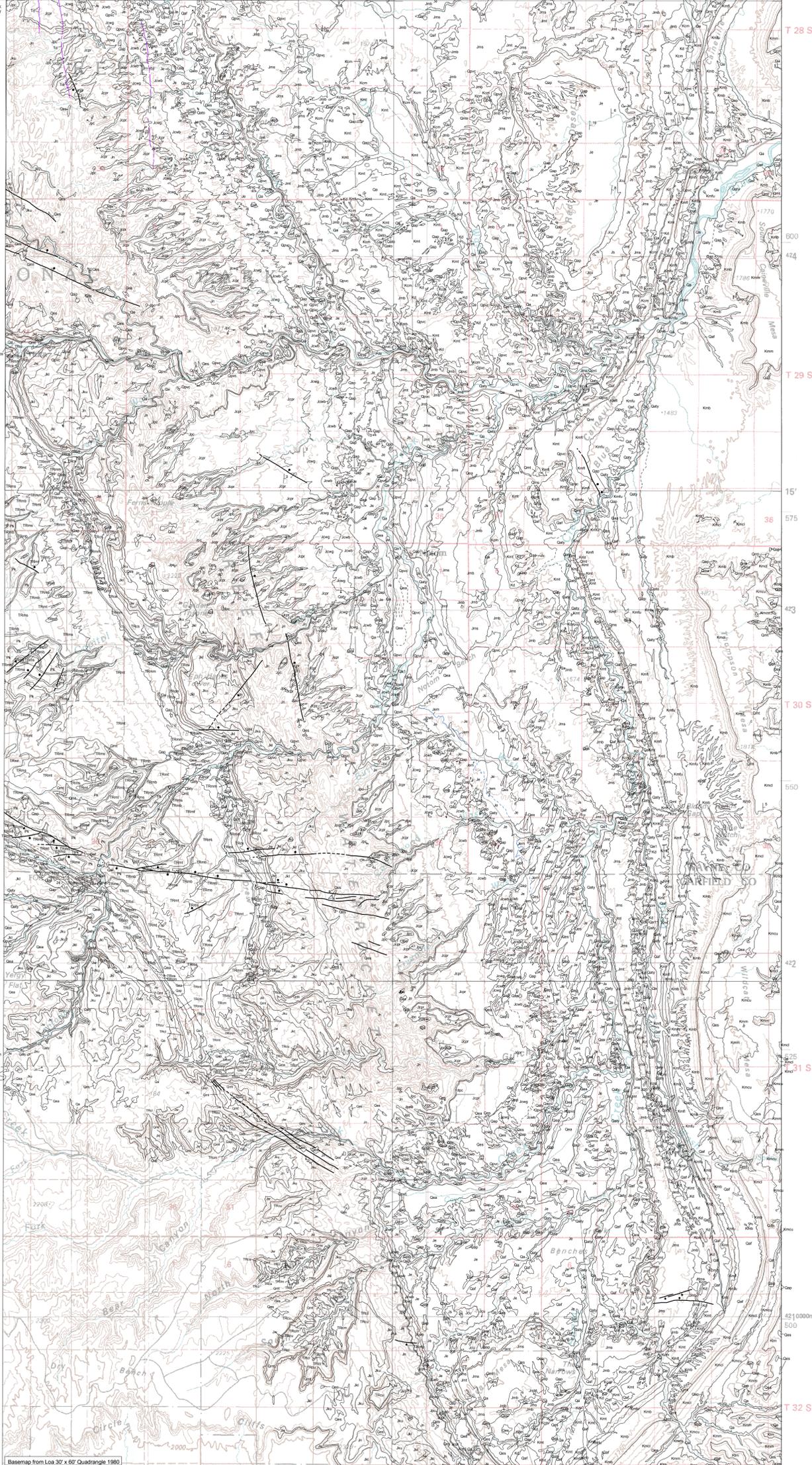


Progress Report Geologic Map of the East Half of the Lo 30' x 60' Quadrangle,  
Emery, Garfield and Wayne Counties, Utah (Year 1 of 2)

by  
Hellmut H. Doelling and Paul A. Kuehne  
2005

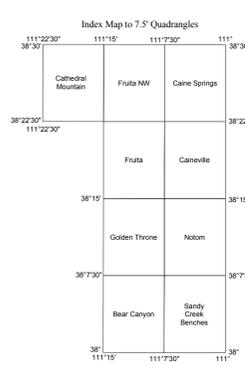
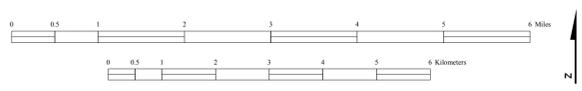
Utah Geological Survey  
Open-File Report 453



