Interim Geologic Map of the Cedar City 7.5-Minute Quadrangle, Iron County, Utah

by

Tyler R. Knudsen

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MAP UNIT DESCRIPTIONS

QUATERNARY

Alluvial deposits

Qal_1 **Stream deposits** (upper Holocene) – Stratified, moderately to well-sorted gravel, sand, silt, and clay deposited in stream channels, floodplains, and man-made flood conveyance channels; includes small alluvial-fan and colluvial deposits, and minor terraces less than 10 feet (3 m) above modern base level; 0 to 30 feet (0–10 m) thick.

Qaly **Young alluvial deposits** (Holocene to upper Pleistocene) – Moderately sorted sand, silt, clay, and pebble to boulder gravel deposited in low-gradient stream channels and floodplains; includes abandoned floodplains of Coal Creek in Cedar Valley; locally includes colluvium from adjacent slopes; incised by active stream channels; probably less than 20 feet (6 m) thick.

Qat **Younger stream-terrace deposits** (middle Holocene to upper Pleistocene) – Stratified, moderately to well-sorted gravel, sand, silt, and clay that forms dissected, level to gently sloping terraces as much as 25 feet (8 m) above modern drainages; deposited in stream-channel and floodplain environments and may include colluvium and alluvial fans too small to map separately; 0 to 25 feet (0–8 m) thick.

Qato **Older stream-terrace deposits** (upper to middle Pleistocene) – Moderately sorted sand, silt, and pebble to boulder gravel that forms isolated, gently sloping terraces incised into Jurassic and Triassic bedrock 90 to 320 feet (27–100 m) above Coal Creek; generally 0 to 30 feet (0–9 m) thick.

Qaf_1 **Level-1 fan alluvium** (Holocene to upper Pleistocene) – Poorly to moderately sorted, subangular to subrounded, clay- to boulder-size sediment deposited principally by debris flows and debris floods at the mouths of major drainages; deposits form active depositional surfaces, although locally the master stream may be deeply entrenched; equivalent to the upper part of younger fan alluvium (Qafy), but differentiated where deposits can be mapped separately; probably less than 30 feet (<9 m) thick.

Qaf_2 **Level-2 fan alluvium** (lower Holocene to upper Pleistocene) – Similar to level-1 fan alluvium (Qaf_1), but forms inactive, incised surfaces cut by younger stream and fan deposits; equivalent to the older, lower part of younger fan alluvium (Qafy); probably less than 30 feet (<9 m) thick.

Qafy **Younger fan alluvium** (Holocene to upper Pleistocene) – Poorly to moderately sorted, non-stratified, subangular to subrounded, boulder- to clay-size sediment deposited at the mouths of streams and washes; forms both active depositional surfaces (Qaf_1 equivalent) and low-level inactive surfaces incised by small streams (Qaf_2 equivalent) that are undivided here; deposited principally as debris flows and debris floods, but colluvium locally constitutes a significant part of the deposits; small isolated deposits are typically less than a few tens of feet thick, but large, coalesced deposits are probably as much as 200 feet (60 m) thick.

Qafc **Coalesced fan alluvium** (Holocene to upper Pleistocene) – Similar to younger fan alluvium (Qafy) but forms large, coalesced fans in central Cedar Valley; typically exhibits a lower overall slope than younger fan alluvium; locally includes small eolian-sand deposits too small to map separately; unconsolidated to poorly consolidated basin-fill deposits are at least 2500 feet (760 m) thick in central Cedar Valley (Hurlow, 2002); only the uppermost part of this basin fill is included in map unit Qafc, which is likely in excess of several tens of feet thick.

Qap, Qapo

Pediment alluvium (Holocene and Pleistocene) – Poorly sorted, subangular to rounded, silt- to boulder-size alluvium that forms a locally resistant cap over gently-sloping erosional surfaces; south of Coal Creek, prominent clasts include basalt and reddish-orange Jurassic siltstone and sandstone; north of Coal Creek, prominent clasts include yellowish-brown Cretaceous sandstone and coquina, reddish-orange Jurassic siltstone and sandstone, and pale bluish-gray limestone of the Carmel Formation; older pediment deposits (Qapo) may be up to several hundred feet above modern base level and may contain clasts derived from strata that are exotic to modern drainages; Qapo is locally buried by coalesced landslide deposits (Qms); deposited principally as debris flows, debris floods, and as ephemeral stream channel deposits; 0 to 30 feet (0–10 m) thick.

Qapf **Fine-grained pediment alluvium** (Pleistocene?) – Moderately to well sorted, reddish-orange, silt- to pebble-size alluvium deposited on eroded bedrock surfaces southeast of the mouth of Cedar Canyon; subangular to subrounded clasts are derived from local bedrock units; 2 to 10 feet (0.6–3 m) of moderately developed pedogenic carbonate forms a resistant cap over the alluvial material; up to 80 feet (24 m) thick.

Qafo **Older alluvial-fan deposits** (Pleistocene) – Poorly to moderately sorted, non-stratified, clay- to boulder-size sediment with moderately developed pedogenic carbonate; forms broad, gently sloping, dissected surfaces exposed due to relative uplift along normal faults paralleling Interstate 15 in the southern part of Cedar City; deposited principally as debris flows and debris floods; prominent clasts include yellowish-brown Cretaceous sandstone, basalt, and reddish-orange Jurassic siltstone and sandstone; exposed thickness is less than 15 feet (<5 m).

QTaf **Basin-fill deposits** (Pleistocene to Pliocene) – Poorly to moderately sorted, non-stratified, subangular to subrounded, clay- to boulder-size sediment with moderately to well-developed calcic soils (caliche); forms deeply dissected surfaces with no remaining fan morphology; widely exposed in the Cross Hollow Hills where exhumed as a fault-bounded horst block; prominent clasts include Tertiary volcanic rocks, pale-reddish-orange and light-pinkish-gray limestone and calcareous mudstone of the Claron Formation, and yellowish-brown Cretaceous siltstone, sandstone, and coquina; includes lesser amounts of chalcedony and recycled quartzite; quartz monzonite clasts are common in the extreme western part of the Cross Hollow Hills; deposits appear interbedded with at least two different lava flows (Qbc_1 and Qbc_2); a 1.12 ± 0.08 Ma ($^{40}Ar/^{39}Ar$) age for Qbc_1 indicates the upper part of QTaf extends into the Quaternary; deposited principally as debris flows; locally rests on Tertiary volcanic rocks in the Cross Hollow Hills, on Jurassic sandstone at The Knoll, and on Tertiary volcanic rocks and Markagunt Megabreccia? east of Interstate 15 in the northeast part of the quadrangle; maximum exposed thickness is about 600 feet (180 m).

Colluvial deposits

Qc **Colluvium** (Holocene to upper Pleistocene) – Poorly to moderately sorted, angular, clay- to boulder-size, locally derived sediment deposited principally by slope wash and soil creep on moderate slopes and in shallow depressions; locally includes talus and alluvium deposits too small to map separately; includes older colluvium now incised by adjacent drainages; typically less than 20 feet (6 m) thick.

Human-derived deposits

Qh, Qhm, Qha

Artificial fill (Historical) – Borrow material and engineered fill used to construct flood-control dams, retaining ponds and other uses; minor fill placed for roadways and building pads generally not mapped; includes waste rock from coal mines on Lone Tree Mountain (Qhm) and gypsum quarries in Cedar Canyon; includes waste coal and ash (Qha) from former California Pacific Utilities power plant in Cedar Canyon.

Mass-movement deposits

Qmt, Qmtg

Talus (Holocene to upper Pleistocene) – Poorly sorted, angular cobbles and boulders and finer-grained interstitial sediment deposited principally by rock fall on or at the base of steep slopes; typically grades downslope into colluvium where impractical to differentiate the two; also may include alluvium in the bottom of washes; talus consisting primarily of gypsum (Qmtg) derived from the Paria River Member of the Carmel Formation (Jcpg) mapped separately; typically less than 30 feet (9 m) thick.

