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DESCRIPTION OF MAP UNITS FOR THE GEOLOGY OF THE PESCADERO/BUTANO CREEK WATERSHED, AND THE HALF MOON BAY AND MONTARA MOUNTAIN QUADRANGLES, SAN MATEO COUNTY, CALIFORNIA

Derived from the maps by Earl E. Brabb, Russell W. Graymer, and David L. Jones (1998,1999)

Digital database by Jason B. Barnes, Sebastian Roberts, and Suzanne K. Mills

DESCRIPTION OF MAP UNITS

af — **Artificial fill (Historic)**—Loose to very well consolidated gravel, sand, silt, clay, rock fragments, organic matter, and man-made debris in various combinations. Thickness is variable and may exceed 30 m in places. Some is compacted and quite firm, but fill made before 1965 is nearly everywhere not compacted and consists simply of dumped materials

Qhsc — **Stream channel deposits (Holocene)**—Poorly to well-sorted sand, silt, silty sand, or sandy gravel with minor cobbles. Cobbles are more common in the mountainous valleys. Many stream channels are presently lined with concrete or rip rap. Engineering works such as diversion dams, drop structures, energy dissipaters and percolation ponds also modify the original channel. Many stream channels have been straightened, and these are labeled Qhasc. This straightening is especially prevalent in the lower reaches of streams entering the estuary. The mapped distribution of stream channel deposits is controlled by the depiction of major creeks on the most recent U.S. Geological Survey 7.5-minute quadrangles. Only those deposits related to major creeks are mapped. In some places these deposits are under shallow water for some or all of the year, as a result of reservoir release and annual variation in rainfall.

Qhbm — **Bay mud (Holocene)**—Water-saturated estuarine mud, predominantly gray, green and blue clay and silty clay underlying marshlands and tidal mud flats of San Francisco Bay, Pescadero, and Pacifica. The upper surface is covered with cordgrass (*Spartina* sp.) and pickleweed (*Salicornia* sp.). The mud also contains a few lenses of well-sorted, fine sand and silt, a few shelly layers (oysters), and peat. The mud interfingers with and grades into fine-grained deposits at the distal edge of Holocene fans, and was deposited during the post-Wisconsin rise in sea-level, about 12 ka to present (Imbrie and others, 1984). Mud varies in thickness from zero, at landward edge, to as much as 40 m near north County line

Qhl — **Natural levee deposits (Holocene)**—Loose, moderately to well-sorted sandy or clayey silt grading to sandy or silty clay. These deposits are porous and permeable and provide conduits for transport of ground water. Levee deposits border stream channels, usually both banks, and slope away to flatter floodplains and basins. Abandoned levee systems, no longer bordering stream channels, have also been mapped

Qyf — **Younger (inner) alluvial fan deposits (Holocene)**—Unconsolidated fine- to coarse-grained sand, silt, and gravel, coarser grained at heads of fans and in narrow canyons

Qyfo — **Younger (outer) alluvial fan deposits (Holocene)**—Unconsolidated fine sand, silt, and clayey silt

Qcl — **Colluvium (Holocene)**—Loose to firm, friable, unsorted sand, silt, clay, gravel, rock debris, and organic material in varying proportions

Qs — **Sand dune and beach deposits (Holocene)**—Predominantly loose, medium- to coarse-grained, well-sorted sand but also includes pebbles, cobbles, and silt. Thickness less than 6 m in most places, but in other places may exceed 30 m

Qal — **Alluvium (Holocene)**—Unconsolidated gravel, sand, silt, and clay along streams. Less than a few meters thick in most places

Qpaf — **Alluvial fan and fluvial deposits (Pleistocene)**—Brown dense gravely and clayey sand or clayey gravel that fines upward to sandy clay. These deposits display variable sorting and are located along most stream channels in the county. All Qpaf deposits can be related to modern stream courses. They are distinguished from younger alluvial fans and fluvial deposits by higher topographic position, greater degree of dissection, and stronger soil profile development. They are less permeable than Holocene deposits, and locally contain fresh water mollusks and extinct late Pleistocene vertebrate fossils. They are overlain by Holocene deposits on lower parts of the alluvial plain, and incised by channels that are partly filled with Holocene alluvium on higher parts of the alluvial plain. Maximum thickness is unknown but at least 50 m.

