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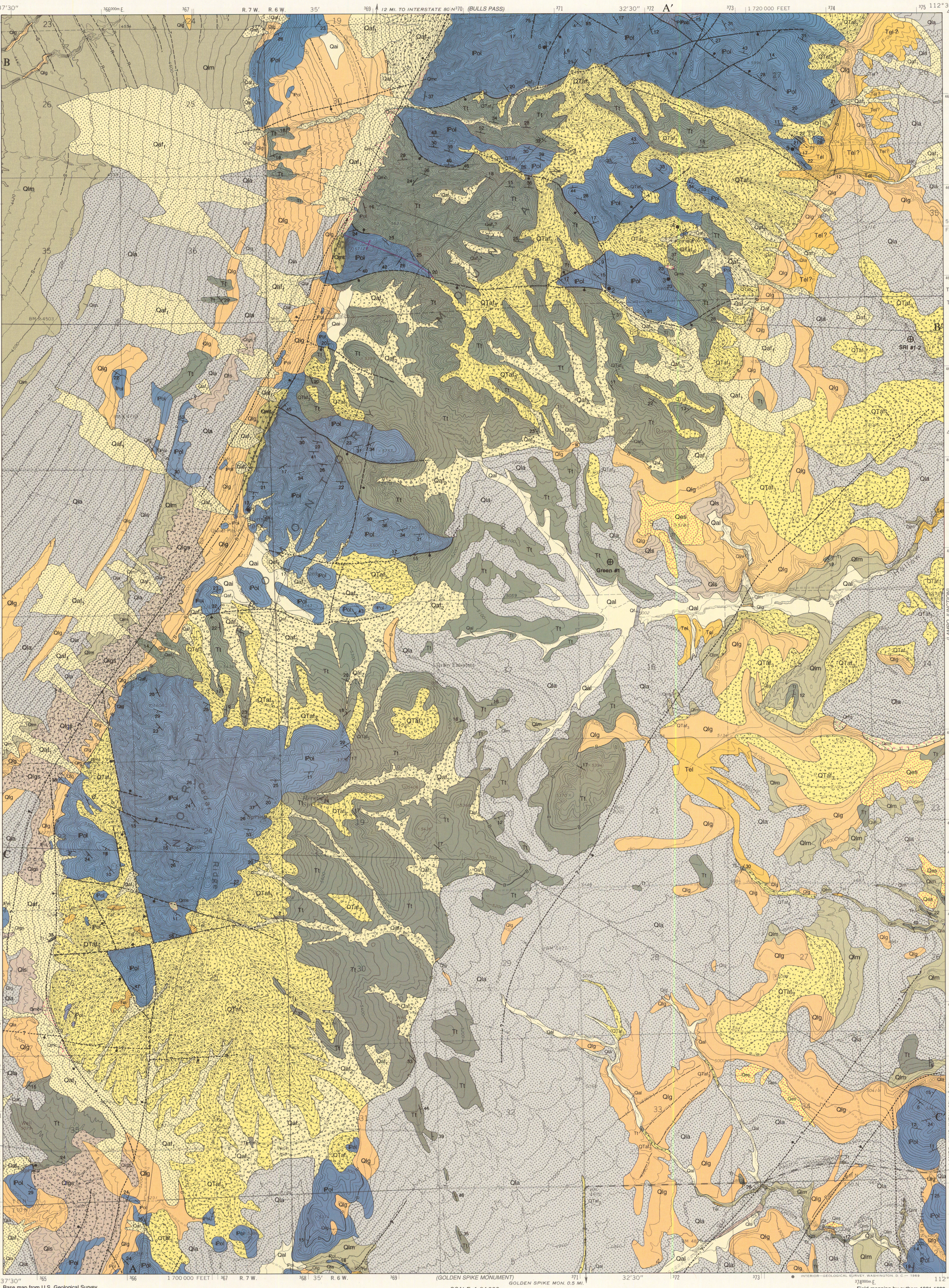

Base map from U.S. Geological Survey,
Sunset Pass Quadrangle, 1968.

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

Field mapping by authors 1981-1990.
Patricia H. Speranza, Cartographer.

1994 MAGNETIC NORTH DECLINATION AT CENTER OF MAP

QUADRANGLE LOCATION

GEOLOGIC MAP OF THE SUNSET PASS QUADRANGLE, BOX ELDER COUNTY, UTAH

by

David M. Miller and Joel D. Schneyer
U.S. Geological Survey

1994

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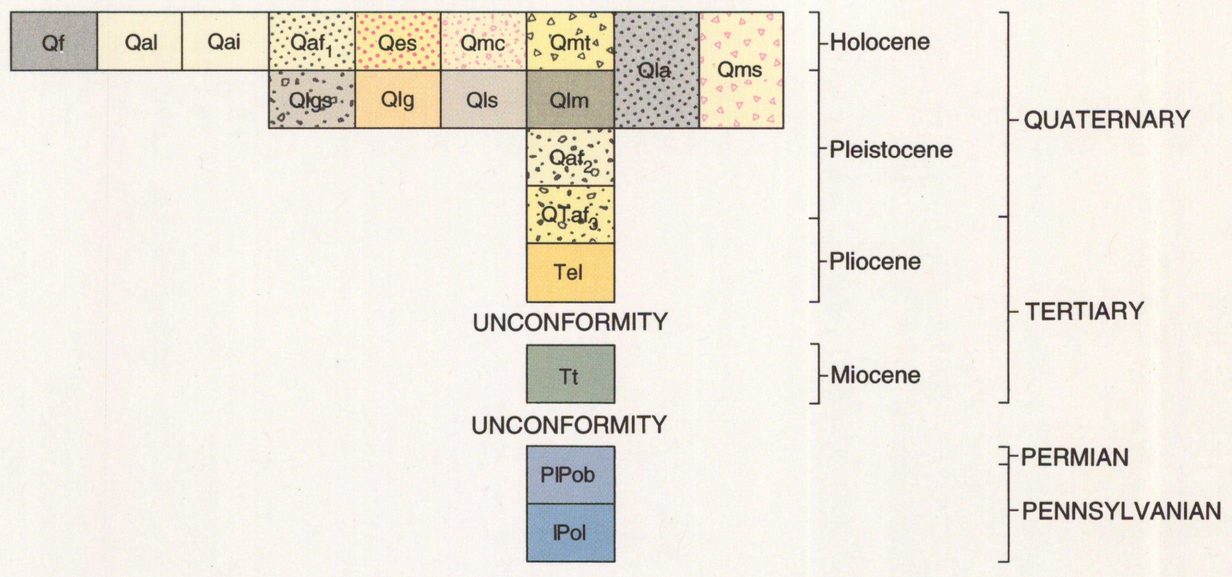
CORRELATION OF MAP UNITS



MAP SYMBOLS

- CONTACT - Dashed where gradational, dotted where covered
- HIGH- OR MODERATE-ANGLE FAULT - Dashed where location inferred, dotted where covered, queried where uncertain; bar and ball on downthrown side; dip indicated; T toward (cross section only)
- BOUNDARY OF SLIDE BLOCK - Dotted where concealed
- ORIENTATION OF BEDDING
- LOCATION OF PALEONTOLOGICAL SAMPLE
- BONNEVILLE SHORELINE
- PROVO SHORELINE
- STANSBURY SHORELINE
- REGRESSIVE SHORELINE
- TRANSGRESSIVE SHORELINE
- INTERMEDIATE SHORELINE
- ANTICLINE
- SRI #1-2 LOCATION OF BOREHOLE
- CONGLOMERATE BEDS (cross section only)

DESCRIPTION OF MAP UNITS

Qf Fill--*Earthen material used to construct railroad grades and dams.*

Qal Alluvium (Holocene)--*Poorly sorted gravel, sand, silt, and clay in ephemeral and perennial stream channels.*

Qai Alluvial silt (Holocene)--*Dark-brown silt and sand formed as ponded deposits behind undissected lacustrine bars of Lake Bonneville, after water withdrawal; overlies similar deposits that formed in lagoons.*

Qaf1 Alluvial-fan deposits (Holocene)--*Poorly sorted gravel, sand, silt, and clay forming fans and terraces. Youngest of the alluvial-fan deposits.*

Qes Eolian sand (Holocene)--*Medium-brown sand in dunes and sheets. Appears to be derived from nearby lacustrine sand deposits.*

Qmc Mass-movement colluvium (Holocene)--*Slope wash forming vegetated moderate-gradient slopes beneath cliffs and talus.*

Qmt Mass-movement talus (Holocene)--*Blocky debris forming sparsely vegetated steep slopes below cliffs; most common near Lake Bonneville shoreline.*

Qla Lacustrine and alluvial deposits, undivided (Holocene and Pleistocene)--*Poorly sorted alluvial deposits partly reworked by shoreline processes, patches of lacustrine fine sediments, local alluvium covering lacustrine deposits, and marly sand of mixed alluvial and lacustrine origin.*

Qms Mass-movement slides (Holocene and Pleistocene)--*Slumped coherent masses of material and coherent slide blocks. Hachures indicate headwall scarp.*

