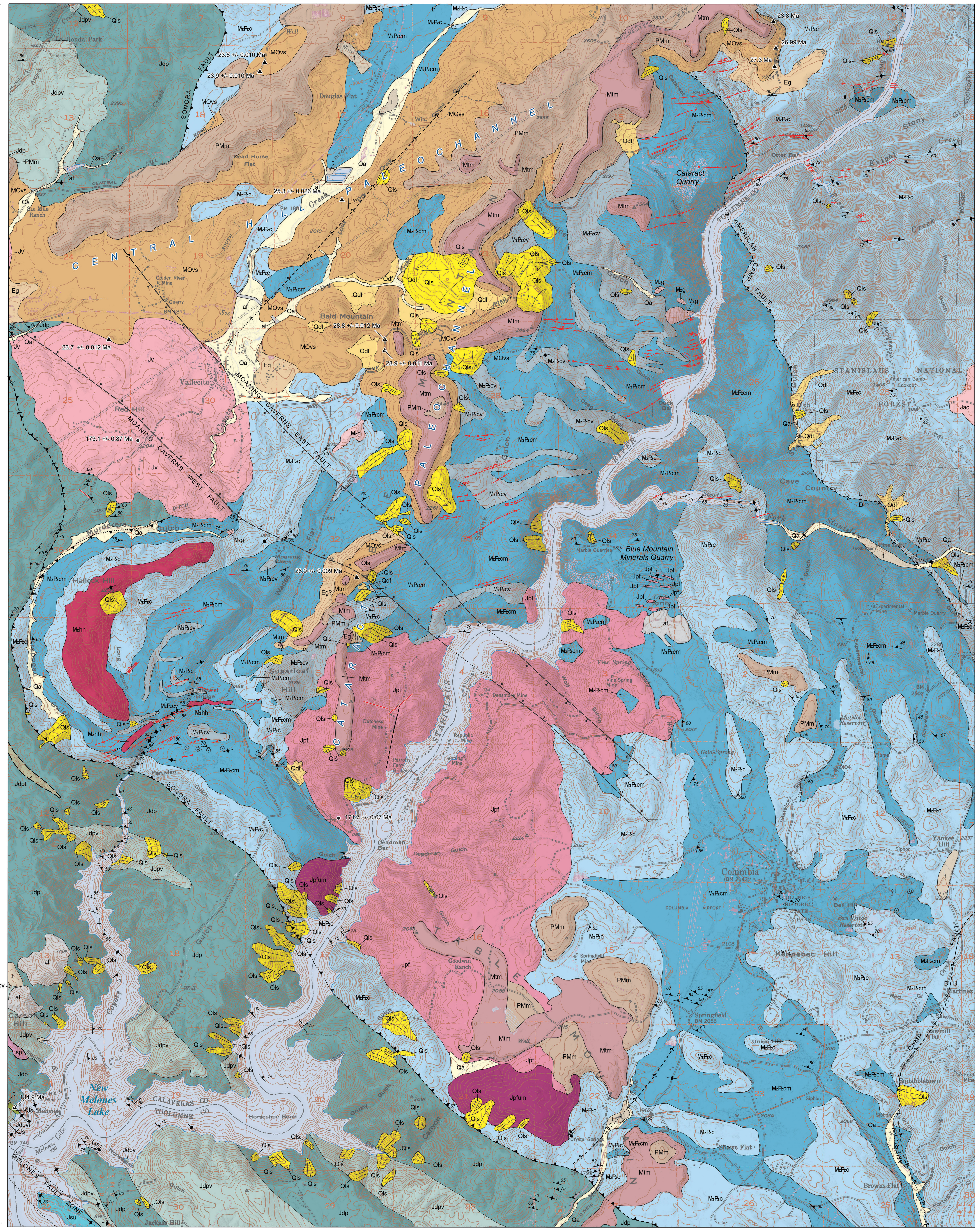

Coordinate System:
Universal Transverse Mercator, Zone 10N
North American Datum 1927

Topographic base from U.S. Geological Survey
Columbia 7.5-minute Quadrangle, 1948, photo revised 1973.
Shaded relief image derived from USGS Lidar DEM, 2012 and 2019

Structural orientation points along New Melones Lake were primarily collected between Fall 2022 and Spring 2023 during low lake levels. As such, many structural orientation points appear to be plotted below the water level depicted on this map.

This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program, STATEMAP Award no. G22AC00356.

