C.G. Oviatt QUATERNARY GEOLOGY OF THE SCIPIO VALLEY AREA, MILLARD AND JUAB COUNTIES, UTAH SPECIAL STUDY 79

QUATERNARY GEOLOGY OF THE SCIPIO VALLEY AREA, MILLARD AND JUAB COUNTIES, UTAH

by

Charles G. Oviatt
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Manhattan, Kansas

SPECIAL STUDY 79 **1992**
UTAH GEOLOGICAL SURVEY
a division of
UTAH DEPARTMENT OF NATURAL RESOURCES

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ABSTRACT

Quaternary deposits and structures have been mapped at a scale of 1:62,500 in a 270-square-mile area (690 km^2) of central Utah that includes Scipio Valley, Little Valley/Mills Valley, and Round Valley. Scipio Valley and adjacent valleys to the north and south occupy structural grabens along the eastern side of the Basin and Range physiographic province. Bedrock in the surrounding mountains varies in age from Precambrian to Miocene, and the area was strongly affected by both Sevier orogenic thrust faulting and late Cenozoic normal faulting. The area is in the transition zone between the Basin and Range and Colorado Plateaus physiographic provinces.

The map area contains basin-fill deposits of Pliocene to middle Pleistocene age, and Quaternary deposits of alluvium, glacial till, and lacustrine deltaic sediments. Plio/Pleistocene basin-fill deposits contain beds of silicic volcanic ash ranging in age from 4.8 Ma to 0.62 Ma, and fine-grained deltaic deposits of Lake Bonneville contain the Pavant Butte basaltic ash (15.5 ka). Late Quaternary faults cut the surficial deposits, and some of the faults in Scipio Valley may have had late Holocene surface rupture. Mapping for this project demonstrates that a previously suggested hypothesis cannot be accepted: that the Sevier River had been captured into the Sevier Desert basin from a former northward course to Utah Lake during the late Cenozoic.

INTRODUCTION

The Scipio Valley area is located in central Utah between the Canyon Mountains and Pavant Range on the west, and the Valley Mountains on the east (figure 1). The map area encompasses three connected valleys, Little Valley/Mills Valley in the north, Scipio Valley in the center, and Round Valley in the south. Elevations range from over 10,000 feet (3,000 m) in the Pavant Range to about 4,900 feet (1,500 m) along the Sevier River near Mills. The Sevier River and its tributaries drain the northern part of the area, and the southern part is drained by Round Valley Creek, which terminates in the topographically closed Scipio Valley.

The purpose of this report is to describe the surficial deposits of Quaternary and late Tertiary age in Round, Scipio, and Little Valleys. The map area (plate 1) encompasses about 270 square miles (690 km^2) in parts of eight 7.5-minute topographic quadrangles (Fool Creek Peak, Mills, Williams Peak, Scipio North, Scipio Pass, Scipio South, Coffee Peak, and Scipio Lake). Surficial deposits were mapped on 1:30,000-scale aerial photographs in the field during the months of June and July, 1989. Field data were later transferred to 1:24,000-scale orthophotoquads, which were reduced to 1:62,500 and compiled to produce the map (plate 1).

Surficial deposits exposed in the map area include basin-fill deposits of late Tertiary to middle Pleistocene age, and

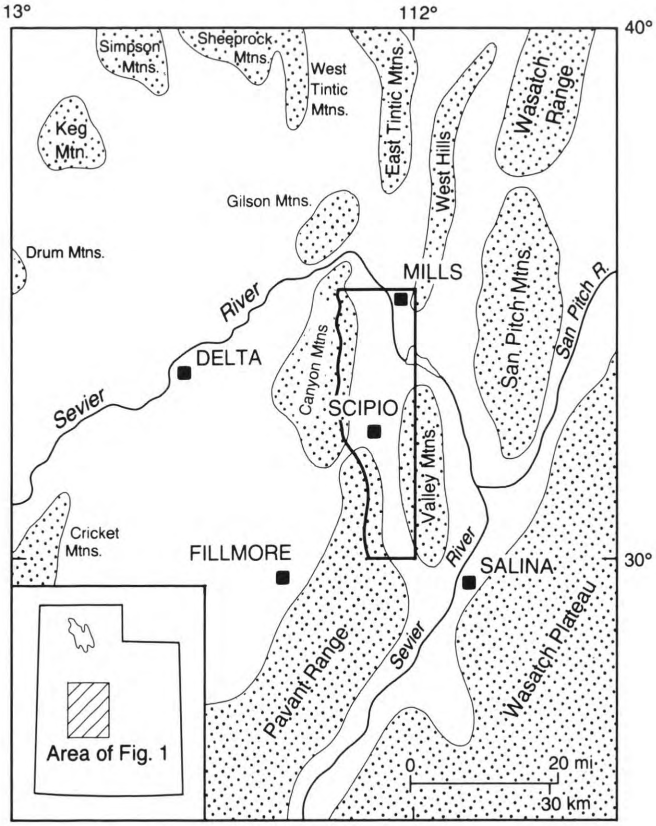

Figure 1. *Location of the Scipio Valley area in central Utah.*

Quaternary alluvial, glacial, and lacustrine deltaic deposits. The Plio/Pleistocene basin-fill deposits include beds of silicic volcanic ash that range in age from 4.8 to 0.62 Ma, and the deltaic deposits of Lake Bonneville contain the Pavant Butte basaltic ash (15.5 ka). Late Quaternary faults cut the surficial deposits, and some of the faults in Scipio Valley may have had late Holocene surface rupture.

The climate of the valley floors is warm and dry. Mean annual temperature at Scipio for the period 1951 to 1980 was 47.5°F (8.6°C), and the mean annual precipitation for the period is 12.51 inches (318 mm) (NOAA, 1988). Winter snows in the Pavant Range last into midsummer where the snow has drifted into cornices on the east sides of the mountain crest, but the valley floors are much drier and warmer.

Interstate Highway 15 and U.S. Highway 50 pass through the area and intersect at the community of Scipio. Mills is a small farming community at the north end of the area. Yuba Lake State Recreation Area attracts many swimmers and water skiers during the hot summer months.

The pre-Quaternary geology of the Scipio Valley area has been mapped, or is now under study (Christiansen, 1952; Tucker, 1954; Campbell, 1978, 1979; Morris, 1978; Higgins, 1982; Millard, 1983; Holladay, 1984; Pampeyan, 1989; Willis, 1991; Felger, in preparation; Michaels, in preparation). Ground-water resources of the area have been investigated by the U.S. Geological Survey (Bjorklund and Robinson, 1968). Very little, however, has been done with the Quaternary deposits, and mapping in the area is considered important for the following reasons:

1. Knowledge of the distribution and ages of Quaternary deposits will be useful in understanding the neotectonic history of the area. Quaternary faults, including scarps of probable Holocene age, are present in all of the valleys (Bucknam and Anderson, 1979a, b).
2. Deltaic (estuarine) sediments of the Sevier River, which were deposited in Lake Bonneville, are well exposed in Mills Valley and provide an opportunity for studying Lake Bonneville history during the lake's highest stages. Some pre-Bonneville basin-fill deposits of middle Pleistocene to late Tertiary age are also exposed in the area and have not been previously mapped or dated.
3. Scipio Valley is a closed depression that contained a small pluvial lake that overflowed into the estuary of Lake Bonneville along the Sevier River when Lake Bonneville was at its highest level. This report documents the evidence for the overflowing lake.
4. The map area contains one small glacial cirque in the Pavant Range. The glacial history of the Pavant Range has not been previously studied in detail.
5. The mapping for this project demonstrates that a previously suggested hypothesis cannot be accepted: that the Sevier River had been captured into the Sevier Desert basin from a former northward course to Utah Lake during the late Cenozoic (Costain, 1960; Oviatt, 1987). An alternative hypothesis is presented to explain the geomorphic features that had suggested the capture hypothesis.

DESCRIPTION OF MAP UNITS

For mapping purposes (plate 1) the Quaternary deposits in the Scipio Valley area are classified primarily on the basis of their environments of deposition. The unconsolidated Quaternary sediments were deposited in lacustrine (l), deltaic (d), alluvial (a), mass-wasting (m), glacial (g), and eolian (e) environments as indicated by the first lowercase letter in the map-unit symbols. Other distinguishing characteristics, such as texture, lithology, or geomorphic expression, are used to subdivide the deposits into mappable units and are indicated by the second lowercase letter in the symbol. In one case in this report a letter subscript is used to distinguish the floodplain alluvium of the Sevier River (Qal_f) from alluvium of lower order streams (Qal).

The reported ages of the map units discussed below are based on several lines of evidence. In certain cases, stratigraphic relationships of the deposits with deposits or landforms of Lake Bonneville, the ages of which are well known (figure 2), can be determined. Other means of age determination used in this report include amino-acid analyses of mollusk samples (table 1), paleomagnetic analyses of sediment samples, the degree of soil development in certain deposits, and tephrochronology. The map units are described below in stratigraphic order under their major genetic categories.

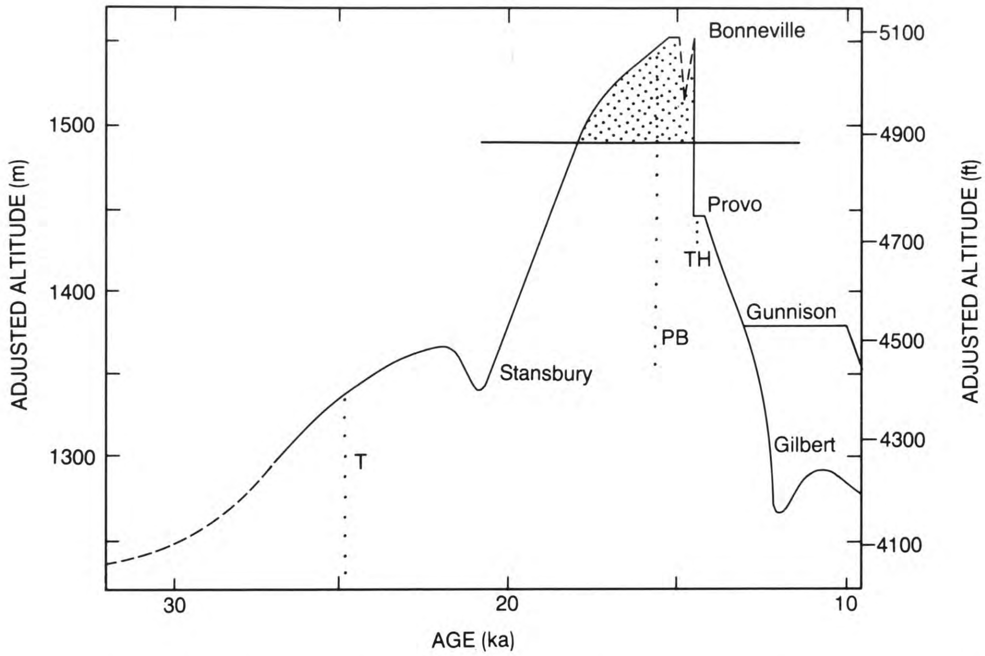

***Figure 2.** Diagram of Lake Bonneville chronology. Stippled area represents the time Lake Bonneville occupied at least part of the area of plate 1. Major shorelines are labeled. Basaltic volcanic ashes are marked with vertical dotted lines (T = "Thiokol" ash; PB = Pavant Butte ash; TH = Tabernacle Hill ash). Altitudes are adjusted for the effects of isostatic rebound (after Currey and Oviatt, 1985).*

Table 1.
Results of amino-acid analyses[1] of mollusk shells collected in the Scipio Valley area.

