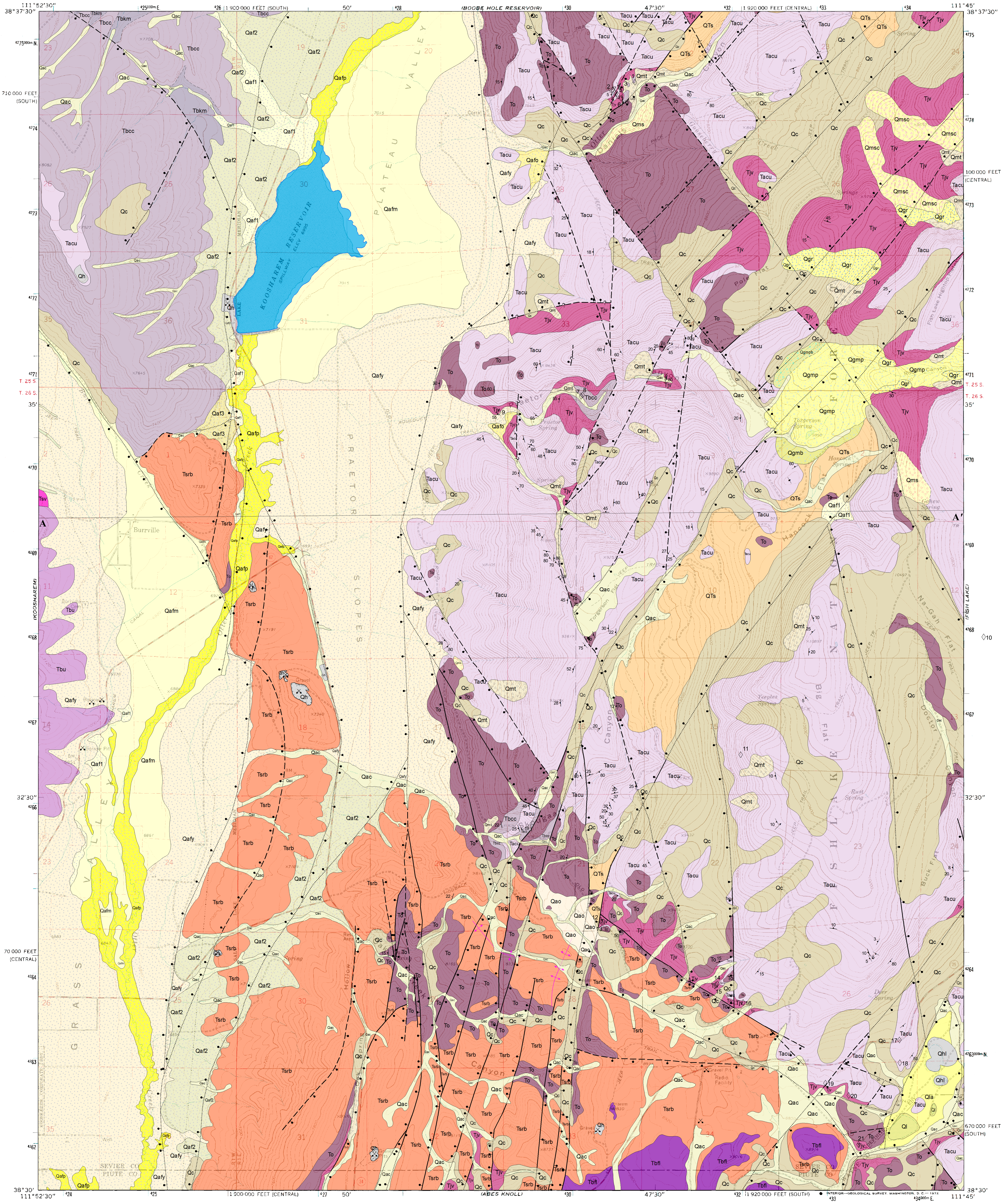
UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources



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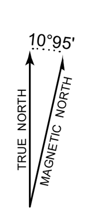


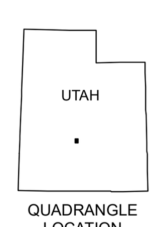
APPROXIMATE MEAN DECLINATION, 2019

SCALE 1:24,000
1 0.5 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 0.5 0 1 KILOMETER
CONTOUR INTERVAL 40 FEET

INTERIM GEOLOGIC MAP OF THE BURRVILLE QUADRANGLE, SEVIER AND PIUTE COUNTIES, UTAH

by
Grant C. Willis and Hellmut H. Doelling

2019



QUADRANGLE LOCATION

Base from USGS Burrville 7.5' Quadrangle (1968)
Projection: UTM Zone 12
Datum: NAD 1983
Spheroid: GRS 80

Project Manager: Robert F. Biek
GIS and Cartography: Zachary W. Anderson and Martha L. Jensen

Utah Geological Survey
1594 West North Temple, Suite 3110
Salt Lake City, UT 84116
(801) 537-3300
geology.utah.gov

This map was created from geographic information system (GIS) data.

1	2	3
4		5
6	7	8

1.Water Creek Canyon
2.Boobe Hole Reservoir
3.Mount Terrill
4.Koosharem
5.Fish Lake
6.Greenwich
7.Abes Knoll
8.Loa

ADJOINING 7.5' QUADRANGLE NAMES

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UTAH DNR GEOLOGICAL SURVEY

OPEN-FILE REPORT 696
UTAH GEOLOGICAL SURVEY
a division of
UTAH DEPARTMENT OF NATURAL RESOURCES
2019

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OVERVIEW

This interim geologic map of the Burrville 7.5′ quadrangle in eastern Sevier and northernmost Piute Counties is part of a project to map the western half of the Salina 30′ x 60′ quadrangle, which in turn is part of a long-term project to produce geologic maps and geographic information system (GIS) databases of the entire state (about 33 of the 46 of the 30′ x 60′ quadrangles are completed, and several are in progress).

The Burrville 7.5′ quadrangle is in the High Plateaus area of central Utah. The northeast side of the quadrangle is dominated by the west nose of Fish Lake Hightop Plateau ("Hightop" to locals) at an elevation of 11,260 feet (3432 m) (11,639 feet [3548 m] just outside the quadrangle), and the southeast flank of Mormon Mountain in the northwest corner. Several ridges and intervening flats at intermediate elevations, and Plateau and Grass Valleys at elevations of about 6840 to 7000 feet (2085–2140 m), provide important cattle and sheep grazing, minor farming, wildlife habitat, and popular recreational areas. The southern end of Fish Lake Valley cuts across the southeast corner (Fish Lake is just east of the quadrangle). Grass and sagebrush dominate low areas, with pinyon, juniper, oak brush, and scrub mahogany on intermediate slopes. Spruce, fir, pine, and aspen flourish at higher elevations, with a few scraggly fir and pine trees near timberline on Hightop. Otter Creek flows southward through Plateau and Grass Valleys and is dammed to form Koosharem Reservoir.

The quadrangle is on the northeast edge of the Marysvale volcanic field and map units consist of volcanic and volcaniclastic rocks derived from pyroclastic volcanoes and calderas in the center of the field 10 to 20 miles (16–30 km) to the southwest. The major capping unit is the Osiris Tuff, an easily recognized, regionally extensive, lithologically uniform, massive, welded tuff derived from the Monroe Peak caldera a few miles southwest of the quadrangle (Cunningham and others, 1983, 2007; Rowley and others, 1986). Most underlying units are considered part of the Bullion Canyon Volcanics. Two widespread welded volcanic units are informally, and probably temporarily, called the latite of Johnson Valley (Tjv) and the tuff of Albinus Canyon and related units (Tacu). Ongoing regional studies will likely tie these units to named units to the west (see discussion in Bullion Canyon Volcanics unit description). These units have layering suggesting derivation from multiple eruptions of stratovolcanoes or other vents.

Thick, highly variable, crudely stratified volcaniclastic deposits (Tbcc) locally underlie and intertongue with the three primary volcanic units. These volcaniclastic deposits were derived from the Marysvale volcanic field and consist of alluvial sediment, debris-flow deposits, weakly to strongly lithified volcanic breccias, and minor ash-flow and air-fall tuffs. The deposits are weakly lithified and generally form poorly exposed, nondescript colluvium- and brush-covered slopes. This unit grades downward into a related volcaniclastic interval, the Kings Meadow member (Tbkm). These two volcaniclastic units are separated by the Three Creeks Tuff Member in areas to the northwest, but the Three Creeks is not exposed in this quadrangle, therefore the intervening contact is questionable. Two units, lava flows of Burrville (Tbu) and volcanic rocks of Signal Peak (Tsv), mapped and described in the Koosharem quadrangle to the west (Rowley and others, 1986) extend slightly into the quadrangle. We are conducting regional mapping and acquiring geochemical and age analyses that are revising ages, sources, and correlations of volcanic units.

