Geologic Map of the Cuddy Valley quadrangle, Kern and Ventura Counties, California

By Karl S. Kellogg

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The database manager is: Karl S. Kellogg
(303) 236-1305
kkellogg@usgs.gov
U.S. Geological Survey
Box 25046, Mail Stop 913
Denver, CO 80225

The data were compiled from unpublished mapping. One review, by Scott Minor, was performed.

DESCRIPTION OF MAP UNITS

Surficial Deposits

Qa **Alluvium (Holocene)--**Silt- to boulder-size, moderately rounded to well-rounded, moderately sorted to well-sorted sediments forming channel and overbank deposits in modern floodplains. Maximum thickness greater than 5 m

Qac **Alluvium and colluvium, undivided (Holocene)**—Alluvium is mostly silt-to boulder-size, moderately sorted to well-sorted sediment forming small channels, and sheetwash alluvium on gentle slopes. Colluvium is poorly bedded, non-indurated to slightly indurated, dark brown to light-gray-brown clay, silt, sand, pebbles, and cobble-size blocks that mantle gently to moderately sloping surfaces and are intermixed by downslope movement of weathered bedrock. Includes minor loess deposits. Deposits commonly capped by moderately developed to well-developed soil profile. Mapped where alluvium is intimately intermixed with or difficult to differentiate at map scale from colluvium. Many smaller deposits not mapped. Typically underlies open meadows. Maximum thickness probably less than 10 m

Qw **Wetland deposits (Holocene)—**Brown to black, organic-rich, commonly water-saturated soil and fine-grained sediment in generally flat areas or closed depressions that may contain standing water. Overgrown in places with water-intensive plants. Deposits mapped in one sag area in San Andreas fault valley near western quadrangle boundary

Qls **Landslide deposits (Holocene and/or Pleistocene)**--Poorly sorted, unstratified to poorly stratified, clay- to boulder-size unconsolidated to consolidated debris. In places, includes almost intact slumped blocks of bedrock as long as several tens of meters. Younger deposits maintain hummocky topography and have identifiable breakaway scarp; older deposits are deeply dissected, with rounded topography. Thickness about 10 m to greater than 50 m

Qf1 **Younger fan deposits (Holocene and upper Pleistocene)—**Mostly alluvial gravel underlying topographically lowest surface in San Andreas rift valley and Lockwood Valley. Contains subrounded to angular, locally derived clasts as large as boulders. Includes minor debris-flow deposits. Locally contains weak to moderate soil profile. Forms fan-shaped or planer surfaces that are active only during intense periods of precipitation. Base not exposed, but may locally be thicker than 50 m

Qtr **Travertine (Holocene? and upper Pleistocene)—**Pale gray and pale grayish-tan, fine-grained, mostly layered, vuggy travertine and limestone. Commonly brecciated and recemented; cut my numerous, randomly oriented calcite veinlets as wide as 1 cm. Locally contains fresh-water gastropods. Several unmapped, brecciated limestone beds as thick as 8 m that are in Caliente Formation (Tcu) on the south side of hill in SW ¼, Sec. 33, T. 9 N., R. 20 W., in places appear to grade into travertine, suggesting that travertine-building springs were associated with faults that cut or were close to limestone beds. Larger (as wide as 10 m) outcrops of travertine mostly overlie areas underlain by sheared augen gneiss (unit Xag). Several smaller outcrops not mapped. Duebendorfer (1979) suggests that these travertine deposits may have formed as tufa adjacent to a lake. Several small travertine deposits also occur in lacustrine member of Plush Ranch Formation, one of which is mapped in NW ¼, Sec. 22, T. 8 N., R.21 W. All carbonate-rich springs from which travertine precipitated are no longer active

Qf2 **Older fan deposits (Holocene? and upper Pleistocene)—**Tan, mostly alluvial gravel containing angular to subrounded, locally derived clasts as large as boulders. Forms locally strongly dissected geomorphic surface about 20-30 m above younger fan deposits (unit Qf1). Deposits contain well-developed soil profile and in places are modified by landsliding. Maximum thickness less than about 30 m

Qf3 **Highly dissected fan deposits (middle? Pleistocene)—**Tan, poorly sorted boulder gravel that occupies elevated surfaces along crests of some ridges. Grain size ranges from clay to boulders. Clasts are angular to subrounded, locally derived, and commonly as large as about 3 m. Present only in western part of quadrangle. Maximum thickness about 20 m, although much thicker immediately west of quadrangle in Sawmill Mountain quadrangle

Qd **Diamicton (middle? Pleistocene)—**Unsorted to poorly sorted, unstratified to poorly stratified, poorly consolidated deposits containing clasts as large as boulders. Interpreted as highly dissected remnants of debris-flow deposits and alluvial fans. Many deposits have flat tops that are remnants of old fan surfaces. On west side of Frazier Mountain in southeast part of quadrangle, deposits are probably derived from extensive landslide deposits directly upslope. Clasts are of local origin and include granitic and gneissic rocks from Mt. Pinos or Frazier Mountain and recycled clasts from Caliente Formation. Correlated with boulder diamicton of Lockwood Valley quadrangle (Kellogg, 1999). Unit is as thick as about 30 m