Strati-graphic unit	Locality[2]	Lab number	Genus	Alloisoleucine/isoleucine[3] Free	Hydrolysate
Qlf	L	AGL1446	*Amnicola*	~0.18	0.14±0.01
Qlf	L	AGL1447	*Valvata*	0.10±0.01	0.087±0.012
Qlf	L	AGL1448	*Pisidium*		0.09±0.01
Qdf	I	AGL1449	*Valvata*	0.087±0.004	0.072±0.007
Qdf	I	AGL1450	*Lymnaea*	0.11±0.01	0.077±0.005
Qdf	I	AGL1451	*Anodonta*	0.27±0.04	0.083±0.006
QTab	G	AGL1452	*Valvata*		0.85±0.02
QTab	G	AGL1453	*Pisidium*	1.31±0.03	0.99±0.02
QTab	G	AGL1454	*Lymnaea(?)*		0.75±0.04
Qlf	G	AGL1455	*Anodonta*		0.14±0.01

[1]All analyses by William D. McCoy, at the Amino Acid Geochronology Laboratory at the University of Massachusetts

[2]Refer to table 2 and figures in the text for information on the location and stratigraphic context of the samples

[3]Ratio of alloisoleucine to isoleucine in the free fraction and in the total hydrolysate

PRE-QUATERNARY ROCKS

Paleozoic and Precambrian rocks (P): Precambrian and Paleozoic rocks in the Canyon Mountains and the north end of the Pavant Range are mapped as one unit. See previous work for more information (Christiansen, 1952; Tucker, 1954; Higgins, 1982; Millard, 1983; Holladay, 1984; Michaels, in preparation).

Upper Cretaceous and lower Tertiary rocks (KT): Upper Cretaceous and lower Tertiary rocks are mapped as one unit. See previous work for more information (Campbell, 1978, 1979; Willis, 1991; Felger, in preparation).

TERTIARY/QUATERNARY DEPOSITS

Sevier River sand and gravel (QTas): Sand and gravel deposited by the Sevier River during the late Tertiary to middle Pleistocene are shown as QTas. The unit is widespread in the lower parts of the map area between Yuba Dam and the northern boundary of plate 1. Pebbles of volcanic rocks, many of which have sources in the Sevier River drainage basin south of the map area, are abundant and quite different in composition from pebbles derived from local sources. Locally derived gravel is composed of sedimentary rocks, primarily Cretaceous/Tertiary limestone and sandstone, or Precambrian quartzite and Paleozoic carbonate rocks. Therefore, the Sevier River gravel is distinctive and is easily mapped.

Sevier River sand and gravel interfingers with fine-grained, basin-fill deposits shown as QTab (figure 3), and with locally derived fan gravel (QTaf). These three facies form a vertically and laterally varying sequence of deposits which fills a dissected sedimentary basin in the northeast corner of the map area, and which extends eastward into the Skinner Peaks quadrangle (Felger, in preparation). The Sevier River sand and gravel varies in thickness from zero to over 20 feet (6 m). Its stratigraphic relationships with the fine-grained basin-fill unit (QTab) and the coarse-grained fan facies (QTaf) are shown schematically in figure 4, and in more detail in figure 5. The sand and gravel were deposited in relatively high-energy parts of the sedimentary system dominated by the Sevier River. Lower energy floodplain and basin-floor deposition is represented by QTab, and the marginal fan facies is represented by QTaf.

Figure 3. Photograph of an exposure of Sevier River sand and gravel (QTas) near the south abutment of Yuba Dam. Crossbedded sand is overlain by a lens of Sevier River gravel, which is overlain by poorly sorted sand and silt (QTab) and another lens of Sevier River gravel.

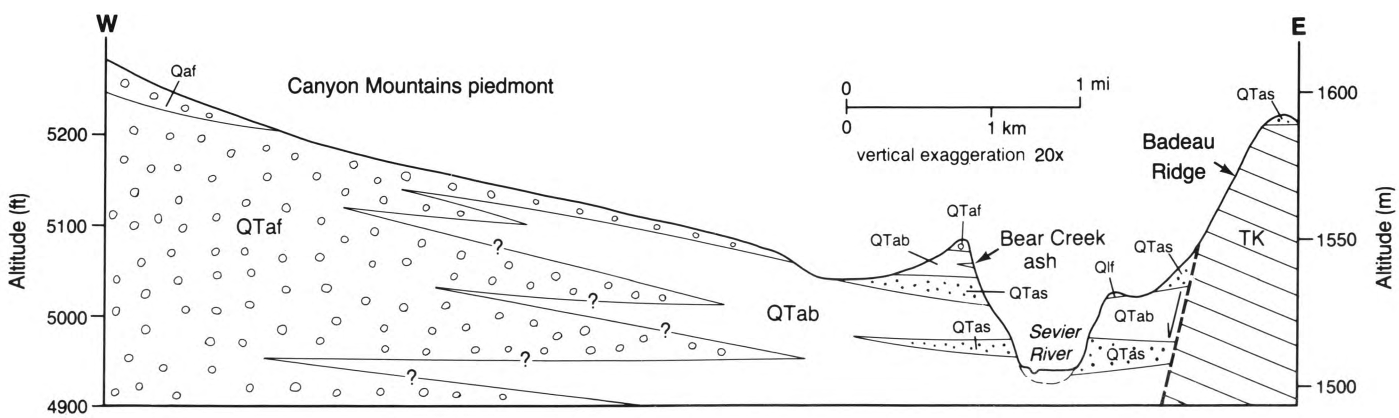

Figure 4. Schematic and generalized cross section of stratigraphic relationships between QTas, QTab, and QTaf between the Canyon Mountains piedmont and Badeau Ridge.

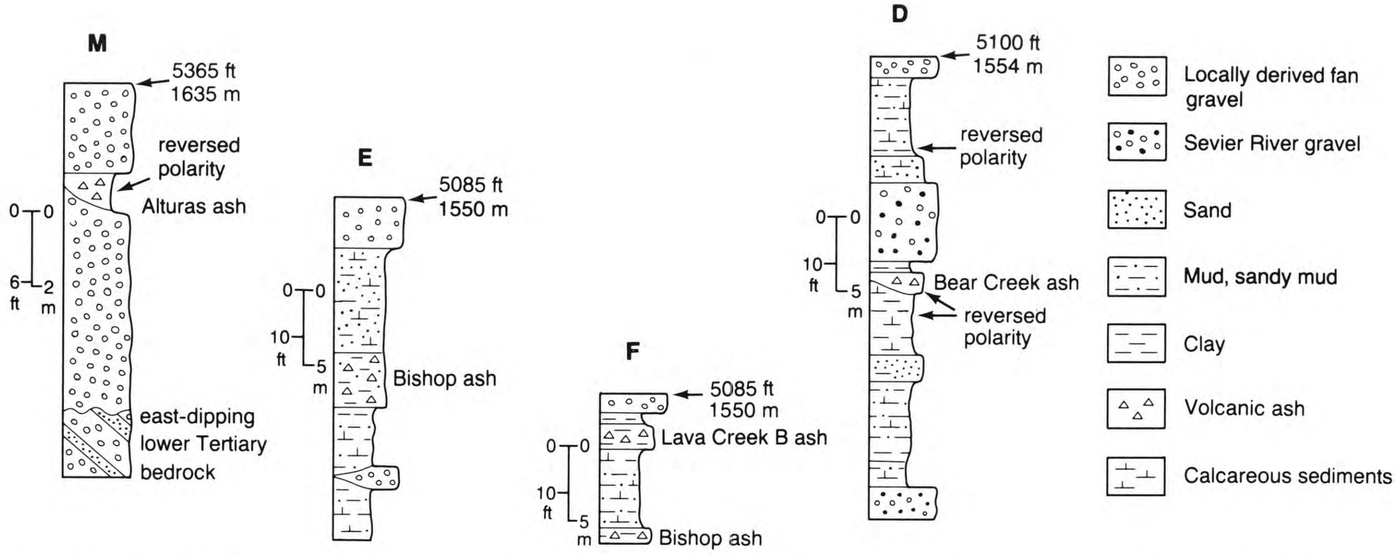

Figure 5. Measured stratigraphic sections in Quaternary/Tertiary deposits. Sections are labeled with locality letters (see table 2). The paleomagnetic polarity of sediment samples from two of the sections is indicated.

An estimate of the upper limit of sedimentation in the basin is given by the highest elevation of outcrops of map unit QTas. The highest outcrops are on the bedrock ridge (Badeau Ridge) just west of Sevier Bridge Reservoir (locality A; table 2), in the low hills west of the community of Mills (locality C; table 2). Maximum altitudes at these localities are 5,250 feet (1,600 m), 5,210 feet (1,590 m), and 5,320 feet (1,595 m), respectively. Assuming the deposits have not been significantly uplifted, basin filling progressed to at least as high as 5,250 feet (1,600 m) in the vicinity of Sevier Bridge Reservoir. However, there is evidence of Quaternary faulting in the map area, and therefore the original depositional altitudes are unknown. The age of the Sevier River sand and gravel is probably at least Pliocene to middle Pleistocene, as shown by its stratigraphic relationships with related units (QTab and QTaf) that have been dated for this project.

