Preliminary Geologic Map of the Susanville 30’ x 60’ Quadrangle, California

Scale 1:100,000

By

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Introduction

In 1988, the California Geological Survey (then Division of Mines and Geology) Regional Geologic Mapping Project began a project in northeastern California to improve the level of detail of geologic data and provide a better understanding of the framework geology of an area previously covered by only small-scale reconnaissance mapping. This project has developed new geologic map data that may be used as the foundation for geologic hazard investigations, natural resource evaluations, and other earth science related studies in this part of northeastern California. The map was compiled and digitized primarily from new geologic mapping that was conducted between 1988 and 1990 and also includes unpublished mapping.

This compilation was prepared by the Department of Conservation, California Geological Survey and was supported in part by the U.S. Geological Survey (USGS) Geothermal Program and the Cooperative Geologic Mapping Program - COGEMAP (Agreement No. 14-08-0001-A0542) the predecessor to STATEMAP. This map is being published as part of the California Geological Survey’s 1:100,000-scale Regional Geologic Map Series and replaces an earlier version released as Open-File Report 91-1.

Geologic Summary

The Susanville 1:100,000-scale quadrangle lies between 40º and 40º30' N. latitude and 120º and 121º W. longitude and includes the junction of four unique and dynamic geologic provinces: the Sierra Nevada, Modoc Plateau, Cascade Range, and the Basin and Range (Fig. 1). The rocks, structures, landforms, geologic histories, and economic mineral and water resources all differ and contrast significantly between these provinces. In other words, each province has its own story.

The Sierra Nevada Province dominates the southern part of the map. The oldest rocks, dating from Devonian into the Jurassic (about 400 million to 150 million years) are complex, thick sequences of pervasively deformed and metamorphosed marine sedimentary and volcanic rocks that were accreted from the Pacific Plate to the margin of the North American Plate. These rocks are located in the southwest corner of the map area (Fig. 1). This complex was repeatedly intruded by granitic plutons in the Jurassic and Cretaceous (between 200 and 65 million years ago). The bulk of the Sierra Nevada is composed of these granodioritic plutons. They occur in the central and southern part of the map. Physiographically, the province is predominantly mountainous with numerous canyons cut by southward-flowing streams. The northern margin is located generally west of Susanville where the older Sierran rocks are covered by the young volcanics of the Cascade Range without a sharp geomorphic break. In contrast, the northeastern margin of the Sierra Nevada is a sharp, linear mountain front that rises 2,000 to 5,000 feet above the floor of the Honey Lake Basin along the Honey Lake Fault Zone.

The southernmost part of the Modoc Plateau Province occurs in the north-central and northeast part of the map area north of the Honey Lake Basin (Fig. 1). The rocks here are entirely volcanic, composed of andesitic and basaltic lava flows and underlying silicic pyroclastic rocks and breccias. The Skedaddle and Amedee mountains comprise the largest and most complex volcanic center in this general region. One area of particular interest in the Modoc Plateau is the northernmost exposure of Sierran granitic rocks located about five miles north-northwest of Susanville at the map’s edge. These Sierran granitic rocks are believed to underlie the Modoc lava flows, but they do not crop out anywhere else in the Modoc Plateau Province.

In the northwest corner of the Susanville 1:100,000-scale quadrangle, two young volcanoes, Roop and Pegleg mountains, and intervening flows, define the southeasternmost extent of the Cascade Range Province. They are slightly eroded andesitic stratovolcanoes about three to four million years old that climb one to two thousand feet above intervening lava-floored valleys. Faults in the young lavas are relatively scarce in this part of the Cascades, perhaps because they are older than the flows and therefore not exposed.

The fourth geologic province in the Susanville 1:100,000-scale quadrangle is the Basin and Range Province. It is represented by the Honey Lake Valley or Basin located in the east central part of the map and the Fort Sage Mountains in the
southeast corner (Fig. 2). The Basin is a deep graben bounded by the Honey Lake Fault on the west and a largely buried fault system along the northern margin. Many thousands of feet of locally derived Miocene to modern volcanic and younger sedimentary layers fill the basin, but its subsurface details remain largely unknown. On the basis of regional gravity, it appears to be one of the deepest basins in the entire Basin and Range Province. Late Quaternary faulting occurs along the Honey Lake Fault Zone and locally on the valley floor in the Fort Sage Mountains area. In regional context, the structural patterns and seismic activity are characteristic of the northwest part of the Walker Lane Fault system. The Fort Sage Mountains comprise a fault-bounded uplifted block of Sierran granitic rocks that broke away from the main Sierra uplift yet did not subside deeply in the Honey Lake Basin. The alignment of the Fort Sage uplift, the Island, and Bald Mountain, as well as a buried subsurface high detected by gravity, define a large uplifted fault block within the deep Honey Lake Basin.
**Igneous Rocks**

Most of the rocks in the Susanville quadrangle are of two basic contrasting igneous types. The plutonic granitic rocks of the Sierra Nevada intruded and cooled at great depth and were later uplifted and deeply eroded. The volcanic rocks of the Modoc Plateau and Cascade Range were erupted from volcanoes and dikes onto the surface of the earth, where they accumulated around eruptive vents and spread out as lava and pyroclastic flow deposits. During Miocene time, the entire region of the Susanville quadrangle was covered with volcanic layers. Now, however, most have been eroded away from the uplifted Sierra Nevada block. Major sources for the younger volcanics include the local volcanoes: Skedaddle, Shaffer, Susanville Peak, Roop and Pegleg mountains as well as numerous intervening cones and dikes. The line of volcanoes from Skedaddle on the east to Pegleg on the west records a westward-younging age progression from 13 to 3 million years. The degree of erosion of each volcano clearly reflects this trend from extensive erosional dissection in the Skedaddle Mountains to none on Pegleg Mountain. This local volcanic history supports the idea of a westward migrating Cascade volcanic arc, and, in its wake, an expanding Basin and Range characterized by back-arc volcanism.

**Structure**

Although the four major geologic provinces in the Susanville quadrangle have different characteristics, there is a pervasive northwest-trending fault system that persists and passes through all of the provinces, i.e. throughout the map area. The Honey Lake Fault Zone is the most prominent in length and displacement. Combined with the Warm Springs Valley Fault Zone and unnamed faults northwest of Antelope Lake, a regional system of *en echelon*, left-stepping, dextral faults is evident. All of the faults are moderate- to high-angle dip-slip with a significant component of right-diagonal slip. Similar fault geometries occur along this trend to the southeast of the map. Collectively these faults characterize the Walker Lane (Grose, 2000; Faulds and others, 2005). A weaker and more diffuse Walker Lane Fault Zone extends north-northwestwardly beyond the Susanville quadrangle.

The Susanville zone (Grose, 2000) is a subtle, little understood, east-west line of abrupt change between the regions to the north and south of Susanville. For example, the many volcanoes of the Modoc Plateau abruptly stop at the line; Sierran granitic rocks are widespread to the south; and east-west fault lines interrupt the regional northwesterly trend.

Active faulting (younger than 10,000 years) is an environmental concern that occurs along the southern part of the Honey Lake Fault Zone, along the west flank of the Fort Sage Mountains, in the Wendel hot springs area, and several miles northeast of Susanville in an area of conjugate fractures. In 1950 an earthquake of magnitude 5.6 occurred in the Fort Sage Mountains causing strong ground shaking and local surface displacement. In 2013, an earthquake of magnitude 5.9 occurred in the Greenville area.

