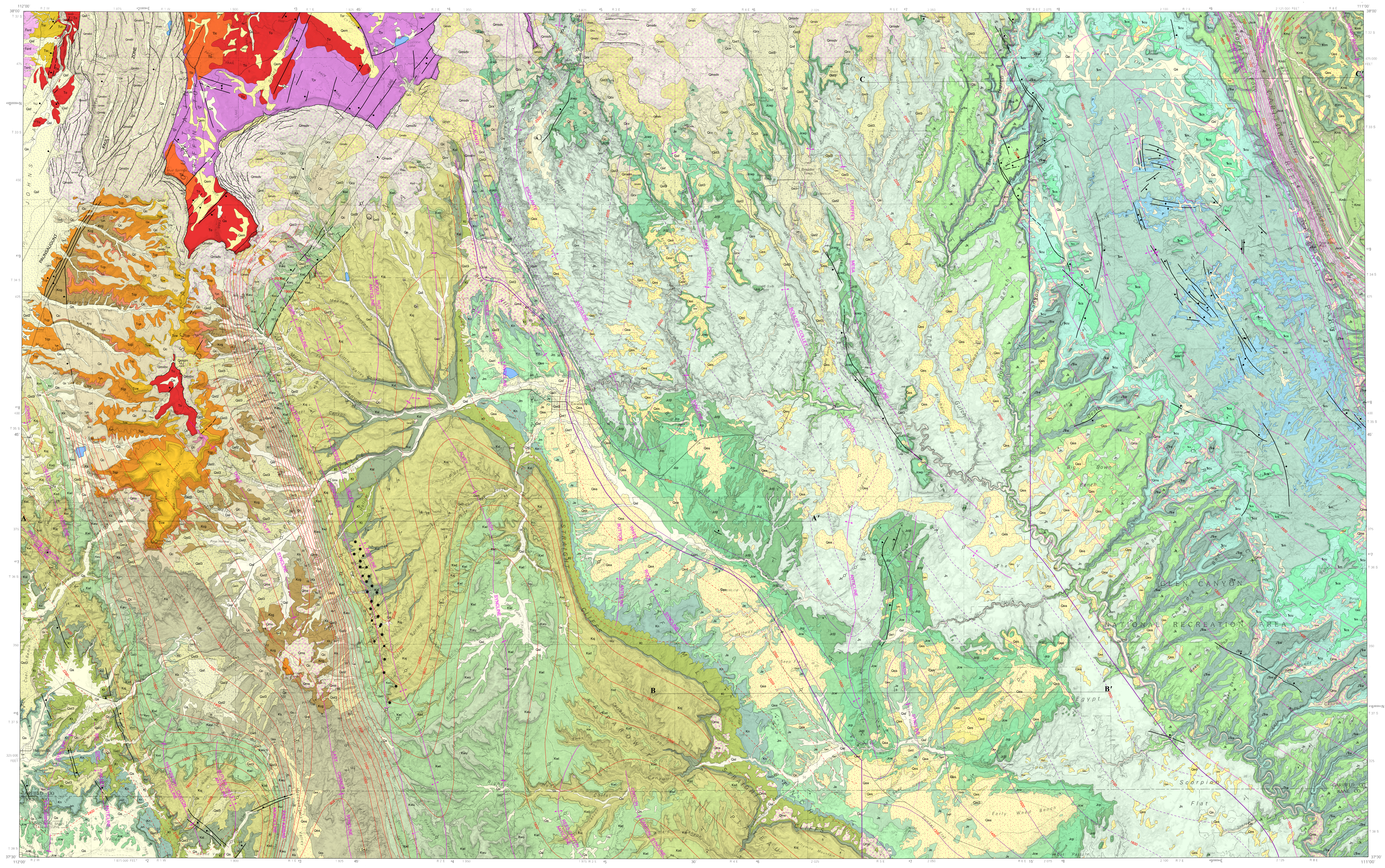
UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources



INTERIM GEOLOGIC MAP OF THE ESCALANTE 30′ X 60′ QUADRANGLE, GARFIELD AND KANE COUNTIES, UTAH

by
Hellmut H. Doelling and Grant C. Willis
2018

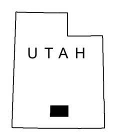
Utah Geological Survey, P.O. Box 146100, Salt Lake City, UT 84114-6100

SCALE 1:100,000

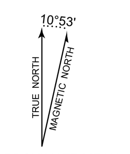
1 0.5 0 1 2 3 4 MILES

1 0.5 0 1 2 3 4 5 6 KILOMETERS

CONTOUR INTERVAL 50 METERS



QUADRANGLE LOCATION



APPROXIMATE MEAN DECLINATION, 2018

Mapping is intended for use at 1:100,000 or smaller scale. This map was produced using various topographic and photographic base maps for spatial (ground) control and does not fit any specific base map. The map depicts geologic formations, faults, folds, and other information, and is accompanied by an explanatory materials that include the geologic unit descriptions, figures, tables, mapping sources, correlation charts, lithologic columns, geologic symbols, and geologic cross sections.

The original geologic map, open-filed in 1999, was funded by the Utah Geological Survey and U.S. Geological Survey through STATEMAP Agreement 1434HQ97AG01797. *The views and conclusions contained in this map and report are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government. While the map is considered a good representation of the geology of the map area, users should be aware that it does not meet all modern cartographic, spatial control, or geologic standards.*

This map is a plot of geographic information system (GIS) files created to visually represent the content of the GIS data files. It is not a published map and it contains many features that do not meet UGS cartographic standards, such as automatically generated labels that may overlap other labels and lines.

Base from USGS Escalante 30′ x 60′ Quadrangle (1980)
Projection: UTM Zone 12
Datum: NAD 1927

Project Manager: Grant C. Willis
GIS and Cartography: Zachary W. Anderson, J. Buck Ehler, Kelli Bacon, Kent D. Brown, and Martha L. Jensen

Utah Geological Survey
1594 West North Temple, Suite 3110
Salt Lake City, UT 84116
(801) 537-3300
geology.utah.gov

This map was created from geographic information system (GIS) data.

Utah Geological Survey
a division of
Utah Department of Natural Resources

KEY TO MAP SYMBOLS

Contact—dashed where approximately located

Fault—dashed where inferred or approximately located; dotted where concealed; bar and ball on down-thrown side; no bar and ball where offset unknown

Landslide or slump scarp

Anticline—showing axial trace; dashed where approximately located; dotted where concealed; arrow shows direction of plunge

Syncline—showing axial trace; dashed where approximately located; dotted where concealed; arrow shows direction of plunge

Monocline—line placed on axial trace of upper hinge; dashed where approximately located; dotted where concealed

1800 / 2000 / 1000 Structural contour—contour interval 100 meters; intermediate contours shown locally; datum separated by purple lines: top of Permian strata (east part of map area), Navajo Sandstone (central part of map area), lower member of Straight Cliffs Formation (west part of map area).

