UTAH GEOLOGICAL SURVEY
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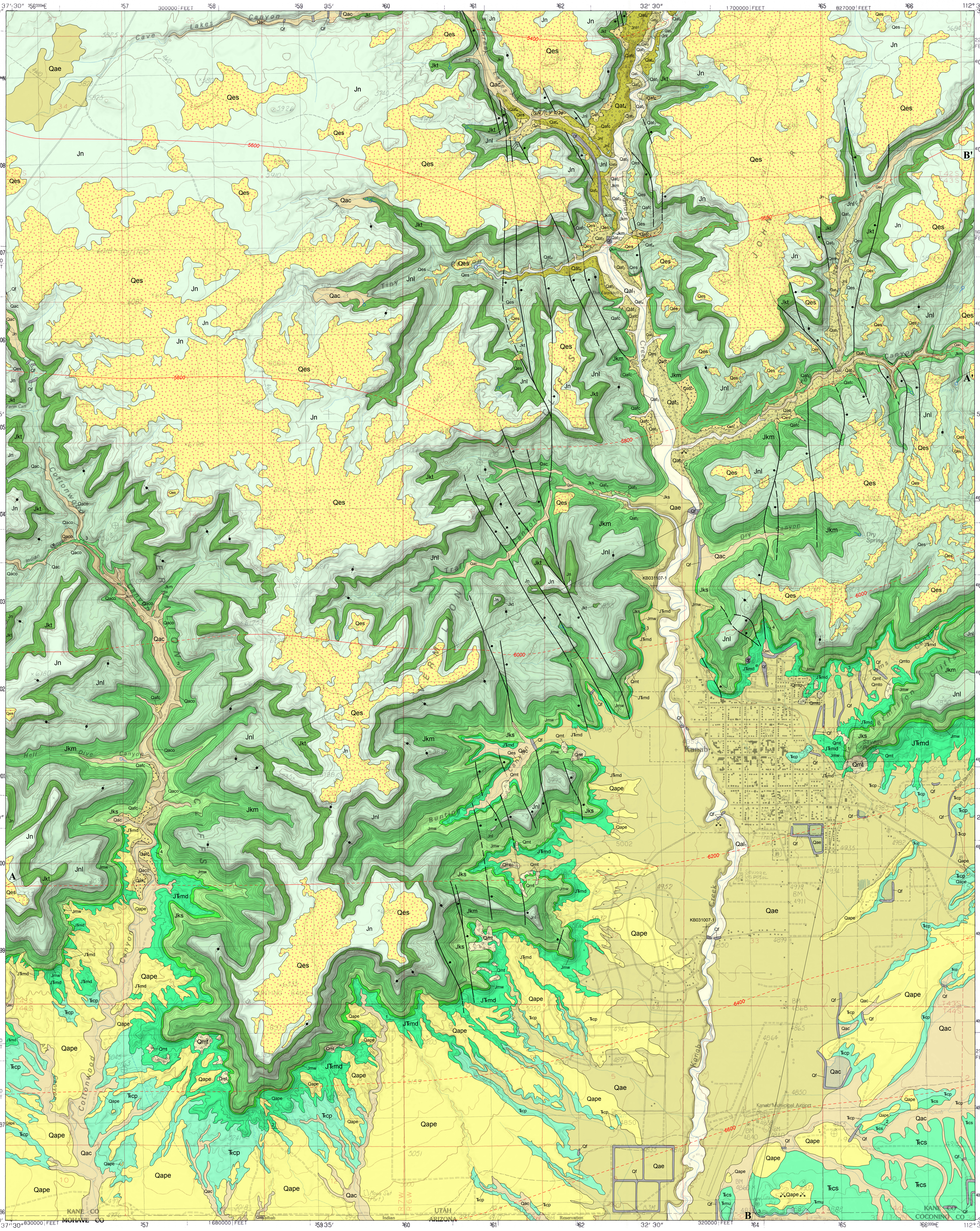

SCALE 1:24,000

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

This geologic map was funded by the Utah Geological Survey and the U.S. Geological Survey, National Cooperative Geologic Mapping Program, through USGS STATEMAP award number 05HQAG0084.

UTAH

QUADRANGLE LOCATION

GEOLOGIC MAP OF THE KANAB 7.5' QUADRANGLE, KANE COUNTY, UTAH AND COCONINO AND MOHAVE COUNTIES, ARIZONA

by
Janice M. Hayden

2011

11°46'
TRUE NORTH
MAGNETIC NORTH

APPROXIMATE MEAN DECLINATION, 2011

Base from U.S. Geological Survey Kanab 7.5' Quadrangle (1987)
Shaded relief derived from 5 meter elevation data
Projection: UTM Zone 12
Datum: NAD 1927
Spheroid: Clarke 1886

Project Manager: Robert F. Biek
GIS and Cartography: J. Buck Ehler

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1	2	3
4		5
6	7	8

1. Mount Carmel
2. White Tower
3. Cutler Point
4. Yellowjacket Canyon
5. Thompson Point
6. Kaibab
7. Fredonia
8. Shinarump Point

ADJOINING 7.5' QUADRANGLE NAMES

UTAH GEOLOGICAL SURVEY
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DESCRIPTION OF MAP UNITS

QUATERNARY

Alluvial deposits

Qa Shown in cross section only as a combination of mixed alluvial and eolian, alluvial and colluvial, and alluvial and eolian pediment-mantle deposits.