Qg **High-level gravel (Pleistocene)—**Well-rounded to angular, poorly indurated, polymict gravel occupying slopes and benches on west side of Frazier Mountain in southeastern corner of quadrangle. Most outcrops consist of scattered clasts in soil matrix. Cobbles consist of a bimodal population of 1) locally derived, angular augen gneiss, biotite gneiss, and vein quartz as long as 1 m, and 2) well-rounded clasts as long as about 20 cm consisting of gray fine-grained to medium-grained granitoid rocks, gray and pink, felsic to intermediate, mostly porphyritic volcanic rocks, basalt, quartzite, and chert. Similarity of the well-rounded clast population to that in much of Caliente Formation, and presence of Caliente beds found locally on the west face of Frazier Mountain, suggests that the gravels were derived from erosion of local Caliente beds. Age interpreted as greater than 37,000 years (Zhou, 1989). Unit is less than 20 m thick

Bedrock Units South of the San Andreas Fault

Tq **Quatal Formation (Pliocene)—**Light-brown to medium-brown sandy mudstone, siltstone, sandstone, and pebbly conglomerate of fluvial origin; poorly to moderately indurated. Beds typically tabular, locally cross-bedded, and 0.5-2 m thick. Conglomerate clasts predominantly granitic rocks, intermediate volcanic rocks, quartzite, and sandstone. Weathers to a light-yellowish-tan, sandy soil. No diagnostic fossils or dated material have been found in the formation, but latest Miocene age for the uppermost Caliente Formation (James, 1963) suggests

Pliocene age for the Quatal. Correlates to south in the Lockwood Valley quadrangle with sandstone and siltstone member of the Quatal Formation (Kellogg, 1999), and to the southwest in the San Guillermo Mountain quadrangle with fluvial sedimentary rocks of the Quatal Formation (Minor, 1999). Unit conformably overlies Lockwood Clay. Approximately equivalent to Member 2 of Quatal Formation of Carman (1964). Top not exposed in quadrangle but thickness is greater than 300 m

Tlc **Lockwood Clay (Pliocene?)**--Chocolate-brown, poorly indurated, massive clay. X-ray analysis indicates clay is almost entirely montmorillonite, with a small amount of kaolin (Carman, 1964). Age is poorly constrained by fossils found just below unit in upper Caliente Formation in Dry Creek (James, 1963), about 10 km west of southern part of quadrangle. Weathers to red-brown clayey soil with sparse vegetation, except for wild onions (*Allium howellii* var. *clokeyi*) and buckwheat (*Erigonium ordii* and *Erigonium trichopes* var. *hooverii*). Protolith uncertain, but may be strongly altered tuff (Carman, 1964) or deeply weathered loess deposit (P.L. Ehlig, personal commun., 1998). Base of unit is disconformable or forms a very-low-angle unconformity above the Caliente Formation. Included in the lowermost part of Quatal Formation by Hill and others (1958). Clay mined commercially in Sec. 19, R. 20 W., T. 8 N. Thickness 0-50 m; typically about 30 m thick in quadrangle

Caliente Formation (Miocene)—Fluvial conglomerate, sandstone, siltstone, and claystone that typically forms well-developed, fluted badland topography mostly southeast of the Lockwood Valley fault. Vertebrate fossils indicate age is Middle Hemingfordian to Hemphillian (late early to latest Miocene) (James, 1963; Kelley and Lander, 1988). Basalt flows in the type Caliente Formation, about 40 km northwest of quadrangle in the Caliente Range, have recalculated K/Ar ages of 14.6-14.8 Ma (Turner, 1970), and a tuff from the middle of the Caliente Formation, collected in Dry Canyon about 10 km west of southern part of quadrangle, has a recalculated K/Ar age of 15.6 Ma (James, 1963). Vertebrate fossils from Dry Canyon and elsewhere indicate that the top of the Caliente beneath Lockwood Clay youngs to the northwest (James, 1963). In map area, mostly divided into four informal members. Maximum observed thickness in Lockwood Valley region about 700 m (Carman, 1964)

Tcm **Metamorphic-clast member—**Gray, grayish-tan, and brown conglomerate and coarse-grained pebbly sandstone. Well-rounded to sub-angular, very poorly sorted clasts as long as 20 cm consist of 50 percent or greater metamorphic rocks, including biotitic augen gneiss and well-foliated biotite gneiss, 10-20 percent granitic rocks, 2-5 percent intermediate-composition porphyritic volcanic rocks, 5 percent quartz, and less than 5 percent quartzite. Upper approximate 50 m consists of grayish-brown, greenish-brown, and greenish-gray clayey sandstone and pebble to cobble conglomeratic sandstone, with lenses of clay resembling Lockwood Clay. Bedding very indistinct, typically 2-10 m thick with gradational contacts between beds. This member clearly underlies the Lockwood Clay in the southeastern part of quadrangle; the steep and poorly defined bedding attitudes preclude determining if there is any angular discordance with respect to the Lockwood. This unit was mapped as member 4 of the Quatal Formation by Carman (1964, p. 45) who noted that it has “striking similarities” to the Caliente Formation but failed to note its relative age relationship to the Lockwood Clay and, therefore, the necessary thrust contact with the Quatal Formation to the west. The base of unit not exposed and is not in contact with other recognized members of the Caliente Formation. Thickness greater than 250 m