Qms, Qmsh, Qmsh(Ktd), Qms(Qb), Qms(Ti), Qms(Tbh), Qms(Tc), Qms(Kcm), Qms(Ktd), Qms(Kst), Qms(Jcw)

Landslides (Historical to middle[?] Pleistocene) – Very poorly sorted, locally derived material deposited by rotational and translational movement; composed of clay- to boulder-size debris as well as large, partly intact, bedrock blocks; characterized by hummocky topography, numerous internal scarps, chaotic bedding attitudes, and small ponds, marshy depressions, and meadows; the largest landslide complexes involve the Tropic Shale and Dakota Formation (Ktd) and are several square miles in size; undivided as to inferred age because even landslides having subdued morphology (suggesting that they are older, weathered, and have not experienced recent large-scale movement) may continue to exhibit slow creep or are capable of renewed movement if stability thresholds are exceeded (Ashland, 2003); age and stability determinations require detailed geotechnical investigations; Qmsh denotes landslides known to be active in historical time, but any landslide deposit may have been active even if not so identified; where possible, landslide debris composed of a single map unit is mapped separately, with the bedrock unit identified in parentheses within the label—for example, Qms(Ktd); Qms(Tbh) denotes landslide material derived from Tertiary Brian Head Formation which consists of volcaniclastic mudstone, siltstone, sandstone, conglomerate, volcanic ash, and chalcedony (Biek and others, 2012); thickness highly variable.

Mixed-environment deposits

Qac **Alluvium and colluvium** (Holocene to upper Pleistocene) – Poorly to moderately sorted, clay- to boulder-size, locally derived sediment deposited in swales and small drainages by fluvial, slope-wash, and creep processes; gradational with alluvial and colluvial deposits; generally less than 20 feet (6 m) thick.

Qea **Eolian sand and alluvium** (Holocene to upper Pleistocene) – Light-orangish-red, moderately to well-sorted, fine- to medium-grained eolian sand locally reworked by alluvial processes, and poorly to moderately sorted gravel, sand, and silt deposited in small stream channels; generally less than 20 feet (6 m) thick.

Spring Deposits

Qst **Spring tufa** (Holocene) – Light-gray calcareous tufa deposited at springs on Lone Tree Mountain.

Basaltic lava flows

Qbl, Qblc

Lone Tree Mountain lava flows and cinder cone (Pleistocene?) – Medium- to dark-gray, crystal-poor basalt with small olivine phenocrysts; at least two to three flows erupted from a vent area at a cinder cone (Qblc) on Lone Tree Mountain near the southern edge of the quadrangle; individual flows at Lone Tree Mountain are typically less than 30 feet (9 m) thick.

Qbs **Square Mountain lava flows** (Pleistocene?) – Medium- to dark-gray, crystal-poor basaltic andesite capping Square Mountain near the southern edge of the quadrangle; correlation is uncertain, but may include individual flows sourced from both the nearby Lone Tree Mountain vent area (Qblc) to the east and a vent area near Pryor Knoll about 3.5 miles (5.6 km) to the south; individual flows are less than 40 feet (12 m) thick; stacked flows on Square Mountain are up to 160 feet (50 m) thick.

Qbc_1, Qbc_2

Cross Hollow Hills lava flows (lower Pleistocene) – Mapped as two separate lava flows in the Cross Hollow Hills, with Qbc_1 being the youngest flow: Qbc_1 is dark-gray, crystal-poor trachybasalt; Qbc_2 is dark-gray, crystal-poor basalt with small olivine phenocrysts; source area is unknown—a local cinder cone may have eroded away, or the lava flows may have cascaded down the Hurricane Cliffs from vent areas at Lone Tree Mountain, Pryor Knoll, or other vent areas farther south; both flows appear interbedded with, and therefore deposited contemporaneously with, basin-fill deposits (QTaf); flows are displaced at least several tens of feet by east- and west-dipping faults associated with the Cross Hollow Hills fault zone; Qbc_1 yielded an $^{40}Ar/^{39}Ar$ isochron age of 1.12 ± 0.08 Ma (UGS and Nevada Isotope Geochronology Laboratory, in preparation), which agrees well with a K-Ar age of 1.2 ± 0.1 Ma reported by Anderson and Rowley (1975); major- and trace-element geochemistry (table 1) shows Qbc_1 and Qbc_2 are distinct flows; based on relative position, Qbc_2 is likely only slightly older than Qbc_1; individual flows are typically 10 to 30 feet (3–9 m) thick.

TERTIARY

Tm(Ti), Tm(Tql), Tm(Tqcb), Tm(Tqh)

Markagunt Megabreccia (lower Miocene) – Chaotic mass of Miocene and Oligocene volcanic rocks interpreted to be part of the Markagunt Megabreccia (Anderson, 1993; Sable and Maldonado, 1997; Biek and others, 2012) that covers several hundred square miles of the central and northern Markagunt Plateau (Biek and others, 2012); typically consists of highly attenuated slivers of Isom Formation (Tm[Ti]), Leach Canyon Formation (Tm[Tql]), Bauers Tuff Member of the Condor Canyon Formation (Tm[Tqcb]), and the Harmony Hills Tuff (Tm[Tqh]); typically forms low, rubble-covered hills; megabreccia deposits near Interstate 15 are locally covered by basin-fill deposits (QTaf) and extensive landslide deposits (Qms) composed of various Cretaceous units; interpreted by Biek and others (2012) as basal gravity-slide deposits derived from the catastrophic failure of oversteepened slopes associated with the pre-caldera inflation of the Marysvale volcanic field between about 20 and 22 Ma; the combined thickness of the allochthonous Leach Canyon and Isom Formations near the northeast corner of the quadrangle is about 300 feet (90 m).

Quichapa Group (lower Miocene to upper Oligocene) – Consists of three regionally distinctive ash-flow tuffs: in ascending order, the Leach Canyon Formation, Condor Canyon Formation, and Harmony Hills Tuff (Mackin, 1960; Williams, 1967; Anderson and Rowley, 1975; Rowley and others, 1995).

Tqh **Harmony Hills Tuff** (lower Miocene) – Pale-pink to grayish-orange-pink, crystal-rich, moderately welded, dacitic ash-flow tuff; contains about 50% phenocrysts of plagioclase (63%), biotite (16%), hornblende (9%), quartz (7%), pyroxene (5%), and sanidine (trace) (Williams, 1967); disconformably overlies the Bauers Tuff in adjacent quadrangles, but mapped here as thin slivers of allochthonous megabreccia near Interstate 15; source of the Harmony Hills Tuff unknown but isopachs are centered on Bull Valley (Williams, 1967), suggesting that it was derived from the eastern Bull Valley Mountains, probably from an early, much more voluminous eruptive phase of the Bull Valley/Hardscrabble Hollow/Big Mountain intrusive arch, as suggested by Blank (1959), Williams (1967), and Rowley and others (1995, 2008); consistent with this interpretation is the fact that the $^{40}Ar/^{39}Ar$ plateau age of the Harmony Hills Tuff is 22.03 ± 0.15

Ma (Cornell and others, 2001), nearly identical to that of those intrusions; incomplete sections are less than 50 feet (15 m) thick.

Tqcb **Bauers Tuff Member of Condor Canyon Formation** (lower Miocene) – Resistant, light-brownish-gray to pinkish-gray, densely welded, rhyolitic ash-flow tuff; contains about 10 to 20% phenocrysts of plagioclase (40–70%), sanidine (25–50%), biotite (2–10%), Fe-Ti oxides (1–8%), and pyroxene (<3%), but lacks quartz phenocrysts (Rowley and others, 1995); bronze-colored biotite and light-gray flattened lenticules are conspicuous; disconformably overlies the Leach Canyon Formation; derived from the northwest part (Clover Creek caldera) of the Caliente caldera complex and at the time of its eruption, covered an area of at least 8900 square miles (23,000 km^2) (Best and others, 1989b; Rowley and others, 1995); the preferred $^{40}Ar/^{39}Ar$ age of the Bauers Tuff is 22.7 Ma (Best and others, 1989a) or 22.8 Ma (Rowley and others, 1995), which is also the $^{40}Ar/^{39}Ar$ age of its intracaldera intrusion exposed just north of Caliente (Rowley and others, 1994b); Fleck and others (1975) reported K-Ar ages of 22.1 ± 0.6 Ma (plagioclase) and 20.7 ± 0.5 Ma (whole rock) for Bauers Tuff on the Markagunt Plateau; typically highly attenuated; highly attenuated and incomplete sections are less than 30 feet (9 m) thick.

Tql **Leach Canyon Formation** (upper Oligocene) – Light-pinkish- to orangish-gray, poorly to moderately welded, crystal-rich ash-flow tuff that contains abundant lithic clasts, including distinctive reddish-brown cinder fragments and white to pale-yellow pumice fragments; contains 25 to 35% phenocrysts of plagioclase, slightly less but subequal amounts of quartz and sanidine, and minor biotite, hornblende, Fe-Ti oxides, and a trace of pyroxene; disconformably overlies the Isom Formation; source is unknown, but it is probably the Caliente caldera complex because isopachs show that it thickens toward the complex (Williams, 1967; Rowley and others, 1995); is widely agreed to be about 23.8 Ma (Best and others, 1993; Rowley and others, 1995; Biek and others, 2012); exposed thickness is less than 80 feet (<24 m).

