INTERIM GEOLOGIC MAP OF THE MOUNT CARMEL QUADRANGLE, KANE COUNTY, UTAH

by

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Description of Map Units

QUATERNARY

Artificial deposits

Qf **Artificial fill deposits** (Historical) – Artificial fill used to create waste-water treatment ponds, small dams and road bases; consists of engineered fill and general borrow material; although only a few deposits have been mapped, fill should be anticipated in all built-up areas, many of which are shown on the topographic base map; 0 to 30 feet (0-9 m) thick.

Alluvial deposits

Qal_1 **Stream alluvium** (Holocene) – Moderately to well-sorted clay to boulder deposits in large, active drainages; mapped along North Fork of the Virgin River and its larger tributaries; includes stream-terrace deposits as much as 10 feet (3 m) above modern channels; 0 to 30 feet (0-9 m) thick.

Qat_2 **Stream-terrace deposits** (Holocene to upper Pleistocene) – Moderately to well-sorted sand, silt, and pebble to boulder gravel that forms level to gently sloping surfaces about 10 to 50 feet (3-15 m) above modern drainages; deposited primarily in stream-channel and flood-plain environments; may include poorly sorted alluvial-fan deposits, slope wash, and minor talus too small to map separately; older part of deposits have calcic soils that exhibit stage II pedogenic carbonate development (Birkeland and others, 1991); upper reaches still receive sediment, but deposits are being incised by North Fork of the Virgin River and its tributaries; 0 to 30 feet (0-9 m) thick.

Qafy **Alluvial-fan deposits** (Holocene) – Non-stratified, poorly to moderately sorted, subangular to subrounded, clay- to boulder-size sediment deposited at the mouths of active drainages; clast composition varies, reflecting rock types exposed in drainage basins upstream; primarily deposited as debris flows on active depositional surfaces; usually 10 to 30 feet (3-9 m) thick.

Qag **Alluvial-gravel deposits** (Holocene to middle Pleistocene) – Poorly to well sorted, subangular to rounded, gravel- and cobble-sized clasts locally mixed with sand and interbedded with silt and mud; deposited principally as debris flows on pediment surfaces and as higher stream-terrace and channel-fill deposits; clasts vary with source, reflecting rock types exposed in drainage basins upstream, from locally derived sandstone to transported quartzite cobbles; 0 to 180 feet (0-55 m) thick.

Eolian deposits

Qes **Eolian-sand deposits** (Holocene to upper Pleistocene) – Well- to very well sorted, very fine to medium-grained, well-rounded, mostly quartz sand derived principally from the Navajo Sandstone; commonly deposited in irregular hummocky mounds on the lee side of ridges, primarily on the Navajo Sandstone but also mapped on adjacent Jurassic units as well as on alluvial-gravel (Qag) and in mixed eolian and alluvial (Qea) deposits; 0 to 20 feet (0-6 m) thick.

Mass-movement deposits

Qmt **Talus** (Holocene to upper Pleistocene) – Very poorly sorted, angular boulders with fine-grained interstitial sediment; deposited mostly by rock fall and sand flow on and at the base of steep slopes; forms primarily from blocks and sand that weather from the Navajo Sandstone; locally contains small landslide and slump deposits; mantles slopes beneath cliffs and ledges; 0 to 20 feet (0-6 m) thick.

Mixed-environment deposits

Qac **Mixed alluvial and colluvial deposits** (Holocene to upper Pleistocene) – Poorly to moderately sorted, clay- to boulder-sized, locally derived sediment deposited in swales and minor active drainages by fluvial, slope-wash, and creep processes; some deposits downstream from the Paria River Member of the Carmel Formation include secondary gypsum (gypcrete) deposition; gradational with alluvial-stream (Qal_1) and mixed alluvial and eolian (Qae) deposits; 0 to 30 feet (0-9 m) thick.

Qaco **Older mixed alluvial and colluvial deposits** (Pleistocene) – Poorly to moderately sorted, clay- to boulder-sized, locally derived sediment deposited primarily in stream-channel and flood-plain environments but also by slope-wash and creep processes, forming level to gently sloping surfaces about 10 to 50 feet (3-15 m) above modern drainages; mapped along the edges of small, active drainages (Qac) such as Sethys Canyon in the southwest corner of the map area; 0 to 20 feet (0-6 m) thick.