Basin-fill mud and sand (QTab): Sevier River sand and gravel interfinger with a sequence of fine-grained deposits ranging from poorly sorted sand and silt, to silty calcareous clay, to pebbly sand derived from local sources (figure 6). These deposits are mapped together as basin-fill mud and sand (QTab). Colors range from white or light gray, in the case of the silty clay, to reddish brown (5YR 5/4 to 5YR 6/3 or 7/3), in the case of the poorly sorted sand and silt. The exposed thickness of QTab ranges from zero to 80 feet (25 m). Many small exposures of QTab within areas of both QTas and QTaf are not shown on plate 1. Bjorkland and Robinson (1968) mapped areas of QTas and QTab as "Lake Bonneville Group."

The basin-fill mud and sand was deposited in a sedimentary basin that was being filled by sediment from both local sources (QTab and QTaf) and the Sevier River (QTas). The fine-grained facies (QTab) probably was deposited in a playa or mud flat setting in which the valley floor was flat and poorly drained and received sediment rapidly. Ponds or marshy environments, represented stratigraphically by the white to light-gray calcareous clay, were locally present on the valley floor. They may have been spring fed, or they may have been marginal to the Sevier River floodplain and fed by the Sevier River. Ostracodes from calcareous clay collected at two localities (G and H; table 2) support these interpretations. The ostracodes from both localities suggest that the ponds were fed by ground-water discharge but that water was also available from other sources, such as streams (R.M. Forester, oral communication, 1990).

Silicic volcanic ash is interbedded with fine-grained basin-fill deposits at three places (localities D, E, and F; table 2; figure 5). At two of these localities (E and F) the ash is mixed with fine sand and silt, but at locality D the ash is exposed as a clean, white lens ranging from 1 foot (0.3 m) to 5 feet (1.5 m) in thickness. Samples of each of these ash beds were submitted to A. M. Sarna-Wojcicki (U.S. Geological Survey, Menlo Park) for chemical analyses and correlation with ashes of known age. Sarna-Wojcicki (written communication, 1990) identified the ash at locality E and the lower ash at locality F as the Bishop ash bed, erupted from the Long Valley caldera in eastern California about 0.74 Ma. At locality F, the Bishop ash is overlain by the Lava Creek B ash, which was erupted from the Yellowstone caldera about 0.62 Ma. Therefore, the QTab deposits in this area are middle Pleistocene in age. Sarna-Wojcicki identified the ash at locality D as most likely the Bear Creek ash bed at 1.9 to 2.0 Ma. Therefore, the QTab deposits near locality D are late Pliocene in age. The stratigraphic relationships between the late Pliocene and middle Pleistocene parts of the QTab sequence have not been deciphered.

Samples were also collected from the measured section at locality D (figure 5) for paleomagnetic analyses and were submitted to K. L. Verosub (Univ. California-Davis). All three samples, including the Bear Creek ash, have reversed polarity, and therefore are older than the Brunhes/Matuyama paleomagnetic polarity boundary (0.78 Ma). The reversed polarity of the Bear Creek ash bed is consistent with its 2 million-year age.

Table 2.
Localities discussed in text and indicated on plate 1.

Locality	Description	Significance	Lat.-Long.
A	outcrops of QTas along the crest of Badeau Ridge	represent known upper limit of QTas deposition (probably uplifted by faulting)	39° 24′ 112° 2.3′
B	high-level outcrops of QTas west of Mills	represent deposition near the upper limit of Mills basin deposition (probably uplifted by faulting)	39° 29.5′ 112° 5.5′
C	high-level outcrops of QTas southwest of Mills	represent deposition near the upper limit of Mills basin deposition (probably uplifted by faulting)	39° 26′ 112° 4.5′
D	exposure of QTab and QTas northwest of Yuba Dam	good exposure of Mills basin-fill sediments, including the Bear Creek ash (see figure 5)	39° 23.55′ 112° 3.70′
E	exposure of QTab southwest of Yuba Dam	Mills basin-fill sediments, including the Bishop ash (see figure 5)	39° 21.80′ 112° 2.90′
F	exposure of QTab southwest of Yuba Dam	Mills basin-fill sediments, including the Bishop and Lava Creek B ashes (see figure 5).	39° 21.5′ 112° 2.75′
G	exposure of QTab and Qlf northwest of Yuba Dam	Mills basin-fill sediments and fine-grained Lake Bonneville sediments (see figures 6 and 7)	39° 3.6′ 112° 3.05′
H	exposure of QTab west of Yuba Dam	Mills basin-fill sediments; good exposure of calcic soil in QTaf	39° 22.5′ 112° 3.3′
I	exposure of Qdf on the south shore of Sevier Bridge Reservoir	deltaic fines of Lake Bonneville, amino-acid sample collected here	39° 22.2′ 112° 1.05′
J	gravel pit along road on west side of Mills Valley	exposure of Qdf containing Pavant Butte basaltic ash	39° 28′ 112° 4.3′
K	roadcut along frontage road west of I-15	exposure of Qds containing Pavant Butte basaltic ash	39° 21.5′ 112° 4.8′
L	just south of the south abutment of Yuba Dam	exposure of Qlf and collection site of amino-acid samples	39° 22.0′ 112° 2.0′
M	outcrop near the crest of the ridge north of the Leamington Pass road west of Mills	exposure of Alturas ash in QTaf pediment gravel	39° 29.25′ 112° 7.25′
N	in the low Hills southwest of Yuba Dam	sinuous outlet channel cut in KT by overflow from Scipio Valley lake	39° 19′ 112° 6′
O	at the base of the Pavant Range north of Maple Grove campground	on Holocene fault scarp; location of figure 15	39° 2.0′ 112° 4.8′

Figure 6. *Photograph of exposures at locality G (table 2). Number 1 marks the small remnant of Qlf at this locality; number 2 marks QTab, which overlies QTas. Number three marks the Sevier River. Other exposures of QTab and QTas are visible in the background, and the Canyon Mountains form the skyline. View is to the southwest. Refer to figure 7 for a measured section of the deposits at this locality.*

Mollusk shells collected from light-gray calcareous mud mapped as QTab at locality G (table 2; figure 7) have very high amino-acid ratios (alloisoleucine to isoleucine) (table 1; W. D. McCoy, 1990, personal communication). These shells are likely to be older than the Brunhes/Matuyama paleomagnetic polarity boundary (W. D. McCoy, 1990, personal communication). Therefore, the tephrochronologic, amino acid and paleomagnetic results, plus the interpretation of soils developed in QTaf (discussed below), indicate that the exposed basin-fill sequence (QTas, and QTaf) is Pliocene to middle Pleistocene in age.

Old alluvial-fan deposits (QTaf): Alluvial-fan deposits that interfinger with the other basin-fill deposits (QTab and QTas) are widespread in the northern part of the map area. Other isolated alluvial-fan deposits are mapped in the central and southern parts of the map ara, but their ages are not as well known as those in the north. Alluvium mapped as QTaf is coarse grained and ranges in thickness from about 3 feet (1 m) to over 50 feet (15 m). It is composed of clasts derived from the surrounding hills and mountains: Cretaceous/Tertiary limestone and sandstone, Precambrian quartzite, and Paleozoic carbonate rocks. Boulders of volcanic rocks, possibly derived from the Oligocene Halls Canyon Conglomerate, are present in QTaf in the northeast corner of the map area. Old alluvial-fan gravel caps a pediment cut across Cretaceous/Tertiary bedrock on the east flank of the Canyon Mountains in the northernmost part of the map area (indicated by stippling on plate 1).

Locally derived QTaf fan gravel interfingers with, and in many places overlies, fine-grained deposits mapped as QTab (figure 4). Therefore, its age is established by its stratigraphic relationships with the dated, fine-grained deposits as discussed above. In addition, at locality M (table 2; figure 5) a lens of silicic volcanic ash is interbedded with the fan (pediment) gravel. The ash is exposed near the ridge top in pediment gravel that is about 25 feet (8 m) thick and has a stage IV calcic soil at its surface. A single sample of the ash has reversed polarity (K.L. Verosub, written communication, 1990), and therefore is older than the Brunhes/Matuyama polarity boundary at 0.78 Ma. Based on microprobe analysis, Andrei Sarna-Wojcicki (written communication, 1990) has identified the ash as the Alturas ash with an age of about 4.8 Ma. Therefore, the pediment on the east flank of the Canyon Mountains is at least early Pliocene in age. Additional information on the age of the entire basin-fill sequence consists of limited data on the soils developed in the fan gravel. No soil pits were dug, but at several localities, including locality H (table 2) (see also figure 8), a calcic soil developed in QTaf at the top of the basin-fill sequence has stage IV carbonate morphology (after Machette, 1985a). The stage IV designation indicates that the soils have laminae of calcium carbonate in the upper part of the Km horizon. Soils having stage IV morphology in a temperate semiarid climate are probably at least early Pleistocene in age in this region (Machette, 1985a).

QUATERNARY ALLUVIAL DEPOSITS

Young alluvial-fan deposits (Qaf): Quaternary alluvial-fan deposits are the most widespread deposits in the map area. They are composed of pebble- to boulder-size gravel

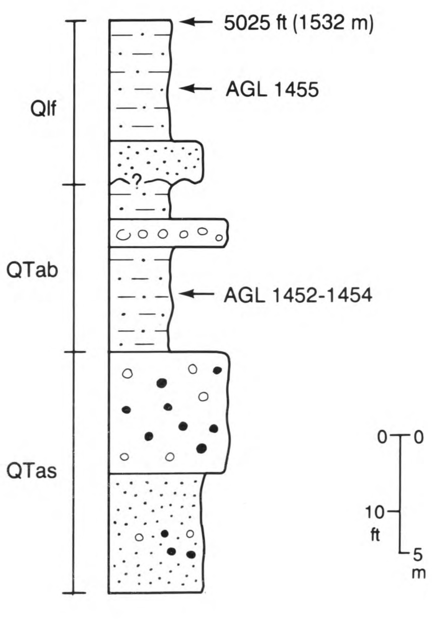

Figure 7. Measured section of deposits at locality G (table 2; see figure 6). The collection sites of amino-acid samples are shown (see table 1). Refer to figure 5 for explanation of symbols.

