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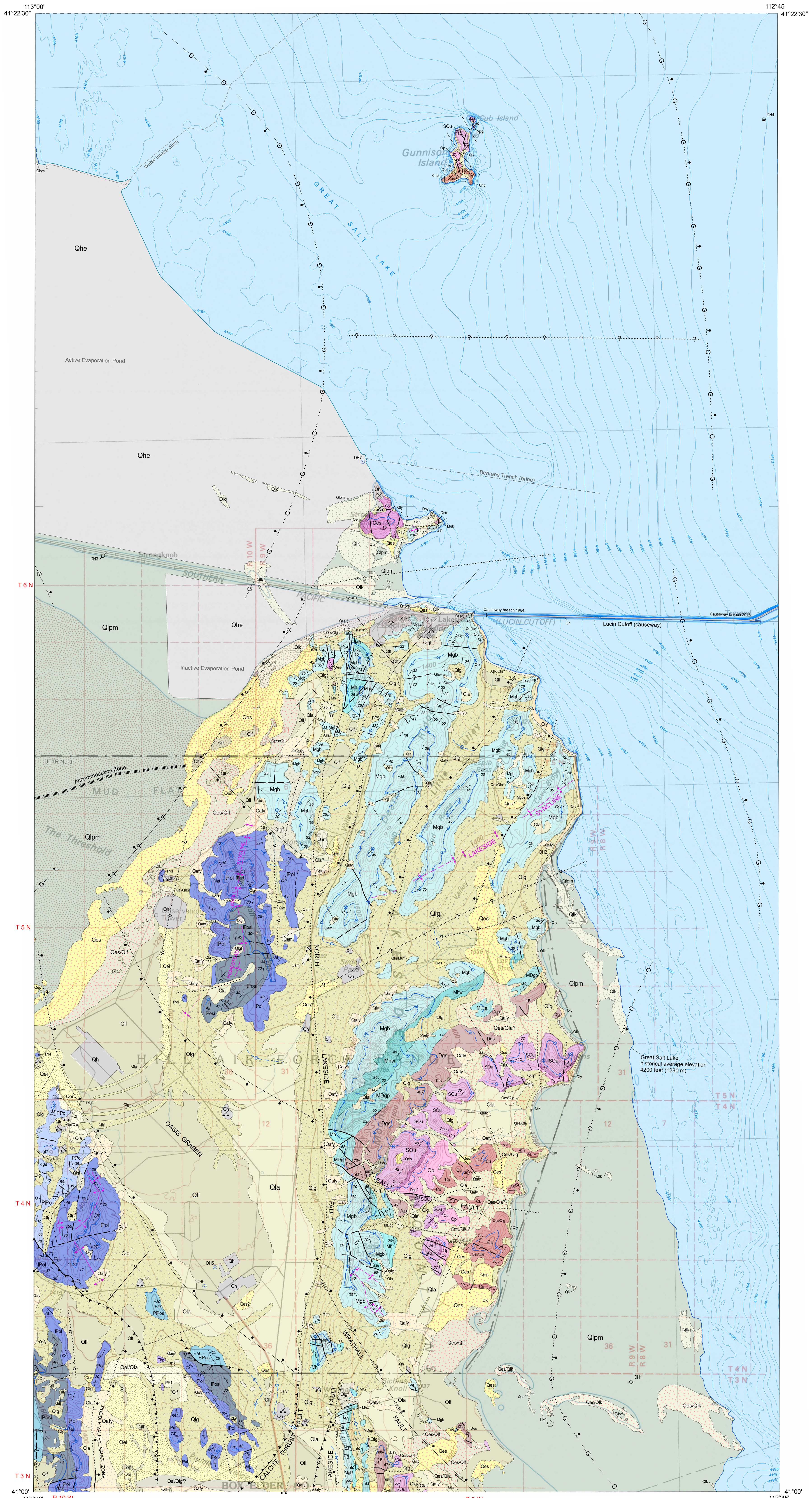


SCALE 1:62,500

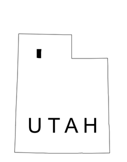
1 0.5 0 1 2 3 4 5 MILES

1 0.5 0 1 2 3 4 5 6 7 8 KILOMETERS

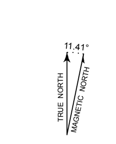
CONTOUR INTERVAL 10 AND 20 METERS

GREAT SALT LAKE BATHYMETRIC CONTOUR INTERVAL 1 FOOT

Great Salt Lake shoreline elevation of 4200 feet (1280 m) from Baskin and Allen, 2005



MAP LOCATION



APPROXIMATE MEAN DECLINATION, 2021

INTERIM GEOLOGIC MAP OF THE PROMONTORY POINT 30' X 60' QUADRANGLE, BOX ELDER, WEBER, DAVIS, AND TOOELE COUNTIES, UTAH—SOUTHWEST PART, YEAR 1

by

Donald L. Clark

2021

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 G20AC00244 (2020-21). 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. This map and explanatory information are submitted for publication with the understanding that the U.S. Government is authorized to reproduce and distribute reprints for governmental use.

Base from USGS Promontory Point 30' x 60' Quadrangle (1987)
Shaded relief derived from USGS 10-meter NED
UTTR boundary was revised
Projection: UTM Zone 12
Datum: NAD 1983
Spheroid: Clarke 1866

Mapping by author: 2020-2021
Program Manager: Grant C. Willis
GIS and Cartography: Basia Matyjasik and Donald L. Clark

Utah Geological Survey
1594 W. North Temple, Suite 3110
Salt Lake City, UT 84116
(801) 537-3300
geology.utah.gov
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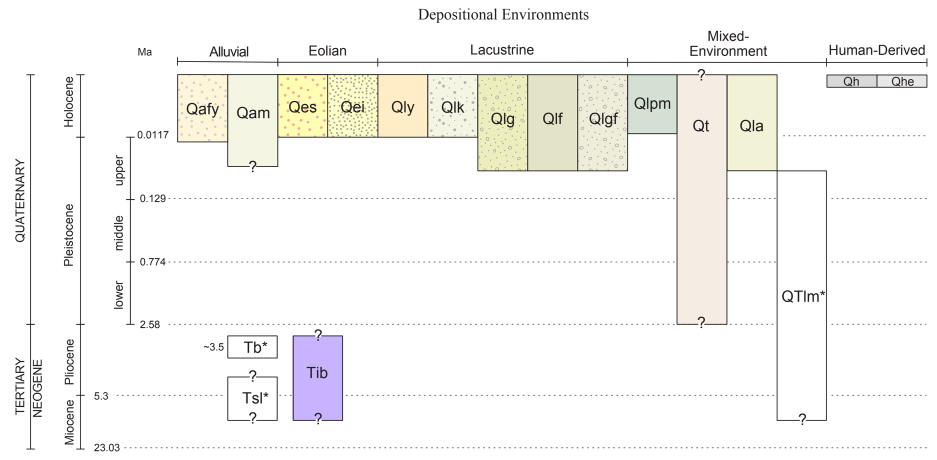
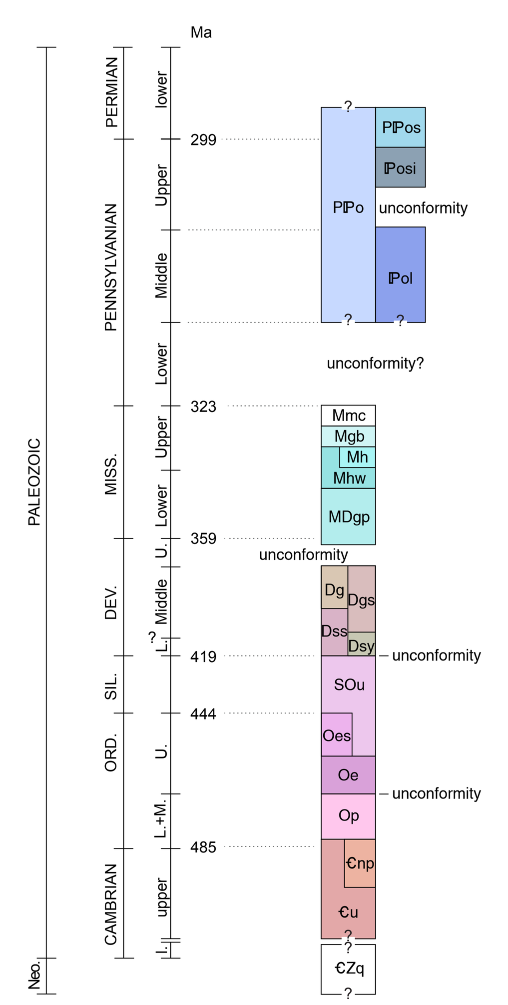
CORRELATION OF QUATERNARY-TERTIARY (NEOGENE) GEOLOGIC UNITS



*Subsurface only

CORRELATION OF PALEOZOIC–NEOPROTEROZOIC? GEOLOGIC UNITS



Boundary ages from International Chronostratigraphic Chart v2020/03. Informal subdivisions of Permian and Cambrian are used.