Qea **Mixed eolian and alluvial deposits** (Holocene to upper Pleistocene) – Moderately to well-sorted, fine- to medium-grained eolian sand partially reworked by alluvial processes; includes some poorly to moderately sorted gravel to mud deposited in minor channels; 0 to 20 feet (0-6 m) thick.

unconformity

CRETACEOUS

Kt? Tropic Shale (Upper Cretaceous) – Shown in cross section only. The formation thickens eastward across the Kanab 30’ x 60’ quadrangle from just a feet thick north of Zion Canyon (Biek and Hylland, 2007) to 1000 feet (300 m) thick in the vicinity of Bryce Canyon National Park (Doelling, 2008).

Kd **Dakota Formation** (uppermost Lower? and Upper Cretaceous) – Steep, slope-forming, light-olive-gray to medium-light-gray mudstone and siltstone interbedded with ledge-forming, pale-yellowish-brown, thick-bedded, fine- to medium-grained sandstone and thin, less than one-foot-thick (0.3 m), coal beds near the base and top of the formation; locally, channel-fill conglomerate to very coarse grained sandstone up to 10 feet (3 m) thick lies at base of the formation above the K unconformity of Pipiringos and O’Sullivan (1978); basal conglomerate may be separated from the rest of the formation by an unconformity since a pollen assemblage from a sample of the lower part indicates a late Early Cretaceous age (Doelling and Davis, 1989), and may be equivalent to the Cedar

Mountain Formation of Biek and Hylland (2007); conglomerate clasts are well-rounded, pebble- to cobble-size quartzite, limestone, and chert and subangular, local petrified wood; although Dakota strata are typically poorly exposed and involved in large landslides throughout southern Utah, exposures in this quadrangle are good and landslides, mostly along the fault zone, are minimal and not mapped separately; however, large landslides are present just north of the quadrangle boundary; unconformable lower contact is drawn at the base of the gray mudstone or, where present, the sandstone to conglomerate beds, and above the friable, yellowish-gray sandstone of the Winsor Member of the Carmel Formation; forms basal portion of the Gray Cliffs step of the Grand Staircase (Gregory, 1950); marine pelecypods and scarce ammonoids occur in lower and upper parts (Sable and Hereford, 2004); deposited in a variety of flood-plain, estuarine, lagoonal, and swamp environments (Gustason, 1989; Laurin and Sageman, 2001; Tibert and others, 2003); Biek and Hylland (2007) placed the upper contact, which is gradational and intertongues with the overlying Tropic Shale, at the top of the "sugarledge sandstone," whereas Doelling (2008) included the "sugarledge sandstone" in the Tropic Shale, with the result that reported thicknesses of Dakota and Tropic strata differ in the west and central parts of the Kanab 30' x 60' quadrangle; the exposed thickness of Dakota strata in this quadrangle is as much as 160 feet (50 m).

K unconformity (Pipiringos and O'Sullivan, 1978)

JURASSIC

Carmel Formation

The Carmel Formation was named by Gilluly and Reeside (1926) and first described by Gregory and Moore (1931) for rocks exposed near Mount Carmel, within this quadrangle; this report follows the nomenclature of Doelling and Davis (1989), who divided the formation into four members, all of Middle Jurassic age (Imlay, 1980).

Jcw **Winsor Member** (Middle Jurassic) **–** Dusky yellow to yellowish-gray, very fine to medium-grained, friable sandstone and minor pinkish-gray to pale-pink siltstone; poorly cemented, thus poorly exposed; weathers to steep, yet smooth and rounded, vegetated slopes; lower conformable contact drawn where the yellowish-gray sandstone gives way to mostly pinkish-gray to pale-pink siltstone and limestone of the Paria River Member; mapped in the hills behind the town of Mount Carmel and in the northwest part of the quadrangle; deposited on a broad, sandy mudflat (Imlay, 1980; Blakey and others, 1983); about 60 to 80 feet (18-25 m) thick.

Jcp **Paria River Member** (Middle Jurassic) **–** Pinkish-gray to pale-pink siltstone and very thin bedded, yellowish-gray to grayish-orange-pink limestone and micritic limestone that overlies a basal, thick-bedded, white, alabaster gypsum bed 5 to 12 feet (1.5-4 m) thick; limestone weathers to small chips and plates and locally contains casts and molds of small pelecypods (Doelling, 2008); basal gypsum forms ledge while the overlying layers form a steep slope; lower conformable contact is sharp and broadly wavy at the base of the massive gypsum bed above the variegated moderate-reddish-brown to pinkish-gray gypsiferous siltstone and mudstone of the Crystal Creek Member; mapped in the northwest corner of the quadrangle and along the northwest-trending fault zone that extends south from Mount Carmel Junction; deposited in shallow-marine and coastal-sabkha environments (Imlay, 1980; Blakey and others, 1983); 80 to 140 feet (25-40 m) thick.

