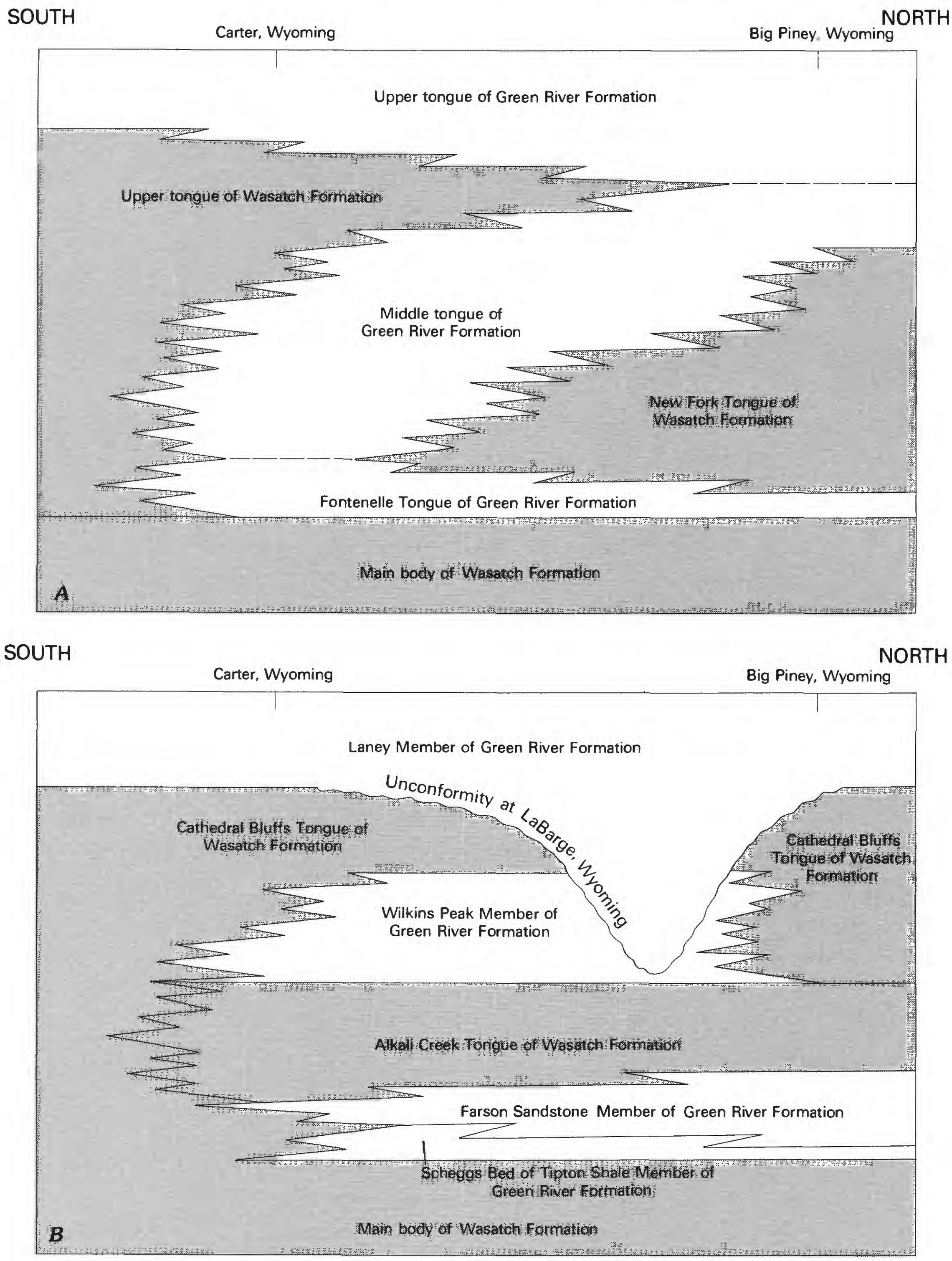


FIGURE 3.—Cross sections showing correlations of intertongued Wasatch and Green River Formations along western margins of Green River basin. *A*, modified from Lawrence (1963); *B*, Roehler (this report). The Wasatch Formation is shaded. Not to scale.

comprising the Green River Formation migrated strangely southward and then back northward in ascending succession along outcrops (see Fontenelle and middle tongues of the Green River Formation, fig. 3). In an attempt to understand these peculiar relationships, a number of sections were measured along the outcrops down the western margins of the basin (Roehler, 1989). The first two sections measured were remeasurements of the type locality of the Fontenelle Tongue of the Green River Formation at Fontenelle Creek and the New Fork Tongue of the Wasatch Formation of Donavan (1950) at the Green River–New Fork junction. Problems involving the rocks at both localities immediately became apparent. The type Fontenelle Tongue included the unrecognized Tipton Shale Member at its base, a thick lacustrine unit composed chiefly of sandstone near its middle (the Farson Sandstone Member), and an unrecognized fluvial tongue of the Wasatch Formation (the Alkali Creek Tongue) near its top. More than 200 ft of lacustrine rocks overlying the Fontenelle section, that includes the middle tongue of the Green River Formation of Oriel (1961), was included in the interval mapped by Donavan (1950) as the Fontenelle Tongue. Thus the interval mapped by Donavan (1950) as the Fontenelle Tongue includes the Tipton Shale, Farson Sandstone, and Wilkins Peak Members of the Green River Formation, and the Alkali Creek Tongue of the Wasatch Formation of this report.

Donavan (1950, p. 23–24) believed that from the Green River–New Fork junction the New Fork Tongue "interfingers with the Green River Formation in such a way that it thins and disappears to the south." My stratigraphic investigations indicate that the New Fork Tongue thins southward from the junction primarily by erosional truncation below the Laney Member (fig. 3). The stratigraphic position of the unconformity at the base of the Laney Member is discernible in outcrops in the La Barge, Wyo., area by a thick layer of white-weathering algal limestone that rests upon the unconformity and forms a distinct stratigraphic marker bed.

Oriel (1961) recognized that rocks assigned by him to the New Fork Tongue had previously been included in the Fontenelle Tongue by Donavan (1950). He nonetheless moved the stratigraphic position of the New Fork Tongue down in section to the interval occupied by the Alkali Creek Tongue of the Wasatch Formation and the Farson Sandstone Member of the Green River Formation of this report (Oriel, 1961, p. B152). The New Fork Tongue of Oriel (1961) was neither the lithostratigraphic nor chronostratigraphic equivalents of the New Fork Tongue of Donavan (1950). What Oriel (1961) called Fontenelle Tongue is equivalent to what is herein defined as the Scheggs Bed of the Tipton Shale Member.

Oriel (1961, p. B152) may have introduced the name upper tongue of the Wasatch Formation because the unit, although of fluvial origin, lacked the basic red colors normally associated with the Wasatch Formation. His uncertainty concerning the colors was apparent when he wrote, "Rocks considered to be of fluvial origin were assigned to the Wasatch Formation; those of lacustrine origin to the Green River Formation. Lack of assurance regarding the origin of the green mudstone–brown sandstone facies, however, makes adoption of this criterion impractical." Had he correlated the fluvial green mudstone–brown sandstone facies comprising his upper tongue of the Wasatch Formation both to the north and to the south of his study area, he would have seen that the non-red colors grade into the normal red colors associated with the formation.

Another nomenclature problem that has troubled me was why the New Fork Tongue of the Wasatch Formation was older than the upper tongue of the Wasatch Formation (fig. 3) and why neither of these units was the stratigraphic equivalent of the Cathedral Bluffs Tongue. A major retreat of the Green River lakes (Lake Gosiute) that is indicated by the fluvial rocks comprising the Cathedral Bluffs Tongue over the central and eastern parts of the greater Green River basin would seemingly also be represented by a stratigraphically equivalent fluvial tongue along the western margins of the greater Green River basin. I resolved this problem by closely examining the geologic mapping of Donavan (1950) and the stratigraphic correlations of Oriel (1961) and Lawrence (1963). In sections measured by these authors near La Barge, Wyo., the strata were miscorrelated. The middle tongue of the Green River Formation (the Wilkins Peak Member of this report) that is present south of La Barge was correlated with the lower part of the Laney Member north of La Barge. This miscorrelation resulted from the fact that the erosion surface at the base of the Laney Member at La Barge rests upon the lower part of the middle tongue of the Green River Formation (fig. 3). Donavan, Oriel, and Lawrence did not recognize the unconformity. As a result, oil shale beds that are present in the basal part of the middle tongue of the Green River Formation were correlated northward across the unconformity to similar-appearing oil shale beds that are present laterally in outcrops at the base of the Laney Member. If the units are correlated in this way, the New Fork Tongue north of La Barge stratigraphically underlies the middle tongue of the Green River Formation, and the upper tongue of the Wasatch Formation south of La Barge stratigraphically overlies the middle tongue of the Green River Formation (fig. 3). In fact, the New Fork Tongue of Donavan and the upper tongue of the Wasatch Formation are one and the same unit, and both units have been proven by subsurface correlations (see later chapters in this volume) to be the stratigraphic equivalents of the Cathedral Bluffs Tongue. Although Sullivan (1980, p. 13) believed the Desertion Point Tongue of the Wasatch Formation was "a distinct and well definable stratigraphic unit," it now appears that it too is the stratigraphic equivalent of the Cathedral Bluffs Tongue (fig. 2). As the Cathedral Bluffs Tongue was named by Schultz in 1920, it has precedence over the names New Fork Tongue (Donavan, 1950), upper tongue (Oriel, 1961), and Desertion Point Tongue (Sullivan, 1980).

NOMENCLATURE OF THE TIPTON SHALE MEMBER (OR TONGUE) OF THE GREEN RIVER FORMATION

HISTORY

The Tipton Shale Member of the Green River Formation was named by Schultz (1920, p. 30–31) for 200 to 250 ft of fissile shale, conglomerate, oolitic limestone, shale, clay, and sandstone of lacustrine origin that crops out as steps and terraces south of Tipton Station on the Union Pacific Railroad (fig. 4). The locality is in T. 19 N., R. 96 W. at the northern edge of the Washakie basin. According to Schultz the Tipton Shale Member there is underlain by the main body of the Wasatch Formation and overlain by the Cathedral Bluffs Tongue of the Wasatch Formation. Schultz (1920, pl. 1) mapped the Tipton Shale Member around the Rock Springs uplift and Washakie basin and southward into northwest Colorado. Sears and Bradley (1924) changed the name Tipton Shale Member to the Tipton Tongue where the unit is overlain by the Cathedral Bluffs.

The Tipton Tongue was informally divided into upper and lower parts by Pipiringos (1961) during his investigations into uranium-bearing coal deposits in the Great Divide basin (fig. 4). Pipiringos' report included several measured sections and a geologic map of the central part of the Great Divide basin. In describing outcrops at Red Desert Station a few miles east of Tipton Station, he wrote, "The tongue is about 280 ft thick. The lower part consists of low-grade oil shale containing yellow dolomitic(?) limestone concretions and is about 160 ft thick. The upper part consists of loosely cemented sandstone and lesser amounts of clay shale, fine-grained calcareous sandstone, and algal reefs and is about 120 ft thick" (Pipiringos, 1961, p. A29). The contact of the upper and lower parts was mapped by him at the top of the lowest "algal ball zone" in the section. Pipiringos noted that the upper and lower parts of the Tipton Tongue differ strikingly in color and lithologic character.

In 1960 I had the opportunity while exploring for oil and gas to map Eocene outcrops along the flanks of the Rock Springs uplift. This work produced numerous measured sections and several detailed stratigraphic correlations. These correlations revealed that the upper part of the type Tipton Shale Member of Schultz (1920) in the Washakie basin was the lithostratigraphic and chronostratigraphic equivalent of the lower part of the Wilkins Peak Member that had then recently been named by Bradley (1959) on the west flank of the Rock Springs uplift. To correct this discrepancy, I redefined the Tipton Shale Member near Tipton Station and designated a principal reference section that excluded rocks equivalent to the Wilkins Peak Member (Roehler, 1968).

From 1968 to 1986 I was involved in the appraisal of oil shale and coal resources in the greater Green River basin. This work indicated that the Tipton Shale Member as redefined by me in 1968 consists of two lithologically distinct and mappable parts: a light-gray-weathering, saltwater oil shale upper part and a drab-brown-weathering, freshwater oil shale lower part. The upper part is mostly dark brown to black kerogenaceous dolomite characterized by thick and persistent beds of calcareous algal limestone (stromatolites), and very rare occurrences of mollusks. The lower part is mostly soft, fissile, tan to medium-brown kerogenaceous shale characterized by few algal limestones and abundant mollusks. For several reasons herein discussed, the upper saltwater part of the Tipton Shale Member was informally named the Rife bed (Roehler, 1974) and placed by me (Roehler, 1981) in the basal part of the Wilkins Peak Member:

1. *Previous definition of units.*—The Tipton Shale Member was described by Bradley (1959, p. 1073) as the rocks deposited in a "very large freshwater lake." He further stated that deposition in this lake ended when the lake contracted and the water became saline. In a later report Bradley (1969, p. B7) defined the overlying Wilkins Peak Member "as the group of beds lying between the stratigraphically lowest and highest occurrence of saline minerals, or their molds." Following these definitions of the Tipton Shale and Wilkins Peak Members by Bradley, Goodwin (1971, p. 9) reported that "in the Diamond Alkali Company DACO number 1 drill hole (sec. 12, T. 18 N., R. 112 W.) two thin beds of trona were found near the top of the Tipton Shale." The top of the Tipton Shale Member (Rife Bed of this report) in this drill hole thus contains saline minerals associated with the Wilkins Peak Member.

2. *Lithologic similarities.*—The oil shales of the Rife Bed intertongue with green mudflat mudstone around the former margins of the Rife lake. These mudstones are characteristic of the Wilkins Peak Member and are normally mapped in the Wilkins Peak Member. Consequently, based on lithostratigraphy, the Rife Bed and Wilkins Peak Member intertongue and are partly lateral equivalents.

FIGURE 4.—Nomenclature of part of the Wasatch and Green River Formations in northern Washakie basin.

3. *Mappability of contacts.*— The Rife Bed and Wilkins Peak Member both weather light gray in outcrops, and their contact is indistinguishable and generally unmappable.

4. *History of mapping.*—Geologic quadrangle maps in the Rock Springs uplift–Washakie basin area (Roehler, 1985) and the geologic map of Wyoming (Love and Christiansen, 1985) restrict the Tipton Shale Member to the lower freshwater oil shales of the member that include rocks now assigned to the Scheggs Bed.

I now believe that the Rife Bed should be recognized as a distinct member of the Green River Formation and should not be included in either the Wilkins Peak or Tipton Shale Members. However, M.E. MacLachlan (U.S. Geological Survey, written commun., 1989) believes that the Tipton Shale Member "should not be revised again" and I am therefore forced to abandon the name Tipton, or as an alternative, formally name the Rife as the upper bed of the Tipton Shale Member. The latter alternative retains the same contacts for Tipton as those used at the principal reference section (Roehler, 1968). The compositional differences of the rocks that make up the saltwater (Rife Bed) and freshwater (Scheggs Bed) parts of the Tipton Shale Member are discussed later in this chapter.

PROPOSED REVISIONS

To distinguish the two parts of the Tipton Shale Member as it was redefined by me in 1968, the upper oil shale beds of saltwater origin are herein named the Rife Bed of the Tipton Shale Member of the Green River Formation, and the lower oil shale beds of freshwater origin are herein named the Scheggs Bed of the Tipton Shale Member of the Green River Formation (fig. 4). The Rife and Scheggs Beds are in conformable contact across the southern and eastern parts of the greater Green River basin (figs. 5, 6), but are never in contact across the central part of the Green River basin and along the northwest flank of the Rock Springs uplift. On the northwest flank of the Rock Springs uplift, the Rife Bed and Scheggs Bed are separated by a persistent tan sandstone (the Farson Sandstone Member) that thins southward and wedges out in outcrops along White Mountain a few miles northwest of the city of Rock Springs. The Rife Bed, Farson Sandstone Member, and Scheggs Bed were previously combined as the Tipton Shale member (fig. 7) by Schultz (1920) and Bradley (1959) along the northwest flank of the Rock Springs uplift. The Rife Bed and Scheggs Bed were both called the Tipton Shale Member by Culbertson and others (1980), who placed the intervening sandstone (the Farson Sandstone Member) in the New Fork Tongue of the Wasatch Formation. The placement of the intervening

FIGURE 5.—Contact of light-gray-weathering Rife Bed (Tgtr) and brown-weathering Scheggs Bed (Tgts) of the Tipton Shale Member in SE¼ sec. 19, T. 13 N., R. 103 W., south of Rock Springs uplift.

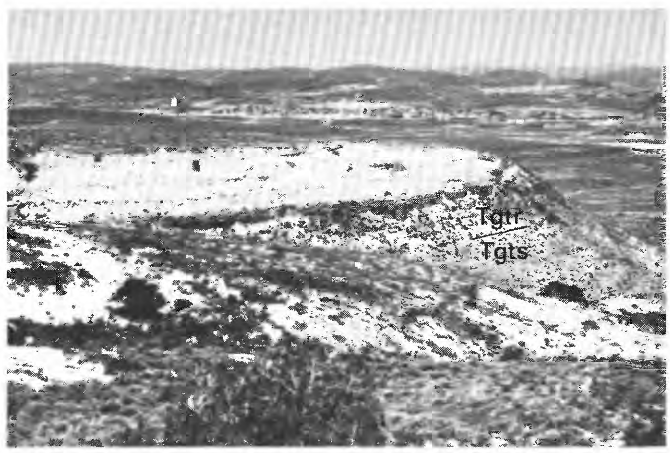


FIGURE 6.—Contact of light-gray-weathering Rife Bed (Tgtr) and brown-weathering Scheggs Bed (Tgts) of the Tipton Shale Member near base of White Mountain, south-center of sec. 30, T. 19 N., R. 105 W., on west flank of Rock Springs uplift. View is east toward city of Rock Springs, Wyo.

sandstone in the New Fork Tongue is unusual, for the sandstone is neither red in color nor fluvial in origin. Along the western margins of the Green River basin, the Alkali Creek Tongue, as well as the Farson Sandstone Member, separates the Rife Bed from the Scheggs Bed (fig. 2).