LITHOLOGIC COLUMN

Northern and central Lakeside Mountains and adjacent areas

CHRONO-STRATI-GRAPHIC UNIT		GEOLOGIC UNIT	MAP SYMBOL	THICKNESS Feet (Meters)	LITHOLOGY
	Plio.	Basalt	Tb	500 (150)	subsurface
TERTIARY (NEOGENE)	Mio–Plio?	Salt Lake Formation	Tsl	1415–2400 (431–732)	subsurface
PERMIAN	lower	Oquirrh Group: sandstone and limestone unit	PPos	850+ (260+)	
		faults			
PENNSYLVANIAN	Upper	Oquirrh Group: sandstone and siltstone unit	IPosi (PIPo)	1700 (520)	
	Middle	Oquirrh Group: limestone unit	IPol	1300+ (400+)	Unconformity
		faults			
MISSISSIPPIAN	U.	Manning Canyon Formation	Mmc		subsurface
	Upper	Great Blue Limestone	Mgb	~4078 (1243)	corals conodonts
	Upper undivided	Humbug Formation	Mh	1058 (278)	
		Woodman Fm.	Mhw	1250 (380)	Delle Phosphatic Mbr.
	Lower	Gardison Ls., Fitchville Fm., Pinyon Peak Ls	MDgp	1000 (300)	Unconformity
DEVONIAN	Middle	Guilmette Fm., Simonson Dolomite	Dg, Dgs, Dss	1471–2156 (448–657)	
	L.	Sevy Dolomite	Dsy	306–341 (93–104)	Unconformity conodonts
SIL.		Laketown Dol., Ely Springs Dol...	SOu	1651(503)	
			Oes	650+ (200+)	
ORDOV.	U.	Eureka Quartzite	Oe	228-230+ (70+)	Unconformity - Tooele Arch Kanosh Shale
	Lower-Middle	Pogonip Group	Op	1616 (493)	
CAMBRIAN	upper undivided	Notch Peak Formation	Ꞓnp	400+ (120+)	
		Orr Formation	Ꞓu	1250+ (380+)	
		Lamb Dolomite?			
CAMB? - NEO?		Quartzite	ꞒZq	85 (26)	subsurface

GEOLOGIC SYMBOLS

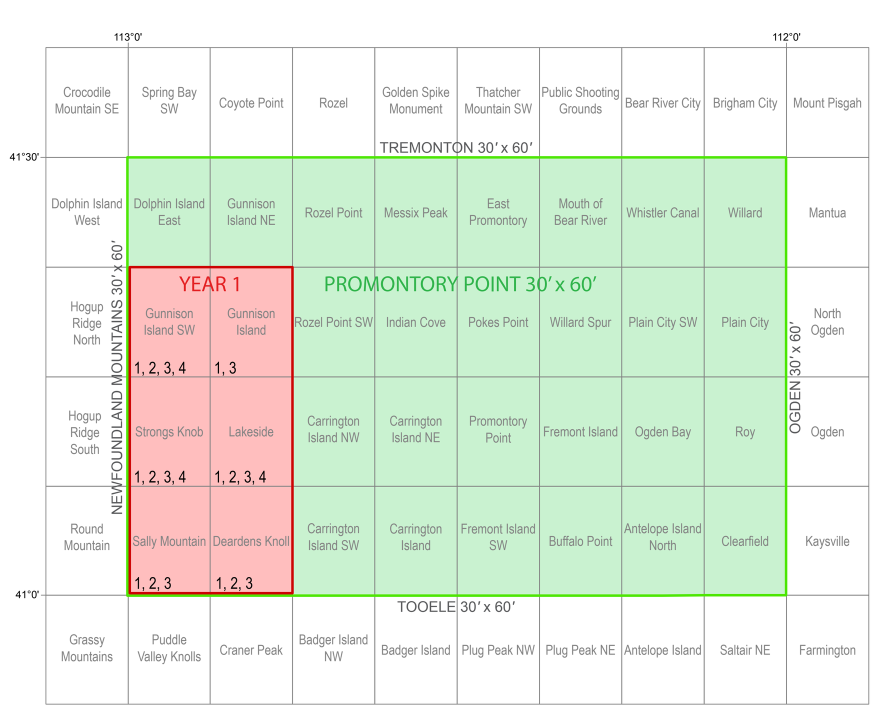
- Contact
- High-angle normal fault – Dashed where approximately located, dotted where concealed; dotted and queried where existence and location inferred; bar and ball on downthrown side
- Normal fault, geophysical, gravity – Located from gravity data, dashed where concealed and very approximately located; bar and ball on downthrown side
- Oblique-slip fault – Dotted where concealed; arrows and bar and ball indicate relative displacement
- Fault of unknown geometry and offset – Dashed where approximately located, dotted where concealed, queried where existence and location inferred
- Thrust fault – Dotted where concealed; dotted and queried where existence and location inferred; teeth on hanging wall; bar and ball where later normal movement
- Zone of structural accommodation
- Lineament – From aerial photo interpretation
- Axial trace of anticline – Dashed where approximately located, dotted where concealed
- Axial trace of overturned anticline – Dashed where approximately located
- Axial trace of syncline – Dashed where approximately located, dotted where concealed
- Minor syncline
- Lake Bonneville Shorelines (see Currey, 1982; Chen and Maloof, 2017) – Dashed where approximately located
  - Bonneville shoreline 5300–5340 feet (1616–1628 m)
  - Provo shoreline 4920–4930 feet (1500–1503 m)
  - Stansbury shoreline ~4500 feet (1372 m)
  - Great Salt Lake shoreline (historic average 4200 feet [1280 m])
- Water Boundary
- Ditches in Great Salt Lake
- Causeway breaches
- Sedimentary bedding attitude –
  - Inclined
  - Inclined approximate
  - Inclined photointerpreted
  - Vertical
  - Overturned
- Spring
- Mine or quarry (active and inactive)
- Sand and gravel pit (active and inactive)
- Sediment pit – Great Salt Lake and vicinity
- Drill hole – Oil/Gas exploration wells (see table 2)
  - Dry hole
  - Oil show
  - Abandoned
- Drill hole – Water well (see table 2)
- Tephrochronology sample (see table 1)
- Geochemical sample (see table 3)
- Fossil sample (see table 5)
- Qes/Qlf Stacked unit — Indicates thin cover of the first unit overlying the second unit

GEOLOGIC UNITS

Symbol	Unit
Qafy	Younger fan alluvium, post-Lake Bonneville
Qam	Alluvial mud
Qes	Eolian sand
Qei	Eolian silt
Qly	Younger lacustrine deposits, undivided, Great Salt Lake
Qlk	Younger lacustrine carbonate-chip sand and gravel, Great Salt Lake
Qlg	Lacustrine gravel, Lake Bonneville and Great Salt Lake
Qlf	Lacustrine fine-grained deposits, Lake Bonneville and Great Salt Lake
Qlgf	Lacustrine gravel to fine-grained deposits, Lake Bonneville and pre-Lake Bonneville
Qlpm	Great Salt Lake and playa mud
Qt	Tufa deposits
Qla	Lacustrine and alluvial deposits, undivided
QTlm	Lacustrine, mudflat and eolian deposits, pre-Lake Bonneville [subsurface only]
Qh	Human disturbance
Qhe	Evaporation ponds
Qei/Qlgf?	Eolian silt over lacustrine gravel to fine-grained deposits?
Qei/Qla	Eolian silt over lacustrine and alluvial deposits
Qes/Qlk	Eolian sand over younger lacustrine carbonate-chip sand and gravel
Qes/Qlg	Eolian sand over lacustrine gravel
Qes/Qlf	Eolian sand over lacustrine fine-grained deposits
Qes/Qla	Eolian sand over lacustrine and alluvial deposits
Qlk/Qlg	Younger lacustrine carbonate-chip sand and gravel over lacustrine gravel
Qlg/M?u?	Lacustrine gravel over Mississippian? bedrock
Tb	Basalt [subsurface only]
Tib	Basaltic intrusions
Tsl	Salt Lake Formation [subsurface only]
PIPo	Oquirrh Group, undivided
PPos	Oquirrh Group, sandstone and limestone unit
IPosi	Oquirrh Group, sandstone and siltstone unit
IPol	Oquirrh Group, limestone unit
Mmc	Manning Canyon Formation [subsurface only]
Mgb	Great Blue Limestone
Mhw	Humbug Formation and Woodman Formation, undivided
Mh	Humbug Formation
MDgp	Gardison Limestone, Fitchville Formation, and Pinyon Peak Limestone, undivided
Dgs	Guilmette Formation and Simonson Dolomite, undivided
Dg	Guilmette Formation
Dss	Simonson Dolomite and Sevy Dolomite, undivided
Dsy	Sevy Dolomite
SOu	Laketown Dolomite and Ely Springs Dolomite, undivided
Oes	Ely Springs Dolomite
Oe	Eureka Quartzite
Op	Pogonip Group, undivided
Ꞓu	Notch Peak Formation, Orr Formation, and Lamb Dolomite?, undivided
Ꞓnp	Notch Peak Formation
ꞒZq	Cambrian?–Neoproterozoic? quartzite [subsurface only]
	water (Great Salt Lake)

Note - Repeated queried labels not included here, see Geologic Unit Descriptions in booklet

PRIMARY SOURCES OF GEOLOGIC MAPPING



1. D.L. Clark [UGS] (2020-2021), photogeologic and limited field mapping
2. Doelling (1964)
3. Doelling (1980)
4. A. Rupke and T. Boden (UGS, unpublished data, 2019)

See booklet for geologic unit descriptions, references, figures, and tables.

INTERIM GEOLOGIC MAP OF THE PROMONTORY POINT 30' X 60' QUADRANGLE, BOX ELDER, WEBER, DAVIS, AND TOOELE COUNTIES, UTAH—SOUTHWEST PART, YEAR 1

by

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Disclaimer

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UTAH DNR GEOLOGICAL SURVEY

OPEN-FILE REPORT 739
UTAH GEOLOGICAL SURVEY
a division of
UTAH DEPARTMENT OF NATURAL RESOURCES
2021

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INTRODUCTION

The Promontory Point 30' x 60' quadrangle extends across Great Salt Lake to the Interstate highway 15 (I-15) corridor in Box Elder, Weber, Davis, and Tooele Counties, northwest Utah (figure 1). The map area is predominantly in the eastern Basin and Range Physiographic Province. The quadrangle includes parts of the north and south arms of Great Salt Lake separated by the Lucin Cutoff (Union Pacific railroad causeway). On the west are the northern Lakeside Mountains, Strongs Knob, and Gunnison, Cub and Dolphin Islands. The central area includes the Promontory Mountains and Rozel Hills, and Fremont, Carrington, and Hat Islands. The eastern area includes the Wasatch Front with human-populated areas from Brigham City to Layton (north to south), a small part of the Wasatch Range near Willard, and Antelope Island (figure 1). Most of the western area is public land (Federal and State administered) including restricted-access military land (U.S. Air Force range, also known as UTTR-N—Utah Test and Training Range North area, located south of Lakeside). The main operational area at UTTR-N is referred to as Oasis. Most of the central and eastern areas are private land with smaller areas of public land including Cache National Forest, Bear River National Migratory Bird Refuge and Willard Bay State Park, Hill Air Force Base, and northern Antelope Island State Park. The quadrangle area has a variety of uses including transportation, industry, military operations, agriculture, aquaculture, waste management, mineral (salt) extraction, and recreation.

This geologic map is part of a continued effort by the Utah Geological Survey (UGS) to map the geology of the state of Utah at an intermediate scale (see Willis, 2017). This map displays the first year of work of a multi-year project to map the geology of the Promontory Point 30' x 60' quadrangle at 1:62,500 scale (plate 1, figure 1). Plate 1 also includes the map explanation showing primary sources of geologic mapping, geologic units, unit correlations, lithologic columns, and geologic symbols. A separate booklet contains geologic unit descriptions, acknowledgments, references, figures, and tables.