Ti **Isom Formation** (upper Oligocene) – Medium-gray to reddish-brown, crystal-poor, densely welded, trachydacitic ash-flow tuff; poor exposures in the map area typically form gruss-covered hills; source is unknown, but isopach maps and pumice distribution suggest that it was derived from late-stage eruptions of the 27–32 Ma Indian Peak caldera complex that straddles the Utah-Nevada border, possibly in an area now concealed by the western Escalante Desert (Rowley and others, 1979; Best and others, 1989a, 1989b); is about 26 to 27 Ma on the basis of many $^{40}Ar/^{39}Ar$ and K-Ar ages (Best and others, 1989b; Rowley and others, 1994a); maximum exposed thickness in the Cross Hollow Hills is less than 200 feet (<60 m).

unconformity

Tcp **Pink member of Claron Formation** (Eocene and Paleocene) – Orangish-red, reddish-brown, and light-blue-gray limestone, mudstone, siltstone, sandstone, and conglomerate exposed at two isolated outcrops north and south of the Fiddler Canyon fan; locally mottled; oncolitic beds are common. Limestone is poorly bedded, microcrystalline, generally sandy with 2 to 20% fine-grained quartz sand, and is locally argillaceous; it now forms calcic paleosols, once fluvial and floodplain deposits greatly modified by bioturbation and pedogenic processes (Mullett and others, 1988a, 1988b; Mullett, 1989; Mullett and Wells, 1990); sandstone is thick-bedded, fine- to coarse-grained, calcareous, locally cross-bedded quartz arenite; mudstone is generally moderate reddish orange, silty, calcareous, contains calcareous nodules, and weathers to earthy, steep slopes between ledges of sandstone and limestone; pebbly conglomerate forms lenticular beds typically 5 to 15 feet (2–5 m) thick containing rounded quartzite, limestone, and chert pebbles and cobbles; formation lies on an angular unconformity over tilted beds of the Dakota and Wahweap Formations; exposed thickness is less than 210 feet (65 m).

Claron Formation strata are among the most visually arresting rocks in southwestern Utah, being prominently displayed at Cedar Breaks National Monument and Bryce Canyon National Park among other places. However, because the formation lacks a type section and was named for incomplete, fault-bounded exposures in the Iron Springs mining district, the nomenclatural history of these rocks is complicated as described by Biek and others (2012). The formation contains two informal members—an upper white member not present in this map area and the lower pink member—and as now defined it lacks volcanic clasts or ash-flow or ash-fall tuff. Claron strata were deposited in fluvial, floodplain, and lacustrine environments of an intermontaine basin bounded by Laramide uplifts; the pink member is almost wholly fluvial and the white member is both lacustrine and fluvial (Goldstrand, 1990, 1991, 1992, 1994; Bown and others, 1997). Anderson and Dinter (2010) and Biek and others (2012) showed that east-vergent, Sevier-age compressional deformation continued into early Claron time in the High Plateaus of southwestern Utah. The age of the white member is well constrained as late middle Eocene (Duchesnean land mammal age) based on sparse vertebrate fossils and constraining U-Pb zircon ages of overlying strata (Biek and others, 2012, and references therein), but the maximum age of the mostly nonfossiliferous pink member is poorly constrained as Eocene to Paleocene(?) (Goldstrand, 1994). Biek and others (2012) noted that the lower part of the pink member is likely Paleocene in age, but given its paucity of datable materials, could not rule out the possibility of a latest Cretaceous age.

unconformity

CRETACEOUS

Kw **Wahweap Formation** (Upper Cretaceous) – Interbedded brown and reddish-brown, fine- to medium-grained calcareous sandstone, siltstone, and mudstone; repetitive sandstone and siltstone beds are commonly cross-bedded and form ledgy slopes; contains uncommon pebbly sandstone; top of formation not exposed due to truncation along the pre-Claron unconformity; deposited in braided and meandering river and floodplain environments of a coastal plain (Tilton, 1991; Pollock, 1999; Lawton and others, 2003); map relations indicate the incomplete section north of the mouth of Fiddlers Canyon is about 1000 feet (300 m) thick.

Straight Cliffs Formation (Upper Cretaceous)

Peterson (1969) divided the Straight Cliffs Formation into four members in the Kaiparowits Basin: in ascending order, the Tibbet Canyon, Smoky Hollow, John Henry, and Drip Tank Members. Several geologists mapped these members (separately or as lumped upper and lower Straight Cliffs strata) on the Paunsaugunt Plateau, including Tilton (1991, 2001a, 2001b), Doelling and Willis (1999), Sable and Hereford (2004), and Doelling (2008). Biek and others (2012) described the difficulty encountered in early attempts to carry this nomenclature westward into the Markagunt Plateau.

Ksd **Drip Tank Member** (Upper Cretaceous) – White to light-gray, medium-grained sandstone and pebbly conglomerate; larger clasts (pebble to cobble) are subrounded to rounded, white, gray, and purplish-red quartzite, and locally minor blue-gray Paleozoic limestone and black chert; sand matrix consists of white to light-gray, subangular sand and silt; locally iron stained; forms a low, narrow ridge; these beds were formerly called the lower conglomerate member of the Grand Castle Formation, but Biek and others (2012) established their Drip Tank correlation; deposited by east- and northeast-flowing braided streams (Tilton, 1991, 2001a, 2001b; Lawton and others, 2003); thickness ranges from 10 to 25 feet (3–8 m).

unconformity

Ksj **John Henry Member** (Upper Cretaceous) – Yellowish- to reddish-brown, fine- to medium-grained subarkosic sandstone and siltstone and interbedded, locally mottled, gray, brown, and reddish-brown mudstone; rippled near the base; woody material and leaf impressions are locally abundant; deposited in fluvial and floodplain environments of a coastal plain (Eaton and others, 2001); together with the underlying Smoky Hollow and Tibbet Canyon Members, forms an overall regressive sequence following the last marine incursion of the Western Interior Seaway (see, for example, Eaton and others, 2001; Moore and Straub, 2001; Tibert and others, 2003); about 450 feet (135 m) thick.

unconformity

Kss **Smoky Hollow Member** (Upper Cretaceous) – Brown and gray mudstone, carbonaceous shale, and thin, interbedded, yellowish-brown, fine-grained sandstone; oyster coquina beds are common throughout; locally contains gastropods; along the base of the Hurricane Cliffs near the mouth of Fiddlers Canyon, Smoky Hollow strata form a strike valley between the more resistant, west-dipping sandstones of the Tibbet Canyon and John Henry Members; contact placed at top of the highest coquina bed below a basal yellowish-brown rippled sandstone of the John Henry Member; about 250 feet (75 m) thick.

Kst **Tibbet Canyon Member** (Upper Cretaceous) – Yellowish-brown, medium- to thick-bedded, generally planar bedded, fine- to medium-grained quartzose sandstone and interbedded gray mudstone, carbonaceous shale, and thin to thick beds of oyster coquina; generally forms bold cliffs, although from east to west across the quadrangle, the component of interbedded mudstone, shale, and coquina increases, resulting in several alternating slopes and cliffy ledges; represents initial progradational (overall regressive) strata of the Greenhorn Cycle deposited in shoreface, beach, lagoonal, and estuarine environments adjacent to a coastal plain (Laurin and Sageman, 2001; Tibert and others, 2003); about 650 feet (200 m) thick.