Tcua **Upper arkosic member—**Light-grayish-tan, poorly to moderately indurate, poorly sorted, ledgy, silty, coarse-grained arkosic sandstone and conglomerate. Contains subrounded to subangular matrix-supported clasts of granite and gneiss as long as 30 cm, derived either from crystalline rocks of Mount Pinos or Plush Ranch beds (second-generation clasts). Member is locally stratified with good bed forms, including cross bedding and laminae. Crops out adjacent to Lockwood Valley fault where it is overturned in many places. Conformably overlies volcanic-clast conglomerate member. Forms basal part of member 1 of Carman (1964, p. 39), who notes “a paucity of volcanic cobbles in float near the Big Pine fault” (Lockwood Valley fault of this study). The unit is also very similar to Carman’s member 3. Top of unit not exposed; thickness greater than 120 m

Tcc **Volcanic-clast conglomerate member—**Gray-brown, light buff, and greenish-brown clayey and silty sandstone and conglomerate. Clasts well rounded, as much as 25 cm in diameter, and composed predominantly of intermediate to felsic volcanic rock; pink and purple felsite particularly common. Clasts also include fine- to medium-grained granitic rocks, quartzofeldspathic gneiss, vein quartz, and basalt. Beds are typically 0.1-3 m thick Lies conformably below upper arkosic member (Tcua) in south-central part of quadrangle. Weathers to orange-tan soil with scattered cobbles. Corresponds approximately to Carman’s member 1. Thickness in quadrangle variable and difficult to estimate; probably locally as thick as 400 m

Tcs **Green claystone and sandstone member—**Medium- to coarse-grained, gray-green and locally tan, interbedded clayey and silty sandstone, pebble and cobble conglomerates, and claystone. Beds typically 0.1-3 m thick. Underlies and partially interfingers with the volcanic-clast conglomerate member (Tcc) in a prominent anticline in the southwestern corner of quadrangle. Corresponds to member 2 of Carman (1964), who reports finding fresh-water gastropods and thin limestone beds indicating lacustrine environment of deposition. Maximum exposed thickness about 325 m

Tcu **Caliente Formation, undifferentiated—**Fault-bounded, mostly poorly exposed, gray, yellow-tan, and reddish-brown clayey sandstone and pebble to cobble conglomeratic sandstone that have uncertain correlation with other mapped Caliente units. In exposures on north side of Cuddy Saddle fault, most clasts are angular to subrounded and locally derived (granitic rocks similar to those on Mount Pinos, Pelona schist, and Frazier Mountain augen gneiss). In partially sheared exposures 1 km southwest of Lake of the Woods, unit consists of white and light gray-green, well indurated, weakly bedded to massive, clayey sandstone containing angular limestone clasts as long as 1 cm that were presumably derived from the lacustrine member of the Plush Ranch Formation (Tpl). About 1-1.5 km farther southwest, poor exposures include thin beds of tan, cross-bedded sandstone and yellowish-tan, brown, and brick-red conglomeratic sandstone containing well-rounded clasts as long as 8 cm of quartzite, intermediate volcanic rocks (commonly purple), and granitic rocks. Total thickness unknown

Tfp **Felsite porphyry sill (lower Miocene?)—**Gray, fine-grained, silicic biotite porphyry sill of approximately dacitic composition. Contains about 5 percent biotite phenocrysts as large as 2 mm and abundant iron-oxide minerals that weather to orange limonitic spots. Outcrop strongly fractured into angular orange-tan-weathering fragments. Poorly exposed at one locality on border between NW¼ , Sec. 23 and NE¼ , Sec. 22, T. 22 N., R. 21 W. Age unknown, but felsite porphyry sill is stratigraphically high in Plush Ranch section, above most basalt that is dated at 27-21 Ma (Frizzell and Wegand, 1993) so its age is most likely early Miocene or younger. Early Miocene age is inferred from period of late Oligocene and early Miocene volcanism in region, although felsic volcanism during this period is generally late Oligocene (27-25 Ma) (Stanley and others, 2000). Sill is less than 3 m thick.