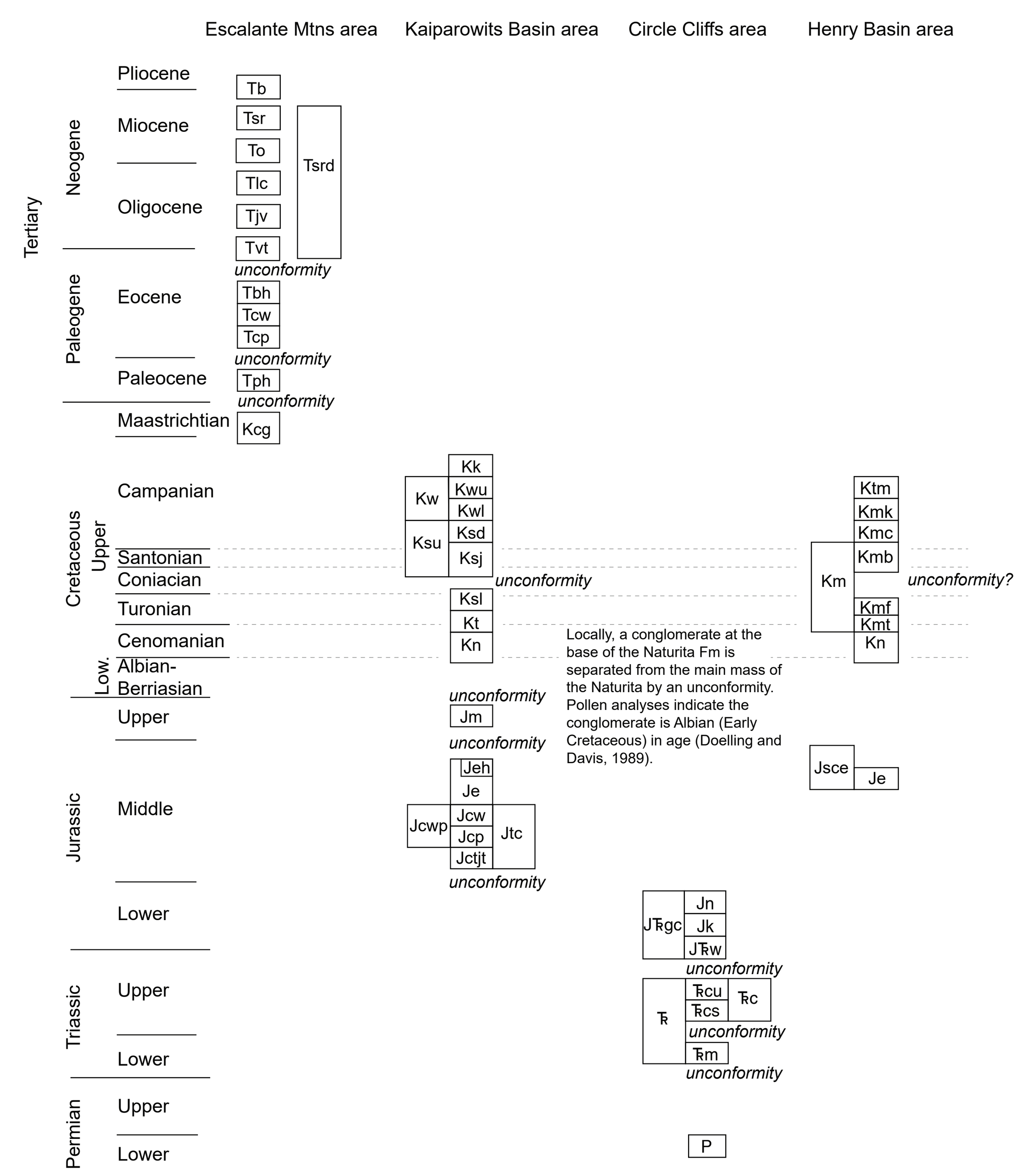
A———A′ Line of cross section

Strike and dip of strata
- inclined
- horizontal

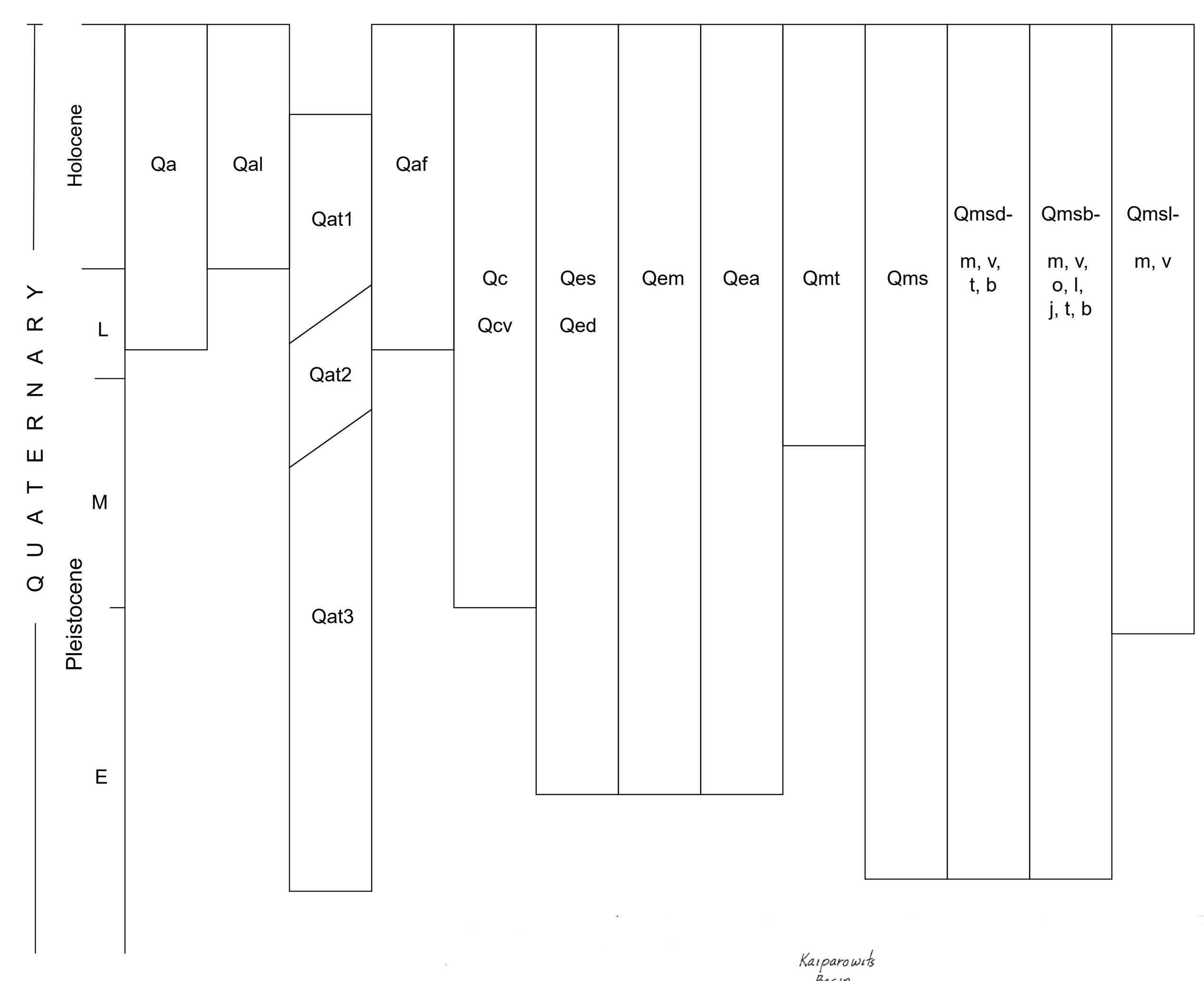
Exploration drill hole (Utah Division of Oil, Gas and Mining data, June 14, 2018)
- plugged and abandoned
- injection well
- oil and gas well
- oil well, abandoned
- oil exploration, used for water

Mines, quarries, prospects – not shown (see text)

CORRELATION OF BEDROCK UNITS



CORRELATION OF SURFICIAL DEPOSITS



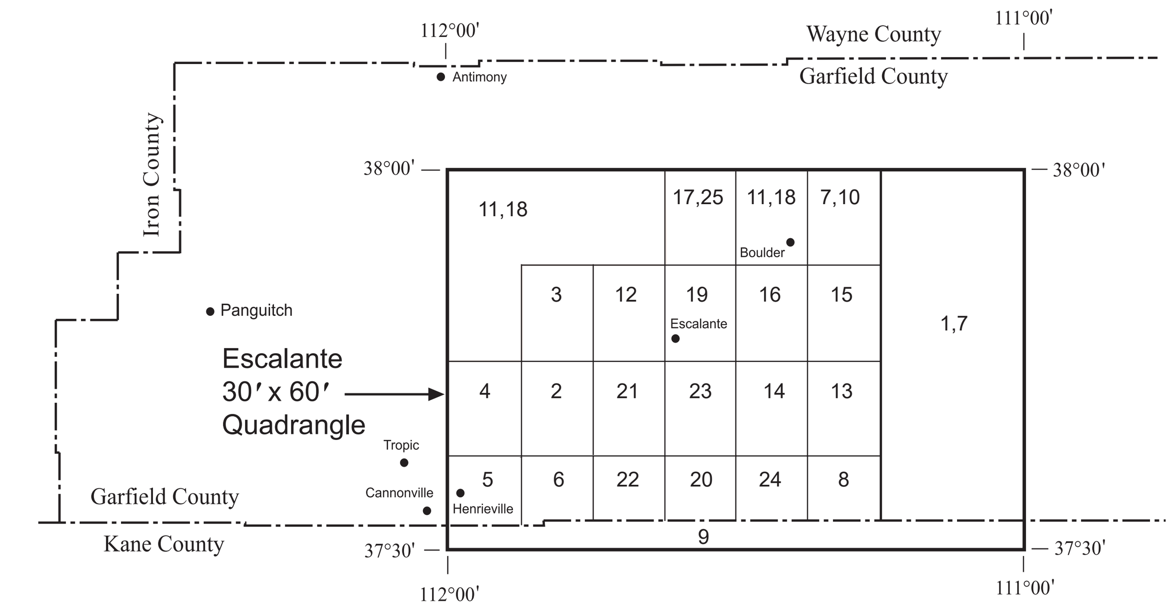


***Figure 1.** The geologic map was produced from new mapping by the authors and compiled from published sources. Numbers refer to sources in References Cited in text booklet.*