Qpaf1 — **Alluvial terrace deposits (Pleistocene)**—Deposits consist of crudely - bedded, clast-supported, gravels, cobbles, and boulders with a sandy matrix. Clasts are as much as 35 cm in intermediate diameter. Coarse sand lenses may be locally present. Pleistocene terrace deposits are cut into Pleistocene alluvial fan deposits (Qpaf) a few meters and lie up to several meters above Holocene deposits

Qof — **Coarse-grained older alluvial fan and stream terrace deposits** (Pleistocene)—Poorly consolidated gravel, sand, and silt, coarser grained at heads of old fans and in narrow canyons

Qmt — **Marine terrace deposits (Pleistocene)**—Poorly consolidated and poorly indurated well- to poorly-sorted sand and gravel. Thickness variable but probably less than 30 m

QTsc — **Santa Clara Formation (lower Pleistocene and upper Pliocene)**—Gray to red-brown poorly indurated conglomerate, sandstone, and mudstone in irregular and lenticular beds. Conglomerate consists mainly of subangular to subrounded cobbles in a sandy matrix but locally includes pebbles and boulders. Cobbles and pebbles are mainly chert, greenstone, and graywacke with some schist, serpentinite, and limestone. Sarna-Wojcicki (1976) found a tuff bed in Santa Clara Formation near Woodside, and correlated it with a similar tuff in Merced Formation. Thickness of Santa Clara Formation is variable.

Qc — **Colma Formation (Pleistocene)**—Yellowish-gray and gray to yellowish-orange and red-brown, friable to loose, fine- to medium-grained arkosic sand with subordinate amounts of gravel, silt, and clay. Total thickness unknown, but may be as great as 60 m

QTm — **Merced Formation (lower Pleistocene and upper Pliocene)**—Medium-gray to yellowish gray and yellowish orange, medium- to very fine-grained, poorly indurated to friable sandstone, siltstone, and claystone, with some conglomerate lenses and a few friable beds of white volcanic ash. In many places sandstone is silty, clayey, or conglomeratic. Some of the conglomerate, especially where fossiliferous, is well cemented. Volcanic ash is in beds as much as 2 m thick and consists largely of glass shards. In type section of Merced Formation, the ash has been reported by Sarna-Wojcicki (1976) to be 1.5 ± 0.8 m.y. old, but more recent work by Sarna-Wojcicki and others (1991) indicates that the formation contains ash both about 435,000 and 740,000 years old. Merced Formation is about 1525 m thick in the sea cliffS north of Mussel Rock

Tp — **Purisima Formation (Pliocene and upper Miocene)**—Predominantly gray and greenish-gray to buff fine-grained sandstone, siltstone, and mudstone, but also includes some porcelaneous shale and mudstone, chert, silty mudstone, and volcanic ash. West of Portola Valley, this unit consists of fine- to medium-grained silty sandstone. Locally divided into:

Tptu — **Tunitas Sandstone Member (Pliocene)**—Greenish-gray to light-gray, pale-orange, or greenish-brown, very fine- to medium-grained sandstone with clay matrix. Concretions generally less than 30 cm across are present locally. Tunitas ranges in thickness from 76 m at type section to 122 m elsewhere

Tpl — **Lobitos Mudstone Member (Pliocene)**—Dark-gray to light-gray and shades of brown, unbedded, silty mudstone. Lobitos has a maximum thickness of 140 m.

