GEOLOGIC MAP OF THE SAINT JOHN QUADRANGLE, TOOELE COUNTY, UTAH

by Stefan M. Kirby

MAP 264DM
UTAH GEOLOGICAL SURVEY
a division of
UTAH DEPARTMENT OF NATURAL RESOURCES
2013

GEOLOGIC MAP OF THE SAINT JOHN QUADRANGLE, TOOELE COUNTY, UTAH

by Stefan M. Kirby

SCALE: 1:24,000

Cover photo: *View to the southwest across the Saint John quadrangle. The quadrangle covers most of the valley floor in the foreground and the snowcapped Onaqui Mountains in the distance.*

ISBN: 978-1-55791-885-7

MAP 264DM
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

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 G10AC00386. 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

GEOLOGIC MAP OF THE SAINT JOHN QUADRANGLE, TOOELE COUNTY, UTAH

by Stefan M. Kirby

INTRODUCTION

Location and Geographic Setting

The Saint John quadrangle covers part of Rush Valley in southeastern Tooele County, Utah (plate 1). State Highway 36 runs roughly north to south across the eastern part of the quadrangle. State Highway 199 runs east to west through the communities of Clover and Rush Valley near the center of the quadrangle. The community of Saint John is along the Mormon Trail Road in the northwest part of the quadrangle. Clover Creek flows to the east parallel to State Highway 199. The grounds of the Tooele Army Depot South Area cover part of the quadrangle along its eastern boundary.

Scope of Work

The Saint John quadrangle was mapped in conjunction with adjoining Faust quadrangle to the south as part of the 2010 US Geological Survey STATEMAP award number G10AC00386 made to the Utah Geological Survey (UGS). This geologic map continues geologic mapping in the adjacent Vernon NE, Lofgreen, Vernon, Faust, and Ophir quadrangles (see Kirby, 2010a, b, c, and d; Kirby, 2012), and was completed 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 1:24,000-scale Saint John 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 Saint John quadrangle during the spring of 2010.

Previous Investigations and Mapping Background

Several investigators mapped the geology of the Saint John quadrangle at various scales smaller (less detailed) than 1:24,000, including Bucknam (1977), Moore and Sorensen (1979), and Everitt and Kaliser (1980). Several adjoining quadrangles to the south and east have been mapped at 1:24,000 scale (Kirby, 2010a, b, c, and d; Kirby 2012) and areas to the north have been mapped recently at 1:62,500 scale (Clark and others, 2012). Perkins and others (1998) provided age control for the Salt Lake Formation using an ash correlation methodology for several sites in the adjacent Faust and Vernon NE quadrangles. Adjoining mapping relevant to both bedrock and unconsolidated deposits includes Gilluly (1932), Disbrow (1957), Cohenour (1959), Groff (1959), Armin and Moore (1981), 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 Saint John quadrangle.

Geologic Summary

Sedimentary rocks exposed in the quadrangle include Pennsylvanian bedrock of the Oquirrh Group and consolidated Tertiary basin fill of the Salt Lake Formation. Pennsylvanian-age Oquirrh Group bedrock of the Butterfield Peaks Formation(?) crops out at a single location in the southwest corner of the quadrangle where these rocks dip to the northwest. Oquirrh Group bedrock in adjoining quadrangles is structurally complicated by folds and faults. Basin fill of the Salt Lake Formation(?) crops out just north of Saint John and at small exposures in the west central part of the quadrangle and along the eastern edge of the quadrangle. Based on gravity data and well logs (Everitt and Kaliser, 1980; Pan-American Center for Earth and Environmental Studies, 2010; Utah Division of Water Rights, 2010), the Salt Lake Formation underlies unconsolidated surficial deposits across at least the eastern two-thirds of the quadrangle.

Unconsolidated surficial deposits of Holocene to early(?) Pleistocene age, and possibly late Pliocene age, cover nearly the entire the quadrangle. These deposits include various alluvial fan and channel sediments, and lacustrine units deposited during both the transgression and regression of Lake Bonneville. Below the elevation of ~5220 feet (1590 m) Rush Valley was isolated from the main body of lake Bonneville by Stockton Bar. Following regression of Lake Bonneville below this level, Rush Valley hosted at least two unique lake elevation shorelines (Burr and Currey, 1988, 1992). The western quarter of the quadrangle is above the highstand of Lake Bonneville and consists of east-sloping alluvial-fan and fluvial channel deposits. The remainder of the quadrangle is characterized by a mix of alluvial, fluvial, and lacustrine deposits. Unconsolidated lacustrine deposits related to the transgression and regression of Lake Bonneville are mapped below the elevation (5230 feet [1594 m] above sea level) of a prominent erosional shoreline located south of Clover. Elsewhere shoreline features related to the Lake Bonneville highstand are mapped at elevations between 5240 feet (1597 m) in the north and 5220 feet (1591 m) in the south part of the quadrangle. Shoreline features are absent across much of the central part of the quadrangle. A prominent regressional lake level (Shambip level [Burr and Currey, 1988, 1992]), unique to Rush Valley and below the Lake Bonneville highstand, is located near the 5050 foot (1539 m) elevation. Deposits relating to this lake level include erosional benches, constructional barriers and spits, and correlative lagoon fill deposits in the central and eastern parts of the quadrangle.