Qlgs Lacustrine gravel and sand (Pleistocene)--*Well-sorted gravel and sand. Commonly underlies slopes below beach complexes of lacustrine gravel (Qlg) along west side of North Promontory Mountains.*

Qlg Lacustrine gravel (Pleistocene)--*Cobble and pebble gravel with silt matrix. Forms bars and benches.*

Qls Lacustrine sand (Pleistocene)--*Brown, well-sorted sand. Thickest deposits are below Provo shoreline.*

Qlm Lacustrine marl (Pleistocene)--*White to pale-brown, laminated marl with dropstones. Locally includes sand beds and gravel lenses. Deposited by Lake Bonneville. Lower part of unit shows convolute lamination and roll structures in many exposures.*

Qaf2 Alluvial-fan deposits (Pleistocene)--*Partly consolidated, poorly sorted gravel, sand, and silt forming moderately dissected fans and terraces. Deposits cut by shorelines of Lake Bonneville.*

QTaf3 Alluvial-fan deposits (Pleistocene and Pliocene)--*Moderately consolidated to caliche-cemented, poorly sorted deposits of boulders, cobbles, and pebbles forming highly dissected fans and terraces.*

Tel Eolian loess and alluvial gravel (Pliocene)--*Moderately consolidated red loess and alluvium. Loess in locally thick accumulations; fine sand and silt sized; thin to thick bedded; source unknown. Alluvium is well bedded; clasts are rounded to subangular quartzite, limestone, shale, and siltstone.*

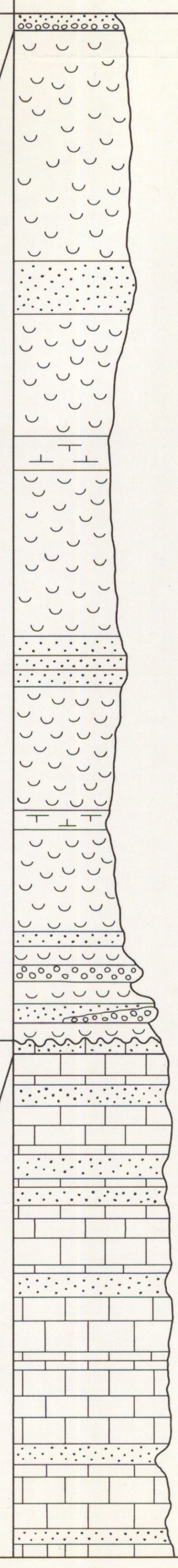
Tt Sedimentary rocks and tuff (Miocene)--*Moderately consolidated, gray to brown air-fall tuff and tuffaceous rock redeposited in fluvial and lacustrine environments, and conglomerate and sandstone. Air-fall tuff is mainly glass shards, locally with feldspar and pumice. Redeposited tuff, generally sand and silt sized, contains varying amounts of lithic fragments, and is size sorted and bedded; interbedded with sand, silt, and marl containing little tuff. Conglomerate and coarse sand beds typically at base of section near underlying Paleozoic bedrock.*

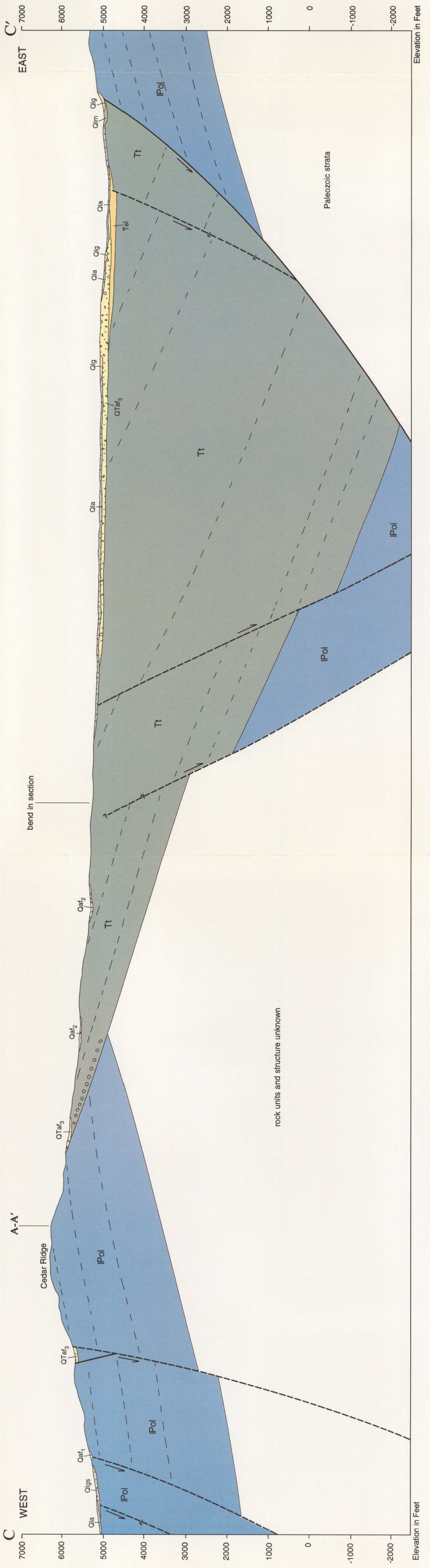
Oquirrh Formation (Permian and Pennsylvanian)--Divided into:

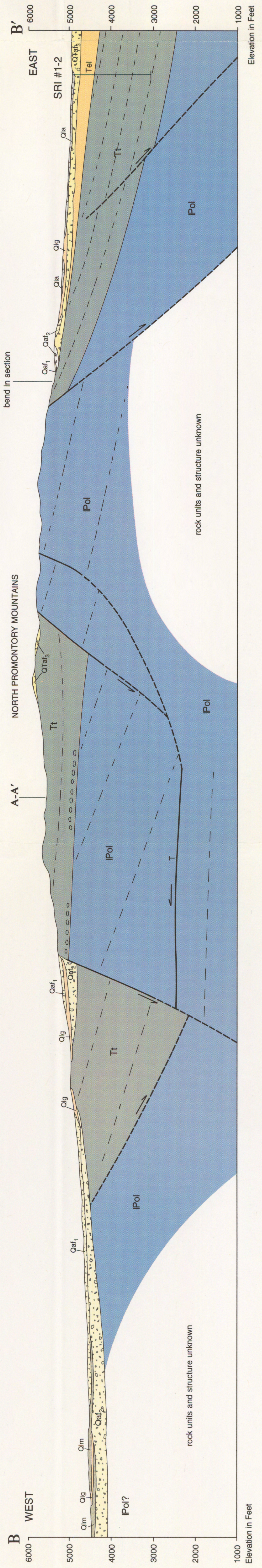
PIPob Bioturbated limestone member (Lower Permian and Upper Pennsylvanian)--*Light-medium-gray, silty and sandy clastic limestone and brown, calcareous very fine-grained quartz sandstone. Bioturbated beds and laminated beds are interbedded on medium scale.*

IPol Limestone member (Upper and Middle Pennsylvanian)--*Light- to medium-gray clastic limestone and minor brown quartz sandstone. Thick to medium bedded, fossiliferous, and locally cherty.*

FORMATION	MEMBER	SYMBOL	THICKNESS feet (meters)	LITHOLOGY
Eolian loess and alluvial gravel		Tel	100 (30)	
Sedimentary rocks and tuff		Tt	7900 (2400)	
Oquirrh Formation	Bioturbated limestone member	PIPob	100 (30)	
	Limestone member	IPol	3940 (1200)	



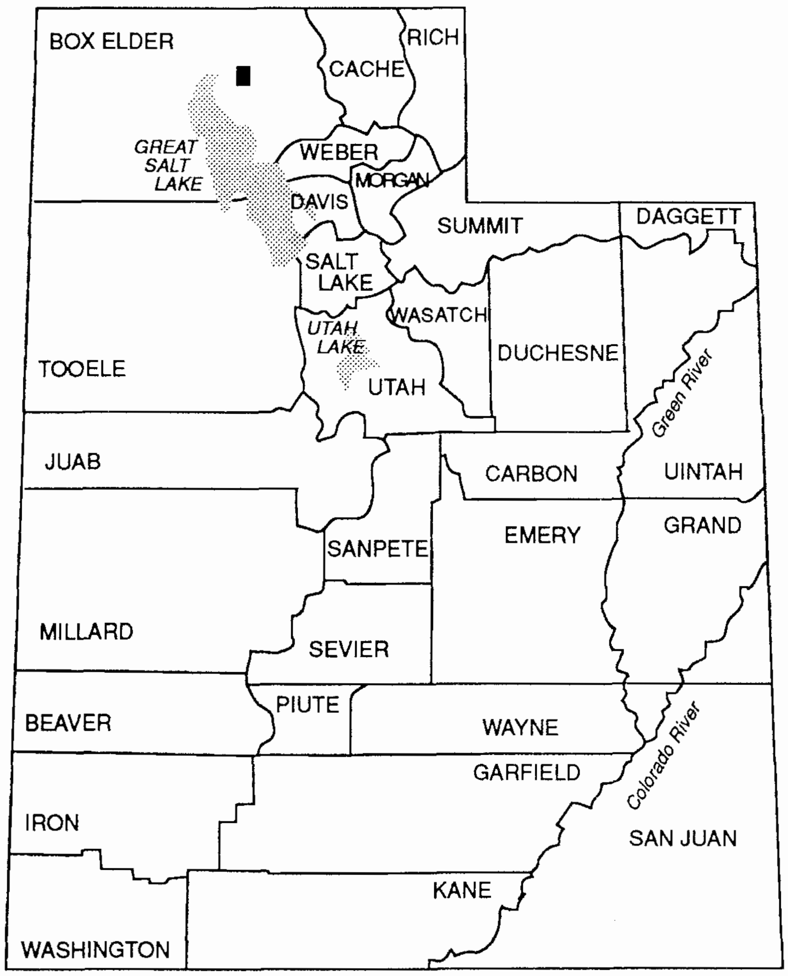




Miller, Schneyer
GEOLOGIC MAP OF THE SUNSET PASS QUADRANGLE, BOX ELDER COUNTY, UTAH
UTAH GEOLOGICAL SURVEY MAP 154

GEOLOGIC MAP OF THE SUNSET PASS QUADRANGLE, BOX ELDER COUNTY, UTAH

by
David M. Miller and Joel D. Schneyer
U.S. Geological Survey – Menlo Park, California



