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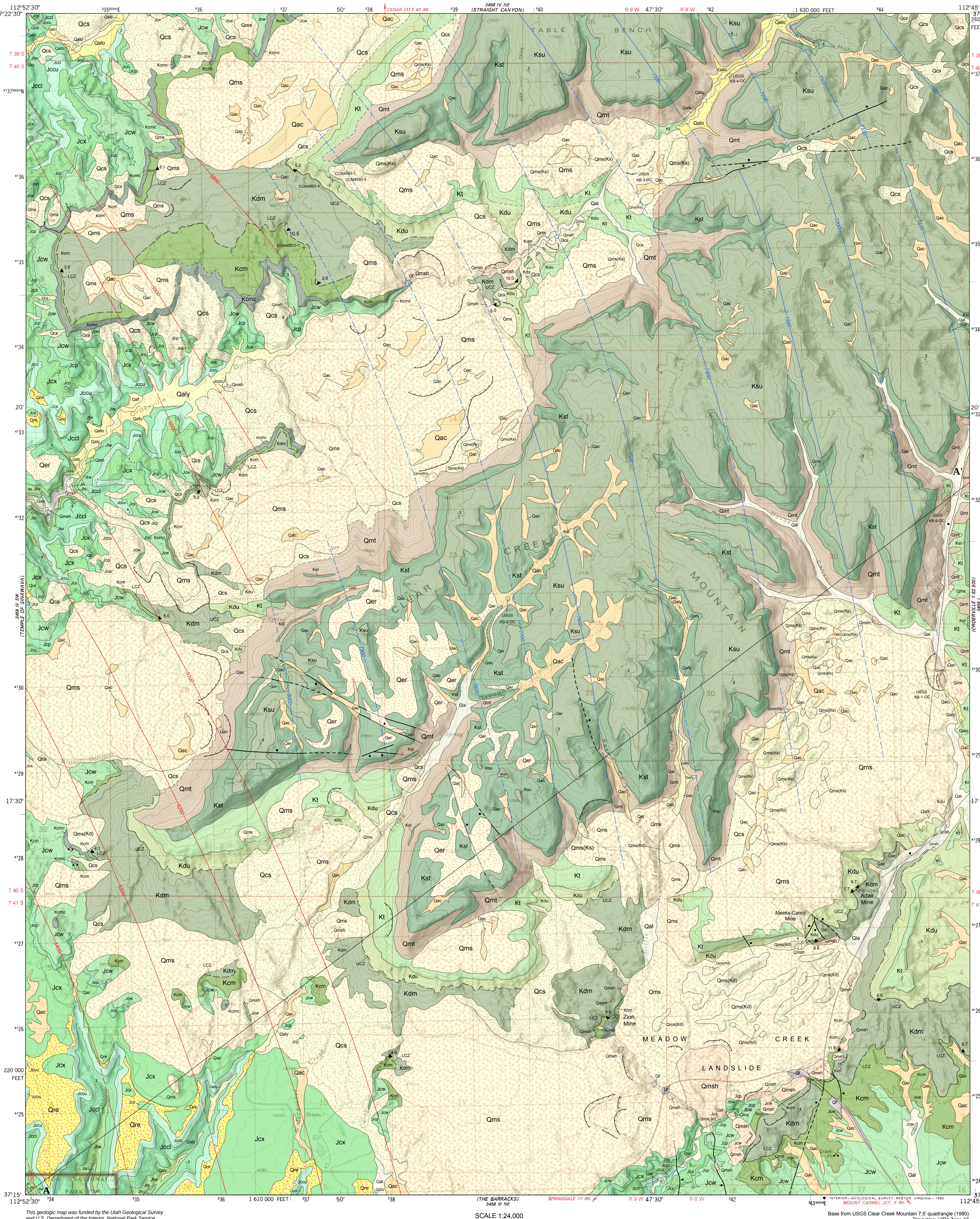

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SCALE 1:24,000

1 — 0.5 — 0 — 1 MILE

1000 — 0 — 1000 — 2000 — 3000 — 4000 — 5000 — 6000 — 7000 FEET

1 — 0.5 — 0 — 1 KILOMETER

CONTOUR INTERVAL 40 FEET

UTAH

QUADRANGLE LOCATION

GEOLOGIC MAP OF THE CLEAR CREEK MOUNTAIN QUADRANGLE, KANE COUNTY, UTAH

by
Michael D. Hylland
2010

11°53'
TRUE NORTH
MAGNETIC NORTH

APPROXIMATE MEAN DECLINATION, 2010

Base from USGS Clear Creek Mountain 7.5' quadrangle (1980)
Projection: UTM Zone 12
Datum: NAD 1927
Spheroid: Clarke 1886

Field mapping by author, 1997-2000
Project Manager: Robert F. Biek
GIS: Kent D. Brown and Denise Y.M. Laes
Cartography: Jay Hill

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1	2	3
4		5
6	7	8

1. Cogswell Point
2. Straight Canyon
3. Strawberry Point
4. Temple of Sinawava
5. Orderville
6. Springdale East
7. The Barracks
8. Mount Carmel

ADJOINING 7.5' QUADRANGLE NAMES

DESCRIPTION OF MAP UNITS

QUATERNARY

Alluvial Deposits

Qaly, Qalo, Qal — **Stream alluvium** (Holocene to upper Pleistocene) – Generally stratified, moderately to well-sorted sand, silt, clay, and pebble to boulder gravel in channels and floodplains; locally includes small alluvial-fan, debris-flow, and colluvial deposits too small to map separately. Younger stream alluvium (Qaly) includes terraces as much as 10 feet (3 m) above modern stream level; older stream alluvium (Qalo) forms incised, level to gently sloping surfaces 10 to 30 feet (3–9 m) above modern channels and may include inset deposits of younger stream alluvium too small to map separately; undifferentiated stream alluvium (Qal) mapped where deposit age is uncertain. Thickness 0 to 30 feet (0–9 m).

