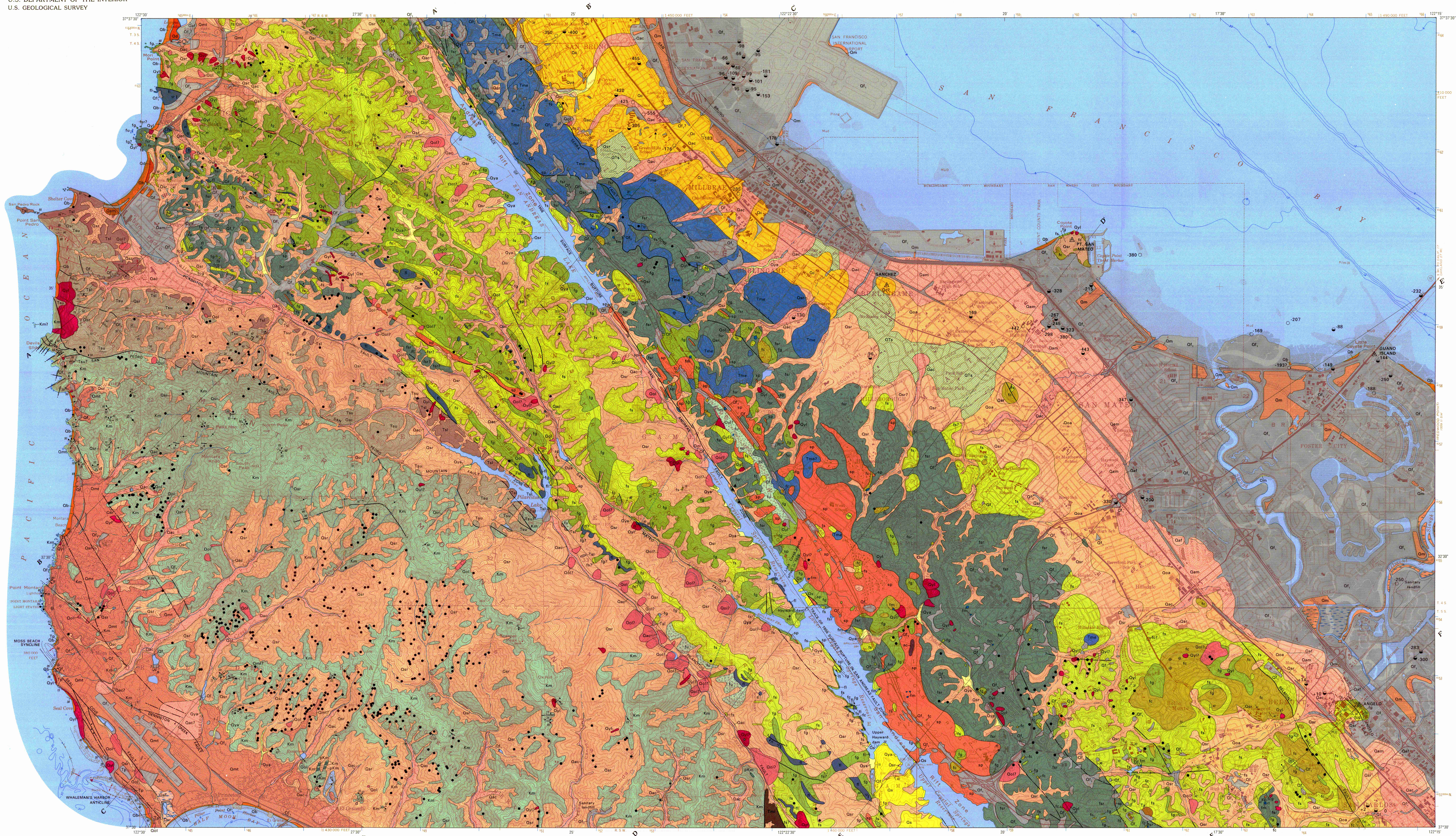
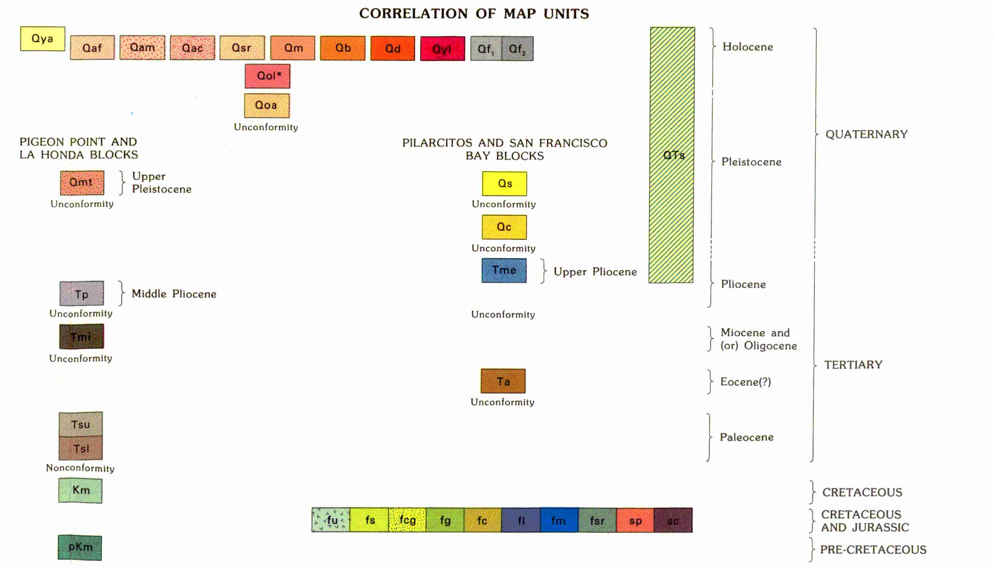