The contact of the Scheggs and Rife Beds is visible in outcrops along the east slopes of Granary Draw in NW sec. 33, T. 14 N., R. 100 W., in the southwest part of the Washakie basin (fig. 1). At that locality, five oil shale samples were collected for X-ray diffraction analyses and two samples were collected for rapid rock analyses (figs. 8 and 9, tables 1 and 2). The X-ray analyses (table 1) clearly show high concentrations of quartz in the Scheggs

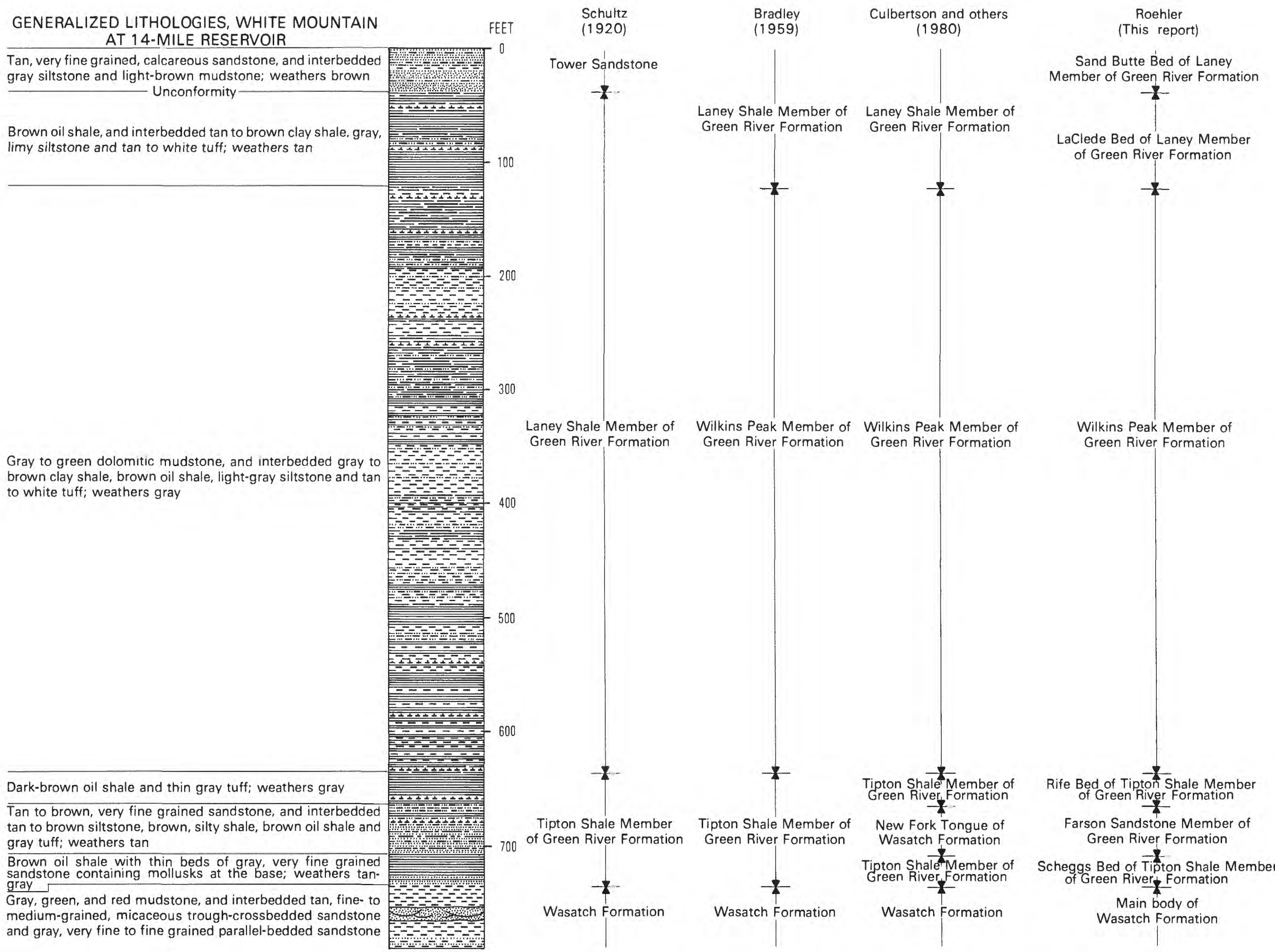


FIGURE 7.—Nomenclature of part of the Wasatch and Green River Formations on northwest flank of Rock Springs uplift.

TABLE 1.—*Peak heights of minerals determined by X-ray diffraction*

[OS, off scale. Samples 1–3, Scheggs bed of Tipton Shale Member; samples 4–5, Rife Bed of Tipton Shale Member. See figures 8 and 9 for the stratigraphic location of the samples]

Sample No.	Quartz	Calcite	Dolomite
5	53	20	66
4	84	0	67
3	OS	3	0
2	OS	47	4
1	OS	13	44

TABLE 2.—*Major constituents of oil shale samples from the Scheggs and Rife Beds of the Tipton Shale Member of the Green River Formation determined by rapid rock analysis (Shapiro and Bannock, 1962)*

[See figures 8 and 9 for locations of sample sites. Values are percent of whole rock]

Rock constituent	Sample No. 2 (Scheggs Bed)	Sample No. 5 (Rife Bed)
SiO_2	53.2	29.1
Al_2O_3	16.0	7.0
Fe_2O_3	3.5	1.3
FeO	.88	1.4
MgO	1.6	7.0
CaO	.40	16.0
Na_2O	.46	.25
K_2O	2.5	2.3
H_2O+	5.8	3.7
H_2O-	3.7	1.4
TiO_2	.67	.30
P_2O_5	.18	.07
MnO	.00	.07
CO_2	<.05	17.8
Other volatiles	11.2	12.4

FIGURE 8.—Contact of light-gray-weathering Rife Bed (Tgtr) and brown-weathering Scheggs Bed (Tgts) of the Tipton Shale Member of the Green River Formation in NW¼ sec. 33, T. 14 N., R. 100 W., along east slopes of Granary Draw, southwest part of Washakie basin. Sites where samples were collected for analysis are numbered 1–5. Lithologies are illustrated in figure 9.

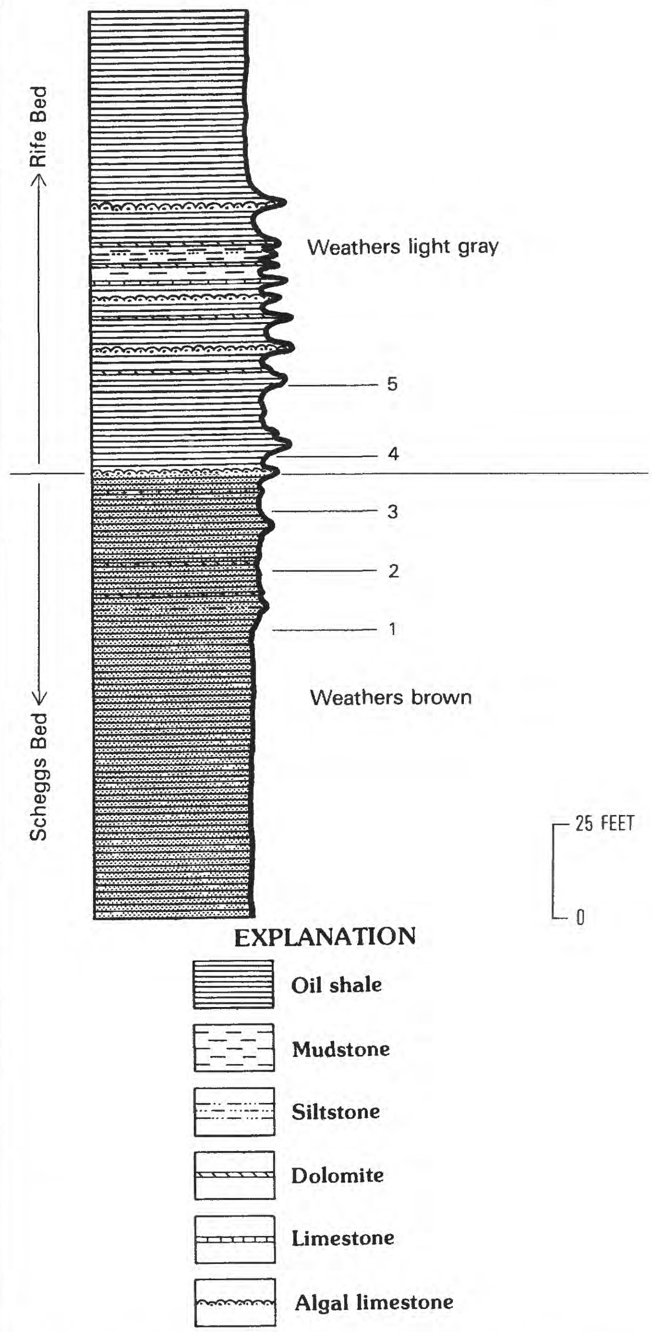
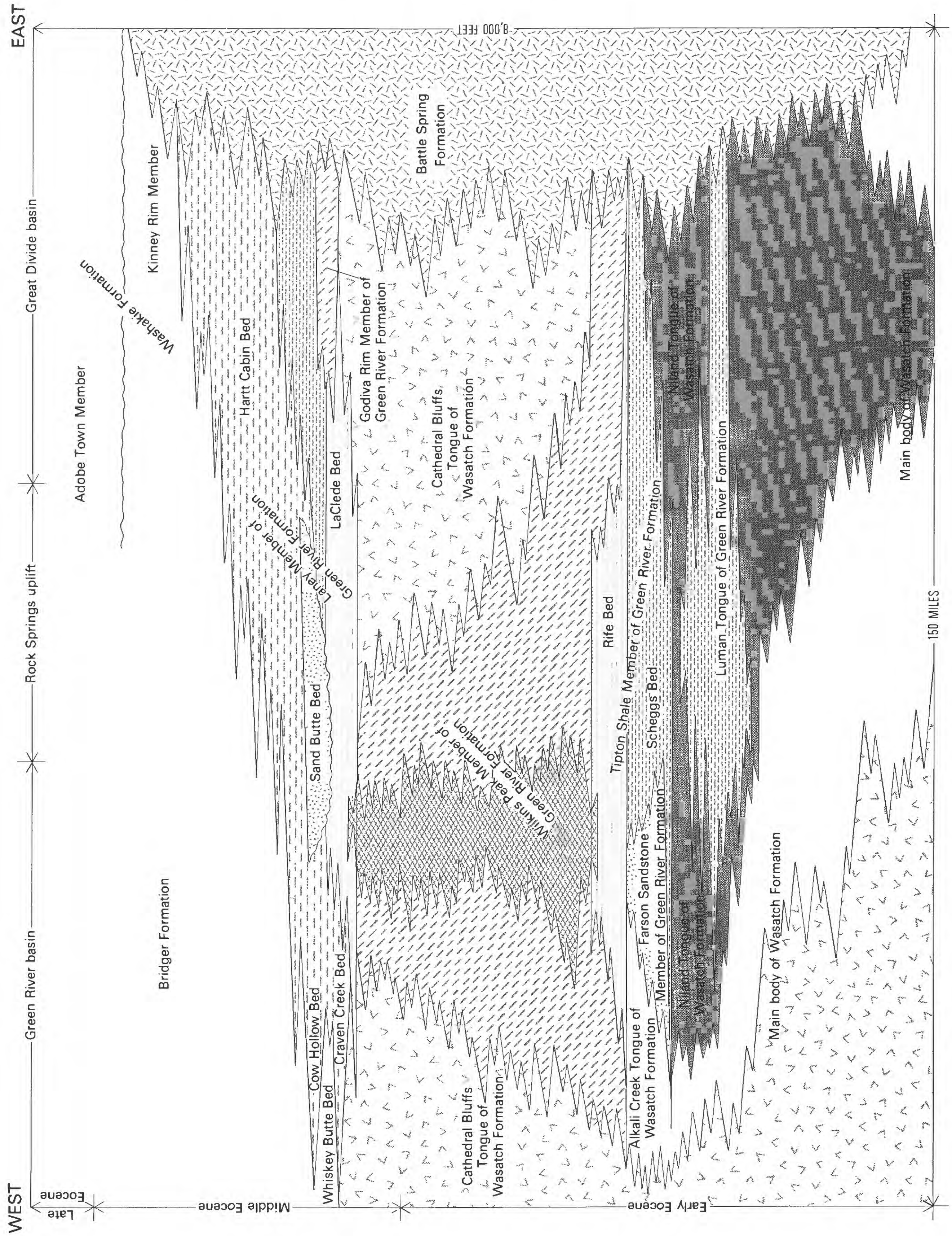


FIGURE 9.—Stratigraphic section across contact of the Scheggs and Rife Beds of the Tipton Shale Member of the Green River Formation on east slopes of Granary Draw. Sample collection sites are numbered 1–5. Scheggs Bed patterns shaded to indicate darker color. Photograph of outcrops at the locality, figure 8.

Bed and high concentrations of dolomite in the Rife Bed. The rapid rock analyses (table 2) indicate a high percentage of SiO_2 and low percentages of MgO, CaO, and CO_2 in the Scheggs Bed (typical of shale) and high percentages of MgO, CaO, and CO_2 in the Rife Bed (typical of dolomite). Additional information concerning


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
Battle Spring Formation
Hartt Cabin Bed
Laney Member of Green River Formation
LaClede Bed
Sand Butte Bed
Godiva Rim Member of Green River Formation
Cathedral Bluffs Tongue of Wasatch Formation
Wilkins Peak Member of Green River Formation
Rife Bed
Tipton Shale Member of Green River Formation
Scheggs Bed
Farson Sandstone Member of Green River Formation
Niland Tongue of Wasatch Formation
Luman Tongue of Green River Formation
Main body of Wasatch Formation
Cow Hollow Bed
Whiskey Butte Bed
Craven Creek Bed
Alkali Creek Tongue of Wasatch Formation

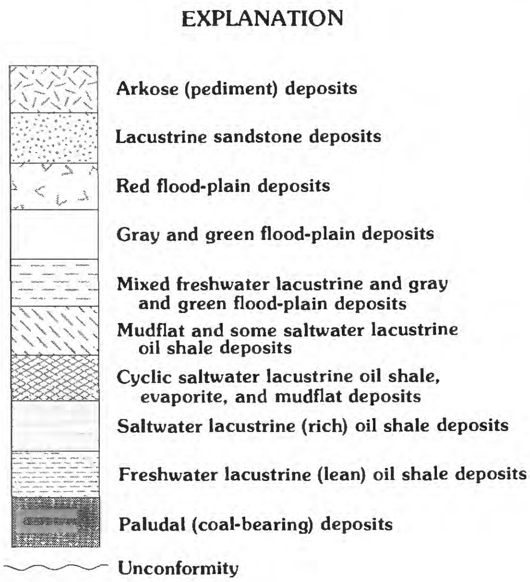


FIGURE 10 (above and facing page).—West-east stratigraphic correlation of Eocene rocks across greater Green River basin. Not to scale.

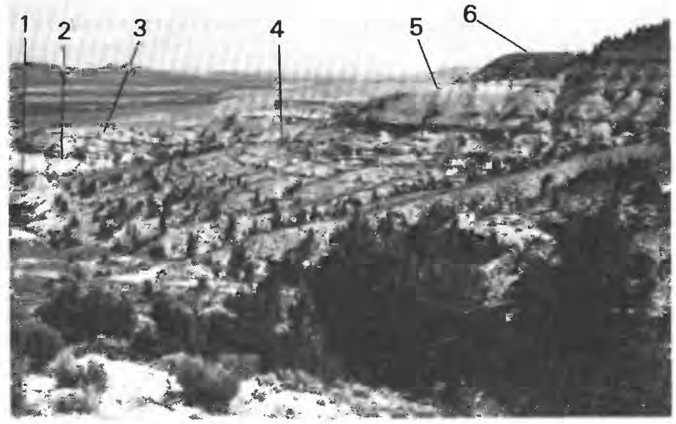


FIGURE 11.—Outcrops of the Wasatch and Green River Formations in bluffs east of the Green River, 1.5 mi northeast of La Barge, Wyo. View is to the north. 1, red beds in the main body of the Wasatch Formation; 2, gray siltstone ledges in the Scheggs Bed of the Tipton Shale Member; 3, gray and brown sandstone and siltstone in the Farson Sandstone Member; 4, light-gray-green mudstone and siltstone and brown sandstone in the Alkali Creek Tongue; 5, white algal limestone that rests on the unconformity at the base of the Laney Member; and 6, tan, brown, and gray oil shale, siltstone and sandstone in lower part of the Laney Member.

the mineral composition of the Scheggs and Rife Beds is presented in chapter D of this volume.

DESCRIPTION OF NEW STRATIGRAPHIC UNITS

The stratigraphic positions, depositional environments, and intertonguing relationships of the Alkali Creek Tongue of the Wasatch Formation and the Farson Sandstone Member and Scheggs and Rife Beds of the Tipton Shale Member of the Green River Formation are indicated on a west-east cross section of Eocene rocks in the greater Green River basin, figure 10. As indicated in figure 10, the Alkali Creek Tongue intertongues with the Farson Sandstone Member, which in turn intertongues with the Scheggs Bed of the Tipton Shale Member. The three units are all of freshwater origin and are essentially lateral equivalents. The Rife Bed of the Tipton Shale Member of the Green River Formation is of saltwater origin and rests conformably upon the Alkali Creek Tongue, Farson Sandstone Member, and Scheggs Bed of the Tipton Shale Member.

ALKALI CREEK TONGUE OF THE WASATCH FORMATION

The name Alkali Creek Tongue is herein applied to a wedge of interbedded brown, green, and gray sandstone, siltstone, mudstone, and shale, and locally conglomerate lenses situated between the overlying Wilkins Peak Member or Cathedral Bluffs Tongue and the underlying Farson Sandstone Member in outcrops along the northwestern part of the Green River basin (fig. 3). The tongue is well exposed in west-facing escarpments along the west margins of the Green River basin from about 25 mi south of Kemmerer, Wyo., where it loses its identity by intertonguing with red beds comprising the main body of the Wasatch Formation, to the area northeast of Big Piney, Wyo., where it is mostly covered by Quaternary alluvium. Near La Barge, Wyo., it crops out as bright-gray-green mudstone and thin brown sandstone situated between drab-brown-weathering overlying and underlying members of the Green River Formation (fig. 11). The tongue normally is 100–250 ft thick along outcrops, but thins by intertonguing and lateral replacement northwestward (toward the basin margins) with the main body of the Wasatch Formation and southeastward (basinward) with the Farson Sandstone Member of the Green River Formation (fig. 10).

The Alkali Creek Tongue was deposited as a band of northwest-trending sediments, about 25 mi wide, that extended from the front of the Wyoming thrust belt, near Kemmerer, Wyo., to the front of the Wind River Mountains, near Pinedale, Wyo. The Eocene geographic

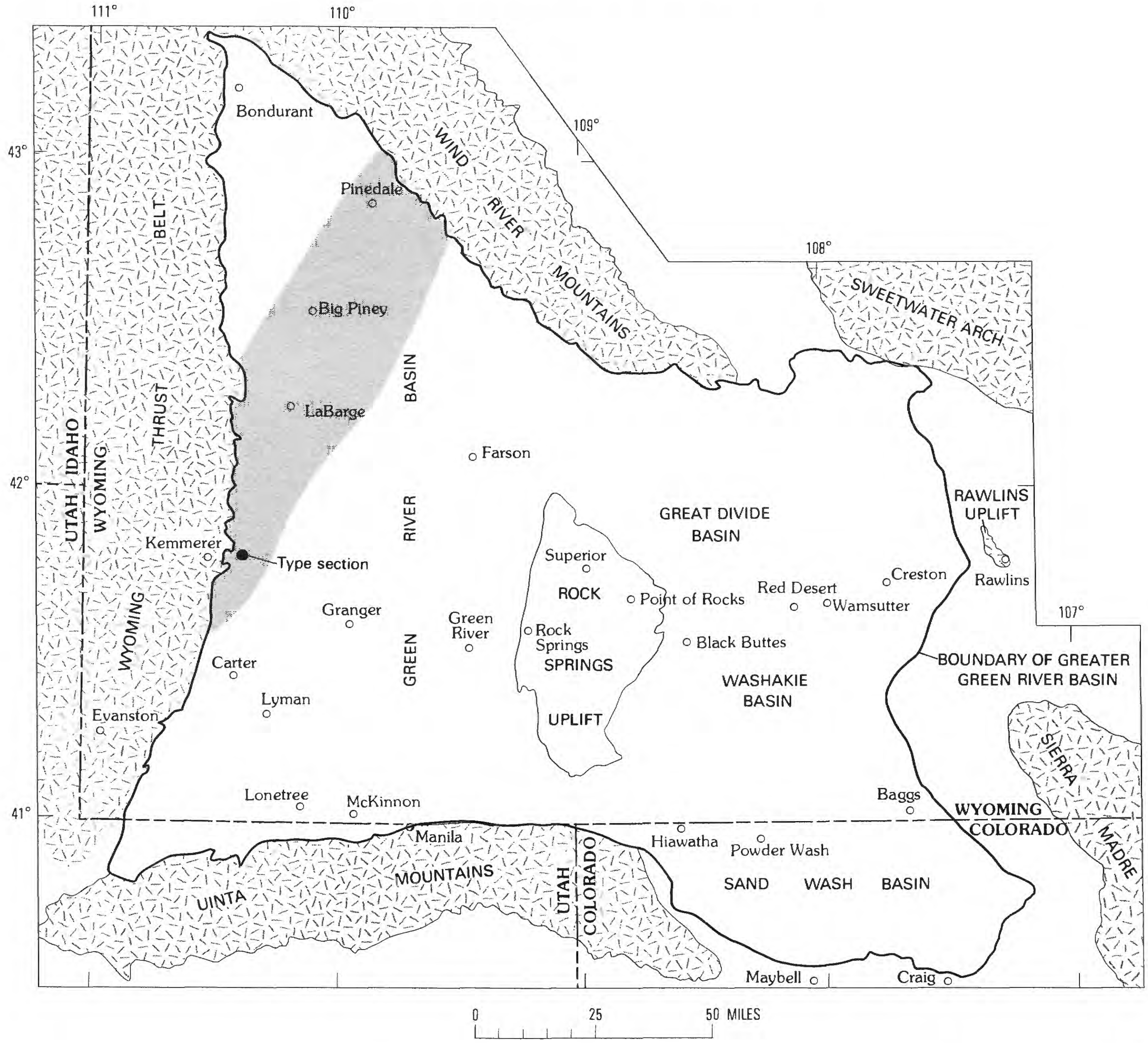


FIGURE 12.—Map showing the Eocene areal distribution of the Alkali Creek Tongue of the Wasatch Formation (shaded), northwestern part of greater Green River basin.

distribution of the Alkali Creek Tongue is shown in figure 12.