Figure 8. Photograph of eroded calcic soil profile developed in QTaf, which caps QTab south of Yuba Dam. The notebook and shovel blade are resting on the laminar horizon which overlies a tabular Km horizon. The shovel handle is 1.5 feet (0.5 m) long.

in alluvial fans and bajadas along the piedmonts on both sides of the long, interconnected valleys in the map area. The total thickness of the fan gravel is unknown but is probably hundreds of feet in many areas. The age of the young alluvial-fan deposit unit (Qaf) has not been determined directly, but its relative age can be determined by its relationships with other deposits whose ages are known. Deposits mapped as Qaf overlie both older fan gravel (QTaf) and deposits of Lake Bonneville (Qdf), and they are contiguous with alluvium of low-order streams (Qal) of Holocene age. Therefore, Qaf is inferred to be late Pleistocene to Holocene in age.

Alluvium of low-order streams (Qal): Alluvium of Holocene age in narrow valley floors of low-order streams and in broad valley bottoms, such as Scipio Valley and Round Valley, is shown as unit Qal. Qal is fine grained in most places, but locally contains a large amount of gravel. In most places the boundary between Qaf and Qal is mapped where the texture changes from the coarse-grained fan facies to the finer grained valley-bottom facies; gravel of active alluvial fans grades into sand and silt of Qal.

Silt and fine sand in Scipio Valley are mapped as unit Qal, although it is clear that the deposits have been reworked by the wind into low dunes, especially in the north end of the valley (these dunes cannot be mapped at the scale of plate 1). Deposits of Scipio Valley lake (see discussion under Quaternary deltaic sand) probably underlie Qal in Scipio Valley, but have not been observed. Qal is also seen in small fault-controlled valleys in the Valley Mountains.

Sevier River floodplain deposits (Qal_f): Fine-grained deposits of the Sevier River floodplain are depicted separately as Qal_f, even though they are essentially the same age as Qal. This is done to show the extent of influence of the Sevier River in Holocene time. The Sevier River floodplain widens northward from Yuba Dam to the north boundary of the map area. The entire floodplain is post-Lake Bonneville in age (Holocene), but it is narrow south of Chase Springs because in that area the river valley has formed in post-Bonneville time; north of Chase Springs the valley was widened prior to Lake Bonneville (see discussion under [Qdf] deltaic fines).

QUATERNARY DELTAIC DEPOSITS

Deltaic (estuarine) fines (Qdf): Fine sand, silt, and clay deposited in Lake Bonneville as an estuary fill along the Sevier River Valley are shown as Qdf. These deposits are over 60 feet (20 m) thick in the vicinity of Sevier Bridge Reservoir, and they cover an extensive area north of the reservoir where they are dissected to form "The Washboard." In most exposures the lower part of Qdf consists of ripple-laminated and cross-bedded medium sand that grades upward into fine sand and silt, thinly to massively bedded. The upper part of the sequence is silty clay (figure 9). The Qdf sequence, therefore, fines upward, and probably repre-

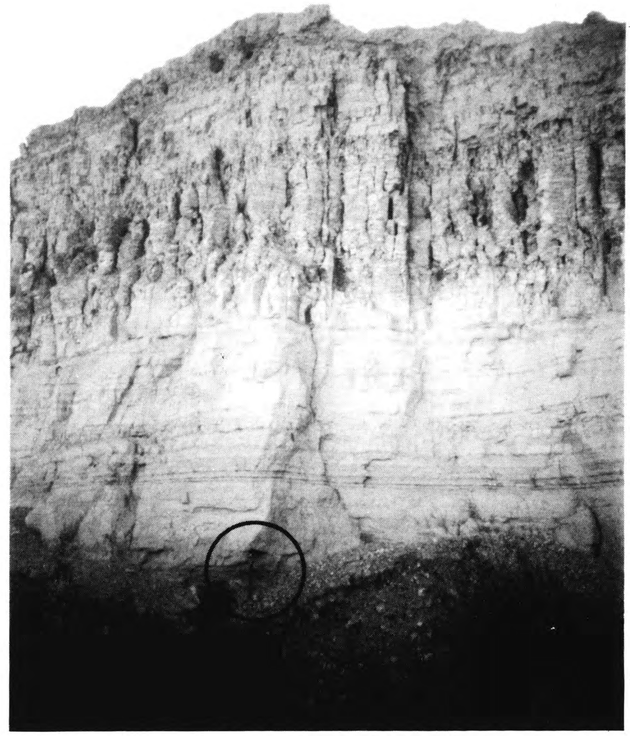

Figure 9. *Photograph of an exposure of deltaic fines (Qdf) on the south shore of Sevier Bridge Reservoir. The sequence consists of fine sand at the base of the exposure that grades upward into silt and then into silty clay (dark blocky material) at the top. Circled shovel handle is 1.5 feet (0.5 m) long.*

sents the transgression of Lake Bonneville to its highest level prior to the Bonneville flood (the catastrophic event that dropped the lake from its highest level to the Provo shoreline; figure 2).

The elevation of the highest outcrop of Qdf in the map area is about 5,075 feet (1,547 m), and the elevation of the Bonneville shoreline (the highest level of the lake) is about 5,115 feet (1,559 m). During the deposition of the youngest part of Qdf the water was about 40 feet (12 m) deep in the vicinity of Badeau Ridge (figures 10 and 11). During the rapid drawdown that occurred during the Bonneville flood, the Sevier River was let down across the southern end of Badeau Ridge where it cut a new course through the bedrock of the ridge and through the basin-fill deposits downstream from there. The former valley east of Badeau Ridge was abandoned (figures 10 and 11).

Deposits similar to Qdf have been mapped downstream from Mills Valley in isolated exposures through Leamington Canyon to the large delta complex at the mouth of the Sevier River west of the Canyon Mountains (Varnes and Van Horn, 1951, 1984, 1991; Oviatt, 1989; Pampeyan, 1989). Although there is evidence that the Qdf in the Sevier River delta area represents deposition in at least two deep lakes (Oviatt, 1989; Oviatt and others, 1991), Varnes and Van Horn (1991) suggest that most of the Qdf in that area is pre-Bonneville in age and part of the "Alpine Formation." In their view, the "Alpine Formation" is either early Wisconsin

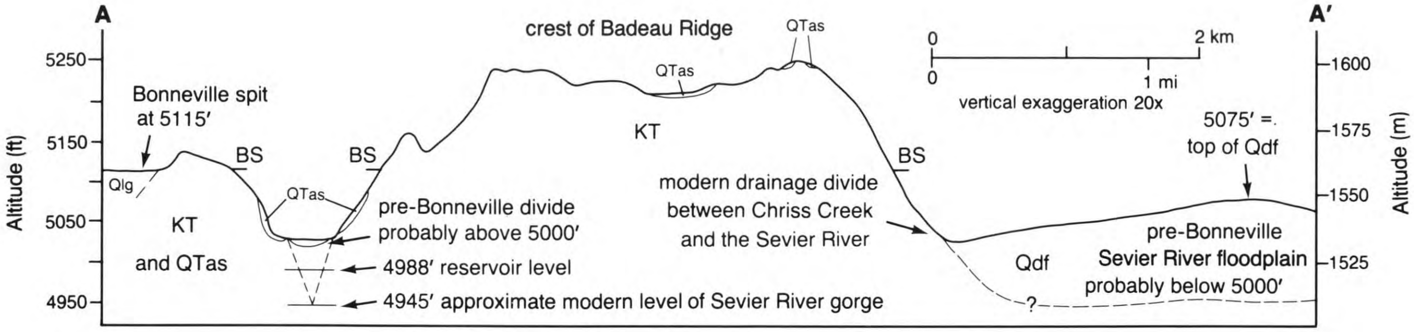

Figure 10. Topographic profile and schematic cross section along A-A' on the map in figure 11. The purpose of the diagram is to show how infilling of the valley east of Badeau Ridge by Qdf caused the Sevier River to be diverted across the southern end of the ridge as Lake Bonneville dropped during the Bonneville flood. BS = Bonneville shoreline.

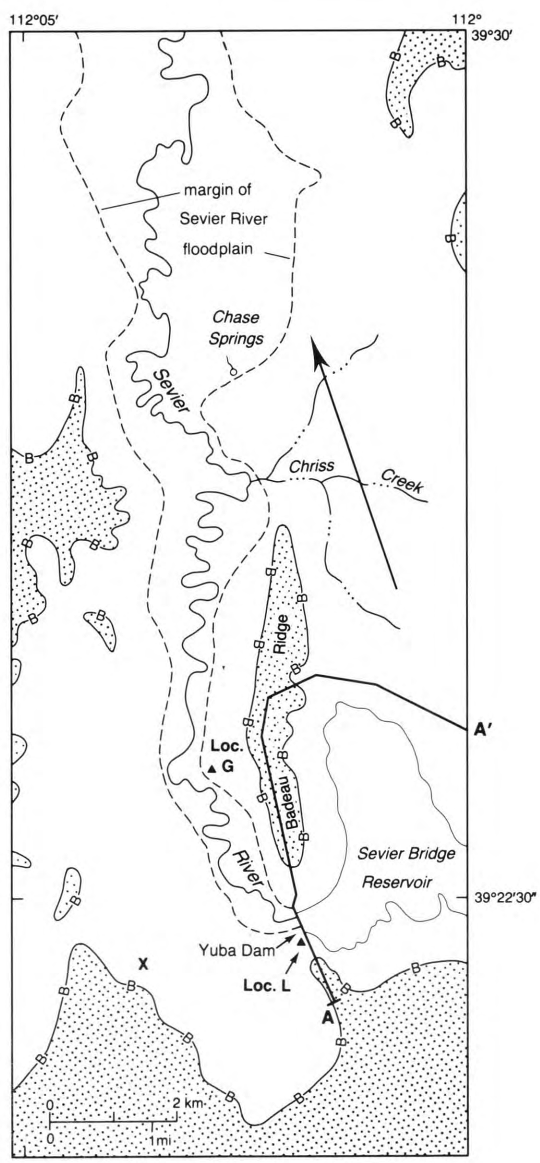

Figure 11. Location of cross section A-A' (figure 10) and other features related to the diversion of the Sevier River from its pre-Bonneville northward course (large arrow) to its post-Bonneville course across Badeau Ridge. Localities G and L (table 2), where remnants of Qlf are preserved, are shown. The "x" marks another Qlf locality. Areas above the Bonneville shoreline (B) are stippled.

or Illinoian in age, and represents deposition in a lake almost (within 90 feet [27 m]) as deep as Lake Bonneville. In Mills Valley, however, Qdf is clearly Bonneville in age as shown by three lines of evidence.

