GEOLOGIC MAP OF THE SAN RAFAEL DESERT 30′ x 60′ QUADRANGLE, EMERY AND GRAND COUNTIES, UTAH

by Hellmut H. Doelling, Paul A. Kuehne, Grant C. Willis, and J. Buck Ehler

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SCALE: 1:62,500

Cover photo: *Aerial view looking west across south end of San Rafael Swell.*

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DESCRIPTION OF MAP UNITS

QUATERNARY

Qh **Human-emplaced fill and disturbed areas** (Historical) – Gypsum, crushed stone, and road fill quarries; small dams across washes and streams; most road fill deposits and other disturbed areas not mapped.

Qalh **Historical alluvial river channel deposits** (Historical) – Sand, silt, clay, gravel, and human-emplaced fill deposited in cut-off river meander channel; only mapped in the city of Green River in northeast part of map where a major meander of the Green River was cut off during a major flood event in the early 1930s, leaving an abandoned channel that was gradually filled by river flood deposits, local slope wash, and human-emplaced fill; because the river had been previously established as the boundary between Emery and Grand Counties, this left a small area of Grand County "stranded" on the west side of the river; in 2003, the Utah legislature revised the county boundaries to include this area within Emery County; commonly less than 5 meters (16 ft) thick.

Qa **Alluvial river, stream, and wash deposits, undifferentiated** (Holocene to late Pleistocene) – Sand, silt, clay, granules, pebbles, and sparse cobbles in and adjacent to river, stream, and wash channels; commonly well sorted along rivers and larger streams and poorly to moderately sorted along smaller streams and washes; commonly includes variable amounts of locally derived colluvium and slopewash, and windblown sand and silt; consists primarily of locally derived material along wash channels; Qa includes deposits in active channels and on incised low-level benches and terraces generally up to about 10 meters (33 ft) above active channels (locally higher); larger benches are differentiated as Qa2 or Qa3; locally includes other types of deposits too small to map separately; generally 0 to 10 meters (0–33 ft) thick.

Qa2, Qa3 **Level two and three alluvial deposits** (Holocene to late Pleistocene) – Sand, silt, granules, pebbles, and sparse cobbles forming large, incised, low-level alluvial terraces or broad benches; similar to older parts of Qa; mapped where deposits form large benches in protected areas near the margins of larger alluvial drainages; consists primarily of locally derived materials; locally includes lower level terrace deposits similar to Qat that are not mapped separately; Qa2 deposits are commonly 5 to 10 meters (15–33 ft) above active channels and Qa3 deposits are typically more than 10 meters (33 ft) above active channels; locally includes other types of deposits too small to map separately; generally 0 to 10 meters (0–33 ft) thick.

Qat **Terrace alluvium** (early Holocene to Pleistocene) – Moderately well sorted pebble to cobble gravel with some silt and sand in terraces along major rivers and streams; clasts are mostly rounded to subrounded but a few locally derived clasts are angular; contains clasts of quartzite, chert, limestone, sandstone, siltstone, dolomite, and petrified wood to 0.6 meter (2 ft) in diameter, but mostly pebbles to cobbles up to 10 centimeters (4 in) in diameter; basal parts are generally coarser; commonly partly to fully consolidated in basal parts with cementing calcic soil (caliche), especially in the older (higher) deposits; caliche is locally as thick as 3.5 meters (12 ft); deposits are found at irregular levels to as high as 180 meters (600 ft) above modern drainages; commonly covered by a thin mantle of eolian sand and silt (mapped as Qate where eolian component is thicker north of Ten-Mile graben along the Green River); thickness varies widely, but commonly less than 10 meters (33 ft) thick; Qat consists mostly of clasts transported from sources outside of map area, including from units in the Book Cliffs and Uinta Mountains (Green River terraces) and the San Rafael Swell (San Rafael River and larger intermittent drainages); major river incision rates have been estimated by Dethier (2001) at 0.15 meter per thousand years (0.5

ft/kyr) and by Burnside and others (2013) at 0.17 meter per thousand years (0.56 ft/kyr); 0 to 10 meters (0–33 ft) thick.

Qate **Mixed alluvial terrace and eolian deposits** (Holocene to Pleistocene) – Alluvial terrace deposits similar to Qat capped by thick eolian deposits similar to Qes; located east of the Green River north of Ten-Mile graben; 15 meters (50 ft) or less thick.

Qaf **Alluvial-fan deposits** (Holocene to late Pleistocene) – Poorly sorted, angular to subrounded gravel containing cobbles and sparse boulders in crudely bedded to nonstratified granule to clay matrix; cut-and-fill channel features locally present; deposited by debris flows near the base of steep slopes, cliffs, and ledges, and at the mouths of streams and washes; thickness commonly less than 15 meters (50 ft).

Qap **Pediment-mantle deposits** (early Holocene to early Pleistocene) – Poorly to moderately sorted, rounded to angular boulders, cobbles, pebbles, granules, sand, silt, and clay; commonly mantled by eolian deposits; consist primarily of locally derived materials deposited by debris flows and ephemeral streams; covers beveled bench-like bedrock surfaces as high as 120 meters (400 ft) above local base level; commonly less than 10 meters (33 ft) thick.

Qea, Qae

Mixed eolian sand and alluvial deposits (Holocene to middle Pleistocene) – Wind-blown sand and silt interspersed with silt, sand, and gravel of alluvial origin; generally dominated by eolian deposits; near Temple Wash a large area consisting primarily of eolian and alluvial deposits that has been deflated by wind scour is mapped as Qae; commonly displays a well-developed calcic soil (caliche) horizon in the upper part; locally includes other types of deposits too small to map separately; 15 meters (50 ft) or less thick.

Qes **Eolian sand deposits** (Holocene to middle Pleistocene) – Unconsolidated wind-blown sand deposited in sheets and low mounds; generally pale orange brown but locally nearly white to pale brown; fine to medium-grained wind-blown sand commonly covers Qea, Qa, Qat, Qap, and bedrock units; especially extensive in areas underlain by and adjacent to Entrada Sandstone deposits; locally interlayered with alluvial deposits; contains small areas of dune deposits, especially longitudinal dunes trending northeast in response to prevailing winds; 0 to 4.5 meters (0–15 ft) thick, but locally thicker.

Qed **Eolian dune sand deposits** (Holocene to middle Pleistocene) – Fine- to medium-grained, wind-blown sand that forms dunes and mounds; generally pale orange brown; commonly associated with Qes and Qea deposits; only larger deposits mapped, typically on the lee side of small escarpments and cliffs; deposits trend northeasterly in response to prevailing winds; 0 to 15 meters (0–50 ft) thick.

Ql **Lacustrine deposits** (Holocene) – Thin silt and sand deposits in an abandoned river meander channel (oxbow lake); includes minor alluvial and eolian sand and river gravel remnants; mostly well sorted in thin planar beds; mostly less than 3 meters (9 ft) thick.

Qms **Mass-movement landslide deposits** (Holocene to late Pleistocene) – Coherent to broken and jumbled masses of bedrock, talus, and colluvium that have moved downslope due to gravity; contains talus and colluvium mostly in the distal parts; forms hummocky slopes; includes rotated slump blocks most commonly associated with the Jurassic Morrison Formation; present on the flanks of Little Flat Top near south-central edge of the quadrangle, west of the Green River across from Salt Wash, and south of the San Rafael Reef on the flanks of the Wild Horse Mesas; San Rafael Desert quadrangle has relatively few landslides compared to other parts of the Colorado Plateau; varied thicknesses.

Qmtc **Mass-movement talus and colluvial deposits** (Holocene to late Pleistocene) – Very poorly sorted, mostly angular rock-fall blocks, boulders, angular gravel, sand, and silt deposited on low to moderate slopes below cliffs and steep slopes; grades downslope from talus to colluvium where unit is mostly angular pebbles to cobbles in a sandy to silty matrix; only larger deposits mapped; generally 4.5 meters (15 ft) or less thick.

Qst **Spring tufa deposits** (Holocene to middle Pleistocene) – Mostly drab, light-yellow-gray with lesser yellow-ocher to dusky-red-brown, calcareous tufa; porous, crudely laminated, and locally thin bedded; weathers to thin plates; formed by cold-water springs and locally by a geyser that formed from an old drill hole; present on the east side of the Green River in Ten-Mile graben, and near Crystal Geyser north of Ten-Mile graben; Burnside and others (2013) obtained U-Th ages ranging from 413.4 ± 15 to 113.9 ± 0.6 ka in Ten-Mile graben; as much as 7.5 meters (25 ft) thick.

Qste **Spring tufa deposits partially covered by eolian sand deposits** – Unit present in the San Rafael Desert near Rattlesnake Butte; see separate descriptions of Qes and Qst.

ALTERED ROCKS OF POORLY CONSTRAINED AGE

bs, bmb

Bleached, altered, and subsided "collapse features" of Temple Mountain and surrounding areas (Holocene? to Early Tertiary?) – Collapse features in the Temple Mountain area consisting of bleached, faulted, discordant, and fractured rocks that collapsed into the Chinle and Moenkopi Formations; collapsed and altered rock shown as map unit for larger features and shown with hachured round symbol for smaller features (see plate 2 for discussion and enlarged map); the strata collapsed similar to a mine stope in the center of the feature, and the features are commonly surrounded by strata that dip gently inward from all directions toward probable underground caverns created by dissolution of Permian limestone; most collapse features are associated with faults or prominent joints; subsurface studies show that collapses seem to be restricted to strata above the White Rim Sandstone (Keys, 1956); collapses pre-date development of modern ground surface (Doelling and Kuehne, 2008); three deposits associated with collapse features on Temple Mountain consist of blocks of sandstone that have "stoped" down; the west block (bmb) is bleached Moss Back Member of the Chinle Formation; field mapping and microscopic comparisons of samples strongly suggest the upper two blocks (bs) are Wingate Sandstone; feature just west of Flat Top also has a block of collapsed Moss Back Member large enough to map (bmb); thicknesses vary; Wallace (2012, 2013) suggested the three features at Temple Mountain are sand injectites forced upward from underlying Permian White Rim Sandstone by high-pressure fluids derived from the Paradox Basin; we agree that these features have experienced extensive fluid migration, but our studies indicate that the features collapsed downward; thickness of altered zone and sand bodies vary, but none exceed 600 m (1500 feet) in diameter (Doelling and Kuehne, 2008); age poorly constrained.

TERTIARY

Td **Lamproite dikes** (Miocene) – Dark-gray mafic igneous rock with abundant phlogopite, olivine, and carbonate mafic-mineral-pseudomorph phenocrysts and vesicle fillings in a phlogopite-rich, microcrystalline matrix that contains small percentages of sanidine, apatite, hematite, and magnetite; located in south-central San Rafael Desert; Hulen and others (1997) obtained an $^{40}Ar/^{39}Ar$ age of 22.0 ± 0.2 Ma indicating that the dikes are not related to the 3 to 7 Ma (Delaney and Gartner, 1997) "San Rafael dike swarm" to the west; up to 1-meter-thick (≤ 3 ft) dikes intruded into Middle Jurassic Entrada Sandstone.

CRETACEOUS

Km **Mancos Shale, undivided** (shown on cross sections only) – The Mancos Shale has commonly been treated as a formation by geologic mappers and stratigraphers, but Molenaar and Wilson (1990) and Johnson and Johnson (1991) proposed elevating it to group status. This recommendation did not become widely adopted, but recently Kirkland (verbal communication) has also suggested that it be elevated. We chose to leave it as a formation until the group status becomes more widely adopted.

Kmb, Kmbs

Blue Gate Shale Member; sandstone beds in Blue Gate Shale (Late Cretaceous, Campanian to Turonian [Molenaar and Cobban, 1991]**)** – Mostly light- to dark-gray, thinly laminated to medium-bedded shale and shaly siltstone with sparse, interlayered, thin, yellow-brown to yellow-gray sandstone beds (prominent sandstone beds south of I-70 in northeastern part are mapped separately, and labeled Kmbs); forms low rounded hills and flat plains; deposited in shallow-marine environment; lower contact with the Juana Lopez Member is gradational; 800 to 1000 meters (2600–3300 ft) thick, but only the lower part is exposed in the northeast corner of the quadrangle.