The Alkali Creek Tongue was mostly deposited on flood plains and consists of brown and gray fluvial-channel and flood-plain-splay sandstone, and inter-bedded gray and green flood-basin mudstone. A few thin beds of fossiliferous gray to green lacustrine sandstone, siltstone, and shale are present locally.

The type section of the Alkali Creek Tongue is located on the east slopes of Alkali Creek, a tributary of the

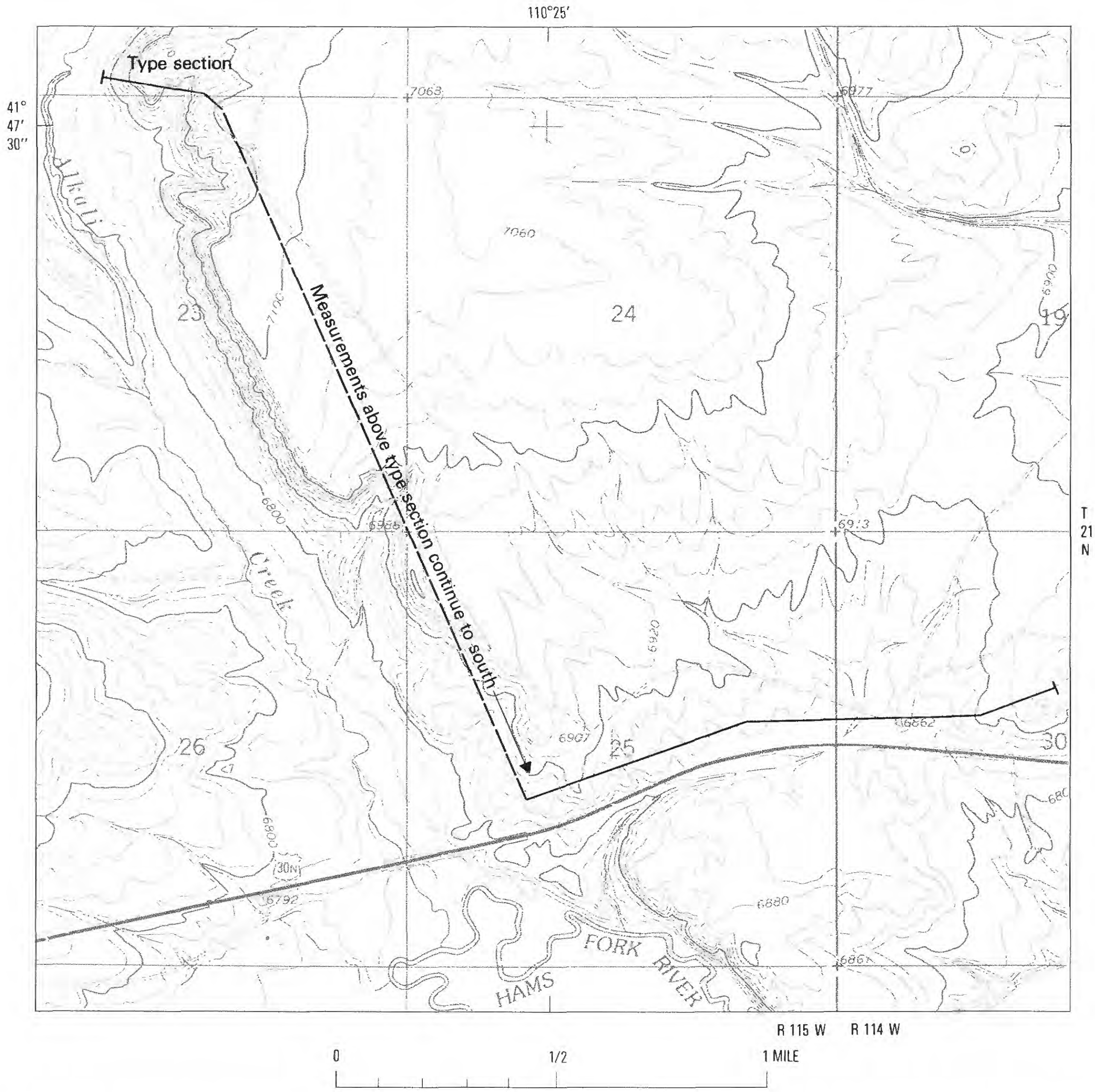
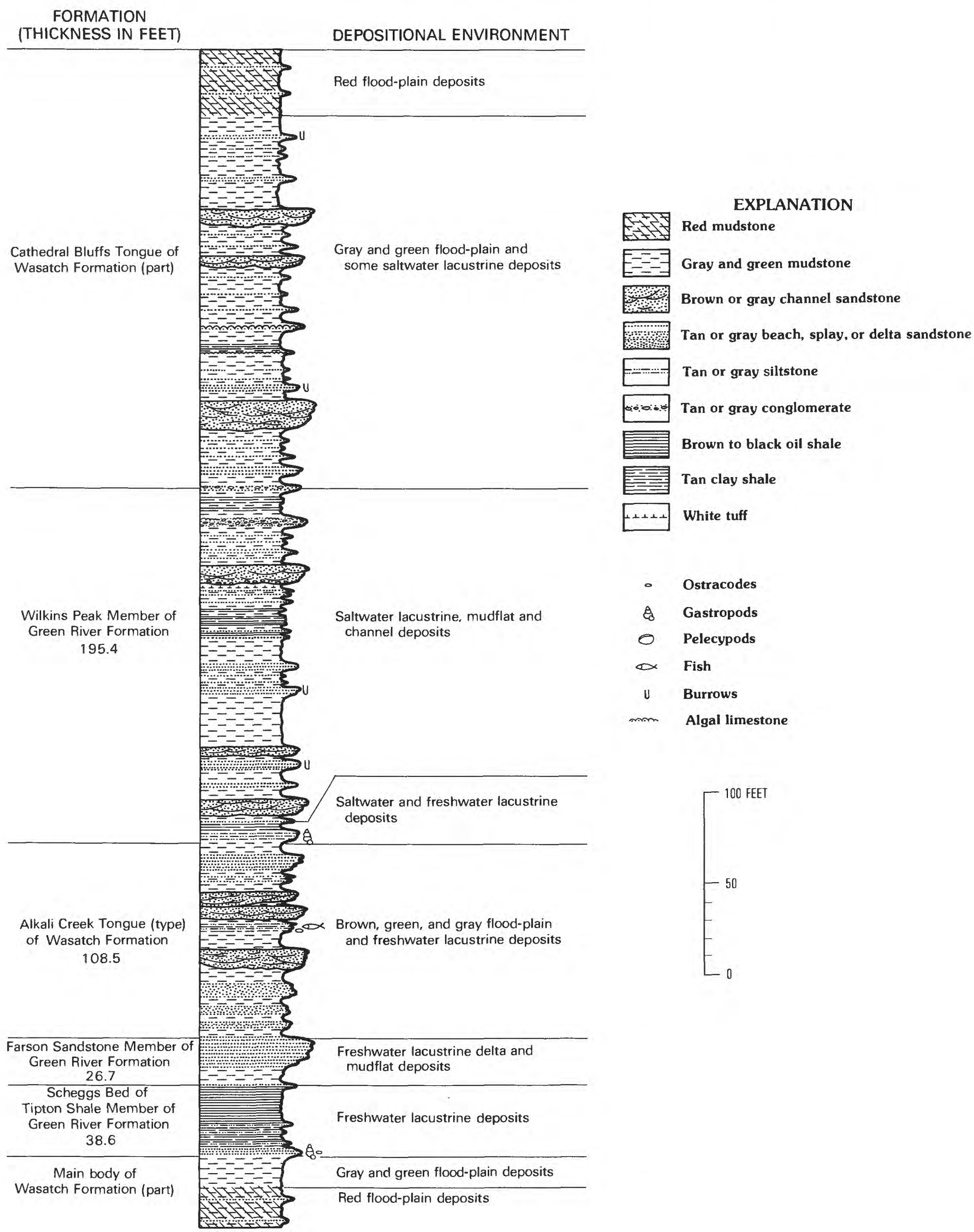


FIGURE 13.—Geographic location of the type section of the Alkali Creek Tongue of the Wasatch Formation in secs. 14 and 23, T. 21 N., R. 115 W. Base from U.S. Geological Survey, Willow Springs (Wyo.) quadrangle; scale 1:24,000; contour interval 20 feet.

Hams Fork River, in T. 21 N., R. 115 W. (fig. 13). It is accessible by an unimproved road that branches northward from U.S. Highway 30N, in the west-center of sec. 30, T. 21 N., R 114 W., 10 mi southeast of Kemmerer, Wyo. The type section is included on a columnar section (fig. 14) composed of rocks that crop out along Alkali Creek and along the north side of U.S. Highway 30N (fig. 13). Depositional environments and thicknesses of the rock units illustrated on the columnar section are identified in the following lithologic descriptions.


FORMATION (THICKNESS IN FEET)
DEPOSITIONAL ENVIRONMENT
Red flood-plain deposits
Cathedral Bluffs Tongue of Wasatch Formation (part)
Gray and green flood-plain and some saltwater lacustrine deposits
Wilkins Peak Member of Green River Formation 195.4
Saltwater lacustrine, mudflat and channel deposits
Saltwater and freshwater lacustrine deposits
Alkali Creek Tongue (type) of Wasatch Formation 108.5
Brown, green, and gray flood-plain and freshwater lacustrine deposits
Farson Sandstone Member of Green River Formation 26.7
Freshwater lacustrine delta and mudflat deposits
Scheggs Bed of Tipton Shale Member of Green River Formation 38.6
Freshwater lacustrine deposits
Main body of Wasatch Formation (part)
Gray and green flood-plain deposits
Red flood-plain deposits
EXPLANATION
Red mudstone
Gray and green mudstone
Brown or gray channel sandstone
Tan or gray beach, splay, or delta sandstone
Tan or gray siltstone
Tan or gray conglomerate
Brown to black oil shale
Tan clay shale
White tuff
Ostracodes
Gastropods
Pelecypods
Fish
Burrows
Algal limestone
100 FEET
50
0

Type section of the Alkali Creek Tongue and adjacent rocks in the Wasatch and Green River Formations

[Measured by Jacob's staff on the east slopes of Alkali Creek in south-center of sec. 14 and north-center of sec. 23, T. 21 N., R. 115 W. Strata overlying the type section were measured across east-center of sec. 25, T. 21 N., R. 115 W., and west-center of sec. 30, T. 21 N., R. 114 W.]

		Thickness Feet
Cathedral Bluffs Tongue of Wasatch Formation (part):		
83.	Mudstone, red, gray, gray-green, variegated, silty, soft, and some very thin interbedded sandstone, gray, very fine to fine-grained; flood-plain and flood-plain-splay deposits	37.0
82.	Mudstone, gray-green, silty, firm; flood-plain deposits	11.0
81.	Sandstone, medium-gray, medium-grained, fairly well sorted, subangular, calcareous; abundant black grains; in subparallel beds; abundant burrows; flood-plain-splay deposit	1.9
80.	Mudstone, gray, gray-green, silty, blocky, firm; and some thin interbedded siltstone, gray, calcareous, massive; parallel bedded; flood-plain and flood-plain-splay deposits	12.5
79.	Mudstone, green, blocky, firm; weathers to a brown band in outcrops; flood-plain deposit	8.7
78.	Sandstone, gray, fine-grained, massive; flood-plain-splay deposit	2.4
77.	Mudstone, gray, green, blocky, firm; flood-plain deposit	15.0
76.	Sandstone, gray, fine- to medium-grained, poorly sorted, subangular; abundant dark grains; in trough crossbeds; fluvial-channel deposit	7.4
75.	Mudstone, green, gray-green, blocky, firm, and some very thin interbedded lenticular sandstones, gray, fine-grained; flood-plain and flood-plain-splay deposits	18.0
74.	Sandstone, gray, very fine to fine-grained, calcareous; abundant dark grains; in trough crossbeds; fluvial-channel deposit	5.0
73.	Mudstone, gray-green, gray, silty, blocky, and some very thin interbedded lenticular sandstones, gray, fine-grained; flood-plain and flood-plain-splay deposits	33.0
72.	Algal limestone, tan, gray; in parallel, wavy beds composed mostly of algal fragments; nearshore lacustrine deposit	2.4
71.	Mudstone, gray, silty, blocky, firm; flood-plain deposit	8.3
70.	Clay shale, light-gray, hard; in subparallel laminae; lacustrine deposit	2.6
69.	Mudstone, gray, sandy, firm; lacustrine deposit	1.0
68.	Algal limestone, tan; toadstool-shaped colonies	0.4
67.	Mudstone, gray, sandy, firm; flood-plain deposit	8.2
66.	Mudstone, gray-green, silty, blocky, and some very thin interbedded sandstone, gray, fine-grained, in small lenses; flood-plain deposits	10.0

FIGURE 14 (facing page).—Columnar section of the type Alkali Creek Tongue and adjacent rocks in the Wasatch and Green River Formations. Locations of outcrops measured, figure 12.

Type section of the Alkali Creek Tongue and adjacent rocks in the Wasatch and Green River Formations—Continued

		Thickness Feet
Cathedral Bluffs Tongue of Wasatch Formation (part)—Continued		
65.	Sandstone, gray, very fine grained, silty, very poorly sorted, subangular; in thin parallel beds; the top 0.5 ft has abundant pencil-size vertical burrows; flood-plain-splay deposits	3.2
64.	Mudstone, green, blocky; and interbedded clay shale, light-gray, in thin parallel laminae; mudflat and shallow lacustrine deposits	5.4
63.	Sandstone, medium-gray, medium-grained, fairly well sorted, subangular; abundant dark grains; trough crossbedded; scoured base; fluvial-channel deposit	15.6
62.	Mudstone, gray, sandy, flaky to platy, brittle, hard, and some thin interbedded sandstone, gray, fine- to medium-grained, in current-rippled laminae; flood-plain and flood-plain-splay deposits	21.0
61.	Sandstone, gray, very fine grained, silty; in thin, parallel beds; flood-plain-splay deposits	4.6
60.	Mudstone, gray, silty, firm; flood-plain deposits	6.2
	Total Cathedral Bluffs Tongue measured	240.8
Wilkins Peak Member of Green River Formation:		
59.	Sandstone, gray, fine- to coarse-grained, calcareous; abundant dark grains; in thin, parallel, current-rippled beds and laminae with scattered clay pebbles on the upper surface; lacustrine beach deposit	2.8
58.	Mudstone, gray-green, blocky, firm; and interbedded clay shale, tan, platy, hard; some kerogen content; mudflat and lacustrine deposits	14.3
57.	Conglomerate, gray, calcareous; composed mostly of randomly oriented gray clay pebbles and algal fragments in a very coarse grained sandstone matrix; pebbles are matrix supported; lacustrine beach deposit	4.6
56.	Mudstone, gray-green, silty, soft, and some thin interbedded sandstone, gray, fine to very coarse grained, calcareous, hard; in current-rippled beds containing scattered clay pebbles; mudflat and lacustrine beach deposits	21.9
55.	Sandstone, gray, fine- to coarse-grained, poorly sorted, subangular, calcareous; abundant dark grains; scattered small gray clay pebbles, becoming more abundant near the base; trough crossbedded; fluvial-channel deposit	9.0
54.	Mudstone, gray-green, soft, silty; 0.7 ft white tuff near the middle; mudflat deposits	4.5
53.	Sandstone, gray, fine- to medium-grained, calcareous, hard; in current-rippled beds and laminae; lacustrine beach deposit	0.9
52.	Mudstone, gray, very sandy, soft; mudflat deposit.	1.0
51.	Sandstone, gray, fine-grained, calcareous; in thin parallel beds; lacustrine beach deposit	0.4
50.	Mudstone, gray-green, gray, partly clayey; mudflat deposit	3.5

Type section of the Alkali Creek Tongue and adjacent rocks in the Wasatch and Green River Formations—Continued

		Thickness Feet
Wilkins Peak Member of Green River Formation—Continued		
49.	Sandstone, gray, very coarse grained, calcareous, hard; lacustrine beach deposit	0.3
48.	Mudstone, gray-green, silty, blocky; mudflat deposit	4.0
47.	Clay shale, tan, dolomitic, platy; low kerogen content; lacustrine deposit	0.5
46.	Mudstone, gray, clayey, blocky, soft; mudflat deposit	2.3
45.	Clay shale, tan, flaky, dolomitic, brittle; low kerogen content; lacustrine deposit	1.6
44.	Clay shale, tan, flaky, soft; very low kerogen content; lacustrine deposit	1.9
43.	Oil shale, brown, flaky, brittle; weathers light gray; lacustrine deposit	1.5
42.	Mudstone, gray-green, blocky, soft; mudflat deposit	4.7
41.	Sandstone, gray, very fine grained, calcareous; in thin parallel beds and laminae; lacustrine beach deposit	0.7
40.	Oil shale, brown, flaky, dolomitic, brittle; weathers light gray; lacustrine deposit	1.8
39.	Sandstone, gray, fine-grained, calcareous; massive	0.8
38.	Mudstone, gray-green, gray-brown, silty, blocky, soft; mudflat deposit	14.7
37.	Sandstone, gray, fine-grained, fairly well sorted, calcareous; in parallel and current-rippled laminae; lacustrine beach deposit	3.4
36.	Mudstone, gray, silty to sandy, blocky, soft, and two very thin interbedded sandstones, gray, very fine grained; in current-rippled laminae; mudflat deposits	9.7
Bed 36 marks the base of measurements in sec. 25, T. 21 N., R. 115 W. The section continues at north-center of sec. 23, T. 21 N., R. 115 W.		
35.	Sandstone, light-gray, very fine grained, silty; in current-rippled laminae at the base with some small-scale trough-crossbedded laminae at the top; abundant small crawling trace fossils on the upper surface; lacustrine deposit	3.9
34.	Mudstone, gray-green, green, very silty to sandy, blocky, firm; mudflat deposits	29.4
33.	Sandstone, brown, fine- to medium-grained, poorly sorted, subangular; abundant dark grains, abundant biotite; trough crossbedded; scoured base; fluvial-channel deposit	4.9
32.	Mudstone, light-gray-green, blocky, hard; mudflat deposit	2.3
31.	Sandstone, gray, fine-grained, fairly well sorted, calcareous, and some interbedded mudstone, gray-green, sandy; subparallel, wavy bedded; abundant crustacean burrows; splay deposit	5.0
30.	Mudstone, green, flaky to blocky, firm; mudflat deposit	7.7

Type section of the Alkali Creek Tongue and adjacent rocks in the Wasatch and Green River Formations—Continued