Ktd **Tropic Shale and Dakota Formation, undivided** (Upper Cretaceous) – Interbedded, slope- and ledge-forming sandstone, siltstone, mudstone, claystone, carbonaceous shale, coal, and marl; sandstone is yellowish brown, thin to very thick bedded, fine to medium grained; mudstone and claystone are gray to reddish brown and commonly smectitic; oyster coquina beds, clams, and gastropods are common; 5 to 12 feet (1.5–4 m) of dark gray and yellowish-brown sandy mudstone, coal, and shale near the top of the map unit represent a thin (0 to 8 feet [0–2.5 m] thick) Tropic Shale and underlying Upper Culver coal zone of Averitt (1962) and Averitt and Threet (1973); Tropic and Dakota strata are typically poorly exposed and involved in large landslide complexes; deposited in marginal-marine environments including floodplain, river, estuarine, lagoonal, and swamp environments for the Dakota Formation (Gustason, 1989; Eaton and others, 2001; Laurin and Sageman, 2001; Tibert and others, 2003) and a shallow-marine environment dominated by fine-grained clastic sediment for the Tropic Shale (Tibert and others, 2003); the Dakota Formation is about 950 feet (290 m) thick in Cedar Canyon.

unconformity

Kcm **Cedar Mountain Formation** (Cretaceous) – Grayish-brown, poorly cemented, basal conglomerate overlain by brightly colored variegated mudstone; conglomerate ranges from 0 to 10 feet (0–3 m) thick and contains subrounded to rounded, pebble- to small-cobble-size quartzite, chert, and limestone clasts; mudstone is variegated gray, purplish red, and reddish brown; clay is smectitic and weathers to "popcorn-like" soils; upper contact is poorly exposed and corresponds to a color and lithologic change, from comparatively brightly colored smectitic mudstone below to gray and light-yellowish-brown mudstone and fine-grained sandstone above; volcanic ash from correlative strata on the Kolob Plateau yielded a single-crystal $^{40}Ar/^{39}Ar$ age of 97.9 ± 0.5 Ma on sanidine (Biek and Hylland, 2007), and pollen analyses indicate an Albian or older age (Doelling and Davis, 1989; Hylland, 2010); Dyman and others (2002) obtained an $^{40}Ar/^{39}Ar$ age of 101.7 ± 0.42 Ma (latest Albian) on similar strata near Gunlock; additionally, palynomorphs from a thin mudstone interval in Cedar Canyon (NW1/4 NW1/4 SE1/4 section 17, T. 36 S., R. 10 W.), including rare occurrences of *Trilobosporites humilis* and possibly *Pseudoceratium regium*, suggest a late Albian age for this horizon (M.D. Hylland, Utah Geological Survey, unpublished data, November 9, 2001); deposited in floodplain environment of a broad coastal plain (Tschudy and others, 1984; Kirkland and others, 1997; Cifelli and others 1997; Kirkland and Madsen, 2007); previously mapped as the lower part of the Dakota Formation, but the lithology, age, and stratigraphic position of these beds suggest correlation with the Cedar Mountain Formation (Biek and others, 2000, 2009, 2012; Biek and Hylland, 2007); specifically, the mudstone interval appears to be time-correlative with the Mussentuchit Member of the Cedar Mountain Formation of central and eastern Utah (Hylland, 2010); detrital zircons in the stratigraphically equivalent basal conglomerate near Gunlock Reservoir indicate a correlation with the Short Canyon member (conglomerate) that locally underlies the Mussentuchit Member in the western San Rafael Swell (Gary Hunt, UGS, verbal communication in Hylland, 2010) typically 50 to 60 feet (15–18 m) thick.

unconformity

JURASSIC to UPPERMOST TRIASSIC

Carmel Formation (Middle Jurassic) – Nomenclature follows that of Sprinkel and others (2011); deposited in a shallow inland sea of a back-bulge basin—together with the underlying Temple Cap Formation, the first clear record of the effects of the Sevier orogeny in southwestern Utah; age from Imlay (1980).

Jcw **Winsor Member** (Middle Jurassic) – Light-reddish brown, fine- to medium-grained sandstone and siltstone; uppermost beds typically bleached white under the Cretaceous unconformity; poorly cemented and so weathers to vegetated slopes or, locally, badland topography; Winsor strata are unusually well-cemented and form a bold cliff at the head of Squaw Creek; deposited on a broad, sandy mudflat (Imlay, 1980; Blakey and others, 1983); 250 to 300 feet (75–90 m) thick.

Jcp, Jcpl, Jcpg

Paria River Member (Middle Jurassic) – Consists of two parts mapped separately where possible: (1) upper part (Jcpl) is about 35 to 50 feet (11–15 m) of cliff-forming, olive-gray, micritic and argillaceous limestone and calcareous mudstone; laminated in very thick beds; locally contains small pelecypod fossils; (2) lower part (Jcpg) is massive alabaster gypsum as much as 120 feet (37 m) thick in nodular, highly fractured and contorted beds and as thin, laminated beds; upper contact with the Winsor Member is sharp and planar; deposited in shallow-marine and coastal-sabkha environments (Imlay, 1980; Blakey and others, 1983); about 170 feet (52 m) thick.

Jcx **Crystal Creek Member** (Middle Jurassic) – Thin- to medium-bedded, reddish-brown siltstone, mudstone, and fine- to medium-grained sandstone; commonly gypsiferous and contains local contorted pods of gypsum; forms vegetated, poorly exposed slopes; upper contact is sharp and broadly wavy and corresponds to the base of the thick Paria River gypsum bed; deposited in coastal-sabkha and tidal-flat environments (Imlay, 1980; Blakey and others, 1983); 295 feet (90 m) thick in Cedar Canyon.

Jcc **Co-op Creek Limestone Member** (Middle Jurassic) – Regionally divisible into two informal units, but undivided here due to poor exposure and structural complications: (1) upper unit is thin- to thick-bedded, light-gray and yellowish-gray micritic limestone and calcareous siltstone and shale that weathers into small plates, slabs, and pencil-like fragments; about 300 feet (90 m) below the top of the upper unit is a distinctive 54-foot-thick (16 m) interval of light-red sandstone, siltstone, and mudstone, and white alabaster gypsum shown on the map as a marker bed; total thickness of upper unit is 467 feet (142 m); (2) lower unit is thinly laminated to thin-bedded, light-gray micritic limestone, calcareous shale, and platy limestone; limestone is locally oolitic and contains crinoid fragments and fossil hash; forms steep, ledgy slopes; contact with upper unit corresponds to a subtle break in slope and change in vegetation patterns; deposited in a shallow-marine environment (Imlay, 1980; Blakey and others, 1983); total thickness from measured sections in Cedar Canyon and at White Mountain is 634 feet (193 m; D.A. Sprinkel, Utah Geological Survey, written communication, September 6, 2012).

Temple Cap Formation (Middle to Lower Jurassic)

Jtm **Manganese Wash Member** (Middle to Lower Jurassic) – Slope-forming, light-reddish-orange to medium-brown mudstone, siltstone, and fine-grained silty sandstone; contains several laterally discontinuous white and light-gray alabaster gypsum beds as much as 50 feet (15 m) thick; forms narrow, but prominent, deep-reddish-brown, vegetated slope with a prominent gypsum cap at the top of the Navajo Sandstone; upper contact placed below light-gray calcareous shale and micritic limestone of the Co-op Creek Limestone Member; deposited in coastal-sabkha and tidal-flat environments (Blakey, 1994; Peterson, 1994); the Temple Cap in the Cedar City quadrangle lacks the eolian sandstone (White Throne Member) of the Zion National Park area, and therefore I follow the recommendation of Sprinkel and others (2011) and use the new Manganese Wash Member name designated for similar strata in the Pine Valley Mountains-Gunlock area; Sprinkel and others (2009) and Kowallis and others (2011) reported that the Temple Cap Formation ranges from about 179 to 171 Ma based on several $^{40}Ar/^{39}Ar$ and U-Pb zircon ages; a section measured on the south slope of White Mountain totaled 120 feet (37 m) thick (D.A. Sprinkel, Utah Geological Survey, written communication, September 6, 2012).

Unconformity

Jn **Navajo Sandstone, main body** (Lower Jurassic) – Pale-reddish-orange to salmon-pink, massively cross-bedded, calcareously cemented sandstone that consists of well-rounded, fine- to medium-grained, frosted quartz sand; commonly highly brecciated; exposures near The Knoll are bleached white; upper, unconformable contact is sharp and planar and regionally corresponds to a prominent break in slope, with cliff-forming, cross-bedded sandstone below and reddish-brown mudstone and white gypsum above; deposited in a vast coastal and inland dune field with prevailing winds principally from the north (Blakey, 1994; Peterson, 1994); correlative in part with the Nugget Sandstone of northern Utah and Wyoming and the Aztec Sandstone of southern Nevada and adjacent areas (see, for example, Kocurek and Dott, 1983; Riggs and others, 1993; Sprinkel, 2009); ranges from about 1200 to 1400 feet (365–425 m) thick.

Kayenta Formation (Lower Jurassic)

Marzolf (1994) and Blakey (1994) presented evidence to restrict the Moenave Formation to the Dinosaur Canyon and Whitmore Point Members, with a major regional unconformity at the base of the Springdale Sandstone. Further work supports this evidence, indicating that the Springdale Sandstone is more closely related to the Kayenta Formation and should be made its basal member (see, for example, Lucas and Heckert, 2001; Molina-Garza and others, 2003; Lucas and Tanner, 2006).

