Geologic Map of the Oceanside 30' x 60' Quadrangle, California

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CALIFORNIA GEOLOGICAL SURVEY
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Introduction

In 1990 the U.S. Geological Survey, as part of the National Geologic Mapping Program, initiated the Southern California Areal Mapping Project (SCAMP) (http://scamp.wr.usgs.gov) in cooperation with the California Geological Survey (then Division of Mines and Geology) Regional Geologic Mapping Project (http://www.conservation.ca.gov/cgs/rghm/rgm/index.htm). SCAMP's objectives were two-fold: to provide a basic understanding of the geologic framework and geologic history of southern California; and to develop a uniform digital geologic map database that could be used in a Geographic Information System (GIS) and be the foundation for geologic hazard investigations, natural resource evaluations, and other related earth science studies. These types of digital data can provide an important component for performing GIS analyses throughout southern California.

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Geologic Summary

The Oceanside 1:100,000-scale quadrangle lies within the Peninsular Ranges Geomorphic Province of southern California, between 33° and 33°30' N. latitude and 117° and 118° W. longitude, in a rapidly urbanizing part of southern California (Fig. 1). The area is tectonically and seismically active and includes parts of four major, northwest-striking, right-lateral, strike-slip, Pacific/North American Plate boundary fault zones. They include the Elsinore Fault Zone in the northeastern corner of the quadrangle, the Newport-Inglewood Fault Zone in the center of the quadrangle (source of the 1933, M=6.3, Long Beach earthquake), the Coronado Bank Fault in the near offshore region and the San Diego Trough Fault Zone in the southwestern corner of the quadrangle (source of the 1986, ML=5.3, Oceanside earthquake) (Fig. 1). Seismic hazards are numerous throughout the area. In addition, rapid uplift of relatively weak sedimentary rocks has lead to an abundance of landslides in the western and offshore parts of the quadrangle. A tsunami hazard zone also exists along the coastal margin.

The Peninsular Ranges of southern California form a northwest-trending geomorphic province that occupies the southwestern corner of California and extends southeastward to form the Baja California peninsula. Its physiography is characterized principally by steep mountain highlands with elevations exceeding 3,500 meters and dramatic intermontane basins, valleys, and rivers. The highlands are flanked on the west by a relatively narrow, westward sloping coastal margin that includes the San Diego embayment. On the east the highlands are bounded from the adjoining Colorado Desert and the Gulf of California by precipitous fault scarps, 2,000 to more than 3,000 meters high.

The Peninsular Ranges province is comprised of rocks that range in age from Quaternary to Paleozoic. Most of the rocks are Jurassic and Cretaceous igneous rocks of the Peninsular Ranges batholith and the Triassic and Jurassic metasedimentary sequence they intrude. Along the western margin of the province are large undivided bodies of Jurassic and Cretaceous pre-batholithic and synbatholithic volcanic, metavolcanic, and metasedimentary rocks. In addition, thick sequences of Upper Cretaceous and Tertiary units composed of post-batholithic sedimentary and volcanic rocks flank the older rocks on the west. The youngest deposits are Quaternary marine, lagoonal, and fluviatile sediments that discontinuously crop out over the entire province. A dramatic series of marine, wave-cut terraces and their overlying paralic sediments occur along the western coastal margin of the province. These

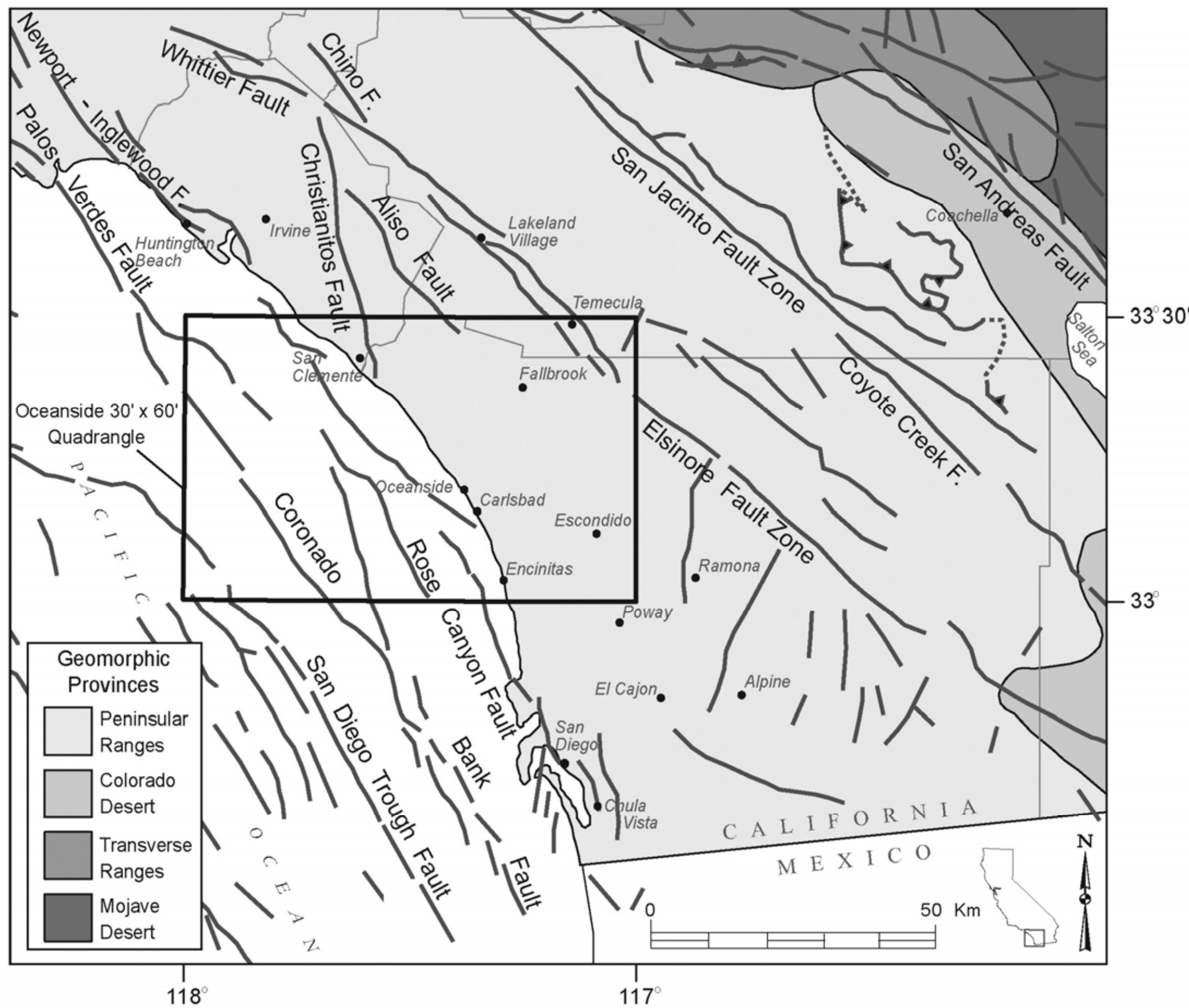

Figure 1. Index map showing the location of the Oceanside 30' x 60' quadrangle, major cities and faults, as well as the geomorphic provinces of southwestern California. Modified from Jennings and Saucedo, 2002.

terraces, coupled with available ^{18}O data, provide clear evidence of regional uplift during the past million years (Plate 2).