Kmjl, Kmju

Juana Lopez Member; lower part; upper part (Late Cretaceous, upper to middle Turonian [Molenaar and Cobban, 1991; Edwards and others, 2005]) – Brown-gray to yellow-gray, fine-grained, cross-bedded sandstone, sandy mudstone, and carbonaceous shale; fissile to medium planar bedded; commonly forms two sandstone cuestas (mapped separately as Kmju [upper] and Kmjl [lower]) with intervening slope of light-gray to black carbonaceous shale and shaly siltstone (included with Kmju); locally fossiliferous; deposited in shallow-marine environment; lower contact is a subtle scour surface locally overlain by lenticular lag deposits of pebbly, medium- to coarse-grained sandstone; present east of the San Rafael Swell in northeastern part of the map area; formerly designated Ferron Sandstone in this area, but Molenaar and Cobban (1991) and Edwards and others (2005) showed that strata are of different provenance and environment than Ferron Sandstone; part of the formation correlates with the upper unit of the Ferron Sandstone; 15 to 50 meters (50–165 ft) thick.

Kmf **Ferron Sandstone Member** (Late Cretaceous, middle Turonian [Molenaar and Cobban, 1991]) – Sandstone and mudstone; sandstone is light to dark brown, very fine to medium grained, well to moderately sorted with rare coarse-grained lenses, lenticular, and cross-bedded; sandstone commonly contains nodules of pyrite coated with limonite, and worm tracks and burrows; mudstone is gray to green-gray and silty, and decreases upward in section; Kmf can be divided into two units to the southwest (Edwards and others, 2005), but only lower unit exposed here; unit grades into the Tununk Shale below; only exposed in the southwest corner of the quadrangle; 100 m (330 ft) thick.

Kmt, Kmtc

Tununk Shale Member, Coon Springs Bed (Late Cretaceous, Turonian to Cenomanian [Molenaar and Cobban, 1991]) – Light- to dark-gray shale, shaly siltstone, and mudstone; contains pale-yellow, fine-grained sandy zones, especially near the top; forms slopes and low rounded hills; locally contains the Coon Springs Bed (Kmtc, mapped as marker bed), which is a conspicuous zone of sandy, fossiliferous, concretionary limestone and calcareous sandstone in the upper third of the unit; locally contains discontinuous ledges of silicified shale; lower contact with Dakota is generally abrupt but conformable, but is a disconformity where the Dakota is thin or missing, and is marked by a change from gray-green shale (Cedar Mountain Formation) to gray shale and by a local basal gravel (Eaton and others, 1990); a zone of fossil bivalves (*Pycnodonte newberryi*) is found a few feet above the contact; 90 to 130 meters (300–430 ft) thick, generally thickening to the west.

Kdcm **Dakota Formation and Cedar Mountain Formation, undivided** – on cross section only.

Kd **Dakota Formation** (Cenomanian, Late Cretaceous [Gustason, 1989; Eaton and others, 2001]) – Light-yellow and yellow-brown, friable, quartzitic, medium to coarse-grained, cross-bedded, fluvial sandstone, conglomeratic sandstone, and conglomerate, with minor interbedded carbonaceous shale and impure coal; quartzite and chert pebbles as much as 2.5 centimeters (1 in) in diameter; locally contains silicified wood and plant impressions; yellow, iron-stained bands or streaks present along some cross-beds; forms isolated ridges and mounds; discontinuous and commonly missing; 0 to 9 meters (0–30 ft) thick.

unconformity

Kcmu **Cedar Mountain Formation upper members** (Late to Early Cretaceous, Cenomanian to Aptian [Kirkland and others, 1999; Kirkland and Madsen, 2007; Hunt and others, 2011]) – Variegated pale-gray, lavender, and pastel purple, red, and green mudstone, siltstone, and shale (commonly smectitic), with several zones of brown, nodular limestone, especially near the base, and sparse gray, green, or light-brown, thin-bedded, lenticular, fine-grained sandstone beds; forms gentle to steep badland slopes devoid of vegetation; consists of two upper members in the west part of the quadrangle, the Ruby Ranch and Mussentuchit Members, and four members in the east part where the underlying Yellow Cat and Poison Strip Members are present (not mapped separately) (Kirkland, 2005; Kirkland and Madsen, 2007); 22 to 58 meters (75–190 ft) thick.

Kcmb **Buckhorn Conglomerate Member** (Early Cretaceous, Aptian to Barremian [Greenhalgh and Britt, 2007; Kirkland and Madsen, 2007; Hunt and others, 2011]) – Locally mapped at the base of the formation in the northeast part of the map area; dark-brown, fluvial, massive to thick cross-bedded conglomerate, conglomeratic sandstone, and sandstone that forms a cliff or ledge containing mostly white to very pale yellow-gray quartzite and black and light-brown chert pebbles and cobbles; locally contains logs and branches of petrified wood; correlates with Yellow Cat Member (Kirkland and Madsen, 2007), which locally includes Buckhorn facies but is fine-grained overbank deposits (not mapped separately); the lower contact is a disconformity with channels incised into the underlying Morrison Formation; 0 to 9 meters (0-30 ft) thick.

K-0 unconformity

JURASSIC

Jm **Morrison Formation, undivided** – on cross sections only.

Jmb **Brushy Basin Member** (Late Jurassic, Tithonian [Demko and others, 2004; Kowallis and others, 2007]) – Color-banded, variegated (gray-purple, gray-green, yellow, moderate-red-brown, white) siltstone, claystone, mudstone, and shale interbedded with minor brown and gray nodular limestone beds and white, gray, and light-brown-gray, cross-bedded sandstone lenses; contains a few ledgy conglomeratic sandstone beds at base; commonly smectitic; generally forms steep slopes devoid of vegetation; lower contact is placed at base of the mudstone sequence or at the base of the lowest conglomerate ledge; 45 to 130 meters (150–425 ft) thick.

Jms **Salt Wash Member** (Late Jurassic, Tithonian to Kimmeridgian [Demko and others, 2004; Bradshaw and Kowallis, 2009]) – Red-brown and gray mudstone and siltstone interbedded with light-yellow-gray lenticular sandstone and conglomerate; mudstone and siltstone form slopes and recesses between channel sandstone lenses; sandstone lenses thicken and coarsen upward in the unit; upper lenses are commonly coarse grained, trough cross-bedded, and locally contain vanadium and uranium minerals; exposures in southern part of map area generally contain more sandstone than mudstone; also contains thin sandy limestone beds, especially in the lower parts of the member; lower contact is placed at the base of the lowest dominant sandstone lens; 45 to 90 meters (150–300 ft) thick.

Jmt **Tidwell Member** (Late Jurassic, Kimmeridgian [Demko and others, 2004; Bradshaw and Kowallis, 2009]) – Gray-red-purple, dark-red-brown, and light-gray, thin-bedded, calcareous siltstone and marl interbedded with very fine grained sandstone and gray, thin-bedded or nodular-weathering limestone; mostly slope forming; locally contains a thick gypsum bed as much as 5 meters (15 ft) thick at the base; lower contact is a disconformity; generally 6 to 15 meters (20–50 ft) thick, but locally may be thicker.

J-5 unconformity

Jsr **San Rafael Group**: Summerville, Curtis, Entrada, and Carmel Formations, undivided – on cross sections only.

Js **Summerville Formation** (Late Jurassic, Oxfordian [Imlay, 1980; Wilcox and Currie, 2006; Wilcox, 2007]) – Thin, even-bedded, red-brown siltstone, sandstone, and gypsum, interbedded with minor limestone and shale; forms local steep slopes or vertical cliffs and locally forms earthy slopes; sandstone is generally fine grained and weathers platy; limestone is gray, crystalline, and nodular; gypsum is present in veinlets, thin beds, and nodule zones; jasper nodules are present near the top; lower contact is gradational with the Curtis Formation; 30 to 120 meters (100–400 ft) thick.

Jct **Curtis Formation** (Late Jurassic, Oxfordian [Imlay, 1980; Wilcox and Currie, 2006; Wilcox, 2007]) – Green-gray to brown, fine- to coarse-grained sandstone and green-gray to moderate-red shale, becoming mostly red-brown east of the Green River; glauconitic; locally contains moderate-red, very light gray, and clear siliceous nodules; lower part forms cliff, upper part forms slope and grades upward into Summerville Formation; zone of limestone beds containing jasper occurs about 1.5 to 3 meters (5–10 ft) below the Summerville contact; unit is locally saturated with asphalt; 9 to 75 meters (30–250 ft) thick.

J-3 unconformity

Je **Entrada Sandstone, undivided** (Middle Jurassic, Callovian [Anderson and Lucas, 1994; Hunt and Lockley, 1995; Perkes and Morris, 2011]) – Red-brown, silty to very fine grained sandstone, alternating with yellow-gray to orange-brown massive sandstone in the San Rafael Desert; west of the San Rafael Swell, red-brown silty rocks dominate ("earthy facies"- not mapped separately); in east-central part of quadrangle two members are identifiable and mapped separately, an earthy member (Jee) and the Slick Rock Member (Jes); 75 to 160 meters (250–530 ft) thick in the San Rafael Desert and south part of quadrangle, and nearly 245 meters (800 ft) thick in the northwest corner of the map area.

Jee **Earthy member** – Mostly red-brown, silty to very fine grained sandstone; thick, nodular to indistinct bedding; less resistant than the Slick Rock Member below; lower contact placed above smooth-weathering sandstone of the Slick Rock Member; only mapped separately in the east-central part of the quadrangle; this member forms the "goblins" in Goblin Valley Sate Park; 18 to 45 meters (60–150 ft) thick.

Jes **Slick Rock Member** – Orange-brown, massive, cross-bedded eolian sandstone, sometimes referred to as "slick rim" sandstone; generally fine grained, massive, and resistant and smooth weathering; only mapped separately in the east-central part of the quadrangle east of the San Rafael Swell; 45 to 90 meters (150–300 ft) thick.

Jc **Carmel Formation, undivided** (Middle Jurassic, Callovian to Bajocian [Imlay, 1980; Blakey and others, 1983; Sprinkel and others, 2011; Doelling and others, 2013]) – Undivided only along part of San Rafael Reef where steep-dipping beds create a narrow outcrop band.

Jcu **Upper member** (Winsor Member) – Moderate-red and gray-green sandy siltstone and shale interbedded with alabaster gypsum beds; generally forms slopes with ledge-forming gypsum beds; in the west part of the quadrangle the member consists of two subunits, a lower gypsiferous unit containing very thick gypsum beds (>10 feet [3 m] thick) with mostly red siltstone and fine-grained sandstone interbeds, and an upper banded unit dominated by alternating (banded) red and gray-green siltstone and mudstone

interbedded with mostly relatively thin (<3 feet [1 m] thick) gypsum beds; in the east part of the quadrangle, the member thins and loses gypsum beds, grading into reddish fine-grained sandstone known as the Dewey Bridge Member in the Moab 30' x 60' quadrangle (Doelling, 2001); 18 to 122 meters (60–400 ft) thick, thickening northwestward.

Jcl **Lower members** (Paria River, Crystal Creek, and Judd Hollow Members, and correlative units) – In west part of quadrangle exposures show the following sequence of strata (top to bottom): light-gray-weathering, resistant limestone and calcarenite underlain by a discontinuous, locally thick gypsum bed and some yellow-gray fine-grained sandstone (Paria River Member); relatively thin, red-brown, slope-forming sandstone and siltstone (Crystal Creek Member); and mostly resistant unit of irregularly bedded limestone, calcarenite and sandstone (Judd Hollow Member); thickness ratio for the three members is about 60-10-30 percent. These member names are extended into the map area based on a regional detailed study of middle Jurassic strata (Doelling and others, 2013). The Paria River and Crystal Creek Members thin eastward, and the limestone and calcarenite of the Paria River Member grade into a white, fine-grained sandstone. Both the Paria River and Crystal Creek Members may locally be missing along the east edge of the quadrangle where the Judd Hollow Member remains as a red-brown, resistant, irregularly bedded calcareous sandstone. The combined lower members are 15 to 75 meters (50–245 ft) thick, thickening westward.

