U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Preliminary geologic map of the onshore part of the Palo Alto 1:100,000 Quadrangle, California

Compiled by

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PALO ALTO GEOLOGY

INTRODUCTION

The purpose of this map is to integrate the geology of San Mateo and Santa Cruz Counties along their common border; add new information on the San Gregorio fault since the map by Brabb and Pampeyan (1983) was submitted for publication; add new information along the northern border of Santa Cruz County since the map by Brabb (1989) was submitted for publication; and to compile and integrate the geology of Santa Clara County within the map boundary.

Film positives of the publication negatives for the geology of San Mateo and Santa Cruz Counties were cut to fit the format of a new base map enlarged from the U.S. Geological Survey Palo Alto 1:100,000 quadrangle. Inasmuch as the film positives did not fit precisely on the enlarged base, geologic features may not be shown in their correct position in relation to streams, roads, and other cultural features. The largest error observed is about 1 mm (60 m ground distance). This error is likely to be reduced substantially or eliminated when the map is published.

Publication of the San Mateo and Santa Cruz County maps in color provided an opportunity to identify geologic units with colors and patterns in addition to letters. For this map, letters had to be added to many polygons representing a map unit. In addition, some of the units, such as marine terrace deposits, had different letter identifiers on the two county maps, that had to be changed to be consistent. The pattern used for surficial deposits in San Mateo County could not be removed easily or added to the other counties, so surficial deposits in Santa Cruz and Santa Clara Counties are identified almost entirely by letters.

Geologic mapping in large parts of Santa Clara County within the area of this map is considered to be obsolete and in need of extensive revision. Resources are not currently available for this revision, so the data shown are provisional and speculative.

DESCRIPTION OF MAP UNITS

Qyf **Younger 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 alluvial fan deposits (Holocene)**--Unconsolidated fine sand, silt, and clayey silt

Qb **Basin deposits (Holocene)**--Unconsolidated, locally organic, plastic silt and silty clay

Qab **Altered basin deposits**--Clay and minor silt and sand altered by salt water. Characterized by iron stains and calcareous nodules

Qcl **Colluvium (Holocene)**--Loose to firm, friable, unsorted sand, silt, clay, gravel, rock debris, and organic material in varying proportions. Mapped only in San Mateo County.

Qls **Landslides (Holocene and possibly Pleistocene)**--Loose to firm rock and soil. They are so numerous and would obscure the bedrock geology so extensively that they have been intentionally omitted, except for a very large landslide along the west side of Stevens Creek Reservoir. Information about landslides is extensive. The principal references are reports by Nilsen and others (1979), Ellen and Wieczorek (1988), Brabb and Pampeyan (1972), Brabb, Pampeyan and Bonilla (1978), Cooper-Clark and Associates (1975) and unpublished reports by William Cotton and Associates for the towns of Woodside and Los Altos Hills and Santa Clara County.

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

Qm **Bay mud (Holocene)**--Blue-gray, dark-gray, or black unconsolidated silty clay and clay containing abundant organic matter, with interspersed lenses and layers of sand, peat, gravel, and shell fragments. Mud varies in thickness from zero, at landward edge, to more than 60 m in San Francisco Bay along Dumbarton Bridge right-of-way

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

Qaf **Artificial fill (Holocene)**--Loose to very well consolidated gravel, sand, silt, clay, rock fragments, organic matter

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, gravel and minor silt. Thickness variable but probably less than 30 m in most places

Qt **Terrace deposits (Pleistocene)**--Weakly consolidated to semiconsolidated heterogeneous deposits of moderately to poorly sorted silt, silty clay, sand, and gravel. Mostly deposited in a fluvial environment.

Thickness highly variable; locally as much as 20 m thick. Some of the deposits are relatively well indurated in upper 3 m of weathered zone.

QTs **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. On Coal Mine Ridge, south of Portola Valley, conglomerate contains boulders of an older conglomerate up to a meter in diameter. Gray to buff claystone and siltstone beds on Coal Mine Ridge contain carbonized wood fragments as large as 60 cm in diameter. Included in Santa Clara Formation are similar coarse-grained clastic deposits near Burlingame. Sarna-Wojcicki (1976, p. 27) reports a tuff bed (the Rockland pumice ash bed, 400 ka) which was erupted from the Lassen Peak area of northern California in Santa Clara Formation near Woodside, and correlated it with a similar tuff in Merced Formation. In the lower part of the Santa Clara Formation in the Sevens Creek Reservoir and Saratoga area are lacustrine beds (Qtsl) up to 35 m thick that contain fresh water mollusks, fish remains, and rare land mammal fossils of late Pliocene (Blancan) age (Sorg & McLaughlin, 1975). Thickness of Santa Clara Formation is variable but reaches a maximum of about 500 m along Coal Mine Ridge

Tme **Merced Formation (upper Pliocene)**--Dusky-yellow to dark-yellowish-orange, fine-grained sandstone, pebbly sandstone, and silty sandstone.

