New Names for Units in the Lower Part of the Green River Formation, Piceance Creek Basin, Colorado

GEOLOGICAL SURVEY BULLETIN 1529–I

New Names for Units in the Lower Part of the Green River Formation, Piceance Creek Basin, Colorado

By RONALD C. JOHNSON

CONTRIBUTIONS TO STRATIGRAPHY

GEOLOGICAL SURVEY BULLETIN 1529–I

A fresh-water lacustrine unit is assigned a new name, and the Douglas Creek Member is redefined. New names are also assigned to the marker beds in this lower part of the Green River Formation

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1984

UNITED STATES DEPARTMENT OF THE INTERIOR

WILLIAM P. CLARK, *Secretary*

GEOLOGICAL SURVEY

Dallas L. Peck, *Director*

Library of Congress Cataloging in Publication Data
Johnson, Ronald C.
New names for units in the lower part of the Green River Formation, Piceance Creek Basin, Colorado.

(Contributions to stratigraphy)(Geological Survey bulletin; 1529–I)
Bibliography: 20 p.
1. Geology, Stratigraphic—Eocene. 2. Geology, Stratigraphic—Nomenclature—Colorado—Piceance Creek Watershed. I. Title. II. Series. III. Series: Geological Survey bulletin ; 1529–I.

QE75.B9 no. 1529–I 557.3s 82–600250
[QE692.2] [551.7'84'0978815]

For sale by Branch of Distribution
U.S. Geological Survey
604 South Pickett Street
Alexandria, VA 22304

CONTENTS

ILLUSTRATIONS

CONTRIBUTIONS TO STRATIGRAPHY

NEW NAMES FOR UNITS IN THE LOWER PART OF THE GREEN RIVER FORMATION, PICEANCE CREEK BASIN, COLORADO

By RONALD C. JOHNSON

ABSTRACT

New names are assigned to three units of the Green River Formation in the Piceance Creek Basin of western Colorado. The name Cow Ridge Member is given to the oldest member of the Green River Formation, a mixture of sandstone, limestone, and shale deposited during an early fresh-water stage of Eocene Lake Uinta. The unit contains a diverse fresh-water mollusk assemblage. The name Long Point Bed is given to a distinctive ostracod-, oolite-, and mollusk-rich bed that marks the next major transgression of Lake Uinta. The Long Point Bed has been mapped as the basal bed of the Anvil Points, Garden Gulch, and Douglas Creek Members, depending upon the lithology of the overlying unit. A laterally persistent tuff bed is named the Kimball Mountain Tuff Bed. The tuff has been mapped as part of the Parachute Creek, Anvil Points, Garden Gulch, and Douglas Creek Members depending upon the lithology of the surrounding unit.

INTRODUCTION

Detailed geologic studies by the U.S. Geological Survey in the Piceance Creek Basin (fig. 1) have demonstrated the need for revision of the presently used nomenclature for the Green River Formation. The nomenclature established by Bradley (1931) 50 years ago cannot accommodate the large amount of stratigraphic information gathered during recent years. A new name is given to the oldest member of the Green River Formation, a mixture of sandstone, limestone, and shale deposited during an early fresh-water stage of Eocene Lake Uinta. Earlier workers have treated the unit in a variety of ways using formal and informal nomenclature and inconsistent boundaries.

Names are given also to a distinctive marker bed and a persistent tuff bed that have been extensively mapped. Both beds are useful because they occur in the lower part of the Green River Formation where no surface marker beds were previously delineated.

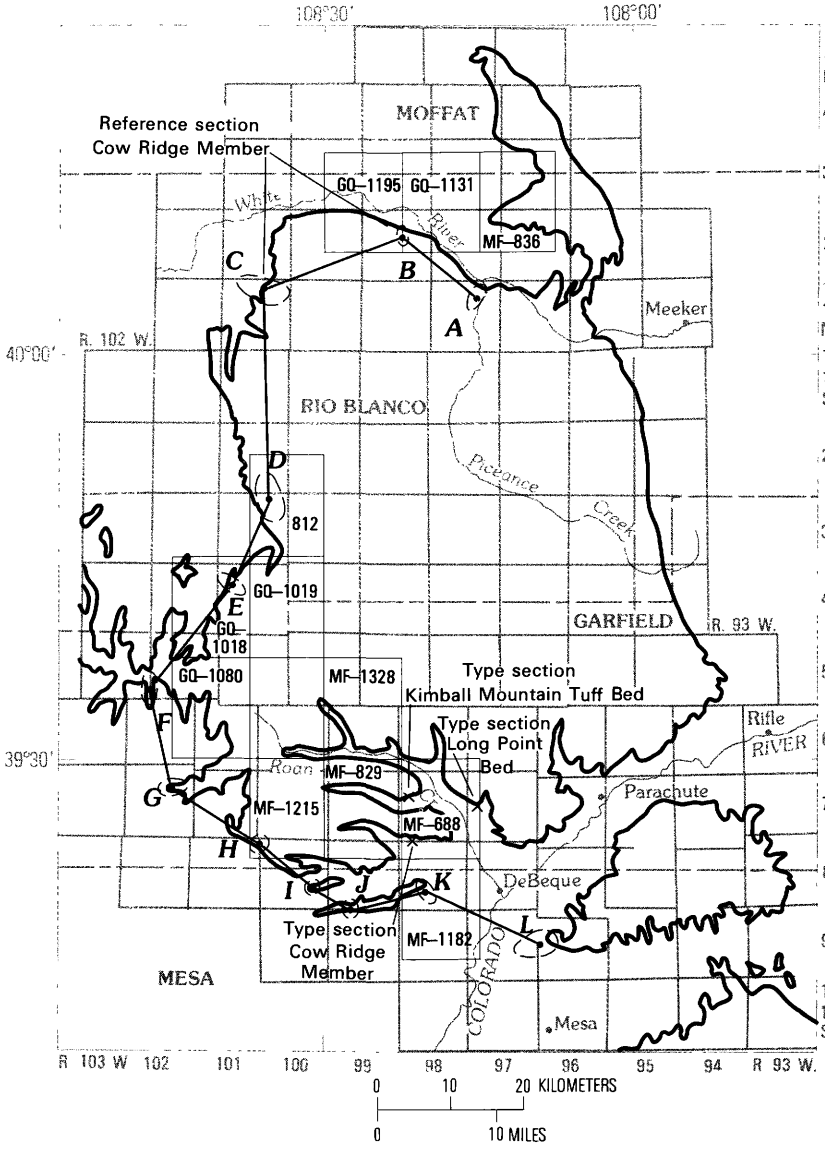


FIGURE 1.—Index map showing location of measured sections, line of cross section *A–L*, and of published 7½-minute quadrangle geologic maps of areas in which the Cow Ridge Member occurs.

Revisions in the nomenclature used for other units in the Green River Formation also are necessary but are beyond the scope of this paper. For the present, the established nomenclature is used for these units on the stratigraphic sections presented.