Base from U.S. Geological Survey
Montara Mountain, San Mateo Photorevised 1980
Polyconic projection
10,000-foot grid based on California coordinate System, zone 3
1000-meter Universal Transverse Mercator grid ticks, zone 10, shown in blue

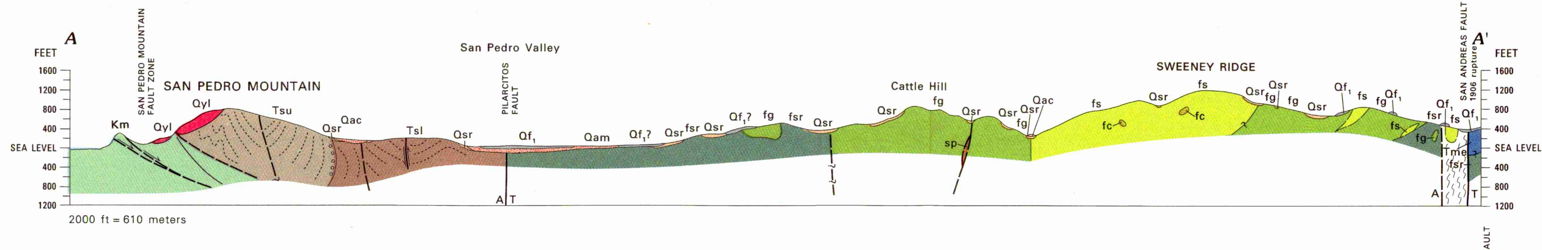
APPROXIMATE MEAN DECLINATION, 1994

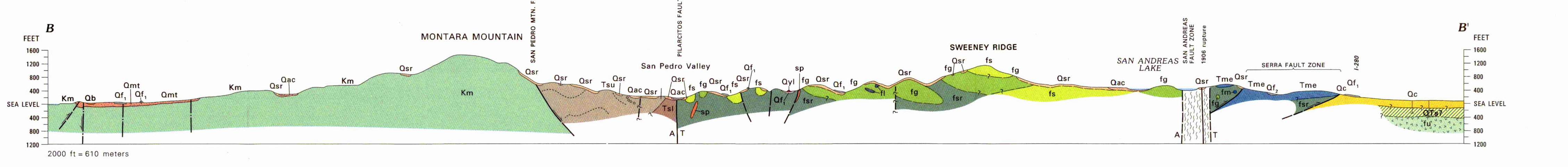
Geology mapped 1970–73, 1980; some minor additions and revisions 1982
Edited by Julia Thomas; cartographic design by Kevin Ghequiere
Manuscript approved for publication October 14, 1992