Collectively, the volcanic and volcaniclastic units are up to about 1200 feet (370 m) thick, but each unit is highly variable, ranging from locally absent to a few hundred feet thick. Most volcanic and volcaniclastic units thin eastward and some are not present in the eastern part of the quadrangle (cross section A-A′), suggesting deposition in a valley and lapping against a highland; however, the latite of Johnson Valley thickens eastward. The tuff of Albinus Canyon and related units thin rapidly southward in the southern part of the quadrangle and are missing near the southern border, though they are present in some areas farther south where Biek and others (2015a) mapped them as the informally named trachyte of Lake Creek. Abrupt thickness changes suggest deposition over significant paleotopographic relief, or possible faulting with differential erosion, prior to emplacement of the final and most distinctive widespread unit in the area, the Osiris Tuff (To).

Thick basin fill of the informal Burrville member of the Sevier River Formation (Tsrb) comprises hills in the southern half of the quadrangle. The distal edge of a basalt flow that interfingers with the Burrville member (Tbfl) extends into the southern part of the quadrangle; the vent may be within the Burrville quadrangle but its location is uncertain (Biek and others, 2015a). Very poorly exposed, unnamed Quaternary-Tertiary sediments (QTs) that are probably partially correlative with the Burrville member are preserved in two grabens in the northern and central parts of the quadrangle. All of these deposits are cut by young normal faults.

The quadrangle is extensively mantled by surficial cover of colluvium and a few landslides in the sloping areas and thicker alluvial fill in Plateau and Grass Valleys, canyons, flats, and hollows. Glacial and rock glacier deposits are present at high elevations in the northeast part of the quadrangle. Colluvium is nearly ubiquitous over the volcanic and volcaniclastic units. We have only mapped the larger and more contiguous surficial deposits. In general, we have tried to "see through" the extensive colluvial and vegetative cover to show the underlying bedrock units, but bedrock exposures are rare, probably comprising less than 10 percent of the total mapped area.

Structurally, the Burrville quadrangle is part of the High Plateaus of central Utah, an area noted for high, generally north-south-trending plateaus and deep, wide valleys that form a transition zone between the extensively faulted Basin and Range Province to the west and relatively unfaulted Colorado Plateau to the east. The plateaus and basins were created by generally high-angle normal faults, some of which have scarps that displace Holocene sediment, though no Holocene scarps have been recognized in this quadrangle. South of the quadrangle, a well-defined north-northeast-trending fault zone bounds the west side of the Awapa Plateau and the east side of Grass Valley (Biek and others, 2015a, 2015b). Near the southern Burrville quadrangle boundary the fault zone begins to splay or "horsetail." As these faults enter the quadrangle, the splays merge into northeast- and northwest-trending block faults that bound several large linked conjugate horsts and grabens. Grass, Plateau, and Fish Lake Valleys are three of the larger grabens. These linked faults extend through adjacent quadrangles north, east, and west of the quadrangle. Fish Lake Valley is a deep closed graben depression that hosts a scenic, large, high-elevation lake. The Osiris Tuff provides the best control on the amount of displacement on these faults. For example, the tuff caps Fish Lake Hightop at 11,639 feet (3548 m) just east of the quadrangle but is present in Grass Valley at an elevation of about 6930 feet (2112 m), as well as in the floor of most intermediate-level grabens.

We have not been able to unequivocally identify displacement of Holocene or latest Pleistocene sediment in the quadrangle. Nevertheless, perched benches, out-of-gradient streams, steep slopes, local closed or mostly closed depressions, and beheaded or abandoned streams all suggest that the faults have probable Quaternary displacement and may be capable of generating significant earthquakes.

Folds include a large monocline expressed in the 23 Ma Osiris Tuff and older layered rocks and small shallow faulted anticlines expressed in the Burrville member. Rocks in the monocline are tilted 20° to 30° westward in the central and northern part of the quadrangle, and southwestward to southward in the southern part, though the monoclinal axis is faulted and poorly defined and not shown on the map. The younger Burrville member seems to have been involved in the monoclinal folding though exposures are not ideal to confirm this. Farther south in the adjacent Abes Knoll quadrangle, equivalent strata mapped as Sevier River Formation dip moderately west as part of a monocline (Biek and others, 2015a). However, these may not be the same structures as they are separated by faults and strata with different dips. Judge (2007) and Doelling and Willis (2016) described large monoclinal folds to the north that primarily involve older strata.

Relating structures in the Burrville quadrangle to regional structures is a challenge. Conjugate faults trend northeastward into the Fish Lake-Fremont River fault system (Bailey and others, 2007) and northwestward into the Sevier fault system near Richfield, the primary basin-and-range boundary fault of central Utah (Hintze and others, 2003). Thus, the quadrangle area seems to be in a zone of reorganization and linkage between different basin-and-range structural regimes north, south, and west of the quadrangle. The monoclinal westward tilt may be related to gravity-driven "withdrawal" of weak Jurassic Arapien Formation and overlying units from beneath the high plateaus as proposed by Cline and Bartley (2007), but we have not been able to confirm this hypothesis.

Road fill and gravel are the only geologic resources known to have been extracted from the quadrangle, though the recently discovered Covenant oil field is located just a few miles to the northwest (Chidsey and others, 2007). Due to high elevations with high precipitation, the quadrangle is part of a major watershed for several important streams and valleys in central Utah. The water table is at or near the ground surface in the lower parts of Plateau and Grass Valleys. The Utah Geological Survey website provides general and area-specific information on geologic resources in Utah (geology.utah.gov).

Geologic hazards present a significant risk in the area, though it is sparsely populated. Several faults may have undergone middle to late Quaternary displacement and present a significant but unquantified earthquake risk. Some landslides have been mapped and others are probably present on moderate and steep slopes but are difficult to identify due to heavy forest cover and lack of lidar imagery. Slope creep, rockfalls, clay-bearing soils and rock, and expansive or collapsible soils may present some risk. Volcanic and volcaniclastic rocks in the area may also produce radon gas, a known carcinogen. Significant colluvial and alluvial cover in the area may yield large debris flows and mass wasting during or after heavy rains and/or rapid spring snowmelt. The Utah Geological Survey website provides general and area-specific information on geologic hazards in Utah (geology.utah.gov).

Williams and Hackman's (1971) Salina 1° x 2° quadrangle (1:250,000-scale) is the only previous local or regional geologic map that covers the quadrangle. Doelling and Kuehne (2016a) mapped the east half of the Salina 30′ x 60′ quadrangle. Biek and others (2015a) are mapping the Loa 30′ x 60′ quadrangle to the south. Adjacent 7.5′ quadrangles were recently mapped and are being prepared for publication as part of our Utah Geological Survey project to map the entire Salina 30′ x 60′ quadrangle (figure 1). Papers by Rowley and others (1994, 1998, 2002) and Cunningham and others (1983, 1998, 2007) were useful in identifying and mapping volcanic units, and work by Anderson and Barnhard (1992), Chidsey and others (2007), Cline and Bartley (2007), and Schelling and others (2007) was useful for understanding the structure and regional tectonics.

ACKNOWLEDGMENTS

We appreciate Bob Biek, Stephanie Carney, and Mike Hylland of the UGS, who reviewed this document, and Paul Kuehne, who assisted in mapping adjacent quadrangles to the north and northwest and helped establish stratigraphic units and structural concepts continued in this quadrangle.

DESCRIPTION OF MAP UNITS

QUATERNARY

Human-derived units

Qh **Fill and disturbed ground** (Historical) – Gravel, storage piles, fine-grained material (rejected from gravel screening), and exposed older deposits in and near excavated pits; fill was mostly used for road and dam construction, including road base for State Highways 24 and 62 and county roads; most road fill, dams for small stock ponds, and other fill or disturbed surfaces, were not mapped but are common in parts of the quadrangle; scattered piles within mapped areas are up to 20 feet (6 m) thick.

Qhd **Fill for Koosharem Reservoir dam** (Historical) – Engineered fill used to construct the dam for Koosharem Reservoir in the northern part of the quadrangle; variable thickness up to 40 feet (12 m).

Qhl **Berms and sewage evaporation ponds** (Historical) – Constructed berm and encircled sewage treatment and evaporation ponds in southeast corner of quadrangle; berms up to 10 feet (3 m) high.

Alluvial deposits

Qafp **Floodplain alluvium** (Holocene) – Mostly well-sorted silt, sand, and clay, variably organic, in flat or nearly flat floodplain of Otter Creek in Plateau and Grass Valleys; thinly layered to disturbed (bioturbated) bedding; grades into coarser deposits with some cobbles and pebbles where streams, debris flows, and minor slope wash have encroached upon the deposits; deposited in low-energy stream channels, as overbank deposits, and in oxbow lakes and marshes (cutoff stream meander channels) in nearly flat parts of valleys; locally includes peat and well-sorted, well-stratified mud and clay; generally equivalent to Qaly of Biek and others (2015a); note that most alluvium in smaller streams and washes is mapped as alluvial and colluvial deposits (Qac – see below) because it generally includes colluvium on stream side-slopes; ranges from current stream level to about 10 feet (3 m) above; 0 to 10 feet (0–3 m) thick exposed; much thicker in subsurface.