The composite Peninsular Ranges batholith of southern California and Baja California was emplaced across the lithospheric boundary between the North American and Pacific plates during the Jurassic and Cretaceous periods (Todd, and others, 2003). In southern California, numerous studies (summarized in detail by Morton and Miller, 2006), using geo-chemical and geophysical techniques, have been conducted to determine rock ages, properties and structural relationships. Most workers divide the batholith into two major longitudinal parts. The older western part is of Early and mid-Cretaceous age and composed of tonalite, gabbro and granodiorite plutons. The younger eastern part is mid- to Late Cretaceous and composed of less mafic granitic rocks with little or no gabbro. The eastern part also contains Jurassic metagranitic plutons that are now considered part of the Peninsular Ranges batholith (Shaw, and others, 2003). The Oceanside 1:100,000-scale quadrangle lies almost entirely within the western part of the batholith. Jurassic metagranitic rocks in the Pala and Valley Center 7.5-minute quadrangles crop out near the boundary between the eastern and western parts of the batholith. In the northwest part of the quadrangle, Jurassic and Triassic meta-sedimentary rocks occur as northwest-trending screens that have been intruded and assimilated by Jurassic and Cretaceous plutons. Most of these pre-batholithic rocks are quartzofeldspathic schist, pelitic schist, quartzite, injection gneiss and breccia. These rocks have been informally correlated with the Julian Schist (e.g. Irwin and Greene, 1970).

The undivided prebatholithic and synbatholithic Jurassic and Cretaceous rocks include volcanic and metavolcanic rocks (Santiago Peak Volcanics) of Larsen (1948), metasedimentary rocks (Bedford Canyon Formation) of Larsen (1948) and volcanic, metavolcanic, sedimentary and metasedimentary rocks (Black Mountain Volcanics) of Hanna (1926). Part of what earlier workers mapped as Santiago Peak Vocanics (e.g. Larsen, 1948) is a Creta-ceous subaerial island-arc volcanic sequence consisting of basaltic andesite, andesite, dacite, rhyolite, volcaniclastic breccia, welded tuff and epiclastic rocks (Herzig, 1991). They are the extrusive and shallow intrusive parts of the batholith (Herzig and Kimbrough, 1991; Anderson, 1991).

The Upper Cretaceous and Tertiary sedimentary rocks that flank the western margin of the Peninsular Ranges province consist of a relatively thick (>1000 m) succession of marine and nonmarine lagoonal, paralic and terrestrial sedimentary rocks. Quaternary marine and nonmarine beach, bar, dune, fluviatile and alluvial fan deposits discontinuously cover the older sedimentary succession along the western margin of the subaerial part of the province. Holocene alluvium and colluvium, derived from fractured and deeply weathered bedrock associated with K/T boundary subaerial extremes, mantle much of the interior highlands and particularly the steep slopes adjacent to and southwest of the Elsinore Fault Zone.

Compilation

The onshore part of the ***Geologic Map of the Oceanside 30’ x 60’ Quadrangle, California*** was digitized at a scale of 1:24,000 while the offshore part has been enlarged from the 1:250,000-scale Continental Margin Map (Clarke and others, 1987). New geologic mapping for the onshore area was completed in each of the eighteen 7.5-minute quad-rangles. Geologic maps of the Oceanside, San Luis Rey, San Marcos, Encinitas, and Rancho Santa Fe quadrangles were published by the California Geological Survey (Division of Mines and Geology) as Open-File Report 96-02 (Tan and Kennedy, 1996). The remaining thirteen 7.5-minute quadrangles were completed during the period July 1998 to June 2001 under STATEMAP funding awards no. 98HQAG2049, 99HQAG0134, and 00HQAG0120. The geologic maps produced from these awards along with the previously published maps were digitized with minor modifications to produce this seamless digital map.

The original digital work for the individual quadrangles, as well as the merged database file, was completed using ArcInfo® 8.3, a commercial GIS software package by Environmental Systems Research Institute (ESRI). For publication purposes the merged coverage was converted into the ESRI geodatabase format. The merged geology, structure, and annotation files along with base layers and shaded-relief images were combined using the ArcMap application within ArcInfo® 9.1 (ESRI).

An effort was made to apply the currently accepted standards for unit designations and colors to the geologic map (http://ngmdb.usgs.gov/fgdc_gds/). On the geologic map Quaternary sedimentary rocks are shown in shades of yellow and gold, Tertiary sedimentary rocks are depicted in shades of brown and reddish-brown, while Cretaceous sedimentary rocks and Jurassic metasedimentary rocks are shown in shades of green. Volcanic rocks are depicted in shades of orange while plutonic rocks are shown in shades of pink or purple, with purple designating more mafic units.

Base Material

The base for the Oceanside 30' x 60' quadrangle consists of shaded-relief and topographic digital data. The onshore portion of the base consists of hydrography, hypsography, and transportation files that were converted from 1:100,000 Digital Line Graph (DLG) data into ArcInfo® coverages. The DLG data is available from the USGS Geographic Data Download website at http://edc2.usgs.gov/geodata/index.php. Place names were vectorized from scanned 30' x 60' USGS topographic map separates. Carlos Gutierrez (CGS) generated the onshore shaded-relief image from 30-meter resolution elevation data obtained from the National Elevation Dataset (NED) at http://ned.usgs.gov/. The offshore shaded-relief bathymetry was prepared by Peter Dartnell (USGS) from multibeam data available at http://map.ngdc.noaa.gov/website/mgg/multibeam/viewer.htm and single-beam data available at http://map.ngdc.noaa.gov/website/mgg/nos_hydro/viewer.htm.

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DESCRIPTION OF MAP UNITS

Approximate stratigraphic relationships; see Plate 2 for detailed correlation.

MODERN SURFICIAL DEPOSITS

Sediment that recently has been transported and deposited in channels and washes, on surfaces of alluvial fans and alluvial plains, and on hill slopes and in artificial fills. Soil-profile development is non-existent. Includes:

af **Artificial fill (late Holocene)** – Deposits of fill resulting from human construction, mining, or quarrying activities; includes compacted engineered and non-compacted non-engineered fill. Some large deposits are mapped, but in some areas no deposits are shown.

