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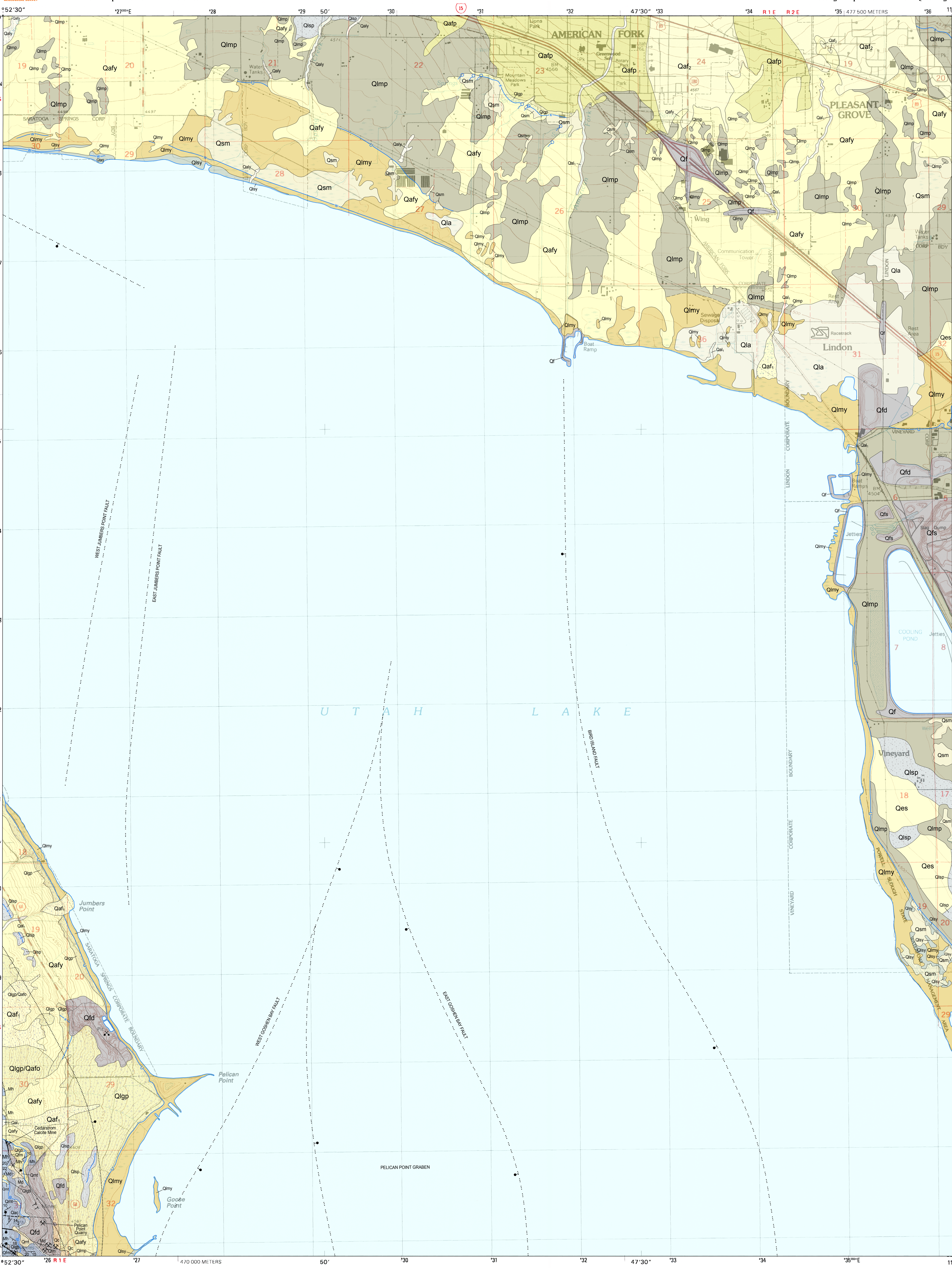

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12°23'
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 2009

SCALE 1:24,000
1 0.5 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 0.5 0 1 KILOMETER
CONTOUR INTERVAL 5 FEET

GEOLOGIC MAP OF THE PELICAN POINT QUADRANGLE, UTAH COUNTY, UTAH

by
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2009
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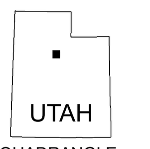

QUADRANGLE LOCATION

Base from USGS Pelican Point 7.5' Quadrangle (1999)
Projection: UTM Zone 12
Datum: NAD 1927
Spheroid: Clarke 1886

GIS and Cartography: Kent D. Brown, J. Buck Ehler, James W. Parker, and Jay C. Hill

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1	2	3
4		5
6	7	8

1. Jordan Narrows
2. Lehi
3. Timpanogos Cave
4. Saratoga Springs
5. Orem
6. Soldiers Pass
7. Lincoln Point
8. Provo

ADJOINING 7.5' QUADRANGLE NAMES

INTRODUCTION

Purpose and Scope

This 1:24,000-scale map of the Pelican Point quadrangle in Utah Valley is part of a larger project to compile the geology of the Provo 30' x 60' quadrangle. A large part of the Pelican Point quadrangle is covered by Utah Lake, but the adjacent lake shore is underlain by unconsolidated Quaternary deposits and bedrock is exposed near Pelican Point.

Machette (1992) mapped the surficial geology of eastern Utah Valley as part of a program by the U.S. Geological Survey to map the geology of the active Wasatch fault zone. He eliminated outdated stratigraphic terminology and concepts and updated the fault mapping of Cluff and others (1973). Machette (1992) mapped the Quaternary geology of the northern and eastern shore of Utah Lake in the Pelican Point quadrangle, but he did not map Pelican Point in the southwest corner of the quadrangle. Our mapping extends the Quaternary stratigraphy and concepts of Machette (1992) to Pelican Point, includes the bedrock, and remaps the remainder of the quadrangle in greater detail. The contacts between some lacustrine units mapped by Machette (1992) and us were interpreted from the U.S. Soil Conservation Service soil maps of Utah County (Swenson and others, 1972). We mapped Quaternary geologic units in more detail than in the adjacent Lehi quadrangle to the north (Biek, 2005b), and therefore some small outcrops along the northern border of the Pelican Point quadrangle are not mapped along the southern border of the Lehi quadrangle.