Qafm **Low-level fan alluvium with marsh and spring deposits** (Holocene) – Mostly well-sorted silt, sand, clay, and generally minor gravel with variable organic materials; deposited as distal parts of low alluvial fans that slope gently towards Otter Creek in parts of Plateau and Grass Valleys; coarsens toward valley sides with some cobbles and pebbles where alluvium, debris-flow deposits, and colluvium have encroached upon the deposits; commonly water-saturated with abundant springs and seeps; mostly correlative in age and depositional level with Qafy and Qafp; 0 to 10 feet (0–3 m) exposed but overlies much thicker alluvial and alluvial-fan deposits in subsurface.

Qafy **Young fan alluvium, undivided** (Holocene to upper Pleistocene?) – Poorly sorted, non- to weakly stratified, pebble to large boulder gravel in mixed clay to gravelly sand matrix; clasts are angular to subrounded and highly variable in size; deposited as fans in areas where stream gradients decrease at the mouths of stream channels and washes and at the base of slopes; deposited mostly by spring runoff, debris flows, and floods; commonly includes some colluvium; most form active depositional surfaces, but include slightly incised fans in some areas; 0 to 30 feet (0–10 m) thick.

Qaf1,2,3

Levels 1, 2, and 3 fan alluvium (Holocene to middle Pleistocene?) – Poorly sorted, non- to weakly stratified, pebble to large boulder gravel in mixed clay to gravelly sand matrix; clasts are angular to subrounded and highly variable in size; deposited as fans in areas where stream gradients decrease at the mouths of stream channels and washes and at the base of slopes; deposited mostly by spring runoff, debris flows, and floods; commonly includes some colluvium; level 1 and 2 roughly equivalent to Qafy; level 1 fans are active with intermittent deposition during major storm events; levels 2 and 3 are mostly incised and subject to erosion rather than active deposition, and locally include inset small active fans and slope wash too small to map separately; level 2 are generally incised 10 to 30 feet (3–10 m) and level 3 are incised 30 to 60 feet (10–20 m); 0 to 60 feet (0–20 m) thick.

Qafo **Older alluvial-fan remnants** (Middle to lower Pleistocene?) – Poorly sorted, non- to weakly stratified, pebble to large boulder gravel in mixed clay to gravelly sand matrix in remnants of old alluvial fans; clasts are subangular to subrounded and highly variable in size; commonly have well-developed soil with thick calcic (caliche) horizon; includes some colluvium; generally more than 60 feet (20 m) above active nearby drainages; 0 to 60 feet (0–20 m) thick.

Qao **Older alluvium** (Pleistocene) – Poorly to moderately sorted silt, sand, gravel, and boulders containing angular to subrounded clasts; dissected and forms erosional remnants mostly isolated from active deposition as streams incise around them; includes small active fans and slope wash too small to map separately; has thick soil profile with abundant calcic soil (caliche); mapped in fault zone in tributary of Skougard Creek in south-central part of quadrangle; due to faulting, relationship with other alluvial deposits unclear; incised up to about 40 feet (12 m); up to 40 feet (12 m) thick.

Qac **Alluvium and colluvium** (Holocene to upper Pleistocene) − Poorly to moderately sorted, generally poorly stratified, boulder to pebble gravel, sand, silt, and clay; clasts are angular to subrounded; locally derived and deposited in streams, washes, and small swales by alluvial, slope-wash, and creep processes; 3 to 20 feet (1–6 m) thick.

Colluvial deposits (also see Qac and Qmsc)

Qc **Colluvium** (Holocene to middle Pleistocene) – Poorly to moderately sorted, angular to subrounded boulders, cobbles, gravel, sand, silt, and clay; locally derived by residual weathering, diffuse slope wash, and soil and regolith creep on slopes; includes small active fans and ephemeral stream deposits too small to map separately; locally includes small landslides and slumps; commonly grades into adjacent surficial deposits; colluvium is nearly ubiquitous on slopes throughout the quadrangle but only more contiguous deposits were mapped; 0 to 30 feet (0–9 m) thick.

Glacial deposits

Small ice and rock glacier deposits are present at high elevations in the northeastern part of the quadrangle. More extensive glacial deposits are present on the north and east sides of Fish Lake Hightop Plateau just east of the quadrangle (Weaver and others, 2006; Marchetti, 2006, 2007; Marchetti and others, 2011); additional studies have been done on glacial deposits at Thousand Lakes Mountain to the east and Boulder Mountain to the south (Marchetti and others, 2005, 2007). Most deposits are likely related to the Pinedale alpine glacial advance, which is roughly coeval with the late Wisconsin glaciation, Last Glacial Maximum (LGM), and Marine Oxygen Isotope Stage 2 (MIS 2), with lesser and more subdued deposits probably related to the Bull Lake (Illinoian) glacial advance of Marine Oxygen Isotope Stage 6 (MIS 6). The Bull Lake glacial advance is well dated near its type locality near Pinedale, Wyoming at 150 ± 4 ka (Pierce and others, 2018). Marchetti and others (2011) studied glaciation on the Fish Lake Plateau and recognized deposits from these two glacial advances. They calculated that the main Pinedale advance occurred about 21.1 ka based on cosmogenic exposure ages of boulders. Their poorly constrained Bull Lake ages averaged 129 ± 39 ka, consistent with the more reliable and better constrained 150 ± 4 ka age. They also calculated an equilibrium line altitude (ELA) for Rock Canyon in the Burrville quadrangle during the Pinedale maximum of 10,265 +330/-100 feet (3130 +100/-30 m), that temperatures averaged about 14.8° to 19.2°F (8.2°–10.7°C) colder than the modern average, and that precipitation was 1 to 1.5 times the modern average.

Qgr **Rock glacier deposits** (Holocene to upper Pleistocene) – Angular and blocky boulder fields on steep canyon floors and slopes at high elevations; surfaces have lobate mounds that show downslope movement; blocks mostly derived from tuff of Albinus Canyon and latite of Johnson Valley; 10 to 60 feet (3–18 m) thick; not dated but post-date Pinedale glacial deposits where both are present.

Studies in other areas have shown that during cold wet periods ice will accumulate near the base of loose boulder fields, forming a core of ice; accumulating talus adds to the rock mantle (Konrad and others, 1999). The ice core allows the rock glacier to creep downhill similar to ice glaciers. During dry warm periods the ice reduces or disappears and movement slows or ceases; however, rock glaciers tend to move long after ice glaciers have disappeared because they gain ice during cold seasons, cold air settles to the base of the mantle, and the rock mantle insulates and slows melting (Konrad and others, 1999). Many rock glaciers in the Rocky Mountain area continued to flow during the Holocene, long after most surface-ice glaciers disappeared near the end of the Pinedale glaciation about 15,000 to 20,000 years ago—some remain active today. Time of latest movement on rock glaciers in the quadrangle is unknown but youthful features suggest some have moved in the late Holocene.

Qgmp **Pinedale-age moraine** (upper Pleistocene) – Mostly poorly to very poorly sorted, angular to subangular boulders, cobbles, gravel, sand, silt, and clay in hummocky linear ridges in and near Rock Canyon; has weak soil development; 0 to 40 feet (0–12 m) thick. Dated at about 21 ka (Marchetti and others, 2011).

Qgmpb

Pinedale- or Bull Lake-age moraine (upper to middle Pleistocene) – Similar to Qgmp and Qgmb deposits but poorly exposed and modified by colluvial processes that obscure relationships; 0 to 30 feet (0–9 m) thick; about 21 and/or 150 ka in age (see units Qgmp and Qgmb).

Qgmb **Bull Lake-age moraine** (middle Pleistocene) – Mostly poorly to very poorly sorted, angular to subangular boulders, cobbles, gravel, sand, silt, and clay in hummocky linear ridges in and near Rock Canyon; hummocks and linear ridges smaller and more degraded than Pinedale-age deposits; has weak to moderate soil development; 0 to 30 feet (0–9 m) thick. Bull Lake moraines near where first defined near Pinedale, Wyoming are well dated at 150 ± 4 ka (Pierce and others, 2018).

Lacustrine and related deposits

Ql **Lacustrine deposits** (Holocene to Pleistocene) – Well-sorted, stratified to bioturbated mud (sand, silt, and clay) in Fish Lake graben in southeast corner of quadrangle; generally pale-gray to very pale yellowish-gray; thickness unknown but only about 5 feet (1.5 m) exposed.

