GEOLOGIC MAP OF THE VERNON NE QUADRANGLE, TOOELE COUNTY, UTAH

by Stefan M. Kirby

MAP 266DM
UTAH GEOLOGICAL SURVEY
a division of
UTAH DEPARTMENT OF NATURAL RESOURCES
2013

GEOLOGIC MAP OF THE VERNON NE QUADRANGLE, TOOELE COUNTY, UTAH

by Stefan M. Kirby

SCALE: 1:24,000

Cover photo: *View to the northeast across the Vernon NE quadrangle of Salt Lake Formation outcrop and the Oquirrh Mountains in the distance.*

ISBN: 978-1-55791-887-1

MAP 266DM
UTAH GEOLOGICAL SURVEY
a division of
UTAH DEPARTMENT OF NATURAL RESOURCES
2013

STATE OF UTAH
Gary R. Herbert, Governor

DEPARTMENT OF NATURAL RESOURCES
Michael Styler, Executive Director

UTAH GEOLOGICAL SURVEY
Richard G. Allis, Director

PUBLICATIONS
contact
Natural Resources Map & Bookstore
1594 W. North Temple
Salt Lake City, UT 84114
telephone: 801-537-3320
toll-free: 1-888-UTAH MAP
website: mapstore.utah.gov
email: geostore@utah.gov

UTAH GEOLOGICAL SURVEY
contact
1594 W. North Temple, Suite 3110
Salt Lake City, UT 84114
telephone: 801-537-3300
website: geology.utah.gov

Although this product represents the work of professional scientists, the Utah Department of Natural Resources, Utah Geological Survey, makes no warranty, expressed or implied, regarding its suitability for a particular use, and does not guarantee accuracy or completeness of the data. 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. For use at 1:24,000 scale only.

This geologic map was funded by the Utah Geological Survey and U.S. Geological Survey, National Cooperative Geologic Mapping Program, through USGS STATEMAP award number G09AC00152. 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.

CONTENTS

INTRODUCTION 1
Location and Geographic Setting 1
Scope of Work 1
Previous Investigations and Mapping Background 1
Geologic Summary 1
MAP UNIT DESCRIPTIONS 2
QUATERNARY 2
Human Disturbance 2
Alluvial Deposits 2
Lacustrine Deposits 3
Eolian 3
Mixed-Environment Deposits 3
Stacked Unit Deposits 4
TERTIARY 4
PENNSYLVANIAN 4
ACKNOWLEDGMENTS 4
REFERENCES *4*

GEOLOGIC MAP OF THE VERNON NE QUADRANGLE, TOOELE COUNTY, UTAH

by Stefan M. Kirby

INTRODUCTION

Location and Geographic Setting

The Vernon NE quadrangle covers part of the southeastern floor of Rush Valley in southeastern Tooele County (plate 1). The Pony Express Road extends from east to west across the quadrangle and the Union Pacific Railroad crosses the southwest quarter of the quadrangle. Sabie and Boulter Creeks flow northeast across the southeast quarter of the quadrangle. The quadrangle consists of low hills, alluvial surfaces, and channels that slope gently towards a low-lying playa surface near the northern quadrangle boundary.

Scope of Work

The Vernon NE quadrangle was mapped in conjunction with the adjoining Lofgreen and Vernon quadrangles as part of the 2009 US Geological Survey STATEMAP award number G09AC00152 made to the Utah Geological Survey (UGS). The Vernon NE quadrangle is one of six 1:24,000 scale geologic maps that include the Lofgreen, Vernon, Saint John, Faust, and Ophir quadrangles (see Kirby, 2010b, c, d, and e; Kirby, 2012) mapped in conjunction with a larger mapping project for the Rush Valley 30' x 60' quadrangle (Clark and others, 2012), and a hydrogeologic framework study of the Rush Valley area (Gardner and Kirby, 2011). I mapped geologic contacts directly on available digital orthophotography and the 1:24,000-scale Vernon NE topographic map base using ArcGIS. I also examined available 1:20,000-scale black and white air photos and 5-meter digital elevation data to delineate unit contacts. I completed several weeks of mapping and field checking of units in the Vernon NE quadrangle during the spring of 2009.

Previous Investigations and Mapping Background

Several investigators have mapped the geology of the Vernon NE quadrangle at various scales smaller (less detailed) than 1:24,000, including Heylmun (1965), Bucknam (1977), Moore and Sorensen (1979), and Everitt and Kaliser (1980). Perkins and others (1998) provide age control for the Salt Lake Formation using an ash correlation methodology for several sites in the study area. Adjoining mapping relevant to both bedrock and unconsolidated deposits includes Gilluly (1932), Disbrow (1957), Cohenour (1959), Groff (1959), Armin and Moore (1981), Moore and McKee (1983), Tooker (1987), Pampeyan (1989), Tooker and Roberts (1998), and Clark and others (2012). Work by Hood and others (1969) and Gardner and Kirby (2011) examined the hydrogeology of the Rush Valley area including the Vernon NE quadrangle.