Tp **Purisima Formation, undivided (Pliocene and upper Miocene)**--Predominantly gray and greenish-gray to buff fine-grained sandstone, siltstone, and mudstone, but also includes some procelaneous shale and diatomaceous mudstone, chert, silty mudstone, and reworked volcanic ash. Sarna-Wojcicki and others (1991) believe that this ash may be the Ishi Tuff Member of the Tuscan Formation, which erupted in the Cascade Range of Oregon about 2.5 Ma. West of Portola Valley the Purisima Formation 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, member is 700 m thick

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

Tsc **Santa Cruz Mudstone (upper Miocene)**--Brown and gray to light-gray, buff, and light-yellow siliceous organic mudstone with nonsiliceous mudstone and siltstone and minor amounts of sandstone. Santa Cruz Mudstone ranges in thickness from 140 m in type section to more than 1000 m

Tsm **Santa Margarita Sandstone (upper Miocene)**--Light-gray to grayish-orange to white, friable, very fine- to very coarse-grained arkosic sandstone, locally bituminous and/or calcareous. Fine-grained sandstone commonly contains glauconite. A quartzite and granitic pebble conglomerate occurs locally at the base of unit. Santa Margarita Sandstone is as much as 130 m thick

Tss **Unnamed sandstone (upper Miocene)**--Light-gray to grayish-orange to white, friable, fine- to medium-grained, poorly cemented sandstone with minor interbeds of siliceous mudstone and semi-siliceous shale. The sandstone contains shallow water, late Miocene (Margaritan) marine mollusks, according to W.O. Addicott (written comm., 1974)

Tm **Monterey Formation (middle Miocene)**--Grayish-brown and brownish-black to very pale orange and white, porcelaneous shale with chert, siliceous organic mudstone, impure diatomite, calcareous claystone, and with

small amounts of siltstone, sandstone and dolomite. Monterey closely resembles the Santa Cruz Mudstone and parts of Purisima Formation, especially Pomponio Mudstone Member. Thickness ranges from 120 to 815 m

Tld **Ladera sandstone (upper and middle Miocene)**--Medium- to light-gray to yellowish-gray and buff, fine-grained, poorly cemented sandstone and siltstone in Palo Alto area with minor amounts of coarse-grained sandstone, yellow-brown dolomitic claystone, and white to light-gray porcelaneous shale and porcelanite. Fine-grained sandstone and siltstone comprise more than 90 percent of formation. Coarse-grained sandstone occurs in beds less than a few meters thick in lower half of section; dolomitic claystone and porcelaneous shale beds are less than a meter thick and occur scattered through upper half of section; porcelanite occurs in thin-bedded lenses less than a few meters thick in lower part of section. At and near base of unnamed sandstone are medium to thick lenticular beds of well-cemented fossiliferous, chert granule sandstone which interfingers with fine-grained sandstone. About 450 m thick

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

Tpm **Page Mill Basalt (middle Miocene)**--Interlayered, columnar-jointed basaltic flows and agglomerate. Flows are dark greenish gray to light gray, dense to vesicular, and finely crystalline; agglomerate is light gray to reddish brown. Volcanic rocks are pyritiferous in part. Ranges in thickness from 0 to 15 m

Tuv **Unnamed sedimentary and volcanic rocks (Miocene to Oligocene)**--Mainly dark-gray, hard mudstone in Año Nuevo area and massive, coarse-grained and pebbly, crossbedded, hard sandstone in Pescadero Point area. Mapped as Vaqueros(?) Formation by Hall and others (1959, fig. 2), but rocks do not resemble those of Vaqueros Sandstone in Santa Cruz Mountains. Includes basalt flows and breccia. Contains foraminifers and mollusks of Zemorrian (Oligocene) and Saucesian (Miocene) age according to Clark and Brabb (1978, p. 7-8). About 420 m thick near Pescadero Point and at least 85 m thick near Año Nuevo

Tlsl **Lambert Shale and San Lorenzo Formation, undivided (lower Miocene, Oligocene, and middle and upper Eocene)**--Brown and dark-gray to gray, brown and red, mudstone, siltstone and shale. Includes some beds of fine- to coarse-grained sandstone. Lambert Shale is generally more siliceous than San Lorenzo Formation, but the two units cannot be distinguished where out of stratigraphic sequence and without fossils

Tla **Lambert Shale (Oligocene and lower Miocene)**--Dark gray to pinkish-brown, moderately well-cemented mudstone, siltstone and claystone. Chert occurs in a few places in upper part of section and phosphatic laminae and lenses in lower part. Sandstone interbeds as much as 30 m thick, glauconitic sandstone beds, and fine-grained 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 has a maximum thickness of 1460 m.

