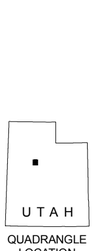
UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources

Plate 1
Utah Geological Survey Open-File Report 563
Interim Geologic Map of the Lofgreen Quadrangle

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 08HQAG0096.



QUADRANGLE 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

INTERIM GEOLOGIC MAP OF THE LOFGREEN QUADRANGLE, TOOELE COUNTY, UTAH

by
Stefan M. Kirby

2010

APPROXIMATE MEAN DECLINATION, 2009

Base from USGS Lofgreen 7.5' Quadrangle (1998)
Projection: UTM Zone 12
Datum: NAD 1927
Spheroid: Clarke 1886

Project Manager: Donald Clark
GIS: Richard Emerson and Stefan Kirby
Cartography: Jay Hill

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1	2	3
4		5
6	7	8

1. Faust
2. Vernon NE
3. Fivemile Pass
4. Vernon
5. Boulter Peak
6. Dutch Peak
7. Sabie Mountain
8. Tintic Junction

ADJOINING 7.5' QUADRANGLE NAMES

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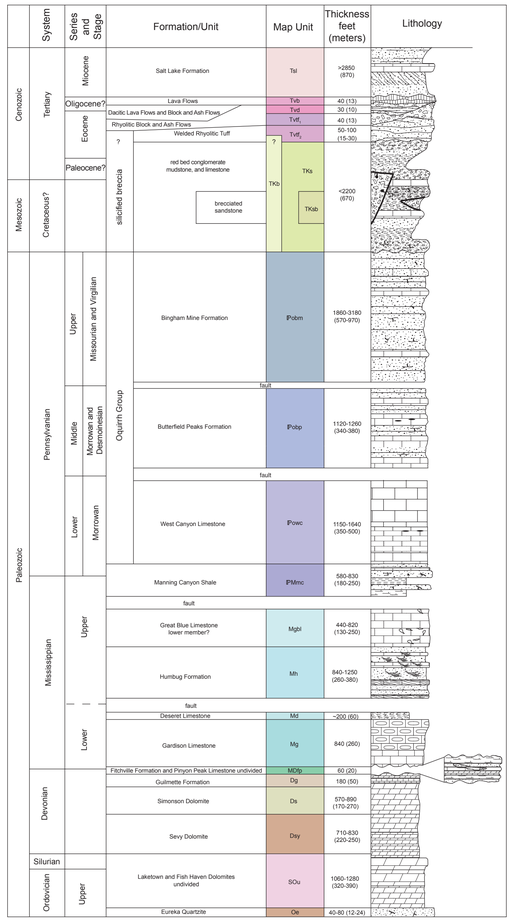
Plate 2
Utah Geological Survey Open-File Report 563
Interim Geologic Map of the Lofgreen Quadrangle

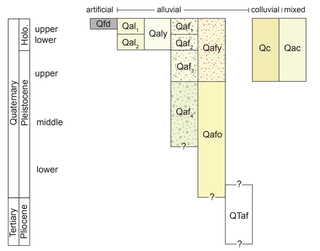
LITHOLOGIC COLUMN



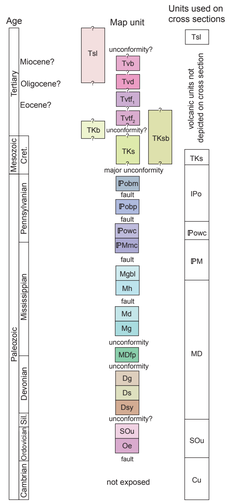
GEOLOGIC MAP SYMBOLS

- Contact - Dashed where approximately located
- Normal fault - Dashed where approximately located; dotted where concealed. Bar and ball on down-thrown block
- Fault - Dashed where approximately located; dotted where concealed; relative motion unknown
- Thrust fault - Dashed where approximately located; dotted where concealed; barb on hanging wall
- Low Angle Normal Fault - Dashed where approximately located; dotted where concealed.
- Anticline axis - Dashed where approximately located; dotted where concealed; arrow indicates direction of plunge
- Syncline axis - Dashed where approximately located; dotted where concealed; arrow indicates direction of plunge
- Antiformal (Inverted) Syncline axis - arrow indicates direction of plunge
- 19 — Strike and dip of inclined bedding
- 57 — Strike and dip of overturned bedding
- 521 — Microfossil sampling site - Number corresponds with table 3
- 301 — Volcanic rock geochemical sampling site - Number corresponds with tables 1 and 2
- Sand and gravel pit
- Water well
- X — Prospect
- Spring
- A — A' — Line of cross section

CORRELATION OF UNCONSOLIDATED DEPOSITS



CORRELATION OF BEDROCK UNITS



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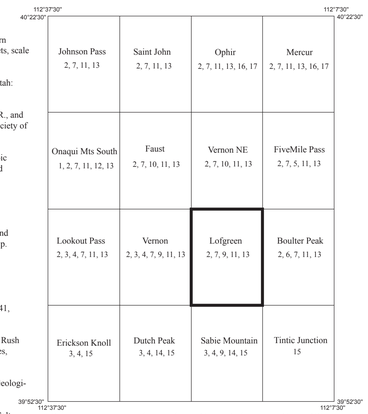


Selected geologic map references for the Vernon, Lofgreen, and Vernon NE quadrangles and adjoining areas. Numbers correspond with selected geologic map references.

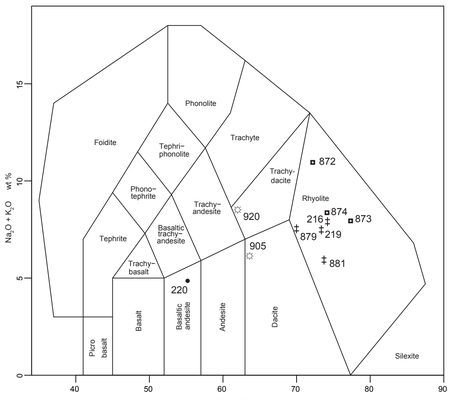


Figure 1. *TAS diagram and plot of volcanic rock samples, using the scheme of Middlemost (1994), from the Vernon and Lofgreen quadrangles. Sample location and geochemical data presented in table 1.*

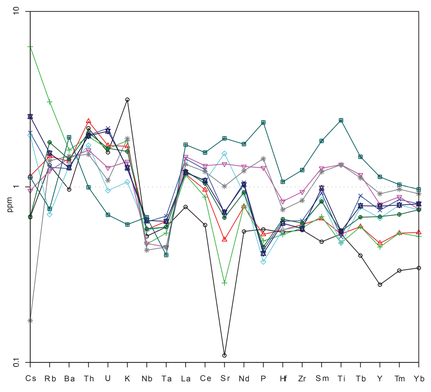


Figure 2. *Spider diagram of normalized trace-element composition of volcanic rocks in the Vernon and Lofgreen quadrangles. Data is normalized for upper continental crust using the methodology of Taylor and McLennan (1995). Trace-element geochemical data is presented in table 2.*