Qw **Wash deposits (late Holocene)** – Unconsolidated bouldery to sandy alluvium of active and recently active washes.

Qf **Alluvial fan deposits (late Holocene)** – Active and recently active alluvial fans. Consists of unconsolidated, bouldery, cobbly, gravelly, sandy, or silty alluvial fan deposits, and headward channel parts of alluvial fans. Trunk drainages and proximal parts of fans contain greater percentage of coarse-grained sediment than distal parts.

Qa **Alluvial flood-plain deposits (late Holocene)** – Active and recently active flood-plain deposits. Consists of unconsolidated sandy, silty, or clay-bearing alluvium. Does not include alluvial fan deposits at distal ends of channels.

Qls **Landslide deposits, undivided (Holocene and Pleistocene)** – Highly fragmented to largely coherent landslide deposits. Unconsolidated to moderately well consolidated. Most mapped landslides contain scarp area as well as slide deposit. In some areas the scarp is shown separately. Most of the landslides in the quadrangle have occurred within the Capistrano Formation; however, there are many within the Monterey and Santiago formations as well.

Qmb **Marine beach deposits (late Holocene)** – Unconsolidated beach deposits consisting mostly of fine- and medium-grained sand.

Qpe **Paralic estuarine deposits (late Holocene)** – Unconsolidated estuarine deposits. Composed mostly of fine-grained sand and clay.

Qmo **Undivided marine deposits in offshore region (late Holocene)** – Unconsolidated, often ponded marine sediments. Composed mostly of very fine to medium-grained sand and silt.

Qfo **Marine fan deposits (late Holocene)** – Unconsolidated submarine fan deposits. Composed primarily of coarse- to fine-grained sand.

YOUNG SURFICIAL DEPOSITS

Sedimentary units that are slightly consolidated to cemented and slightly to moderately dissected. Alluvial fan deposits typically have high coarse-fine clast ratios. Young surficial units have upper surfaces that are capped by slight to moderately developed pedogenic soil profiles. Includes:

Qyf **Young alluvial fan deposits (Holocene and late Pleistocene)** – Poorly consolidated and poorly sorted sand, gravel, cobble and boulder alluvial fan deposits.

Qya **Young alluvial flood-plain deposits (Holocene and late Pleistocene)** – Poorly consolidated, poorly sorted, permeable flood-plain deposits of sandy, silty or clay-bearing alluvium.

Qyc **Young colluvial deposits (Holocene and late Pleistocene)** – Poorly consolidated and poorly sorted sand and silt slope wash deposits.

Qyv **Young alluvial valley deposits (Holocene and late Pleistocene)** – Fluvial deposits along valley floors. Consists of unconsolidated sand, silt and clay-bearing alluvium.

OLD SURFICIAL DEPOSITS

Sediments that are moderately consolidated and slightly to moderately dissected. Older surficial deposits have upper surfaces that are capped by moderate to well-developed pedogenic soils. Includes:

Qof **Old alluvial fan deposits, undivided (late to middle Pleistocene)** – Reddish-brown, gravel and sand alluvial fan deposits that are usually indurated and slightly dissected. Includes:

Qof_2 **Old alluvial fan deposits, Unit 2 (late to middle Pleistocene)** – Reddish-brown, gravel and sand alluvial fan deposits that are usually indurated and slightly dissected.

Qof_1 **Old alluvial fan deposits, Unit 1 (late to middle Pleistocene)** – Reddish-brown, gravel and sand alluvial fan deposits that are usually indurated and slightly dissected.

Qoa **Old alluvial flood-plain deposits, undivided (late to middle Pleistocene)** – Fluvial sediments deposited on canyon floors. Consists of moderately well consolidated, poorly sorted, permeable, commonly slightly dissected gravel, sand, silt, and clay-bearing alluvium. Where more than one number is shown (e.g., Qoa_{2-6}) those deposits are undivided. Includes:

Qoa_7 **Old alluvial flood-plain deposits, Unit 7 (late to middle Pleistocene)** – Well-consolidated, poorly sorted, permeable gravel, sand, silt and clay-bearing alluvium.

Qoa_6 **Old alluvial flood-plain deposits, Unit 6 (late to middle Pleistocene)** – Well-consolidated, poorly sorted, permeable gravel, sand, silt and clay-bearing alluvium.

Qoa_5 **Old alluvial flood-plain deposits, Unit 5 (late to middle Pleistocene)** – Well-consolidated, poorly sorted, permeable gravel, sand, silt and clay-bearing alluvium.

Qoa_{2-6} **Old alluvial flood-plain deposits, Units 2-6 (late to middle Pleistocene)** – Well-consolidated, poorly sorted, permeable gravel, sand, silt and clay-bearing alluvium.

Qoa_{1-2} **Old alluvial flood-plain deposits, Units 1-2 (late to middle Pleistocene)** – Well-consolidated, poorly sorted, permeable gravel, sand, silt and clay-bearing alluvium.

Qoc **Old colluvial deposits (late to middle Pleistocene)** – Moderately well consolidated, poorly sorted slope wash.

Qop **Old paralic deposits, undivided (late to middle Pleistocene)** – Poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the now emergent wave cut abrasion platforms preserved by regional uplift (Plate 2). Where more than one number is shown (e.g., $Qop_{2\text{-}6}$) those deposits are undivided. Includes:

Qop_7 **Old paralic deposits, Unit 7 (late to middle Pleistocene)** – Poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the 9-11 m Bird Rock terrace (Plate 2).

Qop_6 **Old paralic deposits, Unit 6 (late to middle Pleistocene)** – Poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the 22-23 m Nestor terrace (Plate 2).

Qop_4 **Old paralic deposits, Unit 4 (late to middle Pleistocene)** – Poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the 34-37 m Stuart Mesa terrace (Plate 2).

Qop_3 **Old paralic deposits, Unit 3 (late to middle Pleistocene)** – Poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the 45-46 m Guy Fleming terrace (Plate 2).

Qop_1 **Old paralic deposits, Unit 1 (late to middle Pleistocene)** – Poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the 61-63 m Golf Course terrace (Plate 2).

VERY OLD SURFICIAL UNITS

Sediments that are slightly to well-consolidated to indurated, and moderately to well-dissected. Upper surfaces are capped by moderate to well-developed pedogenic soils. Includes:

Qvof **Very old alluvial fan deposits (middle to early Pleistocene)** – Well-dissected, well-indurated, reddish-brown sand and gravel alluvial fan deposits.