Qal_1 **Stream alluvium** (upper Holocene) – Stratified, moderately to well-sorted clay, silt, sand, and gravel deposits in large, active drainages; mapped along Kanab Creek and its major tributaries; includes alluvial-fan and colluvial deposits too small to map separately, and alluvial-terrace deposits as much as 10 feet (3 m) above modern channels; 0 to 30 feet (0–9 m) thick.

Qat_2, Qat_3, Qat_4 **Alluvial-terrace deposits** (Holocene to upper Pleistocene) – Moderately to well-sorted sand, silt, and pebble to boulder gravel that forms level to gently sloping surfaces above modern drainages; subscript denotes height above active drainages: level-2 deposits are about 10 to 50 feet (3–15 m), level-3 deposits are 50 to 100 feet (15–30 m), and level-4 deposits are 100 to 140 feet (30–43 m) above modern drainages; deposited primarily in stream-channel and floodplain environments; important local source of sand and gravel; mapped north of Kanab Reservoir dam along Kanab Creek; some older deposits partially mantled by eolian sand (Qes); four samples taken from level-4 deposits at 37°07′04.54″ N., 112°32′38.96″ W. yielded radiocarbon ages ranging from 4460 ± 90 ^{14}C yr B.P. (4862–5313 cal yr B.P.) to 3320 ± 60 ^{14}C yr B.P. (3440–3692 cal yr B.P.) (Smith, 1990); three samples taken from level-2 deposits at the same location yielded radiocarbon ages ranging from 625 ± 70 ^{14}C yr B.P. (523–680 cal yr B.P.) to 420 ± 40 ^{14}C yr B.P. (330–520 cal yr B.P.) (Smith, 1990; Summa, 2009); Summa (2009) proposed three periods of aggradation along Kanab Creek: older than 6000 to 3500 years ago, about 3000 to 1000 years ago, and 700 to 120 years ago that correlate to the cooler and wetter climatic intervals of early and late Neoglacial time and the Little Ice Age (Weng and Jackson, 1999; Refsnider and Brugger, 2007); entrenchment of the current channel began in 1882; 0 to 50 feet (0–15 m) thick.

Artificial deposits

Qf **Artificial fill** (Historical) – Artificial fill used to create small dams; consists of engineered fill and general borrow material; although only a few deposits have been mapped, fill should be anticipated in all areas with human impact, many of which are shown on the topographic base map; 0 to 90 feet (0–27 m) thick.

Eolian deposits

Qes **Eolian sand** (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 main body of the Navajo Sandstone and on gentle slopes of the Lamb Point Tongue of the Navajo Sandstone, but also deposited on alluvial-terrace (Qat) deposits where side canyons widen; 0 to 20 feet (0–6 m) thick.

Mass-movement deposits

Qmt, Qmto **Talus** (Holocene to upper Pleistocene) – Very poorly sorted, angular boulders with minor fine-grained interstitial sediment; deposited mostly by rock fall on and at the base of steep slopes; forms primarily from blocks that break off from the Navajo and Kayenta Formations and come to rest on the more gentle slope of the Moenave Formation; locally contains small landslide and slump deposits; may include and is gradational with older alluvium and eolian pediment-mantle deposits (Qape) farther downslope; Qmt mantles slopes beneath cliffs and ledges, whereas older deposits (Qmto) are dissected remnants that mantle and armor bedrock-cored hills now isolated from nearby cliffs due to slope retreat; 0 to 20 feet (0–6 m) thick.

Mixed-environment deposits

Qac, Qaco **Mixed alluvial and colluvial deposits** (Holocene) – Poorly to moderately sorted, clay- to boulder-sized, locally derived sediment deposited in swales and minor active drainages by alluvial, slope-wash, and creep processes; gradational with stream alluvium (Qal_1), mixed alluvium and eolian pediment-mantle (Qape) deposits, and mixed alluvial and eolian (Qae) deposits; older deposits (Qaco) mapped in Cottonwood Canyon are being dissected by and are currently 10 to 50 feet (3–15 m) above modern drainages; 0 to 30 feet (0–9 m) thick.