Map data were compiled from several prior sources and new mapping was added (see plate 1, mapping sources). We extended intermediate-scale geologic mapping from adjacent areas including the Bonneville Salt Flats and east Wendover 30' x 60' quadrangles (Clark and others, 2020a), Tooele 30' x 60' quadrangle (Clark and others, 2020b), Newfoundland Mountains and east Wells 30' x 60' quadrangles (Miller and others, 2021), Grouse Creek and east Jackpot 30’ x 60’ quadrangles (Miller and others, 2020), and Tremonton 30' x 60' quadrangle (Miller and others, in prep.). Barnhard and Dodge (1988) reported on the Puddle Valley fault zone. The Great Salt Lake shoreline (4200 feet [1280 m] average historical elevation) and bathymetric data are from Baskin and Allen (2005) and Baskin and Turner (2006). Updated Great Salt Lake shoreline topographic contours have been recently derived from lidar data (Utah Division of Forestry, Fire and State Lands, unpublished data, 2020), but this partial dataset does not mesh well with the prior topographic and bathymetric data. This map updates the prior, less detailed geologic mapping by Stokes (1963) and Doelling (1980). Additional revisions to this part of the map could occur in subsequent years of the project.

Geophysical gravity data were used to map some concealed faults. Two data sets were used including (1) adjusted data from the Pan-American Center for Earth and Environmental Studies (PACES) (2012) and UGS-collected data from 2011–2014 (compiled in 2020 by Christian Hardwick, UGS, unpublished data, primarily for the adjacent Bonneville Salt Flats 30' x 60' quadrangle geologic map), and (2) PACES (2012). The first dataset covered the northern Lakeside Mountains and adjacent Great Salt Lake area, and the second set covered the northern part of the year 1 map area. The computed final values are Complete Bouguer Gravity Anomaly. Clark and others (2020a) provided details of the data collection and methods. Cook and others (1980) reported on prior interpretations of gravity data.

DESCRIPTION OF GEOLOGIC UNITS

QUATERNARY SURFICIAL DEPOSITS

Alluvial deposits

Qafy **Younger fan alluvium, post-Lake Bonneville** (Holocene to uppermost Pleistocene) – Poorly sorted gravel, sand, silt, and clay; deposited by streams, debris flows, and debris floods on alluvial fans and in mountain valleys; includes alluvium and colluvium in mountain valleys; may include small areas of lacustrine fine-grained deposits below the Bonneville shoreline; includes active and inactive fans younger than Lake Bonneville, but may include older alluvial deposits above the Bonneville shoreline; locally includes eolian silt and sand cover commonly less than 3 feet (1 m) thick; locally, unit Qafy spreads out on lake terraces and, due to limitations of map scale, is shown to abut Lake Bonneville shorelines even though it is not cut by these shorelines; Qafy also locally drapes over, but does not completely conceal shorelines; thickness variable, up to 50 feet (15 m) or more.

Qam **Alluvial mud** (Holocene to upper Pleistocene?) – Silt, clay, some sand, and minor gravel deposited by streams and sheetwash in depressions that were lagoons behind gravel barriers deposited during the Bonneville lake cycle (some low-elevation lagoon depressions may be related to Great Salt Lake rather than Lake Bonneville); some lagoon basins include unexposed, thin, fine-grained deposits beneath the alluvial mud, laid down while the lagoon was active and the barriers were forming; thickness less than about 20 feet (6 m).

Eolian deposits

Qes, Qes?

Eolian sand (Holocene) – Windblown sand and silt in dunes and sheets; bedding is variable from laminated to thin, with locally abundant cross-bedding; includes well-sorted, fine to very fine grained quartz sand, and also coarse to very fine grained sand of variable composition including ooids, gypsum, carbonate lumps, and shell fragments (gastropods and ostracodes); ooid-rich sand is locally present along the shore of Great Salt Lake; grades into units Qei and Qlk; Qes locally forms thin cover on map units (see stacked units), only thicker deposits mapped as unit Qes; as much as 20 feet (6 m) thick.

Qei **Eolian silt** (Holocene) – A few areas of windblown silt with minor clay and fine sand that is locally oolitic; Qei occurs extensively as sheets that typically cover lacustrine and alluvial deposits and some bedrock in stacked units and locally as small dunes; in addition, forms thin, unmapped cover on several map units; thickness as much as 10 feet (3 m).

Lacustrine deposits of Great Salt Lake

Qly **Younger lacustrine deposits, undivided** (Holocene) – Deposits along the margin of Great Salt Lake that are not easily differentiated at map scale or not field checked; composed of various deposits including lacustrine gravel, carbonate-cemented gravel and sand, boulders, tufa, carbonate-chip sand and gravel, sand, and mud; larger tufa deposits are mapped separately (unit Qt); grades into units Qlpm, Qlk, Qlg, Qafy; thickness is probably less than 10 feet (3 m).

Qlk **Younger lacustrine carbonate-chip sand and gravel** (Holocene) – Lacustrine sand and gravel composed of calcium-carbonate clasts, including ooids, pellets, and rounded, irregularly shaped flakes and chips, with some rounded pebbles of local rocks; pebble content varies greatly and can locally include some gravel deposits; unit grades into Qly, Qlpm, Qlf, Qlg, Qafy; formed on the floor of Great Salt Lake when adjacent mudflats were submerged, or were precipitated from pore waters in mud and later reworked by waves; locally present in barrier bars and islands fringing Great Salt Lake and some beaches; also mapped as part of stacked units Qlk/Qlg, Qlk/Qlg?, and locally present as thin shorelines on units Qlg and Qlf up to an elevation of 4250 feet (1296 m) that are difficult to separate at map scale; exposed thickness as much as 6 feet (2 m).

Lacustrine deposits (Great Salt Lake and Lake Bonneville)

See figure 2 for a simplified hydrograph and chronology of Lake Bonneville and Great Salt Lake. I mapped the three major shorelines of Lake Bonneville including the Stansbury, Bonneville, and Provo (see, for example, Oviatt, 2015; Oviatt and Shroder, 2016). Currey (1982) and Chen and Maloof (2017) provided shoreline elevation data (see plate 1). The deposits of Lake Bonneville and Great Salt Lake are not easy to map separately.

The Pilot Valley shoreline (~4280–4290 feet [1305–1308 m] elevation) and Gilbert shoreline (~4250 feet [1296 m]) have been mapped in adjacent areas (see Miller and Phelps, 2016; Miller and others, 2021), but C.G. Oviatt does not consider them regional shorelines (see Oviatt, 2014; Clark and others, 2020a, 2020b). Lake Bonneville was succeeded by a lake during the Gilbert episode (figure 2), but these deposits are localized, generally thin, and difficult to recognize (see Oviatt, 2014; Clark and others, 2020a, 2020b; Oviatt and others, 2021).

Great Salt Lake is controlled by a threshold(s) near an elevation of 4214–4215 feet (1285 m) west of the map area (shown as The Threshold on the USGS Newfoundland Mountains 30' x 60' quadrangle topographic map). At times of higher water, Great Salt Lake spilled over to the west to the Great Salt Lake Desert basin. Eardley and others (1957) noted this threshold, and Currey (1982) discussed the Desert Threshold. The Great Salt Lake/Hogup pumping station used in the 1980s to remove water from the Great Salt Lake basin is located nearby (Austin, 2002).

The historical highstand shoreline of Great Salt Lake is near 4212 feet (1284 m). Evidence of this shoreline is a 'trash line' of wood, lumber, plastic, metal (attached to materials that floated) and other debris, commonly on a barrier of Qlk. I did not map this shoreline, but it is commonly an upper contact of unit Qlk with other deposits. The shoreline is locally present and can vary somewhat in elevation due to coastal processes (see Atwood, 2006).

Homestead Cave located on northern Homestead Knoll at UTTR-N has undergone numerous studies of vertebrate fauna bones from the Pleistocene and Holocene (see for example, Madsen and others, 2000; Terry and Novak, 2015; Wolfe and Broughton, 2016).

Qlg, Qlg?

Lacustrine gravel (Holocene to upper Pleistocene) – Sandy gravel to boulders composed of rock fragments deposited in shore zones of Great Salt Lake and Lake Bonneville; clasts are typically well rounded and sorted; locally includes unit Qlk and younger lacustrine deposits along the margin of Great Salt Lake that are difficult to map at target scale; Lake Bonneville shorelines are locally calcareous tufa-cemented and draped on bedrock (especially at the Provo shoreline, figure 2); includes both Lake Bonneville transgressive and regressive phase gravels; unit may include small areas of lacustrine sand and fines, eolian silt and sand, and pre-Lake Bonneville deposits; thinner gravel deposits on bedrock are not mapped; Sack (1995) and Oviatt and others (1997) reported on the Puddle Valley inflow feature (a gravel deposit with hummocks and swales) at the north side of Puddle Valley; thickness variable, up to 100 feet (30 m) or more.

Qlf **Lacustrine fine-grained deposits** (Holocene to upper Pleistocene) – Sand, silt, marl, and calcareous clay of Lake Bonneville; thin to very thick bedded; may include ostracode- and gastropod-rich layers; locally includes small areas of sand or sand and gravel; Doelling (1964) reported diatomaceous marl in northwest Puddle Valley and also in nearby Ripple Valley; unit Qlf locally includes the white marl of Gilbert (1890); locally can include thin eolian silt and sand deposits and Qlk deposits at surface; hand dug pit LE1 (plate 1) to a depth of 3.3 feet (1.0 m) encountered Lake Bonneville early transgressive phase marl based on sediment character and ostracode evaluation (C.G. Oviatt, email to Clark, Sept. 29, 2020) underlying thin (few in and cm) deposits of Great Salt Lake; thickness as much as 60 feet (20 m) or more.

Lacustrine deposits (Lake Bonneville and pre-Lake Bonneville)

Qlgf **Lacustrine gravel to fine-grained deposits** (Holocene to upper Pleistocene) – Lake Bonneville and locally pre-Bonneville deposits with mixed grain sizes; see Qlg and Qlf unit descriptions above; may include small areas of eolian and alluvial deposits, as well as bedrock; thickness up to 100 feet (30 m) or more.