**Map Explanation**

- Contact
- - - Contact, Approximately Located
- Coal Bed
- Dike, Well Located
- - - Dike, Approximately Located
- Fault, Well Located, Bar and ball on downthrown side
- - - Fault, Approximately Located, Bar and ball on downthrown side
- - - Fault, Concealed
- Landslide Main Scarp
- Anticline, Well located
- - - Anticline, Approximately Located
- Syncline, Well located
- - - Syncline, Approximately Located
- Marker Bed, Well Located
- - - Marker Bed, Approximately Located
- Sill
- Strike and dip of inclined bedding

Scale 1:62,500  
Contour Interval - 50 Meters



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a division of

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**Disclaimer**

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**DESCRIPTION OF MAP UNITS  
EAST HALF OF LOA 30' x 60' QUADRANGLE**

Quaternary deposits

- Qa     **Alluvium:** Sand, silt, clay, granules, pebbles, cobbles, and sparse boulders in areas where modern alluvium and younger terrace alluvium can not be differentiated on the map. As much as 30 feet thick, but generally much thinner. Holocene to late Pleistocene.
- Qa1    **Modern alluvium:** Sand, silt, clay, granules, pebbles, cobbles, and sparse boulders present as channel fills along the more active streams and washes; unconsolidated, poorly to well sorted. Thickness varies widely, but commonly less than 30 feet (10 m) thick. Holocene
- Qaty    **Younger terrace alluvium:** Sand, silt, clay, granules, pebbles, cobbles, and sparse boulders present in terraces adjacent to modern stream channels; unconsolidated, poorly to well sorted. Thickness varies widely, but locally may exceed 40 feet (12 m). Middle Holocene to late Pleistocene.
- Qato    **Older terrace alluvium:** Mostly silt to cobbles, angular to rounded; contains chert, limestone, sandstone, siltstone, conglomerate, dolomite, and igneous lava boulders to 2 feet (0.6 m) or more in diameter, but mostly pebbles to cobbles up to 2 inches (5 cm) in diameter; poorly to well sorted; basal parts are generally more coarse; deposits are found at irregular levels above modern drainages. 0-30 feet (0-9 m) thick. Middle to late Pleistocene.
- Qaf     **Alluvial fans, local alluvium:** Sand, silt, clay, granules, cobbles, and sparse boulders; angular to subrounded clasts; cut-and-fill channel features locally present, crudely bedded to unstratified; deposited at the foot of cliffs, ridges, and higher ground and at the mouths of some streams and washes. Thickness commonly less than 50 feet (15 m). Holocene to late Pleistocene
- Qap     **Pediment mantle deposits:** Boulders, cobbles, and pebbles in matrix of granules, sand, silt, and clay; rounded to angular, generally poorly sorted and fining upward; covers bedrock surfaces between drainages at various levels above local base level. Commonly less than 50 feet (15 m) thick. Mostly late Pleistocene, but may extend to Holocene.
- Qpvc    **Pediment mantle and colluvial deposits with volcanic boulders:** Same as Qap, except contain significant quantities of volcanic (vesicular andesitic basalt) rocks; generally gray to dark gray in overall appearance; undersides of volcanic boulders locally exhibit white calcium carbonate (caliche) coatings. Commonly less than 50 feet (15 m) thick. Holocene to Pleistocene.