Geologic Summary

Geologic units in the Vernon NE quadrangle include Tertiary basin fill of the Salt Lake Formation and various Quaternary unconsolidated deposits. The Salt Lake Formation is exposed in the western half of the quadrangle as a series of topographically low outcrops partially overlain and surrounded by unconsolidated deposits. The Salt Lake Formation was likely deposited in a series of shallow lacustrine basins formed by regional extension during the Miocene (Heylmun, 1965; Perkins and others, 1998). Ages for tephra based on ash interpolations and correlations indicate deposition during the late Miocene between 6.6 ± 0.03 and 9.8 ± 0.23 Ma for the Salt Lake Formation in the western part of the quadrangle and the adjoining Faust quadrangle (Perkins and others, 1998). A detrital zircon sample from Salt Lake Formation sandstone in the adjoining Faust quadrangle yielded a maximum depositional age based on a single grain of 6.49 ± 0.38 Ma (Utah Geological Survey and Apatite to Zircon Inc., 2013). The contact of the Salt Lake Formation and underlying bedrock is not exposed in the quadrangle, but three drill holes intercepted between 2800 and 4200 feet (850–1280 m) of Salt Lake Formation resting directly on Oquirrh Group bedrock (Utah Division of Oil, Gas, and Mining, 2009) (plate 2). Outcrops of Oquirrh Group bedrock are mapped south and west of the quadrangle in the Vernon Hills in the Vernon and Lofgreen quadrangles (Kirby, 2010b, c). Bedrock of the Salt Lake Formation generally dips shallowly to the west across most of the quadrangle (Heylmun, 1965); this westward dip is only locally interrupted by several normal faults and a series of north-south trending folds in the central and western portion of the map area. Offset across these normal faults is presumed to be down to the east based on offset ash correlations ages and available gravity data that indicate increasing basin depths on the east side of these faults (Mabey and

Morris, 1967; Everitt and Kaliser, 1980; Perkins and others, 1998). Evidence of Quaternary faulting was not found in the quadrangle and mapped faults have apparently been inactive since at least the deposition of unfaulted upper Pleistocene sediments (Bucknam, 1977; Everitt and Kaliser, 1980).

Unconsolidated deposits in the Vernon NE quadrangle include both lacustrine units deposited during the transgression and highstand of Lake Bonneville, and alluvial units that both pre- and post-date the lake and are in part contemporaneous with it. Shoreline features related to the highstand of Lake Bonneville include several prominent wave-cut platforms and benches in Salt Lake Formation bedrock in the central part of the quadrangle. The highest wave-cut benches occur at approximately 5250 feet (1600 m) above sea level (table 1). In the adjoining Faust and Fivemile Pass quadrangles, Currey (1982) gives respective elevations of 5210 and 5185 feet (1588 and 1581 m) above sea level for depositional Lake Bonneville beach ridges. Despite the localized well developed wave platforms within the quadrangle, the contact of lacustrine and alluvial sediments is commonly gradational across most of the quadrangle and shoreline features are not obvious. An erosional shoreline mapped in the north part of the quadrangle near the 5045 foot (1537 m) elevation is the southernmost expression of the Shambip Lake level that is mapped in the adjoining Faust and Saint John quadrangles (Kirby, 2010d, e). Alluvial fan and channel deposits cover part of the northern two-thirds and most of the southern third of the quadrangle. These deposits include Holocene alluvium incised into Pleistocene deposits, late Pleistocene alluvial fans that grade to near the Lake Bonneville highstand, and older incised and inactive Pleistocene alluvial fans that likely predate the transgression of Lake Bonneville. Based on available well logs (Utah Division of Water Rights, 2009) and exposed geology, the thickness of unconsolidated deposits is generally less than 300 feet (100 m) across most of the southern two-thirds of the quadrangle. Near the northern quadrangle boundary unconsolidated deposits may be considerably thicker beneath alluvial fans sloping southward from the Oquirrh Mountains. Across most of the quadrangle unconsolidated deposits presumably rest on the Salt Lake Formation. In the southwest corner of the quadrangle Quaternary deposits may rest on Pennsylvanian-age bedrock of the Oquirrh Group.

Salt Lake Formation and unconsolidated deposits exposed at the surface in the Vernon NE quadrangle were deposited during Miocene to Holocene Basin-and-Range extension. These deposits rest on bedrock of the Oquirh Group that experienced significant east-directed shortening and crustal thickening during the Late Jurassic to Eocene Sevier orogenic event (Armstrong, 1968; DeCelles and Coogan, 2006, and references therein). Exposures of folded and faulted rocks directly related to the Sevier orogenic event occur in the adjoining Vernon, Lofgreen, Faust, Mercur, and Fivemile Pass quadrangles (Clark and others, 2012). During the Eocene, crustal shortening was replaced by roughly east-west extension and significant regional volcanism (Constenius, 1996; Constenius and others, 2003). Extension remains the dominant tectonic style in the area, but it has varied in magnitude, style, and extent across Eocene to Holocene time. Major pulses of extension during the Miocene and possibly the Pliocene, correlate with deposition and deformation (faulting and folding) of the Salt Lake Formation (table 2) (Perkins and others, 1998). Subsequent extension has controlled deposition of unconsolidated sediments and nearby surface faulting during the Quaternary (Everitt and Kaliser, 1980).

MAP UNIT DESCRIPTIONS

QUATERNARY

Human Disturbance

Qh **Fill and disturbed areas** (Historical) – Fill and associated excavations; mapped at a single small stock pond dam near the center of the quadrangle; material includes sand, gravel, silt, and clay; variable thickness 0 to 20 feet (0–6 m).

Alluvial Deposits

Qaly **Younger alluvial deposits, undivided** (Holocene to upper Pleistocene) – Moderately to well-sorted sand, pebble, and cobble gravel, silt, and minor clay; deposited along major drainages and along parts of the valley floor below the highstand of Lake Bonneville; locally includes small alluvial-fan and colluvial deposits; includes reworked Lake Bonneville lacustrine deposits across the northern part of the Vernon NE quadrangle; includes mid-Holocene to late Pleistocene stream deposits incised by active stream channels and partly overlain by late Holocene stream deposits that cannot be differentiated because of map scale or in areas where the specific age of these deposits cannot be determined; postdates regression of Lake Bonneville; thickness variable, probably less than 15 feet (5 m).

Qaf_1 **Level-1 alluvial-fan deposits** (upper Holocene) – Poorly to moderately sorted, crudely stratified or massive, pebble to cobble gravel, with boulders near bedrock exposures, sand, silt, and minor clay; clasts angular to subrounded and commonly matrix supported; deposited principally by debris flows and sheet floods at the mouths of small, intermittent stream channels draining bedrock or near the mouth of other channels in older alluvial-fan and other unconsolidated deposits; locally incised in and/or overlying older alluvial fan deposits; deposits equivalent to, and grade into the younger part of young alluvial-fan deposits (Qafy); differentiated from other alluvial-fan deposits due to a relatively smooth undissected

fan surface radiating away from a defined fan apex; mapped in the southwest corner of the quadrangle; exposed thickness less than 10 feet (3 m).