Plush Ranch Formation (lower Miocene and upper Oligocene)—The formation was first described in detail and named by Carman (1964). Cole and Stanley (1995) subsequently adopted the formation as a formal stratigraphic unit with a type section established along North Fork of Lockwood Creek in the Sawmill Mountain quadrangle (Kellogg and Miggins, 2002). Cole and Stanley (1995) interpreted the Plush Ranch Formation as a lacustrine fan-delta sequence that formed during lower Miocene and upper Oligocene extension. The formation in map area is divided into:

Tpb **Granite- and gneiss-breccia member—**Light- to dark-gray massive to poorly stratified sedimentary breccia and interbedded, moderately to well-bedded, medium-grained to pebbly light-grayish-brown arkosic sandstone. Clasts in conglomerate are angular to subrounded and as long as 2 m and are composed of varying proportions of Cretaceous granite of Lockwood Peak (Kellogg, 1999) and Precambrian Frazier Mountain augen gneiss (Carman, 1964; Kellogg, 1999), both derived from southeast of Lockwood Valley fault system. Clast size decreases to north, which, along with clast imbrication (Cole and Stanley, 1995), also indicate source to southeast. Interpreted as coarse-grained fan-delta deposits adjacent to basin-bounding normal fault proposed to exist at site of present Lockwood Valley fault system (Cole and Stanley, 1995). Corresponds to Carman's Plush Ranch member 5. Base of unit not exposed. Maximum thickness in quadrangle about 120 m; greater than 375 m about 3 km southwest of southwest corner of quadrangle (Minor, 1999)

Tps **Sandstone member—**Light-gray-brown, orange-brown, and olive-brown, flaggy to blocky, well-indurated, interbedded, sandy mudstone, well-sorted arkosic sandstone, and subordinate pebble and cobble conglomerate; clasts mostly granitic with lesser amounts of gneiss and minor quartzite. Beds planar and 0.5-10 m thick. Contains interbedded light-gray-brown, moderately consolidated, sandy siltstone typically as thick as 1 m. Interpreted as alluvial-plain deposits and subaqueous fan-delta deposits (Cole and Stanley, 1995). The subaqueous fan-delta deposits consist mostly of thin- to medium-bedded, laterally continuous sandstone beds and interbedded mudstone. The alluvial-plain deposits consist mostly of medium- to coarse-grained, well-sorted sandstone, with interbeds of pebble to cobble conglomerate, siltstone, and mudstone. Petrified wood found about 300 m east of mouth of Middle Fork Lockwood Creek (SE¼, SW¼, T. 8 N., R. 21 W). Corresponds approximately to Carman's Plush Ranch members 1 and 2. Thickness variable; as much as 820 m thick

Tpl **Lacustrine member**—Light-olive-brown to orange-brown, commonly fissile shale and siltstone, evaporites, and fine- to very-fine-grained sandstone. Sandstone is thin-bedded, ledgy, tan, well consolidated, laterally continuous, and normally graded; some soft-sediment deformation in finer-grained beds. Weathers yellowish tan. Orange-brown beds predominate in western exposures of unit. Near base of sequence near west boundary of quadrangle are white, greenish, and light-brown ribbony clay, mudstone, and interbedded laminar fine- to medium-grained light-brown sandstone; locally gypsiferous. Locally contains lenses of pebble conglomerate; pebbles almost entirely granite and gneiss. In and near Seymour Creek, thin limestone and shale beds are interbedded with borax-bearing evaporite minerals, mostly colemanite, which was mined until World War I (Carman, 1964). Correspond approximately to Plush Ranch members 3, 4, and 4a of Carman (1964). Interpreted as basin-center lacustrine deposits (Cole and Stanley, 1995). Thickness variable; as thick as 900 m in quadrangle. Includes:

Tpgy **Gypsum beds**—Sequences thin-bedded (1 to 8 cm), closely spaced (mostly 0-10 cm apart) white gypsum (mostly selenite; minor alabaster) beds interbedded with dark-brown mudstone. The sequences are as thick as about 50 m.

Tpbx **Granite-megabreccia**—Gray, massive, poorly sorted, well consolidated, clast-supported, almost monolithologic breccia; clasts mostly angular blocks of granite of Mt. Pinos as long as 10 m (15 m reported by Bohannon, 1976); less than 2 percent of clasts are aplitic to medium-grained granite. Matrix, where exposed, consists of medium- to coarse-grained grusy sandstone. Contact with surrounding mostly mudstone beds of the lacustrine member is sharp; blocks appear to have disturbed underlying beds, indicating soft-sediment deformation during deposition. Interpreted as rockslide deposits that slid into subaqueous sediments of unit Tpl (Cole and Stanley, 1995). Unit forms oval-shaped outcrops as wide as 80 m and as long as 700 m

Tpba **Basalt member**—Black, medium- to fine-grained, locally vesicular basalt flows and sills. Contains about 65 percent calcic plagioclase (An_{50}), 20 percent clinopyroxene, 15 percent olivine, partially altered to iddingsite, and 5 percent opaque minerals. Plagioclase forms small phenocrysts as long as 2 mm. Mostly massive; faint pillow structures reported at some localities (Carman, 1964; Cole and Stanley, 1995). Unit clearly cross cuts beds of the lacustrine member of the Plush Range at some localities and is intrusive. Flows or sills locally interlayered with subaqueous mudstone and evaporite deposits of the lacustrine member. Weathers to dark-brown sandy grus-rich soil containing abundant basalt clasts. Potassium-argon ages for the basalt range from 20.9 $\pm$ 0.9 to 26.5 $\pm$ 0.5 Ma (Frizzell and Weigand, 1995), or Late Oligocene to Early Miocene. Corresponds to part of member 4 of Carman (1964). Maximum thickness in quadrangle about 200 m