MAP 154 **1994**
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UTAH CENTENNIAL 1896-1996
TAKE Pride IN UTAH

GEOLOGIC MAP OF THE SUNSET PASS QUADRANGLE, BOX ELDER COUNTY, UTAH

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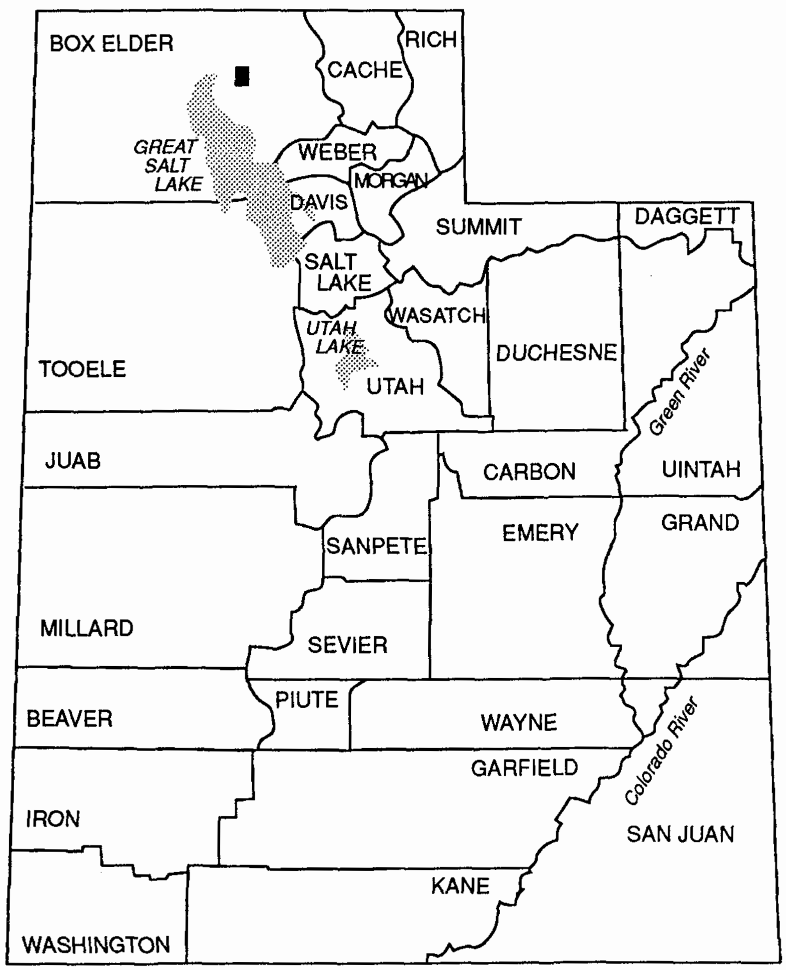

MAP 154 **1994**
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GEOLOGIC MAP OF THE SUNSET PASS QUADRANGLE, BOX ELDER COUNTY, UTAH

by
David M. Miller and Joel D. Schneyer
U.S. Geological Survey - Menlo Park, California

ABSTRACT

The Sunset Pass quadrangle, north of Great Salt Lake, is centered on the southern end of the North Promontory Mountains. The mountains are underlain by Pennsylvanian and Permian rocks of the Oquirrh Formation and by Miocene volcanogenic strata. Adjacent upland plains and valleys on the east are underlain by a thin Pliocene sequence of loess and alluvium, which in turn overlies tilted and eroded Miocene strata deposited in a deep basin. Hansel Valley on the west is underlain by Pennsylvanian, Permian, and Miocene strata similar to those in the North Promontory Mountains. Most faults in the quadrangle are normal faults that accommodated growth of Miocene basins. Alluvial, lacustrine, eolian, and mass-movement deposits of late Pleistocene and Holocene age overlie the faulted older units. In addition to lacustrine deposits of late Pleistocene Lake Bonneville, widespread shorelines attest to its presence. The regionally known Stansbury, Provo, and Bonneville shorelines are well represented, as are numerous locally prominent shorelines.

INTRODUCTION

The Sunset Pass quadrangle is located in northwestern Utah, about 48 kilometers (29 mi) west of Brigham City. Its southern part is traversed by a highway that leads to Golden Spike National Historic Site headquarters. Much of the National Historic Site lies within the southern part of the quadrangle. The quadrangle is sparsely populated.

The southern part of the North Promontory Mountains traverses the Sunset Pass quadrangle from the southwest to the northeast. Their crest reaches 1,932 meters (6,339 ft) altitude. The Promontory Mountains and their extension, Engineer Mountain, continue from south of to east of the quadrangle, passing through the southeastern corner (figure 1). Stretching between these mountains and the North Promontory Mountains are broad upland plains of roughly 1,448 to 1,737 meters (4,750 to 5,700 ft) altitude. West of the North Promontory Mountains, along the west side of the quadrangle, lies the eastern part of Hansel Valley. The lowest point in the quadrangle, about 1,341 meters (4,400 ft), lies in Hansel Valley. Much land of the upland plains and Hansel Valley is fertile and farmed intensively, whereas mountainous parts are rocky and used mainly for grazing.

Our geologic mapping began as part of a tectonic synthesis of the region from the thrust belt in the Wasatch Range westward to the belt of metamorphic terranes near the western border of Utah. The North Promontory Mountains and adjacent land previously was mapped only in reconnaissance (Adams, 1962; Doelling, 1980). Recently, detailed geologic maps of adjoining quadrangles (Jordan, 1985; Jordan and others, 1988a; Miller and others, 1991) have been published (figure 1), and comprehensive reconnaissance maps by Robison and McCalpin (1987) and Crittenden (1988) depicted the geology of parts of the Sunset Pass region.

GEOLOGIC SETTING

The Sunset Pass quadrangle is located within the eastern Cordilleran miogeocline, just west of the hingeline with the craton. The Paleozoic miogeoclinal strata are generally carbonate rocks, with minor quartzite and shale. The oldest rocks exposed in the Sunset Pass quadrangle—the Oquirrh Formation—were deposited in the Middle Pennsylvanian to Early Permian Oquirrh basin, which was typified by more siliciclastic sedimentation than is noted for older rocks. Jordan (1985) and Jordan and Douglass (1980) delineated rapid thickness changes at the margin of the Oquirrh basin, about 16 kilometers (10 mi) east of the Sunset Pass quadrangle.

The Sunset Pass area occupied a transitional position between the hinterland and the fold and thrust belt structural provinces of the Cordilleran thrust belt during Mesozoic and early Cenozoic time (Allmendinger and others, 1984). The exposed Paleozoic strata lie within the hanging wall of the Willard and Absaroka thrusts (Crittenden, 1972, 1982, 1988; Royse and others, 1975) and also lie 5 to 10 kilometers (3-6 mi) west of smaller thrust faults in the Blue Spring Hills (Jordan and others, 1988b; Miller and others, 1991). Granitoid plutons, regional metamorphism, and bedding-plane faulting of the hinterland mainly are exposed about 100 kilometers (60 mi) west of Sunset Pass (Allmendinger and others, 1984).

The Sunset Pass area also lies within the Basin and Range Province, which is characterized by north-trending block-faulted mountain ranges separated by broad valleys containing Cenozoic sedimentary and volcanic deposits. Major normal faults bound the east side of Cache Valley and the Wasatch Front, 50 kilometers (30 mi) or more to the east of the Sunset Pass quadrangle, and mark the eastern margin of the Basin and Range Province. The North Promontory Mountains lie about four major fault blocks west from the Wasatch Front, and, therefore, lie in the hanging wall of the Wasatch fault zone, a major, active, moderate- to low-angle normal fault system (Smith and Bruhn, 1984). Miocene strata at Sunset Pass record basin development and volcanism accompanying the extensional tectonism. The youngest Tertiary deposits are Pliocene loess and alluvium that once formed an extensive piedmont that has been slightly disrupted by extensional tectonics.

