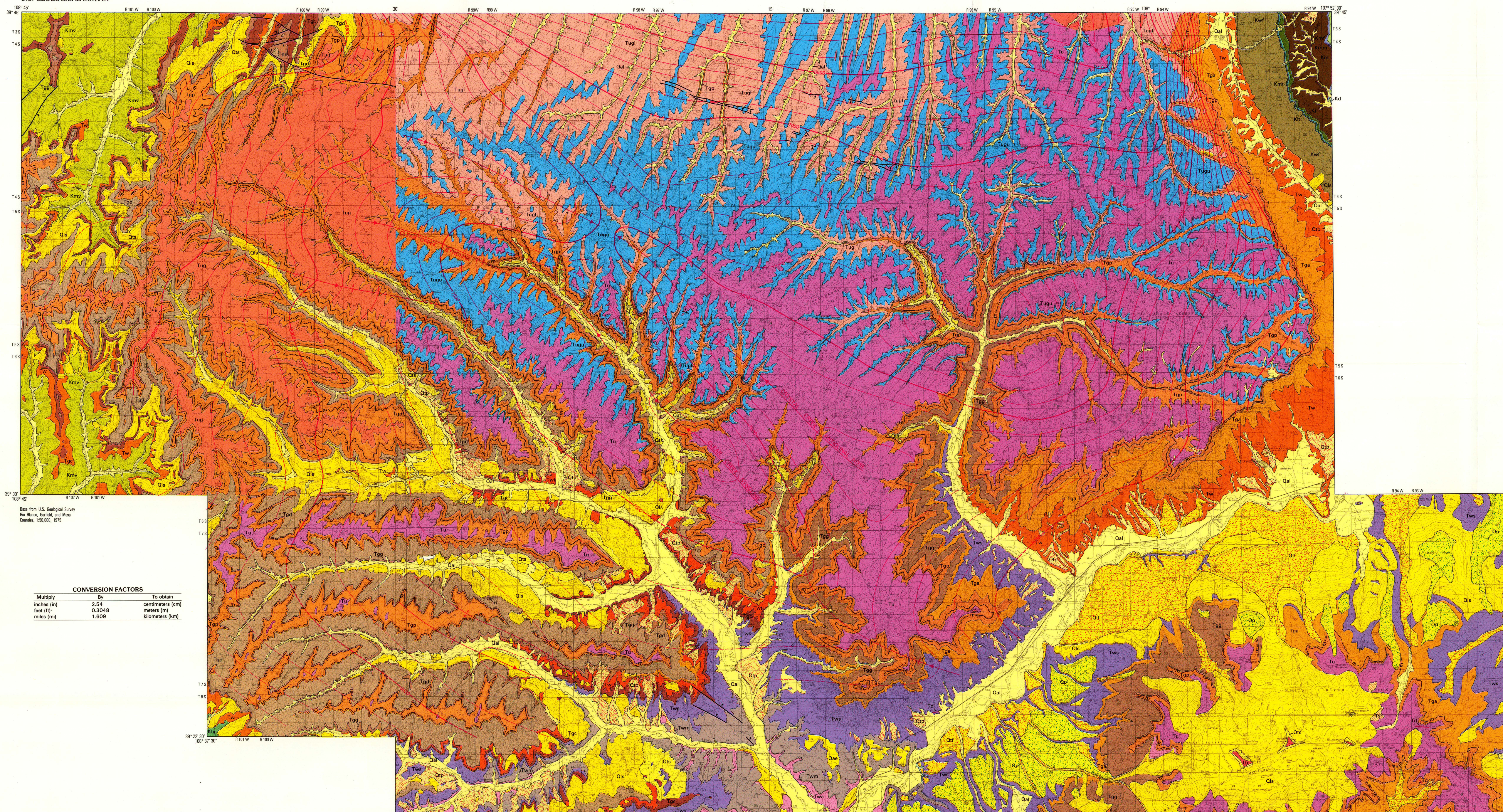
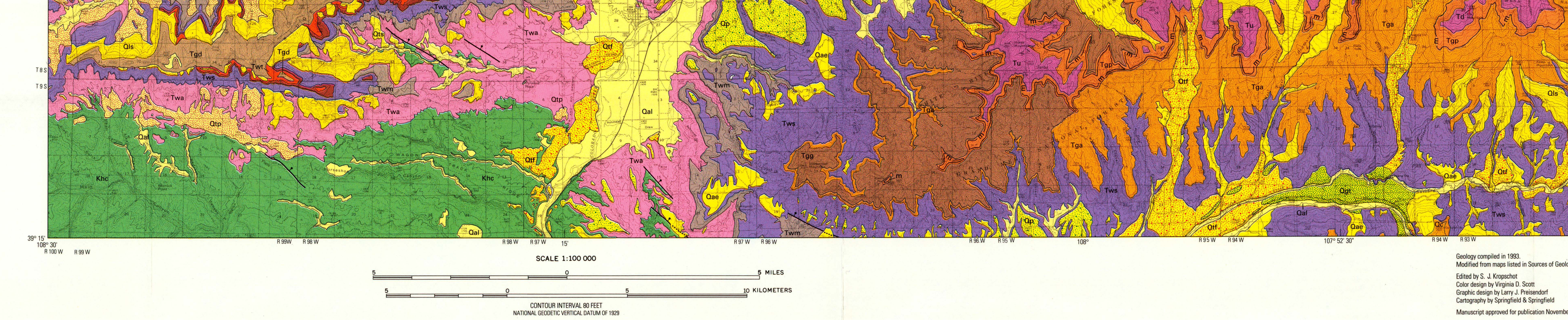

Base from U.S. Geological Survey
Rio Blanco, Garfield, and Mesa
Counties, 1:50,000, 1975

SCALE 1:100 000

5 MILES

10 KILOMETERS

CONTOUR INTERVAL 80 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology compiled in 1993.
Modified from maps listed in Sources of Geologic Mapping

Edited by S. J. Kropschot
Color design by Virginia D. Scott
Graphic design by Larry J. Preisendorf
Cartography by Springfield & Springfield

Manuscript approved for publication November 30, 1994

CONVERSION FACTORS

Multiply	By	To obtain
inches (in)	2.54	centimeters (cm)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)

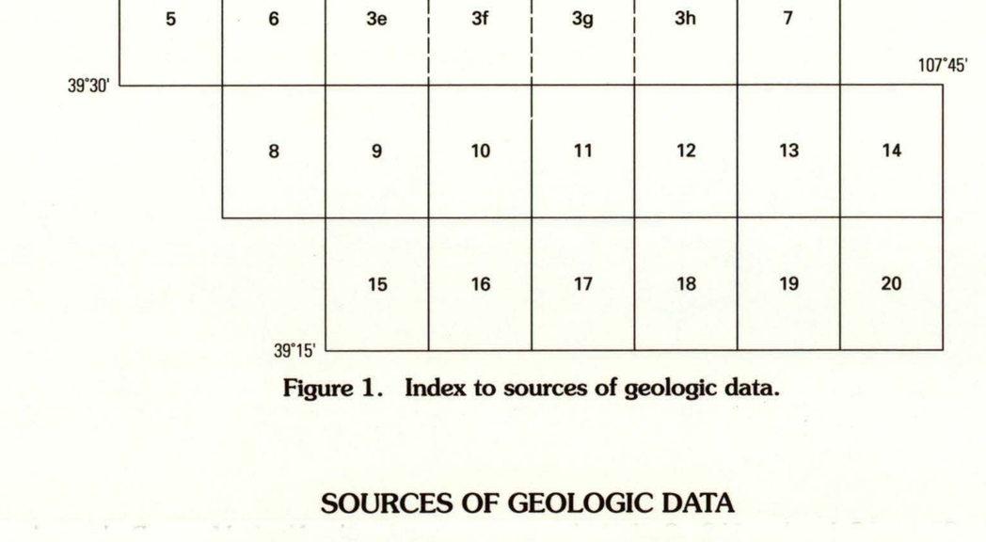

Figure 1. Index to sources of geologic data.