Jkc **Cedar City Tongue of Kayenta Formation** (Lower Jurassic) – Moderate- to dark-reddish-brown, thin- to thick-bedded siltstone, fine-grained sandstone, and mudstone that separates the main body and Shurtz Tongue of the Navajo Sandstone; sandstone and siltstone have planar, low-angle, and rippled bedding; cross-cutting gypsum veinlets are common; forms steep, ledgy slope; upper contact is conformable and corresponds to the top of the highest thin siltstone and mudstone beds, above which are the towering cliffs of the main body of the Navajo Sandstone; deposited in distal river, playa, and minor lacustrine environments (Tuesink, 1989; Sansom, 1992; Blakey, 1994; Peterson, 1994); 425 feet (130 m) thick in Cedar Canyon.

Jns **Shurtz Tongue of Navajo Sandstone** (Lower Jurassic) – Similar to main body of Navajo Sandstone but bedding is markedly more planar with few large-scale cross-beds; unit is unusually thick immediately north of State Route 14 in Cedar Canyon where it is likely structurally thickened by unmapped bedding-parallel thrust faults; about 300 feet (90 m) thick where it caps Red Hill; deposited in a coastal dune field and sabkha environment; thins abruptly to the south where it is only about 60 feet (20 m) thick near the west-central edge of the Cedar Mountain quadrangle only 8 miles (13 km) to the south of Red Hill (Averitt, 1962), and farther south it appears to pinch out southward near Kanarraville (Biek and Hayden, 2013).

Jkm **Kayenta Formation, main body** (Lower Jurassic) – Pale- to dark-reddish-brown siltstone, fine-grained sandstone, and mudstone similar to the Cedar City Tongue of the Kayenta Formation; includes several thin light-gray siltstone beds, giving the unit a striped appearance; forms a steep slope grading up to ledgy cliffs at top; upper conformable contact placed at the base of thick, planar-bedded sandstone ledge of the Shurtz Tongue; equivalent to the lower member of the Kayenta Formation of Averitt and others (1955) and Averitt and Threet (1973), but renamed here since this interval is no longer considered the basal part of the formation with the inclusion of the underlying Springdale Sandstone; Milner and Spears (2007) reported theropod tracks in the

Kayenta Formation near the water tank above the Cedar City golf course; deposited in distal river, playa, and minor lacustrine environments (Tuesink, 1989; Sansom, 1992; Blakey, 1994; Peterson, 1994); about 290 feet (88 m) thick in Cedar Canyon.

Jks **Springdale Sandstone Member** (Lower Jurassic) – Pale purple, medium- to thick-bedded, fine- to medium-grained sandstone with planar and low-angle cross-stratification, and minor, discontinuous lenses of moderate-reddish-brown or greenish-gray mudstone and siltstone; forms a steep, ledgy slope rather than a single prominent cliff as in Zion National Park; upper contact placed at top of highest pale-purple siltstone ledge below red beds of the main body of the Kayenta Formation; deposited in braided-stream and minor floodplain environments (Clemmensen and others, 1989; Blakey, 1994; Peterson, 1994; DeCourten, 1998); about 135 feet (40 m) thick in Cedar Canyon.

unconformity

Moenave Formation (Lower Jurassic to Upper Triassic)

JTRmd **Dinosaur Canyon Member** (Lower Jurassic to Upper Triassic) – Generally thin-bedded, moderate-reddish-brown and moderate-reddish-orange, fine-grained sandstone, fine-grained silty sandstone, and lesser siltstone and mudstone with planar, low-angle, and ripple cross-stratification; mudstone locally yields small selenite crystals; basal part typically includes a single bed of reddish-brown, fine-grained silty sandstone up to 45 feet (14 m) thick; siltstone and sandstone beds are locally "speckled" by small, light-tan and white reduction spots; in the middle part of the member, about 20 feet (6 m) above the silty sandstone ledge, a 1- to 3-foot-thick (0.3–1 m) ledge of light-gray, dolomitic limestone (mapped as a marker bed) with conspicuous reddish-brown chert blebs may be the thin, distal northern end of strata associated with the Whitmore Point Member of the Moenave Formation (Milner and Spears, 2007); upper unconformable contact is placed where the color of alternating sandstone and siltstone ledges changes from reddish brown to pale purple of the Springdale Sandstone; deposited in river-channel and floodplain environments of a northward-flowing river system (Clemmensen and others, 1989; Blakey, 1994; Peterson, 1994; DeCourten, 1998); age from Molina-Garza and others (2003) and Lucas and others (2005); about 300 feet (90 m) thick in Cedar Canyon.

unconformity

TRIASSIC

Chinle Formation (Upper Triassic)

TRcp **Petrified Forest Member** (Upper Triassic) – Bright purple, grayish-red, dark-reddish-brown, light-greenish-gray, and olive-gray bentonitic mudstone, claystone, and siltstone that weather to a “popcorn” surface; locally contains prominent but laterally discontinuous, dark-purple to yellow-brown sandstone and pebbly sandstone ledges; upper contact placed at the top of a 1- to 3-foot-thick (0.3–1 m) bed of light-gray nodular limestone; deposited in a variety of fluvial, floodplain, and lacustrine environments of a back-arc basin formed inland of a magmatic arc associated with a subduction zone along the west coast of North America (Stewart and others, 1972a; Dickinson and others, 1983; Lucas, 1993; Dubiel, 1994; DeCourten, 1998); about 300 feet (90 m) thick in Cedar Canyon.

TRcs **Shinarump Conglomerate Member** (Upper Triassic) – Greenish-gray and pale-yellow-brown, medium- to coarse-grained sandstone, pebbly sandstone, and lesser pebbly conglomerate, locally with silty sandstone, claystone, and smectitic claystone interbeds, that forms prominent hogbacks; clasts are subrounded chert and quartzite; mostly thick bedded with both planar and low-angle cross-stratification; commonly stained by iron-manganese oxides, locally forming “picture stone”; contains poorly preserved petrified wood and plant debris, commonly replaced in part by iron-manganese oxides; upper contact marks a sharp topographic break and typically corresponds to the first appearance of varicolored, swelling mudstone; due to substantial bentonitic mudstone that resembles the Petrified Forest Member below the Shinarump cliff in the Cedar City quadrangle, some have speculated that the prominent sandstone ledge there could be either the Sonsela or Mossback Member of the Chinle Formation and that the Shinarump is absent (e.g., Hintze, 2005); however, field reconnaissance revealed an uninterrupted Shinarump ledge extending from the Kolob Canyons area of Zion National Park north to Cedar City; deposited in braided streams that flowed north and northwest (Stewart and others, 1972a; Dubiel, 1994; DeCourten, 1998); thickness varies from 30 to 50 feet (9–15 m).

TRcl **Lower member** (Upper Triassic) – Medium-purple, dark-reddish-brown, and medium-greenish-gray mudstone and siltstone with sparse thin lenses of silty sandstone; an iron-stained, dark-olive silicified limestone(?) bed near the top may be a paleosol; upper contact is sharp and placed below the Shinarump ledge; deposited in fluvial, floodplain, and lacustrine environments; about 200 feet (60 m) thick in Cedar Canyon; thins abruptly to the south to about 75 feet (23 m) at Shurtz Creek, and to about 25 feet (8 m) at Kanarra Mountain Road in the west-central part of the Cedar Mountain quadrangle, but appears to then thicken farther south into the Kolob Arch quadrangle since about 40 feet of grayish-purple mudstone appears below the Shinarump cliff adjacent to Kolob Canyon Road in Zion National Park.

unconformity

Moenkopi Formation (Lower Triassic)

TRmu **Upper red member** (Lower Triassic) – Moderate-reddish-orange to moderate-reddish-brown, mostly thin- to medium-bedded siltstone, mudstone, and fine-grained sandstone with planar, low-angle, and ripple cross-stratification; locally contains thin gypsum beds and abundant discordant gypsum stringers and typically forms ledgy slopes; locally includes a prominent, dark-reddish-brown, cliff-forming, 20- to 30-foot-thick (6-9 m), fine-grained sandstone near the top; upper, unconformable contact is at the conspicuous color change in mudstone from reddish-brown of the upper red member to medium grayish-purple of the lower member of the Chinle Formation; deposited in tidal-flat and coastal-plain environments (Stewart and others, 1972b; Dubiel, 1994); about 400 feet (120 m) thick in Cedar Canyon.