Qla **Lacustrine and alluvial deposits** (Holocene to Pleistocene) – Well-sorted, generally pale-gray to very pale yellowish-gray, stratified to bioturbated mud (sand, silt, and clay) that grades outward from lacustrine deposits (Ql) into marsh and low-level alluvial-fan deposits; fan deposits include variable amounts of pebble to boulder gravel, especially near adjacent slopes; mapped in shallow depression at south end of Fish Lake graben in southeast corner of quadrangle; thickness unknown but only about 10 feet (3 m) exposed.

Mass-movement deposits

Qms **Landslides** (Holocene to Pleistocene) – Poorly sorted, locally derived, clay- to boulder-size debris and large blocks of displaced bedrock deposited by rotational and translational slump or slide movement; characterized by chaotic bedding attitudes, hummocky topography, and internal scarps; base in poorly welded volcanic tuff, mudflows, and other volcaniclastic deposits; variable thickness; some unmapped landslides may be included in colluvial deposits and on sloping bedrock surfaces; thickness unknown.

Qmsc **Landslides and colluvium** (Holocene to Pleistocene) – Mix of landslides and colluvium described above; landslide features are generally poorly expressed and difficult to distinguish from slope creep and other colluvial processes; gradational with Qms and Qc deposits; thickness unknown.

Qmt **Talus** (Holocene to upper Pleistocene) – Unconsolidated, poorly sorted, angular volcanic boulders and cobbles deposited by rockfall on or at the base of steep slopes; forms steep, commonly fan-shaped deposits derived from weathering of adjacent cliffs or ridges; present on steep slopes in many areas, but only larger, well-defined deposits are mapped where they conceal contacts or form broad aprons below resistant bedrock units; locally grades into Qms and Qc deposits; 10 to 20 feet (3–6 m) thick.

QUATERNARY-NEOGENE (Late Tertiary)

QTs **Older sediments** (Quaternary to Miocene?) – Mostly unconsolidated, clay to boulder sediment deposited in faulted basins (grabens); rarely exposed so description based on surface float; upper part is mostly variable thicknesses of colluvium and alluvium eroded from adjacent steep slopes; form smooth ledge-free slopes; mapped in Daniels Canyon and Hancock Flat areas where overlies Osiris Tuff and other volcanic units; age unknown but lower part of unit includes Miocene to Pliocene Burrville member of Sevier River Formation (Tsrb); to south and west Sevier River Formation has been dated at 5 to 14 Ma (Hintze and others, 2003; Biek and others, 2015a); deposition of colluvium and alluvium continues in some areas; thickness estimated at 0 to 200 feet (0–60 m).

NEOGENE (Late Tertiary)

Tsrb **Burrville member of Sevier River Formation** (Pliocene to Miocene) – Pale-pinkish-gray to yellowish-gray, weakly to moderately consolidated, poorly to moderately sorted, pebbly sandstone, mudstone, and conglomerate; clasts range from grit to boulders up to about 3 feet (1 m) in diameter and from matrix-supported in some exposures to clast-supported with minor matrix in others; most clasts are angular to subangular but some exposures also have rounded to subrounded clasts; stratification is generally present but ranges from weak to moderate and discontinuous; includes a basaltic lava flow in the southern part of the quadrangle (Tbfl); forms rounded slopes with few outcrops in most areas but locally well exposed in washes; cut by faults in most areas; up to about 600 feet (180 m) thick; is stratigraphically highest unit in area and upper surface is commonly deeply eroded; partly correlative with unit QTs but forms erosional remnants mostly isolated from active deposition.

The Sevier River Formation has been mapped throughout the Sevier River basin area of central and southern Utah and is generally viewed as basin fill related to older basin-and-range faulting with different active faults than those currently active today. The formation is noted for predating (being cut by) faults that define current ranges and valleys, and for not having facies that conform to modern topography—for example, gravelly intervals that do not coarsen or thicken toward current topographic highs and canyon mouths. The term “Burrville member” is an informal local term for extensive deposits in the Burrville area—overall they have more angular gravel and fewer fine-grained intervals than most other Sevier River exposures throughout the region.

Tbfl **Basaltic lava flows of Fish Lake** (Miocene?) – Dark-brownish-black, weakly to moderately vesicular, potassic trachybasalt to shoshonite with sparse small phenocrysts of plagioclase, clinopyroxene, and altered olivine (iddingsite); has near-vertical blocky joints; forms weathered caps on small benches with ledges at margins; interlayered with lower part of Burrville member of Sevier River Formation (Tsrb) and covered by upper part of Burrville member; Biek and others (2015a) speculated that it erupted from a source in the Burrville quadrangle—we have not identified a vent though a candidate is the small broad hill at 431035 E, 4262484 N (UTM zone 12S, NAD83) that has poorly exposed scoria; is more widely and better exposed in the Loa 30′ x 60′ quadrangle to the south (Biek and others, 2015a); not dated but flows in the Forsyth Reservoir and Greenwich quadrangles to the east and southwest, respectively, yielded ages of 4.98 ± 0.04 Ma and 14.08 ± 0.16 Ma (Biek and others, 2015a), indicating the possible age range; maximum exposed thickness is about 30 feet (9 m) though locally probably much thicker.

The lava flows of Fish Lake are in the northeasternmost part of the extensive basaltic volcanic field of central and southwestern Utah, southeastern Nevada, and northern Arizona, which includes hundreds of flows, cones, and vents. The Burrville quadrangle only “clips” the edge of the group of flows in the Sevier-Awapa Plateaus area, which are much more extensive in the Loa 30′ x 60′ quadrangle to the south (Biek and others, 2015a). Biek and others (2015a) noted that these basaltic rocks are synchronous with basin-and-range extension, and thus with initial development of modern topography that began in central and southwestern Utah between 23 and 17 million years ago and continues to the present. Most flows are part of mostly small, bimodal (basalt and high-silica rhyolite) eruptive centers (Christiansen and Lipman, 1972; Rowley and Dixon, 2001). Few of these relatively small-volume, widely scattered, basaltic lava flows are dated, but most appear to be of Pliocene to middle Miocene age. The basaltic source magmas were partial melts derived from the compositionally heterogeneous lithospheric mantle, which, coupled with fractional crystallization, may account for most of the geochemical variability between individual lava flows (Lowder, 1973; Best and Brimhall, 1974; Mattox, 1991; Nelson and Tingey, 1997; Johnson and others, 2010). For virtually all samples of basaltic and andesitic lava flows from the map area Nb/La ratios are less than 1.0, suggesting a lithospheric mantle source (Fitton and others, 1991). Rock names follow LeBas and others (1986) and are based on limited geochemistry; virtually all flows in the Awapa Plateau area are classified as basalt, potassic trachybasalt, or less commonly basaltic trachyandesite (Biek and others, 2015a). Major- and trace-element data for volcanic rocks in this area will be published separately at the end of this multi-year project.

EARLY NEOGENE-PALEOGENE (Late-Early Tertiary)

To **Osiris Tuff** (lower Miocene to upper Oligocene) – Medium- to dark-gray, lavender-gray, brown, brown-gray, and locally red-brown, densely welded, moderately crystal-rich ash-flow tuff of trachytic composition containing abundant 0.04 to 0.12 inch (1–3 mm) white plagioclase and common prominent black biotite phenocrysts; biotite is commonly weathered to gold to copper-black; outcrops weather to rounded, massive to slabby knobs with abundant grus rubble at base; joints and faults commonly mineralized with secondary quartz and calcite; 3- to 10-foot-thick (1–3 m) basal vitrophyre; though rarely exposed, commonly overlies up to 10-foot-thick (3 m) biotite-rich volcanic sandstone bed (likely a basal surge); best exposed along Bamberger Road (south-central part of quadrangle); is stratigraphically highest resistant welded tuff unit; unconformably overlain by weakly consolidated Burrville member of Sevier River Formation in some areas; is about 23 Ma (Fleck and others, 1975; Cunningham and others, 2007); Ball and others (2009) reported several $^{40}Ar/^{39}Ar$ ages on sanidine that average 23.03 ± 0.08 Ma (Biek and others, 2015a); the Miocene-Oligocene boundary in the current International Chronostratigraphic Chart (Cohen and others, 2016) is currently calculated at 23.03 Ma, therefore, the standard error places the Osiris in either the latest Oligocene or earliest Miocene; because top is eroded and unit is commonly faulted thickness is difficult to ascertain; better exposures are up to 130 feet (40 m) thick but may be thicker locally.

In the quadrangle area the Osiris Tuff generally directly overlies the tuff of Albinus Canyon, but locally overlies other units of the Bullion Canyon Volcanics. Outcrops range from resistant ledges and cliffs to ragged piles of large rounded boulders that commonly look like elephant backs. The boulders occur in clusters or are randomly scattered, commonly show evidence of downslope creep, and are part of the thin colluvial mantle abundant on some slopes. The Osiris Tuff erupted from the Monroe Peak caldera (Anderson and Rowley, 1975; Rowley and others, 1981), the northeastern margin of which is about 3 miles (5 km) west of the southwest corner of the quadrangle (Steven and others, 1984; Rowley and others, 1986).