First, the Qdf in the area of plate 1 is at the top of the stratigraphic sequence (except for Holocene alluvium), and has a surface soil developed in it that is typical of post-Bonneville soils in this region (maximum of stage II carbonate morphology). Second, amino-acid ratios of three genera of mollusk shells collected from Qdf at locality I (table 2) all indicate a Bonneville age (W.D. McCoy, written communication, 1990). Third, the Pavant Butte basaltic ash (table 3; W.P. Nash, 1990, personal communication) is interbedded with Qdf at locality J (table 2). The Pavant Butte ash was erupted from Pavant Butte, about 35 miles (55 km) southwest of the collection site, about 15.5 ka when Lake Bonneville was within 50 feet (15 m) of the Bonneville shoreline (Oviatt and Nash, 1989).

Deltaic sand (Qds): One small patch of sand about 2.5 miles (4 km) west of Yuba Dam along Interstate 15 is mapped as Qds (locality K; table 2). The sand is exposed in a road cut along the I-15 frontage road, and consists of about 13 feet (4 m) of medium to coarse sand with some locally derived pebbles near the base. This basal unit is overlain by about 9.5 feet (2.9 m) of poorly sorted fine sand that has ripple laminations oriented to the north. The poorly sorted fine sand at the top of the sequence contains a thin bed of the Pavant Butte basaltic ash (table 3), and therefore is Bonneville in age. A calcic soil having stage II carbonate morphology is developed at the surface of the sand.

Unit Qds is interpreted as the remnant of a small delta that formed at the margin of Lake Bonneville by overflow from the shallow lake in Scipio Valley (Scipio Valley lake). Although Scipio Valley is now hydrologically closed, it has a well-defined outlet channel at its north end (locality N; table 2; figure 12) that leads directly downstream to the remnant of Qds. The outcrop of Qds is only a few feet below the Bonneville shoreline. Therefore, during the highest stage of Lake Bonneville, Scipio Valley lake was full and overflowing, and it was probably fed by runoff from the high mountains to the south.

Table 3.
Microprobe analyses of basaltic ash samples collected in the Scipio Valley area[1]

oxide	Locality J Qdf	Locality K Qds	Pavant Butte average[2]
Na_2O	3.49	3.43	3.45
MgO	5.23	5.44	5.22
Al_2O_3	15.55	15.69	15.62
SiO_2	49.85	49.61	49.93
P_2O_5	0.43	0.45	0.44
K_2O	1.21	1.15	1.23
CaO	8.31	8.52	8.48
TiO_2	1.83	1.91	1.71
MnO	0.20	0.20	0.20
FeO	12.15	11.54	11.90
H_2O	1.88	1.63	1.95
TOTAL	**100.13**	**99.57**	**100.13**

[1]Analyses by W.P. Nash, University of Utah
[2]Average of all available analyses of Pavant Butte ash; includes samples reanalyzed from Oviatt and Nash (1989), and other unpublished results.

Figure 12. Photograph of the outlet channel of Scipio Valley lake (near locality N; table 2). The channel is flat bottomed and sinuous, and probably represents erosion during multiple overflow events. Fine-grained alluvium (Qal) fills the channel now. View is to the south with the Valley Mountains in the background.

QUATERNARY LACUSTRINE DEPOSITS

Lacustrine gravel (Qlg): Well-sorted lacustrine gravel is preserved in several small areas near the Bonneville shoreline. In these places it forms spits and barrier beaches. The age of the lacustrine gravel is established by its relationship with the Bonneville shoreline (figure 2), which has been mapped regionally by Gilbert (1890) and Currey (1982), and which is well dated. The Bonneville shoreline is shown on plate 1 as a dashed line marked with a "B." Most lacustrine gravel is mapped south of the Sevier Bridge Reservoir, which is at the south end of what would have been an open bay in Mills Valley. Waves would have been relatively large due to the fetch in this area and were more likely to erode, transport, and deposit gravel.

Lacustrine fines (Qlf): Other lacustrine deposits in the area are shown as Qlf. These consist of calcareous mud preserved in three small outcrops in the vicinity of Yuba Dam (including localities G and L; table 2). At all three localities, the deposits are thin, less than 20 feet (6 m), and contain mollusks and ostracodes. Qlf overlies the basin-fill mud (QTab) or Sevier River sand (QTas) at all three localities, although the unconformity between Qlf and the older deposits is not clear-cut and is not marked by a buried soil (figure 6). Sedimentation in Lake Bonneville at these three localities was by settling out of fine clastics and precipitation of calcium carbonate in quiet, probably turbid water. The area west of Badeau Ridge was not directly affected by the high-sediment influx from the Sevier River, as was the case east of the ridge where Qdf was deposited. This is interpreted as evidence that the post-Bonneville course of the Sevier River on the west side of the ridge is new, and that prior to Lake Bonneville the Sevier River course was east of Badeau Ridge (figures 10 and 11).

Ostracodes were collected from two exposures of Qlf (at localities G and L; table 2). According to R.M. Forester (oral communication, 1990) the ostracodes from Qlf at locality G indicate that there was a direct connection with Lake Bonneville during deposition, and that the water was fresh and cold. Ostracodes from Qlf at locality L indicate that during deposition at this site the water had higher salinity and higher summer temperature than the water during deposition of Qlf at locality G, and that there was no direct connection with Lake Bonneville. Therefore, the Qlf at locality L is best thought of as a marginal-lacustrine facies related to the rise of Lake Bonneville, but deposited prior to inundation by the lake.

Amino-acid ratios of mollusk shells collected from Qlf at localities G and L (table 2) indicate that Qlf is Bonneville in age (table 1; W. D. McCoy, personal communication, 1990). The surface of the deposits at all three localities appears to have been eroded, and therefore no soil has been preserved.

QUATERNARY EOLIAN DEPOSITS

Eolian sand (Qes): A few small areas of eolian sand dunes are mapped in the northeastern part of the map area. The sand is derived from nearby exposures of Sevier River sand (QTas) or deltaic fines (Qdf). All sand dunes in this area are post-Lake Bonneville in age.

Eolian mud (Qem): One small area of eolian mud dunes or lunettes is mapped on the northeast shore of Scipio Lake. The dunes consist of pellets of mud that have blown off the floor or margins of Scipio Lake. They therefore suggest that, prior to damming by humans, Scipio Lake was a wetland area that was periodically wetted and dried. The eolian mud contains abundant fragments of snail shells that presumably were derived from snails living in the shallow lake. Although the mud dunes have not been dated directly, they are probably Holocene in age because they overlie a late Pleistocene to Holocene alluvial fan (Qaf).

QUATERNARY MASS-WASTING DEPOSITS

Slide deposits (Qms): One small landslide is mapped in the Valley Mountains just south of Cal Valley. The landslide is composed of Cretaceous/Tertiary rocks and straddles a late Quaternary fault on the margin of a small unnamed valley. It probably was initiated by oversteepening caused by movement on the fault. The age of the landslide has not been determined but is probably late Pleistocene to Holocene.

Colluvium (Qmc): Four small areas of colluvium are mapped in the compound glacial cirque in Robins Valley in the Pavant Range. The colluvium covers slopes in the cirque headwalls above the glacial deposits and is probably less than 30 feet (10 m) thick. It was deposited after melting of the glacial ice in the late Pleistocene. Other thin colluvial deposits are present in the Pavant Range, Valley Mountains, and Canyon Mountains, but are not shown on plate 1.

QUATERNARY GLACIAL DEPOSITS

Glacial till (Qgt): Glacial till is mapped in the compound cirque in Robins Valley in the Pavant Range. It consists of poorly sorted bouldery deposits forming well-developed moraines. Four small cirques fed a single valley glacier that extended down valley about 1.4 miles (2.3 km) from the cirque headwalls. The moraines are sharp crested and well preserved (figure 13), and they most likely are late Wisconsin (Pinedale) in age, although no numerical or relative dating has been attempted. These and other glacial deposits in the Pavant Range were mapped by Tucker (1954). The maximum thickness of till in Robins Valley is 260 feet (80 m) or less.

__Figure 13.__ Photograph of the end moraines in Robins Valley in the Pavant Range. Note the steep moraine front and the clearly defined hummocky crests indicating a probable Pinedale (late Wisconsin) age. View is to the north.

STRUCTURE

The Scipio Valley area is in the transition zone between the Basin and Range and the Colorado Plateaus physiographic provinces (Stokes, 1977), and it is approximately on the hingeline between the stable continent represented by the Colorado Plateaus to the east and the miogeocline to the west (Hintze, 1988). Therefore, the area has been affected by Sevier orogenic thrusting and basin and range normal faulting. The evidence for Quaternary normal faulting is widespread in the map area and consists of faults that cut rocks ranging in age from at least Cretaceous/Tertiary to Holocene. The pattern of faults mapped in this project is shown in figure 14, in which all the Quaternary/Tertiary and Quaternary units have been mapped as one unit. Only the faults that cut Quaternary deposits along at least part of their length are shown, although there are probably numerous parallel faults in the Cretaceous/Tertiary rocks in the Valley Mountains that are not shown. New bedrock mapping in this area is needed to fully delineate this complex fault zone.

Bucknam and Anderson (1979a, b) made reconnaissance studies of the Quaternary fault scarps in the area. They noted that most of the fault scarps are older than the Bonneville shoreline based on scarp morphology. However, some of the scarps in Scipio Valley and along the east front of the Pavant Range show evidence of both late Pleistocene and Holocene displacement events. The evidence for Holocene movement consists of an oversteepened, vegetation-free slope in the middle of some of the late Pleistocene scarps. Along the front of the Pavant Range a Holocene scarp is formed in many places between the Cretaceous/Tertiary bedrock and the valley alluvium (figure 15).

Bjorklund and Robinson (1968) describe elongate sinkholes in the fine-grained alluvium on the floor of Scipio Valley that they attribute to collapse into caverns that have formed along faults in the underlying bedrock. Some of the sinkholes were evident in the field during the summer of 1989, and they show up on aerial photographs as lineaments. On plate 1 and in figure 14 lineaments are shown with dashed lines without the bar and ball symbol because there is no apparent offset. Piping is undoubtedly an important process in the formation of the sinkholes, but it is unknown whether the sinkholes are connected in some way to faults at depth.