TRms **Shnabkaib Member** (Lower Triassic) – Forms "bacon-striped," ledgy slopes of laminated to thin-bedded, gypsiferous, pale-red to moderate-reddish-brown mudstone and siltstone, resistant, white to greenish-gray gypsum, and minor thin, laminated, light-gray dolomite beds; gypsum is present as laterally continuous structureless beds, finely laminated commonly silty or muddy beds, nodular intervals as much as about 10 feet (3 m) thick, and as secondary cavity fillings and cross-cutting veins; includes sparse limestone beds as much as about 5 feet (1.5 m) thick; typically weathers to soft, gypsiferous soils; upper conformable and gradational contact corresponds to the top of the highest thick gypsum bed; deposited in supratidal, intertidal, and subtidal environments on a broad, coastal shelf of low relief (Stewart and others, 1972b; Lambert, 1984); 320 feet (98 m) thick in Cedar Canyon.

TRmm **Middle red member** (Lower Triassic) – Interbedded, slope-forming, laminated to thin-bedded, moderate-reddish-brown to moderate-reddish-orange siltstone, mudstone, and fine-grained sandstone with thin interbeds and veinlets of greenish-gray to white gypsum; includes two to three white alabaster gypsum beds up to 10 feet (3 m) thick near the base; upper, conformable and gradational contact corresponds to the base of the first thick gypsum bed of the Shnabkaib Member; deposited in a tidal-flat environment (Stewart and others, 1972b; Dubiel, 1994); 410 feet (128 m) thick in Cedar Canyon.

TRmv **Virgin Limestone Member** (Lower Triassic) – Light-gray, light-olive-gray, and yellowish-brown limestone and silty limestone that forms three to four resistant ledges each as much as 25 feet (8 m) thick; locally fossiliferous with circular and five-sided crinoid columnals and pelecypod shell hash; intervening slopes account for about 70% of the member and are mudstone and siltstone that have variable gray, yellowish-gray, and grayish-purple hues; upper, conformable contact corresponds to the top of the uppermost Virgin limestone bed; deposited in a variety of shallow-marine environments (Stewart and others, 1972b; Dubiel, 1994); 130 feet (40 m) thick.

TRml **Lower red member** (Lower Triassic) – Interbedded, slope-forming, laminated to thin-bedded, moderate-reddish-brown mudstone, siltstone, and fine-grained sandstone with local, thin, laminated, light-olive-gray gypsum beds and veinlets; upper contact corresponds to the base of the first Virgin limestone bed; deposited in a tidal-flat environment (Stewart and others, 1972b; Dubiel, 1994); about 250 feet (75 m) thick.

TRmt **Timpoweap Member** (Lower Triassic) – Light-yellow- to blue-gray thick-bedded limestone with locally abundant light-yellowish- to orangish-tan chert; includes several feet of light-yellow-gray shaly limestone at top; commonly brecciated due to involvement in thrust faulting; forms short, low, and discontinuous cliff at the base of the Hurricane Cliffs; upper contact with the lower red member is conformable and gradational and corresponds to a change from yellowish-weathering, light-gray thin-bedded siltstone and limestone to reddish-brown siltstone and mudstone above; deposited in a shallow-marine environment (Nielson and Johnson, 1979; Dubiel, 1994; Lucas and others, 2007); Lucas and others (2007) reported a late Smithian (early Olenekian) age for the unit and reiterated a correlation with the Sinbad Limestone of central and eastern Utah; exposed thickness is less than 120 feet (37 m).

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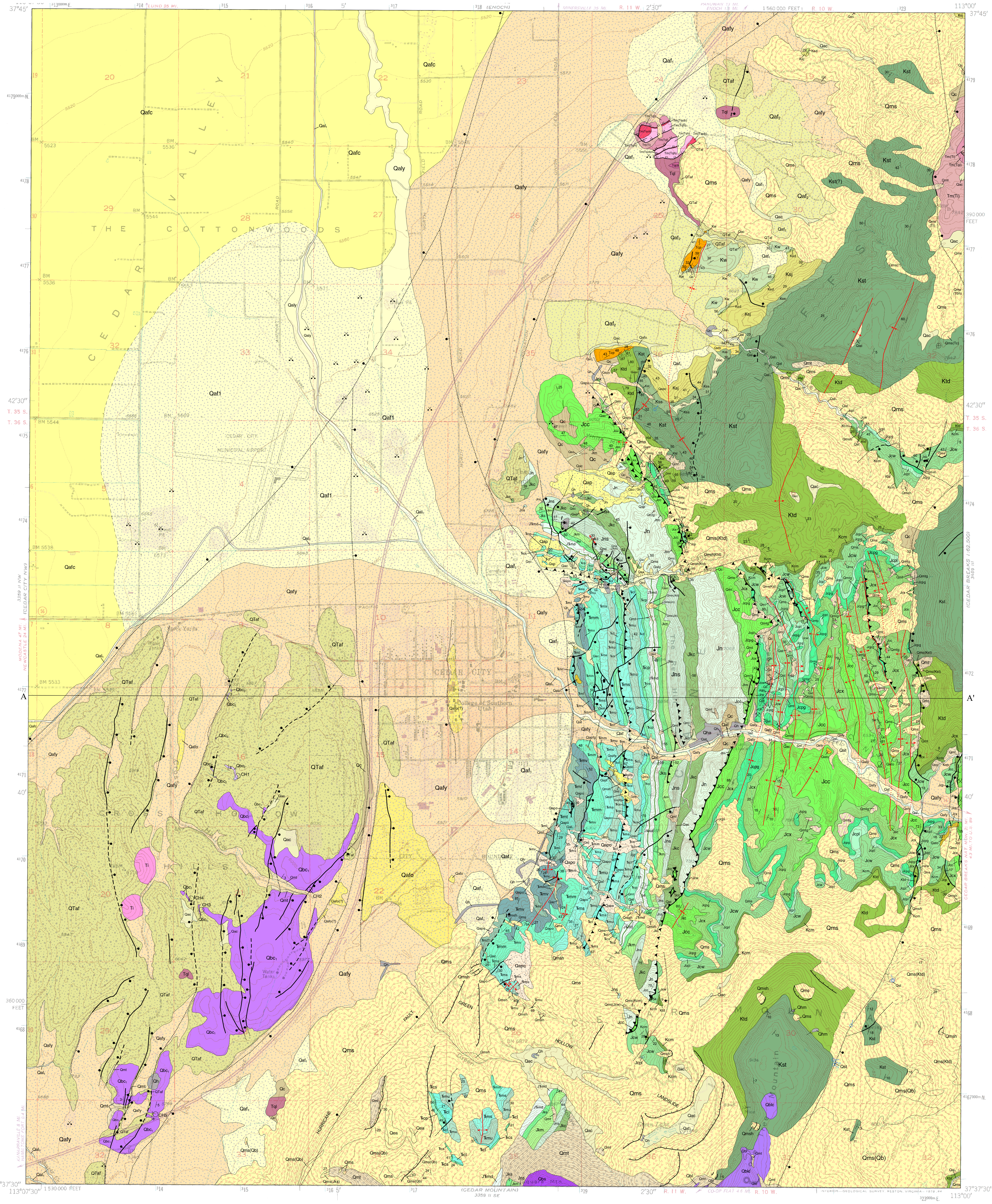

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For use at 1:24,000 scale only.

INTERIM GEOLOGIC MAP OF THE CEDAR CITY 7.5-MINUTE QUADRANGLE, IRON COUNTY, UTAH

by
Tyler R. Knudsen

2014

11°78'
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 2013

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

Base from USGS Cedar City 7.5' Quadrangle (1950)
Projection: UTM Zone 12
Datum: NAD 1927
Spheroid: Clarke 1866