**Compilation**

The *Preliminary Geologic Map of the Susanville 30’ x 60’ Quadrangle, California* was compiled and digitized from new and existing, published and unpublished, geologic maps covering the area. New geologic mapping was completed between June 1979 and June 1990 in six (and part of one) of the eight 15-minute quadrangles covering the area. Geologic maps of the Doyle, Litchfield, Milford, Susanville, Wendel, Westwood, and part of the Kettle Rock quadrangles (Fig. 3) were published by the California Geological Survey (Division of Mines and Geology) as individual Open-File Reports. The original fieldwork was supported in part by USGS – COGEOOMAP funds, the predecessor to STATEMAP. The geology for the Greenville and western part of the Kettle Rock 15-minute quadrangles was compiled from existing and unpublished references, at various scales, on to 15-minute topographic base maps. The geologic maps were put into digital format by hand, using stable base material on a digitizing tablet or by scanning and digitizing on screen. The individual maps were digitized at a scale of 1:62,500 with minor modifications to produce this seamless digital map.

The original digital work for the individual
quadrangles, as well as the merged database file, was completed using ArcInfo® (Versions 8.3 and 9.3), a commercial GIS software package by Environmental Systems Research Institute (ESRI). For publication purposes the merged coverage was converted into the ESRI File Geodatabase format. The merged geology, structure, and annotation files along with base map and shaded-relief images were combined using the ArcMap application within ArcGIS 10.1 (ESRI).

**Base Materials**

The base for the Susanville 30’ x 60’ quadrangle consists of topographic map and shaded-relief raster images. The topographic base map is taken from the USGS digital raster graphic (DRG) of the Susanville 1:100,000-scale quadrangle available from the California Spatial Information Library (CaSIL) (http://www.atlas.ca.gov/). The shaded-relief image was derived from 30-meter resolution elevation data obtained from the National Elevation Dataset (NED) at http://ned.usgs.gov/.

**Acknowledgements**

The authors wish to thank D.S. Harwood (USGS) for providing copies of his unpublished mapping of Mount Jura and sharing his views on the regional stratigraphic correlations of the Mesozoic and Paleozoic rocks. In addition, we thank Geoff Christe (Virginia Department of Environmental Quality) for providing copies of his unpublished mapping in the Kettle Rock and Greenville 15-minute quadrangles. We also appreciate the careful review provided by both Harwood and Christe. Thanks also to C.J. Wills (CGS) for his thoughtful review. We would also like to thank Karen Toman-Sager, Heather Lackey, Victoria Walker, and Jerry Wampole of CGS for their assistance in the preparation of this map for publication.
Figure 2. Index map of the Susanville 30' x 60' quadrangle showing the locations of geographic features referenced in the Description of Map Units. Map also shows locations of volcanic rocks dated by radiometric methods (numbers correspond to Location Number in Tables 1 - 3).
DESCRIPTION OF MAP UNITS  
(Approximate stratigraphic relationships)

SURFICIAL DEPOSITS

Mine tailings (historic, late Holocene) – Lights Creek area – Moonlight Peak 7.5’ quadrangle.

Artificial dam fill (historic, late Holocene) – Earth dams, rock-fill dams and embankments constructed to impound water.

Lake deposits (Holocene) – Clay, silt, and sand, exposed around margin of Honey Lake and at low water stand at Mud Flat.

Playa deposits (Holocene) – Clay, silt, and sand; thin deposits in small local basins derived mainly from redistributed Lake Lahontan sediments.

Eolian, fluvial, and lacustrine deposits (Holocene) – Sand, silt, and clay; mainly derived from reworking of Lake Lahontan sediments.

Sand sheet and sand bar deposits (Holocene) – Sand and silt locally grading into sand dunes; usually downwind from source areas; mainly eolian, in part lacustrine.

Dune sand (Holocene) – Partially stabilized dune field grading into sand sheet and Lake Lahontan deposits.

Alluvial fan deposits (Holocene) – Fine to coarse gravel up to boulder size, poorly to non-bedded. Occurs generally as small (< 1 km) fan-shaped deposits on margins of Honey Lake basin and Mountain Meadows basin.

Talus debris (Holocene) – Boulder-sized, angular blocks of mafic andesite of Susanville Peak (Tspa) located 4 kilometers northeast of Susanville along an early Quaternary (?) fault scarp.

Alluvium (Holocene and Pleistocene) – Sand, gravel, and silt; fluvial deposits along modern drainages; grades into colluvium and lacustrine deposits. May locally include colluvium, talus debris, and terrace deposits.

Landslide deposits (Holocene and Pleistocene) – Coarse sand to boulder size, subangular to angular clasts and locally larger coherent masses of volcanic and granitic rocks on steep slopes.

Delta deposits of the Susan River (Holocene and Pleistocene) – Mud and channel sand, prograding southward into lacustrine beds of Honey Lake.

Older alluvial fan deposits (Holocene and late Pleistocene) – Gravel and sand; in part arkosic, moderately incised.

Colluvium (Holocene and Pleistocene) – Coarse to fine gravel, angular to rounded; mostly non-bedded blanket of unconsolidated debris. Contains minor coarse sand interbeds and matrix. Occurs mainly along base of mountain slopes and locally in small drainages.

Tufa and minor sinter (Holocene and Pleistocene) – Hot spring and algae deposits from interaction between waters of Wendel Hot Springs and Lake Lahontan.

Lake deposits (Holocene and Pleistocene) – Sand, silt, and clay; thin lacustrine deposits in ephemeral lakes.

Fan-delta deposits of Long Valley Creek (Pleistocene) – Fluvial and lacustrine deposits of fine-grained arkosic sand and silt with lesser gravel in channels; thin-to thick-bedded, cross-bedded; progrades
northward into large delta of Lake Lahontan deposits of silt and clay.

Qpl  **Near-shore deposits of Lake Lahontan (Pleistocene)** – Sand silt, and gravel derived from volcanic and granitic sources and deposited in marginal areas of Lake Lahontan mainly in the northern half of the Honey Lake basin.

Qplg  **Gravel deposits of Lake Lahontan (Pleistocene)** – Gravel and coarse sand with minor silt matrix; massive to poorly bedded. Occurs as local thick alluvial accumulations in mainly fluvial-lacustrine environments as well as in lake-margin blanket deposits along north margin of the Honey Lake basin.

Qpf  **Fan and pediment gravel (Pleistocene)** – Gravel, massive remnants of old and mostly eroded pediments and fans occurring at moderately high elevations in the Fort Sage Mountains and northeast flank of Shaffer Mountain.

Qpgl  **Glacial deposits (Pleistocene)** – Undifferentiated glacial till, moraine, and outwash deposits.

Qols  **Older landslide deposits (Pleistocene)** – Moderately eroded landslide deposits on steep slopes.

QTg  **Older gravel deposits (Pleistocene and (or) Pliocene)** – Boulder and cobble conglomerate and gravel.

TI  **Lake deposits (Pliocene)?** – Clay, silt, sand and minor tuff.

**VOLCANIC ROCKS**

[Listed in general order of increasing age; see Figure 2 or geologic map for sample locations (Location Number); see Tables 1, 2, and 3 for the results of radiometric and chemical analyses; see Table 4 for an explanation of terminology used in the description of volcanic rocks.]

Qwb  **Basalt of Westwood (Pleistocene)** – Dark-gray to black, diktytaxitic, aphanitic to moderately finely olivine porphyritic. Occurs in a large field of horizontal flows with moderately fresh constructional surface features preserved. Also preserved discontinuously in the bottom of the Susan River canyon from sources located several miles northwest of the map area.

Qsb  **Basalt of Susanville (Pleistocene)** – Dark-gray to black, diktytaxitic, aphanitic to locally sparsely finely olivine porphyritic. Massive multiple flows, 3-5 m thick, locally columnar jointed; source unknown. K-Ar age: 1.3±0.3 Ma (Location No. 1) (Grose and McKee, 1986).

Tmb  **Basalt of Merrill Flat (early Pleistocene or late Pliocene)** – Light- to dark-gray, aphanitic, dense to moderately diktytaxitic, subophitic, locally sparsely finely olivine-phyric, with clinopyroxene. Occurs as horizontal flows infilling between older volcanic highs.