Our mapping was performed between July 2007 and June 2008 using standard field mapping methods. We used 1:20,000-scale black-and-white aerial photographs taken in 1965 for the U.S. Department of Agriculture, Soil Conservation Service (now Natural Resources Conservation Service) to map geology prior to most development in the quadrangle. Because most Quaternary geology can be accurately mapped only from aerial photos, limited field checking was conducted for two weeks in the spring of 2008 to study significant Quaternary features.

Location and Geographic Setting

The Pelican Point quadrangle covers northern Utah Lake and the adjacent lake shore in Utah Valley. Pelican Point is in the southwest corner of the Pelican Point quadrangle, extending into Utah Lake from the eastern edge of the Lake Mountains. The quadrangle includes parts of the cities of American Fork, Lindon, Pleasant Grove, and Saratoga Springs, and the town of Vineyard. American Fork is the primary stream in the quadrangle; it flows southward from American Fork Canyon in the Wasatch Range to the north side of Utah Lake. U.S. Interstate 15 extends from northwest to southeast in the northeast corner of the quadrangle, U.S. Highway 89 lies parallel to Interstate 15, and State Route 68 follows the western shore of Utah Lake near Pelican Point.

Geologic Summary

Bedrock Stratigraphy and Geologic Structure

Bedrock is exposed in the southwest corner of the Pelican Point quadrangle where Mississippian sedimentary rocks crop out at the base of the Lake Mountains near Pelican Point (Biek, 2004; Biek and others, 2009). Utah Lake separates the Lake Mountains from eastern Utah Valley and the Wasatch Range and is underlain by several geologic structures. Bedrock strata were deformed by Late Cretaceous to early Tertiary contractional folding and faulting of the Sevier orogeny (Smith and Bruhn, 1984; Willis, 1999; DeCelles, 2006), middle Tertiary regional extensional collapse (Constenius, 1996; Constenius and others, 2003), and late Tertiary to recent basin-and-range extensional faulting (see, for example, Zoback and others, 1981).

Lake Mountains: Strata of Mississippian age crop out on slopes of the Lake Mountains in the southwest corner of the Pelican Point quadrangle, and excellent exposures are found there in the Pelican Point limestone quarry (E1/2 section 31, T. 6 S., R. 1 E., Salt Lake Baseline and Meridian [SLBLM]). Regionally, the Mississippian beds are part of the faulted eastern limb of the Lake Mountains syncline (Bullock, 1951) and lie on the upper plate of a reverse fault mapped to the west in the adjacent Soldiers Pass quadrangle (Biek, 2004; Biek and others, 2009). The rocks are in the footwall of a concealed normal fault at the base of the Lake Mountains, inferred on the adjacent Soldiers Pass quadrangle (Biek and others, 2009) from gravity data (Floyd, 1993; Cook and others, 1997).

Structures under Utah Lake: Utah Lake separates the Lake Mountains from eastern Utah Valley. Utah Lake is underlain by both east- and west-dipping faults that form the western boundary of Utah Valley, with the Wasatch fault zone forming the eastern boundary. Cook and Berg (1961) recognized the probable existence of faults on the floor of Utah Lake based on the measurement of gravity anomalies in the vicinity of Utah Valley. The first conclusive evidence of active faulting within the Utah Lake fault zone was based on the acoustical-profiling survey of Brimhall and others (1976) which showed pronounced displacements of Bonneville lake sediments less than 16,000 years old. Brimhall and Merritt (1981) mapped several faults and folds beneath Utah Lake based on widely spaced seismic reflection transects. Baskin and Berryhill (1998) conducted a seismic investigation of the shallow subsurface sediments south of Pelican Point in the Lincoln Point-Bird Island area of Utah Lake (in the adjacent Lincoln Point quadrangle) using a continuous, high-resolution profiler. Their data show that faulting is prominent in the study area, with mostly minor displacements, but they did not map faults between profiles. Baskin and others (1994) noted that springs in the Lincoln Point-Bird Island area are all near bedrock faults inferred by Cook and Berg (1961) and faults mapped by Brimhall and others (1976) that displace lake-bottom sediments, and proposed that the faults and associated joints may play an important role in the location of warm springs in the area.

Cook and others (1997, p. 9, footnote 4) accepted ". . . the location and sense of displacements of the faults mapped specifically along the transects on plate 1 by Brimhall and others (1976) . . ." but questioned the interpretations of Brimhall and Merritt (1981) because, in their opinion, mapped faults were extrapolated over longer distances than were justified by the data and the extrapolation was made without regard to maintaining a consistent sense of fault displacement. Although the locations of the faults are uncertain and the interpretation of data upon which they were mapped was questioned by Cook and others (1997), the structures shown in the Pelican Point quadrangle in Utah Lake by Brimhall and Merritt (1981) are on our map to indicate the presence of lakebed faulting. However, we do not include a geologic cross-section with this map because of the uncertain location and sense of displacement of the Utah Lake fault zone and lack of knowledge related to the depth of valley-fill marker beds. An exploratory well drilled in 1977 by Gulf Oil just west of Spanish Fork, about 15 miles (25 km) southeast of Pelican Point, encountered valley fill to a total depth of about 13,000 feet (4,000 m) (Hintze and Kowallis, 2009, p. 108). A recent palynological study indicates that the lower 2,000 feet (600 m) of material recovered from the well ranges in age from late Eocene to middle Miocene (G. Waanders, unpublished palynology report for K. Constenius, 2008). Cook and others (1997) estimated that the thickness of Cenozoic rocks beneath a gravity low near the Gulf Oil well is about 4.3 kilometers (14,000 ft).

Structures under Utah Lake trend mostly north to northeast and include, from west to east: (1) an unnamed transverse down-to-the-southwest normal fault in the northwest corner of the Pelican Point quadrangle, (2) the West Jumbers Point and East Jumbers Point faults, a pair of normal faults that may be splays diverging from the range-bounding fault east of the Lake Mountains, (3) the West Goshen Bay fault, a normal fault that extends southward into a monocline, (4) an unnamed down-to-the-east normal fault that bifurcates from the West Goshen Bay fault, and the East Goshen Bay normal fault, both bounding the Pelican Point graben, and (5) the Bird Island fault, an extension of the concealed White Lake fault mapped by Clark (2009) on the west side of West Mountain south of Utah Lake.