The cause of the Quaternary faulting in the area of plate 1 is probably basin and range extension. The fault traces form a consistent north-south pattern parallel to the major structures that define the mountain blocks. Although it is possible that salt deformation caused by dissolution or flowage of salt at depth in the Jurassic Arapien Shale (Witkind, 1982; Witkind and Marvin, 1989) has created some of the pre-Quaternary or Quaternary structures, there is no direct evidence for it in the map area.

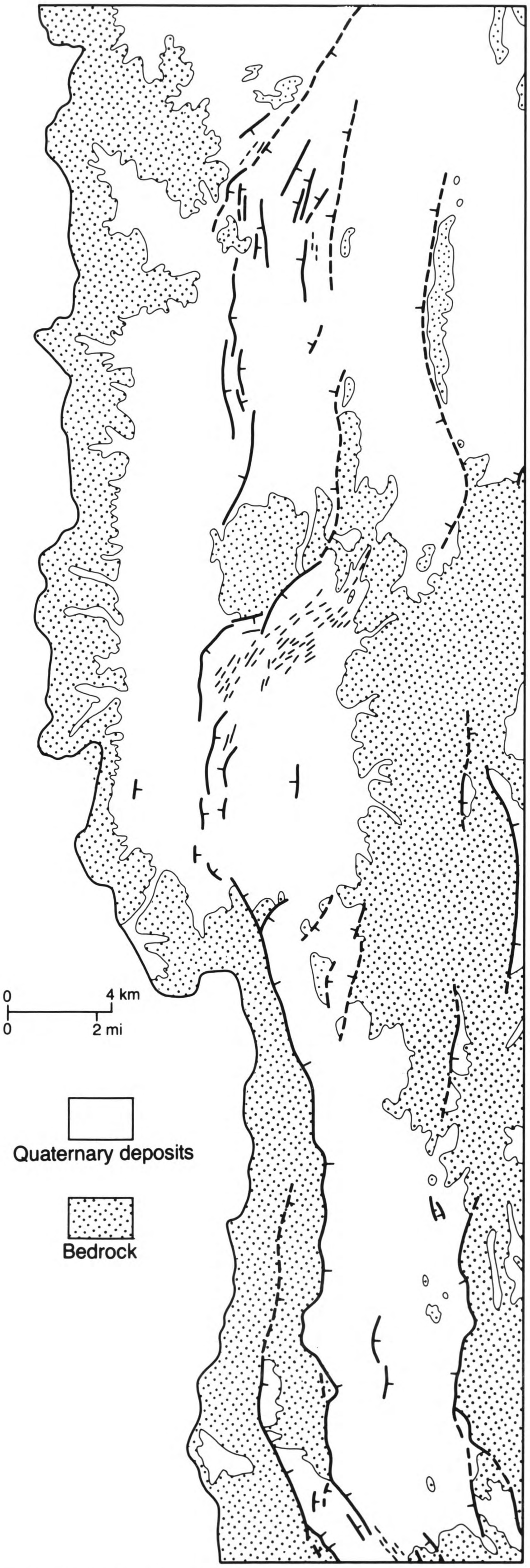

Figure 14. Faults in the valley fill in the area of plate 1. Known faults are shown by heavy lines with tick marks on the downthrown sides. Lineaments are shown by fine dashed lines. Inferred faults are shown by heavy dashed lines.

Figure 15. Photograph of a Holocene fault scarp at the base of the Pavant Range (locality O; table 2). The scarp (# 1) is at the contact between the Cretaceous/Tertiary bedrock and the Holocene fan gravel (Qaf; # 2). The juniper tree growing on the scarp on the left side of the photo is approximately 1.5 feet (0.5 m) in diameter. This and other trees growing on the scarp may have a record of prehistoric displacement events preserved in their rings.

LATE TERTIARY AND QUATERNARY HISTORY

The late Tertiary and Quaternary history of the map area is reviewed below in three sections: history of the Mills sedimentary basin; evaluation of the Sevier River capture hypothesis; and late Pleistocene and Holocene. The area has had a complex history during the last few million years, and the review below should be regarded as a first approximation because of the reconnaissance nature of the present investigation.

HISTORY OF THE MILLS SEDIMENTARY BASIN

As discussed above under the descriptions of QTas, QTab, and QTaf, deposited during the late Tertiary (Pliocene) to middle Pleistocene time, a sedimentary basin formed in the northern part of the map area. This basin is referred to in this report as the Mills basin. Late Tertiary and Quaternary deposits of the basin-fill sequence are probably at least 400 feet (120 m) thick (Bjorklund and Robinson, 1968, minimum estimated thickness of "Lake Bonneville Group" in Little Valley area), but the total thickness of basin fill is unknown. The sequence has been faulted and dissected, although the exposures are still relatively undeformed and there is much potential for detailed study to understand the history of development of what is probably a typical small back-valley basin on the edge of the Basin and Range Province. The basin is similar in tectonic setting and age to the Beaver basin 80 miles (130 km) to the southwest (Machette, 1985b).

Basin-fill deposits similar to the fine-grained (QTab) and coarse-grained (QTaf)facies have been mapped several miles east of the area of plate 1 (T.J. Felger, oral communication, 1989), but the limits of the basin have not yet been fully defined. Within the area of plate 1 the basin can be thought of as bounded by outcrops of QTaf in the northeast corner of the map.

The Mills basin probably formed in response to normal faulting associated with basin and range extension, although the hypothesis that salt diapirism and collapse (e.g., Witkind, 1982) were partly responsible cannot be completely rejected. In either case, the interior of the basin subsided relative to the surrounding highlands, and the basin filled with sediment derived from local sources and the Sevier River. Sevier River gravel (QTas) is exposed at as low an elevation as 4,940 feet (1,506 m) west and northwest of Yuba Dam, and as high as 5,250 feet (1,600 m) west of Mills. Although there are faults between these two exposures, it is clear that the Sevier River was actively depositing sediment in the basin, and that the basin was hydrologically open to a through-flowing Sevier River during the filling of the basin. Sand and gravel have been reported in a well log from Mills Valley to a depth of 465 feet (142 m) below the ground surface (Bjorkland and Robinson, 1968), or to an altitude (in the subsurface) of 4,495 feet (1,370 m). The composition of the sand and gravel, however, is unknown, so it is not possible to infer that the gravel was deposited by the Sevier River.

Areas adjacent to the river must have been perennially wet from the Sevier River, but the red to pink color, high carbonate content, and suggestions of multiple weak calcic soil profiles within the fine-grained facies (QTab) indicate that the interior of the Mills basin was arid or semiarid. Lenses of calcareous silty clay containing mollusks and ostracodes typical of marsh or spring habitats within the generally massive and sandy fine-grained facies suggest that springs were common marginal to the river in the lower part of the basin.

EVALUATION OF THE SEVIER RIVER CAPTURE HYPOTHESIS

Costain (1960) and Oviatt (1987) have suggested that the Sevier River formerly flowed northward through Juab Valley, instead of turning westward around the north end of the Canyon Mountains in its modern course. Presumably the former path was eastward through Mills Gap where Chicken Creek, which is an underfit stream, now flows. According to the hypothesis, for some reason the Sevier River was diverted over a low divide west of Mills and into Leamington Canyon. The causes of the diversion have been postulated to be the growth of a large alluvial fan across the former path of the Sevier River in Juab Valley, and headward erosion in Leamington Canyon. The geomorphic evidence for this is fairly strong (Oviatt, 1987), but alternative interpretations are possible. Evidence gathered in this study that has a bearing on the hypothesis is reviewed below, and an alternative hypothesis is presented.

The filling of the Mills sedimentary basin is consistent with the capture hypothesis, although it is not sufficient in itself to permit acceptance of the hypothesis, and other evidence shows that the capture is unlikely. Filling of the basin while the Sevier River was continuously through-flowing might be interpreted as evidence of slow damming of the Sevier River downstream from the basin. Damming could have been caused by several possible mechanisms: faulting, landsliding, rapid growth of an alluvial fan across the course of the river, or possibly other mechanisms. Although there is a large fan in Juab Valley that could have formed a dam, other available evidence does not support the fan hypothesis. No evidence of landsliding at any appropriate location is known. Faulting is a sufficient hypothesis to explain the origin of the Mills basin and, as outlined below, it also explains the geomorphic features that have been interpreted as evidence for river capture.

The large fan in Juab Valley that Oviatt (1987) postulated could have formed a dam across the Sevier River is the Four Mile Creek fan. It is formed of alluvium from steep drainages on the west flank of the San Pitch Mountains and has strongly developed calcic soils (stage III?) at its surface. If it had formed the dam at the mouth of the Mills basin, it should have deposits similar to the basin-fill mud (QTab) and Sevier River gravel (QTas) interfingering with the fan gravel. However, no Sevier River gravel has been found in the vicinity of Mills Gap in this mapping project, nor has any been found in reconnaissance investigations in Juab Valley south of the Four Mile Creek fan. This is strong (negative) evidence that the fan hypothesis, and therefore the capture hypothesis, should be rejected. The possibility that Sevier River gravel is present in buried positions in Juab Valley cannot be rejected without further testing, but it seems unlikely because deposits equivalent to those shown as QTab and QTaf are well exposed east of Mills Gap in the Skinner Peaks quadrangle, and no Sevier River gravel has been found there.