Temple Cap Formation

An interval generally 0 to 10 meters (0-30 ft) thick of eolian and planar sandstone interbedded with thin siltstone beds sits between the top of the Navajo Sandstone and the base of the Carmel Formation. Older maps generally include this interval in the Navajo Sandstone (for example, Williams and Hackman, 1971; Trimble and Doelling, 1978); some stratigraphic studies have placed it in the Page Sandstone (Peterson, 1986). Doelling and others (2013) assigned this interval to the Temple Cap Formation. The Temple Cap was previously only mapped in the southwestern part of the state, but Doelling and others' (2013) work expands its geographic range into central Utah (their study also restricts the use of the term Page Sandstone to northern Arizona and southernmost Utah near Glen Canyon Dam). The Temple Cap is light-gray, light-orange-gray, and light-brown to light-red-brown, medium to fine-grained sandstone, with large trough cross-beds. To the southeast the Temple Cap can be distinguished from the Navajo Sandstone because it tends to be a darker color with thinner large-scale cross-bed sets and forms more vertical cliffs. However, we have included the Temple Cap with the Navajo Sandstone as it is quite thin and difficult to distinguish from the Navajo Sandstone on aerial photographs of the map area, and it was differentiated after field mapping was completed for this project.

J-1 unconformity

JTRgc **Glen Canyon Group –** on cross sections only. Consists of the Navajo, Kayenta, and Wingate Formations; in some areas these units have characteristic pale- to moderate red-brown colors, but in the San Rafael Swell they are commonly bleached or altered mostly light yellow gray due to the presence or former presence of hydrocarbons.

Jn, Jnl

Navajo Sandstone, limestone beds in Navajo Sandstone (Early Jurassic [Dickinson and Gehrels, 2003]) – Mostly light-yellow-gray to light-gray-pink to light-gray, fine- to medium-grained, cross-bedded quartz sandstone in large trough sets; well sorted and friable; mostly massive; lower third commonly weathers to cliffs, the remainder into domes and rounded knolls; locally on eastern side of quadrangle contains thin, hard, lenticular, gray limestone beds as much as 5 meters (15 ft) thick (Jnl); in some places 0 to 10 m (0–30 ft) of the uppermost part of map unit includes the Temple Cap Formation (see discussion above); 135 to 200 meters (400–650 ft) thick, increasing from east to west.

Jk **Kayenta Formation** (Early Jurassic, Pleinsbachian to Sinemurian [Peterson, 1994; Curtis and Padian, 1999]) – Light-purple-gray to light-yellow-gray to light-red-brown, medium- to thick-bedded to locally massive, irregularly bedded and cross-bedded (mostly low-angle), fine- to coarse-grained sandstone; thin moderate- to dark-red-brown to purple-gray shaly siltstone forms local partings; contains minor very light gray and dark-brown beds of intraformational mudstone-pebble, ripup-clast conglomerate, lenses of gritstone, and limestone; many sandstone beds are micaceous; lower contact with the Wingate Sandstone is conformable and sharp; forms a series of thick step-like ledges, cliffs, and benches; mostly fluvial, but contains a few eolian beds in upper part; mostly 45 to 90 meters (150–300 ft) thick.

JURASSIC-TRIASSIC

JTRw **Wingate Sandstone** (Early Jurassic to Late Triassic [Dubiel, 1989; Jensen and Kowallis, 2005]) – Light-yellow-gray to moderate-red-orange, fine-grained, massive, cross-bedded, eolian, quartzose sandstone; forms vertical cliffs along canyon walls, commonly

stained with brown to brown-black iron-manganese oxide (desert varnish); local partings of sandy siltstone are common near the base; generally well cemented with calcium carbonate, but is locally siliceous; contact with unit below is generally abrupt and placed at the base of the Wingate cliff; 73 to 130 meters (240–420 ft) thick; brecciated and recemented as collapse features at and near Temple Mountain – see bs and bmb.

TR-5 unconformity

TRIASSIC

TR **Triassic rocks** – on cross sections only. Consists of the Chinle and Moenkopi Formations and their members as described below; in some areas these units have characteristic colors, but in the San Rafael Swell they are commonly bleached or altered mostly to pale yellow gray due to the presence or former presence of hydrocarbons.

TRc **Chinle Formation, undivided** (Late Triassic, Carnian to Rhaetian [Lucas, 1993; Irmis and others, 2011]) – Undivided in Labyrinth Canyon and along part of the San Rafael Reef near Greasewood Draw. Lucas (1993) and Lucas and others (1997) recommended that the Chinle Formation be elevated to a group, and have reclassified member names from Stewart and others (1972) as formations. We have chosen to follow the member classification of Stewart and others (1972), Beer (2005), and Dubiel and Hasiotis (2011). Brecciated and recemented in subsidence and collapse features at and near Temple Mountain – see bs and bmb.

TRcu **Upper members** (Church Rock, Owl Rock, Petrified Forest Members) – Consists of three members not mapped separately. Church Rock Member is medium- to dark-red-brown, pink-gray, light-brown (upper third is commonly bleached to yellow-gray to tan-gray), very fine to fine-grained, blocky and resistant sandstone beds 1 to 2 meters (3–5 ft) thick with few partings of gritstone and fine- to coarse-grained, cross-bedded sandstone and siltstone, and forms step-like cliff; Owl Rock Member consists of an upper slope-forming, mottled, pale-purple to yellow-gray to medium-red-brown siltstone with thin to indistinct bedding, and below is a ledge-forming, lenticular and cross-bedded sandstone, conglomeratic sandstone, and conglomerate with petrified wood; Petrified Forest Member consists of an upper mottled paleosol slope that is mostly gray-purple, gray, green-gray, and red-brown sandy mudstone, and a lower sandstone bench that is fine to medium grained, mostly moderate red to light brown, and 1.5 to 8 meters (5–25 ft) thick; deposited in fluvial-lacustrine environment with overbank floodplain deposits and abundant paleosols (Dubiel, 1987); total thickness of the three members is 73 to 113 meters (240–370 ft) in the San Rafael Swell, thickening southward.

TRcl **Lower members** (Moss Back, Monitor Butte, and Temple Mountain Members) – Consists of three members not mapped separately; overall, lower members are gray or gray-brown, interfingering sequence of cliff- and bench-forming quartzose pebble conglomerate, fine- to medium-grained massive sandstone, limestone pebble conglomerate, fine-grained platy-weathering sandstone, and minor gray mudstone; these beds interfinger and intergrade, and one or more may be locally absent; contains scattered fragments and logs of petrified wood, especially near the top and bottom; contains clay galls, pellets, and carbonized wood near the base; locally contains uranium and copper ore; has calcareous cementation; sandstone beds are cross-bedded (low angle), lenticular, and weather platy toward the top; fluvial deposit; member thickens where it is channeled into units below; Moss Back Member overlies Monitor Butte or Temple Mountain Member, or locally the Moody Canyon Member of the Moenkopi Formation unconformably; Temple Mountain and Monitor Butte Members are discontinuous and locally intergrade and intertongue; Temple Mountain (basal member) consists mostly of mottled (mostly grayish-purple, white, and moderate-yellow) indistinct to massive siltstone and sandstone (paleosols), whereas Monitor Butte contains less massive siltstone beds and lenses of medium- to coarse-grained quartzose sandstone; Moss Back Member is ledgy, gray, medium to thick-bedded lenticular sandstone, conglomeratic sandstone, and conglomerate. Combined lower members are 0 to 52 meters (0–170 ft) thick; Moss Back is 0 to 45 meters (0–150 ft) thick; combined Temple Mountain and Monitor Butte Members are 0 to 20 meters (0–66 ft) thick; in San Rafael Swell the lower members are mostly 4 to 52 meters (12–170 ft) thick; under the San Rafael Desert and in Labyrinth Canyon the lower members range from 0 to about 23 meters (0–75 ft) thick.

TR-3 unconformity

TRm **Moenkopi Formation, undivided** (Early Triassic, Olenekian [Dubiel, 1994; Lucas and others, 2007]) – Mapped where outcrop belt is thin due to steep dips along a small part of the San Rafael Reef south of I-70, and where it is thin in Labyrinth Canyon in southeast part of quadrangle where entire formation is similar to the Moody Canyon Member in the San Rafael Swell. Lucas and others (2007) proposed

raising the Moenkopi to group status, but until this is more widely used we continue to treat it as a formation. In the San Rafael Swell commonly bleached or altered mostly to pale yellow gray due to the presence or former presence of hydrocarbons.

Trmu **Upper Moenkopi Formation, undivided –** Consists of Moody Canyon and Torrey Members; mapped where outcrop belt is thin due to attenuation and/or steep dips along the San Rafael Reef.

Trmm **Moody Canyon Member –** Red-brown and moderate-brown, fine-grained sandstone and siltstone in even thin beds with local medium beds; forms steep slope with subtle resistant ribs and a few ledges near the top; gradational and intertongues with underlying Torrey Member, but forms slope that is not generally as steep; locally contains thin veinlets of cross-cutting satin spar gypsum; 43 to 75 meters (140–250 ft) thick.

Trmt **Torrey Member –** Green-gray and yellow-gray, locally red-brown, locally banded yellow-gray and red-brown, thin- to medium-bedded, shaly siltstone and very fine grained sandstone; forms alternating slopes and cliffy ledges; slopes are generally earthy weathering and ledges are platy and slabby weathering; beds are commonly ripple marked; locally petroliferous; 90 to 130 meters (300–420 ft) thick.

Trms **Sinbad Limestone Member –** Medium- and pale-gray to pale-yellow-gray limestone and calcareous sandstone with a few thin shaly siltstone partings; thin to medium bedded; resistant ledge and bench former; generally contains fine-grained sand-sized fossil particles and bivalve casts; locally stylolitic and oolitic; weathers hackly; locally petroliferous; shallow-marine to tidal-flat deposit; 0 to 45 meters (0–150 ft) thick; thins eastward; forms broad bench throughout much of San Rafael Swell, and is exposed in Labyrinth Canyon just south of quadrangle.

Trmb **Black Dragon Member –** Mostly green-gray or yellow-gray (due to hydrocarbon alteration), dark-red-brown where not altered, thin- to medium-bedded siltstone, fine-grained sandstone, and mudstone; forms a steep slope beneath the Sinbad Limestone Member; local chert-pebble conglomerate at the base; locally dark-gray due to hydrocarbon saturation; 20 to 60 meters (65–200 ft) thick.

TR-1 unconformity

PERMIAN

P **Permian rocks, undivided –** on cross sections only. Includes the Kaibab Formation, White Rim Sandstone, and Elephant Canyon Formation as exposed in Eardley Canyon; and the Organ Rock Formation, Cedar Mesa Sandstone, and lower Cutler beds as exposed to the east in Canyonlands National Park area, which pinch out westward under the San Rafael Desert (Condon, 1997; Doelling, 2001).

Pk **Kaibab Formation** (Early Permian, Leonardian [Sorauf and Billingsley, 1991; Condon, 1997]) – Blocky, light-gray to cream-colored, locally oolitic, cherty dolomite and limestone and overlying yellow-gray to gray sandstone; generally forms an upper ledge (dolomite, limestone, and blocky sandstone) and a lower slope (earthy weathering sandstone, and dolomite); locally missing along axis of the San Rafael Swell; contains small chert, quartz, and calcite geodes locally filled with oil residue; locally fossiliferous; deposited in shallow-marine environment; locally has sandy, light-brown, thin-bedded limestone at the base that reflects reworking of the underlying White Rim Sandstone; recognizing that the Kaibab Formation of the San Rafael Swell is dolomite in most places, Welsh and others (1979), proposed the name Black Box Dolomite for these strata, however, we prefer Kaibab Formation to show regional correlation, but agree that the carbonate rock is dolomitized in some places; 0 to 26 meters (0–85 ft) thick.