Table 2. *Trace-element geochemistry for volcanic rocks in the Vernon and Lofgreen quadrangles.*

ID	Ba (ppm)	Ce (ppm)	Co (ppm)	Cr (ppm)	Cs (ppm)	Cu (ppm)	Dy (ppm)	Er (ppm)	Eu (ppm)	Ga (ppm)	Gd (ppm)	Hf (ppm)	Ho (ppm)	La (ppm)	Lu (ppm)	Mo (ppm)	Nb (ppm)	Nd (ppm)	Ni (ppm)	Pb (ppm)	Pr (ppm)	Rb (ppm)	Sm (ppm)	Sn (ppm)	Sr (ppm)	Ta (ppm)	Tb (ppm)	Th (ppm)	Tl (ppm)	Tm (ppm)	U (ppm)	V (ppm)	W (ppm)	Y (ppm)	Yb (ppm)	Zn (ppm)	Zr (ppm)
216	789	66.9	3.6	nd	2.51	26	2.3	1.46	0.78	13.7	3.52	3.8	0.47	37	0.26	nd	14.4	24.2	nd	31	6.65	201	3.72	1	234	1.3	0.43	21.8	0.8	0.23	4.65	15	4	14.9	1.63	26	118
219	709	69.6	3.1	10	9.32	15	2.71	1.72	0.84	15.3	3.76	3.6	0.56	36.3	0.28	nd	16.1	26.8	nd	32	7.15	174.5	4.43	2	251	1.4	0.5	20.9	0.9	0.26	5.82	15	3	17.1	1.76	29	110
220	1055	100.5	36.4	360	4.2	51	4.74	2.61	1.92	18.4	7.38	6.2	0.94	52.2	0.32	nd	16.8	45.6	118	16	11.2	84	8.23	2	662	0.9	0.95	10.65	1.1	0.34	1.94	113	2	25.1	2.13	80	237
872	531	38.8	3.5	10	2.49	5	1.21	0.77	0.56	15	1.89	3.2	0.25	23.1	0.14	nd	13.1	14.5	nd	12	4.75	149	2.19	1	38.3	1.3	0.26	23.1	<0.5	0.11	4.41	19	6	6.1	0.76	34	108
873	769	61.6	3.2	10	4.26	5	1.86	1.26	0.75	15.1	2.82	3.3	0.39	35.5	0.22	nd	14.3	20.1	nd	24	6.56	167.5	2.97	1	175	1.4	0.38	25.3	0.5	0.18	4.82	26	6	10.5	1.21	46	116
874	892	56	3.4	10	23.3	5	1.73	1.2	0.73	12.4	2.69	3.1	0.38	35.1	0.21	nd	11.8	20.3	nd	19	6.59	342	3.05	1	99.2	1.2	0.38	20.7	4.1	0.18	4.62	63	21	10	1.15	30	111
879	699	80.3	2.4	nd	7.53	nd	2.73	1.94	1.03	15.1	3.98	3.7	0.6	43.4	0.3	2	15.8	27.5	nd	23	8.78	145	4.16	2	249	1.5	0.57	21.1	0.5	0.28	6.04	20	4	16.2	1.76	41	122
881	728	68.9	2.6	10	7.27	nd	2.42	1.69	0.93	13.9	3.33	3.3	0.56	36.2	0.28	nd	14.2	23.8	nd	22	7.49	78	3.8	1	543	1.3	0.49	18.45	bd	0.26	2.67	21	15	14.6	1.63	35	113
905	800	84.5	12.2	20	3.52	8	3.32	2.05	1.52	17.8	5.04	4.8	0.71	44.6	0.28	nd	11.9	34	7	18	10	138.5	5.75	1	473	1	0.75	17.35	bd	0.29	3.6	102	2	17.5	1.64	67	178
920	823	78.2	12.2	20	0.64	6	3.53	2.29	1.42	16.3	4.89	4.3	0.78	40.4	0.35	nd	10.9	32.1	6	19	9.22	158	5.48	1	353	1	0.72	16.4	0.5	0.32	3.05	84	2	20.1	2.01	66	159

[1] Trace-element geochemistry determined by ICP-MS analyses

West-dipping tuffaceous sandstone, sandstone, and siltstone of the Salt Lake Formation overlain by Qaf_3 alluvial fan along the Union Pacific Railroad tracks in the Lofgreen Quadrangle.

Recrystallized curly-bedded stromatolitic limestone facies of the Fitchville-Pinyon Peak undivided (map unit MDfp) in the southern Vernon Hills.

Table 1. *Summary of whole-rock geochemical data for volcanic rocks in the Vernon and Lofgreen quadrangles.*

