UTAH GEOLOGICAL SURVEY
a division of
UTAH DEPARTMENT OF NATURAL RESOURCES

Utah Geological Survey Map 150
Quaternary Geologic Map of Skull Valley

Base map from U. S. Geological Survey,
Rush Valley and Tooele, Utah,
30 x 60 minute series, 1979.

Lori J. Douglas, Cartographer

MAP EXPLANATION
(full map unit description in accompanying book)

Qac	Undifferentiated alluvium and colluvium
Qaf	Active alluvial-fan deposits
Qafa	Abandoned alluvial-fan deposits
Qafo	Inactive alluvial-fan deposits
Qal	Channel alluvium
Qed	Eolian dune deposits
Qes	Nondunal eolian deposits
Qla	Mixed lacustrine and alluvial deposits
Qld	Lacustrine mud
Qlf	Fine-grained lacustrine deposits
Qlg	Lacustrine gravel
Qll	Lagoon deposits
Qlm	White marl
Qls	Lacustrine sand
Qsm	Marsh deposits
B	Undifferentiated bedrock within and immediately adjacent to the study area.

- Contact
- Bonneville shoreline
- Provo shoreline
- Stansbury shoreline
- Gilbert shoreline
- Piedmont fault scraps; bar and ball on downthrown side
- Faults or fractures having small or undetermined displacement
- Drainage divide or other study-area boundary
- S-5 Sediment sample site
- Gravel or borrow pit

QUATERNARY GEOLOGIC MAP OF SKULL VALLEY, TOOELE COUNTY, UTAH

by
Dorothy Sack
1993

SCALE 1:100 000
1 CENTIMETER ON THE MAP REPRESENTS 1 KILOMETER ON THE GROUND
CONTOUR INTERVAL 20 AND 50 METERS

MILES 1 0 1 2 3 4 5
KILOMETERS 1 0 1 2 3 4 5 6 7 8 9 10
METERS 1000 0 5000 10 000 15 000
FEET 5000 0 10 000 20 000 30 000 40 000 50 000

Sack

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UGS MAP 150

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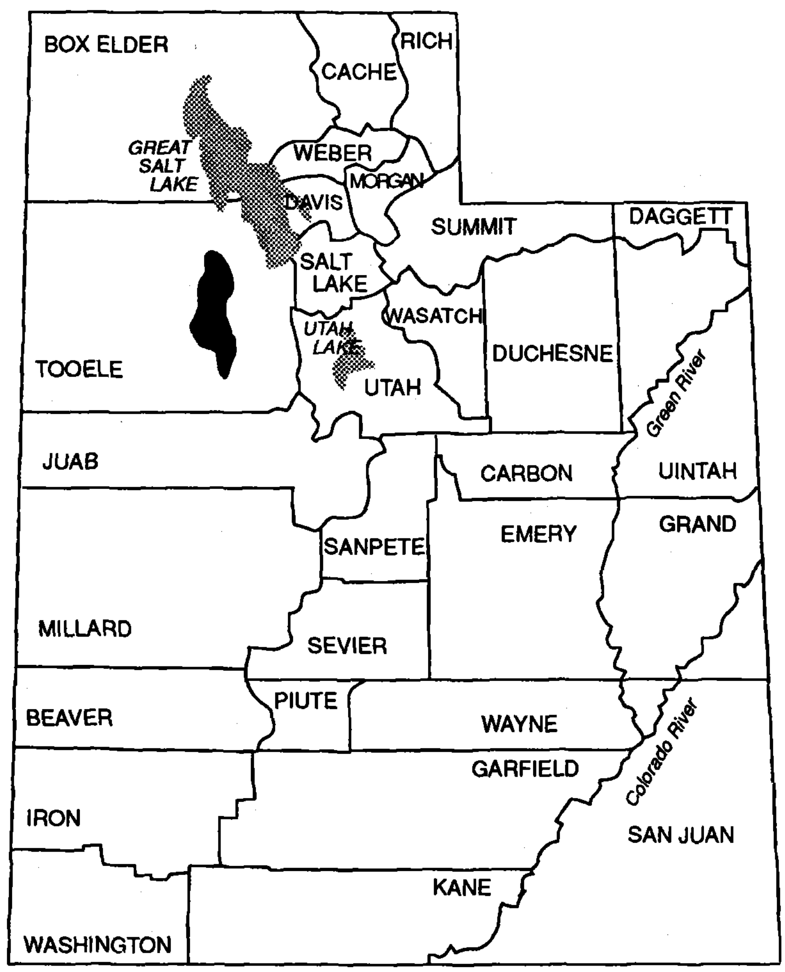

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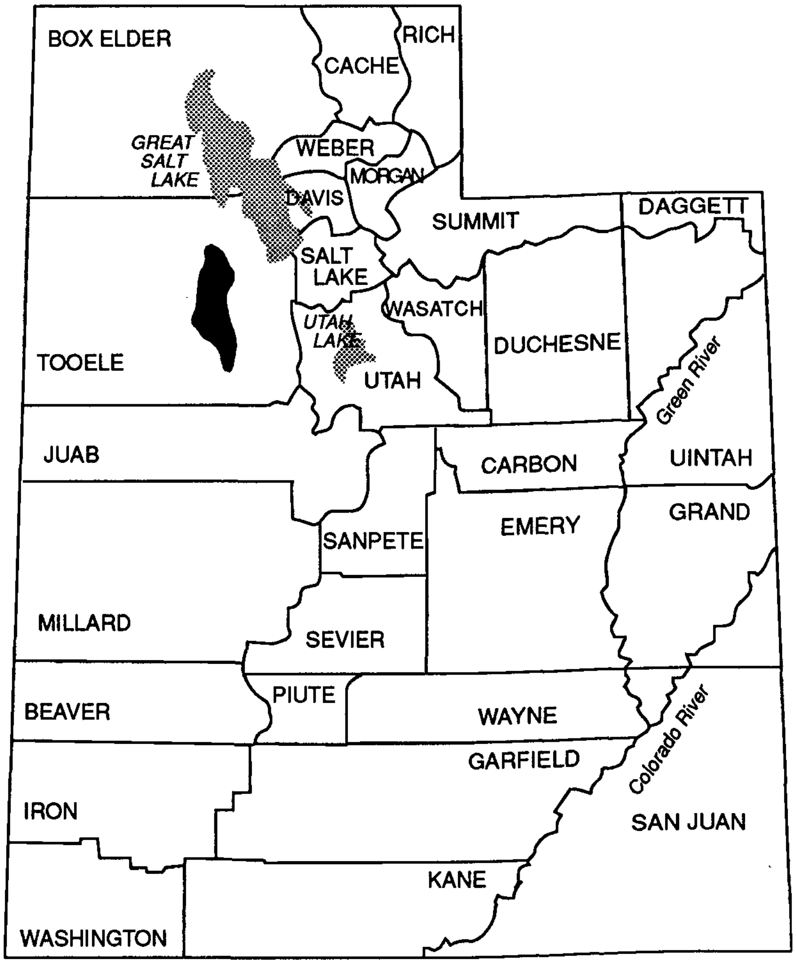

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QUATERNARY GEOLOGIC MAP OF SKULL VALLEY, TOOELE COUNTY, UTAH

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ABSTRACT

Skull Valley lies in the Great Salt Lake drainage basin approximately 40 miles (64 km) west of Salt Lake City. The nature and distribution of its landforms and surficial deposits reveal that it was subjected to a long period of aridity before becoming an arm of late Pleistocene Lake Bonneville. Physical evidence of Lake Bonneville consists of substantial deposits of lacustrine fines, sand, and gravel. Much of the gravel occurs in large relict beaches, barriers, spits, and tombolos. After the Bonneville lacustral cycle, only the lowest elevations of northern Skull Valley were inundated during the highest levels of Great Salt Lake. Most of the valley has been dominated by subaerial processes in the Holocene, and today Great Salt Lake lies beyond the study area to the northeast. In addition to the drastic fall in lake level, the regional post-Bonneville return to conditions of less effective moisture is evidenced in Skull Valley by extensive alluvial-fan and eolian deposits.

The 1:100,000-scale map compiled for this investigation depicts a wide variety of Quaternary sediments, including alluvial, eolian, lacustrine, and spring deposits. These general categories of depositional environment are subdivided into 15 Quaternary map units. The map portrays preserved segments of the three principal Lake Bonneville shorelines, the Stansbury, Bonneville, and Provo, and one Great Salt Lake shoreline, the Gilbert. In addition, the map shows the location of numerous Quaternary faults and lineaments, many of which have not been previously mapped.

Geologic hazards in the study area consist of debris flows, flash floods, sand and dust storms, rising levels of Great Salt Lake, and seismic hazards. At present, gravel is the most important economic resource within the Quaternary deposits of Skull Valley.

INTRODUCTION

Skull Valley is located in northeastern Tooele County, Utah, approximately 40 miles (64 km) west of Salt Lake City (figure 1). It occupies a north-south-trending structural basin in the Basin and Range physiographic province. Skull Valley is bordered by the Cedar Mountains to the west, the Stansbury and Onaqui Mountains to the east, Davis Mountain and the Sheeprock Mountains to the south, and by Puddle Valley, the Lakeside Mountains, and Great Salt Lake to the north (figure 2). Skull Valley is part of the Great Salt Lake drainage basin, and contained an arm of Lake Bonneville during the late Pleistocene. Surficial deposits include alluvial-fan, eolian, lacustrine, and spring sediments, and are crossed by shorelines of Lake Bonneville and Great Salt Lake as well as by piedmont faults scarps.