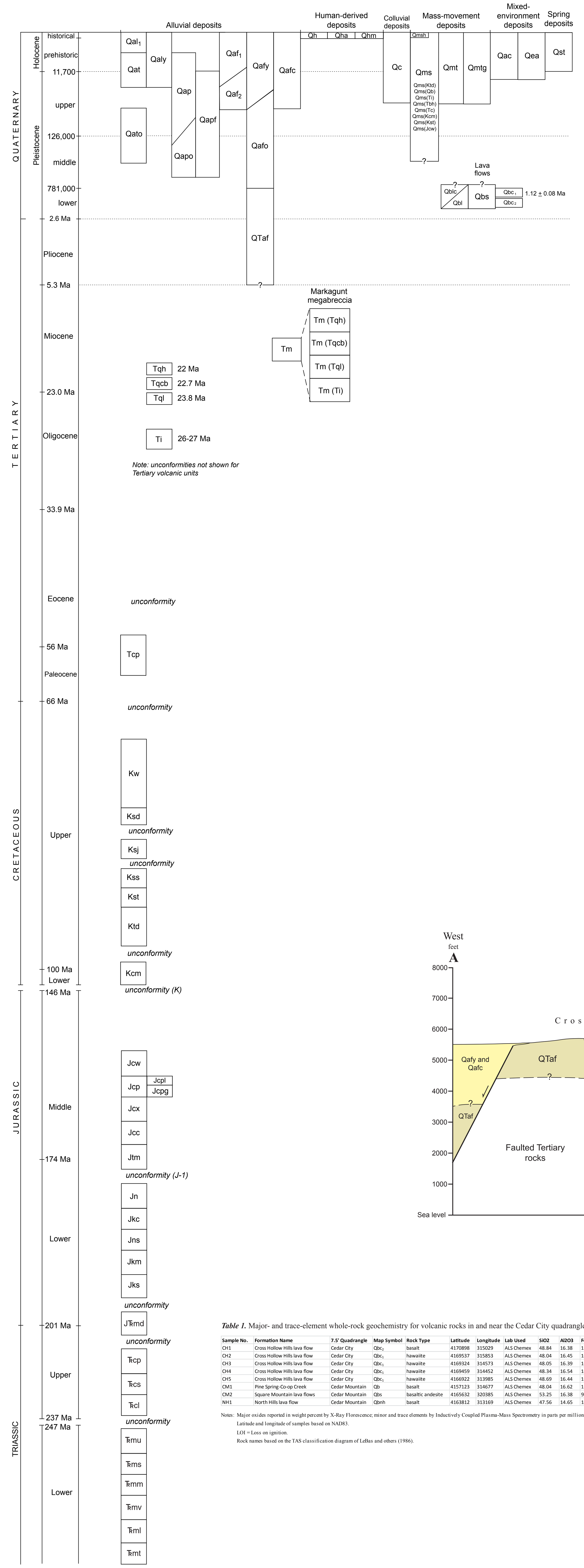
Project Manager: William R. Lund
GIS and Cartography: Tyler R. Knudsen

1	2	3
4		5
6	7	8

1. The Three Peaks
2. Enoch
3. Summit
4. Cedar City NW
5. Flanigan Arch
6. Kanarraville
7. Cedar Mountain
8. Webster Flat

ADJOINING 7.5' QUADRANGLE NAMES

CORRELATION OF MAP UNITS



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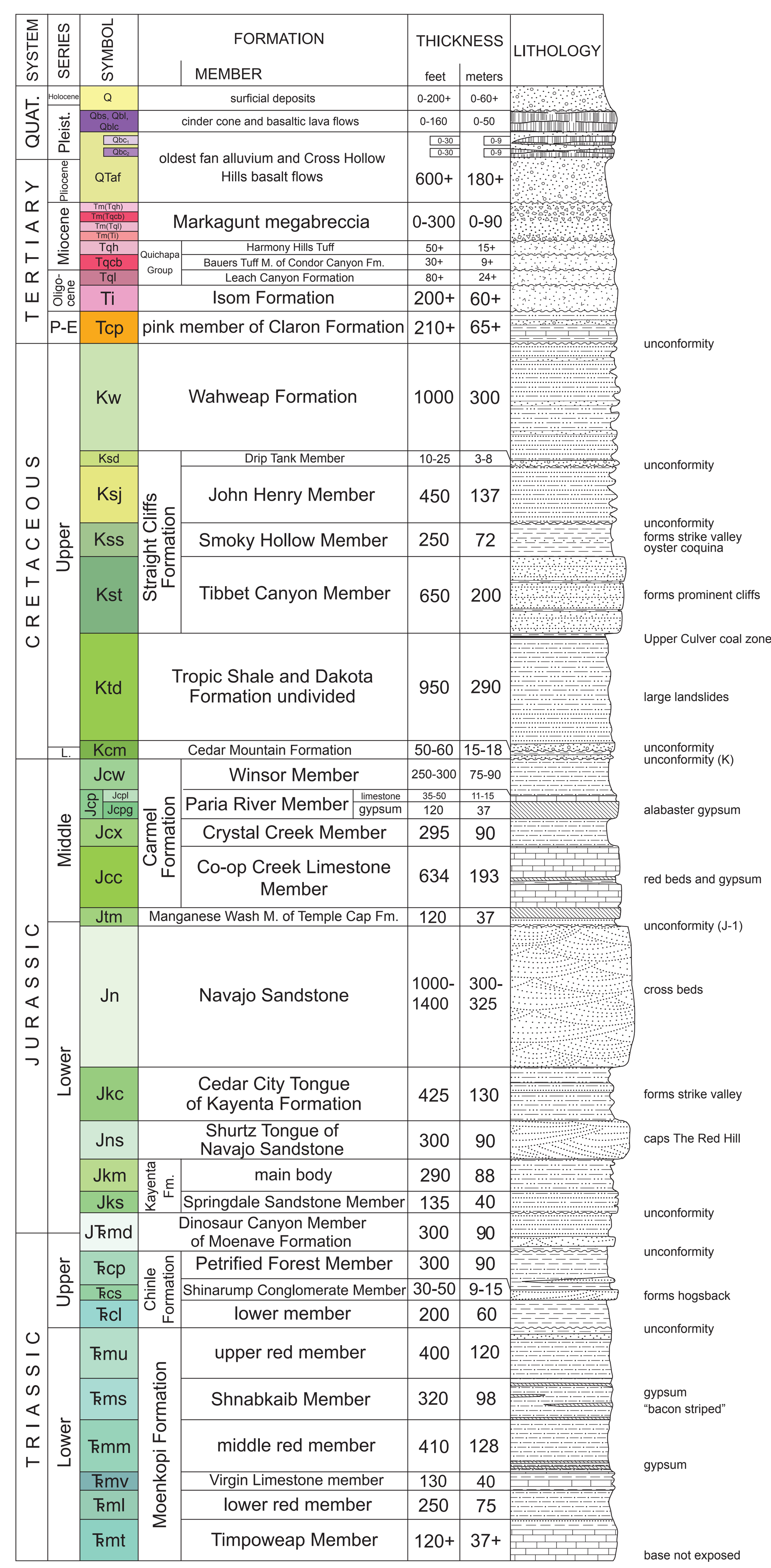
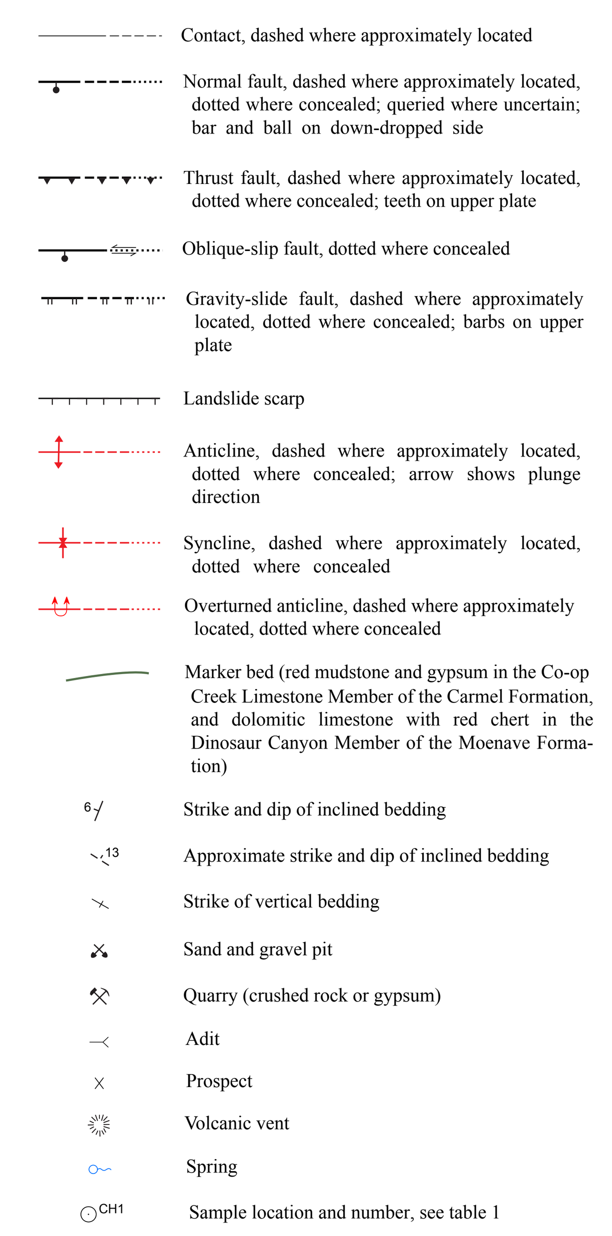