Qafy, Qafo — **Fan alluvium** (Holocene to upper Pleistocene) – Poorly stratified, poorly to moderately well sorted, boulder- to clay-sized sediment deposited as relatively small alluvial fans along major drainages; deposited by intermittent streams, debris flows, and debris floods graded to or slightly above modern stream level; locally includes minor colluvium and talus along upslope margins of the fans, and grades into stream alluvium at fan toes. Younger fan alluvium (Qafy) forms active depositional surfaces and grades into younger stream alluvium (Qaly) at toes of the fans; older fan alluvium (Qafo) forms deeply incised, generally inactive surfaces as much as 30 feet (9 m) above modern stream channels. Thickness 0 to 40 feet (0–12 m).

Qla — **Lacustrine and alluvial basin-fill deposits** (Holocene to upper Pleistocene) – Stratified, thin-bedded, light-brown to gray silt and clay with interbeds and lenses of fine to coarse sand and fine gravel; locally abundant organic matter. Location of these deposits along Clear Creek (Willow Canyon) and Meadow Creek upstream of landslide deposits suggests accumulation in quiet water behind landslide dams; these "lakes" probably held water only during brief wet periods and were probably more like shallow ponds or swampy alluvial plains; deposits are similar to those of numerous Holocene and Pleistocene lakes in Zion National Park (see discussion in Biek and others, 2003). Thickness 0 to 50 feet (0–15 m).

Artificial-Fill Deposits

Qf — **Artificial fill** (historical) – Primarily road-embankment fill used in the construction of State Route 9; other deposits, too small to map separately, are scattered across the quadrangle and include stock-pond embankments and waste-rock piles at uranium and coal mines and prospects; 0 to 60 feet (0–18 m) thick.

Colluvial Deposits

Qcs — **Colluvium** (Holocene to upper Pleistocene) – Unsorted, nonstratified, locally derived sand and silt with subangular to angular gravel, cobbles, and boulders; color and clast composition vary with parent material; deposited primarily by creep and slope wash, but some deposits, particularly on the upper unit of the Straight Cliffs Formation, may also result in part from shallow landsliding; gradational with and locally includes talus and mixed alluvial and colluvial deposits; estimated to be less than 10 feet (3 m) thick.

Mass-Movement Deposits

Qmsh, Qms, Qms(Ks), Qms(Kd), Qms(Jc) — **Landslide deposits** (Holocene to middle[?] Pleistocene) – Poorly sorted masses of rock and unconsolidated material that have undergone translational and/or rotational downslope movement; deposits display hummocky topography, internal scarps, back-tilted geomorphic surfaces, and chaotic bedding attitudes; typically associated with low-strength clay in the Cedar Mountain, Dakota, and Tropic Formations. Some of the deposits form large complexes of contiguous but separate landslides having different movement histories and directions; where discernible, individual landslides are delineated on the basis of drainages and other geomorphic features that indicate landslide flanks and toes. Geomorphically youthful scarps and hummocky topography indicate new or reactivated movement, whereas geomorphically subtle landslide features and/or surfaces that are deeply incised by stream channels may indicate relatively old initiation of movement; however, very slow movement may be occurring in some landslide areas that lack obvious geomorphic evidence of recent movement. Formation symbol in parentheses denotes large block of bedrock that has been displaced by landsliding, but internal stratigraphy has remained relatively intact (Toreva block). Historical landslides (Qmsh) have landslide features such as scarps and slide blocks that are morphologically distinct, as well as clear evidence of historical movement (i.e., disturbed vegetation, damaged cultural features such as roads and culverts); the Meadow Creek landslide, crossed by Utah Highway 9, presents ongoing road maintenance issues (see Stouffer, 1964; Doelling and Davis, 1989; Ashland and others, 2009). Thickness of landslide deposits is highly variable; the larger slides are possibly hundreds of feet (100 m ±) thick.

The Meadow Creek landslide was the subject of survey-grade Global Positioning System (GPS) monitoring between October 2005 and October 2008 (Ashland and others, 2009; Ashland and McDonald, in press). In the area crossed by Highway 9 mapped as Qmsh, measured horizontal displacement ranged from 24 to 64 inches (61–163 cm) (Ashland and McDonald, in press). With the exception of a few monitoring stations, movement was not detected elsewhere in the Meadow Creek landslide (areas mapped as Qms); where movement was detected (mostly near Highway 9), horizontal displacement ranged from 6 to 10 inches (15–25 cm) (Ashland and McDonald, in press).

