INTERIM GEOLOGIC MAP OF THE SOLDIERS PASS QUADRANGLE, UTAH COUNTY, UTAH

by

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MAP UNIT DESCRIPTIONS

QUATERNARY

Alluvial deposits

Qal_1 **Modern stream deposits** (Holocene) − Moderately sorted sand, silt, clay, and pebble to boulder gravel deposited in active stream channels and flood plains; locally includes small alluvial-fan and colluvial deposits, and minor terraces up to about 10 feet (3 m) above current base level; mapped in ephemeral washes draining the Lake Mountains and low hills to the south; typically less than 20 feet (<6 m) thick.

Alluvial-fan deposits represent a thin apron of sediment over a piedmont upslope from range-bounding normal faults. Downslope from these faults, the deposits are much thicker and represent the upper part of thick basin-fill deposits of Utah Valley and Cedar Valley.

Qaf_1 **Level-1 alluvial-fan deposits** (Holocene) − Poorly to moderately sorted, non-stratified, clay- to boulder-size sediment deposited principally by debris flows and debris floods at the mouths of active drainages; upper parts typically characterized by abundant boulders and debris-flow levees that radiate away from the apex of the fan; equivalent to the younger part of Qafy, but differentiated because they form smaller, isolated fans; probably less than 20 feet (<6 m) thick.

Qafy **Young undifferentiated alluvial-fan deposits** (Holocene to Upper Pleistocene) − Similar to level-1 alluvial-fan deposits (Qaf_1), but forms coalesced apron of post-Bonneville sediment shed off the Lake Mountains and low hills to the south; upper parts of fans are locally deeply incised; older parts of deposit are equivalent to Qaf_2, which is locally present in the adjacent Saratoga Springs quadrangle (Biek, 2004); thickness unknown, but likely as much as several tens of feet thick.

Qafo **Old alluvial-fan deposits** (Upper to Middle Pleistocene) − Similar to young undifferentiated alluvial-fan deposits (Qafy), but forms deeply dissected alluvial apron truncated by, and thus predating, the Bonneville shoreline; upper parts of fans locally receive sediment from minor washes; thickness unknown, but may locally exceed several tens of feet thick.

Artificial deposits

Qfm **Mine-dump deposits** (Historical) − Waste rock and overburden from clay quarries; as much as about 30 feet (9 m) thick.

Qfd **Disturbed land** (Historical) − Land disturbed by clay and aggregate operations; only the larger operations are mapped, and their outlines are based in part on the 1997 topographic base map; land within these areas contains a mix of cuts and fills as well as excellent exposures of Manning Canyon Shale and the formation of White Knoll.

Colluvial deposits

Qc **Colluvial deposits** (Holocene to Upper Pleistocene) − Poorly to moderately sorted, angular, clay- to boulder-size, locally derived sediment deposited by slope wash and soil creep on moderate slopes and in shallow depressions; locally grades upslope into talus deposits and downslope into mixed alluvial and colluvial deposits; because many bedrock slopes are covered by at least a veneer of colluvium, only the larger, thicker deposits are mapped; typically 0 to 20 feet (0-6 m) thick.

Qco **Older colluvial deposits** (Upper to Middle Pleistocene) − Similar to colluvial deposits (Qc), but forms deeply dissected slopes at the base of Long Ridge and in the lower reaches of Mercer Canyon where it is as much as about 30 feet (9 m) thick; also is mapped in sections 20 and 29, T. 7 S., R. 1 W., where it is generally less than 10 feet (< 3 m) thick, consisting of silt, clay, and bedrock detritus derived from the formation of White Knoll.

Eolian deposits

Qes **Eolian sand deposits** (Holocene) − Well- to very well-sorted, fine- to medium-grained, well-rounded, windblown sand near The Knolls and west of Clyde Knoll; forms small dunes mostly stabilized by vegetation; typically 0 to 10 feet (0-3 m) thick.

Lacustrine deposits

Deposits of the Provo (regressive) phase of the Bonneville lake cycle (Currey and Oviatt, 1985) are identified with the last map symbol letter "p," and deposits of the Bonneville (transgressive) phase of the Bonneville lake cycle are identified with the last map symbol letter "b."

Qly **Younger lacustrine and marsh deposits** (Holocene) − Silt, clay, and minor fine-grained sand deposited along the margin of Utah Lake; locally organic rich, and locally includes pebbly beach gravel; Brimhall and others (1976) reported that Holocene-age gray clayey silt composed mostly of calcite comprise the upper 15 to 30 feet (5-10 m) of the lake sediments under Utah Lake; sediments of the Bonneville lake cycle underlie these beds.

Qlgb, Qlgp

Lacustrine gravel and sand (Upper Pleistocene) − Moderately to well-sorted, moderately to well-rounded, clast-supported, pebble to cobble gravel and lesser pebbly sand; thin to thick bedded; typically interbedded with or laterally gradational to sand and silt facies; gastropods common in sandy lenses; locally partly cemented with calcium carbonate; typically forms wave-cut or wave-built benches, bars, and spits; wave-cut benches are commonly partly covered by colluvium derived from adjacent oversteepened slopes; intermediate shorelines are locally well developed on Provo-level deposits; Qlgb deposited at and below highest Bonneville shoreline but above the Provo shoreline, and Qlgp deposited at and below the Provo shoreline; typically 0 to 30 feet (0-9 m) thick.

Qlsb, Qlsp

Lacustrine sand and silt (Upper Pleistocene) − Fine- to coarse-grained sand and silt with minor gravel; typically well sorted and laminated in thick beds; gastropods locally common; grades downslope from sandy nearshore deposits to finer grained offshore deposits; shorelines typically poorly developed on this facies; locally concealed by loess veneer; Qlsb deposited at and below highest Bonneville shoreline but above the Provo shoreline, and Qlsp deposited at and below the Provo shoreline; probably less than 30 feet (<9 m) thick.

Qlmb, Qlmp

Lacustrine silt and clay (Upper Pleistocene) − Calcareous silt (marl) with minor clay and fine-grained sand; typically laminated, but weathers to appear thick bedded; locally grades upslope into lacustrine sand and silt (Qlsb, Qlsp) and locally concealed by loess veneer; shorelines typically poorly developed on this facies; contact with distal parts of younger alluvial-fan deposits is difficult to identify and commonly based on subtle geomorphic differences; Qlmb deposited below Bonneville shoreline but above the Provo shoreline, and Qlmp deposited below the Provo shoreline; thickness uncertain, but may exceed several tens of feet thick.

Qllb, Qllp

Lagoon-fill deposits (Upper Pleistocene) − Forms level, grassy areas behind offshore gravel bars; not exposed, but likely consists of thick-bedded silt with sand and minor pebbles washed in from adjacent slopes; may be capped by loess, and is typically concealed by a veneer of colluvial deposits; probably less than 20 feet (<6 m) thick.

Mass-movement deposits

Qms **Landslide deposits** (Historical? to Upper Pleistocene) − Very poorly sorted, locally derived material deposited by rotational and translational movement; typically clay- to boulder-size debris, but some landslides include large bedrock blocks; characterized by hummocky topography, numerous internal scarps, and chaotic bedding attitudes; basal slip surfaces most commonly form in the Manning Canyon Shale and in fine-grained lake deposits over bedrock; undivided as to inferred age because new research shows that even landslides with subdued morphology (suggesting that they are older, weathered, and have not moved recently) may continue to exhibit slow creep or are capable of renewed movement if stability thresholds are exceeded (Francis Ashland, Utah Geological Survey, verbal communication, April 2006); age and stability determinations require detailed geotechnical investigations; thickness highly variable.

Qmt **Talus deposits** (Holocene to Upper Pleistocene) − Very poorly sorted, angular cobbles and boulders and finer-grained interstitial sediment deposited principally by rock fall on or at the base of steep slopes; only a few deposits are mapped because most talus in the area is gradational with colluvial deposits and is thus mapped as talus and colluvium undivided (Qmtc); generally less than 20 feet (<6 m) thick.

Mixed-environment deposits

Qac **Alluvial and colluvial deposits** (Holocene to Upper Pleistocene) − Poorly to moderately sorted, generally poorly stratified, clay- to boulder-size, locally derived sediment deposited in swales and small drainages by fluvial, slope-wash, and creep processes; generally less than 20 feet (6 m) thick.

Qaco **Older alluvial and colluvial deposits** (Upper Pleistocene) − Similar to mixed alluvial and colluvial deposits (Qac), but form isolated remnants deeply incised by adjacent streams; generally less than 20 feet (<6 m) thick.

