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GEOLOGIC MAP OF THE PRICE 30' x 60' QUADRANGLE, CARBON, DUCHESNE, UINTAH, UTAH, AND WASATCH COUNTIES, UTAH

by

Malcolm P. Weiss, Irving J. Witkind, and William B. Cashion

Utah Geological Survey 2003
Map 198DM
digitized from U.S. Geological Survey
Miscellaneous Investigations Series Map I-1981 (1990)

GIS Data Preparation: Basia Matyjasik

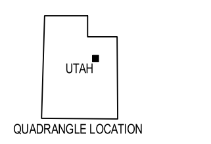
Base from U.S. Geological Survey, 1980
Projection: UTM Zone 12
Units: Meters
Datum: NAD 1927
Spheroid: Clarke 1866

SCALE 1:100 000

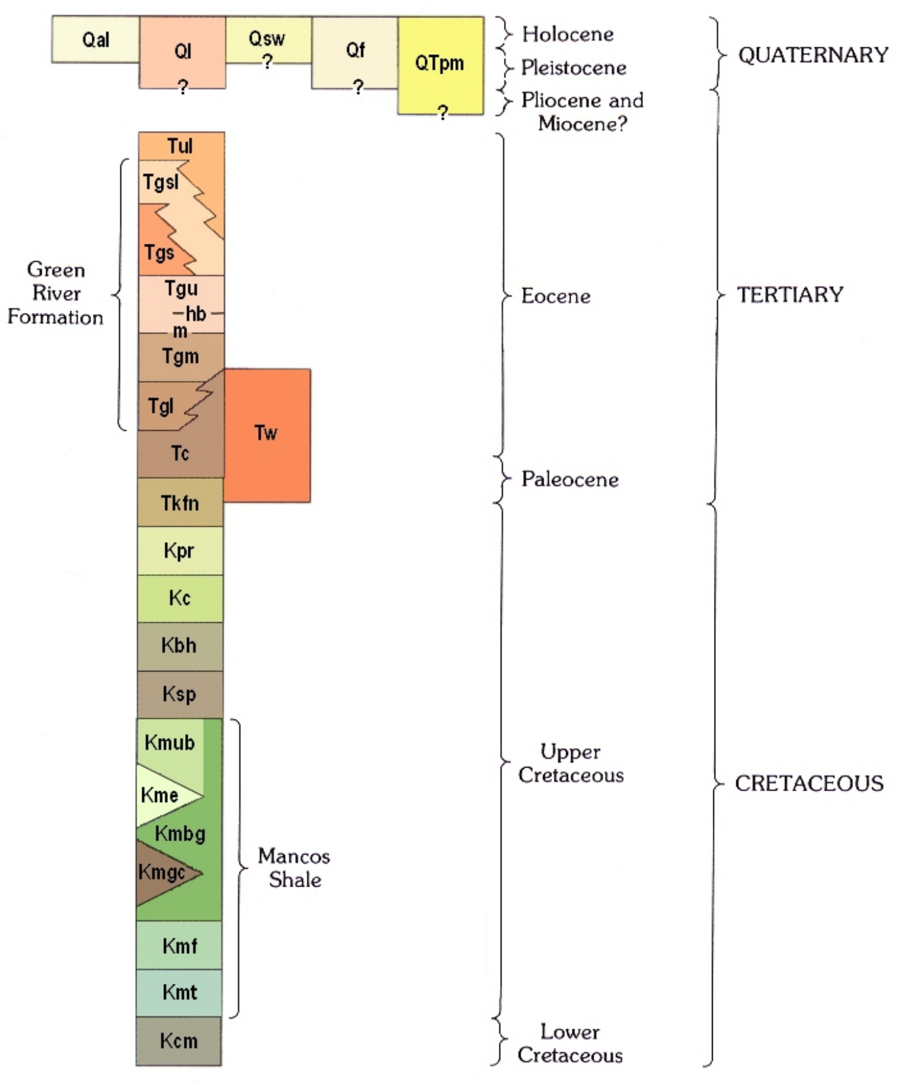
CONTOUR INTERVAL 50 METERS

5 0 5 10 15 Kilometers

5 0 5 Miles



CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Qal **Alluvium (Quaternary)**—Dark brown to gray, thin to thick bedded, locally massive, crossbedded in places. Unconsolidated. Consists of clay, silt, sand, granules, pebbles, and sparse cobbles of fluvial origin. Clasts commonly reflect sedimentary formations exposed along valley walls. Forms narrow to broad deposits, with even surfaces of low relief. As mapped, unit locally includes higher patches of older alluvium of Pleistocene age. Thickness ranges widely, generally less than 15 m (50 ft) thick

Ql **Landslide deposits (Quaternary)**—Brown to dark-brown and gray, heterogeneous mixture of rock fragments of diverse size and shape. Consists of irregular to lobate masses of detached bedrock that have slid downslope to form chaotic, hummocky accumulations of rubble. Locally marked by concentric ridges on surface. Some deposits may be as old as Miocene. Thickness ranges widely; may be as much as 45 m (150 ft) thick locally

Qsw **Slope-wash deposits (Quaternary)**—Light- to dark-gray, unconsolidated to weakly cemented, thin- to thick-bedded, faintly crossbedded detritus. Consists of clay, silt, sand, granules, and some pebbles. Forms broad, gently sloping sheets. Locally includes valley-fill deposits. Thickness ranges from a thin veneer to as much as 8 m (25 ft)

Qf **Alluvial-fan deposits (Quaternary)**—Light-brown to brown, locally gray, unconsolidated to semiconsolidated, moderately well sorted silt, sand, granules, pebbles, and cobbles at stream mouths. Commonly lobate. Thickness uncertain, probably as much as 15 m (50 ft) locally

QTpm **Pediment mantle (Holocene to Miocene?)**—Light-brown to brown, gray, or locally reddish-brown, unconsolidated to well-cemented, massive to crudely bedded sediments of fluvial origin. Consists of a poorly bedded mixture of silt, sand, granules, pebbles, cobbles, and boulders derived from adjacent uplands. Chiefly siltstone and sandstone clasts. Surfaces of deposits are smooth and slope gently away from the uplands. Includes deposits near present stream level that formed essentially during the Pleistocene, as well as older and higher deposits that probably began to form chiefly during either the Miocene or Pliocene. Unit ranges in thickness from about 3 m (10 ft) to more than 45 m (150 ft)

TERTIARY SEDIMENTARY ROCKS

Both the facies and thicknesses of lower Tertiary sedimentary units change significantly throughout that part of the Uinta Basin included within the Price 30′ × 60′ (1:100,000) quadrangle. These changes bear on both the recognition and distribution of Tertiary strata in eastern Utah and western Colorado. Many of these changes are discussed below under the descriptions of the stratigraphic units

Tul **Lower member of the Uinta Formation (Eocene)**—Consists of beds of light-gray calcareous mudstone and light-brown to brown sandstone that alternate irregularly to give some sequences a banded appearance. Sandstone beds, thicker and more abundant in lower part of member, are fine grained, evenly bedded, and tend to weather to shades of yellow and grayish orange. Locally, contorted bedding, probably the result of soft-sediment slump in a shallow-water lacustrine environment, disrupts some sandstone beds. Unit ranges in thickness from 90 to 120 m (300–400 ft) in northeast sector of quadrangle to an erosional pinch-out farther west, near Bad Land Cliffs in the north-central sector of the quadrangle. Thickens downdip into the Uinta Basin, and becomes more red.

East of longitude 110°15′ W., our lower member of the Uinta Formation is equivalent to Dane's (1955) basal sandstone facies, part of his banded facies, and part of his limestone and sandstone facies. West of longitude 110°15′ W., our lower member changes facies to a more lacustrine sequence, and we include it in the Green River Formation, either in Bryant's (in press) saline facies or his sandstone and limestone facies

Green River Formation (Eocene)—The Green River Formation, characterized by thick sequences of evenly layered, laterally persistent strata, is part of the largest lacustrine deposit in the world. Green River sediments were deposited in lake environments that changed significantly through geologic time.

Any study of the Green River Formation inevitably involves the problem of nomenclature. Multiple facies changes, plus intertonguing and gradational boundaries with both the underlying Colton or Wasatch Formations and the overlying Uinta Formation, preclude the use of a single set of stratigraphic terms. Bradley (1931) recognized this problem, and, based on what he perceived to be fundamental differences, set up two sets of stratigraphic terms for the various facies of the Green River Formation. One set applied to those Green River facies exposed in the western Uinta Basin, a second set applied to those Green River facies exposed in both the Piceance Creek Basin and the eastern sector of the Uinta Basin. Dane (1954, 1955) accepted Bradley's nomenclature (as used in the eastern Uinta Basin) for the upper part of the Green River Formation, and extended it into the western Uinta Basin. Cashion and Donnell (1974) subsequently abandoned Bradley's (1931) term Evacuation Creek Member. For the purposes of this map, the nomenclature used by Bradley and by Dane are not quite acceptable, chiefly because we have selected different contacts, and thus the gross lithologic units we recognize differ somewhat from the units recognized by Bradley and by Dane. Further, we have used stratigraphic terms and boundaries for facies recognized by other authors in adjacent quadrangles. The significant differences between the units we recognize and those recognized by Bradley and by Dane are described below.

We divide the Green River Formation into five stratigraphic units, which are, in descending order: (1) sandstone and limestone facies as used by Bryant (in press), (2) saline facies, (3) upper member, (4) middle member, and (5) lower member

Tgsl **Sandstone and limestone facies of Bryant (1992)**—Consists of beds of light-brown to brown, fine-grained sandstone, siltstone, and shale, and white to light-gray marlstone and limestone that alternate irregularly. This alternation gives the unit a conspicuous banded appearance. Unit is a transitional facies that lies between the Uinta Formation and saline facies of the Green River Formation. Thickness ranges from 180 to 260 m (600–850 ft) along its southern exposures. Unit was probably thickest toward the northwest where top is eroded. In its most northerly exposures, toward the northeast (basinward), the unit thins to 100–180 m (300–540 ft).

Unit is correlative with the upper part of Dane's (1955) basal sandstone facies in eastern sector of quadrangle, his banded facies in central sector, and the lower part of his limestone and sandstone facies in western sector. Dane included these facies in the Uinta Formation. We differ and, following Ryder and others (1976, fig. 2) and Bryant (1992), include these facies in the upper part of the Green River Formation

Tgs **Saline facies**—Light-brown to brown to gray shale, shaly marlstone, and marlstone. Contains abundant chert both as small nodules and as thin, interbedded, crenulated lenses. Sandstone lenses, as much as 15 m (50 ft) thick, are common near top of unit. Many thin tuff beds in lower part. Widespread empty molds of leached saline minerals give unit its name. Locally, as much as half of some shale beds are composed of abundant calcite pseudomorphs after salt crystals (Ray and others, 1956). Intertongues with overlying sandstone and limestone facies. Saline facies is about 380 m (1,250 ft) thick in northwest sector of quadrangle but thins rapidly eastward and pinches out in north-central sector of map area.