Qmt — **Talus** (Holocene to upper[?] Pleistocene) – Very poorly sorted, angular, gravel- to boulder-sized sandstone blocks and finer grained interstitial sediment on steep slopes below ledges and cliffs of the Straight Cliffs Formation; deposited primarily by rock fall, but creep and slope wash also involved; locally includes undifferentiated colluvium; generally 0 to 20 feet (0–6 m) thick.

Spring Deposits

Qsm — **Spring mud** (Holocene) – Brown and greenish-gray clay and organic mud with white evaporitic surface encrustation (efflorescence); deposited immediately downslope of small, active springs in the southeastern part of the quadrangle (NW1/4 section 33, T. 40 S., R. 8 W., SLBLM); highly susceptible to piping and erosion; estimated to be less than 15 feet (5 m) thick.

Qst — **Spring tufa** (Holocene) – Gray, white, and tan, blocky, porous, calcareous sinter that forms small, earthy mounds; contains abundant root casts; associated with presently inactive springs; two small deposits are mapped in the southeastern part of the quadrangle (NE1/4 section 36, T. 40 S., R. 9 W., and NW1/4 section 5, T. 41 S., R. 8 W., SLBLM); thickness uncertain, but probably less than 10 feet (3 m).

Mixed-Environment Deposits

Qac — **Alluvial and colluvial deposits** (Holocene to upper Pleistocene) – Poorly to moderately sorted, generally poorly stratified sand, silt, and clay with scattered, subangular to angular gravel and cobbles; deposited in minor drainages and topographic depressions primarily by fluvial, debris-flow, slope-wash, and creep processes; commonly scattered across landslide deposits where displaced blocks, back-tilted surfaces, and closed depressions form sediment traps; thickness less than 20 feet (6 m).

Qer — **Eolian and residual deposits** (Holocene to upper[?] Pleistocene) – Well-sorted fine sand with scattered, subrounded to subangular gravel and cobbles of sandstone derived from the Straight Cliffs Formation; deposited by wind and in-place weathering of bedrock; forms discontinuous fill in shallow topographic depressions on mesa tops; 0 to 5 feet (0–1.5 m) thick.

Qre — **Residual and eolian deposits** (Holocene to upper[?] Pleistocene) – Reddish-brown silt and fine sand with scattered subangular gravel derived from the Crystal Creek Member of the Carmel Formation; deposited by in-place weathering of bedrock and partly reworked by the wind; forms a thin (0 to 2 feet [0–0.6 m]), discontinuous mantle on top of the Co-op Creek Limestone.

unconformity

CRETACEOUS

Ks — **Straight Cliffs Formation** – Shown undivided where one or more members form bedrock blocks displaced by landsliding, but internal stratigraphy has remained relatively intact (see "Landslide deposits").

Ksu — **Upper unit** (Upper Cretaceous, Santonian to Turonian) – Slope- and ledge-forming sandstone, siltstone, shale, and minor conglomerate; sandstone is subarkosic, light gray, brown, and pale orange, typically trough cross-bedded; variegated shale near top of unit is maroon and greenish gray. Limonite-stained pebble conglomerate and gritstone with clasts of quartzite and chert is poorly exposed locally in the lower 200 feet (60 m) of the unit; the conglomerate likely comprises multiple beds, one or more of which may be correlative with the Calico bed of Peterson (1969a). Deposited in fluvial, floodplain, and lagoonal environments of a coastal plain (Eaton and others, 2001); interpreted to be correlative with Smoky Hollow Member and possibly John Henry Member of the Straight Cliffs Formation of the Kaiparowits Plateau (see, for example, Eaton and others, 2001). At least 700 feet (210 m) thick in the quadrangle, but upper contact not preserved.

Kst — **Tibbet Canyon Member** (Upper Cretaceous, Turonian) – Predominantly cliff-forming sandstone, quartzose, light gray to grayish orange, medium to thick bedded with local low-angle cross-beds; interbedded with minor shale, mudstone, and siltstone; locally contains pelecypods, ammonoids, and bioturbation features. Upper contact corresponds to a break in slope and is placed at top of coquinoid oyster bed that caps the member. Deposited in shoreface, lagoonal, estuarine, and floodplain environments of a coastal plain (Laurin and Sageman, 2001, 2007; Tibert and others, 2003). About 240 to 440 feet (75–135 m) thick.

Kt — **Tropic Shale** (Upper Cretaceous, Turonian to Cenomanian) – Slope-forming, thin-bedded, sandy shale and mudstone with minor fine-grained sandstone and limestone; brown to gray, weathers to yellowish gray; septarian nodules (concretions containing angular, mineral-filled cavities or cracks) weather out of thin limestone bed near base; locally includes sandstone of overlying Straight Cliffs Formation that grades into and intertongues with upper part of Tropic Shale (e.g., in the main scarp of the Meadow Creek landslide). Upper contact gradational, placed at base of lowermost, laterally continuous, cliff-forming Tibbet Canyon sandstone. Deposited in shallow-marine environment dominated by fine-grained clastic sediment (Elder and others, 1994; Tibert and others, 2003; Laurin and Sageman, 2007). About 240 to 500 feet (75–150 m) thick; thickness decreases northward and westward, thinning dramatically to perhaps just a few feet thick in the western part of the adjacent Cogswell Point quadrangle (Biek and Hylland, 2007).