SOURCES OF GEOLOGIC DATA

1. Roehler, H.W., 1972, Geologic map of the Brushy Point quadrangle, Rio Blanco and Garfield Counties, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ–1018, scale 1:24,000.
2. Roehler, H. W., 1972, Geologic map of the Razorback Ridge quadrangle, Rio Blanco and Garfield Counties, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ–1019, scale 1:24,000.
3. Hail, W.J., Jr., O'Sullivan, R.B., and Smith, M.C., 1989, Geologic map of the Roan Plateau area, northwestern Colorado: U.S. Geological Survey Miscellaneous Field Investigations Map I–1797–C, scale 1:50,000.

3a. Johnson, R.C., 1977, Preliminary geologic map of the Figure Four Spring quadrangle, Rio Blanco and Garfield Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–912, scale 1:24,000.

3b. Hail, W.J., Jr., 1977, Preliminary geologic map of the Bull Fork quadrangle, Rio Blanco and Garfield Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–830, scale 1:24,000

3c. Hail, W.J., Jr., 1975, Preliminary geologic map of the Cutoff Gulch quadrangle, Rio Blanco and Garfield Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–691, scale 1:24,000.

3d. O'Sullivan, R.B., Wahl-Pierce, Frances, and Arbelbide, S.J., 1981, Preliminary geologic map of the McCarthy Gulch quadrangle, Rio Blanco and Garfield Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–860, scale 1:24,000.

3e. Johnson, R.C., 1981, Preliminary geologic map of the Desert Gulch quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–1328, scale 1:24,000.

3f. Hail, W.J., Jr., 1978, Preliminary geologic map of the Mount Blaine quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–984, scale 1:24,000.

3g. Hail, W.J., Jr., 1982, Preliminary geologic map of the Circle Dot Gulch quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–1293, scale 1:24,000.

3h. O'Sullivan, R.B., and Hail, W.J., Jr., 1987, Preliminary geologic map of the Forked Gulch quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–1953, scale 1:24,000.

4. O'Sullivan, R.B., 1985, Preliminary geologic map of the Rio Blanco quadrangle, Rio Blanco and Garfield Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–1816, scale 1:24,000.
5. Roehler, H.W., 1973, Geologic map of the Calf Canyon quadrangle, Garfield County, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ–1086, scale 1:24,000.
6. Roehler, H.W., 1973, Geologic map of the Henderson Ridge quadrangle, Garfield County, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ–1113, scale 1:24,000.
7. O'Sullivan, R.B., 1986, Preliminary geologic map of the Anvil Points quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–1882, scale 1:24,000.
8. Johnson, R.C., 1980, Preliminary geologic map of the Middle Dry Fork quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–1215, scale 1:24,000.
9. Johnson, R.C., 1977, Preliminary geologic map and cross section of The Saddle quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–829, scale 1:24,000.
10. 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, scale 1:24,000.
11. Donnell, J.R., Schmitt, L.J., and Smith, M.C., 1992, Geologic map of the Red Pinnacle quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–2202, scale 1:24,000.
12. Donnell, J.R., Yeend, W.E., and Smith, M.C., 1986, Preliminary geologic map of the Grand Valley quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–1883, scale 1:24,000.
13. Yeend, W.E., Donnell, J.R., and Smith, M.C., 1988, Geologic map of the Rulison quadrangle, Garfield County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–2060, scale 1:24,000.
14. Donnell, J.R., Yeend, W.E., and Smith, M.C., 1989, Geologic map of the North Mamm Peak quadrangle, Garfield County Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–2093, scale 1:24,000.
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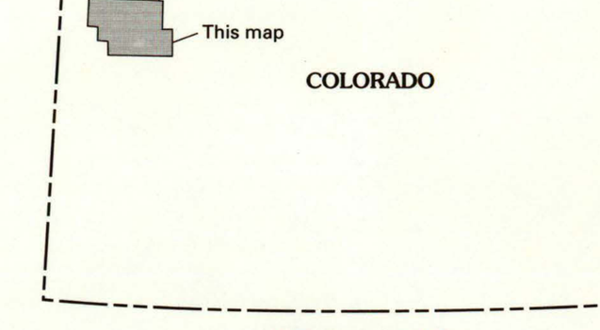
16. Johnson, R.C., and Douglas, B.J., 1980, Preliminary geologic map of the Wagon Track Ridge quadrangle, Garfield and Mesa Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–1182, scale 1:24,000.
17. Donnell, J.R., Yeend, W.E., Schmitt, L.J., and Smith, M.C., 1992, Geologic map of the De Beque quadrangle, Garfield and Mesa Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–2201, scale 1:24,000
18. Donnell, J.R., Yeend, W.E., and Smith, M.C., 1987, Geologic map of the Housetop Mountain quadrangle, Garfield and Mesa Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–1965, scale 1:24,000.
19. Donnell, J.R., Yeend, W.E., and Smith, M.C., 1988, Geologic map of the Hawxhurst Creek quadrangle, Garfield and Mesa Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–2026, scale 1:24,000.
20. Donnell, J.R., Yeend, W.E., and Smith, M.C., 1990, Geologic map of the South Mamm Peak quadrangle, Garfield and Mesa Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–2113, scale 1:24,000.

Table 1.—*Correlation of map symbols for Uinta Formation and intertonged units of Uinta and Green River Formations on this map with those used on consistituent maps of the southern part of the Piceance Creek Basin (fig. 1)*

[Leaders (---) indicate unit nor present, not mapped, or present in subsurface only]

Quadrangle or map name	Uinta Formation	Intertongued units of Uinta and Green River Formations: Upper group	Lower group	Undifferentiated
This map	Tu	Tugu	Tugl	Tug
Brushy Point quadrangle	---	---	---	Tge
Razorback Ridge quadrangle	---	---	---	Tge
Figure Four Spring quadrangle	Tu	Tgbf, [1]Tu, Tgb	Tgbs, Tgs, Tgu, Tgc	---
Bull Fork quadrangle	---	Tgbf, Tud,Tgb, Tuc	Tgs, Tub, Tgc, Tua	---
Cutoff Gulch quadrangle	Tud	Tgb, Tuc	Tgs, Tub, Tgc, Tua	---
McCarthy Gulch quadrangle	Tu	Tgj, [1]Tu	Tgs, Tgc, [1]Tu	---
Rio Blanco quadrangle	Tu	Tgj, [1]Tu	Tgc, [1]Tu	---
Calf Canyon quadrangle	---	---	---	Tge
Henderson Ridge quadrangle	---	---	---	Tge
Desert Gulch quadrangle	Tu, Ts	Tgsk, Tgsl, [1]Tu	---	---
Mount Blaine quadrangle	Tuf, Tud	Tgss, Tgsk, Tue, Tgsl,Tuc	Tgs, Tub, Tgc, Tua	---
Circle Dot Gulch quadrangle	Tud	Tgj, Tuc	Tgs, Tub, Tgc, Tua	---
Forked Gulch quadrangle	Tud	Tgj, Tuc, Tus	Tgs, Tub, Tgc, Tua	---
Roan Plateau area	Tu	Tugu	Tugl	---
Anvil Points quadrangle	Tub, Tuc	Tgj, Tua	---	---
Middle Dry Fork quadrangle	Tu	---	---	---
The Saddle quadrangle	Tu	---	---	---
Long Point quadrangle	Tu	---	---	---
Red Pinnacle quadrangle	Tu	---	---	---
Grand Valley quadrangle	Tu	---	---	---
Rulison quadrangle	Tu	---	---	---
North Mamm Peak quadrangle	Tu	---	---	---
Housetop Mountain quadrangle	Tu	---	---	---
Hawxhurst Creek quadrangle	Tu	---	---	---
South Mamm Peak quadrangle	Tu	---	---	---

[1]Unnamed Uinta tongue(s)



MAP LOCATION

Table 2.—*Estimated oil-shale resources in the Green River Formation, southern part of the Piceance Creek Basin*

[All information in this table is adapted from reports by Pitman and Johnson (1978), Pitman (1979), and Pitman and others (1989). All Fischer assay values and bed thicknesses are included; There are no low-limit cutoffs. Resources above the Mahogany oil-shale zone and below the R-1 oil-shale zone are not included. Resources in the Battlement Mesa are not included]