A tephra in the walls of the Lakeside gravel pit about 12–20 inches (30–50 cm) thick (Oviatt and others, 1997) indicates a geochemical correlation age of 35,000–40,000 years B.P., corresponding to Mt. St. Helens set Cw (A. Sarna-Wojicki email to D.M. Miller, Oct. 1, 2020; see Mullineaux, 1996) (geochemical data in table 1) (emails from C.G. Oviatt and D.M. Miller to Clark, Oct. 1–2, 2020); the tephra is interpreted to be preserved in lagoon-fill deposits that are younger than the Cutler Dam lake cycle and older than Lake Bonneville (C.G. Oviatt, email to Clark, Oct. 2, 2020).

Mixed-environment deposits

Qlpm **Great Salt Lake and playa mud** (Holocene) – Clay, silt, oolitic sand, pelletal sand, and carbonate composing the bed of Great Salt Lake and some slightly higher adjacent areas; as mapped includes typical playa mud, which is subaerial in origin, and is washed in and/or derived from in-place weathering of the underlying deposits (probably less than 1 foot [0.3 m] in most places); also includes Great Salt Lake mud, which in many cases is difficult to distinguish from subaerial mud, and we did not attempt to separate them on the map; locally reworked by alluvial, eolian and lacustrine processes; locally mud is organic rich and contains carbonate chips and fins; salts accumulate on playa surfaces as these deposits are locally and intermittently exposed depending on lake level; gradational with units Qafy, Qlf, Qlk, Qt; the sediments of Great Salt Lake are muddy, and the thickness is highly variable but generally less than 15 feet (5 m); unit Qlpm overlies Lake Bonneville deposits and pre-Bonneville deposits as recorded in several sediment cores within deeper parts of the Great Salt Lake basin (east of current map area); unit Qlpm ranges in thickness from about 1 inch (3 cm) to 50 feet (15 m) or more in fault zones on the floor of the lake (Spencer and others, 1984; Thompson and Oviatt, 1995, unpublished data; Schnurrenberger and Haskell, 2001; Colman and others, 2002; McKean and others, 2019; Clark, unpublished data; Dinter, unpublished data).

The historical extent of Great Salt Lake is indicated on the map by the average elevation of 4200 feet (1280 m) (Baskin and Allen, 2005; Baskin and Turner, 2006; U.S. Geological Survey, 2021); the north and south arms of the lake are separated by a railroad causeway and vary in elevation as recorded by gauges at Saline and Saltair, Utah, respectively; the historic high-stand of Great Salt Lake (south arm) was 4211.6 feet (1284 m) in 1986 and 1987 (U.S. Geological Survey, 2021); Atwood (2006) reported on shoreline superelevation in 1986–1987 that locally exceeded 4212 feet (1284 m) due to prevailing wind fetch; the historic low stand (south arm) was 4191.35 feet (1278 m) in 1963 and levels have declined below this low level during the 2021 drought (exposing large expanses of the lake bed), but the causeway was breached again in 2016 making comparison of elevation data difficult (U.S. Geological Survey, 2021).

During post-Bonneville time (that is, during the past 13,000 years), Great Salt Lake rose and fell frequently, but the precise ages and elevations of high stands and low stands has not been determined except for the high stand during the Gilbert episode at 11,600 yr B.P. (4250 feet or 1295 m) (Oviatt and others, 2021); all high-stands younger than the Gilbert episode have been lower than the Gilbert-episode lake.

Qt **Tufa deposits** (Holocene? and/or Pleistocene?) – Several small areas of bulbous tufa deposits located on and near bedrock promontories at the Lakeside rail siding and Strongs Knob areas; some deposits appear to have their tops eroded exposing a bedrock or beachrock core, other tufa deposits appear to be interlayered with consolidated beach gravel (beachrock); smaller tufa heads have been called "monks heads"; deposits include layers of dolomite and carbonate; some deposits near Lakeside include (1) Twin Hills Point, (2) Dos Equis Point, (3) Death Point, (4), Atwoods Point, (5) Currey Point, and (6) Cave Ridge South (see numbers on unit labels on plate 1); prior studies were by Pedone and Dickson (2000) and Homewood and others (2018, 2021), and ongoing work is by Pedone and Oviatt (Oviatt, personal communication to Clark, June 4, 2021); these deposits have proven difficult to date; thickness is generally less than 20 feet (6 m).

Qla, Qla?

Lacustrine and alluvial deposits, undivided (Holocene to upper Pleistocene) – Sand, gravel, silt, and clay; consists of alluvial deposits reworked by Lake Bonneville, lacustrine deposits reworked by streams and covered by slopewash and alluvial fans, as well as alluvial and lacustrine deposits that cannot be readily differentiated at map scale; grades into other lacustrine and alluvial deposits; thickness locally exceeds 30 feet (10 m).

QTlm **Lacustrine, mudflat, and eolian deposits, undivided** (pre-Lake Bonneville) (Pleistocene to Pliocene) – Subsurface only. Basin-fill deposits consisting of light-gray to white marl with lacustrine ostracodes (lacustrine facies); mud, sandy mud, and fine sand; locally includes non-lacustrine ostracodes and gastropods, poorly sorted sandy mud, soil carbonate, and rootlet casts, and some massive sandy muds may be eolian ("marsh/mudflat facies" of Oviatt and others, 1999); relatively well-sorted beds of sand and/or gravel (fluvial or shore zone lacustrine facies) (Oviatt and others, 1999); deposits were encountered in several sediment cores and drill holes in the Great Salt Lake basin; Williams (1994) reported on several ash beds in the Burmester core (in adjacent Tooele 30' x 60' quadrangle) dated from about 0.11 to 3.29 Ma; unit QTlm underlies Lake Bonneville deposits and overlies the Salt Lake Formation; thickness in map area is uncertain, incomplete thickness is 1000 feet (300 m) in the Burmester and other "Eardley" cores (Saltair, S28 cores) (see Clark and others, 2020b), and complete thickness roughly 4500 feet (1370 m) in the Amoco Antelope Island drill hole (Bortz, 2002).

Human-derived deposits

Qh **Human disturbance** (historical) – Deposits and disturbed areas from human development; includes sand and gravel and borrow pits, quarries, railroad causeways, waste management and developed areas on the U.S. Air Force range (UTTR-N); more laterally extensive evaporation ponds are mapped separately; thickness generally less than about 20 feet (6 m).

Qhe **Evaporation ponds** (historical) – Active and former solar evaporation pond systems for potash (potassium chloride salt) production; the active pond system (Clyman Bay pond, now Compass Minerals) was completed in the early 1990s northwest of the Lakeside siding; brine is transferred by flow of denser solutions in the subaqueous Behrens trench west to east beneath Great Salt Lake (Blinkhorn and Schwinn, 2002; Butts, 2002; Gwynn, 2002); the inactive pond was operated by Bill Colman (Gwynn, 2002); thickness is 20 feet (6 m) or less.

Stacked-unit deposits

Consists of thin surficial deposits covering underlying surficial deposit and bedrock geologic units. Thin cover materials may also be present on other geologic units throughout the map area.

Qei/Qlgf?

Eolian silt over lacustrine gravel to fine-grained deposits? (Holocene over upper Pleistocene?) – One area in northern Puddle Valley of eolian silt forming a mantle on possible Lake Bonneville lacustrine gravel to fines; lacustrine feature may be related to Puddle Valley shoreline A of Sack (1995) (C.G. Oviatt, email to Clark, Nov. 13, 2020); cover unit thickness unknown, but possibly as much as 6 feet (2 m) or more.

Qei/Qla, Qei/Qla?

Eolian silt over lacustrine and alluvial deposits (Holocene over Holocene to upper Pleistocene) – Eolian silt forming a mantle on mixed lacustrine and alluvial deposits; see descriptions for units Qei and Qla; may locally include eolian sand; cover unit thickness is less than 6 feet (2 m).

Qes/Qlk

Eolian sand over younger lacustrine carbonate chip sand and gravel (Holocene over Holocene) – Areas of Qlk near the western margin of Great Salt Lake that locally have an eolian sand cover consisting of siliciclastic sand, ooids (rods and spheres), carbonate lumps, probable gypsum flakes; see descriptions for units Qes and Qlk; cover unit thickness is less than 6 feet (2 m).

Qes/Qlg

Eolian sand over lacustrine gravel (Holocene over Holocene to upper Pleistocene) – Eolian sand and silt forming a mantle on lacustrine gravel of Lake Bonneville and Great Salt Lake; see descriptions for units Qes and Qlg; cover unit thickness unknown, but possibly as much as 6 feet (2 m).

Qes/Qlf

Eolian sand over lacustrine fine-grained deposits (Holocene over Holocene to upper Pleistocene) – Eolian sand and silt forming a mantle on lacustrine fines; also present in patchy sheets and dunes on Qlf, typically around perimeter of large Qes areas; see descriptions for units Qes and Qlf; cover unit thickness from 0 to as much as 6 feet (2 m).

Qes/Qla, Qes/Qla?

Eolian sand over lacustrine and alluvial deposits (Holocene over Holocene to upper Pleistocene) – Eolian sand and silt forming a mantle on mixed lacustrine and alluvial deposits; also present in patchy sheets and dunes on Qla; see descriptions for units Qes and Qla; cover unit thickness from 0 to as much as 6 feet (2 m).

Qlk/Qlg, Qlk/Qlg?

Younger lacustrine carbonate-chip sand and gravel over lacustrine gravel (Holocene over Holocene to upper Pleistocene) – Exposures east and west of Lakeside of younger carbonate-chip sand and gravel over gravel; cover unit thickness uncertain, possibly as much as 3 feet (1 m).

Qlg/Mu?

Lacustrine gravel over Mississippian? bedrock (upper Pleistocene over Mississippian?) – Three small knobs in Sedal Valley on UTTR-N that were not field checked; may consist of Lake Bonneville gravel over possible Mississippian bedrock (Great Blue Limestone or Manning Canyon Formation); see descriptions for unit Qlg and Mississippian rock units.

TERTIARY (NEOGENE) ROCK UNITS

Neogene rocks are thick in basins in the quadrangle, but typically not exposed at the surface. See table 2 for data on subsurface rock units from drill holes/hydrocarbon exploration wells.

Tb **Basalt** (Pliocene) – Subsurface only. Basalt encountered in the Amoco State P1 well (aka East Gunnison well); probably basaltic lava flows that form the reservoir of the Rozel oil field (see Bortz, 2002); palynology (aquatic pollen) from adjacent strata provided age data, no direct radiometric dating is reported (Bortz, 2002), but Miller and others (1995) reported basalt K-Ar ages of about 3.5 Ma in the nearby Rozel Hills and Black Mountain area; thickness in Amoco P1 well is 500 feet (150 m) (table 2).