Tmb **Mindego Basalt and related volcanic rocks (lower Miocene and upper 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. Intrustive rock is dark greenish gray to orange brown and medium to coarsely crystalline. It commonly weathers spheroidally, and occurs as roughly tabular bodies up to 180 m thick intruding older sedimentary rocks. Minor amounts of sandstone and mudstone are locally included

Tv **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 commonly are 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

Tz **Zayante Sandstone (Oligocene)**--Thick- to very thick-bedded, yellowish-orange arkosic non-marine sandstone containing thin interbeds of greenish and reddish siltstone and lenses and thick interbeds of pebble and cobble conglomerate. Thickness 550 m along Lompico Creek

Tsl **San Lorenzo Formation, undivided (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 unbedded 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. Locally subdivided into:

Tbu **Upper sandstone member**--Thin-bedded to very thick bedded medium-gray, fine- to medium-grained arkosic sandstone containing thin interbeds of medium-gray siltstone. Thickness about 975 m

Tbm **Middle siltstone member**--Thin- to medium-bedded, nodular, olive-gray pyritic siltstone. Thickness about 215 m

Tbl **Lower conglomerate and sandstone member**--Thick to very thick interbeds of sandy pebble conglomerate and very thick bedded to massive, yellowish-gray, granular, medium- to coarse-grained arkosic sandstone. Thickness as much as 1500 m

Tw **Whiskey Hill Formation (middle and lower Eocene)**--Formation name proposed by Pampeyan (in press) to replace Butano Sandstone(?), as used by Brabb and Pampeyan (1983). Light-gray to buff coarse-grained feldspathic sandstone, with light-gray to buff silty claystone, glauconitic sandstone, and tuffaceous siltstone. Sandstone beds constitute about 30 percent of map unit. Tuffaceous and silty claystone beds are expansive. Locally sandstone beds are well cemented with calcite. At apparent base of section on north side of Jasper Ridge, just east of Searsville Lake, a thin, greenstone pebble conglomerate is in contact with underlying serpentinite; at apparent base on south side of Jasper Ridge approximately 60 m of cobble conglomerate is present. In places within this map unit sandstone and claystone beds are chaotically disturbed. The Whiskey Hill Formation is as much as 900 m thick

Tu **Unnamed sedimentary rocks (Eocene?)**--Mudstone, shale and argillite with minor sandstone

Tl **Locatelli Formation (Paleocene)**--Nodular, olive-gray to pale-yellowish-brown micaceous siltstone. Thickness 245-275 m

Tlss **Sandstone**--Massive medium-gray, fine- to medium-grained arkosic sandstone locally at base. Maximum thickness 25 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

Ksh **Unnamed shale (Upper Cretaceous)**--Dark-gray, thin-bedded, nodular shale and silty shale. Unit is exposed only in the bed of San Francisquito Creek, in Menlo Park, where about 15 m of section was visible in the 1950's. Fossils from these rocks described by Graham and Church (1963)

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

Franciscan Complex (Cretaceous and Jurassic)--Part of the Permanente tectono-stratigraphic terrane of Blake and others (1984), 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, and 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 occurs in lenticular bodies varying in thickness from a few meters to many hundreds of meters. Part or all of the greenstone may belong to the Coast Range ophiolite sequence of Blake and others (1984) rather than Franciscan Complex.

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 occurs in very thick layers. In San

Carlos chert has been altered along faults to tan- to buff-colored clay. Chert and shale occur in lenticular bodies as much as 75 m thick; chert bodies commonly are 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 occurs in lenticular bodies up to 120 m thick, usually surrounded by Franciscan greenstone

fh **Argillite**--Dark-gray to grayish-black argillite and shale with minor beds of sandstone.

fsr **Sheared rock or melange**--Predominantly graywacke, siltstone, and shale, substantial portions of which have been pervasively sheared, and can contain tectonically included, resistant blocks of chert, greenstone, amphibolite and blue schist facies rocks. The included blocks are generally too small to show at this map scale.