Qvoa **Very old alluvial flood-plain deposits, undivided (middle to early Pleistocene)** – Fluvial sediments deposited on canyon floors. Consists of moderately to well-indurated, reddish-brown, mostly very dissected gravel, sand, silt, and clay-bearing alluvium. Includes:

$Qvoa_{13}$ **Very old alluvial flood-plain deposits, Unit 13 (middle to early Pleistocene)** – Moderately to well-indurated, dissected gravel, sand, silt and clay-bearing alluvium.

$Qvoa_{12}$ **Very old alluvial flood-plain deposits, Unit 12 (middle to early Pleistocene)** – Moderately to well-indurated, dissected gravel, sand, silt and clay-bearing alluvium.

$Qvoa_{11}$ **Very old alluvial flood-plain deposits, Unit 11 (middle to early Pleistocene)** – Moderately to well-indurated, dissected gravel, sand, silt and clay-bearing alluvium.

Qvoc **Very old colluvial deposits, undivided (middle to early Pleistocene)** – Well-indurated, poorly sorted, hill slope deposits consisting mostly of clay, silt and sand.

Qvop **Very old paralic deposits, undivided (middle to early Pleistocene)** – Poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the now emergent wave cut abrasion platforms preserved by regional uplift (Plate 2). Where more than one number is shown (e.g., $Qvop_{2-3}$) those deposits are undivided. Includes:

$Qvop_{13}$ **Very old paralic deposits, Unit 13 (middle to early Pleistocene)** – Poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the 67-69 m San Elijo terrace (Plate 2).

$Qvop_{12}$ **Very old paralic deposits, Unit 12 (middle to early Pleistocene)** – Poorly sorted, moderately permeable, reddish-brown, interfingered strand-line, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the 83-85 m Fire Mountain terrace (Plate 2).

$Qvop_{11}$ **Very old paralic deposits, Unit 11 (middle to early Pleistocene)** – Poorly sorted, moderately permeable, reddish-brown, interfingered strand-line, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the 92-94 m Clairemont terrace (Plate 2).

$Qvop_{10}$ **Very old paralic deposits, Unit 10 (middle to early Pleistocene)** – Poorly sorted, moderately permeable, reddish-brown, interfingered strand-line, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the 104-106 m Tecolote terrace (Plate 2).

$Qvop_9$ **Very old paralic deposits, Unit 9 (middle to early Pleistocene)** – Poorly sorted, moderately permeable, reddish-brown, interfingered strand-line, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the 113-115 m Linda Vista terrace (Plate 2).

$Qvop_8$ **Very old paralic deposits, Unit 8 (middle to early Pleistocene)** – Poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the 123-125 m Tierra Santa terrace (Plate 2).

$Qvop_7$ **Very old paralic deposits, Unit 7 (middle to early Pleistocene)** – Poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the 129-131 m Mira Mesa terrace (Plate 2).

$Qvop_5$ **Very old paralic deposits, Unit 5 (middle to early Pleistocene)** – Poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the 153-157 m Rifle Range terrace (Plate 2).

$Qvop_4$ **Very old paralic deposits, Unit 4 (middle to early Pleistocene)** – Poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the 170-174 m Aqueduct terrace (Plate 2).

$Qvop_3$ **Very old paralic deposits, Unit 3 (middle to early Pleistocene)** – Poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the 181-185 m Aliso Canyon terrace (Plate 2).

$Qvop_2$ **Very old paralic deposits, Unit 2 (middle to early Pleistocene)** – Poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the 190-194 m Flores Hill terrace (Plate 2).

$Qvop_1$ **Very old paralic deposits, Unit 1 (middle to early Pleistocene)** – Poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine and colluvial deposits composed of siltstone, sandstone and conglomerate. These deposits rest on the 201-205 m Eagle terrace (Plate 2).

SEDIMENTARY AND VOLCANIC BEDROCK UNITS

Qps
Qpf **Pauba Formation (early Pleistocene)** – Siltstone, sandstone, and conglomerate. Includes two informal facies (Kennedy, 1977): **Qps** (sandstone facies) - Light-brown, moderately well indurated, extensively cross-bedded, channeled and filled sandstone and siltstone with minor cobble to boulder conglomerate interbeds; **Qpf** (fanglomerate facies) – well-indurated, poorly sorted sedimentary breccia and mudstone. Named by Mann (1955) for exposures at Rancho Pauba about 5 km southeast of Temecula. Vertebrate fauna from the Pauba Formation are of late Irvingtonian and early Rancholabrean ages (Reynolds and Reynolds, 1990a; 1990b).

Qd **Dripping Springs Formation (early Pleistocene)** – Pebble, cobble and boulder fanglomerate in a reddish-brown, poorly consolidated, poorly sorted, sandstone matrix. Named by Mann (1955) for exposures of fanglomerate that crop out immediately east of the area in road cuts along State Highway 71 near Dripping Springs.

QTso **Undivided sediments and sedimentary rocks in offshore region (Holocene, Pleistocene, Pliocene and Miocene)** – Unconsolidated and poorly consolidated Pleistocene sand, silt and clay deposits that mantle the modern seafloor. Includes unmapped sandstone, siltstone, conglomerate and breccia.

Tta **Temecula Arkose (late Pliocene)** – Pale greenish-yellow, well-indurated, medium and coarse-grained sandstone with thin interstratified beds of fine-grained, tuffaceous sandstone, siltstone and claystone. Pebble and cobble conglomerate interbeds composed of locally derived basement rock clasts are also common and range in thickness from a few centimeters to a meter or more. Named by Mann (1955) for exposures of nonmarine fluvial sandstone exposed southeast of Temecula. The Temecula Arkose has been assigned an Irvingtonian I age (Woodburne, 1987) which makes it approximately 1.9 Ma.

Tn **Niguel Formation (late Pliocene)** – Light-gray, friable, micaceous fine-grained, mostly marine sandstone interbedded with gray, sandy siltstone. Breccia and conglomerate locally present at or near the base. Unconformably overlies both the Capistrano and Monterey formations. Named by Vedder (1957). Marine mollusks suggest deposition in sublittoral-depth water (Vedder, 1960).

Tpo **Undivided sedimentary rocks in offshore region (Pliocene)** – Sandstone, siltstone and conglomerate.

Tcs
Tct **Capistrano Formation (early Pliocene and late Miocene)** – Marine sandstone and siltstone. Includes two facies: **Tcs** (siltstone facies) - white to pale-gray, massive to crudely bedded, friable, marine siltstone, mudstone and diatomaceous shale: **Tct** (turbidite facies) - marine channel deposits composed of coarse-grained, poorly bedded, weakly cemented sandstone and conglomeratic sandstone. Named by Woodford (1925).