Qmtc **Talus and colluvium** (Holocene to Upper Pleistocene) − Very poorly sorted, angular to subangular cobbles and boulders and finer-grained interstitial sediment deposited by rock fall and slope wash on and at the base of steep slopes; includes minor alluvial sediment in the bottom of washes; generally less than 20 feet (<6 m) thick.

Stacked-unit deposits

Qc/Qlgp

Colluvial deposits over lacustrine gravel and sand deposits (Holocene/Upper Pleistocene) − Mapped at Clyde Knoll, where colluvial deposits partly conceal gravel and sand associated with the regressive (Provo) phase of Lake Bonneville.

The following stacked units are used to denote various surficial and bedrock units that are partly eroded by wave action associated with the rise and fall of Lake Bonneville, and that are concealed by a discontinuous veneer of undifferentiated lacustrine gravel, sand, silt, or clay; coarser-grained lacustrine facies commonly exhibit intermediate-level shorelines. The southern part of the Lake Mountains were formerly referred to as the Fox Hills and Mosida Hills, but are not presently indicated as such on the topographic base map. The Fox Hills lie between Soldiers Pass and Goshen Pass, and the Mosida Hills lie south of Goshen Pass.

Ql/Qafo

Lacustrine deposits over older alluvial-fan deposits (Upper Pleistocene/Upper Pleistocene) − Mapped along the margins of Lake Mountain and the low hills to the south.

Ql/QTaf, Qlgb/QTaf

Lacustrine deposits over oldest alluvial-fan deposits (Upper Pleistocene/Pleistocene-Pliocene) − Mapped west of Mercer Canyon.

Ql/Tb **Lacustrine deposits over trachybasalt lava of Mosida** (Upper Pleistocene/Lower Miocene) − Mapped along the west side of Fox Hills.

Ql/Twk

Lacustrine deposits over formation of White Knoll (Upper Pleistocene/Upper or Lower Oligocene) − Mapped along the margins of Fox Hills.

Ql/IPou

Lacustrine deposits over undifferentiated Oquirrh Group (Upper Pleistocene/Lower Pennsylvanian-uppermost Mississippian) − Mapped between Pfeiffer and Burnt Canyons on the southeast flank of the Lake Mountains, where the contact between the West Canyon Limestone and overlying Butterfield Peaks Formation is concealed.

Ql/IPob

Lacustrine deposits over Butterfield Peaks Formation (Upper Pleistocene/Middle-Lower Pennsylvanian) − Mapped just north of Burnt Canyon on the southeast flank of the Lake Mountains.

Ql/Mmc

Lacustrine deposits over Manning Canyon Shale (Upper Pleistocene/Upper Mississippian) − Mapped near Big Cove in the northeast part of the quadrangle.

Ql/Mgb

Lacustrine deposits over undifferentiated Great Blue Formation (Upper Pleistocene/Upper Mississippian) − Mapped near Big Cove in the northeast part of the quadrangle.

Qlgb/Mgbu

Lacustrine deposits over the upper part of the Great Blue Formation (Upper Pleistocene/Upper Mississippian) − Mapped west of the entrance to Mercer Canyon on the west side of the mountain.

Ql/Mh **Lacustrine deposits over Humbug Formation** (Upper Pleistocene/Upper Mississippian) − Mapped in the Mosida Hills in the southwest corner of the quadrangle.

Ql/Mg **Lacustrine deposits over Gardison Limestone** (Upper Pleistocene/Upper Mississippian) − Mapped in the Mosida Hills in the southwest corner of the quadrangle.

Unconformity

QUATERNARY/TERTIARY

QTaf **Oldest alluvial-fan deposits** (Pleistocene to Pliocene) − Poorly to moderately sorted, clay- to boulder-size sediment deposited principally by debris flows and debris floods; consists of Butterfield Peaks Formation clasts shed off the southwest side of Lake Mountain; forms cobble- and boulder-covered, deeply dissected remnant between Mercer and Long Canyons; maximum thickness exceeds 200 feet (60 m).

Unconformity

TERTIARY

New informal names are applied to Tertiary rock units; see table 1 for major- and trace-element whole-rock geochemical data; rock names for lava flows and tuffs derived from total alkali-silica diagram of LeBas and others (1986); updated geochronologic data from the New Mexico Geochronology Research Laboratory is pending. The southern part of the Lake Mountains were formerly referred to as the Fox Hills and Mosida Hills, but are not presently indicated as such on the topographic base map. The Fox Hills lie between Soldiers Pass and Goshen Pass, and the Mosida Hills lie south of Goshen Pass.

Tb **Trachybasalt lava of Mosida** (Lower Miocene) − Medium-dark-gray, weathering to light olive gray and blue gray, porphyritic, potassic trachybasalt (or absarokite in some classifications) lava flow; phenocrysts (10 to 20%) of olivine (Fo_{60}), plagioclase (An_{60} to An_{70}), and clinopyroxene (Mg# 0.78 to 0.72) in a fine-grained groundmass; olivine commonly altered to iddingsite and appears as rust-colored blebs; locally vesicular; caps ridges of Fox Hills and forms blocky ledges and small cliffs; source vent probably located near Soldiers Pass; $^{40}Ar/^{39}Ar$ age pending, but yielded K-Ar age of about 17.0 Ma (McKee and others, 1993); thickness from 0 to 120 feet (0-35 m).

Unconformity

Ts **Shoshonite lava of Goshen Pass** (Upper or Lower Oligocene?) − Dark-gray, white, pale-reddish-brown, and pale-red shoshonite lava flow; crops out mostly as distinctive, brecciated, carbonate-impregnated lava; also occurs as medium-gray, blue-gray, and pale-red lava flow, and is locally vesicular; fine-grained with trachytic to felty groundmass of plagioclase, olivine (typically altered), and oxides; calcite near margins of flow appears to be primary and formed as flow entered lake (formation of White Knoll); crops out in southern Fox Hills near Goshen Pass as slopes, ledges, rounded knobs, and small cliffs; source vent unknown; $^{40}Ar/^{39}Ar$ age pending; thickness from 0 to 160 feet (0-50 m).

Twk **Formation of White Knoll** (Upper or Lower Oligocene?) − White and pale-yellowish-orange, yellowish-gray-weathering limestone with interbedded very pale orange, white, and pale-red claystone; locally light-gray pyroclastic-fall beds; limestone locally sandy and conglomeratic and with fossilized plant remains; locally with vertical structures and algal laminations suggestive of spring deposits; bedding laminated to medium to indistinct; generally flat-lying deposits are locally draped on paleotopography; interfingers locally with shoshonite lava of Goshen Pass (Ts); forms ledges and slopes in Fox Hills and northernmost Mosida Hills; claystone excavated from quarries and pits in quadrangle, including the Fox Hills clay pit in the SW1/4 section 20, T. 7 S., R. 1 W. (Stringham and Sharp, 1950); thickness from 0 to 240 feet (0-75 m).

Unconformity?

Ta **Andesite lava of Black Point** (Lower Oligocene) − Medium-gray andesitic lava flow weathering to pale yellowish brown and pale brown; no phenocrysts; has platy fracture and weathers to blocks and chips; crops out near Black Point as ledges and rounded hills of limited extent; source vent unknown; $^{40}Ar/^{39}Ar$ age pending, but yielded K-Ar age of 32.6 Ma (McKee and others, 1993); thickness from 0 to 40 feet (0-12 m).

Unconformity

Tr **Rhyolite tuff of pumice pit** (Upper Eocene) − Yellowish-gray, weathering to grayish orange and medium dark gray, non-welded, pumice-rich, porphyritic, rhyolitic ash-flow tuff; phenocrysts (20%) of quartz, reversely zoned plagioclase (An_{30} to An_{50}), Ba-rich sanidine (Or_{50} to Or_{75}), and biotite in a glassy groundmass; contains pumice fragments (20%) up to 6 inches (15 cm) in length and lithic fragments; exposed as ledges and slopes north of Soldiers Pass and in Fox Hills; named for pit in section 17, T. 7 S., R. 1 W; source vent unknown; it extends into the adjacent Allens Ranch quadrangle where it is well exposed in Chimney Rock Pass and overlies the Packard Rhyolite (E.H. Christiansen, Brigham Young University, unpublished data); new $^{40}Ar/^{39}Ar$ age pending, but yielded preliminary $^{40}Ar/^{39}Ar$ age of 34.2 Ma (S.T. Nelson, Brigham Young University, unpublished data); exposed thickness as much as 60 feet (20 m).