Tp  **Intrusive plug, undifferentiated (Tertiary)** – Intrusive core of eroded volcano or smaller mass.

Thma  **Mafic andesite of Highway 36 (Pliocene)** – Light- to dark-gray, moderately finely pyroxene and plagioclase-porphyritic. Massive near-horizontal vesicular flows with pumice lapilli tuff interbeds relatively continuous; several meters thick.

Tbca  **Mafic andesite of Bridge Creek (Pliocene)** – Light- to medium-gray, sparsely micro-to finely porphyritic with olivine and pyroxene phenocrysts and local glomerocrystals of plagioclase set in a pilotaxitic matrix. K-Ar age: 3.4±0.2 Ma (Location No. 2); K-Ar age on pyroclastic vent debris within Tbca: 1.8±0.5 Ma (Location No. 3) (Grose and
<table>
<thead>
<tr>
<th>Code</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tlrb</td>
<td>Basalt of Lava Rock Reservoir (Pliocene)</td>
<td>Medium-gray to black, moderately diktytaxitic, sparsely olivine microporphyritic. Occurs as thin horizontal flows in eastern part of Secret Valley. May be correlative with Tsvb.</td>
</tr>
<tr>
<td>Tsvb</td>
<td>Basalt of Secret Valley (Pliocene)</td>
<td>Dark-gray, diktytaxitic, moderately finely olivine, augite, plagioclase porphyritic with prominent 1-2 cm glomerocrysts of plagioclase in middle of sequence with interbedded fine to coarse white tuff and lapilli tuff in basal and lower part of unit. Flows are &lt; 10 m thick some with columnar joints. May correlate with Tlrb. K-Ar age: 4.9±0.5 Ma (Location No. 4) (Grose and McKee, 1986; Roberts, 1985).</td>
</tr>
<tr>
<td>Tvb</td>
<td>Olivine basalt of Viewland (Pliocene)</td>
<td>Black, dense, moderately finely olivine porphyritic. Flows overlie Tlrt on irregular surface.</td>
</tr>
<tr>
<td>Tvbi</td>
<td>Olivine basalt intrusives of Viewland (Pliocene)</td>
<td>As Tvb above. Dike and plug source of Tvb.</td>
</tr>
<tr>
<td>Tlrt</td>
<td>Tuff of Lava Rock Reservoir (Pliocene)</td>
<td>White to gray crystal vitric, locally pumice lapilli with fossiliferous lacustrine tuffaceous clays and cross-bedded fluvial layers in middle of unit. Massive to poorly bedded, horizontal beds. Underlies basalt in Secret Valley. (Grose, 1989a; Grose and Porro, 1989a,b; Roberts, 1985)</td>
</tr>
<tr>
<td>Tspa</td>
<td>Mafic andesite of Susanville Peak (Pliocene)</td>
<td>Light- to dark-brownish-gray, aphanitic to fine-grained, olivine and pyroxene intergranular with local sparse fine phenocrysts. Flows derived from dikes in summit area of Susanville Peak.</td>
</tr>
<tr>
<td>Trma</td>
<td>Mafic andesite of Roop Mountain (Pliocene)</td>
<td>Medium dark-gray, aphanitic-crystal splotchy, locally sparsely finely porphyritic with olivine and pyroxene. Flow-on-flow sequence derived from several summit vents. Slightly older than K-Ar age: 3.9±0.2 Ma (Location No. 5) (Grose and McKee, 1986).</td>
</tr>
<tr>
<td>Tpa</td>
<td>Andesite of Pegleg Mountain (Pliocene and (or) Miocene)</td>
<td>Light- to dark-gray, aphanitic to variously porphyritic, very dense to slightly vesicular flows from obscure vents in summit area.</td>
</tr>
<tr>
<td>Thmi</td>
<td>Andesite intrusives and flows (?) of Hamilton Mountain (Pliocene and (or) Miocene)</td>
<td>Medium- to dark- gray, sparsely finely olivine and plagioclase porphyritic. These andesites occur as dense plugs, sills (?), and proximal flows (?).</td>
</tr>
<tr>
<td>Tci</td>
<td>Intrusives of Coppervale (Pliocene and (or) Miocene)</td>
<td>Light- to dark- gray, aphanitic to coarsely moderately feldspar porphyritic, locally strongly columnar jointed. Occurs as three hornblende latite to andesite plugs.</td>
</tr>
<tr>
<td>Tda</td>
<td>Andesite of the Diamond Mountains (Pliocene and (or) Miocene)</td>
<td>Undivided andesitic volcanic rocks; includes massive flows, breccia, mudflow, tuff, and volcaniclastic sedimentary rocks. May also include intrusive bodies. Hornblende andesite is the most common lithology; some andesite contains pyroxene and olivine. Composition can range from basalt to dacite (?).</td>
</tr>
<tr>
<td>Tdbi</td>
<td>Basalt intrusives of the Diamond Mountains (Pliocene and (or) Miocene)</td>
<td>Minor intrusions of scoriaceous, jointed basalt along faults of the Honey Lake Fault Zone.</td>
</tr>
</tbody>
</table>
Tdai  **Andesite intrusives of the Diamond Mountains (Pliocene and (or) Miocene)** – Dark- to light-gray, plugs and dikes of heterolithologic andesite; includes a distinctive gray andesite with hornblende phenocrysts > 1 cm across; also includes biotite- bearing andesite or dacite. $^{40}$Ar/$^{39}$Ar age at Dixie Mountain: 10.98±0.27 Ma (Location No. 6) (This report).

Tdaf  **Andesite flows of the Diamond Mountains (Miocene)** – Massive, dark-gray to pinkish-gray andesite. Plagioclase-phyric mafic andesite is the most common lithology present, although hornblende-phyric mafic andesite and hornblende andesite are common; pyroxene phenocrysts occur in some andesite. Flows generally are jointed and form prominent ridge-capping outcrops. Flow banding and platy flow structure is well developed. SiO$_2$ ranges from 53% to 60%. K-Ar age: 7.05±0.35 Ma (Location No. 7) (This report).

Tdap  **Andesitic pyroclastic deposits of the Diamond Mountains (Miocene)** – Heterogeneous andesite, laharic breccia, tuff breccia, stream-laid andesitic sand and gravel; may include local flows. Clasts in the breccias display a wide variety of andesitic lithologies with some basalt. Andesites are gray, red, brown, and pink; most are porphyritic with phenocrysts of plagioclase, hornblende, and some pyroxene. K-Ar age: 9.60±0.24 Ma from andesite clast in tuff-breccia; 8.94±0.17 Ma from andesite dike intruding breccias (Location No. 9) (This report).

Tfda  **Dacite and andesite of the Fort Sage Mountains (Pliocene and (or) Miocene)** – Flows of hornblende dacite and pyroxene andesite with rhyolite tuff and obsidian tuff breccia in upper part. Flows are discontinuous and lenticular, < 4 m thick. This relatively heterogeneous unit has a preserved thickness of about 130 m, and is the youngest in the layered volcanic sequence in the Fort Sage Mountains.

Tfbi  **Basalt intrusives of the Fort Sage Mountains (Pliocene and (or) Miocene)** – Black, aphanitic to abundantly coarsely porphyritic with labradorite laths < 10 mm, with varying amounts of olivine and pyroxene, dense. Basalt occurs in tabular and lensic dikes and locally in sills (?) in a 2 km-long, north-south zone in the Fort Sage Mountains.

Tfai  **Andesite intrusives of the Fort Sage Mountains (Pliocene and (or) Miocene)** – Medium- to dark-gray, aphanitic to moderately microporphyritic, with varying amounts of pyroxene, hornblende, and rare olivine, and possible rare hypersthene in one plug. These andesites occur mostly in circular and elliptical plugs intruded into the volcanic extrusive sequences in the Fort Sage Mountains.