Normal faults cut unconsolidated deposits in the western half and northeast corner of the quadrangle. Faults of the “Saint John Station fault zone” (U.S. Geological Survey and Utah Geological Survey, 2006) offset late Pleistocene mixed alluvial and lacustrine and alluvial-fan deposits. Conjugate normal faults form a prominent horst and series of west-facing scarps in late Pleistocene mixed alluvial and lacustrine deposits. Scarp heights are between 3 and 30 feet (1–10 m), and the largest scarp forms the western margin of this significant horst block. Upper Pleistocene shoreline deposits related to the 5050 foot (1539 m) Lake Shambip level overlap scarps that form the prominent horst block, and none of these scarps appear to offset deposits younger than late Pleistocene. Numerous scarps in the western part of the study area near the communities of Clover and Saint John generally occur in a north-south-trending belt. The northern series of scarps near Saint John is part of the “South Mountain marginal fault” discussed by Everitt and Kaliser (1980), and the southern scarps are the northern part of the “Clover Fault Zone” (U.S. Geological Survey and Utah Geological Survey, 2006). The “South Mountain marginal fault” near Clover and Saint John is a zone of three to four subparallel, down-to-the-east fault scarps, each with heights ranging between 3 and 9 feet (1–3 m). These faults cut both transgressive lacustrine deposits of the Lake Bonneville highstand (unit Qlao) and alluvial fans (units Qafo, Qafy, Qaf_3, and Qaf_2) that may be as young as early Holocene. Faults of the “Clover fault zone” cut late Pleistocene and older alluvial fan deposits (units QTaf, Qafo, and Qaf_3) in the western part of the quadrangle. Most of these scarps face to the east and scarp heights range between 3 and 20 feet (1–7 m). Trenching studies of both the “Clover fault zone” and the “South Mountain marginal fault” have not been performed, and numerical age control is lacking for surface faulting along both of these fault zones.

Rush Valley area gravity data suggest that several thousand feet of basin fill, consisting primarily of Salt Lake Formation, overlies bedrock near the center of the quadrangle east of Clover (Everitt and Kaliser, 1980; Pan-American Center for Earth and Environmental Studies, 2010). The total thickness of basin fill is unconstrained by well data in the quadrangle, but correlation of gravity anomalies in the quadrangle with those in areas of known basin depth in the adjoining Vernon NE quadrangle indicates a total thickness of up to 4200 feet (1280 m) (plate 2). The thickness of unconsolidated sediment fill is greatest near the center of the quadrangle. Water well drill holes near the center of the quadrangle encounter at least 1100 feet (336 m) of unconsolidated sediment without the presence of the Salt Lake Formation (Utah Division of Water Rights, 2010). Unconsolidated deposits and basin fill likely thin westward across the quadrangle and may rest directly on Oquirrh Group bedrock near the western quadrangle boundary.

The early tectonic history of the quadrangle is recorded by exposed Pennsylvanian-age strata that were deposited within the rapidly subsiding Oquirrh basin (Geslin, 1998). These rocks were then folded and faulted by dominantly east-directed thrust faulting and compression during the Late Jurassic to Eocene Sevier orogeny (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, and Onaqui Mountain South quadrangles (Groff, 1959; Armin and Moore, 1981; Kirby, 2010b and c). During the Eocene, crustal shortening was replaced by roughly east-west extension and significant regional volcanism (Constenius, 1996; Constenius and others, 2003). Pennsylvanian-age bedrock is overlain by a thick section of basin fill deposited during Miocene to Holocene Basin-and-Range extension. Extension remains the dominant tectonic style in the area, but it has varied in magnitude, style, and extent through Eocene to Holocene time (Stewart, 1998). Major pulses of extension, during the Miocene and possibly the Pliocene, correlate with deposition and deformation (faulting and folding) of the Salt Lake Formation (Perkins and others, 1998). Subsequent extension has controlled deposition of unconsolidated sediments and surface faulting during the Quaternary (Everitt and Kaliser, 1980).

MAP UNIT DESCRIPTIONS

QUATERNARY

Human Disturbance

Qh **Fill and disturbed areas** (Historical) – Excavations and fill, soil disturbance, and associated fill at part of the Tooele Army Depot South Area along the east margin of the quadrangle, fill along major roads, railroads, and several earthen dams; mapped where surficial grading, road building, excavations, and associated fill obscure the underlying unconsolidated deposits; material includes sand, gravel, angular cobble-size clasts, silt, and clay; variable thickness 0 to 50 feet (0–15 m).