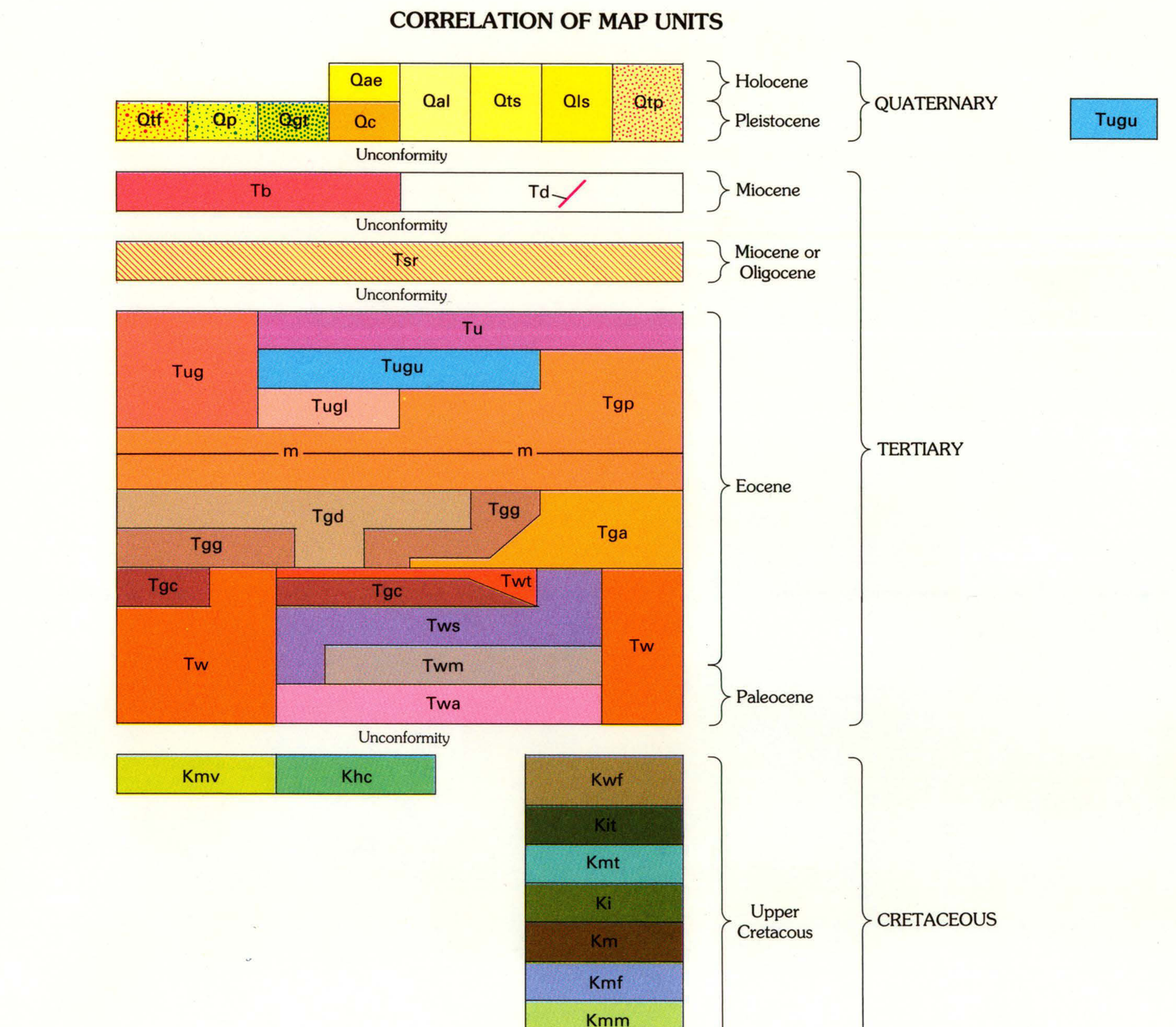
Oil-shale zone	Shale-oil resources (millions of barrels)	Approximate range in thickness of oil-shale zones, in feet (meters)
Mahogany	67,584	<60–170 (<18–52)
R–6	56,327	<120–280 (<37–85)
L–5	14,641	<55–>160 (<17–49)
R–5	43,246	<82–>240 (<25–>73)
L–4	10,925	<27–>72 (<8–>22)
R–4	18,813	<60–>120 (<18–>37)
L–3	2,924	<16–45 (<5–14)
R–3	6,175	<25_70 (<8–210)
L–2	2,632	<20–100 (<6–30)
R–2	7,398	<60–136 (<18–40)
L–1	2,060	<85–136 (<26–41)
R–1	24,421	220–>400 (67–>122)
Total	257,146	

GEOLOGIC MAP OF THE SOUTHERN PART OF THE PICEANCE CREEK BASIN, NORTHWESTERN COLORADO

By
William J. Hail, Jr., and Marjorie C. Smith

1997

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Qae **Alluvial and eolian deposits, undifferentiated (Holocene)**—Yellowish-brown sand and silt, mostly derived from nearby sedimentary rocks. Commonly fill depressions and young tributary valleys. Shown only where extensive

Qal **Alluvium (Holocene and Pleistocene)**—Mud, silt, sand, and gravel. Mostly flood plain deposits of stream valleys. Includes some lower-most terraces along Colorado River, and some slopewash along steep valley walls. Also includes alluvial fans at the mouths of tributary streams; coalescing fans form the dominant alluvium along the floors of Parachute and Roan Creeks. Mostly derived from nearby sources, but in the valley of the Colorado River contains abundant clasts of crystalline and other rocks from distant sources to the east

Qts **Talus and slopewash deposits (Holocene and Pleistocene)**—Unconsolidated, poorly sorted mud, silt, sand, and gravel on or at the base of steep canyon walls. Only the thickest or most extensive deposits are shown

Qls **Landslide deposits (Holocene and Pleistocene)**—Coherent to chaotic masses of broken rock detached and moved downslope. Include slumped ground, block slides, soil creep, and mudflow deposits. Locally include talus and slopewash deposits. Most of Battlement Mesa is covered by basalt-block slides (Yeend, 1969, p. 30). Elsewhere most of the larger landslide masses occur on the lower slopes and bases of steep canyon walls, and most originate in the Douglas Creek and Garden Gulch Members of the Green River Formation, and in the Wasatch Formation

Qtp **Terrace and pediment deposits, undifferentiated (Holocene and Pleistocene)**—Unconsolidated poorly sorted silt, sand, and gravel at various levels above present drainages, capping terrace and pediment surfaces. Locally include alluvial-fan, talus, slopewash, and other surficial deposits. Most gravel clasts are sedimentary rocks and basalt derived from nearby sources, but some terrace gravels near the Colorado River commonly contain crystalline and other rocks from more distant sources

Qtf **Terrace and fan-gravel deposits, undifferentiated (Pleistocene)**—Mud, silt, sand, and gravel; mostly poorly sorted pebble, cobble, and boulder gravel in a sandy matrix. Gravel includes very abundant locally derived sedimentary rocks, and lesser amounts of crystalline rocks of distant easterly sources. Some terrace deposits along the Colorado River represent former flood-plain levels. Large areas south of the Colorado River are composite fans of alluvial and mudflow origin derived from Battlement Mesa; some of these fans extend to the present Colorado River flood plain (Yeend, 1969, p. 9, 29–30)

Qp **Pediment-gravel deposits (Pleistocene)**—Angular to subrounded pebble, cobble, and boulder gravel in a poorly sorted sand matrix capping pediment surfaces on the northern lower slopes of Battlement Mesa south of the Colorado River. Siltstone, claystone, and marlstone, mostly derived from the Green River and Wasatch Formations, make up most of the gravel; basalt detritus is present locally. Commonly mantled by a thin layer of windblown sand and silt

Qgt **Glacial till (Pleistocene)**—Abundant angular to subangular pebbles, cobbles, and boulders in a matrix of grayish-brown sand, silt, and clay. Gravelly material is more than 90 percent basalt. Many cobbles and boulders have sole marks and are faceted. Mostly underlies till plains along Buzzard and Plateau Creeks, but also present in isolated patches of lateral moraines. Probably Pinedale in age (Yeend, 1969, p. 20–27)

Qc **Colluvial deposits, undifferentiated (Pleistocene)**—Angular to subangular poorly sorted sedimentary rocks and basalt pebbles, cobbles, and boulders in a matrix of greenish-gray sandy silt. Includes basalt boulders as long as 5 ft (1.5 m), and sandstone, marlstone, and claystone slabs as long as 2 ft (0.6 m). Present only between Buzzard and Plateau Creeks in the southeast part of the map area

Tb **Basalt (Miocene)**—Erosional remnants of basalt flows that once covered much of Battlement Mesa, and presently cover Grand Mesa to the south. Also, a small outcrop caps the top of Mount Callahan, north of the Colorado River, in the Grand Valley quadrangle (fig. 1, no. 12).