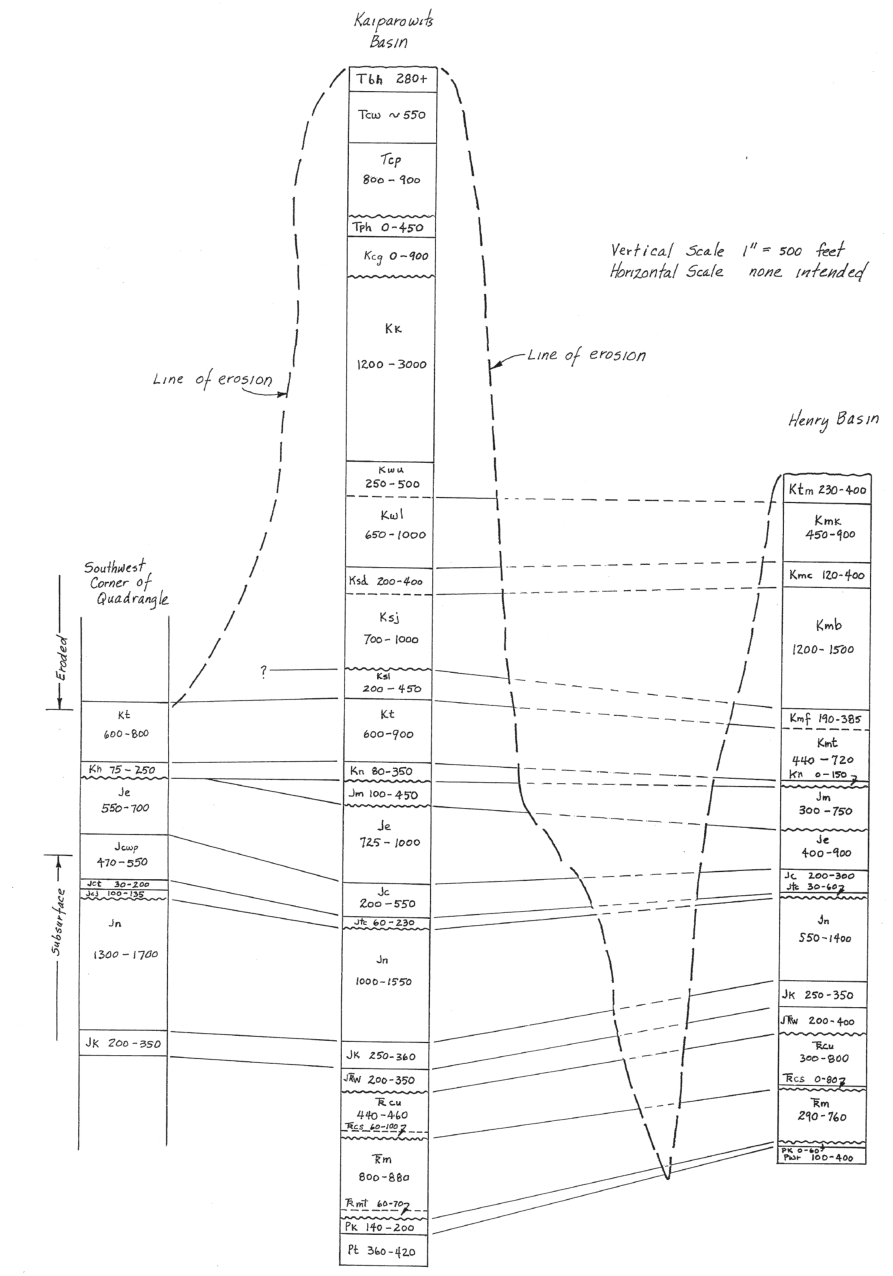
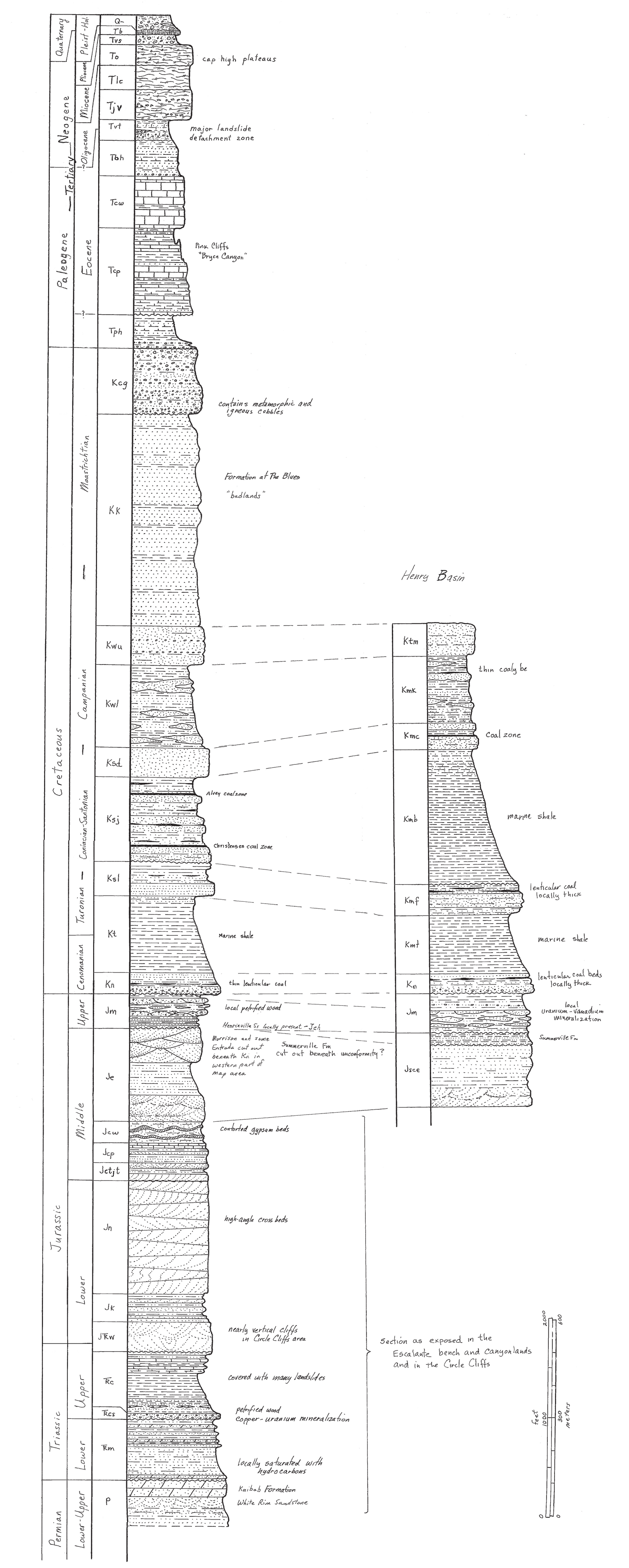
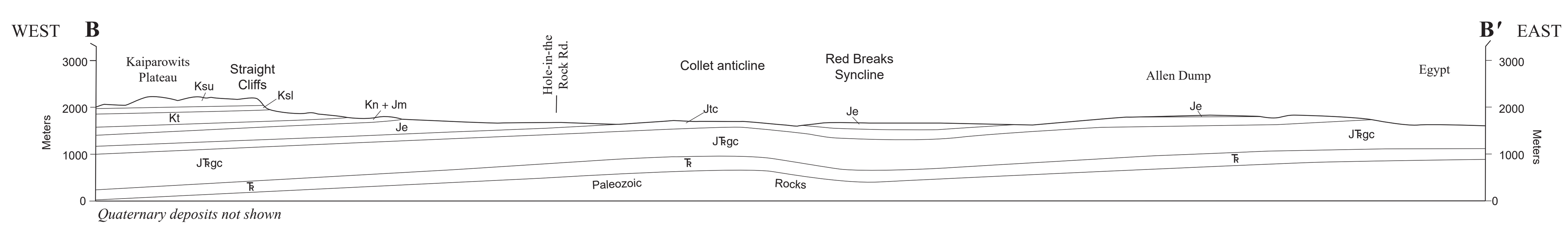
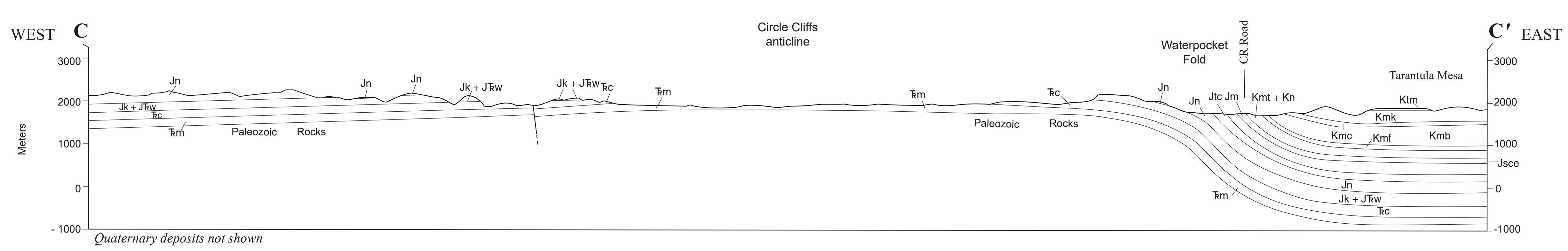
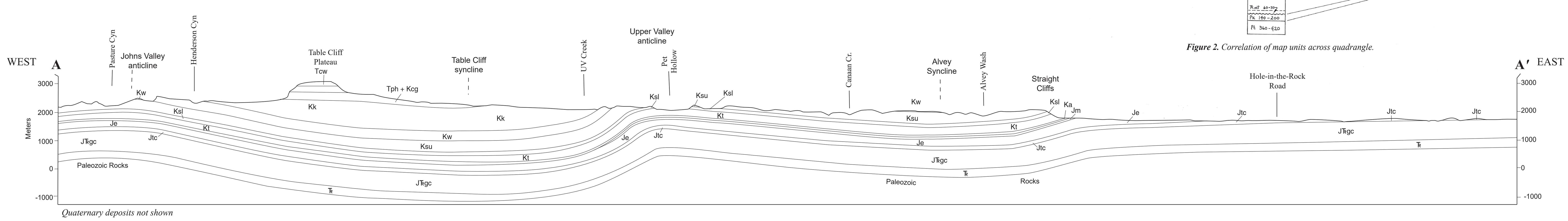


***Figure 2.** Correlation of map units across quadrangle.*









See text booklet for descriptions of map units

GEOLOGIC UNIT NAMES

Qa—Alluvium, undifferentiated
Qal—Stream alluvium
Qat1—Alluvial terrace deposits, level 1
Qat2—Alluvial terrace deposits, level 2
Qat3—Alluvial terrace deposits, level 3
Qaf—Alluvial-fan deposits
Qc—Colluvium
Qcv—Volcanic colluvium
Qes—Eolian sand deposits
Qed—Eolian sand dune deposits
Qem—Eolian silt deposits in mounds
Qea—Eolian and alluvial deposits
Qmt—Talus deposits
Qms—Landslides and slumps, undifferentiated

Qmsdm—Landslides, debris-slide deposits, mixed lithology
Qmsdv—Landslides, debris-slide deposits, mostly volcanic rock
Qmsdt—Landslides, debris-slide deposits, mostly tuffaceous sediments unit
Qmsdb—Landslides, debris-slide deposits, mostly Brian Head Formation
Qmsbm—Landslides, slump block deposits, mixed lithology
Qmsbv—Landslides, slump block deposits, mostly volcanic rock
Qmsbo—Landslides, slump block deposits, mostly Osris Tuff
Qmsbl—Landslides, slump block deposits, mostly latite tuff unit
Qmsbj—Landslides, slump block deposits, mostly latite of Johnson Valley
Qmsbt—Landslides, slump block deposits, mostly tuffaceous sediments unit
Qmsbb—Landslides, slump block deposits, mostly Brian Head Formation
Qmslm—Landslides, lobate slide debris, mixed lithology
Qmslv—Landslides, lobate slide debris, mostly volcanic rock

Tb—Basalt
Tsr—Sevier River Formation
Tsrd—Sevier River Formation over Mount Dutton Formation
To—Osiris Tuff
Tlc—Trachyte of Lake Creek
Tjv—Latite of Johnson Valley
Tvt—Tuffaceous sediments
Tbh—Brian Head Formation
Tcw—Claron Formation, white member
Tcp—Claron Formation, pink member
Tph—Pine Hollow Formation
Kcg—Grand Castle and Canaan Peak Formations, undivided
Kk—Kaiparowits Formation
Kwu—Wahweap Formation, upper member

Ktm—Tarantula Mesa Sandstone
Kwl—Wahweap Formation, lower member
Kmk—Masuk Formation
Ksd—Straight Cliffs Formation, Drip Tank Member
Kmc—Muley Canyon Sandstone
Ksj—Straight Cliffs Formation, John Henry Member
Kmb—Mancos Shale, Blue Gate Shale Member
Ksl—Straight Cliffs Formation, lower members
Kmf—Mancos Shale, Ferron Sandstone Member
Kt—Tropic Shale
Kmt—Mancos Shale, Tununk Shale Member
Kn—Naturita Formation (formerly Dakota Formation)
Jm—Morrison Formation
Jsce—Summerville, Curtis, and Entrada Formations, undivided

Jeh—Henrieville bleached sandstone facies of Entrada Sandstone
Je—Entrada Sandstone, main part
Jcwp—Carmel Formation, Winsor and Paria River Members, undivided
Jtc—Carmel and Temple Cap Formations, undivided
Jcw—Carmel Formation, Winsor Member
Jcp—Carmel Formation, Paria River Member
Jctjt—Carmel Formation, Thousand Pockets and Judd Hollow Members, and Temple Cap Formation
Jn—Navajo Sandstone
Jk—Kayenta Formation
JTRw—Wingate Sandstone
TRcu—Chinle Formation, Church Rock, Owl Rock, Petrified Forest, and Monitor Butte Members, undivided
TRcs—Chinle Formation, Shinarump Member
TRm—Moenkopi Formation
P—Permian Formations
Water

Interim Geologic Map of the Escalante 30′ x 60′ Quadrangle, Garfield and Kane Counties, Utah

by

Hellmut H. Doelling and Grant C. Willis

Disclaimer

The original geologic map, open-filed in 1999, was funded by the Utah Geological Survey and U.S. Geological Survey through STATEMAP Agreement 1434HQ97AG01797. The views and conclusions contained in this map and report are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

OPEN-FILE REPORT 690DM
UTAH GEOLOGICAL SURVEY
a division of
UTAH DEPARTMENT OF NATURAL RESOURCES
2018

Blank pages are intentional for printing purposes.

INTRODUCTION

This open-file release is a partially revised version of Utah Geological Survey Open-File Report 368 (Doelling and Willis, 1999). The 1999 map consisted of new field mapping combined with compiled mapping from several older geologic maps at various scales (figure 1on plate 2). This map includes an interim GIS database and corrects and improves a few selected geologic features on the original map. However, most map features are not modified from the original and many aspects of this map do not meet modern standards of precision or accuracy. Most significant revisions were near the western border to better match the recently published geologic map of the Panguitch 30′ x 60′ quadrangle (Biek and others, 2015b) and along the western part of the northern border to better match an interim geologic map of part of the Loa 30′ x 60′ quadrangle (Biek and others, 2015a). A few units were updated with newer names and a few geologic unit descriptions were updated with newer ages and selected other information. Spatial placement of most geologic features used methods in common practice in the 1980–90s and does not match modern standards.