Tib **Basaltic intrusions** (Pliocene? - Miocene?) – Two exposures of medium to dark gray, weathering to reddish brown, basaltic dike(s) located north of Puddle Valley and southwest of the Oasis area of UTTR-N; aphanitic and somewhat vesicular; form discontinuous outcrops trending north (also see Doelling, 1964); new geochemical data in table 3; no direct age data, but possibly of similar age to basalts in northwest Utah from Pliocene to Miocene in age (see for example, Miller and others, 1995, 2020, 2021); width is 15 to 50 feet (5–15 m) (Doelling, 1964).

Tsl **Salt Lake Formation** (Pliocene? and Miocene) – Subsurface only. This unit is expected to be present in the subsurface based on regional geologic mapping; typically tuffaceous sandstone and siltstone, sandstone, shale, conglomerate, limestone, and rhyolitic tuff or ash beds (tephras); 1415 feet (431 m) of Tertiary reported from the Cities Service Lakeside A-1 well, and 2400 feet (732 m) of Miocene strata from the Amoco State P1 well (table 2), but lithologic information not provided.

PERMIAN TO CAMBRIAN ROCK UNITS OF THE NORTHERN LAKESIDE MOUNTAINS, ROUND MOUNTAIN TO HOMESTEAD KNOLL AREA, STRONGS KNOB, GUNNISON AND CUB ISLANDS

See table 2 for data on subsurface rock units from drill holes/hydrocarbon exploration wells. Table 4 provides a comparison of stratigraphic nomenclature from this map and that of Doelling (1964, 1980).

PERMIAN AND PENNSYLVANIAN

See figure 3 for a correlation diagram of Oquirrh Group/Formation and adjacent rock units.

Oquirrh Group strata of Round Mountain to Homestead Knoll area (Calcite thrust sheet)

Modified from Doelling (1964, 1980) and Jordan (1979b).

PIPo **Oquirrh Group, undivided** (lower Permian [Leonardian?-Wolfcampian] to Middle and Lower? Pennsylvanian) – Combined unit in the hills west of Oasis at UTTR-N (U.S Air Force informally calls MSA Hills) that probably includes units of the Oquirrh Group described below but are difficult to separate due to limited exposures and structural complications.

PIPos **Oquirrh Group, sandstone and limestone unit** (lower Permian, Leonardian?-Wolfcampian to Upper Pennsylvanian, uppermost Virgilian) – Limited exposures of light- to dark-gray limestone and fossiliferous limestone that is locally cherty and light- to dark-brown sandstone, gray calcareous sandstone that weathers to light and dark brown (also see description in Clark and others, 2020a); medium to thick bedded, forms ledges and slopes; present in one area southwest of Oasis at UTTR in footwall of thrust fault, and in an area of poor exposures in southwest corner of map area, most exposures there are brecciated; in the Grassy Mountains and adjacent areas fossil fusulinids and conodonts were reported to indicate an early Leonardian through early Wolfcampian age (Doelling, 1964; Jordan, 1979a, 1979b; Clark and others, 2020a); G.P. Wahlman (independent biostratigrapher) reevaluated the fusulinid data in Doelling (1964), results are provided in Clark and others (2020a); Doelling (1964) reported other fossils in the Grassy Mountains including crinoids, brachiopods, pelecypods, sponges, trilobites, and bryozoans; unit PIPos corresponds to Oquirrh Formation units 6, 5, 4, 3 and upper part of unit 2 of Doelling (1964); incomplete thickness in map area is about 850 feet (260 m), and complete thickness is 7620 to 9004 feet (2323–2745 m) in the nearby Grassy Mountains (Doelling, 1964).

IPosi, IPosi?

Oquirrh Group, sandstone and siltstone unit (Upper Pennsylvanian, Virgilian) – Light-brown, light-gray, and pale-red sandstone, calcareous sandstone and siltstone, and minor silty and sandy limestone; local intraformational conglomerate beds; thin to medium bedded; forms slopes and ledges; in Grassy Mountains fossil fusulinids from lower part were reported to be of Virgilian age (Doelling, 1964; Jordan, 1979a, 1979b) (see Clark and others, 2020a); corresponds to Doelling's (1964) Oquirrh Formation unit 2, excluding the upper part (272 feet, 83 m) of limestone that is placed in unit PIPos; unconformably overlies unit IPol (fossils indicate Missourian missing); queried near northwest Puddle Valley where separation from unit PIPos is difficult (see Doelling, 1964); complete thickness of 1700 feet (520 m) in map area, similar to the 1934 feet (590 m) in Grassy Mountains (Doelling, 1964).

IPol **Oquirrh Group, limestone unit** (Middle and Lower? Pennsylvanian, Desmoinesian-Atokan?-Morrowan?) – Medium-gray limestone and cherty limestone with minor interbedded light-brown sandstone and calcareous sandstone; typically thick bedded, forming cliffs and ledges; in the Grassy Mountains and adjacent areas fossil fusulinids and conodonts from the unit indicate a Desmoinesian to late Atokan? age (Clark and others, 2020a), and Doelling (1964) noted that it is uncertain if the lower part of the unit might contain Atokan- or Morrowan-age strata; other fossils in the Grassy Mountains include brachiopods, corals, trilobites, and bryozoans (Doelling, 1964); corresponds to Oquirrh Formation, unit 1 of Doelling (1964); incomplete thicknesses of 1300 feet (400 m) in map area and 1607 feet (490 m) in Grassy Mountains (Doelling, 1964), base is not exposed.

MISSISSIPPIAN AND DEVONIAN

Mmc **Manning Canyon Formation** (Lower Pennsylvanian? to Upper Missisippian) – Subsurface only. Formation is exposed in the southern Lakeside Mountains (Clark and others, 2020b), but does not crop out in the northern Lakeside Mountains.

Mgb, Mgb?

Great Blue Limestone (Upper Mississippian) – Primarily limestone with minor shale, siltstone and sandstone; bluish-gray to medium- and dark-gray limestone is locally fossiliferous, cherty, and argillaceous; bedding is typically medium to very thick; formation forms ledges and cliffs; locally black chert occurs as nodules and beds; rugose (horn) corals are typically diagnostic but other macrofossils include brachiopods, bryozoans, and crinoids (Doelling, 1964); Doelling (1964) found coral *Faberophyllum* in the lower part of a measured section (his lower member) (now Death Ridge in northern part of UTTR-North) that corresponds to western North America Coral zone IV and IIID indicating upper Meremecian North American Series (Sando and Bamber, 1985); new fossil sample PP5 from the lower and faulted part of unit Mgb (south of Lakeside) yielded a few broken elements of conodonts *Cavusgnathus* sp. and *Hindeodus* sp.; *Cavusgnathus* is found in Lower Pennsylvanian to Upper Mississippian rocks (S.M. Ritter, BYU, email to Clark, April 16, 2021) (table 5); thickness is incomplete due to faulting, Doelling (1964) measured 3640 feet (1110 m) of the formation three miles south of Lakeside and 438 feet (134 m) at Sally Mountain and he stated the combined 4078 feet (1243 m) may represent a nearly complete section; an incomplete section of 1537 feet (469 m) was measured at the southern Lakeside Mountains (Young, 1953).

Mhw **Humbug Formation and Woodman Formation, undivided** (Upper to Lower Mississippian) – Combined unit at Sally Mountain and south of Wrathall Pass (Doelling [1964] called Parallel Ridges) where the Woodman is largely covered to poorly exposed and access was very limited at Sally Mountain on UTTR-N; see Humbug description below; at Sally Mountain the Woodman includes an upper part of pale red, light brown and dark gray calcareous siltstone and sandstone that is flaggy and platy and lower part of poorly exposed siltstone, chert, limestone and cherty limestone (probable Delle Phosphatic Member); the Woodman is reported in the southern Lakeside Mountains where it yielded Osagean fossils (Sandberg and Gutschick, 1984; Poole and Sandberg, 1991; Silberling and Nichols, 1992a, 1992b); combined unit thickness is about 1250 feet (380 m).

Mh, Mh?

Humbug Formation (Upper Mississippian) – Light-brown and gray interbedded sandstone, calcareous sandstone, limestone, and sandy limestone; bedding is generally thin to thick; forms ledges and slopes; macrofossils include corals and other typical Mississippian fauna (Doelling, 1964); locally queried in exposures that are difficult to separate from unit Mgb; thickness is 1548 feet (472 m) near crest of Sally Mountain and 1058 feet (278 m) in central Lakesides, other incomplete exposures at Twin Hills (Doelling, 1964); 850 feet (260 m) thick in southern Lakeside Mountains (Clark and others, 2020b).

MDgp **Gardison Limestone, Fitchville Formation, Pinyon Peak Limestone, undivided** (Lower Missisippian and Upper Devonian) – Combined unit mapped near Twin Hills, Sally Mountain and south of Wrathall Pass areas; upper and middle parts (Gardison and Fitchville) are moderate- to dark-gray silty limestone and limestone that is commonly cherty and fossiliferous, locally with shale and sandstone near base; lower part (Pinyon Peak) is moderate gray silty and sandy limestone that weathers light brown to light gray with laminated surface texture and local rip-up clasts, may include minor dolomite, sandstone, and shale that are typically poorly exposed; combined unit is thin to very thick bedded and forms ledges, cliffs, and slopes; megafossils include corals, gastropods, brachiopods, bryozoa, and crinoid columnals; in the southern Lakeside Mountains conodonts range from Osagean to Kinderhookian to Fammenian (Sandberg and Gutschick, 1979, 1984; Silberling and Nichols, 1992a); unconformably overlies Devonian dolomite; varying stratigraphic nomenclature has been used (see table 4); partial exposures exist at Twin Hills and south of Wrathall Pass; a more complete section at Sally Mountain showed 115 feet (35 m) of Pinyon Peak present at the base (this study); thickness is about 1000 feet (300 m) (this study); 640 to 1000 feet (195–300 m) thick in the southern Lakeside Mountains (Silberling and Nichols, 1992a; Clark and others, 2020b).