Unconformity

Td **Trachydacite tuff of Soldiers Pass** (Upper Eocene) − Medium-gray, weathering to light olive gray, densely welded, porphyritic, trachydacite ash-flow tuff; phenocrysts (30%) of quartz, strongly zoned plagioclase (An_{40} to An_{80}), and Mg-rich biotite, hornblende, and clinopyroxene in a glassy groundmass; has local red and black banding; exposed as rounded ledges on east side of Fox Hills; source vent unknown; new $^{40}Ar/^{39}Ar$ age pending, but yielded preliminary $^{40}Ar/^{39}Ar$ age of 34.7 Ma (S.T. Nelson, Brigham Young University, unpublished data); exposed thickness as much as 60 feet (20 m).

Major unconformity

PENNSYLVANIAN and MISSISSIPPIAN

Oquirrh Group (Upper Pennsylvanian to uppermost Mississippian) − Principally calcareous sandstone, sandy limestone, limestone, and minor orthoquartzite that form the bulk of Lake Mountain; divided into, in ascending order, the West Canyon Limestone and Butterfield Peaks Formation; believed to be part of the Bingham sequence of Tooker and Roberts (1970); best exposed along or just below ridge crests – elsewhere, slopes are commonly covered by a veneer of colluvium and talus not practical to map at a scale of 1:24,000; ages from Gordon and Duncan (1970), Davis and others (1994), and Biek

(2004); deposited in the Oquirrh marine basin of north-central Utah and southern Idaho, with fine arkosic sand derived principally from the Weber shelf and Uncompahgre Uplift (Welsh and Bissell, 1979); only the lower 4850 to about 5500 feet (1480-1675 m) is preserved in the Lake Mountain syncline, but the group is in excess of 17,800 feet (5425 m) thick in the Oquirrh Mountains (Tooker and Roberts, 1970) and about 25,000 feet (7600 m) thick near Mt. Timpanogos (Baker, 1964).

IPob **Butterfield Peaks Formation** (Middle – Lower Pennsylvanian [Desmoinesian – uppermost Morrowan]) − Interbedded, brown-weathering, fine-grained calcareous sandstone, medium-gray, fine-grained sandy limestone, minor orthoquartzite, and several limestone intervals, four of which are mapped separately; typically cyclically interbedded with several tens of feet of calcareous sandstone capped by gray limestone several feet thick; contains minor siltstone and mudstone interbeds that are very poorly exposed; forms ledgy to cliffy slopes. Calcareous sandstone is typically medium to thick bedded, light brownish gray to medium gray but grayish orange to brown weathering, very fine to fine grained, locally with planar, low-angle, and ripple cross-stratification and bioturbation; sandstone is commonly non-calcareous on weathered surfaces and so appears similar to orthoquartzite, but fresh surfaces are invariably calcareous. Orthoquartzite is grayish orange pink to light brown, very thick bedded, very fine to fine grained, with faint low-angle cross-stratification and a prominent conchoidal fracture; it is restricted to a prominent, 35-foot-thick (11 m) ledge between the “upper” (IPou) and “lower” (IPol) limestones and a few thinner beds above the “upper” limestone. Unmapped limestone intervals are typically medium gray, medium to thick bedded, locally with fine-grained sand, locally fossiliferous with syringoporid and rugose corals, bryozoans, brachiopods, and fossil hash, locally with irregularly shaped black chert nodules and ribbon chert, and commonly grade upward to finer grained, platy weathering limestone and argillaceous limestone; *Chaetetes* coral bed is about 325 feet (100 m) above the base of the formation. A partial measured section on the west flank of Lake Mountain, just north of the quadrangle, is 3823 feet (1166 m) thick, but the incomplete thickness of the formation at Lake Mountain is as much as 4500 feet (1370 m) (Biek, 2004); Tooker and Roberts (1970) reported the formation is 9070 feet (2765 m) thick in the Oquirrh Mountains.

IPou **Upper limestone** (upper to middle Desmoinesian) − Thin- to medium-bedded, medium-gray, fine-grained limestone and very fine to fine-grained sandy limestone with minor, brown-weathering, irregularly shaped black chert nodules; locally includes sandstone interbeds that pinch out along strike; locally difficult to trace unit across fold axes and areas of poor exposure, and as mapped, may locally include adjacent thin limestone intervals; forms ledgy slopes at the top of Lake Mountain; contains uncommon crinoid, brachiopod, bryozoan, and fusulinid fossils; about 220 feet (67 m) thick.

IPol **Lower limestone** (upper to middle Desmoinesian) − Thin- to medium-bedded, platy weathering, light- to medium-gray, fine-grained limestone with common, irregularly shaped black chert nodules; lower part contains minor spherical black chert nodules; upper part is typically medium to thick bedded, coarser grained, has less chert, and contains crinoid, bryozoan, and brachiopod fossils; forms slopes; locally includes sandstone interbeds that pinch out along strike; locally difficult to trace unit across fold axes and areas of poor exposure, and as mapped, may locally include adjacent thin limestone intervals; about 320 feet (98 m) thick.

IPobu **Upper billiard ball limestone** (middle Desmoinesian) − Light-gray-weathering, medium-dark-gray, thin-bedded, fine-grained limestone and argillaceous limestone with characteristic black spherical chert 0.25 to 2 inches (0.5-5 cm) in diameter in the lower two-thirds of the unit; upper part typically medium- to thick-bedded, medium- to coarse-grained limestone and fine-grained sandy limestone with common, irregularly shaped black chert nodules, and, in the upper 10 feet (3 m), brachiopod and crinoid fossils and fossil hash; well developed in section 2, T. 7 S., R. 1 W.; conspicuously platy weathering, forming slopes and saddles high on the flanks of Lake Mountain; 295 feet (90 m) thick.

IPobl **Lower billiard ball limestone** (middle to lower Desmoinesian) − Divisible into two parts not mapped separately: lower half has a ledge-forming basal bed several feet thick of medium-dark-gray, medium- to coarse-grained fossiliferous limestone with crinoid fossils and fossil hash overlain by thin- to medium-bedded, laminated and platy weathering, fine-grained limestone and argillaceous limestone with typically abundant black spherical chert nodules 0.25 to 2 inches (0.5-5 cm) in diameter; upper half tends to be light- to medium-gray, medium- to thick-bedded limestone with planar and low-angle cross-stratification and uncommon irregularly shaped black chert nodules; conspicuously platy weathering, forming slopes and saddles; 105 to 140 feet (32-43 m) thick.

IPMowc

West Canyon Limestone (Lower Pennsylvanian [Morrowan] to uppermost Mississippian) − Medium-light-gray to medium-gray, thick- to very thick bedded, fine- to medium-grained limestone and fossiliferous limestone; locally thin- to medium-bedded and laminated, and locally with brown-weathering silt and very fine grained sand laminae; macrofossils include typically sparse crinoid columnals, brachiopods, bryozoans, and rugose corals; lower part forms ledges and slopes, upper part contains three prominent cliff-forming limestone beds with brown- to black-weathering irregularly shaped chert nodules and irregular beds that impart a slight “black banded” appearance, especially to the upper cliff; 15- to 20-foot-thick (4-6 m) cliff-forming, light-brown- to grayish-orange-pink-weathering, light-olive-gray to olive-gray, very thick bedded, fine-grained calcareous sandstone with planar and low-angle cross-stratification is present near middle of formation; upper and lower contacts are gradational and conformable; upper and lower parts correspond to slope-forming intervals about 180 feet (55 m) and 145 feet (45 m) thick, respectively, that contain interbedded calcareous sandstone, limestone, and minor shale or mudstone (Biek, 2004); Shoore (2005) reported that the lower few meters of the Bridal Veil Falls Limestone at Cascade Mountain, as this unit is known in the Wasatch Range, contain latest Chesterian conodonts (Upper Mississippian); he recognized 21 sequence boundaries within the member, caused by world-wide glacio-eustatic sea-level fluctuations, and reasoned that the member was deposited in cool, shallow-marine water, showing evidence of shoaling and steady progradation of the Weber shelf; 1025 feet (313 m) thick at Lake Mountain (Biek, 2004), but may be slightly thinner at the south end of the mountain.