The present physiographic form of the Sunset Pass area was established by Pleistocene time. Alluvium deposited along the flanks of the North Promon-

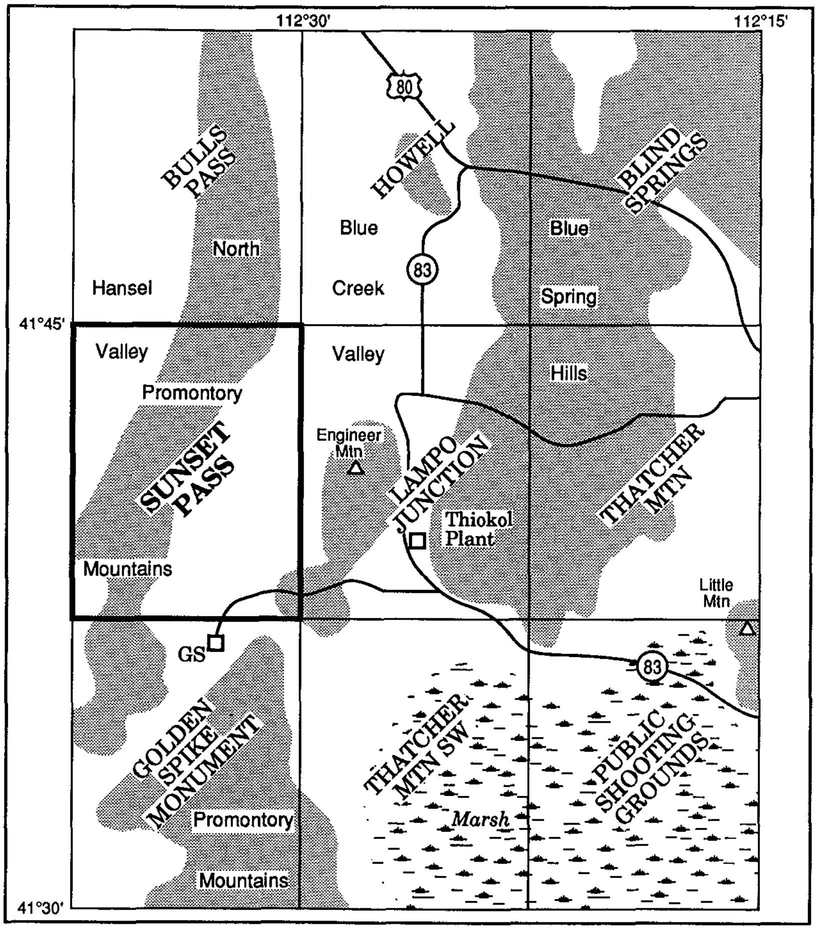

Figure 1. *Index to topographic quadrangles and major physiographic features of the Sunset Pass area. GS = Golden Spike National Historic Site headquarters. Quadrangles published as geologic maps are: Bulls Pass (Jordan, 1985), Howell (Jordan and others, 1988a), Thatcher Mountain (Jordan and others, 1988b), and Lampo Junction (Miller and others, 1991).*

tory Mountains formed extensive piedmonts. Huge lakes, including Pleistocene Lake Bonneville, episodically inundated the lowland parts of the quadrangle. These lakes blanketed much of the lowland with sediment, and their waves eroded benches into hills and constructed wide bars and other shoreline features.

STRATIGRAPHY

Paleozoic strata exposed in the Sunset Pass quadrangle belong to the Oquirrh Formation and were deposited in the shelf region near the northeast margin of the Oquirrh basin (Jordan and Douglass, 1980). Underlying miogeoclinal strata as old as Silurian were intersected by a drill hole 3 kilometers (2 mi) east of the quadrangle at Engineer Mountain (Miller and others, 1991), but none have been encountered in the Sunset Pass quadrangle. Cenozoic deposits, exposed widely in the quadrangle, include Miocene tuffaceous sediments, Pliocene loess and alluvium, and varied Quaternary lacustrine, alluvial, eolian, and mass-movement deposits.

Pennsylvanian and Permian

Oquirrh Formation

The Oquirrh Formation is the most widespread Paleozoic unit in Box Elder County, cropping out north of Great Salt Lake and exceeding 3,000 meters (10,000 ft) thickness in this area. At the type section of the Oquirrh Group in the Oquirrh Mountains, Tooker and Roberts (1970) divided the group into several formations. In the Sunset Pass quadrangle and nearby areas (Jordan, 1985; Jordan and others, 1988a; Miller and others, 1991), most of these formations have not been recognized, and the Oquirrh is designated as a formation that is divided into informal members (Jordan and others, 1988a, and references therein). Only the lowest two members of the Oquirrh Formation crop out at Sunset Pass: (ascending) limestone member and bioturbated limestone member.

Limestone member: The limestone member (Pol) underlies light-colored slopes within the North Promontory Mountains and the northern Promontory Mountains. Fine- to medium-grained calcarenite predominates, but quartzose (and less commonly, arkosic) sand is intermixed with lime sand locally, and in places forms calcareous sandstone beds. Coarsely bioclastic beds are common; they contain crinoid debris, bryozoans, fusulinids, corals, gastropods, and brachiopods. Cross-lamination is present locally. Chert-nodule limestone is common; the chert may be a diagenetic product of quartz sand. An arkosic upper part of the limestone member, greater than 100 meters (330 ft) thick, crops out on Cedar Ridge. The uppermost 50 meters (165 ft) of the limestone member near the north edge of the quadrangle consists of medium-thick, laminated beds of alternating siliciclastic and clastic carbonate rocks, with a few bioclastic beds. The alternating beds impart a striped aspect to the ridges.

The limestone member has no exposed base in the quadrangle, so no complete section is known. Moreover, it is poorly exposed and in many places could be cut by unrecognized faults. Its thickness, estimated from section AA', is greater than 915 meters (3,000 ft). The unit must be at least 915 meters (3,000 ft) thick to the east at Engineer Mountain (Miller and others, 1991) and was estimated as greater than 1,200 meters (3,940 ft) thick in the adjacent Bulls Pass quadrangle to the north (Jordan, 1985).

The limestone member lithologically resembles the Lower Pennsylvanian (Morrowan) West Canyon Limestone of the Oquirrh Mountains (Tooker and Roberts, 1970), which is the lowest formation of the Oquirrh Group. However, foraminifers (table 1, numbers 1-6) collected in the Sunset Pass quadrangle support a Late Pennsylvanian age for the limestone member. In the Bulls Pass quadrangle to the north, Jordan (1985) documented a Middle and Late Pennsylvanian age for the limestone member. Conodonts, corals, and bryozoans collected in the Blue Spring Hills to the east support an Early or Middle Pennsylvanian age for the limestone member. On the basis of faunal collections in the Sunset Pass quadrangle and contiguous rocks in the Bulls Pass quadrangle, we consider the age of the limestone member in the North Promontory Mountains to be Middle and Late Pennsylvanian. In the absence of Early Pennsylvanian fauna in the North Promontory Mountains, we suggest that either rocks of similar appearance in the Blue Springs Hills are a time-transgressive extension of those in the North Promontory Mountains, or that an early Pennsylvanian lower part of the member, unexposed and (or) undated as yet, is present in the North Promotory Mountains.

Bioturbated limestone member: The bioturbated limestone member (PIPob) underlies a small part of the North Promontory Mountains at the north edge of the quadrangle. It consists of arenite containing quartz, feldspar, and calcite grains. Beds are commonly burrowed, and non-burrowed beds show parallel- or cross-lamination. A thickness of about 30 meters (100 ft) of the member is exposed in the quadrangle; where complete in the adjacent Bulls Pass quadrangle, the member is 20 to 150 meters (66 to 490 ft) thick (Jordan, 1985).

No fossils were recovered from the bioturbated limestone member in the Sunset Pass quadrangle, but Late Pennsylvanian fossils were reported from the member in the Bulls Pass quadrangle (Jordan, 1985), and Late Pennsylvanian and Early Permian fossils were reported from the member in the Lampo Junction quadrangle (Miller and others, 1991). We consider the member to be Late Pennsylvanian and Early Permian in age in the Sunset Pass quadrangle. Strata of this age in the Oquirrh Group, in the Oquirrh Mountains, differ lithologically from those in the Sunset Pass quadrangle, precluding use of terminology established for the Oquirrh Group.

Tertiary

Sedimentary Rocks and Tuff

Fine-grained sedimentary deposits and associated volcanic tuff (Tt) underlie much of the Sunset Pass quadrangle. Outcrops typically are subdued in expression, as the unit is non-resistant. The unit overlies the Oquirrh Formation and is overlain by a Pliocene loess and alluvial gravel unit, and younger deposits, in several places.

