INTERIM GEOLOGIC MAP OF THE JOHNSON LAKES QUADRANGLE, KANE COUNTY, UTAH, AND COCONINO COUNTY, ARIZONA

by

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Disclaimer

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Description of Map Units

QUATERNARY
Alluvial deposits

Qa Undifferentiated alluvial and other surficial deposits – hown on cross section only; 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 Johnson Wash 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.

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 20 feet (0-6 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 gentle slopes of the Lamb Point Tongue of the Navajo Sandstone and the dip slope of the Shinarump Conglomerate Member of the Chinle Formation, but also deposited on the main body of the Kayenta Formation and on mixed alluvial and eolian (Qae) deposits where side canyons widen near Johnson Canyon; 0 to 20 feet (0-6 m) thick.

Mass-movement deposits

Qmt **Talus** (Holocene) – 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, and from blocks of the Shinarump Conglomerate Member of the Chinle Formation that come to rest on the slope of the Moenkopi Formation; locally contains small landslide and slump deposits; may include and is gradational with older, mixed alluvial and eolian pediment-mantle deposits (Qape) farther downslope; mantles slopes beneath cliffs and ledges; 0 to 20 feet (0-6 m) thick.

Mixed-environment deposits

Qac **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 alluvial and eolian pediment-mantle deposits (Qape), and mixed alluvial and eolian deposits (Qae); 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 Johnson Wash creating an arroyo; this well-documented entrenchment began in 1882 during a series of large floods and continued until 1910, thus exposing older depositional phases; six samples taken from incised walls of Kanab Creek to the west yielded radiocarbon ages that ranged from 5345 $\pm$ 90 ^{14}C yr B.P. (5934-6291 cal yr B.P.) to 570 $\pm$ 70 ^{14}C yr B.P. (508-664 cal yr B.P.) (Smith, 1990) while optically stimulated luminescence (OSL) ages obtained from two samples are much older yielding ages of 8580 $\pm$ 510 years B.P., and 11,240 $\pm$ 840 years B.P., suggesting prior cutting and filling events (Hayden, 2011a); also along Kanab Creek, 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); 10 to 15 miles (16-24 km) east of the quadrangle at Park Wash and Kitchen Corral Wash, radiocarbon ages from similar deposits indicate six depositional phases separated by periods of incision or nondeposition beginning at 6320, 5650, 5390, 4330, 2145, and 340 years before present (Sable and Hereford, 2004); forms broad, sloping surfaces in Johnson Canyon and its tributaries, and in other drainages coming off the Vermilion Cliffs; 0 to 30 feet (0-9 m) exposed thickness.

Qafe **Mixed alluvial-fan and eolian deposits** (Holocene) – Poorly to moderately sorted, non-stratified, subangular to subrounded, boulder- to clay-size sediment deposited at the mouths of washes in the southwest corner of the quadrangle; clasts composed of the Shinarump Conglomerate Member of the Chinle Formation and the upper red member of the Moenkopi Formation exposed upstream; deposited principally as debris flows and debris floods on active depositional surfaces, but also has significant eolian component; 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; 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 as much as 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 (main body)** (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); 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); only mapped in the northwest corner of the quadrangle; the lower contact is drawn where the massively bedded, vertically jointed sandstone above gives way to the thinner bedded siltstone and sandstone of the Tenney Canyon Tongue of the Kayenta Formation below, where present; otherwise, the Navajo Sandstone main body is divided from the Lamb Point Tongue of the Navajo Sandstone for short distances along the contact only by a break in the cliff face, which is mapped as a single line; only lower 50 feet (15 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 Kanab 7.5’ topographic quadrangle map west of the Johnson Lakes quadrangle (Doelling, 2008); to the west, the Tenney Canyon Tongue conformably lies between the Navajo Sandstone and the Lamb Point Tongue of the Navajo Sandstone, normally with sharp upper and lower contacts; however, in the adjacent Thompson Point quadrangle, near the base of the Tenney Canyon Tongue, lenses of siltstone and mudstone are interbedded with sandstone typical of the Lamb Point Tongue, thus making this contact gradational (Hayden, 2011b); locally along this gradational contact, the Tenney Canyon Tongue pinches out and reappears; lower contact is placed where the thin, interbedded siltstone, mudstone, and sandstone above, where present, give way to the massively cross-bedded sandstone of the Lamb Point Tongue of the Navajo Sandstone; generally thickens westward; 0 to 60 feet (0-20 m) thick.