Acoustical profiles show from less than 7 to 16 feet (<2 to 5 m) of displacement across individual faults and folds beneath the lake in a persistent 25- to 50-foot-deep (8–15 m) layer identified as the Provo Formation by Brimhall and Merritt (1981). Machette (1992) interpreted the layer as lake-bottom sediments probably deposited during the regressive phase of Lake Bonneville. The displacements occurred in the past 14 to 16 ka (period of the Bonneville regression) and indicate slip rates from < 0.1 to about 0.4 millimeter/year (Black and others, 2003). The reflection profiles suggest that displacements decrease upward in strata above the marker horizon, indicating episodic or recurring movement on the faults. Displacement occurs up to within a few feet of the lake bottom, but there is no evidence of displaced surficial Lake Bonneville deposits onshore along either the West Jumbers Point and East Jumbers Point faults in the Pelican Point Quadrangle or the Bird Island-White Lake fault in the Lincoln Point quadrangle to the south (Solomon and Biek, 2009), though exposures are poor.

Quaternary Geology

The oldest Quaternary deposits in the Pelican Point quadrangle are middle to upper Pleistocene coalesced alluvial fans that underlie piedmont slopes. The fans were deposited during the interlacustral episode between the last two major lake cycles in the Bonneville Basin, the Bonneville and Little Valley lake cycles (Machette, 1992). The Little Valley lake cycle ended about 130,000 years ago and is correlative with marine oxygen-isotope stage 6 (Oviatt and others, 1999); its highest level is below the elevation of the subsequent Lake Bonneville highstand (Scott and others, 1983) and thus is buried throughout most of the Bonneville Basin. Remnants of the fans are preserved beneath a thin veneer of lacustrine gravel and sand reworked from underlying alluvial-fan deposits during the regressive phase of Lake Bonneville.

The surficial deposits in the quadrangle were mostly associated with late Pleistocene Lake Bonneville (Currey and Oviatt, 1985; Oviatt and others, 1992), which was largely contemporaneous with the last glacial advance, the Pinedale glaciation (marine oxygen-isotope stage 2; Oviatt and others, 1999). Lips and others (2005) estimated that the Pinedale maxima occurred from about 17 to 15 ka based on ^{10}Be exposure ages measured from moraines at Little Cottonwood Canyon in the Wasatch Range near Salt Lake City.

Other surficial deposits in the quadrangle are mostly younger than Lake Bonneville and reflect post-glacial landscape evolution. Catastrophic overflow of the lake's threshold in southern Idaho and warming climatic conditions reduced the size of Lake Bonneville, ultimately leaving remnants such as Utah Lake stranded in Bonneville sub-basins (Jarrett and Malde, 1987; O'Conner, 1993). Utah Lake deposits, mapped below the elevation of the Utah Lake threshold of 4500 feet (1372 m) at the northern end of the lake (Jordan Narrows), are found on the margins of modern Utah Lake in the Pelican Point quadrangle. With the regression of Lake Bonneville, streams incised in response to the lowering base level, depositing alluvium on large alluvial fans at the mouth of American Fork as it flowed toward the north shore of Utah Lake, and in smaller streams and alluvial fans near the lake shore. Wind locally reworked Lake Bonneville sands into eolian blankets and small dunes, and eroded finer-grained desiccated Bonneville lake beds, depositing a thin but widespread mantle of calcareous loess on stable geomorphic surfaces. The loess is friable to moderately firm, homogenous, nonstratified, and porous, and forms steep to vertical faces where exposed in stream cuts. Most argillic B horizons of late Pleistocene-age soils in the region are formed in this loess (Machette, 1992), which is typically 3 to 5 feet (1–1.5 m) thick.

Lake Bonneville

Deposits and shorelines of Pleistocene Lake Bonneville dominate the surficial geology of the Pelican Point quadrangle. Lake Bonneville was a large pluvial lake that covered much of northwestern Utah and adjacent parts of Idaho and Nevada. The lake began to rise above levels comparable to those of Holocene Great Salt Lake after about 35,000 years ago (CRONUS-Earth Project, 2005). Four regionally extensive shorelines of Lake Bonneville are found in the Bonneville Basin. Gilbert (1890) identified the earliest three of these shorelines (the Stansbury, Bonneville, and Provo shorelines) in the first comprehensive study of Lake Bonneville over a century ago, and Eardley and others (1957) later defined the youngest shoreline (the Gilbert shoreline). Currey (1980) published an important summary of the lake, refining many previously published interpretations of lake-level change in the Bonneville basin, and mapped all four major shorelines in the vicinity of Great Salt Lake. Oviatt and Thompson (2002) reviewed additions to the geologic literature of Lake Bonneville published after 1980, summarizing many recent changes in the interpretation of Lake Bonneville radiocarbon chronology, and research has continued since. We include more recent changes in Lake Bonneville chronology in table 1, which shows references for the following discussion of the lake.

Each shoreline is actually a composite of multiple shorelines that formed as the lake level fluctuated within a short vertical interval. Only the two highest and most prominent (the Bonneville and Provo shorelines) are present in the quadrangle. The earliest of the regional shorelines is the Stansbury, which resulted from a climatically induced lake-level oscillation from about 27,000 to 24,000 years ago during expansion (transgression) of Lake Bonneville. The Stansbury shoreline formed at elevations below the Utah Valley threshold and thus did not occupy the quadrangle. The lake continued to rise, entering the quadrangle from the northwest at an elevation of about 4500 feet (1370 m) about 23,000 years ago. In the Bonneville Basin, the lake reached its highest level and began to overflow about 18,300 years ago near Zenda, in southern Idaho. This highstand created the Bonneville shoreline, which can be traced over most of northwest Utah. The Bonneville shoreline forms the highest bench near the base of the Lake Mountains in the Pelican Point quadrangle.

About 17,400 years ago, catastrophic overflow and rapid downcutting through the Zenda threshold resulted in lowering of the lake by 340 feet (100 m) (Jarrett and Malde, 1987), perhaps in less than one year (O'Conner, 1993). Lake Bonneville then stabilized at a new lower threshold near Red Rock Pass, Idaho, and the Provo shoreline was formed. The Provo shoreline is mapped on slopes of the Lake Mountains near Pelican Point in the Pelican Point quadrangle.