Drill holes and other resource features were not shown on the original source map. Drill holes shown on this map were extracted from Utah Division of Oil, Gas and Mining data accessed June 14, 2018; accuracy and completeness have not been verified. Mines, quarries, and prospects are not shown because they are not available from a uniform database or source map. The Utah Geological Survey website contains much resource information for the area, including many publications, resource maps, and the Utah Mineral Occurrence System database.

MAP UNIT DESCRIPTIONS

QUATERNARY

Alluvial deposits

Qa **Alluvium, undifferentiated** (Holocene to upper Pleistocene) – Gravel, sand, silt, and clay in poorly to moderately sorted and stratified deposits in most drainages and depressions; clast size and composition vary between drainages and are dependent on local bedrock; dominantly ephemeral stream deposits, but commonly include some debris flow deposits, eolian sand and silt, colluvium, low-level alluvial terrace deposits, alluvial-fan deposits, and floodplain deposits too small to map separately at this scale; 1.5 to 9 meters (5–30 ft) thick in most drainages, may be thicker in Johns Valley.

Qal **Stream alluvium** (Holocene) – Pebble to boulder gravel, sand, silt, and clay deposited by streams and rivers; generally in sediment-choked, flat-bottomed canyons and washes; generally moderately to poorly sorted but locally well sorted; mostly silt and clay in broad, low-gradient floodplain areas; coarsens up drainages; locally includes colluvium and alluvial fan deposits from side slopes and small side drainages; in upper parts of drainages is similar to many Qa deposits but in most areas still has a flat-bottomed stream channel near the middle of the deposit; generally 0 to 9 meters (0–30 ft) thick, but locally thicker; may include thick valley fill in Johns Valley.

Qat1, Qat2, Qat3

Alluvial terrace deposits, level 1 (Holocene to upper Pleistocene), **level 2** (upper to middle Pleistocene), **level 3** (middle to lower Pleistocene) – Poorly to moderately sorted boulders and cobbles with pebbles, sand, silt, and clay matrix preserved as terrace remnants above present stream levels and on wider pediment-like benches; similar in composition to alluvium (Qa), but generally with larger percentage of bouldery clasts; most clasts moderately to poorly rounded; composition varies from dominantly volcanic-derived to dominantly quartzite, sandstone, or limestone, dependent on local source; commonly includes eolian silt and sand and pedogenic carbonate in upper part of deposit that gradually accumulated such that older deposits have thicker accumulations; in general, older deposits are preserved as relatively higher benches; in Boulder Creek drainage may be partly glacial outwash; level 1 deposits are generally 6 to 18 meters (20–60 ft) above current well-graded stream valleys, level 2 are 18 to 50 meters (60–165 ft) above, and level 3 are over 50 meters (165 ft) above with some as much as 400 meters (1300 ft) above (relative elevations vary across the area and some exceptions exist due to local geologic factors); probably entirely Quaternary in age but a few highest-level deposits may be Pliocene, though no definitive ages exist; 0 to 15 meters (0–50 ft) thick.

Qaf **Alluvial-fan deposits** (Holocene to upper Pleistocene) – Poorly to moderately well sorted sand, silt, clay, and gravel deposited where gradients decrease at the mouths of canyons and washes; commonly include boulders up to a few meters in diameter near the mouths of canyons; clasts decrease in size down-slope from canyon mouths; some eolian sand and silt common on older fan surfaces; deposited by debris flows and alluvial processes; form fan-shaped deposits where not confined by side slopes; composition reflects local source materials; generally less than 15 meters (50 ft) thick, but locally may be as much as 30 meters (100 ft) thick.

Colluvial Deposits

Qc, Qcv

Colluvium, volcanic colluvium (Holocen to Pleistocene) – Poorly sorted, subangular to subrounded, pebble- to boulder-sized clasts in a silty to sandy matrix; generally mantles low to moderate slopes, especially slopes with a northern aspect; mapped as mixed lithology (mostly limestone, sandstone, and quartzite) (Qc) or as dominantly volcanic clasts (Qcv); locally includes varying amounts of alluvial stream, slope wash, rock-slide, rockfall, and eolian deposits; includes active and older inactive deposits that have been isolated by downcutting streams and washes; surfaces of older deposits are typically mantled by a thin cover of eolian silt and sand; deposits commonly migrate slowly downslope through slope-creep processes; as much as 30 meters (100 ft) thick.

Eolian-Dominated Deposits

Qes, Qed

Eolian sand deposits, eolian sand dune deposits (Holocene to Pleistocene) – Fine to very fine grains of quartz sand and minor silt deposited by wind; common on Jurassic sandstones (primarily Navajo and Entrada) and locally on Cretaceous sandstones; form thin sheets and small dunes; local larger dune areas mapped as Qed; up to 9 meters (30 ft) thick.

Qem **Eolian silt deposits in mounds** (Holocene to Pleistocene) – Gray-brown silt, sand, and small angular volcanic pebbles deposited by wind in evenly spaced mounds in treeless areas on the Escalante Mountains; up to 1 meter (3 ft) thick.

Qea **Eolian and alluvial deposits** (Holocene to Pleistocene) – Moderately to moderately well sorted sand, silt, and small angular to subangular rock fragments over pebble to cobble gravel; accumulates on broad surfaces now protected from alluvial activity by inset incised drainages; windblown material is commonly slightly to moderately reworked by water; locally buries or partly buries coarser gravel deposits (terrace or pediment-mantle deposits); commonly have thin to thick pedogenic carbonate (caliche) in upper part of deposit that indicates long period of soil development; 3 to 15 meters (10–50 ft) thick.

Mass-Movement Deposits

The quadrangle contains extensive mass-movement landslide deposits. Deposits on the flanks of the Escalante Mountains are differentiated as slump block masses, debris slides, and lobate slides following the mapping of Williams (1985), with some modifications by the authors. Other landslide deposits are not differentiated by type (Qms). Colluvium (Qc, Qcv) and some bedrock areas also contain undifferentiated landslides. Extensive debris-flow deposits are associated with the landslides; some are mapped as alluvial units (Qa, Qaf) while others are included in the various landslide map units.

Qmt **Talus deposits** (Holocene to middle Pleistocene) – Fallen, angular blocks that have accumulated at the base of steep slopes and cliffs; generally contain minor fine-grained matrix; composition and size of materials dependent on source bedrock; blocks are typically up to 3 meters (10 ft) in diameter but locally are 9 to 30 meters (30–100 ft) across; typically up to 9 meters (30 ft) thick.

Qms **Landslides and slumps, undifferentiated** (Holocene to Pleistocene) – Very poorly sorted, chaotic deposits ranging in composition from silt to large blocks several tens of meters in average diameter that moved down-slope by slumping, sheet-sliding, or flowing; upper surfaces are typically hummocky and some have closed depressions; most landslides and slumps are inactive but some show evidence of historical movement; involve most units but most detachment surfaces are in units containing abundant smectitic materials, including the tuffaceous sandstone unit, the Claron Formation, Tropic Shale, Morrison Formation, Carmel Formation, and Chinle Formation; locally include alluvial, colluvial, and eolian deposits; highly variable in thickness, generally 5 to 15 meters (16–50 ft) thick, but locally up to 90 meters (300 ft).

Qmsdm, Qmsdv, Qmsdt, Qmsdb

Landslides, debris-slide deposits (Holocene to Pleistocene): Qmsdm—mixed lithology, Qmsdv—mostly volcanic rock, Qmsdt—mostly tuffaceous sediments unit, Qmsdb—mostly Brian Head Formation – Very poorly sorted, chaotic boulders typically up to 9 meters (30 ft) in diameter in a sandy, silty matrix; moved downslope primarily as sheets or disarticulated flows; follows mapping of Williams (1985); upper surfaces are typically hummocky and some have closed depressions; most landslides and slumps are inactive but some show evidence of historical movement; most detachment surfaces are in units containing abundant smectitic materials; locally differentiated by primary involved units (last letter of label); typically 5 to 15 meters (16–50 ft) thick.

Qmsbm, Qmsbv, Qmsbo, Qmsbl, Qmsbj, Qmsbt, Qmsbb

Landslides, slump block deposits (Holocene to Pleistocene): Qmsbm—mixed lithology, Qmsbv—mostly volcanic rock, Qmsbo—mostly Osiris Tuff, Qmsbl—mostly tuff of Lake Creek, Qmsbj—mostly latite of Johnson Valley, Qmsbt—mostly tuffaceous sediments unit, Qmsbb—mostly Brian Head Formation – Large, intact blocks of rock that have separated from bedrock along distinct fractures and rotated backwards while sliding down-slope; follows mapping of Williams (1985); slumps of mixed lithology or primarily sedimentary rocks mapped as Qmsbm; upper surfaces are typically hummocky and some have closed depressions; most landslides and slumps are inactive but some show evidence of historical movement; most detachment surfaces are in units containing abundant smectitic materials; locally differentiated by primary involved units (last letter of label); slumps of more than one volcanic map unit mapped as Qmsbv; Qmsbt has high smectitic clay content and is primary detachment zone for many landslides; the slump complex on the west flank of the Escalante Mountains includes some slump blocks in excess of 2 km (1.2 mi) across with only minor internal deformation; this area is also complicated by the Paunsaugunt fault zone—some mapped slump scarps may have developed along fault scarps with part of the offset due to tectonic fault movment; some large coherent slump blocks are differentiated by involved bedrock unit; contacts are highly generalized.

Qmslm, Qmslv

Landslides, lobate slide debris (Holocene to Pleistocene): Qmslm—mixed lithology, Qmslv—mostly volcanic rock – Very poorly sorted, chaotic clay to boulder materials that primarily flowed rather than slid downslope; follows mapping of Williams (1985); typically has higher silty, sandy matrix content than sheet-slide deposits; forms hummocky, lobate mounds and ridges, flank levees, and closed depressions; most landslides and slumps are inactive but some show evidence of historical movement; most detachment surfaces are in units containing abundant smectitic materials; may include some debris-flow deposits; mapped as Qmslm where composed primarily of sedimentary rocks or rocks of mixed lithology; mapped as Qmslv where composed primarily of volcanic rock; 5 to 15 meters (16–50 ft), but locally may be up to 90 meters (300 ft) thick.

PALEOGENE-NEOGENE (TERTIARY)

Tb **Basalt** (probably Pliocene or Miocene) – Dark-gray, olivine-clinopyroxene-labradorite basalt in thin flows; commonly weathers to rough blocks; less than 60 meters (200 ft) thick on Aquarius Plateau. These small basalt outcrops, mapped only near the northern edge of the quadrangle, are part of a large group of basalt flows in the Loa 30′ x 60′ quadrangle to the north (Biek and others, 2015a). Biek and others noted that few of these relatively small-volume, widely scattered, basaltic lava flows are dated but most appear to be of Pliocene to middle Miocene age.

