UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources

Plate 1
Utah Geological Survey Map 208
Geologic Map of the Jordan Narrows Quadrangle

Base map from U.S. Geological Survey
Jordan Narrows 7.5' quadrangle, 1999

This geologic map was funded by the Utah Geological Survey and the U.S. Geological Survey, National Cooperative Geologic Mapping Program, through USGS STATEMAP award number 02HQAG0055.

The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

Although this product represents the work of professional scientists, the Utah Department of Natural Resources, Utah Geological Survey, makes no warranty, express or implied, regarding its suitability for a particular use. The Utah Department of Natural Resources, Utah Geological Survey, shall not be liable under any circumstances for any direct, indirect, special, incidental, or consequential damages, with respect to claims by users of this product.

SCALE 1 : 24,000

1 1/2 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

13.14°
233 mils
2005 MAGNETIC DECLINATION
AT CENTER OF SHEET

UTAH
QUADRANGLE LOCATION

1	2	3
4		5
6	7	8

1 Copperton
2 Midvale
3 Draper
4 Tickville Springs
5 Lehi
6 Cedar Fort
7 Saratoga Springs
8 Pelican Point

ADJOINING 7.5' QUADRANGLE NAMES

The topographic base map appears shifted because the newer base map, published in 1999 using the North American Datum of 1983 (NAD 83), was used to show recently developed areas. The geology is projected in NAD 27 to conform to adjoining geologic maps.

Project Manager, Grant Willis
Field mapping by author, 2002-2003
Cartographers, Lori J. Douglas and Kent D. Brown

ISBN 1-55791-720-5

GEOLOGIC MAP OF THE JORDAN NARROWS QUADRANGLE, SALT LAKE AND UTAH COUNTIES, UTAH

by

Robert F. Biek

2005

UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources

MAP UNIT DESCRIPTIONS

QUATERNARY

Alluvial deposits

Qal$_1$ Stream deposits (Holocene) – *Moderately to well-sorted sand, silt, clay, and pebble to boulder gravel in river channels and flood plains; locally includes small alluvial-fan and colluvial deposits, and minor terraces up to 10 feet (3 m) above current base level; mapped along the Jordan River north of Jordan Narrows; probably less than 30 feet (9 m) thick.*

Qat$_{2-7}$ Stream-terrace deposits (Holocene to Upper Pleistocene) – *Moderately to well-sorted sand, silt, clay, and pebble to boulder gravel that forms level to gently sloping terraces incised by modern streams; subscript denotes height above modern stream channels; level 2 deposits are 10 to 30 feet (3-9 m), level 3 deposits are 30 to 75 feet (9-20 m), level 4 deposits are 75 to 100 feet (20-30 m), level 5 deposits are 100 to 140 feet (30-40 m), level 6 deposits are 140 to 160 feet (40-50 m), and level 7 deposits are greater than 160 feet (50 m) above modern drainages; deposited in river channels and flood plains; may include older lacustrine and alluvial sediment below a veneer of terrace deposits along the Jordan River north of Jordan Narrows; older (higher level) terraces may include loess veneer; generally 0 to 20 feet (0-6 m) thick.*

Qaly Young alluvial deposits (Holocene to Upper Pleistocene) – *Moderately sorted sand, silt, clay, and pebble to boulder gravel deposited in river channels and flood plains; incised by active stream channels, and locally include small alluvial-fan and colluvial deposits; equivalent to modern stream deposits (Qal$_1$) and older, post-Bonneville stream deposits that are undifferentiated because units are complexly overlapping; probably less than 20 feet (6 m) thick.*

Qaf$_1$ Modern alluvial-fan deposits (Holocene) – *Poorly to moderately sorted, weakly to non-stratified, clay- to boulder-size sediment deposited principally by debris flows 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; generally less than 30 feet (9 m) thick.*

Qaf$_2$ Level 2 alluvial-fan deposits (Holocene to Upper Pleistocene) – *Poorly to moderately sorted, clay- to boulder-size sediment deposited principally by debris flows; incised by modern alluvial-fan and alluvial deposits; forms moderately dissected surfaces equivalent to the lower part of Qafy; probably less than 30 feet (9 m) thick.*

Qaf$_3$ Level 3 alluvial-fan deposits (Upper Pleistocene) – *Poorly to moderately sorted, clay- to boulder-size sediment deposited principally by debris flows; covers the Bonneville shoreline and is incised by younger undifferentiated alluvial deposits; forms deeply dissected surface at the west end of Steep Mountain; probably less than 40 feet (12 m) thick.*

Qafy Younger undifferentiated alluvial-fan deposits (Holocene to Upper Pleistocene) – *Poorly to moderately sorted, weakly to non-stratified, clay- to boulder-size sediment deposited principally by debris flows, debris floods, and streams; equivalent to modern (Qaf$_1$), level-2 alluvial-fan deposits (Qaf$_2$), and level-3 alluvial-fan deposits (Qaf$_3$), but undifferentiated because units are complexly overlapping or too small to show separately; commonly obscures Lake Bonneville shorelines; upper parts of fans are locally deeply incised; thickness unknown, but likely up to several tens of feet.*

Qafo Older alluvial-fan deposits (Upper Pleistocene) – *Similar to younger 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 likely up to several tens of feet.*

Artificial deposits

Qf Artificial fill (Historical) – *Engineered fill used in the construction of Interstate 15 and other road and railroad beds; although only larger fill deposits are shown, fill of variable composition may be present in any developed area; variable thickness up to about 60 feet (20 m).*

Qfm Mine-dump deposits (Historical) – *Waste rock and overburden from clay quarries in the Beverly Hills; variable thickness up to several tens of feet.*

Qfl Landfill deposits (Historical) – *Miscellaneous fill, principally building and road construction debris, placed in sand and gravel or aggregate pits; variable thickness up to several tens of feet.*

Qfd Disturbed land (Historical) – *Land disturbed by sand and gravel and aggregate operations; only the larger operations are mapped and their outlines are based on aerial photographs taken in May 2002; land within these areas contains a complex, rapidly changing mix of cuts and fills as well as excellent exposures of Bonneville and pre-Bonneville sediments and Paleozoic bedrock.*

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 most bedrock is covered by at least a veneer of colluvium, only the larger, thicker deposits are mapped; 0 to about 20 feet (0-6 m) thick.*

Qco Older colluvial deposits (Upper Pleistocene) – *A single deposit of moderately sorted, angular, mostly small pebble-size orthoquartzite clasts is present in the SW1/4 section 13, T. 4 S., R. 1 W. near Point of the Mountain; deposited as a colluvial wedge against a fault scarp in Oquirrh orthoquartzite and truncated by gravels associated with the Bonneville highstand; bedding of colluvial wedge strikes N. 35° E. and dips 25° NW., and the fault strikes N. 50° E. and dips 75° NW.; exposed thickness of colluvial wedge is about 15 feet (5 m). Older colluvial deposits are also mapped in the upper reaches of Beef Hollow where the deposits conceal the Beef Hollow thrust and grade downslope into older alluvial-fan deposits.*

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." Deposits mapped below the Provo shoreline that are undivided by phase use both "b" and "p."