Unit weathers to form thickly bedded masses of unusually fissile shale that stand as both vertical and overhanging faces.

The saline facies we map is the same as the saline facies of the Uinta Formation of Dane (1954, 1955), and Ray and others (1956)

Tgu **Upper member**—Consists chiefly of light-gray to light-brown thin beds of marlstone, limestone, mudstone, siltstone, sandstone, and sparse shale that alternate irregularly, plus many thin, low-grade, oil-shale beds that thin westward. Includes many light-gray to white, resistant, thin tuff beds that weather yellowish gray. Thickness ranges from 200 to 400 m (640–1,330 ft); thickest in north-central sector of quadrangle, but thins to the east and west.

The Horse Bench Sandstone Bed, a thick, conspicuous marker in the middle of the member, varies from fine-grained sandstone in the east to siltstone in the west. Characterized by ripple marks, crossbedding, and interbedded mudstone layers, it is uniformly 9–12 m (30–40 ft) thick. In the subsurface, the Horse Bench Sandstone Bed is approximately equivalent to the upper marker of Fouch (1975).

Some tuff beds are characterized by wavy upper and (or) lower surfaces, and by internal undulatory structures, all of which suggest soft-sediment plastic flow (Cashion, 1967). One such bed, known as the wavy-bedded tuff, is noted for its internal undulatory structures and is an important regional marker above the Mahogany ledge (Fouch and others, 1976). This tuff bed is within the tuff zone of the Parachute Creek Member of the Green River Formation as defined by Dane (1955), and by Ray and others (1956).

We have included the Mahogany ledge—a zone of multiple oil-shale beds (Bradley, 1931; Cashion, 1967)—as the lowermost unit of this member, and accordingly select the base of the ledge as the base of the upper member. The Mahogany ledge extends across much of the quadrangle and persists far to the east. In this quadrangle it ranges in thickness from 4.6 to 46 m (15–150 ft). Most of this interval is not oil shale. The Mahogany bed—the major oil-shale bed in this zone—is as thin as 0.8 m (2.5 ft) and as thick as 1.8 m (6 ft) in this quadrangle. Although we select the base of the Mahogany ledge as the boundary between the upper and middle members, we have, for ease of mapping, drawn the boundary between the members at the top of the Mahogany oil-shale bed—a readily recognizable unit in the field. The Mahogany bed generally is about 10 m (a few tens of feet) above the base of the Mahogany ledge, but locally as much as 75 m (250 ft)

——hb—— **Horse Bench Sandstone Bed**

——m—— **Top of Mahogany bed**

Tgm **Middle member**—Light-gray and light-brown beds of mudstone, siltstone, and sandstone, plus light-green to gray sandy marlstone with many intercalated light-gray beds of limestone, shale, siltstone, and lenticular sandstone. Sandstone beds are more abundant in eastern half of quadrangle. Sparse, thin oil-shale beds are below the Mahogany ledge, restricted essentially to the upper 25 m (80 ft) of this member, but locally these oil-shale beds are within the upper 75 m (250 ft) of the member. Basal part of member consists of a distinctive cliff-forming sequence, about 20 m (60 ft) thick, composed of calcareous mudstone, shale, limestone, and marlstone beds. We correlate this basal unit with the carbonate marker of Ryder and others (1976). The middle member ranges from 60 to 680 m (200–2,230 ft) in thickness, being thickest in the northwest sector of quadrangle and thinnest updip in south-central and southeastern sectors.

As mapped, the middle member is equivalent to most of the delta facies of Bradley (1931), to the lower part of the Parachute Creek Member of Dane (1955), and to the Douglas Creek Member (Cashion, 1967) of the eastern Uinta Basin

Tgl **Lower member**—Divisible into upper and lower lacustrine shale units separated by an alluvial unit. Lacustrine shale deposits are light brown to light gray, fissile, rich in ostracodes, and contain lenses and beds of gray to brown algal limestone and marlstone. Alluvial unit consists chiefly of light-gray and yellowish-gray to light-brown siltstone and sandstone beds with intercalated beds of gray to reddish-brown calcareous mudstone. Member ranges in thickness from a pinch-out to about 260 m (850 ft). Thickest near center of quadrangle but thins southeastward and pinches out north of Sunnyside.

We correlate the lower lacustrine shale unit with the basal lacustrine phase of Bradley (1931), and the upper lacustrine shale unit with Bradley's second lacustrine phase. We believe that our upper and lower lacustrine shales are equivalent to a part of the black shale facies of Picard (1959). We interpret the alluvial unit that separates these shales to be a tongue of the Colton Formation. These same alluvial deposits were considered by Bradley (1931, pl. 11) to be a tongue of the Wasatch Formation

Tc **Colton Formation (Eocene and Paleocene)**—Dark-reddish-brown to green beds of mudstone and shaly siltstone interlayered with yellowish- to grayish-orange and grayish-brown, thin, fine- to medium-grained quartzose sandstone beds. Sparse limestone. Formation is locally variegated in shades of red and gray. Many sandstones are crossbedded in large and small trough sets. Root structures and mudcracks are common in the mudstone beds. Chiefly of alluvial origin; includes some units of marginal lacustrine, and deltaic origin. Formation is from 200 to 350 m (660–1,170 ft) thick in northwest sector of quadrangle, and thickens southward to 500–800 m (1,650–2,770 ft) in south-central and southeast sectors

Tw **Wasatch Formation (Eocene to Paleocene?)**—Variegated mudstone in shades of red, green, and gray intercalated with beds and lenses of sandstone, conglomerate, and minor limestone and dolomite(?).

West of Desolation Canyon of the Green River (near southeast edge of map area), the Colton Formation is separable from underlying similar-appearing North Horn Formation by interleaved beds of Flagstaff Limestone. These limestone beds persist east of Desolation Canyon but they become thinner and fewer in number, and where they are sparse, Colton is separable from North Horn only with great difficulty. To resolve this problem we have arbitrarily grouped beds west of Desolation Canyon (a readily recognizable geographic feature) into two map units: the Colton Formation (Tc), and the combined Flagstaff Limestone and North Horn Formation (TKfn). East of Desolation Canyon we have grouped the beds equivalent to the Colton, Flagstaff, and North Horn Formations and mapped them as the Wasatch Formation (Tw), following usage suggested by previous authors (Fisher and others, 1960; Cashion, 1967). These stratigraphic relations are best displayed in the Huntington quadrangle to the south

TERTIARY AND CRETACEOUS SEDIMENTARY ROCKS

TKfn **Flagstaff Limestone (Paleocene) and North Horn Formation (Paleocene and Upper Cretaceous)**—Reddish-brown and grayish-brown mudstone with interbedded calcareous siltstone, sandstone, limestone conglomerate, and limestone; some carbonaceous shale. Thin to medium bedded. Crops out as an irregular alternation of resistant and nonresistant beds. Sandstone is quartzose, fine grained, locally coarse grained. Interbedded fresh-water limestone beds—the Flagstaff Limestone—are dark gray to gray, dense, thin bedded, and locally very fossiliferous, with snails and bivalves dominant. In places, some of these limestone beds are irregularly layered and contain many algal nodules. The Flagstaff Limestone, of lacustrine origin, contrasts with the North Horn, of fluvial origin. Thickness ranges from 60 to 340 m (200–1,100 ft); thickest in northwest sector and thinnest near southern edge of quadrangle.

In the Sanpete–Sevier Valley sector of central Utah, the Flagstaff Limestone and the North Horn Formation have been mapped separately. In the Price quadrangle, the two units intertongue and cannot be separated readily, consequently we have mapped them as an undivided unit.

The Tertiary-Cretaceous boundary in the westernmost Book Cliffs is within the sequence of beds described above. W.B. Cashion and T.D. Fouch (U.S. Geological Survey, oral commun., 1981) have suggested that a distinctive, well-developed, easily recognizable white zone of kaolinite-rich sandstone beds marks the Cretaceous-Tertiary boundary. The zone, commonly referred to as the bleached zone, is readily traceable across eastern half of this quadrangle (fig. 3), and extends eastward into Colorado. It appears to be the same zone as that recognized in the Piceance Creek Basin in Colorado by Johnson and May (1980), who refer to it as the white-colored kaolinitic zone.

The zone extends as far west as Whitmore Canyon (figs. 2 and 3); we are uncertain whether it extends farther west. From Whitmore Canyon eastward to Desolation Canyon of the Green River, therefore, we have arbitrarily assigned units above the bleached zone to the undivided Flagstaff and North Horn Formations, and consider both formations, in that sector, to be Tertiary in age. We consider the Wasatch Formation east of Desolation Canyon to be of Tertiary age also. We include the bleached zone, and the beds beneath it but above the Bluecastle Tongue of the Castlegate Sandstone (table 1), in the Price River Formation (Kpr) of Late Cretaceous age. West of Whitmore Canyon, where the bleached zone seems to be missing, we are unable to recognize the Cretaceous-Tertiary boundary, for fossil control is not available. We have, therefore, in that sector, grouped the strata between the base of the Colton Formation and the top of the Price River Formation as the undivided Flagstaff–North Horn sequence. The mapped sequence includes units of both Tertiary and Cretaceous age.

Locally, beyond the limits of this quadrangle, where the overlying Colton Formation is absent, the Flagstaff Limestone grades into the lower part of the Green River Formation and these two units are then inseparable. Many workers in the Uinta Basin consider the Flagstaff to be a member of the Green River Formation (Ryder and others, 1976)

CRETACEOUS SEDIMENTARY ROCKS

Kpr **Price River Formation (Upper Cretaceous)**—Light-gray to gray, and grayish-brown to dark-gray beds of sandstone, plus some beds of conglomerate and conglomeratic sandstone; sparse mudstone; irregularly bedded; thin bedded to massive, commonly thick bedded; crossbedded. Beds alternate irregularly to form steep, steplike slopes. Ranges in thickness from 9 to 75 m (30–250 ft). Fluvial origin. This unit is equivalent, in part, to the Tuscher and Farrer Formations of the eastern Book Cliffs (Fouch and others, 1983, fig. 3)

Kc **Castlegate Sandstone (Upper Cretaceous)**—Light gray to dark gray, thin bedded to massive, platy, fine to coarse grained, quartzose. Some conglomerate beds. The sandstone beds of the Castlegate are chiefly gray, differing, thus, from the sandstone beds of the underlying Blackhawk Formation which are commonly some shade of brown. Locally, the Castlegate Sandstone beds are white. Commonly forms cliffs or steep slopes. Fluvial deposit.