Tsr **Sevier River Formation** (probably Miocene) – Poorly to moderately sorted, crudely stratified conglomerate, sandstone, and siltstone derived mostly from volcanic source deposits; forms poorly exposed slopes and low hills mantled by colluvium and residuum; thickness 0 to 60 meters (0–200 ft); not dated in this area but in areas to northwest yielded isotopic ages of about 5 to 14 Ma (Steven and others, 1979; Best and others, 1980; Willis, 1988; Rowley and others, 1994, 2005; Biek and others, 2015a, 2015b).

Tsrd **Sevier River Formation over possible Mount Dutton Formation** (probably Miocene over Oligocene) – Poorly to moderately sorted, crudely stratified conglomerate, sandstone, and siltstone derived mostly from volcanic source deposits; poorly exposed due to colluvium and residuum cover; thickness 0 to 60 meters (0–200 ft). Dissected slopes (whalebacks) near the northwest quadrangle corner may consist of Sevier River Formation unconformably overlying Mount Dutton Formation, both mostly obscured by thin colluvium and residuum. Based on good exposures in the Panguitch 30′ x 60′ quadrangle about 1 kilometer (0.6 mi) west of the boundary, Biek and others (2015b) mapped Mount Dutton Formation to the quadrangle boundary, though exposures are poor near the boundary making identification uncertain. A few Sevier River Formation outcrops are exposed a few hundred meters east of the quadrangle boundary, but we have not recognized any exposed Mount Dutton Formation. Like Biek and others (2015b), we did not recognize a contact or fault in the poorly exposed interval between the Mount Dutton and Sevier River outcrops. Mapping to the north (Biek and others, 2015a) has Sevier River Formation against the quadrangle boundary, whereas mapping to the northwest (Rowley and others, 2005) has Mount Dutton Formation in its quadrangle corner. Additional mapping is planned for this area before final maps are published.

To **Osiris Tuff** (Miocene) – Gray, purplish-gray, and red-brown trachyte ash-flow tuff; densely welded; crystal rich; 20–25 percent phenocrysts of andesine, biotite, sanidine, minor quartz, and clinopyroxene; characterized by prominent black to coppery biotite and large white plagioclase phenocrysts; weathers to rounded boulders; thickness 0 to 180 meters (0–600 ft); early to middle Miocene age, about 23 Ma (summarized in Biek and others, 2017); Ball and others (2009) reported that several $^{40}Ar/^{39}Ar$ ages on sanidine average 23.03 ± 0.08 Ma.

Tlc **Trachyte of Lake Creek** (Oligocene) – Dark-gray to purplish-gray, aphyric to sparsely porphyritic, welded trachyte ash-flow tuff; commonly contains 5–10 percent phenocrysts of andesine, sanidine, and clinopyroxene; commonly weathers to thin plates and flat chips; probably about 25.3 to 25.8 Ma as summarized in Biek and others (2015a); thickness 0 to about 180 meters (0–600 ft); name is temporary pending completion of ongoing work to correlate and name volcanic rocks in this area as explained in Biek and others (2015a).

Tjv **Latite of Johnson Valley** (Oligocene) – Dark-gray, dark-brown, and dark-red, dense to vesicular, crystal-rich, blocky to massive basaltic trachyandesite flows and flow breccias; contains large distinctive green augite and equant labradorite, and less common olivine phenocrysts; probably about 26 Ma as summarized in Biek and others (2015a); thickness 0 to 215 meters (0–700 ft); name is temporary pending completion of ongoing work to correlate and name volcanic rocks in this area as explained in Biek and others (2015a).

Tvt **Tuffaceous sediments** (Oligocene to Eocene?) – White, pale-brown, and red tuffaceous siltstone, shale, arkosic sandstone, and pebble conglomerate in thin planar to thick lenticular beds; local silicified zones yield dense red, orange, yellow, and white chalcedony; exposed under cliffs of Tlc or Tjv; thickness 0 to 180 meters (0–600 ft); possibly equivalent to upper part of Brian Head Formation as mapped to north (Biek and others, 2015a) and west (Biek and others, 2015b).

Tbh **Brian Head Formation** (middle Eocene?) – Pink to red-brown to pale-gray sandstone, siltstone, mudstone, and limy mudstone; slope-former; interbedded with white to gray, fine- to coarse-grained sandstone; 3- to 9-meter-thick (10- to 30-ft) basal conglomerate contains well-rounded black chert, light quartzite, and gray limestone and is possibly equivalent to conglomerate at Boat Mesa (Bowers, 1990; Biek and others, 2015b); thickest exposures west of Griffin Top; pinches out to east near Rogers Peak; thickness 0 to 180 meters (0–600 ft), thickening northward.

Claron Formation (middle to lower Eocene)

Tcw **Claron Formation, white member** – White to light-gray limestone to muddy limestone and yellow-gray mudstone; limestone is very finely crystalline to microcrystalline and increases upward; some beds contain early to middle Eocene fresh-water gastropods; pinches out to east in upper part of North Creek; caps Table Cliff Plateau and forms vertical cliffs or steep forested slopes; thickness 0 to about 180 meters (0–600 ft).

Tcp **Claron Formation, pink member** – Pink, pale-orange, and light-gray, calcareous mudstone to white muddy limestone; commonly mottled pink or yellow; irregularly bedded to massive; contains thin gray to red limy mudstone interbeds; locally contains lenticular fine- to coarse-grained calcareous sandstone or calcarenite and thin (0.3–2 m; 1–6 ft) dark-gray microcrystalline limestone beds that contain dark shell fragments; overall has distinctive "salmon" pink color; forms deeply eroded cliffs, columns, and spires, or steep forested slopes; 0 to 270 meters (0–900 ft) thick; the basal Claron is early Eocene in age near Sweetwater Creek (Jeff Eaton, written communication, Jan. 24, 2018).

unconformity?

TERTIARY-CRETACEOUS

Ages of Pine Hollow, Grand Castle, and Canaan Peak Formation exposures in the Table Cliff Plateau area are not well established (Larson and others, 2010; Jeff Eaton, written communication, Jan. 24, 2018). Tentative ages assigned here are based on sparse, poorly constrained fossil and isotopic ages and stratigraphic relationships.

Tph **Pine Hollow Formation** (Paleocene?) – Purple-gray to red-brown conglomerate, mudstone, siltstone, and claystone; mudstone is commonly arenaceous and calcareous, locally grading to light-gray or white argillaceous or silty limestone; claystone is commonly smectitic, particularly near middle of formation; contains interbeds of gray, tan, or red, fine- to coarse-grained sandstone in lower part and thin conglomerate lenses mostly near base; generally poorly exposed around flanks of Table Cliff Plateau (figure 2); overlies Grand Castle or Canaan Peak Formation; thins to north; 0 to 135 meters (0–450 ft) thick (Bowers, 1972); probably Paleocene in age (Larsen and others, 2010; Jeff Eaton, written communication, Jan. 24, 2018).

possible unconformity?

Kcg **Grand Castle and Canaan Peak Formations, undivided** (Upper Cretaceous?, Maastrichtian? to upper Campanian?) – Grand Castle is boulder to pebble conglomerate and sandstone; clasts are quartzite, limestone, silicified carbonate, and minor dolostone and kaolinite (Goldstrand, 1990, 1994; Goldstrand and Mullett, 1997); Paleozoic fossils are common in carbonate clasts; highly variable in thickness, ranging from 0 to as much as 230 meters (0–750 ft) in short distances. Underlying Canaan Peak is interbedded sandstone, conglomeratic sandstone, and conglomerate; upper part is tan, pink, or red and lower part is light-brown or gray; contains well-rounded pebbles, cobbles, and small boulders of quartzite, chert, dense to porphyritic igneous rocks, and some gray limestone; boulders may locally exceed 30 cm (12 inches) in diameter; generally forms steep gravel-covered slopes; as much as 140 meters (460 ft) thick. The map unit is probably unconformable beneath the Pine Hollow Formation where present, and beneath the Claron Formation in other areas such as along Johns Valley anticline. It unconformably overlies the Kaiparowits Formation throughout the region. Larson and others (2010) maintained that the two formations cannot be distinguished in the quadrangle and called the entire interval Canaan Peak Formation. Biek and others (2015a) found evidence indicating that the Grand Castle is Late Cretaceous in age in the Panguitch 30′ x 60′ quadrangle to the west.

unconformity

CRETACEOUS

Cretaceous strata are exposed in two widely separated parts of the quadrangle, the Kaiparowits Plateau area in the western part, and the Henry (geologic) basin (Henry Mountains basin in some older reports but Henry basin is preferred usage) in the northeastern part northeast of Capitol Reef National Park (figure 2). Though some units are mostly correlative, they have different names and contacts (see figure 2 on plate 2). Most ages, correlations, and names used here are from Seymour and Fielding (2013); the formation rank of the Masuk and Muley Canyon units follows Eaton (1990).

Kk **Kaiparowits Formation** (*Kaiparowits Plateau area*) (Upper Cretaceous, middle to lower Campanian) – Green to brown-gray, very fine to fine-grained, friable sandstone; contains a few thin, light-gray mudstone interbeds and buff to brown, moderately resistant, lenticular, fine- to medium-grained sandstone interbeds; locally contains dinosaur bones, turtle shells, and fresh-water mollusks; weathers to badland topography or is poorly exposed; thins northward; correlative strata in Henry basin not preserved in quadrangle; base conformable and gradational with Wahweap Formation below; 365 to 915 meters (1200–3000 ft) thick.

Kw **Wahweap Formation** (*Kaiparowits Plateau area*) (Upper Cretaceous, middle to lower Campanian) – shown on cross sections.

Kwu **Upper member** (*Kaiparowits Plateau area*) (middle Campanian) – Light-gray to white sandstone; medium- to coarse-grained, massive, cross-bedded, cliff-forming, grades upward into the Kaiparowits Formation; approximately correlates with Tarantula Mesa Sandstone in Henry basin area; 75 to 150 meters (250–500 ft) thick.

Kwl **Lower member** (*Kaiparowits Plateau area*) (middle to lower Campanian) – Light- to dark-brown sandstone; fine- to medium-grained, cross-bedded, lenticular, with interbedded olive-gray to tan mudstone; lower part forms steep slope with local ledges and is conformable on Straight Cliffs Formation; approximately correlates with Masuk Formation in Henry basin area; 200 to 300 meters (660–1000 ft) thick.

Ktm **Tarantula Mesa Sandstone** (*Henry basin area*) (Upper Cretaceous, middle Campanian) – Yellow-gray to light-brown, fine- to medium-grained sandstone with partings of platy-weathering sandstone and gray sandy mudstone; intertongues with Masuk Member of Mancos Shale below; mostly cliff forming; approximately correlates with upper member of Wahweap Formation in Kaiparowits Plateau area; 70 to 120 meters (230–400 ft) thick.

Kmk **Masuk Formation** (*Henry basin area*) (middle to lower Campanian) – Sandy to silty, gray to olive-gray mudstone near the base, interbedded with light-yellow to brown sandstone beds that increase in number and thickness upward; sandstone beds are slope-forming, friable, and thin to thick bedded with local ledges; shales become more carbonaceous higher in the section and locally coaly; approximately correlates with lower member of Wahweap Formation in Kaiparowits Plateau area; 135 to 270 meters (450–900 ft) thick; see Eaton (1990) for nomenclature information.