Jcx **Crystal Creek Member** (Middle Jurassic) – Alternating bands of thin- to medium-bedded, pale- to moderate-reddish-brown, gypsiferous siltstone and very fine to medium-grained sandstone, and gypsum with thin interbeds of pinkish-gray mudstone; friable; forms vegetated slopes; poorly exposed except in road cuts and along fault zones; lower conformable contact is at the base of the alternating, pale- to moderate-reddish-brown bands of siltstone, above the light-olive-gray interbedded shale and limestone of the Co-op Creek Limestone Member; Kowallis and others (2001) reported two $^{40}Ar/^{39}Ar$ ages of 167 to 166 million years old for altered volcanic ash beds (likely derived from a magmatic arc in what is now southern California and western Nevada) within the member near Gunlock, about 50 miles (80 km) west of the quadrangle; deposited in coastal-sabkha and tidal-flat environments (Imlay, 1980; Blakey and others, 1983); about 120 to 150 feet (35-45 m) thick.

Jcc **Co-op Creek Limestone Member** (Middle Jurassic) **–** Light-olive-gray to light-gray, thin- to medium-bedded, micritic limestone and sandy limestone interbedded with mostly light-gray, thinly laminated to thin-bedded, micritic limestone, calcareous shale, platy limestone, and very fine to fine-grained sandstone; forms ledge to small cliff near base and top with steep, ledgy slope in between; sparsely vegetated; locally contains *Isocrinus* sp. crinoid columnals, pelecypods, and gastropods especially in the upper beds, and Tang and others (2000) reported significant crinoid-bearing beds in the upper part of the unusually thick, lower limestone ledge at Mount Carmel Junction; lower unconformable contact is at the base of reddish-brown to light-gray sandy siltstone that underlies the lower limestone ledge, above the massively cross-bedded, very light gray to grayish-pink sandstone of the White Throne Member of the Temple Cap Formation; Kowallis and others (2001) reported several $^{40}Ar/^{39}Ar$ ages of 168 to 167 million years old for altered volcanic ash beds (likely derived from a magmatic arc in what is now southern California and western Nevada) within the lower part of the member in southwest Utah; deposited in a shallow-marine environment (Imlay, 1980; Blakey and others, 1983); 160 to 200 feet (50-60 m) thick.

J-2 unconformity (Pipiringos and O'Sullivan, 1978), formed about 169 to 168 million years ago in southwest Utah (Kowallis and others, 2001)

Jt **Temple Cap Formation** (Middle Jurassic) **–** Consists of two interfingering members that are mapped as one unit because of eastward thinning of the lower member. Upper **White Throne Member** is yellowish-gray to pale-orange, very thick bedded, well-sorted, fine-grained quartz sandstone with high-angle cross-bed sets as much as 20 feet (6 m) thick; cliff forming, similar to the Navajo Sandstone but much less resistant to erosion; basal grayish-red, blocky, angular weathering sandstone forms a ledge; deposited in coastal dune field (Blakey, 1994; Peterson, 1994); 120 to 200 feet (35-60 m) thick. Lower

Sinawava Member is moderate-reddish-brown mudstone, siltstone, and very fine grained, gypsiferous, silty sandstone; thins eastward; where present, it forms a prominent, narrow, vegetated slope at the top of the Navajo Sandstone; weathered reddish-brown clay particles form vertical streaks as they stain the upper "white" portion of the Navajo Sandstone red; lower, unconformable contact is at the base of the moderate-reddish-brown mudstone slope, or where not present, at the break in slope, above the vertical cliff of the massively bedded, light-gray Navajo Sandstone; deposited in coastal-sabkha and tidal-flat environments (Blakey, 1994; Peterson, 1994); Kowallis and others (2001) reported several $^{40}Ar/^{39}Ar$ ages of 170 to 169 million years old for altered volcanic ash beds (likely derived from a magmatic arc in what is now southern California and western Nevada) within the Sinawava Member in southwest Utah; 0 to 15 feet (0-5 m) thick.