Alluvial Deposits

Qaly **Younger alluvial deposits** (Holocene to upper Pleistocene) – Moderately to well-sorted sand, pebble and cobble gravel, silt, and minor clay; deposited along the major drainage on the valley floor; locally includes small alluvial-fan and colluvial deposits; mapped along incised drainages where alluvial deposits cannot be differentiated because of map scale or in areas where the specific age of Holocene deposits cannot be determined; postdates regression of Lake Bonneville; thickness variable, probably less than 15 feet (5 m).

Qat **Stream-terrace deposits** (middle Holocene to upper Pleistocene) – Moderately to well-sorted sand, pebble and cobble gravel, silt, and minor clay; deposited as a gently sloping terrace along the south side of Clover Creek; includes inactive stream and flood-plain deposits; all terrace deposits lie 10 to 20 feet (3–6 m) above active stream and flood-plain levels; thickness varies from 5 to 20 feet (1.5–6 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 are angular to subrounded and commonly matrix supported; deposited principally by debris flows and sheet floods at the mouths of small, intermittent stream channels, and near the mouths of other channels in older alluvial-fan or lacustrine deposits 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 and deposition overlying or incised into other alluvial and lacustrine units; no fault scarps cut Qaf_1 deposits in the quadrangle; exposed thickness less than 10 feet (3 m).

Qaf_2 **Level-2 alluvial-fan deposits** (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 are 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 and lacustrine 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; south of Clover Creek Qaf_2 obscures Shambip shoreline; deposits grade above alluvial-fan level (Qaf_1); several fault scarps offset Qaf_2 fan surface southeast of Clover below the Bonneville highstand elevation; exposed thickness less than 15 feet (5 m).

Qaf_3 **Alluvial-fan deposits, Bonneville lake cycle, undivided** (upper Pleistocene) – Poorly to moderately sorted, crudely stratified or massive sand, pebble gravel, 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 and just below the Lake Bonneville highstand shoreline and exposures of Lake Bonneville sediments; deposition was contemporaneous with transgression, regression, and highstand of Lake Bonneville in Rush Valley; surface is incised by active drainages; forms extensive surface in western part of the quadrangle south of Clover Creek; fault scarps 6 to 9 feet (2–3 m) high cut Qaf_3 in the western half of the quadrangle south of Clover Creek; 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 are 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; mapped along much of the Clover Creek drainage; includes level-1 and -2 alluvial-fan deposits (Qaf_1 and Qaf_2) that postdate Lake Bonneville and the youngest part of alluvial fans deposited during Lake Bonneville regression (Qaf_3); also mapped in areas where the specific age of deposits that postdate the Lake Bonneville highstand cannot be determined; thickness variable, probably less than 40 feet (12 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; Qafo fans are etched by or overlain by shoreline deposits of the Lake Bonneville highstand; Qafo mapped in the northeast corner of the quadrangle is below the Lake Bonneville shoreline but lacks obvious lacustrine deposits; fan surface is generally more incised than younger fan deposits; Qafo alternately overlaps and is cut into oldest (QTaf) alluvial fans in the southwest and northwest parts of the quadrangle; unit is incised by and alternately overlain by syn- and post-Bonneville alluvial fan deposits (Qafy, Qaf_1, Qaf_2, and Qaf_3); thickness probably less than 60 feet (18 m).

Lacustrine Deposits

Qlgsh **Lacustrine gravel and sand deposits, Shambip lake level** (upper Pleistocene) – Moderately to well sorted, sub-rounded to rounded pebble gravel, sand, and minor silt; deposited as gravel bars and sheets at and below the Lake Shambip shoreline elevation (~ 5045 to 5060 feet [1538–1542 m]) in northern Rush Valley (Burr and Currey, 1992; Nelson, 2012); locally contains small gastropod shells; locally overlies and is inset in older lacustrine and or mixed units including Qlf and Qlao; unit is cut by and overlain by alluvial fans that postdate the Lake Bonneville highstand (Qafy); Qlgsh deposits lack overlying lacustrine fine-grained lacustrine deposits; age of Lake Shambip deposits ranges from 13,300 to 14,300 ^{14}C years BP (Nelson, 2012) for correlative deposits to the north in the South Mountain quadrangle; thickness is less than 25 feet (8 m).

Qllsh **Lacustrine lagoon deposits, Shambip lake level** (upper Pleistocene) – Light-colored, well-sorted silt, clay, sand, and marl; deposited leeward of barrier bars and spits of Qlgsh near the Shambip lake level (~5045 to 5060 feet [1538–1542 m]); unit overlies older mixed lacustrine and alluvial deposits (Qlao) and appears to interfinger with or be overlain by younger lacustrine deposits of unit Qlgsh; age of Lake Shambip deposits ranges from 13,300 to 14,300 ^{14}C years BP (Nelson, 2012) for correlative deposits to the north in the South Mountain quadrangle; sediment in this unit may also include alluvial material transported into areas bounded by barrier bars (Qlgsh); thickness is less than 20 feet (6 m).