EXPLANATION

BASE OF GREEN RIVER FORMATION

A B LINE OF SECTION

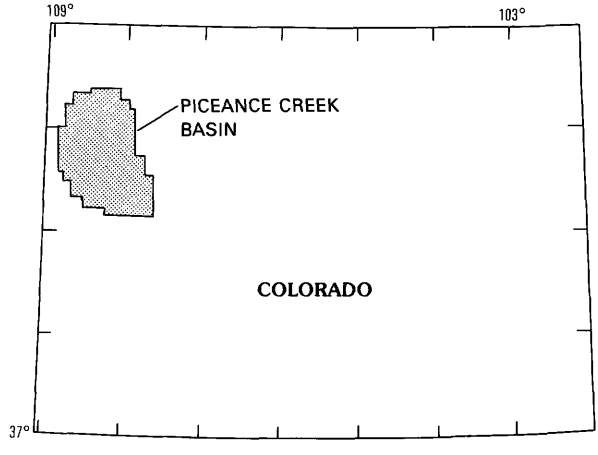
.C LOCATION AND EXTENT OF MEASURED SECTION

× LOCATION OF TYPE SECTION

GQ–812 AREA AND NUMBER OF PUBLISHED MAP

PUBLISHED MAPS

MAP NO.	QUADRANGLE NAME	REFERENCE
GQ–1195	Rough Gulch	Hail (1974)
GQ–1131	Smizer Gulch	Hail (1973)
MF–836	Indian Valley	Pipiringos and Rosenlund (1977)
GQ–812	Black Cabin Gulch	Cashion (1969)
GQ–1018	Brushy Point	Roehler (1972a)
GQ–1019	Razorback Ridge	Roehler (1972b)
GQ–1080	Calf Canyon	Roehler (1973)
MF–1328	Desert Gulch	Johnson (1981)
MF–1215	Middle Dry Fork	Johnson (1980)
MF–829	The Saddle	Johnson (1977)
MF–688	Long Point	Johnson (1975)
MF–1182	Wagon Track Ridge	Johnson and Douglas (1980)



COW RIDGE MEMBER

The name Cow Ridge Member of the Green River Formation is given to a fresh-water lacustrine unit of early Eocene to early middle Eocene age found mostly in the western half of the Piceance Creek

Basin. The type section is in sec. 31, T. 7 S., R. 98 W. on the south side of Cow Ridge, in the Long Point Quadrangle. In previous reports (pl. 1, in pocket) this unit has been mapped as the Douglas Creek Member of the Green River Formation (Cashion, 1969; Roehler, 1972a, b, 1973), the lacustrine unit of the Wasatch Formation (Hail, 1973, 1974), the middle part of the Shire Member of the Wasatch Formation (Johnson, 1975, 1977), the unnamed member of the Green River Formation (Pipiringos and Rosenlund, 1977), and the tongue at Cow Ridge of the Douglas Creek Member (Johnson and Douglas, 1980). Cross sections constructed from surface sections and drill holes (Johnson 1979a, b, and c) have demonstrated that all these fresh-water lacustrine units are part of the same lacustrine system (pl. 1). Therefore, the name Cow Ridge Member is used for this unit throughout its extent.

The Cow Ridge Member is the oldest member of the Green River Formation and was deposited in an early Eocene to early middle Eocene fresh-water stage of Lake Uinta. This stage of the lake was smaller in area than later stages and was confined to the central and northwestern parts of the basin for most of its history (fig. 2). Thin tongues of the Cow Ridge Member, however, are present in all but the eastern and southeastern edges of the basin, indicating that this early fresh-water phase occasionally expanded to cover most of the basin (fig. 2).

The Cow Ridge Member is a heterogeneous mixture of gray, clay-rich low-grade oil shale, brown carbonaceous shale with thin coal beds, and gray to tan siltstone, sandstone, and limestone. Siltstone and sandstone beds are commonly ripple-laminated, fairly persistent laterally, and commonly fossiliferous. The limestones contain abundant ostracods and mollusks and only rarely contain stromatolite structures. The Cow Ridge contains a diversified fauna consisting of the remains of fish, turtles, crocodiles, flamingos, ostracods, and fresh-water mollusks such as *Goniobasis tenera*, Unionidae gen. and sp. indet., *Lioplacodes*, sp. indet. *Promenetus*, sp. indet., *Physa*, sp. indet., *Hydrobia*, sp. indet., and *Valvata*, sp. indet.

Throughout most of the basin, the Cow Ridge Member is underlain and overlain by fluvial sequences of the Wasatch Formation or a tongue of the Wasatch, and hence is not likely to be confused with younger members of the Green River Formation. In the northwest corner of the basin, however, the Cow Ridge is directly overlain by the Garden Gulch Member of the Green River Formation. Here the top of the Cow Ridge is marked by a change from the heterogeneous mixture of clay-shale, carbonaceous shale, and fossiliferous siltstone, sandstone, and limestone that is typical of the member to all low-grade, clay- rich oil shale. This change marks the beginning of the

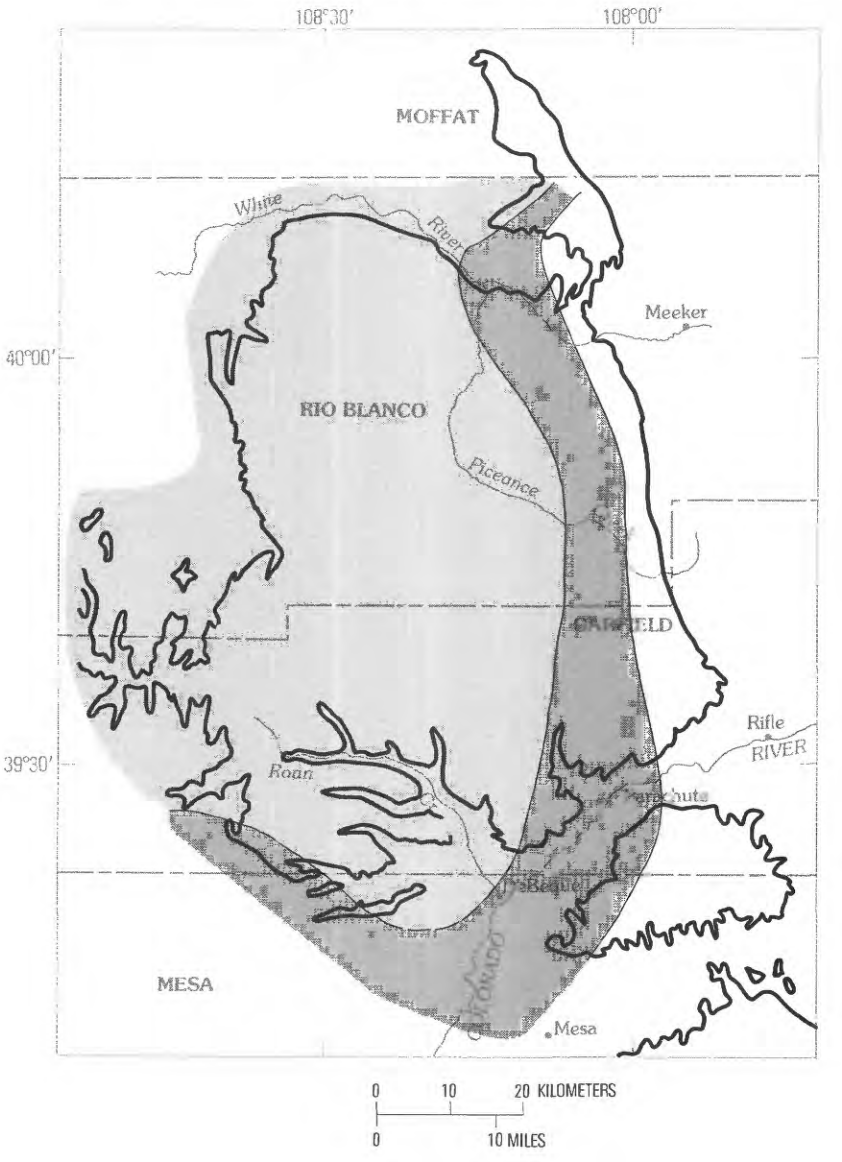


FIGURE 2.—Map showing area and extent of the Cow Ridge Member (dark stipple), and extent of Long Point transgression (light stipple) beyond area occupied by the Cow Ridge Member.