Qaf_2 **Level-2 alluvial-fan deposits** (middle Holocene to lower Holocene) – Poorly to moderately sorted, crudely stratified or massive, pebble to cobble gravel, with boulders near bedrock exposures, sand, silt, and minor clay; clasts angular to subrounded and commonly matrix supported; deposited principally by debris flows and sheet floods; locally incised in and/or overlying older alluvial fan deposits; deposits equivalent to, and grade to the older part of Qafy, locally above younger Qafy deposits; fan surface is abandoned and commonly dissected and irregular; deposits grade above modern stream (Qaly) or alluvial fan level (Qaf_1); mapped in the southwest corner of the quadrangle; exposed thickness less than 15 feet (5 m).

Qafy **Younger alluvial-fan deposits** (Holocene to upper Pleistocene) – Poorly to moderately sorted, crudely stratified or massive, pebble to cobble gravel, with boulders near bedrock exposures, sand, silt, and minor clay; clasts angular to subrounded and commonly matrix supported; deposited principally by debris flows and sheet floods at the mouths of intermittent stream channels draining bedrock, near the mouths of other channels in older alluvial-fan and other unconsolidated deposits, or across large alluvial slopes where individual fan surfaces cannot be differentiated; includes level-1, -2, and -3 alluvial-fan deposits (Qaf_1, Qaf_2, and Qaf_3) that postdate the transgression of Lake Bonneville or in areas where the specific age of deposits cannot be determined; no shorelines exist on these alluvial fans although some of these fans may grade to near the Bonneville shoreline; thickness variable, probably less than 40 feet (12 m).

Qaf_3 **Alluvial-fan deposits, Bonneville lake cycle, undivided** (upper Pleistocene) – Poorly to moderately sorted, crudely stratified or massive, pebble gravel, sand, silt, and minor clay; clasts subangular to subrounded and commonly matrix supported; deposited principally by debris flows and sheet floods; locally incised in older alluvial fan deposits; locally above younger Qafy deposits; fan surface grades near the Lake Bonneville highstand and exposures of Lake Bonneville sediments; deposition is contemporaneous with transgression and highstand of Lake Bonneville and no shorelines exist on these alluvial fans; surface is incised by active drainages; mapped in the southern half of the quadrangle; exposed thickness less than 15 feet (5 m).

Qafo **Older alluvial-fan deposits, pre-Bonneville lake cycle** (upper to lower Pleistocene) – Poorly sorted, pebble to cobble gravel, locally bouldery, in a matrix of sand, silt, and clay; mapped in areas where pre-Bonneville lake cycle alluvial-fan deposits are undifferentiated because they are poorly exposed or lack distinct geomorphic expression; unit is incised by and locally overlain by syn- and post-Bonneville alluvial fan units (Qafy, Qaf_1, Qaf_2, and Qaf_3); mapped in the southern quarter of the quadrangle; thickness probably less than 60 feet (20 m).

Lacustrine Deposits

Qlgb **Lacustrine gravel and sand deposits, transgressive phase of the Bonneville lake cycle** (upper Pleistocene) – Moderately to well sorted, sub-rounded to rounded pebble gravel, sand, and minor silt; deposited as gravel and sand bars and sheets below the Lake Bonneville highstand; deposited during the transgressive phase of Lake Bonneville; thickness is less than 40 feet (13 m).

Qlmb **Lacustrine silt and marl deposits, Bonneville lake cycle** (upper Pleistocene) – Light-colored, moderately to well sorted silt, marl, sand, and clay; deposited in discontinuous pods and sheets below the Lake Bonneville highstand; commonly contains small gastropods; thickness variable but generally less than 10 feet (3 m).

Qpm **Playa mud deposits** (Holocene) – White to very pale gray, finely bedded clay and silt; deposited as smooth, nearly level surface in the low-lying northern part of the Vernon NE quadrangle (in an area labeled depression); active alluvial deposits grade to playa surface; thickness likely less than 20 feet (7 m).

Eolian

Qes **Eolian sand deposits** (Holocene) – Very well sorted, very fine and fine-grained sand and minor silt; deposited in small dunes and localized interdune sand flats below the Lake Bonneville highstand in the Vernon NE quadrangle; overlies Lake Bonneville lacustrine deposits; dunes are partially vegetated and may not be currently active; mapped at a single location along the western edge of the quadrangle; thickness 0 to 9 feet (0–3 m).

Mixed-Environment Deposits

Qlay **Lacustrine deposits and younger alluvial-fan deposits, undivided** (Holocene to upper Pleistocene) – Poorly to well sorted sand, silt, clay, and marl;

deposited below the Lake Bonneville highstand as sloping sheets of sediment; includes a variety of lacustrine and alluvial facies either too complex or too poorly exposed to map; differentiated from Qlao by a lack of shoreline features and a relatively smooth and undissected surface topography similar to Qafy; mapped below inferred Bonneville highstand in the northeast corner of the quadrangle; thickness less than 40 feet (13 m).

Qlao **Lacustrine deposits and older alluvial-fan deposits, undivided** (upper to middle Pleistocene) – Poorly to well sorted sand, pebble gravel, silt, clay, and marl; deposited below the Lake Bonneville highstand as sloping sheets and swales of sediment; incised by post Bonneville alluvial channels and fans; includes a variety of lacustrine and alluvial facies either too complex or too poorly exposed to map; locally contains small gastropods several millimeters in diameter; mapped below inferred Bonneville highstand; contact with Qaf_3 syn-Bonneville alluvial fans is approximate and shoreline features are commonly absent along the contact of this unit and other unconsolidated deposits; thickness less than 40 feet (13 m).