Tea  **Andesite of Eisenheimer Peak (Pliocene and (or) Miocene)** – Pale blue-gray porphyritic andesite flows; columnar jointed.

Tvma  **Mafic andesite (Miocene)** – Fine-grained, dense olivine-bearing andesite; columnar jointing is well developed in places. Mafic andesite appears to occur as intrusions along faults of the Honey Lake Fault Zone. Mafic andesite flows were apparently extruded along fissure vents along faults. SiO$_2$ is 52% to 53%. K-Ar age: 9.60±0.24 Ma (Location No. 8) (This report).

Tbmi  **Basalt intrusives of Bald Mountain (Miocene)** – Black, dense dikes with rare olivine phenocrysts. Basaltic agglomerate around intrusives.
Tbma **Andesite breccia of Bald Mountain**  
(*Miocene*) – Two-pyroxene andesite flow breccias, and laharc debris flows with minor flows of basalt and dacite; occasional lenses of fluvial and lacustrine sediments. Probably correlative with Tamb unit. Clast size from fine pebbles to 3 m boulders. K-Ar age: 10.0±0.4 Ma (Location No. 10) (Grose and McKee, 1986; Roberts, 1985).

Tha **Andesite of Highway 139**  
(*Miocene*) – Light- to medium-gray, moderately finely plagioclase and pyroxene porphyritic with pilotaxitic matrix. Massive flows may be correlative in part with Tama unit.

Tamb **Andesite breccia of Antelope Mountain**  
(*Miocene*) – Gray-brown to mauve, monolithic autobrecciated, two-pyroxene andesite breccia flows and poly lithic laharc debris flows interbedded with minor flows of andesite and basalt; local tuff interbeds. Probably correlative with Tbma unit.

Tama **Andesite of Antelope Mountain**  
(*Miocene*) – Gray, moderately finely augite and plagioclase porphyritic, platy to massive flows. K-Ar age: 10.4±0.4 Ma (Location No. 11) (Grose and McKee, 1986; Roberts, 1985).

Ttma **Mafic andesite of Tunnison Mountain, basal unit**  
(*Miocene*) – Gray to black, moderately to abundantly finely to coarsely pyroxene and plagioclase porphyritic, glomeroporphyritic, and seriate. Forms basal flow member of extrusive unit in Tunnison Mountain (Peterson and Goeldner, 1987).

Ttmt **Lithic-crystal tuff of Tunnison Mountain**  
(*Miocene*) – Gray, coarse-grained to lapilli, lithic clasts of intermediate to mafic volcanics. Usually occurs within Ttma unit in Tunnison Mountain

Tld **Latite domes of Litchfield**  
(*Miocene*) – Light-gray, abundantly finely feldspar porphyritic with minor hornblende and two pyroxenes. Massive uniform to flow brecciated, with occasional cognate lithic inclusions.

Tlf **Andesite flows and pyroclastics of Litchfield**  
(*Miocene*) – Flows are abundantly finely pyroxene and plagioclase porphyritic and glomeroporphyritic. Minor interbedded tuffs and flow breccias.

Tlp **Latitic to andesitic flow breccias and tuffs of Litchfield**  
(*Miocene*) – White massive crystal vitric fine-grained tuff, gray lithic pumice lapilli bedded; dark flow breccias and tuff breccias mostly in lower part of unit; minor flows.

Tsmi **Two-pyroxene andesite intrusive of Shaffer Mountain**  
(*Miocene*) – Dark-gray, aphanitic, seriate, intergranular, dense, locally flow banded, massive plug, surrounded by pyroclastics and flows

Tsma **Two-pyroxene andesite flows of Shaffer Mountain**  
(*Miocene*) – Gray, moderately finely plagioclase and pyroxene porphyritic, glomeroporphyritic and seriate with intergranular matrix and minor olivine. Forms flow-on-flow sequence of Shaffer Mountain. K-Ar age: 10.9±0.4 Ma (Location No. 12) (Grose and McKee, 1986).

Tesi **Mafic andesite intrusives of East Shaffer shield**  
(*Miocene*) – Light-gray to black, aphanitic to diabasic, locally variously olivine, pyroxene, and plagioclase porphyritic; dense, locally with prominent apatite crystals. Forms elongate plugs and dikes.

Tesa **Mafic andesite flows of East Shaffer shield**  
(*Miocene*) – Dark-gray, variously
olivine and pyroxene porphyritic, seriate with inter granular matrix. Flow-on-flow sequences from several vents.

Tesp Andesitic tuff of East Shaffer shield (Miocene) – Tuffaceous, lapilli and minor lahar lenses, proximal to Tesi plugs.

Tvsa Mafic andesite flows of Viewland shield (Miocene) – Dark-gray, moderately finely pyroxene and olivine (minor) porphyritic. Occurs as flows, 2-4 m thick, derived from two major plugs on small compound shield.

Tvsi Mafic andesite intrusives of Viewland shield (Miocene) – Similar to Tvsa above, but more dense. Occurs in plugs central to small shields; the youngest and westernmost of several shields within the Wendel 15-minute quadrangle.

Twsa Mafic andesite of Wendel shield (Miocene) – Medium- to dark-gray, moderately finely pyroxene and olivine porphyritic. Occurs as flows, 3-5 m thick, derived from major plug on small shield.

Tawi Mafic andesite intrusives of Wendel shield (Miocene) – Similar to Twsa above, with variable amounts of pyroxene (major) and olivine (minor). Occurs as large conspicuous plug central to a small shield, and also in zone of regional dike swarm.

Tf Andesite flows and flow breccias (Miocene) – Light- to dark-gray, mostly aphanitic with pyroxene and minor olivine, platy to massive. Intertongues with Tft unit mostly below.

Tft Rhyolite, dacite, and andesite (Miocene) – Flows, breccias, tuffs, and lahars; minor volcanioclastic lenses and layers, local pebble to boulder conglomerate lenses more common in lower part. Intertongues with and transitional with units below (Tvg) and above (Tf). Probably in part correlative with Tsd unit.

Tfti Andesite intrusive plug or small dome (Miocene) – Equivalent to and possible source of Tft unit.

Tsd Rhyolite to dacite (Miocene) – Minor andesite flows, breccias, and pyroclastics; commonly massive, hornblende dacite flows. Complex unit probably reflecting small caldera fill southwest of Susanville. Partly correlative with Tama, Tamb, Tbma, and Tft. K-Ar age: 11.4±0.3 Ma (Location No. 13) (Grose and McKee, 1986).

Tsd Rhyolitic tuff (Miocene) – White, crystal vitric, fine-grained, massive, laminated. Probably a facies of Tsd complex unit.

Tsdt Rhyolitic tuff (Miocene) – White, crystal vitric, fine-grained, massive, laminated. Probably a facies of Tsd complex unit.

Tsva Altered volcanic rocks of Skedaddle center (Miocene) – Tan, gray, yellow, white. Includes propylitized tuff of Tat unit, breccia complexes of Tafp and flows of Tsba and an altered intrusive mass of andesitic-dacitic composition

Taa Andesite flows of the Amedee Mountains (Miocene) – Light- to dark-gray variously pyroxene porphyritic, mainly flows, 2-6 m thick with minor flow breccia masses. Occurs as southeast-directed flows from Skedaddle center. K-Ar age: 11.7±0.2 Ma (Location No. 14); 11.6±0.2 Ma (Location No. 15) (Diggles and others, 1989). These are the youngest preserved extrusives from the Skedaddle volcanic center.