- Qea **Mixed eolian and alluvial deposits:** Sand and silt of eolian origin interspersed with silt, sand, and gravel of fluvial origin; poorly stratified; upper parts generally dominated by eolian deposits; commonly displays a caliche soil horizon near the top; generally found covering pediment mantle deposits or low flat areas. Thickness 50 feet (15 m) or less. Holocene to middle Pleistocene.
- Qes **Eolian sand:** Unconsolidated sand deposited in sheets or low dunes, light orange brown, nearly white, or light-brown, fine to medium grained, well sorted; especially common in areas underlain with the Entrada Sandstone or similar sandstone deposits. 0-20 feet (0-6 m) thick, may be thicker where deposited on the lee sides of cliffs. Holocene.
- Qmt **Talus, colluvium, and rock fall deposits:** Rock-fall blocks, boulders, angular gravel, sand, and silt; deposited on slopes below cliffs and steeper slopes; only larger deposits mapped. Thickness generally 15 feet (4.5 m) or less. Holocene to late Pleistocene.
- Qms **Slumps and landslide deposits:** Coherent to broken and jumbled masses of hard bedrock units to hummocky unsorted materials derived from softer, clayey units, that have moved downslope. Varied thicknesses. Holocene to middle Pleistocene.
- Qmb **Bouldery deposits below cliffs, sills, and steep gradients:** Angular to subrounded boulders and cobbles in a matrix of gravel, silt, and clay particles. Varied thicknesses, but generally 20 feet (6 m) or less. Holocene to middle Pleistocene.

#### Tertiary intrusions

- Ts **Sills:** Tephrite and phonotephrite, light gray to dark green gray, commonly differentiated into tephrite and phonotephrite horizons and exhibiting chilled zones at contacts with sedimentary rocks, described as composite sills of syenite and diabase (Williams and Hackman, 1971); locally porphyritic with phenocrysts of olivine, biotite, basaltic hornblende, and feldspar in a groundmass of anorthoclase, labradorite, hornblende, analcite, and thomsonite; resistant; intruded into several sedimentary horizons, mostly into Middle Jurassic rocks; sills locally split and divide and change stratigraphic position. A few inches to nearly 100 feet (30 m) in thickness. Pliocene.  $4.35 \pm 0.04$  Ma ( $^{40}\text{Ar}/^{39}\text{Ar}$ ) unpublished UGS data.
- Td **Dikes:** Trachybasalt and basalt, dark gray to dark green gray, consisting chiefly of augite, biotite, labradorite, anorthoclase, olivine, thomsonite, and analcite; referred to as diabase dikes (Williams and Hackman, 1971); most are nearly vertical and appear to cut sills (Ts), but are probably related to them; intruded into

sedimentary rocks of Triassic to Late Jurassic age, some as much as 3 miles in length. 0-10 feet (0-3m) thick. Pliocene.

#### Cretaceous rocks

**Ktm Tarantula Mesa Sandstone:** Sandstone, yellow gray and light yellow brown, mostly fine grained, in thick resistant beds, cross-bedded with partings of shaly to platy sandstone; contains local conglomeratic intervals with clasts to 1 inch (2.5 cm) in diameter; forms cliffs; lower contact transitional, but sharp where the slope-forming Masuk is overlain by Tarantula Mesa cliffs. 300+ feet (90 m) thick. Upper Cretaceous (Campanian).

#### **Km Mancos Shale**

**Kmm Masuk Shale Member:** Sandy muddy shale, sandy carbonaceous shale, and muddy sandstone, mostly gray, light green gray, and yellow gray; laminated to irregularly bedded; forms long steep slope at base of Tarantula Mesa Sandstone cliffs; contains petrified wood, shell fragments, and rare shark teeth. 600-670 feet (185-205 m) thick. Upper Cretaceous (Campanian).

#### **Kmc Muley Canyon Sandstone Member**

**Kmcb Upper unit of Muley Canyon Sandstone Member:** Sandstone, mudstone, carbonaceous mudstone, and coal; sandstone is light to dark brown, fine to medium grained, in lenticular thin to massive beds, and commonly resistant; mudstone is gray, green gray, and yellow gray, laminated to thin bedded, slope forming, and locally bentonitic; carbonaceous mudstone is dark gray, medium to dark brown, to black, laminated to thin bedded, and slope forming; coal, in mostly thin beds, but locally as thick as 6 feet (2 m), high-volatile bituminous C, with Btu values ranging from 7,700 to 10,800 and sulfur content from 0.5 to 3.5 percent (Doelling and Graham, 1972); upper Muley Canyon Sandstone forms ledges and slopes. 100-200 feet (30-60 m) thick. Upper Cretaceous (Campanian).