Qlgp, Qlgbp, Qlgb Lacustrine gravel and sand deposits (Upper Pleistocene) – *Moderately to well-sorted, moderately to well-rounded, clast-supported, pebble to cobble gravel and pebbly sand; thin to thick bedded; typically interbedded with or laterally gradational to sand and silt facies; gastropods locally common in sandy lenses; locally partly cemented with calcium carbonate; typically forms well-developed wave-cut or wave-built benches, bars, and spits, including the classic spit at Point of the Mountain; elsewhere forms veneer that drapes over pre-existing topography; some shoreline deposits characterized by abundant subangular boulders derived from nearby slopes; intermediate shorelines are locally well developed on these units; Qlgb deposited at and below highest Bonneville shoreline but above the Provo shoreline, and Qlgp deposited at and below the Provo shoreline; Qlgbp denotes deposits near Jordan Narrows that likely contain both transgressive (Bonneville) and regressive (Provo) lacustrine sand and lesser gravel; Qlgp deposits north of Steep Mountain commonly form a veneer 1 to 10 feet (0.3-3 m) thick over highly fractured orthoquartzite; 0 to about 300 feet (0-90 m) thick.*

Qlsp, Qlsbp, Qlsb Lacustrine sand and silt deposits (Upper Pleistocene) – *Fine- to coarse-grained lacustrine sand and silt with minor gravel; typically thick bedded and well sorted; gastropods locally common; grades downslope from sandy nearshore deposits to finer grained offshore deposits; locally concealed by loess veneer; intermediate shorelines typically poorly developed on this facies; Qlsb deposited at and below highest Bonneville shoreline but above the Provo shoreline, and Qlsp deposited at and below the Provo shoreline; Qlsbp denotes deposits north of Jordan Narrows that likely contain both transgressive (Bonneville) and regressive (Provo) sediments; exposed thickness less than 40 feet (12 m).*

Qlmp, Qlmbp, Qlmb Lacustrine silt and clay deposits (Upper Pleistocene) – *Calcareous silt (marl) with minor clay and fine-grained sand; typically laminated but weathers to appear thick bedded; locally concealed by loess veneer; Qlmb deposited below Bonneville shoreline and Qlmp deposited below the Provo shoreline; Qlmbp denotes deposits north of Jordan Narrows that lack shorelines and likely contain both transgressive (Bonneville) and regressive (Provo) sediments; Qlmb is inferred to be exposed in cutbanks along the Jordan River south of Jordan Narrows (see, for example, Machette, 1992); grades upslope into lacustrine sand and silt; exposed thickness less than about 40 feet (12 m).*

Qlu Lacustrine deposits, undivided (Upper Pleistocene) – *Mapped in the vicinity of Jordan Narrows where it is difficult to differentiate lacustrine gravel, sand, silt, and minor clay; includes both transgressive (Bonneville) and regressive (Provo) sediments; exposed thickness less than about 40 feet (12 m).*

Qll Lagoon-fill deposits (Upper Pleistocene) – *Forms level, grass-covered field behind Bonneville barrier bar southwest of Bluffdale; not exposed, but likely consists of thick-bedded silt with minor fine-grained sand and few small pebbles washed in from adjacent slopes; may be capped by loess; 0 to about 20 feet (0-6 m) thick.*

Mass-movement deposits

Qmsh, Qmsy Landslide deposits (Historical to Upper Pleistocene) – *Very poorly sorted, clay- to boulder-size, locally derived material deposited by rotational and translational movement; characterized by hummocky topography, numerous internal scarps, and chaotic bedding attitudes; basal slip surfaces most commonly form in Holocene to Upper Pleistocene alluvial and lacustrine deposits; Qmsh denotes a small historical landslide at Jordan Narrows, and a 2003 landslide that involved failure of railroad fill near the entrance to Beef Hollow; two small landslides (Qmsy) at Jordan Narrows and west of clay quarries in the southwest quarter of the quadrangle are characterized by slightly to moderately subdued landslide features indicative of early Holocene to Late Pleistocene age; older landslides (Qmso) are not recognized in this quadrangle, but are mapped in the adjacent Lehi quadrangle (Biek, 2005); up to a few tens of feet thick. The northwest-facing slope of Steep Mountain is covered by colluvium that, in low light, shows evidence of creep as wavy, subhorizontal ridges and swales (shown by a hachure pattern on plate 1).*

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; locally grades downslope into colluvial deposits, and may include colluvial deposits where impractical to differentiate the two; 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, small drainages, and the upper reaches of larger ephemeral streams by fluvial, slope wash, and creep processes; generally less than 30 feet (9 m) thick.*

Qesc Eolian sand and colluvial deposits (Holocene to Upper Pleistocene) – *Well-sorted, fine- to medium-grained eolian sand mixed with colluvium derived from adjacent Oquirrh slopes; sand likely derived from Bonneville sediment at the base of Steep Mountain and deposited by northwest winds on the lee side of the mountain; 0 to about 10 feet (0-3 m) thick.*

Qlay, Qlao Lacustrine and alluvial deposits (Holocene to Upper Pleistocene) – *Younger (Qlay) deposits consist of moderately to well-sorted, fine-grained sand, silt, and clay adjacent to the Jordan River that postdate the Bonneville lake cycle; older (Qlao) deposits in Jordan Narrows are interbedded lacustrine sand and gravel and alluvial sandy gravel that may record complex shoreline fluctuations during the early part of the Bonneville lake cycle; exposed thickness up to about 90 feet (30 m).*

Qlag Lacustrine and alluvial coarse-grained deposits (Pleistocene) – *Poorly to moderately sorted, clay- to boulder-size sediment deposited principally by debris flows and streams, locally overlain by moderately to well-sorted, moderately to well-rounded, clast-supported, pebble to cobble gravel and lesser pebbly sand of the Bonneville lake cycle; typically exhibit well-developed shorelines; mapped in the Beverly Hills area where it is impractical to differentiate alluvial-fan, alluvial, and nearshore lacustrine deposits; 0 to about 60 feet (0-18 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 principally by rock fall and slope wash at the base of steep washes in the west Traverse Mountains; includes minor alluvial sediment at the bottom of the washes; generally less than 30 feet (9 m) thick.*

Stacked-unit deposits

Qlsb/Qafo, Qlgb/Qafo, Qlsp/Qafo, Qlu/Qafo Lacustrine deposits over older alluvial-fan deposits (Upper Pleistocene) – *Older alluvial-fan deposits planated by wave action and partly concealed by a discontinuous veneer of lacustrine deposits; where lacustrine deposits are thin or absent, fan surfaces are commonly covered by a lag of angular to subangular boulders; closely spaced, well-preserved shorelines are common on the upper parts of the fans, but are less well developed lower on the fans where lacustrine deposits tend to be finer grained and thicker; locally, as in sections 18, 27, and 28, T. 4 S., R. 1 W., characterized by lag of subangular boulders of Oquirrh orthoquartzite with minor lacustrine gravel and sand; Qlu denotes lacustrine sediments that grade downslope from coarse-grained to fine-grained deposits.*

Qlgb/₽obm(?) Lacustrine gravel and sand over Bingham Mine Formation(?) (Upper Pleistocene/Pennsylvanian) – *Discontinuous veneer of Bonneville-level gravel and sand that partly conceals orthoquartzite of the Bingham Mine Formation(?); mapped east-southeast of Jordan Narrows.*

Qlgb/Tvy, Qlsb/Tvy, Qlsp/Tvy, Qlu/Tvy, Qlgb/Tvby Lacustrine deposits over volcanic rocks of the west Traverse Mountains (Upper Pleistocene/Oligocene) – *Volcanic rocks of the west Traverse Mountains planated by wave action and partly concealed by a discontinuous veneer of lacustrine deposits; Qlu denotes lacustrine sediments that grade downslope from coarse-grained to fine-grained deposits; where lacustrine deposits are thin or absent, fan surfaces are commonly covered by a lag of angular to subangular volcanic boulders; closely spaced, well-preserved shorelines are common; surficial deposits are generally a few feet to about 10 feet (1-3 m) thick.*

Qlsp/Mgb Lacustrine sand and silt of the Provo phase of Lake Bonneville over Great Blue Limestone (Upper Pleistocene/Upper Mississippian) – *Mapped below the Provo shoreline at the northeast side of the Beverly Hills, where foundation excavations revealed a pediment-like bench eroded into the Great Blue Limestone that is concealed by about 3 to 20 feet (1-6 m) of lacustrine sand and silt.*