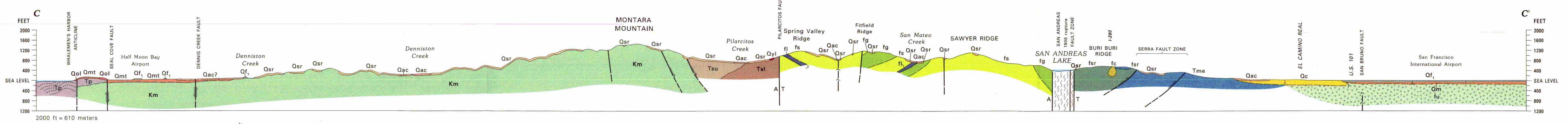
CORRELATION OF MAP UNITS

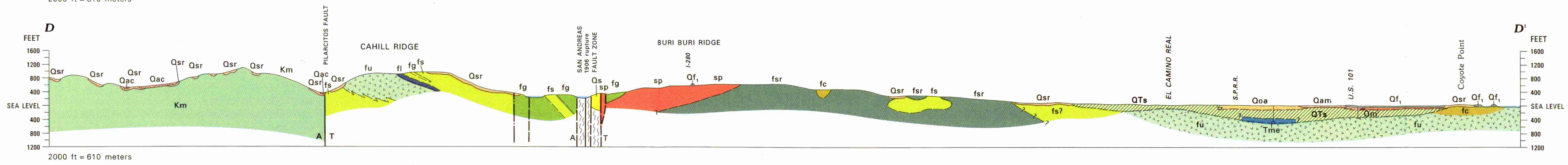


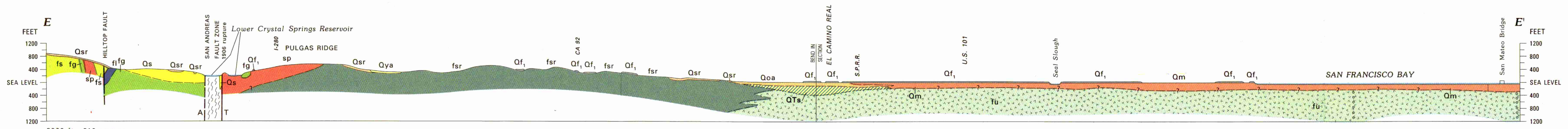
*See DESCRIPTION OF MAP UNITS for specific unit age asssignment