Qae **Mixed alluvial and eolian deposits** (Holocene to upper Pleistocene) – Moderately to well-sorted, clay- to sand-sized alluvial sediment that locally includes abundant eolian sand and minor alluvial gravel; includes alluvial-fan deposits too small to map separately in the upper part; calcic soils exhibit stage II pedogenic carbonate development (Birkeland and others, 1991); upper reaches accumulate sediment but deposits are deeply incised by Kanab Creek creating an arroyo; this well documented entrenchment began in 1882 during a series of large floods and continued until 1910 when the channel reached a depth of 65 to 100 feet (20-30 m) and a width of over 650 feet (200 m), thus exposing older depositional phases; tree-ring evidence substantiates an increase in precipitation intensity suggesting that a short-term fluctuation in climate is the principal cause for arroyo initiation, exacerbated by poor land-use practices that increased runoff (Webb and others, 1991); however, at least three arroyos were cut and back-filled along Kanab Creek in the past 5200 years in the absence of modern agriculture, irrigation, and grazing practices (Webb and others, 1991); to the east of the quadrangle at Park Wash and Kitchen Corral Wash, radiocarbon dates from similar stacked deposits indicate six depositional phases separated by periods of incision or non-deposition beginning at 6320, 5650, 5390, 4330, 2145, and 340 years before present (Sable and Hereford, 2004); six samples taken from incised walls of Kanab Creek at 37°03′40.31″ N., 112°32′21.86″ W. yielded radiocarbon ages that ranged from 5345 ± 90 ^{14}C yr B.P. (5934–6291 cal yr B.P.) taken from 17 feet (5 m) above creek level to 570 ± 70 ^{14}C yr B.P. (508–664 cal yr B.P.) taken from 82 feet (25 m) above the creek level (Smith, 1990); optically stimulated luminescence (OSL) ages obtained from two samples taken from the incised walls along Kanab Creek are much older: KB031107-1, sampled 80 feet (25 m) below the valley surface yet 3 feet (1 m) above Kanab Creek, yielded an age of 8580 ± 510 years B.P., and KB031007-1, farther down stream, sampled 40 feet (12 m) below the valley surface yet 20 feet (6 m) above Kanab Creek, yielded an age of 11,240 ± 840 years B.P., suggesting prior cutting and filling events; main part of upper surface correlates to level-3 terrace deposits that extend up stream from Kanab Reservoir; mapped in the southeast corner of the quadrangle beneath the City of Kanab and extending up Kanab Creek to the reservoir dam, and in the northwest corner of the quadrangle on a broad, nearly flat area of the Navajo Sandstone; 0 to 90 feet (0–27 m) exposed thickness.

Qafc **Mixed alluvial-fan and colluvial deposits** (Holocene) – Poorly to moderately sorted, non-stratified, subangular to subrounded, boulder- to clay-size sediment deposited at the mouths of active streams and washes; clast composition ranges widely and reflects rock types exposed in upstream drainage basins; deposited principally as debris flows and debris floods on active depositional surfaces, but also has significant colluvial component; mapped on level-3 and level-4 alluvial-terrace deposits in upper Kanab Creek drainage and on older mixed alluvial and colluvial deposits in Cottonwood Canyon; 0 to 20 feet (0–6 m) thick.

Qape **Mixed alluvium and eolian pediment-mantle deposits** (Holocene to upper Pleistocene) – Unconsolidated to weakly consolidated clay- to small boulder-size debris that forms a pediment mantle, commonly with a thin cover of eolian sand and loess, principally on broad planar surfaces cut across the non-resistant Petrified Forest Member of the Chinle Formation, but also on the Dinosaur Canyon Member of the Moenave Formation at the base of the Vermilion Cliffs; extends into valleys along the south edge of the quadrangle from the base of the Vermilion Cliffs; part next to cliffs still receives sediment and locally includes small, poorly sorted alluvial-fan, slope wash, and minor talus deposits; commonly dissected and left as remnants up to 60 feet (18 m) above modern drainages; lower end merges with mixed alluvial-colluvial (Qac) and mixed alluvial-eolian (Qae) deposits; important local source of sand and gravel; 0 to 20 feet (0–6 m) thick.

unconformity

JURASSIC

Navajo Sandstone and Kayenta Formation

Jn **Navajo Sandstone** (Lower Jurassic) – Light-gray to pale-orange and moderate-reddish-orange to moderate-reddish-brown, massively cross-bedded, moderately well-cemented sandstone with well-rounded, fine- to medium-grained, frosted quartz sand grains; strongly jointed; forms the White Cliffs step of the Grand Staircase (Gregory, 1950; Hintze and Yochelson, 2009); springs develop at lower contact with the Tenney Canyon Tongue of the Kayenta Formation; deposited in a vast coastal and inland dune field with prevailing winds principally from the north, and in rare interdunal ephemeral lakes and playas (Blakey, 1994, Peterson, 1994); lower contact is drawn where the massively bedded, vertically jointed sandstone gives way to the thinner bedded siltstone and sandstone of the Tenney Canyon Tongue of the Kayenta Formation; map unit includes areas of weathered sandstone regolith and Quaternary eolian sand too small to map separately; only lower 400 feet (120 m) is present in the quadrangle, but total thickness in this area is 1800 to 2000 feet (550–600 m) (Sargent and Philpott, 1987).