DEVONIAN

Dgs **Guilmette Formation and Simonson Dolomite, undivided** (Upper? and Middle Devonian) – Combined unit at Sally Mountain and south of Wrathall Pass where is difficult to separate formations as section is predominantly dolomite; gray, color-banded dolomite and minor light-brown sandstone (Doelling, 1964); bedding is typically medium to thick and forms ledges; no biostratigraphic control, but regional ages on Devonian formations are in Hintze and Kowallis (2009); Doelling (1964) reported combined unit thicknesses of 2156 feet (657 m) and 1471 feet (448 m) at Sally Mountain and south of Wrathall Pass (Parallel Ridges) respectively but is not well exposed in the central Lakesides; in southern Lakeside Mountains complete thickness of unit is 1469 to 1850 feet (448–565 m) (Young, 1953; Doelling, 1964; Clark and others, 2020b).

Dg **Guilmette Formation** (Upper and Middle Devonian) – Guilmette is mapped separately in fault block west of Twin Hills; small section of upper Guilmette is present. See description for unit Dgs.

Dss, Dss?

Simonson Dolomite and Sevy Dolomite, undivided (Middle and Lower Devonian) – Combined unit at eastern Strongs Knob in small exposure that is faulted and brecciated; Simonson probably includes dark gray dolomite that is very brecciated and also exposures of Sevy that are less structurally disturbed; queried in a fault block near Salley fault that may include the Simonson and Sevy formations but no access there on UTTR-N; incomplete thickness is roughly 200 to 300 feet (60–90 m).

Dsy **Sevy Dolomite** (Lower Devonian) – Light- to moderate-gray dolomite that is finely to coarsely crystalline with laminated surface appearance; bedding is medium to thick, forms ledges and slopes; lighter colored and less resistant than surrounding formations; thickness is 306 and 341 feet (93 and 104 m) at Sally Mountain and south of Wrathall Pass, respectively (Doelling, 1964); in southern Lakesides is 220 to 242 feet (67–74 m) (Young, 1953; Petersen, 1956).

SILURIAN AND ORDOVICIAN

SOu **Laketown Dolomite and Ely Springs Dolomite, undivided** (Silurian and Upper Ordovician) – Combined unit mapped at Sally Mountain and south of Wrathall Pass, also mapped at northern Gunnison Island and Cub Island where in fault contact with underlying rocks; Laketown is medium- to light-gray dolomite (dolomite and limestone at Cub Island) that is medium to coarsely crystalline; Ely Springs is color banded to mottled to laminated, very dark- to medium-gray dolomite that is finely to medium crystalline; chert nodules typically gray to black are locally present in both units; bedding is medium to very thick; primarily forms ledges and cliffs; fossils include brachiopods, corals and crinoids (Doelling, 1964); regional age from Hintze and Kowallis (2009); stratigraphic study in Lakeside Mountains by Harris and Sheehan (1996); new fossil sample PP9 from Cub Island had a fauna of conodont elements with an abundance of simple cones and one variety of broken platforms; the critical fossil *Pterospathodus pennatus procerus* (Walliser) is Early Wenlockian (middle Silurian) (S.M. Ritter, BYU, email to Clark, April 16, 2021) (table 5); unconformable with underlying Eureka Quartzite; incomplete thickness is about 1200 feet (365 m) at Gunnison Island, complete thickness is 1651 feet (503 m) in northern Lakesides (Doelling, 1964) and 1075 feet (328 m) thick in southern Lakeside Mountains (Young, 1953).

Oes **Ely Springs Dolomite** (Upper Ordovician) – Formation is mapped separately at Strongs Knob; see description for unit SOu; thins southward onto the Tooele arch (Hintze, 1959); incomplete thickness is 650 feet (200 m) at Strongs Knob (Doelling, 1964).

Oe **Eureka Quartzite** (Upper Ordovician) – White to very pale orange weathering to yellowish brown and brown quartzite that is fine to medium grained, locally pitted; thick to very thick bedded; forms cliffs and rubbly slopes; mapped at Strongs Knob and Sally Mountain; thins to south onto the Tooele arch (Hintze, 1959), Clark and others (2020b) mapped with unit SOu; incomplete thickness is 230 feet (70 m) at Strongs Knob, complete thickness is 228 feet (70 m) at Sally Mountain (Doelling, 1964), and only ~15 to 35 feet (5–10 m) in the southern Lakeside Mountains (Young, 1953; Doelling, 1964).

Op **Pogonip Group, undivided** (Middle to Lower Ordovician) – Medium-gray limestone and lesser dolomite (variably sandy and cherty) with yellowish-orange argillaceous partings and laminae interbedded with siltstone, shale, and intraformational pebble conglomerate; bedding is thin to medium, and soft-sediment deformation exists as wavy bedding, slump folds, and intraformational breccia; forms ledges and slopes; mapped at Sally Mountain and on southern Gunnison Island; unit includes Kanosh Shale at top and underlying Juab Limestone, Wah Wah Limestone and Fillmore Formation; fossils include trilobites and other marine fauna (Doelling, 1964; this study); regional age from Hintze and Kowallis (2009); Pogonip thins to south onto the Tooele arch (see Young, 1955; Hintze, 1959; Doelling, 1964); incomplete thickness is about 1100 feet (335 m) at Gunnison Island where top is faulted; complete thickness is 1616 feet (493 m) at Sally Mountain (Doelling, 1964), and 1137 to 1186 feet (347–362 m) in the southern Lakeside Mountains (Young, 1955; Doelling, 1964).

CAMBRIAN

Ꞓu **Notch Peak Formation, Orr Formation, and Lamb Dolomite?, undivided** (lowermost Ordovician? to upper and middle? Cambrian) – Combined unit of Upper Cambrian formations on east part of UTTR-N where there was no access due to military operations, and presence of Lamb Dolomite is uncertain (see table 4); ***Notch Peak*** is dark-gray dolomite locally with very light gray intervals, bands and mottling; common chert nodules and stringers, *Girvanella* (microbial oncolites), pisolites, and calcite rods; medium to very thick bedded, forms ledges and cliffs; ***Orr*** has upper part of gray silty dolomite, dolomite, limestone, moderate-brown sandstone, and light-brown weathering dolomite; lower part is light- and dark-gray dolomite (Big Horse Member) with calcite rods and blebs, pisolites, oolites, and *Girvanella*; bedding is typically medium to very thick bedded; forms ledges, slopes, and cliffs; ***Lamb?*** consists of thin upper part of moderate-gray silty limestone with rust-colored silty laminae and some oolites, and thicker lower part of light- and dark-gray dolomite; bedding is thin to thick; forms ledges, slopes, and cliffs; combined unit has no biostratigraphic control here; for regional ages of the Notch Peak, Orr and Lamb refer to Hintze and Davis (2003); incomplete thickness is estimated at 1250 feet or more (380+ m); in the southern Lakeside Mountains the Notch Peak is 1375 feet (420 m), the Orr is 935 feet (285 m), and Lamb is 1075 feet (325 m) thick (Clark and others, 2020b).

Ꞓnp **Notch Peak Formation** (lowermost Ordovician? to Upper Cambrian) – Mapped separately at southern Gunnison Island; see description under unit Ꞓu; incomplete thickness is about 400 feet (120 m), lower part not exposed.

CAMBRIAN?-NEOPROTEROZOIC?

ꞒZq **Cambrian?-Neoproterozoic? quartzite** (lower Cambrian? and/or Neoproterozoic?) – Subsurface only. Precambrian quartzite (85 feet [26 m]) was reported in the bottom of the Cities Service Lakeside A-1 well (table 2); however, this call is uncertain and could be Cambrian Prospect Mountain Quartzite, Neoproterozoic quartzite units, or less likely Eureka Quartzite (Clark viewed well cuttings at the Utah Core Research Center).

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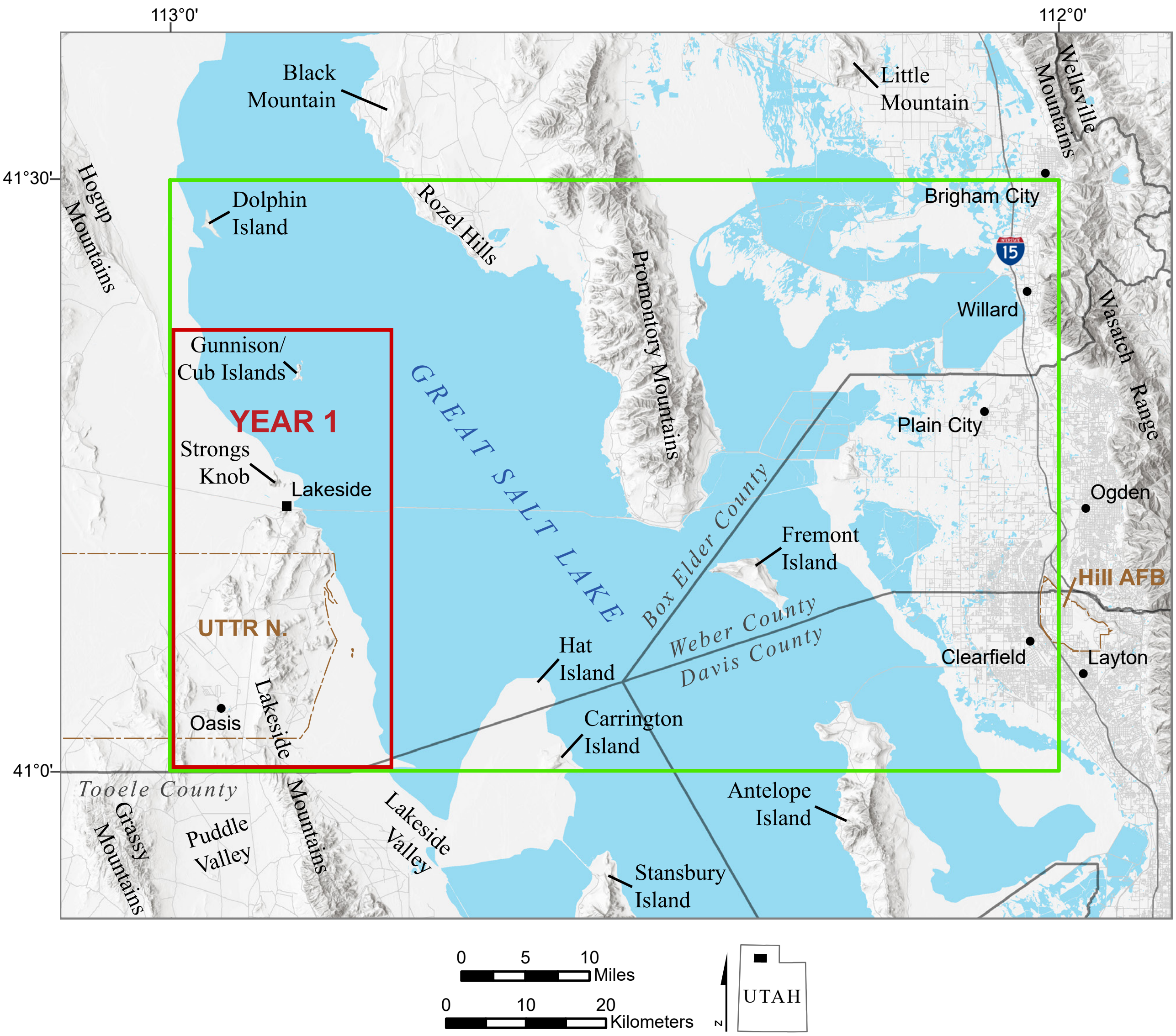

Figure 1. Primary geographic features and progress of geologic mapping in the Promontory Point 30′ x 60′ quadrangle (green rectangle). UTTR-N is Utah Test and Training Range (U.S. Air Force), North area.