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 bars and sheets at and below the Lake Bonneville highstand; deposited during the transgressive phase of Lake Bonneville; mapped where lacustrine gravel deposits cannot be correlated directly with the regressional Shambip shoreline above ~5045 to 5060 feet (1538–1542 m), mapped Qlgb in the southeast corner of quadrangle includes lacustrine gravels and sand west of Faust Creek that lack a defined Shambip shoreline but range in elevation from ~5040 to 5070 feet (1536–1545m); thickness is less than 40 feet (12 m).

Qlsb **Lacustrine sand deposits, transgressive phase of the Bonneville lake cycle** (upper Pleistocene) – Moderately to well-sorted sand, silt, and minor gravel, deposited in sheets at and below the Lake Bonneville highstand; mapped along a broad gently sloping shoreline platform south of Clover Creek and above the Lake Shambip shoreline; deposited during the transgressive and highstand phase of Lake Bonneville; thickness is less than 30 feet (10 m).

Qlmb **Lacustrine silt, clay, and marl, transgressive phase of the Bonneville lake cycle** (upper Pleistocene) – Light-colored, well-sorted silt, clay, marl, and very fine grained sand deposited in sheets and pods below the Lake Bonneville highstand; deposited during the transgressive phase of Lake Bonneville, mapped near the center of the quadrangle; thickness is less than 10 feet (3 m).

Qlf **Lacustrine fine-grained deposits, Bonneville lake cycle** (upper Pleistocene) – Light colored, poorly to moderately sorted silt, clay, marl, and very fine grained sand deposited below the Lake Bonneville highstand; unit is mapped along areas of the valley floor where surface is dominated by a variety of fine-grained lacustrine deposits either too thin or stratigraphically complex to map separately; includes fine-grained sediment probably deposited during both the transgressive and regressive phases of Lake Bonneville in Rush Valley; thickness is less than 30 feet (10 m).

Spring Deposits

Qsm **Spring and marsh deposits** (Holocene) – Moderately to well-sorted silt, sand, clay, and dark organic-rich material in areas of high water tables, perennial spring flow, and seasonal standing water in the quadrangle; mapped in several broad low-gradient areas and confined channels along the central valley floor with seasonal or perennial standing water and/or shallow groundwater; total thickness up to 30 feet (10 m).

Mixed-Environment Deposits

Qlay **Lacustrine deposits and younger alluvial-fan deposits, undivided** (Holocene to upper Pleistocene) – Poorly to well-sorted sand, silt, clay, gravel and marl; deposited below the Lake Bonneville highstand as smooth, sloping sheets of sediment; differentiated from Qlao by a lack of shoreline features and a relatively smooth and undissected surface topography similar to Qafy; includes a variety of lacustrine and alluvial facies either too complex or too poorly exposed to map; thickness less than 40 feet (12 m).

Qlao **Lacustrine deposits and older alluvial-fan de-**

posits, undivided (upper 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; contact with Qaf_3 syn-Bonneville alluvial fans is approximate; shorelines including the Shambip Lake level, the Lake Bonneville highstand level and various intermediate levels are mapped on Qlao; thickness less than 60 feet (18 m).

QUATERNARY-TERTIARY

QTaf **Oldest alluvial-fan deposits** (lower Pleistocene? to Pliocene?) – Poorly sorted boulder, cobble, and pebble gravel, sand, silt, and clay; unit composed of unconsolidated boulders, cobbles, and gravels; clasts include sandstone, limestone, and various Paleozoic carbonate rocks apparently sourced from bedrock exposed to the west in the Onaqui Mountains; QTaf is the highest standing alluvial-fan unit and is deeply incised by all younger alluvial fan units including Qafy and Qafo; in the southwest corner of the quadrangle QTaf mantles Oquirrh Group bedrock; fault scarps between 15 between 20 feet (5–7 m) abut QTaf; absolute age is unknown; thickness up to 300 feet (90 m).