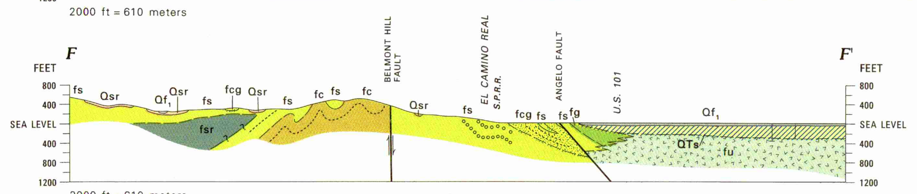






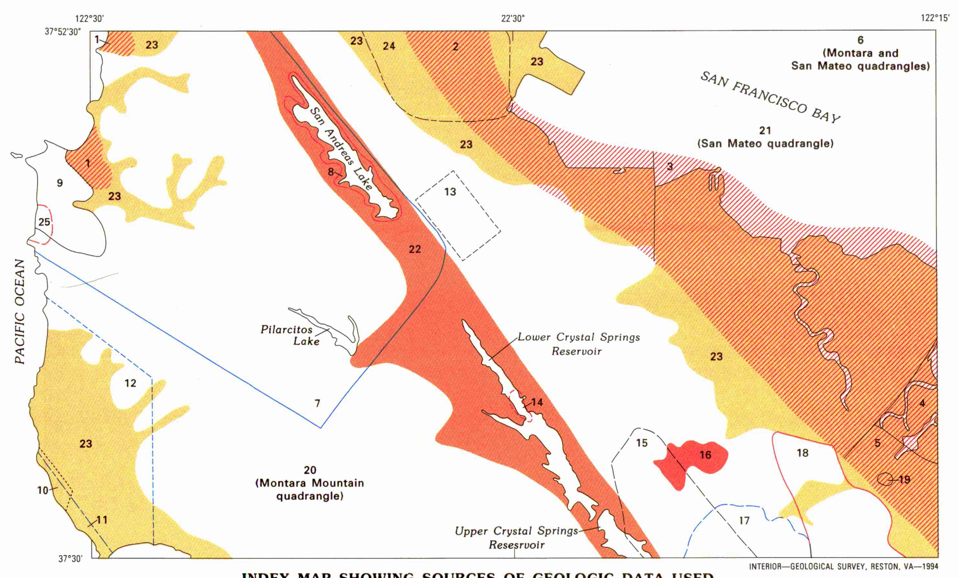






SOURCE OF DATA

1. Historic shoreline data from U.S. Coast Survey (1853a, 1869) and U.S. Geological Survey (1899, 1915)
2. Historic shoreline data from U.S. Coast Survey (1854, 1868)
3. Historic shoreline data from U.S. Coast Survey (1853b)
4. Historic shoreline data from U.S. Coast Survey (1857a)
5. Historic shoreline data from U.S. Coast Survey (1857b)
6. Lawson (1914), with numerous modifications and additions; some data on marine terraces and faulting from Smith (1960)
7. Darrow (1963), with extensive modifications north of San Pedro Valley
8. Pampeyan (1975); some data from U.S. Coast Survey (1867)
9. Some stratigraphic data from Morgan (1981a)
10. Subsurface and some surface data from Leighton and Associates (1971)
11. Glen (1959), with modifications
12. Some data on marine terraces and terrace deposits from Jack (1969)
13. Faults located by geophysical methods from Donely and others (1969)
14. Data on 1906 surface rupture along San Andreas Fault from Louderback (1937) and San Francisco Public Utilities Commission (1924,1931)
15. Some geologic data from Bechtel Corporation (1966)
16. Data on landslides and faults from Woodward-Lundgren and Associates (1971), with modifications
17. McLaughlin (1969), with modifications
18. Some geologic data from Julius Schlocker (unpub. data) and Earth Sciences Associates (1975)
19. Julius Schlocker (unpub. data), with modifications
21. Pampayne (1981b)
20. Pampeyan (1981a)
22. Data on 1906 surface rupture along San Andreas Fault from Schussler (1906) and Pampeyan (1983)
23. Geology of surficial deposits adapted from Helley and Lajoie (1979), with modifications and additions
24. Depth to basement data from Bonilla (1971b), with additions
25. Selected fault data from Beeston and Gamble (1980)



INDEX MAP SHOWING SOURCES OF GEOLOGIC DATA USED IN THIS REPORT

DESCRIPTION OF MAP UNITS

Qya **Younger alluvium (Holocene)**—Unconsolidated and undissected, poorly sorted gravel, sand, silt, clay, and organic matter in active modern drainage channels and small fans. Grades into fine- to coarse-grained alluvial deposits. Locally interfingers with or includes slope wash, ravine fill, and colluvium. In many places included with other alluvial deposits because of map-scale limitations

QTs **Sedimentary deposits, undivided (Holocene to Pliocene)**— Predominantly fine grained to coarse grained clastic deposits in densely urbanized flatland area adjacent to historic bay margin, where grading and landscaping have obscured geologic relations. As mapped, may locally include older alluvium (Qoa), slope wash, ravine fill, and colluvium (Qsr), Colma Formation (Qc), Merced Formation (Tme), and unnamed Tertiary and Quaternary coarse clastic deposits (Lajoie and others, 1974)

Qaf **Fine-grained alluvium (Holocene)**—Unconsolidated, poorly sorted, plastic, organic clay and silty clay in poorly drained interfluvial basins, usually at margins of tidal and marsh lands. Locally contains thin, well-sorted interbeds of sand and fine gravel; contains modern vertebrate and invertebrate fossils. Interfingers with bay mud (Qm) and medium-grained alluvium. Generally less than 10 ft thick

Qam **Medium-grained alluvium (Holocene)**—Unconsolidated to moderately consolidated, moderately sorted sand and silty to clayey sand chiefly forming alluvial plains along northeast edge of map area. Locally contains interbeds of well-sorted clay, silt, and gravel; contains modern vertebrate and invertebrate fossils. Interfingers with fine- and coarse-grained alluvium (units Qaf and Qac, respectively). Generally less than 20 ft thick

Qac **Coarse-grained alluvium (Holocene)**—Unconsolidated, moderately sorted sand and gravel forming stream levees, fans, and flood plains in and close to upland areas. Grades coarser headward. Locally contains lenticular interlayers of well-sorted silt, sand, and gravel; locally contains modern vertebrate and invertebrate fossils. Interfingers with medium-grained alluvium and colluvial deposits (units Qam and Qsr, respectively). Maximum thickness probably less than 75 ft

Qsr **Slope wash, ravine fill, and colluvium (Holocene)**—Unconsolidated to moderately consolidated deposits of sand, silt, clay, and rock fragments accumulated by slow downslope movement of weathered rock debris and soil. Composition dependent upon underlying rocks. Commonly unsorted and unbedded, but locally crudely layered by downslope movements. Mapped where thickness presumed to exceed 5 ft; as thick as 20 ft on north side of San Pedro Valley. Maximum accumulations commonly develop near bases of slopes underlain by sheared rock (fsr) of the Franciscan Complex. Deposits interfinger with alluvial deposits at bases of slopes. Locally includes alluvial deposits and older landslide deposits (Qol) too small to show at this scale. Numerous small shallow landslides (shown by small dots) occur in this unit on southwest flank of Montara Mountain