J-1 unconformity (Pipiringos and O'Sullivan, 1978), formed prior to about 170.5 million years ago in southwest Utah (Kowallis and others, 2001)

Jn **Navajo Sandstone** (Lower Jurassic) **–** Light-gray to pale-orange in upper part and moderate-reddish-orange to moderate-reddish-brown in the lower part, massively cross-bedded, moderately well-cemented sandstone with well-rounded, fine- to medium-grained, frosted quartz sand grains; locally, ironstone bands, and concretions called "Moki marbles," are common; strongly jointed (see Rogers and Engelder, 2004; Rogers and others, 2004); forms the White Cliffs step of the Grand Staircase (Gregory, 1950); based on color and weathering, divisible into three informal units of roughly equal thickness (Doelling, 2008) (but not mapped separately): (1) "white" sandstone, which forms the upper part of the Navajo Sandstone, is less resistant than the "brown" sandstone at the base of the formation and is pale gray, yellowish gray, and orangish gray because of alteration, remobilization, and bleaching of limonite and hematite cement, probably because of hydrocarbon migration (see Beitler and others, 2003); (2) "pink" sandstone, which forms the middle part of the Navajo Sandstone, is generally the least resistant of the three units, is the most covered with eolian sand, and is pale-reddish-orange due to more uniformly dispersed hematite cement; and (3) "brown" or red sandstone, which forms the lower massive cliff of the Navajo Sandstone that is only partly exposed in the quadrangle, is streaked medium- to dark reddish-brown because of iron oxide remobilization caused by ground-water or hydrocarbon migration; the Navajo Sandstone is the main aquifer for much of the region (Heilweil and others, 2002; Rowley and Dixon, 2004); deposited in a vast coastal and inland dune field with prevailing winds principally from the north, with rare interdunal ephemeral lakes (Blakey, 1994; Peterson, 1994); originally, much of the sand may have been carried to the area by a transcontinental river system that eroded Grenvillian-age (about 1.0 to 1.3 billion-year-old) crust that was involved in the Appalachian orogenesis of eastern North America (Dickinson and Gehrels, 2003; Rahl and others, 2003); map unit includes areas of weathered sandstone regolith and Quaternary eolian sand too small to map separately; only upper 1400 feet (450 m) is present in the quadrangle, but total thickness in this area is 1800 to 2000 feet (550-600 m) (Sargent and Philpott, 1987).

Subsurface Unit

MzPzu Mesozoic-Paleozoic, undivided – shown on cross section only.

Sevier Fault Zone

The approximately 300-mile-long (480 km) Sevier fault zone extends from about 35 miles (56 km) south of the Grand Canyon in Arizona north to central Utah (Doelling and Davis, 1989). It has been divided into four sections as reported by Lund and others (2008), with the section boundary between the northernmost Sevier section and the Northern Toroweap section to the south lying within the Mount Carmel quadrangle at Clay Flat. This section boundary is also considered a probable seismogenic segment boundary (Lund and others, 2008). North of the quadrangle, the Sevier fault has displaced Quaternary volcanic rocks at Black Mountain and Red Canyon. Schiefelbein (2002) mapped four strands of the fault cutting 0.57 $\pm$ 0.02 million-year-old Black Mountain volcanic rocks where complex geologic relations are complicated by poor exposures, pre-basalt topography, and landslides. Initiation of faulting on the Sevier fault is estimated to be 12 to 15 million years ago (Davis, 1999); Lund and others (2008) used that age to calculate a poorly constrained middle Miocene to present vertical slip rate of 0.002 inches/year (0.04 mm/yr) at this location with an average recurrence interval of 50 ka. The average vertical slip rate increases to 0.003 inches/yr (0.07 mm/yr) and the average recurrence interval decreases to 29 ka for the fault segment that includes Red Canyon (Lund and others, 2008). No historical earthquakes have ruptured the surface and there are no scarps on unconsolidated deposits on the Utah portion on the fault (Lund and others, 2008). Paleoseismic information is summarized on the U.S. Geological Survey Quaternary Fault and Fold Database of the United States at http://earthquake.usgs.gov/regional/qfaults/.