Qlag/Mmc Mixed lacustrine and alluvial coarse-grained deposits over Manning Canyon Shale (Pleistocene/Upper Mississippian) – *Older alluvial-fan and alluvial deposits overlain by a veneer of lacustrine sand and gravel that collectively conceal Manning Canyon Shale at the north end of the Beverly Hills; surficial deposits vary from a few feet to about 30 feet (1-10 m) thick.*

Qlag/Mgb Lacustrine and alluvial deposits over Great Blue Limestone (Pleistocene/Upper Mississippian) – *Mapped in the Beverly Hills, which are cored by the Great Blue Limestone and locally by the Humbug Formation; closely spaced, well-preserved wave-cut terraces are present on these hills in the adjacent Saratoga Springs quadrangle (Biek, 2004); in the Jordan Narrows quadrangle the hills are mantled by poorly sorted, subangular to subrounded cobbles and boulders of orthoquartzite and minor limestone (Qlag) that probably represent the remnants of old alluvial-fan deposits, possibly of late Tertiary age, partly reworked by Lake Bonneville; thickness of surficial deposits uncertain, but likely less than about 20 feet (6 m) in the Jordan Narrows quadrangle.*

unconformity

QUATERNARY-TERTIARY

QTst Spring deposits (Pleistocene to late Pliocene) – *White to very light gray calcareous tufa and travertine in laminated, typically very thick beds; locally porous and vuggy (tufa), and locally dense (travertine); forms shelf-like deposits just below Bonneville shoreline near Jordan Narrows and is partly covered by lake deposits; varies from a few feet to at least 30 feet (1-10 m) thick. Large deposit north of Beef Hollow has manganese oxides as very dark brown to black irregular veins and masses that fill fractures, bedding planes, and vugs in the travertine; travertine varies greatly in strike, and dips vary from 0 to about 50 degrees, suggestive of initial dips around a series of closely spaced springs; Marsell (1932) reported that travertine was quarried for use by local sugar beet companies, and Crittenden (1951) reported a grade of 12 to 25% manganese for about 200 tons of ore shipped to the Columbia (Geneva) Steel Company; Marsell (1932) reported the gastropods* Planorbis *and* Lymnaea, *and partial jaw bones of a camel and horse from the travertine; Marsell (1932) assigned an early Pleistocene age to the fossils, but Slentz (1955) reported a revised late Pliocene (Blancan) age for the fossil horse; the upper age for the deposits is unknown.*

unconformity

TERTIARY

Salt Lake Formation (Pliocene to Miocene)
Divided into two units following Slentz (1955).

Tslc Camp Williams unit – *Light-brown to reddish-brown mudstone, siltstone, and lesser fine-grained sandstone and pebble conglomerate; includes basal conglomerate about 15 feet (5 m) thick; clasts are roughly 60 to 70% Oquirrh orthoquartzite and 30 to 40% Traverse Mountain volcanics; rare green quartzite and Paleozoic limestone clasts are also present; may unconformably overlie the Jordan Narrows unit with a subtle angular discordance of about 5°; includes strata that Slentz (1955) assigned to the Harkers fanglomerate; probably deposited in fluvial and flood-plain environments; exposed thickness about 450 feet (135 m).*

Tslj Jordan Narrows unit – *White to light-gray tuffaceous marlstone and micrite, lesser limestone that is locally cherty or oolitic, and minor claystone, sandstone, and rhyolitic tuff; typically blocky weathering and poorly exposed; manganese-oxide stains are common on fractures and bedding planes; includes at least two white, very fine to fine-grained volcanic ash (tuff) beds each about 6 feet (2 m) thick composed almost entirely of glass shards; tuff beds are structureless except for planar laminations in upper part that suggest minor fluvial reworking; includes reddish-brown-weathering, light-brown, medium- to thick-bedded, locally nodular weathering, silty and very fine grained, sandy, tuffaceous limestone and light-brown, very fine to fine-grained tuffaceous sandstone in the middle part near State Highway 68; probably deposited principally in a lacustrine environment; Naeser and others (1983) reported a fission-track age of 6.5 ± 0.5 Ma for a rhyolitic tuff at Jordan Narrows; exposed thickness likely at least 1500 feet (500 m).*

unconformity

Taf Alluvial-fan deposits (Miocene[?] to Oligocene[?]) – *Unconsolidated, pebble- to boulder-size, subangular to subrounded orthoquartzite, calcareous sandstone, limestone, and volcanic clasts; unconformably overlies the volcanic rocks of the west Traverse Mountains southwest of Jordan Narrows and appears to lack tuffaceous sediments and so is likely older than the Salt Lake Formation; likely correlative with Taf deposits in the Lehi quadrangle (Biek, 2005); age poorly constrained between middle Oligocene(?) and Miocene(?); about 200 feet (60 m) thick.*

unconformity

Volcanic and intrusive rocks of the west Traverse Mountains

Part of the younger volcanic suite (about 33 to 31 million years old) of Waite (1996; see also Waite and others, 1997) and also described by Moore (1973a, b, and c); probably derived from volcanic centers in the west Traverse Mountains, including the Step Mountain andesite plug, South Mountain vent area, and nearby smaller vents, and possibly by one or more vents now concealed under Salt Lake Valley.

Tdi Dacite dike (Oligocene) – *Medium-gray, medium- to coarse-grained dacite with common euhedral biotite; mapped in NE1/4 section 18, T. 4 S., R. 1 W.; forms dike-like body that is probably in fault contact with Oquirrh Group strata; dikes of similar composition are present in the adjacent Tickville Spring quadrangle (Biek and others, 2004); exposure is less than about 30 feet (10 m) wide.*

Tvfy Volcanic lava flows (Oligocene) – *Dark-gray to pinkish-gray porphyritic dacite to trachydacite with conspicuous 0.04- to 0.12-inch (1-3 mm) plagioclase phenocrysts and rare to common euhedral biotite and hornblende; flow banding, created by thin, alternating dark-gray to black and pale-reddish-brown to grayish-red layers, is prominent in some flows; weathers to boulder-covered slopes; mapped only northwest of Beverly Hills although similar flows are present in undifferentiated volcanic rocks elsewhere in the quadrangle; up to about 60 feet (20 m) thick.*

Tvby Volcanic block and ash-flow tuff (Oligocene) – *White to light-gray or locally pink, typically massive, coarse-grained dacitic to andesitic crystal tuff with subangular to subrounded, pebble- to boulder-size volcanic clasts; matrix contains abundant feldspar and euhedral biotite, and variable amounts of sand- to pebble-size volcanic fragments; contains uncommon quartzite pebbles in stratigraphically lowest deposits; typically matrix supported; clast size appears to increase upsection; locally shows bedding indicative of laharic or mudflow deposition; volcanic clasts are dark-gray or reddish-gray, porphyritic biotite dacite and andesite with abundant feldspar phenocrysts; other clasts locally include abundant, non-welded, tuffaceous clasts that weather to a brown, pitted surface but otherwise look similar to and are more resistant than matrix; forms poorly exposed slopes covered by lag of resistant volcanic clasts; the best exposures are in the NW1/4NW1/4SE1/4 section 4 and the south-central part of section 7, T. 5 S., R. 1 W., and in the SE1/4NW1/4SW1/4 section 29, T. 4 S., R. 1 W.; biotite from dacitic tuff from near the base of the section (sample JN22703-1) yielded an $^{40}Ar/^{39}Ar$ plateau age of 31.68 ± 0.24 Ma; Deino and Keith (1997) reported an $^{40}Ar/^{39}Ar$ plateau age on plagioclase (their sample Tick 28) of 32.12 ± 0.14 Ma from a dacite block and ash-flow tuff near the base of the section near the head of Oak Hollow in the adjacent Tickville Spring quadrangle; at least 300 feet (100 m) thick in the Jordan Narrows quadrangle, but likely exceeds 1000 feet (300 m) thick in the Tickville Spring quadrangle (Biek and others, 2004).*