Stacked Unit Deposits

Qlgb/Tsl

Lacustrine gravel and sand deposits over Salt LakeFormation (upper Pleistocene over Miocene) – Lacustrine gravel and sand deposited below the Lake Bonneville highstand over Salt Lake Formation; unit is mapped where lacustrine gravel and sand deposits overlie and partially obscure bedding in underlying Salt Lake Formation; thickness 0 to 6 feet (0–2 m).

TERTIARY

Tsl **Salt Lake Formation** (Miocene) – Tan, light-brown to pale-gray, or white, interbedded tuffaceous sandstone, limestone, calcareous sandstone, gritty or pebbly sandstone, sandy mudstone, siltstone, marl, and claystone; tuffaceous sandstone in the west-central part of the Vernon NE quadrangle is dominated by intervals 60 to 100 feet (20–30 m) thick of fine-grained, waterlain, reworked and cross-bedded, poorly consolidated sandy ash; elsewhere in the Vernon NE and Lofgreen quadrangles tuffaceous sandstones form interbeds between 3 and 10 feet (1–3 m) thick of planar or cross-bedded semiconsolidated sandy ash; limestone intervals are pale gray, medium- to thick-bedded, sandy, crystalline and locally silicified limestone; the base of the Salt Lake Formation is not exposed but unit likely rests in angular unconformity on Oquirrh Group rocks across much of the quadrangle; age in the study area is between 6.6 ± 0.03 and 9.8 ± 0.23 Ma based on tephra interpolations and correlations from Perkins and others (1998) (table 2), and in the adjoining Faust quadrangle, a detrital zircon sample yielded a maximum depositional age based on a single grain with an age of 6.49 ± 0.38 Ma (Utah Geological Survey and Apatite to Zircon Inc., 2013); unit crops out as topographically low hogbacks and knobs; faulting and folding complicate thickness estimates but continuous exposed thickness is up to 2850 feet (870 m); total thickness in the subsurface is 2800 to 4200 feet (850–1280 m) based on several drill holes along the Pony Express Road in the Vernon NE quadrangle (table 3).

PENNSYLVANIAN

IPo **Oquirrh Group, undivided** (Pennsylvanian) – Present in subsurface and shown only on cross sections; limestone, and interbedded sandy limestone, sandstone, and quartzite; reported beneath the Salt Lake Formation in three drill holes (table 3); age of unit is based on correlation with Oquirrh Group bedrock exposed in the adjoining Faust and Lofgreen quadrangles.

ACKNOWLEDGMENTS

I thank Don Clark and Barry Solomon of the UGS for discussions concerning the geology of the Vernon NE quadrangle. I also thank Jack Oviatt (Kansas State University) and Daren Nelson (University of Utah) for helpful discussions in the field regarding Lake Bonneville deposits in the Vernon NE quadrangle. UGS staff including Don Clark, Barry Solomon, Grant Willis, and Robert Ressetar provided important reviews of this map. I thank Richard Emerson, Jay Hill, and Kim Nay of the UGS for help with GIS, cartography, and construction of plates and figures.

REFERENCES

Numbers correspond to index map on plate 2.

[1]Allen, T., 2012, Mafic alkaline magmatism in the East Tintic Mountains, west-central Utah—implications for a late Oligocene transition from subduction to extension: Provo, Utah, Brigham Young University, M.S. thesis, 55 p., 2 plates, scale 1:24,000.

[2]Armin, R.A., and Moore, W.J., 1981, Geology of the southeastern Stansbury Mountains and southern Onaqui Mountains, Tooele County, Utah: U.S. Geological Survey Open-File Report 81-247, 2 sheets, scale 1:48,000.

Armstrong, R.L., 1968, Sevier orogenic belt in Nevada and Utah: Bulletin of the American Association of Petroleum Geologists, v. 79, p. 429–458.

[3]Barnhard, T.P., and Dodge, R.L., 1988, Map of fault scarps formed in unconsolidated sediments, Tooele 1° x 2° quadrangle, northwestern Utah: U.S. Geological Survey Miscellaneous Field Studies Map MF-1990, scale 1:250,000.

[4]Bucknam, R.C., 1977, Map of suspected fault scarps in unconsolidated deposits, Tooele 2° sheet, Utah: U.S. Geological Survey, Open-File Report 77-495, scale 1:250,000.

Burr, T.N., and Currey, D.R., 1988, The Stockton Bar, *in* Machette, M.N., editor, In the footsteps of G.K. Gilbert—Lake Bonneville and neotectonics of the eastern Basin and Range Province, Guidebook for Field Trip 12, Geological Society of America Annual Meeting, Denver, Colorado: Utah Geological and Mineral Survey Miscellaneous Publication 88-1, p. 66–7th3.

Burr, T.N., and Currey, D.R., 1992, Hydrographic modeling at the Stockton Bar, *in* Wilson, J.R., editor, Field guide to geologic excursions in Utah and adjacent areas of Nevada, Idaho, and Wyoming, for Geological Society of America Rocky Mountain Section Meeting, Ogden, Utah: Utah Geological and Mineral Survey Miscellaneous Publication 92-3, p. 207–219.

[5]Christie-Blick, N., 1983, Structural geology of the Sheeprock Mountains, *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. 101–124.

[6]Clark, D.L., Kirby, S.M., and Oviatt, C.G., 2012, Interim geologic map of the Rush Valley 30' x 60' quadrangle, Tooele, Utah, and Salt Lake Counties, Utah: Utah Geological Survey Open-File Report 593, 65 p., 1 plate, scale 1:62,500.

[7]Cohenour, R.E., 1959, Sheeprock Mountains, Tooele and Juab Counties—Precambrian and Paleozoic stratigraphy, igneous rocks, structure, geomorphology, and economic geology: Utah Geological and Mineralogical Survey Bulletin 63, 201 p.