MISSISSIPPIAN

Mmc **Manning Canyon Shale** (Upper Mississippian) − Lithologically diverse, interbedded, black to grayish-purple, calcareous and carbonaceous shale and siltstone; light-brown to pale-yellow-brown, very fine to fine-grained calcareous sandstone with planar and low-angle cross-stratification; brown-weathering, thick-bedded, fine-grained orthoquartzite with a vitreous and scintillating luster; and medium-gray to bluish-gray, thin- to thick-bedded fossiliferous limestone and argillaceous limestone; fossils include brachiopods, bryozoans, rare trilobites, and leaves; weathers to form strike valleys, but at the south end of Lake Mountain, south of Pfeiffer Canyon, holds up uncommonly steep, ledgy slopes mapped by previous workers as lower Butterfield Peaks Formation; slopes and soils developed on Manning Canyon strata tend to have slight reddish-brown to lavender hues in contrast to the browns and grays of enclosing units; upper contact is conformable and gradational and corresponds to a change from predominantly clastic to predominantly carbonate strata; age from Gordon and Duncan (1970); Bullock (1951) reported thicknesses of 1121 feet (west side) and 1419 feet (east side) (342-433 m) at Lake Mountain, but the thicker section on the east side of the mountain likely results from structural complications.

Great Blue Limestone (Upper Mississippian)

Mgb **Great Blue Limestone, undivided** − Undivided in the vicinity of Soldiers Pass, at The Knolls, and in the northeast corner of the quadrangle due either to limited exposure or structural complications.

Mgbu **Upper limestone member** − Medium- to very thick bedded, bluish-gray limestone, locally cherty and commonly fossiliferous with brachiopods, corals, and bryozoans; contains interbedded shale in lower part; typically forms ledges and cliffs; upper contact marks a prominent change from cliff-forming limestone to slope-forming shale; Gordon and others (2000) reported a thickness of 1540 feet (470 m) for the upper limestone unit in the southern Oquirrh Mountains, but in the Lake Mountains, we estimate the member is about 2100 feet (640 m) thick.

Mgbl **Long Trail Shale Member and lower limestone member, undivided** − **Long Trail Shale Member** is interbedded, reddish-brown, dark-gray, and grayish-purple calcareous and locally carbonaceous shale, and thin-bedded, medium-gray limestone and fossiliferous limestone; locally abundant rugose corals, pelecypods, brachiopods, and bryozoans; weathers to form strike valleys and saddles; locally contains limonite pseudomorphs after pyrite; neither the lower nor upper contact of the Long Trail Shale Member is well exposed, but regionally both appear conformable and gradational; Gordon and others (2000) reported a thickness of 108 feet (33 m) for the Long Trail Shale Member in the southern Oquirrh Mountains; the member is about 90 feet (28 m) thick in the Lake Mountains (Bullock, 1951). **Lower limestone member** is medium- to very thick bedded, light- to dark-gray but typically medium-gray limestone and fossiliferous limestone; upper part is typically thin-bedded and platy weathering argillaceous limestone and interbedded gray to grayish-purple shale; bryozoans are locally abundant; the lower limestone member is 850 feet (260 m) thick in the southern Oquirrh Mountains (Gordon and others, 2000), but appears to be only about 300 feet (90 m) thick in the Lake Mountains. Queried where designation is uncertain.

Mh **Humbug Formation** (Upper Mississippian) − Interbedded calcareous quartz sandstone, orthoquartzite, and limestone that weather to ledgy slopes. Sandstone is light- to dark-brown weathering, pale yellowish brown to olive gray, medium to very thick bedded, variably calcareous or siliceous, locally with planar or low-angle cross-stratification. Limestone rarely contains dark-gray chert nodules and is: (1) light gray weathering, medium dark gray, medium to thick bedded, and fine grained with local small white chert blebs; (2) dark gray, very thick bedded with small white calcite blebs; or (3) locally medium to coarse grained with sparse fossil hash. Upper half contains several distinctive, ledge-forming, white, medium- to thick-bedded sublithographic limestone beds up to 10 feet (3 m) thick; upper contact is conformable and gradational and represents a change from interbedded sandstone and limestone to limestone; age from Morris and Lovering (1961); about 700 to 750 feet (210-230 m) thick.

Md **Deseret Limestone** (Upper to Lower Mississippian) − Medium- to very thick bedded, medium-dark-gray, variably sandy and fossiliferous limestone; contains distinctive white calcite nodules and blebs and local to common brown-weathering chert nodules; fossils include rugose corals, uncommon brachiopods, crinoids, bryozoans, and fossil hash; lower part not exposed, but regionally the lower 20 to 30 feet (6-9 m) is marked by slope-forming, thin-bedded, black phosphatic chert likely of the Dell Phosphatic Member; upper contact is conformable and gradational and corresponds to a change from fossiliferous limestone to predominantly sandstone; query indicates uncertain correlation at Clyde Knoll; age from Morris and Lovering (1961) and Sandberg and Gutschick (1984); about 700 to 750 feet (210-230 m) thick.

Mg **Gardison Limestone** (Lower Mississippian) − Medium- to very thick bedded, medium-gray to medium-dark-gray limestone, cherty limestone, and fossiliferous limestone; contains minor medium-dark-gray, medium- to thick-bedded dolomite near the base; chert is present as black, irregularly shaped nodules and thin, discontinuous beds; fossils include rugose and colonial corals, brachiopods, gastropods, and bryozoans replaced by white calcite; upper contact appears conformable and gradational and generally corresponds to a break in slope, with slope-forming, thinner bedded, cherty limestone below and thicker bedded, ledge-and cliff-forming limestone above; age from Morris and Lovering (1961); thickness uncertain due to structural complications, but probably about 500 to 650 feet (150-200 m) thick.

Pzu Paleozoic, undivided – Shown in cross section only.

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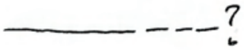
Harold J. Bissell, Brigham Young University (BYU), conducted the first geologic mapping of surficial deposits in this area as part of his Ph.D. dissertation (1949) and USGS Professional Paper (1963); meanwhile, his colleague Kenneth C. Bullock produced the first reconnaissance geologic map of the Lake Mountains (Bullock, 1951). They advised BYU graduate students Calderwood (1951), Hoffman (1951), Okerlund (1951), Smith (1951), and Ornelas (1953) on mapping projects within the quadrangle. This area also served as a training ground for field classes led by Eric H. Christiansen at BYU, and several recent BYU undergraduate students contributed to the understanding of the southern Lake Mountains, Fox Hills, and northern Mosida Hills. Baxter and others (2005) and Christiansen and others (in preparation) recently conducted petrologic, geochemical, and geochronologic analyses on the Tertiary volcanic rocks of the quadrangle.

We thank Scott Ritter, BYU, for previously identifying conodonts in the Butterfield Peaks Formation at Lake Mountain. We also extend thanks to the late John Welsh who generously donated many years of unpublished geologic research on Permian-Pennsylvanian strata to the UGS. Utah Geological Survey (UGS) geologists Grant Willis and Robert Ressetar reviewed the map and associated materials. Kent Brown (UGS) set up the digital photogrammetry.

Map Symbols


Contact, dashed where approximately located, queried where uncertain

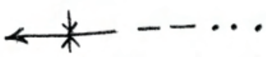

Normal fault, dashed where approximately located, dotted where concealed, dotted and queried where inferred; bar and ball on down-dropped side


Normal fault, concealed; inferred principally from gravity data (Floyd, 1993; Cook and others, 1997) and shallow sonar-like data (Brimhall and Merritt, 1981); very approximately located; bar and ball on down-dropped side


Thrust or reverse fault, dashed where approximately located, dotted where concealed; saw teeth on upper plate; query indicates uncertain presence

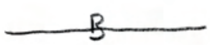

Tear fault, dotted where concealed; arrows show direction of relative offset

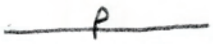

Axial trace of anticline, dashed where approximately located, dotted where concealed; arrow shows direction of plunge

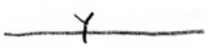

Axial trace of syncline, dashed where approximately located, dotted where concealed; arrow shows direction of plunge; syncline under Utah Lake after Brimhall and Merritt (1981)

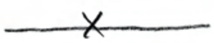

Axial trace of monocline, dotted where concealed; after Brimhall and Merritt (1981)

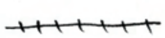
Lake Bonneville shorelines – Major shorelines of the Bonneville lake cycle. Mapped at the top of the wave-cut platform, dashed where approximately located