Tsm **San Mateo Formation (early Pliocene and late Miocene)** – Yellowish-gray, nearshore marine and paralic siltstone, sandstone and conglomerate. Named by Woodford (1925) for exposures along San Mateo Creek in the northwest corner of the quadrangle. Considered to be in part a channel facies within the lower part of the Capistrano Formation (Vedder, 1972).

Tvsr **Santa Rosa basalt of Mann (1955) (late Miocene)** – Olivine basalt flow remnants having relatively unmodified flow surfaces. Originally described by Fairbanks (1893) and informally named by Mann (1955) for basalt flows west of Temecula. Hawkins (1970) provides detailed petrologic description of basalt. The flows were extruded on deeply weathered surfaces of low relief similar to Paleocene-age surfaces found elsewhere in southern

California. To the north of the area near Elsinore Peak, correlative flows were extruded on sedimentary rocks closely resembling Paleogene age rocks in the Santa Ana Mountains. Morton and Morton (1979) report whole-rock conventional K-Ar ages for the Santa Rosa basalt of 6.7 and 7.4 Ma. A slightly older age of 8.7 Ma was obtained by Hawkins (1970).

Tda **Dacite stock (Miocene)** – Small bodies of igneous rock of dacitic to basaltic composition.

Tv **Volcanic rocks, undivided (Miocene)** – Dark-gray and black, fine-grained volcanic flows of dacitic composition.

Tvt **Basalt of Temecula area (Miocene)** – Olivine basalt. Includes scattered exposures of basalt east of Temecula (Mann, 1955; Kennedy, 1977; Hull, 1990).

Tm **Monterey Formation (middle and late Miocene)** – Interbedded white to pale-brown, thinly laminated siltstone and tan, fine- to medium-grained feldspathic sandstone. Contains abundant foraminifera and fish remains. Siliceous and diatomaceous marine siltstone and sandstone correlated with Monterey Formation of central California (Blake, 1856; Kew, 1923; Bramlette, 1946).

Tso
Tsoss **San Onofre Breccia (middle Miocene)** – Marine sedimentary breccia, conglomerate, and lithic sandstone. Includes two parts: **Tso** (breccia) - green, greenish-gray, gray, brown, and white, massive- to well-bedded, well-indurated breccia with interbedded conglomerate, sandstone, siltstone, and mudstone; **Tsoss** (sandstone) - greenish-gray and brown lithic sandstone. The clasts of the breccia are large and angular and were derived from basement rock sources offshore to the west. They are characterized by blueschist and related rocks derived from Catalina Schist (Woodford, 1924). Unit is up to 900 m thick. Named by Ellis and Lee (1919) for exposures in the San Onofre Hills. Detailed descriptions of petrology and paleontology are given by Woodford (1925), who described unit as "San Onofre facies of the Temblor Formation" based on occurrence of Turritella ocoyana fauna in sandstone underlying breccia.

Tto **Topanga Formation (middle Miocene)** – Pale-gray, massive, tuffaceous sandstone and thin-bedded siltstone. Named by Kew (1923) for sandstone exposures in the Santa Monica Mountains of southern California.

Tmo **Undivided sedimentary rocks in offshore region (Miocene)** – Consists primarily of well-consolidated, bedded sandstone and siltstone.

Tmvo **Undivided volcanic rocks in offshore region (Miocene)** – Consists primarily of dark-gray and black basaltic rock.

Tmuo **Undivided volcanic and sedimentary rocks in offshore region (Miocene)** – Includes **Tmo** – well-consolidated, bedded sandstone and siltstone: or **Tmvo** – dark-gray and black basaltic rock.

Tsv **Sespe and Vaqueros Formations, undivided (early Miocene, Oligocene and late Eocene)** – Marine interbedded siltstone, mudstone and sandstone of the Vaqueros Formation interlayered with nonmarine coarse-grained sandstone, clayey and silty sandstone and conglomeratic sandstone of the Sespe Formation.

Trm **Sandstone of Redonda Mesa (Paleogene)** – Basalt capping Redonda Mesa is underlain by a sequence of poorly consolidated to well-indurated, white to pale-gray, fine- to coarse-grained, locally pebbly sandstone. Some sandstone lacks basalt cover.

Tmv **Mission Valley Formation (middle Eocene)** – Predominantly light-olive-gray, soft and friable, fine- to medium-grained marine and nonmarine sandstone containing cobble conglomerate tongues. Contains a diverse late Uintan mammal fauna (Walsh and others, 1996) and a robust molluscan fauna assigned to the Tejon stage (Givens and Kennedy, 1979). A bentonite bed within the upper part of the Mission Valley Formation yielded a single crystal $^{40}Ar/^{39}Ar$ date of 42.83 ± 0.24 Ma (reported in Walsh and others, 1996). The Mission Valley Formation has a maximum thickness of 60 m and was named for exposures along the south wall of Mission Valley on the west side of State Highway 163 (Kennedy and Moore, 1971).

Tst **Stadium Conglomerate (middle Eocene)** – Massive cobble conglomerate with a dark-yellowish-brown, coarse-grained sandstone matrix. The conglomerate contains up to 85% slightly metamorphosed rhyolitic to dacitic volcanic and volcaniclastic rocks and up to 20% quartzite. It yields early Uintan mammals (Walsh and others, 1996) and Tejon stage mollusks (Givens and Kennedy, 1979). Named for exposures in Mission Valley, San Diego (Kennedy and Moore, 1971).

Tf **Friars Formation (middle Eocene)** – Yellowish-gray, medium-grained, massive, poorly indurated nonmarine and lagoonal sandstone and claystone with tongues of cobble conglomerate. It contains early Uintan mammals (Walsh and others, 1996) and was named for exposures along the north side of Mission Valley near Friars Road (Kennedy and Moore, 1971).

Tt **Torrey Sandstone (middle Eocene)** – White to light-brown, medium- to coarse-grained, moderately well indurated, massive and broadly cross-bedded, arkosic sandstone. This unit is the Torrey Sand Member of Hanna (1926) and was named for exposures at Torrey Pines State Park. It is now considered a formation of the La Jolla Group (Kennedy and Moore, 1971).

Td **Delmar Formation (middle Eocene)** – Dusky yellowish-green, sandy claystone interbedded with medium-gray, coarse-grained sandstone. This unit is the Delmar Sand Member of Hanna (1926) and was named for exposures in the sea cliffs at Del Mar. It is now considered a formation of the La Jolla Group (Kennedy and Moore, 1971).