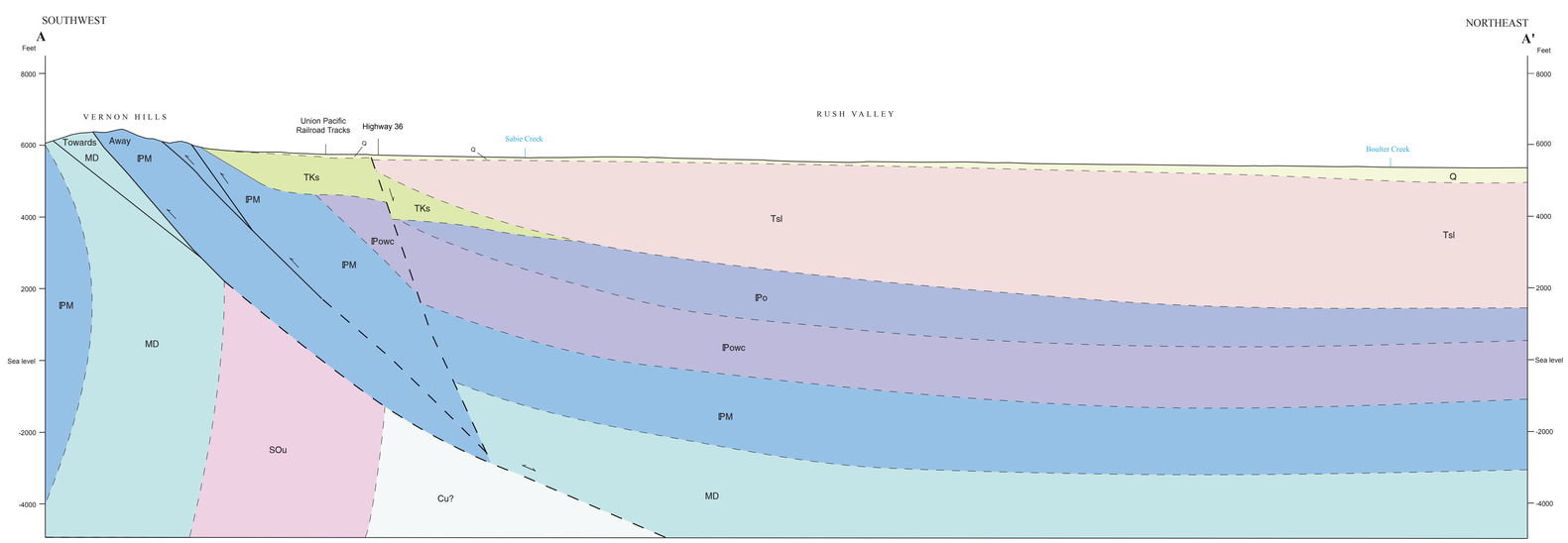
Site ID	East[1]	North[1]	Quad	Map Unit	TAS classification[2]	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	CaO (%)	MgO (%)	Na_2O (%)	K_2O (%)	Cr_2O_3 (%)	TiO_2 (%)	MnO (%)	P_2O_5 (%)	SrO (%)	BaO (%)	LOI[4] (%)	Total (%)
216	382688	4428566	Lofgreen	$Tvtf_2$	Rhyolite	71.54	12.46	1.9	2.19	0.41	2.28	5.37	0.02	0.28	0.03	0.073	0.02	0.09	1.75	98.42
219	381617	4434991	Vernon	$Tvtf_1$	Rhyolite	72.97	13.38	2.12	1.67	0.44	3.27	4.34	0.01	0.28	0.08	0.067	0.03	0.08	0.66	99.41
220	381529	4434651	Vernon	Tvb	Basaltic Andesite	53.99	14.65	8.46	6.72	7.36	2.62	2.06	0.08	1.2	0.13	0.374	0.07	0.14	2.07	99.94
872	382096	4430373	Vernon	$Tvtf_2$	Rhyolite	72.11	13.06	1.92	0.5	0.29	0.21	10.6	nd	0.27	0.02	0.092	0.01	0.06	0.71	99.84
873	381537	4430359	Vernon	$Tvtf_2$	Rhyolite	73.11	13.08	2.28	1.16	0.48	2.15	5.75	nd	0.27	0.04	0.086	0.02	0.09	1.19	99.7
874	381063	4430389	Vernon	$Tvtf_2$	Rhyolite	76.25	11.16	1.72	0.66	0.4	1.7	6.19	nd	0.24	0.03	0.079	0.01	0.11	1.24	99.79
879	380034	4434853	Vernon	$Tvtf_1$	Rhyolite	70.14	14.39	2.09	2.05	0.75	3.1	4.27	nd	0.26	0.07	0.07	0.03	0.08	2.53	99.84
881	380159	4432918	Vernon	$Tvtf_1$?	Rhyolite	70.05	13.37	1.85	2.35	0.7	2.2	3.6	nd	0.24	0.07	0.06	0.08	0.09	4.93	99.59
905	384211	4437458	Lofgreen	Tvd	Dacite	62.83	14.55	5.2	4.85	1.78	2.19	4.7	nd	0.67	0.07	0.206	0.06	0.08	2.12	99.31
920	382814	4437572	Lofgreen	Tvd	Trachydacite	59.93	14.75	5.04	4.98	1.83	1.83	6.35	nd	0.67	0.11	0.232	0.05	0.1	2.71	98.57

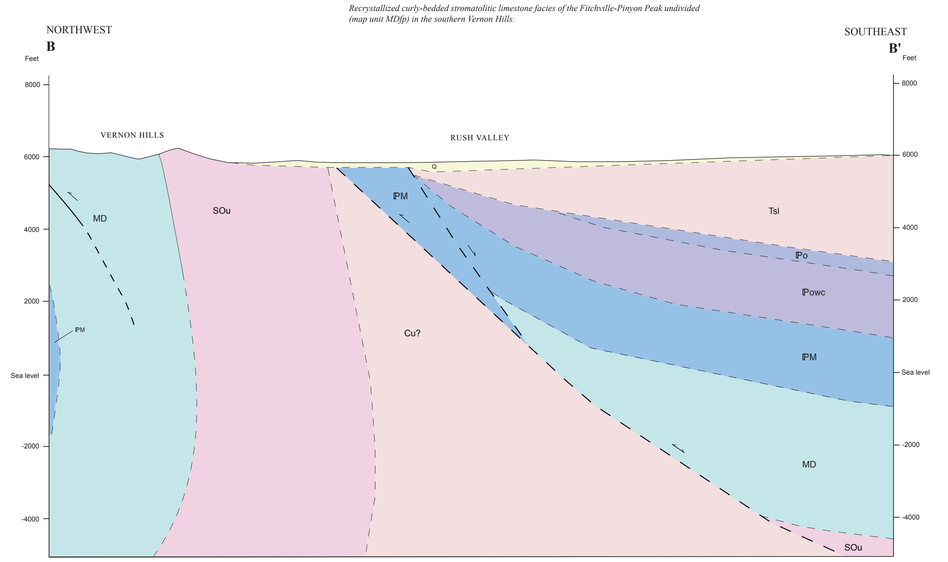
[1]Coordinates in UTM NAD 27 zone 12N
[2]Rock type classification based on TAS scheme (Middlemost, 1994)
[3]Major element-whole rock geochemistry in weight percent determined by XRF analyses
[4]LOI is loss on ignition.

Table 3. *Summary of microfossils collected from rocks of the Oquirrh Group in the Lofgreen and Vernon quadrangles. Microfossil analysis and interpretation performed by A.J. Wells, independent paleontologist.*

Site ID	East[1]	North[1]	Map Unit	Quadrangle	Rock description	Fossil types	Fauna	Calcareous algae present	Preservation	Assigned age
720	383405	4441220	IPobm	Lofgreen	Biomicrite: Wackestone	Fusulinid	*Pseudofusulinella*	no	Fair	late Missourian through Virgilian
726	383688	4440907	IPobm	Lofgreen	Biomicrite: Wackestone	Fusulinid	*Pseudofusulinella: P. cf. fergusonensis*	no	Fair	Wolfcampian, Virgilian, Missourian
245	383170	4440190	IPobp	Lofgreen	Biomicrite: Mudstone	Fusulinid	*Profusulinella*	no	Good	early Atokan
586	382346	4439325	IPowc	Vernon	Biomicrite: Wackestone	Foraminifera	Morrowan Forams?	no	Poor	Morrowan?