Scale 1:24,000

Contour Interval 40 Feet
Dotted Lines Represent 20-Foot Contours
Contour Interval on River Surface 5 Feet
National Geodetic Vertical Datum of 1929

Approximate Mean Declination, 2023 (12.83°)

Professional License and Certification:
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Publication Title:"Preliminary geologic map of the Columbia 7.5′ Quadrangle, Calaveras and Tuolumne counties, California: California Geological Survey Preliminary Geologic Map 23-01, scale 1:24,000"

PRELIMINARY GEOLOGIC MAP OF THE COLUMBIA 7.5' QUADRANGLE CALAVERAS AND TUOLUMNE COUNTIES, CALIFORNIA

VERSION 1.0

By
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2023

Preliminary Geologic Maps available from:
https://www.conservation.ca.gov/cgs/rgm/preliminary

California Department of Conservation
California Geological Survey

DESCRIPTION OF MAP UNITS

SURFICIAL UNITS

af — **Artificial fill (historic)**—Consists of anthropogenic deposits of earth materials that may be engineered or non-engineered.

t — **Tailings (historic)**—Consists of anthropogenic deposits of earth materials that are the by-product of historic placer and lode gold mining.

Qa — **Alluvium (Holocene to Pleistocene)**—Alluvium deposited in fan, terrace, or fluvial environments. Also occurs as ponded alluvium in Krappeau Gulch, on the upstream side of a landslide (map unit Qls). Typically consists of poorly to moderately sorted sand, silt, and gravel.

Qdf — **Debris fan deposits (Holocene)**—Unconsolidated, poorly sorted gravel, sand, silt, and clay forming relatively steep, fan-shaped deposits at the mouths of small drainages and along steep hillsides where it includes undifferentiated colluvium. Deposits are derived mainly from debris slides and debris flow events rather than fluvial processes.

Qls — **Landslide deposits (Holocene to Pleistocene)**—Mostly unconsolidated, jumbled, and chaotic fragments of bedrock materials of various compositions and thicknesses. Recognized by geomorphic expression. Arrows indicate direction of movement; queried where landslide existence is questionable.

TERTIARY UNITS

PMm — **Mehrten Formation (early Pliocene to Miocene)**—Volcanic debris flows (lahar) deposits interbedded with sandstone and conglomerate. Compositionally distinct and dominated by intermediate volcanic rock types, especially andesite and lesser dacite. Within the Columbia Quadrangle, the Mehrten Formation attains a maximum thickness of approximately 210 meters north of Cataract Quarry. In the northern part of the quadrangle, the Mehrten Formation includes mostly lahar deposits, while in the southern part, it is composed mainly of latite, sandstone, and conglomerate. Conglomerate beds contain well-rounded clasts (of sandstone and andesite). Lahar beds are laden with volcanic cobbles and breccia and are relatively erosion resistant and commonly present as ridge-capping and cliff-forming outcrops, such as the conspicuous cliffs west of Douglas Flat. Although relatively uncommon in the map area, sandstone occurs along Camp Nine Road. Near Cataract Quarry, a sandstone unit attains a maximum thickness of nearly 20 meters. The near complete absence of older clasts within the Mehrten Formation deposits indicates a voluminous outpouring of volcanic and derivative sedimentary rocks, dominating the channel systems in a net depositional environment. Volcanic rocks represent Ancestral Cascade Arc magmatism (e.g., Cousens and others, 2008). Mapped separately, the Mehrten also includes:

Mtm — **Table Mountain Latite (late Miocene)**—High-potassium trachyandesite flows. Commonly porphyritic with plagioclase and trace augite phenocrysts in a gray aphanitic groundmass (King and others, 2007). Exhibits vesicular and non-vesicular texture. Characteristically erosion resistant and often ridge-capping. Poorly to moderately developed columnar jointing is present and widely exposed in the cliffs that are commonly formed by this unit. The latite attains an approximate thickness of 30 meters and occurs as a tongue within the Mehrten Formation. In some places mappable outcrops of Mehrten conglomerate overlie the Table Mountain Latite (TML). Within the Columbia Quadrangle the TML is best exposed on the ridge north of the Parrotts Ferry Bridge, just above the Duchess Mine Trail.