Pwr **White Rim Sandstone, undifferentiated** (Early Permian, Leonardian and Wolfcampian [Stanesco and Campbell, 1989; Condon, 1997; Dubiel and others, 2009]) – Massive, eolian, cross-bedded, light-gray, brown, yellow-gray, and light-brown sandstone; medium to coarse-grained; calcareous; locally blotched irregularly with red and brown patches; generally cliff-forming and cut by deep canyons; locally limonitic or hematitic; 150 to 290 meters (500–950 ft) thick in the San Rafael Swell and as determined in nearby drill holes; to east under the San Rafael Desert, drill holes indicate about 90 meters (300 ft) of White Rim Sandstone overlying 150 meters (500 ft) of Organ Rock Formation and Cedar Mesa Sandstone (Steele, 1987; Condon, 1997).

Pec **Elephant Canyon Formation** (Early Permian, Wolfcampian [McNair, 1951; Williams, 2009]) – Pink dolomite, light-gray dolomitic sandstone, light-brown and moderate-red, fine-grained sandstone, basal conglomerate and conglomeratic sandstone, and limestone; mostly in thin to thick beds; locally cherty; weathers to medium brown; forms hackly, blocky ledges and intervening slopes; basal conglomerate moderately sorted with clasts of chert up to 1 inch (3 cm) in diameter; only exposed in Eardley (Straight) Canyon where it is about 90 meters (300 ft) thick; 90 to 245 meters (300–800 ft) thick where identified by drillers as Early Permian

carbonates in San Rafael Desert drill holes. In the center of the Paradox Basin the basal part of this unit (or the correlative lower Cutler beds) is probably Pennsylvanian in age, but the data are inconclusive and exposed beds are here considered Permian in age (Loope and others, 1990; Condon, 1997).

Unconformity

IP **Pennsylvanian –** on cross sections only. Pennsylvanian-age strata are missing or were never deposited in the San Rafael Swell area due to the Emery paleohigh (Pennsylvanian surface that extends across most of the San Rafael Swell), but drill hole logs show that IP strata thicken eastward under the San Rafael Desert from 0 meters (0 ft) to over 1500 meters (5000 ft) near the east quadrangle boundary (Welsh and Bissell, 1979; Condon, 1997, Doelling, 2001; Morgan and Waanders, 2013).

Unconformity

MISSISSIPPIAN

Mr **Redwall Limestone** (Mississippian [Armstrong and Holcomb, 1989; Condon, 1995]) – Light-gray to pink limestone, dolomite, and chert; locally brecciated into large angular fragments; massive cliff former; contains large solution cavities (incipient sink holes) as much as 3 meters (10 ft) across; weathers hackly; incomplete section of 32+ meters (105+ ft) exposed at bottom of Eardley Canyon; thins westward on Emery High; identity of mapped outcrop is probably Redwall, but still needs confirmation.

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Correction: Two polygons labeled as map unit Ts *(tephritic sills) on an earlier release have been corrected to* TRms*; no tephritic sills are known in this map area.*

Table A-1. *Drillhole data for the geologic map of the San Rafael Desert 30'x60'. Data from Utah Division of Oil, Gas, and Mining (http://oilgas.ogm.utah.gov/Data_Center/LiveData_Search/files.htm) accessed October 2014.*

API	COMPLETION DATE	WELL NAME	QTR_ QTR	SECT.	TOWNSHIP	RANGE	COUNTY	LAT.	LONG.	COMPANY	TD (FEET)	WELL STATUS
4301510019	11/30/1961	AMAX-SINCLAIR GOVT 29-4B	NWNW	29	T22S	R15E	EMERY	38.874	-110.300	AMAX PETROLEUM CORP	6201	plugged and abandoned
4301510020	5/13/1961	BLACK DRAGON GOVT 1	NESE	32	T21S	R13E	EMERY	38.942	-110.509	AMAX PETROLEUM CORP	4640	plugged and abandoned
4301510021	1/5/1964	GREEN RIVER DESERT U 9-7	SWNE	09	T22S	R15E	EMERY	38.914	-110.272	AMAX PETROLEUM CORP	8991	plugged and abandoned
4301510022	10/3/1964	GREEN RIVER DESERT U 24-1	NENE	24	T22S	R13E	EMERY	38.891	-110.435	AMAX PETROLEUM CORP	6799	plugged and abandoned
4301510023	2/1/1959	RED HILLS GOVT 1	NWNW	27	T25S	R09E	EMERY	38.614	-110.917	AMAX PETROLEUM CORP	3382	plugged and abandoned
4301510028	9/17/1962	USA COLMAN 1	NWSW	17	T23S	R09E	EMERY	38.813	-110.942	AMERADA	3665	plugged and abandoned
4301510029	1/2/1961	USA ELLIOTT TRACT 1	SESE	14	T24S	R09E	EMERY	38.718	-110.884	AMERADA	3253	plugged and abandoned
4301510116	4/6/1951	45-56	NESW	05	T24S	R15E	EMERY	38.760	-110.287	GENERAL PETROLEUM CORP	7161	plugged and abandoned
4301510180	10/28/1936	1 (WSW)	SWSW	22	T23S	R11E	EMERY	38.796	-110.684	STANDARD OIL CO OF CALIF	2285	plugged and abandoned
4301510181	6/12/1937	2	NWNW	27	T23S	R11E	EMERY	38.792	-110.684	STANDARD OIL CO OF CALIF	4900	plugged and abandoned
4301510182	10/25/1957	LOOKOUT POINT UNIT 1	SESW	29	T25S	R16E	EMERY	38.601	-110.173	STANDARD OIL CO OF CALIF	6701	plugged and abandoned
4301510183	10/3/1956	MOONSHINE WASH U 1	NESW	32	T25S	R15E	EMERY	38.591	-110.284	STANDARD OIL CO OF CALIF	5843	plugged and abandoned
4301510229	7/4/1958	MOONSHINE WASH U 2	SWNE	22	T25S	R15E	EMERY	38.623	-110.242	CONTINENTAL OIL COMPANY	6396	plugged and abandoned
4301510373	6/22/1963	FOREST GOVT 1	NENE	11	T23S	R14E	EMERY	38.833	-110.343	FOREST OIL CORP	7250	plugged and abandoned
4301510498	2/1/1922	1	NESE	34	T23S	R11E	EMERY	38.772	-110.670	HUMBLE OIL & REFINING CO	3035	plugged and abandoned
4301510499	12/31/1958	DUGOUT CREEK U 1	NESE	21	T24S	R14E	EMERY	38.709	-110.381	HUMBLE OIL & REFINING CO	7655	plugged and abandoned
4301510501	10/15/1958	NEQUOIA ARCH U 3	SESE	26	T26S	R14E	EMERY	38.514	-110.348	HUMBLE OIL & REFINING CO	6700	plugged and abandoned
4301510502	12/25/1961	NEQUOIA ARCH U 7	SWSW	30	T26S	R14E	EMERY	38.514	-110.434	HUMBLE OIL & REFINING CO	6007	plugged and abandoned
4301510603	1954	A K WILSON 1	SWSW	02	T24S	R13E	EMERY	38.752	-110.468	NO RESPONSIBLE OPERATOR	2420	temporarily abandoned

Table A-1. *continued*

API	COMPLETION DATE	WELL NAME	QTR_ QTR	SECT.	TOWNSHIP	RANGE	COUNTY	LAT.	LONG.	COMPANY	TD (FEET)	WELL STATUS
4301510620	7/29/1957	T P UTAH 27-1	SENE	07	T23S	R13E	EMERY	38.829	-110.528	KERR-MCGEE CORP	2218	plugged and abandoned
4301510651	9/6/1962	1 MID TOP	SESW	17	T26S	R13E	EMERY	38.543	-110.522	LARUE, E B JR	5783	plugged and abandoned
4301510661	7/15/1958	HATT 1	SESE	19	T23S	R14E	EMERY	38.793	-110.417	LION OIL COMPANY	6060	plugged and abandoned
4301510736	8/16/1961	JAKEY'S RIDGE 12-3	SWNW	03	T23S	R16E	EMERY	38.842	-110.150	MOBIL OIL CORPORATION	9450	plugged and abandoned
4301510737	10/6/1961	JAKEY'S RIDGE 34-15	SWSE	15	T23S	R16E	EMERY	38.806	-110.140	MOBIL OIL CORPORATION	8440	plugged and abandoned
4301510778	11/4/1959	FEDERAL 1	NWNW	07	T26S	R14E	EMERY	38.568	-110.434	ODESSA NATURAL CORP	5750	plugged and abandoned
4301510824	2/19/1958	ANDERSON-FEDERAL 1	SWSE	24	T23S	R10E	EMERY	38.795	-110.749	PAN AMERICAN PETROLEUM COR	2000	plugged and abandoned
4301510826	6/24/1949	NEQUOIA ARCH UNIT 9	NWSW	25	T26S	R13E	EMERY	38.517	-110.454	PAN AMERICAN PETROLEUM COR	5472	plugged and abandoned
4301510827	2/20/1963	NEQUOIA ARCH UNIT 10	SWNE	35	T26S	R13E	EMERY	38.507	-110.461	PAN AMERICAN PETROLEUM COR	6040	plugged and abandoned
4301510828	1/5/1959	USA-C M BROWN 1	NWNW	24	T25S	R12E	EMERY	38.627	-110.547	PAN AMERICAN PETROLEUM COR	5929	plugged and abandoned
4301511030	8/29/1959	CHAFFIN UNIT 1	NENW	21	T23S	R15E	EMERY	38.801	-110.277	SHELL OIL COMPANY	7702	plugged and abandoned
4301511031	11/27/1958	GRUVERS MESA 1	SENW	19	T24S	R16E	EMERY	38.711	-110.200	SHELL OIL COMPANY	8677	plugged and abandoned
4301511033	3/6/1959	GRUVERS MESA 2	NENW	10	T25S	R16E	EMERY	38.656	-110.137	SHELL OIL COMPANY	7393	plugged and abandoned
4301511138	3/22/1965	GREEN RIVER UNIT 1	NENW	33	T21S	R16E	EMERY	38.948	-110.166	TEXAS EASTERN SKYLINE OIL	9621	plugged and abandoned
4301511181	1/18/1962	BOW KNOT UNIT 14-5	SWSW	05	T26S	R17E	EMERY	38.574	-110.087	SUPERIOR OIL COMPANY	6498	plugged and abandoned
4301511182	5/19/1961	GRAND FAULT UNIT 14-24	SWSW	24	T21S	R15E	EMERY	38.967	-110.226	SUPERIOR OIL COMPANY	10606	plugged and abandoned
4301511183	11/24/1958	IRON WASH UNIT 23-2	NESW	02	T24S	R13E	EMERY	38.752	-110.465	SUPERIOR OIL COMPANY	5326	plugged and abandoned
4301511184	8/11/1963	N SPRING WASH 31-15	NWNE	15	T25S	R15E	EMERY	38.641	-110.243	SUPERIOR OIL COMPANY	6470	plugged and abandoned
4301511274	10/31/1957	FEDERAL 1	NESW	26	T22S	R15E	EMERY	38.867	-110.240	TEXAS EASTERN TRANS CO	8490	plugged and abandoned
4301511324	1/28/1960	TEMPLE SPRINGS UNIT 1	NWNW	14	T25S	R13E	EMERY	38.642	-110.455	TEXACO INC	7314	plugged and abandoned