The sedimentary rocks and tuff unit consists of several lithologic types, most of them medium to thin bedded. Chief among these is silty and sandy vitric tuff that in most cases was redeposited by water in fluvial and lacustrine conditions. Lacustrine beds range from marl to calcareous sand. Calcareous sand consists of well-sorted, very fine-grained, calcite-cemented beds of tuff, clay, redeposited minerals derived from tuff, and iron oxide cement. Other rock types include: coarse-grained, moderately sorted, cross-bedded, laminated, or massive vitric rhyolite tuff probably deposited directly by air fall and ash flow; coarse conglomerate and sedimentary breccia; thick, featureless beds of pebbly brown mudstone to sandstone composed chiefly of tuff, but containing abundant scattered limestone pebbles, possibly deposited by mud flows; lacustrine marl; and siltstone and fine-grained sandstone of probable fluvial origin. Eolian sand is present near Sand Hollow. Nearly all lithologic types are tuffaceous, reddish brown to gray, and moderately indurated. Less reworked beds contain trace amounts of biotite, feldspar, pyroxene, magnetite, and hornblende, and are typically white to light gray in color. Most glass shards in these beds are clear but with brown rims; less common are brown glass shards. Lithic fragments of flow-banded rhyolite are present, but rare, in tuff.

Thick conglomerate sequences, sedimentary breccia, and pebbly beds are widespread near the base of the unit; these beds primarily contain locally derived clasts from the Oquirrh Formation. Sparse data from the orientations of fluvial crossbeds, pebble imbrication, and vertical to overhanging channel banks indicate mainly east-directed currents in these coarse strata, although northeast- and north-directed currents were also measured.

At three areas in the central and south-central part of the quadrangle (all in T. 11 N., R. 6 W.), Miocene strata are strongly cemented, more resistant to erosion, and underlie higher topographic features than typical. Lithic-rich tuff and coarse sandstone are cemented by calcite in section 9. Marl, sandstone, and conglomerate beds in sections 31 and 32, and farther south, were cemented by chalcedony and opaline material and by calcite. For these two areas, silicification and calcification seem to be bedding controlled, and the replacement of originally deposited materials may have been caused by hydrothermal(?) alteration associated with emplacement of volcanic-ash deposits. However, adjacent tuff is not obviously of air-fall or ash-flow origin, so the alteration alternatively may have resulted from hydrothermal fluids. Hills northeast of the county road in sections 17, 20, and 21 are underlain by silicified tuffaceous rocks containing chalcedony and opaline material. In this area, alteration appears to cut across bedding. Although many of the altered rocks in the three areas described are green in color, no zeolite minerals have been identified in the one sample

Table 1. Paleontologic data for the Sunset Pass quadrangle.

Map no.	Field (USGS) no.	Rock unit	Fossil age	Date of report	Paleontologist	Faunal description	Latitude	Longitude
1	J282 (f14491)	Oquirrh Formation	Late Pennsyl-vanian	5/6/82	R.C. Douglass	Grainstone with rounded and algal-coated grains. The fusulinids are also broken, abraded, rounded and coated. TRITICITES sp. PSEUDOFUSULINELLA sp.	41°42'03"	112°35'32"
2	J394 (f14492)	Oquirrh Formation	Late Pennsyl-vanian	5/6/82	R.C. Douglass	Calcareous grainstone with many components well rounded but some quite angular; no algal coatings. The fusulinids are not badly abraded and are not rounded. staffellid undet. TRITICITES sp. aff. T. PYGMAEUS Dunbar and Condra	41°43'23"	112°32'40"
3	J407 (f14493)	Oquirrh Formation	Late Pennsyl-vanian	5/6/82	R.C. Douglass	Calcareous sandstone with abundant larger, mostly angular clasts and scattered abraded fusulinids. TRITICITES sp.	41°43'26"	112°32'10"
4	J410 (f14494)	Oquirrh Formation	Late Pennsyl-vanian	5/6/82	R.C. Douglass	Sandy grainstone with angular clasts and some sparry matrix. Fusulinids are fragmental and abraded. TRITICITES sp.	41°43'43"	112°32'05"
5	J418 (f14495)	Oquirrh Formation	Late Pennsyl-vanian	5/6/82	R.C. Douglass	Calcareous sandstone with scattered fusulinids. EOWAERINGELLA sp. A Missourian age is suggested.	41°44'18"	112°31'11"
6	J425 (f14496)	Oquirrh Formation	Late Pennsyl-vanian	5/6/82	R.C. Douglass	Calcareous grainstone with rounded detrital fragments including fusulinids. staffellids undet. PSEUDOFUSULINELLA? sp. TRITICITES sp	41°44'48"	112°33'08"

studied by x-ray methods (D.W. Fiesinger, 1991, written communication).

The thickness of the sedimentary rocks and tuff unit varies. The top of the unit is an angular unconformity, so its original thickness is unknown. The thickness of the unit in small basins exposed within the North Promontory Mountains is generally less than 600 meters (1,970 ft), but it is much thicker in the Sand Hollow basin (figure 2) in the east-central part of the quadrangle. There, estimates of low-density fill based on gravity data of Cook and others (1989) suggest a basin about 2,100 meters (7,000 ft) deep (section CC') and a stratigraphic thickness of at least 2,400 meters (7,900 ft). Two boreholes (SRI #1-2 and Green #1) penetrated nearly 610 meters (2,000 ft) of tuffaceous sediments in the northern part of Sand Hollow basin.

The age of the sedimentary rocks and tuff unit is constrained as Miocene by preliminary K-Ar ages, by the age of overlying loess, and by regional correlations. K-Ar ages on glass separated from tuffaceous beds yielded 18.2 $\pm$0.46 and 17.1 $\pm$0.43 Ma ages low in the section, 14.6 $\pm$ 0.4 Ma in the middle of the section, and 9.6 $\pm$ 0.24 Ma near the top (Miller and others, 1992). Phenocrysts are rare, but for two samples they yield similar ages to those determined for matrix glass, verifying the general approach of dating glass. Plagioclase in the mid-section sample yielded 13.5 $\pm$ 6.2 Ma by the $^{40}Ar/^{39}Ar$ method, and plagioclase in the sample near the top of section yielded an 11.6 $\pm$ 0.4 Ma age. These K-Ar ages confirm a Miocene age for the unit. In several parts of northern Utah, Eocene strata underlie Miocene deposits (Miller, 1990), but no evidence for Eocene strata exists in the Sunset Pass quadrangle because (1) no lithic breaks are present and (2) glass K-Ar ages from samples close to the basal unconformity are Miocene in age. Discordantly overlying loess contains ash and fossils in its upper part, both of which are earliest Pliocene in age (Nelson and Miller, 1990). The sedimentary rocks and tuff unit is therefore older than Pliocene and probably entirely Miocene in age, on the basis of local evidence.

Regional evidence is in accord with local ages. Tuff and limestone in the Howell quadrangle to the north were assigned to the Salt Lake Group by Jordan and others (1988a) and considered to be Miocene or Pliocene in age. A similar tuffaceous unit at Wellsville Mountain (48 kilometers [30 mi] east) was considered to be late Tertiary in age by Oviatt (1986). Similar vitric tuff deposits west of the Sunset Pass area have well-established ages. In the Raft River Valley of southern Idaho, Williams and others (1982) demonstrated a late Miocene age for a tuffaceous sequence, which is overlain by a less tuffaceous Pliocene interval. Similar rocks are unconformably overlain by approximately 7 million-year-old basalt about 66 kilometers (40 mi) west of Sunset Pass (D.W. Fiesinger, 1991, written communication). At the Nevada-Utah border, a similar sequence includes a roughly 13 million-year-old welded ash flow and is capped by volcanic flows dated at 8.8 Ma (Miller, 1986). Using a geochemical study of vitric ashes, Smith (1975) and Smith and Nash (1977) suggested that ashes of the Salt Lake Group across northern Utah broadly correlate, but that younger ashes are present to the east.

Eolian Loess and Alluvial Gravel

Loess and alluvium (Tel) crop out in gullies in and north of Sand Hollow, in the northeastern part of the quadrangle, and in widely scattered places elsewhere in the quadrangle. The unit is composed mainly of red and reddish-brown loess and interbedded red and brown gravel, sand, and silt. The unit also contains minor lacustrine beds, white rhyolitic ash, and black basaltic ash. Loess is thick bedded to massive in exposures in the northeast part of the quadrangle. It primarily consists of iron oxide-coated calcite, clay, and volcanic mineral fragments. Loess contains only minor volcanic ash near Sand Hollow, but ash is more abundant in exposures farther west. In the Sand Hollow exposures, coarse alluvial and fluvial beds fine eastward, and cross-bedding and pebble imbrication indicate east-directed currents. Clasts in these exposures are exotic with respect to the North Promontory Mountains and appear to be derived from a slightly metamorphosed Late Proterozoic quartzite assemblage, a red-bed sequence, and Tertiary(?) calcareous siltstone. Clasts in the unit at the northeastern extreme of the North Promontory Mountains in the quadrangle, however, are locally derived from the Oquirrh Formation. Coarse materials probably were deposited by debris flows and streams, and as colluvium. Locally thick accumulations of fine sand- and silt-sized loess are associated with colluvium and thin lacustrine (pond?) and tuff beds. At least three highly calcified soil profiles were developed within the massive beds of loess, suggesting considerable time for loess accumulation. The unit is greater than 30 meters (100 ft) thick in the northeastern part of the quadrangle and may be thicker at the south side of Cedar Ridge. Generally, the base and top of the unit are not well exposed. The loess and alluvium dip more steeply east than overlying alluvium, but not as steeply as underlying Miocene strata.