Long Point transgression, a time of rapid expansion and deepening of Lake Uinta.

Age of the Cow Ridge Member determined by palynomorphs is early to early middle Eocene. Early to early middle Eocene pollen

has been collected in the Cow Ridge Member throughout the southwestern part of the basin (Johnson and May, 1978). Eocene pollen was collected only 11 m above the base of the Cow Ridge at Fletcher Gulch in an area where the base of the Cow Ridge is older than it is in most of the basin.

DETAILED SECTIONS

Three detailed sections, Cow Ridge, Fletcher Gulch, and Yellow Creek were measured and described (pl. 1). The Cow Ridge section (fig. 3; pl. 1) was measured in the southwestern part of the basin and was designated as the type section. The Fletcher Gulch section (fig. 4; pl. 1) was measured in the extreme northwest corner of the basin and the Yellow Creek section (fig. 5; pl. 1) was measured in the north-central part of the basin. The Yellow Creek section is designated as the reference section. At Yellow Creek, the Cow Ridge Member is well exposed, easily reached and lithologically quite different from the type section.

Each section of the Cow Ridge Member differs considerably from the other two. At the type section, the member is 63 m thick and is characterized by brown ostracodal clay shale, carbonaceous shale, thin persistent sandstones, and siltstones and ostracodal limestones. One ostracodal limestone is more than 6 m thick and is the thickest limestone yet found in the Cow Ridge Member. Mollusks are common in the Cow Ridge Member. They were not found at the type section although mollusk localities are not uncommon in the area. In general, the Cow Ridge Member contains more carbonaceous shale and thin coal beds in the southwestern part of the basin than in any other area examined.

At Fletcher Gulch, the Cow Ridge Member is 216 m thick and is mostly low-grade clay-rich oil shale in the lower half, and claystone and mudstone interbedded with conglomeratic sandstone in the upper half. Ostracodal shales and ostracodal limestones are scattered throughout most of the section, and abundant mollusks are found in the basal transgressive sandstone. A diverse assemblage of ostracods of apparent fresh-water origin has been identified by R. M. Forrester (oral commun., 1980).

At Yellow Creek, the reference section, the Cow Ridge Member is 149 m thick and is mostly interlayered sandstone, clay shale, and ostracodal limestones. Climbing ripples are present in many of the sandstones suggesting rapid deposition. Ostracodal limestones usually occur at the tops of sandstone beds—a common association in higher units of the Green River as well. Abundant mollusks occur in roughly

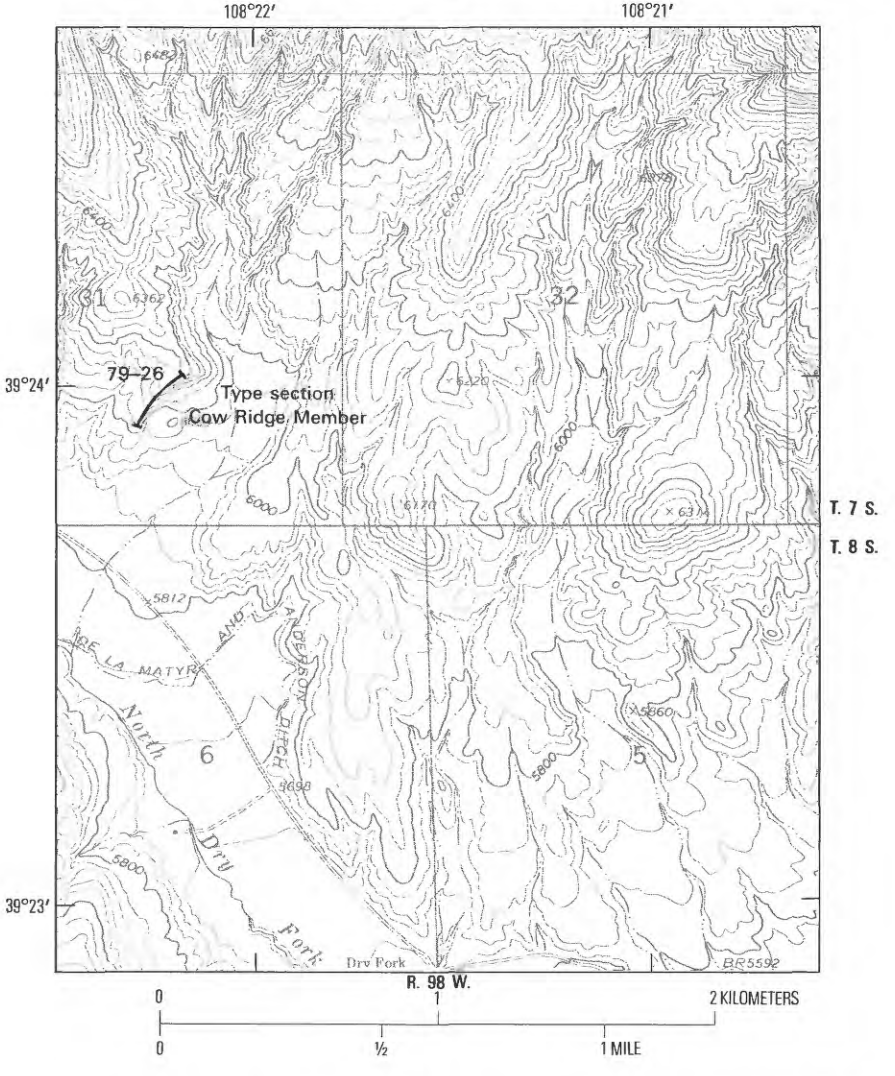


FIGURE 3.—Location of type section of Cow Ridge Member, sec. 31, T. 7. S., R. 98 W. Cow Ridge is about 2 to 3 km to the north. Base is from the Long Point 7½-minute topographic quadrangle: contour interval, 40 ft.

one-third of the sandstones and several of the limestone. Turtle, fish, and unidentified bones also are common. Kerogen content in the claystones appears to be quite low, but the claystones are typically poorly exposed at Yellow Creek. Sandstones and fossils are much more abundant in this section than at either Fletcher Gulch or Cow Ridge.