Td **Dikes (Miocene)**—Steeply dipping to vertical basaltic dikes. Some are probably feeders to basalt flows

Tsr **Unnamed sedimentary rocks (Miocene or Oligocene)**—Poorly exposed. Present only in two small outcrops near North Mamm Peak on Battlement Mesa. Probably correlative to strata about 24 mi (39 km) to the southwest on Grand Mesa, that include variegated claystone, mudstone, fine- to medium-grained sandstone, and conglomerate. Conglomerate contains mostly stream worn quartz, quartzite, and chert pebbles from lower Paleozoic sedimentary rocks, with lesser amounts of Precambrian igneous and metamorphic pebbles, and mid-Tertiary basalt pebbles, all derived from the White River uplift about 28 mi (45 km) to the east-northeast

Uinta Formation (Eocene)—Consists mainly of clastic sedimentary rocks that make up the generally southward-prograding lacustrine delta complex that ultimately filled ancient Lake Uinta in the Middle Eocene. These deposits represent the coarser grained near-shore facies of lacustrine deposition. They grade laterally into, intertongue with are in part equivalent to, and in part younger than, the finer grained offshore facies which characterize the younger rocks of the Green River Formation. Southward-thinning wedges of mostly sandstone and siltstone of the Uinta Formation intertongue with northward-thinning tongues of mainly marlstone of the Green River Formation

Tu **Main body of Uinta Formation**—The following description of the main body of the Uinta Formation also applies, in general, to the tongues of the Uinta, except as noted. Mostly brown weathering, dominantly tuffaceous sandstone and siltstone, but also includes some interbedded dolomitic marlstone, shale, oil shale, mudstone, and minor limestone, claystone, and thin tuff beds. The sandstone beds are highly variable in lithology; they range from very fine to coarse grained, are generally massive or poorly bedded, but in a few areas are crossbedded to parallel bedded. Lenticular channels of conglomeratic sandstone occur locally; a few contain clay fragments and fossil wood. Some calcite-cemented sandstone and siltstone beds form resistant cliffs or ledges. Soft, poorly cemented friable sandstone and siltstone underlie weathered slopes. Marlstone beds, including some oil shale, are fairly abundant. Most if not all of the marlstone beds included in the main body are lenticular and nonpersistent, and are not regarded as tongues of the Green River Formation. Marlstone beds locally contain relatively rich beds of oil shale which are generally thin and nonpersistent, and have no present economic potential. Paleoslump blocks and soft-sediment deformation are fairly common especially where resistant sandstone or siltstone bodies overlie marlstone beds. In the Desert Gulch quadrangle (fig. 1, no. 3e) a large paleoslump deposit of Eocene age (map unit Ts of Johnson, 1981) includes highly contorted rocks of the Uinta Formation as well as marlstone tongues of the Green River Formation; the unit is here arbitrarily included in the main body of the Uinta. Smaller paleoslump blocks are present elsewhere, especially at the base of the main body.

Throughout the map area, rocks assigned to the main body of the Uinta include all Eocene strata lying above the stratigraphically highest tongue or member of the Green River Formation. In approximately the northern third of the map area, the main body of the Uinta overlies the upper group of interbedded tongues of the Uinta and Green River Formations (Tugu). Southward beyond the termination of the upper group of interbedded Uinta and Green River tongues, the main body of the Uinta lies on the Parachute Creek Member of the Green River Formation. The top of the main body is eroded; the maximum preserved thickness is as much as 1,000 ft (300 m). Table 1 shows map units of constituent maps (fig. 1) that are here included in the Uinta Formation

Intertongued Uinta and Green River Formations (Eocene—The thick stratigraphic section overlying the Parachute Creek Member of the Green River Formation and underlying the unit designated as the main body of the Uinta Formation (Tu) consists of complexly intertongued units of both formations. On the constituent 7 1/2-minute quadrangle maps tongues of the Uinta Formation are unnamed. Some are designated by letters in ascending alphabetical order; others are designated simply as Tu. Tongues of the Green River Formation include two formally named tongues and several informally named or unnamed tongues. The Green River tongues merge laterally, generally southward, with other Green River tongues or with the Parachute Creek Member of the Green River Formation. The Uinta tongues are generally as described above: mostly brown weathering sandstone and siltstone, lesser dolomitic marlstone including oil shale, and minor limestone. These tongues gradually become thinner, finer grained, and more marly toward their southern termination. The Green River tongues are mostly dolomitic marlstone, including oil shale, of essentially the same lithology as the Parachute Creek Member of the Green River Formation into which they merge. In general, oil-shale beds become thicker and oil-shale values increase to the south. Some of the Green River tongues are mostly oil shale where they merge with the Parachute Creek Member. The Green River tongues locally include sandstone and siltstone beds. Owing to limitations of map scale, individual tongues are not shown on this map. The intertongued Uinta and Green River is here divided into two map units, an upper group of tongues (Tugu) and a lower group of tongues (Tugl). This usage follows that of the map of the Roan Plateau area, northwestern Colorado (fig. 1, no. 3,). A similar usage was applied in the 1:100,000-scale map of the northern part of the Piceance Creek Basin (Hail and Smith, 1994). (See also discussion in Hail, 1992, p. 11-18). Where possible, contacts between the two map units are drawn at the top or base of certain widespread, persistent tongues as originally shown on the large-scale source maps (fig. 1), but arbitrary lateral contacts are drawn where such tongues terminate, or where tongues were not mapped on the original large-scale maps. Placement of specific contacts is discussed under individual unit descriptions

Tugu **Upper group of tongues of the Uinta and Green River Formations**—Includes as many as ten tongues of the Uinta and Green River Formations that were mapped separately on the constituent 7 1/2-minute quadrangle maps (fig. 1). No formally named tongues are included in the upper group of tongues. Informally named tongues of the Green River are (top to bottom) the marlstones at Skinner Ridge, Sleepy Ridge, Bull Fork, Barnes Ridge, and Jackrabbit Ridge (table 1, units **Tgsk**, **Tgsl**, **Tgbf**, **Tgb**, **Tgj**, respectively). The marlstone at Skinner Ridge is light gray, weathering to light brown, variably silty, laminated to papery, generally contains thin oil-shale beds and locally mudstone; thickness 15–65 ft (5–20 m). The marlstone at Sleepy Ridge is interbedded with variably marly siltstone, some mudstone, and minor sandstone; also contains beds of lean to moderately rich oil shale; thickness 40–200 ft (12–60 m). The marlstone at Bull Fork is light-gray to white, weathering light brown, dolomitic, and variably silty, and contains minor interbedded mudstone, siltstone and sandstone, and very lean oil shale; thickness 30–60 ft (9–18 m). The marlstone at Barnes Ridge is mostly light gray to light brown, laminated, variably silty and dolomitic, and contains minor marly siltstone, very fine grained sandstone, and thin beds of very lean oil shale; thickness 5–50 ft (1–15 m). The marlstone at Jackrabbit Ridge is mostly light gray to light brown, variably silty, and contains interbedded lean to moderately rich oil shale, minor tuffaceous siltstone and very fine grained sandstone, a few thin tuff beds, and some fossilized plant and insect remains on bedding planes of marlstone and siltstone; thickness 40–115 ft (12–35 m). At various places in the map area, the upper boundary of each of these tongues forms the upper boundary of the upper group of tongues. The highest part of the upper group is the marlstone at Skinner Ridge, present only in parts of the Desert Gulch and Mount Blaine 7 1/2-minute quadrangles (fig. 1, nos. 3e, 3f, respectively). In much of its outcrop area, the basal contact of the upper group is placed at the base of a widespread Uinta tongue which overlies the Stewart Gulch Tongue of the Green River Formation or laterally equivalent strata. In the northwestern part of the map area (Figure Four Spring quadrangle, fig. 1, no. 3a) where locally the basal sandstone unit is not mapped separately, the basal contact is arbitrarily placed at the base of the next higher Uinta sandstone tongue. In the northeastern part of the map area (Rio Blanco quadrangle and Forked Gulch quadrangles, fig. 1, nos. 4, 3h, respectively) where the basal sandstone merges with a lower sandstone tongue, the contact is placed at the base of the merged sandstone unit. Maximum thickness about 600 ft (180 m)