An alternative to the capture hypothesis involves a scenario of faulting, basin filling, and basin dissection. Just north of the area of plate 1 the Sevier River exits Mills Valley on the northwest side by way of a narrow canyon entrenched into the lower part of a pediment cut in Tertiary volcanic rocks, which are probably part of the Goldens Ranch Formation (T.J. Felger, oral communication, 1990). This area is interpreted as being close to the hypothesized drainage divide between Mills Valley and Leamington Canyon in the capture hypothesis (figure 16; Oviatt, 1987), but alternatively may represent the outlet of the Sevier River from the Mills basin for its entire history. The volcanic rocks at the outlet consist of at least 80 feet (24 m) of weathered tuff overlain by about 60 feet (20 m) of coarse boulder conglomerate composed of volcanic clasts (figure 17). Sevier River gravel overlies the boulder conglomerate and the contact between the two gravels has an elevation of about 5,080 feet (1,550 m). Sevier River gravel is exposed on the ridge above this contact to about 5,230 feet (1,595 m) (figure 17). Exposures on the east side of the valley along this cross section show that the weathered tuff is overlain by the coarse con-

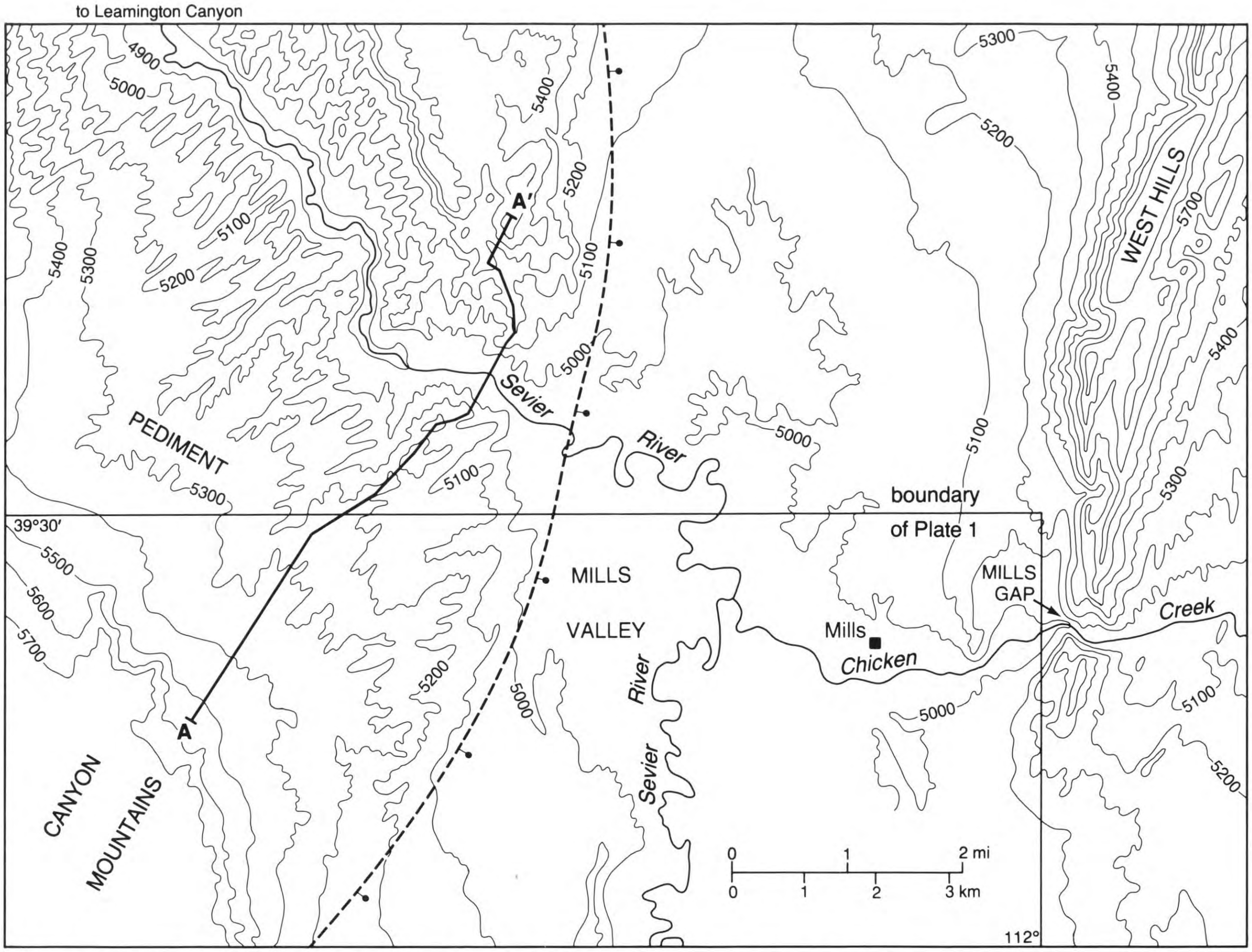

Figure 16. The outlet of the Sevier River from the Mills basin. Profile and cross section A-A' are shown in figure 17. The heavy dashed line represents the trace of an inferred fault along the western margin of the Mills basin. Modified from Oviatt (1987, figure 2).

glomerate, which includes finer grained volcaniclastic sediments. The volcaniclastics are overlain by a sequence of welded tuffs, all of which may be part of the Goldens Ranch Formation of Oligocene age (T.J. Felger, oral communication, 1990).

It seems probable that this area has always been the outlet for the Sevier River, and that the river had eroded the upper part of the volcanic sequence in the outlet area during or before the formation and filling of the Mills basin. In this hypothesis the Sevier River continuously flowed out through Leamington Canyon, while the Mills basin was subsiding and filling with sediments. While the Sevier River flowed out of the basin over the resistant volcanic rocks, it maintained a relatively constant, to rising, base level and allowed a pediment to form on the flank of the Canyon Mountains (stippled area on plate 1). Sevier River gravel (QTas) apparently interfingers with and overlies pediment gravel (figure 17), suggesting that the river was agrading above the threshold elevation for part of its history. The major fault controlling subsidence in the Mills basin runs along the west side of Mills Valley at the base of the pediment (dashed line in figure 16).

Other geomorphic features in the area are also explained by this hypothesis. Chicken Creek was probably always tributary to the Sevier River and became superimposed over the south end of the West Hills when the basin was full of sediment (figure 16). With the lowering of base level and dissection of the Mills basin, Chicken Creek was lowered through the West Hills to form Mills Gap. The cause of downcutting was probably headward erosion in Leamington Canyon, which eventually would have caused the Sevier River to cut through the welded tuff and coarse conglomerate in the outlet area and into the nonresistant weathered tuff. Downcutting through the weathered tuff would have been rapid and would have caused the Sevier River and its tributaries to dissect the Mills basin sedimentary fill and the pediment on the flank of the Canyon Mountains (stippled area on plate 1; figure 16).

The above hypothesis explains the development and subsequent dissection of the Mills basin, and explains the geo-

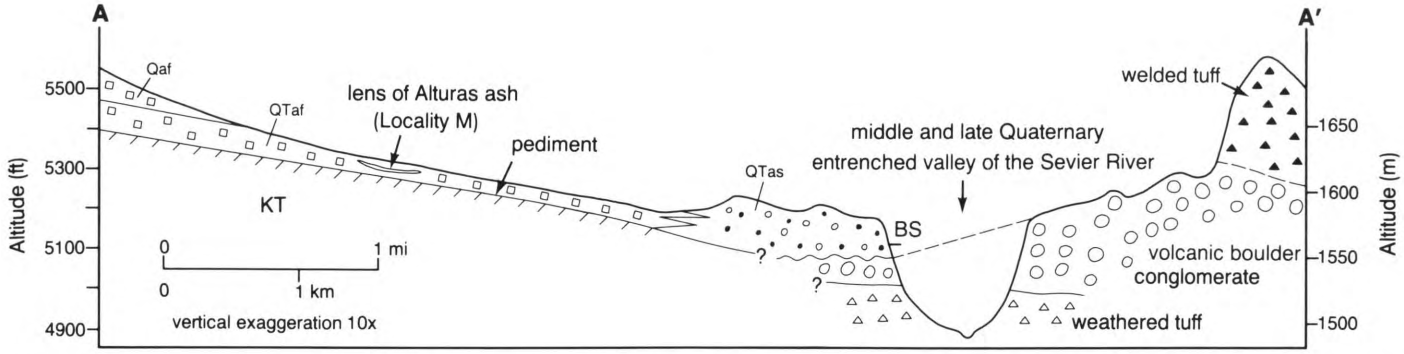

Figure 17. *Schematic and generalized cross section along line A-A' shown in figure 16. The diagram shows the relationships between QTas, QTaf, and the older Tertiary volcanic rocks. See the text for further discussion. BS = Bonneville shoreline.*

morphic features that had previously been interpreted as evidence for river capture (i.e., Mills Gap, Canyon Mountains pediment, entrenchment at the outlet from Mills Valley). It is also simpler and fits better with the evidence from Juab Valley. The geochronometric data collected for this study indicate that the Canyon Mountains pediment formed during the late Tertiary, and that basin filling continued into at least the middle Pleistocene.

LATE PLEISTOCENE AND HOLOCENE

Late Pleistocene events in the map area consist of erosion, faulting, the transgression of Lake Bonneville, the overflow of Scipio Valley lake, and the advance of the Pinedale glacier in Robins Valley in the Pavant Range. Dissection of the Mills basin may have begun in the middle Pleistocene and has continued to the present. Faulting has probably been continuous through this time period as well. Although the Mills basin area is being degraded, other parts of the map area, such as Scipio Valley and Round Valley, are still accumulating sediment, and are being downfaulted relative to the adjacent mountain blocks.

With the transgression of Lake Bonneville into the Mills Valley area about 15 ka, the former course of the Sevier River east of Badeau Ridge was filled with fine-grained deltaic (estuarine) sediment, and the Sevier River was diverted to its present course west of Badeau Ridge (figures 10 and 11). No evidence for the Keg Mountain oscillation (Currey and Oviatt, 1985) or of other high-level oscillations of Lake Bonneville has been found in the Lake Bonneville deposits in the Mills Valley area.

The Robins Valley glacier probably advanced to its maximum down-valley position about 20 ka, if its timing was similar to the timing of glaciers in the Wasatch Range (Madsen and Currey, 1979; Scott and others, 1983). Scipio Valley lake may have been overflowing during this entire period, but it is clear that it was definitely overflowing during the maximum stage of Lake Bonneville (see discussion under Quaternary deltaic sand (Qds)).

The Holocene history of the area is one of continued erosion in the Mills basin area, alluvial deposition throughout much of the rest of the area, and continued faulting in Scipio Valley and along the Pavant Range. The Sevier River has constructed a floodplain and some low terraces during the Holocene.

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Base map from U.S. Geological Survey, Delta, Utah, 30 x 60 minute series, 1980.