Geologists have used the term Castlegate Sandstone in different ways. In the Woodside quadrangle, including the Sunnyside area, the term has been applied to a gray to grayish-brown, cliff-forming, fine- to coarse-grained sandstone that underlies the mudstone member of the Price River Formation (Osterwald and Maberry, 1974). (As defined by Osterwald and Maberry, the Price River Formation includes the Bluecastle Sandstone Member at the top underlain by the mudstone member, table 1). In Price Canyon, near the type locality of the Castlegate Sandstone, Fouch and others (1983) concluded that the Castlegate Sandstone consists of a series of braided stream deposits that are essentially equivalent to the Bluecastle Tongue, the mudstone member, and the Castlegate Sandstone (fig. 3 and table 1). In their interpretation, the Bluecastle is considered to be a tongue of the Castlegate Sandstone. In like fashion, we consider the mudstone member to be a unit of the more inclusive Castlegate Sandstone. Spieker (1931, p. 41) recognized that sandstone beds that were included in the Castlegate Sandstone at some localities were assigned elsewhere to the upper part of the Price River Formation. He notes: "In the Price River Canyon * * * where the member [now Castlegate Sandstone] is thickest, the upper 200 to 300 feet undoubtedly consists of beds included elsewhere in the overlying part of the Price River Formation."

The Castlegate Sandstone in the Sunnyside area is about 40 m (130 ft) thick. The Castlegate Sandstone in the Price Canyon area is about 155 m (500 ft) thick

Kbh **Blackhawk Formation (Upper Cretaceous)**—Dominantly light-brown, locally light-gray and brownish-gray, thin- to medium-bedded, fine- to medium-grained quartzose sandstone interleaved with shaly siltstone, shale, carbonaceous shale, and coal. Forms steep slopes. Many minor thin to thick coal zones in lower part; an important thick coal zone at base. In map area, formation contains two or three coal seams, splits of the Upper Sunnyside coal bed. Deltaic deposits. Ranges in thickness from about 120 m (400 ft) to about 270 m (900 ft)

Ksp **Star Point Sandstone (Upper Cretaceous)**—Light-brown to brown, fine- to medium-grained, platy, quartzose sandstone; some shale partings and interbeds of shale and shaly siltstone. Forms cliffs and steep slopes. Locally divisible into three sandstone beds, separated by seams of shale and shaly siltstone. The sandstone beds are equivalent, in descending order, to the Spring Canyon, Storrs, and Panther Tongues of the Star Point Sandstone (Spieker, 1931, p. 22). Formation crops out only in west-central part of quadrangle; pinches out east of Helper. Beach sand and intermediate marine shale. Formation ranges in thickness from about 60 to 305 m (200–1,000 ft); generally about 107 m (350 ft) thick. Pinches out to east

Mancos Shale (Upper Cretaceous)—Consists of (in descending order): (1) upper part of Blue Gate Member, (2) Emery Sandstone Member, (3) Blue Gate Member, (4) Garley Canyon Beds, (5) Ferron Sandstone Member, and (6) Tununk Member. Marine origin. Total thickness ranges from 700 to 1,860 m (2,300–6,100 ft)

Kmub **Upper part of Blue Gate Member**—Light-, bluish-, and dark-gray, thin- to medium-bedded shale and shaly siltstone; few thin interlayered brown sandstone beds. Includes sparse discontinuous ledges of silicified shale. About 305 m (1,000 ft) thick.

In south-central part of quadrangle, the Blue Gate Member is an unbroken sequence of shale beds. In southwestern part of quadrangle, however, the Emery Sandstone Member separates the Blue Gate into an upper part, and the bulk of the member which underlies the Emery. We map this division of the Blue Gate west of U.S. Highway 6, but are unable to recognize these units east of the highway, where it pinches out.

In the past the upper part of the Blue Gate has been called the Masuk Member of the Mancos Shale. Peterson and Ryder (1975), however, suggested that this unit is neither the same age nor composition as the Masuk of the Henry Mountains area. They proposed, therefore, that the name Masuk be restricted to the Henry Mountains area, and that the unit in the Price area previously known as Masuk be referred to as the upper part of the Blue Gate Member. Fouch and others (1983, Appendix C) concurred with this recommendation

Kme **Emery Sandstone Member**—Consists of upper and lower sandstone units separated by a middle shale unit. Maximum thickness of member about 90 m (285 ft). Pinches out to north and east

Upper and lower sandstone units—Light-brown to yellowish-brown, thin- to medium-bedded, locally crossbedded, very fine grained quartzose sandstone. Stand as low cliffs. Each bed ranges in thickness from 11 to 15 m (35–50 ft)

Middle shale unit—Light-gray to gray, thin- and even-bedded shale and shaly siltstone, and a few interleaved thin sandstone beds. About 60 m (200 ft) thick

Kmbg **Main body of Blue Gate Member**—Light-bluish-gray, and gray, thin- to medium-bedded shale and shaly siltstone. Sparse interlayered thin sandstone beds. Resembles upper part of Blue Gate and Tununk Members. As much as 610 m (2,000 ft) thick

Kmgc **Garley Canyon Beds of the Emery Sandstone Member**—Consists of two thin sandstone beds separated by dark-gray shale. Sandstone is light gray to light brown, locally orange brown, thin and even bedded, very fine to fine grained and quartzose. Locally crossbedded. Salt and pepper aspect. Firmly cemented by calcium carbonate. Stands as low cliffs. Beds range in thickness from a pinchout to about 8 m (0–25 ft)

Kmf **Ferron Sandstone Member**—Consists of upper and lower sandstone units separated by a middle shale unit. Member is about 50 m (160 ft) thick

Upper and lower sandstone units—Light-brown, thin- and even-bedded, crossbedded, very fine grained to fine-grained sandstone. Contains many large rounded concretions. Each sandstone bed stands as a cliff or a prominent series of ledges

Middle shale unit—Light-gray to dark-gray, thin- to medium-bedded, even-bedded shale and shaly siltstone

Kmt **Tununk Member**—Light- to dark-gray, thin- to medium-bedded, even-bedded shale and shaly siltstone. Locally contains discontinuous ledges of silicified shale. Few sandstone concretions. Forms low rounded hills. Ranges in thickness from 120 to 200 m (400–650 ft)

Kcm **Cedar Mountain Formation (Lower Cretaceous)**—Consists of two units, of which only the upper crops out in this quadrangle

Upper unit—Dominantly massive to thick-bedded mudstone variegated in shades of purple, red, gray, and green; calcareous; few discontinuous sandstone and limestone lenses; surfaces commonly littered with rounded limestone nodules, 5–10 cm (2–4 in.) in diameter. Contains many well-rounded polished chert pebbles, possibly gastroliths. Fluviolacustrine origin. Thickness of upper unit ranges from 45 to 75 m (150–250 ft)

Contact—Approximately located or inferred

scratch--color change with no line

gradational

Fault—Dashed where approximately located; dotted where concealed. Bar and ball rest on downthrown block

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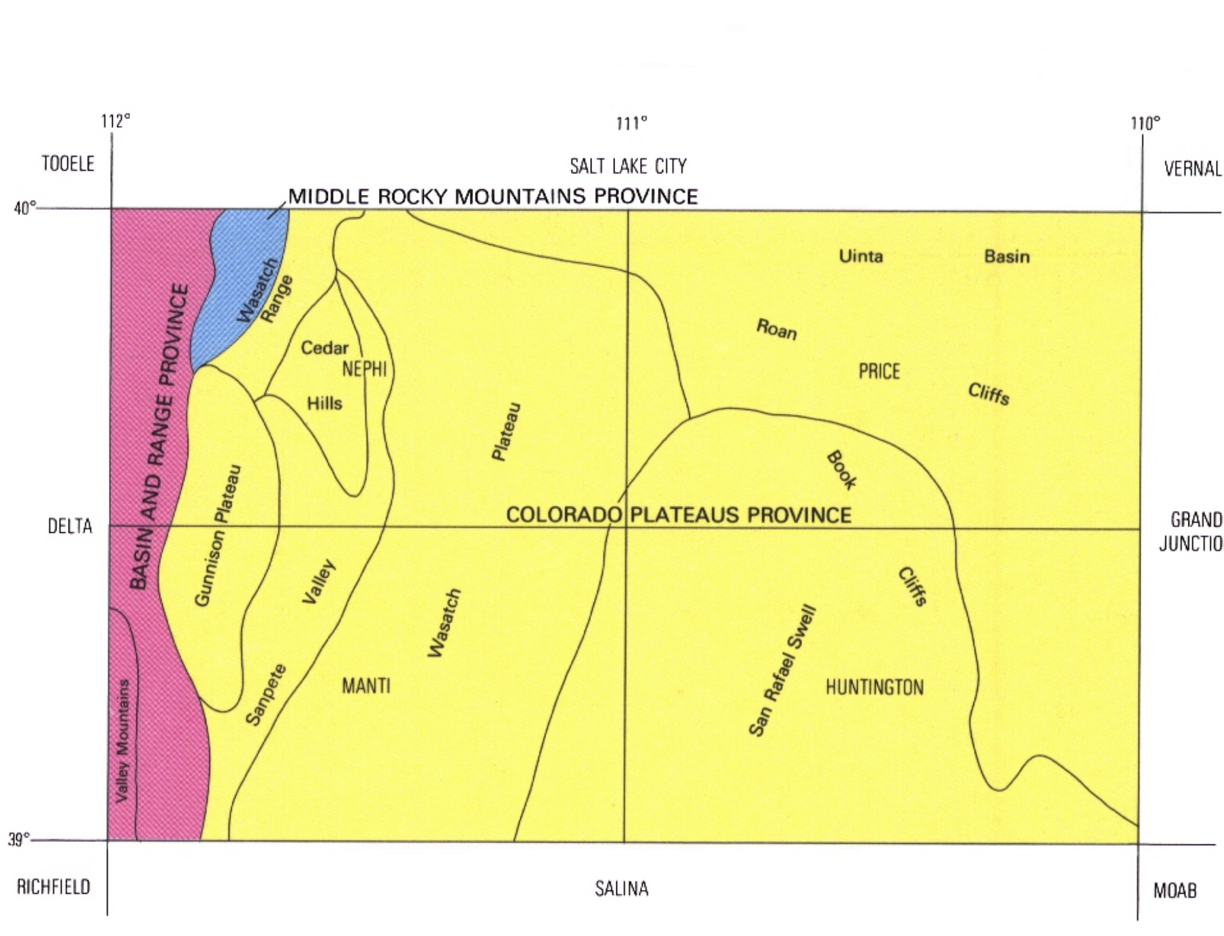

Figure 1.—Regional physiographic features of the Price 1° × 2° (1:250,000) quadrangle, and the names of included 30′ × 60′ (1:100,000) quadrangles and adjacent 1° × 2° (1:250,000) quadrangles.