Tugl **Lower group of tongues of the Uinta and Green River Formations**—Includes as many as seven tongues of the Uinta and Green River Formations as mapped separately on the constituent 7 1/2-minute quadrangle maps. Includes two formally named tongues of the Green River Formation, the Stewart Gulch and Coughs Creek Tongues, as well as one unnamed Green River tongue, as many as four unnamed Uinta tongues, and two undifferentiated Uinta and Green River units. In stratigraphic sequence, top to bottom, in the central part of its outcrop area, the lower group of Uinta and Green River tongues includes the Stewart Gulch Tongue of the Green River, an unnamed Uinta tongue, the Coughs Creek Tongue of the Green River, and at the base, an unnamed Uinta tongue. Both the Stewart Gulch and Coughs Creek Tongues are widespread and distinctive. The Stewart Gulch Tongue consists mainly of light-gray, dolomitic, variably silty marlstone, including oil shale which increases in oil content to the south; also includes some fine-grained sandstone. The Coughs Creek Tongue is mostly light gray marlstone, but commonly contains beds of siltstone, sandstone and, locally, oil shale. An undifferentiated unit, map unit **Tgbs** of the Figure Four Spring quadrangle (fig 1., no. 3a; table 1), is here arbitrarily included in the lower group of tongues of the Uinta and Green River Formations. Includes the lateral equivalent of the informally named marlstone at Barnes Ridge, an underlying unnamed tongue of the Uinta Formation, and the Stewart Gulch Tongue of the Green River Formation. In other areas the marlstone at Barnes Ridge and the underlying Uinta tongue have been included in the upper group of Uinta and Green River tongues (**Tugu**). An unnamed Green River tongue, map unit **Tgu** of the Figure Four Spring quadrangle (fig. 1, no. 3; table 1), lies between the Stewart Gulch and Coughs Creek Tongues and consists mostly of laminated marlstone including low-grade oil shale, and some gray, massive, mudstone, sandstone, and siltstone. In the Razorback Ridge quadrangle (fig. 1, no. 2; table 1), that part of the Evacuation Creek Member (map unit **Tge**) lying north of T. 4 S., is here arbitrarily included in the lower group of Uinta and Green River tongues. Additional discussion included in description of unit **Tug**. In the northern part of the outcrop area (east part of the McCarthy Gulch quadrangle, and the Rio Blanco quadrangle, fig. 1., nos. 3d, 4, respectively), beyond the pinchout of the Stewart Gulch Tongue, the top of the lower group of Uinta and Green River tongues is placed at the top of the Coughs Creek Tongue. Maximum thickness of exposed rocks about 750 ft (230 m)

Tug **Uinta Formation and tongues of Uinta and Green River Formations, undivided (Eocene)**—In the Brushy Point, Razorback Ridge, Calf Canyon, and Henderson Ridge 7 1/2-minute quadrangles in the northwesternmost part of the map area (fig. 1, nos. 1, 2, 5, 6, respectively), all Eocene strata above the Parachute Creek Member of the Green River Formation were included in the Evacuation Creek Member of the Green River Formation (table 1, unit **Tge**). This designation has been abandoned and replaced by the Uinta Formation by Cashion and Donnell (1974). Geologic mapping in the quadrangles adjacent to the east shows that the former Evacuation Creek Member includes not only the Uinta Formation but underlying strata of the intertongued Uinta and Green River Formations (units **Tugu**, **Tugl**). Inasmuch as no Uinta or Green River tongues were mapped separately in this area, all these rocks except those lying north of T. 4 S. are assigned to this map unit. Rocks include gray to brown dolomitic claystone, dark-brown papery oil shale, and light-brown dolomitic siltstone and sandstone. Base of the unit is placed at the base of the lowermost brown-weathering siltstone or sandstone bed overlying the Parachute Creek Member. Top is eroded and maximum thickness is about 400 ft (120 m)

Green River Formation (Eocene)—Sediments deposited in a variety of mostly lacustrine environments. The Green River Formation in general is a continuous lacustrine depositional unit. The several members of the Green River represent distinct facies of lacustrine rocks. Lateral and vertical changes are largely gradational; significant erosional breaks are absent. Intertonguing with the generally overlying Uinta Formation discussed previously. The Green River, for the most part, conformably overlies and is intertongued with the mostly fluvial rocks of the Wasatch Formation

Tgp **Parachute Creek Member**

Main body—Youngest and most widespread member of the Green River Formation in the Piceance Creek Basin. Deposited in relatively quiet offshore, highly alkaline, and variably saline lake water. Consists mostly of dolomitic marlstone, oil shale, and some dolomitic clay shale and claystone. Member also contains several beds of gray to light-brown marly siltstone and sandstone, numerous thin beds of analcimized tuff, and sparse algal limestone beds. Marlstone is massive to platy, gray to light grayish brown, and weathers light gray. Oil shale is thin parallel bedded, locally fissile, medium to very dark brown, and weathers light gray; the richest oil shale weathers light bluish gray. Organically rich clay shale is light brownish gray, very thin bedded to thinly laminated, and locally papery weathering. Contains by far most of the oil-shale resources in the Green River Formation in the map area and throughout the Piceance Creek Basin. The top of the main body is located at the base of the conformably overlying Uinta Formation or the lowermost tongue of the Uinta Formation; thus the upper contact rises stratigraphically southward beyond the southern pinchout edges of the Uinta tongues. Conformably overlies the Douglas Creek, Garden Gulch, or Anvil Points Members of the Green River Formation west to east. Lower part thins and merges laterally toward the north-east and southeast basin margins with rocks of the underlying Green River members. The marlstone and oil-shale beds are relatively resistant and the member is a major cliff-forming unit throughout most of the map area. Thickness ranges from about 1,500 ft (460 m) in the subsurface in the north-central part of the map area to about 200 ft (60 m) in outcrop near the west boundary; thickness in the Battlement Mesa area in the southeast is as much as 600 ft (185 m)

m **Mahogany ledge**—Top of a rich oil-shale zone in the Parachute Creek Member indicated on map. The term Mahogany ledge is used for the outcropping Mahogany zone. It is one of the richest and most persistent oil-shale zones in the Piceance Creek Basin. Thickness 60–170 ft (18–52 m)

Tgd **Douglas Creek Member**—Shallow-water nearshore western lacustrine facies of the Green River Formation. Consists mostly of variably silty dolomitic and calcareous claystone and mudstone, lesser but varying amounts of marlstone, dolomitic shale, clay shale, siltstone, sandstone, and limestone, and minor oil shale and thin analcimized tuff beds. Claystone and mudstone are gray, brownish gray to greenish gray, and mostly lack distinct bedding. Marlstone and dolomitic shale are brown to gray, generally laminated. Clay shale is dark brown to dark gray, locally fissile. Fairly widespread and persistent siltstone and sandstone beds are light gray to grayish brown, even bedded, mostly calcareous, locally ostracodal or oolitic. Sandstone beds are mostly fine to medium grained. Limestone beds are commonly thin, ostracodal, oolitic, or algal. Algal limestone beds are present mostly in the upper part of the member and become more numerous in the western and southwestern part of the map area. Sparse oil-shale beds are very thin, dark brown, locally dolomitic, clayey, and papery. Most rocks are nonresistant and form slopes but many of the siltstone and sandstone beds are relatively resistant and form ledges. In most of the Clear Creek drainage the upper contact of the member is the top of a cliff-forming, brown-weathering silty dolomitic claystone. Grades laterally eastward and southeastward into the deeper-water lacustrine organic-rich clay shale of the Garden Gulch Member. The eastern boundary of the Douglas Creek Member is arbitrarily drawn along Conn Creek in the central part of the map area. The Douglas Creek Member here includes the unnamed member of the Green River Formation shown on the Brushy Point, Razorback Ridge, Calf Canyon, and Henderson Ridge quadrangles (fig. 1, nos. 1, 2, 5, 6, respectively). Thickness ranges from about 200 ft (60 m) in the northwestern part of the map area to about 1100 ft (335 m) in the southwest

