UTAH GEOLOGICAL SURVEY
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Utah Department of Natural Resources

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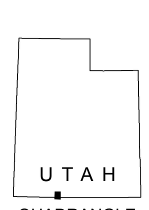


QUADRANGLE LOCATION

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

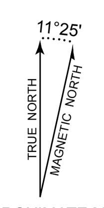
CONTOUR INTERVAL 40 FEET

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

by

Janice M. Hayden

2013



APPROXIMATE MEAN DECLINATION, 2013

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

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: Jay C. Hill, Kent D. Brown, J. Buck Ehler

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DESCRIPTION OF MAP UNITS

QUATERNARY

Alluvial 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 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 Sandstone and Kayenta Formation 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 deposits; locally includes 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 — **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 — **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 (after Birkeland and others, 1991); upper reaches that are not deeply incised accumulate sediment, but middle and lower reaches are deeply incised by Johnson Wash creating an arroyo; 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.

The Johnson Lakes quadrangle is characterized by large arroyo valleys with thick alluvial fill. Several studies have documented that throughout the geologic record, arroyos of the southwest (and streams in other climates as well) cycle between episodes of incision and back-filling. Well-documented entrenchment in this part of southwest Utah began in 1882 during a series of large floods and continued until 1910, thus exposing older depositional phases (Smith, 1990; Webb and others, 1991; Summa, 2009; Nelson and Rittenour, 2011; see also Hereford, 2002). Six samples taken from incised walls of Kanab Creek, in a similar depositional setting about 10 miles (16 km) to the west of the Johnson Lakes quadrangle, yielded radiocarbon ages that ranged from 5345 ± 90 ^{14}C yr B.P. (5934–6291 cal yr B.P.) to 570 ± 70 ^{14}C yr B.P. (508–664 cal yr B.P.) (Smith, 1990), whereas optically stimulated luminescence (OSL) ages obtained from two samples are much older—8580 ± 510 yr B.P. and 11,240 ± 840 yr B.P.—suggesting prior cutting and filling events (Summa, 2009; Nelson and Rittenour, 2011; see also 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. In some cases, this may be 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). About 10 to 15 miles (16–24 km) east of the Johnson Lakes 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).

Qafe — **Alluvial-fan and eolian deposits** (Holocene to upper Pleistocene) – 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 are from the Shinarump Conglomerate Member of the Chinle Formation and the upper red member of the Moenkopi Formation; 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 — **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; lower end merges with mixed alluvial-colluvial (Qac) and mixed alluvial-eolian (Qae) deposits; some deposits are dissected and left as remnants as much as 60 feet (18 m) above modern drainages; 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; Hayden, 2011a); 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, the base of the White Cliffs step of the Grand Staircase (Gregory, 1950); 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; mostly thin to medium bedded; 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-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 (2006) 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

JŦm — **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 Semionotid fossil fish scales; forms poorly exposed ledgy slope; to the west near Kanab, the member consists of lower and upper lacustrine intervals separated by a red sandstone and siltstone ledge, but eastward, the lower lacustrine interval pinches out beneath the thickening red bed, resulting in a dramatic thinning of the unit (Hayden, 2011a, 2011b); 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).

JŦmd — **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 (Hayden, 2005, 2011c), but in this area, a 1.5- to 2-foot-thick (0.5–0.6 m) gypsum bed with local chert pebbles is more common; 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).

Ŧ-5 ***unconformity***, previously 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 and is not at an unconformity, thus the regional unconformity is in Upper Triassic strata and is probably the Ŧ-5 unconformity of Lucas and Tanner (2007) (see also Molina-Garza and others, 2003; Kirkland and Milner, 2006).

TRIASSIC

Chinle Formation

Ŧcu — **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 a cap of mixed alluvial and eolian pediment-mantle deposits (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 (Qes), 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).

Ŧcs — **Shinarump Conglomerate Member** (Upper Triassic) – Varies from dark-brown to moderate-yellowish-brown, medium- to coarse-grained sandstone with locally well-developed Liesegang 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 (Shinarump) 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 presence of this map unit may reflect gentle folding, or possibly the mapped beds are actually channel sands in the undifferentiated upper members of the Chinle Formation; thickness is 50 to 100 feet (15–30 m).

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

Moenkopi Formation

Ŧmu — **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.

Ŧms — **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 on step slopes; 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.