The lake oscillated at or near the Provo level as intermittent landsliding and subsequent scour of alluvium in the outlet channel near Red Rock Pass caused the lake level to fluctuate (Currey and Burr, 1988). Rivers flowing into the lake at or near the Provo level formed large deltas, such as the American Fork delta in the Lehi quadrangle (Biek, 2005b) to the north of the Pelican Point quadrangle and the Provo River delta in the Orem quadrangle (Solomon and others, 2009) to the east. About 14,600 years ago, climatic factors induced further lowering of the lake level within the Bonneville Basin (Godsey and others, 2005). As Lake Bonneville fell below the elevation of the natural threshold of Utah Valley at Jordan Narrows, Utah Lake became isolated from the main body of Lake Bonneville (Machette, 1992). By about 13,500 years ago, the level of Lake Bonneville had fallen below the elevation of present Great Salt Lake (Currey and others, 1988; Godsey and others, 2005), but a subsequent minor expansion of Lake Bonneville from about 12,500 to 11,500 years ago formed the Gilbert shoreline (Oviatt and others, 2005). During the Gilbert expansion of Lake Bonneville, Utah Lake drained into Lake Bonneville through the Jordan River, thus preventing the Utah Lake level from similarly rising (Machette, 1992). After formation of the Gilbert shoreline, Lake Bonneville had fallen to near the current level of Great Salt Lake, leaving Great Salt Lake and Utah Lake as its two most prominent remnants.

Isostatic rebound following overflow of Lake Bonneville, as well as displacement along the Wasatch fault zone, uplifted regionally extensive shorelines in the Bonneville basin (Crittenden, 1963; Currey, 1982; Bills and others, 2002). The amount of isostatic uplift increases toward the center (deepest part) of the basin where the volume of removed water was greatest; Crittenden (1963) originally estimated a maximum isostatic uplift of 210 feet (64 m) near the Lakeside Mountains west of Great Salt Lake, but Currey (1982) estimated maximum isostatic uplift of 240 ft (74 m) using additional topographic data and aerial photographs. Machette (1992) reported combined isostatic and fault uplift of the Bonneville and Provo shorelines as much as 110 feet (34 m) and 65 feet (20 m), respectively, along the Wasatch fault zone in eastern Utah Valley. In the Pelican Point quadrangle, shorelines are not affected by displacement of the Wasatch fault zone, which lies at least 10 miles (16 km) east of Pelican Point, and isostatic uplift of both shorelines is less than the maximum combined uplift recorded by Machette (1992). The maximum elevation of the Bonneville shoreline in the Pelican Point quadrangle is about 5160 feet (1575 m) compared to its threshold elevation of 5092 feet (1552 m) at Zenda, and the maximum elevation of the Provo shoreline in the quadrangle is about 4780 feet (1455 m) compared to its threshold elevation of 4737 feet (1444 m) at Red Rock Pass (table 1). Thus, isostatic uplift of the Bonneville and Provo shorelines in the quadrangle is about 68 feet (23 m) and 43 feet (11 m), respectively.

Previous Investigations

Several investigators have conducted geologic and geophysical studies in the Pelican Point quadrangle. Bullock (1951) produced a reconnaissance geologic map of the Lake Mountains, including the small part of the range extending into the southwest corner of the Pelican Point quadrangle, and Okerlund (1951) mapped the same corner of the quadrangle as part of his study of calcite and aragonite deposits in the Lake Mountains. Davis (1983) and Bryant (1992) published regional compilations of geology that covered the Pelican Point quadrangle at respective scales of 1:100,000 and 1:125,000. Geophysical investigations of Utah Lake in the Pelican Point quadrangle include Bouguer gravity surveys (Cook and Berg, 1961; Cook and others, 1997) and seismic reflection transects and acoustical profiles (Brimhall and others, 1976; Brimhall and Merritt, 1981).

Surficial geologic maps by Hunt and others (1953) and Miller (1982) were early attempts to identify the texture of Quaternary unconsolidated deposits of Utah Valley and place the deposits in a stratigraphic framework of map units. However, interpretations of Quaternary geology, and particularly of Lake Bonneville stratigraphy, continued to evolve until Machette (1992) mapped the surficial geology of eastern Utah Valley, including part of the Pelican Point quadrangle.

In addition to our geologic map of the Pelican Point quadrangle, recent mapping for the project to compile the geology of the Provo 30' x 60' quadrangle also includes: (1) geology of the adjacent Jordan Narrows (Biek, 2005a), Lehi (Biek, 2005b), Timpanogos Cave (Biek, 2005b; Constenius, 2007), Orem (Solomon and others, 2009), Provo (Solomon and Machette, 2009), Lincoln Point (Solomon and Biek, 2009), Soldiers Pass (Biek and others, 2009), and Saratoga Springs (Biek, 2004) quadrangles, and (2) geology of the Wasatch Range part of the Aspen Grove quadrangle and other 7.5' quadrangles in the eastern part of the Provo 30' x 60' quadrangle (Constenius and others, 2006). Other quadrangles mapped during the project include Bridal Veil Falls (Constenius and others, 2006), Charleston (Biek and Lowe, 2009), Goshen Valley North (Clark and others, 2009), Spanish Fork (Solomon and others, 2007), Spanish Fork Peak (Constenius and others, 2006; Solomon, 2006), Springville (Constenius and others, 2006; Solomon and Machette, 2008), and West Mountain (Clark, 2009).

ACKNOWLEDGMENTS

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MAP UNIT DESCRIPTIONS

QUATERNARY

Alluvial deposits

Qal₁ — **Level-1 stream deposits (upper Holocene)** – Moderately sorted pebble and cobble gravel with a matrix of sand, silt, and minor clay; contains thin discontinuous sand lenses; subangular to rounded clasts; thin to medium bedded. Mapped along perennial streams such as American Fork, smaller streams draining areas of shallow ground water near the north shore of Utah Lake, and ephemeral streams draining the Lake Mountains near Pelican Point; includes deposits on active floodplains and minor terraces less than 5 feet (1.5 m) above stream level; locally includes minor colluvial deposits along steep stream embankments; equivalent to the younger part of young stream deposits (Qaly), but differentiated where modern deposits with active channels can be mapped separately. Exposed thickness less than 10 feet (3 m).

Qaly — **Young stream deposits, undivided (Holocene to upper Pleistocene)** – Moderately sorted pebble and cobble gravel with a matrix of sand and minor silt and clay. Mapped along Dry and Spring Creeks west of American Fork City; locally includes small colluvial deposits; includes middle Holocene to upper Pleistocene stream deposits 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 from the Provo shoreline and lower levels. Thickness variable, probably less than 10 feet (3 m).