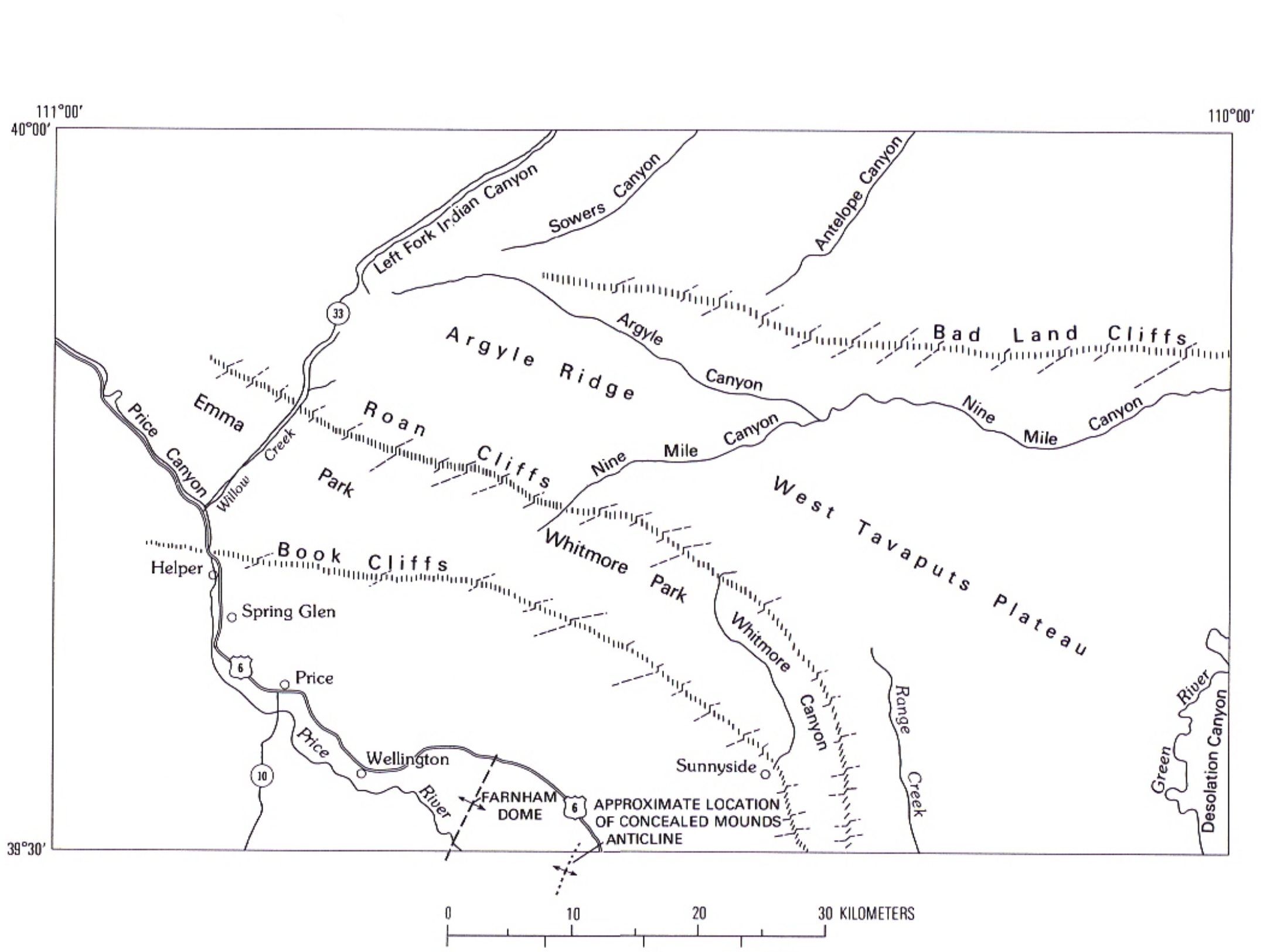

Figure 2.—Physiographic features of the Price 30′ × 60′ (1:100,000) quadrangle.

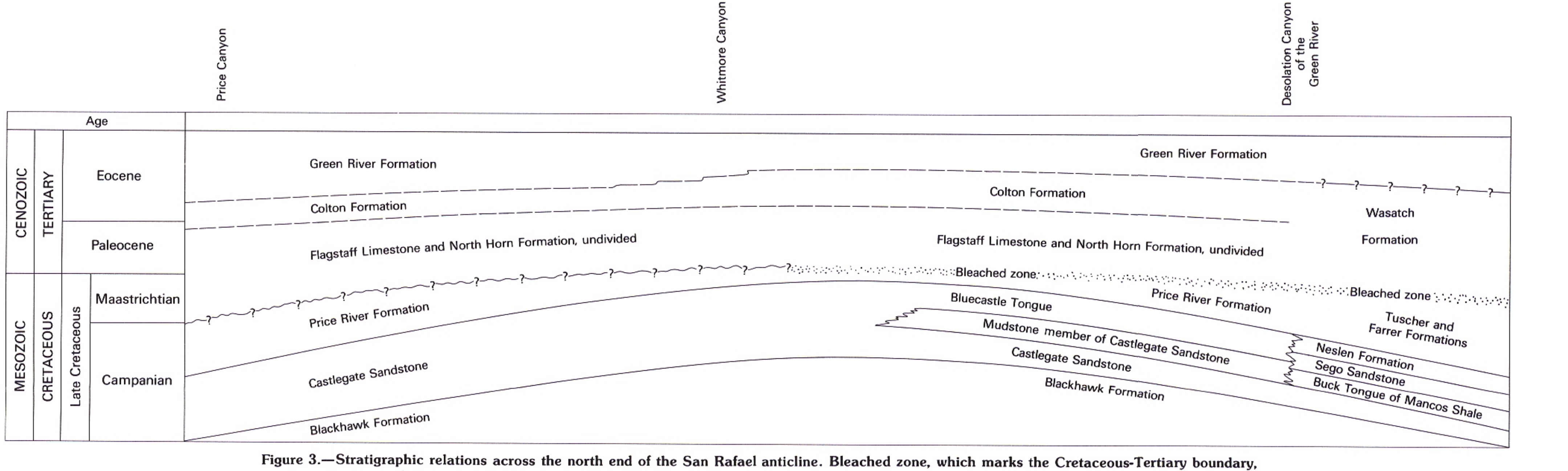

Figure 3.—Stratigraphic relations across the north end of the San Rafael anticline. Bleached zone, which marks the Cretaceous-Tertiary boundary, truncates some of the gently folded strata. Arching of the bleached zone suggests that upward movement of the anticline persisted into the Tertiary.

Table 1.—*Correlation chart*

Age				This map		Huntington quadrangle (Witkind, 1988)	Woodside quadrangle (Osterwald and Maberry, 1974)
CENOZOIC	TERTIARY	Paleocene		Flagstaff Limestone and North Horn Formation, undivided	Whitmore Canyon Flagstaff Limestone and North Horn Formation, undivided	Flagstaff Limestone and North Horn Formation, undivided	Flagstaff Limestone and North Horn Formation
					Bleached	zone	
MESOZOIC	CRETACEOUS	Late Cretaceous	Maastrichtian		Price River Formation	Upper part of Price River Formation (Price River Formation)	
			Campanian	Castlegate Sandstone	Bluecastle Tongue of the Castlegate Sandstone[1]	Bluecastle Sandstone Member and mudstone member of Price River Formation (Price River Formation)	Bluecastle Sandstone Member (Price River Formation)
					Mudstone member of Castlegate Sandstone		Mudstone member (Price River Formation)
						Castlegate Sandstone	Castlegate Sandstone
				Blackhawk Formation		Blackhawk Formation	Blackhawk Formation

[1] Mapped with the Castlegate Sandstone of this map.

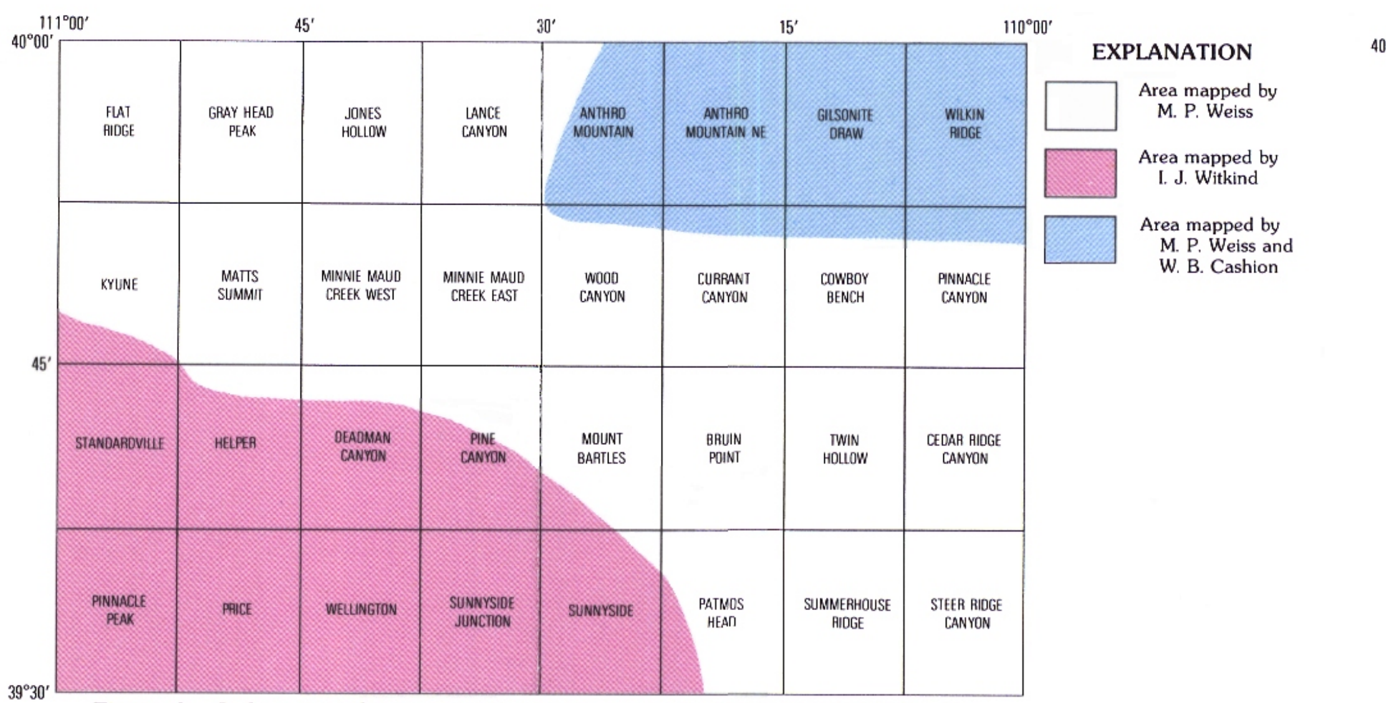

Figure 4.—Index to geologic mapping and 7½–minute (1:24,000) quadrangles. Some sectors of this quadrangle, covered by published geologic maps (see "Sources of Geologic Data"), reflect a modification of the published material by one or another of the co-authors of this quadrangle.