Jnl **Lamb Point Tongue of Navajo Sandstone** (Lower Jurassic) – Grayish-white to grayish-orange, very fine to fine-grained, massively cross-bedded, quartz sandstone; locally includes thin interbeds of Tenney Canyon Tongue-like beds near the top; forms cliff; type section at Ed Lamb Point is west of the quadrangle at the southernmost point of the Vermilion Cliffs just east of the Sevier fault (Wilson, 1958); 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 about 400 to 500 feet (120-150 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 thickens and coarsens as it extends eastward 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 300 feet (60-90 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 mostly to angular ledges that become more massive eastward along the Vermilion Cliffs, but locally forms more rounded cliffs that are typical of this member farther west (Hayden, 2011a); 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; DeCourten, 1998); generally thickens eastward but locally thickens and thins abruptly; 200 to 250 feet (60-75 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

Jm **Moenave Formation, undivided** – Shown on cross section only.

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 in lenticular or wedge-shaped beds; claystone is generally flat bedded; locally contains 2- to 4-inch-thick (5-10 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; to the west, the member consists of a lower and upper lacustrine interval separated by a red sandstone and siltstone ledge but the lower lacustrine interval pinches out beneath the thickening red bed, resulting in a dramatic thinning of the unit eastward (Hayden, 2011a, b); in this quadrangle, the unit containing fish scales continues to thin to the center of the quad, where it then is traced eastward as a finer grained marker bed that forms a break in slope in the nearly vertical Vermilion Cliffs; no fish scales were found in this bed along the east side of the quadrangle; lower, conformable contact is placed at a pronounced break in slope at the base of the lowest light-gray, thin-bedded, dolomitic limestone, where present, 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; DeCourten, 1998; Milner and Kirkland, 2006); thickens to the west from 5 to 20 feet (1.5-6 m).

JTRmd **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); to the west in the St. George area, 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 Chinle Formation below; deposited on broad, low floodplain that was locally shallowly flooded (fluvial mud flat) (Clemmensen and others, 1989; Blakey, 1994; Peterson, 1994; DeCourten, 1998); thickness varies from 200 to 300 feet (60-90 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 and may be the TR-5 unconformity of Lucas and Tanner (2007b) (Molina-Garza and others, 2003; Kirkland and Milner, 2006; Lucas and Tanner, 2007b).

TRIASSIC
Chinle Formation

TRcu **Upper members, undivided** (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 fairly low relief; some of the best exposed outcrops are protected from erosion by mixed alluvial and eolian pediment-mantle (Qape) at the base of the Vermilion Cliffs; mostly slope forming; consists mostly of the Petrified Forest and Owl Rock Members, but may include other upper Chinle units; lower contact with the Shinarump Conglomerate Member of the Chinle Formation is placed at the base of the purplish-gray clay slope and above the prominent sandstone and conglomerate ledge; deposited in lacustrine, floodplain, and braided-stream environments (Stewart and others, 1972a; Dubiel, 1994); poorly exposed within the quadrangle due to cover by eolian sand, mixed alluvial and eolian pediment-mantle deposits (Qape), alluvial-eolian deposits (Qae), and alluvial-colluvial deposits (Qac); thickness is 450 to 600 feet (140-195 m).

TRcs **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 cross-stratification, although thin, platy beds with ripple cross-stratification occur locally; strongly jointed with common slickensides; contains poorly preserved petrified wood, locally as much as 4 feet (1.2 m) long with a diameter of 2 feet (0.6 m), 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); lower unconformable contact is drawn at the base of the small cliff above the slope-forming 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); just south of Highway 89 near the center of the map the unit resurfaces, perhaps because of gentle folding, or because mapped beds are channel sands in the undifferentiated upper members of the Chinle Formation; thickness is 50 to 100 feet (15-30 m).

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

Moenkopi Formation

TRmu **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; lower conformable and gradational contact, marked by a prominent color change and lesser slope change, is placed at the top of the highest light-colored, thick gypsum bed, above which are steeper slopes of laminated to thin-bedded, moderate-reddish-brown siltstone and sandstone of the upper red member; deposited in coastal-plain and tidal-flat environments (Stewart and others, 1972b; Dubiel, 1994); complete section exposed in the southeast and southwest corners of the quadrangle; 120 to 150 feet (40-45 m) thick.