Tpsr **Red-bed member**—Maroon to pale pink, poorly sorted, poorly to moderately indurated, muddy siltstone, sandstone and pebble conglomerate. Clasts well rounded, as long as 3 cm, and consist predominantly of quartzite with subordinate aplite, gneiss, and intermediate volcanic rocks. Beds typically 0.1-1.0 m thick. In Middle Fork Lockwood Creek and Amargosa Creek, where member rests unconformably on unnamed marine shale unit (Tms). Clast size and thickness increases to northwest and along-strike stratigraphic relation with basal red conglomerate member covered by surficial deposits (unit Qf3). Included with sandstone member (Tps) in Sawmill Mountain quadrangle to the west (Kellogg and Miggins, 2002). Member as thick as about 30 m

Tpc **Basal conglomerate—**Maroon and reddish-tan, well-indurated, poorly sorted, massively bedded conglomerate with subordinate lenses typically 0.5-2 m thick of tan, medium- to coarse-grained sandstone. Clasts are angular to well rounded, both matrix and clast supported, as long as 1 m, and consist of about 60-70 percent biotite gneiss, 20-30 percent granitoid rocks, and about 5 percent each quartz and schist similar to Pelona Schist (unit Tps). Clast population is devoid of volcanic rocks and possible source areas are all within 5 km. Sandstone consists primarily of quartz, feldspar, rock fragments, and a few percent biotite. Massive conglomerate beds in lower 100 m are as thick as 30 m. Up section, bedding thickness and clast size decreases and relative abundance of sandstone increases; bed thickness near top of section mostly about 0.1-3 m. Contact with overlying sandstone member mapped at abrupt color change from bright maroon below to tan above. Member as thick as about 220 m

Tmsh **Marine shale (lower Eocene)—**Black to dark-brown, fissile, marine, micaceous siltstone and shale with minor fine- to medium-grained, thin-bedded, tabular, brown, muddy sandstone. Contains black dolomitic concretions as long as 2 m. Bedding in finer-grained rocks commonly indistinct. Locally contains abundant mollusks. Shale weathers to light-brownish gray and is rusty colored along abundant joint surfaces. Early Eocene age and tentative correlation with extensive Juncal Formation to the south of quadrangle (Kellogg, 1999; Minor, 1999) is based on abundant mollusks and benthic foraminifera (Squires, 1988). Unit was deposited on deeply weathered granite of Mt. Pinos (Kgp), but base of unit is locally faulted against granite, indicating either minor normal movement, probably coeval with southward tilting of sequence, or, more likely, due to Quaternary gravitational settling of granite (Kellogg, 2001). Unit overlain unconformably by rocks of Plush Ranch Formation. One measured section about 1.9 km west of quadrangle is 605 m thick (Squires, 1988); thickness in quadrangle considerably thinner

Tmy **Sawmill Mountain mylonite (Paleocene?)—**Greenish-gray to dark green, very well indurated augen-rich mylonite along the trace of the Sawmill Mountain thrust fault. The rock is mostly chloritic and grades structurally upward into chloritic gneiss. Base is ribbony, with thin white quartz stringers. In most places, the contact between mylonite and structurally underlying unmylonitized Pelona schist is sharp. The degree of mylonitization generally decreases upward, although locally there are several discrete mylonite zones over a 100-m vertical range. There is considerable brittle deformation near the structural top of the mylonite zone, with small offsets in the mylonitic fabric and many slickensided surfaces. Lower few meters contain mylonitized Pelona schist, but most of protolith of the mylonite is hanging-wall gneiss, as shown by abundant augens of quartz, feldspar, and quartz-feldspar intergrowths. Greenschist-grade metamorphism and ductile deformation along the Sawmill Mountain fault reflect mid-crustal conditions during movement, which most likely predates regional uplift and deposition of unmetamorphosed lower Eocene rocks in the area. The Sawmill Mountain fault is correlated with the Vincent-Orocopia-Chocolate Mountain thrust system of southern California (Crowell, 1962) which is thought to be Late Cretaceous or Paleocene in age (Ehlig, 1968). An early Paleocene metamorphic age for the Pelona Schist immediately west of the Cuddy Valley quadrangle (Kellogg and Miggins, 2002) requires that the mylonite be no older than Paleocene. The total thickness of the mylonite varies greatly and is as much as about 140 m