Constenius, K.N., 1996, Late Paleogene extensional collapse of the Cordilleran foreland fold and thrust belt: Geological Society of America Bulletin, v. 108, p. 20–39.

Constenius, K.N., Esser, R.P., and Layer, P.W., 2003, Extensional collapse of the Charleston-Nebo salient and its relationship to space-time variations in Cordilleran orogenic belt tectonism and continental stratigraphy, *in* Raynolds, R.G., and Flores, R.M., editors, Cenozoic systems of the Rocky Mountain region: Denver, Rocky Mountain Section, Society of Economic Paleontologists and Mineralogists, p. 303–353.

[8]Copfer, T.J., and Evans, J.P., 2005, Provisional geologic map of the Deseret Peak East 7.5' quadrangle, Tooele County, Utah: Utah Geological Survey Open-File Report 450, 32 p., 3 plates, scale 1:24,000, CD.

Currey, D.R., 1982, Lake Bonneville—selected features of relevance to neotectonic analysis: U.S. Geological Survey Open-File Report 82-1070, 30 p., scale 1:500,000.

DeCelles, P.G., and Coogan, J.C., 2006, Regional structure and kinematic history of the Sevier fold-and-thrust belt, central Utah: Geological Society of America Bulletin, v. 118, p. 841–864.

[9]Disbrow, A.E., 1957, Preliminary geologic map of the Fivemile Pass quadrangle, Tooele and Utah Counties, Utah: U.S. Geological Survey Mineral Investigations Map MF-131, scale 1:24,000.

[10]Disbrow, A.E., 1961, Geology of the Boulter Peak quadrangle, Tooele and Utah Counties, Utah: U.S. Geological Survey Geologic Quadrangle map GQ-141, 2 plates, scale 1:24,000.

[11]Everitt, B.L., and Kaliser, B.N., 1980, Geology for the assessment of seismic risk in the Tooele and Rush Valleys, Tooele County, Utah: Utah Geological and Mineral Survey Special Study 51, 33 p.

Gardner, P., and Kirby, S.M., 2011, Hydrogeologic and geochemical characterization of groundwater resources of Rush Valley, Tooele County, Utah: U.S. Geological Survey Scientific Investigations Report 2011-5068, 68 p.

[12]Gilbert, G.K., 1890, Lake Bonneville: U.S. Geological Survey Monograph 1, 438 p.

[13]Gilluly, J., 1932, Geology and ore deposits of the Stockton and Fairfield quadrangles, Utah: U.S. Geological Survey, Professional Paper 173, 171 p.

[14]Groff, S.L., 1959, Geology of the West Tintic Range and vicinity, Tooele and Juab Counties, Utah: Salt Lake City, University of Utah, Ph.D. dissertation, 183 p.

[15]Heylmun, E.B., 1965, Reconnaissance of Tertiary sedimentary rocks in western Utah: Utah Geological and Mineralogical Survey Bulletin 75, 2 plates, 38 p.

Hood, J.W., Price, D., and Waddell, K.M., 1969, Hydrologic reconnaissance of Rush Valley, Tooele County, Utah: Utah Department of Natural Resources Technical Publication 23, 63 p.

[16]Kirby, S.M., 2010a, Interim geologic map of the Vernon NE quadrangle, Tooele County, Utah: Utah Geological Survey Open-File Report 562, 10 p., scale 1:24,000, CD.

[17]Kirby, S.M., 2010b, Interim geologic map of the Lofgreen quadrangle, Tooele County, Utah: Utah Geological Survey Open-File Report 563, 17 p., 2 plates, scale 1:24,000, CD.

[18]Kirby, S.M., 2010c, Interim geologic map of the Vernon quadrangle, Tooele County, Utah: Utah Geological Survey Open-File Report 564, 18 p., 2 plates, scale 1:24,000, CD.

[19]Kirby, S.M., 2010d, Interim geologic map of the Saint John quadrangle, Tooele County, Utah: Utah Geological Survey Open-File Report 572, 11 p., 2 plates, scale 1:24,000, CD.

[20]Kirby, S.M., 2010e, Interim geologic map of the Faust quadrangle, Tooele County, Utah: Utah Geological Survey Open-File Report 573, 12 p., 2 plates, scale 1:24,000, CD.

[21]Kirby, S.M., 2012, Geologic map of the Ophir quadrangle, Tooele County, Utah: Utah Geological Survey Digital Map 257DM, 2 plates, 1:24,000 scale, 13 p.

Mabey, D.R., and Morris, H.T., 1967, Geologic interpretation of gravity and aeromagnetic maps of Tintic Valley and adjacent areas, Tooele and Juab Counties, Utah: U.S. Geological Survey Professional Paper 516-d, 15 p.

Miller, D.M., Oviatt, C.G., and McGeehin, J.P., 2012, Stratigraphy and chronology of Provo shoreline deposits and lake-level implications, Late Pleistocene Lake Bonneville, eastern Great Basin, USA: Boreas, p. 1–20, DOI 10.1111/j.1502-3885.2012.00297.x.

[22]Moore, W.J., and McKee, E.H., 1983, Phanerozoic magmatism and mineralization in the Tooele 1- x 2-degree quadrangle, Utah, *in* Miller, D.M., Todd, V.R., Howard, K.A., and Crittenden M.D., editors, Tectonic and stratigraphic studies in the eastern Great Basin: Geological Society of America Memoir 157, p. 183–190.

[23]Moore, W.J., Sorensen, M.L., and Armin, R.A., 1978, Reconnaissance geologic map of Onaqui Mountains South quadrangle, Tooele County, Utah: U.S. Geological Survey MF-921, 2 sheets, scale 1:48,000.

[24]Moore, W.J., and Sorensen, M.L., 1979, Geologic map of the Tooele 1° x 2° quadrangle: U.S. Geological Survey Miscellaneous Geologic Investigations I-1132, scale 1:250,000, 1 plate.

[25]Mukul, M., and Mitra, G., 1998, Geology of the Sheeprock thrust sheet, central Utah, new insights: Utah Geological Survey Miscellaneous Publication 98-1, 56 p.