The purposes of this investigation are to map at the scale of 1:100,000 and describe the Quaternary deposits, major shorelines, and piedmont fault scarps in Skull Valley. The Quaternary geology of Skull Valley has not previously been mapped in detail despite the valley's large size, accessibility, location near military installations, and proximity to the densely populated Wasatch Front. It is important to study the Quaternary deposits of Skull Valley because they are extensive, of potential economic value, useful in regional Quaternary paleoenvironmental reconstructions, and helpful in identifying local geologic hazards. Surficial geologic mapping is also warranted here because Skull Valley has been and probably will again be considered as the site of large-scale military, industrial, and research-oriented construction projects. Increasing the state's information base regarding the nature and distribution of basin material will aid the decision-making process regarding such large-scale projects. This study extends northward recent Quaternary geologic mapping conducted in west-central Utah (Oviatt, 1989, 1991a,b; Sack, 1989a,b, 1990; Oviatt and others, 1991).

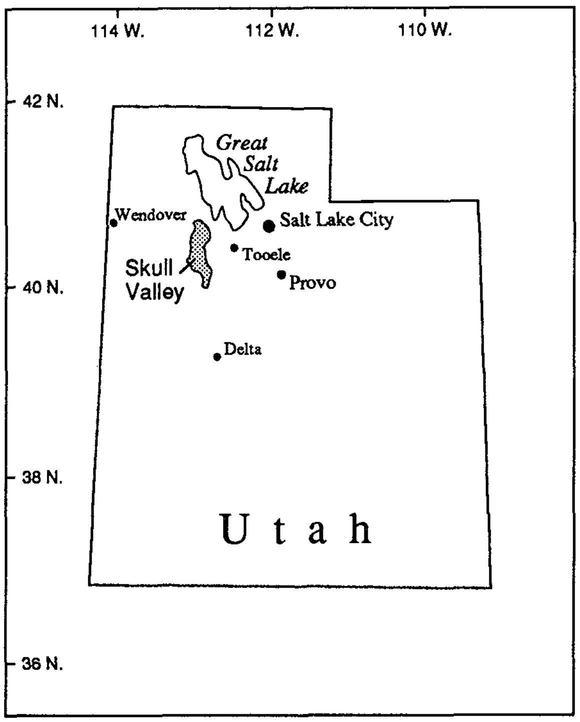

Figure 1. Map showing general location of Skull Valley.

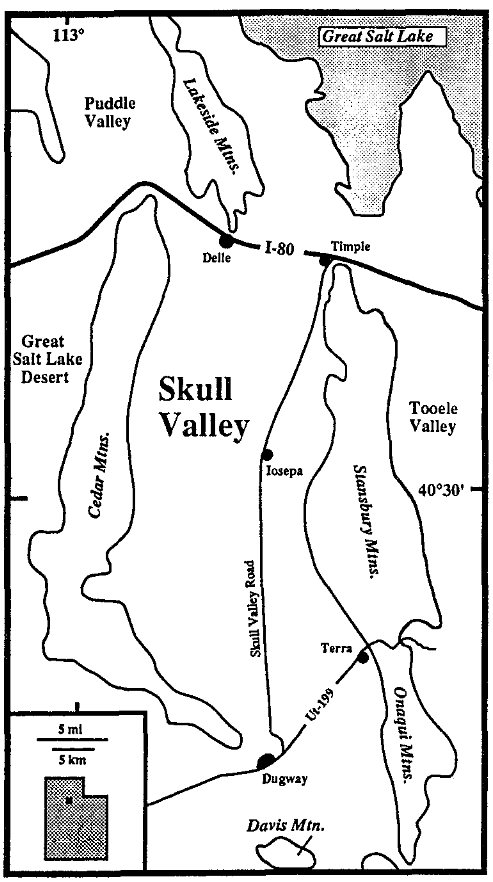

Figure 2. Regional map of the Skull Valley area showing some of its principal physical and cultural features.

STUDY AREA

The area included in this investigation consists of the Skull Valley floor and piedmont, up to the piedmont junction. The perimeter of the study area approximately separates zones of unconsolidated material at lower elevations from higher zones of bedrock. In those few places where Skull Valley is not bounded by mountains, and therefore locally lacks a piedmont, the specific study area boundary lies along the drainage divide with the adjacent valley. Because Skull Valley is part of the Great Salt Lake drainage basin, the northeastern boundary was arbitrarily located between Skull Valley and Great Salt Lake. Defined in this way, Skull Valley has a maximum length of about 53 miles (86 km), maximum width of about 16 miles (26 km), and occupies approximately 550 square miles (1,425 km^2). Local relief is impressive, with elevations ranging from about 4,214 feet (1,284 m) on the northeastern valley floor to 11,031 feet (3,362 m) at Deseret Peak in the Stansbury Range (figure 3). The area of investigation covers substantial parts of the Rush Valley and Tooele, Utah, 1:100,000-scale USGS topographic quadrangles. At least portions of 22 7.5-minute topographic quadrangles are required for complete map coverage at the scale of 1:24,000 (table 1).

***Table 1.** 7.5-minute topographic quadrangles covering Skull Valley*

Camels Back Ridge NE	Lookout Pass
Craner Peak	Low
Davis Knolls	Onaqui Mts. South
Delle	Poverty Point
Deseret Peak West	Quincy Spring
Hastings Pass	Salt Mountain
Hastings Pass NE	Tabbys Peak
Hastings Pass SE	Tabbys Peak SE
Hickman Knolls	Tabbys Peak SW
Indian Peaks	Terra
Johnson Pass	Timpie

Cultural use of the study area is moderate. Interstate 80 and the Western Pacific Railroad cross the northern end of Skull Valley, Utah Highway 199 traverses the southern end, and an unnumbered, paved road called Skull Valley Road extends almost the length of the valley from northeast to southwest (figure 2). The study area contains the Skull Valley Indian Reservation, the town of Dugway, the settlements of Iosepa and Terra, small service centers along Interstate 80 at Delle and Timpie, scattered ranches, the Bureau of Land Management's Muskrat Field Station, Hercules's Tekoi testing range, the Marblehead quarry, and a small portion of Dugway Proving Ground. Grazing is an important economic activity throughout the valley. The federal government manages the Cedar Mountains wild horse preservation area and the Stansbury Wilderness and Roadless areas, which lie partly in Skull Valley.

Skull Valley has a mid-latitude dry climate with hot summers and cold winters. For the period 1950 through 1986, Dugway had an average July temperature of 78.3°F (25.7°C), January temperature of 27.2°F (-2.7°C), and annual temperature of 51.4°F (10.8°C) (Stevens and Brough, 1987). In the same period, Dugway received an average annual precipitation of 7.63 inches (19.38 cm) (Stevens and Brough, 1987). The average annual pan evaporation in Skull Valley has been estimated at 61 inches (155 cm) (Hood and Waddell, 1968).

Figure 3. *Photograph of Skull Valley and the Stansbury Mountains, including Deseret Peak. The photograph was taken from the upper piedmont of the Cedar Mountains.*

Figure 4. *Photograph to the west-southwest showing unvegetated playa mudflats (Qld) in the foreground, grass-covered marsh deposits (Qsm) in the middle ground, and the Cedar Mountains in the background.*

Skull Valley soils are moderately to strongly alkaline, locally saline, Aridisols and Entisols (Krausmann, 1984); vegetation varies with elevation and soil type. Low-elevation mudflats are largely unvegetated. Adjacent, very saline vegetated lowlands are dominated by iodine bush *(Allenrolfia occidentalis)*, pickleweed *(Salicornia rubens)*, salt grass *(Distichlis stricta)*, and alkali grass (*Puccinellia sp.*) (figure 4). Slightly less saline portions of the basin floor are dominated by saltbush (*Atriplex gardneri*), shadscale (*Atriplex confertifolia*), and greasewood (*Sarcobatus vermiculatus*). At higher elevations soils become coarser, better drained, and less saline. Dominant vegetation on the piedmont includes Indian rice grass (*Oryzopsis hymenoides*), cheat grass (*Bromus tectorum*), saltbush, shadscale, sagebrush (*Artemesia tridentata*), and, at highest piedmont locations, juniper (*Juniperus osteosperma*).

Late Cenozoic crustal extension created the dominant north-south-trending fault-block topography that characterizes the northern half of the Basin and Range physiographic province, including the study area (Hintze, 1988). That the extensional activity is ongoing in western Utah is evidenced by numerous Quaternary piedmont fault scarps, such as those that occur in Skull Valley (figure 5). Basin-fill thickness is estimated to be 1,200 feet (366 m) to the east of Davis Mountain and 6,000 to 7,000 feet (1,829 to 2,134 m) near the eastern flank of the Cedar Mountains (Hood and Waddell, 1968). The mountain ranges adjacent to Skull Valley consist of Paleozoic sedimentary rocks and quartzite; Tertiary volcanics, intrusives, and conglomerate; and Quaternary alluvial, colluvial, glacial, and mass-wasting deposits (Maurer, 1970; Moore and Sorensen, 1977, 1979; Moore and others, 1978; Sorensen, 1982).

Figure 5. Photograph of the west face of the Stansbury Mountains showing a trace of the Stansbury fault zone (indicated with arrow) crossing the upper piedmont.