**Kmcl Lower unit of Muley Canyon Sandstone Member:** Sandstone and sandy mudstone, mostly light to dark brown, with a nearly white (very light gray) unit at top, very fine to medium grained, cross-bedded, thin to thick bedded and lenticular, and generally cliff forming. 150-200 feet (45-60 m) thick. Upper Cretaceous (Campanian).

**Kmb Blue Gate Shale Member:** Marine shale, mudstone, and siltstone; pale blue gray; nodular and irregular with several yellow-gray sandy beds which increase upward; weathers into low rolling hills and badlands, except under the Muley Canyon Sandstone Member cliffs where it stands as a steep slope. 1200-1600 feet (365-490 m) thick. Upper Cretaceous (Santonian-Campanian).

**Kmf Ferron Sandstone Member**

- Kmfu **Upper unit of Ferron Sandstone Member:** Sandstone, mudstone, carbonaceous mudstone, and coal; sandstone is light to dark brown, very fine to coarse grained, locally with chert pebbles, thin to massive lenticular beds, many units cross-bedded; mudstone is gray, yellow gray, or green gray, commonly bentonitic, laminated to thin bedded, carbonaceous varieties are dark gray; coal is mostly in thin beds (< 2 feet [0.6 m] thick), high-volatile bituminous C, with Btu values ranging between 10,000 and 11,000 and sulfur content ranging from 1 to 2.5% sulfur (Doelling and Graham, 1972); upper unit is ledge and slope forming. 20-200 feet (6-60 m) thick. Upper Cretaceous (late Turonian).
- Kmfl **Lower unit of Ferron Sandstone Member:** Sandstone and mudstone; sandstone is mostly light to dark brown, very fine to medium grained with rare coarse-grained lenses; lenticular and cross-bedded, generally forms a cliff; mudstone is gray to green gray and silty and decreases upwards where it appears as partings; grades downward into the Tununk Shale. 130-300 feet (40-90 m) thick. Upper Cretaceous (late Turonian).
- Kmt **Tununk Shale Member:** Marine shale, mudstone, and siltstone, medium to dark gray; becomes progressively sandier upward in the section; forms steep slope under Ferron Sandstone Member cliff; grades downward into the Dakota Sandstone. 500-600 feet (150-185 m) thick. Upper Cretaceous (late Cenomanian and Turonian).
- Kd **Dakota Sandstone:** Sandstone, mudstone, carbonaceous mudstone, and thin coal and conglomerate; sandstone is gray, yellow gray, and light brown, very fine to medium grained, as lenticular cross-stratified discontinuous channels; conglomerate where present occurs as lenses in the sandstone, pebbles and cobbles in conglomerate are dominantly quartzitic; mudstone is found in shades of gray, dependent on carbon content; coals are generally thin and lenticular, but locally thicken to as much as 2 feet (0.6 m); ledgy, but with intervening slope-forming mudstones; slopes can form the base, middle, or top of unit; locally contains no sandstone; upper contact placed above a zone of *Pycnodonte newberryi* and *Exogyra levis* that is everywhere present in the mapped area (some authors place this fossil zone in the Tununk Shale Member of the Mancos Shale). 10-60 feet (3-20 m) thick. Upper Cretaceous (Cenomanian).

*unconformity*

- Kcm **Cedar Mountain Formation:** Mudstone, shale, sandstone, conglomeratic sandstone, conglomerate, calcareous nodules, and siltstone; gray, gray brown, lavender, green gray, and red; sandstones are commonly cross-bedded; mudstones locally bentonitic; mostly slope-forming; base may be a conglomeratic ledge known as the Buckhorn Conglomerate; where it is missing it is difficult to separate from the Brushy Basin Member of the Morrison Formation; contains

dinosaur bones, gastroliths, plant remains, and fresh-water shellfish locally. 35-170 feet (10-50 m) thick. Lower Cretaceous (Albian).