Tvy Volcanic rocks of the west Traverse Mountains, undivided (Oligocene) – *Consists of block and ash-flow tuff, volcanic mudflow breccia, minor lava flows, and minor fluvial volcaniclastic deposits that are impractical to map separately throughout most of the quadrangle due to poor exposures; classified as borderline dacite, andesite, and trachyte on the TAS diagram of LeBas and others (1986) (see table 1 for analytical data); flows appear to be more common in the upper part of the section; block and ash-flow tuffs are typically gray, brownish-gray, or pinkish-gray, massive, coarse-grained crystal lithic tuff with sparse to abundant volcanic clasts up to 6 feet (2 m) or more in diameter; tuff matrix contains abundant sand- to pebble-size volcanic fragments, small feldspar crystals, and typically uncommon euhedral biotite and hornblende; volcanic mudflow breccia composed of subangular to subrounded pebbles to large boulders of gray, porphyritic volcanic clasts is well exposed in Wood Hollow; Oligocene age based on map relationships with adjacent Tickville Spring quadrangle; at least 1000 feet (330 m) thick.*

unconformity

PENNSYLVANIAN and MISSISSIPPIAN

Oquirrh Group (Upper Pennsylvanian to Upper Mississippian) – *Principally calcareous sandstone, orthoquartzite, sandy limestone, and limestone in the west Traverse Mountains; almost entirely orthoquartzite and calcareous sandstone with minor sandy or locally cherty limestone in the east Traverse Mountains; typically highly fractured, intensely brecciated, or locally pulverized in the east Traverse Mountains; divided into, in ascending order, the West Canyon Limestone, Butterfield Peaks Formation, and the Bingham Mine Formation; believed to be part of the Bingham sequence of Tooker and Roberts (1970); best exposed along or just below ridge crests, but 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) and Davis and others (1994); total thickness in the Jordan Narrows quadrangle is unknown, but the group is in excess of 17,800 feet (5400 m) thick in the Oquirrh Mountains (Tooker and Roberts, 1970) and about 25,000 feet (7600 m) thick near Mt. Timpanogos (Baker, 1964).*

₽obm, ₽obm(?) Bingham Mine Formation (Upper Pennsylvanian) – *In the west Traverse Mountains consists of interbedded, brown-weathering, fine-grained orthoquartzite and calcareous sandstone, medium-gray, fine-grained sandy limestone, and several limestone intervals; Douglass and others (1974) reported* Triticites *sp. foraminifera (Virgilian) from the top of the section (near my sample locations JN120502-1 and JN120502-2; A.J. Wells, written communication, December 22, 2004, identified* Tricities cullomensis *[Virgilian] from sample JN120502-2); marker limestone beds at and near the base of the formation – the Jordan and Commercial Limestones – are apparently overridden by the Beef Hollow thrust and thus not exposed in the Jordan Narrows quadrangle; the total thickness in the Jordan Narrows quadrangle is unknown due to poor exposures and structural complexity; the Bingham Mine Formation is about 7300 feet (2200 m) thick in the Oquirrh Mountains (Tooker and Roberts, 1970). Pitcher (1957) mapped Paleozoic strata in the Jordan Narrows part of the east Traverse Mountains that he assigned to the Lower and Middle Pennsylvanian (Oquirrh Group), but that I reinterpret as the upper part of the Upper Pennsylvanian (Bingham Mine Formation); the query indicates my uncertainty (see Biek, 2005).*

₽obp Butterfield Peaks Formation (Middle Pennsylvanian [Desmoinesian – Atokan]) – *Interbedded, brown-weathering, fine-grained orthoquartzite and calcareous sandstone, and medium-gray, fine-grained sandy limestone; contains minor siltstone and mudstone that are very poorly exposed; typically cyclically interbedded with several tens of feet of calcareous sandstone capped by gray limestone several feet thick; forms ledgy to cliffy slopes. Calcareous sandstone is typically medium to thick and planar bedded, light brownish gray to medium gray on fresh surfaces, grayish orange to brown weathering, very fine to fine grained, locally with low-angle and ripple cross-stratification and bioturbation; it 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. Limestone is typically medium gray, medium to thick bedded, commonly 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 grades upward to finer grained, platy weathering limestone and argillaceous limestone; sample JN110502-2 yielded a single* Idiognathodus *species conodont, most likely* I. delicatus *(Desmoinesian); the total thickness in the Jordan Narrows quadrangle is unknown due to poor exposures and structural complexity; Tooker and Roberts (1970) reported the formation is 9070 feet (2765 m) thick in the Oquirrh Mountains.*

₽Mowc West Canyon Limestone (Lower Pennsylvanian to Upper Mississippian [Morrowan-Chesterian]) – *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; fossils include crinoid columnals, brachiopods, bryozoans, rugose corals, and fusulinids; upper contact is gradational and conformable; probably about 1000 feet (300 m) thick in this quadrangle; Maxfield (1956) measured an incomplete section of about 860 feet (260 m) near Cedar Point in this quadrangle, and Davis and others (1994) reported a thickness of 1007 feet (307 m) in the southern Oquirrh Mountains.*

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 both planar bedding 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; upper contact not exposed, but regionally it is conformable and gradational and corresponds to a change from predominantly clastic to predominantly carbonate strata; age from Davis and others (1994); incompletely exposed north of the Beverly Hills area; about 1100 to 1400 feet (335-425 m) thick in the Lake and Oquirrh Mountains (Bullock, 1951; Tooker, 1999).*

Mgb Great Blue Limestone, undivided (Upper Mississippian) – *Medium- to very thick bedded, light- to dark-gray but typically bluish-gray limestone; locally cherty and fossiliferous with brachiopods, corals, and bryozoans; commonly laminated and platy weathering; "curly" limestone exposed near common border of sections 8 and 17, T. 4 S., R. 1 W. just below Bonneville shoreline; upper contact not exposed, but regionally marks a prominent change from cliff-forming limestone to slope-forming shale; incompletely exposed and complexly folded and thrust-faulted in the Beverly Hills area; age from Gordon and others (2000); thickness uncertain, but regionally the formation is about 2500 feet (750 m) thick (Gordon and others, 2000).*

Mh Humbug Formation (Upper Mississippian) – *Subsurface only; age from Morris and Lovering (1961); about 700 to 750 feet (210-230 m) thick at Lake Mountain (Biek, in 2004).*

Md Deseret Limestone (Upper Mississippian) – *Subsurface only; age from Morris and Lovering (1961) and Sandberg and Gutschick (1984); about 700 to 750 feet (210-230 m) thick at Lake Mountain (Biek, 2004).*

Mg Gardison Limestone (Lower Mississippian) – *Subsurface only; age from Morris and Lovering (1961); probably about 500 to 650 feet (150-200 m) thick at Lake Mountain (Biek, 2004).*

REFERENCES

Baker, A.A., 1964, Geology of the Aspen Grove quadrangle: U.S. Geological Survey Geological Quadrangle Map GQ-239, scale 1:24,000.

Biek, R.F., 2004, Geologic maps of the Cedar Fort and Saratoga Springs quadrangles, Utah County, Utah: Utah Geological Survey Maps 201 and 202, 3 plates, scale 1:24,000.

—2005, Geologic map of the Lehi quadrangle, Salt Lake and Utah Counties, Utah: Utah Geological Survey Map 210, 2 plates, scale 1:24,000.

Biek, R.F., Solomon, B.J., Keith, J.D., and Smith, T.W., 2004, Interim geologic maps of the Copperton, Magna, and Tickville Spring quadrangles, Salt Lake and Utah Counties, Utah: Utah Geological Survey Open-File Report 434, 3 plates, scale 1:24,000.

Bullock, R.L., 1951, Geology of Lake Mountain, Utah: Utah Geological and Mineralogical Survey Bulletin 41, 46 p.

Crittenden, M.D., Jr., 1951, Manganese deposits of western Utah: U.S. Geological Survey Bulletin 979-A, 62 p.