MAP SYMBOLS



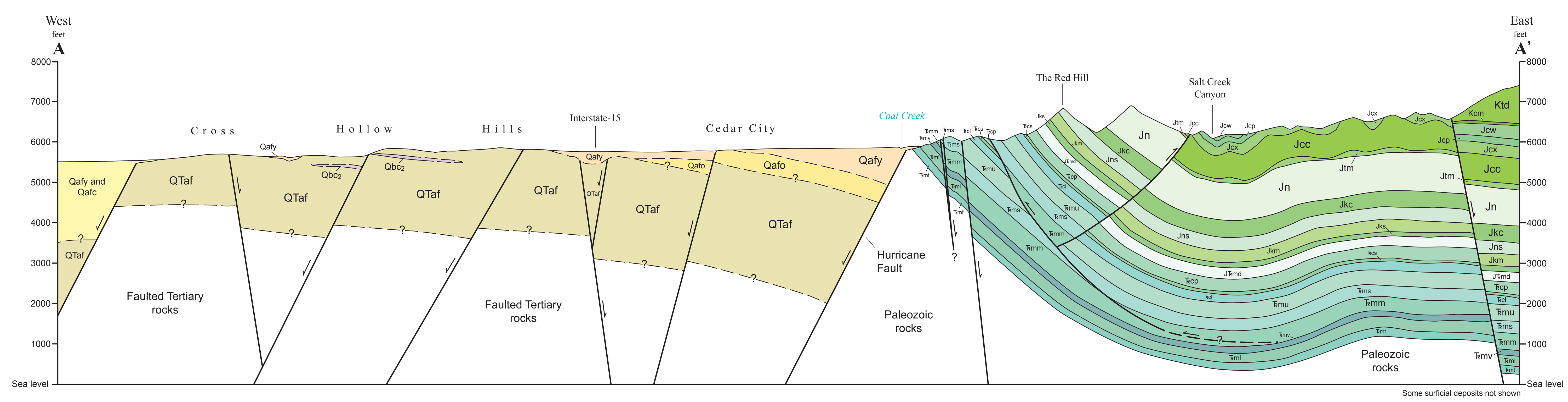


Table 1. Major- and trace-element whole-rock geochemistry for volcanic rocks in and near the Cedar City quadrangle.

Sample No.	Formation Name	7.5' Quadrangle	Map Symbol	Rock Type	Latitude	Longitude	Lab Used	SiO2	Al2O3	Fe2O3	CaO	MgO	Na2O
CH1	Cross Hollow Hills lava flow	Cedar City	Qbc_2	basalt	4170898	315029	ALS Chemex	48.84	16.38	11.94	9.48	7.02	3.25
CH2	Cross Hollow Hills lava flow	Cedar City	Qbc_1	hawaiite	4169537	315853	ALS Chemex	48.04	16.45	10.82	7.82	7.6	4.18
CH3	Cross Hollow Hills lava flow	Cedar City	Qbc_1	hawaiite	4169324	314573	ALS Chemex	48.05	16.39	10.65	8.03	7.59	4.16
CH4	Cross Hollow Hills lava flow	Cedar City	Qbc_1	hawaiite	4169459	314452	ALS Chemex	48.34	16.54	10.75	7.88	7.64	4.25
CH5	Cross Hollow Hills lava flow	Cedar City	Qbc_1	hawaiite	4166922	313985	ALS Chemex	48.69	16.44	10.4	7.9	7.76	4.11
CM1	Pine Spring-Co-op Creek	Cedar Mountain	Qb	basalt	4157123	314677	ALS Chemex	48.04	16.62	11.15	10.54	6.17	3.24
CM2	Square Mountain lava flows	Cedar Mountain	Qbs	basaltic andesite	4165632	320385	ALS Chemex	53.25	16.38	9.13	7.94	4.98	3.63
NH1	North Hills lava flow	Cedar Mountain	Qbnh	basalt	4163812	313169	ALS Chemex	47.56	14.65	11.08	9.39	8.97	3.34

Sample No.	K2O	Cr2O3	TiO2	MnO	P2O5	SrO	BaO	LOI	Total	Ba	Ce	Cr	Cs	Dy	Er	Eu	Ga	Gd	Hf	Ho	La	Lu
CH1	0.67	0.02	1.56	0.18	0.287	0.05	0.06	-0.19	99.55	503	38.7	220	0.24	5.25	3.07	1.57	19.4	5.28	3.6	1.07	16.9	0.4
CH2	1.38	0.03	1.98	0.17	0.594	0.09	0.1	0.21	99.46	1010	68.1	250	0.18	5.7	3.13	2.15	18.2	6.29	5.9	1.1	30.9	0.41
CH3	1.39	0.03	1.96	0.16	0.599	0.09	0.05	0.4	99.55	443	68.2	240	0.11	5.75	3.19	2.16	17.8	6.53	6	1.12	31.1	0.4
CH4	1.42	0.03	1.99	0.16	0.593	0.09	0.05	-0.12	99.61	372	67.2	240	0.15	5.72	3.17	2.12	17.8	6.53	6	1.13	30.6	0.4
CH5	1.38	0.03	1.87	0.16	0.544	0.08	0.05	-0.29	99.12	402	65.8	300	0.16	5.74	3.2	2.1	17.7	6.34	5.8	1.12	30.5	0.43
CM1	1.05	0.01	1.62	0.18	0.639	0.09	0.11	0.24	99.7	1015	92.7	140	0.22	5.44	3.06	2.23	20.4	6.72	4.5	1.08	47.8	0.4
CM2	1.68	0.01	1.48	0.14	0.63	0.12	0.17	-0.14	99.39	1655	134	90	0.3	5.21	2.69	2.52	20.9	7.06	5.6	0.98	66.6	0.34
NH1	1.51	0.04	2.08	0.17	0.615	0.08	0.09	0.04	99.62	874	88.3	410	0.35	5.53	2.82	2.36	19.6	6.88	5.6	1.02	45.3	0.35

Sample No.	Nb	Nd	Pr	Rb	Sm	Sn	Sr	Ta	Tb	Th	Tl	Tm	U	V	W	Y	Yb	Zr	Ag	As	Cd	Co	Cu	Mo	Ni	Pb	Sc	Zn
CH1	9.3	20.2	4.95	11.4	4.79	1	434	0.6	0.84	1.86	<0.5	0.47	0.46	256	<1	27.1	2.73	140	<0.5	<5	<0.5	39	80	1	83	9	31	104
CH2	20.8	32.3	8.45	11.9	6.64	4	847	1.4	0.96	2.51	<0.5	0.46	0.9	191	1	29.3	2.81	300	<0.5	<5	<0.5	37	52	2	138	136	22	94
CH3	20.3	32.4	8.49	10.9	6.52	2	848	1.4	0.98	2.46	<0.5	0.47	1.19	200	5	29	2.78	300	<0.5	8	<0.5	35	45	2	130	6	21	82
CH4	20	31.8	8.43	11.5	6.59	3	807	1.4	1	2.47	<0.5	0.47	0.84	181	<1	28.2	2.83	290	<0.5	<5	<0.5	36	47	2	133	51	22	83
CH5	19.4	31.3	8.17	12.8	6.29	2	762	1.3	0.98	2.72	<0.5	0.49	0.82	200	2	27.8	2.81	280	<0.5	<5	<0.5	37	58	2	139	6	23	82
CM1	37.1	40.7	11.1	16.3	7.28	2	818	2.1	0.96	7.48	<0.5	0.45	1.78	286	<1	27.1	2.66	190	<0.5	6	<0.5	34	72	2	51	25	31	105
CM2	27.6	55	15.1	24.7	9.15	2	1110	1.4	0.96	7.22	<0.5	0.4	1.84	206	4	25.7	2.32	230	<0.5	<5	<0.5	27	46	1	73	18	20	107
NH1	41	40.3	10.65	23.5	7.75	2	771	2.5	0.98	6.77	<0.5	0.4	1.67	267	<1	26	2.33	240	<0.5	<5	<0.5	40	59	3	160	9	27	102

Notes: Major oxides reported in weight percent by X-Ray Florescence; minor and trace elements by Inductively Coupled Plasma-Mass Spectrometry in parts per million.
Latitude and longitude of samples based on NAD83.
LOI = Loss on ignition.
Rock names based on the TAS classification diagram of LeBas and others (1986).