TERTIARY

Tsl? **Salt Lake Formation?** (Miocene?) – White to pale-gray, consolidated, interbedded marl and siltstone; Tsl? is mapped at a poorly exposed outcrop near Saint John and at a single small outcrop along the eastern boundary of the quadrangle; unit is queried because of the limited exposures in the quadrangle and their unknown correlation with mapped Tsl in the adjoining Faust and Vernon NE quadrangles; the base of the Salt Lake Formation is not exposed, but it likely rests on underlying Paleozoic age rocks in angular unconformity; there are no direct ages for the Salt Lake Formation in the quadrangle, south of the study area in the adjoining Vernon NE and Faust quadrangles (Kirby, 2010a, d) the age of the Salt Lake Formation is between 6.6 ± 0.03 and 9.8 ± 0.23 Ma, based on tephra interpolations and correlations from Perkins and others (1998); thickness estimate is complicated by poor exposure and lack of direct measurement of the strike and dip, but exposed thickness could be up to 100 to 200 feet (30–60 m); total thickness in the subsurface is 3600 to 4200 feet (1100–1280 m) based on several drill holes along the Pony Express Road in the adjacent Vernon NE quadrangle (Kirby, 2010a).

PENNSYLVANIAN

IPobp? **Butterfield Peaks Formation of the Oquirrh Group?** (Middle to Lower Pennsylvanian [Desmoinesian-Morrowan]) – Interbedded, brown- to gray-weathering, fine- to medium-grained calcareous and quartzitic sandstone, and medium-gray, fine- to medium-grained limestone, sandy limestone, and minor siltstone; unit characterized by repeated intervals of quartzitic or calcareous sandstone overlain by intervals of gray limestone or sandy limestone; sandstone is typically light brownish gray and planar bedded, and locally displays low-angle cross-stratification and small-scale cross-bedding; both calcareous and quartzitic sandstone exist in nearly equal proportions; limestone intervals are typically medium gray, medium to thick bedded, commonly sandy with very fine to fine-grained sand; fossils include rugose corals, crinoids, brachiopods, fossil hash, and fusulinids in localized beds; locally contains black chert nodules and thin chert beds; limestone and sandy limestone commonly grade upward to finer grained, platy-weathering limestone and argillaceous limestone and siltstone; generally poorly exposed; forms slopes and ridge at a single isolated outcrop mantled by QTaf in the southwest corner of the quadrangle; age of Butterfield Peaks exposures in the Vernon Hills to the south is Atokan (Middle Pennsylvanian) (Kirby, 2010b and c); unit is queried in the quadrangle because of limited exposure and a lack of age control; incomplete exposed thickness in the quadrangle is roughly 300 feet (~100 m); Tooker and Roberts (1970) reported the formation is about 9000 feet (2740 m) thick in the Oquirrh Mountains.

ACKNOWLEDGMENTS

I thank Don Clark of the UGS and Jack Oviatt of Kansas State University for discussions concerning the geology of the Saint John quadrangle. UGS staff, including Don Clark, Grant Willis, and Robert Ressetar, provided important reviews of this map. I thank Jay Hill and Rich Emerson 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, 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 Moun-

tains, 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. 66–73.

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.

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.

Geslin, J.K., 1998, Distal ancestral Rocky Mountains tectonism—evolution of the Pennsylvanian-Permian Oquirrh–Wood River basin, southern Idaho: Geological Society of America Bulletin, v. 110, no. 5, p. 644–663.

[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., 2 plates, map scale 1:62,500.

[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., 4 plates, map scale 1:21,120.

[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., 2 plates, scale 1:24,000.

[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.

[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.

[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.

[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.

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 Series Map I-1132, 1 plate, scale 1:250,000.

[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.

Pan-American Center for Earth and Environmental Studies, 2010, GeoNet—United States Gravity Data Repository System: University of Texas El Paso Pan-American Center for Earth and Environmental Studies: Online, http://paces.geo.utep.edu/gdrp, accessed February 2010.

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.

Stewart, J.H., 1998, Regional characteristics, tilt domains, and extensional history of the late Cenozoic Basin and Range Province, western North America, *in* Faulds, J.E, and Stewart, J.H., editors, Accommodation zones and transfer zones—The regional segmentation of the Basin and Range Province: Geological Society of America Special Paper 323, p. 47–74.

[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.

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, M., Jr., and Duncan, H.M.,: U.S. Geological Survey Professional Paper 629-A, 76 p.

[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.