[1] Coordinates in UTM NAD 27 Zone 12N





INTERIM GEOLOGIC MAP OF THE LOFGREEN QUADRANGLE, TOOELE COUNTY, UTAH

by

Stefan M. Kirby

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2010

INTRODUCTION

Location and Geographic Setting

The Lofgreen quadrangle covers part of southern Rush Valley in southeastern Tooele County, Utah (plate 1). State Highway 36 extends across the southern half of the quadrangle and the Union Pacific Railroad runs roughly north to south across the quadrangle. Boulter and Sabie Creeks flow to the north and northeast across the quadrangle. The quadrangle includes part of the Vernon Hills along the western edge and adjoining parts of the valley floor to the east.

Scope of Work

The Lofgreen quadrangle was mapped in conjunction with the adjoining Vernon NE and Vernon quadrangles as part of the 2009 USGS STATEMAP award # 08HQAG0096 made to the Utah Geological Survey (UGS). I mapped geologic contacts directly on available digital orthophotography and 1:24,000-scale Lofgreen topographic map bases 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 Lofgreen quadrangle during the spring of 2009.

Geologic Summary

The bedrock exposed in the quadrangle includes sedimentary and volcanic rocks that range from Tertiary to Ordovician in age. Volcanic rocks crop out near the western margin of the quadrangle along the flanks of the Vernon Hills. The chemical composition of these rocks ranges from basaltic andesite to rhyolite, and they may correlate with Eocene to Miocene volcanic rocks in the nearby Oquirrh and East Tintic Mountains (Moore and McKee, 1983; Eric Christiansen, Brigham Young University, written communication, 2008). Many of these volcanic rocks are also exposed in the adjoining Vernon quadrangle. The youngest consolidated sedimentary unit in the quadrangle is the Tertiary Salt Lake Formation, which is exposed in a series of railroad and road cuts and several other outcrops where it is mantled by unconsolidated deposits in the southern portion of the quadrangle. Water-well logs indicate that unconsolidated deposits directly overlie the Salt Lake Formation across the eastern three-fourths of the quadrangle. The Salt Lake Formation was likely deposited in a series of shallow fault-bounded lacustrine basins formed by regional extension during the Miocene to Pliocene (Heylmun, 1965; Perkins and others, 1998). Ash correlation ages for tephra from the Salt Lake Formation, exposed in the adjacent Vernon NE quadrangle, indicate deposition between 6 and 9 Ma (Perkins and others, 1998). Discontinuous exposure of the Salt Lake Formation limits direct correlation of these rocks in the Lofgreen quadrangle with those in the Vernon NE quadrangle, and the Lofgreen deposits may therefore be older or younger than those to the north. The contact of the Salt Lake Formation and underlying

bedrock is not exposed in the quadrangle, but based on well logs to the north (plate 2; Kirby, in prep) and structural cross sections, the Salt Lake Formation rests unconformably on bedrock of the Oquirrh Group across much of the quadrangle. Along the western margin of the quadrangle is a section of folded and faulted conglomerates that may range from Cretaceous to Tertiary in age, based on correlation with similar regional deposits to the east (Constenius and others, 2006) and south (DeCelles and Coogan, 2006). These deposits are well exposed along Highway 36 and rest in apparent angular unconformity on structurally complicated Paleozoic bedrock. The extent of the conglomerate beds in the subsurface is unknown, but deep wells to the northeast in the Vernon NE quadrangle do not intercept similar deposits (Kirby, in prep). Formations ranging from Ordovician to Pennsylvanian in age constitute the remainder of the exposed sedimentary bedrock. Upper Mississippian and Pennsylvanian rocks crop out north of the Vernon Hills fault. South of the Vernon Hills fault, a steeply dipping and overturned east-dipping panel of Ordovician through Pennsylvanian rocks is exposed. This panel includes a nearly stratigraphically complete section of Upper Ordovician to Upper Mississipian rock units that extends across the western quadrangle boundary into the Vernon quadrangle.

Pliocene? to Holocene unconsolidated deposits in the Lofgreen quadrangle include primarily alluvial-fan and channel deposits of various ages. Nearly all of the quadrangle is above the highstand of Lake Bonneville, based on the elevation (~ 5250 feet [1600 m] above sea level) of prominent wave-cut platforms in the Vernon NE quadrangle to the north. North-sloping alluvial-fan and fluvial-channel deposits cover most of the quadrangle. Based on available water-well logs, these deposits are up to several hundred feet (~100 m) thick and rest on the Salt Lake Formation (Utah Division of Water Rights, 2009). In the southern Vernon Hills and southwest corner of the quadrangle, unconsolidated deposits of cobble- to boulder-size material lacking a consistent alluvial slope may be the eroded remnants of a once contiguous alluvial surface that extended into the adjoining Vernon quadrangle where similar deposits exist.

The early tectonic history of the quadrangle is recorded by Ordovician to Pennsylvanian strata that were deposited first across a broad subsiding carbonate platform and later within the rapidly subsiding Oquirrh basin. 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). East-dipping overturned rocks juxtaposed across the Vernon Hills fault with folded strata may be evidence of a major west-directed back thrust and shear fault within this portion of the Sevier orogenic belt. This back thrust is inferred east of overturned bedrock exposures of the Vernon Hills, possibly linking with the previously mapped Sabie Mountain thrust (Mukul and Mitra, 1998) to the south in the adjoining Sabie Mountain quadrangle. Folded conglomerates were deposited during or just prior to backthrusting and large-scale folding. Steeply dipping, roughly east-west striking faults cut overturned Paleozoic strata in the Vernon Hills and may record east-west directed shear during later stages of the Sevier orogenic event. During the Eocene, crustal shortening was followed by Sevier belt collapse/relaxation 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 from Eocene to Holocene time. Normal faulting typical of modern Basin-and-Range extension began after 20 Ma (Stewart, 1998, and references therein). Within the quadrangle, the modern extensional strain field is exemplified by several segments of the down-to-the-east Vernon Hills marginal fault (Everitt and Kaliser, 1980) that offset Quaternary unconsolidated deposits.

Previous Investigations and Mapping Background

Several investigators have mapped the geology of the Lofgreen quadrangle at various scales smaller (less detailed) than 1:24,000, including Cohenour (1959), Groff (1959), Bucknam (1977), Moore and Sorensen (1979), Everitt and Kaliser (1980), and Moore and McKee (1983). Adjoining mapping relevant to both bedrock and unconsolidated deposits includes Gilluly (1932), Disbrow (1957), Cohenour (1959), Groff (1959), Armin and Moore (1981), Pampeyan (1989), and Tooker and Roberts (1998). Hood and others (1969) discussed the hydrogeology of the quadrangle.

MAP UNIT DESCRIPTIONS

QUATERNARY

Qfd **Artificial fill and disturbed areas** (Historical) – Excavations and fill primarily along State Highway 36, the Union Pacific railroad siding, and several gravel pits near Lofgreen; material includes sand, gravel, angular cobble-size clasts, silt, and clay; variable thickness 0 to 50 feet (0-17 m).