Qm **Bay mud (Holocene)**—Very poorly consolidated to well-consolidated, blue-gray to black silty clay with interspersed layers of sand, gravel, peat, and shell fragments. Bedding ranges from distinct to indistinct. Interfingers with fine-grained alluvium (Qaf). May be as thick as 100 ft near San Francisco International Airport (Hensolt and Brabb, 1990). Soft and plastic when wet; firm when dry. When wet has moderate to high potential for liquefaction under seismic loading conditions

Qb **Beach deposits (Holocene)**—Loose clastic deposits composed of sand- to cobble-size fragments in the tidal zone. Moderately well sorted by wave action. Along exposed coast thickness varies with seasons; maximum thickness probably less than 50 ft adjacent to El Granada breakwater in Pillar Point Harbor. Near Little Coyote Point beach deposits are composed mostly of oyster shell fragments; west of Coyote Point deposits are composed mostly of rock debris derived from artificial fill. Deposits along Pacific Coast are derived mostly from granitic rock of Montara Mountain (Km)

Qd **Dune sand (Holocene)**—Loose, fine- to medium-grained, well-sorted, eolian sand. Present along Pacific Coast northeast of Shelter Cove and northeast of Mori Point. Unit may be as thick as 30 ft

Qyl **Younger landslide deposits (Holocene)**—Unconsolidated to moderately consolidated deposits whose composition and structure depend upon bedrock geologic unit involved and type of landslide. Considered to be active and (or) unstable. More younger landslide deposits may be present than are shown on this map

Artificial fill (Holocene)—Divided into:

Qf_1 **Unit 1**—Poorly consolidated to well-consolidated gravel, sand, silt, and rock fragments in various combinations used in a variety of applications including riprap, highway-, railroad-, and airport runway-fills, earthfill dams, reservoir embankments, and building-site grades. Thickness and consolidation dependent upon type of application and site. Includes organic and man-made debris in sanitary landfills and spoil from tunneling operations. Many small fills not shown because of map-scale limitations

Qf_2 **Unit 2**—Fill deposits consisting of locally derived earth materials placed during grading operations in urban areas and subsequently covered by residential development. Location of deposits based on changes in topographic contours between 1949 and 1956 editions of the Montara Mountain quadrangle

Qol **Older landslide deposits (Holocene and Pleistocene?)**—Moderately consolidated to well-consolidated deposits whose composition and structure depends upon bedrock geologic unit involved and type of landslide. Assumed to be inactive and (or) stabilized, as no evidence of recent movement observed; susceptible to reactivation by unusually high or prolonged rainfall, earthquakes, and (or) improper grading or drainage procedures. More older landslide deposits may be present than are shown on this map

Qoa **Older alluvium (Pleistocene)**—Weathered, unconsolidated to moderately consolidated gravel, sand, silt, and clay in various proportions and combinations. Chiefly older alluvial fan deposits. Distribution and extent largely inferred from drainage patterns on historic maps, as natural exposures are concealed by urban development. Locally includes younger alluvial and colluvial deposits too small to show at map scale

PIGEON POINT AND LA HONDA BLOCKS

Qmt **Marine terrace deposits (upper Pleistocene)**—Poorly to moderately consolidated deposits of marine, eolian, and alluvial sand, silt, gravel, and clay in various proportions and combinations, in indistinct to distinct lenses and beds. Locally includes thin lenses of lignite and asphaltic sand. Lower part of a single terrace unit commonly is marine, fine-grained, moderately well consolidated, and forms near-vertical cliffs along the exposed coast; upper part of a terrace unit commonly is sub-aerial, coarse-grained, poorly consolidated, and forms rounded or subdued topography. Deposits are as thick as 60 ft between El Granada and Princeton and 75 ft thick at Montara (Jack, 1969) and as thick as 90 ft near Laguna Salada (Smith, 1960). Unit locally may include some stream terrace deposits, alluvium, beach deposits, and younger eolian sands