Age information currently available indicates that the loess and alluvial gravel unit is Pliocene in age, but the unit may include upper Miocene rocks near its base. A fossil bone collected in colluvium interbedded with the upper(?) part of the loess deposits in Sand Hollow was identified as a mandible from an extinct marmot, *Paenemarmota sawrockensis*, and is considered to be earliest Pliocene (earliest Blancan) in age (Nelson and Miller, 1990). Rhyolite ash about 1 meter (3 ft) stratigraphically above the fossil is chemically similar to ash derived from the eastern Snake River Plain and Yellowstone caldera system, and preliminary chemical correlation suggests that it is lithologically equivalent to the Alturas ash bed estimated to be 4.8 million years old (A. Sarna-Wojcicki, U.S. Geological Survey, 1988, written communiccation).

Unconsolidated Deposits

Quaternary and latest Tertiary unconsolidated deposits in the Sunset Pass quadrangle are primarily alluvial and lacustrine. The oldest deposits are alluvial-fan deposits formed in valleys incised into bedrock of the North Promontory Mountains and in piedmonts across flanking Tertiary deposits. Intermediate-age fans were deposited on and adjacent to the oldest fans. Both sets of alluvial-fan deposits were reworked in Lake Bonneville and overlapped by its sediments but are preserved locally above the lake's highstand. Lake Bonneville, a late Pleistocene (about 32,000 to 10,000 years old) lake that inundated much of northern Utah, covered about 60 percent of the quadrangle, drowning all but the North Promontory Mountains (Gilbert, 1890). After its withdrawal, the lake left shorelines and varied deposits. Local deposits of alluvium, eolian sand, colluvium, and talus postdate the withdrawal of the lake.

Tertiary and Quaternary

Alluvial-Fan Deposits

The oldest alluvial-fan deposits ($QTaf_3$) consist of white cobble and boulder conglomerate and gravel derived from the Oquirrh Formation. These deposits underlie broad, rolling piedmonts that have in many places been modified by Lake Bonneville shore processes. Rarely, pebbly massive silt, possibly of debris-flow origin, is interbedded with gravel. The piedmonts are extensive in the central and eastern parts of the quadrangle and locally in the North Promontory Mountains. Because of reworking by lacustrine processes, the unit is difficult to distinguish (in many places) from lacustrine gravel (Qlg).

Piedmonts underlain by the gently dipping alluvial-fan deposits comprise much of the quadrangle. They were dissected prior to deposition of sediments by Lake Bonneville. The piedmonts rise gradually from about 1,494 meters (4,900 ft) at the east edge of the quadrangle westward to 1,890 meters (6,200 ft) in the North Promontory Mountains. The piedmonts seem to describe a broad, east-sloping surface that overlapped the foothills, and in places the peaks, of the current North Promontory Mountains. A few smaller piedmonts in and west of the North Promontory Mountains crestline dip south and west, suggesting that the ancestors of the North Promontory Mountains were approximately in the same position. At the east edge of the quadrangle, the old alluvial-fan deposits contain massive boulders derived from Engineer Mountain and the Promontory Mountains close by to the east, once again demonstrating that ancestors of these ranges were in approximately the same position.

The alluvial-fan deposits unconformably overlie Pliocene loess and underlie upper Pleistocene deposits of Lake Bonneville. They are at least 10 to 20 meters (33 to 66 ft) thick at the top of Cedar Ridge. They display extensive development of pedogenic calcite. We regard the alluvial-fan deposits to be Pliocene and Pleistocene in age.

Intermediate Alluvial-Fan Deposits

Alluvial fans (Qaf_2) that were formed after earlier alluvial piedmonts ($QTaf_3$), but that predate Lake Bonneville, are present in and at the mouths of canyons draining the North Promontory Mountains. These fans formed during and after pronounced dissection of the Pliocene and Pleistocene alluvial piedmonts and show only a modest development of pedogenic calcite, suggesting that they are middle to late Pleistocene in age.

Lacustrine Marl

Lacustrine marl (Qlm) (white marl of Gilbert, 1890) is widely exposed in the northwest part of the Sunset Pass quadrangle, where it is mainly the regressive deposit left by the withdrawal of Lake Bonneville from the Bonneville shoreline. The lacustrine marl is generally white to light brown and finely laminated in its lower part, whereas silty to sandy beds typify its less prominently laminated upper part. Lacustrine marl is sandy at exposures offshore from lacustrine gravel bars in the eastern part of the quadrangle.

Lower parts of lacustrine marl sequences in Sand Hollow and in a valley about 2 kilometers (3 mi) to the south show pronounced current ripples, convolute laminations, rip-ups, roll structures, and folds. The lower part contains many thin beds of silty and sandy ashy material, probably reworked from the subjacent Tertiary tuff. The upper part of the unit is generally thin-bedded, sandy marl. Similar sedimentary structures are present in the upper, regressive, sandy marl deposits in the northwest part of the quadrangle.

The lacustrine marl unit overlies soil profiles developed within the oldest alluvial-fan deposits ($QTaf_3$) and it underlies a wide variety of alluvial units. Its widespread exposure in the northwest part of the quadrangle suggests that little erosion has occurred in that part of the Hansel Valley area during the Holocene.

Lacustrine Sand

Brown, well-size-sorted sand deposited in Lake Bonneville is present in three places: in the northwest part of the quadrangle at about 1,408 meters (4,620 ft) altitude, in the west-central part of the quadrangle just above the Provo shoreline, and in the east-central part of the quadrangle north of Sand Hollow around 1,524 meters (5,000 ft) altitude. In each case, the sand represents accumulations near (generally offshore from) beach-gravel deposits. The latter two cases probably represent reworked Tertiary sedimentary rocks, a ready source of sand-size material.

Lacustrine Gravel

Locally thick lacustrine gravel was deposited along Lake Bonneville shorelines in several places, of which the most prominent are at or near the Bonneville shoreline. Lacustrine gravel probably was derived chiefly from alluvium reworked as the lake surface rose, because transgressive bars are more prominent than regressive bars and gravel accumulations are not noticeably greater near mouths of canyons. The regionally developed sequence of shoreline formation is: (1) Stansbury shorezone formed during the early rise of the lake about 22 thousand years ago; (2) the lake ascended to its highest level, the Bonneville shoreline, about 15 thousand years ago; (3) the lake catastrophically drained and its level fell to the Provo shoreline about 14 thousand years ago; (4) the lake level rapidly fell to near that of present Great Salt Lake by 12 thousand years ago; and (5) the lake rose about 13 meters (43 ft) to form the Gilbert shoreline about 10 thousand years ago and then declined to near present levels (Currey and others, 1984). All of these regional shorelines are present in the Sunset Pass quadrangle but the Gilbert, which is present east and west of the quadrangle at lower altitudes. In addition to these regional shorelines, minor gravel accumulations mark many other shorelines. Those between the Provo and Bonneville shorelines were termed intermediate shorelines by Gilbert (1890). Those below the Provo shoreline are distinguished as transgressive and regressive. Impure marl associated with regression of the lake level overlaps transgressive bars, whereas marl interfingers with or is overlapped by gravel in regressive shorelines.

Altitudes of prominent bars in the Sunset Pass quadrangle are: Bonneville shoreline, 1,594 to 1,600 meters (5,230 to 5,250 ft); intermediate shorelines, 1,579, 1,567, 1,524, 1,518, and 1,512 meters (5,180, 5,140, 5,000, 4,980, 4,960 ft); Provo shoreline, 1,487 to 1,478 meters (4,880 to 4,850 ft); transgressive shorelines, 1,404 and 1,364 meters (4,605 and 4,475 ft); and regressive shorelines, about 1,413, 1,396, 1,387, 1,384, 1,378, and 1,372 meters (about 4,635, 4,580, 4,550, 4,540, 4,520, and 4,500 ft). In addition, several wave-developed gravel platforms bound the edges of piedmont crests underlain by the Pliocene and Pleistocene alluvial-fan deposits. The morphology of the lacustrine gravel deposits indicates that wave energy was directed from south to north.

The Stansbury shorezone, a complex of transgressive gravel bars and finer-grained deposits constructed during one or more fluctuations in lake depth (Oviatt and others, 1990), appears to be represented by several shorelines (some west of the Sunset Pass quadrangle) from below 1,329 meters to 1,364 meters (4,360 to 4,475 ft). Lacustrine sand at 1,408 meters (4,620 ft) altitude is a transgressive deposit associated with a transgressive gravel bar at 1,404 meters (4,605 ft) that we tentatively interpret as representing a lake-level oscillation slightly younger than the Stansbury shorezone, because the sand occurs between lacustrine marl sequences.

Lacustrine Gravel and Sand

Interbedded lacustrine gravel and sand (Qlgs) deposited in Lake Bonneville is present between Provo and Bonneville shorelines along the west side of the North Promontory Mountains. These deposits do not have the typical bar morphology of lacustrine gravel deposits, but rather form inclined ramps below prominent bars at or near the Bonneville shoreline. The lacustrine gravel and sand deposits locally are thicker than 10 meters (30 ft).