Highest shoreline of the Bonneville (transgressive) phase

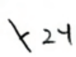

Highest shoreline of the Provo (regressive) phase


Other transgressive shorelines of the Bonneville phase (present above the Provo shoreline)

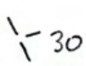

Other mostly regressive shorelines of the Provo phase (present below the Provo shoreline)


Crest of offshore bar


Landslide main scarp



Strike and dip of inclined bedding; green symbols indicate attitudes from BYU students



Approximate strike and dip of inclined bedding

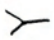
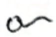
	Approximate strike and dip direction of inclined bedding
	Strike of vertical bedding
	Horizontal bedding
	Sand and gravel pit
	Quarry, cl = clay, p = pumice, no letter = crushed rock
	Prospect, cl = clay, c = calcite, no letter = metals or unknown
	Prospect trench, c = calcite, m = metals, no letter = clay
	Adit, c = calcite
	Spring
+ SP-3903	Rock sample location and number

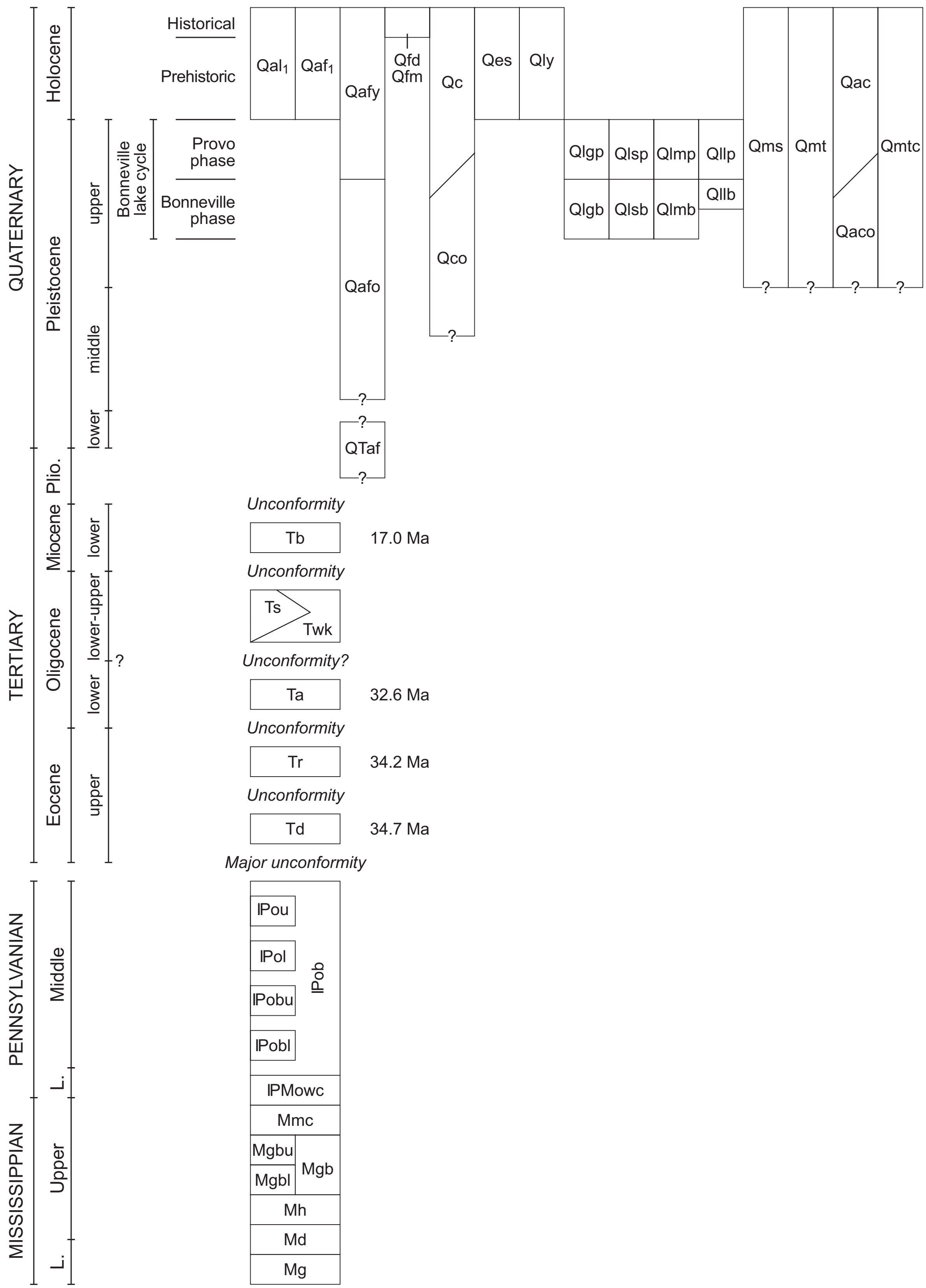
Table 1. Major and trace element analyses of volcanic rocks from the Soldiers Pass Quadrangle