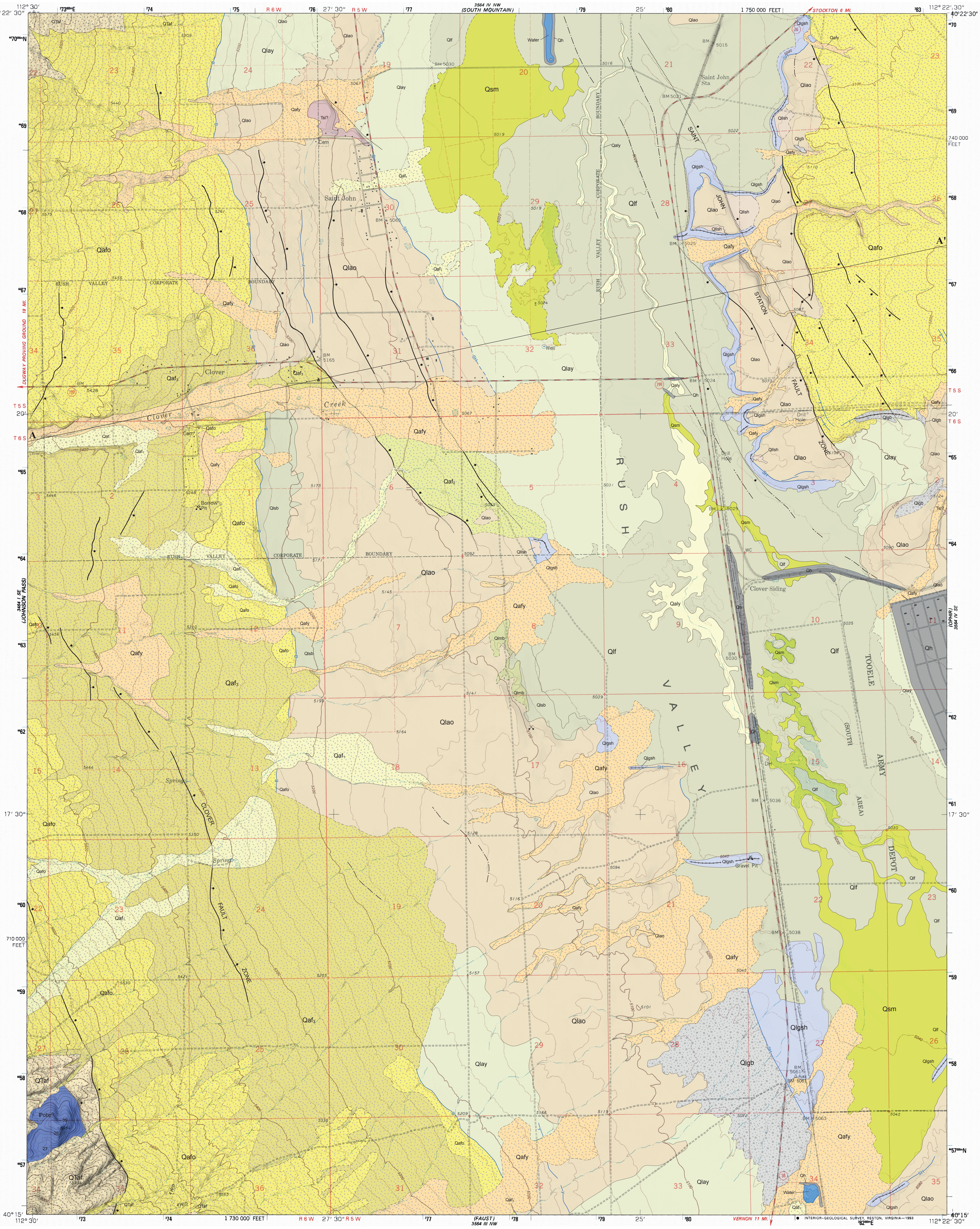
[31]Tooker, E.W., and Roberts, R.J., 1998, Geologic map of the Oquirrh Mountains and adjoining south and western Traverse Mountains, Tooele, Salt Lake, and Utah Counties, Utah: U.S. Geological Survey Open-File Report 98-581, 2 sheets, scale 1:50,000.

[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.

U.S. Geological Survey and Utah Geological Survey, 2006, Quaternary fault and fold database for the United States: Online, http//earthquakes.usgs.gov/regional/qfaults/, accessed June 2013.

Utah Division of Water Rights, 2010, Well-drilling database: Online, http://nrwrt4.waterrights.utah.gov/download/wrpod.exe, Utah Division of Water Rights, accessed February 2010.

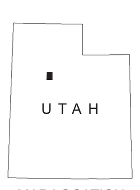
[33]Wu, D., and Bruhn, R.L., 1994, Geometry and kinematics of active normal faults, South Oquirrh Mountains, Utah—implication for fault growth: Journal of Structural Geology, v. 16, p. 1061–1075.



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 G10AC00386.

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, 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.



MAP LOCATION

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

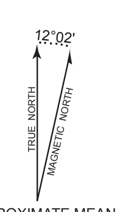
CONTOUR INTERVAL 20 FEET
SUPPLEMENTARY CONTOUR INTERVAL 10 FEET

GEOLOGIC MAP OF THE SAINT JOHN QUADRANGLE, TOOELE COUNTY, UTAH

by

Stefan M. Kirby

2013



APPROXIMATE MEAN DECLINATION, 2013

1	2	3
4		5
6	7	8

1. Deseret Peak East
2. South Mountain
3. Stockton
4. Johnson Pass
5. Ophir
6. Onaqui Mountains South
7. Faust
8. Vernon NE