Tpsh **Pelona Schist (early Paleocene)**—Silvery-gray to brownish-gray, medium-grained quartzofeldspathic schist and micaceous quartzite. Typically contains 30-60 percent quartz, commonly as porphyroblasts as long as about 4 mm containing many small inclusions, 15-20 percent albite, 10-20 percent muscovite, 2-20 percent biotite, 10 percent epidote, 2-5 percent calcite, trace to 2 percent garnet, and traces of zircon and opaque minerals. Grades in a few places into micaceous quartzite; Davis (1983) reports small lenses of talc-actinolite schist, although this rock not observed during mapping for this study. Relict bedding is parallel to foliation at all locations, based on common presence of graded beds. Generally shallow, south-plunging lineation defined by micaceous streaks on foliation surfaces. Oxidized iron-oxide minerals form rusty surfaces along fractures. Correlated with the Paleocene or latest Cretaceous Pelona-Orocopia-Rand Schist in southeastern California, on the northeast side of the San Andreas fault (Ehlig, 1968; Haxel and Dillon, 1978; Jacobson and others, 2000). The metamorphic age of the Pelona-Orocopia-Rand Schist is Paleocene or Latest Cretaceous (Haxel and Dillon, 1978). Preliminary $^{40}Ar/^{39}Ar$ age on muscovite from the Sawmill Mountain quadrangle immediately west of the Cuddy Valley quadrangle is 63.24$\pm$0.26 Ma; $^{40}Ar/^{39}Ar$ age on biotite from the same locality is 56.66$\pm$0.15 Ma (Kellogg and Miggins, 2002). The muscovite age is believed to be a better representation of the true metamorphic age for the sample

Kgp **Granite of Mt. Pinos (Cretaceous)**—Coarse-grained to very coarse grained, pink to pinkish-gray, massive, porphyritic granite. Contains approximately 10-25 percent quartz, 50-70 percent microcline, mostly as subhedral phenocrysts as long as 2 cm, 15 percent plagioclase, 3-10 percent biotite, commonly clumped and surrounding the microcline phenocrysts, and traces of sphene, zircon, and opaque minerals. Forms grusy outcrops and soil over large areas. Outcrops blocky due to the common presence of joints having variable orientations. Unit undated, but is similar to coarse-grained granite of Mt. Lockwood in Lockwood Valley quadrangle, several kilometers to the south of the quadrangle, which has a U-Pb zircon date of 76.05$\pm$0.22 Ma (Kellogg, 1999; analysis by W.R. Premo). This date is problematic, however, as it is older than $^{40}Ar/^{39}Ar$ ages of units into which the granite of Mt. Pinos intrudes (Kellogg and Miggins, 2002)

Kgpb **Border phase**—Gray, medium- to coarse-grained, massive to moderately well foliated, equigranular granodiorite or quartz diorite forming a relatively mafic border to granite of Mt. Pinos (Kgp). Contains about 50 percent plagioclase, 25 percent quartz, 0-10 percent microcline, 15 percent biotite, 15 percent blue-green (in thin section) amphibole, 1 percent large sphene, and traces of zircon and opaque minerals. Unit clearly indicates that granite of Mt. Pinos is intrusive into other granitoid phases. Border phase is as wide as about 300 m in map view

Kgrn Granite of Cerro Noroeste (Cretaceous)—Mostly medium-grained, massive to strongly foliated, light-gray, biotite granodiorite or quartz monzonite. Locally coarse grained. Grades into layered biotite gneiss, in which black biotitic layers are interpreted to be planes of high strain. Typically contains 15-35 percent quartz, 25-50 percent plagioclase (An_{25}), 10-30 percent microcline, 5-20 percent biotite, 2-4 percent muscovite, trace-2 percent sphene, trace-1 percent garnet, and traces of zircon, apatite, and opaque minerals. Cut by numerous aplite and pegmatite dikes. Weathers into tan blocky outcrops. Preliminary $^{40}Ar/^{39}Ar$ age on biotite from the Sawmill Mountain quadrangle is 67.2$\pm$0.5 Ma (Kellogg and Miggins, 2002)

Kgdg Granodiorite gneiss (Cretaceous)—Gray to dark-gray, medium-grained to coarse-grained, massive to well foliated, equigranular to porphyritic granodioritic to tonalitic orthogneiss. Phenocrysts commonly deformed and sheared into augens. Grades into zones with well-defined light and dark layers, depending on biotite content, by ductile shearing and recrystallization. Relatively massive orthogneiss contains 25-30 percent quartz, 30-50 percent plagioclase (about An_{30}), 0-20 percent microcline, 10-20 percent biotite (much higher in some schistose layers), 0-5 percent hornblende, 0-3 percent muscovite, 0-2 percent opaque minerals, and traces garnet, zircon, and apatite. Preliminary $^{40}Ar/^{39}Ar$ age on biotite from the Sawmill Mountain quadrangle is 65.9$\pm$ 0.2 Ma (Kellogg and Miggins, 2002)

Kbg Biotite gneiss (Cretaceous?)--Gray and black, medium-grained, layered biotite gneiss. Leucocratic layers contain quartz, plagioclase, microcline (generally less than plagioclase), and biotite. Locally contains hornblende and is interlayered with streaks and pods of amphibolite. Not studied in detail. Mapped at one locality on east side of Mount Pinos, adjacent to Mill Canyon

