Table 1. -- Generalized section of geologic units, Sacramento Valley

System and series		Map unit (plate 1)	Geologic unit	Lithologic character	Reported maximum thickness (ft)	Remarks
QUATERNARY	Holocene	Qs	Sand dunes	Windblown sand and dune sand	--	Southwestern part of valley, generally lie above saturated zone.
		Qb	Flood-basin deposits	Clay, silt, and some sand; in delta area include mud, muck, loam, and sand	160	Deposited during flood stages of major streams. Impede vertical movement of water and restrict yields to wells. In places may include part of Modesto formation (Pleistocene).
		Qr	River deposits	Gravel, sand, silt, and minor amounts of clay	115	Among more permeable deposits in valley; include channel and flood-plain deposits, generally not tapped by wells. In places may include part of Modesto Formation (Pleistocene).
TERTIARY AND QUATERNARY	Pliocene to Holocene	QTc	Continental rocks and deposits	Heterogeneous mix of poorly sorted clay, silt, sand, and gravel; some beds of claystone, siltstone, sandstone, and conglomerate	3,000±	Include some informal units: younger alluvium (Holocene), older alluvium (Pleistocene and Holocene?) and fanglomerate (Pleistocene); four formations of Pleistocene age: Red Bluff, Modesto, Riverbank, and Turlock Lake; the Tehama Formation[1] (Pliocene and Pleistocene) on western side of valley, and the Laguna Formation (Pliocene) on eastern side. Difficult to determine subsurface contacts of formations and informal units. In total, forms major aquifer of valley. Fanglomerate yields up to 2,800 gal/min to wells, rocks and deposits on eastern side reportedly yield up to 3,700 gal/min, on western side up to 4,000 gal/min.
	Pliocene and Pleistocene	QTvs	Volcanic rocks and deposits at Sutter Buttes	Tuff and tuff breccia	--	Important source of water around Sutter Buttes
		QTv	Volcanic rocks	Andesitic and rhyolitic porphyry and tuff	--	Form core of Sutter Buttes
TERTIARY	Miocene and Pliocene	Tvd	Volcanic rocks and deposits	Andesite; obsidian; pumice; tuff; volcanic breccia, gravel, and sand; volcanic mudflows; some basalt	1,000	Include Tuscan Formation (Pliocene) in northeastern part of valley, Nomlaki Tuff Member (Pliocene) of the Tehama Formation in western part, Lawlor Tuff (Pliocene) and Sonoma Volcanics (Miocene and Pliocene) in southwestern part, and Lovejoy Basalt (Miocene) near Oroville. Tuscan Formation is an important aquifer and yields up to 3,000 gal/min to wells.
		Tcpm	Continental rocks and deposits	Gravel, sand, silt, clay, breccia, conglomerate, and sandstone; contain andesitic material	500	Principally Mehrten Formation on eastern side of valley, yield large quantities of water to wells.
	Oligocene and Miocene	Tcmo	Continental rocks and deposits	Gravel, sand, silt, and clay, siltstone, numerous tuffaceous beds, contain rhyolitic material	200	Principally Valley Springs Formation on eastern side of valley, generally a small-yield aquifer.
	Uncertain age	Tvu	Volcanic rocks	Andesite and basalt	200±	Basalt at Orland Buttes may include Lovejoy Basalt (Miocene), and andesitic material east of Marysville includes Reeds Creek Andesite of Clark and Anderson (1938) of late Eocene or Oligocene age. Andesitic material yields water to wells.
	Eocene	Tce	Continental rocks and deposits	Sand, clay, sandy to gravelly clay, sandstone, contain anauxite	400?	Principally Ione Formation (Eocene) on eastern side of valley, may include some of Valley Springs Formation (Oligocene and Miocene). Generally a small-yield aquifer.
	Paleocene and Eocene	Tm	Marine rocks and deposits	Clay, shale, siltstone, and sandstone	7000±?	Include Nortonville Shale Member of Kreyenhagen Formation (Eocene), Domegine Formation (Eocene), Martinez Formation (Paleocene), and some Paleocene rocks and deposits on western side of valley. Generally contain saline water; no yields to wells reported.
	Uncertain age	Tcu	Continental rocks and deposits	Auriferous and non-auriferous gravel on eastern side of valley, volcanic claystone, mudstone, and lenses of conglomerate on southwestern side of valley	--	Of limited use to ground-water basin.
PRE-TERTIARY		pTs	Marine rocks	Shale, siltstone, and conglomerate	25,000+	Crop out chiefly on western side of valley, some on eastern side. Include Knoxville Formation (Upper Jurassic), Chico Formation (Cretaceous), and Lower Cretaceous rocks (formerly called Shasta series, now obsolete). Generally contain saline water.
		pTg	Granitic rocks	Chiefly granitic rocks, in places consist of mafic intrusive rock	--	Crop out on eastern side of valley. Where fractured and saturated would yield small quantities of water to shallow wells.
		pTm	Metamorphic rocks	Metasedimentary and metavolcanic rocks, volcanic breccia and some slate	--	Crop out on eastern side of valley. Where fractured, weathered, and saturated, would yield small quantities of water to shallow wells.

[1]The Pliocene and Pleistocene age of the Tehama Formation used in this report does not conform to the Pliocene age of the Tehama as used by the U.S. Geological Survey.