Table A-1. *continued*

API	COMPLETION DATE	WELL NAME	QTR_ QTR	SECT.	TOWNSHIP	RANGE	COUNTY	LAT.	LONG.	COMPANY	TD (FEET)	WELL STATUS
4301511325	2/10/1961	TEMPLE SPRINGS UNIT 2	SESW	22	T25S	R14E	EMERY	38.616	-110.357	TEXACO INC	7010	plugged and abandoned
4301511398	9/16/1961	FEDERAL 1	SWSW	11	T22S	R08E	EMERY	38.911	-110.998	UTAH PLATEAU URANIUM CO	1422	plugged and abandoned
4301511399	7/30/1961	FEDERAL 1-X (WSW)	SWSW	11	T22S	R08E	EMERY	38.911	-110.998	UTAH PLATEAU URANIUM CO	2246	plugged and abandoned
4301511490	9/20/1943	1	SWNW	21	T22S	R16E	EMERY	38.884	-110.171	WHISNANT, W P	435	plugged and abandoned
4301515012	12/28/1966	FEDERAL 1	SWNE	15	T24S	R16E	EMERY	38.725	-110.140	PLEDGER, ROY	4617	plugged and abandoned
4301520214	5/6/1967	TEMPLE WASH STATE 1	NWNW	32	T24S	R13E	EMERY	38.686	-110.524	UNION OIL CO OF CALIFORNIA	2250	plugged and abandoned
4301520215	4/25/1967	TEMPLE WASH GOVT 019-1	SWSE	01	T25S	R12E	EMERY	38.660	-110.538	UNION OIL CO OF CALIFORNIA	2355	plugged and abandoned
4301520224	6/14/1967	TEMPLE WASH GOVT 998-A-1	NWNW	11	T25S	R13E	EMERY	38.656	-110.456	UNION OIL CO OF CALIFORNIA	5175	plugged and abandoned
4301520334	9/27/1954	SINBAD UNIT 1	NESW	06	T22S	R12E	EMERY	38.937	-110.625	THREE STATES NATURAL GAS	4183	plugged and abandoned
4301520336	5/23/1955	SINBAD 1	NENE	26	T22S	R12E	EMERY	38.878	-110.570	BOW VALLEY PETROLEUM INC	5105	plugged and abandoned
4301520338	1921	1		27	T22S	R12E	EMERY	38.878	-110.589	SCHWEIKHART, H A	150	plugged and abandoned
4301520340	1928	1	SESE	05	T22S	R15E	EMERY	38.921	-110.286	CALIFORNIA UTAH OIL CO	1600	plugged and abandoned
4301520342	1/12/1952	FEDERAL 1	SENW	28	T22S	R15E	EMERY	38.871	-110.277	EQUITY OIL COMPANY	8134	plugged and abandoned
4301520344	7/4/1961	STRAT TEST 1-362	NESE	07	T24S	R09E	EMERY	38.736	-110.959	AMERADA	1835	plugged and abandoned
4301520346	12/22/1954	GOVT 1-28	NESW	28	T24S	R10E	EMERY	38.692	-110.820	BLACKWOOD-NICHOLS DRLG CO	4182	plugged and abandoned
4301520348	10/10/1954	MOORE 1	SENW	06	T24S	R15E	EMERY	38.756	-110.316	ENGLISH, P B	2370	plugged and abandoned
4301520350	6/7/1953	RUSSELL 1	SWSW	34	T25S	R12E	EMERY	38.587	-110.584	DELHI-TAYLOR OIL CORP	6008	plugged and abandoned
4301520360	1913	1	SESW	19	T26S	R13E	EMERY	38.529	-110.541	DES MOINES OIL CO	2910	plugged and abandoned
4301520362	1946	1	NENE	32	T26S	R13E	EMERY	38.512	-110.511	CALLAHAN, GEORGE	2638	plugged and abandoned
4301520364	1947	1	NESW	32	T26S	R13E	EMERY	38.503	-110.522	ROBINSON, R D	2642	plugged and abandoned

Table A-1. *continued*

API	COMPLETION DATE	WELL NAME	QTR_ QTR	SECT.	TOWNSHIP	RANGE	COUNTY	LAT.	LONG.	COMPANY	TD (FEET)	WELL STATUS
4301520366	1912	NO NAME		29	T26S	R14E	EMERY	38.519	-110.410	DES MOINES OIL CO	2140	plugged and abandoned
4301530007	12/11/1969	FEDERAL 1	SENW	21	T25S	R14E	EMERY	38.623	-110.376	REYNOLDS & CARVER	5144	plugged and abandoned
4301530009	12/15/1970	IRON WASH FED 1	NWSE	03	T24S	R13E	EMERY	38.753	-110.479	FLYING DIAMOND OIL CORP	3803	plugged and abandoned
4301530010	3/25/1972	USA FED 1	SWSW	31	T26S	R16E	EMERY	38.501	-110.215	HUNT PETROLEUM CORP	5000	plugged and abandoned
4301530011	10/9/1972	FEDERAL ARMSTRONG 1	NENE	10	T24S	R14E	EMERY	38.745	-110.363	UNION TEXAS PETROLEUM	7284	plugged and abandoned
4301530017	1/29/1974	FEDERAL 11-24-13 (WSW)	SENE	11	T24S	R13E	EMERY	38.742	-110.456	TEXAS GAS EXPLORATION CORP	4224	plugged and abandoned
4301530048	4/2/1977	UTAH STATE 1	SENW	36	T24S	R11E	EMERY	38.681	-110.655	ST CROIX EXPLORATION	209	plugged and abandoned
4301530049	3/7/1978	UTAH STATE 2	NENW	36	T24S	R11E	EMERY	38.684	-110.655	RAINY RIVER RESOURCES INC	307	plugged and abandoned
4301530052	2/11/1987	UTAH STATE 4	NESW	36	T24S	R11E	EMERY	38.677	-110.653	RAINY RIVER RESOURCES INC	380	plugged and abandoned
4301530054	9/1/1977	UTAH STATE 1 (6)	NWNE	32	T24S	R12E	EMERY	38.685	-110.628	ST CROIX EXPLORATION	350	plugged and abandoned
4301530055	2/12/1987	UTAH STATE 5	NESW	36	T24S	R11E	EMERY	38.680	-110.653	RAINY RIVER RESOURCES INC	182	plugged and abandoned
4301530058	8/22/1978	JESSIES TWIST FED 1-9	SESE	09	T23S	R14E	EMERY	38.823	-110.382	CABOT CORP	5446	plugged and abandoned
4301530065	9/28/1979	PARADOX 1-12	NENW	12	T25S	R13E	EMERY	38.656	-110.432	COLUMBIA GAS DEVELOP CORP	4940	plugged and abandoned
4301530066	9/26/1979	PARADOX 1-23	SESW	23	T24S	R13E	EMERY	38.704	-110.464	COLUMBIA GAS DEVELOP CORP	2275	plugged and abandoned
4301530069	12/1/1979	UTAH STATE 3	SWNE	32	T24S	R12E	EMERY	38.684	-110.625	ST CROIX EXPLORATION	1050	plugged and abandoned
4301530076	11/11/1980	UTAH STATE 3	NESW	36	T24S	R11E	EMERY	38.679	-110.653	RAINY RIVER RESOURCES INC	205	plugged and abandoned
4301530078	6/6/1981	FEDERAL 2-20	SESE	20	T26S	R17E	EMERY	38.530	-110.073	MEGADON ENTERPRISES, INC	6836	plugged and abandoned
4301530079	3/22/1982	GEYSER DOME 1-14	NESW	14	T22S	R15E	EMERY	38.896	-110.240	MEGADON ENTERPRISES, INC	9110	plugged and abandoned
4301530089	12/23/1981	SALERATUS FED ST 2-36	NWNW	36	T21S	R14E	EMERY	38.949	-110.337	MEGADON ENTERPRISES, INC	9184	plugged and abandoned
4301530105	1983	HARVEY FED 1-21	SENW	21	T26S	R16E	EMERY	38.537	-110.174	HARVEY, M J JR	0	plugged and abandoned

Table A-1. *continued*

API	COMPLETION DATE	WELL NAME	QTR_ QTR	SECT.	TOWNSHIP	RANGE	COUNTY	LAT.	LONG.	COMPANY	TD (FEET)	WELL STATUS
4301530112	7/24/1982	GRUVER FED 1-22	NENW	22	T24S	R16E	EMERY	38.714	-110.144	INCA OIL & GAS INC	4600	plugged and abandoned
4301530145	1/2/1983	POOL UNIT 1	SWSW	17	T26S	R17E	EMERY	38.545	-110.085	DAVIS OIL COMPANY	6969	plugged and abandoned
4301530159	3/30/1983	LITTLE FLAT TOP UNIT 1-25	NESE	25	T25S	R14E	EMERY	38.605	-110.312	UNION TEXAS PETROLEUM	2600	plugged and abandoned
4301530162	4/8/1983	WILDCAT BUTTE UNIT 1-2	NESE	02	T26S	R13E	EMERY	38.576	-110.457	UNION TEXAS PETROLEUM	2590	plugged and abandoned
4301530195	9/8/1984	HATT RANCH 27-33	NWSE	27	T22S	R14E	EMERY	38.870	-110.366	SAMEDAN OIL CORPORATION	6371	plugged and abandoned
4301530197	7/26/1984	UTAH STATE 1	SWSE	02	T25S	R11E	EMERY	38.661	-110.670	ST CROIX EXPLORATION	2041	plugged and abandoned
4301530205	1/20/1985	N SPRING CREEK FED 1	NWNE	21	T26S	R15E	EMERY	38.541	-110.279	BOSWELL ENERGY CORP	6166	plugged and abandoned
4301530217	2/12/1987	UTAH STATE 3-A	NESW	36	T24S	R11E	EMERY	38.679	-110.653	RAINY RIVER RESOURCES INC	205	plugged and abandoned
4301530220	12/5/1985	USA 1-26HR	SWNW	26	T22S	R14E	EMERY	38.872	-110.357	COORS ENERGY	7056	plugged and abandoned
4301530226	9/23/1986	GOVT J S WEBER-NCT 1	NWSE	13	T23S	R13E	EMERY	38.811	-110.440	TEXACO INC	6203	plugged and abandoned
4301530235	1/27/1990	FEDERAL 1-29MW	NENW	29	T24S	R15E	EMERY	38.700	-110.295	COORS ENERGY	8434	plugged and abandoned
4301530240	6/17/1992	NEQUOIA STATE 16-1	SESE	16	T26S	R14E	EMERY	38.543	-110.385	WILDROSE RESOURCES CORP	2360	plugged and abandoned
4301530642	2/16/1963	CITIES 9 STRAT	NWSE	06	T23S	R13E	EMERY	38.841	-110.532	CITIES SERV OIL & GAS CORP	1500	plugged and abandoned
4301530643	6/22/1964	SHELL 3	NE	18	T23S	R11E	EMERY	38.819	-110.728	SHELL OIL COMPANY	364	plugged and abandoned
4301530644	6/20/1964	SHELL 1	SW	34	T23S	R10E	EMERY	38.768	-110.793	SHELL OIL COMPANY	362	plugged and abandoned
4301530645	7/2/1964	SHELL 5	NE	28	T23S	R10E	EMERY	38.790	-110.802	SHELL OIL COMPANY	420	plugged and abandoned
4301530646	6/30/1964	SHELL 2	NE	20	T23S	R10E	EMERY	38.805	-110.820	SHELL OIL COMPANY	671	plugged and abandoned
4301530647	12/30/1966	CITIES 11-4-66	SWNE	04	T23S	R10E	EMERY	38.845	-110.804	CITIES SERV OIL & GAS CORP	60	plugged and abandoned
4301530648	12/29/1966	CITIES 9-34-66	SWSW	34	T22S	R10E	EMERY	38.854	-110.795	CITIES SERV OIL & GAS CORP	100	plugged and abandoned
4301530649	12/30/1966	CITIES 10-34-66	NENW	34	T22S	R10E	EMERY	38.864	-110.790	CITIES SERV OIL & GAS CORP	190	plugged and abandoned