		Thickness Feet
Wilkins Peak Member of Green River Formation—Continued		
29.	Sandstone, brown, fine- to medium-grained, poorly sorted, subangular, micaceous; lenticular; scoured base; fluvial-channel deposit	2.5
28.	Mudstone, gray-green, silty to sandy, blocky, firm; mudflat deposit	6.5
27.	Sandstone, brown, fine- to medium-grained, poorly sorted, subangular, micaceous, calcareous, firm; abundant colored grains; trough crossbedded; scoured base; fluvial-channel deposit	8.8
26.	Mudstone, gray-green, silty, firm; mudflat deposit	3.0
25.	Sandstone, gray-brown, very fine grained, calcareous, firm; in current-rippled laminae	1.5
24.	Clay shale, light-gray, silty, soft; lacustrine deposit	4.4
23.	Siltstone, light-gray, limy, hard; in subparallel wavy beds and laminae; scattered ostracodes and mollusks including *Goniobasis* sp. and *Viviparus* sp.; weathers to a distinct white ledge in outcrops; lacustrine deposit	4.7
	Total thickness of Wilkins Peak Member	195.4
Alkali Creek Tongue (type) of Wasatch Formation:		
22.	Mudstone, gray-green, silty, blocky, soft; top 0.5 ft very silty; flood-plain deposit	8.4
21.	Sandstone, brown, fine- to medium-grained, poorly sorted, subangular, micaceous; abundant dark grains; in thin parallel beds at the top and bottom, and thick parallel beds in the middle; splay deposit	8.3
20.	Mudstone, gray-green, silty, blocky, firm; flood-plain deposit	3.3
19.	Sandstone, gray, fine-grained, in thin parallel, wavy, rippled laminae, at the top and bottom; and mudstone, gray-green, silty, blocky, in the middle; lacustrine deposits	4.0
18.	Mudstone, light-gray-green, blocky, hard; flood-plain deposit	5.1
17.	Sandstone, brown, very fine grained, fairly well sorted; lenticular; in small-scale trough crossbeds; scoured base; fluvial-channel deposit	4.6
16.	Mudstone, light-gray-green, blocky, hard; flood-plain deposit	3.0
15.	Sandstone, brown, fine- to medium-grained, poorly sorted, subangular; lenticular; abundant biotite and muscovite, abundant dark grains; in small-scale trough crossbeds; scoured base; fluvial-channel deposit	6.7
14.	Mudstone, green, blocky, hard; flood-plain deposit	2.3

Type section of the Alkali Creek Tongue and adjacent rocks in the Wasatch and Green River Formations—Continued

	Thickness Feet
Alkali Creek Tongue (type) of Wasatch Formation—Continued	
13. Siltstone, light-gray, calcareous, hard; in thin, parallel, wave-rippled beds and laminae; scattered ostracodes and fish bones, and thin interbedded shale, green, silty, soft; freshwater lacustrine deposits	4.4
12. Mudstone, light-gray-green, silty, blocky, hard; flood-plain deposit	9.6
11. Sandstone, brown, fine-grained, fairly well sorted, micaceous; abundant dark grains; lenticular; in small trough crossbeds; fluvial-channel deposit.	10.8
10. Mudstone, medium-green, light-green-weathering, silty, blocky, firm, and interbedded sandstone, brown, fine- to medium-grained, micaceous, soft, loose; no visible bedding	38.0
Total Alkali Creek Tongue	108.5
Farson Sandstone Member of Green River Formation:	
9. Sandstone, brown, very fine to coarse-grained, very poorly sorted, subangular; scattered colored grains, abundant biotite, chlorite and muscovite, soft and loose; no visible bedding	16.7
8. Mudstone, gray-brown, sandy, blocky, soft; lacustrine deposit	10.0
Total Farson Sandstone Member	26.7
Scheggs Bed of Tipton Shale Member of Green River Formation:	
7. Sandstone, gray, very fine grained, calcareous; in thin current-rippled laminae; lacustrine beach deposit	0.7
6. Oil shale, brown, fissile, soft; lacustrine deposit	20.0
5. Shale, gray-brown, silty, and interbedded siltstone, light-gray, calcareous, blocky; lacustrine deposit	14.4
4. Sandstone, gray, very fine to fine-grained, silty, calcareous, hard; abundant ostracodes and scattered *Goniobasis* sp.; lacustrine beach deposit	0.6
3. Sandstone, light-gray, very fine grained, silty, limy; abundant randomly oriented *Goniobasis* sp.; lacustrine beach deposit	2.9
Total Scheggs Bed of Tipton Shale Member	38.6
Main body of Wasatch Formation (part):	
2. Mudstone, green, silty, soft; flood-plain deposit	18.3
1. Mudstone, red, gray, green, variegated, blocky, silty, soft, and a few thin interbedded sandstones, gray, fine- to medium-grained, calcareous, firm; flood-plain deposits	145.0
Total main body of Wasatch Formation measured	163.3

FARSON SANDSTONE MEMBER OF THE GREEN RIVER FORMATION

The Farson Sandstone Member comprises gray, tan, and brown sandstone and thin interbedded gray shale and siltstone, and locally conglomerate of lacustrine origin situated stratigraphically between the Rife and Scheggs Beds of the Tipton Shale Member along the northwest flank of the Rock Springs uplift and between the Alkali Creek Tongue and Scheggs Bed of the Tipton Shale Member along the western margins of the Green River basin. It receives its name from the town of Farson, Wyo., where it is nearly 400 ft thick in oil and gas drill holes. The Farson Sandstone Member intertongues with and is replaced laterally across the Green River basin by the Alkali Creek Tongue of the Wasatch Formation and the Scheggs Bed of the Tipton Shale Member of the Green River Formation (fig. 10).

The Farson Sandstone Member consists of a tongue of coarse clastics that is more than 400 ft thick near the Wind River Mountains at the northern margins of the Green River basin. It thins progressively southward from the Wind River Mountains across the northern and central parts of the Green River basin before wedging out across the southern part of the Green River basin (fig. 15). Parts of the member lapped eastward onto what is now the northwest flank of the Rock Springs uplift and westward onto the east margins of the Wyoming thrust belt. The overall configuration and trend of thickening indicate that the sediments composing the Farson Sandstone Member were mainly derived from the Wind River Mountains following a major tectonic disturbance. The nature of this disturbance has not been determined, but the huge volume of sediments involved suggests that a significant mountain-building event had occurred. The sandstones of the Farson Sandstone Member contain lenses of conglomerate composed of pebbles of gray and white chert and quartzite, gray quartz, gray-green to black schist, and tan gneiss in outcrops north of the Rock Springs uplift. The composition of these conglomerates indicates that the Wind River Mountains had been breached to their Precambrian core prior to deposition of the Farson Sandstone Member. Increased percentages of dark-colored rock fragments and mica grains in the sandstones along the western margins of the Green River basin suggest that the adjacent Wyoming thrust belt probably also contributed sediments to the Farson Sandstone Member. The Rock Springs uplift did not have topographic expression during this period and was not a source area for sediments.

The sediments of the Farson Sandstone Member completely filled the northwest part of Lake Gosiute during the deposition of the Scheggs Bed of the Tipton Shale Member, reducing the lake size by nearly 6,500 mi^2. The lake infilling took place by the slow basinward

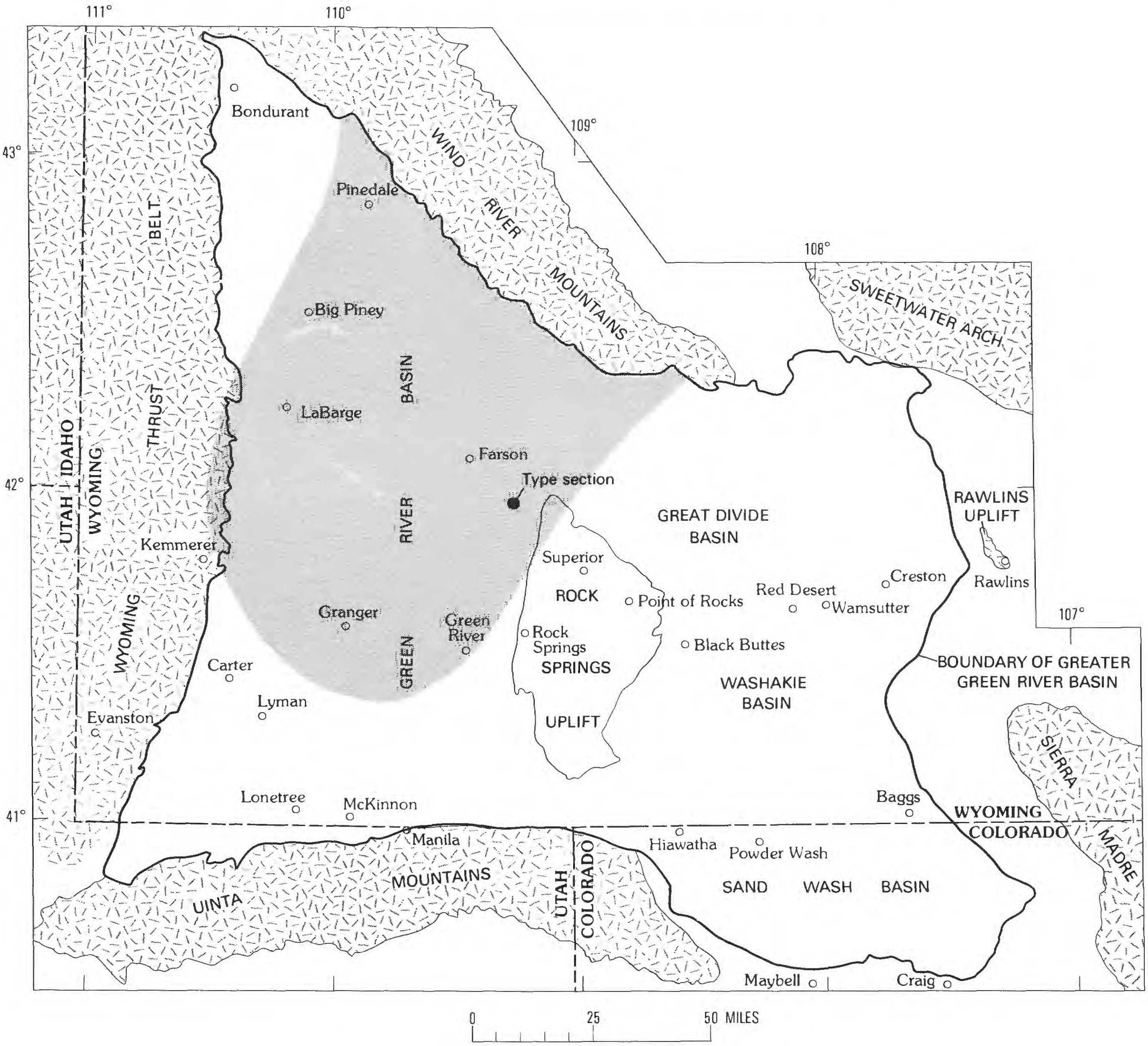


FIGURE 15.—Map showing the Eocene areal distribution of the Farson Sandstone Member of the Green River Formation (shaded), greater Green River basin.

accretion of sediments deposited primarily as fan deltas. These deltas are characterized by parallel beds of sandstone and siltstone in coarsening-upward parallel laminae (fig. 16). Some of the beds exhibit low-angle, basinward-dipping foresets. Between the beds of sandstone and siltstone are occasional thin beds of shale or clay shale and a few lenticular beds of distributary channel sandstone. The distributary channel sandstones are fine- to coarse-grained, poorly sorted, micaceous, and arkosic. They occur in large-scale, low-angle, trough crossbeds containing lenses of pebble conglomerate. Near Oregon Buttes in sec. 21, T. 27 N., R. 101 W., the Farson Sandstone Member is composed of three cyclic fan delta sequences, from 50 to 120 ft thick, consisting of trough-crossbedded distributary channel sandstone at the top, planar-crossbedded sandstone with south-dipping foresets in the middle, and parallel-bedded sandstone at the base (fig. 17). These sandstone units

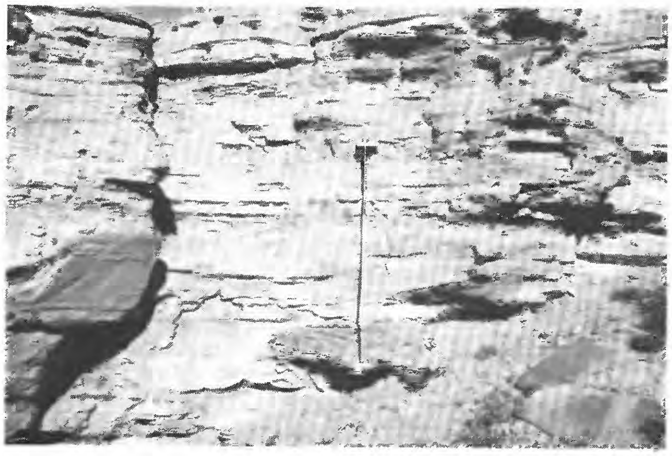


FIGURE 16.—Parallel-bedded delta sandstones in the Farson Sandstone Member on White Mountain in SW¼SE¼ sec. 13, T. 15 N., R. 105 W. The sandstones are part of bed 23 in the type section of the member. Jacob's staff is 5 ft long.

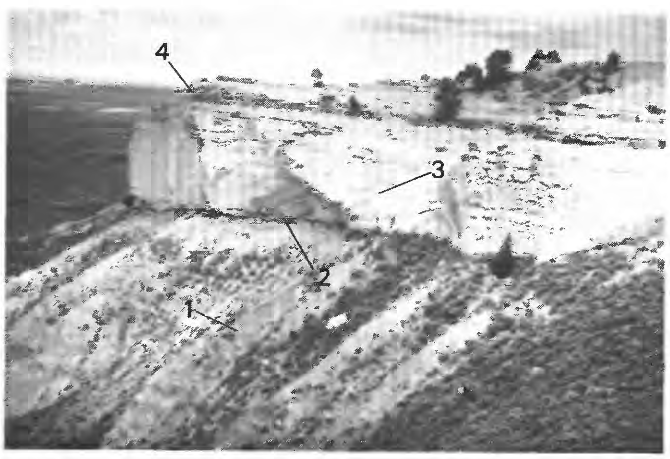


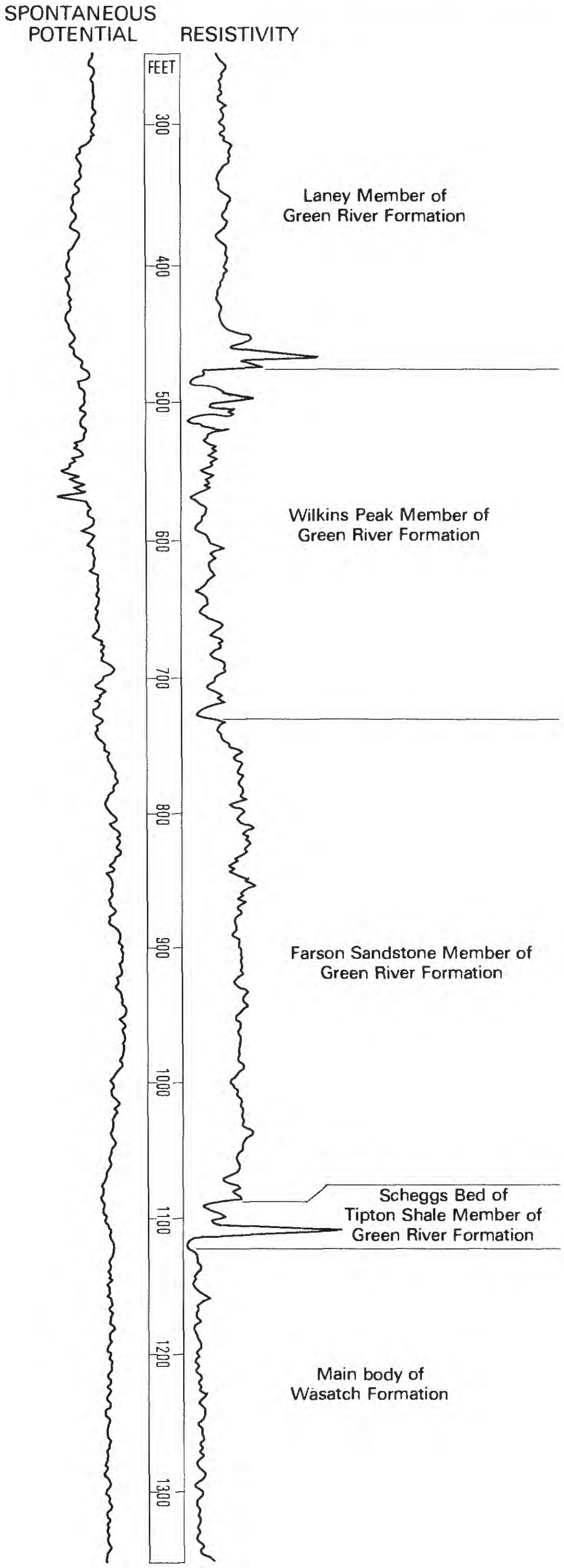
FIGURE 17.—Outcrops of fan delta sandstone in the Farson Sandstone Member 2 mi north of Oregon Buttes, south-central sec. 21, T. 27 N., R. 101 W. View is toward the west. 1, variegated mudstone in the main body of the Wasatch Formation; 2, thin parallel-bedded sandstone containing *Viviparus* sp.; 3, planar-crossbedded sandstone with south-dipping foresets; 4, trough-crossbedded sandstone.

correspond to the proximal, medial, and distal parts of prograding fan delta systems. On the north slopes of Slate Creek in sec. 24, T. 23 N., R. 115 W., the Farson Sandstone Member consists of a single 60-ft-thick sandstone that forms a Gilbert-type delta. The topset beds of this delta consist of 7 ft of parallel-bedded sandstone; the middle foreset sandstones are 42 ft thick and exhibit low-angle, basinward dips; the bottomset beds consist of 11 ft of parallel-bedded sandstone (fig. 18).

FIGURE 18.—Outcrops of the Wasatch and Green River Formations on north slopes of Slate Creek, south-center sec. 24, T. 23 N., R. 115 W. View is northwest. 1, variegated mudstone in the main body of the Wasatch Formation; 2, brown and gray oil shale and siltstone in the Scheggs Bed of the Tipton Shale Member; 3, 4, 5, bottomset, foreset, and topset beds of a Gilbert-type delta in the Farson Sandstone Member; 6, Alkali Creek Tongue. Cliff face is about 60 ft high.

The Farson Sandstone Member has distinctive electric log characteristics in oil and gas drill holes in the northern part of the Green River basin. The resistivity curves on these logs are consistently amplified through the member, contrasting sharply with the lower amplitude of the curves produced by underlying and overlying members of the Green River and Wasatch Formations. The Scheggs Bed of the Tipton Shale Member underlying the Farson Sandstone member is identified by a sharp resistivity "spike." From surface correlations this spike is believed to be the resistivity response of a thick oolitic limestone. Typical resistivity curves are shown on a segment of an electric log from the Davis Oil Company and Southland Royalty Company, Simpson Gulch Well No. 1, drilled in sec. 31, T. 24 N., R. 107 W., 8 mi west of Farson, Wyo. (fig. 19).