Currey, D.R., and Oviatt, C.G., 1985, Durations, average rates, and probable causes of Lake Bonneville expansions, stillstands, and contractions during the last deep-lake cycle, 32,000 to 10,000 years ago, *in* Kay, P.A., and Diaz, H.F., editors, Problems of and prospects for predicting Great Salt Lake levels – Proceedings of a NOAA conference, March 26-28, 1985: Salt Lake City, University of Utah, Center for Public Affairs and Administration, p. 9-24.

Davis, L.E., Webster, G.D., and Dyman, T.S., 1994, Correlation of the West Canyon, Lake Point, and Bannock Peak Limestones (Upper Mississippian to Middle Pennsylvanian), basal formations of the Oquirrh Group, northern Utah and southeastern Idaho: U.S. Geological Survey Bulletin 2088, 30 p.

Deino, Alan, and Keith, J.D., 1997, Ages of volcanic and intrusive rocks in the Bingham mining district, Utah, in John, D.A., and Ballantyne, G.H., editors, Geology and ore deposits of the Oquirrh and Wasatch Mountains, Utah: Society of Economic Geologists Guidebook Series, v. 29, p. 91-100.

Douglass, R.C., Moore, W.J., and Huddle, J.W., 1974, Stratigraphy and microfauna of the Oquirrh Group in the western Traverse Mountains and northern Lake Mountains, Utah: Journal of Research of the U.S. Geological Survey, v. 2, no. 1, p. 97-104.

Gordon, MacKenzie, Jr., and Duncan, H.M., 1970, Biostratigraphy and correlation of the Oquirrh Group and related rocks in the Oquirrh Mountains, Utah, in Tooker, E.W., and Roberts, R.J., Upper Paleozoic rocks in the Oquirrh Mountains and Bingham mining district, Utah: U.S. Geological Survey Professional Paper 629-A, p. A38-A70.

Gordon, MacKenzie, Jr., Tooker, E.W., and Dutro, J.T., Jr., 2000, Type locality for the Great Blue Limestone in the Bingham nappe, Oquirrh Mountains, Utah: U.S. Geological Survey Open-File Report 00-012, 61 p.

LeBas, M.J., LeMaitre, R.W., Streckeisen, A., and Zanettin, B., 1986, A chemical classification of volcanic rocks based on the total alkali-silica diagram: Journal of Petrology, v. 27, p. 745-750.

Machette, M.N., 1992, Surficial geologic map of the Wasatch fault zone, eastern part of Utah Valley, Utah County and parts of Salt Lake and Juab Counties, Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-2095, scale 1:50,000.

Marsell, R.E., 1932, Geology of the Jordan Narrows region, Traverse Mountains, Utah: Salt Lake City, University of Utah, M.S. thesis, 117 p.

Maxfield, E.B., 1956, Sedimentation and stratigraphy of the Morrowan Series in central Utah: Provo, Utah, Brigham Young University, M.S. thesis, 46 p.

Moore, W.J., 1973a, A summary of radiometric ages of igneous rocks in the Oquirrh Mountains, north-central Utah: Economic Geology, v. 68, p. 97-101.

—1973b, Igneous rocks in the Bingham mining district, Utah: U.S. Geological Survey Professional Paper 629-B, 42 p.

—1973c, Preliminary geologic map of western Traverse Mountains and northern Lake Mountains, Salt Lake and Utah Counties, Utah: U.S. Geological Survey Miscellaneous Field Studies Map MF-490, 1 plate, scale 1:24,000.

Morris, H.T., and Lovering, T.S., 1961, Stratigraphy of the East Tintic Mountains, Utah: U.S. Geological Survey Professional Paper 361, 145 p.

Naeser, C.W., Bryant, Bruce, Crittenden, M.D., Jr., and Sorensen, M.L., 1983, Fission-track ages of apatite in the Wasatch Mountains, Utah – an uplift study, *in* Miller, D.M., Todd, V.R., and Howard, K.A., editors, Tectonic and stratigraphic studies in the eastern Great Basin: Geological Society of America Memoir 157, p. 29-36.

Pitcher, G.G., 1957, The geology of the Jordan Narrows quadrangle, Utah: Provo, Utah, Brigham Young University, M.S. thesis, 46 p., 1 plate, scale 1:24,000.

Sandberg, C.A., and Gutschick, R.C., 1984, Distribution, microfauna, and source-rock potential of Mississippian Delle Phosphatic Member of Woodman Formation and equivalents, Utah and adjacent states, *in* Woodward, Jane, Meissner, F.F., and Clayton, J.L., editors, Hydrocarbon source rocks of the greater Rocky Mountain region: Rocky Mountain Association of Geologists Field Conference Guidebook, p. 135-178.

Slentz, L.W., 1955, Tertiary Salt Lake Group in the Great Salt Lake basin: Salt Lake City, University of Utah, Ph.D. dissertation, 62 p., 3 plates, scales 1:24,000 and 1:8,000.

Tooker, E.W., 1999, Geology of the Oquirrh Mountains, Utah: U.S. Geological Survey Open-File Report 99-571, 150 p.

Tooker, E.W., and Roberts, R.J., 1970, Upper Paleozoic rocks in the Oquirrh Mountains and Bingham mining district, Utah, with a section on biostratigraphy and correlation by Gordon, MacKenzie, Jr., and Duncan, H.M.: U.S. Geological Survey Professional Paper 629-A, 76 p.

Waite, K.A., 1996, Petrogenesis of the volcanic and intrusive rocks associated with the Bingham porphyry Cu-Mo deposit, Utah: Provo, Utah, Brigham Young University, M.S. thesis, 143 p.

Waite, K.A., Keith, J.D., Christiansen, E.H., Whitney, J.A., Hattori, Keiko, Tingey, D.G., and Hook, C.J., 1997, Petrogenesis of the volcanic and intrusive rocks associated with the Bingham Canyon porphyry Cu-Au-Mo deposit, Utah, *in* John, D.A., and Ballantyne, G.H., editors, Geology and ore deposits of the Oquirrh and Wasatch Mountains, Utah: Society of Economic Geologists Guidebook Series, v. 29, p. 69-90.