Ks **Straight Cliffs Formation** (*Kaiparowits Plateau area*) (Upper Cretaceous, lower Campanian to lower Turonian)

Ksu **Drip Tank and John Henry Members, undivided** (upper members) (*Kaiparowits Plateau area*) – shown on cross sections

Ksd **Drip Tank Member** (*Kaiparowits Plateau area*) (Upper Cretaceous, lower Campanian) – Light-gray, gray-orange, and white sandstone; medium- to coarse-grained and locally conglomeratic, massive, cross-bedded, and cliff forming; base is reworked marine beach sand; approximately correlates with Muley Canyon Sandstone in Henry basin area; 60 to 120 meters (200–400 ft) thick.

Ksj **John Henry Member** (*Kaiparowits Plateau area*) (Upper Cretaceous, lower Campanian to lower Coniacian) – Interbedded light-yellow-orange, tan, and light-brown sandstone, olive-gray to tan mudstone, dark-gray to black carbonaceous mudstone, and coal; forms alternating cliffs and slopes; base may contain thin pebble conglomerate lenses and lower sandstone lenses may contain fragmentary inoceramus shells; base rests unconformably on lower member of Straight Cliffs Formation; contains commercial coal deposits in at least two zones–an upper or Alvey zone and a lower or Christensen-Henderson zone; approximately correlates with Blue Gate Shale Member of Mancos Shale in Henry basin area; 215 to 300 meters (700–1000 ft) thick.

unconformity

Ksl **Lower members** (*Kaiparowits Plateau area*) (Upper Cretaceous, lower Coniancian to lower Turonian) – Consists of combined Smoky Hollow and underlying Tibbett Canyon Members; Smoky Hollow Member consists of a white sandstone, medium- to very coarse grained, conglomeratic, massive, cross-bedded, and cliff-forming, 7.5 to 27 meters (25–90 ft) thick, overlying interbedded sandstone, mudstone, carbonaceous mudstone, and a few very thin impure coal beds; underlying Tibbet Canyon Member is tan to light-brown sandstone, fine-grained, partly cross-bedded, cliff forming, and marine, and intertongues with the Tropic Shale below; approximately correlates with Ferron Sandstone Member of Mancos Shale in Henry basin area; Smoky Hollow Member is 34 to 90 meters (110–300 ft) thick; Tibbet Canyon Member is 24 to 55 meters (80–180 ft) thick; entire unit is 60 to 140 meters (200–460 ft) thick.

Kmc **Muley Canyon Sandstone** (*Henry basin area*) (Upper Cretaceous, lower Campanian) – Upper part is light-brown, lenticular, cross-bedded sandstone at the top, up to 40 meters (130 ft) thick, that scours into a coal-bearing unit of interlensed sandstone, sandy shale, gray shale, carbonaceous shale, and coal, 0 to 15 meters (0–50 ft) thick; middle part is cliff-forming, massive, cross-bedded sandstone that is fine to medium grained, calcareous, with thin shale or sandy shale partings, and 30 to 60 meters (100–200 ft) thick; lower part is interbedded gray to tan sandstone and gray shale, transitional with the Blue Gate Shale Member, and up to 23 meters (75 ft) thick; approximately correlates with Drip Tank Member of Straight Cliffs Formation in Kaiparowits Plateau area; 37 to 120 meters (120–400 ft) thick; see Eaton (1990) for nomenclature information.

Km **Mancos Shale** (*Henry basin area*) (Upper Cretaceous, lower Campanian to upper Cenomanian)

Kmb **Blue Gate Shale Member** (*Henry basin area*) (Upper Cretaceous, lower Campanian to lower Coniacian) – Blue-gray, finely laminated mudstone, thin smectitic clay, and limestone beds in lower two-thirds; becomes progressively sandier in upper third by adding thin beds of yellow-gray calcareous sandstone toward the top; forms a fluted slope; may overlie the Ferron Sandstone Member unconformably; approximately correlates with John Henry Member of Straight Cliffs Formation in Kaiparowits Plateau area; 365 to 460 meters (1200–1500 ft) thick.

unconformity

Kmf **Ferron Sandstone Member** (*Henry basin area*) (Upper Cretaceous, middle Turonian) – Consists of three units (descending), a coal-bearing unit of interbedded lenticular sandstone, shale, carbonaceous shale and coal up to 21 meters (70 ft) thick; a cliff-forming unit of yellow-gray, tan, or brown fine- to coarse-grained sandstone that is cross-bedded, calcareous, and massive, with partings of shale or sandy shale, 18 to 60 meters (60–200 ft) thick; and a lower unit of interbedded gray to light-brown, very fine-grained sandstone and gray sandy shale, up to 27 meters (90 ft) thick; intertongues with the Tununk Shale Member below; lower contact is placed at base of the first prominent sandstone bed; approximately correlates with lower members of Straight Cliffs Formation in Kaiparowits Plateau area; 58 to 117 meters (190–385 ft) thick.

Kmt **Tununk Shale Member** (*Henry basin area*) (Upper Cretaceous, middle Turonian to upper Cenomanian) – Dark-gray to blue-gray, thinly laminated, marine shale that is calcareous and locally fossiliferous; forms a slope gradational with Naturita (Dakota) Sandstone; contains a few thin beds of very fine grained quartzose sandstone; approximately correlates with Tropic Shale in Kaiparowits Plateau area; 134 to 220 meters (440–720 ft) thick.

Kt **Tropic Shale** (*Kaiparowits Plateau area*) (Upper Cretaceous, lower Turonian to upper Cenomanian) – Medium- to olive-gray marine shale; contains thin tan, yellowish-gray, or light-brown, very fine grained to fine-grained sandstone interbeds in upper 30 meters (100 ft) and thin beds of bentonite and fossil-bearing limestone concretions near the base; forms steep slope; approximately correlates with Tununk Shale Member of Mancos Shale in Henry basin area; 180 to 270 meters (600–900 ft) thick.

Kn **Naturita Formation (formerly Dakota Formation)** (Cretaceous, Cenomanian to Albian) – Gray-orange to light-brown, moderately resistant, locally fossiliferous sandstone interbedded with light-olive-gray shale in upper half of formation; mostly thin, but locally thick, coal beds in middle of formation; dark-brown to black carbonaceous claystone, gray shale, and siltstone, and some beds of gray-orange to white coarse-grained sandstone in lower half of formation; locally channel conglomerate at base; forms ledges and slopes; Late Cretaceous in age; channel conglomerate at base may be separated from remainder of formation by an unconformity and may be Albian in age based on pollen (may be part of Cedar Mountain Formation) (Doelling and Davis, 1989); typically 24 to 60 meters (80–200 ft) thick, but locally varies from 0 to 107 meters (0–350 ft) thick.

unconformity; cuts deeper into underlying section to southwest

JURASSIC

Jm **Morrison Formation** (Upper Jurassic, Tithonian to Oxfordian) – Consists of Brushy Basin, Salt Wash, and possibly Tidwell Members, which are too thin to map separately; Brushy Basin Member is variegated mudstone and claystone, minor sandstone and conglomerate, mostly slope-forming, and 0 to 90 meters (0–300 ft) thick, thinning westward due to unconformity; underlying Salt Wash Member is mostly ledge- and cliff-forming, gray or yellow-gray, medium- to coarse-grained sandstone and conglomerate; conglomerate contains pebbles and cobbles of red, black and gray chert, petrified wood, and quartzite; contains a few interbeds of red and green siltstone; locally uraniferous and vanadiferous in the bases of channel sandstones; 0 to 137 meters (0–450 ft) thick, varying irregularly across the quadrangle; underlying Tidwell Member is alternating thin beds of light-gray and greenish-gray, fine-grained, calcareous sandstone and moderate-red or green shale; calcareous; beds on east side of Kaiparowits Plateau mapped by previous workers as Summerville Formation are here considered part of the Tidwell Member (the Tidwell Member in the Escalante area may include thin beds of actual Summerville Formation); Salt Wash is 0 to 55 meters (0–180 ft) thick; total Morrison Formation is 0 to 230 meters (0–750 ft) thick; sub-Naturita unconformity cuts increasingly deeper westward, and has cut out all of Morrison Formation in southwest corner of quadrangle.

unconformity

Jsce **Summerville, Curtis, and Entrada Formations, undivided** (Middle Jurassic, Oxfordian to Callovian) (locally includes Tidwell Member of Morrison Formation) – Mapped only along Waterpocket Fold in northeastern part of map; Summerville is red-brown, ribbed or thin-bedded siltstone and mudstone and brown to white, fine-grained sandstone; locally includes pink and white gypsum near top, generally forms a steep slope, about 9 meters (30 ft) thick; due to compilation from older maps and difficulty in mapping contact, upper part of Summerville interval includes interbedded red and gray mudstone, pink and white gypsum, gray limestone, and gray sandstone that are part of Tidwell Member of Morrison Formation; underlying Curtis Formation is up to 1.5 meters (5 ft) of discontinuous, ledge-forming, white, calcareous sandstone to sandy limestone that pinch out a few kilometers south of latitude 38° N.; top of Entrada is an unconformity; the Entrada Sandstone is slope- to cliff-forming, thin- to thick-bedded, reddish-brown sandstone and siltstone in upper and lower parts, separated by a middle silty, slope-forming unit; upper part of Entrada is 52 to 76 meters (170–250 ft) thick; middle part is 98 to 110 meters (320–360 ft) thick; lower part is 64 to 110 meters (210–365 ft) thick; Entrada ranges from 215 to 275 meters (700–900 ft) thick; map unit ranges from 225 to 285 meters (740–935 ft) thick.

unconformity?

Entrada Sandstone

Jeh **Henrieville bleached sandstone facies of Entrada Sandstone** (Middle Jurassic, Callovian) – White to pale-yellow, fine- to medium-grained, poorly sorted, calcareous sandstone, siltstone, claystone, and shale in upper part of Entrada Sandstone; highly altered by bleaching from overlying coaly beds in Naturita (Dakota) Formation; contains scattered coarse grains; lower part (25 to 33% of formation) is planar-bedded siltstone, claystone, and shale of probable fluvial origin; upper part is mostly cross-bedded sandstone of eolian origin; entire unit forms cliff or steep slope; present only in Tropic Ampitheater (SW corner of Escalante 30′ x 60′ and SE corner of Panguitch 30′ x 60′ quadrangle); upper part may include some beds that correlate with overlying unit; 0 to 70 meters (0–230 ft) thick.