Qal_1 **Level-1 stream deposits** (upper Holocene) – Moderately to well-sorted sand, pebble and cobble gravel, silt, and minor clay in active stream channels and flood-plains; deposit is alternately clast or matrix supported; mapped along Boulter and Brush Creeks in the Lofgreen quadrangle; includes deposits on active flood plains and minor terraces less than 10 feet (3 m) above stream level and locally includes small colluvial deposits along steep stream embankments; equivalent to and grades into the younger part of young alluvial deposits (Qaly); exposed thickness less than 15 feet (5 m).

Qal_2 **Level-2 stream deposits** (middle Holocene to upper Pleistocene) – Moderately to well-sorted sand, pebble and cobble gravel, silt, and minor clay in major drainages above active stream channels and flood plains (Qaf_1); deposit is alternately clast or matrix supported; unit includes inactive stream and flood-plain deposits on terraces more than 10 feet (3 m) above incised active channel and flood-plain deposits of Qal_1; mapped along major drainages where modern streams have incised and inactivated middle Holocene to upper Pleistocene stream and flood-plain deposits along Boulter Creek in the quadrangle; includes deposits on largely inactive flood plains and minor terraces; locally includes small colluvial deposits along steep stream embankments; equivalent to and grades into

the older part of young alluvial deposits (Qaly); exposed thickness less than 15 feet (5 m).

Qaly **Younger alluvial deposits, undivided** (Holocene and 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 level; locally includes small alluvial-fan and colluvial deposits; includes level-2 stream deposits (Qal_2) incised by active stream channels and partly overlain by level-1 stream deposits (Qal_1) that 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).

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 mouths 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; exposed thickness less than 10 feet (3 m).

Qaf_2 **Level-2 alluvial-fan deposits** (middle 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; locally incised in and/or overlying older alluvial fan deposits; deposits equivalent to, and grade to the older part of Qafy; fan surface is abandoned and commonly dissected and irregular; deposits grade above modern stream (Qal_1) or alluvial fan level (Qaf_1); 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, or 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, and -2 alluvial-fan deposits (Qaf_1 and Qaf_2) that postdate the transgression and highstand of Lake Bonneville, and in areas where the specific age of deposits cannot be determined; no

shorelines exist on these alluvial fans; 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; deposits equivalent to, and grade to the oldest part of Qafy; fan surface grades near the Lake Bonneville highstand and exposures of Lake Bonneville sediments in the Vernon NE quadrangle to the north; deposition is contemporaneous with the transgression and highstand of Lake Bonneville and no shorelines exist on these alluvial fans; surface is incised by active drainages; exposed thickness less than 15 feet (5m).

Qaf_4 **Alluvial-fan deposits, pre-Bonneville lake cycle** (upper? to middle? Pleistocene) – Poorly sorted, clast-supported pebble to cobble gravel, with matrix-supported interbeds in the upper part; locally bouldery in a matrix of sand, silt, and clay; clasts angular to subrounded; medium to very thick bedded; equivalent to the youngest part of older alluvial-fan deposits (Qafo) but differentiated where pre-Bonneville deposits can be subdivided based on fan morphology, degree of dissection, and incision of younger deposits into older deposits; exposed thickness less than 30 feet (10 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 locally overlain by or grades into pre-Bonneville alluvial fan deposits (Qaf_4) where relative fan chronology is apparent; unit is incised by and alternately overlain by syn- and post-Bonneville alluvial fan units (Qafy, Qaf_1, Qaf_2, and Qaf_3); thickness probably less than 60 feet (20 m).

Qac **Alluvial and colluvial deposits** (Holocene and upper Pleistocene) – Poorly to moderately sorted pebble or in places cobble gravels, sand, silt, and clay; generally locally derived and mapped in areas where alluvium and colluvium cannot be subdivided; unit deposited by alluvial, fluvial, and slope wash, and by soil creep in topographically confined parts of the Vernon Hills; total thickness 0 to 40 feet (0-13 m).

Qc/IPo

Colluvium over Pennsylvanian Oquirrh Group, undivided (Holocene to upper Pleistocene/Pennsylvanian) – Deposits consist of locally derived angular cobble- to gravel-size blocks, sand, silt, and clay deposited primarily by slope wash processes along swales, slopes, and drainages; mapped where colluvium thinly mantles and partially obscures outcrops and bedding in Oquirrh bedrock in the northern Vernon Hills; thickness 0 to 10 feet (0-3 m).

Qc/TKs

Colluvium over Tertiary-Cretaceous sedimentary rocks (Holocene/Tertiary-Cretaceous) – Deposits consist of locally derived, angular, cobble- to gravel-size blocks, sand, silt, and clay deposited primarily by slope wash and soil forming processes; mapped where colluvium thinly mantles and partially obscures outcrops and bedding in Tertiary-Cretaceous sedimentary bedrock in the northern Vernon Hills; thickness 0 to 10 feet (0-3 m).

Qaf_2/Tsl

Level-2 alluvial-fan deposits over Salt Lake Formation (middle Holocene to upper Pleistocene/Miocene to Oligocene?) – 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 (Qal_1) or alluvial fan level (Qaf_1); mapped where alluvial fans thinly mantle and partially obscure outcrops of Salt Lake Formation in the Vernon Hills; thickness 0 to 10 feet (0-3 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 quartzite, diamictite, and various Paleozoic carbonates apparently sourced from bedrock exposed to the south in the northern Sheeprock Mountains and Sabie Mountain; unit is the highest standing unconsolidated unit but does not have consistent slope characteristic of alluvial fans; instead unit forms rounded hills in the southern part of the Lofgreen and the southeastern part of the Vernon NE quadrangles that overlie various bedrock; alluvial fan units Qafo and Qaf_4 are topographically below and inset in this unit; stratigraphy and extent of unit suggest these deposits may be a remnant of a previously extensive alluvial pediment developed on the northern flank of the Sheeprock Mountains and Sabie Mountain northeast of the Vernon Creek fault; absolute age is unknown but this unit may be much older than all other unconsolidated deposits; thickness up to 300 feet (100 m).

TERTIARY

Tsl **Salt Lake Formation** (Pliocene? to Miocene to Oligocene?) – Tan, light-brown to pale gray or white, interbedded tuffaceous sandstone, limestone, calcareous sandstone, gritty or pebbly sandstone, sandy mudstone, siltstone, marl, and claystone; in the Lofgreen quadrangle 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 underlying Paleozoic age rocks primarily of the Oquirrh Group; age in the Rush Valley area is between 6.6 $\pm$ 0.03 and 9.8 $\pm$ 0.23 Ma, based on tephra interpolations and correlations from Perkins and others (1998); direct isotopic age estimates have not been completed in the Rush Valley area; faulting complicates thickness estimates but continuous exposed thickness is up to 2850 feet (870 m) in the adjoining Vernon NE quadrangle; 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.