Mass-Movement Slides

Small disaggregated masses of slide and slump material (Qms) are present within Pleistocene lacustrine gravel and Tertiary sediments. The small slide in section 33, T. 12 N., R. 6 W. disturbed Holocene alluvium. A larger landslide mass that is nearly monolithologic is present in one location in the east-central part of the quadrangle; this slide mass is distinguished on the map (plate 1) by structural boundaries and primarily affects one lithologic unit, lacustrine gravel (Qlg)

Lacustrine and Alluvial Deposits, Undivided

Alluvial and lacustrine deposits (Qla) complexly interfinger in several areas, making their separation on the map difficult. Piedmonts flanking the North Promontory Mountains are underlain by alluvium that commonly has a large fraction of reworked ash. Below the Bonneville shoreline, that alluvium was reworked by Lake Bonneville and deposited in a lacustrine setting, which subsequently was reworked as Holocene alluvium. The resulting tuffaceous sediments cannot be confidently assigned to alluvial or lacustrine origins. In many places below the Provo shoreline these deposits probably consist chiefly of alluvium overlying regressive lacustrine marl.

Mass-Movement Talus

Steep, unvegetated slopes beneath cliffs of the Oquirrh Formation are composed of talus (Qmt) along much of the west side of the North Promontory Mountains. These talus slopes cover shorelines of Lake Bonneville, indicating that they are Holocene in age.

Mass-Movement Colluvium

Moderately inclined slopes along the west side of the North Promontory Mountains are composed of colluvium (Qmc). These colluvial aprons cover shorelines of Lake Bonneville, indicating that they are Holocene in age.

Eolian Sand

Brown eolian sand (Qes) in sheets and dunes lies just below the Bonneville and Provo shorelines in a few places in the eastern part of the quadrangle. The sand is composed of glass shards, shell fragments, lithic grains, and ooids. The eolian accumulations in the southeastern part of the quadrangle are derived from lacustrine sand composing foresets of the Provo shoreline bars.

Alluvial-Fan Deposits

Young alluvial fans (Qaf_1) have formed at the mouths of several canyons within the mountainous parts of the quadrangle since Lake Bonneville withdrew, and similar deposits are present in canyon bottoms within the mountains. Many of these alluvial fans are currently active.

Alluvial Silt

Fine-grained alluvium (Qai) that mostly consists of reworked fine-grained lacustrine and tuffaceous materials is present behind and upslope from bars formed along the Bonneville and nearby shorelines. The alluvial silt in some cases overlies lagoonal deposits of Pleistocene age, deposited by Lake Bonneville.

Alluvium

Alluvium (Qal) was deposited within several low-gradient stream channels, primarily at Sand Hollow and in the southeast part of the quadrangle. Much smaller exposures within other stream channels were not mapped.

Fill

Construction fill (Qf) was used mainly for the railroad grades constructed for the first transcontinental railroad. Other fill was used to construct an earthen dam in upper Sand Hollow. The railroad and dam fill is locally derived material.

STRUCTURE

The large-scale structure of the Sunset Pass quadrangle consists of a central bedrock mountain block, the North Promontory block, bounded on the east and west by structural basins (figure 2). Moderate- to high-angle faults in the North Promontory block are mostly normal faults, many of which accommodated growth of basins that filled with Miocene strata. Faults bounding the North Promontory block are poorly exposed, and appear to belong to two main systems: those bounding the block on the west (North Promontory fault) and those accommodating development of the deep Miocene (Sand Hollow) basin on the east. Tilting during and after basin formation is indicated by Tertiary strata that dip north to northeast in subbasins within Sand Hollow basin and that dip generally to the east in the main basin.

North Promontory Block

The North Promontory block consists of alternating exposures of the Oquirrh Formation and Miocene strata along its length, the units being bounded by normal faults and unconformities. Miocene strata dip to the north and northeast and lie in basins whose north margins are fault-bounded. Faults in the North Promontory block are poorly exposed and generally are approximately located on the basis of offset stratigraphic units. Areas underlain by thick sequences of the Oquirrh Formation and Miocene strata may also be cut by unrecognized faults. The faults mapped in the North Promontory Mountains can be divided into two sets: one with north to northeast strike, and one with approximately east strike.

The largest faults have easterly strikes; most have normal offset down to the south and bound small Miocene basins (section AA'). Stratigraphic throw and other measures of offset are not possible because internal stratigraphy within Paleozoic and Cenozoic units is uncertain. If the displacement was primarily dip slip, offset is several hundred meters for faults bounding these basins, and greater than 720 meters (2,360 ft) for the largest, southernmost basin. At rare exposures of these faults, the Oquirrh Formation is brecciated and Miocene strata are contorted and fractured. Several small north-striking faults are probably related to development of the larger east-striking faults. The east-striking faults are Miocene in age, since they are overlapped by Pliocene and lower Pleistocene deposits and were probably active during deposition of Miocene strata. On the basis of east-directed paleocurrents at their bases, the basins within the North Promontory block most likely are fragments of a faulted, once-uniform base of the Sand Hollow basin.

The east-striking faults cut east-northeast- and northwest-striking faults in the block composed of the Oquirrh Formation along the north boundary of the quadrangle. The northwest-striking faults, which are either older than or coeval with the Miocene east-striking faults, are high angle and have small stratigraphic throws in most cases.

A set of faults distinctly younger than others in the North Promontory block is present in the west part of Cedar Ridge. Although the Oquirrh Formation at Cedar Ridge is mostly unfaulted, as determined by marker beds that are continuous over lengths of as much as 2 kilometers (1.2 mi), it and overlying units as young as early Pleistocene in age are cut by a main fault and several small faults. The main fault strikes N. 10° W. and displaces the contact between the eolian loess and alluvial gravel unit and the oldest alluvial-fan deposits down to the west about 90 meters (300 ft). It and the small faults with north and east strikes are overlapped by upper Pleistocene alluvium and lacustrine deposits, suggesting that last movement on these faults was in the early or middle Pleistocene.

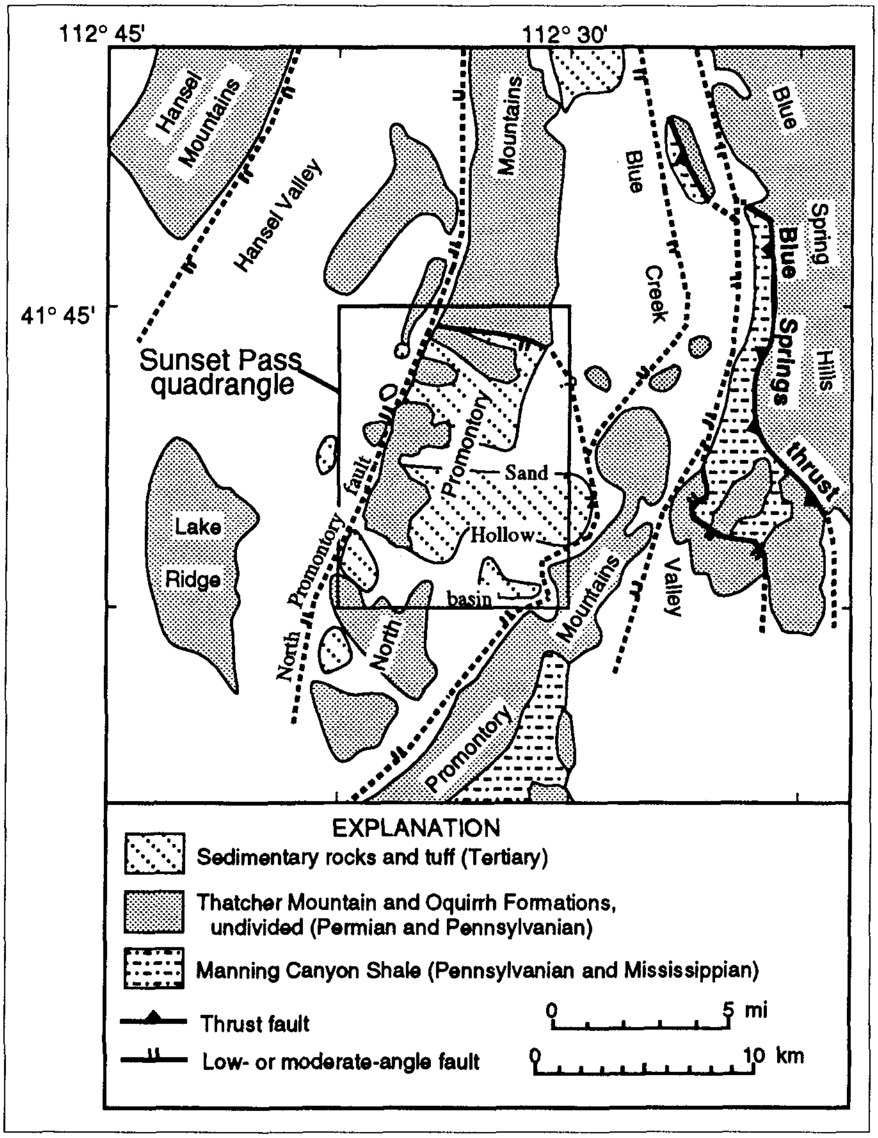

Figure 2. Generalized geologic map of the Sunset Pass area, showing major faults. Unpatterned area represents Pliocene and Quaternary deposits. Modified from Doelling (1980), Allmendinger and others (1984), Jordan and others (1988a, 1988b), and Miller and others (1991).