PREVIOUS WORK

Over a century ago in the course of his investigations of Lake Bonneville, G.K. Gilbert travelled south along the east side of Skull Valley and across to the southern Cedar Mountains north of Dugway (Gilbert, 1890, plate III; Hunt, 1982). Gilbert's field notes contain brief comments concerning the structure and bedrock of the mountains, piedmont fault scarps along the base of the Stansbury Mountains, brackish springs on the valley floor, and elevations of the Bonneville and Provo shorelines of Lake Bonneville (Gilbert, in Hunt, 1982). In U.S. Geological Survey Monograph 1, Gilbert (1890) used topographic profiles of Bonneville-level bayhead barriers from six localities, including one from the south end of Skull Valley, in a geomorphic analysis of the Bonneville shoreline (figure 6). From that data, Gilbert (1890) concluded that the compound nature of the Bonneville shoreline was created by moderate oscillations in the water level during Bonneville shoreline time.

The two most prominent shorelines of Lake Bonneville, which Gilbert (1875) named the Bonneville and Provo beaches, were first delineated for the entire Bonneville basin, including Skull Valley, by Gilbert (1890) in Monograph 1. Plate XIII of that classic report shows the extent of the lake at the Bonneville and Provo shorelines at the approximate scale of 1:2,700,000; a large, folded map included in a pocket in the monograph depicts Lake Bonneville at its highest level, the Bonneville shoreline, at a scale of 1:800,000. Gilbert's (1890) field mapping of the two shorelines compares quite favorably to modern renditions (Currey, 1980, 1982; Currey and others, 1984), including this report, which rely heavily on aerial photographs. In general, modern maps extend the Provo shoreline farther south into Skull Valley than Gilbert portrayed it, and do not extend the Bonneville shoreline quite as far into southeastern Skull Valley as Gilbert did.

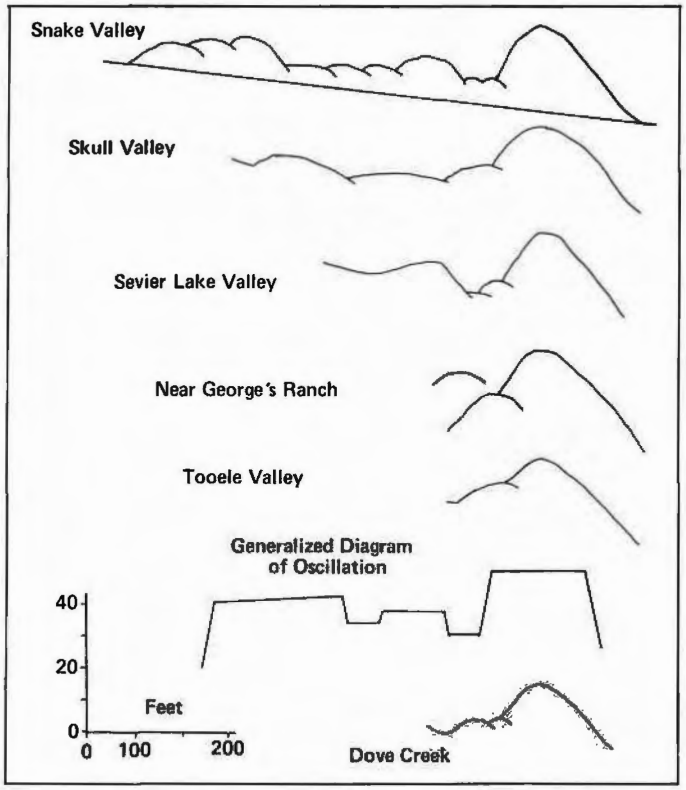

Figure 6. Topographic profiles of Bonneville shoreline depositional features from six sites, including Skull Valley (Gilbert, 1890, plate XI; redrawn by Burr, 1989, figure 4).

After Gilbert's (1890) work, the next major map of Bonneville basin shorelines is Currey's (1980) 1:250,000-scale delineation of the principal shorelines of Lake Bonneville and Great Salt Lake in the vicinity of Great Salt Lake. The area covered by that map includes a small portion of Skull Valley. In a 1982 report, Currey compiled a map of the Bonneville and Provo shorelines for the entire Bonneville basin at the scale of 1:500,000. Skull Valley is also included on Currey and others' (1984) definitive 1:750,000-scale basinwide map of all the major levels of Lake Bonneville and Great Salt Lake. Mapping of Lake Bonneville and Great Salt Lake shorelines as conducted for the present study differs from these previous investigations in its scale, its restriction to Skull Valley, and in not interpolating between preserved shoreline segments.

Previously published regional maps that depict Quaternary deposits of the study area cover only small portions of Skull Valley or were compiled at small scales. Hood and Waddell (1968, plate 1) divided Skull Valley surficial deposits into seven general Quaternary units on their 1:420,000-scale hydrologic map of the area. Dean (1976) delineated a few large areas of eolian dunes in Skull Valley as part of his 1:250,000-scale map of sand dunes in the Great Salt Lake Desert region. Moore and Sorensen (1977, 1979), Moore and others (1978), and Sorensen (1982) did not subdivide the Quaternary portions of their geologic maps, which cover parts of Skull Valley. Dames and Moore (1987) included a small area of northwestern Skull Valley in their 1:50,000-scale map of the proposed Cedar Mountains site for the superconducting supercollider.

Gilbert (1890, plate XLV) first depicted Skull Valley's Stansbury fault zone in U.S. Geological Survey Monograph 1. The Stansbury fault zone is a system of Quaternary piedmont fault scarps that lies along the western piedmont of the Stansbury Mountains. On their small-scale geologic map of the Tooele 1° x 2° USGS topographic map, Moore and Sorensen (1979) portrayed the Stansbury fault zone, its extension along the base of the Onaqui Mountains, and numerous bedrock faults in the mountains adjacent to the study area. Barnhard and Dodge (1988) studied the Stansbury fault zone and mapped it at the scale of 1:250,000, along with the nine other western Utah Quaternary fault zones included in their investigation.

Hydrologic studies were conducted in the study area in the late 1960s. Waddell (1967) performed chemical analyses on 65 well, spring, and stream samples from Skull Valley. Dissolved-solids content ranged from 253 to 4,010 ppm in wells, and from 696 to 17,200 ppm in springs and streams. In general, sources north of Iosepa (figure 2) have higher dissolved-solids content than sources in the southern part of Skull Valley. Waddell (1967) found sodium and chloride to be the principal chemical constituents of the samples. Hood and Waddell (1968) reported on the source, distribution, and movement of surface and ground water in Skull Valley.

METHODOLOGY

The Quaternary geology of Skull Valley was mapped for this report using a combination of fieldwork and air-photo interpretation. An initial period of reconnaissance fieldwork was employed to determine map units and to identify their photographic signatures on 1:60,000-scale air photos. Considerable portions of the Quaternary deposits, shorelines, and fault scarps in Skull Valley were then mapped from the air photos. That work was checked in a subsequent phase of intensive fieldwork before it was transferred to the 1:100,000-scale base map.

Map units are identified with letter symbols. The first letter, Q or B, is capitalized and indicates whether the unit consists of Quaternary deposits (Q) or pre-Quaternary bedrock (B). A hierarchical scheme involving two or three lower case letter symbols is employed to further subdivide the Quaternary-age units (table 2). The first lower case letter symbol designates the general depositional environment of a map unit as alluvial, eolian, lacustrine, or spring. A second lower case letter provides information on the depositional subenvironment. For some units, such as lagoon deposits (Qll) and channel alluvium (Qal), the subenvironment is given directly; other symbols at this level indirectly describe the subenvironment through a material modifier, such as gravel (g), sand (s), or marl (m). A third lower case letter is used to subdivide alluvial fans that are not presently active into two groups, those that are completely abandoned (Qafa) and those that could again receive alluvial-fan deposition (Qafo). A diagram showing the approximate correlation of the Quaternary map units appears in figure 7.

Some areas in Skull Valley exhibit a cover of one map unit overlying another. Those places are portrayed on the map by stacking of the appropriate units. For example, localities where nondunal eolian sand overlies bedrock appear with the symbol Qes/B. Areas on the map that are composed of stacked units are colored according to the overlying unit.