Within the Mount Carmel quadrangle, the generally north-northeastward-striking faults that comprise the fault zone are high-angle normal faults, typically with down-to-the-west displacement. Some blocks between these faults are moderately tilted to perhaps 40^{o}, as near the north edge of the quadrangle. Just east of the town of Mount Carmel, displacement reaches approximately 1600 feet (500 m) with the Dakota Formation on the downthrown block juxtaposed against the Navajo Sandstone. In the quadrangle, the more resistant Navajo Sandstone on the upthrown block forms an escarpment as much as several hundred feet tall. The more developed drainages coming off of these cliffs cut down into the sandstone, creating slot canyons.

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MAP SYMBOLS

Contact

Normal fault

dashed where location inferred; dotted where concealed; bar and ball on downthrown side

Structure contour on top of the Navajo Sandstone

short dash where projected; contour interval 100 feet

Strike and dip of bedding

inclined

horizontal

Joint nearly vertical

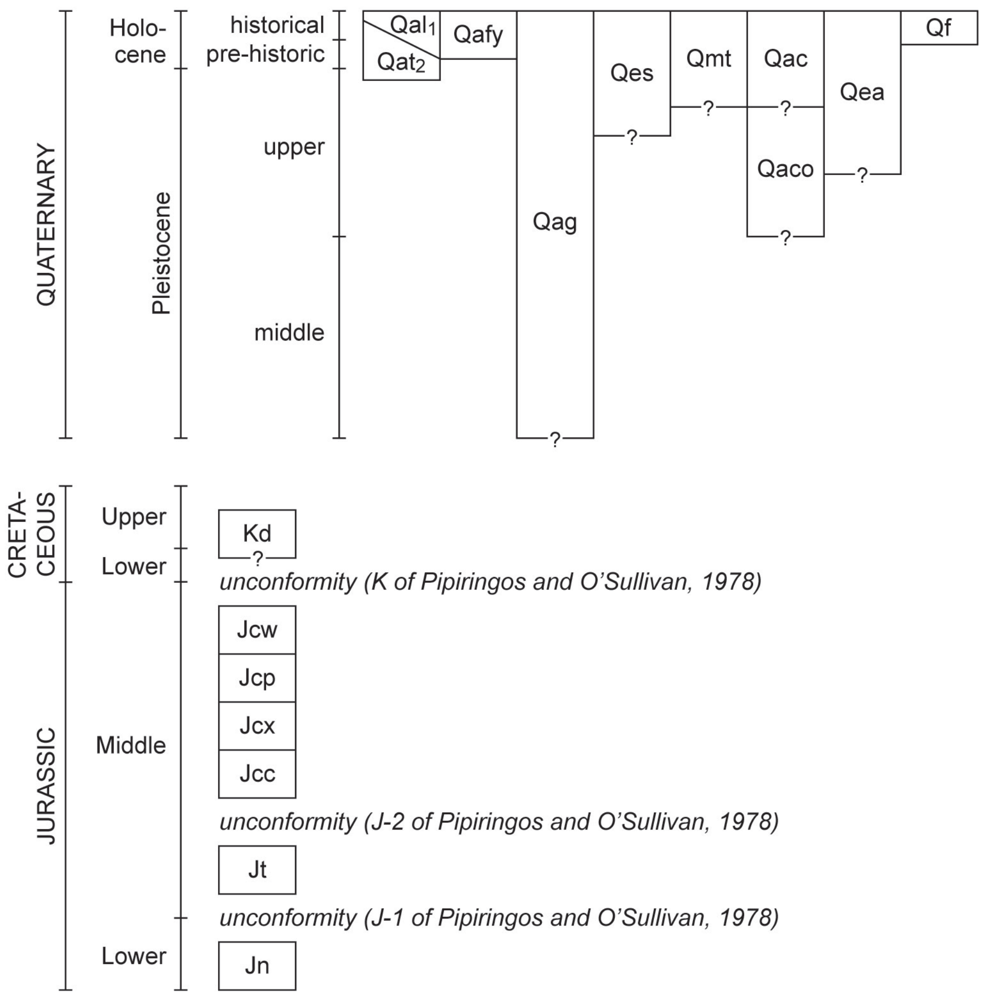
Petroleum exploration drill hole

plugged and abandoned

Spring

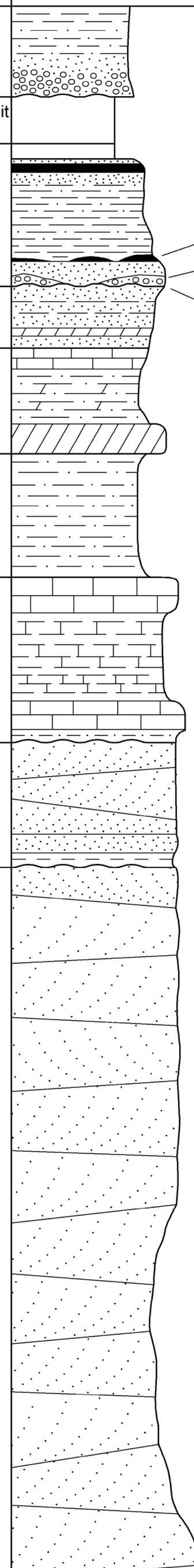
Gravel pit

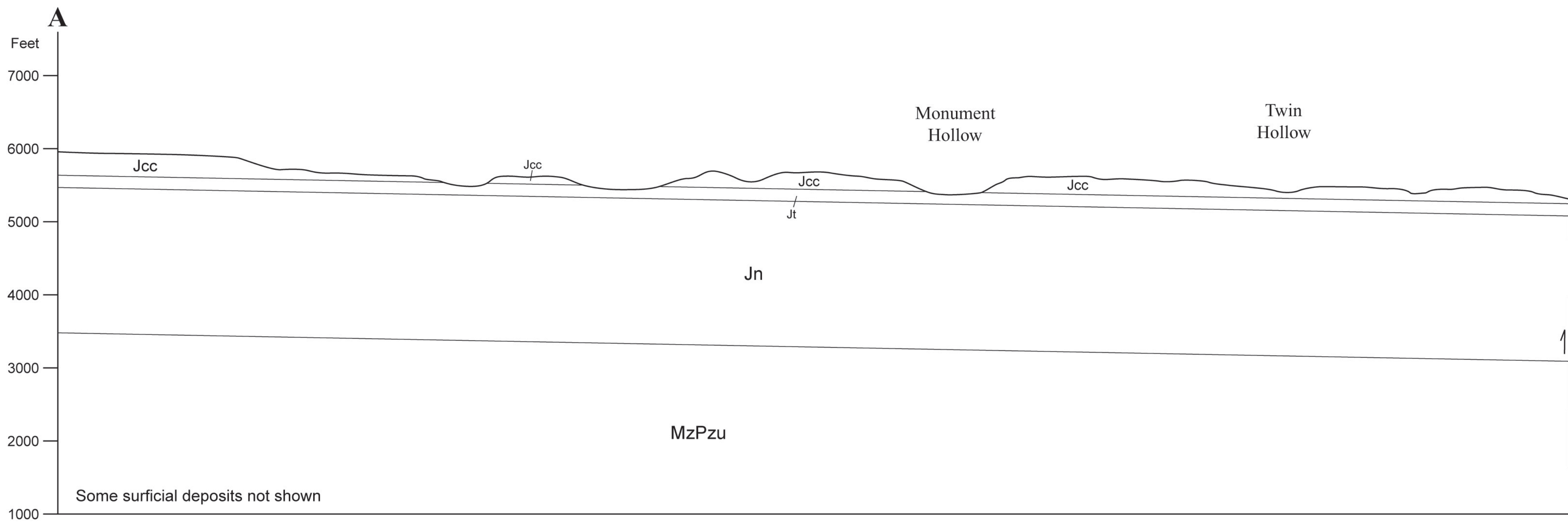
CORRELATION OF MAP UNITS
Mount Carmel Quadrangle