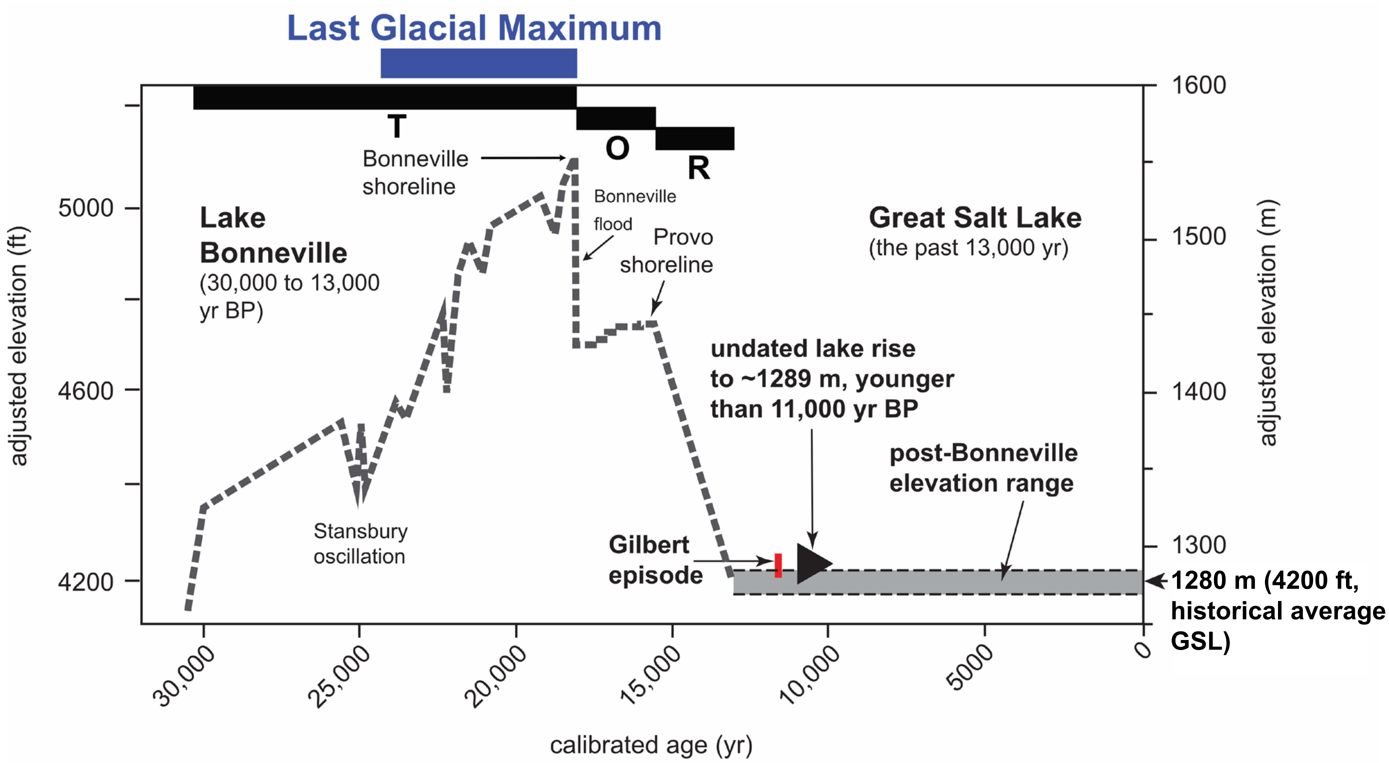

__Figure 2.__ Simplified Lake Bonneville hydrograph and chronology (based on Oviatt, 2015). Elevations are adjusted for isostatic rebound. T is Transgressive Phase, O is Overflowing Phase, and R is Regressive Phase for Lake Bonneville. GSL is Great Salt Lake. Information for GSL is from Oviatt and others (2021).

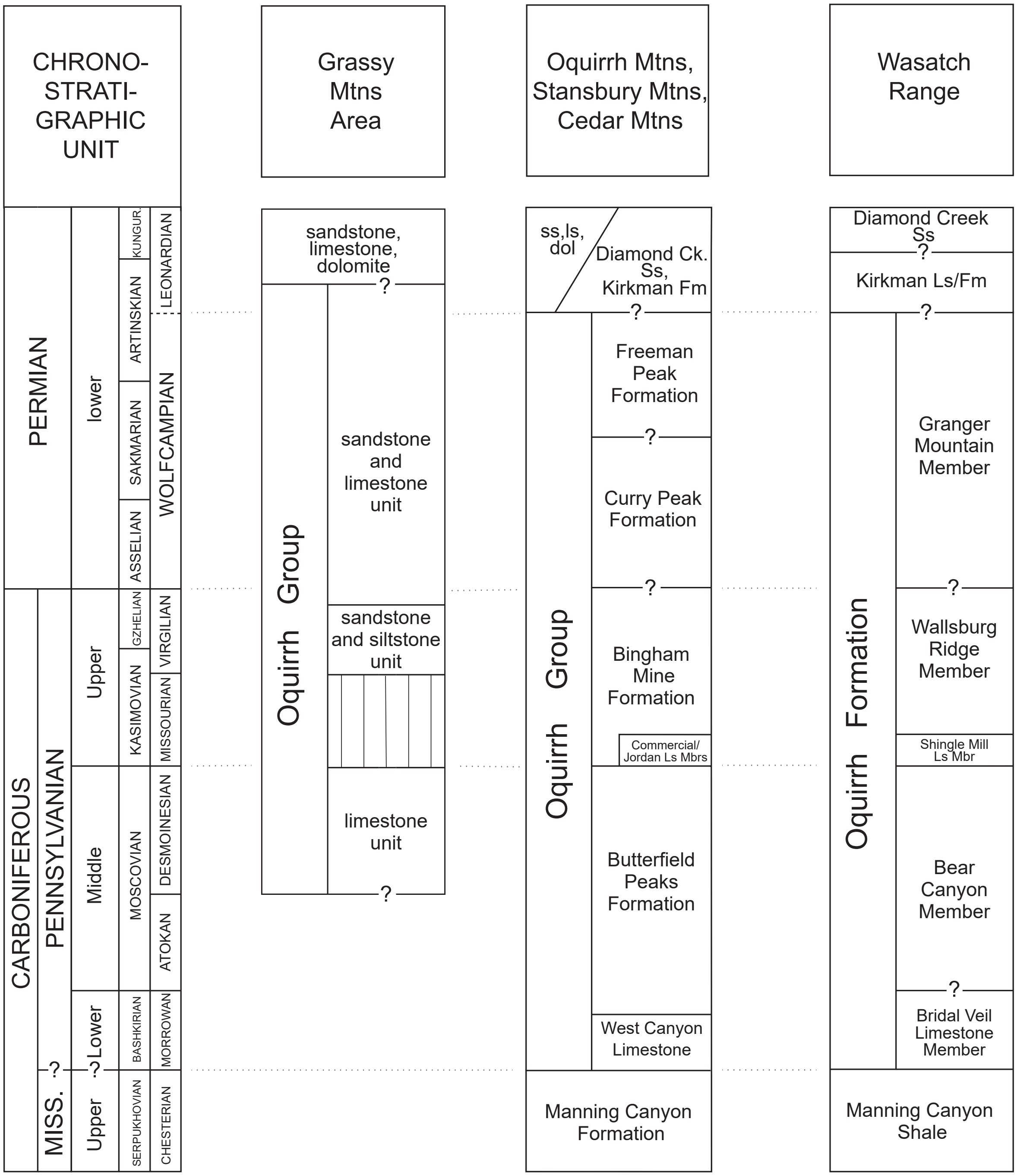

Figure 3. *Comparison of Permian-Pennsylvanian nomenclature of the Oquirrh Group/Formation and other units used in this map and adjacent areas. Grassy Mountains modified from Doelling (1964) and Jordan (1979a, 1979b). See Clark and others (2020) for Oquirrh, Stansbury, and Cedar Mountains. See Constenius and others (2011) for Wasatch Range.*

Table 1. *Major-element geochemical analysis of tephra from the Lakeside gravel pit in the southwest part of the Promontory Point 30' x 60' quadrangle.*

Sample ID	SiO2	Al2O3	Fe2O3	MgO	MnO	CaO	TiO2	Na2O	K2O	Total (recal.)
L-1	76.67	13.67	0.92	0.28	0.04	1.64	0.08	4.38	2.34	100.02
CwSH(1), T5-11	76.89	13.66	0.94	0.26	0.03	1.69	0.10	4.12	2.30	99.99
CwSH(2), T32-4	76.50	14.08	0.87	0.24	0.03	2.01	0.08	3.91	2.28	100.00
CwSH(2A), T401-7	76.85	13.71	0.97	0.25	0.03	1.66	0.09	4.16	2.27	99.99
CySH, T32-5	76.15	14.05	1.03	0.30	0.04	1.62	0.12	4.32	2.36	99.99
CySH2, T401-8	76.23	13.88	1.11	0.34	0.04	1.66	0.15	4.26	2.32	99.99

Notes:

Sample L-1 was collected by C.G. Oviatt and D.M. Miller on July 12, 1996. Approximate sample location is 343370 E, 4564550 N UTM NAD83.

Sample analyzed by M.E. Perkins (University of Utah).