Preserved segments of three major Lake Bonneville shorelines, the Stansbury, Bonneville, and Provo, and one Great Salt Lake shoreline, the Gilbert, are delineated on the map. Their chronologic order and relative water-level elevations are shown on the hydrograph in figure 8. The Stansbury shoreline was created by at least one major oscillation during Lake Bonneville's early transgressive phase (Currey and Oviatt, 1985; Oviatt and others, 1990). Preserved portions of the Stansbury

Table 2. *Symbols used for map units.*

First Letter, Temporal Designation:			
	Q	=	Quaternary deposits
	B	=	pre-Quaternary bedrock
Second Letter, General Depositional Environment:			
	a	=	alluvial
	e	=	eolian
	l	=	lacustrine
	s	=	spring
Third and Fourth Letters, Subenvironment Indicator:			
Alluvial:	c	=	colluvium
	f	=	active fan
	fa	=	abandoned fan
	fo	=	inactive fan
	l	=	channel
Eolian:	d	=	dunal
	s	=	sheet-like
Lacustrine:	a	=	alluvial
	d	=	mud
	f	=	fine-grained
	g	=	gravel
	l	=	lagoon
	m	=	marl
	s	=	sand
Spring:	m	=	marsh

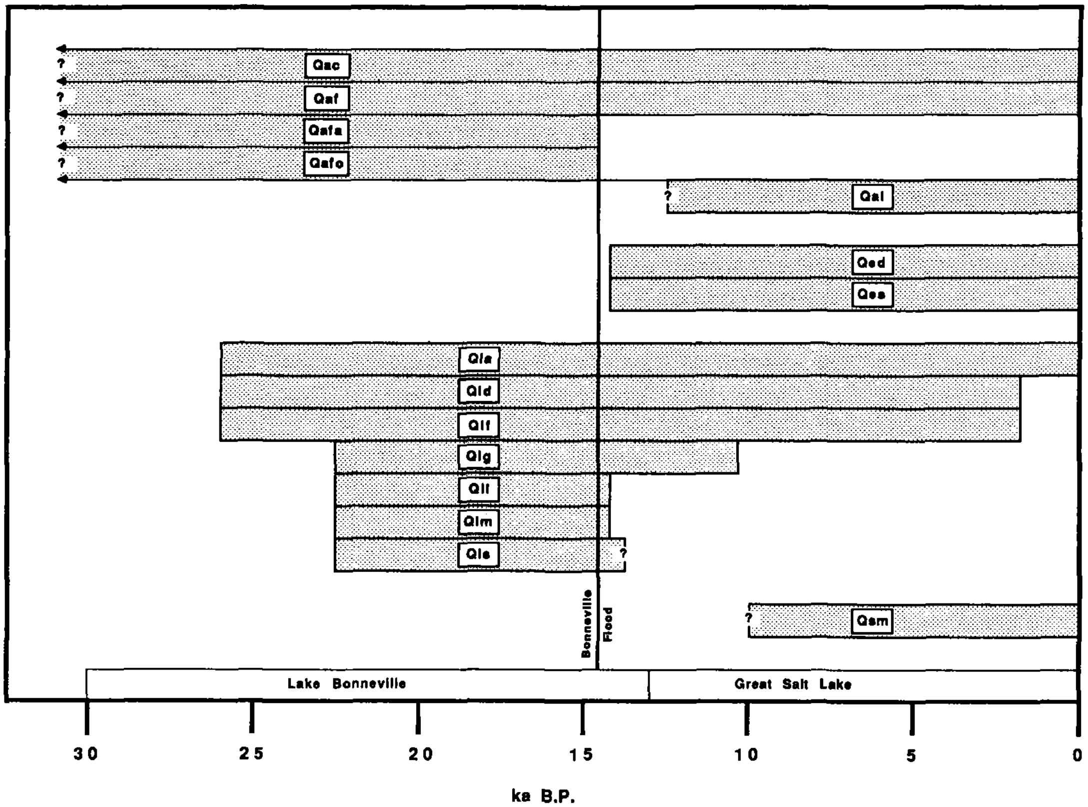

Figure 7. Approximate correlation of Quaternary map units.

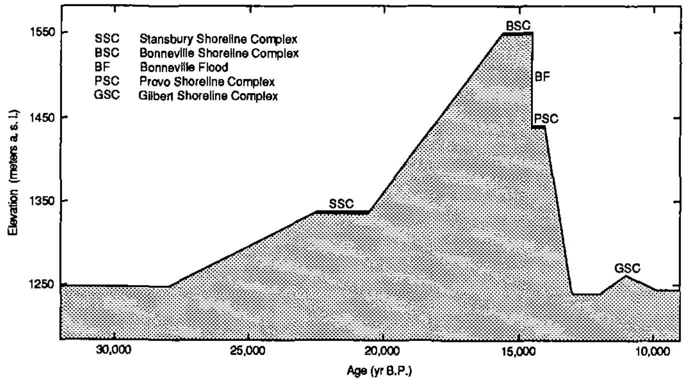

Figure 8. Schematic hydrograph of Lake Bonneville and early Great Salt Lake (after Burr and Currey, 1988).

shoreline, therefore, vary considerably in elevation. In Skull Valley, mapped segments of the Stansbury shoreline are generally found lying between 4,470 and 4,520 feet (1,362 and 1,378 m). The Bonneville shoreline is the most conspicuous shoreline in the Bonneville basin because it is the highest and was maintained by external threshold control for a considerable length of time (Gilbert, 1890). Its elevation varies across Skull Valley from approximately 5,230 feet (1,594 m) at the south to 5,310 feet (1,618 m) at the north, primarily because of differential hydroisostatic rebound (Gilbert, 1890; Currey, 1982). Approximately 14,500 years ago (Burr and Currey, 1988), Lake Bonneville fell catastrophically from the Bonneville shoreline when unconsolidated material failed at the threshold, unleashing the Bonneville flood (Gilbert, 1890; Malde, 1968) (figure 8). The water level restabilized at a new threshold approximately 380 feet (116 m) below the highest component of the Bonneville shoreline (Burr and Currey, 1988). This lower threshold-controlled shoreline is the Provo, which is the second most prominent shoreline in the Bonneville basin. Because of differential hydroisostatic rebound, in Skull Valley the Provo shoreline is found at elevations ranging from about 4,855 feet (1,480 m) in the south to 4,920 feet (1,500 m) in the north. Climate change caused Lake Bonneville to regress rapidly from the Provo shoreline beginning approximately 14,200 years ago (Burr and Currey, 1988). Lake Bonneville fell rapidly to levels even lower than modern Great Salt Lake (Currey and Oviatt, 1985) (figure 8). After about 13,000 years ago, Great Salt Lake rose to its highest shoreline, the Gilbert shoreline complex, which it occupied between about 10,900 and 10,300 years ago (Currey, 1990) (figure 8). In Skull Valley, the Gilbert shoreline is mapped at elevations ranging from about 4,275 to 4,320 feet (1,303 to 1,317 m).

DESCRIPTION OF MAP UNITS

Alluvial Deposits

Undifferentiated Alluvium and Colluvium (Qac)

A few small, steep areas just below the piedmont junction or adjacent to bedrock outcrops are mapped as undifferentiated alluvium and colluvium. Qac consists of alluvium which has a significant colluvial component, colluvium that has been subjected to moderate fluvial action, and areas where alluvium and colluvium are not distinguishable at the map scale. This unit is generally coarse grained and angular, but contains some fine-grained and rounded coarse-grained lacustrine deposits where it lies below the Bonneville shoreline. Qac is still being deposited. Above the Bonneville shoreline, its deposition began at an unknown time, but probably in the late Pleistocene.

Active Alluvial-Fan Deposits (Qaf)

Deposits of active alluvial fans, Qaf, are widespread on the upper, middle, and lower piedmonts of Skull Valley. They are found both above and below the Bonneville shoreline, wherever recent fan sedimentation has occurred. Qaf consists of poorly sorted coarse- to fine-grained stream and debris-flow deposits, with sediments generally fining in the down-fan direction. Qaf locally consists of fluvially reworked fine-grained lake deposits, especially in the lower piedmont zone. Below the Bonneville shoreline, Qaf deposits are of post-Bonneville shoreline age. Active alluvial-fan deposits are late Pleistocene and Holocene in age.

Abandoned Alluvial-Fan Deposits (Qafa)

Abandoned segments of alluvial fans appear on the map as Qafa. Abandoned alluvial-fan segments are deeply entrenched by the channels that form part of the active alluvial-fan system (Qaf). Abandoned segments have not experienced alluvial-fan sedimentation for a very long time. Moreover, their position with respect to active channels and the degree of channel entrenchment make it extremely unlikely that they will be the sites of active fan deposition again. These segments are undergoing lateral erosion by the entrenched active channels and degradation by gullies which originate on the abandoned segments. The abandoned fans are composed of fine- to very coarse-grained alluvium, which in some places is set in a matrix of, or is overlain by, fine-grained eolian sediments and the products of *in situ* weathering. Where Qafa is overlain by significant accumulations of eolian sand it is mapped as Qes/Qafa.

The principal regions of Qafa lie between Salt Mountain and the Stansbury Mountains, and along the upper piedmont of the Onaqui Mountains. Abandoned alluvial fans occupy only a small portion of the upper piedmont of the Cedar Mountains. Qafa is found only above the Bonneville shoreline and generally represents those fan segments that were abandoned when base level was lowered by the fall of Lake Bonneville from the Bonneville shoreline, about 14,500 years ago (Burr and Currey, 1988). The abandoned-fan segments are therefore of pre-Bonneville shoreline age, although they may locally include small amounts of more recent alluvium or colluvium.

Inactive Alluvial-Fan Deposits (Qafo)

Inactive segments of alluvial fans that have probably not experienced active deposition since the late Pleistocene, but which may again be the sites of alluvial sedimentation, are mapped as Qafo. Alluvial-fan segments mapped as Qafo have been isolated from present deposition by stream channel changes, which resulted from surface offset by faulting, and by base-level changes due to the regression of Lake Bonneville. However, unlike Qafa, active stream channels issuing from the mountains are not deeply incised into inactive alluvial-fan surfaces, and would again deposit sediment on those surfaces as a result of relatively minor changes in course. Therefore, Qafo is geomorphically distinct from Qafa. Qafo consists of fine- to very coarse-grained alluvial sediments that are locally overlain by or mixed with fine-grained eolian deposits or weathering products. Inactive fan segments that are covered by blanket-like eolian deposits are mapped as Qes/Qafo. Qafo is widespread on the upper piedmont of the Stansbury and Onaqui Mountains; only very small areas of inactive alluvial fans occur on the upper piedmont of the Cedar Mountains. Like Qafa, Qafo is late Pleistocene in age.