Qaf₁ — **Level-1 alluvial-fan deposits (upper Holocene)** – Poorly to moderately sorted, weakly to non-stratified, pebble to cobble gravel with a matrix of sand, silt, and minor clay; clasts commonly well-rounded, derived from Lake Bonneville gravel; medium to very thick bedded; deposited by debris flows, debris floods, and streams on the piedmont slope of the Lake Mountains near Pelican Point; equivalent to the younger part of young alluvial-fan deposits (Qafy) but differentiated where modern deposits of small, active, discrete fans not incised by younger channels can be mapped separately. Exposed thickness less than 10 feet (3 m).

Qaf₂ — **Level-2 alluvial-fan deposits (middle Holocene to upper Pleistocene)** – Poorly sorted pebble and cobble gravel, locally bouldery, with a matrix of sand, silt, and minor clay; clasts angular to subrounded, with sparse well-rounded clasts derived from Lake Bonneville gravel; medium to very thick bedded. Deposited by debris flows, debris floods, and stream flow from American Fork as the river lost confinement beyond the American Fork delta front in the adjacent Lehi quadrangle (Biek, 2005b); equivalent to the older part of Qafy, but differentiated where deposits are graded slightly above modern stream level and can be mapped separately. Exposed thickness less than 15 feet (5 m).

Qafy — **Young alluvial-fan deposits, undivided (Holocene to upper Pleistocene)** – Poorly to moderately sorted, pebble to cobble gravel with boulders near bedrock sources, with a matrix of sand, silt, and clay, grading to mixtures of sand, silt, and clay on gentler slopes; deposited by debris flows, debris floods, and streams at the mouths of mountain canyons near the base of the Lake Mountains near Pelican Point and at the mouths of American Fork, Dry Creek, and Spring Creek as they flowed toward the north shore of Utah Lake, where they may include undifferentiated deltaic sediment deposited by streams flowing into the lake; includes level-1 and level-2 alluvial-fan deposits (Qaf_1 and Qaf_2) that postdate the regression of Lake Bonneville from the Provo shoreline and lower levels that cannot be differentiated because of map scale or are in areas where the specific age of Holocene deposits cannot be determined; no Lake Bonneville shorelines are found on these alluvial fans. Thickness variable, probably less than 30 feet (10 m).

Qafp — **Alluvial-fan deposits, regressive (Provo) phase of Lake Bonneville (upper Pleistocene)** – Poorly to moderately sorted, pebble to cobble gravel, locally bouldery, with a matrix of sand, silt, and minor clay; clasts typically angular, but well rounded where derived from Lake Bonneville gravel; medium to very thick bedded; deposited by debris flows, debris floods, and stream flow from American Fork as the river lost confinement beyond the American Fork delta front in the adjacent Lehi quadrangle (Biek, 2005b). The B soil horizon of paleosols developed on regressive-phase alluvial-fan deposits commonly shows an intensification of brown colors due to oxidation of iron-bearing minerals or a slight accumulation of clay, and may include a pedogenic accumulation of calcium carbonate as thin, discontinuous coatings on gravel; Machette (1992), using the terminology of Birkeland (1984), designated the soil profile of this unit and others of similar age as A/Bw/Bk(or Cox) to A/Bt(weak)/Bk(or Cox). Exposed thickness less than 30 feet (10 m).

Fill deposits

Qf — **Artificial fill (Historical)** – Earth fill used in the construction of (1) elevated sections of U.S. Interstate Highway 15, (2) levees bounding an abandoned cooling pond at the site of the former Geneva Steel plant (near the town of Vineyard), and (3) boat ramps adjacent to Utah Lake; unmapped fill is locally present in most developed areas, but only the largest deposits are mapped. Maximum thickness about 20 feet (6 m).

Qfd — **Disturbed land (Historical)** – Land disturbed by: (1) a limestone quarry in Mississippian rock (Mh and Md) near Pelican Point, (2) borrow pits used to remove soil from Lake Bonneville deposits (Qlmp) for fill and foundation material near the former Geneva Steel plant, and (3) sand and gravel operations in regressive Lake Bonneville deposits (Qlgp) near Pelican Point. The Pelican Point quarry has excellent exposures of the Deseret Limestone; the outlines of disturbed land are based on 1965 aerial photographs and the 1999 Pelican Point orthophotographic quadrangle, and the outline of the limestone quarry is also based on maps of the Pelican Point quarry permit application on file with the Utah Division of Oil, Gas, and Mining; only the larger areas of disturbed land are mapped, and many sites have since been regraded and developed and may contain unmapped deposits of artificial fill (Qf); land within these areas contains a complex, rapidly changing mix of cuts and fills. Thickness unknown.

Qfm — **Mine-dump deposits (Historical)** – Waste rock and overburden from calcite prospects southwest of Pelican Point; the larger area of Qfm to the north is part of a calcite quarry (the Cedarstrom calcite mine), where both massive calcite and calcite as travertine are present in a large vein that dips steeply east, coincident with the main fault (Bullock and Okerlund, 1951). Maximum thickness about 30 feet (9 m).

Qfs — **Slag deposits (Historical)** – Material produced from the steelmaking process (slag) and accumulated in mounds at the former site of the Geneva Steel plant. Maximum thickness about 70 feet (20 m).

Colluvial deposits

Qc — **Colluvial deposits (Holocene to upper Pleistocene)** – Pebble, cobble, and boulder gravel, commonly clast supported, with a matrix of sand, silt, and clay; angular to subrounded clasts, poorly sorted, poorly stratified, locally derived sediment deposited by slopewash and soil creep on moderate slopes southwest of Pelican Point; because many bedrock slopes are covered by at least a veneer of colluvium, only the larger, thicker deposits are mapped. Maximum thickness about 20 feet (6 m).

Lacustrine deposits

Deposits younger than the Bonneville lake cycle: Mapped only below the Utah Lake highstand elevation of about 4495 to 4500 feet (1370–1372 m) (table 1).

Qlsy — **Young lacustrine sand and silt (Holocene to upper Pleistocene)** – Well-sorted, fine to medium sand and silt that forms beach deposits at Utah Lake's high stand near Powell Slough and barrier beaches below the high stand at the slough and on the north shore of Utah Lake. Maximum thickness about 5 feet (1.5 m).