Tgg **Garden Gulch Member**—A marginal offshore lacustrine facies of the Green River Formation, dominated by dark-gray to brown fissile clay shale including oil shale; also contains variably silty and dolomitic claystone and shale, gray marlstone, and some sandstone, siltstone, and mudstone. Also contains a few beds of algal, ostracodal, or oolitic limestone. Marlstone, present mostly in the upper part of the member, and generally very low in oil-shale values, grades upward into the oil-shale-rich marlstone of the overlying Parachute Creek Member. Kerogen-bearing clay shale is generally low in oil-shale values throughout the map area; rich oil shale is sparse. Where the Garden Gulch Member lies on the Wasatch Formation, its basal bed is the Long Point Bed (Johnson, 1984, p. 11-16), a widespread transgressive lacustrine unit which is as thick as 12 ft (3 m); includes sandstone, limestone, and shale that locally contain gastropods, ostracods, and oolites. Grades eastward or southeastward into the upper part of the Anvil Points Member (**Tga**) with an increase in the number and thickness of sandstone beds. The eastern and southeastern lateral contacts with the Anvil Points are arbitrarily drawn where sandstone characterizing the Anvil Points becomes dominant. The upper part of the Garden Gulch, which includes much clay shale, grades westward into dominantly claystone and mudstone of the Douglas Creek Member; the lower part, consisting mostly of dark fissile clay shale, continues westward below the Douglas Creek Member. The western lateral contact of the upper part of the Garden Gulch with the Douglas Creek Member is arbitrarily drawn at Conn Creek where claystone and mudstone characterizing the Douglas Creek become dominant. Rocks assigned to the Garden Gulch Member near its southwesternmost outcrops in the Horsethief Mountain area, appear to be transitional to rocks typical of the Douglas Creek Member, and so are designated by Johnson and others (1979, sheet 1). The name Garden Gulch Member is, however, here retained for these rocks in this area. The member is mostly nonresistant and forms slopes. Thickness ranges from about 100 ft (30 m) in the extreme northwestern part of the map area to about 1,400 ft (427 m) in the southeastern part

Tga **Anvil Points Member**—Eastern nearshore lacustrine facies of the Green River Formation, consisting of mostly sandstone dominated rocks derived from sources to the east and southeast of the map area. In the eastern and southeastern parts of the map area, consists of mostly light-gray to brown, fine- to coarse-grained, locally conglomeratic, cliff- and ledge-forming sandstone, lesser amounts of brown-weathering siltstone and shale, minor light-brown to gray ostracodal limestone, gray marlstone, and a few thin beds of low-grade oil shale. Conformably underlies the Parachute Creek Member; there is a slight stratigraphic rise in the upper boundary toward the southeast on the eastern flank of Battlement Mesa. Everywhere overlies the Wasatch Formation and in most of the map area the basal unit is the widespread transgressive lacustrine Long Point Bed (Johnson, 1984, p. 11-16) described previously. Grades westward into the Garden Gulch Member, mostly by a decrease in the number and thickness of sandstone and siltstone beds, and by an increase in the number and thickness of kerogen-bearing clay-shale beds. The stratigraphically lowermost beds of the member extend farthest west. Where the Garden Gulch Member is present, as in the drainages of Parachute and Roan Creeks, the Anvil Points contains a considerable proportion of kerogen-bearing clay shale as well as thin but conspicuous cliff- and ledge-forming sandstone and siltstone beds. Ranges in thickness from as much as 1,500 ft (460 m) in the east to 250 ft (76 m) in the west

Tgc **Cow Ridge Member**—A heterogeneous body of lacustrine, paludal, and fluvial rocks that includes the oldest lacustrine deposits of the Green River Formation in the Piceance Creek Basin. Consists of mostly gray ostracodal clay shale, including low-grade locally papery-weathering oil shale, silty gray shale, brown to dark-gray carbonaceous shale with thin coal beds, varicolored claystone, gray to brown siltstone, fine-grained sandstone, and limestone. The sandstone beds are mostly evenly bedded, persistent, and commonly contain ostracods or oolites; some sandstone beds are crossbedded. Limestone beds locally contain abundant ostracods and gastropods. In the drainage area of Roan Creek and its tributaries, the Cow Ridge is overlain by a tongue of the Wasatch Formation (**Twt**). In the northwestern part of the map area the Wasatch tongue is absent and the Cow Ridge is overlain by the Garden Gulch Member of the Green River. The eastern margin is arbitrarily terminated as a map unit at Conn Creek, although some intertonguing lacustrine beds extend east of Conn Creek in the Red Pinnacle quadrangle. Named by Johnson (1984, p. 3-11) for outcrops on Cow Ridge, several miles northwest of DeBeque, in which lacustrine and other rocks of the unit are conspicuously distinct from the overlying and underlying varicolored beds of the Wasatch Formation. Geologic maps of The Saddle and Long Point 7 1/2-minute quadrangles (fig. 1, nos. 9, 10, respectively), show the unit as a part of the Shire Member of the Wasatch Formation. More recent maps in this area designate the unit as Cow Ridge. Older maps of the Brushy Point, Razorback Ridge, Calf Canyon, and Henderson Ridge 7 1/2-minute quadrangles (fig. 1, nos. 1, 2, 5, 6, respectively) show the unit as the Douglas Creek Member of the Green River Formation. The designation of the unit as Cow Ridge Member of the Green River in this area by Johnson and others (1988, sheet 1), however, is followed here. The Cow Ridge is generally a nonresistant slope-forming unit, but some siltstone, sandstone, and limestone beds are relatively resistant and locally form cliffs and ledges. Thickness ranges from about 80 to 400 ft (24–120 m) in the northwestern part of the map area, and from 40 to 225 ft (12–69 m) in the southwest part

Wasatch Formation (Eocene and Paleocene)—Mostly of fluvial and paludal origin but contains a few lacustrine beds. Intertongues with, but mostly underlies, rocks of the Green River Formation in the map area. Everywhere lies unconformably on rocks of Late Cretaceous age

Tw **Wasatch Formation, undivided**—Shown in the western and northeastern parts of the map area.

In the northwestern part of the map area (Brushy Point, Razorback Ridge, Calf Canyon, and Henderson Ridge quadrangles, fig. 1, nos. 1, 2, 5, 6, respectively), includes gray, green, and some red silty mudstone, gray to grayish-green, fine-grained, crossbedded sandstone, gray calcareous siltstone, lesser amounts of gray to brown carbonaceous shale, and a few thin ostracod- or mollusk-bearing limestone beds. Mostly nonresistant and forms slopes interrupted by prominent sandstone ledges. Conformably overlain by the Cow Ridge Member of the Green River Formation in this area. Thickness ranges from 0 to about 500 ft (0–150 m).

In the Middle Dry Fork quadrangle (fig. 1, no. 8) at the western edge of the map area, the basal Atwell Gulch Member was mapped separately, and the overlying Shire and Molina Members were mapped as a single undivided unit. These units are here shown as undivided Wasatch. Rocks equivalent to the Shire and Molina Members include well banded gray, purple, and maroon mudstone, and fine- to medium-grained, massive, nonpersistent light-brown- weathering sandstone. The basal equivalent of the Atwell Gulch Member consists of mostly gray and maroon mudstone, some black claystone, and a few thin fine-grained sandstone beds. In the western part of the area the Wasatch is conformably overlain by the Garden Gulch Member of the Green River Formation. Thickness 760–1,080 ft (230–330 m).