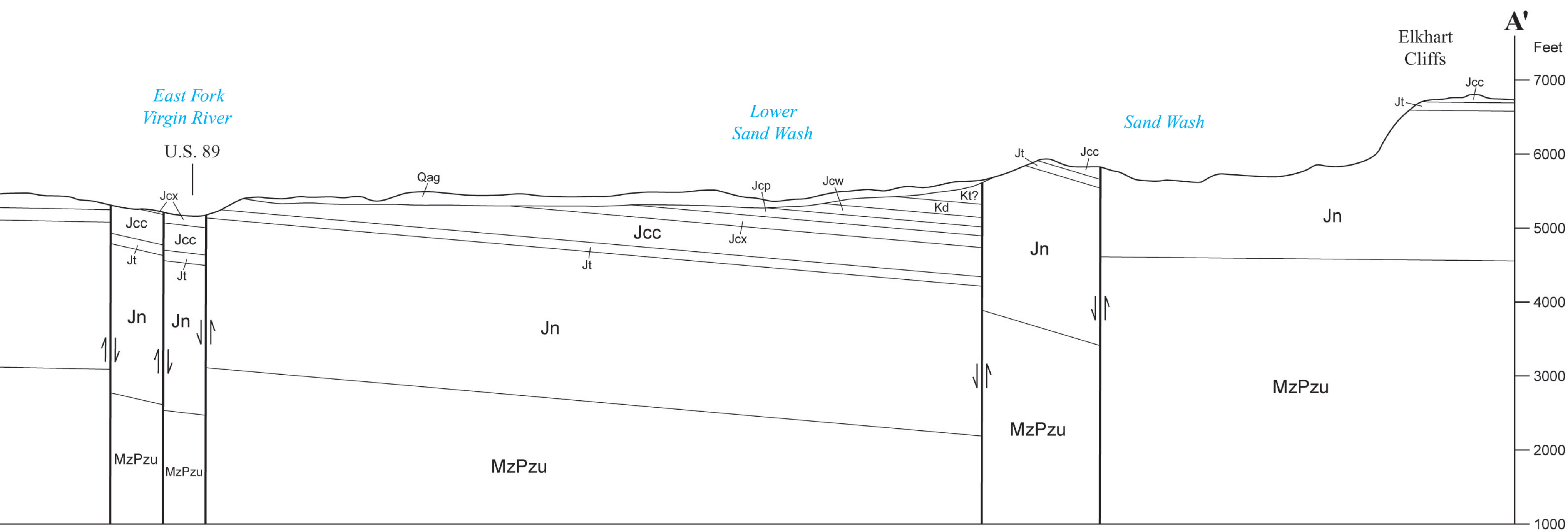


LITHOLOGIC COLUMN
Mt. Carmel Quadrangle

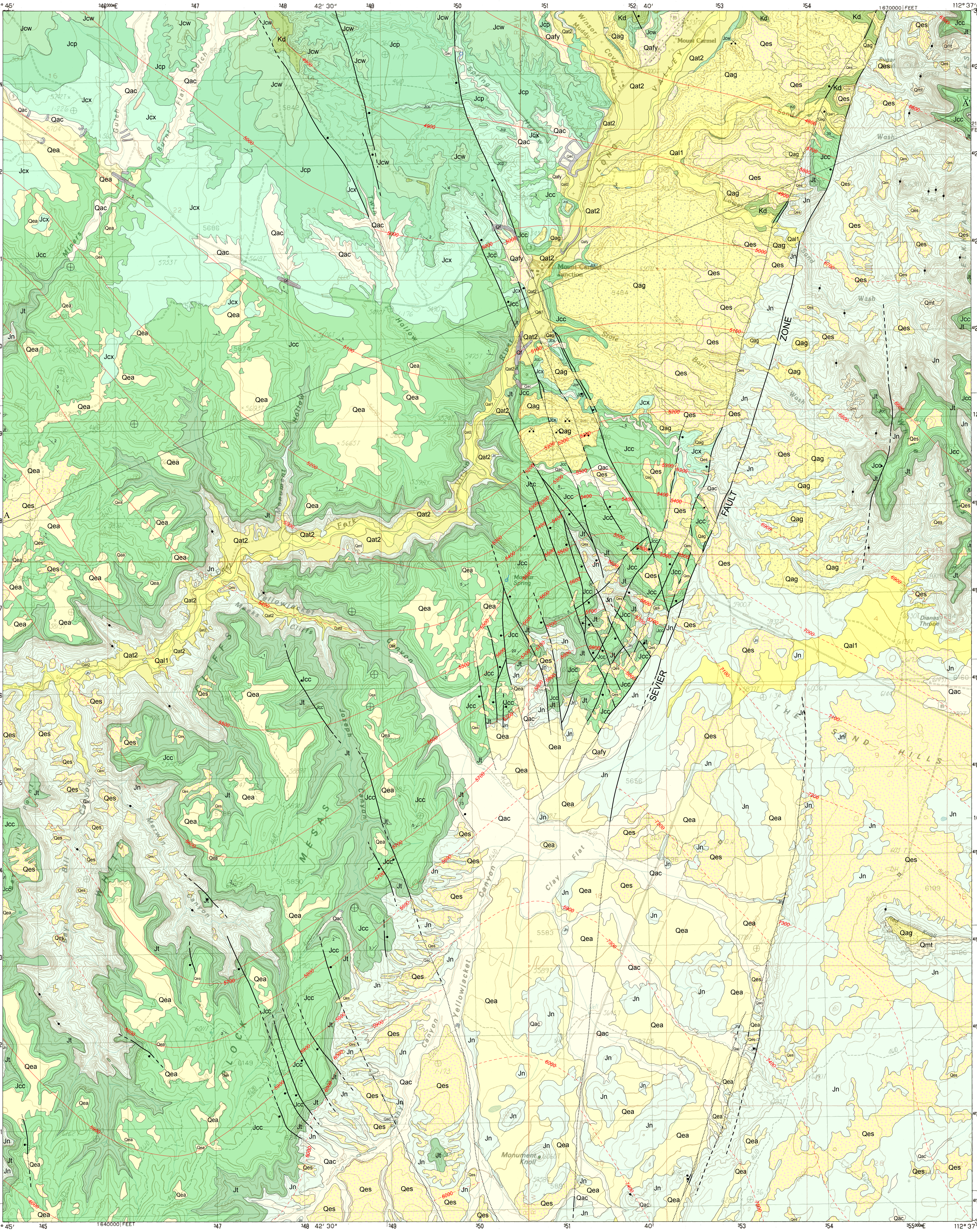
ERA	PERIOD	SERIES AND STAGE	MAP UNIT	MAP SYMBOL	THICKNESS Feet (Meters)	LITHOLOGY
CENOZOIC	QUAT.	Holocene to middle Pleistocene	surficial deposits	various Q	0-180 (0-55)	
MESOZOIC	CRETACEOUS	Upper	Tropic Shale	Kt?	See map unit description	Not exposed
		Upper ? Lower	Dakota Formation	Kd	160+ (50+)	Thin coal Thin coal Local basal conglomerate K unconformity
	JURASSIC	Middle	Carmel Formaiton: Winsor Member	Jcw	60-80 (18-25)	
			Carmel Formaiton: Paria River Member	Jcp	80-140 (25-40)	Alabaster gypsum
			Carmel Formaiton: Crystal Creek Member	Jcx	120-150 (35-45)	*Isocrinus* sp.
			Carmel Formaiton: Co-op Creek Limestone Member	Jcc	160-200 (50-60)	J-2 unconformity
			Temple Cap Formation	Jt	120-200 (35-60)	White Throne Member Sinawava Member J-1 unconformity
		Lower	Navajo Sandstone	Jn	1400+ (450+) 1800-2000 (550-600) total	Less resistant "white" sandstone Massive cross-bedding Least resistant "pink" sandstone More resistant "red" or "brown" sandstone Base not exposed