Table A-1. *continued*

API	COMPLETION DATE	WELL NAME	QTR_ QTR	SECT.	TOWNSHIP	RANGE	COUNTY	LAT.	LONG.	COMPANY	TD (FEET)	WELL STATUS
4301530650	12/29/1966	CITIES 8-33-66	NWSE	33	T22S	R10E	EMERY	38.857	-110.804	CITIES SERV OIL & GAS CORP	180	plugged and abandoned
4301530651	11/25/1966	CITIES 7-33-66	SENE	33	T22S	R10E	EMERY	38.860	-110.799	CITIES SERV OIL & GAS CORP	535	plugged and abandoned
4301530652	11/9/1966	CITIES 6-33-66	SENE	33	T22S	R10E	EMERY	38.860	-110.799	CITIES SERV OIL & GAS CORP	1328	plugged and abandoned
4301530653	1/14/1963	CITIES 6 STRAT	SWNW	32	T22S	R10E	EMERY	38.860	-110.822	CITIES SERV OIL & GAS CORP	1370	plugged and abandoned
4301530654	8/1/1966	CITIES 3-30-66	NWSE	30	T22S	R10E	EMERY	38.872	-110.842	CITIES SERV OIL & GAS CORP	1320	plugged and abandoned
4301530655	7/29/1966	CITIES 2-30-66	SWNW	30	T22S	R10E	EMERY	38.874	-110.850	CITIES SERV OIL & GAS CORP	1487	plugged and abandoned
4301530656	6/3/1966	CITIES 1-29-66	SESW	29	T22S	R10E	EMERY	38.867	-110.827	CITIES SERV OIL & GAS CORP	1502	plugged and abandoned
4301530657	3/17/1963	CITIES 7 STRAT	NWNW	18	T25S	R14E	EMERY	38.642	-110.418	CITIES SERV OIL & GAS CORP	1542	plugged and abandoned
4301530658	2/23/1963	CITIES 8 STRAT	NE	01	T25S	R13E	EMERY	38.672	-110.430	CITIES SERV OIL & GAS CORP	1500	plugged and abandoned
4301530659	1/3/1966	SUN 3	NWNW	04	T25S	R11E	EMERY	38.669	-110.712	SUN OIL COMPANY	540	plugged and abandoned
4301530660	12/28/1965	SUN 2	NESE	34	T24S	R11E	EMERY	38.677	-110.682	SUN OIL COMPANY	538	plugged and abandoned
4301530661	5/7/1965	SUN 1	NWNW	25	T24S	R11E	EMERY	38.698	-110.656	SUN OIL COMPANY	530	plugged and abandoned
4301530662	4/12/1965	CLARKE 2-28	NESW	28	T24S	R10E	EMERY	38.693	-110.821	SIMMS, CLARKE N.	365	plugged and abandoned
4301530663	4/11/1965	CLARKE 1-12	SESE	12	T24S	R10E	EMERY	38.734	-110.755	SIMMS, CLARKE N.	381	plugged and abandoned
4301530664	6/24/1964	SHELL 4	NW	06	T24S	R10E	EMERY	38.761	-110.859	SHELL OIL COMPANY	553	plugged and abandoned
4301530665	1/2/1963	CITIES 5 STRAT	SWSW	22	T22S	R10E	EMERY	38.882	-110.794	CITIES SERV OIL & GAS CORP	1140	plugged and abandoned
4301530666	8/29/1966	CITIES 4-66	NESE	17	T22S	R10E	EMERY	38.901	-110.820	CITIES SERV OIL & GAS CORP	1442	plugged and abandoned
4301530667	9/29/1966	CITIES 5-16-66	SESE	16	T22S	R10E	EMERY	38.896	-110.802	CITIES SERV OIL & GAS CORP	1595	plugged and abandoned
4301530715	4/17/2008	STATE 36-11	NENE	36	T22S	R15E	EMERY	38.859	-110.211	PETRO-CANADA RESOURCES (USA)	8090	plugged and abandoned
4301910030	8/10/1948	AMERADA GREEN RIVER U 1	NWNW	02	T22S	R16E	GRAND	38.933	-110.131	KERN COUNTY LAND CO	5645	plugged and abandoned

Table A-1. *continued*

API	COMPLETION DATE	WELL NAME	QTR_ QTR	SECT.	TOWNSHIP	RANGE	COUNTY	LAT.	LONG.	COMPANY	TD (FEET)	WELL STATUS
4301910086	9/14/1962	FLOY UNIT 1	SESW	11	T23S	R17E	GRAND	38.821	-110.017	BELCO DEVELOPMENT CORP	9670	plugged and abandoned
4301910817	1949	SHARP STATE 1	NENE	32	T22S	R17E	GRAND	38.860	-110.062	PACIFIC WESTERN OIL CORP	5046	plugged and abandoned
4301910831	4/12/1961	SALT WASH UNIT 1	NWSW	15	T23S	R17E	GRAND	38.809	-110.039	PAN AMERICAN PETROLEUM COR	9523	plugged and abandoned
4301910832	11/16/1961	SUNILAND STATE A 1	NESE	16	T23S	R17E	GRAND	38.808	-110.044	PAN AMERICAN PETROLEUM COR	8904	plugged and abandoned
4301910833	12/23/1963	SUNILAND STATE A-2	SESW	16	T23S	R17E	GRAND	38.805	-110.052	S W ENERGY CORPORATION	8890	plugged and abandoned
4301910989	4/8/1964	FEDERAL ROSENBLATT 1	NENE	20	T23S	R17E	GRAND	38.801	-110.062	S W ENERGY CORPORATION	2402	plugged and abandoned
4301911187	2/14/1961	BOWKNOT UNIT 43-20	NESE	20	T25S	R17.5E	GRAND	38.614	-110.062	SUPERIOR OIL COMPANY	7225	plugged and abandoned
4301911188	9/5/1958	SALT WASH UNIT 22-34	SENW	34	T22S	R17E	GRAND	38.856	-110.034	SUPERIOR OIL COMPANY	10293	plugged and abandoned
4301911469	7/27/1949	GREEN RIVER U 2	NESE	02	T22S	R16E	GRAND	38.924	-110.119	AMERADA	5896	plugged and abandoned
4301911519	1891	BAMBERGER & MILLIS 1	SWSE	15	T21S	R16E	GRAND	38.981	-110.141	BAMBERGER & MILLIS	1000	plugged and abandoned
4301911520	6/30/1936	GLEN RUBY ET AL 1-X	SESE	34	T21S	R16E	GRAND	38.938	-110.135	RUBY, GLEN ET AL	2627	plugged and abandoned
4301911521	9/14/1926	MARLAND OIL COMPANY 1	NWSE	35	T21S	R16E	GRAND	38.941	-110.122	MARLAND OIL CO	3820	plugged and abandoned
4301911522	3/31/1913	CRESCENT DRILLING CO 1	NWNE	20	T21S	R17E	GRAND	38.977	-110.061	CRESCENT DRILLING CO	2100	plugged and abandoned
4301911523	1913	CRESCENT DRILLING CO 2	NENE	21	T21S	R17E	GRAND	38.977	-110.043	CRESCENT DRILLING CO	1600	plugged and abandoned
4301911544	7/17/1949	AMERADA PETRO CORP 2	NWNW	02	T22S	R16E	GRAND	38.931	-110.131	AMERADA	5896	plugged and abandoned
4301911552	1912	BRITISH-AMERICAN PET CO 3	SESE	26	T22S	R17E	GRAND	38.863	-110.007	BRITISH-AMERICAN PETRO CO	425	plugged and abandoned
4301911553	1949	DELANEY PETRO CORP 1	NENW	32	T22S	R17E	GRAND	38.859	-110.073	DELANEY PETROLEUM CORP	980	plugged and abandoned
4301911554	1912	BRITISH-AMERICAN PET CO 2	NENW	35	T22S	R17E	GRAND	38.860	-110.016	BRITISH-AMERICAN PETRO CO	1500	plugged and abandoned
4301915819	2/25/1963	CF&I 22-16	SENW	16	T23S	R17E	GRAND	38.812	-110.052	SMOOT, RICHARD P	8910	plugged and abandoned
4301915820	4/13/1963	CF&I 42-16	SENE	16	T23S	R17E	GRAND	38.812	-110.044	SMOOT, RICHARD P	8941	plugged and abandoned

Table A-1. *continued*

API	COMPLETION DATE	WELL NAME	QTR_ QTR	SECT.	TOWNSHIP	RANGE	COUNTY	LAT.	LONG.	COMPANY	TD (FEET)	WELL STATUS
4301916047	4/23/1962	GOVT SMOOT 1	SENE	17	T23S	R17E	GRAND	38.816	-110.062	S W ENERGY CORPORATION	8876	plugged and abandoned
4301916048	1/19/1963	GOVT SMOOT 2	NWSE	17	T23S	R17E	GRAND	38.809	-110.067	S W ENERGY CORPORATION	8748	producing oil well
4301930029	7/11/1969	FEDERAL 1-26	SENE	26	T21S	R17E	GRAND	38.958	-110.007	SHELL OIL COMPANY	11895	plugged and abandoned
4301930044	12/17/1969	GOVT SMOOT 3	NESE	17	T23S	R17E	GRAND	38.810	-110.062	S W ENERGY CORPORATION	8687	producing oil well
4301930074	11/20/1971	U-TEX ET AL 1-14	NENW	14	T22S	R16E	GRAND	38.904	-110.127	FERGUSON OIL CO	6765	plugged and abandoned
4301930124	3/14/1973	MT FUEL-SKYLINE GEYSER 1-25	NWNW	25	T22S	R16E	GRAND	38.875	-110.113	MOUNTAIN FUEL SUPPLY CO	9508	plugged and abandoned
4301930282	6/20/1976	SALT WASH NORTH 1	NESW	09	T23S	R17E	GRAND	38.823	-110.053	RESERVE OIL & GAS	9069	plugged and abandoned
4301930327	2/18/1977	FEDERAL SKYLINE 1A SW	SESE	21	T23S	R17E	GRAND	38.791	-110.044	PEASE OIL & GAS COMPANY	8870	plugged and abandoned
4301930658	1/10/1981	GORMAN FED 1	NENW	21	T23S	R17E	GRAND	38.801	-110.053	S W ENERGY CORPORATION	8997	plugged and abandoned
4301930679	8/17/1981	GOVT 18-2	NENE	18	T23S	R17E	GRAND	38.816	-110.082	QEP ENERGY COMPANY	9350	producing oil well
4301930681	2/3/1981	STATE 1-16	SESE	16	T23S	R17E	GRAND	38.805	-110.044	MEGADON ENTERPRISES, INC	1560	plugged and abandoned
4301930688	8/24/1981	FEDERAL 1-26	SWSW	26	T24S	R17E	GRAND	38.689	-110.019	MEGADON ENTERPRISES, INC	8615	shut-in oil well
4301930746	11/17/1981	GOVERNMENT-SMOOT 21-3	SWNE	21	T23S	R17E	GRAND	38.797	-110.048	S W ENERGY CORPORATION	2301	plugged and abandoned
4301930752	2/8/1981	FEDERAL 1-15	NWSW	15	T23S	R17E	GRAND	38.808	-110.040	MEGADON ENTERPRISES, INC	8585	shut-in oil well
4301930783	9/17/1981	STATE 1-16A	SWSE	16	T23S	R17E	GRAND	38.805	-110.048	S W ENERGY CORPORATION	8825	plugged and abandoned
4301930817	9/21/1981	FEDERAL 1-14	NWNW	14	T22S	R16E	GRAND	38.904	-110.130	TEXAS ENERGY PETRO CORP	6336	plugged and abandoned
4301930829	8/10/1982	FEDERAL 27-2	NWNW	27	T23S	R17E	GRAND	38.787	-110.039	S W ENERGY CORPORATION	2301	plugged and abandoned
4301930904	1982	FEDERAL 1-14 2	SWSW	14	T22S	R16E	GRAND	38.893	-110.133	TEXAS ENERGY PETRO CORP	9856	plugged and abandoned
4301931356	3/22/1995	SALT WASH 1-16	NESW	16	T23S	R17E	GRAND	38.809	-110.053	CHESAPEAKE OPERATING INC	8744	plugged and abandoned
4301931461	2/23/2007	GREENTOWN ST 32-42	SENE	32	T22S	R17E	GRAND	38.856	-110.063	DELTA PETROLEUM CORP	9176	plugged and abandoned