Table 2. -- Generalized section of geologic units, San Joaquin Valley

System and series		Map unit (plate 2)	Geologic unit	Lithologic character	Reported maximum thickness (ft)	Remarks
QUATERNARY	Holocene	Qs	Sand dunes	Windblown sand and dune sand	140	Generally lie above saturated zone, but are permeable.
		Qb	Flood-basin deposits	Clay, silt, and some sand; near Stockton consist of muck, peat, and other organic soils	100	Impede vertical movement of water and restrict yields to wells. In places may include part of Modesto Formation (Pleistocene).
		Qr	River deposits	Gravel, sand, silt, and minor amounts of clay	100±	Among more permeable deposits in valley; include channel and flood-plain deposits of main streams, generally not tapped by wells. In places may include part of Modesto Formation (Pleistocene).
TERTIARY AND QUATERNARY	Pliocene to Holocene	QT1	Lacustrine and marsh deposits	Clay, silt, and some sand	3,600+	Deposited in lakes and marshes. Thickest section beneath Tulare Lake Bed. In subsurface, include three widespread clays, A (Pleistocene and Holocene?), C (Pleistocene), and modified E clay (Pleistocene)--includes Corcoran Clay Member of Tulare Formation. Impede vertical movement of water.
	Miocene to Holocene	QTc	Continental rocks and deposits	Heterogeneous mix of generally poorly sorted clay, silt, sand, and gravel; some beds of clay stone, siltstone, sandstone, and conglomerate	([1])	Include some informal units: younger alluvium (Holocene), older alluvium (Pleistocene and Holocene?) and continental deposits (Pliocene and Pleistocene); three formations of Pleistocene age: Modesto, Riverbank, and Turlock Lake; Tulare Formation (Pliocene and Pleistocene) on western side of valley, Laguna Formation (Pliocene) on eastern side, and Kern River Formation (Miocene to Pleistocene?) on southeastern part. Difficult to determine subsurface contacts of formations and informal units. In total, forms major aquifer of valley. Rocks and deposits on eastern side reportedly yield up to 4,500 gal/min, on western side up to 3,300 gal/min.
TERTIARY	Miocene and Pliocene	Tvd	Volcanic rocks and deposits	Massive tuff with large fragments of vesicular basalt northwest of Tracy, tuff and volcanic breccia at south end of valley	--	Of limited importance to ground-water basin.
		Tcpm	Continental rocks and deposits	Gravel, sand, silt, clay, conglomerate, sandstone, silt stone, and claystone, contain andesitic material	1,200	Principally Mehrten Formation (Miocene and Pliocene) on eastern side of valley; include continental equivalents of Etchegoin Formation (Miocene and Pliocene) on western side of valley, and Chanac Formation (Miocene) on southern part. The Mehrten is the principal aquifer and yields large quantities of water to wells.
		Tcmd	Continental and marine rocks and deposits	Gravel, sand, silt, clay, silty sand stone, and siltstone		Crop out in small area north of Kettleman Hills, include continental and marine equivalents of San Joaquin Formation (Pliocene) and Etchegoin Formation (Miocene and Pliocene). On western side of valley near Kettleman Hills, a shoreline phase of the San Joaquin Formation yields fresh water to many deep wells.
	Eocene, Oligocene, Miocene, and Pliocene	Tm	Marine rocks and deposits	Sand, clay, silt, sandstone, shale, mudstone, and siltstone		On western side of valley include the San Joaquin and Etchegoin Formations, Temblor Formation (Oligocene and Miocene), and Kreyenhagen Formation (Eocene). On southeastern side include the Santa Margarita Formation of various authors, the Round Mountain Silt, the Olcese Sand, the Freeman Silt, and the Jewett Sand (including the Pyramid Hill Sand Member) (all Miocene), and the Vedder Sand (Oligocene). On southeastern side of valley, marine rocks and deposits yield fresh water to wells.
	Oligocene and Miocene	Tcmo	Continental rocks and deposits	Gravel, conglomerate, sand, tuffaceous sand, clay, and sandy clay; contain rhyolitic material on eastern side of valley	450?	Principally Valley Springs Formation (Oligocene and Miocene) on eastern side of valley; unnamed fan glomerate in the southern part of the valley. Valley Springs Formation generally a small-yield aquifer.
	Eocene to Miocene	Tcme	Continental rocks and deposits	Conglomerate, sandstone, consolidated fanglomerate, claystone, tuff, and tuff breccia; near Fresno consist of tuffaceous sand and gravel		Near Bakersfield include Walker Formation (Eocene to Miocene) and the Bealville Fanglomerate (Oligocene to Miocene). Generally not penetrated by water wells.
	Eocene	Tce	Continental rocks and deposits	Conglomerate and sandstone; along eastern side of valley contain anauxite	400+?	Principally Ione Formation (Eocene) on eastern side of valley. Generally a small-yield aquifer and in places reported to yield saline water.
PRE-TERTIARY		pTs	Marine rocks	Sandstone, shale, siltstone, and some limestone; in places contain abundant secondary gypsum	20,000+	Crop out chiefly on western side of valley. Include Moreno Formation (Cretaceous and Paleocene) and Panoche Formation (Cretaceous). Where fractured, weathered, and saturated would yield small quantities of water to shallow wells.
		pTg	Granitic rocks	Chiefly granitic rocks, in places consist of mafic intrusive rocks	--	Mesozoic granitic rocks crop out chiefly on eastern side of valley. Where fractured, weathered, and saturated would yield small quantities of water to shallow wells.
		pTm	Metamorphic rocks	Metasedimentary, metavolcanic, and other metamorphic rocks	--	Crop out on eastern side of valley. Where fractured, weathered, and saturated would yield small quantities of water to shallow wells.

[1]Post-middle Pliocene continental rocks and deposits reported to be over 15,000 feet thick in extreme southern part of San Joaquin Valley (de Laveaga, 1952, p. 102).