TRms **Shnabkaib Member** (Lower Triassic) – Light-gray to pale-red, gypsiferous siltstone with bedded gypsum and several thin interbeds of dolomitic, unfossiliferous limestone near the base; upper part is very gypsiferous and weathers to a powdery soil commonly covered by microbiotic crust; forms ledge-slope "bacon-striped" topography; commonly prone to landsliding where topographic expression steeper; lower conformable and gradational contact is drawn at the base of the lowest thick gypsum bed below which the sequence is predominantly reddish-brown siltstone; deposited on broad coastal shelf of very low relief where minor fluctuations in sea level produced interbedding of evaporites and red beds (Stewart and others, 1972b; Dubiel, 1994); 160 to 220 feet (50-65 m) thick.

TRmm **Middle 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; deposited in coastal-plain and tidal-flat environments (Stewart and others, 1972b; Dubiel, 1994); incomplete section exposed in the southeast corner of the quadrangle; lower contact not exposed although 300 feet (90 m) is present in the quadrangle and total thickness in this area is 300 to 360 feet (90-110 m) (Doelling and Davis, 1989; Sable and Hereford, 2004; Doelling, 2008).

Subsurface Unit

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

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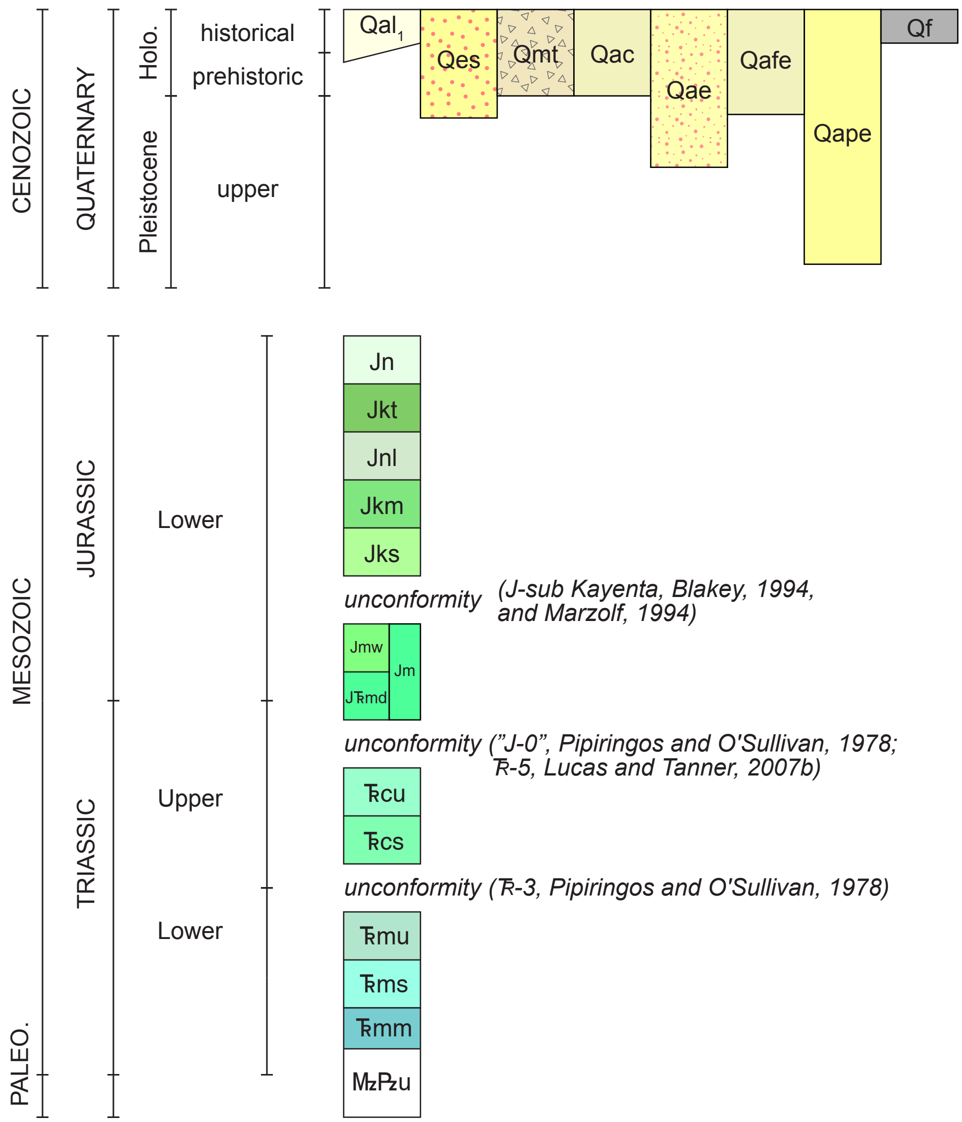
MAP SYMBOLS