Tvb **Basaltic andesite** (Miocene? or Oligocene?) – Dark-gray or black, very fine grained basaltic andesite lava flow (figures 1 and 2; tables 1 and 2); contains abundant olive-green to orange-brown altered granular olivine phenocrysts 1 mm or less in diameter; unit crops out on the east flank of the Vernon Hills north of Highway 36 in the Lofgreen quadrangle; age based on correlation with the Mosida Basalt (19.6 Ma), a geochemically similar unit that occupies comparable stratigraphic position to the east in the East Tintic Mountains (Eric Christiansen, Brigham Young University, written communication, 2009); total exposed thickness is approximately 40 feet (13 m).

Tvd **Dacite and trachydacite** (Eocene?) – Light-gray to reddish-brown porphyritic dacite and trachydacite lava flows; contains abundant altered white plagioclase phenocrysts 1-4 mm in length, minor hornblende phenocrysts less than 2 mm in length; also contains a few angular black or dark-gray porphyritic lithic fragments up to 4 mm in length, possibly correlative with $Tvtf_1$ or $Tvtf_2$; unit crops out as several topographically low, lava flow remnants along the flanks of the Vernon Hills in the Lofgreen quadrangle; unit appears to be shallow dipping and overlies and/or abuts exposures of TKs sedimentary deposits; age of unit is unconstrained but assumed to be Eocene based on correlation with similar volcanic units exposed to the east and north near the East Tintic Mountains (Eric Christiansen, Brigham Young University, written communication, 2009); radiometric age pending; maximum exposed thickness is about 30 feet (10 m).

$Tvtf_1$ **Younger rhyolite** (Eocene?) – White to light-gray or locally dark-gray, typically massive, rhyolitic crystal-rich, lithic, or vitric block and ash-flow tuff; with glass-rich matrix ranging from densely welded and banded to largely unwelded and ashy with no apparent flow banding; contains angular to subangular lithic clasts, up to 10 mm in diameter, of older volcanic unit $Tvtf_2$, and dark gray to black angular vitrophyre clasts up to 20 mm in diameter; unit contains no lithic clasts similar to Tvd or Tvb units; unit crops out along the flanks of the Vernon Hills in the quadrangle; apparently underlies Tvb in the adjoining Vernon quadrangle; absolute age of unit is uncertain but superposition places this unit after emplacement of $Tvtf_2$ and before Tvb; unit produces a colorful concentrically

banded rock (wonderstone) sought after by rock hounds from a small quarry north of State Highway 36; unit is similar in appearance and geochemistry to the Packard Quartz Latite (35 Ma) exposed to the east in the Lake and East Tintic Mountains (Eric Christiansen, Brigham Young University, written communication, 2009); radiometric age is pending; exposed thickness is 40 feet (13 m).

$Tvtf_2$ **Older rhyolite** (Eocene?) – Pale-red to pink or gray, welded phenocrystic tuff; major phenocrysts include euhedral plagioclase up to 3 mm in length, biotite, and hornblende; unit is generally densely welded with thin vitrophyric bands; small-scale flow banding is apparent in many exposures; unit crops out in the southern Lofgreen quadrangle in the southwestern part of the Vernon Hills; K-Ar biotite age of 38.0 $\pm$ 0.5 Ma from Moore and McKee (1983) is likely from this unit near the Vernon Creek Ranch in the Vernon quadrangle; new radiometric age pending; exposed thickness 50 to 100 feet (15-30 m).

TERTIARY-CRETACEOUS

TKb **Siliceous breccia and sinter** (Miocene? or Oligocene? to Cretaceous?) – Dark-brown silicified angular breccia; forms pods within otherwise unaltered Paleozoic sedimentary units; locally relict bedding is preserved from the host rock, more commonly all textural features of the host rock have been overprinted and heavily silicified; one small outcrop occurs in the northern Vernon Hills in the Lofgreen quadrangle where TKb is mapped as small pod in steeply dipping rocks of the Oquirrh Group; no other cross-cutting relationship constrain the age of these deposits, and they may be related to either compression during the Sevier orogeny or regional volcanism during the Miocene to Eocene; exposed thickness of several hundred feet (~100 m).

TKsb **Unnamed breccia** (Eocene? to Cretaceous?) – Yellow to pale-tan, penetratively fractured, calcareous, quartzose sandstone; isolated, apparently fault bounded, structurally disrupted block of calcareous quartz sandstone mapped within TKs north of State Highway 36 in the Lofgreen quadrangle; original bedding and cross-beds exist but this unit is brecciated and internally faulted; correlation of this sandstone with other Paleozoic sandstones exposed in the Vernon Hills is ambiguous, but TKsb bears some resemblance to sandstone intervals in the Butterfield Peaks Formation and Bingham Mine Formation; total thickness is unknown.

TKs **Unnamed sedimentary rocks** (Eocene? to Cretaceous?) – Red to brown to pale-gray interbedded conglomerate, limestone, mudstone, siltstone, and tuffaceous sandstone; clast-supported conglomerate consists of subangular to rounded pebbles, cobbles, and boulders of quartzite, carbonate, and sandstone in a sandy, gritty, calcareous or arkosic matrix; clasts as much as 1 foot (0.3 m) in diameter. Conglomerate clasts include a range of Paleozoic sedimentary rock sources including medium-gray cherty limestone, dark-gray dolomite, well-bedded light-

gray dolomite, fossiliferous limestone, tan calcareous sandstone, and cross-bedded quartzite; volcanic clasts are conspicuously absent from the conglomerate; limestone intervals are commonly 10 to 20 feet (3-6 m) thick, consisting of medium-bedded tan to pale-gray sparsely fossiliferous micrite; mudstone intervals are red to reddish-brown, locally sandy and crudely bedded; siltstone intervals are purple to pale red and finely bedded; unit unconformably overlies Great Blue Limestone, West Canyon Limestone, and Manning Canyon Shale in central portion of the Vernon Hills north and south of State Highway 36; TKs is steeply to moderately dipping and folded in a series of northwest trending folds; unit contains fault-bounded block of brecciated Paleozoic? sandstone (TKsb); radiometric age is pending; estimate of exposed thickness is complicated by folding, but unit may be just less than 2200 feet (670 m) thick.