A
Feet
7000
6000
5000
4000
3000
2000
1000
Jcc
Jcc
Jcc
Jcc
Jt
Monument Hollow
Twin Hollow
Jn
MzPzu
Some surficial deposits not shown


East Fork
Virgin River
U.S. 89
Jcx
Jcc
Jt
Jn
MzPzu
Qag
Lower
Sand Wash
Jcp
Jcw
Kt?
Kd
Jcx
Jcc
Jt
Jn
MzPzu
Jt
Jcc
Sand Wash
Jn
MzPzu
Elkhart
Cliffs
Jt
Jcc
A'
Feet
7000
6000
5000
4000
3000
2000
1000

UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources



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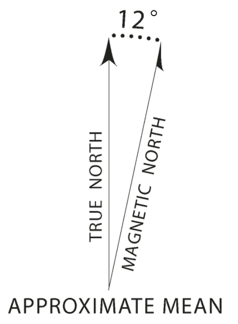
SCALE 1:24,000

1 0.5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 0.5 0 1 KILOMETER

TOPOGRAPHIC CONTOUR INTERVAL 40 FEET
STRUCTURAL CONTOUR INTERVAL 100 FEET
Structure contours drawn on top of the Navajo Sandstone



APPROXIMATE MEAN
DECLINATION, 2007

INTERIM GEOLOGIC MAP OF THE MOUNT CARMEL QUADRANGLE, KANE COUNTY, UTAH

By
Janice M. Hayden

2008

Base from USGS Mount Carmel 7.5' Quadrangle (1985)
Projection: UTM Zone 12
Datum: NAD 1927
Spheroid: Clarke 1886

Project Manager: Bob Biek
GIS and Cartography: J. Buck Ehler

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This map was created from Geographic Information System (GIS) files using ArcMap software from ESRI