Jkt **Tenney Canyon Tongue of Kayenta Formation** (Lower Jurassic) – Interbedded pale-reddish-brown siltstone, mudstone, and very fine grained, very thin bedded to laminated, quartz sandstone; ledgy slope former; deposited in distal river, playa, and minor lacustrine environments (Tuesink, 1989; Blakey, 1994; Peterson, 1994); type section located in what is now called Tiny Canyon (rather than Tenney Canyon) on the topographic map (Doelling, 2008); conformably lies between the Navajo Sandstone and the Lamb Point Tongue of the Navajo Sandstone with sharp upper and lower contacts; lower contact is placed where the thin, interbedded siltstone, mudstone, and sandstone above give way to the massively cross-bedded sandstone of the Lamb Point Tongue of the Navajo Sandstone; thickens westward from 120 to 200 feet (40–60 m).

Jnl **Lamb Point Tongue of the Navajo Sandstone** (Lower Jurassic) – Grayish-white to grayish-orange, very fine to fine-grained, massively cross-bedded, quartz sandstone; forms cliff; type section is at Ed Lamb Point, just west of the quadrangle, the southernmost point of the Vermilion Cliffs that barely crosses into Arizona west of Cottonwood Canyon (Wilson, 1958); adits are abandoned glass sand or decorative sand mines (Doelling and Davis, 1989); conformably lies between Tenney Canyon Tongue and main body of the Kayenta Formation; springs develop at the lower contact with the main body of the Kayenta Formation; lower contact is placed where the massively bedded, vertically jointed sandstone gives way to thinner bedded siltstone and sandstone; deposited in an eolian erg and sabkha environment (Tuesink, 1989; Blakey, 1994; Peterson, 1994); thickens northeastward across the quadrangle from 250 to 450 feet (75–135 m)

Jkm **Main body of Kayenta Formation** (Lower Jurassic) – Reddish-brown to moderate-reddish-brown to pale-red siltstone and mudstone interbedded with very fine to fine-grained sandstone; includes minor intraformational pebble conglomerate and thin beds of light-gray limestone; light-gray siltstone marker bed about 30 feet (9 m) below the top extends across the quadrangle; forms ledgy slope; deposited in distal river, playa, and minor lacustrine environments (Tuesink, 1989; Blakey, 1994; Peterson, 1994); thickness varies from 200 to 350 feet (60–105 m).

Jks **Springdale Sandstone Member of Kayenta Formation** (Lower Jurassic) – Mostly pale-reddish-purple to pale-reddish-brown, moderately sorted, fine- to medium-grained, medium- to very thick bedded sandstone, and minor, thin, discontinuous lenses of intraformational conglomerate and thin interbeds of moderate-reddish-brown or greenish-gray mudstone and siltstone; has large lenticular and wedge-shaped, low-angle, medium- to large-scale cross-bedding; secondary color banding that varies from concordant to discordant to cross-beds is common in the sandstone; weathers to rounded cliffs in the west half of the quadrangle and to more angular ledges in the east half; unconformable lower contact with the Whitmore Point Member of the Moenave Formation is placed at the base of the more massive, ledgy sandstone beds above the slope of interbedded mudstone and claystone; contains locally abundant petrified and carbonized fossil plant remains; deposited in braided-stream and minor floodplain environments (Clemmensen and others, 1989; Blakey, 1994; Peterson, 1994; and DeCourten, 1998); generally thickens eastward but locally thickens and thins abruptly; 100 to 250 feet (30–75 m) thick.

unconformity, J-sub Kayenta of Blakey (1994) and Marzolf (1994), who proposed a major regional unconformity at the base of the Springdale Sandstone, thus restricting the Moenave Formation to the Dinosaur Canyon and Whitmore Point Members. Subsequent work by Lucas and Heckert (2001), Molina-Garza and others (2003), and Lucas and Tanner (2007a) also suggested that the Springdale Sandstone is more closely related to, and should be made the basal member of, the Kayenta Formation.