Sample #	Map Unit	Rock Type	Rock Name	Latitude (N)	Longitude (W)	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Subtotal	LOI	Total
SP-5	Tb	lava flow	trachybasalt	40.18296	111.97442	46.05	2.59	15.90	12.47	0.14	3.95	9.80	3.13	2.10	0.51	96.63	1.89	98.52
SP-PB-95	Tb	lava flow	trachybasalt	40.16843	111.98270	48.02	2.73	16.20	12.24	0.14	4.55	7.87	3.29	2.32	0.78	98.13	1.79	99.92
SP-1303	Tb	lava flow	trachybasalt	40.15122	111.98023	48.44	2.71	16.13	11.99	0.16	4.39	7.93	3.44	2.34	0.71	98.23	1.32	99.55
SP-1403	Tb	lava flow	trachybasalt	40.16759	111.98297	47.89	2.68	16.76	12.15	0.14	2.48	8.71	3.38	2.36	0.72	97.28	1.83	99.11
SP-203	Tb	lava flow	trachybasalt	40.14549	111.98637	48.10	2.64	16.21	12.08	0.16	4.06	8.31	3.49	2.27	0.71	98.01	1.28	99.29
SP-3003	Tb	lava flow	trachybasalt	40.16849	111.98271	48.55	2.67	16.33	11.93	0.16	4.75	7.59	3.35	2.30	0.72	98.36	1.08	99.44
SP-3103	Tb	lava flow	trachybasalt	40.17209	111.98247	48.02	2.69	16.05	11.92	0.16	4.65	7.54	3.20	2.46	0.70	97.39	1.26	98.65
SP-3203	Tb	lava flow	trachybasalt	40.17540	111.97634	48.09	2.27	17.42	11.35	0.14	4.91	9.58	2.99	1.89	0.60	99.22	1.02	100.24
SP-3303	Tb	lava flow	trachybasalt	40.17759	111.97360	48.85	2.68	16.58	11.93	0.16	5.05	7.61	3.49	2.24	0.69	99.26	1.06	100.32
SP-3403-A	Tb	lava flow	trachybasalt	40.18424	111.97330	48.91	2.64	16.80	12.06	0.16	5.18	8.13	3.29	2.15	0.69	100.02	0.60	100.62
SP-4003	Tb	lava flow	trachybasalt	40.15062	111.98955	47.89	2.74	16.01	11.99	0.14	4.43	8.10	3.40	2.20	0.68	97.59	1.20	98.79
SP-3403	Ts	lava flow	shoshonite	40.14677	111.99395	51.29	1.37	14.86	9.65	0.12	3.73	10.23	3.28	2.32	0.50	97.35	-	97.35
SP-3503	Ts	lava flow	shoshonite	40.14690	111.99342	50.84	1.44	15.47	10.65	0.13	4.20	9.20	3.60	2.46	0.57	98.56	-	98.56
SP-3703	Ts	lava flow	shoshonite	40.14757	111.99435	52.19	1.62	15.28	9.33	0.10	3.00	9.41	3.57	2.55	0.52	97.58	3.03	100.61
SP-3803	Ts	lava flow	shoshonite	40.14815	111.99458	50.96	1.34	14.68	9.18	0.14	3.82	10.76	3.54	2.37	0.54	97.32	3.24	100.56
SP-3903	Ts	lava flow	shoshonite	40.15083	111.99655	50.21	1.36	14.54	9.52	0.12	3.59	10.15	3.15	2.31	0.46	95.40	3.20	98.60
SP-903-3	Ta	lava flow	andesite	40.15750	111.97230	54.70	0.98	14.48	7.81	0.12	4.11	8.63	3.22	2.29	0.34	96.68	2.63	99.31
SP-ATS-95	Ta	lava flow	andesite	40.15820	111.97107	56.20	1.02	14.99	8.14	0.13	4.41	7.82	3.46	2.44	0.35	98.94	1.50	100.44
SP-GDL-95	Ta	lava flow	andesite	40.15824	111.97106	55.71	1.03	14.98	8.01	0.15	4.38	7.78	3.49	2.39	0.35	98.28	1.63	99.91
SP-JB-95	Ta	lava flow	andesite	40.15826	111.97106	54.61	1.03	14.72	8.07	0.13	4.27	7.94	3.36	2.40	0.29	96.81	1.82	98.63
SP-4103	Ta	lava flow	andesite	40.15850	111.97190	56.44	1.05	15.26	8.30	0.12	4.08	7.07	3.50	2.40	0.40	98.62	1.38	100.00
SP-4303	Ta	lava flow	andesite	40.15742	111.97103	55.54	1.02	15.23	7.71	0.11	3.97	7.31	3.54	2.43	0.39	97.25	-	97.25
SP-403	Ta	lava flow	andesite	40.15853	111.97093	57.53	1.07	15.46	7.86	0.16	4.14	7.42	3.56	2.49	0.41	100.10	-	100.10
SP-4203	Ta	lava flow	andesite	40.15789	111.97078	56.20	1.03	15.06	8.18	0.15	4.48	7.88	3.52	2.40	0.39	99.27	1.26	100.53
SP-KM-95	Tr	ash-flow tuff	rhyolite	40.17569	111.95466	72.26	0.25	13.25	0.96	0.02	0.53	1.74	2.12	6.01	0.07	97.19	4.58	101.77
SP-603-A	Tr	ash-flow tuff	rhyolite	40.20338	111.97778	72.58	0.22	13.35	1.58	0.03	0.57	1.20	2.27	5.99	0.06	97.85	2.79	100.64
SP-803-A	Tr	ash-flow tuff	rhyolite	40.17485	111.95498	71.32	0.23	12.99	1.60	0.03	0.38	2.63	2.37	5.83	0.02	97.39	3.47	100.86
SP-490	Tr	ash-flow tuff	rhyolite	40.20456	111.97915	71.09	0.22	13.21	1.63	0.02	0.59	1.07	4.79	5.94	0.00	98.57	3.54	102.11
SP-SP1	Tr	ash-flow tuff	rhyolite	40.20439	111.97877	71.24	0.23	12.77	1.55	0.02	0.30	1.80	2.14	6.02	0.03	96.10	3.73	99.83
SP-103-A	Tr	pumice clast	rhyolite	40.14294	111.98414	72.59	0.23	13.15	1.69	0.03	0.48	1.57	2.21	6.15	0.05	98.14	2.76	100.90
SP-1203-B	Tr	pumice clast	rhyolite	40.15833	111.97417	72.04	0.15	12.84	1.10	0.06	0.48	2.00	2.16	6.20	0.05	97.07	3.25	100.32
SP-603B	Tr	pumice clast	trachydacite	40.15686	111.97667	68.72	0.24	13.75	1.40	0.05	0.35	2.11	2.96	6.64	0.09	96.31	4.75	101.06
SP-1005	Tr	pumice clast	trachydacite	40.17658	111.96550	64.76	0.31	14.14	1.27	0.05	0.56	3.61	3.01	5.80	0.15	93.66	6.35	100.01
SP-1703	Td	ash-flow tuff	trachydacite	40.15765	111.97958	62.95	0.83	16.77	4.00	0.06	1.16	4.24	2.85	4.64	0.20	97.71	2.14	99.85
SP-1803	Td	ash-flow tuff	trachydacite	40.15621	111.97524	63.56	0.73	15.81	3.83	0.06	1.20	4.20	2.75	4.54	0.17	96.84	2.79	99.63
SP-1903	Td	ash-flow tuff	trachydacite	40.15631	111.97585	63.82	0.80	17.05	3.19	0.05	1.06	4.21	2.87	4.68	0.18	97.92	2.27	100.19
SP-2003	Td	ash-flow tuff	trachydacite	40.15646	111.97629	63.51	0.80	16.89	4.03	0.06	1.04	4.17	2.85	4.65	0.18	98.17	2.26	100.43
SP-2103	Td	ash-flow tuff	trachydacite	40.15677	111.97680	64.37	0.78	16.80	3.61	0.06	1.07	4.03	2.92	4.77	0.20	98.60	2.22	100.82
SP-2203	Td	ash-flow tuff	trachydacite	40.17320	111.95648	62.72	0.84	16.62	3.89	0.05	1.01	3.98	2.82	4.51	0.19	96.63	3.24	99.87
SP-2403	Td	ash-flow tuff	trachydacite	40.17317	111.95404	65.08	0.74	16.34	3.78	0.05	1.02	3.90	3.02	4.60	0.18	98.69	1.86	100.55
SP-703	Td	ash-flow tuff	trachydacite	40.17380	111.95702	63.76	0.84	16.97	4.20	0.05	1.02	4.04	2.83	4.46	0.18	98.35	1.87	100.22

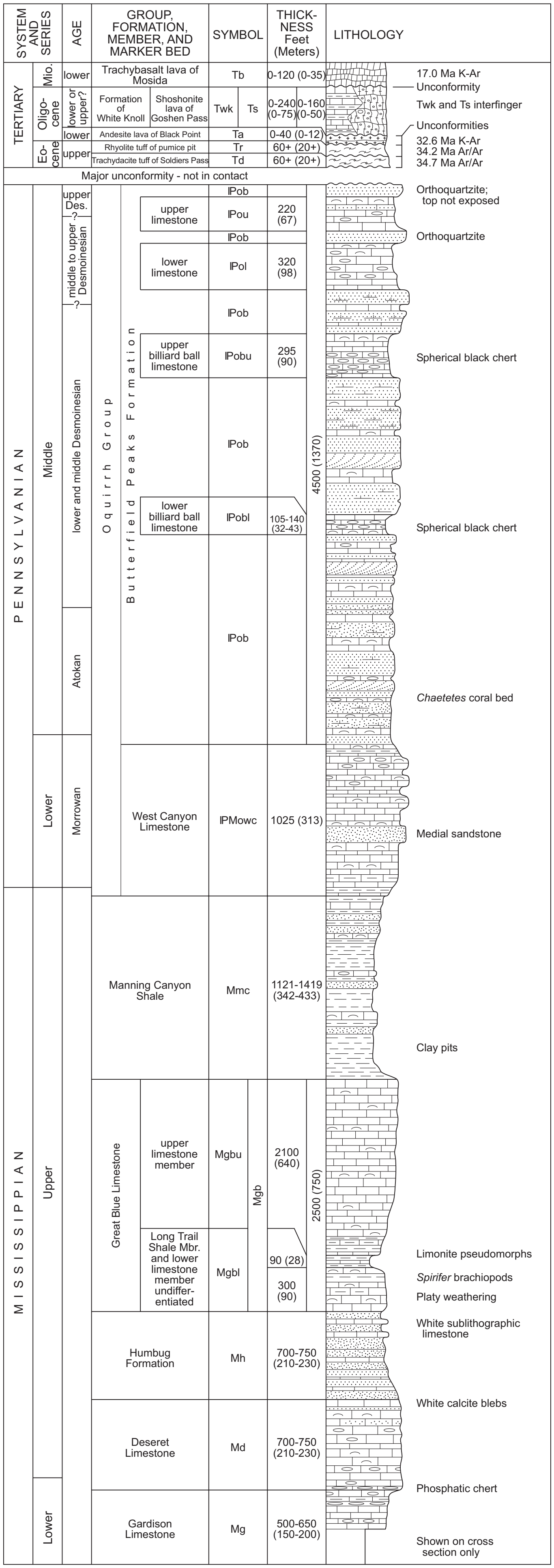
Notes:
Major oxides reported in weight percent and trace elements reported in parts per million (ppm) by X-ray fluorescence spectrometry.
Analyses by Brigham Young University, Department of Geological Sciences.
Sample location coordinates determined from topographic base map (NAD27).
Rock name using total alkali-silica diagram of LeBas and others (1986).
LOI is loss on ignition at 1000°C for 4 hours.