MOvs — **Valley Springs Formation (Miocene to Oligocene)**—Tuffaceous sandstone, siltstone, and conglomerate interbedded with rhyolitic tuff. The Valley Springs Formation is distinguishable from other Cenozoic deposits by significant rhyolitic ash component. Also, the conglomerate is heterolithologic and includes significant proportions of Paleozoic-Mesozoic metamorphic basement rocks in contrast to the Eocene gravels and Mehrten Formation. Tuff beds are often present as resistant, sometimes welded, cliff-forming outcrops. The Valley Springs unit was deposited within approximately the same drainage network as the older Eocene gravels (Eg) and commonly forms inverted topography. Ten sanidine $^{40}Ar/^{39}Ar$ ages from ash-flow tuff samples collected within the map area range from 23.7 Ma to 28.9 Ma (O'Neal and others, 2023); ages on map shown with +/-1 sigma analytical uncertainty. These rhyolitic tuffs are comprised of volcanic material erupted from volcanoes in Nevada and transported as channelized pyroclastic density currents in excess of 200 km (Henry and Faulds, 2010).

Eg — **Eocene gravels (Eocene)**—Conglomerate and sandstone. Sandstone is quartz rich and conglomerate is heterolithologic, dominated by angular vein quartz pebbles and cobbles. Unit is distinguishable from the younger Valley Springs Formation sediments by the absence of rhyolite and a greater proportion of quartz clasts. Eocene gravels were the primary target of historic hydraulic and drift mining. The extensive use of these mining methods has fully exposed the underlying bedrock in some areas. Where exposed, this unit has commonly been disturbed or reworked by historic strip mining and exploratory excavations. Lindgren (1911) indicated that extensive surficial mining of an Eocene surface occurred in the 1850s and targeted gold-bearing gravels in this area that were deposited on and around the karstic surface of the Calaveras marble (MzPzcm). No mappable remnants of the Eocene gravels remain near the town of Columbia, although well-developed paleosols with hematitic concretions preserved on the weathered phyllite of the Calaveras Complex bedrock were observed south of Columbia Historic State Park.

MESOZOIC AND PALEOZOIC UNITS

Jdp — **Don Pedro terrane, undifferentiated (Jurassic)**— Phyllite and schistose metavolcanic rocks previously identified and mapped in detail as "schistose amphibole-bearing metavolcanics and phyllitic rocks" by Eric and others (1955) in the Angels Camp 7.5' Quadrangle adjacent to the west and the Sonora 7.5' Quadrangle adjacent to the south. This unit also contains varying amounts of intermediate to silicic metavolcanic rocks, including metatuff and metarhyolite. Although rare, this unit also includes marble lenses up to 1 m thick. These phyllitic and greenschist metamorphic rocks are regionally included within the Don Pedro Terrane (originally defined by Blake and others (1982), see also Schweickert and others (1988) and Schweickert (2015)). This unit is structurally bounded on the east by the Sonora Fault and on the west by the Melones Fault. The phyllitic rocks may be difficult to distinguish from similar rock types in the Calaveras Complex in outcrop and hand sample; however, well-exposed phyllite outcrops are strongly cleaved and have a distinctive bluish sheen. Near the New Melones Reservoir, the phyllite locally contains pyrite crystals up to 1 cm. Where schistose metavolcanic rocks predominate, they are mapped separately as:

Jdpv — **Don Pedro terrane, Metavolcanic rocks (Jurassic)**—Weakly foliated to massive dark-gray to green, fine- to medium-grained metamorphosed felsic to mafic volcanic rocks which includes lenses of phyllite. Near the New Melones Reservoir, this unit includes metatuff, metarhyolite, and fine-grained, undifferentiated metavolcanic rock with pyrite crystals up to 1 cm. Locally includes pyroclastic agglomerates with stretched breccia clasts up to 30 cm long along lower Coyote Creek (Baird, 1962).

Jdpt — **Talc-bearing schist (Jurassic)**—Schist composed chiefly of ankerite and talc in various proportions. This unit was mapped by Clark (1970) in the adjacent Angels Camp 7.5' Quadrangle, however aerial and lidar imagery indicates the talc schist continues into the Columbia quadrangle southwest of Krappeau Gulch where it pinches out along a fault. Though the host rock is Jurassic in age, Clark (1970) indicates the age of talc mineralization could be Jurassic to Cretaceous.