INTRUSIVE AND METAMORPHIC ROCKS

qd **Quartrz Diorite (Cretaceous)**--Grades to granodiorite south and east of Ben Lomond Mountain

ga **Granite and adamellite (Cretaceous)**

gd **Gneissic granodiorite (Cretaceous)**

hcg **Hornblende-cummingtonite gabbro (Cretaceous)**

sch **Metasedimentary rocks (Mesozoic or Paleozoic)**--Mainly pelitic schist and quartzite

m **Marble (Mesozoic or Paleozoic)**--Locally contains interbedded schist and calc-silicate rocks

sp **Serpentinite (Cretaceous and(or) Jurassic)**--Greenish-gray to bluish-green sheared serpentinized ultramafic rock

db **Diabase and gabbro (Jurassic?)**

Contact

Fault--Dashed where approximately located; dotted where concealed; queried where uncertain. Arrows indicate direction of relative movement

Fault--Inferred from geophysical information

Thrust fault--Saw teeth on upper plate

Anticline--Dashed where approximately located; queried where uncertain. Arrow on axis indicates direction of plunge

Syncline--Dashed where approximately located; queried where uncertain. Arrow on axis indicates direction of plunge

Strike and dip of beds

30 Inclined--Value shown where known

Vertical

Horizontal

25 Overturned

25 Strike and dip of foliation

Landslide deposit--Arrows indicate direction of movement

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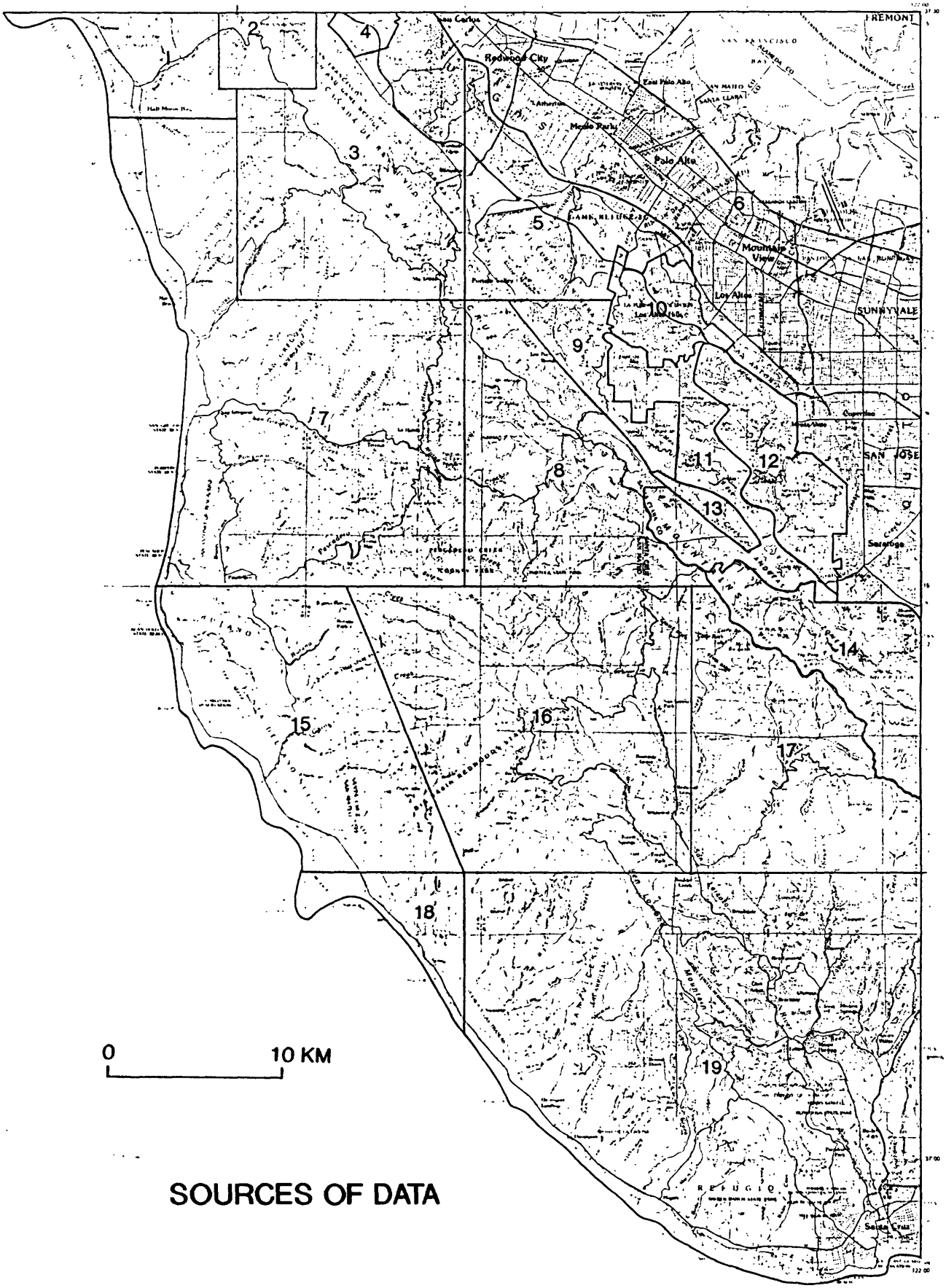
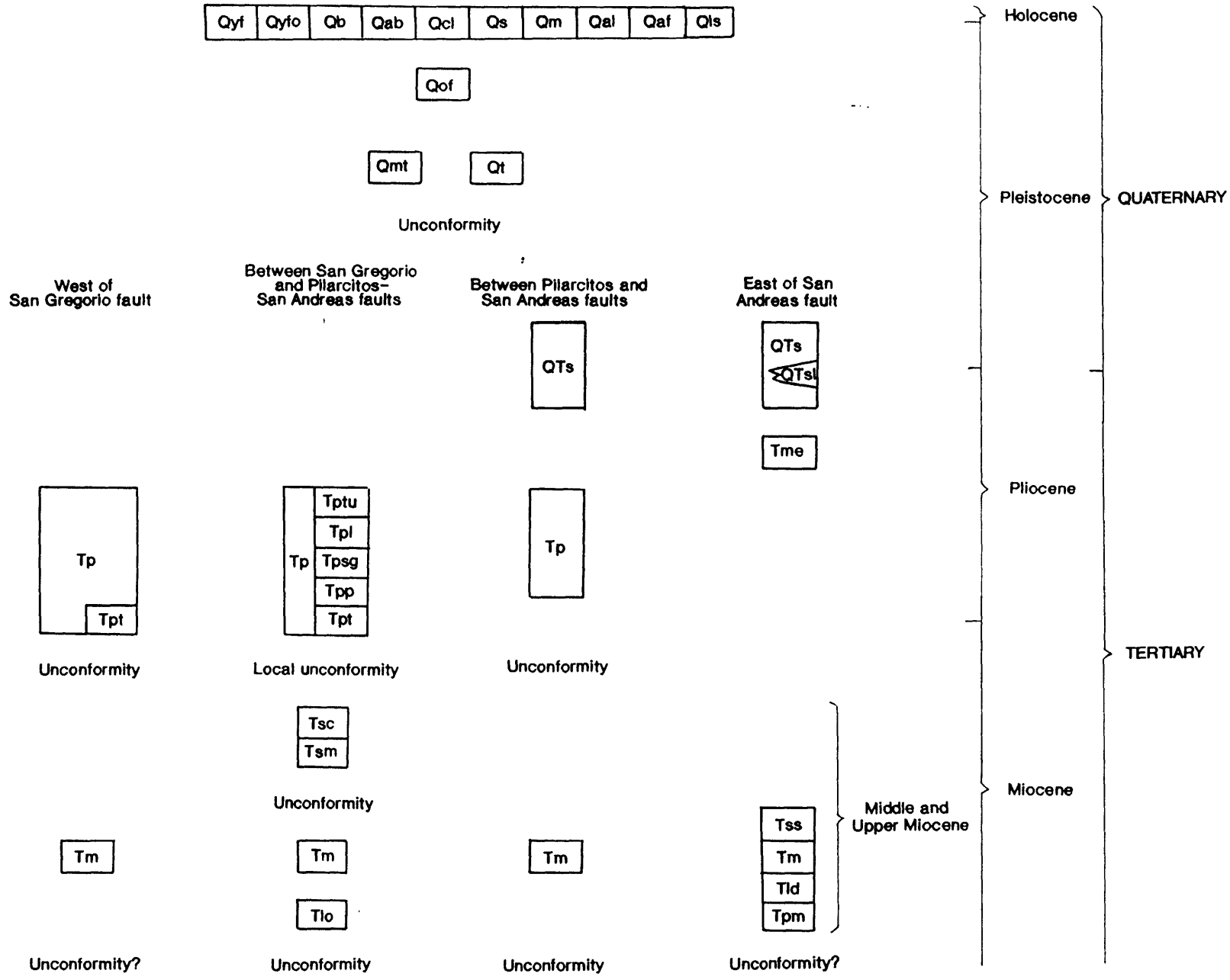


SOURCES OF DATA

PALO ALTO, CALIFORNIA
N3700 W12200/30X60
1982

CORRELATION OF MAP UNITS



CORRELATION OF MAP UNITS (CONTINUED)