The type section of the Farson Sandstone Member is located on the east slopes of White Mountain in the south-center of sec. 13, T. 23 N., R. 105 W., about 14 mi southeast of Farson, Wyo. (fig. 20). It lies 3 mi directly west of a prominent volcanic feature known as the Boars Tusk. The type section is 256 ft thick, well exposed, and contains an abundance of trace fossils (figs. 21, 22). It is accessible by an unimproved road that branches eastward from U.S. Highway 191, 8 mi south of Farson, Wyo. From this road junction the unimproved road winds eastward for 10 mi, skirting the south edge of an area of sand dunes, to the type section located on White Mountain. The type section is included on a columnar



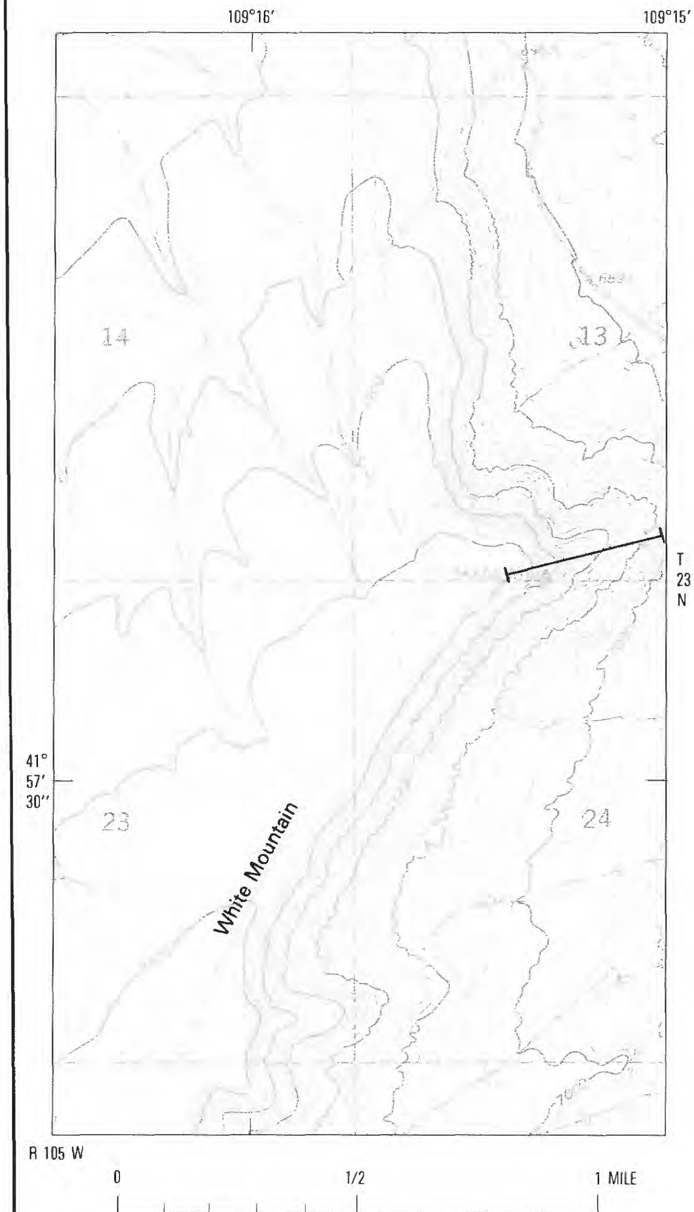


FIGURE 20.—Geographic location of the type section of the Farson Sandstone Member of the Green River Formation in sec. 13, T. 23 N., R. 105 W. Base from U.S. Geological Survey White Rocks (Wyo.) quadrangle; scale 1:24,000; contour interval 20 feet.

FIGURE 19 (facing column).—Electric log of the Farson Sandstone Member and adjacent parts of the Green River and Wasatch Formations in the Davis Oil Company and Southland Royalty Company, Simpson Gulch Well No. 1, drilled 8 mi west of Farson, Wyo.

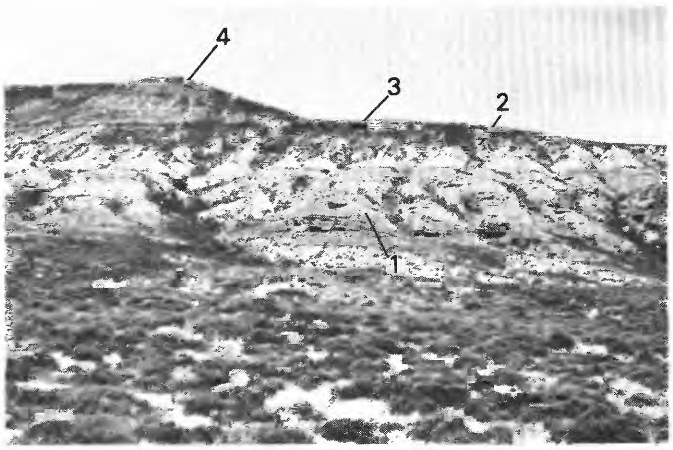


FIGURE 21.—Outcrops of the type section of the Farson Sandstone Member on White Mountain in south-central sec. 13, T. 23 N., R. 105 W. View is toward the west. 1, Farson Sandstone Member; 2, Rife Bed of Tipton Shale Member; 3, Wilkins Peak Member; 4, Laney Member. Location of section, figure 19.

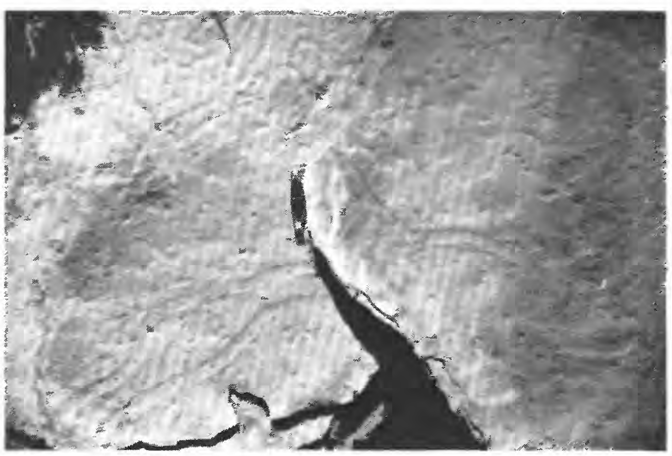


FIGURE 22.—Crawling trace fossils on the surface of bed 22 in the type section of the Farson Sandstone Member at White Mountain in sec. 13, T. 23 N., R. 105 W. Pocket knife for scale, 0.3 ft long.

section composed of rocks measured from the base to the top of White Mountain (fig. 23). Depositional environments and thicknesses of the rock units illustrated on the columnar section are identified in the following lithologic descriptions.

Type section of the Farson Sandstone Member and adjacent rocks in the Green River and Wasatch Formations

[Measured by Jacob's staff on the east slopes of White Mountain in south-center of sec. 13, T. 23 N., R. 105 W.]

		Thickness Feet
Laney Member of Green River Formation (part):		
111.	Oil shale, brown, flaky, and some thin interbedded sandstone, gray, very fine grained, calcareous, hard; lacustrine deposit	31.0
110.	Tuff, gray, hard; lacustrine deposit (airfall ash)	0.5
109.	Oil shale, brown, flaky, soft; lacustrine deposit	5.4
108.	Tuff, gray, hard; lacustrine deposit (airfall ash); marks color change of white-weathered rocks below to tan-brown-weathered rocks above	0.4
107.	Oil shale, brown, flaky; lacustrine deposit	34.0
	Total Laney Member measured	71.3
Wilkins Peak Member of Green River Formation:		
106.	Tuff, tan, rust, hard; lacustrine deposit (airfall ash)	0.8
105.	Clay shale, tan, flaky, soft; low kerogen content; lacustrine deposit	8.1
104.	Tuff, rust; airfall ash	0.2
103.	Mudstone, gray-green, firm; mudflat deposit	1.5
102.	Clay shale, brown, flaky, brittle; some kerogen contents; lacustrine deposit	9.0
101.	Tuff, rust; airfall ash	0.3
100.	Clay shale, brown, flaky; very low kerogen content; lacustrine deposit	9.2
99.	Mudstone, gray-green, blocky; mudflat deposit	2.0
98.	Clay shale, brown, flaky; some kerogen; lacustrine deposit	5.0
97.	Mudstone, gray-green, blocky, soft; mudflat deposit	10.0
96.	Tuff, white, hard; airfall ash	0.2
95.	Oil shale, brown, flaky; lacustrine deposit	1.5
94.	Clay shale, tan, platy; some kerogen content; lacustrine deposit	5.7
93.	Tuff, tan; airfall ash	0.3
92.	Mudstone, gray-green, blocky; mudflat deposit	2.5
91.	Tuff, tan; airfall ash	0.3
90.	Oil shale, brown, flaky; lacustrine deposit	4.6
89.	Mudstone, gray-green, blocky, firm; mudflat deposit	4.9
88.	Oil shale, brown, flaky; lacustrine deposit	9.0
87.	Mudstone, gray-green, blocky, firm; mudflat deposit	3.4
86.	Oil shale, brown, flaky; lacustrine deposit	3.8
85.	Mudstone, gray-green, soft; mudflat deposit	2.6
84.	Oil shale, brown, flaky; lacustrine deposit	0.6
83.	Mudstone, gray, soft; mudflat deposit	1.7
82.	Oil shale, brown, flaky; lacustrine deposit	2.6
81.	Mudstone, gray-green, soft; mudflat deposit	2.8
80.	Oil shale, brown, flaky; lacustrine deposit	1.6

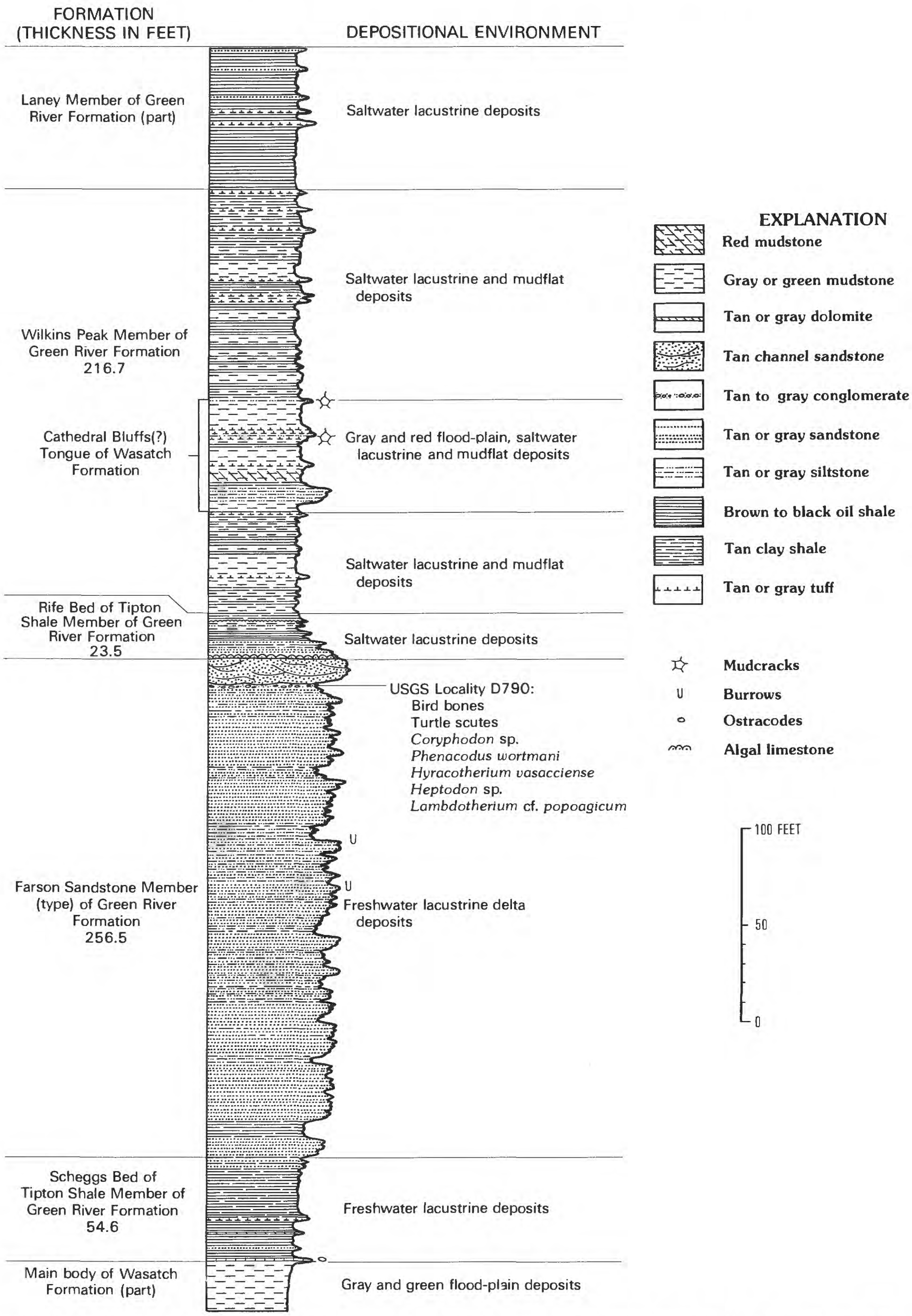


FIGURE 23.—Columnar section of the type Farson Sandstone Member and adjacent rocks in the Green River and Wasatch Formations. Location of section, figure 20.

Type section of the Farson Sandstone Member and adjacent rocks in the Green River and Wasatch Formations—Continued

		Thickness Feet
Wilkins Peak Member of Green River Formation—Continued		
79.	Mudstone, gray-green, flaky, soft; mudflat deposit	4.6
78.	Oil shale, brown, flaky; lacustrine deposit	2.8
77.	Mudstone, gray-green, flaky; mudflat deposit	1.5
76.	Clay shale, tan; grades upward into oil shale, brown, flaky; lacustrine deposits	4.3
Note: Beds 65–75 have some red coloration and could be included in the Cathedral Bluffs Tongue of the Wasatch Formation.		
75.	Siltstone, gray, calcareous, hard; in thin current-rippled beds; some synaeresis cracks	0.6
74.	Mudstone, gray-green, flaky to blocky; mudflat deposit	13.8
73.	Tuff, white, silty; weathers to small blocks; airfall ash	4.2
72.	Siltstone, light-gray, calcareous, hard; in thin parallel laminae; some synaeresis cracks	0.4
71.	Tuff, light-gray, very silty; airfall ash	1.4
70.	Mudstone, dark-gray-green, blocky; mudflat deposit	1.9
69.	Oil shale, brown, flaky; lacustrine deposit	1.6
68.	Clay shale, brown, flaky, brittle; some kerogen content	0.7
67.	Mudstone, dark-gray-green, blocky; flood-plain deposit?	7.9
66.	Tuff, white, silty; airfall ash	1.8
65.	Mudstone, dark-gray-green, blocky, firm; one layer in the lower part has red mottling; flood-plain deposit	8.3
64.	Clay shale, tan, light-brown, flaky; some kerogen content	1.5
63.	Siltstone, gray-brown, shaly to sandy; in parallel laminae; flood-plain deposit	8.5
62.	Mudstone, very dark green, blocky; weathers to dark band in slopes; flood-plain deposit	4.4
61.	Clay shale, tan, flaky, dolomitic, brittle, hard; some kerogen content; lacustrine deposit	1.2
60.	Tuff, white; airfall ash	0.3
59.	Clay shale, tan, dolomitic, platy; some kerogen content; lacustrine deposit	2.2
58.	Mudstone, gray-green, soft; mudflat deposit	0.9
57.	Clay shale, tan, platy, dolomitic, hard; some kerogen content; lacustrine deposit	1.4
56.	Mudstone, gray, soft; mudflat deposit	1.0
55.	Oil shale, brown, flaky; lacustrine deposit	1.5
54.	Mudstone, gray-green, flaky; mudflat deposit	1.5
53.	Oil shale, dark-brown, flaky; weathers gray; lacustrine deposit	0.4
52.	Clay shale, light-tan, platy; some kerogen content; lacustrine deposit	2.3
51.	Oil shale, brown, flaky; lacustrine deposit	5.4
50.	Mudstone, gray-green, soft; mudflat deposit	1.6
49.	Oil shale, brown, dolomitic, platy; lacustrine deposit	1.6
48.	Mudstone, gray-green, silty; mudflat deposit	12.5

Type section of the Farson Sandstone Member and adjacent rocks in the Green River and Wasatch Formations—Continued

		Thickness Feet
Wilkins Peak Member of Green River Formation—Continued		
47.	Tuff, rust, powdery; airfall ash	0.5
46.	Mudstone, gray, soft; mudflat deposit	5.0
45.	Clay shale, tan, brown, dolomitic, platy; some kerogen content; lacustrine deposit	2.3
44.	Mudstone, gray, silty, soft; mudflat deposit	1.7
43.	Clay shale, tan, dolomitic, platy; some kerogen content; lacustrine deposit	0.7
42.	Mudstone, gray, silty, soft; mudflat deposit	2.2
41.	Clay shale, tan, dolomitic, platy; some kerogen content; lacustrine deposit	2.3
40.	Mudstone, dark-green, soft; mudflat deposit	3.8
	Total Wilkins Peak Member	216.7
Rife Bed of Tipton Shale Member of Green River Formation:		
39.	Clay shale, tan, brown, dolomitic, platy; some kerogen content; lacustrine deposit	3.4
38.	Limestone, tan, gray; contains some flat gray clay pebbles, some coarse sand grains, some oolite-like grains of sandstone and limestone, and algal fragments; lacustrine beach deposit	0.7
37.	Mudstone, gray-green, silty; mudflat deposit	1.8
36.	Siltstone, light-gray, limy; in thin current-rippled beds	0.2
35.	Mudstone, dark-green, silty, soft; mudflat deposit.	2.6
34.	Oil shale, dark-brown, flaky, brittle, dolomitic; weathers gray; lacustrine deposit	5.2
33.	Sandstone, gray, very fine grained; and interlaminated gray siltstone, gray shale and brown oil shale; lacustrine deposits	4.8
32.	Sandstone, light-gray, fine-grained, firm, massive, well-sorted; mostly quartz grains with a few red and black grains; lacustrine beach deposit	2.5
31.	Algal limestone, gray; in a continuous layer of large rounded heads up to 2 ft in diameter; hummocky upper surface; lacustrine deposit	2.3
	Total Rife Bed of Tipton Shale Member	23.5
Farson Sandstone Member (type) of Green River Formation:		
30.	Sandstone, gray, fine- to medium-grained, poorly sorted, subangular, micaceous; in large trough crossbeds with some gray siltstone drape; a distributary channel deposit in a lacustrine delta	13.1
29.	Sandstone, gray, fine- to very coarse grained, conglomeratic, poorly sorted; abundant colored grains; abundant disarticulated vertebrate fossils; a distributary channel deposit in a lacustrine delta	1.6
28.	Sandstone, gray, calcareous, current-rippled; and interbedded siltstone, gray, very shaly; lacustrine delta deposit	4.2

Type section of the Farson Sandstone Member and adjacent rocks in the Green River and Wasatch Formations—Continued