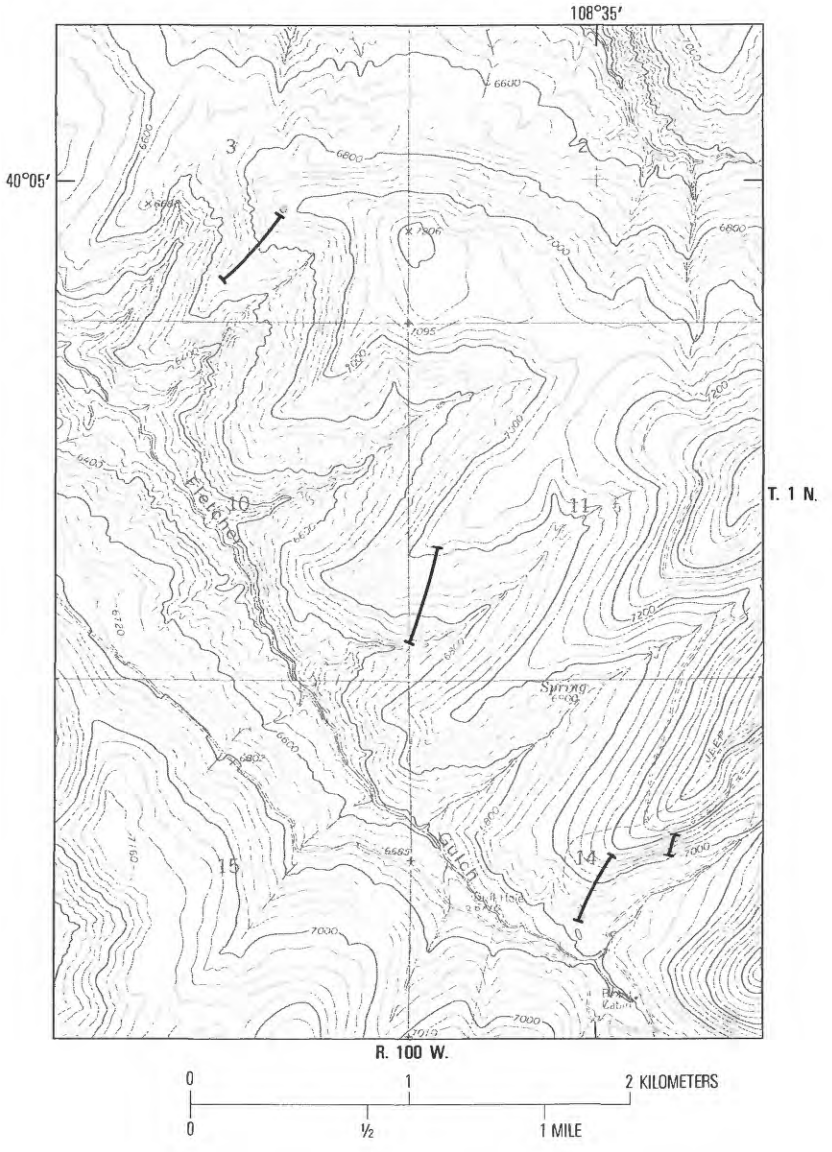


FIGURE 4.—Location of measured section of Cow Ridge Member at Fletcher Gulch, secs. 3, 10, 11, 14, T. 1 N., R. 100 W. Base is from the Calamity Ridge 7½-minute topographic quadrangle: contour interval, 40 ft.

RELATION BETWEEN THE COW RIDGE MEMBER AND THE TYPE DOUGLAS CREEK MEMBER

To determine the relation between the Cow Ridge Member and the Douglas Creek Member an attempt was made to remeasure the

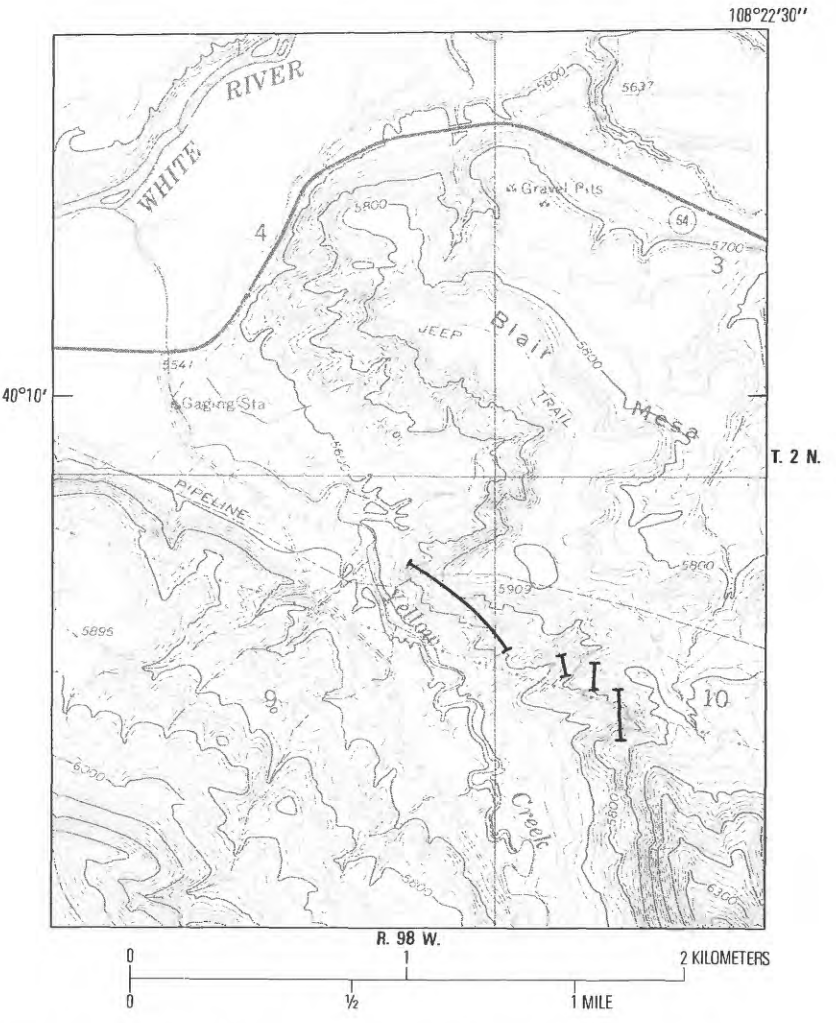


FIGURE 5.—Location of reference section of Cow Ridge Member at Yellow Creek, sec. 9, 10, T. 2 N., R. 98 W. Base is from the Rough Gulch 7½-minute topographic quadrangle: contour interval, 20 ft.

type Douglas Creek. Bradley (1931, pl. 8) did not describe the exact location, but stated only that the type section "was measured near the head of Trail Creek in Garfield County, Colorado." The section presented here was measured in secs. 25 and 36, T. 5 S., R. 102 W. and sec. 30, T. 5 S., R. 101 W. on the east side of Sayles Canyon, a small tributary canyon near the head of Trail Creek (fig. 6). This is the best exposure of the Douglas Creek Member in the area, and probably is within a mile of where Bradley measured his type section.