PENNSYLVANIAN

IPobm **Bingham Mine Formation of the Oquirrh Group** (Upper Pennsylvanian [Virgilian-Missourian]) – Brown- to tan-weathering, fine- to medium-grained calcareous and quartzitic sandstone, and interbedded thin- to medium-bedded, medium-gray, fine-grained sandy and cherty limestone intervals; calcareous and quartzitic sandstone dominate this unit, limestone is less common; sandstone is typically light brownish gray, planar bedded; locally displaying low-angle cross-stratification and small-scale cross-bedding; both calcareous and quartzitic sandstone exist in nearly equal proportions; limestone intervals 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; the Bingham Mine Formation is delineated from the underlying Butterfield Peaks Formation by a comparatively greater amount of sandstone versus limestone and its age; the lower contact is not exposed in the Vernon Hills and the Bingham Mine Formation is apparently in fault contact with the underlying Butterfield Peaks Formation; Missourian and Virgilian age of unit is from fusulinid samples collected in the field (table 3); in the Vernon Hills an incomplete section the Bingham Mine Formation is 1860 to 3180 feet (570-970 m) thick; the formation is about 7300 feet (2200 m) thick in the Oquirrh Mountains (Tooker and Roberts, 1998).

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 and sandy limestone; unit characterized by repeated intervals of quartzitic or calcareous sandstone overlain by intervals of gray limestone or sandy limestone; contains minor siltstone; sandstone is typically light brownish gray, planar bedded, locally displaying low-angle cross-stratification and small-scale cross-bedding; both calcareous and quartzitic sandstone exist in nearly equal proportions; limestone intervals 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 fusilinids 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; siltstone is tan to brown gray and thin bedded; generally poorly exposed, and commonly bioturbated; forms ledgy slopes and ridges in the northern Vernon Hills; age of Butterfield Peaks exposures in the Vernon Hills is Atokan based on fusulinid samples collected in the field (table 3); incomplete thickness of 1120 to 1260 ft (340-380 m) in the Vernon Hills; apparently in fault contact with the West Canyon Limestone below and the Bingham Mine Formation above; Tooker and Roberts (1998) reported the formation is about 9000 feet (2750 m) thick in the Oquirrh Mountains.

IPowc **West Canyon Limestone of the Oquirrh Group** (Lower Pennsylvanian [Morrowan]) – Medium- to thick-bedded, light- to medium-gray, fine- to medium-grained limestone, sandy limestone, and fossiliferous limestone; locally laminated with brown silt and very fine grained sand; fossils include crinoid columns, brachiopods, rugose corals, and fusulinids in localized beds; lower contact is gradational and conformable and mapped at the transition from continuous limestone strata of the West Canyon Limestone to the predominantly interbedded clastic strata of the Manning Canyon Shale; Morrowan age of the unit in the Vernon Hills is based on a single poorly preserved foraminifera sample (table 3); forms prominent cliffs and east-dipping, ledgey slopes in the northern Vernon Hills; the exposed and likely incomplete thickness of West Canyon Limestone in the Vernon Hills is 1150 to 1640 feet (350-500 m) thick; the upper part of the West Canyon Limestone may be in fault contact with the overlying Butterfield Peaks Formation; regional thickness is 1000 to 1440 feet (305-440 m) (Tooker and Roberts, 1970; Davis and others, 1994; Biek, 2004).

PENNSYLVANIAN-MISSISSIPPIAN

IPMmc **Manning Canyon Shale** (Lower Pennsylvanian? to Upper Mississippian) – Generally dark colored, lithologically diverse unit of interbedded quartzite, shale, sandstone, limestone, and siltstone; shale and calcareous siltstone are dark brown to grayish brown to grayish red, commonly weathering to brown orange; quartzite is dark-brown weathering, blocky, medium- to well-bedded, with some well-developed cross-bedding; quartzite hand samples commonly have a distinctive vitreous pleochroism; fine-grained sandstone and calcareous sandstone are medium bedded and display some cross-bedding and low-angle cross-stratification; argillaceous and rarely fossiliferous limestone is medium gray and thin to medium bedded, and most commonly found in the upper several hundred feet of the unit; all Manning Canyon lithologies tend to be laterally discontinuous, however shale and quartzite sections are more continuous than either limestone or sandstone lithologies; structural disruption of the Manning Canyon Shale in the Vernon Hills is common and small scale faults, heavily fractured zones, and folds are apparent in many exposures; the base of the Manning Canyon Shale is not exposed in the Vernon Hills and may be a decollement of regional extent; age

taken from work by Davis and others (1994); exposed thickness between 580 and 830 feet (180-250 m); regional thickness of 1000 to 1650 feet (300-500 m) (Biek and others, 2009; Constenius and others, 2006).

MISSISSIPPIAN

Mgbl **Great Blue Formation, lower member** (Upper Mississippian) – Medium to blue-gray, medium-grained, moderately- to well-bedded limestone and fossiliferous limestone; fossils include common rugose corals, crinoid columns, brachiopods, and fossil hash; unit crops out as ledgey slopes and small cliffs in the central part of the Vernon Hills; lower contact is conformable and gradational; marked by the transition from the interbedded sandstone and limestone lithologies of the underlying Humbug Formation to continuous limestone typical of the Great Blue Formation; upper contact and the upper member of the Great Blue Limestone is not exposed and potentially fault-truncated in the Vernon Hills; nearby in the Onaqui and Oquirrh Mountains the upper member of the Great Blue is mapped where the intervening Long Trail Shale member of the Great Blue Formation is present (Clark and others, 2009); exposed thickness ranges from 440 to 820 feet (130-250 m); Gilluly (1932) described a section measuring approximately 500 feet (150 m) in the southwestern part of the Oquirrh Mountains and Biek (2004) estimated a thickness of 300 feet (90 m) in the Lake Mountains.

Mh **Humbug Formation** (Upper Mississippian) – Interbedded, calcareous, quartz sandstone, quartzite, sandy limestone, and limestone; sandstone is pale yellowish brown to olive gray, weathering to light to dark brown, medium to thin bedded, variably calcareous or siliceous, with well developed planar and low-angle cross-stratification; quartzite is less common and very pale brown to tan and vitreous; sandy limestone and limestone are light to dark gray, medium to thin bedded, and fine grained with well developed cross-stratification and cross-bedding; fossil debris including crinoids and rugose corals are common in carbonate parts of the unit; quartzitic or calcareous sandstone interbed with gray limestone or sandy limestone throughout the Humbug Formation; formation weathers to ledgy slopes; lower contact is a bedding-parallel fault; age from Morris and others (1961); exposed thickness in the Vernon Hills is between 840 and 1250 feet (260-380 m); regional thickness is 350 to 1550 feet (107-472 m) (Hintze and Kowallis, 2009).

Md **Deseret Limestone** (Upper-Lower Mississippian) – Dark-brown to reddish-brown, poorly exposed, phosphatic shale, dark-brown to black chert and quartzite, and medium-bedded, medium-gray limestone; locally some calcareous sandstone and quartz sandstone interbeds in lower part; basal slope-forming interval (20 to 30 feet [6-9 m]) includes thin-bedded, black phosphatic chert of the Delle Phosphatic Member of the Deseret Limestone; unit typically forms slopes between Gardison Limestone and calcareous sandstone of the Humbug Formation in the Vernon Hills; exposures in the Vernon Hills include little if any limestone and may be marked by a bedding-parallel fault which omits much or all of the

limestone typical of the upper portion of the Deseret Limestone as mapped to the east and north; age from Morris and others (1961) and Sandberg and others (1982); thickness is up to 200 feet (60 m) in the Vernon Hills; regional thickness is about 500 to 1175 feet (150-360 m) (Hintze and Kowallis, 2009).