JURASSIC/TRIASSIC

Moenave Formation

Jmw **Whitmore Point Member** (Lower Jurassic) – Interbedded, pale-reddish-brown, greenish-gray, and grayish-red mudstone and claystone, with thin-bedded, moderate-reddish-brown, very fine to fine-grained sandstone and siltstone; siltstone is commonly thin bedded to laminated and locally ripple laminated; claystone is generally flat bedded; contains several 2- to 6-inch-thick (5–15 cm), bioturbated, cherty, very light gray to yellowish-gray, dolomitic limestone beds with algal structures, some altered to jasper, and fossil fish scales, possibly of *Semionotus kanabensis*; forms poorly exposed ledgy slope; eastward across the quadrangle, the percent of red beds increases making the lower contact increasingly difficult to pick; lower, conformable contact is placed at a pronounced break in slope at the base of the lowest light-gray, thin-bedded, dolomitic limestone and above the thicker bedded, reddish-brown sandstone and siltstone ledges of the Dinosaur Canyon Member; deposited in low-energy lacustrine and fluvial environments (Clemmensen and others, 1989; Blakey, 1994; Peterson, 1994; and DeCourten, 1998; Milner and Kirkland, 2006); thickens to the west from 40 to 60 feet (12–18 m).

J̄Ʀmd **Dinosaur Canyon Member** (Lower Jurassic to Upper Triassic) – Uniformly colored, interbedded, generally thin-bedded, moderate-reddish-brown to moderate-reddish-orange, very fine to fine-grained sandstone, very fine grained silty sandstone, and lesser siltstone and mudstone; ripple marks and mud cracks common; forms ledgy slope that steepens eastward; forms the base of Vermilion Cliffs step of the Grand Staircase (Gregory, 1950); regionally, a thin chert pebble conglomerate marks the base of the unit and the unconformity, but in this area, it is more common to have a 1.5- to 2-foot-thick (0.5–0.6 m) gypsum bed with local chert pebbles; unconformable lower contact is placed at the base of the chert pebble conglomerate or gypsum bed where recognized, otherwise, it is placed at the prominent color and lithology change from reddish-brown siltstone above to pale-greenish-gray mudstone of the Petrified Forest Member of the Chinle Formation below; deposited on broad, low floodplain that was locally shallowly flooded (fluvial mud flat) (Clemmensen and others, 1989; Blakey, 1994; Peterson, 1994; and DeCourten, 1998); thickness varies from 150 to 250 feet (45–75 m).

unconformity, "J-0" of Pipiringos and O'Sullivan (1978), who thought it was at the Jurassic-Triassic boundary; however, the Jurassic-Triassic boundary is now considered to be within the Dinosaur Canyon Member of the Moenave Formation, thus the "J-0" unconformity is in Upper Triassic strata (Molina-Garza and others, 2003; Kirkland and Milner, 2006; Lucas and Tanner, 2007b).

TRIASSIC

Chinle Formation

Ʀcp **Petrified Forest Member** (Upper Triassic) – Highly variegated, light-brownish-gray, pale-greenish-gray, to grayish-purple bentonitic shale, mudstone, siltstone, and claystone, with lesser thick-bedded, resistant sandstone and pebble to small cobble conglomerate near base; clasts are primarily chert and quartzite; contains minor chert, nodular limestone, and very thin coal seams and lenses as much as 0.5 inch (1 cm) thick; mudstone weathers to a "popcorn" surface due to expansive clays and causes road and building foundation problems; contains locally abundant, brightly colored fossilized wood; weathers to badland topography; prone to landsliding along steep hillsides, however, most outcrops within this quadrangle have low relief; mostly slope forming; lower contact with the Shinarump Conglomerate Member is placed at the base of the purplish-gray clay slope and above the prominent sandstone and conglomerate ledge; deposited in lacustrine, floodplain, and fluvial environments (Stewart and others, 1972a; Dubiel, 1994); not completely exposed within the quadrangle; underlies the City of Kanab and mixed alluvial-pediment-eolian (Qape), alluvial-eolian (Qae), and alluvial-colluvial (Qac) deposits in the valley in the south part of the quadrangle; thickness is 400 to 500 feet (130–165 m).

Ʀcs **Shinarump Conglomerate Member** (Upper Triassic) – Varies from dark-brown to moderate-yellowish-brown, medium- to coarse-grained sandstone with locally well-developed limonite bands ("picture stone" or "landscape rock"), to moderate-brown, pebbly conglomerate with subrounded clasts of quartz, quartzite, and chert; mostly thick- to very thick bedded with both planar and low-angle and ripple cross-stratification, although thin, platy beds with ripple cross-stratification occur locally; strongly jointed with common slickensides; contains poorly preserved petrified wood, commonly replaced in part by iron-manganese oxides; forms a resistant ledge to small cliff above the Moenkopi Formation, thus capping the Chocolate Cliffs step of the Grand Staircase (Gregory, 1950; Hintze and Yochelson, 2009); reddish-brown siltstone of the upper red member of the Moenkopi Formation; variable in composition and thickness because it represents stream-channel deposition over Late Triassic paleotopography (Stewart and others, 1972a; Dubiel, 1994); only exposed in the southeast corner of the quadrangle; thickness is 45 to 55 feet (14–17 m).