Channel Alluvium (Qal)

Fluvial sediments deposited in and adjacent to ephemeral stream channels appear on the map as Qal. The principal mapped occurrence of Qal lies on the floor of central Skull Valley, and represents sedimentation along the valley's north-flowing axial stream system. That system drains both the western (Cedar) and eastern (Stansbury) piedmonts. The axial fluvial system loses its distinctiveness in the northern part of the study area where spring flow is dominant. Qal is composed predominantly of fine-grained sediments and typically consists of fluvially reworked fine-grained lacustrine deposits. Channel deposits on alluvial fans are mapped as fan sediments instead of Qal. Qal is very late Pleistocene and Holocene in age.

Eolian Deposits

Eolian Dune Deposits (Qed)

Areas mapped as Qed consist of eolian sediments found in geomorphically well-developed dunes. Qed sediments are generally moderately well-sorted, fine sand (table 3) deposited as various forms of transverse dunes, especially parabolic dunes, or as shrub-coppice dunes. Less well-sorted, very fine-grained eolian dune sediments occur near the lacustrine mudflats (Qld) in the northern part of the map area. There, shrub-coppice dunes and irregular source-bordering dune ridges, called lunettes, are composed at least partially of wind-deposited pellets of dried, calcareous mud.

Dunes are found scattered across Skull Valley, but they are most common downwind (northeast) of the passes at the north and south ends of the Cedar Mountains, thus reflecting sand sources in the Great Salt Lake Desert to the west (figure 2). Some of the sand that originates west of the study area also migrates over the Cedar Mountains to collect in small dune fields on the Cedar Mountains piedmont in Skull Valley. Sand from the Great Salt Lake Desert augments local sources that contribute to dunes. These local sources include alluvial-fan and lacustrine sand. Skull Valley eolian dune deposits are late Pleistocene and Holocene in age.

*Table 3. Sediment sample data for selected Skull Valley map units**

Sample No.	Map Unit	% Sand	% Silt	% Clay	% CaC03	Textural Classification
S-1	Qed	84.4	7.5	8.1	49.1	muddy sand
S-2	Qed	97.4	n/a	n/a	n/a	sand
S-3	Qed	95.2	n/a	n/a	n/a	sand
S-4	Qes	92.0	n/a	n/a	n/a	sand
S-5	Qld	19.9	57.9	22.2	42.3	sandy silt
S-6	Qld	22.0	46.0	32.0	49.0	sandy mud
S-7	Qlf	32.7	59.0	8.3	22.7	sandy silt
S-8	Qlf	18.2	66.8	15.1	21.6	sandy silt
S-9	Qlf	19.1	58.6	22.2	28.6	sandy silt
S-10	Qll	5.0	77.4	17.6	16.9	silt
S-11	Qlm (t)+	0.9	78.3	20.7	23.2	silt
S-12	Qlm	0.1	69.7	30.2	52.5	silt
S-13	Qlm (r)+	0.2	76.1	23.7	39.1	silt

*Grain sizes were determined prior to dissolution of the carbonate fraction. Textural classification is from Folk (1974). Sediment sample sites are indicated on the map.
+ t = transgressive marl; r = reworked marl

Nondunal Eolian Deposits (Qes)

Skull Valley contains some sandy eolian sediments, Qes (table 3), that form irregular or sheet-like deposits rather than well-developed dunes. In many places, Qes occurs as a cover over other map units, such as Qaf, Qafa, Qla, Qlg, and B. Some areas of Qes lie adjacent to and grade into eolian dunes (Qed). Locally, Qes may be dunal or reworked by fluvial processes.

Two major regions of Qes are found in the southern part of Skull Valley. One of these lies on the Skull Valley side of the Cedar Mountains divide; the second is located on the piedmont of the Stansbury and Onaqui Mountains northeast of the first area. Both of these regions lie downwind (northeast) of a large sand-dune field that was named the West Dugway dunes by Dean (1976). The West Dugway dunes occur beyond the map area on the southwest piedmont of the Cedar Mountains, west of Dugway (figure 2). Wind has moved sand from that dune field across and around the southern end of the Cedar Mountains into Skull Valley. Sand transported over the Cedar Mountains divide has accumulated in the lee of the mountain barrier, forming the more westerly of the two major regions of Qes. Its sand is probably derived almost exclusively from the West Dugway dune field. The West Dugway dune field and local alluvial-fan and lacustrine sources in Skull Valley are believed to have supplied sand to the large region of Qes on the piedmont of the Stansbury and Onaqui Mountains. Southwesterly winds have transported sand up that piedmont but are unable to move substantial quantities of sand across the high mountain barrier on the east side of Skull Valley. The nondunal eolian deposits are of late Pleistocene and Holocene age.

Lacustrine Deposits

Mixed Lacustrine and Alluvial Deposits (Qla)

Sediments mapped as Qla consist of lake-reworked alluvial-fan deposits, fan-reworked lake deposits, and intertonguing alluvial-fan and lake sediments that are not resolvable at the map scale. Qla is composed of poorly sorted, fine- to coarse-grained sediments, which are locally overlain by fine-grained eolian sediments. Places where the eolian cover is thick are mapped as Qes/Qla. The lake-reworked alluvial-fan deposits consist of pre-Bonneville alluvial fans that were only moderately reworked by transgressive and/or regressive shorelines of Lake Bonneville and Great Salt Lake. On air photos, this type of Qla is expressed geomorphically as alluvial fans etched by numerous shorelines. Other areas of Qla are made of fine- to coarse-grained lake sediments that have only been slightly reworked by post-lacustrine alluvial-fan processes so that both the alluvial and lacustrine character are identifiable. Qla is of late Pleistocene and Holocene age.

Lacustrine Mud (Qld)

A large, low-gradient region of lacustrine mud lies in the northern part of the study area. These lacustrine mudflats are composed of wet, calcareous and saline sandy mud (figure 4, table 3). The deposits are wet primarily because of the shallow depth to ground water (Hood and Waddell, 1968), although surface water may accumulate locally on the mudflats after significant precipitation. Geomorphically, the mudflats act as a ground-water discharging playa. However, they are mapped as lacustrine mud instead of playa mud because they consist of fine-grained deposits of Lake Bonneville and Great Salt Lake. These include in situ deposits as well as marl and other fine-grained lake sediments that have been washed basinward from the adjacent piedmonts. Small areas of white marl (Qlm) and spring marsh deposits (Qsm) are mapped with Qld. In restricted localities, Qld deposits may be reworked by ephemeral streams, spring flow, or hydroeolian planation (Currey, 1990). Wind-blown pellets of dried Qld deposits accumulate locally into shrub-coppice dunes and lunettes. Lacustrine mud deposits are late Pleistocene and Holocene in age.

Fine-Grained Lacustrine Deposits (Qlf)

Large areas of fine-grained lake sediments are found on the floor of Skull Valley, generally downslope from either mixed lacustrine and alluvial deposits (Qla) or active alluvial-fan deposits (Qaf). Fine-grained lacustrine deposits consist of sand, silt, and clay, but are typically calcareous, sandy silt (table 3). Qlf deposits are locally reworked by the wind or by fluvial processes. Where they are too small to be mapped separately, surface exposures of white marl (Qlm) are included in mapped areas of Qlf. Qlf sediments in Skull Valley were deposited by Lake Bonneville and Great Salt Lake. Some of the fine-grained sediments were probably reworked by Lake Bonneville from pre-existing lake, playa, dune, and alluvial-fan deposits. Great Salt Lake may largely have reworked fine-grained Lake Bonneville deposits, including those which were transported downslope by post-Bonneville subaerial processes. Qlf is late Pleistocene and early Holocene in age.

Lacustrine Gravel (Qlg)

Coarse-grained shorezone sediments of Lake Bonneville and Great Salt Lake are mapped as Qlg, especially where they form extensive beaches, barriers, spits, and tombolos (figure 9). Qlg ranges in composition from poorly sorted, sandy gravel to well-sorted, rounded cobbles. Qlg is commonly cross bedded and is locally more than 50 feet (15.2 m) thick. Lacustrine gravel deposits from the transgressive phase of Lake Bonneville are generally sandier and more poorly sorted than those deposited during Bonneville and Provo shoreline time. Areas mapped as Qlg/B consist of gravelly regolith and colluvium reworked by waves and currents of Lake Bonneville. Lacustrine gravel deposits in Skull Valley are typically overlain by several inches of eolian silt or sandy silt (table 4).

Substantial areas of Qlg are found along the valley's western and especially eastern piedmonts where gravel from pre-Bonneville bajadas was available for reworking by coastal processes. A variety of coastal landforms occur in these areas, including well-developed suites of cuspate barriers, which Gilbert (1885, 1890) called V-bars. At the south end of the study area large coastal landforms were built of lacustrine gravel during the latter part of the transgression of Lake Bonneville and at the Bonneville and Provo shorelines. Tombolos and bayhead barriers are the common coastal landforms in that area. Lacustrine gravel in Skull Valley is late Pleistocene in age.