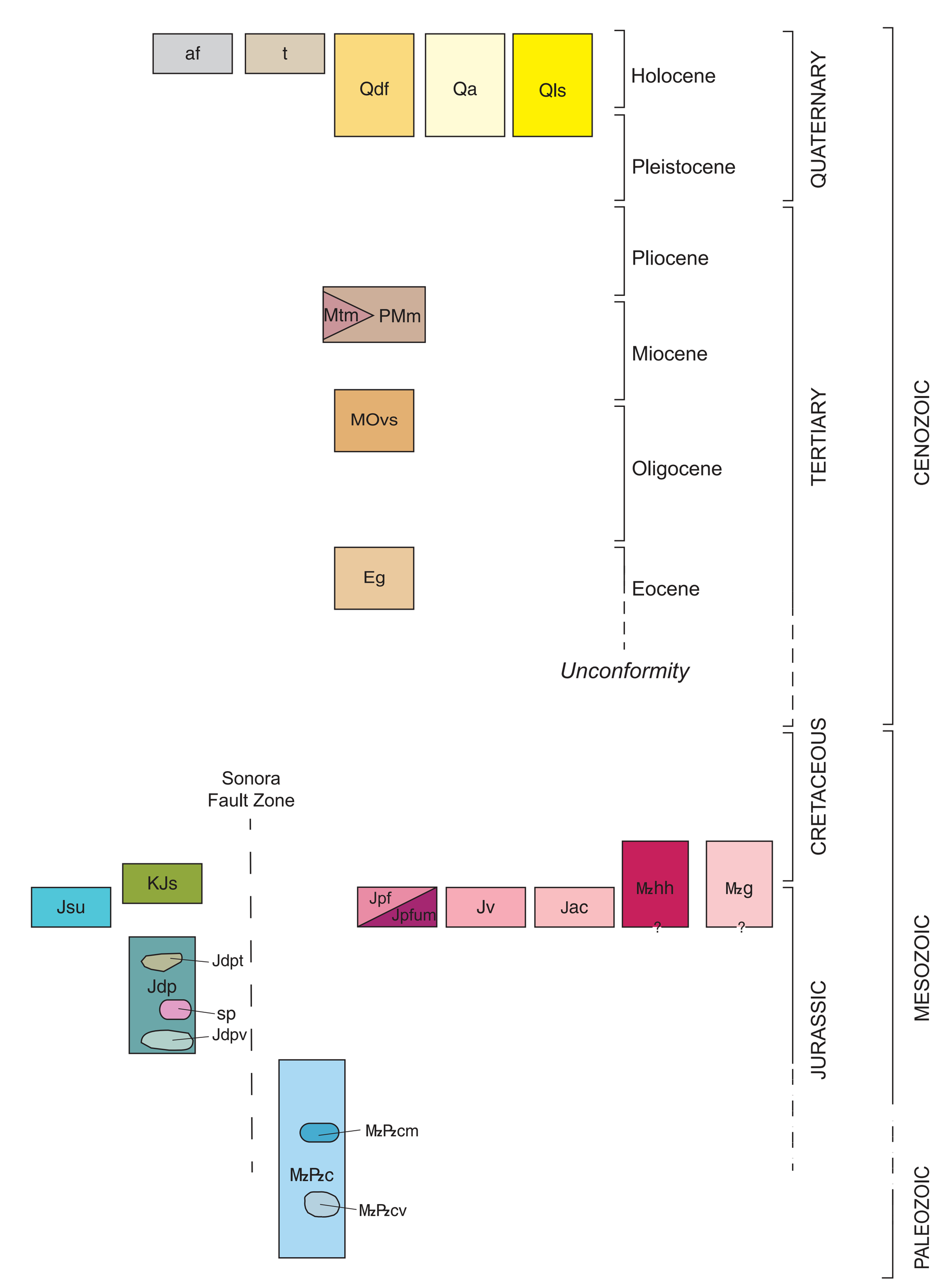
sp — **Serpentinite**—Primarily blue-gray serpentinite, accompanied with less altered ultramafic rocks. Larger pods are blocky with anastomosing brittle shears while smaller slivers along faults are pervasively sheared, foliated, and weathered to yellowish brown.

MzPzc — **Calaveras Complex, undifferentiated (Triassic to Paleozoic)**—A mélange unit with strongly foliated argillite, phyllite, quartzite, schist, chert, and extensive marble lenses and blocks. Originally defined by Schweickert and others (1977 and 1988). Metamorphosed to lower amphibolite facies, with protoliths including argillite, siliceous argillite, chert, chert-argillite melange, limestone, and basalt. Marble and minor talc blocks are interspersed along Camp Nine Road. Older and of somewhat higher (amphibolite and greenschist) metamorphic grade than the Don Pedro terrane (adjacent to west). In thin section, this unit may exhibit well-developed crenulations not always apparent in hand specimen. Structurally bounded by the Sonora Fault on the west and the Calaveras-Shoo Fly Thrust on the east. Distinguishable from Don Pedro terrane by the presence of large marble blocks. Also unique to this unit are dikes of the Sonora dike swarm, oriented in a general east-west strike that occur east of the Sonora Fault and intrude units of the Calaveras Complex. Mapped separately, this unit also includes:

MzPzcm — **Marble**—White to gray-blue recrystallized limestone and dolomite. Medium- to coarse-grained and weakly to strongly foliated. Original bedding is rarely preserved. Includes irregular masses of graphitic marble. The marble unit within the Columbia quadrangle is the largest carbonate body in the Sierra Nevada (Clark and others, 1973). Paleokarst topography is widespread, including meter- to 10s of meter-scale dissolution pits and cavities; where such cavities were exposed in Eocene paleo-river channels, gold-bearing placers accumulated; these were a major target of 19th century placer gold miners. Large dissolution caverns are present within the mapped marble unit, such as Moaning Caverns and many unnamed caves. The marble locally presents sinkhole hazards, specifically in the vicinity of Columbia College, Columbia State Historic Park, and near Natural Bridges (see map symbols indicating documented sinkholes). Fossil occurrences, although rare and poorly preserved, have been documented in the vicinity of lower Coyote Creek (R.A. Schweickert, unpub. data, 2012) and near the confluence of the Stanislaus River with the South Fork Stanislaus River (C. Haughy, oral commun., 2023). The marble has been historically and actively mined in the quadrangle at the Blue Mountain Minerals mine and at Cataract Quarry for dimension stone and crushed aggregate (C. Haughy, oral commun., 2023).

MzPzcv — **Metavolcanic rocks**—Strongly foliated, heterogeneous body of mafic metamorphosed volcanic flows and tuffs interlayered with strongly foliated phyllite, schist, and metachert (Baird, 1962). Includes metavolcanic agglomerates characterized by angular to subrounded clasts of metavolcanic rock. Unit is mapped as undifferentiated due to structural complications, relatively poor exposure, and lack of characteristic marker horizons that weather out in relief from a greenschist matrix.

CORRELATION OF MAP UNITS



Mélange of the Melones Fault Zone (Cretaceous to Jurassic(?))—Fault-bounded slivers and pods of metamorphosed sedimentary, carbonate, volcanic, and ultramafic rocks of uncertain stratigraphic position. Commonly sheared with platy cleavage. Subdivided into the following units:

KJs — **Quartz ankerite-sericite schist (Cretaceous to Jurassic)**—Localized units mapped by Eric and others (1955). This unit appears sheared with varying amounts of white vein quartz. Map unit can have a green color due to the presence of mariposite as reported by Eric and others (1955), and observed during this study.

Jsu — **Metasedimentary units, undifferentiated (Jurassic(?))**—Mostly slate, with a minor tuffaceous component, with interbedded tuff and greywacke. Also includes stretched cobble conglomerate. Appears similar to, and possibly in part equivalent to slate assigned to the Mariposa Formation (Clark, 1970).

INTRUSIVE ROCK UNITS

Intrusive rocks within the map area consist of compositionally variable plutonic units, including three named plutons. Other intrusive rocks that occur in this portion of the Sierra Nevada foothills and in the map area include plutonic bodies of unknown age and dikes of the Sonora dike swarm. Dikes associated with the Sonora dike swarm range in composition from basalt to andesite and have a general east-west strike (Merguerian, 1986). These dikes occur exclusively east of the Sonora Fault, and as noted above in a previous section, intrude units of the Calaveras Complex. These have been extensively documented by previous researchers (Baird, 1962; Merguerian, 1986; Schweickert, 1988, 2015; R.A. Schweickert, unpub. data, 2012). In the Columbia quadrangle, these dikes vary between 1 and 3 meters thick (Baird, 1962) and are well exposed along Camp Nine Road.