Tp **Purisima Formation (Pliocene)**—Highly fractured, well-indurated, soft to medium-hard, fossiliferous mudstone, siltstone, and sandstone in indistinct to distinct thin beds. Bedding clearly distinguished in wave-cut platform exposed at low tide but not readily apparent in weathered exposures. Rests nonconformably upon granitic rock of Montara Mountain (Km) and unconformably overlain by marine terrace deposits (Qmt). In Moss Beach Syncline at Moss Beach, locally derived boulder to pebble conglomerate beds are present at base. Total thickness exposed in wave-cut platform and adjacent sea cliff obscured by faulting and lack of marker beds; thought to be at least a few hundred feet thick (Glen, 1959) but may be much thicker. Unit age is middle Pliocene in this area

Tmi **Mindego Basalt (Miocene and (or) Oligocene)**—Well-indurated, hard, medium-gray to green, fine- to medium-grained, chloritized(?) feldspathic sandstone (wacke) containing abundant red and green altered mafic clasts and cut by quartz and calcite veinlets. Poorly exposed at south edge of map area on west side of Pilarcitos Fault

Sandstone, shale, and conglomerate (Paleocene)—Probable bathyal fan deposits of sandstone, shale, and conglomerate containing Ynezian *Turritella pachecoensis* fossils. Divided into:

Tsu **Upper part**—Predominantly very well indurated, soft to hard, light-gray to brown, fine- to coarse-grained sandstone and pebble to cobble conglomerate, with lesser amounts of conglomeratic sandstone, siltstone, claystone, and carbonate beds, all containing granitic debris. Bedding is distinct and ranges from thin to massive. In roadcut north of Devils Slide, where Highway 1 swings east, a boulder conglomerate containing granitic clasts as large as 5 ft on a side crops out at base of unit. Unit estimated to be 1,300 ft thick by Darrow (1963) and about 1,475 ft thick by Nilsen and Yount (1981)

Tsl **Lower part**—Predominantly laminated to rhythmically bedded, soft to medium-hard, brown, fine- to coarse-grained, thin-bedded, arkosic turbidite sandstone and black shale. Well exposed in slopes around Shelter Cove. Base of unit not exposed, but thickness estimated to be 2,500 ft by Darrow (1963) and approximately 1,475 ft by Nilsen and Yount (1981)

Km **Granitic rock of Montara Mountain (Cretaceous)**—Pervasively fractured, punky, medium-crystalline to coarsely crystalline granitic rock, ranging from largely tonalite to granite and containing abundant hornblende and biotite. Includes aplite, pegmatite, and rhyolite dikes; also includes small masses of coarse-grained felsic rocks containing garnet but no hornblende or biotite. Foliation indicated by preferred orientation of mafic minerals and tabular dioritic inclusions and, in places, by orientation of dikes. Jointing is common and best seen in sea cliffs; epidote alteration occurs along some joint surfaces. Exposures of hard unfractured rock are rare, and commonly the rock is weathered to depths of 100 ft. Southwest flank of Montara Mountain is pockmarked by numerous small shallow landslides (shown by small dots) in weathered rock (grus) or in colluvium developed on weathered rock

pKm **Metasedimentary rock (pre-Cretaceous)**—White to light-brownish-gray, finely to coarsely crystalline marble and graphitic marble near south-central edge of map area, and quartz-feldspar-mica and quartz-mica schists with minor related metamorphosed carbonate sedimentary rocks at El Granada. Marble is fresh and hard; schistose rocks are weathered and soft. Unit occurs as pendants as long as 600 ft and as thick as 100 ft in granitic rock of Montara Mountain. More pendants of metasedimentary rock may be present than are shown on this map

PILARCITOS AND SAN FRANCISCO BAY BLOCKS

Qs **Santa Clara Formation (Pleistocene)**—Poorly sorted, moderately consolidated, tan to orange-brown conglomerate and pebbly to cobbly sand, silt, and clay. Pebbles and cobbles are angular to sub-rounded and materials are rudely stratified, probably representing old alluvial fan deposits derived mainly from graywackes and greenstones of the Franciscan Complex. Exposures at south edge of map area described by Cummings (1968) as Crystal Springs facies I of the Santa Clara Formation and are shown as the youngest unit of his lithofacies sequence (Cummings, 1972). Fault-bounded block of conglomerate in Lower Crystal Spring Reservoir has similar composition but also contains some boulders of glaucophane schist and may be part of Cummings' (1968, 1972) Crystal Springs facies II. Unit may be more than 200 ft thick