ADJOINING 7.5' QUADRANGLE NAMES

Base from USGS Saint John 7.5' Quadrangle (1993)
Projection: UTM Zone 12
Datum: NAD 1927
Spheroid: Clarke 1866

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

ISBN 978-1557918857

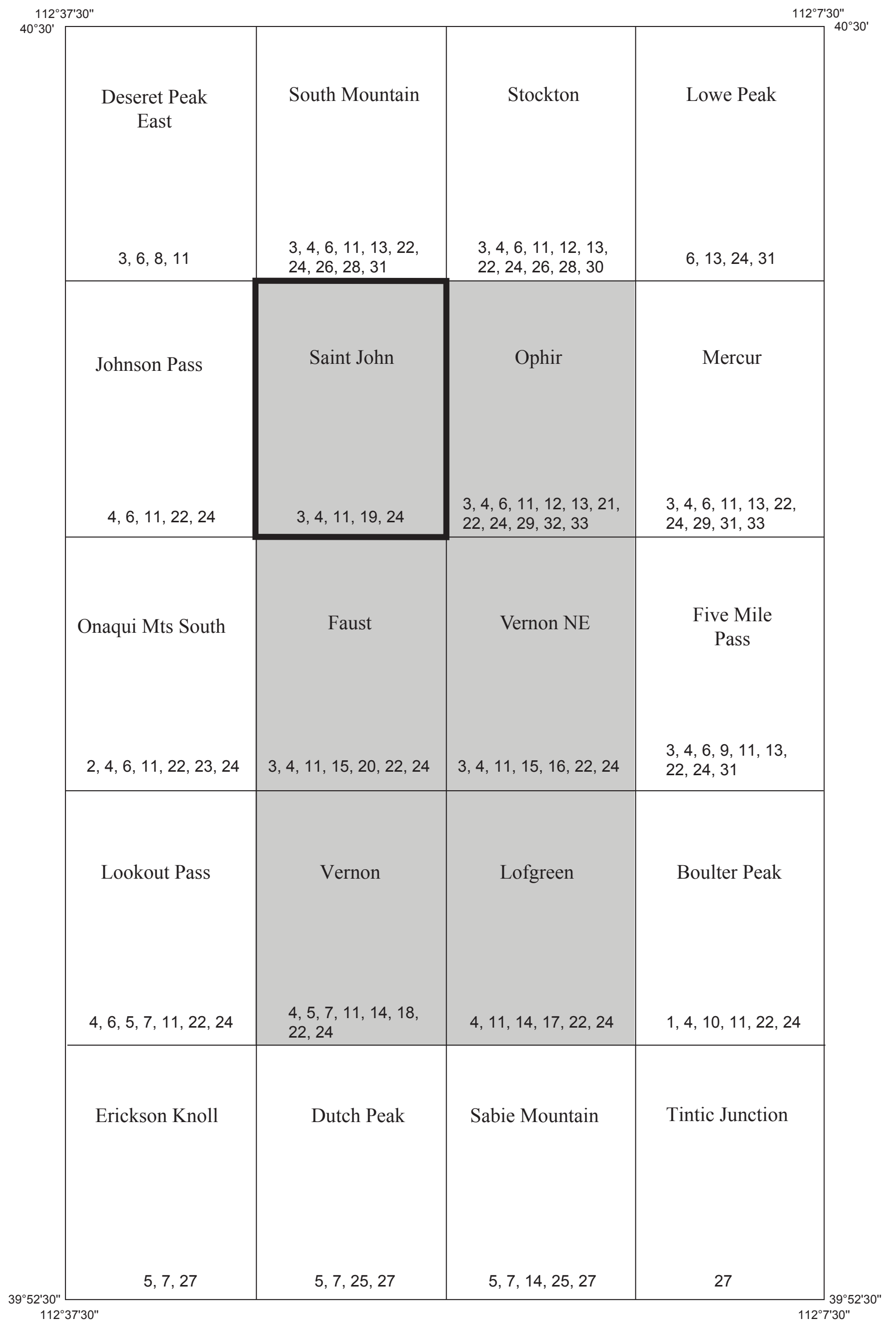
UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources

LITHOLOGIC COLUMN

Era	System	Series and Stage		Formation		Map Unit	Exposed Thickness feet (meters)	Lithology
Cen.	Tertiary	Miocene		Salt Lake Formation?		Tsl?	100-200 (30-60)	
								unconformity
Paleozoic	Pennsylvanian	Lower - Middle	Morrowan to Desmoinesian	Oquirrh Group	Butterfield Peaks Formation?	IPobp?	~300 (~100)	

GEOLOGIC MAP SYMBOLS

Contact - Dashed where approximately located
Normal fault - Dotted where concealed; bar and ball on down-thrown block
Lineament
Lake Bonneville Shorelines –
B — Highest shoreline of the Bonneville (transgressive) phase, dashed where approximate
y — Other transgressive shorelines of the Bonneville phase
SH — Highest shoreline of the Shambip Lake dashed where approximate
Beach ridge crest
19 — Strike and dip of inclined bedding
Sand and gravel pit
Spring
Well
A — A' Line of cross section