Tab Andesite flow breccia of the Amedee Mountains (Miocene) – Includes tuff breccia, laharic breccia with lesser flows and tuff in highly variable sequence grading upward from more tuffaceous rocks below. Locally disconformably overlies horizontal tuffs. Occurs as southerly-directed extrusives from Skedaddle center. May be correlative with Tsfp unit.
Tat  Tuff of the Amedee Mountains (Miocene) – White, gray, tan, bedded tuff, lapilli tuff, and tuff breccia with local flows and flow breccia, silicified layers, and massive propylitic alteration. Horizontal bedding common, suggesting ponding in caldera.

Tafp  Andesite flows and pyroclastics of the Amedee Mountains (Miocene) – Includes complexly interbedded and massive flow breccia and lahars, flows, and tuff breccia and tuff derived from multiple sources in Skedaddle center.

Tsaf  Andesite flows of the Skedaddle Mountains (Miocene) – Medium-dark-gray, abundantly finely pyroxene and andesine porphyritic with hyalophyric matrix, with clinopyroxene and orthopyroxene. Occurs as flows, 5-15 m thick, directed westward from summit vent area of Skedaddle Mountains. K-Ar age: 11.8±0.6 Ma (Location No. 16) (Grose and McKee, 1986).

Tthi  Andesite plugs of Tin House Spring (Miocene) – Dark-gray, dense. Occurs as three elongate plugs intruding Tsfp unit.

Tsfp  Andesite flows and pyroclastics of the Skedaddle Mountains (Miocene) – Includes complex sequence of flows and breccias in proximal facies; tuffs, tuff breccias, lahars, and rubble beds in distal facies to northeast. Direction of transport is northeasterly and easterly from Skedaddle center. May correlate with Tab unit; locally underlies Tsaf unit.

Tsai  Andesite intrusive plug of the Skedaddle Mountains (Miocene) – Altered; may be a source of Tsfp unit. Forms the topographically highest elevation at Hot Springs Peak.

Tsa  Andesite of the Skedaddle Mountains (Miocene) – Flows within distal pyroclastic rocks of Tsfp representing relatively far traveled flows derived from Skedaddle center.

Tscv  Andesite vitrophyre of Spencer Creek (Miocene) – Dark-gray to black, abundantly finely augite and plagioclase porphyritic in glassy to microcrystalline matrix. Occurs as dike, plug, and sill(?) intruding Tat unit.

Tscb  Andesite flow breccia and lahar of Spencer Creek (Miocene) – Generally underlies Tat unit and may be quasi-equivalent to Tafp unit.

Tsba  Andesite flows of Spencer Basin (Miocene) – Gray, tan, locally bleached. Massive flows variously propylitically altered.

Tta  Andesite flows and domes of Thousand Spring Canyon (Miocene) – Light- to dark-gray, abundantly finely hornblende and plagioclase porphyritic and locally vitrophyric. Occurs as irregular flow layered masses. Oldest unit on south flank of Skedaddle center.

Twd  Dacite flows of Wendel Canyon (Miocene) – Light-gray, abundantly finely hornblende and feldspar porphyritic. May be border phase of Twr domal mass. Local, but distinctive unit.

Twf  Andesite flows of Wendel Canyon (Miocene) – Dark-gray, aphanitic, microvesicular, slightly altered. May be generally correlative with Tsba unit.

Twr  Rhyolite of Wendel Canyon (Miocene) – Light-gray to black, hyaline-vitrophyric, finely flow laminated, locally perlitic. Tuffaceous carapace around domal structure of mass.

Tdd  Latite dome (Miocene) – Light-gray, abundantly finely hornblende, plagioclase, and sanidine porphyritic; massive. Surrounded by tuff and tuff breccia deposits of Tdp.
Tdp  **Tuff and tuff breccia with cinders and local dikes (Miocene)** – Complex, variable pyroclastic deposits surrounding latite dome (Tdd).

Tfd  **Latite dikes and sills (Miocene)** – Irregularly intruded into tilted layers of Tfp unit. K-Ar age: $12.5\pm0.6$ Ma (Location No. 17) (Diggles and others, 1989)

Tfp  **Andesitic flows and pyroclastics (Miocene)** – Local sequence moderately tilted to southeast toward latite dome center (Tdd).

Thr I  **Mafic andesite intrusives of Horsecamp Reservoir (Miocene)** – Medium- to dark-gray, aphanitic to sparsely olivine, pyroxene, and plagioclase micro-porphyritic. Occurs as small plugs and irregular dikes and sills.

Tb  **Basalt and mafic andesite flows (Miocene)** – Medium-gray to black, finely sparsely olivine porphyritic; dense massive flows, < 8 m thick, locally with strong platy partings. Occurs probably as oldest unit derived from general Skedaddle center to south. K-Ar age: $12.3\pm0.4$ Ma (Location No. 18) (Diggles and others, 1989).

Tbfi  **Andesite intrusives of Bull Flat (Miocene)** – Dark-gray to brown, aphanitic, dense. Occurs mainly as sills with minor dikes and plugs.

Tmf  **Andesite flows (Miocene)** – Light- to dark-gray, with pyroxene and minor olivine, interbedded with flow breccia and tuffaceous layers. Uppermost unit in layered sequence in Nevada.

Tscf  **Andesitic flows and tuffs of Skedaddle Creek (Miocene)** – Flows are dark-gray to black, aphanitic, locally amygdaloidal, and dense. Occurs as interbedded irregular thin flows and white tuff and lapilli tuff in uppermost Tscp unit.

Tscp  **Andesitic pyroclastics and flows of Skedaddle Creek (Miocene)** – Tuffs are white to gray; flows (minor) are generally gray and tan. Mainly tuff and lapilli tuff with minor volcaniclastic layers and thin flows. Flows are more abundant in southeastern area.

Tasf  **Basalt and mafic andesite flows of Antelope Spring (Miocene)** – Medium-gray to black, aphanitic to variously olivine and pyroxene porphyritic. Mostly flow-on-flow, with considerable beds of fragmental rocks locally. Flows comprise a medium-sized shield north of and beneath the extrusives of the Skedaddle center. K-Ar age: $12.8\pm0.2$ Ma (Location No. 19) (Diggles and others, 1989).

Tcf  **Andesite flows of Cherry Spring (Miocene)** – Medium- to dark-gray, aphanitic to moderately finely pyroxene porphyritic, dense to moderately vesicular flows, 2-4 m thick. Forms a medium-sized, older shield east of the Skedaddle center.

Tgl  **Latite and andesite flows of Gilman Spring (Miocene)** – Dark-gray and brown, sparsely finely hornblende and plagioclase porphyritic, platy dense flows < 8 m thick.

Tgf  **Mafic andesite flows of Gilman Spring (Miocene)** – Medium- to dark-gray, aphanitic to variously porphyritic with pyroxene and minor olivine. Forms extensive flow-on-flow sequence with slight westerly dip.

Tbft  **Tuff of Bull Flat (Miocene)** – White, gray, tan tuff, and lapilli tuff, apparently horizontal underlying Tgf unit.

Tti  **Mafic andesite and basalt of Thompson Peak (Miocene)** – Purplish-gray, aphanitic to porphyritic, local breccia and agglutinate. Shallow intrusive plugs and marginal facies.
Basalt of Thompson Peak, upper unit (Miocene) – Light-gray, diktytaxitic, uniform fine-grained flows with olivine, augite, and plagioclase. Pipe vesicles and scoria common. Yellow to light-gray fluvial volcanic lithic wacke common at base. Maximum preserved thickness of entire unit is 280 m. K-Ar age: 10.1±0.6 Ma (Location No. 20) (Grose and McKee, 1986; Roberts, 1985).

Basalt of Thompson Peak, lower unit (Miocene) – Black, dense, aphanitic with occasional fine phenocrysts of labradorite and olivine with augite in hyalophytic matrix. Flows display characteristic blocky fracture. Maximum thickness 70 m. Probably correlative to flows mapped as Lovejoy Basalt (Tlb) (Roberts, 1985). K-Ar age: 16.3±0.6 Ma (Location No. 21) (Grose and McKee, 1986; Roberts, 1985).