Tsa **Santiago Formation (middle Eocene)** – There are three distinctive parts. A basal member consisting of buff and brownish-gray, massive, coarse-grained, poorly sorted arkosic sandstone and conglomerate (sandstone generally predominating). In some areas the basal member is overlain by a central member that consists of gray and brownish-gray (salt and pepper) soft, medium-grained, moderately well sorted arkosic sandstone. The upper member consists of gray, coarse-grained arkosic sandstone and grit. Vertically and laterally throughout the formation there exists greenish-brown, massive claystone interbeds, tongues and lenses of often fossiliferous, lagoonal claystone and siltstone. The lower part of the Santiago Formation interfingers with the Delmar Formation and Torrey Sandstone in the Encinitas quadrangle. Named by Woodring and Popenoe (1945) for Eocene deposits of northwestern Santa Ana Mountains.

Teo **Undivided Eocene rocks in the offshore area (Eocene)** – Well-indurated, massive arkosic sandstone. Also includes interbeds of claystone, siltstone and conglomerate.

Tsi **Silverado Formation (Paleocene)** – Consists of a lower, nonmarine, coarse-grained sandstone with interbedded siltstone and basal conglomerate and two prominent clay interbeds including the brownish pisolitic Claymont clay bed and whitish Serrano clay bed. Also contains minor carbonaceous shale and lignite. The upper part of the formation is composed of interbedded, medium- to fine-grained marine sandstone, siltstone, shale and conglomerate. Named by Woodring and Popenoe (1945) for Paleocene deposits of northwestern Santa Ana Mountains.

Kp **Point Loma Formation (Upper Cretaceous)** – Interbedded, fine-grained, dusky-yellow sandstone and olive-gray siltstone. Contains calcareous nannoplankton of Upper Cretaceous (Campanian and Maestrichtian) age. Named for exposures in the sea cliffs along the west side of the Point Loma Peninsula and assigned to the intermediate part of the Rosario Group (Kennedy and Moore, 1971). The Point Loma Formation is correlative in part to the Williams Formation in the Santa Ana Mountains (Popenoe and others, 1960; Bukry and Kennedy, 1969).

Kwp
Kwsr **Williams Formation (Upper Cretaceous)** – Sandstone and conglomeratic sandstone. Named by Popenoe (1937, 1942) for exposures near the mouth of Williams Canyon in the northern Santa Ana Mountains. He divided the unit into the Pleasants Sandstone Member (**Kwp**) and the Schulz Ranch Member. Woodring and Popenoe (1945) renamed the Schulz Ranch Member the Schulz Ranch Sandstone Member (**Kwsr**). **Kwp** - consists mostly of marine sandstone. The upper part is a poorly bedded, white to pale-gray, feldspathic sandstone, which generally is coarser grained than sandstone in lower part. The lower part is sandstone and thin-bedded, biotite- and muscovite-bearing sandstone. Massive sandstone contains biotite and black carbonaceous fragments and scattered conglomerate lenses. Fossiliferous concretions are common. **Kwsr** - Schulz Ranch Sandstone Member consists mostly of marine sandstone and conglomerate. The sandstone is coarse

grained, white to brownish gray, and massive. It is locally cross-bedded. Contains scattered matrix-supported pebbles and cobbles and sparse siltstone interbeds. Erosionally resistant; forms prominent cliffs. The Williams Formation is correlative in part to the Point Loma Formation (Popenoe and others, 1960; Bukry and Kennedy, 1969).

Kl **Lusardi Formation (Upper Cretaceous)** – Reddish-brown, cobble and boulder conglomerate with occasional thin lenses of medium-grained sandstone. Named by Nordstrom (1970) for exposures in Lusardi Creek in the Rancho Santa Fe quadrangle and later assigned to the basal part of the Rosario Group by Kennedy and Moore (1971). At one location, near Olivenhain, the Lusardi Formation contains a tongue of Point Loma Formation (Zlotnik, 1981). The Lusardi Formation is correlated to the Trabuco Formation in the Santa Ana Mountains (Nordstrom, 1970).

Ktr **Trabuco Formation (Upper Cretaceous)** – Reddish-brown, massive, nonmarine conglomerate with local sandstone and siltstone beds. Named by Packard (1916) for exposures near Trabuco Canyon in northern Santa Ana Mountains. Correlated to the Lusardi Formation by Nordstrom (1970).

UNNAMED CRETACEOUS ROCKS OF THE PENINSULAR RANGES BATHOLITH

(See Figure 2 for classification diagram)

Kgp **Granite pegmatite dike (mid-Cretaceous)** – Tabular, pegmatitic-textured granitic dikes. Most dikes range in thickness from a few centimeters to over a meter. Larger dikes are typically zoned compositionally and texturally.

Kg **Granite, undivided (mid-Cretaceous)** – Massive, coarse- to medium-grained biotite granite.

Kmg **Monzogranite, undivided (mid-Cretaceous)** – Coarse-grained biotite-hornblende monzogranite.

Kgd **Granodiorite, undivided (mid-Cretaceous)** – Medium- to coarse-grained hornblende-biotite granodiorite.

Kgdfg **Granodiorite, undivided (mid-Cretaceous)** – Fine-grained, massive, dark-gray and black granodiorite.

Kt **Tonalite, undivided (mid-Cretaceous)** – Massive, coarse-grained, light-gray hornblende-biotite tonalite.

Kqbd **Quartz-bearing diorite, undivided (mid-Cretaceous)** – Massive, medium-grained, dark-gray biotite-hornblende quartz-bearing diorite.

Kd **Diorite, undivided (mid-Cretaceous)** – Massive, medium- to coarse-grained, dark-gray hornblende diorite.