Bullion Canyon Volcanics (Miocene to Eocene) – The Bullion Canyon Volcanics is an informal formation (in some cases treated more as a group) consisting of volcaniclastic deposits, lava flows, and ash-flow tuffs apparently sourced in the northeastern part of the Marysvale volcanic field (Rowley and others, 2002; Cunningham and others, 2007). In this area it has one formal unit, the Three Creeks Tuff Member, a welded dacitic ash-flow tuff that forms an important marker bed where present (we did not find any outcrops in the Burrville quadrangle, though it may be present under colluvial cover). In addition, we include all of the following volcanic and volcaniclastic units in the Bullion Canyon Volcanics, though Cunningham and others (2007) excluded the tuff of Albinus Canyon. The lowest unit is a thick sequence of volcaniclastic sandstone and conglomerate, volcanic mudflow breccia, and minor ash-flow and air-fall tuff that we informally call the Kings Meadow member of the Bullion Canyon Volcanics (Tbkm) that underlies the Three Creeks Tuff Member and overlies the Dipping Vat Formation in areas to the north (Doelling and Willis, 2016). Highly variable thicknesses of not-yet-named Bullion Canyon volcaniclastic deposits (Tbcc) overlie the Three Creeks Tuff (or Kings Meadow member where Three Creeks is missing). Overlying the unnamed volcaniclastic deposits is the latite of Johnson Valley, additional unnamed volcaniclastic deposits, the tuff of Albinus Canyon units, and then locally, a thin interval of additional volcaniclastic deposits. It also tentatively includes the lava flows of Burrville (Tbu) and volcanic rocks of Signal Peak (Tsv). The next overlying unit, the Osiris Tuff, is not included in the Bullion Canyon Volcanics (Cunningham and others, 2007). The Bullion Canyon Volcanics range from about 23 to 32 Ma (Fleck and others, 1975; Rowley and others, 1994, 1998; Cunningham and others, 2007). We recently obtained a U-Pb age on zircon from near the top of the underlying Dipping Vat Formation of 32.9 ± 1.6 Ma (unpublished data).

Tbu **Lava flows of Burrville** (upper Oligocene) – The lower east flank of a large lava flow complex mapped by Rowley and others (1986) in the adjacent Koosharem quadrangle extends a few hundred yards into the Burrville quadrangle. They described it as moderately resistant, pink, red, tan, light-gray, and black, strikingly flow foliated, dacitic lava flows; groundmass is glassy to devitrified; contains small linear vesicles; commonly weathers to plates; contains small, sparse phenocrysts of plagioclase, pyroxene, and Fe-Ti oxides; though most of outcrop is in Koosharem quadrangle, best exposures are in Burrville quadrangle; no isotopic age data but Rowley and others (1986) placed its position as partially equivalent to, or slightly older than, the Osiris Tuff, suggesting a late Oligocene age (shown in Miocene, but the International Chronostratigraphic Chart has since been revised; Cohen and others, 2016); sample for laboratory age analysis is in progress at the time of this map release; maximum thickness is about 450 feet (150 m).

Tacu **Tuff of Albinus Canyon and related units** (tentative name) (upper Oligocene) – Consists of several crudely layered welded tuffs, lavas, and volcaniclastic deposits that vary considerably from outcrop to outcrop; dominant facies consists of dark-lavender-gray, brown-gray, dark-gray, to nearly black, phenocryst-poor, densely welded, trachytic ash-flow tuff; has elongated "stretched" vesicles that range from small, scattered, and linear to very abundant and scoria-like; most layers are brittle, platy, and crystal-poor; other facies have abundant large plagioclase crystals and are easily confused with the underlying Tjv unit in isolated outcrops; some facies are very dark brownish black and contain over 50% vesicles that make the rock resemble vesicular basalt; most outcrops are strongly foliated and commonly contorted; the elongated vesicles and contorted foliation (formed while the unit was hot and plastic-like) give many boulders a surface that resembles old weathered wood; typically contains 5% to 15% phenocrysts dominated by plagioclase with some sanidine and pyroxene in a glassy groundmass; commonly forms ledges separated by poorly exposed colluvium-covered slopes; in some areas map unit includes Bullion Canyon volcaniclastic deposits (mapped separately as Tbcc where well exposed) that generally form rubbly poorly exposed slopes; a few small, poorly exposed outcrops are mapped in Mormon Mountain area; thickness varies but may locally exceed 400 feet (120 m); overall thins southward and locally not present in southern part of quadrangle; yielded $^{40}Ar/^{39}Ar$ single-crystal sanidine age of 25.13 ± 0.02 Ma (listed as trachyte of Lake Creek in Utah Geological Survey and Nevada Isotope Geochronology Laboratory, 2012), which compares well with K-Ar age of 25.3 ± 1.3 Ma west of quadrangle (Rowley and others, 1994, 1998; Cunningham and others, 2007).

The "tuff of Albinus Canyon" is one of the most widespread volcanic units throughout the northeastern part of the Marysvale volcanic field and has been mapped on several quadrangles west and north of the quadrangle (Steven, 1979; Rowley and others, 1981, 1994, 1998; Willis, 1986, 1988, 1994; Kuehne and Doelling, 2016). Our recent work suggests that old correlations may not be correct and some of these rocks may be more closely affiliated with the similar Antimony Tuff Member of the Mt Dutton Formation map unit as shown on some earlier maps such as the Annabella quadrangle (Rowley and others, 1981). To confuse matters further, Rowley (written communication, 2018) has found evidence suggesting that there may actually be three different, similar-appearing units. In addition, Bailey and others (2007) and Biek and others (2015a) have used the term trachyte of Lake Creek for probably equivalent rocks to the east and south (see discussion in Biek and others, 2015a). Therefore, we view this name assignment as temporary pending ongoing regional studies that hopefully will resolve these issues.

Tjv **Latite of Johnson Valley** (Oligocene) – Light- to dark-gray, brownish-gray, or gray-black lava flows containing abundant large (>0.4 inch [1 cm]) white or clear plagioclase phenocrysts and dark-greenish-black pyroxene phenocrysts in dark-gray groundmass; the crystal-rich texture is a trademark of this unit, however, some outcrops have fewer and smaller phenocrysts; flows weather to resistant, angular, large blocks locally exceeding 7 feet (2 m) in diameter, but mostly in the 1- to 6-foot (0.3–2 m) range, that commonly form abundant talus on slopes; the best outcrops are in a few ledges in Daniels and Praetor Canyons and near the southeast quadrangle corner; deposited on various volcaniclastic deposits, but base rarely exposed; directly overlain by tuff of Albinus Canyon units in eastern part of quadrangle but by volcaniclastic deposits in areas to the west; informally defined east of the quadrangle on the Fish Lake Plateau (Bailey and others, 2007) where this unit has been dated by an $^{40}Ar/^{39}Ar$ age on plagioclase at 26.01 ± 0.04 Ma (Utah Geological Survey and Nevada Isotope Geochronology Laboratory, 2012); name modified to present term by Biek and others (2015a); may locally include multiple latite flows each up to about 50 feet (15 m) thick with a cumulative exposed thickness of about 160 feet (50 m), but is probably 200 to 300 feet (60–90 m) thick in the quadrangle, though the total thickness is not exposed.

The latite of Johnson Valley is only recognized in a narrow band about 10 miles (16 km) wide that extends for about 20 miles (30 km) north-northeast of the northern part of the Marysvale volcanic field. The unit thins rapidly northward and is only locally present north of the quadrangle (Doelling and Kuehne, 2014, 2015; Doelling and Willis, 2016). Biek and others (2015a) discussed regional thicknesses and noted that it may locally reach over 1000 feet (300 m) in the Fish Lake area. It may be an extension of part of the volcanic rocks of Signal Peak of Rowley and others (1986), but this correlation has not yet been confirmed.

Tsv **Vent facies of volcanic rocks of Signal Peak** (Oligocene) – This unit covers a large part of the Koosharem quadrangle to the west (Rowley and others, 1986), but only a small sliver extends into the Burrville quadrangle. This unit may be partially equivalent to the latite of Johnson Valley though mapped outcrops are separated by a wide alluvial valley—ongoing mapping and analyses should resolve this question. Rowley and others (1986) described this unit as moderately resistant, light- to dark-gray, black, red, reddish-brown, pink, tan, and light-purple, commonly vesicular and amygdaloidal lava flows and minor flow breccia, volcanic mudflow breccia, sandstone, and conglomerate; consists of at least three gradational, intertonguing parts whose mutual contacts are not mapped; all parts consist mostly of andesitic lava flows that contain phenocrysts of plagioclase and pyroxene, and subordinate olivine and Fe-Ti oxides; flows in the upper part are generally lighter colored and more silicic than those in the lower parts; upper flows locally contain minor hornblende phenocrysts; flows in the lower part are dark-colored, commonly red, and contain smaller and less abundant phenocrysts; no age control in the quadrangle area but if partially equivalent to the latite of Johnson Valley then unit is about 26 Ma; about 3000 feet (1000 m) thick regionally (Rowley and others, 1986) but only about 40 feet (12 m) exposed in quadrangle.