Qlmy — **Young lacustrine silt and clay (Holocene to upper Pleistocene)** – Silt, clay, and minor fine-grained sand mapped along the margin of Utah Lake; locally organic rich and locally includes pebbly beach gravel; overlies sediments of the Bonneville lake cycle. Brimhall and others (1976) reported that Holocene gray clayey silt composed mostly of calcite forms the upper 15 to 30 feet (5–10 m) of the lake sediment in Utah Lake.

Deposits of the regressive (Provo) phase of the Bonneville lake cycle: Only mapped below the Provo shoreline, which is at elevations from about 4750 to 4780 feet (1450–1455 m) in the Pelican Point quadrangle (table 1). The B soil horizon of paleosols developed on regressive-phase lacustrine deposits commonly shows an intensification of brown colors due to oxidation of iron-bearing minerals or a slight accumulation of clay, and may include a pedogenic accumulation of calcium carbonate as filaments in fine-grained soil or thin, discontinuous coatings on gravel; Machette (1992), using the terminology of Birkeland (1984), designated the soil profile of these units as A/Bw/Bk(or Cox) to A/Bt(weak)/Bk(or Cox).

Qlgp — **Lacustrine gravel and sand (upper Pleistocene)** – Moderately to well-sorted, subrounded to rounded, clast-supported, pebble to cobble gravel and pebbly sand with minor silt; gastropods locally common in sandy lenses; gravel commonly cemented with calcium carbonate; thin to thick bedded; mapped on the piedmont slope of the Lake Mountains near Pelican Point, with good exposures in the gravel pit and along the lake-shore bluff faces north of the point; bedding ranges from horizontal to primary dips of 10 to 15 degrees on steeper slopes; commonly interbedded with or laterally gradational to lacustrine sand and silt of the regressive phase (Qlsp). Exposed thickness less than 30 feet (10 m).

Qlsp — **Lacustrine sand and silt (upper Pleistocene)** – Moderately to well-sorted, subrounded to rounded, fine to coarse sand and silt with minor pebbly gravel, locally buried by loess veneer; thick to very thick bedded, commonly laminated, with some ripple marks and scour features; gastropods locally common; deposited in relatively shallow water near shore: (1) near Pelican Point as linear beach deposits; (2) north of Utah Lake, down slope from the American Fork delta front in the adjacent Lehi quadrangle (Biek, 2005b), grading downslope into lacustrine silt and clay of the regressive phase (Qlmp); and (3) east of Utah Lake, down slope from the Provo River delta front in the adjacent Orem quadrangle (Solomon and others, 2009), locally reworked into eolian deposits (Qes). Exposed thickness less than 30 feet (10 m).

Qlmp — **Lacustrine silt and clay (upper Pleistocene)** – Calcareous silt (marl) and clay with minor fine sand; typically laminated or thin bedded; ostracodes locally common; deposited in quiet water in moderately deep parts of the Bonneville basin and in sheltered bays; overlies lacustrine silt and clay of the transgressive phase and grades upslope into lacustrine sand and silt (Qlsp); locally buried by loess veneer; regressive lacustrine shorelines typically poorly developed; extensive exposure within two miles (3 km) of the Utah Lake shore incised by young alluvial fans (Qafy), and small remnants south of Pelican Point. Machette (1992) reported that silt and clay of the regressive phase can be differentiated from silt and clay of the transgressive phase by the presence of conchoidal fractures in blocks of transgressive deposits and their absence in regressive deposits, but Qlmp may include some undifferentiated transgressive deposits. Exposed thickness less than 15 feet (5 m), but total thickness may exceed several tens of feet.

Deposits of the transgressive (Bonneville) phase of the Bonneville lake cycle: Mapped between the Bonneville and Provo shorelines. The highest Bonneville shoreline is at elevations from about 5150 to 5160 feet (1570–1575 m) in the quadrangle (table 1). The B soil horizon of paleosols developed on transgressive-phase lacustrine deposits commonly shows a slight to moderate accumulation of clay and may include a pedogenic accumulation of calcium carbonate as filaments in fine-grained soil or thin, discontinuous coatings on gravel; Machette (1992), using the terminology of Birkeland (1984), designated the soil profile of these units as A/Bt/Bk(or Cox).

Qlgb — **Lacustrine gravel and sand (upper Pleistocene)** – Moderately to well-sorted, clast-supported pebble to cobble gravel with a matrix of sand and silt; locally interbedded with thin to thick beds of silt and pebbly sand; clasts commonly subrounded to rounded, but some deposits consist of poorly sorted, angular gravel derived from nearby bedrock outcrops; gastropods locally common in sandy lenses; gravel locally cemented with calcium carbonate (tufa); thin to thick bedded. Deposits are found between the Bonneville and Provo shorelines near the base of the Lake Mountains, and form small outcrops of wave-cut and wave-built benches close to the Bonneville shoreline; wave-cut benches are commonly partly covered by colluvium derived from adjacent oversteepened slopes. Bedding ranges from horizontal to primary dips of 10 to 15 degrees on steeper piedmont slopes. Exposed thickness less than 30 feet (10 m).

Eolian deposits

Qes — **Eolian sand (Holocene to upper Pleistocene)** – Moderately to well sorted, very fine to medium sand, with minor silt and clay; calcareous, loose to moderately firm where cemented by secondary calcium carbonate; forms thin blankets and small dunes along the eastern edge of the quadrangle near Vineyard; wind-blown sand derived from regressive Bonneville beach sand (Qlsp) beyond the toe of the Provo River delta front. Thickness from 3 to 10 feet (1–3 m).

Mass-movement deposits

Qmt — **Talus deposits (Holocene to upper Pleistocene)** – Very poorly sorted, angular cobbles and boulders and minor amounts of finer-grained interstitial sediment deposited principally by rock fall on or at the base of steep slopes; mapped in the Lake Mountains near Pelican Point where it locally rests on the abrasion platform of the Bonneville shoreline. Generally less than 20 feet (6 m) thick.

Spring and marsh deposits

Qsm — **Spring and marsh deposits (Holocene to upper Pleistocene)** – Fine, organic-rich sediment associated with springs, ponds, seeps, and wetlands; commonly wet, but seasonally dry; may locally contain peat deposits as thick as 3 feet (1 m); overlies lacustrine silt and clay (Qlmp and Qlmy) and grades laterally into young lacustrine silt and clay (Qlmy); present where water table is high on the margins of Utah Lake. Thickness commonly less than 10 feet (3 m).