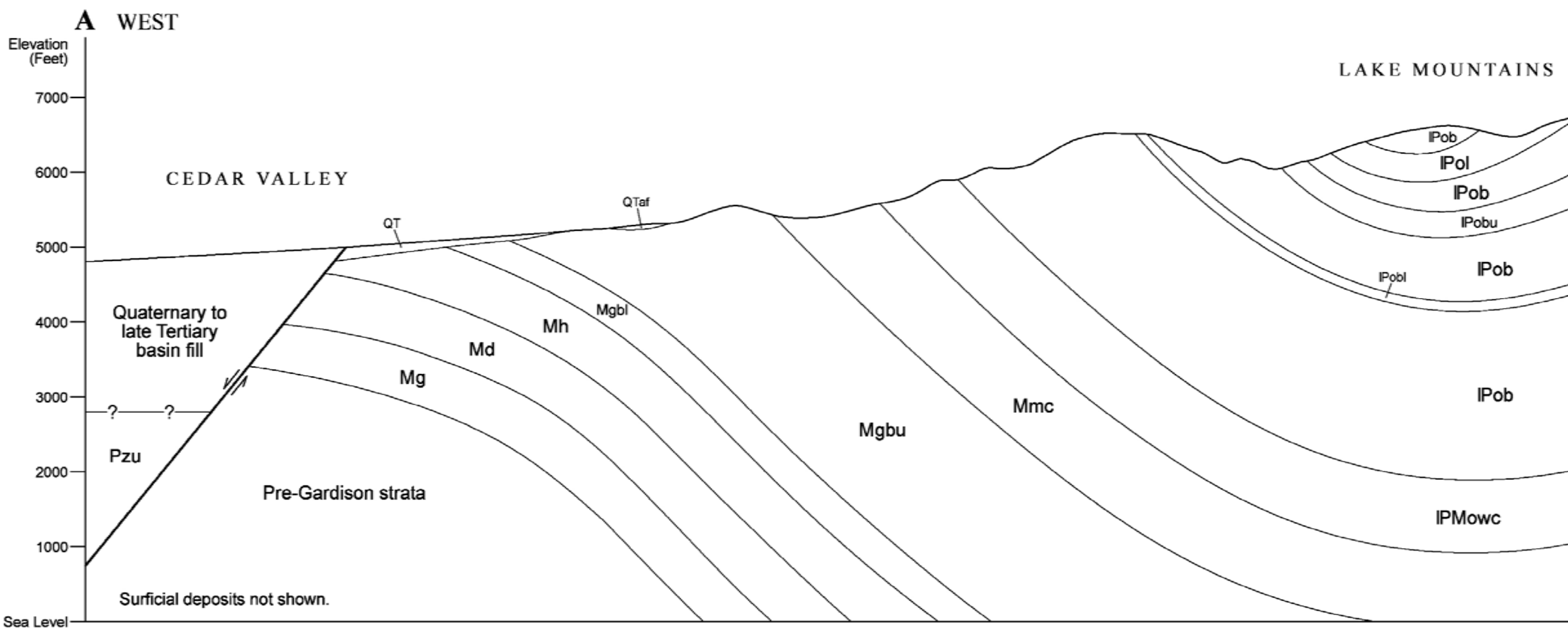
F	Cl	Sc	V	Cr	Ni	Cu	Zn	Ga	Rb	Sr	Y	Zr	Nb	Ba	La	Ce	Nd	Sm	Pb	Th	U
56	58	19	244	27	20	26	108	23	39	1061	24	242	40	1146	47	118	38	11	8	6	3
345	61	17	238	20	15	26	112	23	43	981	26	269	43	899	53	122	44	12	6	8	3
-	-	17	230	17	15	26	90	22	45	887	26	273	38	974	53	132	53	11	8	5	2
330	76	19	248	21	17	24	118	24	44	1018	25	267	43	878	54	124	42	14	6	8	4
-	-	16	201	17	16	28	77	22	43	934	25	253	36	1074	59	152	56	12	9	4	4
-	-	19	244	18	15	31	93	22	43	908	27	276	39	920	51	145	53	10	7	4	2
-	-	17	223	14	14	29	84	21	56	1114	26	279	37	924	49	139	54	12	7	4	4
-	-	21	250	51	32	31	89	22	36	1145	22	245	32	709	43	115	44	13	6	3	4
-	-	20	245	21	16	27	94	22	43	893	27	274	39	907	48	137	51	8	7	5	4
-	-	20	266	29	22	31	97	22	39	959	26	264	38	837	45	131	51	10	7	5	4
-	-	18	221	15	14	27	87	21	42	918	26	262	38	966	57	147	57	13	15	4	2
1290	-	20	264	215	68	33	89	20	54	908	26	226	12	1255	60	148	54	9	13	2	2
1317	-	21	172	256	67	32	79	21	49	922	25	243	12	1270	54	157	54	13	10	5	-
1485	-	21	222	195	47	34	88	20	62	931	26	225	12	1232	56	137	53	13	12	1	4
-	-	22	207	227	61	35	93	20	53	901	30	221	13	1203	62	149	55	13	10	4	2
6	104	19	276	214	73	29	100	21	52	1000	25	210	13	1171	51	117	41	12	14	6	3
-	-	23	167	200	48	37	84	20	59	884	19	219	11	1322	45	122	42	11	19	5	5
158	98	20	187	197	54	40	98	20	57	910	18	205	11	1214	36	92	33	9	12	5	3
103	76	22	182	196	55	31	86	20	56	903	18	207	11	1163	38	94	35	10	12	6	3
95	77	21	183	193	57	39	87	20	57	910	18	207	11	1159	39	97	36	10	11	6	3
-	-	23	177	194	52	42	81	20	59	881	18	233	11	1233	40	107	40	7	15	5	2
-	-	24	179	193	49	34	80	21	61	905	18	235	11	1212	48	118	44	10	17	6	2
-	-	21	175	189	51	31	82	19	60	886	18	229	11	1213	39	117	40	12	14	5	4
40	75	21	179	184	52	36	85	20	55	900	17	207	10	1147	38	94	36	9	13	6	3
730	185	-	19	6	2	2	23	14	245	214	22	161	16	981	49	90	35	5	29	23	8
513	50	-	13	3	3	3	32	14	232	360	22	168	15	1090	58	133	29	8	29	20	8
650	9	-	17	3	3	-	26	14	239	237	17	147	14	1047	49	112	33	5	29	20	9
302	188	-	21	3	2	5	34	14	238	218	21	164	16	1039	59	98	37	6	31	24	8
245	172	-	19	5	-	-	28	14	248	207	22	150	15	1014	53	85	32	6	30	23	8
530	575	-	23	5	2	2	28	14	241	211	20	157	16	953	51	104	34	6	29	22	8
57	187	-	13	1	1	1	17	14	250	161	16	120	14	674	44	95	30	4	29	22	10
196	9674	-	18	-	1	4	36	13	217	290	18	224	15	2191	71	166	44	7	37	22	8
595	6541	-	8	1	-	6	30	13	221	505	28	287	14	2859	65	98	39	8	34	16	6
1433	77	16	60	5	3	5	60	20	153	687	32	347	15	1573	68	134	56	15	19	12	7
1100	27	13	54	7	5	7	58	19	151	630	32	335	15	1390	69	144	55	12	19	14	6
1307	67	13	52	4	4	6	58	19	156	646	34	352	15	1474	71	152	60	16	20	14	6
1507	94	15	64	6	4	7	58	20	150	691	34	356	15	1550	65	152	58	14	19	13	6
1244	180	14	61	8	2	6	58	20	154	765	36	353	16	3003	60	114	48	10	19	14	6
2113	79	15	70	6	6	6	67	21	152	676	33	343	15	1780	64	135	54	13	20	14	7
1264	102	12	53	5	4	6	55	19	157	638	34	340	15	1618	66	151	58	14	22	14	7
1873	44	16	67	6	6	7	68	20	152	660	33	342	15	1640	68	139	57	13	19	12	5