In 1990, a partial skeleton of a large, long-necked plesiosaur (marine reptile) was discovered about 3 miles (5 km) east of the Clear Creek Mountain quadrangle during excavation at a septarian nodule mine in the Muddy Creek drainage. The fossil bones, primarily consisting of vertebrae, were in the *Sciponoceras gracile* Ammonoid Biozone at the base of the Tropic Shale and were the first documented occurrence of plesiosaur remains from the Tropic Shale in Utah (Gillette and others, 1999).

Kd — **Dakota Formation** – Shown undivided where one or more members form bedrock blocks displaced by landsliding, but internal stratigraphy has remained relatively intact (see "Landslide deposits"). In southwestern Utah, the Dakota Formation has traditionally been subdivided into three informal members (see, for example, Doelling and Davis, 1989; Gustason, 1989), following the convention established for the Dakota on the Kaiparowits Plateau (Peterson, 1969b). On the Kolob Terrace, the lower member has recently been reassigned to the Cedar Mountain Formation (Biek and others, 2003; Biek, 2007a, 2007b; Biek and Hylland, 2007; but see Titus and others, 2005) on the basis of lithologic and age similarities with the Mussentuchit Member (see Kirkland and others, 1997; Kirkland and Madsen, 2007), and that convention is followed on this map.

Kdu — **Upper member** (Upper Cretaceous, Cenomanian) – Slope- and ledge-forming, interbedded sandstone, siltstone, mudstone, shale, marl, and minor coal; sandstone is light brown, gray, and white, arkosic to quartzose, thin to thick bedded, planar; siltstone, mudstone, and shale are gray to dark gray, typically with disseminated organic debris; coal occurs as scattered seams 1 to 2 feet (0.3–0.6 m) thick; abundant gastropod (*Craginia*) and pelecypod (*Crassostrea* and *Inoceramus pictus*) fossils in upper part of unit, bioturbation features (*Ophiomorpha*) in lower part. White, ledge-forming sandstone 25 to 50 feet (8–15 m) thick at top of unit correlates to the "sugarledge sandstone" of Cashion (1961). Upper contact placed at top of thin (4 feet [1.2 m]) coal-sandstone couplet that directly overlies the sugarledge sandstone; the coal contains a palynomorph assemblage indicating an age at least as old as Turonian (sample CCM4093-1). Below the sugarledge sandstone, organic mudstone and carbonaceous shale yielded pollen indicating an age of early to late Cenomanian (samples CCM4093-4 and CCM4093-2, respectively). Deposited in shoreface, lagoonal, and estuarine environments of a coastal plain (Gustason, 1989; am Ende, 1991; Elder and others, 1994; Laurin and Sageman, 2001, 2007; Tibert and others, 2003). About 200 to 290 feet (60–90 m) thick.

Kdm — **Middle member** (Upper Cretaceous, Cenomanian) – Slope-forming, interbedded mudstone, claystone, siltstone, shale, coal, and lignite, and ledge-forming sandstone; mudstone and claystone are gray to brown, commonly smectitic; siltstone is dark brown to black, typically with abundant organic debris; shale is gray to dark gray, locally smectitic or carbonaceous; sandstone is light brown to gray, resistant, locally trough cross-bedded. Coal occurs within two laterally persistent zones at the top and base of the unit (upper and lower coal zones, respectively, of Cashion, 1961, 1967; see also Doelling and Graham, 1972); upper contact placed at top of upper coal zone. Middle member of the Dakota is poorly exposed and involved in widespread landsliding. Deposited in estuarine, floodplain, swamp, and lacustrine environments (Gustason, 1989; am Ende, 1991; Laurin and Sageman, 2001, 2007). About 280 to 480 feet (85–145 m) thick.

Dakota coal in the Clear Creek Mountain quadrangle is part of the Kolob coalfield; regionally the coal rank varies between subbituminous A and high-volatile bituminous B (Grose and others, 1967; Doelling and Graham, 1972), and the coal has relatively high ash and sulfur contents (Doelling and Graham, 1972). Three mines in the southeast part of the quadrangle were probably active from about 1930 to 1950 (Doelling and Graham, 1972); production from these mines is unknown, but the largest (Meeks-Carrol mine) had underground workings that extended over 12 acres (5 ha) (Grose and others, 1967). Based on measurements reported by Cashion (1961) and Doelling and Graham (1972) and collected during this mapping, cumulative coal thickness in the upper coal zone within the quadrangle ranges from 2.5 to 10.0 feet (0.8–3.0 m) and averages 6.8 feet (2.1 m), and maximum individual bed thickness is 8.0 feet (2.4 m); cumulative coal thickness in the lower coal zone ranges from 2.8 to 11.9 feet (0.9–3.6 m) and averages 6.4 feet (1.9 m), and maximum individual bed thickness is 7.0 feet (2.1 m). Doelling and Davis (1989) correlated the upper and lower coal zones with the Smirl and Bald Knoll coal zones, respectively, of the Alton coalfield to the east.