*unconformity*

Jurassic rocks

Jm **Morrison Formation**

Jmb **Brushy Basin Member:** Claystone, siltstone, sandstone, conglomeratic sandstone, and conglomerate; variegated in shades of red, brown, lavender, white, gray, green, and gray with color bands varying from a few inches to 20 feet (6 m) or more; common bentonitic units; locally contains siliceous and calcareous nodules; coarser units are lenticular, discontinuous, and cross-bedded, and quartzitic; appears like the Cedar Mountain Formation above, but colors are generally more vivid; generally forms slope with some ledges; may contain silicified wood and bone fragments; grades downward into the Salt Wash Member. 100-200 feet (30-60 m) thick. Upper Jurassic.

Jms **Salt Wash Member:** Sandstone, conglomeratic sandstone, siltstone, and claystone; sandstone and conglomeratic sandstone is mostly light gray, with areas of gray pink, pale red, and yellow gray, very fine-grained to very coarse grained, angular to subrounded, pebbles and cobbles in conglomerates are generally of chert with lesser quantities of quartzite and siliceous limestone; beds are lenticular, cross-bedded, channel-form, and resistant; siltstone and claystone are commonly red or green-gray and form recesses between the thick channels of sandstone; unit is dominated by ledges; locally contains bone fragments and silicified wood; channeled into Tidwell Member below. 30-250 feet (9-75 m) thick, thickening southward. Upper Jurassic.

Jmt **Tidwell Member:** Siltstone, sandstone, mudstone, gritstone, and gypsum; finer-grained clastic units generally red or gray green in crinkly thin beds; coarser units lenticular, cross-bedded, and more resistant than finer-grained units; gypsum is commonly found as a thick alabaster bed at the base of the unit, but is discontinuous and not everywhere present; unit forms a slope or recess beneath the Salt Wash ledges. 40-120 feet (12-65 m) thick, intertongues with Salt Wash above; surface of unconformity below irregular and with a relief of a few feet. Upper Jurassic.

*J-5 unconformity*

Js **Summerville Formation:** Siltstone, mudstone, and fine-grained sandstone, light to medium reddish brown, in mostly thin, even beds; calcareous; gypsum is present, mostly as veinlets or thin beds, increasing toward the top, locally contains red and white cherty nodules near the base; generally forms a steep slope with a few slight fine-grained sandstone ledges. 180-250 feet (55-75 m) thick, gradational with the Curtis Formation below. Middle Jurassic.

Jcu **Curtis Formation:** Sandstone and subordinate siltstone, light to medium gray and white, fine grained to medium grained, dominantly quartzose, glauconitic, and calcareous; thin to thick bedding; generally forms a lower cliff and upper slope; commonly contains red and gray chert in upper part. 0-100 feet (0-30 m) thick, thinning and pinching out to the south and west; contact with Entrada Sandstone below is an erosional unconformity (paraconformity), but locally is an angular unconformity. Middle Jurassic.

*J-3 unconformity*

Je **Entrada Sandstone:** Sandstone with subordinate interbedded siltstone and claystone, mostly red orange, red brown, and white with subordinate purple, yellow, and brown; mostly fine to very fine grained with scattered coarse grains, quartzose, subangular to subrounded, mostly well sorted, and commonly cross-bedded; outcrops range from soft and earthy weathering to hard and cliffy; commonly covered with large tracts of self-derived eolian sand; members as defined in southwest Utah are not developed here; prominent sandstone marker bed (labeled Jem) locally mapped. 400-700 feet (120-215 m) thick, contact with Carmel Formation below is conformable, but abrupt. Middle Jurassic.

Jc **Carmel Formation**

Jcw **Winsor Member**

Jcwb **Banded unit of Winsor Member:** Interbedded mudstone, siltstone, sandstone, and thin gypsum beds arranged in irregular cyclical fashion, mostly gray or light brown gray with subordinate red or red-brown bands; many mudstone and siltstone beds are criss-crossed with satin-spar gypsum veinlets; forms slopes and gypsum ledges; conformable with unit below. About 275 feet (85 m) thick. Middle Jurassic.