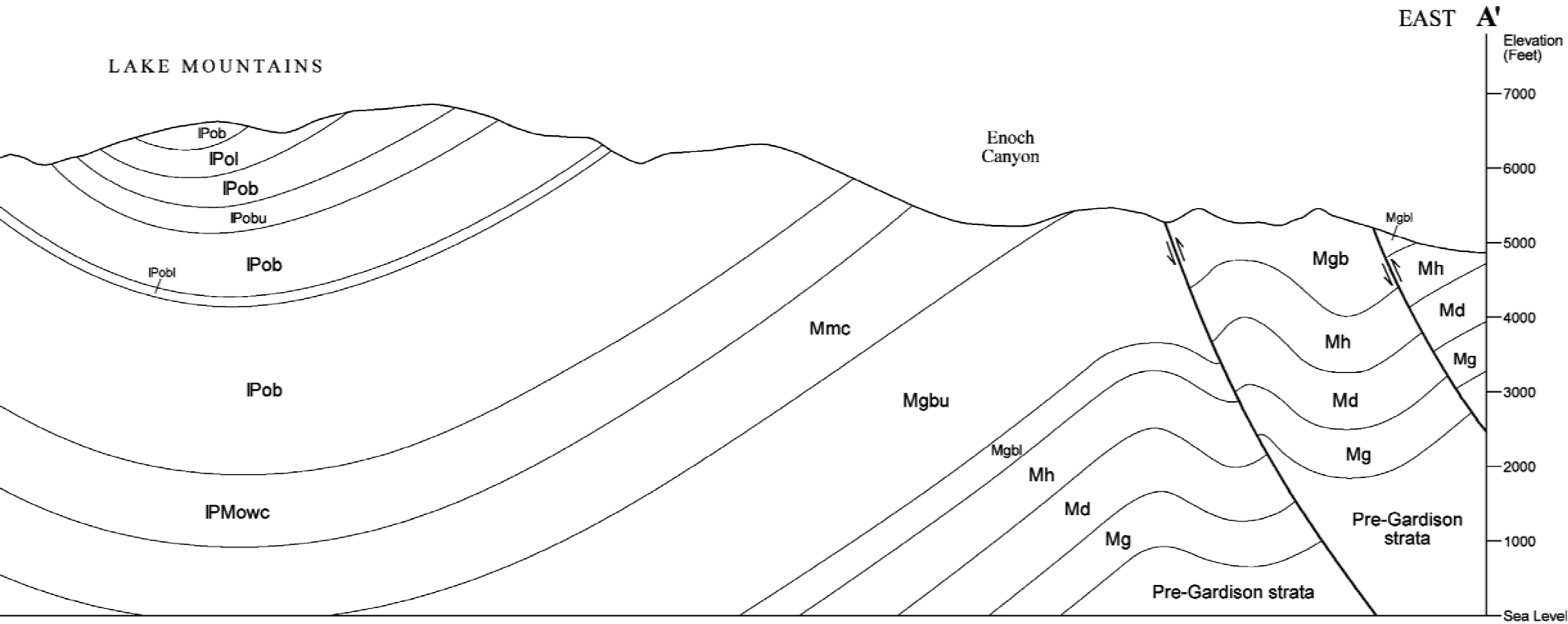
CORRELATION OF MAP UNITS



SOLDIERS PASS LITHOLOGIC COLUMN

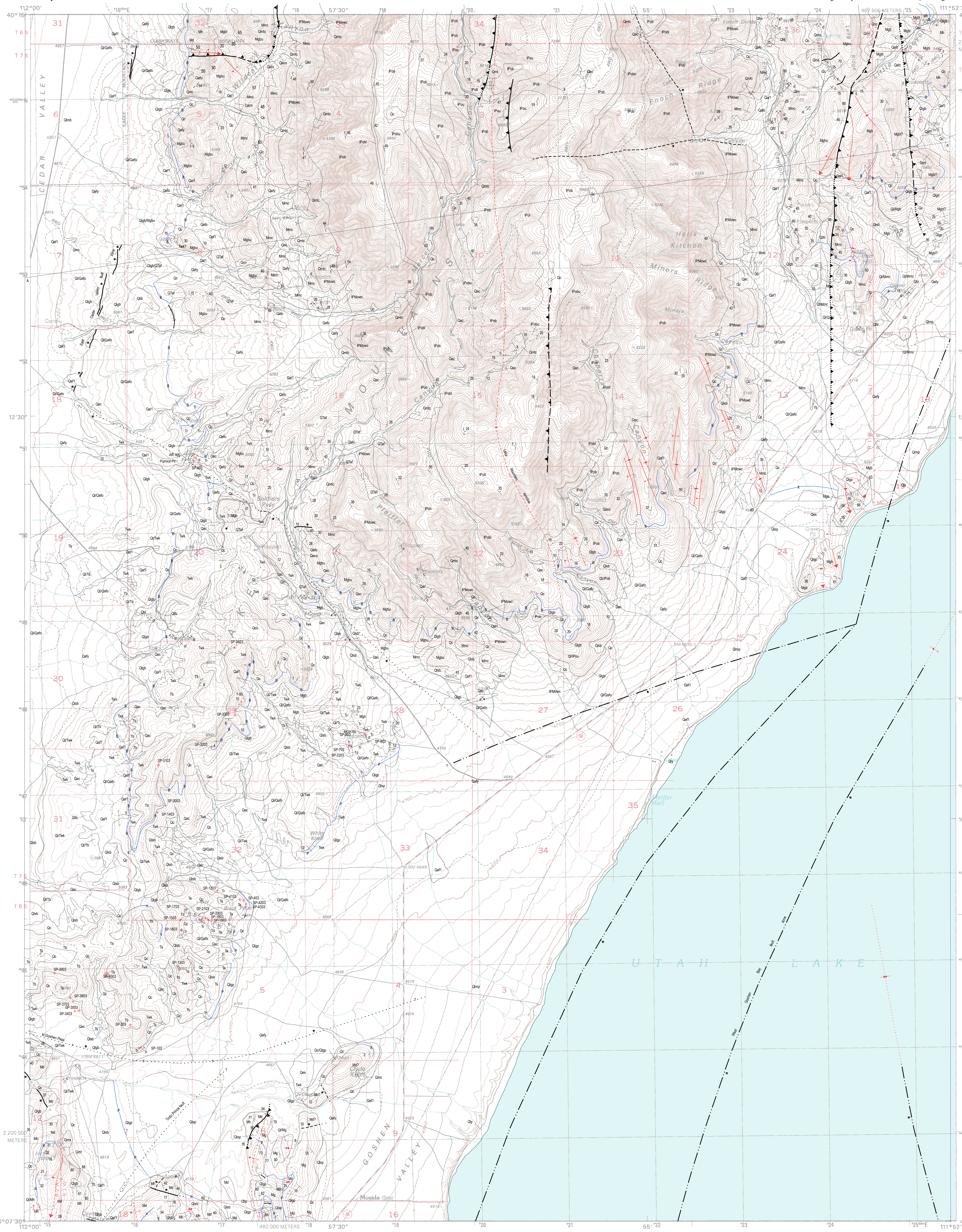



A WEST
Elevation (Feet)
7000
6000
5000
4000
3000
2000
1000
Sea Level
CEDAR VALLEY
LAKE MOUNTAINS
QT
QTaf
Quaternary to late Tertiary basin fill
Pzu
Pre-Gardison strata
Mg
Md
Mh
Mgbl
Mgbu
Mmc
IPob
IPol
IPob
IPobu
IPob
IPobl
IPob
IPMowc
Surficial deposits not shown.


EAST A'
Elevation (Feet)
7000
6000
5000
4000
3000
2000
1000
Sea Level
LAKE MOUNTAINS
IPob
IPol
IPob
IPobu
IPob
IPobl
IPob
IPMowc
Mmc
Enoch Canyon
Mgbu
Mgbl
Mh
Md
Mg
Pre-Gardison strata
Mgb
Mh
Md
Mg
Pre-Gardison strata
Mgbl
Mh
Md
Mg

Utah Geological Survey
a division of
Utah Department of Natural Resources

Plate 1
Utah Geological Survey Open-File Report 484
Interim Geologic Map of the Soldiers Pass Quadrangle



Base from U.S. Geological Survey,
Soldiers Pass Quadrangle, 1997

1:24,000

1 0.5 0 1 2 Miles

Field mapping by authors: 2006
Digital photogrammetry:
Robert F. Biek, Donald L. Clark, and Kent D. Brown

This geology was originally mapped using a USGS topographic base map published in 1993 that conforms to the North American Datum of 1927 (NAD 27). At the time of this printing an updated base map printed in 1997 that conforms to NAD 83 was substituted. The geology remains in NAD 27 to conform to adjoining geologic maps. As a result, the boundaries of the geology and the base map are slightly different, creating the narrow strip near the map edges. However, the geology is accurately shown relative to topographic features on the base map.

Interim Geologic Map of the Soldiers Pass Quadrangle, Utah County, Utah

by
Robert F. Biek[1], Donald L. Clark[1], and Eric H. Christiansen[2]
2006

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