unconformity

Cedar Mountain Formation

Kcm — **Cedar Mountain Formation, undivided** (Lower Cretaceous, Cenomanian to Albian) – Gray to variegated mudstone and minor lignite overlying interbedded pebble conglomerate and conglomeratic sandstone; basal conglomerate is mapped separately (Kcmc) in some areas; slope-forming mudstone is smectitic and locally contains white carbonate nodules and interbedded altered volcanic ash; upper contact placed at base of Dakota lower coal zone. Conglomerate is typically cliff-forming and contains well-rounded clasts of quartzite, chert, and limestone, as well as clay lenses, carbonized wood fragments, and petrified wood that includes silicified logs; local uranium mineralization; basal contact with the Winsor Member of the Carmel Formation is sharp and uneven. Organic mudstone yielded pollen indicating an age of late Albian (sample CCM4091-1), and pollen analyses by Doelling and Davis (1989) indicate an Albian age of the underlying conglomerate. Single-crystal $^{40}Ar/^{39}Ar$ age of 97.9 ± 0.5 Ma obtained from ash layer in mudstone near the North Fork Virgin River in the Straight Canyon quadrangle, about 1 mile (1.5 km) north of the Clear Creek Mountain quadrangle, suggests correlation with ash in Mussentuchit Member of the Cedar Mountain Formation in east-central Utah (see Cifelli and others, 1997; Garrison and others, 2007); geochronologic analysis of detrital zircon from the basal Cretaceous conglomerate near Kolob Reservoir, 10 miles (6 km) northwest of the Clear Creek Mountain quadrangle, resulted in a correlation with the informally named Short Canyon conglomerate (G.J. Hunt, New Mexico State University, verbal communication, 2008) within the Cedar Mountain section on the west side of the San Rafael Swell (Doelling and Kuehne, in preparation). Deposited in floodplain, lacustrine, and fluvial-channel environments of a coastal plain (Tschudy and others, 1984; Kirkland and others, 1997; Garrison and others, 2007; Kirkland and Madsen, 2007). About 80 to 220 feet (25–65 m) thick.

Uranium mineralization occurs along the Cedar Mountain–Winsor contact on both sides of Orderville Gulch (Bulloch group of claims; sections 8, 9, 16, and 21, T. 40 S., R. 9 W., SLBLM), where abnormal radioactivity has been detected along 4000 feet (1200 m) of outcrop (Beroni and others, 1953); the largest exposure of uranium-bearing rock, at the mine location shown in the NE1/4 section 21 (Lynn No. 3 claim), has a weighted average ore grade of 0.13% U_3O_8 (Beroni and others, 1953). Dasch (1967) estimated that between 100 and 1000 tons of ore was mined from the Bulloch claims between 1949 and 1962; Doelling and Davis (1989) reported no production since 1973, and by 1995 all of the claims were closed (Bureau of Land Management, 2009).

Kcmc — **Conglomerate member** (Lower Cretaceous, Albian) – Basal conglomerate is mapped separately where outcrop thickness and extent allow; 8 to 120 feet (2–35 m) thick.

unconformity (K)

JURASSIC

Jc — **Carmel Formation** – Shown undivided where one or more members form a bedrock block displaced by landsliding (NE1/4SW1/4 section 7, T. 41 S., R. 8 W., SLBLM), but internal stratigraphy has remained relatively intact (see "Landslide deposits").

Jcw — **Winsor Member** (Middle Jurassic, Callovian to Bathonian) – Slope-forming, mostly reddish-brown, fine-grained sandstone, siltstone, and minor shale; upper part of member is pale-yellow, friable, fine-grained silty sandstone. Upper contact is the basal Cretaceous (K) unconformity. Deposited on a broad, sandy mud flat (Imlay, 1980; Blakey and others, 1983). Thickness 180 to 280 feet (55–85 m).

Jcp — **Paria River Member** (Middle Jurassic, Bathonian) – Slope-forming, light-gray to yellowish-gray, thin-bedded, platy limestone underlain by shaly limestone and sandstone, in turn underlain by ledge-forming, white gypsum bed. Upper contact is sharp and planar. Deposited in shallow-marine and coastal-sabkha environments (Imlay, 1980; Blakey and others, 1983). Thickness 60 to 100 feet (20–30 m).

Jcx — **Crystal Creek Member** (Middle Jurassic, Bathonian) – Slope-forming, thin- to medium-bedded, "banded" reddish-brown and light-gray, fine-grained sandstone and siltstone; local gypsum veinlets and thin beds, and minor volcanic ash; upper contact is sharp and broadly undulating and corresponds to the base of the Paria River gypsum bed; about 166–167 Ma based on radiometric dating of ash interbeds in southwestern Utah (Kowallis and others, 2001). Deposited in coastal-sabkha and tidal-flat environments (Imlay, 1980; Blakey and others, 1983). Thickness 160 to 220 feet (50–65 m).

Co-op Creek Limestone Member (Middle Jurassic, Bathonian to Bajocian) – Interbedded, micritic to oolitic, thin- to thick-bedded limestone, calcareous and argillaceous shale, platy limestone, and minor dolomite, sandstone, and volcanic ash; locally fossiliferous, including pelecypods, gastropods, and crinoid columnals (*Isocrinus nicoleti*); about 167–168 Ma based on radiometric dating of ash interbeds in southwestern Utah (Kowallis and others, 2001). Deposited in a shallow-marine environment (Imlay, 1980; Blakey and others, 1983).

Jccu — **Upper unit** – Ledge-forming, thin- to medium-bedded, white-weathering, micritic limestone and minor shale; upper contact is sharp and planar; 80 to 110 feet (25–35 m) thick.