Tbcc **Bullion Canyon volcaniclastic deposits** (Oligocene) – Widely distributed, heterogeneous, varicolored, volcanic mudflows (lahars), lava flows, ash-flow tuff, and alluvial volcaniclastic conglomerate, mudstone, and sandstone; locally includes weakly welded, light-pink-gray, light-yellow-gray, and dark-gray ash-flow tuff; generally overlies the Kings Meadow member in this area but in areas to the north mostly overlies the Three Creeks Tuff Member; locally, fingers of this unit overlie latite of Johnson Valley (Tjv) and tuff of Albinus Canyon unit (Tacu); up to 600 feet (180 m) thick.

Bullion Canyon volcaniclastic deposits are widely, though poorly, exposed on Mormon Mountain in the northwestern part of the quadrangle, but are thin or absent in the eastern part of the quadrangle. The deposits apparently filled a broad paleovalley with an eastern side that roughly coincides with current highlands in the quadrangle (see discussion in Overview). This paleovalley accumulated mixed volcanic and sedimentary rocks shed from the early phases of the Marysvale volcanic field.

Tbt **Three Creeks Tuff Member of Bullion Canyon volcanics** (none recognized but may be present in covered areas in northwestern part of quadrangle) (upper Oligocene) – Gray-pink to orange-pink, densely welded, crystal-rich, dacitic ash-flow tuff containing small phenocrysts of plagioclase, amphibole, and biotite; resistant, commonly cliff-forming, and weathers to a blocky outcrop (Willis, 1986, 1988; Doelling and Kuehne, 2014, 2015).

The Three Creeks Tuff Member overlies the Kings Meadow member in areas to the north but we have not recognized any outcrops in this quadrangle; however, it may be present under thin colluvial cover in the northwestern part of the quadrangle. In areas to the north it varies from 0 to 60 feet (20 m) thick, but even along well-exposed slopes, outcrops are discontinuous. The Three Creeks Tuff Member erupted from the Three Creeks caldera in the southern part of the Pahvant Range (Steven and others, 1979) 20 miles (32 km) west of the quadrangle. The unit is about 27.1 Ma based on several K-Ar and fission track ages (Rowley and others, 1994; Cunningham and others, 2007).

Tbkm **Kings Meadow member of Bullion Canyon volcanics** (Oligocene to upper Eocene) – Light- to dark-gray volcaniclastic sandstone and conglomerate, volcanic mudflow breccia, and unwelded ash-flow tuff, all mostly of andesitic composition; overlies the Eocene Dipping Vat Formation in areas to the north; underlies the Three Creeks Tuff Member of the Bullion Canyon Volcanics where it is present, and Bullion Canyon volcaniclastic deposits elsewhere; 700 to 1100 feet (210–380 m) thick in areas to north and west (Doelling and Kuehne, 2013, 2014, 2015), but only about 300 to 400 feet (90–120 m) exposed in northwestern part of the quadrangle.

The Kings Meadow member is a volcaniclastic unit that makes up the basal part of the Bullion Canyon Volcanics. It is similar to but generally overall less coarse than the Bullion Canyon volcaniclastic unit (Tbcc), and is difficult to distinguish in this quadrangle where the Three Creeks Tuff Member is not present; since we have not identified Three Creeks in this quadrangle identity of the mapped Kings Meadow member is questionable. The Kings Meadow member probably accumulated in low areas on the lower distal flanks of the Marysvale volcanic field and received a variety of sedimentary and volcanic rocks shed from the volcanic highlands. Most of the material was probably sourced from stratovolcanoes in the vicinity of Monroe Peak. An ash-flow tuff near the top of the unit in section 11, T. 23 S., R. 1 W. in the Rex Reservoir quadrangle yielded a U-Pb zircon age of about 32 Ma (Doelling and Kuehne, 2014); a sample from the uppermost part of the underlying Dipping Vat Formation, also from the Rex Reservoir quadrangle, yielded an age of 32.9 ± 1.6 Ma (new unpublished data).

SUBSURFACE STRATA

Based on outcrops in nearby quadrangles, the following units are anticipated in the subsurface of the Burrville quadrangle. See Willis (1986, 1988, 1994), Doelling and Kuehne (2016a, 2016b), and Kuehne and Doelling (2016).

Tdv **Dipping Vat Formation** (late Eocene – early Oligocene)

Tau **Aurora Formation** (middle Eocene)

Tch **Crazy Hollow Formation** (Eocene)

Tgr **Green River Formation** (Eocene)

Tf **Flagstaff Formation** (may include few hundred feet of Colton Formation) (lower Eocene to upper Paleocene)

TKn **North Horn Formation** (Paleocene to Upper Cretaceous)

K **Cretaceous formations** (up to 8000 feet [2400 m] thick [Doelling and Kuehne, 2016a]); nomenclature unclear because quadrangle overlies a transition between naming conventions.

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Table 1. *Chemical analyses of selected samples from Burrville quadrangle.*

Map ID	Sample No.	7.5' Quad.	Map Symbol	UTM Easting, NAD83	UTM Northing, NAD83	NEW_LONG_NAD83	NEW_LAT_NAD83	Lab Used	Collected by	wt% SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	wt% K_2O
1	BV101216-1	Burrville	Tacu	430777	4274628	-111.7951	38.6175	ALS	Willis	65.17	15.63	4.55	2.48	1.15	4.22	5.04
2	BV061516-3	Burrville	Tacu	430517	4274542	-111.7981	38.6167	ALS	Willis/Biek	65.75	15.81	3.03	1.36	0.57	4.38	6.5
3	BV101216-3	Burrville	Tjv	430625	4274542	-111.7969	38.6167	ALS	Willis	56.44	18.57	6.49	6.37	1.95	4.1	3.15
4	BV061516-2	Burrville	Tjv	430537	4274510	-111.7979	38.6164	ALS	Willis/Biek	59.19	17.74	5.8	4.96	1.36	4.1	4.12
5	BV040616-1	Burrville	Tjv	430557	4274503	-111.7977	38.6163	ALS	Willis	61.29	15.31	5.43	2.65	1.41	3.47	5.96
6	BV061516-1	Burrville	Tjv	430613	4274442	-111.7970	38.6158	ALS	Willis/Biek	57.09	18.44	6.2	6.25	1.77	4.08	3.44
7	BV031417-4	Burrville	Tbcc	430129	4270954	-111.8022	38.5843	ALS	Willis	57.11	16.04	8.47	5.76	3.11	3.54	3.52
8	BV031417-5	Burrville	Tbcc	430111	4270940	-111.8024	38.5842	ALS	Willis	56.75	16.3	8.71	6.08	3.49	3.65	3.29
9	BV031417-2	Burrville	Tjv	429143	4270760	-111.8135	38.5825	ALS	Willis	55.99	15.64	8.73	5.99	3.67	3.5	3.47
10	BV100516-1	Burrville	Tacu	434826	4268065	-111.7480	38.5586	ALS	Willis	62.86	16.2	4.93	3.04	1.03	4.08	4.93
11	BV091516-1	Burrville	Tacu	431954	4266705	-111.7809	38.5462	ALS	Willis	62.07	16.32	5.39	3.51	1.08	4.07	4.88
12	BV052616-2	Burrville	Tjv	430291	4264768	-111.7997	38.5286	ALS	Willis	57.18	15.83	7.76	5.37	3.03	4	3.92
13	BV052616-1	Burrville	Tjv	430300	4264744	-111.7996	38.5284	ALS	Willis	56.66	15.72	7.58	5.53	3.07	3.83	3.87
14	BV082516-2	Burrville	Tjv	431654	4264011	-111.7840	38.5219	ALS	Willis	57.19	16.13	7.93	5.37	2.58	4.07	3.95
15	BV082516-1	Burrville	Tjv	431640	4263996	-111.7842	38.5217	ALS	Willis	56.98	15.93	7.72	5.66	3.19	3.84	3.83
16	BV082416-1	Burrville	Tjv	431956	4263788	-111.7805	38.5199	ALS	Willis	56.82	16.17	7.97	5.34	2.64	4.03	4
17	BV101916-1	Burrville	Tacu	433794	4263332	-111.7594	38.5159	ALS	Willis	64.74	15.75	4.56	2.26	0.9	4.25	5.69
18	BV111016-8	Burrville	Tacu	433796	4263063	-111.7594	38.5135	ALS	Willis	63.73	15.44	4.68	2.45	1.14	3.85	5.73
19	BV031517-11	Burrville	Tacu	432918	4262831	-111.7694	38.5113	ALS	Willis	65.25	16	3.72	1.9	0.93	4.3	6.06
20	BV031517-10	Burrville	Tjv	433190	4262684	-111.7663	38.5100	ALS	Willis	57.15	16.01	7.94	5.17	2.57	3.96	3.99
21	BV081617-1	Burrville	Tjv	433302	4262107	-111.7649	38.5048	ALS	Willis	57.2	16.02	7.73	5.53	3.07	3.8	3.7
	ALS - ALS USA Inc, Reno Nevada				wt% - weight percent		ppm - parts per million									