Jpf — **Parrotts Ferry Pluton (Jurassic)**—Fine- to medium-grained orthopyroxene-bearing granodiorite, tonalite, and amphibolite. Includes diorite along its southern margin near Highway 49 in Tuolumne County. In thin section, the sample shows quartz and plagioclase in nearly equal amounts, with minor orthoclase. Amphibole, biotite, and pleochroic pyroxene were also noted. Rocks of the pluton form resistant, boulder covered ridges along the canyon walls of the Stanislaus River, and underlie gentle, rolling topography to the southeast of the river in Tuolumne County. On the northwest side of the Stanislaus River, in the vicinity of the Duchess Mine, the pluton is cut by generally northeast-southwest trending mafic dikes exhibiting hydrothermal alteration. These dikes are fine-grained and weathered where observed, and it is unclear if they are related to the Sonora dike swarm. In several places along the margin of the Parrotts Ferry pluton where it is near carbonate units, ultramafic and pegmatitic rocks crop out (Baird, 1962; Higgins, 1997; and R.A. Schweickert, unpub. data, 2012). Hornblendite with large pegmatitic hornblende crystals up to 6 cm in length are located along the southern margin of the Parrotts Ferry Pluton on the southwest side of Table Mountain, and also along Parrotts Ferry Road on the northwest side of the Stanislaus River. Hornblende pegmatites also crop out along Marble Quarry Road and Parrotts Ferry Road near Porcina Way in Tuolumne County (Haughy, oral commun., 2023). New U/Pb dating of one sample obtained along Parrotts Ferry road produced an age of 171.65 +/- 1.31 [3.43] Ma (MSWD = 2) (ages +/- internal 2SE uncertainty [total 2% uncertainty]); analyses were conducted on zircons using laser ablation ICPMS analyses at the CSUN Laser Lab (J. Schwartz, written commun., 2023). Mapped separately, also includes:

Jpfum — **Ultramafic rocks of the Parrotts Ferry Pluton**—Massive and irregularly jointed, greenish-black to black olivine pyroxenite and massive to fine-grained, black, layered hornblendite; weathers to deep reddish-brown. Commonly associated with restricted vegetation types. This ultramafic unit occurs as a half-mile-wide semi-circular mass of pyroxenite southwest of the Parrotts Ferry Bridge in Calaveras County, where it spans the contact between Calaveras Complex marble (MzPzcm) and undifferentiated units (MzPzc). Its contacts are sharp and discordant with lithological layering of the wall rocks (Baird, 1962). In Tuolumne County, near Grizzly Gulch, an approximately 1.5-km-diameter hornblendite body stands topographically higher than the surrounding terrane. Hornblendite ranges from very fine-grained to pegmatitic, with pegmatite crystals between 1 and 3 cm in diameter. The hornblendite exhibits aligned crystals and a banded appearance, alternatingly very fine-grained, medium-grained, and pegmatitic layers that vary between 1 and 10s of meters in thickness. The coarser layers commonly form resistant ridges and steps in the topography.

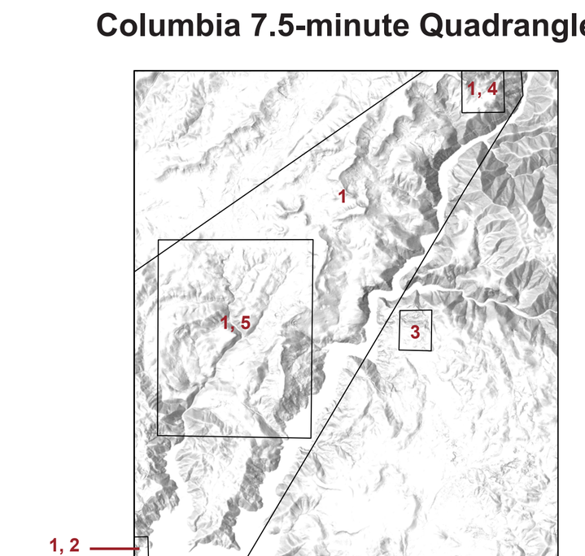
Jv — **Vallecito Pluton (Jurassic)**—Fine- to coarse-grained gabbro with subordinate diorite. Sharp (1984) described the Vallecito pluton as a hornblende tonalite and reported a U/Pb zircon age of 163 Ma. The unit is variable in texture and composition but is commonly gabbroic with over 50% mafic minerals giving the rock a dark greenish-gray color on fresh surfaces and a reddish-brown color on weathered surfaces. Often weathers to a dark reddish-brown soil which is well exposed along Red Hill Road. Leucocratic and more felsic rocks occur near the town of Vallecito and pegmatitic rocks with large pyroxene crystals were observed near the margins of the unit. The contact with surrounding country rocks, although rarely exposed, is sharp and discordant, with variable degrees of contact metamorphism. The contact is best observed in a road cut at the Red Hill Transfer Station where undeformed gabbro is in direct contact with highly foliated metamorphic rocks of the Don Pedro Terrane (Jdp). Where apparent, contact metamorphism formed local hornfels within 30 meters of the contact in metavolcanic rocks along the southern and western pluton. In marble, calcite grain size is increased within 100 meters of the mass (Baird, 1962). Mapping is based on Baird (1962) with significant modifications during this study based on field observations and lidar imagery (U.S. Geological Survey, 2019). New U/Pb dating of one sample obtained along Red Hill Road produced an age of 173.11 +/- 1.71 [3.46] Ma (MSWD = 2.3) (ages +/- internal 2SE uncertainty [total 2% uncertainty]); analyses were conducted on zircons using laser ablation ICPMS analyses at the CSUN Laser Lab (J. Schwartz, written commun., 2023).