Qc **Colma Formation (Pleistocene)**—Weakly consolidated, moderately well bedded, yellowish-gray and tan sandy clay and silty sand, and friable light- to reddish-brown, poorly sorted to well-sorted sand and gravel. Thin- to thick-bedded with cross bedding commonly present in friable sands. Silty sand beds commonly contain zones of scattered well-rounded and polished chert pebbles. A shallow-water marine deposit. Total thickness unknown but probably exceeds 100 feet

Tme **Merced Formation (upper Pliocene)**—Moderately consolidated but commonly friable, yellowish- to grayish-orange where weathered and bluish-gray where fresh, thick-bedded to massive, fine-grained marine sandstone, siltstone, and clayey sandstone. Bedding is indistinct but in places, for example around Crestmoor High School, defined by moderately cemented, erosion resistant fossiliferous beds. Unit present only in or east of San Andreas Fault Zone. In southernmost exposure, near Hillsdale High School, unit is about 100 ft thick; exposures west of San Bruno complicated by faulting and folding but may represent several hundred feet of section

Ta **Arenite (Eocene?)**—Moderately consolidated but friable, grayish- orange-weathered, coarse-grained arkosic sandstone containing minor interbeds of micaceous mudstone and conglomerate. Estimated to be less than 50 ft thick. Present at one locality along south edge of map area, a mile west of Carlmont High, as an outlier of lithologically similar rocks better exposed and preserved a mile farther south and mapped by McLaughlin (1969) as unnamed Eocene(?) arenite

Franciscan Complex and associated rocks (Cretaceous and Jurassic)—Oldest rocks in map area east of Pilarcitos Fault, all of which have been metamorphosed to some extent. Divided into:

fu **Meta-igneous and metasedimentary rocks, undivided**—Meta-igneous and metasedimentary rocks on Cahill and Buri Buri Ridges

fs **Sandstone**—Medium- to coarse-grained, poorly sorted; locally tuffaceous sandstone (lithic graywacke) with interbedded siltstone, shale, and sparse coal. Well indurated, hard, and dark-greenish-gray when fresh; weakly indurated, soft, and grayish-orange when weathered. Most natural exposures are deeply weathered, but locally graywacke forms bold outcrops owing to a higher degree of induration or cementation. West of San Andreas Fault most graywacke occurs in a crudely layered sequence with Franciscan greenstone; east of San Andreas Fault graywacke typically occurs as tectonic inclusions in a matrix of sheared rock (fsr) but also is interlayered with chert (fc). As mapped, unit may locally include sheared rock (fsr)

fcg **Conglomerate**—Well-consolidated, medium-hard, moderate-brown, well-rounded pebble to cobble conglomerate. Pebble conglomerate consists mainly of well-sorted thin beds and lenses of chert clasts in a silty to clayey matrix; cobble conglomerate consists mainly of medium-crystalline to coarsely crystalline granitic rocks, fine-grained to aphanitic volcanic rocks, and graywacke with lesser amounts of chert, quartzite, shale, tuff, and schist in a matrix of micaceous graywacke. Pebble conglomerate occurs as lenses and beds as thick as 5 ft in graywacke on Belmont Hill. West of San Andreas Fault cobble conglomerate is exposed along north slope of San Pedro Valley where it is at least 10 ft thick and surrounded by graywacke (fs) and sheared rock (fsr); east of San Andreas Fault cobble conglomerate is best exposed in eastern part of Belmont where it may be as thick as 500 ft

fg **Greenstone**—Dark-green to red, altered basaltic volcanic rocks, including flows, pillow lava, breccia, tuff, and minor related intrusive rock. Friable to hard and dense depending upon rock type and degree of weathering. West of San Andreas Fault most greenstone occurs in discrete lenticular(?) units interlayered with Franciscan sandstone (fs); east of San Andreas Fault greenstone occurs mainly as rounded tectonic inclusions in a matrix of sheared rock (fsr). Along west side of San Andreas Lake, locally altered to pumpellyite rock; along Angelo Fault, Belmont Hill Fault, and locally at Coyote Point, altered to clay minerals

fc **Chert**—Massive to rhythmically thin bedded, white, grayish- green, yellowish-orange and brown, hard, brittle radiolarian chert, commonly with thin interlayers of reddish-brown shale. In some massive exposures chert has been recrystallized and cut by crystalline quartz veins; in other exposures, as along Belmont Hill Fault, chert has been hydrothermally altered to clay minerals. Largest bodies of chert are in Belmont and San Carlos; elsewhere chert typically occurs as small bodies interlayered with graywacke and greenstone and as rounded tectonic inclusions in sheared rock (fsr)