In the eastern part of the map area all Wasatch beds north of the Colorado River as far west as Parachute Creek are here arbitrarily included in the undivided Wasatch Formation. Includes mostly varicolored red, purple, lavender, gray, and grayish-yellow claystone, shale, silty shale, and siltstone; brown and gray fine- to coarse-grained lenticular sandstone; and minor conglomerate, limestone, coal, and carbonaceous shale. Although all outcropping Wasatch rocks in the Grand Valley quadrangle (fig. 1, no. 12) east of Parachute Creek, were assigned to the Shire Member, they are here included in the Wasatch formation undivided. Elsewhere in the northeastern part of the map area, individual formally named members were not separately identified on the constituent maps. In the Rio Blanco quadrangle (fig. 1, no. 4) the lower 300–400 ft (90–120 m) above the basal sandstone is brown, gray, and black shale and claystone; the basal sandstone, about 50–100 ft (15–30 m) thick, is gray sandstone and chert- and quartzite-pebble conglomerate; these beds are probably Paleocene in age, and probably represent, in part, the equivalent of the Atwell Gulch Member. The Wasatch in the eastern part of the area is mostly nonresistant and slope forming except for the ridge-forming basal sandstone. Conformably overlain by the Anvil Points Member of the Green River Formation. Thickness about 3,600–5,400 ft (1,100–1,600 m)

Twt **Tongue of Wasatch Formation (Eocene)**—Present mostly in the drainage area of Roan Creek and its tributaries. Consists mostly of varicolored red, purple, maroon, gray, and grayish-yellow claystone and mudstone; also some fine- to coarse-grained, flat-bedded, and cross-bedded to massive, persistent to lenticular, sandstone beds. Mostly nonresistant and forms slopes. It separates the underlying Cow Ridge Member of the Green River Formation from higher Green River beds and merges with the Shire Member of the Wasatch Formation east of Conn Creek; absent in the extreme western part of the map area due to westward pinchout or distal interfingering with strata of the Green River Formation. In six of the constituent 7 1/2-minute quadrangles (Mount Blaine, Middle Dry Fork, The Saddle, Long Point, Winter Flats, and Wagon Track Ridge, fig. 1, nos. 3f, 8, 9, 10, 15, 16, respectively), the Wasatch tongue is included in the upper part of the Shire Member. On more recent maps (Desert Gulch and Roan Plateau, fig. 1, nos. 3e, 3, respectively), the unit is designated a tongue of the Wasatch. Thickness ranges from 70 to 480 ft (20–150 m)

Tws **Shire Member (Eocene and Paleocene?)**—All three formally named members of the Wasatch are shown in the south-central part of the map area. The youngest member is the Shire, which consists of mostly varicolored gray, grayish-yellow, brown, red, purple, and maroon mudstone, claystone, and silty claystone; also contains fine- to coarse-grained flat-bedded, crossbedded, and massive, lenticular channelform sandstone beds, and very minor limestone. Mostly nonresistant and forms slopes. Within the Red Pinnacle quadrangle (fig. 1, no. 11), in the Bowdish Gulch-Logan Wash area, locally contains ostracodal and oolitic lacustrine sandstone, siltstone, and shale beds which represent the eastern interfingering margin of the Cow Ridge Member of the Green River Formation. They are here included in the Shire Member of the Wasatch. In the Winter Flats and Wagon Track Ridge quadrangles (fig. 1, nos. 15, 16, respectively), the lowermost beds of the Shire, which overlie the Atwell Gulch Member, are laterally equivalent to the Molina Member. Because basal beds of the Molina may be late Paleocene in age, basal Shire beds in this area may likewise be late Paleocene in age. Thickness north of the Colorado River is about 100 to 1,300 ft (30–400 m); thickness south of the Colorado River ranges from about 900 ft (275 m) to as much as 1,600 ft (490 m). Thickens eastward in the subsurface to as much as 3,800 ft (1,160 m) near the east boundary of the map area

Twm **Molina Member (Eocene and Paleocene?)**—Mostly fluvial sandstone interbedded with mudstone, claystone, and siltstone. Sandstone beds are gray to brown, range from fine to coarse grained, and locally contain chert and quartzite pebbles; massive or poorly bedded to cross-bedded, persistent to lenticular, and generally resistant and ledge forming. Sandstone beds become more lenticular and less abundant to the southwest, and grade laterally into the Shire Member. The generally persistent basal sandstone is laterally continuous with that of the Shire Member. Mudstone, claystone, and siltstone beds are varicolored gray, greenish gray, lavender, purple, and maroon; generally nonresistant and slope forming. The basal beds may be Paleocene in age, based on investigations of palynomorphs collected near the south boundary of the map area by Johnson and May (1978, sheet 2). Although no definitive pollen was found in the Molina Member, pollen of late Paleocene age was found in the underlying Atwell Gulch Member, only 1 ft (0.3 m) below the base of the Molina Member. Thickness of outcropping Molina is 15–450 ft (4.5–140 m). Thins eastward in the subsurface to probably less than 100 ft (30 m) at the east boundary of the map area (Johnson and others, 1979, sheet 1)

Twa **Atwell Gulch Member (Paleocene)**—Well exposed in the DeBeque quadrangle (fig. 1, no. 17) both north and south of the Colorado River. Mostly dark gray to black claystone and mudstone including carbonaceous shale, and a few thin coal beds; lesser amounts of varicolored yellowish-gray, yellowish-brown, purple, lavender, and maroon claystone and mudstone. Also contains a few brown and yellowish-brown sandstone beds mostly in the lower part of the member; these are fine to coarse grained, mostly crossbedded, and lenticular. Basal sandstone beds commonly conglomeratic, containing pebbles of chert, quartzite, and silicified limestone. Unconformably overlies the Upper Cretaceous Hunter Canyon Formation. Exposed thickness is 400–750 ft (120–230 m). In the subsurface, thickens northeastward to as much as 3,000 ft (920 m) at the east boundary of the map area (Johnson and others, 1979, sheet 1)

Kmv **Mesaverde Formation, undifferentiated (Upper Cretaceous)**— Crops out in the northwestern part of the map area. Base not exposed; outcropping rocks entirely of nonmarine flood-basin origin. Unconformably overlain by Tertiary rocks

Upper part—Mostly gray, very fine grained, crossbedded sandstone locally containing coarse-grained sandstone with thin lenses of conglomerate, and a few very thin beds of gray sandy shale. Weathers tan or gray and forms a bench or series of benches. Mapped in the constituent Brushy Point, Razorback Ridge, and Calf Canyon quadrangles (fig. 1, nos. 1, 2, 5, respectively) as Ohio Creek(?) Formation of Paleocene age; included here in the Mesaverde Formation. (See discussion of the Ohio Creek Formation under the description of the Hunter Canyon Formation below). Thickness 0–75 ft (0–23 m)

Lower part—Mostly dark to medium-gray, sandy to silty shale, dark-gray sandy carbonaceous shale, grayish-green shale, gray siltstone and mudstone, and light- to medium-gray and light-brown, fine-grained sandstone. Weathers mostly to dark-gray slopes interrupted by the more resistant ledge-forming sandstone beds. Exposed rocks as thick as 1,000 ft (300 m)

Khc **Hunter Canyon Formation (Upper Cretaceous)**—Crops out in the southwestern part of the map area; outcropping rocks entirely of nonmarine flood-basin origin. Consists mostly of sandstone interbedded with gray mudstone and gray carbonaceous claystone. White and yellowish-gray to grayish-yellow, fine- to coarse-grained sandstone occurs in lenticular beds, which are horizontally bedded to crossbedded. A few conglomeratic lenses containing pebbles of chert and silicified limestone present in upper part. Sandstone beds form cliffs and ledges. White sandstone in the upper part of the formation, locally containing sparse conglomeratic lenses, was redefined as the Ohio Creek Member of the Hunter Canyon Formation or Mesaverde Formation by Johnson and May (1980) who determined that the Ohio Creek is a weathered zone on the Cretaceous-Tertiary unconformity. Previously the Ohio Creek had been considered to be a formation of Paleocene age. The Ohio Creek Member has not been mapped separately from the underlying rocks of the formation, and here, as on the constituent maps, is included in the Hunter Canyon Formation. Exposed rocks as thick as 870 ft (265 m)