Jac — **American Camp Pluton (Jurassic (?))**— Fine- to medium-grained hornblende and pyroxene bearing granite. In thin section, the sample shows abundant quartz and orthoclase feldspar with both microcline and Carlsbad twinning observed. Muscovite and hornblende are common with minor amounts of pyroxene. Occurs as a small isolated granitic body in the northeastern part of the quadrangle. Underlies subtle rolling hills on a broad plateau north of the South Fork Stanislaus River. New U/Pb age dating of one sample that was collected just outside the quadrangle produced an age of 172.48 +/- 1.33 [3.45] Ma (MSWD = 3.1) (ages +/- internal 2SE uncertainty [total 2% uncertainty]); analyses were conducted on zircons using laser ablation ICPMS analyses at the CSUN Laser Lab (J. Schwartz, written commun., 2023).

Mzhh — **Halleck Hill intrusive rocks (Mesozoic (?))**— Fine- to medium-grained diorite, leucocratic porphyry, and pegmatites, distinguished for the first time on the current map. These rocks were previously included within the Vallecito pluton but are here mapped as a separate unit due to the spatial discontinuity with the Vallecito pluton. These rocks also appear lithologically and structurally separate. This unit is primarily ridge-forming in the west central map area. The roughly arcuate band of plutonic rock near Halleck Hill consists of fine- to medium-grained garnet- and pyroxene-bearing diorite, and pyroxene-amphibole pegmatites. Inclusions of dark gray hornfels are common. Near Halleck Hill, abundant xenoliths of more mafic rock types occur within the plutonic mass. South of Halleck Hill near Natural Bridges, two small igneous bodies are cored by medium-grained garnet-bearing diorite, and flanked by leucocratic porphyry with garnet and pyroxene. These two igneous bodies appear to be associated with skarn deposits and are connected by dikes mapped by Baird (1962) and intruded Calaveras Complex marble, map unit MzPzcm.

Mzg — **Plutonic rocks, undifferentiated (Mesozoic (?))**— Plutonic rocks of variable composition that form discrete, small bodies across the map area. These small bodies consist of tonalite, granodiorite, and diorite. Relationship to nearby plutons is poorly understood.

Columbia 7.5-minute Quadrangle



SOURCES OF MAP DATA

1. Baird, 1962
2. Snow and others, 2008
3. Haughy, 2023
4. Henry and Faulds, 2010
5. CSUN Laser Lab, 2023

Data sources that cover entire quadrangle
Schweickert, 2015
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MAP SYMBOLS

Contact between map units—Solid where accurately located; long dash were approximately located; short dash where inferred; dotted where concealed; queried where identity or existence is uncertain.

Fault—Dip of fault plane unknown but sense of displacement known (D = downthrown, U = upthrown); solid where accurately located; long dash where approximately located; short dash where inferred; dotted where concealed; queried where identity or existence is uncertain.

Normal Fault—Ball and bar on downthrown block, solid where accurately located; long dash where approximately located; short dash where inferred; dotted where concealed; queried where identity or existence is uncertain.

Thrust Fault—Sawteeth on upper plate; solid where accurately located; long dash where approximately located; short dash where inferred; dotted where concealed; queried where identity or existence is uncertain.

Dike, undifferentiated

Sonora dike swarm

Landslide—Arrows indicate principal direction of movement. Where mapped as a landslide complex, adjacent defined slides have different relative ages and/or failure types.