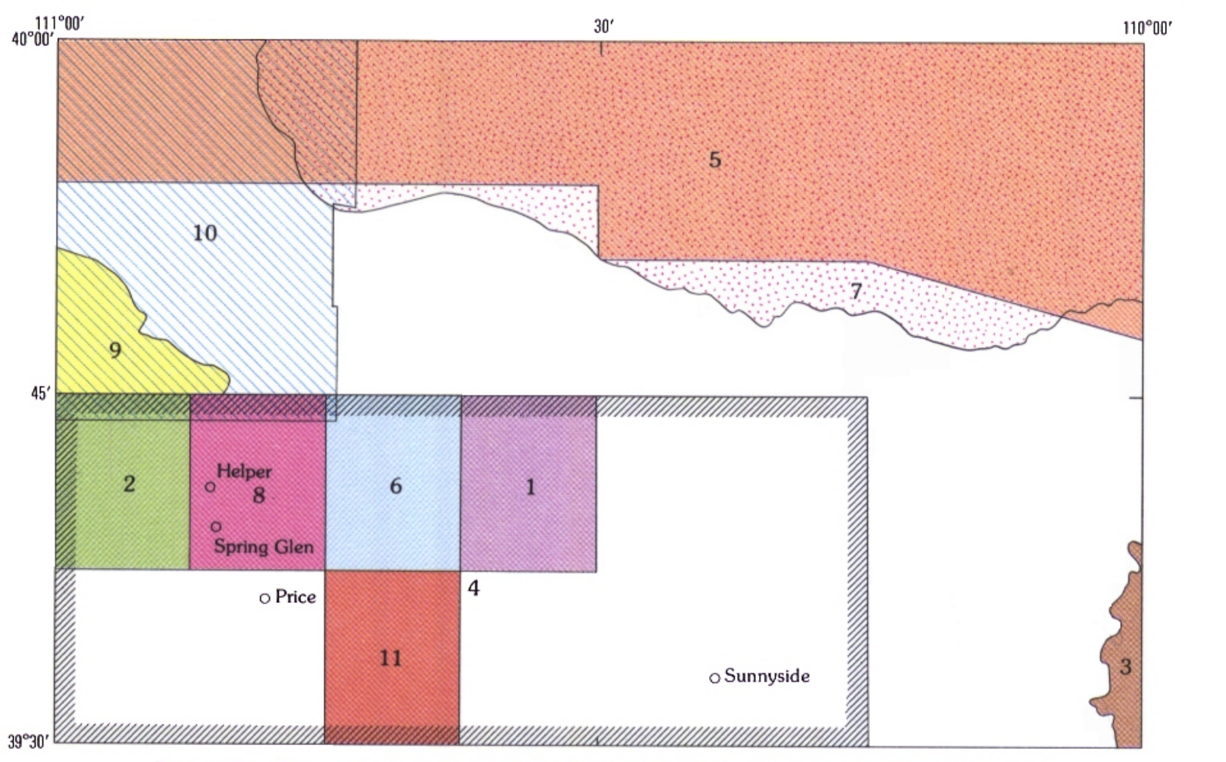

Figure 5.—Sources of geologic data. Sources, shown by colors and patterns, are keyed to "Selected References" section of text.

INTRODUCTION

The U.S. Geological Survey is engaged in a broad program of field studies designed to present the geologic framework of the United States on easily read topographic maps. The maps selected as a base for these geologic data are part of the Army Map Service (AMS) series of 1° × 2° quadrangles at a scale of 1:250,000. The Price, Utah, 1:250,000-scale quadrangle is one of these maps (fig. 1). For certain areas, however, chiefly those sectors of the country involved in the U.S. Geological Survey's coal exploratory program, the geologic data will be published on newly developed base maps at a scale of 1:100,000. On these new maps the configuration of the land is shown by metric contours having a 50-m contour interval. One of these new maps has been used as a base for this geologic map of the Price 30′ × 60′ (1:100,000) quadrangle, the northeastern quadrangle of the four quadrangles that make up the Price 1° × 2° quadrangle.

McGregor (1985) has described the engineering geology of the surficial deposits in the Price 30′ × 60′ (1:100,000) quadrangle.

Detailed geologic maps of several 7 1/2–minute quadrangles (at a scale of 1:24,000) within the Price 30′ × 60′ (1:100,000) quadrangle have been published (Anderson, 1983; Carroll, 1984; Nethercott, 1983; Russon, 1984; Witkind, 1979).

THE PRICE, UTAH, 1° × 2° (1:250,000) QUADRANGLE

The geologic data compiled on the Price 30′ × 60′ (1:100,000) quadrangle are part of a much larger geologic pattern best displayed on the Price 1° × 2° (1:250,000) quadrangle. Parts of three major physiographic provinces are within the Price 1° × 2° (1:250,000) quadrangle—the Colorado Plateaus, the Basin and Range, and the Middle Rocky Mountains (fig. 1). Most of the Price 1° × 2° (1:250,000) quadrangle, including the central and eastern parts, overlies the west margin of the Colorado Plateaus. Within this part of the Colorado Plateaus are the southern edge of the Uinta Basin (expressed as the southward-facing, sinuous escarpments formed by the Book and Roan Cliffs), the northern part of the Canyonlands section (expressed by the northeast-trending San Rafael Swell), and the northernmost part of the High Plateaus of Utah (the Wasatch Plateau). The western part of the Price 1° × 2° (1:250,000) quadrangle includes the east edge of the Basin and Range province (the Great Basin). A small wedge of the Middle Rocky Mountains province—the southern Wasatch Range—dominates the northwest corner of the sheet.

THE PRICE, UTAH, 30′ × 60′ (1:100,000) QUADRANGLE

COLORADO PLATEAUS PROVINCE

The Price 30′ × 60′ (1:100,000) quadrangle, entirely within the Colorado Plateaus province, contains two major physiographic features: the south flank of the Uinta Basin, and a series of interconnected lowlands, shaped somewhat like a southward-facing crescent, that encircle the north end of the San Rafael Swell (fig. 1). By far the most important, geologically, is the south flank of the Uinta Basin, which occupies about four-fifths of the quadrangle. Cities such as Price, Sunnyside, and Wellington are in the lowlands, and all major roads and rail lines follow these interconnected lowlands for access to these cities (fig. 2).

South flank of the Uinta Basin

The Uinta Basin trends eastward and covers about 26,000 km^2 (10,000 mi^2) in northeastern Utah. The basin is bordered on the north by the Uinta Mountains, on the west by the Wasatch Range, on the east by the Douglas Creek arch, and on the south by much of the Canyonlands section of the Colorado Plateaus province. Structurally, the basin, which contains a thick succession of lower Tertiary lacustrine and fluviatile sediments, is an asymmetric syncline, marked by steep to moderate southerly dips along its north flank and gentle northerly dips along its south flank.

Book and Roan Cliffs

The steep, sinuous escarpment known as the Book Cliffs trends northwesterly and westerly through this quadrangle and delineates the sinuous south margin of the Uinta Basin (fig. 2). Northeastward, beyond the Book Cliffs, other prominent topographic rises, such as the Roan Cliffs and the Bad Land Cliffs which are both essentially parallel to the Book Cliffs, reflect underlying durable rock units that dip northward into the center of the basin. Near Price, the Book Cliffs, dipping northeastward, gradually curve in response to the broad San Rafael upwarp, and the exposed strata assume a westward dip where they form the east front of the Wasatch Plateau. The same strata underlie both the Wasatch Plateau and the Book Cliffs.

The Book Cliffs are formed by Cretaceous sandstone and shaly siltstone of the Blackhawk Formation, Castlegate Sandstone, and Price River Formation (Young, 1955). Northeastward beyond the Book Cliffs is a second scarp—the Roan Cliffs—formed by the reddish-brown mudstone and sandstone beds of the Colton Formation. By a quirk of erosion the Roan Cliffs are close to the Book Cliffs in the southeast sector of this quadrangle, but gradually diverge westward and are separated by broad valleys—Whitmore Park near the center of the quadrangle, and Emma Park near the western margin. Even farther to the northeast, beyond the Roan Cliffs, are still other rises, such as the West Tavaputs Plateau and the Bad Land Cliffs, which are underlain and held up by units of the Green River Formation.

San Rafael Swell

The San Rafael Swell is a broad asymmetric northeast-trending upwarp about 115 km (70 mi) long and some 50 km (30 mi) across (fig. 1). This upwarp is part of a much larger, doubly plunging anticline—the San Rafael anticline—that also trends northeast, and that extends far beyond the swell. The anticline has greatly influenced the surrounding rocks. Although the swell (the physiographic unit) and the anticline (the structural unit) are commonly viewed as one and the same feature because they coincide locally, they are, in fact, wholly different.

North end of the San Rafael Swell

The north end of the San Rafael Swell, well exposed south of this quadrangle, appears as a broad wedge flanked on the west by northeast-trending Castle Valley and on the east by an unnamed northwest-trending valley (traversed by U.S. Highways 6 and 50). The cities of Price and Wellington are at the juncture of these two valleys. These valleys form the crescent-shaped lowland, which is mantled by surficial deposits and underlain by beds of drab-gray shale and sandstone of Cretaceous age (Witkind, 1979).