[26]Nelson, D.T., 2012, Geomorphic and stratigraphic development of Lake Bonneville's intermediate paleoshorelines during the late Pleistocene: Salt Lake City, University of Utah, Ph.D. dissertation, 213 p., 2 plates, map scale 1:24,000.

[27]Pampeyan, E.H., 1989, Geological map of the Lynndyl 30- x 60-minute quadrangle, west-central Utah: U.S. Geological Survey Miscellaneous Investigations Map I-1830, scale 1:100,000.

Perkins, M.E., Brown, F.H., Nash, W.P., McIntosh, W., and Williams, S.K., 1998, Sequence, age, and source of silicic fallout tuffs in the middle to late Miocene basins of the northern Basin and Range Province: Geological Society of America Bulletin, v. 110, p. 344–360.

Reimer, P.J., Baillie, M.G., Bard, E., Bayliss, A., Beck, J.W., Blackwell, P.G., Bronk, A., Ramsey, C., Buck, C.E., Burr, G.S., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Hajdas, I., Heaton, T.J., Hogg, A.G., Hughen, K.A., Kaiser, K.F., Kromer, B., McCormac, F.G., Manning, S.W., Reimer, R.W., Richards, D.A., Southon, J.R., Talamo, S., Turney, C.S.M., van der Plicht, J., and Weyhenmeyer, C.E., 2009, IntCal09 and Marine09 radiocarbon age calibration curves, 0–50,000 years cal BP: Radiocarbon v. 51, no. 4, p. 1111–1150.

[28]Solomon, B.J., 1993, Quaternary geologic maps of Tooele Valley and the West Desert Hazardous Industry Area, Tooele County, Utah: Utah Geological Survey Open-File Report 296, 48 p., 20 plates, scale 1:24,000.

[29]Tooker, E.W., 1987, Preliminary geologic maps, cross sections, and explanation pamphlet for the Ophir and Mercur 7½-minute quadrangles, Utah: U.S. Geological Survey Open-File Report 87-152, 3 plates, scale 1:24,000.

[30]Tooker, E.W., and Roberts, R.J., 1992, Preliminary geologic map of the Stockton 7½-minute quadrangle, Tooele County, Utah: U.S. Geological Survey Open-File Report 92-385, 22 p., 1 plate, scale 1:24,000.

[31]Tooker, E.W., and Roberts, R.J., 1998, Geologic map of the Oquirrh Mountains and adjoining south and western Traverse Mountains, Tooele, Salt Lake, and Utah Counties, Utah: U.S. Geological Survey Open-File Report 98-581, 2 sheets, scale 1:50,000.

[32]URS Greiner Woodward Clyde, 1999, Mapping and Quaternary fault scarp analysis of the Mercur and West Eagle Hill faults, Wasatch Front, Utah: Oakland, California, unpublished consultant's report for the U.S. Geological Survey under award number 1434-HQ-97-GR-03154, variously paginated, 3 appendices.

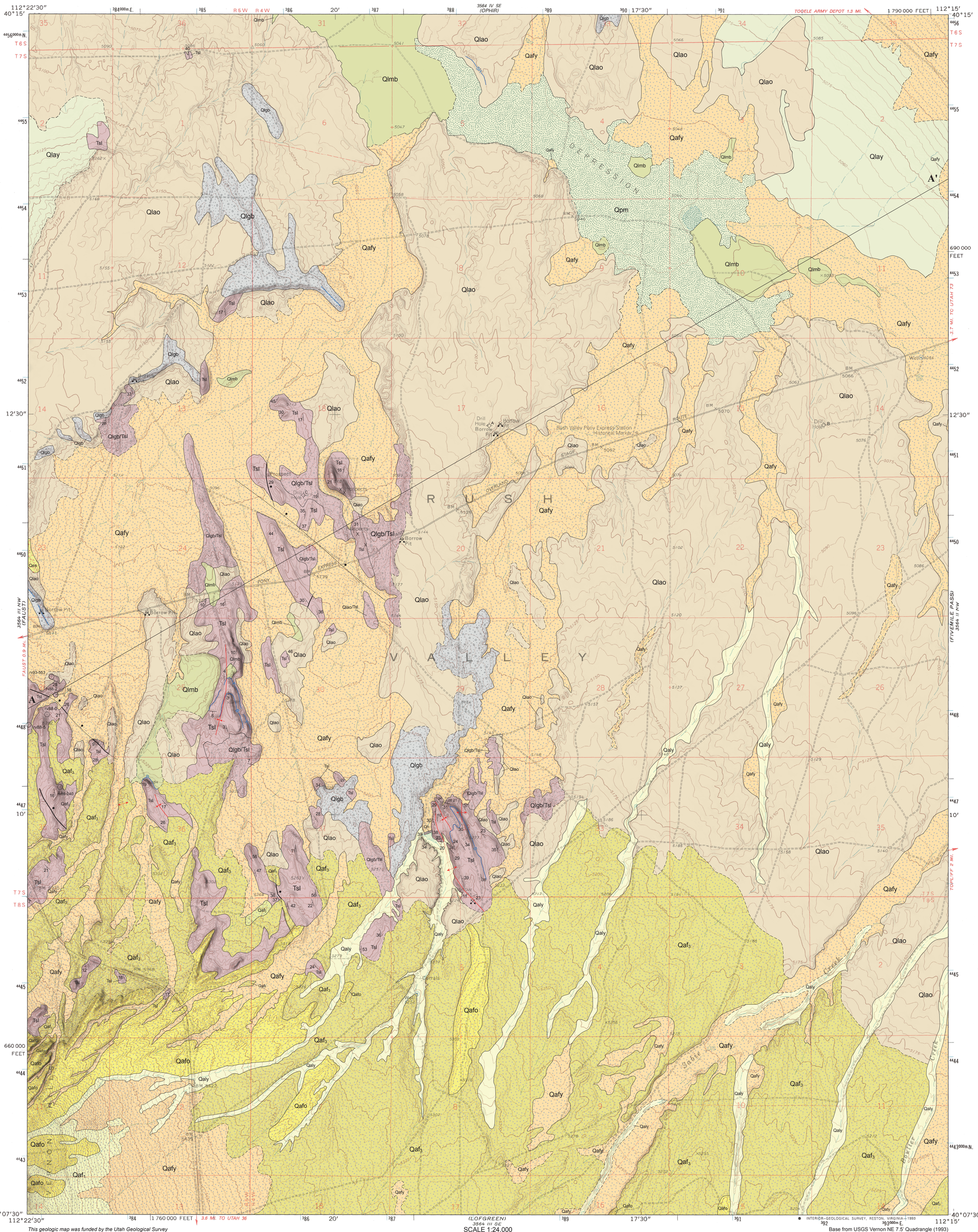
Utah Division of Oil, Gas, and Mining, 2009, online, <http://oilgas.ogm.utah.gov/Data_Center/LiveData_Search/main_menu.htm>, accessed April 2009.