Lagoon Deposits (Qll)

Fine-grained sediments deposited in Skull Valley landward of Lake Bonneville barriers and tombolos are mapped as lagoon deposits (figure 9). Qll includes lake-deposited sand, clay, and especially silt (table 3), and fine-grained sediments deposited by post-lacustrine slope, alluvial-fan, and eolian processes. Although most of the lagoons in Skull Valley occur in association with transgressive Lake Bonneville shorelines that lie between the elevation of the Bonneville and Provo shorelines, they are also found at the Stansbury, Bonneville, and Provo shorelines. Lagoons in the study area range in age from Stansbury shoreline time through Provo shoreline time, therefore Qll deposits are of late Pleistocene age.

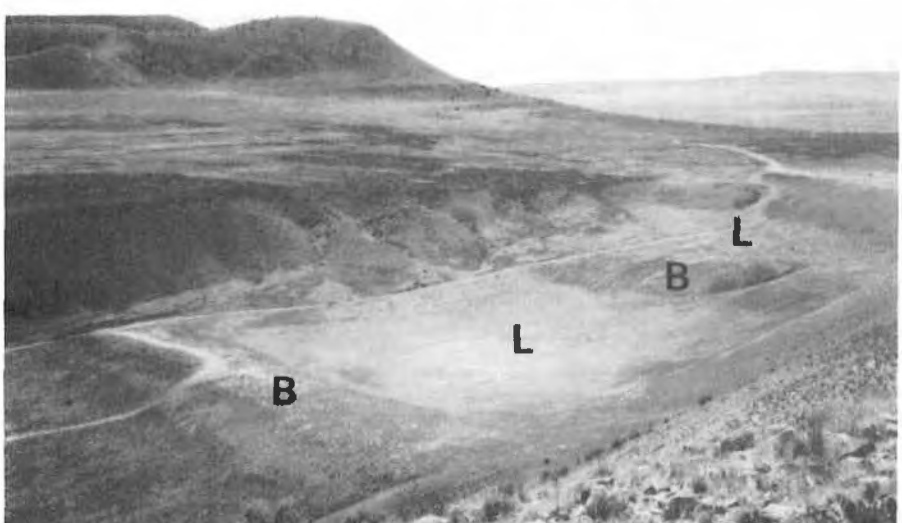

Figure 9. *Photograph showing Lake Bonneville transgressive-phase bayhead barriers (B) and lagoons (L) in northwestern Skull Valley.*

Table 4. *Sediment analyses of eolian fines overlying lacustrine gravel.*

Sample No.	% Sand	% Silt	% Clay	% CaC03	Textural Classification
S-14	12.3	71.7	15.9	16.6	sandy silt
S-15	21.7	70.1	8.3	25.6	sandy silt
S-16	29.5	57.9	12.6	16.6	sandy silt
S-17	8.7	69.4	22.0	20.7	silt

*Grain sizes were determined prior to dissolution of the carbonate fraction. Textural classification is from Folk (1974). Sediment sample sites are indicated on the map.

White Marl (Qlm)

Qlm consists primarily of surficial exposures of the white marl, which was named and first described by Gilbert (1890). The white marl is a laminated, open-water deposit of Lake Bonneville that was laid down during the lake's deeper stages (Gilbert, 1890; Oviatt, 1987). In addition to this pristine (non-reworked) white marl, Qlm includes slightly older, light gray transgressive marl as well as white marl that was reworked during the regressive phase of Lake Bonneville. These variants are distinguished in the field primarily by color and stratigraphic position. Although compositional differences are slight, laboratory analyses show that pristine white marl is texturally the finest of the three types and has the highest calcium-carbonate content, whereas the transgressive marl is the coarsest and has the lowest calcium-carbonate content (table 3). Ostracodes are common and gastropods are occasionally found in each type of marl. Mappable occurrences of marl are restricted in Skull Valley to incised areas along the axial ephemeral stream system (Qal), and to exposures lying between Qlf and Qld. Some exposures of Qlm have been reworked by fluvial processes. Qlm is late Pleistocene in age.

Lacustrine Sand (Qls)

Qls consists of nearshore to offshore sand deposited by Lake Bonneville. Mappable occurrences of Qls are found from below the Stansbury shoreline to well above the Provo shoreline, but Qls is best developed in the zone extending vertically downward from the Provo shoreline about 200 feet (61 m). Qls ranges from poorly to moderately sorted, medium to pebbly sand. Gastropod shells are common in this unit. Qls is locally reworked by fluvial and eolian processes. Qls was deposited during the late Pleistocene.

Spring Deposits

Marsh Deposits (Qsm)

Marsh deposits associated with several flowing springs in northeastern Skull Valley (figure 10) are depicted on the map as Qsm. The springs are warm and saline. Their flowing character is reflected in the planimetric pattern of Qsm sediments as seen on the map. The deposits are fine grained, organic rich, calcareous, and saline. They are Holocene in age.

Bedrock

Undifferentiated Bedrock Within and Immediately Adjacent to the Study Area (B)

The map symbol B is used to identify bedrock outcrops within Skull Valley and to denote bedrock immediately adjacent to the study area. Where the study area is bounded by mountains, its perimeter consists of the piedmont junction. Indicating where bedrock lies just beyond the study area emphasizes the location of the piedmont junction portion of the study area boundary. Mapping above the piedmont junction was not conducted other than to identify that contact. Throughout the map, Quaternary deposits are distinguished from bedrock to an extent appropriate to the map scale. Enclaves of bedrock found within Skull Valley consist primarily of Paleozoic sedimentary rocks and Tertiary igneous and sedimentary rocks. Readers interested in the area's bedrock are referred to specific works on that topic by Maurer (1970), Moore and Sorensen (1977, 1979), Moore and others (1978), and Sorensen (1982).

LATE QUATERNARY GEOLOGIC HISTORY

Basin-range faulting responsible for creating the Skull Valley basin began between 17 and 14 million years ago (Hintze, 1988). Some of the basin fill, therefore, is likely of late Tertiary age and may include the Mio-Pliocene Salt Lake Formation. The fault-block structural topography of the late Tertiary and early Quaternary probably resulted in landform assemblages similar to those of the late Quaternary, that is, alluvial fans, dunes, playas, and lakes. Sediment cores from the Great Salt Lake

Figure 10. Photograph of springs in northeastern Skull Valley. View is to the west-southwest and includes the Cedar Mountains in the background.

subbasin (Eardley and Gvosdetsky, 1960; Eardley and others, 1973) and detailed stratigraphic work elsewhere in the Bonneville basin (McCoy, 1987; Oviatt, 1989) show that several lacustrine episodes occurred in the region during middle and late Pleistocene time (Oviatt and Currey, 1987).

The late Quaternary history of Skull Valley is interpreted from the nature and distribution of its late Quaternary deposits, shorelines, and fault scarps, and from knowledge about late Quaternary lake cycles gathered throughout the Bonneville basin (Scott and others, 1983; Currey and Oviatt, 1985; McCoy, 1987; Burr and Currey, 1988; Oviatt, 1989; Currey, 1990; Sack, 1990). Skull Valley presently lies in the lowest Bonneville subbasin, the Great Salt Lake subbasin. Assuming that this has been the case for the entire late Quaternary and that Skull Valley's elevation has been relatively constant over that period, at least its lowest areas were likely inundated by the pre-Pokes Point (>600,000 years B.P.), Pokes Point (about 200,000 years B.P), Little Valley (about 140,000 years B.P.), and Cutler Dam (about 50,000 years B.P.) lake cycles (McCoy, 1987; Oviatt and others, 1987), as well as by the latest Pleistocene deep-lake cycle in the Bonneville basin, the Bonneville lacustral cycle (Currey and others, 1983). To date, direct physical evidence for only the Bonneville lake cycle has been observed in Skull Valley.

Before the transgression of Lake Bonneville, which may have begun as early as 32,000 years ago (Spencer and others, 1984), Skull Valley, along with the rest of the Bonneville basin, experienced a long period of aridity (Gilbert, 1890). This is evidenced by the great size of pre-Bonneville alluvial fans, which are only superficially reworked into Lake Bonneville coastal landforms (Gilbert, 1890). Inferring from the present geomorphology of arid Bonneville subbasins, this long pre-Bonneville epoch of aridity fostered development of alluvial fans on the piedmont, dunes on the lower piedmont, and playas, springs, and dunes on the valley floor.

As Lake Bonneville rose in its transgressive phase (figure 8), it reworked the pre-Bonneville subaerial deposits to at least some extent. Sand, silt, and clay on the valley floor and lower piedmont would have been quite easily entrained and transported by coastal waves and currents, and may have typically been deposited lakeward of their initial position. As the lake continued to transgress, coastal waves and currents eventually reached coarse-grained sediments higher on the piedmont. Coastal reworking of these deposits has much more pronounced geomorphic expression than do the reworked fine-grained deposits. That geomorphic expression consists of massive gravel beaches, barriers, spits, and tombolos (Qlg), and pre-Bonneville alluvial fans etched by numerous gravel beaches (Qla).