Jccl — **Lower unit** – Slope-forming, light-gray, calcareous and argillaceous shale and platy limestone with sandstone and thick-bedded limestone; about 8 feet (2.4 m) of reddish to purplish shale and thin-bedded sandstone at base; upper contact is gradational and corresponds to a break in slope; 160 to 220 feet (50–65 m) thick.

unconformity (J-2) (?)

The boundary between the Carmel Formation and Temple Cap Formation has traditionally been interpreted as part of a regionally extensive erosional unconformity (Pipiringos and O'Sullivan, 1978; Peterson and Pipiringos, 1979); however, the queried designation reflects ongoing work involving regional stratigraphic correlation, palynology, and radiometric dating that preliminarily indicates this unconformity may not exist or may represent only a brief hiatus (D. Sprinkel, USGS, verbal communication, 2009; see also Sprinkel and others, 2009); exposures of the Carmel–Temple Cap contact in the Clear Creek Mountain quadrangle show no unambiguous evidence of a major unconformity.

Jt — **Temple Cap Formation** (Middle Jurassic, Bajocian) – Shown undivided on cross section only; about 169–174 Ma based on radiometric dating of volcanic ash interbeds in southwestern Utah (Kowallis and others, 2001; Dickinson and others, 2009; D. Sprinkel, UGS, written communication, 2009).

Jtw — **White Throne Member** – Cliff-forming, light-gray to pale-orange sandstone with high-angle, thick cross-bed sets; sandstone is quartzose, well sorted, fine grained; similar to the Navajo Sandstone; upper contact is sharp and planar, marked by red shaly zone at base of Co-op Creek Limestone. Deposited in coastal dune field (Blakey, 1994; Peterson, 1994). Thickness 60 to 165 feet (20–50 m).

Recent work involving regional stratigraphic correlation, palynology, and radiometric dating suggests that the red shaly zone at the base of the Co-op Creek Limestone should perhaps be more appropriately designated the upper part of the Temple Cap Formation (D. Sprinkel, UGS, verbal communication, 2009).

Jts — **Sinawava Member** – Slope-forming, interbedded sandstone, siltstone, and mudstone; forms relatively thin but prominent reddish-orange to reddish-brown slope at top of the Navajo Sandstone. Upper contact is gradational and interfingering with the White Throne Member. Deposited in coastal-sabkha and tidal-flat environments (Blakey, 1994; Peterson, 1994). Thickness 40 to 90 feet (15–25 m).

unconformity (J-1)

Jn — **Navajo Sandstone** (Lower Jurassic, Toarcian to Pliensbachian) – Cliff-forming, light yellowish-gray to pale-orange sandstone with large-scale tabular- and wedge-planar cross-beds and thick cross-bed sets; sandstone is quartzose, well sorted, fine to medium grained; locally prominently jointed. Upper contact is sharp and planar, corresponds to prominent break in slope at top of Navajo cliff. Deposited in a vast coastal and inland dune field (Blakey, 1994; Peterson, 1994). Only upper 200 feet (60 m) exposed in quadrangle, but formation is 1800 to 2200 feet (550–670 m) thick in the Zion National Park area (Gregory, 1950; Biek and others, 2003).