Mg **Gardison Limestone** (Lower Mississippian) – Medium- to thick-bedded, medium-gray to medium-dark-gray limestone, cherty limestone, and fossiliferous limestone; chert occurs as black, irregularly shaped nodules and thin, discontinuous beds, chert is most common in the upper Gardison; fossils include rugose and colonial corals, brachiopods, gastropods, and bryozoans replaced by white calcite; Gardison crops out as dark- to medium-gray ledges, cliffs, and slopes; upper contact appears conformable and abrupt, and is marked by a cliffy chert-banded limestone of the uppermost Gardison, directly overlain by dark-weathering slope-forming phosphatic shale, discontinuous dark brown quartzites, and finely bedded dark limestone of the lowermost Deseret Limestone; lower contact of the Gardison Limestone may be a regional unconformity separating the continuous limestone of the Gardison Limestone from the interbedded and lithologically diverse Fitchville-Pinyon Peak unit (MDfp); age from Morris and others (1961); thickness is approximately 840 feet (260 m) in the Vernon Hills; regional thickness is 300 to 1100 feet (90-340 m) (Hintze and Kowallis, 2009).

MISSISSIPPIAN-DEVONIAN

MDfp **Fitchville Formation and Pinyon Peak Limestone, undivided** (Lower Mississippian to Upper Devonian) – Fine- to coarse-grained lithologically complex, interbedded dolomite, limestone, and intraformational breccia, with a few interbeds of red or brown sandstone and quartzite; carbonate parts of this unit may include both Fitchville and Pinyon Peak lithologies, whereas thin sandstone and quartzite interbeds, particularly where these beds are dolomitic, may correlate with the Victoria Formation; lower contact is marked by transition from continuous dark gray dolomite of the underlying Guilmette Formation to interbedded light gray finely bedded recrystallized limestone, medium-grained dark gray dolomite and thin discontinuous sandstones or quartzites; thickness is approximately 60 feet (20 m); regional thickness is much greater, between 180 and 390 ft (55-120 m), but may include lithologies stratigraphically above or below this interval as mapped in the Vernon Hills (Pampeyan, 1989; Mukul and Mitra, 1998).

DEVONIAN

Dg **Guilmette Formation** (Upper Devonian) – Dark-gray, medium- to fine-grained, dolomite and subordinate limestone; moderately to weakly bedded, sparsely fossiliferous dark-gray dolomite with a few thin, dark-gray, fine-grained limestone beds near the top of the unit; forms even slopes and well-spaced ledges in the central Vernon Hills; lower contact is conformable and gradational and marked by change in color and gradual increase in bed thickness from the pale-

brown to gray, generally well-bedded dolomites of the Simonson Dolomite to the dark-colored and weakly bedded dolomite characteristic of the Guilmette Formation; upper contact is alternately marked by discontinuous thin red-brown sandstone or quartzite or pale- to medium-gray, well-bedded, coarse-grained limestone of the overlying Fitchville-Pinyon Peak unit; upper contact may represent a regional unconformity; age taken from regional fossil correlation data presented by Sandberg and others (1982); unit thickness 180 feet (50 m).

Ds **Simonson Dolomite** (Middle Devonian) – Light-brown to pale- and medium-gray, fine- to medium-grained, massive or thin-bedded dolomite; generally more lithologically variable and less well bedded than the underlying Sevy Dolomite; lower contact with Sevy Dolomite is apparently conformable and gradational and mapped as a gradual change in color, increase in bedding thickness, and reduction of finely bedded intervals more typical of the underlying Sevy Dolomite; upper contact appears conformable and is principally marked by the appearance of dark gray medium-grained dolomite of the Guilmette Formation; age taken from regional fossil correlation data presented by Sandberg and others (1982); thickness in the Vernon Hills is between 570 and 890 feet (170-270 m).

Dsy **Sevy Dolomite** (Lower Devonian) – White to very light or medium-gray, medium- to fine-grained, thin-bedded dolomite, displaying well developed fine-scale planar lamination; unit is rarely fossiliferous; occasional thin, less than 1 foot (0.3 m) thick, beds of sandy dolomite; unit crops out as small ledges and float-covered hills in the southeastern part of the Vernon Hills; upper contact with the Simonson Dolomite is gradational but marked by a transition to more massive, less well bedded, bioturbated, pale-gray or brownish-gray dolomite; lower contact with the dark-gray dolomites of the Laketown and Fish Haven Dolomites is sharp and may represent a regional unconformity; age taken from regional fossil correlation data presented by Sandberg and others (1982); thickness in the Vernon Hills is between 710 and 830 feet (220-250 m); near the Vernon Hills regional thickness is between 360 and 1100 feet (110-335 m) (Pampeyan, 1989; Mukul and Mitra, 1998).

SILURIAN-ORDOVICIAN

SOu **Laketown and Fish Haven Dolomites, undivided** (Silurian to Upper Ordovician) – Dark- to medium-gray, granular or massive, moderately or poorly bedded cherty dolomite; with common pink to dark-gray chert bands or blebs; fossils include rugose corals and rare stromatolites in the lower part of the unit and chain corals (*Halysites*) near the abrupt upper contact with the light-colored well-bedded Sevy Dolomite; poorly bedded parts of this unit appear bioturbated; contact with the underlying Eureka quartzite may be faulted; unit forms small blocky outcrops up to 10 feet (3 m) high and steep slopes along the southeastern flank of the Vernon Hills; age of unit in the Vernon Hills is taken from Groff (1959). Exposed thickness is 1060 to 1280 feet (320-390 m); total thickness from previous workers is approximately 770 feet (235 m) in the Vernon Hills; near the

Vernon Hills regional thickness is between 630 and 1600 feet (190-490 m) (Cohenour, 1959; Groff, 1959; Pampeyan, 1989; Mukul and Mitra, 1998).

ORDOVICIAN

Oe **Eureka Quartzite** (Upper Ordovician) – Light-colored, medium- to well-bedded, medium-grained, vitreous orthoquartzite; commonly displays well-developed trough cross-bedding and planar bedding; unit crops out as small blocky cliff bands less than 10 feet (3 m) high at isolated locations in the southern Vernon Hills; base of unit is not exposed and may be truncated by faulting. Age of unit in the Vernon Hills taken from nearby work by Cohenour (1959); exposed thickness 40-80 feet (12-24 m) thick; nearby regional thickness is between 120 and 645 feet (35-195 m) (Cohenour, 1959; Mukul and Mitra, 1998).

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