Table 1. *Continued.*

wt% Cr_2O_3	TiO_2	MnO	P_2O_5	SrO	BaO	LOI	wt% Total	ppm Ag	As	Cd	Co	Cu	Li	Mo	Ni	Pb	Sc	Tl	Zn	Ba	Ce	Cr	Cs	Dy	ppm Er
<0.01	0.74	0.09	0.233	0.05	0.1	0.96	100.4	<0.5	6	<0.5	5	27	30	3	2	20	9	<10	67	870	109	10	8.91	5.3	2.81
<0.01	0.76	0.09	0.158	0.03	0.12	0.62	99.18	<0.5	13	<0.5	2	14	20	3	2	29	8	<10	62	1020	129.5	<10	8.16	5.32	3.14
<0.01	0.86	0.11	0.492	0.11	0.08	0.73	99.45	<0.5	<5	<0.5	12	78	10	2	3	15	10	<10	74	720	85.5	10	2.99	4.57	2.55
<0.01	0.81	0.11	0.437	0.1	0.09	1.19	100	<0.5	8	<0.5	11	82	20	3	5	20	10	<10	70	790	95.3	10	7.75	4.61	2.56
<0.01	0.92	0.11	0.349	0.04	0.1	2.96	100	<0.5	10	<0.5	7	20	20	4	1	30	10	<10	86	844	121.5	10	7.04	5.64	3.34
<0.01	0.86	0.1	0.483	0.11	0.08	1.36	100.25	<0.5	11	<0.5	13	89	30	1	4	15	11	<10	76	649	83.3	10	3.86	4.14	2.4
<0.01	0.98	0.13	0.38	0.08	0.07	0.49	99.84	<0.5	12	<0.5	26	123	40	2	18	14	17	<10	97	628	95.6	30	6.42	5.22	2.82
<0.01	1	0.13	0.38	0.09	0.07	0.26	100.35	<0.5	6	<0.5	27	137	20	1	22	16	19	<10	104	622	79.2	30	3.09	4.81	2.58
<0.01	1	0.14	0.4	0.08	0.07	0.41	99.22	<0.5	9	<0.5	26	133	30	2	18	16	17	<10	96	589	81.8	40	5.27	4.83	2.65
<0.01	0.8	0.09	0.339	0.06	0.09	1.58	100.05	<0.5	8	<0.5	8	32	20	3	3	20	10	<10	73	833	116.5	<10	6.5	6.67	3.8
<0.01	0.82	0.1	0.378	0.06	0.09	0.89	99.66	<0.5	10	<0.5	8	41	20	2	4	22	10	<10	75	851	110.5	10	7.62	5.49	3.01
<0.01	1.05	0.12	0.48	0.13	0.11	0.95	99.91	<0.5	5	<0.5	21	96	20	2	16	23	15	<10	94	939	109	30	3.62	4.78	2.22
<0.01	1.04	0.12	0.47	0.13	0.1	0.91	99.02	<0.5	<5	<0.5	21	98	20	2	17	20	14	<10	96	943	110	70	5.91	4.48	2.32
<0.01	1.04	0.11	0.51	0.14	0.11	0.94	100.05	<0.5	14	<0.5	22	95	20	2	19	34	15	<10	98	1010	114.5	30	3.46	5.43	2.93
<0.01	1.01	0.12	0.477	0.14	0.12	0.97	99.98	<0.5	<5	<0.5	20	96	20	3	15	21	14	10	92	1005	103.5	30	5.64	4.5	2.37
0.01	1.05	0.11	0.501	0.13	0.12	1.08	99.98	<0.5	8	<0.5	19	98	20	3	19	26	14	<10	94	1075	104.5	30	2.76	5.43	2.69
<0.01	0.79	0.09	0.282	0.04	0.1	0.63	100.1	<0.5	8	<0.5	6	34	20	4	2	29	8	<10	66	905	119	<10	7.69	5.33	3.17
<0.01	0.77	0.09	0.27	0.04	0.1	0.7	99.1	<0.5	10	<0.5	7	36	10	4	1	26	9	<10	78	881	117	10	8.67	5.57	3.19
<0.01	0.73	0.1	0.21	0.04	0.13	0.41	99.91	<0.5	9	<0.5	4	13	30	3	1	29	9	<10	77	1110	127	10	8.58	5.72	3.13
<0.01	1.01	0.12	0.47	0.12	0.11	0.45	99.18	<0.5	11	<0.5	23	103	30	2	17	19	14	<10	95	1040	107	30	3.78	5.51	2.73
0.01	1.03	0.13	0.48	0.13	0.11	0.39	99.42	<0.5	9	<0.5	20	107	30	2	20	20	15	10	118	1030	117.5	30	5.88	5.13	2.72

Table 1. *Continued.*

ppm Eu	Ga	Gd	Hf	Ho	La	Lu	Nb	Nd	Pr	Rb	Sm	Sn	Sr	Ta	Tb	Th	Tm	U	V	W	Y	Yb	ppm Zr
1.8	20.7	6.54	9.5	1.11	52.4	0.45	16.7	49	12.9	183.5	8.29	2	425	1.2	1.01	24.6	0.41	7.48	58	3	27.8	3.16	337
1.65	18.9	7	10.2	1.07	64.1	0.47	18.8	53.6	14.65	238	9.64	3	292	1.2	1.04	30.9	0.48	10.25	29	4	31.7	3.1	413
1.87	23.5	5.9	5.8	0.88	40.3	0.34	10.5	42.9	10.45	83.8	7.85	2	973	0.7	0.84	12.1	0.33	3.79	139	1	23.3	2.33	208
1.83	21.5	6.27	6	0.95	48.7	0.37	11.2	44.5	11.5	148	7.84	2	903	0.7	0.88	19.35	0.35	6.08	134	3	26.9	2.37	239
1.81	19.5	7.49	9.7	1.14	60.1	0.46	16.3	55.2	14.3	173.5	9.71	2	392	1	1.07	19.45	0.45	7.25	68	3	29.8	3.05	338
1.81	21.8	5.87	5.5	0.84	39.2	0.34	10.3	39.4	10.15	111	7.59	2	977	0.6	0.82	12.25	0.33	4.16	153	2	23.5	2.29	216
1.88	22	6.99	6.2	1.04	46.3	0.39	19.4	48.6	12.35	124.5	8.96	3	716	0.7	0.89	14.95	0.4	5.16	212	3	25.1	2.5	230
1.67	21.2	6.03	5.8	0.96	39.3	0.38	10.5	40.5	10.2	98	7.76	2	749	0.7	0.82	13	0.35	4.02	196	2	23.3	2.36	220
1.66	20.7	6.07	5.9	1.01	40.5	0.35	10.4	41.7	10.55	110	7.81	2	678	0.7	0.87	13.8	0.39	4.66	192	2	23.8	2.58	222
2.08	21.4	8.69	9.1	1.35	64.7	0.52	16.7	63.1	15.7	174	10.95	3	502	1	1.26	22.4	0.54	7.44	67	3	34.1	3.67	338
1.93	21.2	7.33	9.1	1.15	52.7	0.43	16.1	53.3	13.25	167	9.34	3	563	1	1.01	21.3	0.44	7.09	78	3	28.9	2.88	322
2.18	21.9	6.83	6.4	0.84	52.6	0.31	11.7	50.6	13.2	130.5	9.42	2	1145	0.7	0.96	17.45	0.32	5.44	207	2	24.4	2	263
2.26	21.7	6.84	6.7	0.83	52.5	0.32	11.8	50.5	13.2	129.5	9.55	2	1195	0.7	0.94	18.25	0.35	5.92	198	2	23.9	2.03	267
2.35	22.6	8.08	6.5	1.06	60	0.39	11.2	57	14.8	119	11.6	2	1180	0.8	1.13	17.25	0.4	5.25	234	2	30.5	2.53	249
2.07	21.8	6.84	6.2	0.83	50.7	0.3	10.8	48.4	12.65	110	9.87	2	1165	0.7	0.93	16.65	0.32	5.54	212	2	23.4	2.03	242
2.36	22.1	8.28	6.5	1.02	57.2	0.33	11.1	58.4	15.15	120	11.9	2	1170	0.7	1.08	17.1	0.36	5.58	228	2	26.9	2.49	256
1.61	21	6.7	10.1	1.12	56.8	0.48	17.5	52.9	13.9	191	9.62	3	379	1.2	0.97	24.6	0.43	7.54	58	3	28.7	2.95	364
1.58	20.6	6.8	9.4	1.11	60.3	0.48	16.8	52.9	14.3	180	9.45	3	368	1.1	1	25.3	0.48	8.32	49	3	28.9	3.27	361
1.85	20.4	7.2	9.9	1.1	65.9	0.48	17.3	57.5	15.6	184.5	10.1	3	387	1.2	0.97	29.6	0.46	9.26	31	3	28.9	3.14	375
2.3	22.6	8.3	6.8	1.07	64.9	0.39	11.2	60.4	15.25	120.5	10.8	2	1140	0.7	1.04	18.45	0.39	5.28	185	2	26.9	2.46	251
2.45	25.4	7.87	7.7	1.01	56.7	0.35	11.6	55.3	14.05	115.5	10.15	3	1220	0.8	0.95	18.2	0.38	6.02	208	3	25	2.49	276