Lab analysis by electron microprobe at the University of Utah.

Major element data in weight percent.

Samples below L-1 are from Mt. St. Helens tephras sets Cw and Cy for comparison purposes (see Mullineaux, 1996).

Table 2. *Summary of drill holes in the Promontory Point 30' x 60' quadrangle, year 1 area.*

Hydrocarbon Exploration Wells (Utah Division of Oil, Gas and Mining)

Map ID	API Number	Operator	Well Name	Year Completed	Status	Type	7.5’ Quadrangle	Latitude (°N) NAD83	Longitude (°W) NAD83	Cadastral Location	Ground Elevation (ft)	Total Depth (ft)	Lithology Notes
DH1	43-003-30013	Cities Service Oil & Gas Corp	Lakeside A-1	1981	Plugged & Abandoned	Dry Hole	Deardens Knoll	41.027729	112.80070	C NE Sec.1, T3N, R9W	4201	2655	Tops: Tertiary sand (1155 ft), Precambrian quartzite (2570 ft)
DH2	43-003-20039	Bridger Petroleum Corp (Lakeshore Oil Co.)	1	1926	Plugged & Abandoned	Unknown	Lakeside	41.16137	112.82785	Sec. 12, T5N, R9W	4250	1200	Tops: Lake beds (surface), bottom (?)
DH3	43-003-20041	unknown	unknown	1900	Plugged & Abandoned	Unknown	Strongs Knob	41.23737	112.97780	Sec. 15, T6N, R10W	4300	800	Tops: Lake beds (surface), bottom (?)
DH4	43-003-30016	Amoco Production Co	State of Utah P 1	1980	Plugged & Abandoned	Dry Hole	Gunnison Island	41.23744	112.97700	Sec. 10, T7N, R8W	4200 (Lake level)	7843	Tops: Pliocene basalt 3200 ft, Miocene (3700 ft), Paleozoic (6100 ft); cores taken - 60 ft cores: Pliocene basalt (3200 ft), Miocene (3700 ft); other core data: Cores #1-#4 3392-3451 ft (basalt) cut 59’ rec 59’,Core #5 4921-4940 ft (basalt) cut 19 ft rec 16 ft, Core #6 7815-7819 ft (limestone) cut 4 ft rec 4 ft
	43-003-30011	Amoco Production Co	State of Utah M 1		location abandoned		Lakeside	41.13263	112.75720				

Selected Water Wells (Utah Division of Water Rights)

Map ID	Well ID Number	Operator	Well Name	Year Completed	Water Right	7.5’ Quadrangle	UTM E NAD83	UTM N NAD83	Cadastral Location	Ground Elevation (ft)	Total Depth (ft)	Lithology Notes
DH5	nd	U.S. Army Corps of Engineers	well #1 (east)	1963	13-265	Sally Mountain	336974.570	4546890.356	S 727 ft E 1524 ft from NW corner, S. 26, T4N, R10W.	nd	739	clay to gravel
DH6	16825	U.S. Army Corps of Engineers	well #2 (west)	1963	13-265	Sally Mountain	336663.674	4546361.224	S 2463 ft E 504 ft from NW corner, S. 26, T4N, R10W	nd	302	clay to gravel
DH7	436992	Great Salt Lake Minerals Corp.		2013	13-3871	Gunnison Island SW	341630.413	4569484.106	N 925 ft W 595 ft from SE corner, S. 5, T6N, R9W	nd	580	0-20 ft fill, 20-634 ft clay to gravel, 634 ft black bedrock

Notes:

Map ID location shown on plate 1.

nd is no data.

DH2 has location discrepancy in Utah Division of Oil, Gas and Mining data (2020). Location shown on 7.5' topographic basemap.

DH4 had free oil on two drill stem tests (Bortz, 2002).

DH5 repaired in 1997, depth is 520 ft.

Lithology notes from Utah Division of Oil, Gas and Mining well files (2020) and Utah Division of Water Rights supplemental files (2021).

Table 3. *Major- and trace-element whole-rock geochemical analyses from the southwest part of the Promontory Point 30′ x 60′ quadrangle.*

								ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	OA-GRA06	ME-XRF06	ME-4ACD81	ME-4ACD81	ME-4ACD81
								%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	ppm	ppm	ppm
Map ID	Sample ID	Map Unit	Rock Name	7.5' Quad	Location Data Latitude (°N) WGS84	Location Data Longitude (°W) WGS84	Source	SiO2	Al2O3	Fe2O3	CaO	MgO	Na2O	K2O	Cr2O3	TiO2	MnO	P2O5	SrO	BaO	LOI	Total	Ag	As	Cd
PP1	PP1	Tib	basalt	Sally Mountain	41.02684	112.95773	This study	48.7	14.71	11.12	9.96	8.04	2.46	1.17	0.06	1.28	0.16	0.42	0.05	0.09	1.54	99.76	<0.5	11	0.8
PP3	PP3	Tib	basalt	Sally Mountain	41.03327	112.95683	This study	49.34	14.65	11.08	9.99	8.1	2.24	1.14	0.06	1.3	0.16	0.40	0.05	0.11	1.49	100.1	<0.5	14	0.6

ME-4ACD81	ME-4ACD81	ME-4ACD81	ME-4ACD81	ME-4ACD81	ME-4ACD81	ME-4ACD81	ME-4ACD81	ME-4ACD81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Co	Cu	Li	Mo	Ni	Pb	Sc	Tl	Zn	Ba	Ce	Cr	Cs	Dy	Er	Eu	Ga	Gd	Hf	Ho	La	Lu	Nb	Nd	Pr	Rb	Sm	Sn
47	44	20	2	165	9	27	<10	107	816	63.7	450	0.35	5.12	3.04	1.62	18.2	5.77	4.9	1.05	30.9	0.41	14.1	31.3	7.57	22.6	6.03	1
47	53	20	<1	181	8	28	<10	109	944	65.5	460	0.48	5.36	3.14	1.71	18.4	5.96	5	1.13	32.4	0.44	14.8	33.1	8.05	26.2	6.55	1

ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81	ME-MS81
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Sr	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
427	0.8	0.84	4.58	0.41	0.88	221	1	28	2.96	193
428	0.8	0.87	4.88	0.45	1.03	222	2	28.5	2.9	204

Notes:

Map ID and map unit correspond to plate 1.

Rock names for this study from total alkali-silica diagram of Le Bas and others (1986).

Analyses for this study performed by ALS Global. Analytical Procedures: ME-XRF06 (whole-rock package by XRF; major oxides), OA-GRA06 (LOI for ME-XRF06 by WST-SIM), ME-4ACD81 (base metals 4-acid digestion by ICP-AES, elemental), and ME-MS81 (lithium borate fusion by ICP-MS, trace elemental).

Major oxides reported in weight percent (%); < indicates value below detection limit.

LOI is loss on ignition.

Minor and trace elements reported in parts per million (ppm); < indicates value below detection limit.

nd is no data.

Table 4. *Comparison of stratigraphic nomenclature for Paleozoic geologic units in the southwest part of the Promontory Point 30′ x 60′ quadrangle.*

	This Map	Northern and Central Lakeside Mountains Doelling (1964), Doelling (1980)	Strongs Knob, Gunnison and Cub Islands Doelling (1964), Doelling (1980)	Newfoundland Mountains 30’x60’ Quad. Miller and others (2021)
Permian	Oquirrh Group - sandstone and limestone unit	Oquirrh Fm, unit 2 (part), 3, 4, 5, 6		Oquirrh Group - interbedded sandstone and limestone unit
Pennsylvanian	Oquirrh Group - sandstone and siltstone unit	Oquirrh Fm, unit 2 (part)		Oquirrh Group - sandstone unit
	Oquirrh Group - limestone unit	Oquirrh Fm, unit 1		Oquirrh Group - limestone unit
Mississippian	Manning Canyon Formation (subsurface)	Manning Canyon Fm (subsurface)		
	Great Blue Ls	Great Blue Fm	Great Blue Fm	
	Humbug Fm	Humbug Fm		
	Woodman Fm	Deseret Ls		
	Gardison Ls, Fitchville Fm, Pinyon Peak Ls, undivided	Madison Ls/Lodgepole Ls	Lodgepole Ls	
Devonian	Guilmette Fm	Guilmette Fm	Guilmette Fm	
	Simonson Dol	Simonson Dol	Simonson Dol	
	Sevy Dol	Water Canyon Dol	Water Canyon Dol	
Silurian-Ordovician	Laketown Dol and Ely Springs Dol, undivided; Eureka Quartzite	Laketown Dol, Fish Haven Dol, Swan Peak Fm	Laketown Dol, Fish Haven Dol, Swan Peak Fm	
Ordovician	Pogonip Group, undivided	Swan Peak Fm, Garden City Fm	Swan Peak Fm	
Cambrian	Notch Peak Fm, Orr Fm, Lamb Dol?, undivided	St. Charles Fm and Nounan Fm, undivided		

Notes:

In this table some age boundaries and correlations are somewhat generalized. Also see map explanation for detailed correlation charts and lithologic columns.

The western extent of the Willard thrust sheet is presently uncertain. If Gunnison Island lies on the Willard sheet, then different stratigraphic nomenclature should be applied there.

Table 5. *Selected fossil identifications and ages from the Promontory Point 30' x 60' quadrangle, year 1 area.*

Map ID	Sample ID	Map Unit	7.5' Quadrangle	Location Data	Location Data	Fossil Type	Fauna	Age	Paleontologist
Data from map area (this study)				**Latitude (°N) WGS84**	**Longitude (°W) WGS84**				
PP5	PP5	Mgb	Strongs Knob	41.19512	112.88377	conodonts	*Cavusgnathus* sp., *Hindeodus* sp. (a few broken elements)	Early Pennsylvanian to Late Mississippian	S.M. Ritter
PP7	PP7	Mgb	Strongs Knob	41.19170	112.87917	conodonts	barren		S.M. Ritter
PP9	PP9	SOu	Gunnison Island	41.34603	112.85319	conodonts	*Pterospathodus pennatus procerus* (Walliser) (elements with an abundance of simple cones and one variety of broken platforms)	Silurian (Early Wenlockian)	S.M. Ritter
PP11	PP11	SOu	Gunnison Island	41.34769	112.85332	conodonts	barren		S.M. Ritter

Notes:

Map ID and map unit correspond to plate 1.

Barren samples not displayed on plate 1.

Age determination by S.M. Ritter (Brigham Young University).