Kwf **Williams Fork Formation (Upper Cretaceous)**—Present only in the northeastern part of map area in the Rio Blanco quadrangle (fig. 1, no. 4). Unconformably overlain by Tertiary rocks, and conformably overlies the Trout Creek Sandstone Member of the Iles Formation. Dominantly of nonmarine origin, and consists of a heterogeneous sequence of lenticular beds of grayish-yellow to brown, fine- to medium-grained, crossbedded and massive sandstone, interbedded with dusky-yellow to olive-gray and brown siltstone and sandy shale, brown sandy limestone, and lenticular beds of carbonaceous shale and shaly coal. Coal beds occur sporadically throughout the formation; some are burned to form clinker. Sandstone beds are generally resistant and form conspicuous ridges that make up most of the Grand Hogback. Thickness about 3,500–4,500 ft (1,070–1,370 m)

Iles Formation (Upper Cretaceous)—Present only in the northeastern part of the map area, in the Rio Blanco quadrangle (fig. 1, no. 4), where it consists of two parts separated by a tongue of the Mancos Shale. Conformably underlies the Williams Fork Formation and conformably overlies the Mancos Shale. In part marine and in part nonmarine origin

Kit **Trout Creek Sandstone Member**—Yellowish-gray to grayish- orange, fine- to medium-grained marine sandstone in beds that are thick bedded and crossbedded. Upper member of the Iles Formation, and is separated from the main body by an unnamed tongue of the Mancos Shale. Forms a prominent light-gray ridge. Thickness about 100 ft (30 m)

Ki **Main body**—Brown and gray massive and crossbedded sandstone, brown and gray shale and siltstone, carbonaceous shale, and thin coal beds; mostly of nonmarine origin. Thickness about 450–500 ft (140–150 m)

Mancos Shale (Upper Cretaceous)—Present only in the northeastern part of the map area in the Rio Blanco quadrangle (fig. 1., no. 4). All units entirely of marine origin

Kmt **Unnamed tongue**—Dark-gray shale and thin interbedded siltstone; contains numerous yellowish-brown-weathering limy septarian concretions as much as 1.5 ft (0.5 m) in diameter. Separates Trout Creek Sandstone Member of the Iles Formation from the main body of the Iles. Thickness about 250 ft (76 m)

Km **Main body**—Dark-gray and brownish-gray variably silty and sandy shale; contains sparse limestone concretions, and is locally gypsiferous. Upper part contains even-bedded, persistent ridge-forming sandstone beds. Lower part is calcareous and contains several thin limestone beds. Thin bentonite beds occur at various stratigraphic levels. Poorly exposed and forms a broad valley east of the Grand Hogback. Thickness as much as 4,400 ft (1,340 m)

Kmf **Frontier Sandstone Member**—Gray and yellowish-gray, very fine grained, thinly bedded sandstone. Resistant, forms ledge and dip slope. Thickness 65 ft (20 m)

Kmm **Mowry Shale Member**—Gray to black, thinly bedded to fissile, siliceous shale. Thickness about 200 ft (60 m)

Kd **Dakota Sandstone (Upper Cretaceous**—Present only in the northeastern part of the map area, in the Rio Blanco quadrangle (fig. 1, no. 4). Yellowish-brown to gray, fine- to coarse-grained, locally conglomeratic sandstone, interbedded gray shale, and some carbonaceous shale. Conformably underlies the Mowry Shale Member of the Mancos Shale. Exposed thickness about 230 ft (70 m)

Contact—Approximately located. Dashed line shows lateral boundaries between map units representing groups of tongues of Uinta and Green River Formations. Placement of boundaries discussed in description of map units

Facies boundary—Arbitrarily placed between laterally gradational map units

Fault—Dotted where covered by Quaternary deposits. Bar and ball on downthrown side

Major fold axes—Showing trace of axial plane and direction of plunge. Fold axes are not shown south of the Colorado River

Anticline

Syncline

8500 **Structure contour**—Approximately located; dashed where eroded. Drawn on top of Mahogany ledge (Mahogany zone in subsurface) showing elevation in feet above mean sea level. Contour interval 100 ft (30.5 m). Structure contours not shown south of the Colorado River

ENERGY RESOURCES

OIL AND GAS

The southern part of the Piceance Creek Basin includes all or parts of 24 gas fields, some of which have produced relatively minor amounts of oil (Colorado Oil and Gas Commission, 1992). The larger active gas fields are Rulison, Parachute, Grand Valley, and Trail Canyon. Part of the Rulison field lies outside the map area. The total cumulative gas production in the map area through 1991 is about 74 million MCF (one MCF equals one thousand cubic feet), of which about 7 million MCF is coal-bed methane (Colorado Oil and Gas Commission, 1992). Most of the gas is produced from fluvial sandstone beds in the Paleocene and Eocene Wasatch Formation, and from the Upper Cretaceous Mesaverde, Iles, Williams Fork, Hunter Canyon, and Mount Garfield Formations which overlie the Mancos Shale. Small amounts of gas have been produced from the Upper Jurassic Morrison Formation, the Upper Cretaceous Dakota Sandstone, and from sandstone beds in the Upper Cretaceous Mancos Shale. Most coal-bed methane is produced from rocks associated with the Cameo coal zone in the middle to lower part of the Mesaverde Formation and equivalent strata.

OIL SHALE

Most rich oil-shale deposits occur within the Parachute Creek Member of the Green River Formation, although some occur in the Garden Gulch Member. Since about 1970, most U.S. Geological Survey reports dealing with oil-shale resources of the Green River Formation of the Piceance Creek Basin have divided the oil-shale-bearing rocks into informally named zones, or numbered rich and lean zones designated R and L, respectively. Zones R–1 and L–1 are in the Garden Gulch Member; all higher zones are in the Parachute Creek Member. Table 2 shows estimated shale-oil resources in that part of the southern Piceance Creek Basin map area north of the Colorado River. Estimates in the table are derived from reports by Pitman and Johnson (1978), Pitman (1979), and Pitman and others (1989); which also describe the constraints used in deriving the estimates. Total shale-oil resources in the map area are about 257 billion (257×10^9) barrels in oil-shale zones between the top of the Mahogany zone down to the base of the R-1 zone. Shale-oil resources above the Mahogany zone and below the R-1 zone are not included. Pitman and Donnell (1973, table 1) however, estimate shale-oil resources of about 102 billion (102×10^9) barrels of oil in beds above the Mahogany zone containing at least 12 gallons of oil per ton from that part of the southern Piceance Creek Basin lying north of the Colorado River.

COAL

Throughout the Piceance Creek Basin, and elsewhere in northwestern Colorado, coal-bearing strata of potential economic interest occur mostly in the nonmarine rocks of Late Cretaceous age that overlie the Mancos Shale. In the map area, they are included in the Mesaverde Formation (**Kmv**) in the northwest, the main body of the Iles (**Ki**), and Williams Fork (**Kwf**) Formations in the northeast, and the Hunter Canyon Formation (**Khc**) in the southwest. The coal-bearing Mount Garfield Formation underlies the Hunter Canyon Formation. Stratigraphically higher parts of the Mesaverde and Hunter Canyon Formations exposed in the northwest and southwest parts of the map area contain no appreciable coal; they do, however, contain coal beds at depth. Coal-bearing rocks of the Iles and Williams Fork Formations are exposed along Piceance Creek at the extreme northeast part of the area in the Rio Blanco quadrangle (fig. 1, no. 4). Mines, now long abandoned, have yielded coal from beds as thick as 6–10 ft (2–3 m) (Gale, 1910, p. 124–127, pls. 10, 13) in sec. 35, T. 3 S., R. 94 W., and secs. 2 and 3, T. 4 S., R. 94 W., in the upper and lower parts of the Williams Fork Formation; there is no current production. Thin coal beds in the Iles Formation are apparently of little or no commercial interest.

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