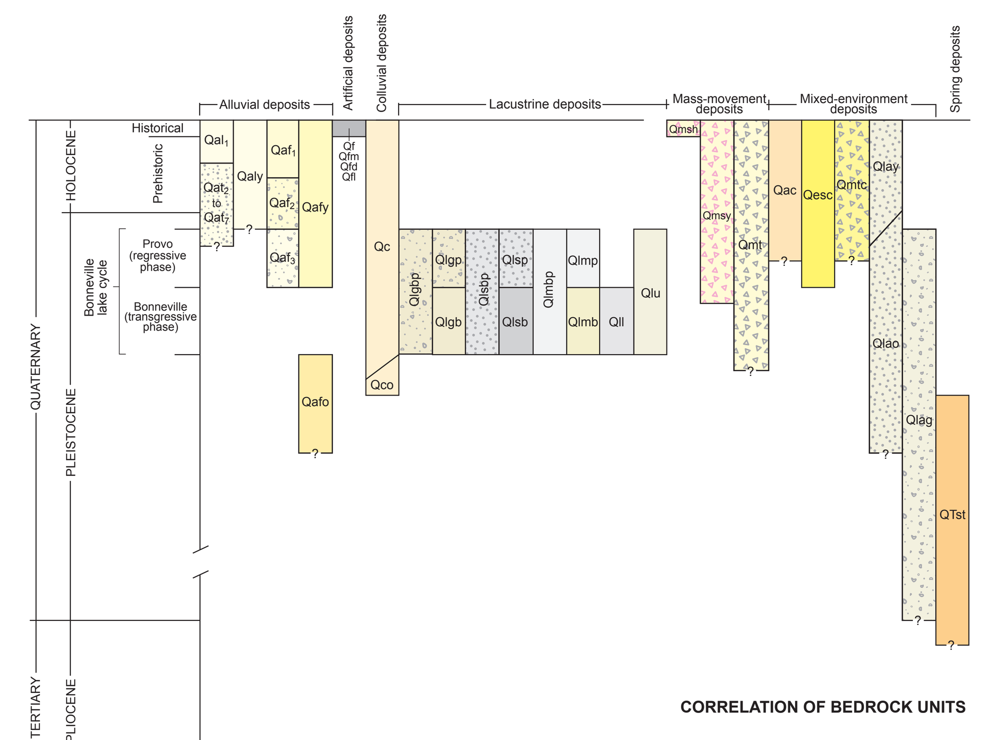
ACKNOWLEDGMENTS

Thanks to Adolph Yonkee (Weber State University), Craig Forster (University of Utah), and Kurt Constenius (Independent) for technical reviews of this map and plate 2 materials and for discussions in the field and office. Craig brought the pre-Bonneville fault exposure north of Point of the Mountain to my attention and made me think carefully about inferred range-bounding faults. I thank Doug Johnson and his Utah National Guard colleagues at Camp Williams for supporting this project and facilitating access to the base. I also thank Scott Ritter, Professor of Geology at Brigham Young University, for identifying conodonts from the Butterfield Peaks Formation in the Jordan Narrows quadrangle; A.J. Wells, retired, identified fusilinids from the Bingham Mine Formation. Kent Brown (Utah Geological Survey [UGS]) set up photogrammetry for this project and cleaned my digital files. Thanks to Mike Hylland, Doug Sprinkel, and Grant Willis (UGS), for their careful review of the map and accompanying materials; Tom Chidsey, Sandy Eldredge, Mike Lowe, and Barry Solomon, each with the UGS, also reviewed parts of this report.

Map Symbols

- Contact, dashed where approximately located
- 65 — Normal fault, dashed where approximately located, dotted where concealed and approximately located; query indicates uncertain presence; bar and ball on down-dropped side; arrow with number shows dip of fault
- Normal fault inferred principally from gravity data; very approximately located; bar and ball on down-dropped side; also used for the inferred Cedar Valley tear fault
- Thrust fault, dashed where approximately located, dotted where concealed and approximately located; teeth on upper plate
- Axial trace of anticline, dashed where approximately located, dotted where concealed and approximately located; arrow shows direction of plunge
- Axial trace of overturned anticline, dashed where approximately located, dotted where concealed and approximately located; arrow shows direction of plunge
- Axial trace of syncline, dashed where approximately located, dotted where concealed and approximately located
- Lake Bonneville shorelines - Major shorelines of the Bonneville lake cycle. Mapped at the top of the wave-cut platform, dashed where approximately located
  - B — Highest shoreline of the Bonneville (transgressive) phase
  - b — Other shorelines of the Bonneville phase – mostly transgressive
  - P — Highest shoreline of the Provo (regressive) phase
  - p — Other shorelines of the Provo phase – mostly regressive shorelines of the Provo phase, but may include some shorelines of the Bonneville (transgressive) phase
- 4800 — Elevation (in feet) of selected Lake Bonneville shoreline feature; elevation determined photogrammetrically
- Crest of Lake Bonneville offshore bar or spit
- Erosional scarp within terraces along Jordan River
- 35 — Strike and dip of inclined bedding (red symbols in the east Traverse Mountains indicate attitudes from J.E. Welsh, unpublished map, 1965; in the west Traverse Mountains red symbols indicate attitudes from Moore, 1973c)
- Landslide scarp, hachures on down-dropped side
- 30 — Approximate strike and dip of inclined bedding
- Approximate strike and dip direction of inclined bedding
- Strike of vertical bedding (red symbols indicate attitudes from Moore, 1973c)
- Horizontal bedding (red symbol in east Traverse Mountains indicates attitude from J.E. Welsh, unpublished map, 1965)
- 30 — Strike and dip of overturned bedding (red symbol in west Traverse Mountains indicates attitude from Moore, 1973c)
- Sand and gravel pit
- Quarry, cl = clay, no letter = crushed rock
- X — Prospect, cl = clay, c = calcite, no letter = metals
- Shaft
- Spring
- L32103-2 — Sample location and number (see table 1 for analytical data)
- Area of colluvium (unmapped over shallow bedrock) locally exhibiting evidence of soil creep, northwest slope of Steep Mountain