Xag Frazier Mountain augen gneiss? (Early Proterozoic?)—Dark-gray to almost black, well-foliated to massive, xenomorphic augen gneiss, containing white to pink microcline porphyroblasts as long as 5 cm (most are less than 2 cm). Contains approximately 30-35 percent undulatory quartz, 40 percent sodic plagioclase, 10-15 percent microcline (almost entirely as augens), 10-20 percent biotite, 2-5 percent muscovite, 1 percent opaque minerals, and traces of apatite, zircon, and, rarely, garnet. Protolith is igneous as evidenced by: 1) microcline augens in massive (relatively unstrained) gneiss that are nearly euhedral, indicating relict porphyritic texture, and 2) dikes of augen gneiss that intrude quartzofeldspathic gneiss. Gneiss has undergone variable amounts of ductile shearing during which augens were highly elongated in tectonic transport direction and commonly define either lensoidal crystal aggregates of microcline or ribbony mylonitic bands composed of leucocratic quartz and feldspar. The unit is cut by numerous, unmapped pegmatite and aplite dikes and pods. Ductile shearing may be associated with previously recognized major orogenic episode in region at 1425-1450 Ma (Silver, 1971). Frazier Mountain gneiss in Lockwood Valley quadrangle has discordant, upper-intercept uranium-lead zircon age of 1690$\pm$5 Ma (Kellogg, 1999 [analysis by W.R. Premo, 1997]; Stanley and others, 1998), interpreted to be intrusive age of protolith

Xqfg **Quartzofeldspathic gneiss (Early Proterozoic)—**Fine- to medium-grained, tan to gray, commonly banded gneiss containing approximately 35-40 percent quartz, 40 percent sodic plagioclase (oligoclase), 10-30 percent microcline, 2-10 percent biotite, and traces of muscovite, zircon, apatite, and opaque minerals. Darker, more biotite-rich bands as thick as 2 cm. Unit is greenish in places due to alteration of feldspar to sericite and biotite to chlorite. Gneiss intruded by igneous protolith of Frazier Mountain augen gneiss. Protolith probably sandstone or felsic tuff that was deposited in region about 1750-1690 Ma (Silver, 1971)

Bedrocks units north of the San Andreas fault

TKrp **Felsite porphyry (Pliocene? to Cretaceous)—**Light-gray, well-indurated rhyolite or dacite porphyry. Matrix is white, silicic, and cherty. Contains about 10 percent rounded quartz phenocrysts as long as 3 mm, 5 percent chalky (strongly sausseritized), white, subhedral feldspar phenocrysts as long as 2 mm, and 3 percent altered biotite as wide as 2 mm. Poorly exposed at one small (about 15 m across) outcrop on ridge in northeastern part of quadrangle. Not studied in detail

TKbs **Biotite schist (Paleocene to Cretaceous)—**Silvery-gray to black, fine-grained, biotite schist and subordinate biotitic quartzite. Schist consists of about 25-50 percent fine-grained, undulatory quartz, 10 percent sericitic sodic plagioclase, 40-60 percent biotite, 10 percent epidote, 5 percent epidote, 2-3 percent apatite, 1-2 percent opaque minerals, 0-5 percent garnet, 1, and trace muscovite. Contains many thin (as wide as about 2 cm) quartz stringers. The mineral assemblage is characteristic of greenschist-facies metamorphism. Crops out in northwestern part of quadrangle in footwall of Pastoria fault. The schist shares many characteristics of the Rand Schist of southern California (Ehlig, 1968; Haxel and Dillon, 1978; Ross, 1989), with which it is tentatively correlated (Davis, 1982). The metamorphic age of the Rand schist is Paleocene or possibly Late Cretaceous (Haxel and Dillon, 1978)

Kgd **Quartz diorite and granodiorite (Cretaceous)—**Gray, medium-grained to coarse-grained, equigranular, massive to moderately foliated quartz diorite, tonalite, and granodiorite. Contains 8-30 percent quartz, 0-30 percent microcline, 30-50 percent plagioclase, 5-15 percent biotite (commonly altered to chlorite), 0-20 percent hornblende, and traces to 1 percent opaque minerals, garnet, zircon, sphene, and epidote. Forms cliffs, rocky hillsides, and weathered grusy surfaces. Preliminary $^{40}Ar/^{39}Ar$ age on hornblende from the Sawmill Mountain quadrangle is 99.8$\pm$0.85 Ma (Kellogg and Miggins, 2002). Approximately equivalent to granite of Brush Mountain and granodiorite of Lebec of Ross (1989), which were not differentiated on this map