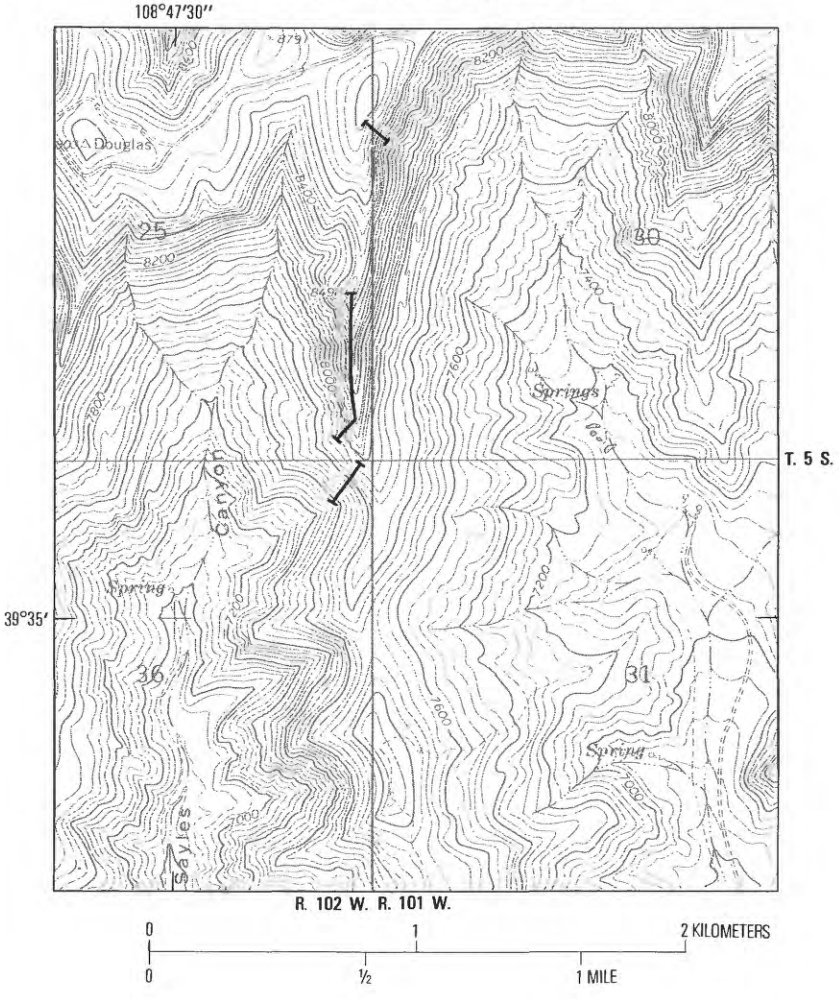


FIGURE 6.—Location of remeasured type section of the Douglas Creek Member. Douglas Creek is about 5 km to the north. Base is from the Douglas Pass 7½-minute topographic quadrangle: contour interval, 40 ft.

The descriptions of Bradley's type section and the section presented here are similar (pl. 1), and hence, it is possible to determine exactly what units were included in the type section. The section is designated as the principal reference section for the Douglas Creek Member. The Douglas Creek is composed mainly of rocks deposited during the next stage of Lake Uinta or the stage that followed the Long Point transgression, and hence, for the most part, is younger than the Cow Ridge Member of this report. However, the type Douglas Creek also includes a thin tongue of fluvial rocks plus a thin tongue of fresh-water lacus-

trine rocks equivalent to the Cow Ridge Member. The type Douglas Creek is hereby redefined to exclude both the thin tongue of Cow Ridge Member, and the thin tongue of fluvial rocks. The fluvial rocks are assigned to the Wasatch Formation. The thickness of those excluded rocks is approximately 35 m, and the base of the redefined Douglas Creek Member is the base of the Long Point Bed, which is labeled on Bradley's section as "oolitic limestone" that is overlain by "limy paper shale and gray mudstone."

At the reference section, the Long Point Bed is a 0.75-m-thick ostracodal limestone bed with abundant gastropods. Overlying the Long Point Bed is about 29 m of fissile clay shale with a few oolitic, ostracodal, and algal limestone beds. This fissile shale unit is widespread and is present throughout the western and southwestern parts of the basin. Overlying the fissile shale unit is a mixture of gray sandstone and siltstone, gray to olive-gray mudstone, and oolitic ostracodal and algal limestone. With the exception of the Long Point Bed, no mollusks are present in the redefined Douglas Creek at its principal reference section.

Bradley's type Douglas Creek Member is also considerably thinner than the remeasured Douglas Creek. Bradley apparently offset while measuring the type section at a place labeled "break of unknown amount, probably not large," near the top of his published section. This break represents about 82 m of section, the lithology of this previously unmeasured section is similar to the rest of the Douglas Creek Member, and the type section is redefined to include these rocks.

LONG POINT BED

The Long Point Bed is a distinctive oolitic-, ostracod-, and gastropod-rich marker bed found at the base of the next highest Green River unit above the Cow Ridge Member throughout the southwestern part of the Piceance Creek Basin and is locally present in other parts of the basin as well (fig. 7). It has been mapped as the basal bed of the Garden Gulch Member (Johnson, 1975, 1977, 1980), the basal bed of the Douglas Creek Member (Johnson and Douglas, 1980) and the basal bed of the Anvil Points Member (Johnson, 1975) depending on the lithology of the overlying unit. The type section for the Long Point Bed is on the south side of Long Point in NE¼SW¼ sec. 18, T. 7 S., R. 97 W. (fig. 8; measured section shown on pl. 1). Here the Long Point Bed is the basal bed of the Anvil Points Member (Johnson, 1975). The bed is at the base of a lithologic sequence deposited during a major transgression of Eocene Lake Uinta,

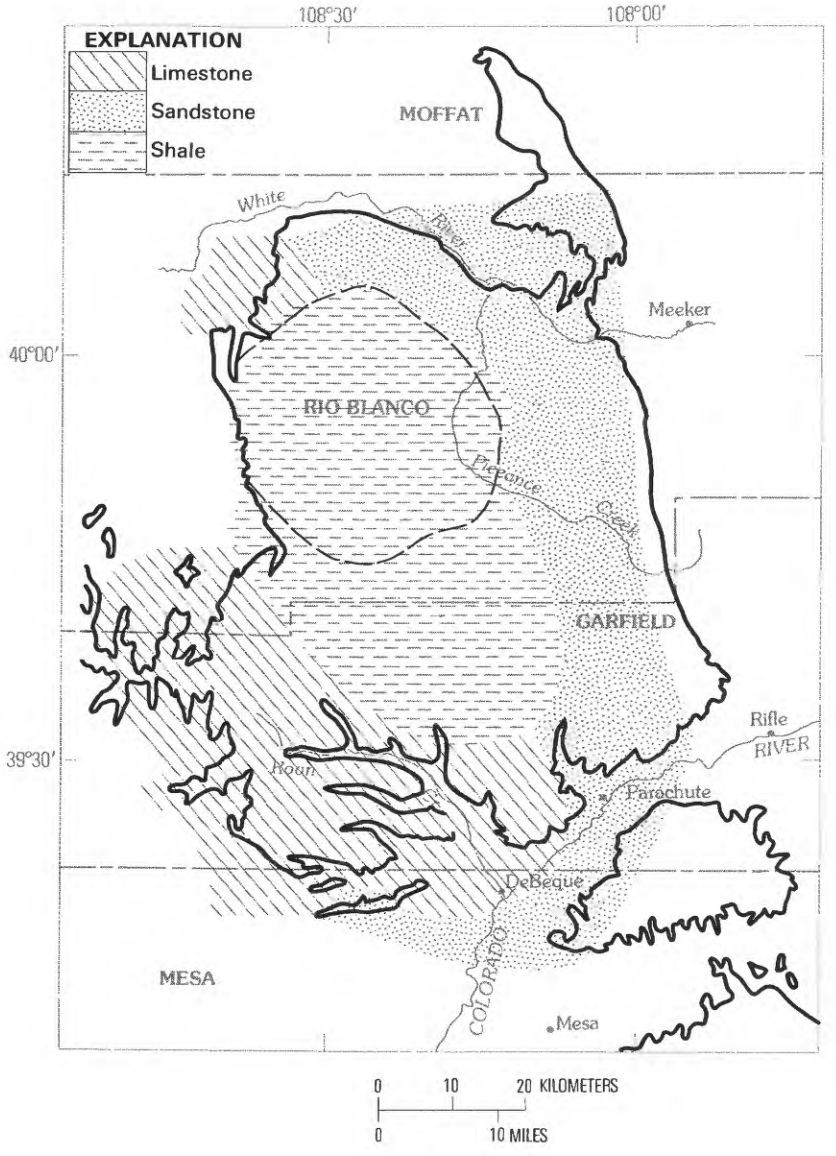


FIGURE 7.—Map showing general composition of basal transgressive bed of Long Point transgression. Dashed line shows approximate extent of Lake Uinta prior to transgression.