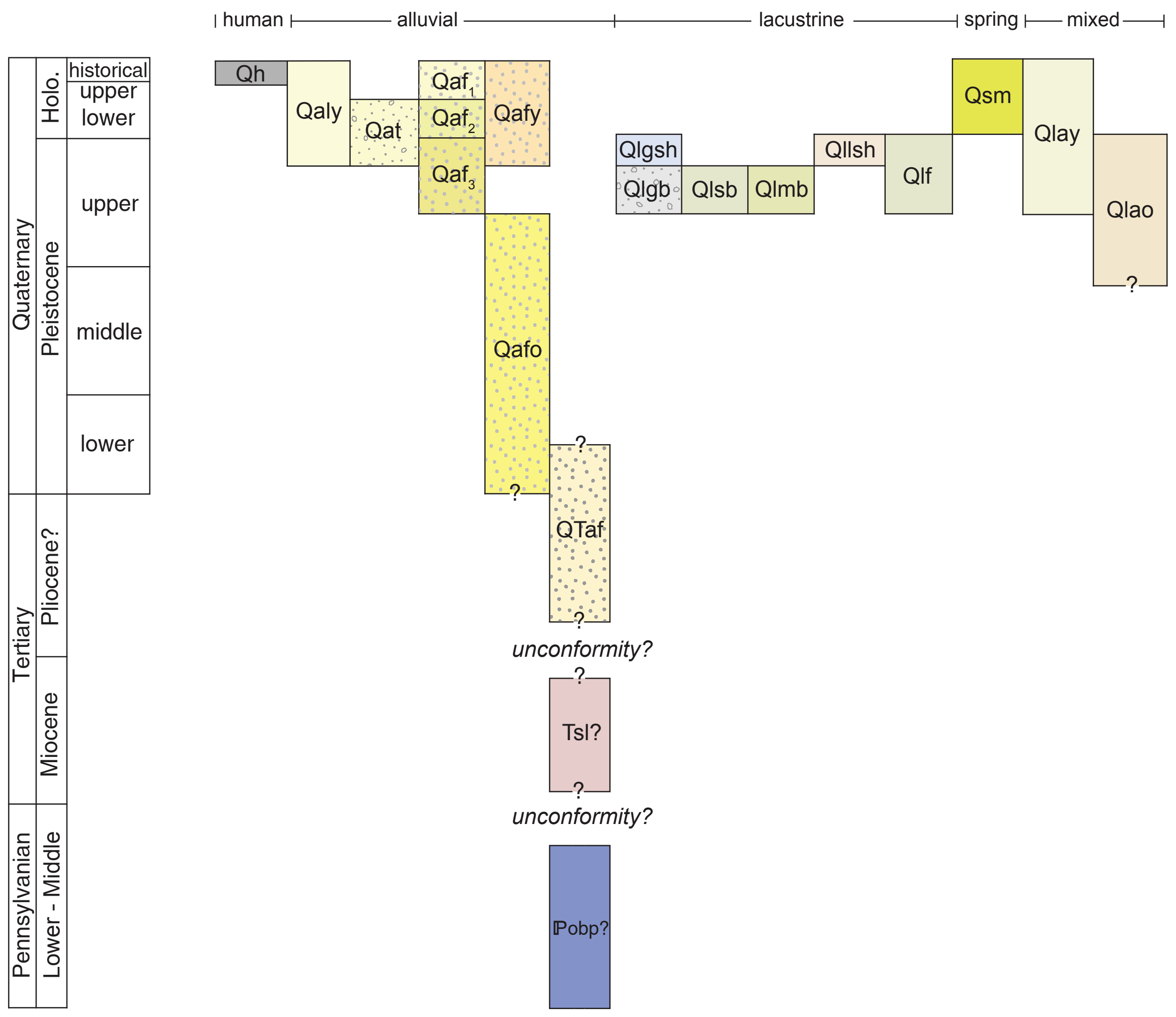
Index to U.S. Geological Survey 7.5-minute quadrangles, and sources of geologic information (refer to numbered list). Gray color includes quadrangles mapped for this project. Numbers correspond to references in the text.

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]	5220–5240 (1591–1597)
	flood			
Regressive Phase[3,4]	Shambip (SH)[3]	14,300–13,300[4]	17,400–16,200[2]	5045-5060 (1538-1542)
	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)

CORRELATION OF UNITS



View to the west across the northern part of the Saint John quadrangle. The community of Clover is in the middle distance. In the foreground is a prominent lacustrine gravel bar formed by Lake Shambip. Southern Stansbury Mountains are in the background.