San Rafael anticline

The north-trending axis of the San Rafael anticline extends into the southwest sector of the Price quadrangle where the anticline is very broad and marked by moderate closure. The anticline is expressed best in the Book Cliffs where its slow but continued growth during post-Cretaceous time arched a widespread bleached zone, the Cretaceous-Tertiary boundary, that was once near horizontal (T.D. Fouch, U.S. Geological Survey, oral commun., 1981; see also discussion of the Flagstaff Limestone and North Horn Formation, undivided) (fig. 3). This slow but persistent anticlinal growth has also influenced the pattern of distribution of the Cretaceous and Tertiary rocks in the Book Cliffs; these strata thin toward the anticlinal axis and thicken away from it.

Age of the San Rafael Swell

Firm evidence for the time of the development of the San Rafael Swell is lacking. Gilluly (1929, p. 126) inferred that the swell was formed after the Cretaceous because Cretaceous strata are involved in the folding and because of the structural similarity between the swell and the Waterpocket fold farther southwest where folded Cretaceous strata are unconformably overlain by near-horizontal Eocene beds. Hunt (1956, p. 73–77) proposed that the folding and uplift of the swell began during the early Paleocene and persisted through the Miocene. Hawley and others (1968, p. 37–38) suggested that the swell likely was arched during the early Tertiary. They based this age on the physiographic similarity between the monocline developed along the east flank of the swell and a comparable one (the Wasatch monocline) formed along the west flank of the Wasatch Plateau that Spieker (1949) has dated as Paleocene. Other workers have provisionally placed the development of the swell at some time between the late Miocene and early Pliocene (Cohenour, 1969, p. 239). As noted above, in the Book Cliffs Upper Cretaceous strata thin toward the axis of the San Rafael anticline; this suggests that the anticline (and thus, the swell) had begun to form during or prior to Late Cretaceous time. Presumably the anticline continued to grow slowly throughout the Paleocene and Eocene. Possibly it continued its uninterrupted growth into the Miocene, although some geomorphic evidence opposes this view. For example, during the Miocene, a time of considerable structural unrest, some streams on the Colorado Plateaus were displaced laterally as new structural features developed and grew (Hunt, 1956, p. 82). Thus, the Dolores River appears to have been displaced eastward as the La Sal Mountains grew; in like fashion the Dirty Devil River appears to have been shifted northeastward off the developing Henry Mountains. By contrast, the San Rafael and Muddy Rivers, which cut through the San Rafael Swell, have not been displaced laterally but appear to have maintained their original southeasterly course. We interpret this to mean that during the Miocene these streams were let down from an older upland, long since removed, onto a stable and previously formed upwarp—the San Rafael anticline.

It seems reasonable to conclude that the swell was formed during the latest Cretaceous or early Tertiary; it may have continued to grow during middle Tertiary time but probably was a stable element during the late Tertiary. As the Book Cliffs are a part of the uplift, they and the Uinta Basin must similarly have been stable during late Tertiary time.

SEDIMENTOLOGIC HISTORY

LATE CRETACEOUS

The stratigraphic pattern and depositional history of the Upper Cretaceous rocks, so well exposed along the Book Cliffs, have been the subject of intense study during the past two decades. Fouch and others (1983) offered the most comprehensive statement, and interested readers are referred to that article. Early studies completed by F.R. Clark (1928) and his close associate E.M. Spieker (1931, 1946, 1949), by Fisher (1936), by Young (1955), and by Fisher and others (1960) form the basis for much of the work done by Fouch and his colleagues. These pioneering studies are basic references for anyone interested in the Upper Cretaceous rocks of this sector of the Colorado Plateaus.

Beginning in Jurassic time and continuing into the Late Cretaceous, major mountain masses formed in western and central Utah. Eastward-flowing streams and rivers carried debris shed from those mountains across central and east-central Utah and eventually debouched into the Mancos sea. By the end of Cretaceous time the shoreline of the seaway had withdrawn eastward and fully continental conditions prevailed across the Price 30′ × 60′ (1:100,000) quadrangle. We mapped the terrestrial deposits formed then as the North Horn Formation of Late Cretaceous and Paleocene age; these deposits include piedmont and alluvial-plain sandstone, mudstone, and lenses of lacustrine limestone.

Dickinson and others (1986) have developed depositional models for these and younger deposits in this region. Lawton (1983) studied Late Cretaceous fluvial systems between the Wasatch Plateau and the Green River. Bruhn and others (1983) and Johnson (1985) presented paleogeographic maps of the region for the Late Cretaceous and early Tertiary.

EARLY TERTIARY

Lake Flagstaff

As a result of post-orogenic deformation and Laramide basement uplifts, a large interior lake, Lake Flagstaff, trending northeastward, formed over broad sectors of southern, central, and northeastern Utah (Stanley and Collinson, 1979). Fresh-water sediments, now known as the Flagstaff Limestone, were deposited in this lake during the Paleocene and early Eocene.

Large volumes of clastic materials shed into the lake from all sides resulted in a gradational interfingering between alluvial, marginal lacustrine, and lacustrine deposits that formed in and near the open lake. We mapped the alluvial fill deposited near the margin of the lake as the Colton Formation. Some of this fill was shed northerly off the still positive San Rafael anticline, and these sediments kept the shores of Lake Flagstaff to the north and west of the upwarp (Hunt, 1956; Weiss, 1969; Stanley and Collinson, 1979). An especially thick accumulation of fluvial materials from the southeast (Dickinson and others, 1986) formed the Colton fan-delta, which underlies the southeastern part of this quadrangle.

During the late Paleocene and early Eocene (Fouch, 1975; Ryder and others, 1976) these fluvial materials greatly reduced the size of the lake. The end result was a broad intermontane basin partly occupied, in its northern sector, by a narrow, crescent-shaped lake (Fouch, 1975; Ryder and others, 1976), and in its southern sector by alluvial flats and small lakes (Weiss, 1980, 1982). Co-author Weiss believes that these small lakes represent the initial stages of Lake Uinta (Weiss, 1980, 1982).

Although Lake Flagstaff was gradually displaced northward by these clastic sediments, the lake persisted as a discrete body of water—the crescent-shaped lake—that eventually expanded, in early middle Eocene time, to form Lake Uinta (Fouch, 1975). This continuity between the old, established Lake Flagstaff and newly created Lake Uinta, in which the Green River Formation was deposited, explains why some workers consider the Flagstaff Limestone to be a member of the Green River Formation (Fouch, 1976; Ryder and others, 1976).

Colton fan-delta

The Colton fan-delta persisted throughout most of the duration of Lake Flagstaff, extended into the opening stages of Lake Uinta, and may have lasted until shortly before Lake Uinta reached its maximum extent during middle Eocene time.

The Colton fan-delta, a large, arcuate alluvial mass that was built northerly into Lake Uinta, grew slowly but persistently as a result of the intertonguing of alluvial and lacustrine sediments deposited in shallow waters. Subaerial, oxidized sediments of the fan (units of the Colton Formation) intertongue, both in outcrop and in the subsurface (Ryder and others, 1976), with lacustrine beds (units of the Green River) over a large part of the eastern third of the quadrangle. Dickinson and others (1986) showed that much of the material was derived from Laramide uplifts far to the southeast. The San Rafael anticline shed some sediment as well and these deposits may have dammed the northwestward-flowing drainage localizing the fan-delta.

As Lake Uinta widened and deepened, the amounts of clastic detritus added to the Colton fan-delta decreased. The depositional environment gradually changed from one dominated by alluvial materials to one dominated by lacustrine sediments, and, in time, the fan-delta was finally overtopped by lake sediments.

LAKE UINTA

Lake Flagstaff began to expand rapidly during early middle Eocene time and eventually formed a large lake—Lake Uinta—that occupied not only the present day Uinta Basin but also much of central Utah. Lake Uinta, south of the Uinta Mountains, is but one of three large lakes that formed at this time; the other two lakes, Fossil Lake and Lake Gosiute, formed north of the Uinta Mountains. All three lakes probably are the result of basinal subsidence (Hansen, 1985). Hunt (1956) suggested that Lake Uinta developed in response to crustal movements, south and east of the present day Uinta Basin, that interrupted through drainage. Johnson (1985) traced the history of the basin, and the effect of climate on the lake level.

Eocene Lake Uinta existed for approximately 13 million years, and, at maximum extent, covered a very large area in what is now northwestern Colorado and central and northeastern Utah. Those sediments of the Green River Formation deposited along and within the trough of Lake Uinta indicate uniform deposition over very large areas during long periods of time; by contrast, those Green River sediments deposited near the shore of the lake imply abrupt depositional changes in both time and space (Johnson, 1985). The Price 30′ × 60′ (1:100,000) quadrangle encompasses an area that lay near the margin of the lake; consequently, exposed Green River strata display many lateral and vertical changes in facies, reflecting repeated alternations from lacustrine to near-shore conditions.

Each of the five stratigraphic units of the Green River Formation that we have mapped formed under somewhat different lacustrine conditions. The lower and middle members of the Green River Formation formed under marginal-lacustrine conditions; the upper member appears to have formed under open-lacustrine conditions; the saline facies appears to have formed under saline-lacustrine conditions; and the sandstone and limestone facies formed under marginal-lacustrine conditions.

During late middle to early late Eocene time, Lake Uinta began to shrink, and in time was gradually displaced westward. As the lake waned, however, sediments from the east or possibly northeast, now represented by the Uinta Formation, were deposited along the margin of the lake. As a result intertonguing now exists between the sandstone and limestone facies of the Green River Formation and the terrestrial deposits in the lower part of the Uinta Formation.

STRUCTURE

FAULTS

High-angle, normal faults of two distinct trends break the rocks in the Price 30′ × 60′ (1:100,000) quadrangle. One group, confined essentially to the eastern half of the quadrangle, trends about N. 70° W. A second group, that crops out in the very northwest corner of the quadrangle, trends about N. 10° W. Displacement on any one fault is not more than 25 m (80 ft).

Northwest-striking faults

Although the northwest-striking faults range from short ones only several kilometers long to long ones as much as 9–15 km (5–10 mi) long, we are uncertain whether these differences in length have any meaning. In general, the shorter faults form a cluster just northeast of the Roan Cliffs; the longer faults, still farther to the northeast, can be separated into three belts: one along the crest of the Tavaputs Plateau, a second along the Bad Land Cliffs, and a third just north of the Bad Land Cliffs. Many of the faults are paired to form grabens.