		Thickness Feet
Farson Sandstone Member (type) of Green River Formation—Continued		
27.	Sandstone, brown, fine-grained, fairly well sorted, micaceous; in thin parallel beds; lacustrine delta deposit	3.4
26.	Sandstone, gray, fine-grained, and thin interbedded gray siltstone, and some shale, gray, very silty, flaky; lacustrine delta deposit	7.7
25.	Sandstone, gray-brown, fine-grained, fairly well sorted, micaceous; in partly current-rippled thin beds and laminae; lacustrine delta deposit	25.5
24.	Sandstone, gray-brown, fine-grained, in thin parallel laminae at the base; grading upward into siltstone, gray, shaly, in parallel current-rippled laminae; lacustrine delta deposit	5.8
23.	Sandstone, gray-brown, fine-grained, fairly well sorted, soft; abundant muscovite and biotite; in thin parallel beds less than 1 ft thick; lacustrine delta deposit	23.1
22.	Siltstone, gray, very shaly in layers; and some thin interbedded sandstone, gray, very fine grained, in parallel laminae. Bed near the top contains large crawling trace fossils; lacustrine delta deposits	32.0
21.	Sandstone, gray, very fine to fine-grained, fairly well sorted; abundant dark grains; and thin interbedded siltstone, gray, very shaly. The top of the interval is a 2.5-ft-thick sandstone containing abundant trace fossils; lacustrine delta deposit	61.8
20.	Sandstone, tan-brown, fine-grained, fairly well sorted; abundant dark grains, abundant muscovite and biotite; in thin parallel beds and laminae; some parallel beds have south-dipping foreset laminae; lacustrine delta deposit	8.3
19.	Sandstone, gray, very fine grained, silty, very shaly; lacustrine delta deposit	9.8
18.	Sandstone, gray, fine-grained, fairly well sorted; abundant dark grains, abundant muscovite and biotite; in thin parallel beds that coarsen upward; lacustrine delta deposit	7.5
17.	Siltstone, gray, platy, hard; in thin parallel laminae; lacustrine delta deposit	4.6
16.	Sandstone, gray, very fine to fine-grained, fairly well sorted; abundant muscovite and biotite grains; tan brown weathering; in thick and thin parallel beds; lacustrine delta deposits	28.4
15.	Clay shale, gray, sandy, argillaceous; weathers to small plates; lacustrine delta deposit	10.0
14.	Sandstone, gray, very fine grained, fairly well sorted, soft; abundant muscovite and biotite grains; tan gray weathering; in thin parallel beds and laminae; lacustrine delta deposit	9.7
	Total Farson Sandstone Member	256.5
Scheggs Bed of Tipton Shale Member of Green River Formation:		
13.	Clay shale, gray, silty, firm to hard; in thin parallel laminae; becomes sandy in the upper part, with some very thin interbedded sandstone the upper 5 ft; dolomitic in the lower part; lacustrine deposit	30.3
12.	Clay shale, tan, very dolomitic, very hard, platy; lacustrine deposit	1.3
11.	Tuff, tan, powdery, soft; airfall ash deposit	0.5
10.	Analcimized tuff, very dark gray, hard, platy	0.1
9.	Oil shale, brown, flaky, hard and dolomitic the top 1 ft; lacustrine deposit	6.7
8.	Dolomite, dark-gray-brown, hard, dense; capped by gray, flat-clay-pebble conglomerate; lacustrine shoreline deposit	0.3
7.	Oil shale, brown, flaky, firm; lacustrine deposit	7.9
6.	Sandstone, gray, very fine grained, very calcareous, hard; lacustrine deposit	0.2
5.	Oil shale, brown, flaky; lacustrine deposit	5.1
4.	Ostracodal limestone, gray, silty, hard; lacustrine deposit	0.1
3.	Oil shale, brown, flaky, soft; lacustrine deposit	1.7
2.	Ostracodal limestone, gray, silty, hard; lacustrine deposit	0.4
	Total Scheggs Bed of Tipton Shale Member	54.6
Main body of Wasatch Formation (part):		
1.	Mudstone, gray-green, silty, soft; flood-plain deposit	25.0

SCHEGGS BED OF THE TIPTON SHALE MEMBER OF THE GREEN RIVER FORMATION

The Scheggs Bed of the Tipton Shale Member is named for 59 ft of oil shale of freshwater lacustrine origin that crops out on the east slopes of Scheggs Draw near the southwest edge of the Washakie basin (fig. 24). The Scheggs Bed was deposited across most of the ancestral greater Green River basin area during the Eocene Epoch. It crops out around the margins of the Green River, Washakie, and Sand Wash basins, and is present in east-west-trending outcrops across the central and western parts of the Great Divide basin. The bed intertongues laterally with the Farson Sandstone Member of the Green River Formation and Battle Spring Formation, and at its base it intertongues with the underlying Niland Tongue or main body of the Wasatch Formation (fig. 10). Its upper contact with the Rife Bed is sharp and everywhere clearly defined by lithologic and

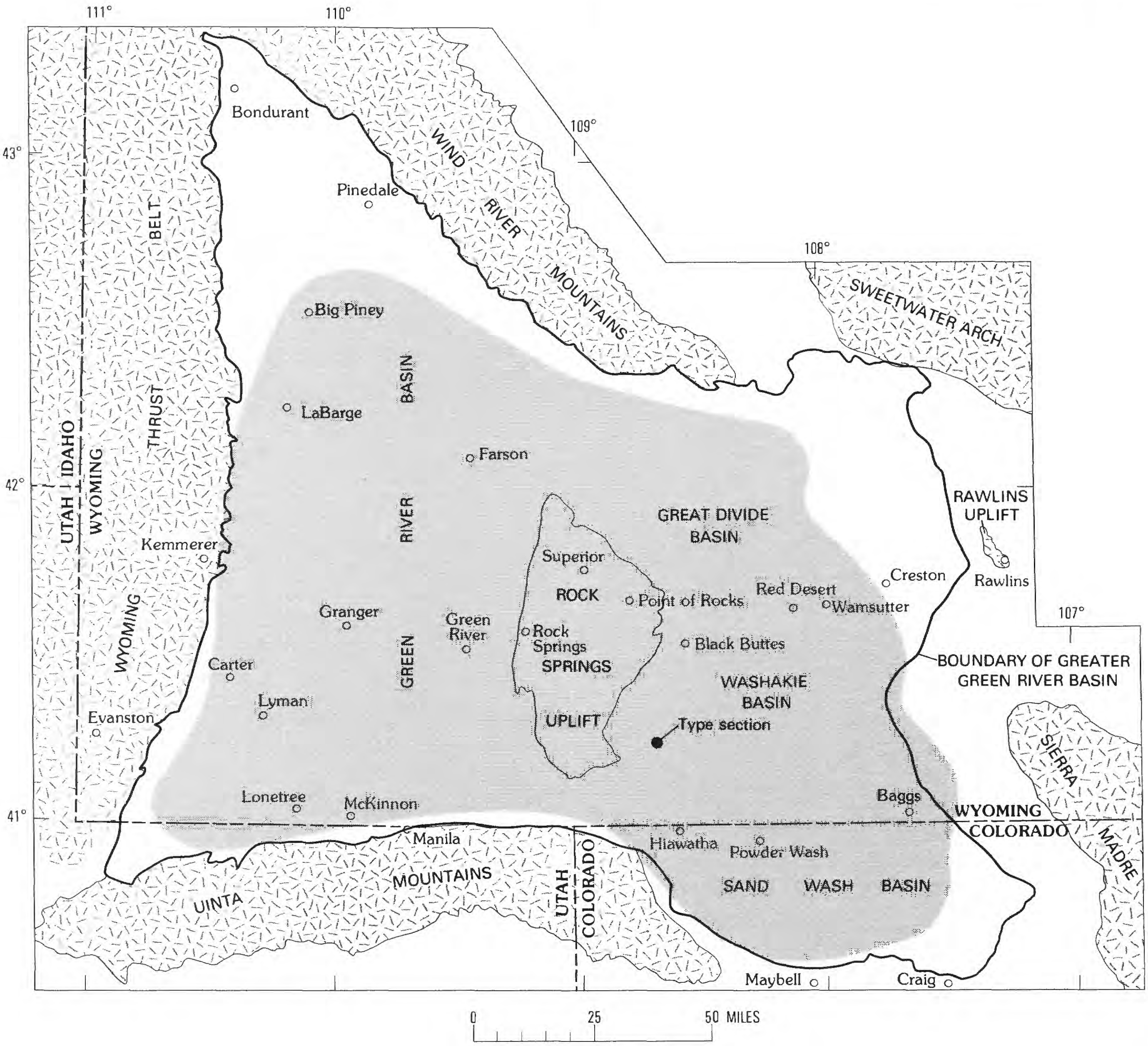
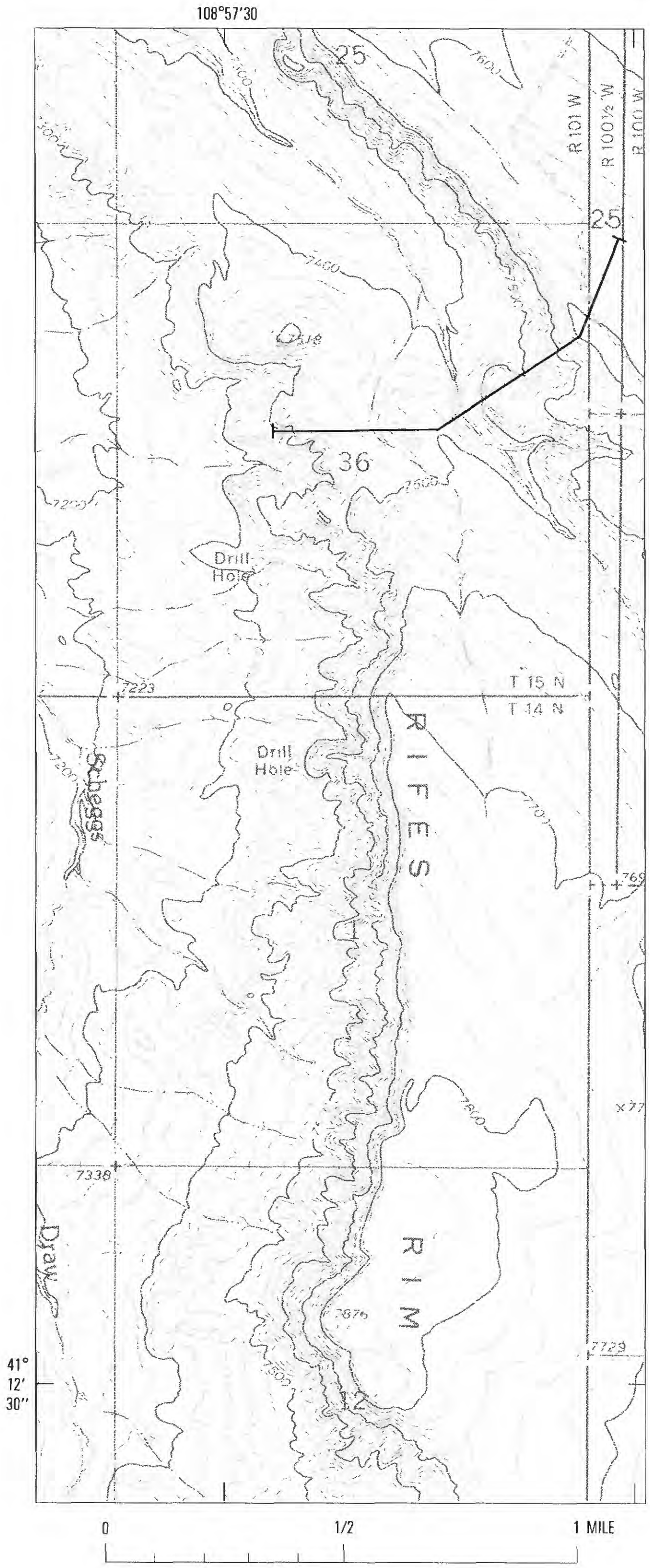


FIGURE 24.—Map showing the Eocene areal distribution of the Scheggs Bed of the Tipton Shale Member of the Green River Formation (shaded), greater Green River basin area.

color changes (discussed previously) that take place within the oil shale section that makes up the Tipton Shale Member.

The Scheggs Bed was deposited during a freshwater stage of Lake Gosiute that occupied about 15,000 mi^2 of the ancestral greater Green River basin in southwest Wyoming and northwest Colorado (fig. 24). The lake originated in a shallow east-west-trending trough located north of the Uinta Mountains. From this trough it expanded across the southern part of the Green River basin, Rock Springs uplift, and Washakie basin, and eventually expanded to its maximum areal extent shown in figure 24. The rocks deposited in the central parts of the lake are mostly oil shale with a few beds of thin interbedded tuff, but nearshore and onshore (beach) areas usually contain additional thin beds of limestone,



dolomite, conglomerate, sandstone, siltstone, carbonaceous shale, and coal. The overall thickness of the bed in various parts of the greater Green River basin ranges from less than 10 to nearly 275 ft. Ostracodes are abundant in most of the oil shale beds, and in nearshore areas they occasionally form thin coquinas. The basal few feet of the Scheggs Bed usually contains concentrations of the freshwater gastropods *Goniobasis tenera* and *Viviparus* sp., and the pelecypod *Lampsilis* sp. These fossil concentrations generally occur in limestone, sandstone, or oil shale deposits laid down along the shorelines as the lake expanded.

The type section of the Scheggs Bed is located in the northern one-half of sec. 36, T. 15 N., R. 101 W., and the southern one-half of sec. 25 (irregular section), T. 15 N., R. 100½ W. (fig. 25). The type section is accessible by an unimproved road that parallels Scheggs Draw. This road branches eastward from Wyoming Highway 430, 35 mi southeast of Rock Springs, Wyo. The type section and its relationship to adjacent rocks measured on the east slopes of Scheggs Draw are shown on a columnar section, figure 26. The thickness and depositional environments of rocks in the type section are indicated in the following lithologic descriptions.

Type section of the Scheggs Bed of the Tipton Shale Member of the Green River Formation and adjacent rocks in the Wasatch and Green River Formations

[Measured by Jacob's staff on the east slopes of Scheggs Draw in the N½ sec. 36, T. 15 N., R. 101 W., and S½ sec. 25, T. 15 N., R. 100½ W.]

	Thickness Feet
Rife Bed of Tipton Shale Member of Green River Formation (part):	
101. Algal limestone, tan, silty, dolomitic; brain type; saltwater lacustrine shoreline deposit	1.0
100. Oil shale, brown, dolomitic, flaky, brittle; saltwater lacustrine deposit	5.5
99. Dolomite, tan-brown, silty, hard; saltwater lacustrine deposit	0.2
98. Oil shale, brown, dolomitic, flaky, brittle; light gray weathering; saltwater lacustrine deposit ..	6.2
97. Dolomite, tan-brown, silty, hard; mud-cracked upper surface; weathers yellow; saltwater lacustrine deposit	0.2

FIGURE 25 (facing column).—Geographic location of the type section of the Scheggs Bed of the Tipton Shale Member of the Green River Formation in sec. 36, T. 15 N., R. 101 W., and sec. 25, T. 15 N., R. 100 W. Base from U.S. Geological Survey Chicken Creek West (Wyo.) quadrangle; scale 1:24,000; contour interval 20 feet.

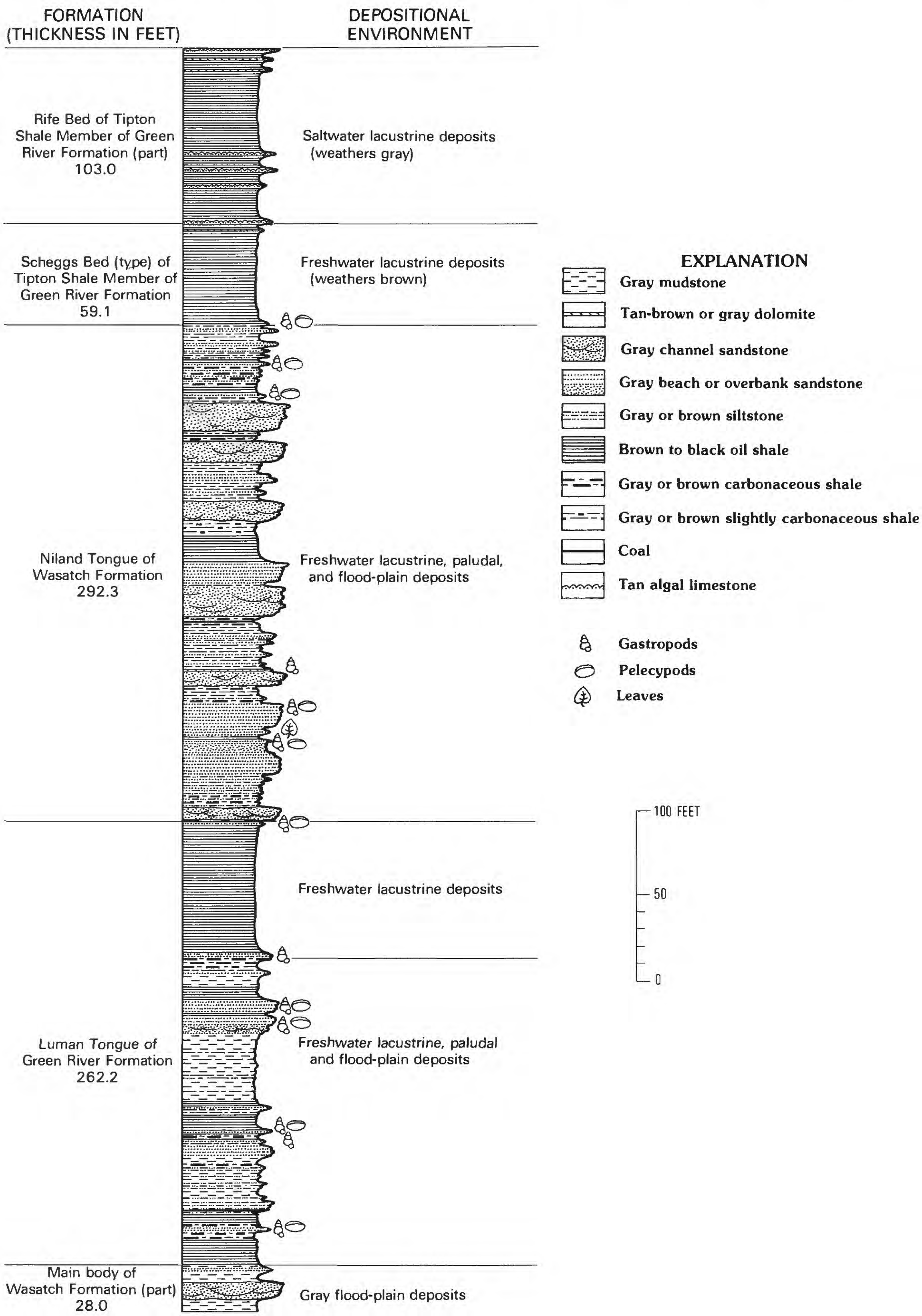


FIGURE 26.—Columnar section of the type Scheggs Bed of the Tipton Shale Member and adjacent rocks in the Green River and Wasatch Formations. Locations of outcrops measured, figure 25.