Lovejoy Basalt (Miocene) – Black, dense, fine-grained olivine basalt flows; highly fractured. Probably correlative with lower basalt of Thompson Peak (Ttbl).

Andesite of Ferris Creek (Miocene) – Light-gray to white andesite. Includes dikes and plugs of coarsely hornblende porphyritic rock with phenocrysts 1 cm or more in diameter. Also includes dacite (?) flows containing biotite and plagioclase phenocrysts. K-Ar age: 10.81±0.32 Ma (Location No. 22); 11.49±0.28 Ma (Location No. 23) (This report).

Pyroxene mafic andesite of the Fort Sage Mountains (Miocene) – Medium- to dark-gray, sparsely to abundantly finely to microporphyritic with euhedral andesine and augite phenocrysts. Flows are semilenticular < 5 m thick. About 20% of volume is olivine-pyroxene basalt, black, finely to moderately porphyritic. This unit, with up to 150 m of preserved thickness, occurs in paleovalleys cut in tuff and locally in granitic basement. K-Ar age: 14.25±0.43 Ma (Location No. 24) (This report).

Rhyolite tuff of the Fort Sage and Diamond Mountains (Miocene and Oligocene) – White to light-gray, mostly coarse-grained to lapilli, pumiceous, crystal vitric; sanidine and biotite crystals nearly ubiquitous; locally with lensic masses of rhyolite, dacite, and andesite tuff breccia; highly variable thickness up to 180 m. Two slightly welded, relatively resistant zones occur locally in middle third of the unit. This unit is the oldest in the Tertiary volcanic sequence. It correlates with 30.5 to 23.0 Ma tuffs in the Seven Lakes Mountain area 6 miles to the southeast.

SEDIMENTARY ROCKS

Boulder to pebble conglomerate (Miocene?) – Contains highly variable discontinuous lenses of volcanic, laharc and flow breccia, tuff, and fluvial sandstone. Prominent round boulders of pre-Cretaceous metavolcanic and siliceous metasedimentary rocks locally mixed with boulders of Tertiary volcanics and rarely of Sierran granodiorite. Occurs with variable thickness at base of Tertiary section and locally as lenses within Tft and Tsd units.

Nonmarine sedimentary rocks (Eocene) – Arkoic quartz sandstone, siltstone, and conglomerate.

"Auriferous gravel" (Eocene) – River channel deposits; pebbles, cobbles, and boulders of pre-Tertiary basement rock types, in places predominately quartzose gravels and sand. Mostly Eocene but locally may include younger deposits.
PRE-CENOZOIC ROCKS

Kgd Hornblende-biotite granodiorite (Cretaceous) – White to gray, medium-grained, generally uniform and massive but locally hornblende-rich, with aplitic, or seriate textures. Locally contains minor schistose roof pendant rocks, mafic xenoliths, and thin aplitic dikes.

Kga Alaskite, aplite, and granite (Cretaceous) – White to medium-gray, locally greenish, strongly seriate and fine-grained; quartz and K-feldspar are irregularly abundant with epidote locally common. This plutonic suite indicates very close proximity to metavolcanic roof pendants.

Kdi Hornblende diorite (Cretaceous) – Medium-dark-gray, fine- to medium-grained, locally gneissic, amphibolitic, and epidotized. Generally in gradational contact with meta-volcanic rocks (Ju), through several hundred feet.

Kls Lucky S Formation (Crickmay, 1933) (Cretaceous?) – Black shale rich in plant fragments, rusty weathering quartzose sandstone, lens of chert pebble conglomerate, and minor blue-gray limestone. Age provided by ammonites (Imlay, 1961) reported at base of formation (Diller, 1908).

Kt Trail Formation (Diller, 1908) (Lower Cretaceous) – Lower portion: gray volcanic cobble conglomerate, tuffaceous pebbly sandstone locally containing dinosaur bone fragments, non-marine invertebrates and plant fossils, and tan, green, blue or red tuffaceous shale. Upper portion: sparsely quartz-phyric, red to blue-gray silicic tuff, friable, calcareous, white or gray sandstone, and tan shale. U/Pb ages of 127.2±3.1 Ma and 129.4±2.0 Ma obtained from samples of silicic tuff in the Greenville, Ca 15-minute USGS quadrangle, and 128.0±1.9-2.0 Ma from a green quartz-phyric tuff in the Kettle Rock, CA 15-minute USGS quadrangle (Christe, 2009).

Jqm Quartz monzonite of the Lights Creek stock (Jurassic?) – Pinkish, fine- to medium-grained, equigranular; commonly with tourmaline and epidote veins. Includes some granite.

Jqd Biotite-hornblende quartz diorite (Jurassic?) – Gray, medium- to fine-grained biotite-hornblende quartz diorite.

Jgb Hornblende gabbro (Jurassic?) – Dark-gray to black, fine- to coarse-grained hornblende gabbro with minor hypersthene and augite; locally banded.

Ju Metavolcanic and metasedimentary rocks, undivided (Jurassic) – Intermediate volcanic flows, tuffs, and breccias, sandstone, siltstone, and conglomerate.

Jif Felsic hypabyssal intrusive rocks (Jurassic?) – Light-gray to purplish-gray, medium- to fine-grained, hypidiomorphic intrusive felsite composed primarily of equigranular quartz, alkali feldspar, and biotite. Occurs in thin stringers and lenticular bodies at widely scattered localities (Harwood, 1993).

Jcga China Gulch alaskite (Late Jurassic) – Light gray, fine-grained Alaskite granite (Smith, 1970).

Jft Unnamed felsic tuff (Middle or Late Jurassic) – Gray and bluish-gray, fine-grained felsic tuff with sparse interbeds of volcanic-clast conglomerate. The tuff is massive to weakly cleaved and sparsely porphyritic with small phenocrysts of quartz and possibly sanidine. Locally the typical gray tuff grades into a maroon tuff and tuffaceous siltstone (Harwood, 1993).
Foreman Formation (Middle Jurassic)

Jfs – Black tuffaceous shale and interbedded tuffaceous siltstone, with beds of quartz-rich sandstone, chert-rich pebble conglomerate, and minor beds of volcanic-clast conglomerate.

Jfb – Felsic tuff breccia composed of angular clasts of felsic hypabyssal rocks, gray tuff, porphyritic andesite, and black argillite in a matrix of finer grained volcanic fragments of similar composition. The unit occurs at the base of the Foreman Formation and is 3 to 10 m thick (Harwood, 1993).

Hinchman Formation (Middle Jurassic) – Andesitic tuff breccia with angular to sub-rounded volcanic fragments ranging in size from 2 to 40 cm. Plagioclase-phyric clasts are common and clinopyroxene phenocrysts are visible in some fragments. Typically massive, fractured, and veined with quartz stringers (Harwood, 1993).

Bicknell Sandstone (Middle Jurassic) – Reddish-brown, green, and greenish-gray volcaniclastic sandstone, red shale, and local cobble and boulder conglomerate. Sandstone beds are typically massive, locally graded and range in thickness from 10 cm to 2 m (Harwood, 1993).

Kettle Formation (Diller, 1908) (Middle Jurassic) – Volcanic lithologies include purple, red, or pink, plagioclase-phyric monolithic breccias and flow rock and minor felsic tuff. Clastic lithologies include parallel bedded to massive, red to dark gray, volcanic cobble conglomerate, pebbly sandstone, and siltstone. Intruded locally by the same brick red, plagioclase-tilite and quartz-phyric dacite found within the Bicknell and Hull Formations on Mount Jura (McMath, 1958) and a U/Pb age of 161.5±3.1 Ma from a red, felsic, monolithic breccias in the middle of the formation (Christe, 2009).