Ŧmm — **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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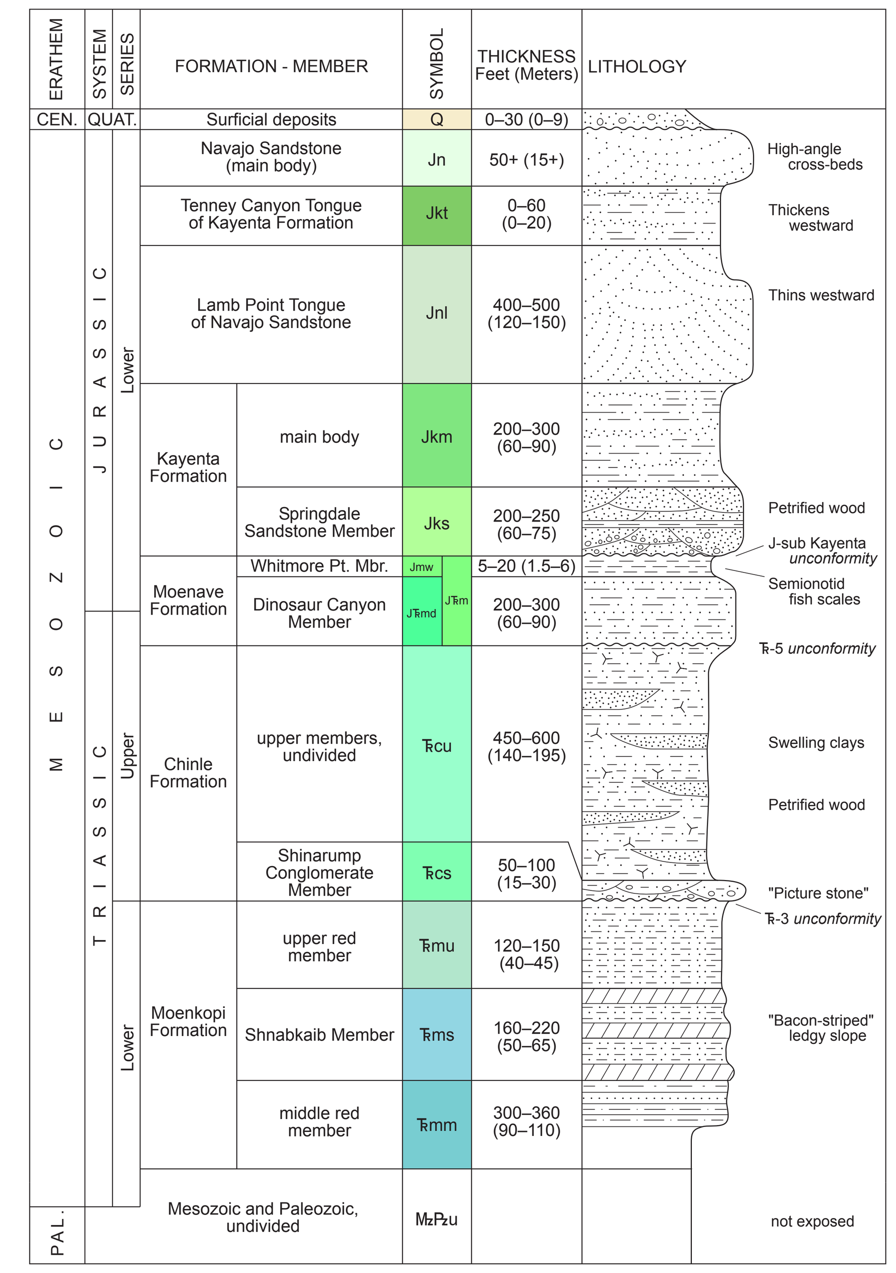
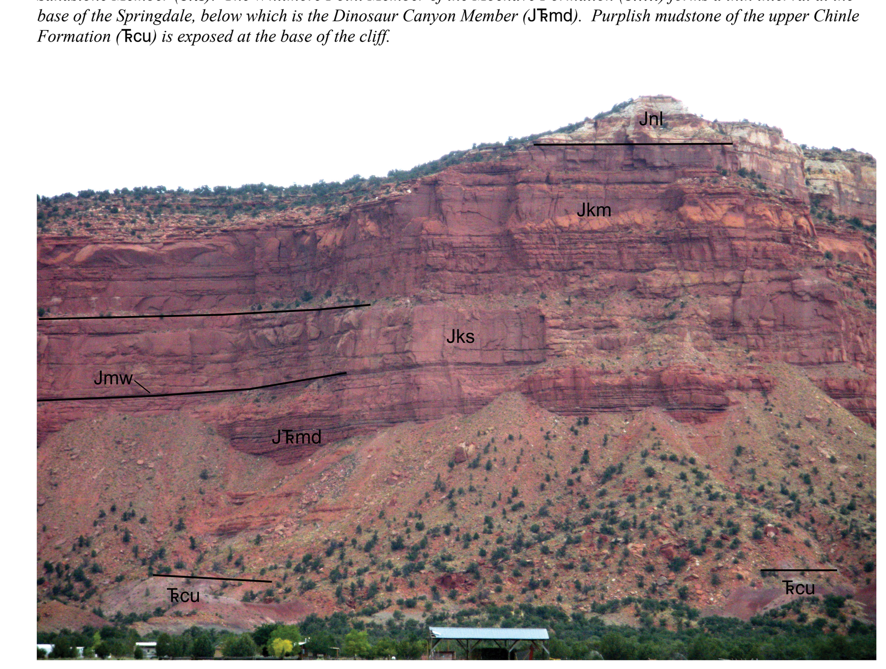
STRATIGRAPHIC COLUMN