During its transgressive phase, Lake Bonneville was a closed-basin lake, having a water level that could change almost constantly. It is therefore very difficult to map individual transgressive-phase shorelines in a continuous fashion around the entire basin. The Stansbury shoreline complex, which formed between about 22,500 and 20,500 years ago (Currey and Oviatt, 1985; Oviatt and others, 1990) (figure 8), is one that has been mapped throughout the Bonneville basin (Currey and others, 1984). Some remnants of the Stansbury shoreline in Skull Valley display the characteristic Stansbury oscillation stratigraphic sequence, which, going up in section, consists of lacustrine gravel, marl, lacustrine gravel, marl. Numerous transgressive-phase shorelines cross the Bonneville basin's piedmont between the Bonneville shoreline and the elevation that the Provo shoreline occupied during the regressive phase of Lake Bonneville (figure 8). These transgressive shorelines, which lie physically between the elevations of the Bonneville and Provo shorelines, were named the Intermediate shorelines by Gilbert (1890). Although the Intermediate shorelines are numerous, none has yet been mapped continuously around the Bonneville basin.

Some of the Skull Valley fault scarps that lie between the Bonneville and Provo shorelines offset the Intermediate shorelines, thus indicating a maximum-limiting age of last movement during the transgressive phase of the lake. Other fault scarps in that zone do not offset shorelines, but retain sufficient geomorphic expression to be seen on aerial photographs. The fact that these scarps are still relatively sharp in form suggests that movement along them may have occurred shortly before or early in the transgressive phase of Lake Bonneville.

Burr and Currey (1988) estimated that Lake Bonneville finally attained the elevation of the lowest point on its drainage divide approximately 15,350 years ago (figure 8). When the lake reached that point it spilled out to the Snake-Columbia drainage system, thus achieving open-basin status. Under this threshold control, Lake Bonneville created the Bonneville shoreline. Many well-developed depositional and erosional coastal landforms are found at the Bonneville shoreline in Skull Valley, including the distinctive shoreline bluff found at the distal end of abandoned and inactive alluvial fans. The compound nature of the Bonneville shoreline, as first discussed by Gilbert (1890) and more recently elaborated upon by Currey and Burr (1988) and Burr (1989), is observable in the depositional record of Skull Valley (figure 6).

Lake Bonneville was maintained at least intermittently at the Bonneville shoreline until about 14,500 years ago, when threshold failure unleashed the Bonneville flood (Gilbert, 1890; Malde, 1968; Jarrett and Malde, 1987; Burr and Currey, 1988). The Bonneville flood resulted in a rapid drop in lake level to the Provo shoreline (figure 8). Because of the rapidity of the flood, Lake Bonneville's transgressive-phase Intermediate shorelines were largely spared significant erosion by lacustrine processes, but some lacustrine fine-grained deposits must have been carried downslope with the falling water level. The Bonneville flood ceased when the water level restabilized at a new threshold, which is believed to have been a bedrock sill (Gilbert, 1890). As soon as the flood re-exposed the upper portions of the piedmont, especially alluvial-fan but also eolian processes began reworking the lacustrine deposits back into the subaerial depositional system.

Lake Bonneville was maintained at the Provo shoreline from approximately 14,500 to 14,200 years ago (Burr and Currey, 1988). A very prominent, well-developed shoreline was formed throughout the Bonneville basin at that level. A distinctive feature of the Provo shoreline in Skull Valley is the presence of what Gilbert (1890) named the underscore, a smaller shoreline just below the main Provo shoreline (figure 11). A topographic profile of the Provo shoreline and the underscore was measured on the Cedar Mountains piedmont just south of a dirt road which crosses erosional segments of those shorelines near the boundary between sections 17 and 20 of T. 6 S., R. 8 W. (figure 12). At that site, the underscore lies approximately 18 feet (5.5 m) below the Provo shoreline. The underscore apparently formed just after the major Provo shoreline. It may be the erosional manifestation of complex threshold dynamics that occurred during Provo shoreline time (Currey and others, 1983; Burr and Currey, 1988).

As depicted in figure 8, Lake Bonneville fell rapidly from the Provo shoreline. This regressive phase of the lake, however, was caused by climate change rather than events at the threshold. The last deep-lake cycle in the Bonneville basin ended between 13,000 and 12,000 years ago, leaving the much smaller Great Salt Lake (Currey, 1990). Great Salt Lake transgressed to the Gilbert shoreline about 10,900 years ago and regressed from it about 10,300 years ago (Currey, 1990). Because the Gilbert shoreline was constructed with a much smaller fetch and is lower on the piedmont than the Lake Bonneville shorelines, it is typically finer, geomorphically less well developed, and more difficult to map than the Stansbury, Bonneville, and Provo shorelines.

Figure 11. Photograph showing erosional segments of the Provo shoreline (P) and underscore (u). Site is located on the piedmont of the southern Cedar Mountains. Topographic profile is shown in figure 12.

Since Gilbert shoreline time, Great Salt Lake has undergone fluctuations of relatively minor amplitude (Currey and others, 1984) leaving Skull Valley subaerially exposed. Without an extensive water body, alluvial-fan, eolian, playa, and spring processes have become re-established as the primary geomorphic processes acting in Skull Valley.

GEOLOGIC HAZARDS

Geologic hazards in Skull Valley consist of debris flows, flash floods, sand and dust storms, rising levels of Great Salt Lake, and seismic hazards. In the early 1980s, debris flows moved down the piedmont of the Stansbury Mountains and crossed Skull Valley Road near Iosepa (figure 2). Deposits containing large boulders that are found on the piedmonts of both the Stansbury and the Cedar Mountains were probably transported by debris flows. The greatest threat from these mass-wasting events exists in the upper and middle piedmont zones of the Stansbury, Onaqui, and Cedar Mountains. The height, steepness, and west-facing aspect of the Stansbury and Onaqui Mountains suggest that they are more susceptible than the Cedar Mountains to debris flows, which are typically triggered by intense thunderstorm precipitation, frontal rain, or rapid snowmelt (Kesseli and Beaty, 1959).

Streamfloods and sheetfloods constitute the main running-water hazards in Skull Valley. Again, the high and steep west-facing slopes of the Stansbury and Onaqui Mountains are more susceptible to this hazard than are other areas in Skull Valley. Summer thunderstorms, intense frontal rain, and rapid snowmelt may cause streamfloods and sheetfloods.

Sand and dust storms can develop within the study area during periods of high winds. The effects are generally local and short-lived but may be serious when the storms impair travel on Interstate 80.

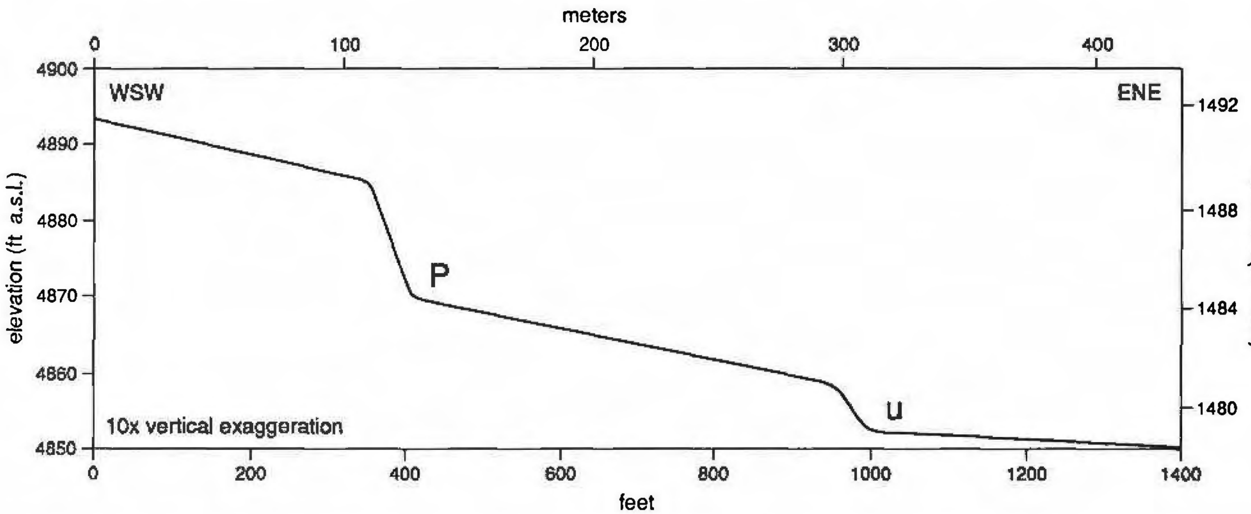

Figure 12. Topographic profile of erosional segments of the Provo shoreline (P) and the underscore (u). Site is located on the piedmont of the southern Cedar Mountains, at sections 17 and 20, T. 6 S., R. 8 W. See figure 11 for photograph of site.

The lowest elevation in Skull Valley, which is approximately 4,214 feet (1,284 m), lies 12 feet (3.6 m) above the historic average level of Great Salt Lake and only 2 feet (0.6 m) above the lake's historic high, which was reached in 1873 and 1986. Although Utah's West Desert Pumping Project was constructed in 1986-87 to prevent Great Salt Lake from reaching such high levels again, a future rapid increase in lake level could occur at a time when the pumps are no longer operative. Under nonengineered conditions a rise in lake level to 4,217 feet (1,285 m), the elevation at which Great Salt Lake naturally spills over thresholds to the Great Salt Lake Desert (Currey and others, 1984), would impact the Western Pacific Railroad line and Interstate 80 in the northeastern part of Skull Valley.