unconformity, TR-3 of Pipiringos and O'Sullivan (1978)

Moenkopi Formation

Ʀmu **Upper red member** (Lower Triassic) – Interbedded moderate-reddish-brown, thin-bedded siltstone and mudstone and moderate-reddish-orange, thin- to medium-bedded sandstone with planar, low-angle, and ripple cross-stratification; contains some thin gypsum beds and abundant discordant gypsum stringers; well-preserved ripple marks common in the siltstone; forms ledgy slope and cliffs; overall, generally coarsens upward; deposited in coastal-plain and tidal-flat environments (Stewart and others, 1972b; Dubiel, 1994); only upper 30 feet (9 m) is exposed in the southeast corner of the quadrangle; complete thickness in the area is 100 to 160 feet (30–50 m) (Doelling and Davis, 1989; Doelling, 2008).

Subsurface Unit

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

REFERENCES

Birkeland, P.W., Machette, M.N., and Haller, K.M., 1991, Soils as a tool for applied Quaternary geology: Utah Geological and Mineral Survey, Miscellaneous Publication 91-3, 63 p.

Blakey, R.C., 1994, Paleogeographic and tectonic controls on some Lower and Middle Jurassic erg deposits, Colorado Plateau, *in* Caputo, M.V., Peterson, J.A., and Franczyk, K.J., editors, Mesozoic systems of the Rocky Mountain region, USA: Denver, Colorado, Rocky Mountain Section of the Society for Sedimentary Geology, p. 273–298.

Clemmensen, L.B., Olsen, H., and Blakey, R.C., 1989, Erg-margin deposits in the Lower Jurassic Moenave Formation and Wingate Sandstone, southern Utah: Geological Society of America Bulletin, v. 101, p. 759–773.

DeCourten, F., 1998, Dinosaurs of Utah: Salt Lake City, University of Utah Press, 300 p.

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 MP-08-2DM, 2 pls., scale 1:100,000.

Doelling, H.H., and Davis, F.D., 1989, The geology of Kane County, Utah—geology, mineral resources, geologic hazards, with sections on petroleum and carbon dioxide by C.J. Brandt: Utah Geological and Mineral Survey Bulletin 124, 192 p., and Map 121 to accompany Bulletin 124, 10 plates., scale 1:100,000.

Dubiel, R.F., 1994, Triassic deposystems, paleogeography, and paleoclimate of the Western Interior, *in* Caputo, M.V., Peterson, J.A., and Franczyk, K.J., editors, Mesozoic systems of the Rocky Mountain region, USA: Denver, Colorado, Rocky Mountain Section of the Society for Sedimentary Geology, p. 133–168.

Gregory, H.E., 1950, Geology and geography of the Zion Park region: U.S. Geological Survey Professional Paper 220, 200 p.

Hintze, L.F., and Yochelson, E., 2009, The Grand Staircase at Kanab Creek in 1879—its remarkable first measurement by C.D. Walcott: Brigham Young University Geology Studies Special Publication 10, 55 p.

Kirkland, J.I., and Milner, A.R.C., 2006, The Moenave Formation at the St. George Dinosaur Discovery Site at Johnson Farm, *in* Harris, J.D., Lucas, S.G., Spielmann, J.A., Lockley, M.G., Milner, A.R.C., and Kirkland, J.I., editors, The Triassic/Jurassic terrestrial transition: New Mexico Museum of Natural History and Science Bulletin 37, p. 289–309.

Lucas, S.G., and Heckert, A.B., 2001, Theropod dinosaurs and the Early Jurassic age of the Moenave Formation, Arizona-Utah, USA: Neues Jahrbuch für Geologie und Paläontologie Mh., Stuttgart, Germany, v. 7, p. 435–448.

Lucas, S.G., and Tanner, L.H., 2007a, The Springdale Member of the Kayenta Formation, Lower Jurassic of Utah-Arizona, *in* Harris, J.D., Lucas, S.G., Spielmann, J.A., Lockley, M.G., Milner, A.R.C., and Kirkland, J.I., editors, The Triassic/Jurassic terrestrial transition: Albuquerque, New Mexico Museum of Natural History and Science Bulletin 37, p. 71–76.

Lucas, S.G., and Tanner, L.H., 2007b, Tetrapod biostratigraphy and biochronology of the Triassic-Jurassic transition on the southern Colorado Plateau, USA: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 244, p. 242–256.

Marzolf, J.E., 1994, Reconstruction of the early Mesozoic Cordilleran cratonal margin adjacent to the Colorado Plateau, *in* Caputo, M.V., Peterson, J.A., and Franczyk, K.J., editors, Mesozoic systems of the Rocky Mountain region, USA: Denver, Colorado, Rocky Mountain Section of the Society for Sedimentary Geology, p. 181–216.