CORRELATION OF QUATERNARY UNITS



CORRELATION OF BEDROCK UNITS

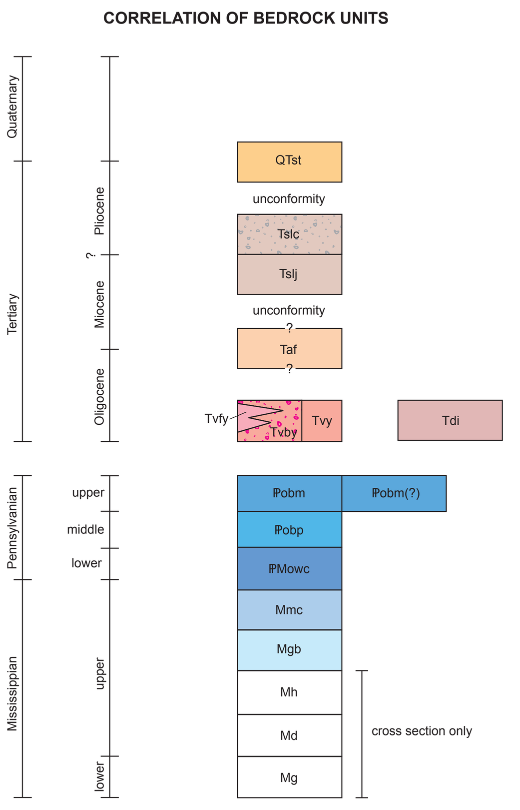
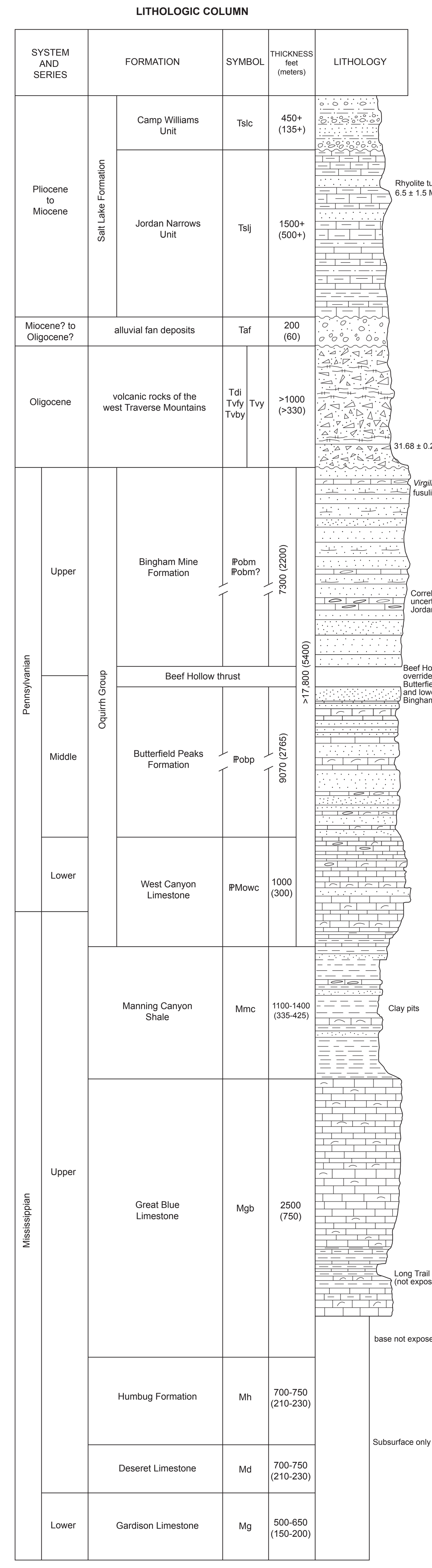
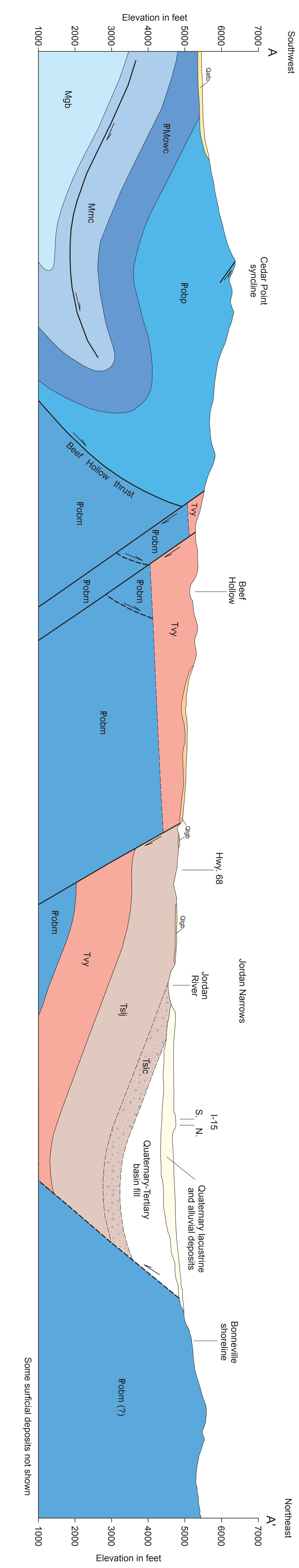
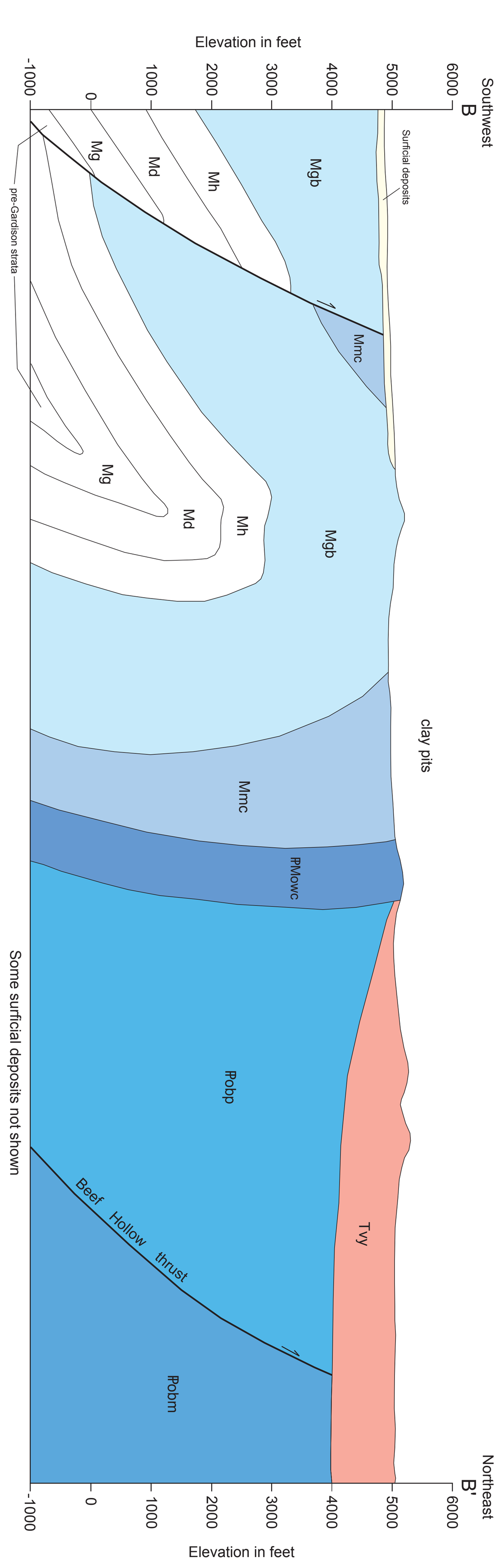
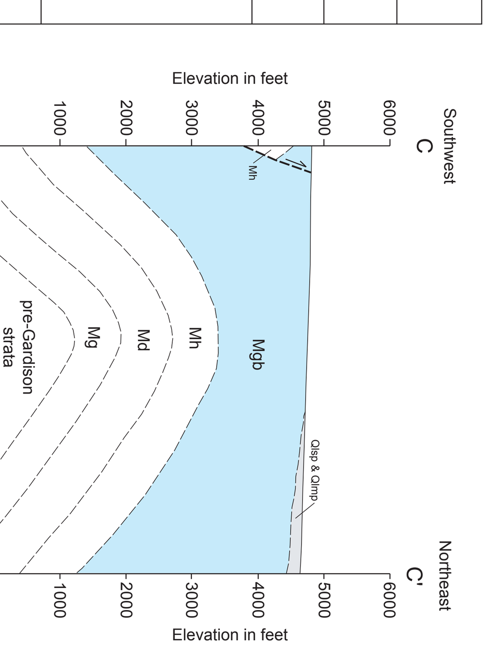


Table 1. Major and trace element whole-rock analyses

SAMPLE	Unit	Rock Type	Rock Name	Latitude	Longitude	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	Cr_2O_3	TiO_2	MnO	P_2O_5	SrO	BaO	LOI	Total
JN110602-3	Tvy	tuff matrix	dacite	40° 26' 18.3"	111° 58' 57.8"	63.75	16.07	4.41	2.93	1.08	3.39	2.71	0.01	0.54	0.06	0.22	0.06	0.16	4.10	99.49
JN110602-4	Tvy	clast	andesite	40° 26' 18.3"	111° 58' 57.8"	59.47	15.99	6.12	4.98	2.84	3.39	2.86	0.01	0.90	0.08	0.38	0.08	0.47	1.71	99.28
JN120502-3	Tvy	flow	trachyte	40° 27' 45.5"	111° 57' 48.9"	63.16	15.86	5.53	3.92	1.69	3.78	3.32	0.01	0.79	0.07	0.34	0.08	0.16	0.96	99.67
JN120602-2	Tvy	flow	dacite	40° 26' 06.5"	111° 56' 32.0"	61.69	16.00	6.04	4.81	2.49	3.70	2.85	0.01	0.81	0.09	0.35	0.08	0.16	0.53	99.60
JN21903-2	Tdi	dike	dacite	40° 28' 28.2"	111° 59' 37.5"	65.76	15.47	3.73	2.86	1.17	3.47	3.38	<0.01	0.46	0.12	0.18	0.06	0.17	2.59	99.43
JN21903-3	Qlu/Tvy	flow	trachyte	40° 28' 09.1"	111° 58' 34.7"	62.78	16.01	5.58	3.60	1.06	3.86	3.35	<0.01	0.87	0.06	0.33	0.07	0.17	1.25	98.98
JN21903-5	Tvy	clast	andesite	40° 28' 10.5"	111° 58' 52.3"	60.26	16.31	6.03	4.65	2.18	3.44	2.93	<0.01	0.84	0.08	0.38	0.08	0.16	1.75	99.09
JN22703-1	Tvby	tuff matrix	dacite	40° 23' 43.4"	111° 59' 37.1"	62.45	16.09	4.42	3.81	1.78	3.56	2.71	<0.01	0.51	0.08	0.20	0.07	0.13	3.48	99.30
JN22703-2a	Tvby	clast	dacite	40° 23' 43.4"	111° 59' 37.1"	68.11	15.58	3.95	2.80	0.95	4.12	3.15	0.01	0.41	0.05	0.17	0.05	0.17	0.43	99.95
JN22703-2b	Tvby	clast	dacite	40° 23' 43.4"	111° 59' 37.1"	65.37	15.76	3.81	3.24	1.34	3.49	3.53	<0.01	0.51	0.07	0.19	0.06	0.15	2.19	99.70
JN22703-3	Tvy	clast	dacite	40° 24' 40.1"	111° 57' 10.5"	60.84	16.08	5.34	4.78	1.80	3.35	3.24	<0.01	0.74	0.08	0.29	0.08	0.14	3.15	99.88
JN22703-4	Tvy	tuff matrix	andesite	40° 24' 40.1"	111° 57' 10.5"	59.38	17.27	5.59	4.69	2.14	3.61	2.27	<0.01	0.81	0.08	0.31	0.08	0.12	2.88	99.22
JN22703-5	Tvy	clast	andesite	40° 27' 18.5"	111° 58' 36.0"	60.77	16.18	6.27	4.62	2.28	3.35	3.14	<0.01	0.82	0.08	0.34	0.07	0.16	1.66	99.73
JN31203-1	Tslj	volcanic ash	rhyolite	40° 26' 28.9"	111° 55' 30.3"	70.78	11.83	1.79	0.64	0.25	2.18	5.74	0.01	0.26	0.03	0.01	0.01	0.07	6.20	99.79
JN31203-2	Tslj	volcanic ash	rhyolite	40° 26' 24.1"	111° 55' 42.3"	70.02	11.96	1.48	0.80	0.49	1.90	5.53	<0.01	0.24	0.03	0.01	0.01	0.05	6.98	99.49
JN9302-1	Tvfy	flow	dacite	40° 23' 46.0"	111° 59' 12.0"	65.36	15.41	5.47	3.76	1.13	3.61	3.21	0.01	0.81	0.07	0.33	0.07	0.15	0.62	100.00