Tpsg — **San Gregorio Sandstone Member (Pliocene)**—Greenish-gray to light-brown fine- to coarse-grained sandstone containing calcareous concretions less than 30 cm across. San Gregorio Member ranges in thickness from 45 m at type section to about 140 m elsewhere

Tpp — **Pomponio Mudstone Member (Pliocene)**—Gray to white porcelaneous shale and mudstone, in places rhythmically bedded with alternating layers of nonsiliceous mudstone. This unit resembles Monterey Shale, Santa Cruz Mudstone, and Lambert Shale. At its type section in Pomponio Creek the member is 700 m thick

Tpt — **Tahana Member (Pliocene and upper Miocene)**—Greenish-gray to white or buff, medium- to very fine-grained sandstone and siltstone, with some silty mudstone. Locally, such as at San Gregorio State Beach, sandstone is tuffaceous and weathers white. Near Memorial Park, this member includes dark-gray porcelaneous mudstone. Pebble conglomerate occurs near base from Memorial Park eastward. Maximum thickness is 655 m

Tsc — **Santa Cruz Mudstone (upper Miocene)**—Brown and gray to light-gray, buff, and light-yellow siliceous mudstone with nonsiliceous mudstone and siltstone and minor amounts of sandstone. Santa Cruz Mudstone is more than 1000 m thick

Tsm — **Santa Margarita Sandstone (upper Miocene)**—Light-gray to grayish-orange to white, friable, very fine- to very coarse-grained arkosic sandstone. Fine-grained sandstone commonly contains glauconite. A quartz and feldspar pebble conglomerate crops out locally at the base of section. Santa Margarita Sandstone is as thick as 60 m

Tm — **Monterey Formation (middle Miocene)**—Grayish-brown and brownish-black to very pale orange and white, porcelaneous shale with chert, porcelaneous mudstone, impure diatomite, calcareous claystone, and with small amounts of siltstone and sandstone near base. Monterey is generally thinner-bedded than the Santa Cruz Mudstone but closely resembles parts of Purisima Formation, especially Pomponio Mudstone Member. Thickness ranges from 120 to more than 600 m

Tlo — **Lompico Sandstone (middle Miocene)**—Very pale orange, fine to coarse-grained, mostly well-cemented and hard arkosic sandstone. Maximum thickness about 300 m

Tla — **Lambert Shale (Oligocene and lower Miocene)**—Dark-gray to pinkish-brown, moderately well-cemented mudstone, siltstone, and claystone. Chert crops out in a few places in upper part of section, and sandstone bodies up to 30 m thick, glauconitic sandstone beds, and microcrystalline dolomite are present in places. Lambert Shale is generally more siliceous than San Lorenzo Formation and less siliceous than the Monterey Shale. It resembles Santa Cruz Mudstone and parts of Purisima Formation. Lambert Shale is about 1460 m thick

Tmb — **Mindego Basalt and related volcanic rocks (Miocene and/or Oligocene)**—Basaltic volcanic rocks, both extrusive and intrusive. Extrusive rock is primarily dark-gray to orange-brown to greenish-gray flow breccia, but includes lesser amounts of tuffs, pillow lavas, and flows. Extrusive rocks have a maximum thickness of 120 m. Intrusive rock is dark greenish gray to orange brown and medium to coarsely crystalline. It commonly weathers spheroidally, and crops out as roughly tabular bodies up to 180 m thick intruding older sedimentary rocks. Minor amounts of sandstone and mudstone are locally included

Tvq — **Vaqueros Sandstone (lower Miocene and Oligocene)**—Light-gray to buff, fine- to medium-grained, locally coarse-grained, arkosic sandstone interbedded with olive- and dark-gray to red and brown mudstone and shale. Sandstone beds are commonly 0.3 to 3 m thick and mudstone and shale beds are as much as 3 m thick. Vaqueros varies from a few meters to as much as 700 m in thickness

Tsl — **San Lorenzo Formation (Oligocene and upper and middle Eocene)**—Dark-gray to red and brown shale, mudstone, and siltstone with local interbeds of sandstone. About 550 m thick. Locally divided into:

Tsr — **Rices Mudstone Member (Oligocene and upper Eocene)**—Olive-gray to red and brown laminated mudstone and siltstone with some laminated shale. Spheroidal weathering is common, as are elongate carbonate concretions. About 300 m thick

Tst — **Twobar Shale Member (middle and upper Eocene)**—Olive-gray to red and brown laminated shale with some mudstone. Includes a few thin interbeds of very fine-grained sandstone which thicken to as much as 30 m near Big Basin. About 240 m thick

Tb — **Butano Sandstone (middle and lower Eocene)**—Light-gray to buff, very fine- to very coarse-grained arkosic sandstone in thin to very thick beds interbedded with dark-gray to brown mudstone and shale. Conglomerate, containing boulders of granitic and metamorphic rocks and well-rounded cobbles and pebbles of quartzite and porphyry, is present locally in lower part of section. Amount of mudstone and shale varies from 10 to 40 percent of volume of formation. About 3000 m thick

Tss — **Unnamed sandstone, shale, and conglomerate (Paleocene)**—Rhythmically alternating beds of sandstone and shale, with a discontinuous boulder and cobble conglomerate near middle of section and some pebble conglomerate beds near base of section. Sandstone is gray to buff, fine- to coarse-grained, and arkosic; the shale is dark gray to brown; conglomerate contains angular boulders of granitic rock as long as 2 m and smaller boulders, cobbles, and rounded pebbles of hornblende gneiss, muscovite gneiss and schist, Franciscan chert, quartzite, limestone, sandstone, and shale. This unit has an estimated total thickness of 1160 m; boulder conglomerate has a maximum thickness of 40 m

Kpp — **Pigeon Point Formation (Upper Cretaceous)**—Sandstone and conglomerate, interbedded with siltstone and mudstone and pebbly mudstone. Sandstone is fine- to coarse-grained, arkosic, and gray to greenish gray; mudstone and siltstone are gray or black to buff. Conglomerate contains well-rounded pebbles, cobbles, and boulders of red and gray fine-grained and porphyritic felsic volcanic rocks, granitic rocks, chert, quartzite, dark-colored metamorphic rock, limestone, and clastic sedimentary rocks. Pigeon Point Formation is estimated to be more than 2600 m thick

Kgr — **Granitic rocks of Montara Mountain (Cretaceous)**—Very light-gray to light-brown, medium- to coarsely-crystalline foliated granitic rock, largely quartz diorite with some granite. These rocks are highly fractured and deeply weathered. Foliation is marked by an alignment of dark minerals and dark dioritic inclusions. Tabular bodies of aplite and pegmatite generally parallel foliation

KJv — **Unnamed volcanic rocks (Cretaceous or older)**—Dark-gray, dense, finely-crystalline felsic volcanic rock, with quartz and albite phenocrysts. Exposed only west of Pescadero. Thickness unknown

KJf — **Franciscan Complex, undivided (Cretaceous and Jurassic)**—Mostly graywacke and shale (fs). May be variably sheared. Partly coeval with Pigeon Point Formation (Kpp), granitic rocks of Montara Mountain (Kgr), unnamed shale (Ksh), unnamed volcanic rocks (KJv), and unnamed sandstone (KJs). Locally divided into:

fs — **Sandstone**—Greenish-gray to buff, fine- to coarse-grained sandstone (graywacke), with interbedded siltstone and shale. Siltstone and shale interbeds constitute less than 20 percent of unit, but in places form sequences as much as several tens of meters thick. In many places, shearing has obscured bedding relations; rock in which shale has been sheared to gouge constitutes about 10 percent of unit. Gouge is concentrated in zones that are commonly less than 30 m wide but in places may be as much as 150 m wide. Total thickness of unit is unknown but is probably at least many hundreds of meters