Mixed-environment deposits

Qac — **Alluvial and colluvial deposits, undivided (Holocene to upper Pleistocene)** – Poor to moderately sorted, generally poorly stratified, clay- to boulder-size, locally derived sediment mapped in a small wash in the Lake Mountains near Pelican Point where deposits of alluvial, slopewash, and creep processes grade imperceptibly into one another; small, unmapped deposits are likely in most small drainages. Thickness less than 10 feet (3 m).

Qla — **Lacustrine and alluvial deposits, undivided (Holocene to upper Pleistocene)** – Sand, silt, and clay in areas of mixed alluvial and lacustrine deposits that are undifferentiated because the units grade imperceptibly into one another; mapped near Lindon. Thickness less than 10 feet (3 m).

Stacked-unit deposits

Qlgp/Qafo — **Lacustrine gravel and sand (regressive phase) over older alluvial-fan deposits (upper Pleistocene/upper to middle Pleistocene)** – A veneer of lacustrine gravel and sand related to the regressive phase of Lake Bonneville reworked from underlying alluvial-fan deposits older than Lake Bonneville; mapped on the Lake Mountains piedmont in the Pelican Point quadrangle below the Provo shoreline, downslope from the mouths of Limekiln and Olaf Canyons in the adjacent Saratoga Springs quadrangle (Biek, 2004). Lacustrine deposits are generally less than 3 feet (1 m) thick.

Major unconformity

MISSISSIPPIAN

Mh — **Humbug Formation (Upper Mississippian)** – Interbedded calcareous quartz sandstone, orthoquartzite, and limestone that weather to ledgy slopes; sandstone weathers light to dark brown, is pale yellowish brown to olive gray, medium to very thick bedded, variably calcareous or siliceous, locally with planar or low-angle cross-stratification; limestone rarely contains dark-gray chert nodules and is: (1) light-gray weathering, medium dark gray, medium to thick bedded, and fine grained with local small white chert blebs; (2) dark gray, very thick bedded with small white calcite blebs; or (3) locally medium to coarse grained with sparse fossil hash. Upper half contains several distinctive, ledge-forming, white, medium- to thick-bedded sublithographic limestone beds as much as 10 feet (3 m) thick; upper contact, exposed just west of the quadrangle, is conformable and gradational and represents a change from interbedded sandstone and limestone to limestone of the Great Blue Formation; age from Morris and Lovering (1961). About 700 to 750 feet (210–230 m) thick (Biek, 2004; Biek and others, 2009).

Md — **Deseret Limestone (Upper to Lower Mississippian)** – Medium- to very thick bedded, medium-dark-gray, variably sandy and fossiliferous limestone; contains distinctive white calcite nodules and blebs and local to common brown-weathering chert nodules and brown-weathering bands (case-hardened surfaces); fossils include rugose corals, brachiopods, crinoids, bryozoans, and fossil hash; quarry southwest of Pelican Point produces crushed limestone for use as aggregate and for water treatment; lower part, not exposed, is about 100 feet (30 m) thick and is marked by slope-forming, light-red and black phosphatic shale and thin-bedded cherty limestone of the Delle Phosphatic Member; upper contact is conformable and gradational and corresponds to a change from locally fossiliferous limestone to predominantly sandstone; age from Morris and Lovering (1961) and Sandberg and Gutschick (1984). About 700 to 750 feet (210–230 m) thick in Lake Mountains (Biek, 2004; Biek and others, 2009).

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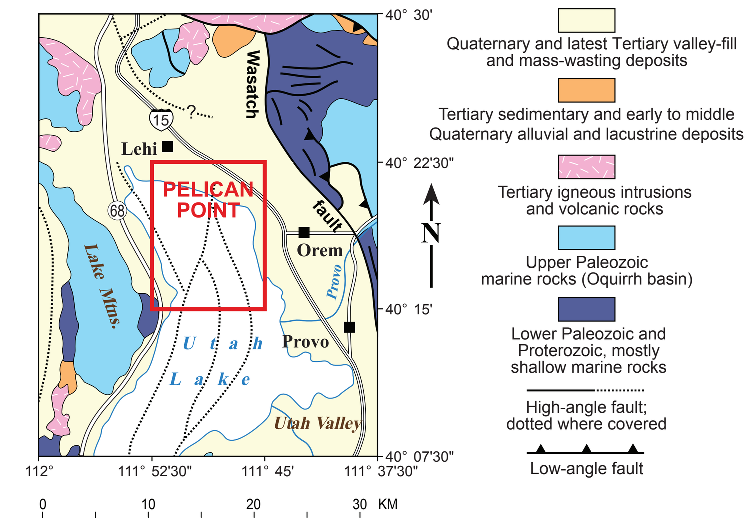
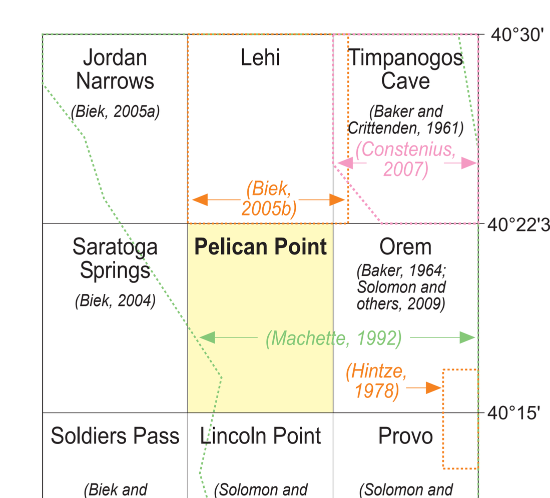
LITHOLOGIC COLUMN

SYSTEM	SERIES	FORMATION	SYMBOL	THICKNESS Feet (Meters)	LITHOLOGY
MISSISSIPPIAN	Upper	Humbug Formation	Mh	700-750 (210-230)	Top not exposed; White sublithographic limestone
	Upper / L.	Deseret Limestone	Md	700-750 (210-230)	White calcite blebs; Base not exposed; Delle Phosphatic Member