Je **Entrada Sandstone, main part** (Middle Jurassic, Callovian) – Generally consists of upper, middle, and lower members that are not mapped separately; upper (Escalante Member) consists of 24 to 120 meters (80–400 ft) of white, light-gray, pale-orange, and yellow-brown, fine- to coarse-grained, massive, high-angle cross-bedded, cliff-forming sandstone; middle (Cannonville Member) consists chiefly of 60 to 128 meters (200–420 ft) of red-brown and gray-banded, slope-forming, silty sandstone and sandy siltstone; lower (Gunsight Butte Member) consists of 45 to 111 meters (150–365 ft) of red-brown, fine-grained, cross-bedded, cliff-forming or earthy-weathering, silty sandstone; total Entrada is 120 to 305 meters (400–1000 ft) thick.

Carmel Formation

Jcwp **Carmel Formation, Winsor and Paria River Members, undivided** – Consists of undifferentiated Winsor and Paria River Members in areas where too thin to map separately; 60 to 168 meters (200–550 ft) thick, thinner sections to east and south; conformable with Entrada Sandstone above.

Jcw **Winsor Member** (Middle Jurassic, Callovian) – Chiefly red-brown siltstone, yellow-brown fine-grained sandstone, and gypsum; 15 to 45 meters (50–150 ft) thick.

Jcp **Paria River Member** (Middle Jurassic, Bathonian) – Red mudstone and sandstone capped by chippy-weathering, white or pink, thin-bedded limestone; 45 to 120 meters (150–400 ft) thick.

Jtc **Carmel and Temple Cap Formations, undivided** (Middle Jurassic, Callovian to Aalenian) – shown on cross sections and mapped in Waterpocket Fold where steeply dipping formations are too thin in map view to map separately; from top: Winsor Member of Carmel Formation is chiefly red-brown siltstone, yellow-brown fine-grained sandstone, and gypsum 15 to 45 meters (50–150 ft) thick; Paria River Member is chiefly red-brown siltstone, yellow-brown fine-grained sandstone, and gypsum 15 to 45 meters (50–150 ft) thick; Thousand Pockets Member is light-gray-orange, fine- to medium-grained, cross-bedded sandstone 0 to 24 meters (0–80 ft) thick; Judd Hollow Member is chiefly red-brown siltstone or mudstone, commonly contorted fine-grained sandstone, and light-gray, thin-bedded limestone 0 to 33 meters (0–110 ft) thick, pinching out to south and east; Temple Cap Formation is light-gray-orange, cross-bedded, fine-grained sandstone with small chert pebbles at base, rests unconformably on Navajo Sandstone, and is 3 to 37 meters (10–120 ft) thick where exposed, generally thickening westward (see Doelling and others, 2013, for discussion of Temple Cap); entire map unit varies from about 50 to 120 meters (160–400 ft) thick. In many places, due to scale and difficulty in mapping the variable lower contact, part of the Temple Cap Formation is included in the underlying Navajo Sandstone.

Jctjt **Thousand Pockets and Judd Hollow Members of Carmel Formation, and Temple Cap Formation** (Middle Jurassic, Bathonian to Aalenian) – Consists of three generally thin units that are combined for mapping: (descending) Thousand Pockets Member of Carmel Formation, Judd Hollow Member of Carmel Formation, and Temple Cap Formation (Doelling and others, 2013); Thousand Pockets Member is light-gray-orange, fine- to medium-grained, cross-bedded sandstone, 0 to 24 meters (0–80 ft) thick; Judd Hollow Member is chiefly red-brown siltstone or mudstone, commonly contorted fine-grained sandstone, and light-gray, thin-bedded limestone 0 to 33 meters (0–110 ft) thick, pinching out to south and east; Temple Cap Formation is light-gray-orange, cross-bedded, fine-grained sandstone with small chert pebbles at base, rests unconformably on Navajo Sandstone, and is 3 to 37 meters (10–120 ft) thick where exposed, generally thickening westward; entire map unit is 18 to 70 meters (60–230 ft) thick. In subsurface in southwest part of map: Thousand Pockets (Jct on figure 2) is 10–60 meters (30–200 ft) thick; Judd Hollow (Jcj on figure 2) is 30-40 meters (100–135 ft). Along the Waterpocket Fold the map unit is too thin (9 to 18 meters [30–60 ft] thick) and the contact too indistinct to map and the unit is included with the Navajo Sandstone.

unconformity

Jn **Navajo Sandstone** (Lower Jurassic, Toarcian to Pliensbachian) (locally includes Temple Cap Formation) – Mostly light-gray-orange, white, gray, and pink, fine- to medium-grained sandstone; cross-bedded on a large scale with very thick cross-bed sets; lower 30 meters (100 ft) are generally planar bedded; crops out as cliffs, rounded to hummocky knobs and monuments, and bare slopes; 168 to 520 meters (550–1700 ft) thick, thickening generally westward.

Jk **Kayenta Formation** (Lower Jurassic, Pliensbachian to Sinemurian) – Gray-red, dusky red, purple-red, thin- to thick-bedded sandstone interbedded with lesser amounts of dusky-red siltstone, shale, light-yellow limestone, and intraformational conglomerate; contains some pink eolian sandstone beds near top that show large-scale cross-bedding; forms ledges, cliffs, and a few slopes; 60 to 110 meters (200–360 ft) thick.

JURASSIC-TRIASSIC

JŦgc **Glen Canyon Group** – Navajo, Kayenta, and Wingate Formations; shown on cross sections

JŦw **Wingate Sandstone** (Lower Jurassic to Upper Triassic, Hettangian to Rhaetian) – Orange-red, gray-red, and red-brown, fine-grained, well-sorted, large-scale cross-bedded, massive sandstone; generally forms vertical cliffs; around parts of the Circle Cliffs the lower part is bleached white to yellow-gray by hydrocarbons; unconformable contact with Chinle below is abrupt, but locally upper Chinle contains similarly colored, but planar sandstones; 60 to 120 meters (200–400 ft) thick.

unconformity

TRIASSIC

Ŧc **Chinle Formation** (Upper Triassic, Norian to Carnian) – shown on cross sections

Ŧcu **Church Rock, Owl Rock, Petrified Forest, and Monitor Butte Members, undivided** – These upper four members are combined in mapping; in descending order: the Church Rock Member is brown to red-brown, fine- to medium-grained, thin planar-bedded sandstone and siltstone and forms thick, blocky and cliffy beds with thin intervening slopes under Wingate Sandstone, and is 0 to 7.5 meters (0–25 ft) thick; the Owl Rock Member is red, brown, and green-gray, ledge- and slope-forming sandstone and green and gray, thin-bedded silty limestone beds with local nonbentonitic mudstones, 46 to 76 meters (150–250 ft) thick; the Petrified Forest Member is slope-forming variegated bentonitic mudstone with a few sandstone and conglomerate beds that bear petrified wood, 46 to 107 meters (150–350 ft) thick; and the Monitor Butte Member is green and gray bentonite, bentonitic mudstone, limestone-pebble conglomerate lentils, and rippled gray to dark-gray micaceous sandstone, 30 to 60 meters (100–200 ft) thick; four combined members are 90 to 245 meters (300–800 ft) thick.

ŦRcs **Shinarump Member** – Chiefly white, light-gray, or light-yellow, medium- to fine-grained, cross-bedded sandstone with minor conglomerate beds; contains interbeds of green-gray mudstone; contains carbonaceous and coaly material, especially near base; locally underlain by mottled siltstone with medium grains of quartz; discontinuous in Circle Cliffs area where consists of channels cut into top of Moenkopi Formation; thickest channels are locally mineralized with uranium, copper, lead, silver, and cobalt; 0 to 30 meters (0–100 ft) thick, thickening westward.

unconformity

ŦRm **Moenkopi Formation** (Lower Triassic, Anisian to Induan) – Divided into several unmapped members in the Circle Cliffs area, in descending order: Moody Canyon Member, Torrey Member, Sinbad Member, and Black Dragon Member; Moody Canyon Member is red-brown mudstone and yellow-gray sandstone, dolomite, and dolomitic sandstone forming ledgy slopes and cliffs, 60 to 98 meters (200–320 ft) thick; Torrey Member is light-yellow to dark-gray sandstone and siltstone, slope-forming with a few ledges; commonly saturated with oil or asphalt, 73 to 94 meters (240–310 ft) thick; Sinbad Member is brown and yellow-orange, oolitic, fossiliferous dolomite and conglomeratic dolomitic sandstone, 0 to 17 meters (0–55 ft) thick; Black Dragon Member consists of white to light-gray, fine-grained, dolomitic sandstone to sandy dolomite containing abundant fragments of white chert, 0 to 12 meters (0–40 ft) thick. The members generally thicken westward and northward from 88 meters (290 ft) in the east to 290 meters (950 ft) in the west (includes Timpoweap Member [ŦRmt] on figure 2). The Moenkopi changes in the subsurface such that it is divided into different members where encountered in drill holes in the western part of the quadrangle and where exposed just south and southwest of the quadrangle (Doelling and Willis, 2006, 2008; Doelling, 2008) (figure 2).

unconformity

PERMIAN

P **Permian Formations** (Lower Permian) – Undivided Kaibab Formation and White Rim Sandstone as mapped in the Circle Cliffs and undivided Permian units in the subsurface; Kaibab is light-yellow, thin-bedded, oolitic dolomite and thin-bedded, fine-grained, very light yellow, calcareous siltstone, and contains chert and chert layers in upper part, cliff-forming, 0 to 60 meters (0–200 ft) thick, thickening northward; White Rim Sandstone is light yellow-gray, thin- to thick-bedded, dolomitic sandstone overlying fine-grained sandstone with medium- to large-scale cross-beds, and is incompletely exposed.

SUBSURFACE UNITS

The following units are present in drill holes in the Upper Valley anticline in the Kaiparowits Basin.

Permian

Kaibab Formation: 43 to 60 meters (140–200 ft) thick (Pk on figure 2).

Toroweap Formation: 110 to 128 meters (360–420 ft) thick (Pt on figure 2).

Organ Rock Formation: 43 to 49 meters (140–160 ft) thick.

Cedar Mesa Sandstone (Queantoweap): 411 to 427 meters (1350–1400 ft) thick.

Pennsylvanian

Hermosa Formation: about 104 meters (340 ft) thick.

Molas Formation: 12 to 21 meters (40–70 ft) thick.

Mississippian

Redwall Limestone: about 274 meters (900 ft) thick.

Devonian

about 119 meters (390 ft) thick.

Cambrian

30+ meters (100+ ft) thick.

REFERENCES CITED

Numbers indicate source maps shown in figure 1 on plate 2, which were slightly to extensively modified for compilation into original map.

Ball, J.L., Bailey, C., and Kunk, M.J., 2009, Volcanism on the Fish Lake Plateau, central Utah: Geological Society of America Abstracts with Programs, v. 41, no. 6, p. 17.

Best, M.G., McKee, E.H., and Damon, P.E., 1980, Space-time-composition patterns of late Cenozoic mafic volcanism, southwestern Utah and adjoining areas: American Journal of Science, v. 280, p. 1035–1050.

Biek, R.F., Eaton, J.G., Rowley, P.D., and Mattox, S.R., 2015a, Interim geologic map of [part of] the western Loa 30′ x 60′ quadrangle, Garfield, Piute, and Wayne Counties, Utah (year 2): Utah Geological Survey Open-File Report 648, 20 p., scale 1:62,500.