Table A-1. *continued*

API	COMPLETION DATE	WELL NAME	QTR_ QTR	SECT.	TOWNSHIP	RANGE	COUNTY	LAT.	LONG.	COMPANY	TD (FEET)	WELL STATUS
4301931462	8/30/2007	GREENTOWN ST 36-11	NWNW	36	T21S	R16E	GRAND	38.948	-110.114	DELTA PETROLEUM CORP	10000	plugged and abandoned
4301931503	1/2/2008	FEDERAL 28-11	NWNW	28	T22S	R17E	GRAND	38.874	-110.057	PACIFIC ENERGY & MINING CO	10069	producing oil well
4301931505	8/29/2007	GREENTOWN ST 36-11S	NWNW	36	T21S	R16E	GRAND	38.947	-110.114	DELTA PETROLEUM CORP	3686	plugged and abandoned
4301931506	5/26/2011	GREENTOWN FED 33-12	SWNW	33	T22S	R17E	GRAND	38.856	-110.057	DELTA PETROLEUM CORP	80	plugged and abandoned
4301931507	7/31/2007	GREENTOWN FED 35-12	SWNW	35	T21S	R16E	GRAND	38.945	-110.131	DELTA PETROLEUM CORP	3500	plugged and abandoned
4301931519	12/7/2008	GREENTOWN ST 36-24H	SESW	36	T21S	R16E	GRAND	38.938	-110.108	DELTA PETROLEUM CORP	10316	plugged and abandoned
4301931547	4/27/2009	GREENTOWN FED 26-43H	NESE	26	T21S	R16E	GRAND	38.957	-110.117	PACIFIC ENERGY & MINING CO	10587	shut-in oil well
4301931551	10/10/2007	GREENTOWN FED 35-12D	SWNW	35	T21S	R16E	GRAND	38.945	-110.131	DELTA PETROLEUM CORP	5731	plugged and abandoned
4301931555	1/15/2008	GREENTOWN ST 31-362216	NWNE	36	T22S	R16E	GRAND	38.859	-110.104	DELTA PETROLEUM CORP	40	plugged and abandoned
4301931569	8/3/2009	GREENTOWN ST 31-362216H	NWNE	36	T22S	R16E	GRAND	38.859	-110.104	PACIFIC ENERGY & MINING CO	9109	temporarily abandoned
4301931570	1/22/2008	GREENTOWN ST 31-362216B	NWNE	36	T22S	R16E	GRAND	38.859	-110.104	DELTA PETROLEUM CORP	40	plugged and abandoned
4301931573	10/16/2009	FEDERAL 15-33	NWSE	15	T22S	R16E	GRAND	38.896	-110.139	DELTA PETROLEUM CORP	40	plugged and abandoned
4301931575	1/11/2009	FEDERAL 11-24	SESW	11	T22S	R16E	GRAND	38.907	-110.127	PACIFIC ENERGY & MINING CO	9978	shut-in gas well
4301931605	5/4/2009	STATE 16-42	SENE	16	T22S	R17E	GRAND	38.899	-110.043	ANADARKO E&P COMPANY LP	10176	shut-in gas well

Plate 1
Utah Geological Survey Map 267DM
Geologic Map of the San Rafael Desert 30' x 60' Quadrangle

UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources

GEOLOGIC MAP OF THE SAN RAFAEL DESERT 30' X 60' QUADRANGLE, EMERY AND GRAND COUNTIES, UTAH

by
Hellmut H. Doelling, Paul A. Kuehne,
Grant C. Willis, and J. Buck Ehler
2015

SCALE 1:62,500

1 0.5 0 1 2 3 MILES

1 0.5 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 50 METERS

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Base from USGS San Rafael Desert 30' x 60' Quadrangle (1986)
Projection: UTM Zone 12
Datum: NAD 27
Spheroid: Clarke 1866
Water Bodies: AGRC 2013

Program Manager: Grant C. Willis
GIS and Cartography: J. Buck Ehler, Paul A. Kuehne, Lori J. Shaddrix, Kent D. Brown, and Patricia H. Speranza

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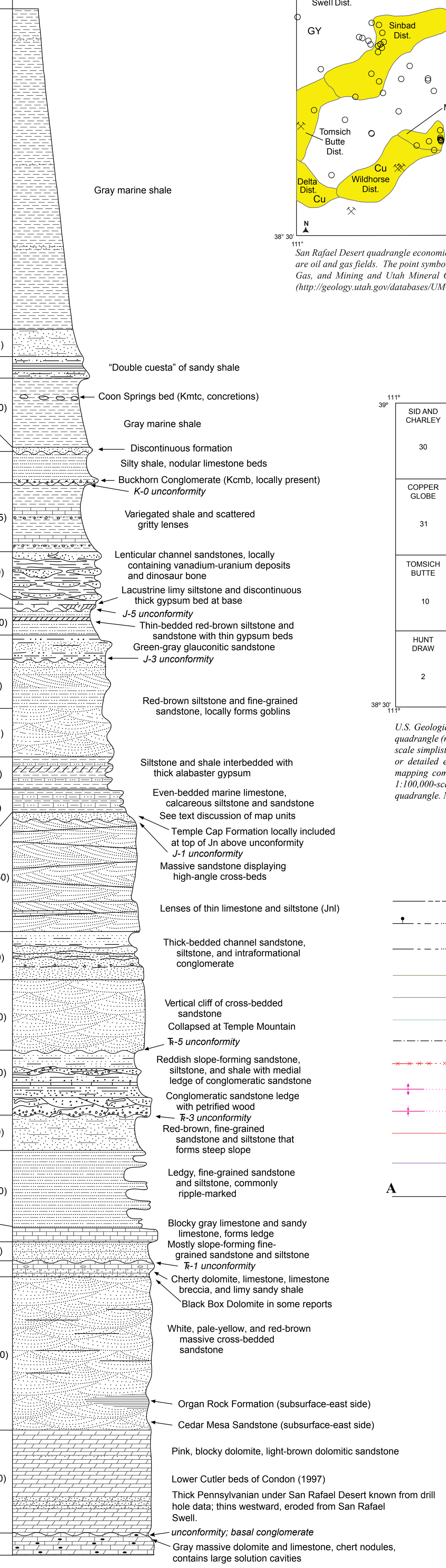
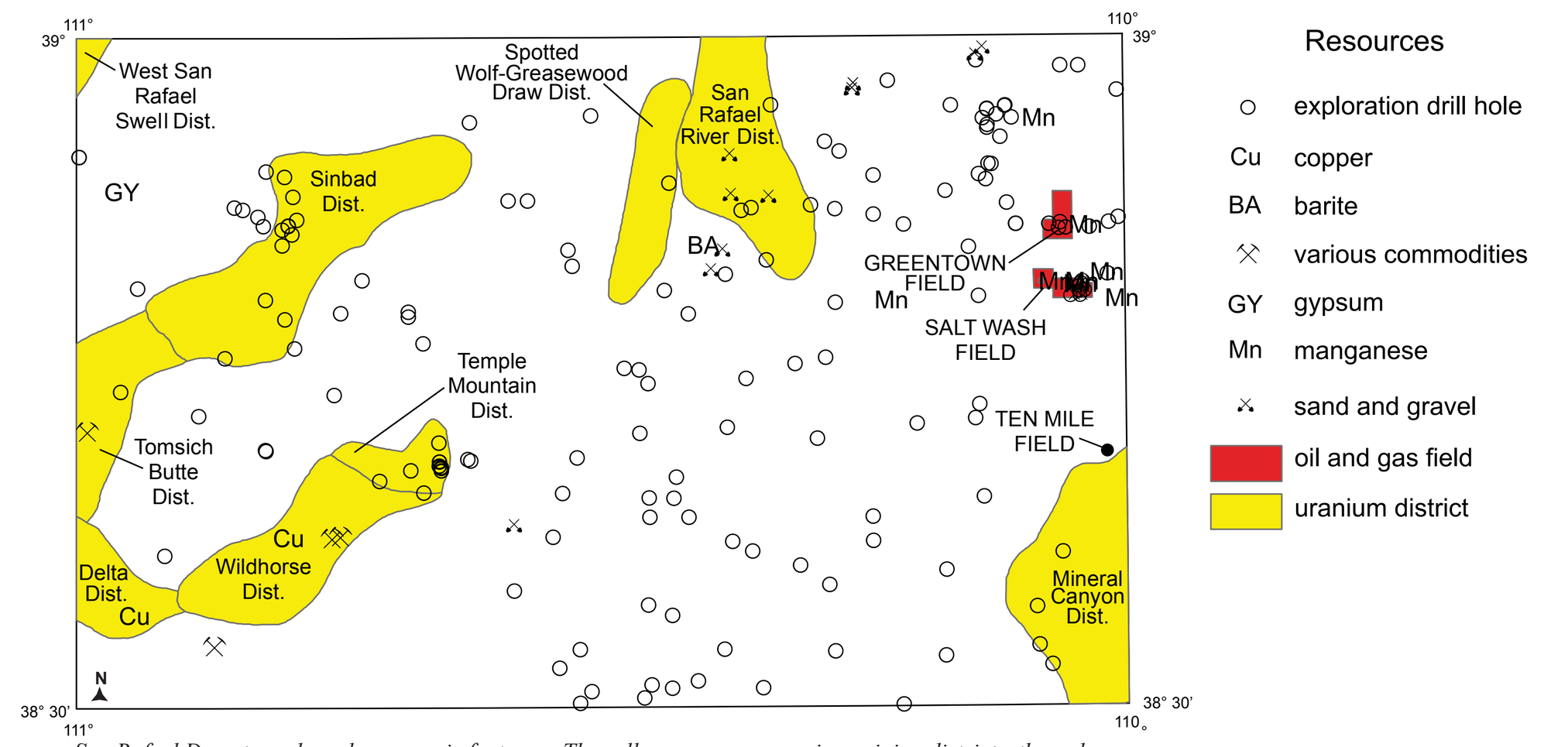
UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources

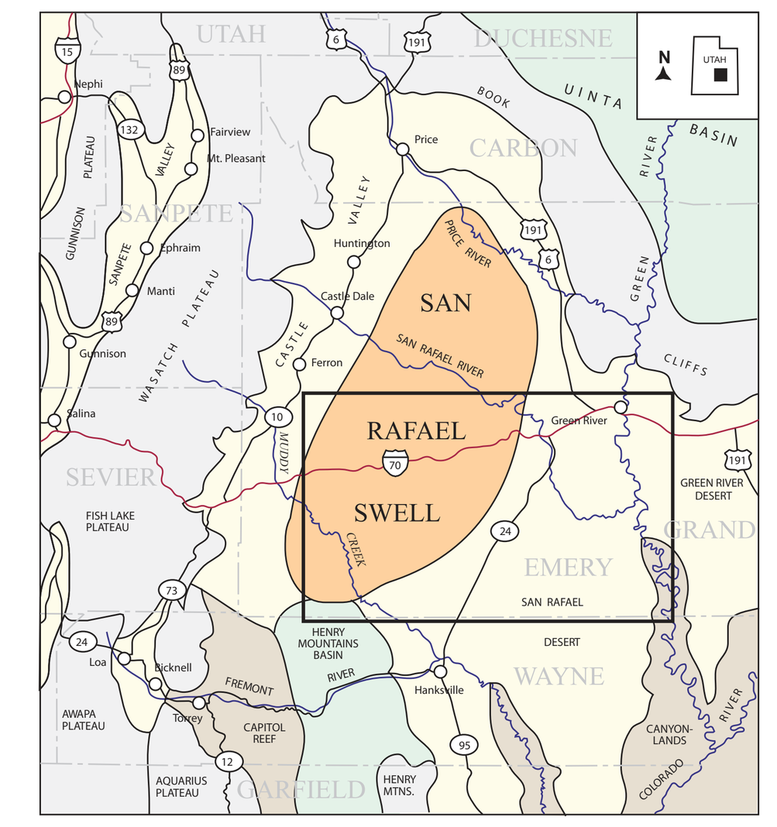
STRATIGRAPHIC COLUMN

System	Series	Formation/Member	Map Symbol	Thickness in meters (feet)
CRETACEOUS	Upper	Mancos Shale – Blue Gate Shale Member (sandstone marker beds)	Kmb, Kmbs	800–1000 (2600–3300)
		Mancos Shale – Juana Lopez Member	Kmjl, Kmju	15–50 (50–165)
		Mancos Shale – Ferron Sandstone Member	Kmf	100 (330)
		Mancos Shale – Tununk Shale Member	Kmtc, Kmt	90–130 (300–430)
		Dakota Formation	Kd (Kdcm)	0–9 (0–30)
	Lower	Cedar Mountain Formation	Kcmu, Kcmb (Kdcm)	0–58 (0–190)
JURASSIC	Upper	Morrison Formation – Brushy Basin Member	Jmb (Jm)	45–130 (150–425)
		Morrison Formation – Salt Wash Member	Jms (Jm)	45–90 (150–300)
		Morrison Formation – Tidwell Member	Jmt (Jm)	6–15 (20–50)
		San Rafael Group – Summerville Formation	Js (Jsr)	30–120 (100–400)
		San Rafael Group – Curtis Formation	Jct (Jsr)	9–75 (30–250)
	Middle	San Rafael Group – Entrada Sandstone – Earthy Member	Jee (Je, Jsr)	18–45 (60–150)
		San Rafael Group – Entrada Sandstone – Slick Rock Member	Jes (Je, Jsr)	45–90 (150–300)
		San Rafael Group – Carmel Formation – upper members	Jcu (Jc, Jsr)	18–122(60–400)
		San Rafael Group – Carmel Formation – lower members	Jcl (Jc, Jsr)	15–75 (50–245)
	Lower	Glen Canyon Group – (Temple Cap Formation)		
		Glen Canyon Group – Navajo Sandstone	Jn, Jnl (JꞦgc)	135–200 (400–650)
		Glen Canyon Group – Kayenta Formation	Jk (JꞦgc)	45–90 (150–300)
TRIASSIC		Glen Canyon Group – Wingate Sandstone	JꞦw (JꞦgc)	73–130 (240–420)
	Upper	Chinle Formation – upper members	Ꞧcu (Ꞧc, Ꞧ)	73–113 (240–370)
		Chinle Formation – lower members	Ꞧcl (Ꞧc, Ꞧ)	0–52 (0–170)
	Lower	Moenkopi Formation – Moody Canyon Mbr.	Ꞧmm (Ꞧmu, Ꞧm, Ꞧ)	43–75 (140–250)
		Moenkopi Formation – Torrey Member	Ꞧmt (Ꞧmu, Ꞧm, Ꞧ)	90–130 (300–420)
		Moenkopi Formation – Sinbad Limestone Mbr.	Ꞧms (Ꞧm, Ꞧ)	0–45 (0–150)
		Moenkopi Formation – Black Dragon Mbr.	Ꞧmb (Ꞧm, Ꞧ)	20–60 (65–200)
PERMIAN	Lower	Kaibab Formation	Pk (P)	0–26 (0–85)
		Cutler Group – White Rim Sandstone	Pwr (P)	150–290 (500–950)
		Cutler Group – Elephant Canyon Formation	Pec (P)	90–245 (300–800)
		Pennsylvanian-not exposed		
Miss.	Middle	Redwall Limestone	Mr	32+ (105+)





San Rafael Desert quadrangle economic features. The yellow areas are uranium mining districts, the red areas are oil and gas fields. The point symbols are various types of wells and mines. Data from Utah Division of Oil, Gas, and Mining and Utah Mineral Occurrence System database maintained by Utah Geological Survey. (http://geology.utah.gov/databases/UMOS/umos_intro.htm). (See Table 1, Appendix)

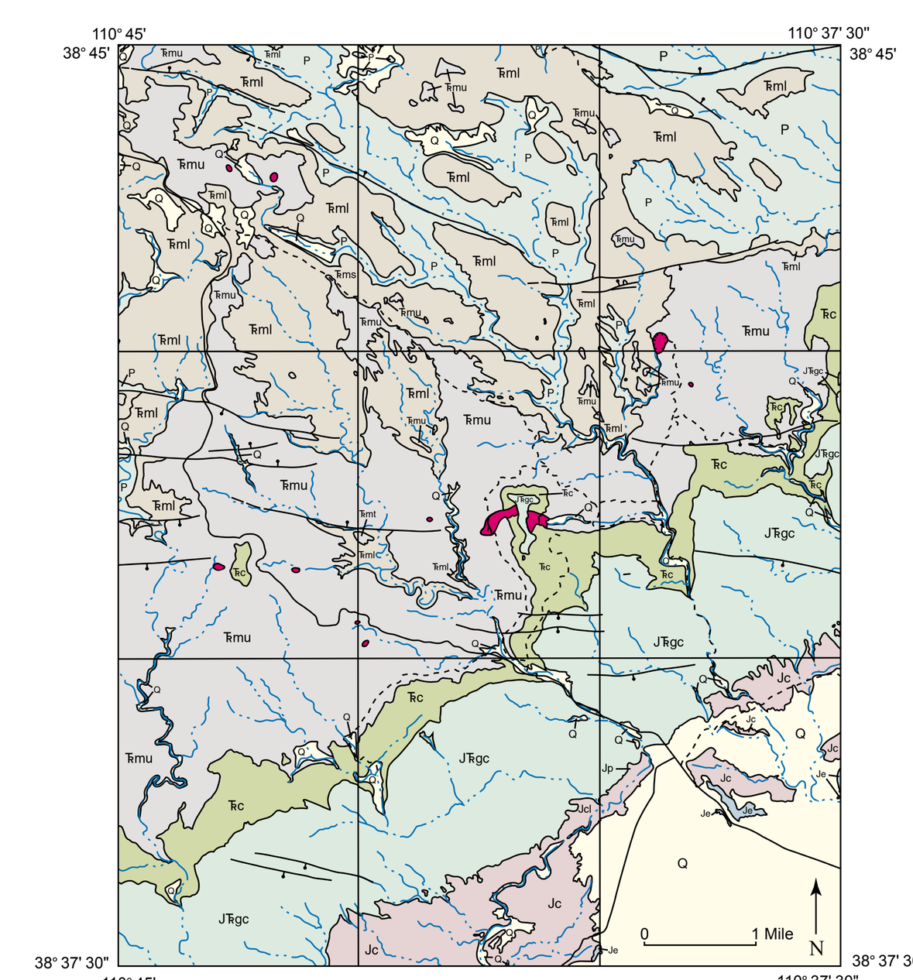


Index map to the San Rafael Swell and surrounding physiographic features. San Rafael Desert 30' x 60' quadrangle is outlined in heavy black.

111° 39°							110° 39°
SID AND CHARLEY 30	THE BLOCKS 29	THE WICKIUP 15	DROWNED HOLE DRAW 47, 48	SPOTTED WOLF CANYON 33, 37	JESSIES TWIST 22, 23	GREEN RIVER 46	DALY 40, 42
COPPER GLOBE 31	SAN RAFAEL KNOB 14	TWIN KNOLLS 16	ARSONS GARDEN 17	GREASE-WOOD DRAW 34, 38	HORSE BENCH WEST 6, 7	HORSE BENCH EAST 44	GREEN RIVER SE 41, 45
TOMSICH BUTTE 10	HORSE VALLEY 39	TEMPLE MOUNTAIN 9,19	OLD WOMAN WASH 18	CROWS NEST SPRING 25, 26	SPRING CANYON 28	MOONSHINE WASH 27	TENMILE POINT 4, 5
HUNT DRAW 2	LITTLE WILD HORSE MESA 3	GOBLIN VALLEY 32	GILSON BUTTE	THE FLAT TOPS	JACKS KNOB	KEG KNOLL 20, 43	BOWKNOT BEND 35, 36
111° 38° 30'							110° 38° 30'

49 (Spotted Wolf Canyon–Greasewood Draw–Jessies Twist–Horse Bench West area); ← 8 → (Green River–Daly area)

U.S. Geological Survey 7.5' quadrangles and sources of previous geologic mapping in the San Rafael Desert 30' x 60' quadrangle (numbers correspond to the selected bibliography in the accompanying text document). Many old 1:24,000-scale simplistic photogeologic maps and generalized maps at other scales cover the area, but these were not accurate or detailed enough to compile directly into the new map (numbers 1-7, 9-47, 49), and were superceded by new mapping completed during this project; they were consulted as references during the new mapping. Number 8 is 1:100,000-scale mapping completed by the lead author that was published as an appendage to the Moab 30' x 60' quadrangle. Number 49 was used with some modifications.



Simplified geologic map of the Temple Mountain 7.5' quadrangle (after Doelling and Kuehne, 2008) showing the location of 12 subsidence collapse features. Red indicates altered, bleached, brecciated, subsided and/or collapsed rock of adjacent or immediately overlying strata. P designates Permian strata; Ꞧml and Ꞧmu lower and upper Moenkopi Formation; Ꞧc Chinle Formation; JꞦgc Glen Canyon Group; Jc Carmel Formation; Je Entrada Sandstone. Q Quaternary surficial deposits.

GEOLOGIC SYMBOLS

- Contact, well located, dashed where approximately located
- Normal fault, well located, dashed where approximately located, dotted where concealed
- Fault, sense of slip unknown, well located, dashed where approximately located, dotted where concealed
- Kmbs marker bed, well located
- Kmtc marker bed, well located
- Jnl marker bed, well located
- Lineament, well located
- Lamproite dike, well located, dashed where approximately located, dotted where concealed
- Anticline, upright, well located, dotted where concealed
- Syncline, upright, well located, dotted where concealed
- Structure contour, in meters, drawn on top of Navajo Sandstone (Jn); includes projected above ground surface; datum equals mean sea level
- Structure contour, in meters, drawn on top of Chinle Formation (Ꞧc); includes projected above ground surface; datum equals mean sea level
- A — A' Cross section
- 6 Strike and dip of bedding, inclined, field measured
- 10 Strike and dip of bedding, photogrammetric (3-point)
- Mine or rock quarry (most not shown due to density)
- Sand and gravel pit
- Drill hole – abandoned
- Drill hole – dry hole
- Drill hole – oil well
- Drill hole – oil well, abandoned
- Drill hole – oil well, shut-in
- Drill hole – gas well, abandoned
- Drill hole – gas well, shut-in
- Arch
- Collapse or subsidence feature

Aerial view west towards Temple Mountain. The top of the mountain is Wingate Sandstone (JꞦw), the Chinle Formation (Ꞧc) forms the upper mostly purple to brown part of the slope below the towers, and the Moody Canyon Member of the Moenkopi Formation (Ꞧmm) forms the deep red base of the slope. The collapse feature in the center of the temple is recognizable between the two towers.

View northeastward along the broad axis of the San Rafael Swell from its southwest corner. Below is the entrenched canyon of Muddy Creek which is cut into members of the Moenkopi Formation: (Moody Canyon –Ꞧmm, mostly Torrey –Ꞧmt, Sinbad –Ꞧms, and Black Dragon Members –Ꞧmb). Chinle Formation (Ꞧc) and Wingate Sandstone (JꞦw) to left in middle ground.

Aerial view west across the south end of the San Rafael Swell. The major part of the reef (light-hued sandstone)is the Lower Jurassic/Upper Triassic Glen Canyon Group. Brownish flatirons (Carmel Formation [Jc]) on the reef and the reddish Entrada Sandstone (Je) in the swale are Middle Jurassic in age. The top of Wild Horse Mesa south of the reef consists of the Upper Jurassic Salt Wash Member of the Morrison Formation (Jms). The two major cliffs on the west side of the swell (upper distant part of the photo) are the Navajo (Jn) and Wingate Sandstones (JꞦw), the upper and lower formations of the Glen Canyon Group.

Aerial view southwest over the San Rafael Reef. The light tan unit that dominates the photo is the Navajo Sandstone (Jn). The Carmel Formation (Jc) forms dark hogbacks. Interstate 70 runs through Spotted Wolf Canyon in the center of the photo.

Oblique aerial view of the north end of Labyrinth Canyon on the Green River. Image was generated with TerrainBender software by draping an orthophoto on top of a digital elevation model.

View of Crystal Geyser from the Green River towards the east. Crystal Geyser is a cold-water geyser that erupts from an exploration well drilled in 1935. The orange rock beneath the geyser is travertine. Summerville (Js) and Morrison Formations (Jm) in background.

CORRELATION OF MAP UNITS