Short faults

The short faults range in length from 2 to 6 km (1–4 mi). On some faults the northeast block is downthrown, on others, the southwest block. Four narrow grabens that average about 0.5 km (0.25 mi) in width result. These short faults have nearly the same orientation as the many faults that cut the Book Cliffs and the east flank of the San Rafael Swell in the Woodside area (Huntington 30′ × 60′ (1:100,000) quadrangle) to the south (Osterwald and Maberry, 1974; Witkind, 1988). These southern faults, however, extend westward into the center of the Huntington quadrangle, but are not found west of that point. Witkind (1988) attributes them to dissolution of salt, and notes that the zero line of the salt in the Paradox basin coincides essentially with the western limit of these faults.

Long faults

Of the three belts of long faults, the most striking is the southernmost belt, which consists of faults and grabens, more or less en echelon, extending N.70°W. from Desolation Canyon across the West Tavaputs Plateau to the center of the quadrangle. Individual grabens are mostly 8 km (5 mi) long and 1 km (0.6 mi) wide.

The second belt of northwest-trending faults lies north of Nine Mile Creek and extends obliquely across the Bad Land Cliffs to Anthro Mountain. The belt, some 33 km (21 mi) long, consists of three parts, each 7–9 km (4.5–5.5 mi) long. Within each part, the grabens are short and localized.

The third belt, north of the Bad Land Cliffs, extends for about 11 km (7 mi) into the Price 30′ × 60′ (1:100,000) quadrangle from the east. This group of faults differs from the others in that all are downthrown to the south.

Some west- and northwest-trending faults and grabens in the Huntington and Price 30′ × 60′ (1:100,000) quadrangles may stem from salt dissolution, as suggested by co-author Witkind, whereas others may be the result of bedrock flow or slump as suggested by co-author Weiss. In whatever way these faults formed, we believe that the trends of most reflect deep-seated fractures that break the crystalline rocks of the basement complex of the Uncompahgre uplift that underlie this area.

North-striking faults

Much less conspicuous are a few discrete, north-striking, high-angle normal faults that offset the rocks in the extreme northwest corner of the quadrangle. These faults are as much as 11 km (7 mi) long in this quadrangle, but extend far to the north in the adjacent Salt Lake City 1° × 2° (1:250,000) quadrangle (Bryant, 1992). All faults are downthrown to the west toward the Wasatch Plateau. In strike, length, and general appearance they are much like the many normal faults that break the rocks along the crest and west flank of the Wasatch Plateau (Witkind and others, 1987). Walton (1959) described similar faults that lie just west of the Price 30′ × 60′ (1:100,000) quadrangle.

Other faults

Two short faults near Kyune Creek (in the northwest corner of the quadrangle) strike easterly and are downthrown to the south. These faults probably are the result of failure of Green River mudstone beds below Reservation Ridge, and border large southward-directed slump blocks.

Age relations of the faults

Clear-cut evidence to indicate the age relations between the northwest-striking and north-striking faults is lacking; possibly both were formed synchronously. The absolute age of the faults is also uncertain; all cut Green River strata of Eocene age, so all were formed after deposition and consolidation of the Green River Formation. Those in the northeast corner of the quadrangle cut the lower member of the Uinta Formation, also of Eocene age. The north-striking faults may be related to regional extension of the crust, much as shown in the Basin and Range province to the west. If the faults result from bedrock flow or slump, as suggested by co-author Weiss, they may be quite young, possibly having formed during the Pleistocene.

SURFACE-WATER RESOURCES

Details about the surface-water resources of the Price 30′ × 60′ (1:100,000) quadrangle are contained in a companion publication, U.S. Geological Survey Miscellaneous Investigations Series Map I–1513 (Price, 1984).

ECONOMIC DEPOSITS

COAL

Thick coal beds are exposed in the western Book Cliffs and along the east face of the Wasatch Plateau. These beds are mostly within the Blackhawk Formation, an eastward-pointing wedge of strata dominated by littoral marine sandstone beds that thin eastward and that eventually grade into the Mancos Shale. Coal-bearing shale and siltstone beds, continental in origin, separate these marine sandstone beds. The coal beds have long been and continue to be of great economic significance in the Price area.

These coal beds have been and are being mined extensively in the Sunnyside area (near the south edge of this quadrangle), in the Helper–Hiawatha area (in the west-central sector of the quadrangle), and in the Huntington–Castle Dale area (directly southwest of this quadrangle). The coal beds are thick in all these areas, but they thin eastward and pinch out west of the Green River. Several coal beds in the Blackhawk Formation of the Spring Canyon area (west of Helper) were important sources in the early days of mining, chiefly because of ease of access. The area has been abandoned since the 1920's and 1930's, and the many old mines, closely spaced and engineered to standards now obsolete, probably cannot be opened again without great expense.

The Blackhawk was formed in a coastal area where eastward- and southeastward-flowing streams emptied into swamps, lagoons, and estuaries of a Cretaceous sea. The environment in which the Blackhawk was deposited has been interpreted as a wave-dominated delta that supported extensive swamps rich in organic material (Balsley, 1980). The organic material concentrated in these swamps eventually gave rise to the coal beds.

Thin coal beds are found locally in the lower part of the North Horn Formation, as in Price Canyon (Fouch and others, 1976).

The coals throughout the area are much alike; they rank as high-volatile B bituminous. Sulfur content is low, ranging from 1 to 3 percent. British thermal units per pound (BTU/lb) average 12,762 (Doelling, 1972, p. xviii). Doelling (1972) discussed the distribution and nature of the coal beds in this general region; Spieker (1931) has discussed the distribution of the coal beds on the Wasatch Plateau. Balsley (1980) and Young (1976) described the depositional environments in which these coal beds formed.

PETROLEUM RESOURCES

Petroleum resources of several kinds, rather widely spread in the Price 30′ × 60′ (1:100,000) quadrangle, are much subordinate to coal in the economy. Currently, gas is the most important product. The Navajo Sandstone (of Jurassic and Triassic age) and the Ferron Sandstone Member of the Mancos Shale (of Late Cretaceous age) yield gas in the lowland region of the southwest sector of this quadrangle and in areas adjacent to it on the south and west. Gas wells in the northeastern sector produce mostly from the Green River Formation; the gentle, uniform, northerly dips of the Tertiary beds into the Uinta Basin are not conducive to favorable structural traps. Even so, some gas accumulation has been discovered on very small closures in the Green River Formation, as in the Stone Cabin gas field. Some oil has been found in the Moenkopi Formation (Triassic) in the Mounds anticline, just at the middle of the south edge of the quadrangle. Tar sands and oil shale, possibly containing large reserves of petroleum, are confined chiefly to the Colton and Green River Formations. Some tar sands have been mined; the exposed oil-shale beds have not yet been exploited.

Oil and gas

Structural traps

A concealed major fold or positive area of pre-Laramide age, trending northwestward beneath the San Rafael Swell (Mahoney and Kunkel, 1963), extends into the southwest corner of this quadrangle. Seemingly, small domes and anticlines have developed locally along the trend of this structure. Most such local closures are in the Huntington 30′ × 60′ (1:100,000) quadrangle to the south, but two, the Mounds anticline and the Farnham dome, are near the south edge of the Price quadrangle (fig. 2).

Mounds anticline.—The Mounds anticline, at the north tip of the San Rafael Swell directly south of Sunnyside Junction, lies across the south border of the quadrangle. The anticline is not expressed at the surface, and was discovered through seismic surveys and subsurface well data (Mahoney and Kunkel, 1963). The upwarp is broken by a fault, and structural closure on the fold is about 150 m (500 ft) (Peterson, 1954). Although the structure has been tested several times, only small shows of oil and gas have been noted, chiefly in Moenkopi strata. Small amounts of oil, however, have been found in the Grassy Trail area some 6 km (4mi) to the east, but we do not know whether the Mounds structure extends that far east. A well drilled in sec. 17, T. 15 S., R 13 E. tested the northeast end of this structure; the hole was plugged and abandoned.

Farnham dome.—The Farnham dome lies mostly within the Price 30′ × 60′ (1:100,000) quadrangle and extends about 1.5–3 km (1–2 mi) southward into the Huntington 30′ × 60′ (1:100,000) quadrangle. The dome, about 8 km (5 mi) east of Wellington, occupies parts of Ts. 14 and 15 S., Rs. 11 and 12 E., and is elongated about N. 25° E. It is about 8 km (5 mi) long and about 5 km (3 mi) wide at its maximum width. The elongate dome is broken by a series of northeast-trending high-angle normal faults that are downthrown to the east. Peterson (1954), on the basis of seismic and subsurface data, interpreted these faults as low-angle eastward-directed thrusts, and suggested that the dome reflects and is underlain by a low-angle eastward-directed thrust fault (Peterson, 1961). The Navajo Sandstone is the producing reservoir, and carbon dioxide is the principal product.

Stone Cabin, Peters Point, and Nine Mile Canyon anticlines.—In the east-central sector of the quadrangle, in Ts. 11–13 S., and Rs. 14–17 E., are several small anticlinal noses, some of them faulted, that have been drilled successfully for gas. Three fields that trend southeast, each essentially linear, were developed in the early 1960's on various of these anticlines: Stone Cabin, Peters Point, and Nine Mile Canyon. Of the three, the Stone Cabin field, at the west end of the group, is now mostly abandoned. The Peters Point field, near the Green River, is at the southeast end of the group and is collinear with the trend of grabens that cut the east-central sector of the quadrangle. Many wells still produce in this field. The smaller and less productive Nine Mile Canyon field is northeast of the Stone Cabin field. Production is from sandstone units of the Colton and Green River Formations (Clem, 1985). These wells yield 10–200 million cubic feet (mcf) per day (Anonymous, 1985). Cretaceous gas, probably from sandstone beds in the North Horn or the Blackhawk, has also been found in T. 11 S., R. 14 E. just north of the Stone Cabin field (Clem, 1985).

Stratigraphic traps

Chokecherry Canyon and Sowers Canyon fields.—A number of wells have been drilled, beginning in the late 1950's and continuing to the mid–1980's, along and north of the Bad Land Cliffs extending from Indian Canyon to an area essentially along the east edge of this quadrangle. The wells extend through Ts. 6–7 S., Rs. 3–7 W., Uinta Special Meridian (USM), and Ts. 10–11 S., Rs. 13–17 E., Salt Lake Meridian (SLM). Most are on the dip slopes north of the Bad Land Cliffs, but a few lie along the face of the cliffs, north of Nine Mile Canyon. They are concentrated in the headwaters of Antelope, Chokecherry, and Fivemile Canyons, and were drilled to delineate the Chokecherry Canyon, Sowers Canyon, and Castle Peak fields. The Castle Peak field is just north of the northeast sector of this quadrangle.