Biek, R.F., Rowley, P.D., Anderson, J.J., Maldonado, F., Moore, D.W., Hacker, D.B., Eaton, J.G., Hereford, R., Sable, E.G., Filkorn, H.F., and Matyjasik, B., 2015b, Geologic map of the Panguitch 30′ x 60′ quadrangle, Garfield, Iron, and Kane Counties, Utah: Utah Geological Survey Map 270DM, 3 pl., 159 p., scale 1:62,500, GIS data.

Biek, R.F., Martram, H., Fleming, Z., Wenrich, E., Bailey, C., and Steele, P., 2017, Interim geologic map of the Lyman quadrangle, Wayne County, Utah: Utah Geological Survey Open-File Report 668, 15 p., 2 pl., scale 1:24,000.

[1]Billingsley, G.H., Hunton, P.W., and Breed, W.J., 1987, Geologic map of Capitol Reef National Park and vicinity, Emery, Garfield, Emery, and Wayne Counties, Utah: Utah Geological and Mineral Survey Map 87, scale 1:62,500.

Bowers, W.E., 1972, The Canaan Peak, Pine Hollow, and Wasatch Formations in the Table Cliff region, Garfield County, Utah: U.S. Geological Survey Bulletin 1331-B, 39 p.

[2]Bowers, W.E., 1973, Geologic map and coal resources of the Upper Valley quadrangle, Garfield County, Utah: U.S. Geological Survey Map C-60, scale 1:24,000.

[3]Bowers, W.E, 1974a, Geologic map and coal resources of the Griffin Point quadrangle, Garfield County, Utah: U.S. Geological Survey Map C-61, scale 1:24,000.

[4]Bowers, W.E., 1974b, Geologic map and coal resources of the Pine Lake quadrangle, Garfield County, Utah: U.S. Geological Survey Map C-66, scale 1:24,000.

[5]Bowers, W.E., 1975, Geologic map and coal resources of the Henrieville quadrangle, Garfield and Kane Counties, Utah: U.S. Geological Survey Map C-74, scale 1:24,000.

[6]Bowers, W.E., 1981, Geologic map and coal deposits of the Canaan Peak quadrangle, Garfield and Kane Counties, Utah: U.S. Geological Survey Map C-90, scale 1:24,000.

Bowers, W.E., 1990, Geologic map of Bryce Canyon National Park and vicinity, southwestern Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-2108, 15 p., 1 plate, scale 1:24,000.

[7]Davidson, E.S., 1967, Geology of the Circle Cliffs area, Garfield and Kane Counties, Utah: U.S. Geological Survey Bulletin 1229, 140 p., scale 1:48,000.

Doelling, H.H., 2008, Geologic map of the Kanab 30′ x 60′ quadrangle, Kane and Washington Counties, Utah, and Coconino and Mohave Counties, Arizona: Utah Geological Survey Miscellaneous Publication MP-08-2DM, scale 1:100,000.

[8]Doelling, H.H., in preparation, Geologic field map of the Sunset Flat quadrangle, Garfield and Kane Counties, Utah: Utah Geological Survey unpublished map, scale 1:40,000.

[9]Doelling, H.H., and Davis, F.D., 1989, The geology of Kane County, Utah: Utah Geological and Mineral Survey Bulletin 124, 192 p., scale 1:100,000.

Doelling, H.H., Sprinkel, D.A., Kowallis, B.J., and Kuehne, P.A., 2013, Temple Cap and Carmel Formations in the Henry Mountains basin, Wayne and Garfield Counties, Utah, *in* Morris, T.H., and Ressetar, R., editors, The San Rafael Swell and Henry Mountains Basin—geologic centerpiece of Utah: Utah Geological Association Publication 42, p. 279–318.

Doelling, H.H., and Willis, G.C., 1999, Interim geologic map of the Escalante and parts of the Loa and Hite Crossing 30′ x 60′ quadrangles, Garfield and Kane Counties, Utah: Utah Geological Survey Open-File Report 368, 19 p., 2 plates, scale 1:100,000.

Doelling, H.H., and Willis, G.C., 2006, Geologic map of the Smoky Mountain 30′ x 60′ quadrangle, Kane and San Juan Counties, Utah and Coconino County, Arizona: Utah Geological Survey Map 213, 2 plates, scale 1:100,000.

Doelling, H.H., and Willis, G.C., 2008, Geologic map of the Smoky Mountain 30′ x 60′ quadrangle, Kane and San Juan Counties, Utah and Coconino County, Arizona: Utah Geological Survey Map 213DM, 2 plates, GIS data, scale 1:100,000.

Eaton, J.G., 1990, Stratigraphic revision of Campanian (Upper Cretaceous) rocks in the Henry Basin, Utah: The Mountain Geologist, v. 27, no. 1, p. 27–38.

Goldstrand, P.M., 1990, Stratigraphy and paleogeography of Late Cretaceous and Paleogene rocks of southwest Utah: Utah Geological Survey Miscellaneous Publication 90-2, 58 p.

Goldstrand, P.M., 1994, Tectonic development of Upper Cretaceous to Eocene strata of southwestern Utah: Geological Society of America Bulletin, v. 106, p. 145–154.

Goldstrand, P.M., and Mullett, D.J., 1997, The Paleocene Grand Castle Formation—a new formation on the Markagunt Plateau of southwestern Utah, *in* Maldonado, F., and Nealey, L.D., editors, Geologic studies in the Basin and Range-Colorado Plateau transition zone in southeastern Nevada, southwestern Utah, and northwestern Arizona, 1995: U.S. Geological Survey Bulletin 2153, p. 59–78.

Larsen, J.S., Link, P.K., Roberts, E.M., Tapanila, L., and Fanning, C.M., 2010, Cyclic stratigraphy of the Paleogene Pine Hollow Formation and detrital zircon provenance of Campanian to Eocene sandstones of the Kaiparowits and Table Cliff basins, south-central Utah, *in* Carney, S.M., Tabet, D.E., and Johnson, C.L., editors, Geology of south-central Utah: Utah Geological Association Publication 39, p. 194–224.

[10]Miller, G.A., and Cadigan, R.A., 1958, Preliminary geologic map of the Circle Cliffs 2 NE (Steep Creek Bench) quadrangle, Garfield County, Utah: U.S. Geological Survey Mineral Investigations Field Studies Map MF-157, scale 1:24,000.

Rowley, P.D., Mehnert, H.H., Naeser, C.W., Snee, L.W., Cunningham, C.G., Steven, T.A., Anderson, J.J., Sable, E.G., and Anderson, R.E., 1994, Isotopic ages and stratigraphy of Cenozoic rocks of the Marysvale volcanic field and adjacent areas, west-central Utah: U.S. Geological Survey Bulletin 2071, 35 p.

Rowley, P.D., Vice, G.S., McDonald, R.E., Anderson, J.J., Machette, M.N., Maxwell, D.J., Ekren, E.B., Cunningham, C.G., Steven, T.A., and Wardlaw, B.R., 2005, Interim geologic map of the Beaver 30′ x 60′ quadrangle, Beaver, Piute, Iron, and Garfield Counties, Utah: Utah Geological Survey Open-File Report 454, 27 p., 1 plate, scale 1:100,000.

[11]Sargent, K.A., and Hansen, D.E., 1982, Bedrock geologic map of the Kaiparowits coal-basin area, Utah: U.S. Geological Survey Miscellaneous Investigations Series I-1033-I, scale 1:125,000.

Seymour, D.L., and Fielding, C.R., 2013, High resolution correlation of the Upper Cretaceous stratigraphy between the Book Cliffs and the western Henry Mountains syncline, Utah, U.S.A.: Journal of Sedimentary Research, v. 83, p. 475–494.

[12]Stephens, E.V., 1973, Geologic map and coal resources of the Wide Hollow Reservoir quadrangle, Garfield County, Utah: U.S. Geological Survey Map C-55, scale 1:24,000.

Steven, T.A., Cunningham, C.G., Naeser, C.W., and Mehnert, H.H., 1979, Revised stratigraphy and radiometric ages of volcanic rocks and mineral deposits in the Marysvale area, west-central Utah: U.S. Geological Survey Bulletin 1469, 40 p.

[13]Weir, G.W., and Beard, L.S., 1990a, Geologic map of the Red Breaks quadrangle, Garfield County, Utah: Utah Geological and Mineral Survey Map 117, scale 1:24,000.

[14]Weir, G.W., and Beard, L.S., 1990b, Geologic map of the Tenmile Flat quadrangle, Garfield County, Utah: Utah Geological and Mineral Survey Map 118, scale 1:24,000.

[15]Weir, G.W., and Beard, L.S., 1990c, Geologic map of the King Bench quadrangle, Garfield County, Utah: Utah Geological and Mineral Survey Map 119, scale 1:24,000.

[16]Weir, G.W., and Beard, L.S., 1990d, Geologic map of the Calf Creek quadrangle, Garfield County, Utah: Utah Geological and Mineral Survey Map 120, scale 1:24,000.

[17]Weir, G.W., Williams, V.S., and Beard, L.S., 1990, Geologic map of the Roger Peak quadrangle, Garfield County, Utah: Utah Geological and Mineral Survey Map 115, scale 1:24,000.

[18]Williams, V.S., 1985, Surficial geologic map of the Kaiparowits coal-basin area, Utah: U.S. Geological Survey Miscellaneous Investigations Series I-1033-L, scale 1:125,000.

[19]Williams, V.S., Weir, G.W., and Beard, L.S., 1990, Geologic map of the Escalante quadrangle, Garfield County, Utah: Utah Geological and Mineral Survey Map 116, scale 1:24,000.

Willis, G.C., 1988, Geologic map of the Aurora quadrangle, Sevier County, Utah: Utah Geological Survey Map 112, 21 p., 2 plates, scale 1:24,000.

[20]Zeller, H.D., 1974a, Geologic map and coal resources of the Carcass Canyon quadrangle, Garfield and Kane Counties, Utah: U.S. Geological Survey Coal Investigations Series Map C-65, scale 1:24,000.

[21]Zeller, H.D., 1974b, Geologic map and coal and oil resources of the Canaan Creek quadrangle, Garfield County, Utah: U.S. Geological Survey Coal Investigations Series Map C-57, scale 1:24,000.

[22]Zeller, H.D., 1973a, Geologic map and coal resources of the Death Ridge quadrangle, Garfield County, Utah: U.S. Geological Survey Coal Investigations Series Map C-58, scale 1:24,000.

[23]Zeller, H.D., 1973b, Geologic map and coal resources of the Dave Canyon quadrangle, Garfield County, Utah: U.S. Geological Survey Coal Investigations Series Map C-59, scale 1:24,000.

[24]Zeller, H.D., and Stephens, 1973, Geologic map and coal resources of the Seep Flat quadrangle, Garfield and Kane Counties, Utah: U.S. Geological Survey Coal Investigations Series Map C-65, scale 1:24,000.