GEOLOGIC SYMBOLS

Contact, dashed were approximately located, queried where uncertain

Normal fault – Dashed where approximately located, dotted where concealed, queried where uncertain

Anticline, dashed where approximately located, dotted where concealed

Strike and dip of bedding

Strike and dip of foliation (foliation in tuff units varies from planar to contorted; we attempted to collect foliation measurements that reflect the overall unit but some measurements may be from contorted layering)

Approximate strike and dip direction of foliation (no number)

Strike and dip direction of vertical foliation

Joint, inclined

Sand, gravel, or roadfill pit

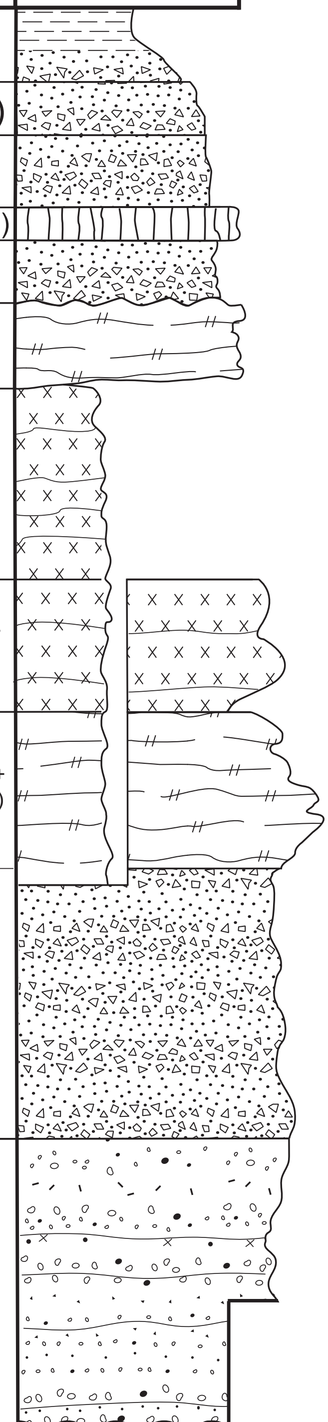
Sample location for geochemical analysis (see table 1)

Flow direction from stretched vesicles in unit Tacu

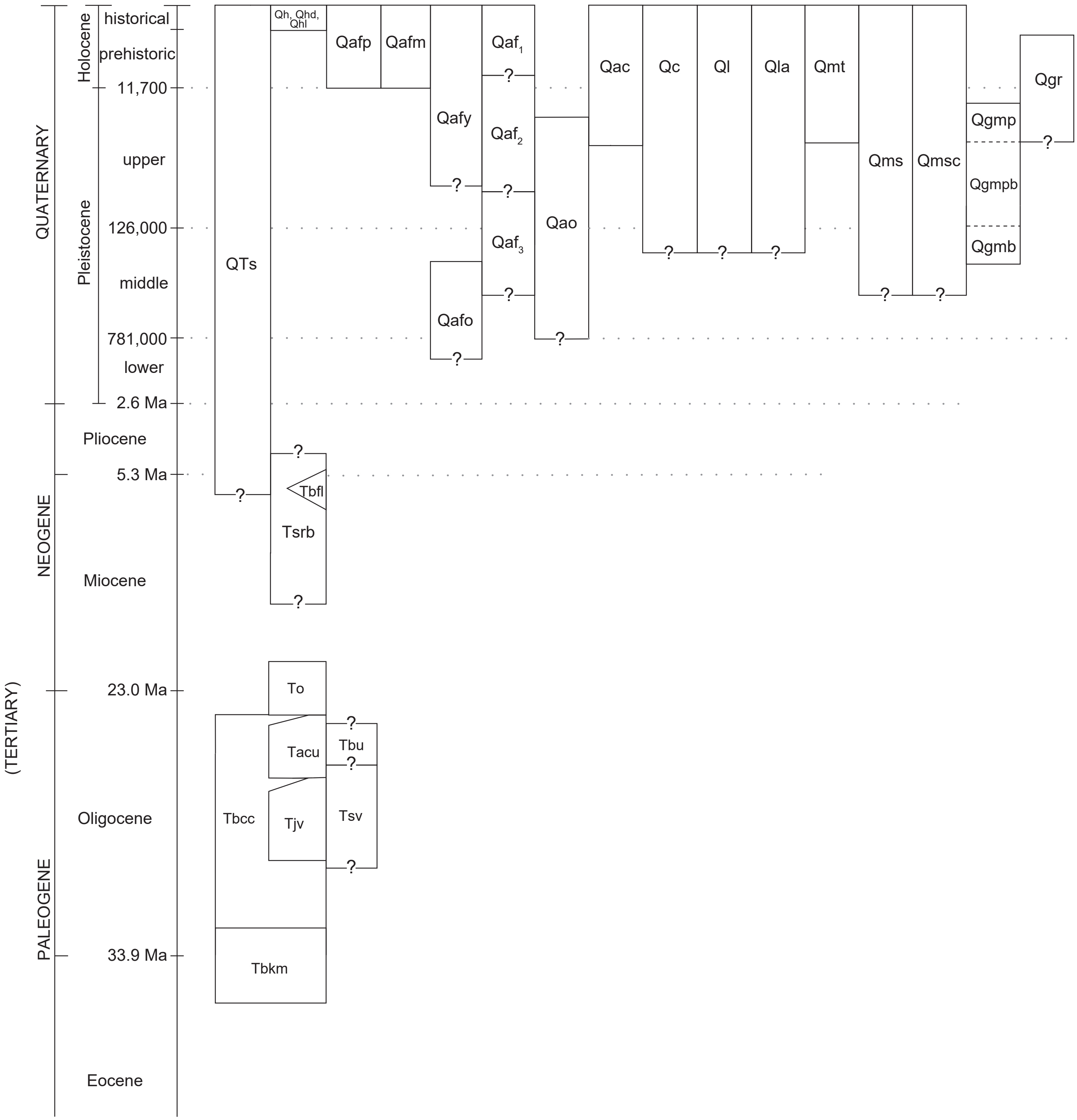
LITHOLOGIC COLUMN FOR BURRVILLE 7.5′ QUADRANGLE

Age		Formation, Member		Map symbol	Thickness in feet (meters)
QUAT. (TERTIARY)	Plt.-H.	Surficial deposits		Q-	0–60 (0–18)
NEOGENE (TERTIARY)	Plio	Older sediment		QTs	0–200 (0–60)
NEOGENE (TERTIARY)	Miocene	Burrville member of Sevier River Formation		Tsrb	0–600 (0–180)
NEOGENE (TERTIARY)	Miocene	Basaltic lava flow of Fish Lake		Tbfl	0–30+(0–9+)
NEOGENE (TERTIARY)	Miocene	Osiris Tuff		To	130+ (40+)
PALEOGENE (TERTIARY)	Oligocene	Bullion Canyon Volcanics	Lava flows of Burrville	Tbu	450 (150)
PALEOGENE (TERTIARY)	Oligocene	Bullion Canyon Volcanics: Vent facies of volcanic rocks of Signal Peak (Tsv)	Tuff of Albinus Canyon and related units	Tacu	3000 (1000) region; 0–400+ (120+)
PALEOGENE (TERTIARY)	Oligocene	Bullion Canyon Volcanics: Vent facies of volcanic rocks of Signal Peak (Tsv)	Latite of Johnson Valley	Tjv	40 (12) quad; 200–300+ (60–90+)
PALEOGENE (TERTIARY)	Oligocene	Bullion Canyon Volcanics	Bullion Canyon volcaniclastics	Tbcc	0–600 (0–180)
PALEOGENE (TERTIARY)	Oligocene / Eoc.	Bullion Canyon Volcanics	Kings Meadow member	Tbkm	300–400+ (90–120+)

Lithology



BURRVILLE QUADRANGLE
CORRELATION OF MAP UNITS



BURRVILLE QUADRANGLE, CROSS SECTION A-A'