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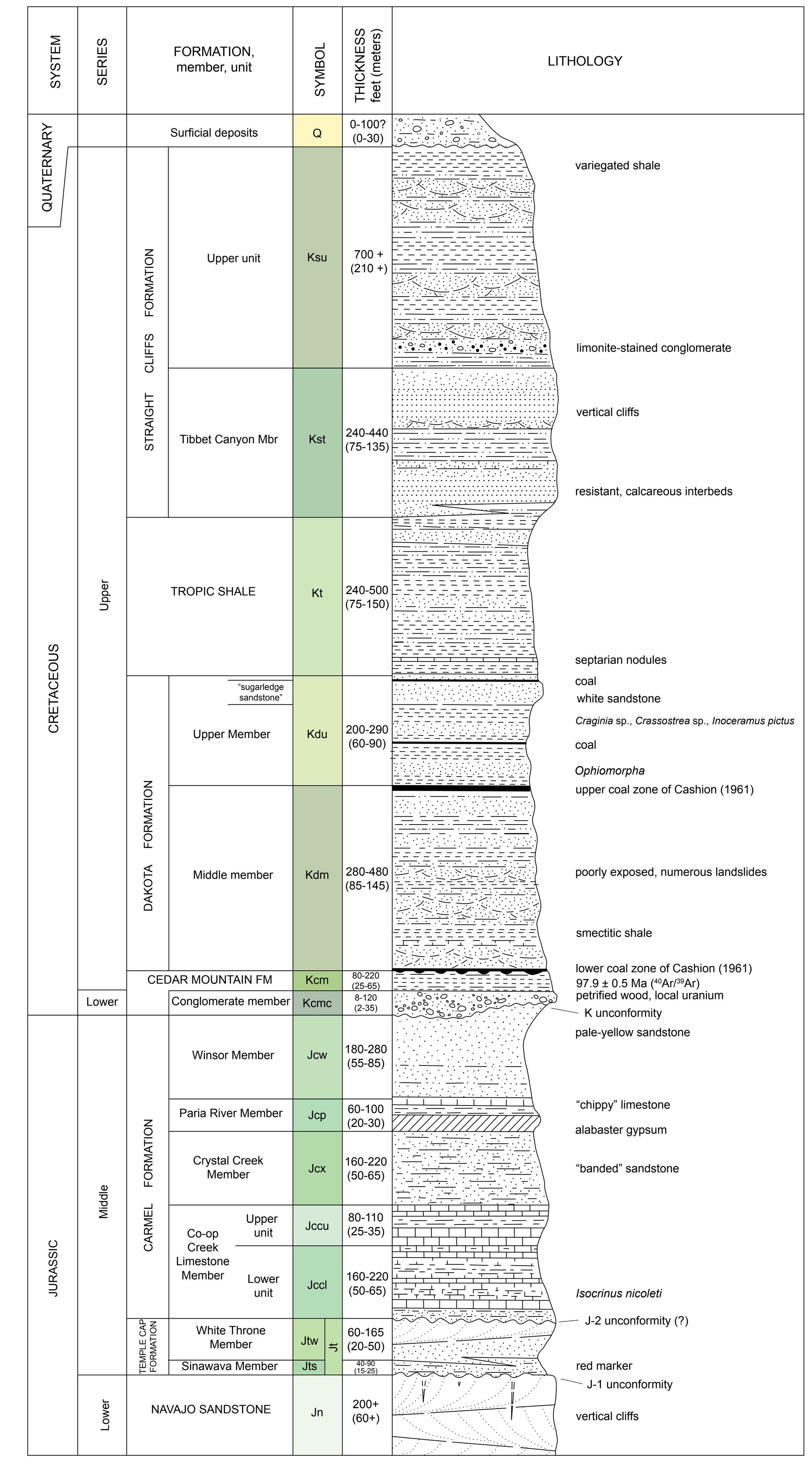
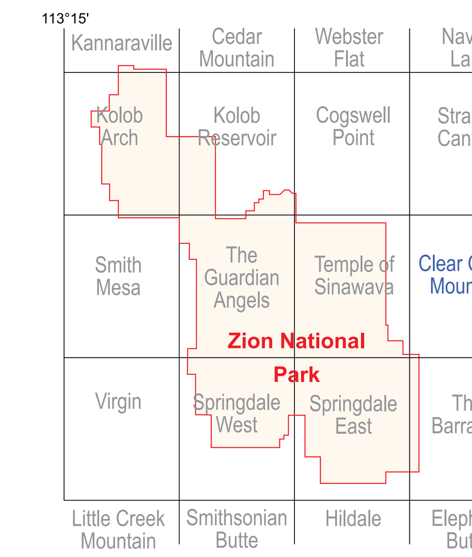
LITHOLOGIC COLUMN

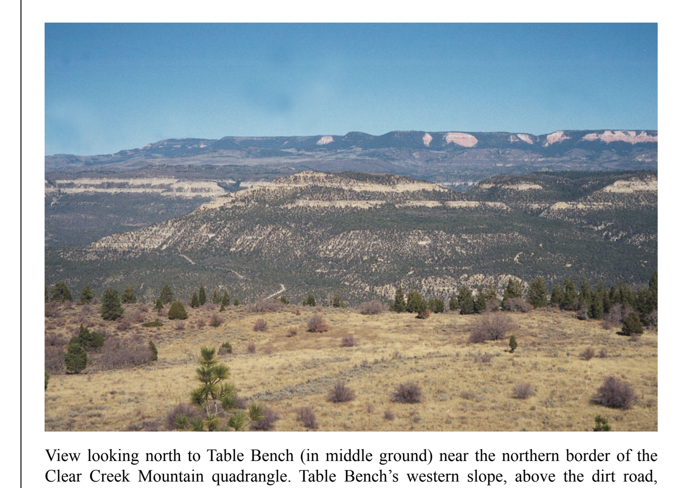


SELECTED GEOLOGIC MAPS AVAILABLE FOR THE ZION NATIONAL PARK AREA



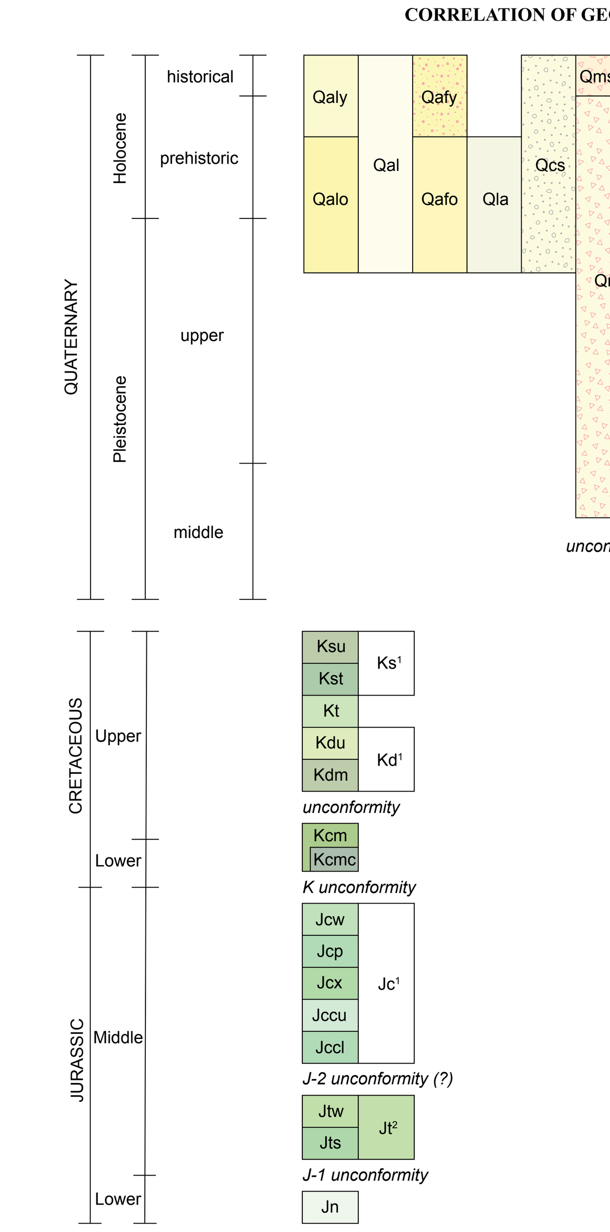
In addition to geologic mapping (mostly 1:24:000 scale) of the 7.5′ quadrangles listed below, Hamilton (1978) provided a 1:31,680-scale geologic map of Zion National Park. See index map for quadrangle locations.