Type section of the Scheggs Bed of the Tipton Shale Member of the Green River Formation and adjacent rocks in the Wasatch and Green River Formations—Continued

		Thickness Feet
	Rife Bed of Tipton Shale Member of Green River Formation (part)—Continued	
96.	Oil shale, dark-brown, dolomitic, brittle; light gray weathering; saltwater lacustrine deposit	1.0
95.	Oil shale, brown, flaky, firm; drab brown weathering; saltwater lacustrine deposit	46.9
94.	Algal limestone, tan, silty, dolomitic; brain type; weathers to bench; saltwater lacustrine shoreline deposit	1.4
93.	Oil shale, brown, dolomitic, flaky, brittle; saltwater lacustrine deposit	8.4
92.	Algal limestone, tan, silty, dolomitic; brain type; saltwater lacustrine shoreline deposit	1.0
91.	Oil shale, brown, dolomitic, flaky, brittle; saltwater lacustrine deposit	8.1
90.	Algal limestone, tan, silty, dolomitic; brain type; saltwater lacustrine shoreline deposit	1.1
89.	Oil shale, brown, dolomitic, flaky, brittle; light gray weathering; saltwater lacustrine deposit	20.9
88.	Algal limestone, tan, silty, dolomitic; brain type; saltwater lacustrine shoreline deposit	1.1
	Total Rife Bed of Tipton Shale Member measured	103.0
	Scheggs Bed (type) of Tipton Shale Member of Green River Formation:	
87.	Oil shale, dark-brown, flaky, soft; brown weathering; freshwater lacustrine deposit	3.3
86.	Dolomite, tan, silty; weathers to small yellow plates; freshwater lacustrine deposit	0.4
85.	Oil shale, dark-brown, papery, soft; drab brown weathering; freshwater lacustrine deposit	55.0
84.	Coquinal oil shale, brown, crumbly; abundant *Goniobasis tenera*, *Viviparus* sp., and *Lampsilis* sp.; freshwater lacustrine deposit	0.4
	Total Scheggs Bed of Tipton Shale Member	59.1
	Niland Tongue of Wasatch Formation:	
33.	Shale, dark-gray, silty, soft; flood-plain deposit	2.1
82.	Sandstone, gray, very fine grained, calcareous, hard, ripple-marked; flood-plain-splay deposit	2.3
81.	Shale, gray, very sandy, soft; flood-plain deposit.	7.0
80.	Sandstone, gray, very fine grained, calcareous, hard, ripple-marked; flood-plain-splay deposit	1.3
79.	Shale, gray, sandy, soft; flood-plain deposit	2.7
78.	Sandstone, gray, very fine grained, fairly well sorted, calcareous, hard, ripple-marked; weathers to small ledge; flood-plain-splay deposit	0.6
77.	Shale, gray, silty, soft; flood-plain deposit	2.9
76.	Siltstone, gray, dolomitic, hard; freshwater lacustrine deposit	0.8

Type section of the Scheggs Bed of the Tipton Shale Member of the Green River Formation and adjacent rocks in the Wasatch and Green River Formations—Continued

		Thickness Feet
	Niland Tongue of Wasatch Formation—Continued	
75.	Oil shale, brown, papery, soft; freshwater lacustrine deposit	3.7
74.	Coquinal sandstone, gray, calcareous, limonitic, crumbly; poorly preserved *Goniobasis* sp., *Viviparus* sp., and *Lampsilis* sp.; freshwater lacustrine shoreline deposit	0.6
73.	Shale, dark-gray, very carbonaceous, silty, soft, and thin interbedded sandstone, gray, very fine grained, argillaceous, slightly calcareous; paludal deposit	11.6
72.	Oil shale, dark-brown, flaky, soft; freshwater lacustrine deposit	5.4
71.	Coquinal sandstone, gray, crumbly, hard; abundant *Goniobasis* sp., *Viviparus* sp., and *Lampsilis* sp.; freshwater lacustrine shoreline deposit	0.8
70.	Shale, dark-gray, dark-brown, fissile, silty, slightly carbonaceous; paludal deposit	3.8
69.	Sandstone, gray, very fine grained, very soft, limonitic, nonresistant; fluvial-channel deposit .	17.0
68.	Shale, gray, sandy, soft; flood-plain deposit	3.0
67.	Shale, dark-gray, silty, very carbonaceous, firm; thin beds of coal in the lower and upper parts; paludal deposits	3.7
66.	Sandstone, gray, very fine grained, argillaceous, soft; nonresistant, and interbedded shale, gray, sandy, soft; flood-plain and fluvial-channel deposits	35.0
65.	Sandstone, gray, very fine grained, calcareous, hard; caps small bench; fluvial-channel deposit.	12.0
64.	Shale, gray, brown, slightly carbonaceous, limonitic, silty, firm; paludal deposit	9.0
63.	Oil shale, brown, flaky, soft; freshwater lacustrine deposit	15.0
62.	Sandstone, gray, very fine grained; very argillaceous at the base with shaly streaks, becomes very calcareous and hard at the top; caps bench; freshwater lacustrine shoreline deposit	12.5
61.	Shale, dark-gray, silty, soft; flood-plain deposit	1.5
60.	Sandstone, gray, very fine grained, partly calcareous and hard, partly argillaceous and soft; fluvial-channel deposit	18.2
59.	Shale, dark-brown, carbonaceous, silty; paludal deposit	1.1
58.	Coal	1.0
57.	Shale, dark-gray, carbonaceous, silty, firm; paludal deposit	1.2
56.	Shale, gray-brown, silty, soft, and interbedded sandstone, gray, very fine grained, argillaceous, soft; flood-plain and flood-plain-splay deposits	27.8
55.	Limestone, gray, brown, silty, hard, dense; contains *Physa pleromatis* and *Anisus* sp.; freshwater pond deposit	0.8
54.	Sandstone, gray, very fine grained, argillaceous, soft; fluvial-channel deposit	9.0

Type section of the Scheggs Bed of the Tipton Shale Member of the Green River Formation and adjacent rocks in the Wasatch and Green River Formations—Continued

	Thickness Feet
Niland Tongue of Wasatch Formation—Continued	
53. Shale, dark-gray, carbonaceous, silty, firm; paludal deposit	1.5
52. Shale, gray, gray-brown, silty, soft; paludal deposit	5.1
51. Shale, dark-gray, silty, very carbonaceous, and interbedded siltstone, light-gray, calcareous, firm; paludal deposits	3.3
50. Sandstone, gray, very fine grained; silty in the upper part, argillaceous in the lower part; the upper 3.0 ft is a coquina composed of *Goniobasis* sp., *Viviparus* sp., and *Lampsilis* sp.; freshwater lacustrine shoreline deposit	14.5
49. Sandstone, gray, very fine grained, argillaceous, in part calcareous, ripple-marked; and interbedded mudstone, gray, silty; contains well-preserved fossil leaves; flood-plain and flood-plain-splay deposits	5.2
48. Oil shale, brown, flaky; silty at the top; freshwater lacustrine deposit	2.7
47. Coquinal sandstone, gray, limy, hard; abundant *Goniobasis* sp., *Viviparus* sp., and *Lampsilis* sp.; freshwater lacustrine shoreline deposit	0.8
46. Sandstone, gray, very fine grained, argillaceous, limonitic, very soft; freshwater lacustrine deposit	6.8
45. Coquinal sandstone, gray, limy, hard; crumbly at the top; abundant *Goniobasis* sp., *Viviparus* sp., and *Lampsilis* sp.; freshwater lacustrine shoreline deposit	1.1
44. Sandstone, gray, very fine grained, micaceous, calcareous; parallel bedded; freshwater lacustrine shoreline deposit	11.5
43. Sandstone, gray, very fine grained, argillaceous, micaceous, soft, and interbedded shaly siltstone, gray, firm; freshwater lacustrine shoreline deposit	10.8
42. Shale, dark-gray, partly very carbonaceous, fissile, soft, and interbedded siltstone, gray, sandy, argillaceous, firm; paludal deposits	8.0
41. Sandstone, gray, very fine grained, partly calcareous, partly argillaceous, limonitic; resistant at the top and bottom; fluvial-channel deposit	7.6
Total Niland Tongue	292.3
Luman Tongue of Green River Formation:	
40. Oil shale, dark-brown, flaky, silty; freshwater lacustrine deposit	1.2
39. Coquinal sandstone, gray, crumbly, firm; abundant *Goniobasis tenera*, *Viviparus paludinaeformis*, and ?*Lampsilis* sp.; freshwater lacustrine shoreline deposits	0.9
38. Oil shale, dark-brown, flaky, soft; freshwater lacustrine deposit	76.9
37. Coquinal sandstone, gray, crumbly, firm; abundant *Goniobasis tenera*, *Viviparus trochiformis*, and *Lampsilis* sp.; freshwater lacustrine shoreline deposit	2.0

Type section of the Scheggs Bed of the Tipton Shale Member of the Green River Formation and adjacent rocks in the Wasatch and Green River Formations—Continued

	Thickness Feet
Luman Tongue of Green River Formation—Continued	
36. Sandstone, gray, very fine grained, very calcareous, hard; some *Goniobasis* sp.; freshwater lacustrine shoreline deposit	1.1
35. Shale, dark-gray, dark-brown, carbonaceous, limonitic, silty; paludal deposit	5.8
34. Shale, gray, silty, soft; flood-plain deposit	2.0
33. Sandstone, gray, very fine grained, poorly sorted, subangular, calcareous; small-scale cross-bedding; flood-plain-splay deposit	1.0
32. Mudstone, dark-gray, sandy, firm; flood-plain deposit	7.1
31. Oil shale, brown, flaky, soft; freshwater lacustrine deposit	8.1
30. Coquinal sandstone, gray, limy, crumbly, hard; abundant *Goniobasis* sp., *Viviparus* sp., and a few *Lampsilis* sp.; freshwater lacustrine shoreline deposit	6.5
29. Oil shale, brown, flaky, soft; freshwater lacustrine deposit	2.8
28. Coquinal sandstone, gray, very fine grained, limy, hard; crumbly at the top; abundant *Goniobasis tenera*, some *Viviparus* sp., and a few *Lampsilis* sp.; freshwater lacustrine shoreline deposit.	5.5
27. Sandstone, gray, very fine grained, calcareous, hard; trough crossbedded; some *Goniobasis* sp.; freshwater lacustrine shoreline deposit	4.8
26. Mudstone, gray, sandy, soft; and interbedded sandstone, gray, very fine grained, argillaceous, soft, and a few thin beds of gray shale; flood-plain deposits	40.0
25. Oil shale, brown, flaky, soft; freshwater lacustrine deposit	3.0
24. Sandstone, gray, very fine grained, calcareous, hard, ripple-marked; freshwater lacustrine shoreline deposit	0.8
23. Shale, gray, fissile, soft; silty at the top; flood-plain deposit	3.1
22. Oil shale, dark-brown, flaky, soft; a few laminae of coquinal siltstone, gray; freshwater lacustrine deposits	10.2
21. Coquinal sandstone, gray, crumbly, hard; abundant *Goniobasis tenera*, *Viviparus paludinaeformis*, and a few ?*Lampsilis* sp.; freshwater lacustrine shoreline deposit	1.2
20. Oil shale, brown, flaky, soft; freshwater lacustrine deposit	0.9
19. Shale, dark-brown, carbonaceous, soft; 0.3-ft-thick coal bed near the base; paludal deposits	2.2
18. Oil shale, dark-brown, silty, soft; abundant mollusk shell fragments; freshwater lacustrine deposit	1.8
17. Coquinal sandstone, gray, crumbly, hard; abundant *Goniobasis tenera* and *Viviparus paludinaeformis*; freshwater lacustrine shoreline deposit	0.4

Type section of the Scheggs Bed of the Tipton Shale Member of the Green River Formation and adjacent rocks in the Wasatch and Green River Formations—Continued

	Thickness Feet
Luman Tongue of Green River Formation—Continued	
16. Shale, light-gray, silty, fissile, soft; flood-plain deposit	1.3
15. Sandstone, gray, very fine grained, calcareous, hard, ripple-marked and crossbedded; freshwater lacustrine shoreline deposit	7.3
14. Mudstone, dark-gray-green, sandy, firm; flood-plain deposit	3.5
13. Shale, dark-gray-brown, silty, carbonaceous, limonitic, firm; paludal deposit	1.8
12. Siltstone, gray, sandy, calcareous; in thin parallel beds; ripple marked; and interbedded mudstone, gray, sandy, firm; flood-plain and flood-plain-splay deposits	20.9
11. Siltstone, gray-brown, very carbonaceous in parts, argillaceous, firm; in thin parallel beds; paludal deposit	6.0
10. Coal	0.6
9. Siltstone, brown, carbonaceous, calcareous, hard; paludal deposit	0.3
8. Oil shale, dark-brown, flaky, soft; freshwater lacustrine deposit	7.9
7. Shale, dark-gray, dark-brown, very carbonaceous, silty, soft; paludal deposit	0.8
6. Coquinal sandstone, gray, calcareous, crumbly; abundant *Goniobasis tenera*, *Viviparus paludinaeformis*, and *Lampsilis* sp.; freshwater lacustrine shoreline deposit	2.6
5. Shale, dark-brown, very carbonaceous, very sandy, soft; paludal deposit	4.9
4. Oil shale, brown, flaky, soft; freshwater lacustrine deposit	15.0
Total Luman Tongue	262.2
Main body of Wasatch Formation (part):	
3. Mudstone, dark-gray-green, sandy, soft; flood-plain deposit	1.0
2. Sandstone, gray, very fine grained, silty, hard, ripple-marked; weathers to ledge; flood-plain-splay deposit	3.0
1. Mudstone, dark-gray-green, sandy, soft, and a thick interbedded sandstone, gray, very fine grained, calcareous, trough-crossbedded, near the middle of the interval; flood-plain and fluvial-channel deposits	24.0
Total main body of Wasatch Formation measured	28.0

RIFE BED OF THE TIPTON SHALE MEMBER OF THE GREEN RIVER FORMATION

The oil shale beds of saltwater lacustrine origin that conformably overlie the Scheggs Bed of the Tipton Shale Member and Farson Sandstone Member of the Green River Formation and Alkali Creek Tongue of the Wasatch Formation and underlie and partly intertongue with the Wilkins Peak Member of the Green River Formation (fig. 10) are herein named the Rife Bed of the Tipton Shale Member of the Green River Formation. The Rife Bed was deposited across most of the central part of the greater Green River basin area (fig. 27). The bed is well exposed across the northern part of the Great Divide basin, around the northern and western parts of the Washakie basin, and along the west flank of the Rock Springs uplift. It was not deposited in the northwest part of the Green River basin. Outcrops of the member normally range in thickness from 25 to 150 ft; they reach a maximum recorded thickness of 315 ft a few miles southwest of Wamsutter, Wyo.

During the deposition of the Rife Bed, Lake Gosiute had an irregular shape but occupied an area of about 7,000 mi^2. The lake extended from the eastern margin to near the southwestern margin of the ancestral greater Green River basin, a distance of about 140 mi, and northward from the north edge of the Uinta Mountains across the Rock Springs uplift, a distance of more than 75 mi (fig. 27). A notable feature of the lake was an embayment that was present at the east end of the Uinta Mountains.

The Rife Bed comprises light-gray-weathering black to brown dolomitic oil shale that contains scattered thin lenses and small podlike inclusions of tan- to orange-weathering, gray to gray-brown dolomite, and widely spaced, thin layers of tan siltstone and tan-gray- or rust-weathering, white tuff. The oil shale beds are mostly replaced by gray or green mudstone deposited as mudflats at the margins of the lake where the Rife Bed intertongues with the Wilkins Peak Member (fig. 10). Shorelines of the lake are characterized by layers of tan to gray algal limestone that developed as linear reefs parallel to the shorelines, and in a few places by thin, white, wave-rippled siltstone. The shorelines along the northern margins of the Uinta Mountains are largely sandstone and conglomerate deposited as deltas and alluvial fans.

The type section of the Rife Bed is located south of the Rock Springs uplift in SW¼ sec. 13 and NW¼ sec. 24, T. 13 N., R. 103 W. (figs. 27, 28). It is situated on the east slopes of Salt Wells Creek, a few miles west of the Rife Ranch buildings. The type section is accessible by Wyoming Highway 430. Forty-four miles south of Rock Springs, Wyo., an unimproved road branches westward from the highway at Rifes Rim. From this junction the unimproved road trends westward along the crest of Rifes Rim for 7 mi to the valley of Salt Wells Creek and then 2 mi south along the creek to the area of the type section. A columnar section, figure 29, includes the type Rife Bed and adjacent rocks in the Green River and Wasatch Formations. Depositional environments and thicknesses of rock units illustrated on the columnar section are identified in the following lithologic descriptions.

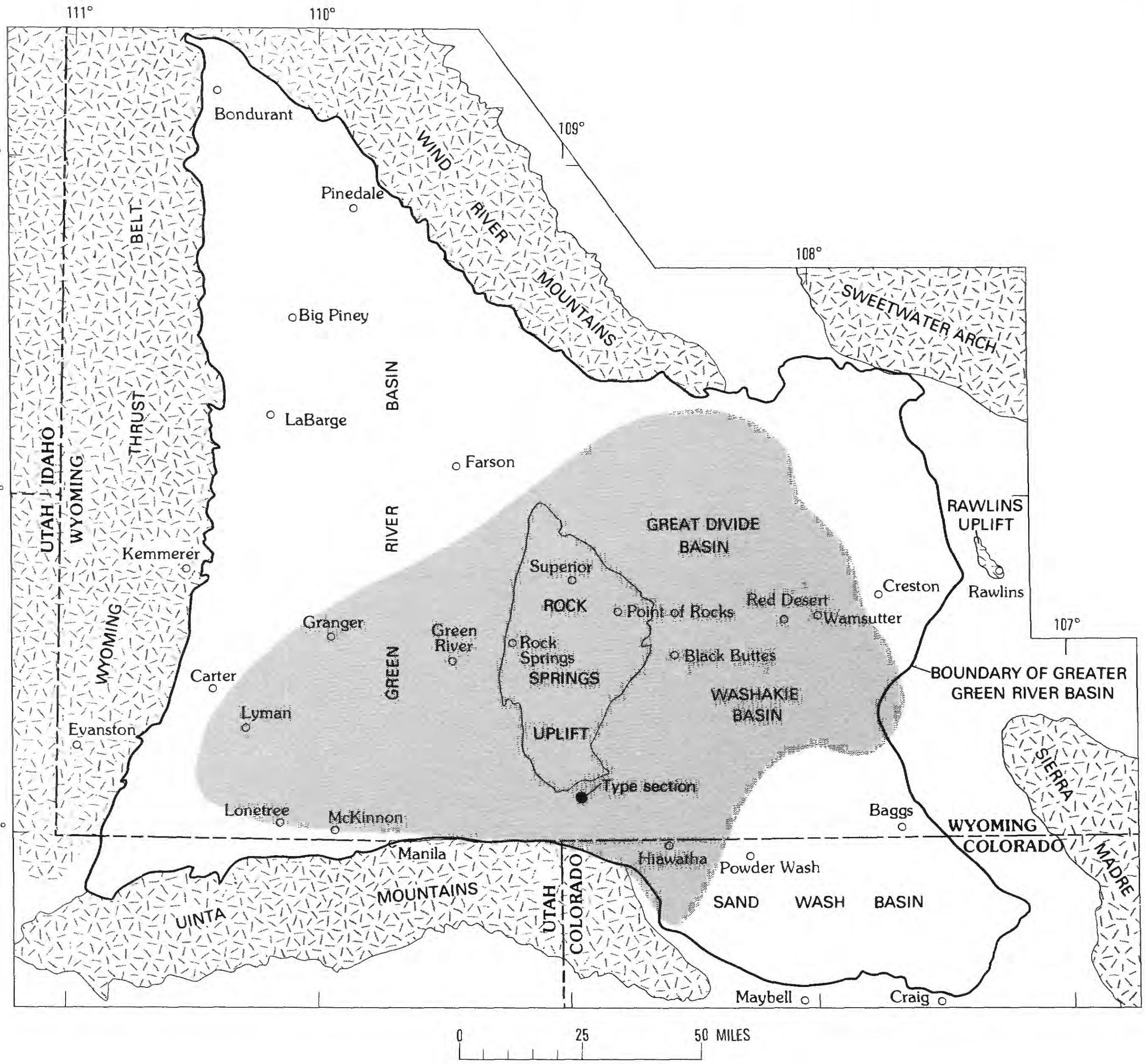


FIGURE 27.—Map showing the Eocene areal distribution of the Rife Bed of the Tipton Shale Member of the Green River Formation (shaded) in the greater Green River basin area.

Type section of the Rife Bed of the Tipton Shale Member and adjacent rocks in the Green River and Wasatch Formations

[Measured by Jacob's staff on the east slopes of Salt Wells Creek in SW¼ sec. 13 and NW¼ sec. 24, T. 13 N., R. 103 W.]