the Long Point transgression (an informal new name). The lithology of the marker bed ranges from an ostracod- and oolite-rich sandstone to an ostracodal and oolitic grayish-white limestone, and at many localities the two lithologies are interbedded. Thin claystone partings

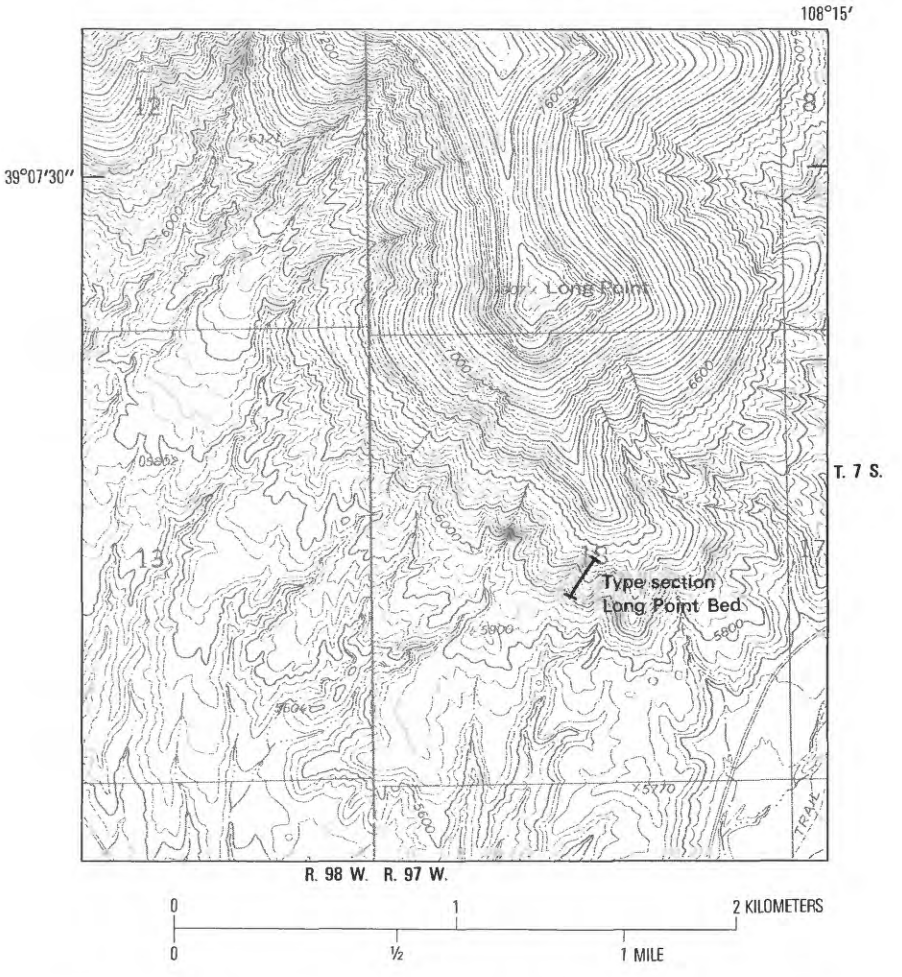


FIGURE 8.—Location of type section of Long Point Bed, sec. 18, T. 7 S., R. 97 W. Base is from the Long Point 7½-minute topographic quadrangle: contour interval, 40 ft.

are also common. The bed ranges in thickness from about 20 cm to 14.6 m in the southwestern part of the basin where it is best developed. Abundant gastropods occur in the Long Point Bed in the southwestern part of the basin. Several gastropod-rich zones commonly occur within the marker bed; however, gastropods rarely are found above the Long Point Bed. Gastropods identified by John H. Hanley are: *Goniobasis tenera*, *Viviparus paludinaeformis*, *Biomphalaria storchi* and Planorbidae. The marker bed is thin or absent in the central part of the basin, and to the east it grades into a thick sandstone sequence and loses its identity. Only a few ostracods and

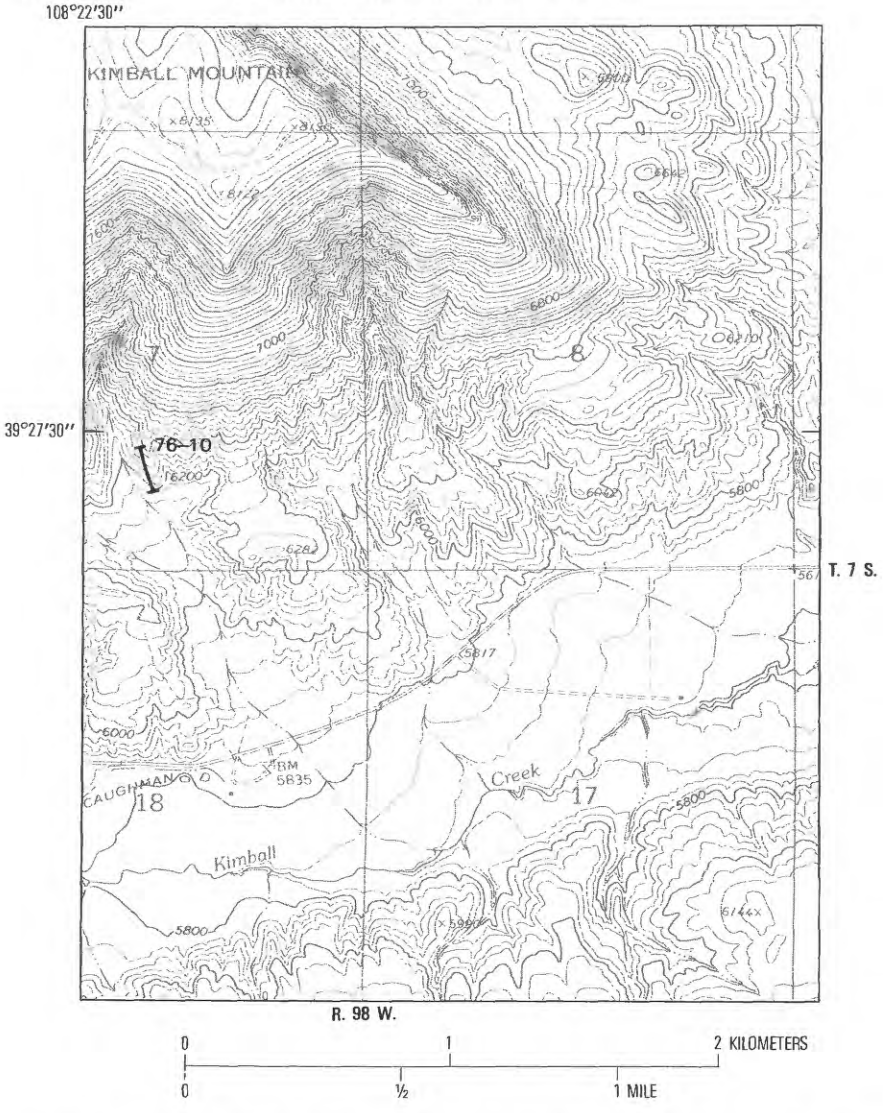


FIGURE 9.—Location of type section of Kimball Mountain Tuff Bed and principal reference section of Long Point Bed, sec. 7, T. 7 S., R. 98 W. Base is from the Long Point 7½-minute topographic quadrangle: contour interval, 40 ft.