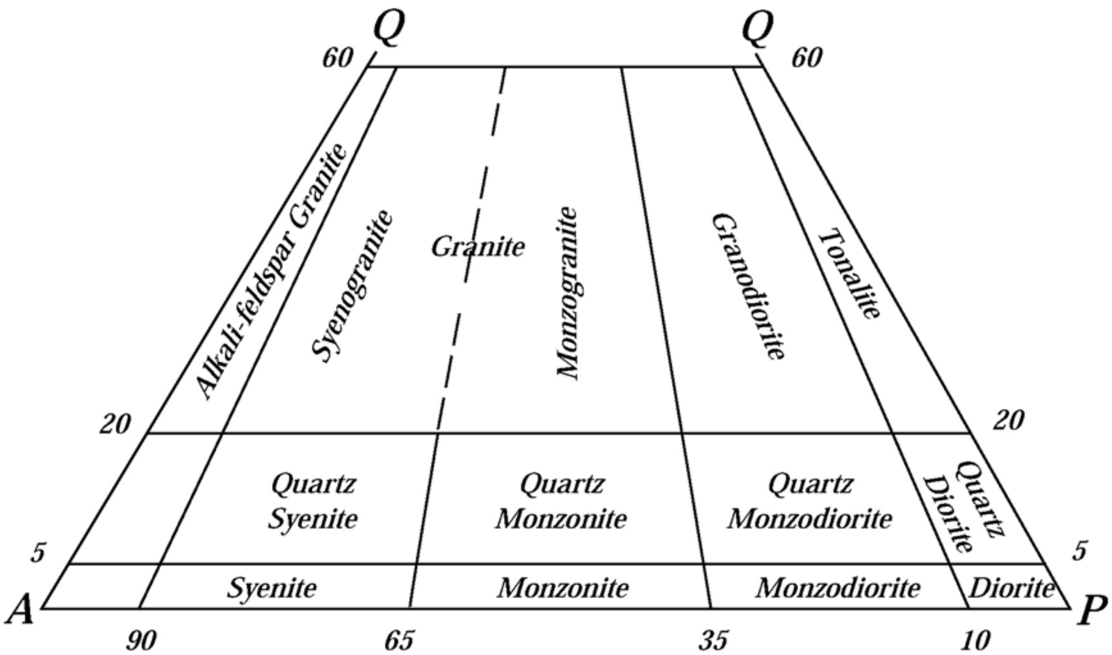

Figure 2. Classification of plutonic rock types (from IUGS, 1973, and Streckeisen, 1973). A, alkali feldspar: P, plagioclase feldspar; Q, quartz.

Kgb **Gabbro, undivided (mid-Cretaceous)** – Massive, coarse-grained, dark-gray and black biotite-hornblende-hypersthene gabbro.

Khg **Heterogeneous granitic rocks (Cretaceous)** – A wide variety of heterogeneous granitic rocks occur in the Oceanside quadrangle. Some heterogeneous assemblages include large proportions of metamorphic rocks.

NAMED CRETACEOUS ROCKS OF THE PENINSULAR RANGES BATHOLITH

(See Figure 2 for classification diagram)

Kdl **Granite of Dixon Lake (mid-Cretaceous)** – Very fine grained, subporphyritic, leucocratic biotite granite.

Kbp **Granite of Bottle Peak (mid-Cretaceous)** – Coarse-grained, leucocratic hornblende-biotite granite.

Kis **Granite of Indian Springs (mid-Cretaceous)** – Fine-grained biotite granite. Similar in appearance to Kdl.

Klh **Leucogranodiorite of Lake Hodges (mid-Cretaceous)** – Massive, coarse- and medium-grained biotite-hornblende, leucogranodiorite.

Kvc **Monzogranite of Valley Center (mid-Cretaceous)** – Massive, coarse-grained, leucocratic biotite monzogranite.

Kmm **Monzogranite of Merriam Mountain (mid-Cretaceous)** – Massive, medium- to coarse-grained, leucocratic hornblende-biotite monzo-granite.

Kwm **Granodiorite of Woodson Mountain (mid-Cretaceous)** – Massive, coarse-grained, leucocratic hornblende granodiorite. Part of the Woodson Mountain Granodiorite of Larsen (1948).

Kjd **Granodiorite of Jesmond Dean (mid-Cretaceous)** – Massive, fine-grained, dark-gray and black granodiorite.

Kbm **Granodiorite of Burnt Mountain (mid-Cretaceous)** – Very fine grained, massive, leucocratic biotite granodiorite.

Km **Granodiorite of Mountain Meadows (mid-Cretaceous)** – Massive, medium- to coarse-grained, dark-gray hornblende granodiorite.

Krr **Granodiorite of Rimrock (mid-Cretaceous)** – Fine-grained, sub-porphyritic biotite granodiorite.

Ki **Granodiorite of Indian Mountain (mid-Cretaceous)** – Massive, medium-grained, leucocratic biotite granodiorite.

Kr **Granodiorite of Rainbow (mid-Cretaceous)** – Massive, medium-to coarse-grained, leucocratic hornblende-biotite granodiorite.

Kpa **Granodiorite of Pala (mid-Cretaceous)** – Fine- to medium-grained, leucocratic granodiorite and migmatite.

Kgdf **Granodiorite, undivided within the Elsinore Fault Zone (mid-Cretaceous)** – Pervasively sheared, leucocratic hornblende-biotite granodiorite.

Kcg **Tonalite of Cole Grade (mid-Cretaceous)** – Massive, coarse-grained hornblende-biotite tonalite.

Kcc **Tonalite of Couser Canyon (mid-Cretaceous)** – Massive, coarse-grained hornblende-biotite tonalite. Contains some granodiorite and is characterized by an abundance of pegmatitic dikes.

Krm **Quartz-bearing diorite of Red Mountain (mid-Cretaceous)** – Massive, coarse-grained, dark-gray, biotite-hornblende diorite.

Kat **Gabbro of the Agua Tibia Mountains (mid-Cretaceous)** – Massive to foliated, coarse-grained, hornblende gabbro. Locally contains minor biotite and quartz.

Kwmt **Gabbro of Weaver Mountain (mid-Cretaceous)** – Massive, coarse-grained, hornblende gabbro.

Kgbf **Gabbro, undivided within the Elsinore Fault Zone (mid-Cretaceous)** – Pervasively sheared, dark-gray and black, biotite-hornblende-hypersthene gabbro.

Kvsp **Santiago Peak Volcanics (Cretaceous)** – Basaltic andesite, andesite, dacite, rhyolite, volcaniclastic breccia, welded tuff, and epiclastic rocks (Herzig, 1991). Originally named Black Mountain Volcanics by Hanna (1926), but name was pre-empted. Larsen (1948) renamed unit Santiago Peak Volcanics for exposures in vicinity of Santiago Peak, northern Santa Ana Mountains. Rocks are very heterogeneous, discontinuous, and poorly exposed. Most of unit is hydrothermally altered; alteration was contemporaneous with volcanism. Zircon ages of Santiago Peak Volcanics range from 123 to 134 Ma (Anderson, 1991), making it coeval with older part of Peninsular Ranges Batholith.

PREBATHOLITHIC AND SYNBATHOLITHC METAMORPHIC ROCKS

Mzu **Metamorphosed and unmetamorphosed volcanic and sedimentary rocks, undivided (Mesozoic)** – Wide variety of unmetamorphosed and low- to high-metamorphic grade volcanic and sedimentary rocks. They include prebatholithic (metamorphosed) and synbatholithic (unmetamorphosed) rocks including metavolcanic rocks (Santiago Peak Volcanics) of Larsen (1948), metasedimentary rocks (Bedford Canyon Formation) of Larsen (1948), volcanic, metavolcanic, sedimentary and metasedimentary rocks (Black Mountain Volcanics) of Hanna (1926). These rocks include a Cretaceous subaerial island-arc volcanic sequence consisting of basaltic andesite, andesite, dacite, rhyolite, volcaniclastic breccia, welded tuff and epiclastic rocks (Herzig, 1991). They are comagmatic with the oldest Cretaceous plutons of the Peninsular Ranges batholith (Herzig and Kimbrough, 1991; Anderson, 1991).