	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 Jkm, Contour interval = 200 ft
8	Strike and dip of bedding
	Joint – near vertical
	Borrow pit
	Gravel
s	Sand
	Quarry (picture stone)
	Spring
A A'	Line of cross section

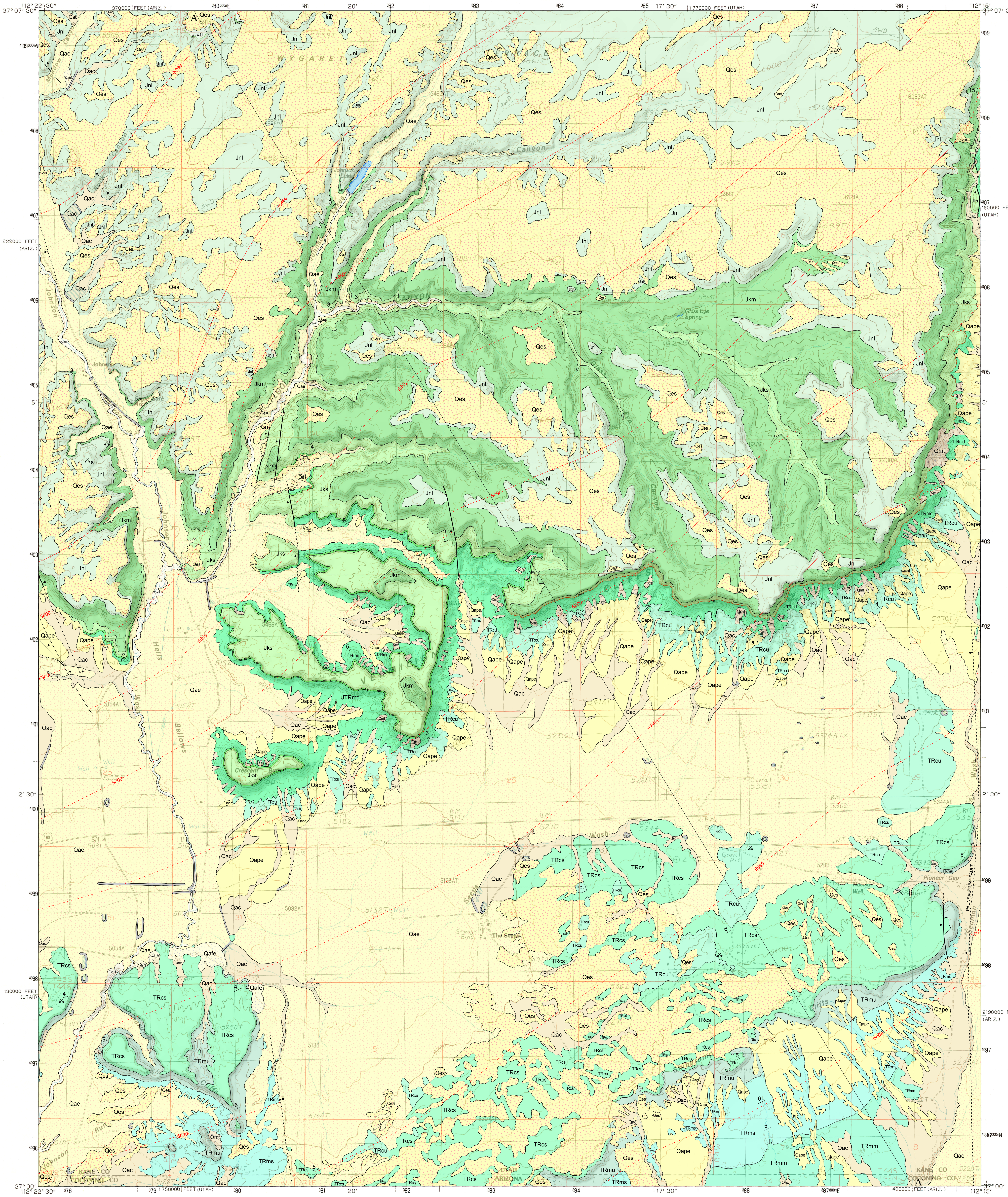
CORRELATION OF GEOLOGIC UNITS

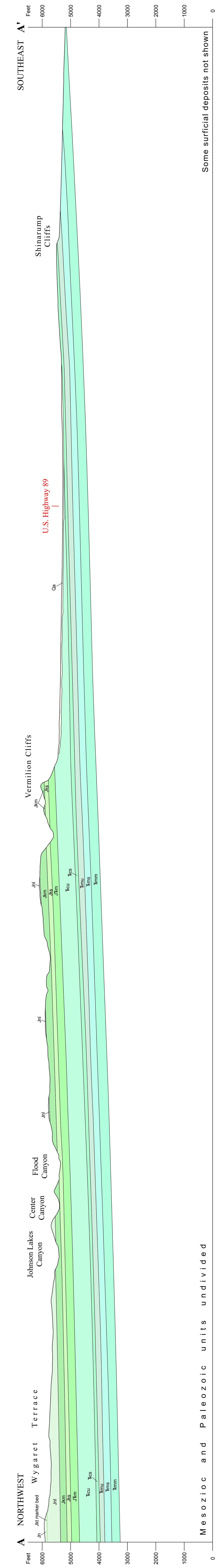


STRATIGRAPHIC COLUMN

ERATHEM	SYSTEM	SERIES	FORMATION	MEMBER	SYMBOL	THICKNESS Feet (Meters)	LITHOLOGY
CEN.	QUAT.		Surficial deposits		Q	0–30 (0–9)	
MESOZOIC	JURASSIC	Lower	Navajo Sandstone		Jn	50+ (15+)	High-angle cross-beds
			Tenney Canyon Tongue of Kayenta Formation		Jkt	0–60 (0–20)	Thickens westward
			Lamb Point Tongue of Navajo Sandstone		Jnl	400–500 (120–150)	Thins westward
			Kayenta Formation	main body	Jkm	200–300 (60–90)	
				Springdale Sandstone Member	Jks	200–250 (60–75)	Petrified wood
							J-sub Kayenta *unconformity*
			Moenave Formation	Whitmore Pt. Mbr.	Jmw (Jm)	5–20 (1.5–6)	*Semionotus kanabensis* (fish scales)
	TRIASSIC			Dinosaur Canyon Member	JŦmd (Jm)	200–300 (60–90)	
							"J-0" or Ŧ-5 *unconformity*
		Upper	Chinle Formation	upper members, undivided	Ŧcu	450–600 (140–195)	Swelling clays Petrified wood
				Shinarump Conglomerate Member	Ŧcs	50–100 (15–30)	"Picture stone"
							Ŧ-3 *unconformity*
		Lower	Moenkopi Formation	upper red member	Ŧmu	120–150 (40–45)	
				Shnabkaib Member	Ŧms	160–220 (50–65)	"Bacon-striped" ledgy slope
				middle red member	Ŧmm	300–360 (90–110)	
PAL.			Mesozoic and Paleozoic, undivided		MzPzu		not exposed

UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources





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UTAH
QUADRANGLE LOCATION

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

INTERIM GEOLOGIC MAP OF THE JOHNSON LAKES QUADRANGLE, KANE COUNTY, UTAH, AND COCONINO COUNTY, ARIZONA

by

Janice M. Hayden

2011

11°38'
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 2011

Base from U.S. Geological Survey Johnson Lakes 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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geology.utah.gov

1	2	3
4		5
6	7	8

1. Cutler Point
2. Pine Point
3. Nephi Point
4. Thompson Point
5. Petrified Hollow
6. Shinarump Point
7. Muggins Flat
8. Buck Pasture Canyon

ADJOINING 7.5' QUADRANGLE NAMES