U-Pb Geochronology point (two samples)

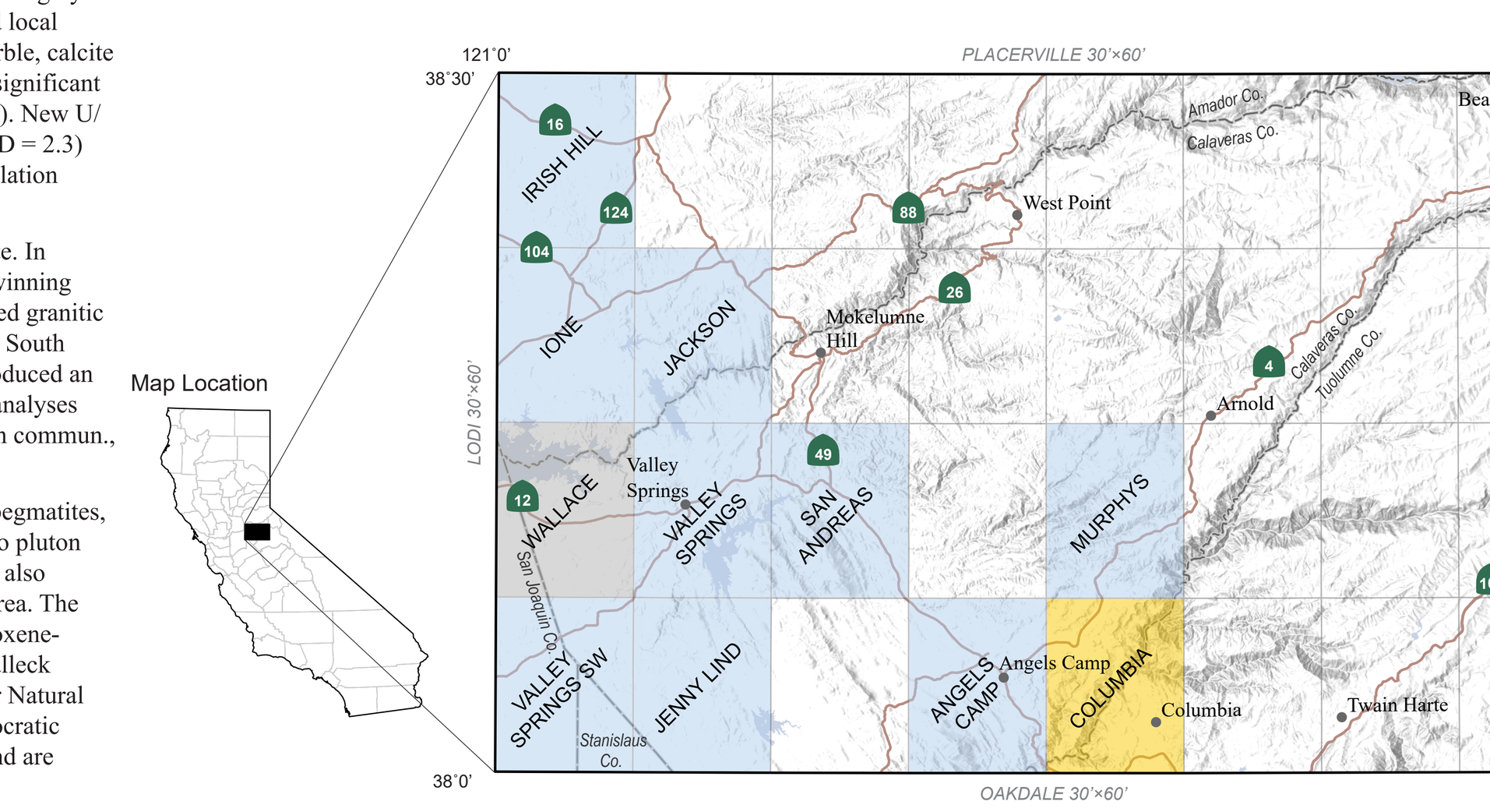
$^{40}Ar/^{39}Ar$ Geochronology point (eleven samples)

Sinkhole

Mine

Strike and dip of geologic structure; number indicates dip angle in degrees.
- 25 Bedding
- 70 Approximate bedding
- 50 Metamorphic foliation
- Vertical metamorphic foliation
- Shear

Map Location



STATEMAP geologic mapping projects within the San Andreas 30'x60' Quadrangle
- This Project
- Other mapping
- Previously completed projects

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AUTHORSHIP DOCUMENTATION AND PRODUCT LIMITATIONS

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LIMITATIONS: This map is considered preliminary, and the California Department of Conservation makes no warranties as to the suitability of this product for any given purpose. This map should not be considered as an authoritative or comprehensive source for landslide and seismic hazard data. For landslide data, please visit the California Geological Survey Landslides web page at: https://www.conservation.ca.gov/cgs/landslides. For seismic hazards data and Zones of Required Investigation, please visit the California Geological Survey Seismic Hazards Program web page at: https://www.conservation.ca.gov/cgs/sh/program.

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