Milner, A.R.C., and Kirkland, J.I., 2006, Preliminary review of the Early Jurassic (Hettangian) freshwater Lake Dixie fish fauna in the Whitmore Point Member, Moenave Formation in southwest Utah, *in* Harris, J.D., Lucas, S.G., Spielmann, J.A., Lockley, M.G., Milner, A.R.C., and Kirkland, J.I., editors, The Triassic/Jurassic terrestrial transition: New Mexico Museum of Natural History and Science Bulletin 37, p. 510–521.

Molina-Garza, R.S., Geissman, J.W., and Lucas, S.G., 2003, Paleomagnetism and magnetostratigraphy of the lower Glen Canyon and upper Chinle Groups, Jurassic-Triassic of northern Arizona and northeast Utah: Journal of Geophysical Research, v. 108, no. B4, 2181, doi: 10.1029/2002JB001909.

Peterson, F., 1994, Sand dunes, sabkhas, streams, and shallow seas—Jurassic paleogeography in the southern part of the Western Interior Basin, *in* Caputo, M.V., Peterson, J.A., and Franczyk, K.J., editors, Mesozoic systems of the Rocky Mountain region, USA: Denver, Colorado, Rocky Mountain Section of the Society for Sedimentary Geology, p. 233–272.

Pipiringos, G.N., and O'Sullivan, R.B., 1978, Principal unconformities of Triassic and Jurassic rocks, western interior United States—a preliminary survey: U.S. Geological Survey Professional Paper 1035-A, 29 p.

Refsnider, K.A., and Brugger, K.A., 2007, Rock glaciers in central Colorado, U.S.A., as indicators of Holocene climate change: Arctic, Antarctic, and Alpine Research, v. 39, p. 127–136.

Sable, E.G., and Hereford, R., 2004, Geologic map of the Kanab 30' x 60' quadrangle, Utah and Arizona: U.S. Geological Survey Geologic Investigations Series I-2655, scale 1:100,000.

Sargent, K.A., and Philpott, B.C., 1987, Geologic map of the Kanab [15'] quadrangle, Kane County, Utah, and Mohave and Coconino Counties, Arizona: U.S. Geological Survey Map GQ-1603, scale 1:62,500.

Smith, S.S., 1990, Relationship of large floods and rapid entrenchment of Kanab Creek, southern Utah: Tucson, University of Arizona, M.S. thesis, 82 p.

Stewart, J.H., Poole, F.G., and Wilson, R.F., 1972a, Stratigraphy and origin of the Chinle Formation and related Upper Triassic strata in the Colorado Plateau region, with a section on sedimentary petrology by R.A. Cadigan and on conglomerate studies by W. Thordarson, H.F. Albee, and J.H. Stewart: U.S. Geological Survey Professional Paper 690, 336 p.

Stewart, J.H., Poole, F.G., and Wilson, R.F., 1972b, Stratigraphy and origin of the Triassic Moenkopi Formation and related strata in the Colorado Plateau region, with a section on sedimentary petrology by R.A. Cadigan: U.S. Geological Survey Professional Paper 691, 195 p., scale 1:2,500,000.

Summa, M.C., 2009, Geologic mapping, alluvial stratigraphy, and optically stimulated luminescence dating of the Kanab Creek area, southern Utah: Logan, Utah State University, M.S. thesis, 2 plates, 170 p.

Tuesink, M.F., 1989, Depositional analysis of an eolian-fluvial environment—the intertonguing of the Kayenta Formation and Navajo Sandstone (Jurassic) in southwestern Utah: Flagstaff, Northern Arizona University, M.S. thesis, 189 p.

Webb, R.H., Smith, S.S., and McCord, V.A.S., 1991, Historic channel change of Kanab Creek, southern Utah and northern Arizona: Grand Canyon Natural History Association, Monograph No. 9, 92 p.