All wells begin either in the upper units of the Green River Formation or in the lower part of the Uinta Formation. All three fields produced either oil or gas from lenticular sandstone beds in the Green River Formation. The Chokecherry field, a former oil producer, is now abandoned. Only the southern part of the Sowers Canyon field lies within this quadrangle, and the field, which produced gas, was shut down as of the mid–1980's. The Castle Peak field, which produces oil, is still active (Clem, 1985).

Miscellaneous tests.—Several wells have been drilled on the West Tavaputs Plateau, north of the Roan Cliffs, in the southeast sector of this quadrangle. The wells, which extend through Ts. 12–14 S., Rs. 14–15 E., penetrated the upper member of the Green River Formation, and were tests to determine if liquid petroleum occurs downdip from the nearby tar sands; only a little heavy oil was found and development ended (Covington and Young, 1985).

Oil shale

Oil shale is dark brownish gray, very fine grained, and thin bedded; commonly it characteristically weathers bluish gray. It has a very high content of kerogen, the compacted organic residue of former micro-organisms in ancestral Lake Uinta. Although somewhat like true shale in its degree of fissility, oil shale has much less mineral matter. Petroleum can be extracted from oil shale by roasting, whereupon the kerogen yields several commercial hydrocarbons. Many factors determine whether oil shales are worth mining for petroleum; among these are the current price of petroleum, as well as the thickness and abundance of the oil-shale beds. Oil-shale beds are both thicker and much more abundant east of this quadrangle, where their extent and oil potential have been studied in more detail (Cashion, 1967; Dana and others, 1980).

In this quadrangle, the Green River Formation contains many thin oil-shale beds in the upper member (Tgu), but only a few in the upper part of middle member (Tgm). These beds are both above and below the Mahogany ledge, which, in this quadrangle, is not a single oil-shale sequence but rather a zone of multiple oil-shale beds interleaved with marlstone and siltstone. Commonly, the ledge consists of four to six thin beds of oil shale, separated by thin marlstone and siltstone beds. The Mahogany ledge, an easily recognizable unit in much of the quadrangle, is widespread and has been used to separate the upper and middle members of the Green River Formation. The ledge ranges greatly in thickness; in places it is as thin as 4.6 m (15 ft). In the subsurface of the northeastern part of this quadrangle it is as much as 46 m (150 ft) thick. The cumulative thickness of the discrete oil-shale beds that make up the ledge do not exceed 1.8 m (6 ft) in thickness (Dane, 1955; Ray and others, 1956). Many thin oil-shale beds are above the Mahogany ledge but only a few are below the ledge (Dane, 1955; Ray and others, 1956). Most of the oil-shale beds distant from the Mahogany ledge are too thin and too limited in extent to be considered economically significant.

The potential for fuel production from these deposits has been discussed by Quigley and Price (1963); on the basis of their criteria the beds in this quadrangle are not of sufficient volume to justify exploitation at present (1988). All oil-shale testing, operation, and production sites are east of the Green River (Wood, 1985).

Oil-impregnated sandstones (tar sands)

Bituminous or asphaltic sandstones, sometimes called tar sands, are those porous rocks from which the more volatile components of liquid petroleum have evaporated, leaving a thick, viscous, tarry material. The enriched rocks are 8–10 percent bitumen by weight. The composition and origin of such bitumens have been described by Hunt (1963).

The tar sands can be used directly as paving material, or the asphalt can be removed by heating, dissolution, or displacement by hot water or steam. Once removed from the host rock, the thick oily substance can be refined into a number of useful petroleum products.

Deposits of tar sands are numerous and abundant in the Uinta Basin, including this quadrangle. For ease of discussion we have grouped the smaller deposits, and discuss them separately from the one large deposit at Sunnyside.

Sunnyside deposit

A large deposit of tar sand and other bituminous rocks is exposed in the Roan Cliffs east of Sunnyside, and extends for about 13 km (8 mi) from the eastern part of T. 13 S., R. 13 E. to the middle of T. 14 S., R. 14 E. (Covington and Young, 1985). The deposit represents the eastern part of a former giant oil field breached by erosion (Ritzma, 1973); in the process the western part of the oil field has been destroyed. The host beds for the bitumen are variously described as Wasatch and (or) Green River Formations (Holmes and others, 1948; Holmes and Page, 1956; Covington, 1963; Campbell and Ritzma, 1979). We include the bituminous zones both in the upper part of the Colton Formation, and in the lower and middle members of the Green River Formation. Individual sandstone bodies tend to be channel-form and locally are as much as 100 m (330 ft) thick (Campbell and Ritzma, 1979). Only those deposits of sandstone containing 8–10 percent bitumen within Colton strata are considered valuable (Covington, 1963).

An extension of the same petroliferous body evidently reappears farther to the northeast as the Stone Cabin–Peters Point gas fields, and the smaller tar sand deposits in Cottonwood, Jacks, and Nine Mile Canyons.

Campbell and Ritzma (1979), in estimating the volume of the resource, have considered both the surface and subsurface extent of the richer part of the Sunnyside deposit. They believe that the deposit thins rapidly downdip, possibly as much as 75 percent, by facies change in the first 2.4 km (1.5 mi). Thin oil-shale beds are interleaved in the overlying strata, which total about 122 m (400 ft), but are not included in the resource estimates. Although the main oil-impregnated zone is as much as 265 m (860 ft) thick, the oil sand is but 210 m (680 ft) thick. Allowing for disparity in specific gravity between bitumen and sand, about 316 million cubic yards (320 million tons) of bitumen are in this deposit. They found the average bitumen content of oil-impregnated rocks within the deposit to be 5.4 percent. By contrast, Holmes and Page (1956) estimated the deposit to contain about 1.6 billion cubic yards of sandstone. If Holmes and Page's estimate is subjected to the same calculations, the final result totals only 190 million cubic yards (192 million tons) of bitumen. Holmes and Page believed, however, that the average bitumen content is about 9 percent.

In terms of petroleum in the Sunnyside deposit, Covington and Young (1985) suggested that nearly 300 million barrels of petroleum are recoverable from a gross reserve of 750 million barrels.

The asphaltic deposits were used for paving material for nearly 60 years, until production stopped in the late 1940's (Covington, 1963; Campbell and Ritzma, 1979). Most of the paving material came from the principal quarries high on the face of the Roan Cliffs at the head of Water Canyon, in the middle of the N 1/2, T. 14 S., R. 14 E.

A number of methods, involving flooding the deposits with hot water or steam, have been tried, some quite recently, in an attempt to extract liquid petroleum from the tar sands. None of the trials has been commercially successful (Ritzma, 1973; Thurber and Welbourn, 1977; Covington and Young, 1985).

Smaller tar-sand deposits

Ritzma (1973) mapped five smaller areas containing tar-sand deposits: (1) Willow Creek, (2) Argyle, (3) Minnie Maud, (4) Nine Mile Canyon, and (5) Cottonwood–Jacks Canyon.

Willow Creek area.—The Willow Creek area, in T. 7 S., Rs. 8–9 W., is north of Reservation Ridge in the northwest sector of the quadrangle. The deposits are confined to the middle member of the Green River Formation. Ritzma (1973) believed that this deposit has "large" reserves.

Argyle area.—The Argyle area, in T. 7 S., Rs. 6–7 W. and Ts. 10–11 S., Rs. 11–13 E., is along the divide that separates Argyle Canyon on the south from the Left Fork of Indian Canyon and Sowers Canyon on the north. The deposits are scattered through the middle, upper, and saline members of the Green River Formation. Ritzma (1973) suggested that this deposit has "very large" reserves.

Minnie Maud area.—The Minnie Maud area, in T. 11 S., Rs. 11–13 E. along the north side of Minnie Maud Creek, is about 5 km (3 mi) south of the Argyle area. The deposits are in the middle member of the Green River Formation, with much of the tar sand mined for paving material coming from asphalt-impregnated sandstone beds (Ritzma, 1973; Covington, 1963). Ritzma (1973) also mentioned some asphalt-impregnated limestone beds. Ritzma (1973) considered that this deposit contains "large" reserves.

Nine Mile Canyon area.—The Nine Mile Canyon area, in T. 11 S., Rs. 14–17 E., is along the north side of Nine Mile Creek. The asphalt-impregnated deposits are within the middle member and the lower part of the upper member of the Green River Formation. Ritzma (1973) classified the deposit, in terms of reserves, as a "small-medium deposit."

Cottonwood–Jacks Canyon area.—The Cottonwood–Jacks Canyon area, in Ts. 11–12 S., Rs. 15–17 E., is south of Nine Mile Canyon chiefly along the north half of the West Tavaputs Plateau. The host rocks are parts of the middle and upper members of the Green River Formation. Ritzma (1973) classified this deposit, in terms of reserves, as "large."

NONMETALLIC MINERAL DEPOSITS

Limestone

Thick and thin beds of microcrystalline limestone with various amounts of mud or sandy fractions are within the North Horn, Flagstaff, Colton, and Green River Formations. Much of the limestone contains interbedded mudstone, shale, siltstone, or sandstone, and consequently is uneconomical to use for lime or for dimension stone—even though many beds in the Flagstaff are compositionally suitable. Thus, the principal use for these limestone beds is as crushed rock; for this purpose the limestones of the Flagstaff (upper part of the "Flagstaff Limestone and North Horn Formation, undivided") are the best and most abundant. Desirability of these limestones for this purpose is enhanced by the fact that all sandstone beds in the region are weak, either friable or having low crushing strength.

Sand and gravel deposits

A mantle of unconsolidated to well-cemented water-laid detritus caps the many spectacular pediments that rim the lowland below the Book Cliffs and around the north end of the San Rafael Swell. This material, mapped as pediment mantle (QTpm), constitutes an almost inexhaustible supply of sand and gravel. The deposits hold up large, broad, even-surfaced benches, mesas, and buttes whose slopes incline gently downward toward the swell from the Book Cliffs on the east and north, and from the Wasatch Plateau on the west. The deposits consist of crudely sorted mixtures of angular to subround clasts that range in size from silt to boulders. The clasts, derived from the Book Cliffs and the Wasatch Plateau, reflect the soft shale, shaly siltstone, and sandstone that make up those land masses. Similar material, thinner and less well cemented generally, is found also in areas of slope wash (Qsw). These slope wash deposits are in the same lowland as the pediments, but are concentrated in the southwest, below the east face of the Wasatch Plateau.

Sand and gravel pits opened locally in these deposits supply most of the material used for road metal, fill, and concrete aggregate. Because the deposits are poorly sorted and contain much soft material, much of the material must be crushed, screened, and washed before it can be used for some construction projects.