gastropods are present in the basal transgressive bed in the eastern part of the basin, where it can still be identified. At the type section, the marker bed consists of two ostracodal limestone beds 0.4 m and 0.3 m thick separated by 0.2-m-thick claystone parting. Unfortunately, no gastropods were found at the type section, and hence the Kimball

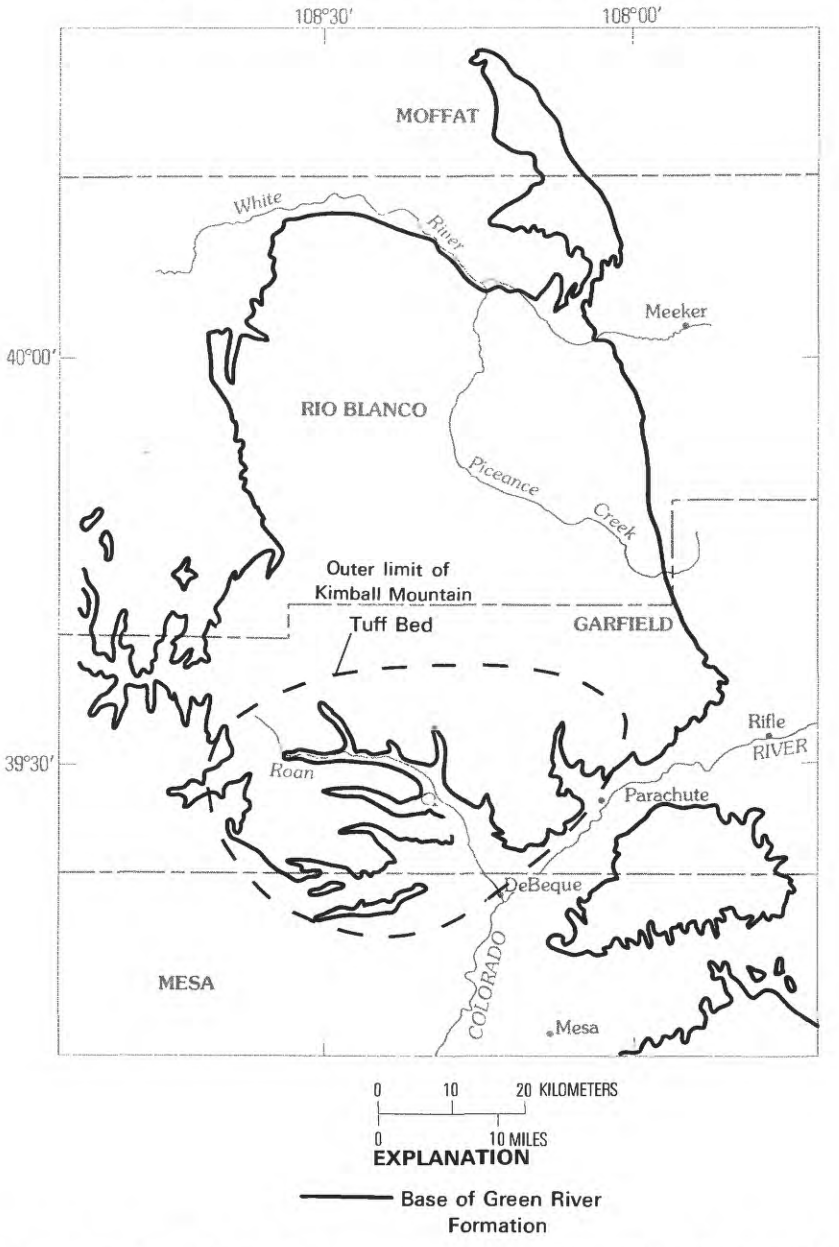


FIGURE 10.—Map showing the presently known distribution of Kimball Mountain Tuff Bed.

Mountain section (fig. 9), a section where the Long Point contains abundant gastropods, is named as the reference section (pl. 1).

Mollusk localities in the Long Point Bed

Location	Mollusks identified
NW¼ sec. 32, T. 7 S., R. 98 W.	cf. *Plesielliptio* n. sp. A of Hanley (1976)
U.S. Geological Survey	*Goniobasis tenera* (Hall)
Cenozoic Locality D1123NM	*Viviparus paludinaeformis* (Hall)
	Viviparus sp.
	Biomphalaria storchi (Russell)
	Planorbidae: Gen. indet. N. sp.
SW¼ sec. 7, T. 8 S., R. 99 W.	*Viviparus* cf. *V. meeki* Wenz
U.S. Geological Survey	*Viviparus* sp.
Cenozoic Locality D1124NM	*Goniobasis* sp.
	Uniondae: gen. and sp. indet.

KIMBALL MOUNTAIN TUFF BED

The name Kimball Mountain Tuff Bed is given to a distinctive tuff bed that occurs from about 60 to 110 m above the base of the Long Point Bed throughout the southwestern part of the Piceance Creek Basin. The Kimball Mountain Tuff Bed has been mapped as a bed in the Douglas Creek Member (Johnson, 1977, Johnson and Douglas, 1980), as the contact between the Douglas Creek and the Garden Gulch (Johnson, 1975, 1977, 1980; Johnson and Douglas, 1980), as the contact between the Garden Gulch and the Parachute Creek (Johnson, 1975), and as the contact between the Anvil Points and the Parachute Creek (Johnson, 1975). The Kimball Mountain Tuff Bed has been used extensively as a contact because it commonly occurs within 10–20 m stratigraphically of major lithologic changes. The type section for the Kimball Mountain Tuff Bed is on the west end of Kimball Mountain in SW¼SE¼ sec. 7, T. 7 S., R. 98 W. (fig. 9; measured section shown on pl. 1). The tuff is exposed about 65 m above the alluvial fan from a small tributary gully of Kimball Creek. Future studies may extend its range into other areas of the basin as well. The tuff ranges in thickness from about 1 to 15 cm, and is locally absent (fig. 10). Throughout most of its range, however, the tuff is from 5 to 7 cm thick with an even top and bottom. Distinctive grooves or load casts typically are present on the lower surface (fig. 11). In thin section, the tuff consists of hexagonal analcime crystals surrounded by large

FIGURE 11.—Kimball Mountain Tuff Bed samples. Note unusual striations on lower surface of sample at right side of photograph. Scale is in millimeters.

crystals of sparry calcite. These sparry crystals are commonly as much as 4 cm in diameter and are easily seen on a fresh surface with the naked eye. Calcite is also replacing and forming pseudomorphs after the hexagonal analcime crystals (fig. 12). Locally the tuff is highly porous, apparently from the leaching of calcite. Dead oil commonly fills these pore spaces. The fresh color varies from light buff to dark gray and most samples are slightly purplish or contain purple stringers. The tuff occurs in a low-grade oil shale bed from 0.5 to 1 m