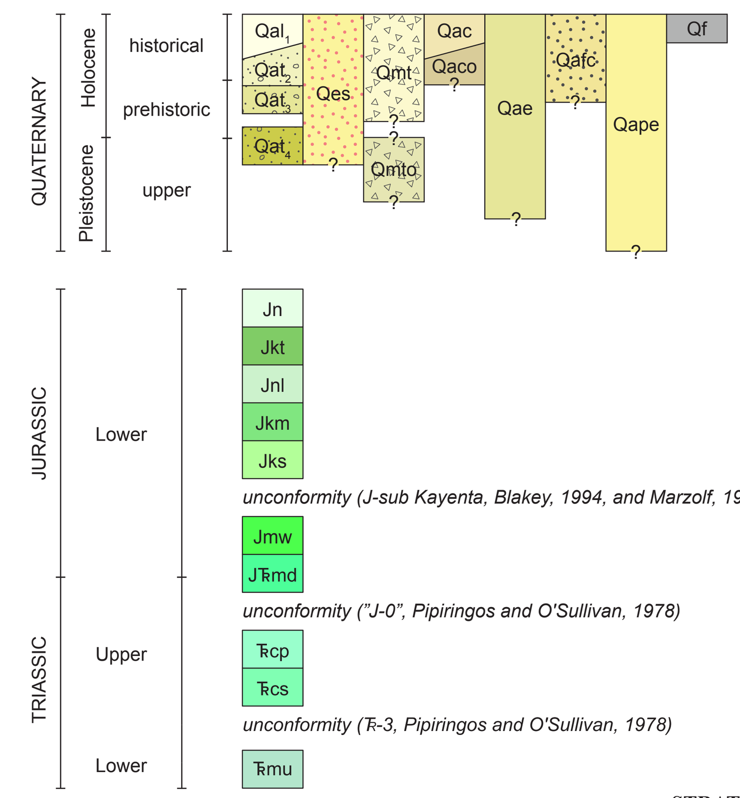
Weng, C., and Jackson, S.T., 1999, Late Glacial and Holocene vegetation history and paleoclimate of the Kaibab Plateau, Arizona: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 153, n. 1-4, p. 179–201.

Wilson, R.F., 1958, The stratigraphy and sedimentology of the Kayenta and Moenave Formations, Vermilion Cliffs region, Utah and Arizona: Palo Alto, California, Stanford University, Ph.D. dissertation, 337 p.

ACKNOWLEDGMENTS

Robert F. Biek, Grant C. Willis, Hellmut H. Doelling, and Robert Ressetar, each with the Utah Geological Survey (UGS), reviewed this report and offered valuable suggestions for improvement. J. Buck Ehler (UGS) created and edited the digital files for this project. J. Doug Powell and Allen Titus, both with the Bureau of Land Management (BLM), shared their knowledge of the area. Dirk Clayson, Ben Clarkson, and Robert and Ruth Hale graciously allowed access to private property. City of Fredonia, Arizona, provided access to upper Cottonwood Canyon. Tammy Rittenour, Utah State University Luminescence Lab, provided OSL ages of mixed alluvial and eolian deposits exposed along Kanab Creek. J. Doug Powell (BLM), J. Buck Ehler (UGS), and John S. Hayden provided valuable field assistance.

CORRELATION OF GEOLOGIC UNITS



MAP SYMBOLS

- Contact
- Normal fault, dashed where approximately located, dotted where concealed; bar and ball on down thrown side
- Structural contour, dashed where projected, drawn on top of Jkt, Contour interval = 200 ft
- Strike and dip of bedding
- Joint - near vertical
- Gravel pit
- Adit (sand)
- Spring
- KB03107-1 Sample location and number
- A — A' Line of cross section

STRATIGRAPHIC COLUMN

ERATHEM	SYSTEM	SERIES	FORMATION - MEMBER		SYMBOL	THICKNESS Feet (Meters)	LITHOLOGY
CENO.	QUAT.		Surficial deposits		Q	0-90 (0-27)	
MESOZOIC	JURASSIC	Lower	Navajo Sandstone		Jn	400+ (120+)	High-angle cross beds
			Tenney Canyon Tongue of Kayenta Formation		Jkt	120-200 (40-60)	
			Lamb Point Tongue of Navajo Sandstone		Jnl	250-450 (75-135)	
			Kayenta Formation	main body	Jkm	200-350 (60-105)	
				Springdale Sandstone Member	Jks	100-250 (30-75)	Petrified wood; J-sub Kayenta unconformity
			Moenave Formation	Whitmore Pt. Mbr.	Jmw	40-60 (12-18)	*Semionotus kanabensis* (fish scales)
				Dinosaur Canyon Member	J̄Ʀmd	150-250 (45-75)	"J-0" unconformity
	TRIASSIC	Upper	Chinle Formation	Petrified Forest Member	Ʀcp	400-500 (130-165)	Swelling clays; Petrified wood
				Shinarump Conglomerate Member	Ʀcs	45-55 (14-17)	"Picture stone"; Ʀ-3 unconformity
		L	Moenkopi Formation	upper red member	Ʀmu	30+ (9+)	

Vermilion Cliffs west of Kanab and just east of Ed Lamb Point formed from mostly Jurassic redbeds. The Navajo Sandstone (Jn) caps the cliff with the Lamb Point Tongue (Jnl) creating the upper massive cliffs. The Tenney Canyon Tongue (Jkt) and the main body (Jkm) of the Kayenta Formation form slopes above and below the cliffs. The lower ledge is the Springdale Sandstone Member of the Kayenta Formation (Jks) while the slope at the base of the cliff is the two members of the Moenave Formation, Whitmore Point (Jmw) and Dinosaur Canyon (J̄Ʀmd). The Petrified Forest Member of the Chinle Formation (Ʀcp) is exposed in the valley.