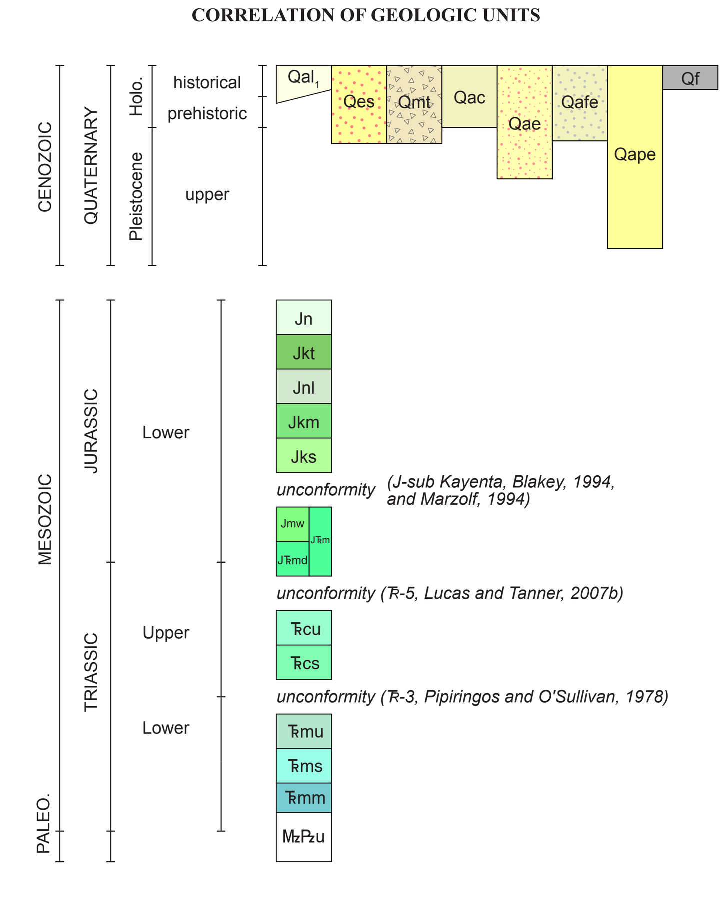


View north of the Vermilion Cliffs just west of Flag Point. The cliffs are composed of the Kayenta and Moenave Formations. The main body of the Kayenta Formation (Jkm) forms the upper part of the cliff, above the Springdale Sandstone Member (Jks). The Whitmore Point Member of the Moenave Formation (Jmw) forms a thin interval at the base of the Springdale, below which is the Dinosaur Canyon Member (JŦmd). Purplish mudstone of the upper Chinle Formation (Ŧcu) is exposed at the base of the cliff.



View north to Flag Point, capped by the Lamb Point Tongue (Jnl) of the Navajo Sandstone. The main body of the Kayenta Formation (Jkm) forms the upper part of the cliff, above the Springdale Sandstone Member (Jks). The Whitmore Point Member of the Moenave Formation (Jmw) forms a thin interval at the base of the Springdale, below which is the Dinosaur Canyon Member (JŦmd). Purplish mudstone of the upper Chinle Formation (Ŧcu) is exposed at the base of the cliff.

CORRELATION OF GEOLOGIC UNITS



MAP SYMBOLS