Utah Division of Water Rights, 2009, Well-drilling database: online, <http://nrwrt4.waterrights.utah.gov/download/wrpod.exe>, Utah Division of Water Rights, accessed February 2009.

Utah Geological Survey and Apatite to Zircon, Inc., 2013, U-Pb zircon geochronology results for the Davis Knolls, Faust, Ophir, and Vernon quadrangles, Utah: Online, Utah Geological Survey Open-File Report 608, variously paginated, http://geology.utah.gov/online/ofr/ofr-608.pdf.

[33]Wu, D., and Bruhn, R.L., 1994, Geometry and kinematics of active normal faults, South Oquirrh Mountains, Utah—implication for fault growth: Journal of Structural Geology, v. 16, p. 1061–1075.

UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources



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 G09AC00152.

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, expressed 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 0.5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 0.5 0 1 KILOMETER

CONTOUR INTERVAL 5 FEET

UTAH
QUADRANGLE LOCATION

GEOLOGIC MAP OF THE VERNON NE QUADRANGLE, TOOELE COUNTY, UTAH

by

Stefan M. Kirby

2013

TRUE NORTH
MAGNETIC NORTH
11°56′
APPROXIMATE MEAN DECLINATION, 2012

1	2	3
4		5
6	7	8

1. Saint John
2. Ophir
3. Mercur
4. Faust
5. Five Mile Pass
6. Vernon
7. Lofgreen
8. Boulter Peak

ADJOINING 7.5′ QUADRANGLE NAMES

Base from USGS Vernon NE 7.5′ Quadrangle (1993)
Projection: UTM Zone 12
Datum: NAD 1927
Spheroid: Clarke 1886

Project Manager: Donald L. Clark
GIS and Cartography: Jay C. Hill, Richard L. Emerson

Utah Geological Survey
1594 West North Temple, Suite 3110
P.O. Box 146100, Salt Lake City, UT 84114-6100
(801) 537-3300
geology.utah.gov

This map was created from Geographic Information System (GIS) data.

ISBN 978-1557918871

Table 1. *Ages and elevations of major shorelines of Lake Bonneville in Rush Valley.*

Lake Cycle and Phase	Shoreline (map symbol)	Age: radiocarbon years (^{14}C yr) B.P.	Age: calendar-calibrated years B.P.	Elevation feet (meters)
Lake Bonneville				
Transgressive Phase	Bonneville (B)	14,800[1]	18,000[2]	5210–5250 (1587–1600)
	flood			
Regressive Phase[4]	Shambip[3] (SH)	14,300–13,300[4]	17,400–16,200[2]	5050 (1534)
	Smelter Knolls[3]	age not constrained[4]		not present

[1] Miller and others (2012).
[2] All calendar calibration made using OxCal ^{14}C calibration and analysis software (Reimer and others, 2009).
[3] Burr and Currey (1988, 1992) reported that regressive-phase shorelines in Rush Valley fluctuated independently from the main body of Lake Bonneville subsequent to construction of the Stockton Bar and lowering of the lake level below this threshold following the Lake Bonneville flood. Both the Shambip and Smelter Knolls lake levels (~5050' [1539m] and ~5010' [1527m] respectively) form erosional shorelines in transgressive Bonneville deposits near Stockton and must therefore have occurred at sometime following the initial regression of Lake Bonneville.
[4] Nelson, (2012)

Table 2. *Tephra correlation and interpolation ages from Perkins and others (1998) for the Salt Lake Formation in the Vernon NE quadrangle. For detailed data and correlation and interpolation methodology see Perkins and others (1998).*

Sample	East[1]	North[1]	Quadrangle	Age (Ma)	Age error (Ma)	Type
rv88-2	383255	4448328	Vernon NE	7.05	0.03	interpolation
rv88-0	383152	4448102	Vernon NE	9.82	0.23	interpolation
rv88-5	382937	4447985	Vernon NE	9.61	0.15	interpolation
rv89-240	383289	4447262	Vernon NE	9.22	0.04	correlation Ar/Ar
rv93-553	383209	4448538	Vernon NE	6.66	0.03	correlation Ar/Ar

[1]Coordinates in UTM NAD 27 zone 12 N

Table 3. *Petroleum exploration drill holes shown on map and cross section. Elevations, depths, and thickness are in feet.*