	Thickness *Feet*
Cathedral Bluffs Tongue of Wasatch Formation (part):	
66. Mudstone, dark-maroon-red, sandy, blocky, hard; flood-plain deposits	30.9

Type section of the Rife Bed of the Tipton Shale Member and adjacent rocks in the Green River and Wasatch Formations—Continued

	Thickness *Feet*
Wilkins Peak Member of Green River Formation:	
65. Siltstone, gray, dolomitic, hard; grades upward into sandstone, gray, very fine grained, very calcareous, platy, hard; rust brown weathering; forms ridge; lacustrine deposits	4.6
64. Mudstone, dark-gray-green, silty, blocky, firm; mudflat deposit	2.5

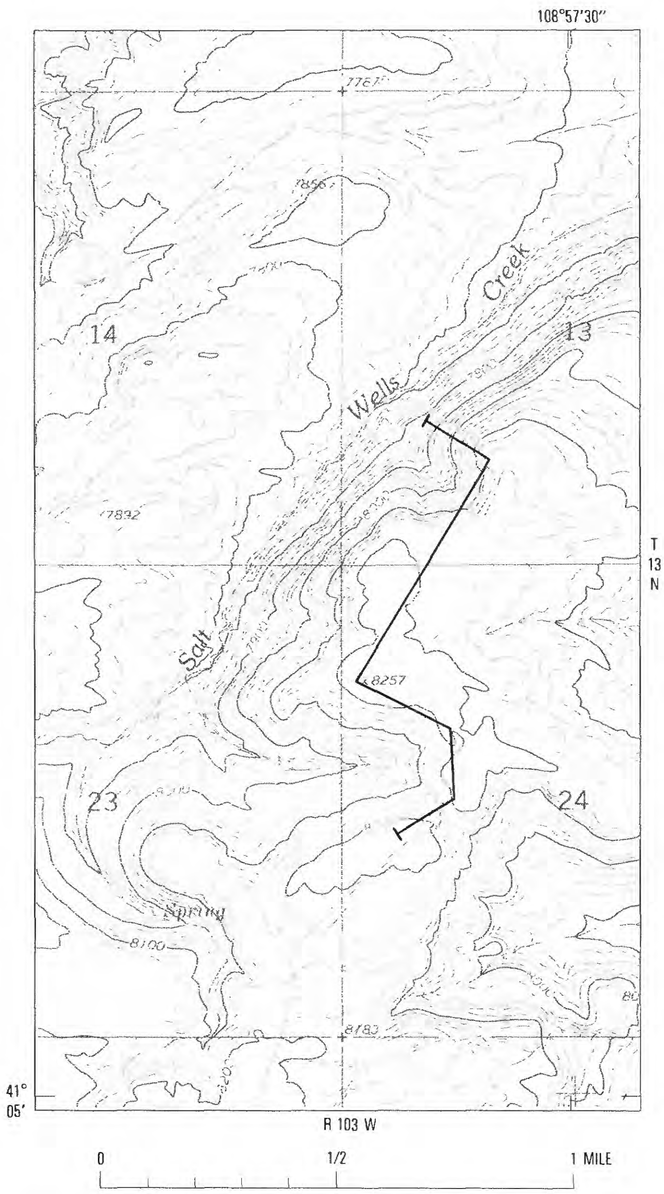


FIGURE 28.—Geographic location of the type section of the Rife Bed of the Tipton Shale Member of the Green River Formation in secs. 13 and 24, T. 13 N., R. 103 W. Base from U.S. Geological Survey Four J Rim (Wyo.-Colo.) quadrangle; scale 1:24,000; contour interval 20 feet.

Type section of the Rife Bed of the Tipton Shale Member and adjacent rocks in the Green River and Wasatch Formations—Continued

	Thickness Feet
Wilkins Peak Member of Green River Formation—Continued	
63. Dolomite, light-brown, very silty, platy, hard; mudflat deposit	0.3
62. Mudstone, dark-green, blocky, hard; mudflat deposit	3.5
61. Dolomite, light-brown, very silty, platy, hard; mudflat deposit	0.6
60. Mudstone, dark-green, blocky, hard; with a 0.2-ft-thick layer of sandstone, red, fine-grained, 6 ft above the base; mudflat deposit	9.9
59. Dolomite, light-brown, very hard, sandy; weathers to small blocks; mudflat deposit	0.4
58. Mudstone, dark-gray-green, dark-gray-brown, silty, blocky, firm; mudflat deposit	15.5
57. Dolomite, light-brown, very hard, dense, sandy; yellow brown weathering; mud-cracked upper surface; mudflat deposit	0.3
56. Mudstone, dark-gray-green, silty, blocky, firm; mudflat deposit	9.4
55. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, biotitic, calcareous, firm; lacustrine deposit	0.6
54. Mudstone, dark-gray-green, silty, blocky, firm; a few laminae of siltstone, gray; mudflat deposit.	41.9
53. Sandstone, light-gray, very fine grained, fairly well sorted, subangular, biotitic, soft, friable; some gray, black, and red grains; trough crossbedded; fluvial channel deposit	8.2
52. Mudstone, dark-gray-brown, dark-gray-green, silty, blocky, firm, and some very thin interbedded lenses of siltstone and sandstone, gray, limy, platy, hard; mudflat and lacustrine deposits	16.3
51. Sandstone, light-gray, very fine grained, limy, platy, hard; rust brown weathering; forms ledge; lacustrine shoreline deposit	1.8
50. Mudstone, dark-gray-brown, silty, blocky, firm, and some thin interbedded siltstone, gray, dolomitic, platy, hard; rust brown weathering; lacustrine deposit	12.4
49. Analcimized tuff, gray, hard; airfall ash	0.2
48. Mudstone, dark-gray-brown, silty, blocky, firm; and some very thin interbedded siltstone, gray, dolomitic, platy, hard; rust brown weathering; lacustrine deposit	12.7
47. Sandstone, light-gray, very fine grained, very calcareous, platy, hard; rust brown weathering; forms ledge; lacustrine deposit	3.1
46. Mudstone, dark-gray-green to dark-gray-brown, silty, blocky, firm; mudflat and lacustrine deposits	50.3
45. Sandstone, gray, very fine grained, fairly well sorted, very calcareous, platy; in thin, parallel, wave-rippled laminae; lacustrine shoreline deposit	1.8
44. Mudstone, dark-gray-brown, some dark-gray-green toward the top, silty, blocky, firm, and very thin interbedded siltstone, tan, gray, dolomitic, hard; mudflat and lacustrine deposits.	23.5
43. Oil shale, dark-brown, flaky, dolomitic, brittle; lacustrine deposit	0.5

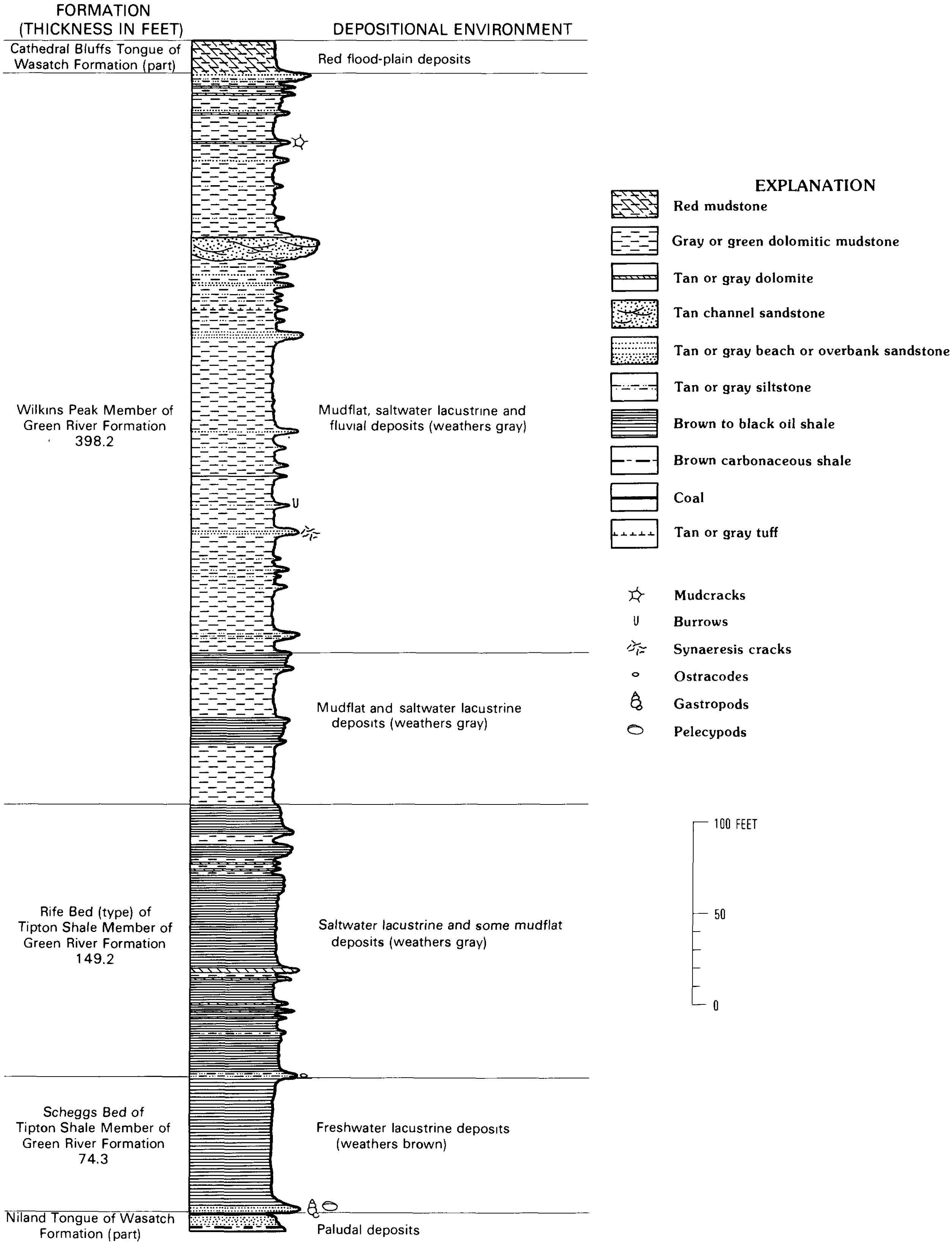


FIGURE 29.—Columnar section of the type Rife Bed of the Tipton Shale Member and adjacent rocks in the Green River and Wasatch Formations. Location of the type section, figure 27.

Type section of the Rife Bed of the Tipton Shale Member and adjacent rocks in the Green River and Wasatch Formations—Continued

	Thickness Feet
Wilkins Peak Member of Green River Formation—Continued	
42. Mudstone, dark-gray-green, silty, blocky, firm; mudflat deposits	15.2
41. Siltstone, gray, very dolomitic, very hard; in thin parallel beds; abundant vertical burrows; lacustrine shoreline deposit	0.4
40. Mudstone, dark-gray-brown, dark-gray-green, silty, blocky, firm; mudflat and lacustrine deposits	13.6
39. Sandstone, light-gray, very fine grained, fairly well sorted, very calcareous, very hard, platy; in thin, parallel, wave-rippled beds; lacustrine shoreline deposit	2.2
38. Mudstone, dark-green, dark-gray-green, dark-gray-brown, silty, blocky, firm, and thin interbedded siltstone, gray, dolomitic; in thin wave-rippled laminae; mudflat and lacustrine shoreline deposits	29.0
37. Mudstone, dark-gray-brown, dark-gray-green, silty, blocky, firm; mudflat deposits	24.9
36. Siltstone, gray, dolomitic, platy, hard; in thin parallel beds; lacustrine shoreline deposit	3.1
35. Mudstone, dark-gray-green, very silty, blocky, firm; mudflat deposit	8.2
34. Oil shale, medium- to dark-brown, flaky, dolomitic, brittle; lacustrine deposit	0.8
33. Oil shale, gray-brown, dolomitic, flaky, hard; lacustrine deposit	7.3
32. Siltstone, light-gray, dolomitic, platy, in thin parallel laminae, and very thin interbedded dolomite, gray-brown, silty, hard; lacustrine shoreline deposits	0.6
31. Mudstone, dark-gray-brown, dolomitic, platy; mudflat deposit	26.0
30. Oil shale, medium-gray-brown, silty, flaky, very dolomitic; lacustrine deposit	1.9
29. Oil shale, dark-gray-brown to dark-brown, silty, blocky, firm, and some very thin interbedded dolomite, tan-gray, silty, hard; lacustrine deposits	15.7
28. Oil shale, dark-gray-brown, very flaky, very dolomitic, brittle; lacustrine deposit	1.6
27. Mudstone, dark-gray-green, silty, blocky, firm; mudflat deposit	27.4
Total Wilkins Peak Member	398.2
Rife Bed (type) of Tipton Shale Member of Green River Formation:	
26. Oil shale, dark-brown, flaky, brittle; lacustrine deposit	12.5
25. Oil shale, very dark brown, flaky, dolomitic, brittle; lacustrine deposit	3.0
24. Mudstone, dark-gray-green, blocky to platy, dolomitic; mudflat deposit	5.3
23. Oil shale, dark-brown, flaky, dolomitic, brittle; lacustrine deposit	6.7

Type section of the Rife Bed of the Tipton Shale Member and adjacent rocks in the Green River and Wasatch Formations—Continued

	Thickness Feet
Rife Bed (type) of Tipton Shale Member of Green River Formation—Continued	
22. Mudstone, dark-gray-green, silty, blocky, firm, and three very thin beds of interbedded dolomite, tan-gray, silty, very hard, dense; in parallel laminae; mudflat deposits	10.0
21. Oil shale, very dark brown, flaky, dolomitic, brittle; lacustrine deposit	9.6
20. Oil shale, dark-brown, flaky, dolomitic, brittle; light gray weathering; lacustrine deposit	23.4
19. Oil shale, medium- to dark-brown, flaky, dolomitic, brittle; light gray weathering; lacustrine deposit	20.0
18. Dolomite, gray-brown, very hard, dense, silty; orange weathering; lacustrine deposit	2.3
17. Mudstone, medium-gray-brown, dolomitic, blocky, hard; mudflat deposit	2.6
16. Dolomite, gray-brown, at the top and bottom, and mudstone, gray-brown, dolomitic, blocky, hard, in the middle; mudflat deposit	0.9
15. Oil shale, medium-brown, dolomitic, flaky, brittle; light gray weathering; lacustrine deposit	12.5
14. Dolomite, tan-gray, silty, very hard, very dense; orange weathering; lacustrine deposit	0.8
13. Oil shale, medium-brown, flaky, dolomitic, brittle; light gray weathering; lacustrine deposit	3.6
12. Dolomite, tan-gray, silty, very hard, very dense; orange weathering; lacustrine deposit	0.4
11. Oil shale, medium-gray-brown, dolomitic, flaky, brittle; light gray weathering; lacustrine deposit	2.9
10. Dolomite, gray-brown, very hard, dense, silty; rust brown weathering; forms a small ledge; lacustrine deposit	0.5
9. Oil shale, medium- to dark-brown, dolomitic, platy, brittle; light gray weathering; lacustrine deposit	7.1
8. Siltstone, tan-brown, limy, dolomitic, platy, hard; lacustrine deposit	1.0
7. Oil shale, dark-brown, dolomitic, flaky, brittle; light gray weathering; lacustrine deposit	22.7
6. Siltstone, tan, limy, platy, hard, shaly; abundant ostracodes in the lower part; lacustrine deposit.	1.7
Total Rife Bed of Tipton Shale Member	149.2
Scheggs Bed of Tipton Shale Member of Green River Formation:	
5. Oil shale, dark-brown, papery, soft; drab brown weathering; lacustrine deposit	72.0
4. Coquinal sandstone, fine-grained, limy, crumbly; abundant *Goniobasis* sp., *Viviparus* sp., and *Lampsilis* sp.; lacustrine shoreline deposit	2.3
Total Scheggs Bed of Tipton Shale Member .	74.3
Niland Tongue of Wasatch Formation (part):	
3. Coal; paludal deposit	0.6

Type section of the Rife Bed of the Tipton Shale Member and adjacent rocks in the Green River and Wasatch Formations—Continued

	Thickness Feet
Niland Tongue of Wasatch Formation (part)—Continued	
2. Sandstone, light-gray, very fine grained, very soft, argillaceous; nonresistant; top 0.5 ft calcareous; splay deposit	7.0
1. Shale, dark-brown, fissile, very carbonaceous, firm; paludal deposit	2.0
Total Niland Tongue measured	9.6

PALEONTOLOGY AND AGE OF THE NEW STRATIGRAPHIC UNITS

The Rife and Scheggs Beds of the Tipton Shale Member and the Farson Sandstone Member of the Green River Formation, and the Alkali Creek Tongue of the Wasatch Formation, are late early Eocene age based on the taxonomy of vertebrate fossils collected at widely separated localities across the greater Green River basin. Vertebrate fossils have been collected in the area for more than 100 years, beginning with Cope (1872). Unfortunately, the geographic location and stratigraphic position data on the fossil collection sites recorded in the area by Cope and by more recent paleontologists are either vague or nonexistent, and thus this information has little stratigraphic value. Consequently, the age of the new units has been determined from four small vertebrate collections that were made by me between 1957 and 1968. The specimens that I collected consisted mostly of individual crowns of mammal teeth. They were sent to C. Lewis Gazin at the Smithsonian Institution, United States National museum, and Paul O. McGrew at the University of Wyoming for identification. The assigned late early Eocene age is based primarily on the presence of *Lambdotherium* (a late early Eocene perissodactyl) and (or) *Hyracotherium* (an early Eocene perissodactyl). The four fossil localities are listed in ascending stratigraphic order and occur either within one of the new stratigraphic units or in subjacent or superjacent units.

The Pinnacles locality.—The collection site is located in the center of NE¼NW¼ sec. 25, T. 24 N., R. 101 W., 4 mi southwest of a cluster of small buttes known as The Pinnacles. The Pinnacles form a prominent landmark in the western part of the Great Divide basin. The fossils at the locality weather from a knobby outcrop of gold-brown fluvial channel sandstone situated within gray flood-plain mudstone. The fossils accumulate in loose sand along the base of the outcrop. The fossil-bearing sandstone is situated in the main body of the Wasatch Formation, 95 ft below the base of the Scheggs Bed of the Tipton Shale Member of the Green River Formation. The mammal assemblage includes *Lambdotherium* sp., *Meniscotherium* sp., *Notharctus* sp., *Hyracotherium* sp., and *Hyopsodus* sp.

Parnell Creek locality.—The collection consists of isolated specimens from three sites along the slopes of Parnell Creek, a tributary of Morrow Creek located in T. 24–25 N., R. 102 W., a few miles north of the Rock Springs uplift. In SW¼NW¼NW¼ sec. 28, T. 24 N., R. 102 W., a mold of a ramus of *Hyracotherium* was found in an ostracodal limestone 3 ft above the base of the Scheggs Bed of the Tipton Shale Member, which is locally 47 ft thick. The incisors of the ramus were present in the matrix in the frontal part of the mold, but only impressions remained of the teeth posterior to the incisors. A second collection site is located in NE¼SE¼ NW¼ sec. 25, T. 25 N., R. 102 W., where specimens of *Lambdotherium* and *Cynodontomys* were found in conglomerate 8 ft below the top of the Farson Sandstone Member. The Farson Sandstone Member is locally 67 ft thick and consists mostly of interbedded oil shale and sandstone. The third collection consists of a single specimen of *Notharctus* collected from gray mudstone 42 ft above the base of the Cathedral Bluffs Tongue in NE¼NE¼NW¼ sec. 25, T. 25 N., R. 102 W. The Rife Bed of the Tipton Shale Member is absent at this locality and the non-red Cathedral Bluffs Tongue rests upon the Farson Sandstone Member.

White Mountain locality.—The type section of the Farson Sandstone Member contains abundant disarticulated vertebrate remains in a conglomerate at the base of a distributary channel sandstone near the top of the section (fig. 23). Most of the identifiable material at the locality was collected from outcrops in the center of SW¼NE¼NW¼ sec. 24, T. 23 N., R. 105 W., a few hundred feet south of the type section as located on figure 20. The collections contain *Coryphodon* sp., *Phenacodus* sp., *Hyracotherium vasacciense*, *Heptodon* sp., and *Lambdotherium* cf. *popoagicum*, clearly demonstrating a late early Eocene age. Fragments of bird bones collected at the site were identified as belonging to a primitive flamingo.

East Hiawatha locality.—The locality is situated near the Wyoming-Colorado State line in NW¼NW¼ sec. 24, T. 12 N., R. 99 W., at the east edge of Hiawatha gas field. *Hyracotherium* sp., an unidentified miacid carnivore, fish and bird bones, and reptile scutes were collected from an outcrop of tan fluvial channel sandstone situated near the contact of the Cathedral Bluffs Tongue and the Wilkins Peak Member. The Wilkins Peak Member is about 350 ft thick; the underlying Rife Bed of the Tipton Shale Member is about 170 ft thick. The occurrence of *Hyracotherium* at this stratigraphic position indicates that the lower part of the Wilkins Peak Member and equivalent parts of the Cathedral Bluffs Tongue, as well as the Rife Bed, are early Eocene age.

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