One of the most striking features of the map is the number and orientation of Quaternary fault scarps and lineaments. Although the existence of the Stansbury fault zone has been recognized since the work of Gilbert (1890), many of the faults and lineaments in the study area are depicted for the first time on this map. Four major areas of Quaternary faults and lineaments may be seen: (1) the Stansbury fault zone, (2) the Onaqui fault zone, (3) the Hickman Knolls fault and lineament zone, and (4) the northwest Hickman Knolls lineament zone. In addition, a fault scarp trace lies high on the piedmont of the Cedar Mountains just below the Provo shoreline north of White Rock.

The Stansbury fault generally cuts close to the piedmont junction and displaces Quaternary deposits down to the west. For much of its trace, the main scarp is accompanied by an antithetic scarp lying approximately 66 feet (20 m) to the west, thereby creating a narrow graben (Barnhard and Dodge, 1988). Barnhard and Dodge (1988) identified an area of north-northwest trending en echelon fault scarps down-piedmont from the main fault trace north of Salt Mountain. Air photo interpretation conducted for the present study revealed two additional areas of en echelon faults downslope from the main trace of the Stansbury fault. These lie south of Salt Mountain. According to Barnhard and Dodge (1988) scarps along the Stansbury fault zone range in height from 16.1 to 82.3 feet (4.9 to 25.1 m), representing surface offsets of 9.2 to 82.0 feet (2.8 to 25.0 m). They found regression lines drawn for plots of maximum scarp-slope angle versus log of scarp height to exhibit lower slopes than similar plots drawn for Bonneville shoreline scarps. This suggests that the fault scarps are older than the Bonneville shoreline. From air photo interpretation the trend of the en echelon scarps can be seen running diagonally across Intermediate shorelines and the Bonneville shoreline. Some of the scarps offset Intermediate shorelines whereas others do not, thus providing relative-age relations. From air photo interpretation a couple of small fault scarps, which were not mapped by Barnhard and Dodge (1988), appear to offset the Bonneville shoreline. Fault-scarp traces mapped within areas of Qaf are not necessarily of post-Bonneville age because deposits of active alluvial fans may just be draping pre-existing fault scarps.

Like the Stansbury fault zone, the main fault at the base of the Onaqui Mountains displaces Quaternary deposits down to the west, and lies very close to the piedmont junction. The Onaqui fault zone appears to be a continuation of the Stansbury fault zone.

The north-south-trending Hickman Knolls fault and lineament zone occurs in lacustrine fine-grained deposits on the valley floor, just north of the Hickman Knolls. One of the traces extends through Qla deposits and colluvium in the Hickman Knolls. Scarp height was not measured at this site, but from air photo interpretation it is inferred to be small. The northwest Hickman Knolls lineaments are found about 4 miles (6.4 km) to the northwest of the Hickman Knolls fault and lineament zone. Lineaments at the northwest Hickman Knolls site trend northwest across the lower piedmont of the Cedar Mountains. Age of the features at both localities is unknown.

The widespread occurrence of numerous Quaternary fault scarps throughout Skull Valley reveals the existence of a moderately high degree of seismic hazard. However, a detailed site-specific study of seismic recurrence intervals has not been conducted on Quaternary faults in Skull Valley. The existing hazards related to earthquakes include surface rupture, ground shaking, liquefaction, rockfall, and other earthquake-triggered mass-wasting events.

ECONOMIC GEOLOGY

Gravel is the most important economic resource within the Quaternary deposits of Skull Valley. Qlg, Qla, Qaf, Qafa, and Qafo deposits have the greatest potential gravel resources. Lacustrine gravel of the Provo shoreline is typically the best sorted in the study area. Gravel has already been excavated at several sites, the locations of which are shown on the map. Those gravel pits found in areas mapped as Qlf or Qlm are located in lacustrine gravel deposits that either are not resolvable at the map scale, have been almost completely excavated, or are overlain by the fine-grained sediments. Most of the excavated gravel has probably been used for construction of road and railroad beds in or near Skull Valley.

Sand has been deposited in significant quantities in Skull Valley by lacustrine and especially eolian processes. Although it has not yet been extracted, it could be of potential economic significance to local construction industries.

Calcareous mud (Qld) and white marl (Qlm) may also be viewed as economic resources. The high calcium-carbonate content of these deposits (table 3) may make them useful for agricultural lime.

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Quaternary Geologic Map of Skull Valley, Tooele County, Utah

Description of Map Units

ALLUVIAL DEPOSITS

Qac – UNDIFFERENTIATED ALLUVIUM AND COLLUVIUM (late Pleistocene and Holocene) — poorly sorted, dominantly coarse-grained and angular sediments consisting of alluvium with a significant colluvial component or fluvially reworked colluvium; occurs just below the piedmont junction or adjacent to bedrock outcrops.

Qaf – ACTIVE ALLUVIAL-FAN DEPOSITS (late Pleistocene and Holocene) — poorly sorted, coarse- to fine-grained, stream and debris-flow deposits found on the Skull Valley piedmont above and below the Bonneville shoreline; generally of post-Bonneville shoreline age.

Qafa – ABANDONED ALLUVIAL-FAN DEPOSITS (late Pleistocene) — poorly sorted, fine- to very coarse-grained, angular alluvium and debris-flow deposits found above the Bonneville shoreline in alluvial-fan segments that were abandoned when Lake Bonneville fell from the Bonneville shoreline; abandoned fan segments have been so deeply entrenched by alluvial-fan channels that renewed deposition is extremely unlikely; generally overlain by loess, locally by eolian sand (Qes).

Qafo – INACTIVE ALLUVIAL-FAN DEPOSITS (late Pleistocene) — similar to Qafa in composition, but channel entrenchment is not as deep as on abandoned alluvial-fan segments; inactive alluvial fans were abandoned by regression of Lake Bonneville and by stream course changes due to faulting; active alluvial-fan sedimentation may become re-established on inactive fan segments.

Qal – CHANNEL ALLUVIUM (late Pleistocene and Holocene) — predominantly sand, silt, and clay deposited in and adjacent to ephemeral stream channels in Skull Valley's north-flowing axial stream system; the alluvium is typically reworked fine-grained lake sediments.

EOLIAN DEPOSITS

Qed – EOLIAN DUNE DEPOSITS (late Pleistocene and Holocene) — moderately well-sorted, fine sand generally forming parabolic dunes to less well-sorted sand, silt, and clay found in shrub-coppice dunes and mudflat-bordering lunettes.

Qes – NONDUNAL EOLIAN DEPOSITS (late Pleistocene and Holocene) — sheet-like deposits of moderately well-sorted sand with a distribution in the southern part of the study area reflecting sources west of Dugway, dominant sand transportation to the northeast, and accumulation related to topographic barriers; commonly found as a stacked unit overlying Qaf, Qafa, Qla, Qlg, and B.

LACUSTRINE DEPOSITS

Qla – MIXED LACUSTRINE AND ALLUVIAL DEPOSITS (late Pleistocene and Holocene) — poorly sorted, coarse- to fine-grained sediments consisting of lake-reworked alluvial-fan deposits, lake deposits that have been only moderately reworked by post-lacustrine alluvial-fan processes, and areas where intertonguing alluvial-fan and lake sediments are not resolvable at the map scale; found in the piedmont zone below the Bonneville shoreline; the lake-reworked alluvial-fan deposits consist of pre-Bonneville alluvial fans etched by shorelines of Lake Bonneville and Great Salt Lake.

Qld – LACUSTRINE MUD (late Pleistocene and Holocene) — calcareous sandy mud deposited by Lake Bonneville and Great Salt Lake; kept wet because of shallow depth to ground water.

Qlf – FINE-GRAINED LACUSTRINE DEPOSITS (late Pleistocene and early Holocene) — calcareous sand, silt, and clay deposited by Lake Bonneville and Great Salt Lake; found mainly on the valley floor where it is locally reworked by fluvial and eolian processes.

Qlg – LACUSTRINE GRAVEL (late Pleistocene) — coarse-grained shorezone sediments of Lake Bonneville and Great Salt Lake; forms beaches, barriers, spits, and tombolos; composition varies from poorly sorted, sandy gravel to well-sorted, rounded cobbles; typically overlain by up to several inches of eolian sandy silt.

Qll – LAGOON DEPOSITS (late Pleistocene) — predominantly silt, but also sand and clay deposited landward of Lake Bonneville barriers and tombolos ranging in age from Stansbury through Provo shoreline time; includes subaerial deposits washed or blown onto the lacustrine lagoon deposits.

Qlm – WHITE MARL (late Pleistocene) — white to light gray, highly calcareous, laminated silt; includes Gilbert's (1890) white marl, slightly older and sandier transgressive marl, and slightly younger reworked white marl; contains ostracodes and gastropods.

Qls – LACUSTRINE SAND (late Pleistocene) — poorly to moderately sorted, medium to pebbly sand; gastropod shells are locally common; consists of nearshore to offshore deposits of Lake Bonneville; especially common within 200 feet (61 m) below the Provo shoreline; locally reworked by the wind.

SPRING DEPOSITS

Qsm – MARSH DEPOSITS (Holocene) — fine-grained, organic-rich, calcareous, and saline deposits associated with flowing springs.

BEDROCK

UNDIFFERENTIATED BEDROCK WITHIN AND IMMEDIATELY ADJACENT TO THE STUDY AREA (pre-Quaternary) — denotes outcrops of Paleozoic sedimentary rocks and Tertiary sedimentary and igneous rocks within the study area: emphasizes contact between piedmont Quaternary deposits within and mountain-block bedrock just beyond the study area at the piedmont junction.