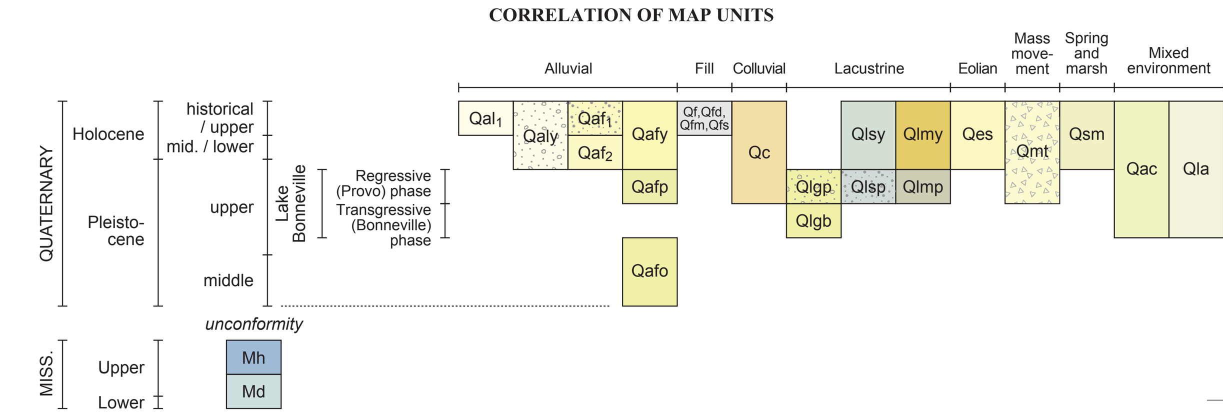


Primary geographic features and generalized geology in the vicinity of the Pelican Point quadrangle. Modified from Hintze and others(2000).



Selected geologic maps available for the Pelican Point and surrounding 7.5' quadrangles.

CORRELATION OF MAP UNITS



GEOLOGIC SYMBOLS

Contact – Dashed where approximately located

Normal fault – Dashed where approximately located, dotted where concealed; bar and ball on down-dropped side

Normal fault – Concealed; inferred principally from shallow sonar-like data (Brimhall and Merritt, 1981); very approximately located; bar and ball on down-dropped side

Lacustrine shorelines – Mapped at the wave-cut bench of erosional shorelines and the top of constructional bars and barrier beaches; may coincide with geologic contacts:

Lake Bonneville shorelines –
- B — Bonneville shoreline
- P — Provo shoreline
- x — Other regressive shorelines

Utah Lake shorelines –
- U — Pleistocene highstand shoreline of Utah Lake
- w — Other shorelines of Utah Lake

27 — Strike and dip of inclined bedding

Sand and gravel pit

Quarry

Prospect

Adit

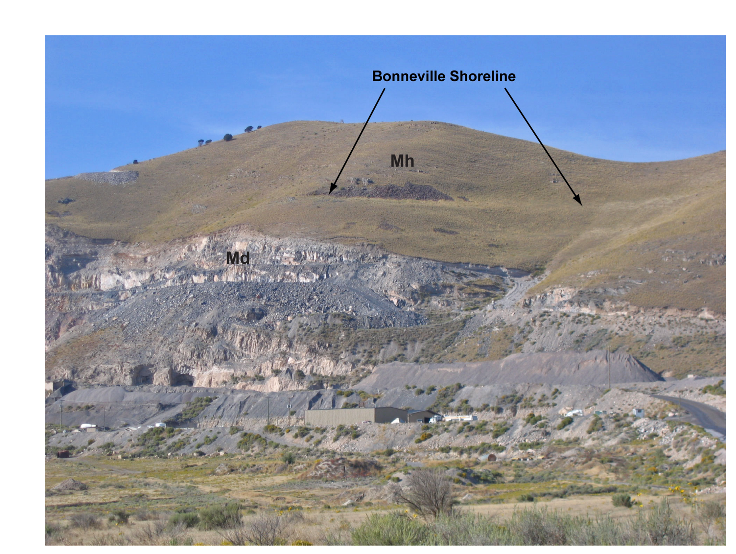
Spring

Table 1. Ages of major shorelines of Lake Bonneville and Utah Lake and shoreline elevations in the Pelican Point quadrangle.

Lake Cycle and Phase	Shoreline (map symbol)	Age: radiocarbon years B.P.	Age: calendar-calibrated years B.P.	Elevation feet (meters)
Lake Bonneville				
Transgressive Phase	Stansbury	22,000-20,000[1]	27,000-24,000[2]	Not present
	Bonneville (B) — flood	15,000-14,500[3]	18,300[4]-17,400[5]	5150-5160 (1570-1575)
Regressive Phase	Provo (P)	14,500-12,000[6]	17,400[5]-14,400[7]	4750-4780 (1450-1455)
	Gilbert	10,500-10,000[8]	12,500-11,500[9]	Not present
	Utah Lake highstand (U)	12,000-11,500[10]	-----	4495-4500 (1370-1372)

[1]Oviatt and others (1990).
[2]Calendar calibration using Fairbanks and others (2005; http://www.radiocarbon.ldeo.columbia.edu/research/radcarbcal.htm).
[3]Oviatt and others (1992), Oviatt (1997).
[4]Oviatt (written communication, 2009), usingStuiver and Reimer (1993) for calibration.
[5]CRONUS-Earth Project (2005), using Stuiver and others (2005) for calibration.
[6]Godsey and others (2005) revised the timing of the occupationof the Provo shoreline and subsequent regression; Oviatt and others (1992) and Oviatt (1997) proposed a range from 14,500 to 14,000 ^{14}C yr B.P. Oviatt and Thompson (2002) summarized many recent changes in the interpretation of the Lake Bonneville radiocarbon chronology.
[7]Godsey and others (2005), using Stuiver and Reimer (1993) for calibration.
[8]Oviatt and others (2005).
[9]Calendar calibration of data in Oviatt and others (2005), using Stuiver and Reimer (1993) and Hughen and others (2004).
[10]Estimated from data in Godsey and others (2005); Machette (1992) estimated the age of the regression of Lake Bonneville below the Utah Valley threshold at 13,000 ^{14}C yr B.P. from earlier data.

When the topographic base map used in this report was constructed in 1985, Goose Point was an island separated from the lake shore. However, the level of Utah Lake had fallen by the time this photograph was taken in 2008. Then, Goose Point, viewed looking east, was connected to the shore by a tombolo, a small barrier beach attaching the island to the lake shore, with an intervening lagoon.



View to the west of the northern part of the Pelican Point quarry in Mississippian Deseret Limestone (Md) on the eastern flank of the Lake Mountains. The late Pleistocene Bonneville shoreline is etched into the Upper Mississippian Humbug Formation (Mh) above the quarry.