Kettle Rock Sequence, undivided (Christe and Hannah, 1990) (Jurassic) – Purple, gray or black, plagioclase-phyric volcanic rock, monolithic tuff breccias, and pumice-bearing tuff. Locally associated with unfossiliferous, gray, variably cross-bedded volcaniclastic rocks. Locally intruded by dark gray felsic or maic hypabyssal rocks.

Mormon Sandstone (Middle Jurassic)

Jms – Dark-gray, fine-grained volcaniclastic sandstone that commonly contains scattered shell casts. Locally graded with beds ranging in thickness from 10 to 50 cm and in places separated by thin beds of dark-gray shale or argillite. Includes a conglomerate composed primarily of well-rounded cobbles and pebbles of volcanic rocks derived mostly from the Fant Meta-andesite.

Jmb – Mottled light- and dark-green volcaniclastic breccia composed mainly of angular fragments of green andesite with some fragments of vein quartz and dark-gray sandstone (Harwood, 1993).

Thompson Limestone (Early Jurassic) – Light-gray, massive to weakly bedded, and locally fossiliferous. Interbedded with light-pink, tuffaceous siltstone that locally contains abundant gastropod impressions. In places the siltstone is more abundant than the limestone (Harwood, 1993).

Fant Meta-andesite (Early Jurassic) – Porphyritic andesite consisting of a fine-grained, dark-green matrix with scattered plagioclase phenocrysts that may make up as much as 40 percent of the rock. Plagioclase phenocrysts range from 2 to 30 mm in length and locally form stellate, glomeroporphyritic aggregates (Harwood, 1993).
Hardgrave Sandstone (Early Jurassic) – Maroon tuffaceous siltstone that contains scattered volcanic lithic fragments that appear in part to be pumiceous. Locally contains thin, cross-laminated beds and lenses of volcaniclastic sandstone. Near the top of the unit, lenses and beds of gray, pebble and cobble volcaniclastic conglomerate are found locally (Harwood, 1993).

Unnamed metarhyolite (Early Jurassic) – Pink to greenish-gray and black, fine-grained and sparsely porphyritic with small, scattered phenocrysts of quartz and sanidine. (Harwood, 1993).

Swearinger Slate (Triassic) – Black slate, argillaceous limestone, and quartzose sandstone.

Hosselkus Limestone (Triassic) – Dark-gray, fine-grained limestone.

Paleozoic rocks, undivided (Paleozoic?) – Undivided metamorphic rocks of Paleozoic (?) age on the south flank of Mt. Jura (Harwood, 1993).

Arlington Formation (Permian) – Andesite breccia, tuff, and tuffaceous slate; minor conglomerate.

Robinson Formation (Permian) – Andesitic tuff, sandstone, and shale; minor conglomerate.

Reeve Formation (Permian) – Plagioclase-rich andesite breccia, flows, tuff, and volcaniclastic rocks.

Pr – Dark purple-gray to black, plagioclase-rich, intrusive andesite.

Goodhue Formation (Permian) – Coarse basaltic to andesitic breccia, tuff, and flows.

Peale Formation (Carboniferous) –
Cpc – Chert member.
Cp – Rhythmically bedded radiolarian chert, chert breccia, and siltstone; intermediate flows, tuff, and tuff breccia.

Taylor Formation (Mississippian and (or) Devonian) – Andesite breccia, tuff, flows, and tuffaceous slate.

Sierra Buttes Formation (Devonian) – Quartz-bearing felsic volcanic flows and tuff; black phosphatic chert, tuffaceous siltstone, and shale; also rhyolitic to andesitic hypabyssal intrusives. Includes rocks mapped as Elwell Formation.

Grizzly Formation (Devonian) – Medium or coarse-grained quartz sandstone, mudstone, and siliceous argillite.

Shoo Fly Complex (Devonian? to Ordovician) – Quartzose and lithic sandstone, slate, and phyllite; chert, and conglomerate, minor limestone.

Ultramafic rocks (Age unknown) – Sheared and serpentinized ultramafic rocks.

Intrusive rocks (Paleozoic?) –
sy – Syenite
di – Diorite
qp – Quartz porphyry
db – Diabase
qd – Quartz diorite
pp – Plagioclase porphyry
px – Pyroxenite
Figure 3. Index map showing the 15-minute and 7.5-minute quadrangles within the Susanville 30' x 60' quadrangle.

Sources of mapping for the Susanville 30' x 60' quadrangle. For complete citation see the reference section following this list.

**Doyle Quadrangle**  

**Greenville Quadrangle**  

**Kettle Rock Quadrangle**  

**Litchfield Quadrangle**  

**Milford Quadrangle**  

**Susanville Quadrangle**  

**Wendel Quadrangle**  

**Westwood Quadrangle**  
REFERENCES


Christe, 2009, personal communication, including map unit descriptions and radiometric age dates.


Grose, T.L.T., and McKee, E.H., 1986, Potassium-argon ages of late Miocene to late Quaternary volcanic rocks in the Susanville-Eagle Lake area, Lassen County, California: Isochron/West, no. 45, p. 5-11.


Table 1. Summary of K-Ar ages on volcanic rocks within the Susanville 30' x 60' quadrangle, California. See Figure 2 for sample locations.

<table>
<thead>
<tr>
<th>Location Number</th>
<th>Map Unit</th>
<th>Sample Number</th>
<th>Material Dated</th>
<th>Latitude (North)</th>
<th>Longitude (West)</th>
<th>Description of Sample</th>
<th>Age (Ma)</th>
<th>Reference</th>
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<td>Qsb</td>
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<td>120°9.8'</td>
<td>Andesite flow</td>
<td>11.8 ± 0.6</td>
<td>Grose and McKee, 1986</td>
</tr>
<tr>
<td>17</td>
<td>Tfd</td>
<td>SM110A</td>
<td>Hornblende</td>
<td>40°19'08&quot;</td>
<td>120°05'11&quot;</td>
<td>Dacite</td>
<td>12.5 ± 0.6</td>
<td>Diggles and others, 1989</td>
</tr>
<tr>
<td>18</td>
<td>Tb</td>
<td>SM319A</td>
<td>Whole Rock</td>
<td>40°28'42&quot;</td>
<td>120°05'18&quot;</td>
<td>Basalt</td>
<td>12.3 ± 0.4</td>
<td>&quot;</td>
</tr>
<tr>
<td>19</td>
<td>Tasf</td>
<td>SM131A</td>
<td>&quot;</td>
<td>40°23'51&quot;</td>
<td>120°07'56&quot;</td>
<td>Basalt</td>
<td>12.8 ± 0.2</td>
<td>&quot;</td>
</tr>
<tr>
<td>20</td>
<td>Ttbu</td>
<td>GAD-6</td>
<td>&quot;</td>
<td>40°15.6'</td>
<td>120°33.3'</td>
<td>Basalt flow</td>
<td>10.1 ± 0.6</td>
<td>Grose and McKee, 1986</td>
</tr>
<tr>
<td>21</td>
<td>Ttbl</td>
<td>RAD-3</td>
<td>&quot;</td>
<td>40°15.3'</td>
<td>120°33.3'</td>
<td>Basalt flow</td>
<td>16.3 ± 0.6</td>
<td>&quot;</td>
</tr>
<tr>
<td>22</td>
<td>Tfca</td>
<td>DW-69SV</td>
<td>&quot;</td>
<td>40°1.0'</td>
<td>120°28.8'</td>
<td>Basalt</td>
<td>10.81 ± 0.32</td>
<td>This report</td>
</tr>
<tr>
<td>23</td>
<td>Tfca</td>
<td>DW-45SV</td>
<td>&quot;</td>
<td>40°5.4'</td>
<td>120°19.7'</td>
<td>Andesite</td>
<td>11.49 ± 0.28</td>
<td>&quot;</td>
</tr>
<tr>
<td>24</td>
<td>Tfa</td>
<td>D-298</td>
<td>&quot;</td>
<td>40°2.0'</td>
<td>120°1.4'</td>
<td>Mafic andesite</td>
<td>14.25 ± 0.43</td>
<td>&quot;</td>
</tr>
</tbody>
</table>

*Age for this sample was determined by the 40Ar/39Ar dating method.
Table 2. K-Ar analytical data for unpublished age determinations presented in this report. See Figure 2 and Table 1 for sample locations.