Kdi **Diorite (Cretaceous)—**Dark gray, medium-grained, equigranular to inequigranular, massive to weakly foliated hornblende-biotite diorite. Contains 5-20 percent quartz, 50-55 percent calcic plagioclase, 0-5 percent potassium feldspar, 10-20 percent biotite, 15 percent hornblende (partially altered to actinolite), 0-10 percent garnet with sieve texture, 2-5 percent opaque minerals, 1-3 percent secondary epidote, and trace apatite. Biotite, in part, is secondary, forming diffuse, fine-grained mosaics along feldspar grain boundaries. Secondary minerals indicate greenschist-facies metamorphism. Minerals weather to black-and-white speckled texture. Unit is undated. Forms prominent exposures in northwest corner of quadrangle in footwall of Pastoria fault. Mapped as quartz diorite-tonalite of Antimony Peak by Ross (1989), who assigned a Cretaceous age

Metamorphic rocks in roof pendants and inliers in granitic rocks (Jurassic, Triassic, and (or) Paleozoic)—Davis and Duebendorfer (1987) correlated these rocks with Jurassic and Triassic rocks in roof pendants in the Kings Canyon region of the Sierras (Saleeby and others, 1978). However, Ross (1989) suggests these rocks may be as old as Paleozoic. Consists of:

cgbg **Biotite gneiss—**Dark-gray, fine-grained, well-foliated and lineated, migmatitic, quartzofeldspathic biotite gneiss and schist. Leuocosomes light-gray, medium-grained granodiorite or quartz diorite comprising about 10 percent of rock. Found at only one locality about 300 m south of summit of Escapula Peak

cgmg **Gray marble—**Gray, medium-grained, strongly foliated, calcitic marble in roof pendants and inliers in granitic bodies

cgqz **Quartzite**--Gray, fine- to medium-grained, well-indurated, mostly foliated quartzite. Locally contains as much as about 10 percent muscovite. Feldspar and quartz content also varies and rock locally grades into meta-sandstone

Bedrock units in the San Andreas fault zone

QTsf **Pervasively sheared, comminuted, and fractured rocks (Holocene to Miocene)—**Shown on cross section only. Produced by intermittent slip and cataclasis along numerous splays of the San Andreas fault. Consists of a variety of rock types, including granitic rocks, sandstone, and quartzite. Movement along the San Andreas fault in the western Transverse Ranges began about 10-12 Ma (Crowell, 1979), so some fault gouge may be as old as Miocene

Twa **White arkosic sandstone and conglomerate (Miocene?)—**White to very pale tan, massive to poorly stratified, arkosic sandstone and conglomerate. Beds are very thick, commonly more than 10 m. Contains large crossbeds and channel fills. About 10 percent of unit is matrix-supported conglomerate, containing moderately rounded to well-rounded clasts as long as about 30 cm of Eocene? sandstone, intermediate to mafic volcanic rocks, granitic rocks, dark-purple quartzite, gneiss, and quartz. Matrix contains angular grains of quartz, feldspar, and sparse biotite. Contains a few thin (typically 1-10 cm) discontinuous, olive-brown silty stringers. Weathers very distinctively into massive, rounded, very pale tan (nearly white) outcrops. Dips steeply at all localities. Unit is fault bounded and total thickness unknown. Minimum thickness in quadrangle about 300 m. Extends about 2 km west into Sawmill Mountain quadrangle. Correlated with Caliente Formation by Davis (1983) and Davis and Duebendorfer (1987), but unit is very distinct from recognized facies of Caliente

Tms **Marine shale and sandstone (Miocene? to Eocene?)—**Olive-gray, olive-green, olive-brown, and grayish-brown, poorly bedded marine shale, mudstone, and siltstone with occasional, thin (less than 10 cm) arkosic sandstone stringers. Sequence becomes sandier down section and lower part of exposed unit contains interbedded, tan, well-indurated, poorly sorted, coarse-grained, locally pebbly, and locally laminated. carbonate-cemented, arkosic sandstone beds typically 10-30 cm thick with well-developed graded bedding, cross bedding, and ripples, typical of turbidites. Pebbles consist almost entirely of subrounded to well-rounded quartz and minor gray, silicic volcanic porphyry as long as about 1 cm. Detrital grains in sandstone beds typically contain about 50 percent quartz, 40 percent feldspar, 5 percent biotite and lithic fragments. Duebendorfer (1979) reports less than 5 percent hornblende, and accessory mineral that include sphene, muscovite, garnet, zircon, epidote, magnetite, and hematite. A few sandstone beds contain small bits of plant remains as charcoal. In the Pinon Pines Estates area are a few fine-grained, pale pinkish-brown limestone beds as thick as 10 cm. In exposures just north of Lake of the Woods, beds are ductilly deformed into tight, disharmonic folds, although sandstone-shale contacts remain sharp. Unit mostly poorly exposed in large, fault-bounded hill ("Peanut Hill" of Deubendorfer, 1979) along south margin of San Andreas fault system just west and north of Lake of the Woods, and in the Pinon Pines Estates area. Age is unknown, although similarity to Eocene marine rocks to the west suggests that the rocks may also be Eocene (Duebendorfer, 1979). Neither top nor bottom of sequence is exposed; unit is greater than about 300 m thick

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