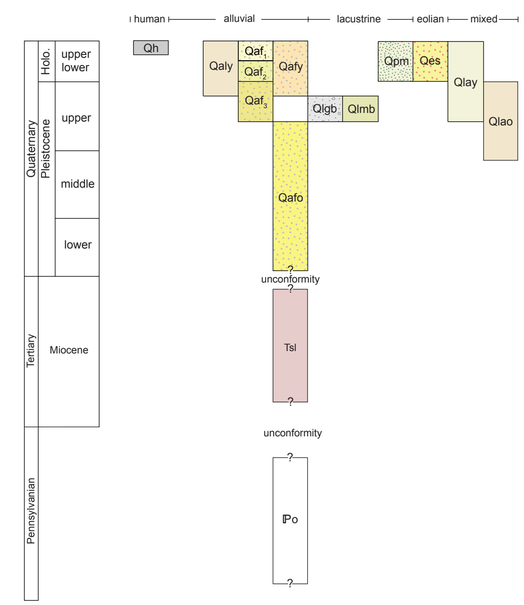
ID[1]	East[2]	North[2]	Elevation[3]	Name	API[4]	Basin fill thickness	Total depth	Bottom Lithology
A	388305	4451367	5107	Lab Energy 17-10	4304530017	4217	7132	Oquirrh Group
B	392115	4451323	5071	Lab Energy 14-12	4304530019	3530	4046	Oquirrh Group
C	386165	4450591	5108	Lab Energy 19-3	4304530020	2780	3250	Oquirrh Group

[1]ID corresponds to those on map and cross section
[2]easting and northing coordinates are in NAD 27 UTM zone 12 N
[3]land surface elevation, in feet, at well site
[4]API number, logs available from the Utah Division of Oil, Gas, and Mining (2009)

GEOLOGIC MAP SYMBOLS

- Contact - Dashed where approximately located
- Normal fault - Dotted where concealed; bar and ball on down-thrown block
- Fault - Dotted where concealed; relative motion unknown
- Anticline axis - Dotted where concealed
- Syncline axis - Dotted where concealed
- Lake Bonneville Shorelines –
  - B — Highest shoreline of the Bonneville (transgressive) phase
  - Y — Other transgressive shorelines of the Bonneville phase
  - SH — Highest shoreline of the Shambip Lake
- Beach ridge crest
- 19 — Strike and dip of inclined bedding
- A — Drill hole - Shown on the Vernon NE quadrangle and cross section
- rv88-2 — Tephra age sample site - Number corresponds with table 2; data from Perkins and others, 1998
- Sand and gravel pit
- Water well
- X — Prospect
- A A' — Line of cross section

CORRELATION OF UNITS

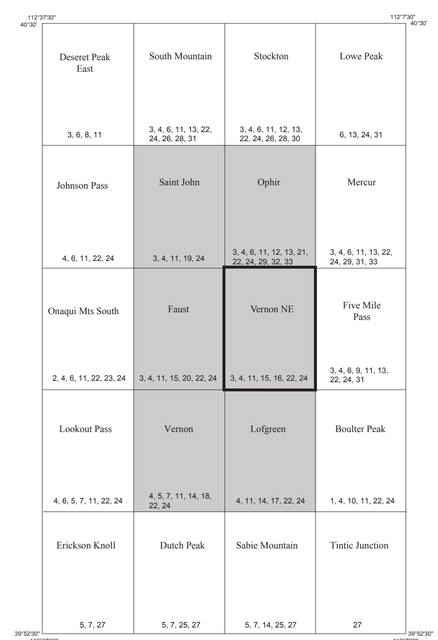
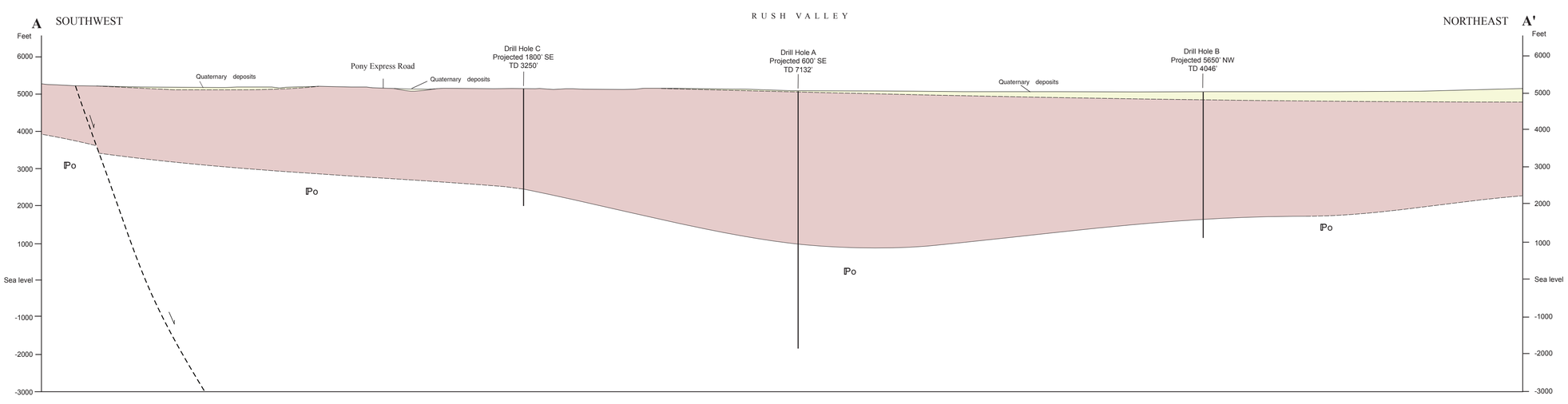


Soft sediment deformation in reworked tephra deposits in the Tertiary Salt Lake Formation.

Shallow-dipping tuffaceous sandstone of the Salt Lake Formation exposed in the Vernon NE quadrangle.

LITHOLOGIC COLUMN

Era	System	Series and Stage	Formation	Map Unit	Thickness feet (meters)	Lithology
Cenozoic	Tertiary	Miocene	Salt Lake Formation	Tsl	>2850 (870)	unconformity
Paleo.	Penn.	?	Oquirrh Group, undivided	IPo	>3000 (1000)	



Index to U.S. Geological Survey 7.5-minute quadrangles, and sources of geologic information (refer to numbered list). Gray color includes quadrangles mapped for this project. Numbers correspond to references in the text.