fg — **Greenstone**—Dark-green to red altered basaltic rocks, including flows, pillow lavas, breccias, tuff breccias, tuffs, and minor related intrusive rocks, in unknown proportions. Unit includes some Franciscan chert and limestone bodies that are too small to show on map. Greenstone crops out in lenticular bodies varying in thickness from a few meters to many hundreds of meters

fc — **Chert**—White, green, red, and orange chert, in places interbedded with reddish-brown shale. Chert and shale commonly are rhythmically banded in thin layers, but chert also crops out in very thick layers. In San Carlos, chert has been altered along faults to tan-to buff-colored clay. Chert and shale crop out in lenticular bodies as much as 75 m thick; chert bodies are commonly associated with Franciscan greenstone.

fl — **Limestone**—Light-gray, finely-to coarsely-crystalline limestone. In places limestone is unbedded, in other places it is distinctly bedded between beds of black chert. Limestone crops out in lenticular bodies up to 120 m thick, in most places surrounded by Franciscan greenstone

fm — **Metamorphic rocks**—Dusky-blue to brownish-gray blocks of metamorphic rock, commonly glaucophane schist, but some quartz-mica granulite. These rocks are finely to coarsely crystalline and commonly foliated. They almost always crop out as tectonic inclusions in sheared Franciscan rocks (fsr) and serpentinite (sp), and they reach maximum dimensions of several tens of meters though many are too small to show on map

fsr — **Sheared rock (melange)**—Predominantly graywacke, siltstone, and shale, substantial portions of which have been sheared, but includes hard blocks of all other Franciscan rock types. Total thickness of unit is unknown, but is probably at least several tens of meters

sp — **Serpentinite (Cretaceous and/or Jurassic)**—Greenish-gray to bluish-green sheared serpentinite, enclosing variably abundant blocks of unsheared rock. Blocks are commonly less than 3 m in diameter, but range in size from several centimeters to several meters; they consist of greenish-black serpentinite, schist, rodingite, ultramafic rock, and silica-carbonate rock, nearly all of which are too small to be shown on the map

m — **Marble and hornfels (Paleozoic?)**—White to gray finely crystalline marble, graphitic marble, and quartz-mica hornfels, in places distinctly bedded, in places foliated. Marble and hornfels crop out as rare isolated bodies as much as 75 m long in granitic rocks of Montara Mountain

MAP SYMBOLS

Contact—Depositional or intrusive contact, dashed where approximately located, dotted where concealed

Fault—Dashed where approximately located, small dashes where inferred, dotted where concealed, queried where location is uncertain.

Reverse or thrust fault—Dotted where concealed

Anticline—Shows fold axis, dotted where concealed

Syncline

35 **Strike and dip of bedding**

Overturned bedding

Flat bedding

Vertical bedding

35 **Strike and dip of foliation**

Vertical foliation

35 **Strike and dip of joints in plutonic rocks**

Vertical joint

Units derived from:

Brabb, E.E., Graymer, R.W., and Jones, D.L., 1999, Digital Geologic Map of the Palo Alto 30′ x 60′ Quadrangle, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-2332, scale 1:100,000

Brabb, E.E., Graymer, R.W., and Jones, D.L., 1998, Geology of the Onshore Part of San Mateo County, California: A Digital Database: U.S. Geological Survey Open File 98-137, scale 1:62,500

This description is a plot derived from data contained in the digital database Open-File Report 00-127, "Possible Costs Associated with Investigating and Mitigating Some Geologic Hazards in Rural Parts of San Mateo County, California." A PostScript image of this map is included in the Open-File Report, but the Open-File Report does not contain a paper copy of this map. The Open-File Report consists of the digital data and a pamphlet explaining the database and indicating how to obtain the data from which this map was prepared as well as the PostScript image of the map.

POSSIBLE COSTS ASSOCIATED WITH INVESTIGATING AND MITIGATING SOME GEOLOGIC HAZARDS IN RURAL PARTS OF SAN MATEO COUNTY, CALIFORNIA

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