Jcwg **Gypsiferous unit of Winsor Member:** Thick alabaster gypsum beds interbedded with subordinate light gray or red siltstone or fine-grained sandstone beds; conformable with unit below. 100-125 feet (30-38 m) thick. Middle Jurassic.

Jcpr **Paria River Member:** Limestone and calcarenite, light gray and yellow gray, sandy and silty; may include a thick alabaster gypsum bed at base; thin to medium bedded, weathers platy and into ledges and slopes; conformable with unit below. About 165 feet (50 m) thick. Middle Jurassic.

Jpc **Page Sandstone and Co-op Creek and Crystal Creek Members of the Carmel Formation, undivided:** Map unit is mostly Page Sandstone, but includes beds correlating with the Co-op Creek Limestone Member and Crystal Creek Members as found in southwestern Utah. Page Sandstone is mostly gray, yellow-brown, or white sandstone, fine to coarse grained, partly cross-bedded, in thick beds; generally resistant and cliff forming; base scoured into Navajo Sandstone below. 0-45 feet (0-14 m) thick. Crystal Creek is gray-pink sandstone that weathers red,

forms steep slope, and contains cross cutting satin-spar gypsum veinlets. 25 to 30 feet (8-9 m) thick. Co-op Creek Limestone Member is mostly ledgy limestone and calcarenite with partings or thin interbeds or partings of siltstone, mudstone, or fine-grained calcareous sandstone. 30-40 feet (9-12 m) thick. Total mapped unit is 55-115 feet (16-35 m) thick. Middle Jurassic.

*J-2 unconformity*

Jn **Navajo Sandstone:** Sandstone, mostly light-hued, fine- to medium-grained, cross-bedded in large trough sets, contains scattered dark mineral grains, which are subangular and frosted, well sorted, clean and friable; mostly massive, weathers into domes and rounded knolls; probably intertongues with Kayenta Formation below. 700-1100 feet (215-335 m) thick, thickening westward. Lower Jurassic.

Jk **Kayenta Formation**

Jku **Upper eolian member:** Sandstone, red, yellow gray, or orange; mostly fine grained; displays high-angle eolian cross-stratification; commonly looks like the Navajo Sandstone and may intertongue with that unit; separated from that unit by very fine grained sandstone or siltstone that is red. 100-200 feet (30-60 m) thick.

Jkl **Lower member:** Interbedded sandstone and siltstone; chiefly red, but gray orange, yellow gray, red orange, and red brown are also common; very fine to fine grained, subangular to subrounded grains; mostly medium to massive beds (up to 12 feet [3.5 m] thick); forms ledges and cliffs. 250-300 feet (75-90 m) thick.

Jw **Wingate Sandstone:** Sandstone, orange brown and locally dark-brown weathering; fine grained, massive, eolian, quartzose; forms vertical cliffs along canyon walls that are commonly stained with manganese oxide (desert varnish); contains local partings of sandy siltstone that are more common near the base; generally well cemented with calcium carbonate and locally siliceous; contact with Chinle below is generally abrupt and placed at the base of the cliff. 300-370 feet (90-115 m) thick. Lower Jurassic, but lower part may be Late Triassic in age.

*unconformity*

Triassic rocks

TRc **Chinle Formation:** Present in four members in the east half of the Loa 30' x 60' quadrangle. All Upper Triassic.

TRcu **Upper slope-forming member:** Siltstone, sandstone, and subordinate limestone; overall appearance is pale red brown; unit forms a slope beneath the Wingate Sandstone cliff, that is commonly covered with sandstone litter; a hard sandstone ledge forms the base that is fine to

medium grained and thin to medium bedded. 110-200 feet (35-60 m) thick.