North Promontory Fault

The North Promontory fault strikes north-northeast and bounds the west side of the North Promontory block (figure 2). Two or more parallel fault strands, only exposed in a few gullies, mark the North Promontory fault. The trace is inferred from a pronounced physiographic break along the west side of the North Promontory Mountains and breccia zones and gouge in the Oquirrh Formation. A prominent breccia surface north of Sunset Pass strikes N. 10° E. and dips 58 degrees west, suggesting that the fault zone dips moderately west and is a normal fault. Although the physiographic break is pronounced, the presence of Oquirrh outcrops west of the fault and the lack of a gravity anomaly (Cook and others, 1989) indicate that eastern Hansel Valley contains little low-density sediment and that offset on the North Promontory fault is probably only a few hundred meters. Segments of the North Promontory fault north of the Sunset Pass quadrangle are as young as Pleistocene in age (~16 thousand years), on the basis of mapping by Jordan (1985) and Robison and McCalpin (1987), but the fault locally is only dated as post-Miocene and pre-late Pleistocene.

Sand Hollow Basin

East of the North Promontory block a wide expanse of Miocene deposits, all dipping roughly easterly, delineate the Sand Hollow basin. The basin strikes north-northeast and is asymmetric with strata dipping eastward 12 to 48 degrees. Gravity measurements compiled by Cook and others (1989) provide indirect evidence for the configuration of the basin and hence, evidence for the locations of faults. A prominent low, ranging from -15 to -25 mgal compared to adjacent bedrock exposures, probably represents a basin containing low-density Tertiary materials that may be as much as 2,100 meters (6,900 ft) thick (section CC'). Drill records for the north end of the basin (SRI #1-2, Green #1) indicate nearly 610 meters (2,000 ft) of tuffaceous sediments for these holes, which did not penetrate the entire basin. We consider that one or more normal faults west of the Promontory Mountains and Engineer Mountain (figures 1, 2) bound Sand Hollow basin, as indicated by gravity data and drill holes.

These bounding faults dip moderately westward by analogy with faults farther east in the Lampo Junction quadrangle (Miller and others, 1991). Hanging walls of the faults contain Tertiary tuff, and earliest Pliocene loess angularly overlies tilted tuff, so the faults are presumed to be Miocene in age. Normal faults (too small to depict on the map) cutting Miocene strata exposed in gullies in the southeast corner of the quadrangle belong to two sets. In one set, faults strike about north and dip 38 to 65 degrees west, and in the second set the faults strike N. 12°W. to N. 50° W. and dip 44 to 65 degrees east and northeast. Slickenlines on one fault in the latter set rake 43 degrees to the south, suggesting oblique (dextral) slip on that fault. Faults probably bound the west side of Sand Hollow basin as well because the dip of the unconformity at the base of the Miocene strata is not great enough to account for the thickness of low-density material inferred from gravity data (section CC'). However, the dip of the unconformity is not well constrained, so the presence of these faults is conjectural.

The Miocene Sand Hollow basin was filled with tuffaceous sediment during structural downdropping, primarily on the east side, during the Miocene. Tilting of these sediments may have been caused by asymmetric faulting and (or) by later tilting of the basin and the North Promontory block. Following tilting, sedimentary deposits in the basin were eroded and uppermost Miocene and lowermost Pliocene loess and alluvium were deposited across this erosional surface. Although the loess deposits dip 10 to 15 degrees eastward, indicating modest tilting since the early Pliocene, these materials have been only slightly deformed by faults near the edges of Sand Hollow basin (Nelson and Miller, 1990). Following tilting of the Pliocene loess deposits, Pliocene and Pleistocene alluvium was deposited across Sand Hollow basin and parts of the North Promontory block.

Thrust Faults

Although no thrust faults are exposed within the Sunset Pass quadrangle, they are inferred at about 4,600 meters (15,000 ft) depth on the basis of exposures of the Blue Springs thrust fault (figure 2) exposed 8 kilometers (5 mi) to the east (Miller and others, 1991). The west-dipping Blue Springs thrust fault had about 3 kilometers (2 mi) of eastward translation, assuming translation was perpendicular to the east-verging megascopic folds (Allmendinger and others, 1984; Miller and others, 1991). The Blue Springs thrust was inferred by Allmendinger and others (1984) to be Late Cretaceous or older in age.

ECONOMIC DEPOSITS

Sand and gravel are the principal economic resources in the Sunset Pass quadrangle. The largest accumulations of gravel and sand are indicated on the map as lacustrine gravel (Qlg), lacustrine gravel and sand (Qlgs), and lacustrine sand (Qls), but many smaller deposits exist. Principal accumulations are near the Bonneville shoreline at Sunset Pass and along both sides of the North Promontory Mountains, and below that shoreline in many places near Sand Hollow. Although lacustrine marl in some places is utilized as a source of diatomaceous materials, the marl contains no notable concentrations of diatoms in the Sunset Pass quadrangle.

A source for clean limestone may be found in the limestone member of the Oquirrh Formation. This member is cleaner elsewhere, such as in the Promontory Mountains, but may be less accessible in those places.

No prospects for mineral ores or evidence of mineralization of bedrock were observed in the Sunset Pass quadrangle. However, siliceous and calcareous alteration of Miocene marl, sandstone, and conglomerate near the west side of Sand Hollow basin may mark ancient hydrothermal systems. Opaline material in the silicified deposits may be of value as decorative stone.

The hydrocarbon resource potential for the area has not been rigorously assessed. A test well 2 kilometers (1.2 mi) to the east of the Sunset Pass quadrangle was abandoned at 2,733 meters (8,966 ft). Other test wells exploring the Tertiary basin in the Sand Hollow area also were abandoned. No favorable organic zones are known within Tertiary deposits in the Sunset Pass quadrangle, and possible source strata of Paleozoic age are probably overmature, judging from high conodont alteration indexes from nearby (Miller and others, 1991).

GEOLOGIC HAZARDS

Floods and Gullying

Floods have potential for creating hazards in much of the Sunset Pass quadrangle. A potential exists for debris flows and floods on alluvial fans. Several Holocene alluvial fans mapped along both sides of the North Promontory Mountains have been active since the deposition of Bonneville lacustrine deposits; all are probable sites for future alluviation, including deposition during floods. Narrow canyons upslope from the fans are also likely sites for powerful floods and debris flows. Gullying has occurred in many areas underlain by unconsolidated to moderately consolidated materials; the uplands undergoing intensive agriculture east of the North Promontory Mountains show especially pronounced gullying. The fine-grained Miocene, Pliocene, and Quaternary materials in the Sunset Pass quadrangle are highly susceptible to the erosion that results from the destruction of natural ground cover.

Earthquakes

Northern Utah is part of a seismic belt characterized by numerous small-magnitude events and by potential for infrequent major events (Smith and Sbar, 1974; Christenson and others, 1987). The region from Hansel Valley east to the Wasatch Range has experienced considerable historic seismic activity, including magnitude 6 and larger events in Hansel Valley in 1909 and 1934. A thorough account of the past seismic activity and potential for future damaging earthquakes is given by Christenson and others (1987).

No fault scarps or faults cutting upper Pleistocene deposits were discovered during field investigations. The youngest faults cut the oldest alluvial-fan deposits of Pliocene and Pleistocene age, but not upper Pleistocene materials, and therefore probably are no younger than middle Pleistocene in age. However, several Quaternary and historic surface ruptures have been documented within a short distance of the Sunset Pass area, and Holocene alluvium or talus may have covered similar young scarps in the quadrangle. During 1934, a magnitude 6.6 event occurred in Hansel Valley (Christenson and others, 1987), and surface rupture from this event is documented about 8 kilometers (5 mi) west of the Sunset Pass quadrangle (Robison and McCalpin, 1987). The western flank of the North Promontory Mountains has a particularly abrupt topographic expression, and Jordan (1985) and Robison and McCalpin (1987) mapped normal faults cutting Pleistocene alluvial-fan deposits in one area and Lake Bonneville deposits in another north of the Sunset Pass quadrangle along the mountain front.

The regional history of seismic activity (Christenson and others, 1987, figure 3) and evidence for Quaternary faults in Hansel Valley raises the possibility of moderate to large earthquakes in the Sunset Pass quadrangle. The Wasatch fault zone and related faults 50 kilometers (30 mi) to the east project westward at moderate angles (Smith and Bruhn, 1984), presenting a potential for a major seismic event that could strongly shake the Sunset Pass area. In addition to hazards from ground shaking and surface rupture, lateral spreads and liquefaction could result from an earthquake.

Landslides

Landslides are present as a few isolated slides within lacustrine deposits and Miocene strata. The slumps within lacustrine materials in the east-central part of the quadrangle involve thick lacustrine gravel deposits that probably were built northward by shoreline processes, overlapping finer-grained sediments. These features create steep, unstable slopes along which slides still are likely to occur.

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