fl **Limestone**—Light-gray, hard, dense, finely crystalline limestone locally containing thin interbeds and lenses of black chert. Outcrops range from bold to subdued and all are fractured throughout. In the Pilarcitos block limestone occurs as discontinuous lenses interbedded with graywacke and greenstone and as tectonic inclusions in sheared rock (fsr), all assigned to the type Calera Limestone. In the San Francisco Bay block one small outcrop of pale-red limestone in Mills Creek drainage of Burlingame lithologically resembles the informally named Laytonville limestone of Alvarez and others (1980) of northern California

fm **Metamorphic rock**—Dusky-blue to brownish-gray and grayish-green, hard, dense, rounded blocks of metamorphic rock of the blueschist facies, chiefly glaucophane schist and gneiss, but also including a wide variety of other metamorphic rock types. Unit appears mostly as rounded tectonic inclusions in sheared rock (fsr) and serpentinite (sp). Many additional bodies of metamorphic rock are too small to show at map scale

fsr **Sheared rock**—Predominantly soft, light- to dark-gray, sheared shale, siltstone, and graywacke containing various-size tectonic inclusions of Franciscan rock types. Weathers to grayish-yellow clayey and silty sand and in places is eroded to form badlands topography. Area of outcrop may be greater than shown and may include some areas labelled as sandstone (fs). Slopes underlain by sheared rock unit are unstable, especially when wet. Thickness unknown but more than several hundreds of feet. Commonly referred to as mélange (Bailey and others, 1964; Hsu, 1968; Cowan, 1985; Fox, 1983) in the California Coast Ranges

sp **Serpentinite**—Soft sheared serpentinite enclosing blocks of hard gray to greenish-gray unsheared serpentinite and ultramafic rocks. West of San Andreas Fault occurs as near-vertical tabular bodies in or along faults or shear zones; east of San Andreas Fault occurs largely as flat-lying sheets overlying other Franciscan rocks and as small, near-vertical tabular bodies

sc **Silica-carbonate rock**—Reddish-orange to reddish-brown, porous to dense, erosion-resistant hydrothermally altered serpentinite. Typically consists of chalcedony, opal, quartz, and ferroan or magnesian carbonate, in various combinations. Occurs in serpentinite (sp) as small isolated outcrops, most too small to show at map scale, and one large outcrop 3,000 ft east of Crystal Springs Dam

Contact—Showing dip where known. Dotted where concealed; queried where existence or position is uncertain

Fault— Showing dip where known. Dashed where inferred; dotted where concealed; queried where existence or extension is uncertain. Bar and ball on downthrown side. A, away, T, toward on cross-sections

Photo-lineament—In sea cliffs, controlled by jointing; elsewhere, most likely controlled by faulting

Folds—Approximately located. Showing axial trace and direction of plunge, where known[1]

- **Anticline**
- **Overturned anticline**
- **Syncline**
- **Overturned syncline**

Strike and dip of beds—Ball indicates top of beds known from sedimentary structures[1]

- **Inclined**
- **Vertical**
- **Horizontal**
- **Overturned**

Direction and amount of apparent dip of beds

Strike and dip of jointing

- **Inclined**
- **Vertical**

Strike and dip of foliation

- **Inclined**
- **Vertical**

Note: Strike and dip symbols may be combined

Shallow landslide, commonly in surficial materials—Generally less than 10 ft. thick and less than 100 ft. in diameter. Visible on 1968 aerial photos. Many more exist than are shown

Portal of tunnel

Quarry—limestone, l; chert, ch; greenstone, g

Borrow pit—Sand, s; decomposed granitic rock, d

Prospect pit

Conglomerate bed

State Earthquake Investigation Commission monument (Lawson, 1908, p. 152)

ANGELO **U.S. Coast Survey triangulation station, showing name**

Historic shoreline and extent of marsh lands from U.S. Coast Survey maps. Compiled for best fit to triangulation stations, landforms, and other old maps. For additional information see Nichols and Wright (1971)

-330 **Borehole, showing altitude of Franciscan basement rocks**—Datum is mean sea level

-205 **Borehole, showing altitude of bottom of hole**—Datum is mean sea level

[1]Some offshore data is on intertidal reefs

GEOLOGIC MAP OF THE MONTARA MOUNTAIN AND SAN MATEO 7-1/2' QUADRANGLES, SAN MATEO COUNTY, CALIFORNIA

By
Earl H. Pampeyan
1994

For sale by the U.S. Geological Survey Map Distribution, Box 25286, Federal Center, Denver, CO 80225