- TRcl **Lower slope-forming member:** Siltstone and very fine grained sandstone, red brown, light brown, grayish red, purple, and lavender; locally concretionary, micaceous. 200-250 feet (60-75 m) thick, grades into Monitor Butte Member below.
- TRcsm **Monitor Butte and Shinarump Members, undivided**
- TRcm **Monitor Butte Member:** Sandstone and siltstone, light gray and green gray, forms slopes and rounded ledges; locally contains much petrified wood. 0-200 feet (0-60 m) thick.
- TRcs **Shinarump Member:** Sandstone, light gray to white, fine to coarse grained, cross-bedded, some conglomeratic lenses and scattered pebbles; bedded lenticularly up to as much as 12 feet (4 m) thick; a few partings of muddy sandstone up to 4 inches (10 cm) thick; resistant and cliff-forming; discontinuous and somewhat channeled (not obvious in most places) into Moenkopi Formation below. 0-200 feet (0-60 m) thick.
- unconformity*
- TRm **Moenkopi Formation:** Present in four members in the east half of the Loa 30' x 60' quadrangle. Lower Triassic
- TRmm **Moody Canyon Member:** Mudstone, claystone, siltstone, and very fine grained sandstone, all medium to dark reddish brown; contains veinlets and thin beds of gypsum; thin to medium bedded with local thick beds, common ripple-marked units; forms steep slope, not as resistant as unit below. 300-450 feet (90-135 m) thick, conformable with Torrey Member below.
- TRmt **Torrey Member:** Sandstone, siltstone, mudstone, mostly medium reddish brown (chocolate-brown), with widely spaced yellow-brown ledges, siltstones and mudstones are generally dark reddish brown; sandstone is fine-grained to very fine grained; most beds are calcareously cemented; units are commonly cross-bedded and ripple-marked; locally petroliferous. 300-350 feet (90-105 m) thick, conformable with Sinbad Limestone Member below.
- TRms **Sinbad Limestone Member:** Limestone, dolomite, dolomitic limestone with subordinate calcareous sandstone and siltstone, light gray, gray-brown, yellow brown; crystalline and clastic; some limestones are oolitic and some beds are stylolitic; generally thin to thick bedded (a few inches to several feet thick), conspicuously jointed and hard; forms a prominent ledge or low cliff, weathers hackly. 70-200 feet (20-60 m) thick, conformable with the Black Dragon Member below.
- TRmb **Black Dragon Member:** Siltstone and very fine-grained sandstone, red-brown, yellow brown and gray; commonly forms a steep slope; locally has a thin (as much as 15 feet [4.5 m] thick) basal conglomerate with angular

pebbles and cobbles derived from the Kaibab Limestone below. 40-120 feet (12-35 m) thick, scoured into the Kaibab Limestone below.

*unconformity*

Permian rocks

- Pk **Kaibab Limestone:** Mostly limestone and dolomite, impure and cherty, and subordinate sandstone and local gray shale; limestone and dolomite beds are mainly white, light gray and yellow gray, and locally yellowish brown, chert is present in the limestone and dolomite beds in light gray thin beds, nodules, or as small geodes whose interiors are commonly lined with small quartz crystals; some beds are sandy and cross-bedded, some are crystalline, others clastic (calcarenite) or chalky; beds are medium to massive (1-8 ft thick), resistant and cliff forming; sandstone is generally gray to gray brown, calcareous, and fine grained, locally exhibits high-angle cross-bedding; local shale lenses are gray and soft. 250 to nearly 400 feet (75-120 m) thick; contact with unit below appears transitional. Mostly Lower Permian.
- Pc **Cedar Mesa Sandstone:** Sandstone, quartzose, mostly white to gray, very fine to fine grained, well sorted, well rounded and frosted; high-angle cross-beds in wedge-shaped lenses; siliceous and calcareous cement; forms cliffs or steep slopes broken by local silty partings. 800+ feet (245+ m) thick, base not exposed at the surface. Lower Permian.

**References**

- Doelling, H.H., and Graham, R.L., 1972, Eastern and northern Utah coalfields: Utah Geological and Mineral Survey Monograph 2.
- Williams, P.L., and Hackman, R.J., 1971, Geology, structure, and uranium deposits of the Salina [1°x2°] quadrangle, Utah: U.S. Geological Survey Miscellaneous Investigation Series Map I-591, scale 1:250,000.

# CORRELATION OF MAP UNITS

## East Half of Lo 30' x 60' Quadrangle, Emery, Garfield and Wayne Counties, Utah