SAMPLE	Ag	Ba	Ce	Co	Cr	Cs	Cu	Dy	Er	Eu	Ga	Gd	Hf	Ho	La	Lu	Mo	Nb	Nd
JN110602-3	<1	1700	129	9.2	20	2.9	18	3.1	1.9	1.5	22	5.4	6	0.6	73.9	0.3	3	19	42.8
JN110602-4	<1	5730	138.5	20	70	1.9	26	4.2	2.4	2.1	24	7.5	6	0.9	86.3	0.3	3	18	55.2
JN120502-3	<1	1745	132.5	15.2	30	3.2	29	3.1	1.6	1.7	23	6.3	6	0.6	73.9	0.2	4	19	48.6
JN120602-2	<1	1665	137	18.3	60	1.7	30	3.5	2.0	1.8	22	6.6	6	0.7	75.2	0.3	2	17	49.1
JN21903-2	<1	1705	112.5	8.8	20	2.1	9	3.1	1.9	1.3	19	5.1	5	0.6	64.3	0.3	3	18	37.1
JN21903-3	<1	1850	116	13.7	30	2.1	28	3.0	1.6	1.8	22	6.0	6	0.5	64.9	0.2	3	19	45.3
JN21903-5	<1	1695	139.5	16.4	30	2.2	20	3.8	2.2	1.8	22	6.9	6	0.8	81.3	0.3	4	18	52.1
JN22703-1	<1	1390	119.5	9.2	20	1.8	29	3.0	1.9	1.4	21	5.4	6	0.6	70.8	0.3	3	16	40.0
JN22703-2a	<1	1780	123	6.8	20	1.2	21	3.3	2.1	1.4	20	5.7	5	0.7	78.5	0.3	3	19	43.9
JN22703-2b	<1	1615	120	8.5	20	2.0	14	3.2	1.9	1.4	20	5.3	5	0.6	71.0	0.3	3	18	41.4
JN22703-3	<1	1500	130.5	13.3	20	2.5	29	3.6	2.1	1.6	20	6.3	6	0.8	75.7	0.3	4	17	47.6
JN22703-4	<1	1275	126	14.3	20	2.0	22	3.8	2.2	1.8	22	6.2	6	0.8	69.8	0.3	2	17	45.8
JN22703-5	<1	1785	128.5	15.8	40	2.2	21	3.6	2.1	1.6	21	6.3	6	0.7	75.8	0.3	4	18	48.9
JN31203-1	<1	568	124	1.6	110	7.4	5	7.6	4.6	0.9	18	8.4	8	1.5	64.6	0.7	9	38	45.4
JN31203-2	<1	473	133	1.5	50	9.6	9	7.7	4.8	0.7	19	8.6	8	1.6	69.1	0.7	9	40	48.6
JN9302-1	<1	1640	134.5	16.8	50	2.1	32	3.3	1.8	1.7	23	6.5	6	0.6	79.2	0.2	2	18	49.1

SAMPLE	Ni	Pb	Pr	Rb	Sm	Sn	Sr	Ta	Tb	Th	Tl	Tm	U	V	W	Y	Yb	Zn	Zr
JN110602-3	16	24	13.3	96.1	6.1	2	586	1.1	0.7	18	<1	<0.5	3.2	71	2	18.3	1.7	64	217
JN110602-4	42	22	16.2	81.2	8.1	1	833	1.1	0.9	17	<1	<0.5	3.3	149	2	23.9	2.0	94	212
JN120502-3	23	24	14.3	105.5	7.2	1	701	1.4	0.7	21	<1	<0.5	4.9	120	2	16.6	1.4	92	218
JN120602-2	36	27	14.4	78.4	7.2	2	724	1.2	0.8	19	<1	<0.5	3.7	112	2	20.0	1.7	88	212
JN21903-2	12	22	11.6	95.2	5.5	2	511	1.2	0.6	17	<1	<0.5	3.6	57	1	18.6	1.7	58	174.5
JN21903-3	23	25	13.1	108.5	7.0	2	700	1.4	0.7	21	<1	<0.5	5.3	114	2	15.0	1.3	90	215
JN21903-5	21	20	15.6	87.1	7.5	2	773	1.1	0.8	18	<1	<0.5	3.8	123	2	21.1	1.9	85	219
JN22703-1	14	20	12.4	101.5	5.6	1	605	1.0	0.6	17	<1	<0.5	2.5	67	1	18.0	1.7	68	201
JN22703-2a	11	21	13.9	85.7	6.2	1	514	1.2	0.7	19	<1	<0.5	4.0	54	2	19.2	1.9	59	183
JN22703-2b	13	27	13.0	96.7	6.0	1	571	1.1	0.6	18	<1	<0.5	3.6	63	2	18.8	1.8	68	182.5
JN22703-3	17	44	14.3	100.5	7.0	2	671	1.1	0.8	17	<1	<0.5	3.2	107	1	20.5	1.9	70	196.5
JN22703-4	20	21	13.6	87.7	7.0	1	763	1.0	0.8	16	<1	<0.5	2.2	110	1	21.3	1.9	76	211
JN22703-5	28	22	14.6	87.3	7.3	1	691	1.2	0.7	18	<1	<0.5	3.6	116	1	19.6	1.8	79	209
JN31203-1	17	25	13.3	215.0	8.6	6	36.4	2.9	1.3	30	<1	0.7	8.2	10	2	44.2	4.7	52	241
JN31203-2	9	23	14.3	219.0	8.8	6	41.6	3.0	1.3	33	<1	0.7	8.1	9	2	45.1	4.6	48	206
JN9302-1	34	27	14.9	102.0	7.4	1	669	1.2	0.7	19	<1	<0.5	4.3	120	2	17.8	1.5	85	225

NOTE: Major oxides reported in weight percent by X-Ray Fluorescence; minor and trace elements reported in ppm by Inductively Coupled Plasma-Mass Spectrometry.
All analyses performed by ALS Chemex, Inc., Sparks, NV.
Latitude and longitude based on NAD83.
Rock name using TAS diagram of LeBas and others (1986). Note high LOI (Loss on Ignition) for many samples.

LITHOLOGIC COLUMN