Cedar Mountain	Averitt (1962)
Cogswell Point	Biek and Hylland (2007)
Elephant Butte	Sable and Doelling (1990)
Hildale	Sable 1995) (
Kanarraville	Averitt 1967) (
Kolob Arch	Biek ( ) (2007a
Kolob Reservoir	Biek (2007b)
Little Creek Mountain	Hayden (2004)
Navajo Lake	Moore and others (2004)
Smith Mesa	Sable and others (in preparation)
Smithsonian Butte	Moore and Sable (2001)
Springdale East	Doelling and others (2002)
Springdale West	Willis and others (2002)
Straight Canyon	Cashion (1967)
Temple of Sinawava	Doelling (2002)
The Barracks	Sable and Doelling (1993)
The Guardian Angels	Willis and Hylland (2002)
Virgin	Hayden and Sable (2008)
Webster Flat	Wilson and Thomas (1964) (part) and Doelling and Graham (1972) (part)



View looking north to Table Bench (in middle ground) near the northern border of the Clear Creek Mountain quadrangle. Table Bench's western slope, above the dirt road, reveals a remarkably complete exposure of the middle Cretaceous section from the upper Dakota Formation to the lower Straight Cliffs Formation. The Tibbet Canyon Member forms the prominent cliff-forming sandstone doublet. Tertiary strata of the Pink Cliffs form the southern margin of the Markagunt Plateau on the skyline.

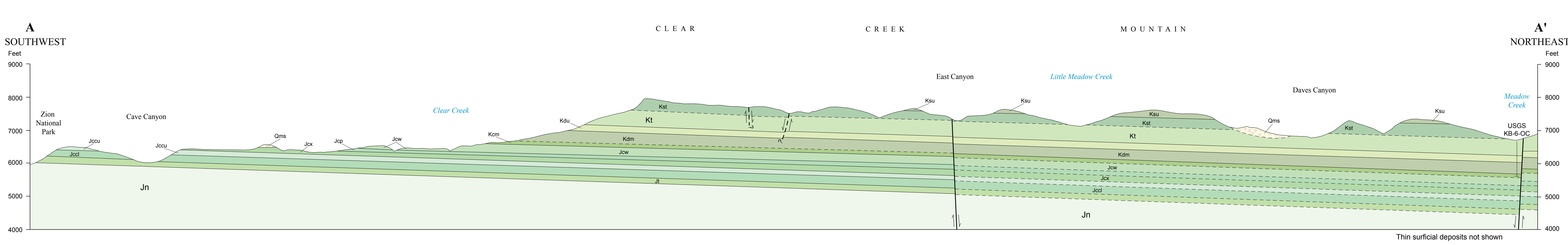
CORRELATION OF GEOLOGIC UNITS



¹Formations undivided where one or more members form bedrock blocks displaced by landsliding; shown on map with landslide patterning (see "Landslide deposits")
²Cross section only

GEOLOGIC SYMBOLS

- Geologic contact; dashed where approximately located
- Internal contact; delineates boundary of individual landslide within a landslide complex
- 8.6 — Laterally continuous coal bed (coincides with geologic contact); dashed where approximately located; triangle indicates location of thickness measurement, in feet; LCZ, lower coal zone; UCZ, upper coal zone
- 6200 — Structure contour on top of upper unit of Co-op Creek Limestone Member (red) and on top of Tibbet Canyon Member (blue); dashed where projected; interval 100 feet
- Fault; dashed where approximately located, dotted where concealed, queried where existence uncertain; bar and ball on downthrown side where known
- Landslide scarp; hachures on down-dropped side
- 3 — Strike and dip of inclined bedding (field measured)
- 4 — Strike and dip of inclined bedding (determined photogrammetrically)
- Gravel pit
- C,U — Mine; C = coal, U = uranium
- USGS KB-6-OC — USGS coal-exploration drill hole (approximately located) reported in Bowers and Strickland (1978)
- CCM4093-1 — Palynology sample location and number
- A — A' — Line of cross section



Thin surficial deposits not shown