Field mapping by author in 1989
Lori J. Douglas, Cartographer

PLATE 1
UTAH GEOLOGICAL SURVEY SPECIAL STUDY 79
QUATERNARY GEOLOGY OF THE SCIPIO VALLEY AREA, MILLARD AND JUAB COUNTIES, UTAH

by

Charles G. Oviatt

1992

SYMBOLS

CONTACT; dashed where inferred; dotted where concealed

FAULTS; bar and ball on downthrown side; dashed where inferred; dotted where concealed (only those faults in bedrock that also cut Quaternary deposits are shown)

PEDIMENT; stippled area represents a pediment cut in Cretaceous/Tertiary bedrock and overlain by QTaf

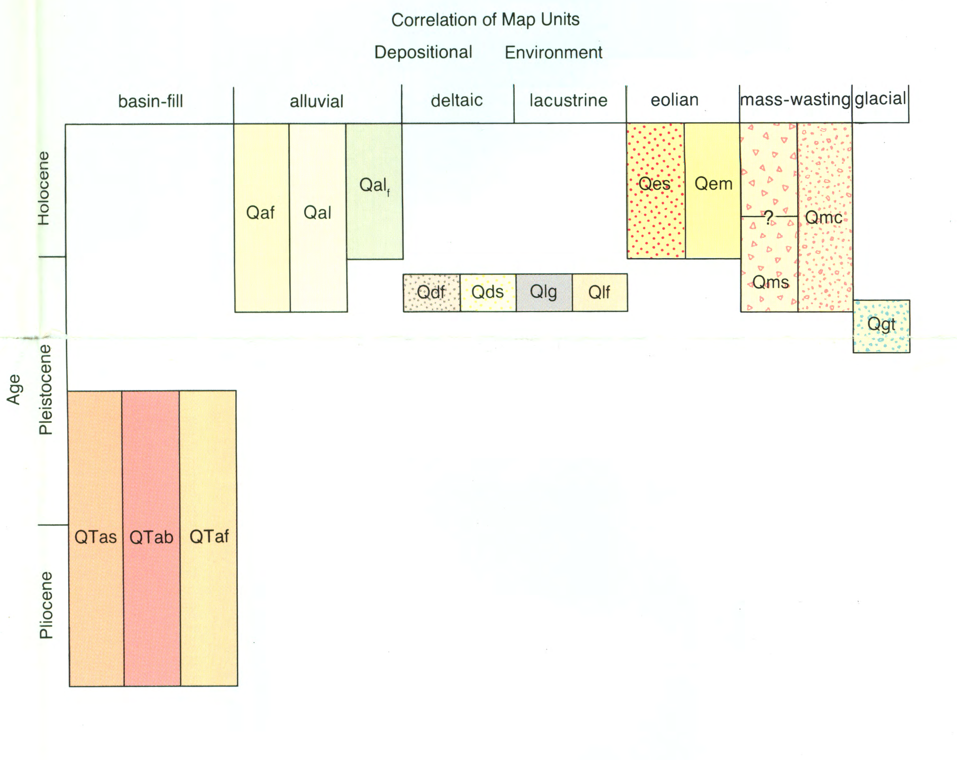
BONNEVILLE SHORELINE; dotted where concealed by younger deposits

SINKHOLE LINEAMENTS in Scipio Valley

MORAINE RIDGE CRESTS in Robins Valley

A ● LOCALITY listed in table 2 and discussed in text

Correlation of Map Units



PRE—QUATERNARY ROCKS

P — PALEOZOIC AND PRECAMBRIAN ROCKS, UNDIVIDED — *Paleozoic and Precambrian rocks in the Canyon Mountains and north end of the Pavant Range mapped as one unit.*

KT — UPPER CRETACEOUS AND LOWER TERTIARY ROCKS, UNDIVIDED — *Upper Cretaceous and lower Tertiary rocks mapped as one unit.*

TERTIARY/QUATERNARY DEPOSITS

QTas — SEVIER RIVER SAND AND GRAVEL — *Well to moderately sorted sand and gravel deposited by the Sevier River; gravel clasts mostly pebbles of volcanic rocks, black chert, and sedimentary rocks derived from upstream in the Sevier River basin; 0 to over 20 feet (6 m) in thickness; interfingers with QTab and QTaf; Pliocene to early Pleistocene in age.*

QTab — BASIN-FILL MUD AND SAND — *Poorly sorted calcareous sand and silt to silty clay; reddish-brown to light-gray; 0 to over 80 feet (25 m) thick; interfingers with QTas and QTaf; fine-grained basin-floor (mud flat) deposits; contains lenses of silicic volcanic ash; Pliocene to early Pleistocene in age.*

QTaf — OLD ALLUVIAL-FAN DEPOSITS — *Coarse-grained, poorly sorted, and dissected alluvial-fan deposits composed of locally derived rock types (sedimentary rocks); 3 feet (1 m) to over 50 feet (15 m) thick; interfingers with QTas and QTab; bears stage IV calcic soil at relict surfaces; Pliocene to early Pleistocene in age. Stippled area indicates Cretaceous/Tertiary bedrock underneath.*

QUATERNARY ALLUVIAL DEPOSITS

Qaf — YOUNG ALLUVIAL-FAN DEPOSITS — *Poorly sorted pebble to boulder gravel in alluvial fans in piedmont slopes; composed of locally derived rock types; 0 to probably hundreds of feet thick locally; late Pleistocene to Holocene in age.*

Qal — ALLUVIUM OF LOW-ORDER STREAMS — *Fine-grained, poorly sorted alluvium in ephemeral stream valleys and on the floor of Scipio Valley; thickness variable and probably less than 20 feet (6 m) in most places, but possible over 100 feet (30 m) in Scipio Valley; late Pleistocene to Holocene in age.*

Qal_f — SEVIER RIVER FLOODPLAIN DEPOSITS — *Fine-grained deposits of the Holocene Sevier River; total thickness unknown, but up to 10 feet (3 m) are exposed; late Pleistocene to Holocene in age.*

QUATERNARY DELTAIC DEPOSITS

Qdf — DELTAIC (ESTUARINE) FINES — *Fine sand, silt, and clay; thinly bedded to cross bedded; forms a fining upward sequence over 60 feet (20 m) thick; deposited in the Sevier River estuary of Lake Bonneville about 15 thousand years ago.*

Qds — DELTAIC SAND — *Moderately sorted, medium to fine sand in one small patch about 2.5 miles (4 km) west of Yuba Dam along I-15; contains Pavant Butte basaltic ash (15.5 ka), and was deposited at the margin of Lake Bonneville by overflow from Scipio Valley lake.*

QUATERNARY LACUSTRINE DEPOSITS

Qlg — LACUSTRINE GRAVEL — *Sandy gravel composed of locally derived rock fragments; beach or spit gravel deposited in Lake Bonneville.*

Qlf — LACUSTRINE FINES — *Calcareous mud containing ostracodes and mollusks; found in three small patches west of Yuba Dam; deposited in Lake Bonneville at its highest stage.*

QUATERNARY EOLIAN DEPOSITS

Qes — EOLIAN SAND — *Well-sorted sand in dunes in the northern part of the area; Holocene in age.*

Qem — EOLIAN MUD — *One small area of poorly sorted mud pellets in a low dune on the northeast side of Scipio Lake in Round Valley; contains fragments of mollusks; probably less than 10 feet (3 m) thick; Holocene in age.*

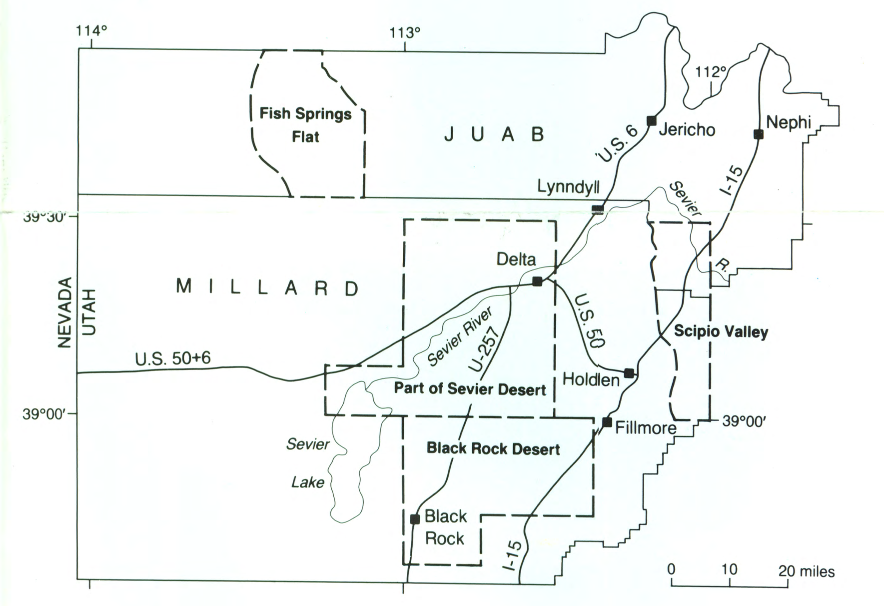
QUATERNARY MASS-WASTING DEPOSITS

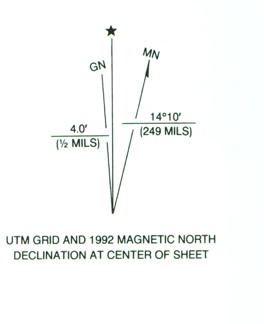
Qms — SLIDE DEPOSITS — *One small landslide in the Valley Mountains just south of Cal Valley; poorly sorted bouldery debris; thickness unknown, but probably less than 50 feet (15 m); late Pleistocene to Holocene in age.*

Qmc — COLLUVIUM — *Four small areas of poorly sorted bouldery colluvium in the compound cirque in Robins Valley in the Pavant Range; thickness probably less than 20 feet (6 m); late Pleistocene and Holocene in age.*

QUATERNARY GLACIAL DEPOSITS

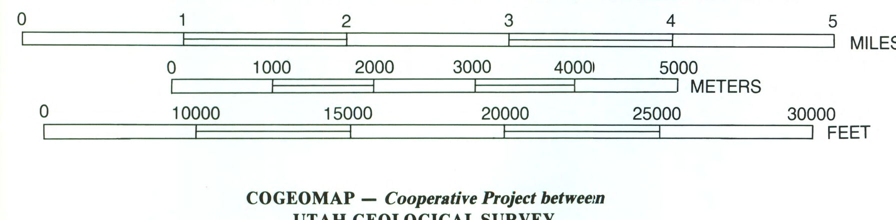
Qgt — GLACIAL TILL — *Poorly sorted bouldery deposits in moraines in Robins Valley in the Pavant Range; thickness over 100 feet (30 m); late Pleistocene (Pinedale) in age.*





UTM GRID AND 1992 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:62,500



COGEOMAP — *Cooperative Project between*
UTAH GEOLOGICAL SURVEY
Utah Department of Natural Resources, *and*
THE UNITED STATES GEOLOGICAL SURVEY