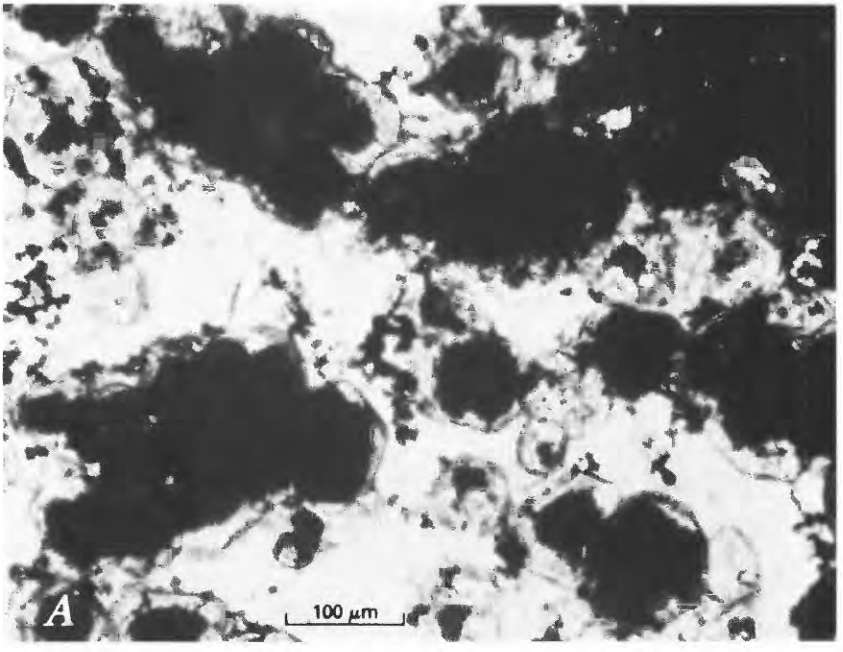


FIGURE 12.—Photomicrographs of samples of Kimball Mountain Tuff Bed. Note calcite pseudomorphic after analcime. *A*, crossed nichols; *B*, Crossed nichols and the gypsum plate inserted.

thick in the northern part of its presently defined range; however, the oil shale becomes progressively leaner southward and in the southern half of its range, claystone surrounds the tuff. A sandstone and siltstone ledge of varying thickness occurs a few feet below the tuff, and a distinctive buff weathering claystone slope occurs a few feet above the tuff. A thin stromatolite unit occurs from 0 to 30 cm below the tuff in the southwestern part of its range (fig. 10).

REFERENCES CITED

Bradley, W. H., 1931, Origin of microfossils of the oil shale of the Green River Formation of Colorado and Utah: U.S. Geological Survey Professional Paper 168, 58 p.

Brobst, D. A., and Tucker, J. D., 1973, X-ray mineralogy of the Parachute Creek Member, Green River Formation, in the northern Piceance Creek Basin, Colorado: U.S. Geological Survey Professional Paper 803, 53 p.

Cashion, W. B., 1969, Geologic map of the Black Cabin Gulch Quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ–812.

Cashion, W. B., and Roehler, H. W., 1975, Stratigraphic section of part of the Green River Formation and underlying units exposed in Tommys Draw, western Piceance Creek Basin, Colorado: U.S. Geological Survey Open-file Report 75–422, 16 p.

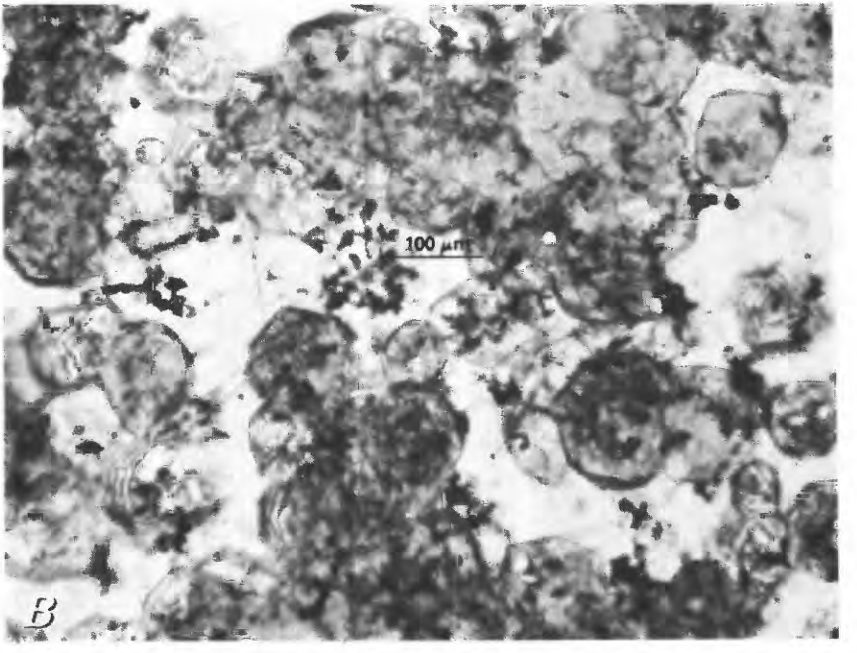


FIGURE 12.—Continued

Hail, W. J., Jr., 1973, Geologic map of the Smizer Gulch Quadrangle, Rio Blanco and Moffat Counties, Colorado: U.S. Geological Survey Geological Quadrangle Map GQ–1131.

———1974, Geologic map of the Rough Gulch Quadrangle, Rio Blanco and Moffat Counties, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ–1195.

Johnson, R. C., 1975, Preliminary geologic map, oil shale yield histograms and stratigraphic sections, Long Point Quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–688.

———1977, Preliminary geologic map and cross section of the Saddle Quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–829.

———1979a, Cross section *A–A′* of Upper Cretaceous and Lower Tertiary rocks northern Piceance Creek Basin, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–1129A, (2 sheets).

———1979b, Cross section *B–B′* of Upper Cretaceous and Lower Tertiary rocks northern Piceance Creek Basin, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map–1129B, (2 sheets).

———1979c, Cross section *C–C′* of Upper Cretaceous and Lower Tertiary rocks northern Piceance Creek Basin, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–1129C (2 sheets).

———1980, Preliminary Geologic Map of the Middle Dry Fork Quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–1215.

———1981, Preliminary geologic map of the Desert Gulch Quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–1328.

Johnson, R. C., and Douglas, B. J., 1980, Preliminary geologic map of the Wagon Track Ridge Quadrangle, Garfield and Mesa Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–1182.

Johnson, R. C., and May, Fred, 1978, Preliminary stratigraphic studies of the upper part of the Mesaverde Group, the Wasatch Formation, and lower part of the Green River Formation, DeBeque area, Colorado, including environments of deposition and investigations of palynomorph assemblages: U.S. Geological Survey Miscellaneous Field Studies Map MF–1050.

Pipiringos, G. N., and Johnson, R. C., 1976, Preliminary geologic map and correlation diagram of the White River City Quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–736.

Pipiringos, G. N., and Rosenlund, G. C., 1977, Preliminary geologic map of the Indian Valley Quadrangle, Rio Blanco and Moffat Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–836.

Roehler, H. W., 1972a, Geologic map of the Brushy Point Quadrangle, Rio Blanco and Garfield Counties, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ–1018.

———1972b, Geologic map of the Razorback Ridge Quadrangle, Rio Blanco and Garfield Counties, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ–1019.

———1973, Geologic map of the Calf Canyon Quadrangle, Garfield County Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ–1080.

☆ U. S. GOVERNMENT PRINTING OFFICE: 1984—776-041/2473