<table>
<thead>
<tr>
<th>Location Number</th>
<th>Sample Name</th>
<th>Material</th>
<th>Weight (grams)</th>
<th>Ar/Ar Age (Ma) ± 1σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>11.76 ± 0.44</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>10.98 ± 0.62</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td>11.00 ± 0.26</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>11.17 ± 0.30</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td>11.34 ± 0.36</td>
</tr>
</tbody>
</table>

Age determination on the samples listed in Tables 2 and 2a by Alan Deino and Timothy Becker at the Berkeley Geochronology Center, Institute of Human Origins.
Table 3. Major-element chemical analyses on volcanic rocks within the Susanville 30’ x 60’ quadrangle, California. See Figure 2 and Table 1 for sample locations.

<table>
<thead>
<tr>
<th>Location Number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Number</td>
<td>GAD-1</td>
<td>GAD-9</td>
<td>GAD-4</td>
<td>RAD-1</td>
<td>GAD-3</td>
<td>DW-59SV</td>
<td>DW-64SV</td>
<td>DW-63SV</td>
</tr>
<tr>
<td>Map Unit</td>
<td>Qsb</td>
<td>Tbca</td>
<td>Tbca</td>
<td>Tsvb</td>
<td>Trma</td>
<td>Tdai</td>
<td>Tdaf</td>
<td>Tvma</td>
</tr>
</tbody>
</table>

Oxide Whole-rock analyses (weight percent)

<table>
<thead>
<tr>
<th></th>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>Fe₂O₃</th>
<th>FeO</th>
<th>MgO</th>
<th>CaO</th>
<th>Na₂O</th>
<th>K₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>48.39</td>
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<td>-</td>
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<td>10.83</td>
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<td>0.26</td>
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<td></td>
<td>55.23</td>
<td>17.56</td>
<td>-</td>
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<td>5.06</td>
<td>7.76</td>
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<td>-</td>
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<td>10.69</td>
<td>2.85</td>
<td>1.33</td>
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<tr>
<td></td>
<td>49.38</td>
<td>17.69</td>
<td>-</td>
<td>9.31</td>
<td>2.92</td>
<td>10.69</td>
<td>2.85</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
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<td>17.74</td>
<td>-</td>
<td>-</td>
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<td>7.12</td>
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<tr>
<td></td>
<td>56.07</td>
<td>19.06</td>
<td>-</td>
<td>-</td>
<td>4.23</td>
<td>7.06</td>
<td>3.47</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>52.95</td>
<td>20.06</td>
<td>-</td>
<td>-</td>
<td>4.47</td>
<td>8.24</td>
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<td>0.14</td>
</tr>
<tr>
<td></td>
<td>52.72</td>
<td>19.74</td>
<td>-</td>
<td>-</td>
<td>4.25</td>
<td>8.27</td>
<td>3.94</td>
<td>0.13</td>
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</tbody>
</table>

See reference cited in Table 1 for chemical data on these samples.

<table>
<thead>
<tr>
<th></th>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>Fe₂O₃</th>
<th>FeO</th>
<th>MgO</th>
<th>CaO</th>
<th>Na₂O</th>
<th>K₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>67.88</td>
<td>15.99</td>
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<td>0.44</td>
<td>3.84</td>
<td>5.16</td>
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<td>4.66</td>
<td>7.92</td>
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<td>1.35</td>
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<tr>
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<td>60.45</td>
<td>16.93</td>
<td>-</td>
<td>-</td>
<td>2.55</td>
<td>5.30</td>
<td>3.47</td>
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<td>6.43</td>
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<td>1.29</td>
</tr>
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<td>3.61</td>
<td>6.50</td>
<td>3.44</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td>63.39</td>
<td>16.92</td>
<td>-</td>
<td>-</td>
<td>1.31</td>
<td>4.39</td>
<td>3.48</td>
<td>0.08</td>
</tr>
</tbody>
</table>

*Total Fe reported as Fe₂O₃ for these samples.
Table 3 (continued). Major-element chemical analyses on volcanic rocks within the Susanville 30’ x 60’ quadrangle, California. See Figure 2 and Table 1 for sample locations.

<table>
<thead>
<tr>
<th>Location Number</th>
<th>GAD-11</th>
<th>SM110A</th>
<th>SM319A</th>
<th>SM131A</th>
<th>GAD-6</th>
<th>RAD-3</th>
<th>DW-69SV</th>
<th>DW-45SV</th>
<th>D-298</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Map Unit</td>
<td>Tsaf</td>
<td>Tfd</td>
<td>Tb</td>
<td>Taf</td>
<td>Ttbu</td>
<td>Tbl</td>
<td>Tfa</td>
<td>Tfa</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oxide</th>
<th>Whole-rock analyses (weight percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO$_2$</td>
<td>60.72</td>
</tr>
<tr>
<td>Al$_2$O$_3$</td>
<td>17.53</td>
</tr>
<tr>
<td>Fe$_2$O$_3$</td>
<td>5.99</td>
</tr>
<tr>
<td>FeO</td>
<td>-</td>
</tr>
<tr>
<td>MgO</td>
<td>2.27</td>
</tr>
<tr>
<td>CaO</td>
<td>5.00</td>
</tr>
<tr>
<td>Na$_2$O</td>
<td>3.85</td>
</tr>
<tr>
<td>K$_2$O</td>
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</tr>
<tr>
<td>TiO$_2$</td>
<td>0.70</td>
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<td>P$_2$O$_5$</td>
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<tr>
<td>MnO</td>
<td>0.08</td>
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<tr>
<td>Total</td>
<td>98.58</td>
</tr>
</tbody>
</table>

*Total Fe reported as Fe$_2$O$_3$ for these samples.

Chemical analyses on samples labeled DW and GJS were performed by Dennis Fox, Department of Geology, San Jose State University.
Table 4. Terminology used in the description of volcanic rocks.

<table>
<thead>
<tr>
<th>DESCRIPTIVE TERMINOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Porphyritic volcanic rock features</strong></td>
</tr>
<tr>
<td>Abundantly porphyritic -- phenocrysts &gt;20% (volume)</td>
</tr>
<tr>
<td>Moderately porphyritic -- phenocrysts 5-20%</td>
</tr>
<tr>
<td>Sparsely porphyritic -- phenocrysts &lt;5%</td>
</tr>
<tr>
<td>Coarsely porphyritic -- phenocrysts &gt;5 mm (size)</td>
</tr>
<tr>
<td>Finely porphyritic -- phenocrysts 1-5 mm</td>
</tr>
<tr>
<td>Microporphyritic -- phenocrysts &lt;1 mm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Volcanic rock names</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basalt -- &lt;52% SiO₂ (weight %)</td>
</tr>
<tr>
<td>Mafic andesite -- 52-57%</td>
</tr>
<tr>
<td>Andesite -- 57-63%</td>
</tr>
<tr>
<td>Dacite -- 63-68%</td>
</tr>
<tr>
<td>Rhyodacite -- 68-72%</td>
</tr>
<tr>
<td>Rhyolite -- &gt;72%</td>
</tr>
</tbody>
</table>

**Example** - sparsely finely olivine porphyritic mafic andesite; abundantly coarsely plagioclase, sanidine porphyritic dacite.