Mzd **Metavolcanic dikes (Mesozoic)** – Very fine grained, dark-gray, massive dikes within Mzu.

Mzg **Metagranitic rocks (Mesozoic)** – Consists primarily of light-gray to white, massive gneiss.

Mzq **Quartzite and quartz conglomerate (Mesozoic)** – Quartzite, quartz conglomerate and meta-arkose.

Mzs **Schist with minor amphibolite and marble (Mesozoic)** – Quartz-mica schist, quartz-mica-amphibole schist, and feldspathic amphibole schist.

INDEX MAP

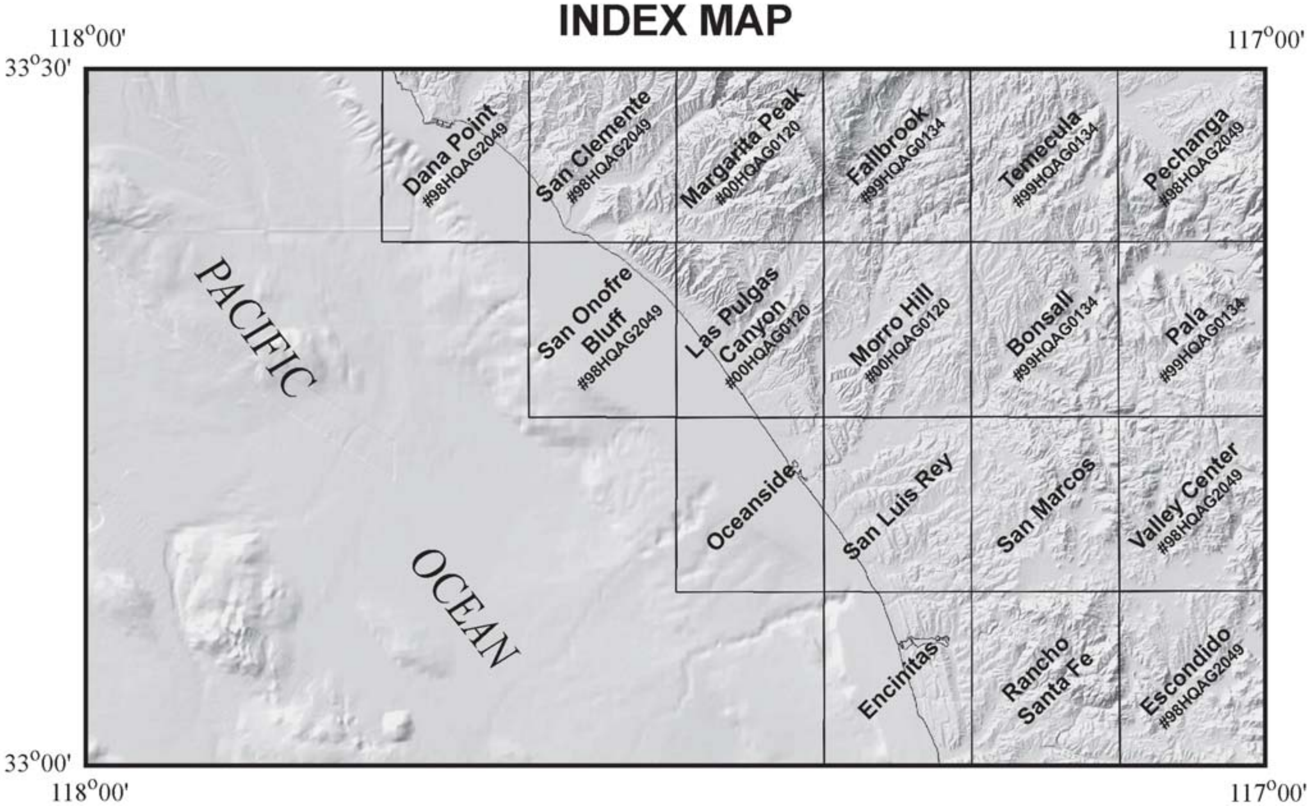

Figure 3. Index map showing the 7.5-minute quadrangles in the Oceanside 30' x 60' quadrangle and the U.S. Geological Survey STATEMAP award numbers for those quadrangles mapped under that funding source. DEM from U.S. Geological Survey.

Sources of mapping for the Oceanside 30' x 60' quadrangle and individuals who digitized the geologic mapping (*primary compilation sources shown in bold type*). For complete citation see the reference section following this list.

Bonsall Quadrangle

Larsen, 1948; **Tan, 2000a**; Weber, 1963. *Digital preparation by*: Ursula Edwards and Gary W. Patt.

Dana Point Quadrangle

Edgington, 1974; Kern, 1996a; Kern and others, 1996; Morton and Miller, 1981; Tan, 1984; **Tan, 1999a**; Tan and Weber, 1984; Vedder, 1975. *Digital preparation by*: Gary W. Patt and Kelly R. Ruppert.

Encinitas Quadrangle

Kern, 1996a; Tan, 1986; **Tan and Kennedy, 1996**; Tan and Giffen, 1995; Wilson, 1972. *Digital preparation by*: Diane Burns and Geoff Faneros.

Escondido Quadrangle

Kennedy and Peterson, 1975; Larsen, 1948; Tan and Giffen, 1995; **Tan and Kennedy, 1999**; Weber, 1963. *Digital preparation by*: Henry L. Jones and Kelly R. Ruppert.

Fallbrook Quadrangle

Tan, 2000b; Larsen, 1948; Weber, 1963. *Digital preparation by*: Ursula Edwards and Gary W. Patt.

Las Pulgas Canyon Quadrangle

Boss and others, 1958; Craig, 1984; Cranham and others, 1994; Ehlig and Farley, 1976; Kern, 1996a; Kern, 1996b; **Kennedy, 2001.** *Digital preparation by*: Ursula Edwards-Howells.

Margarita Peak Quadrangle

Boss and others, 1958; **Tan, 2001a**; Larsen, 1948. *Digital preparation by*: Michael J. Watson and Sybil Jorgensen.

Morro Hill Quadrangle

Boss and others, 1958; Elliot, 1985; Larsen, 1948; **Tan, 2001b**; Weber, 1963. *Digital preparation by*: Kelly Corriea.

Oceanside Quadrangle

Kern, 1996a; **Tan and Kennedy, 1996**; Tan and Giffen, 1995; Weber, 1982. *Digital preparation by*: Diane Burns and Geoff Faneros.

Pala Quadrangle

Hanley and Jahns, 1950; Irwin and Greene, 1970; Jahns and Wright, 1951; **Kennedy, 2000a**; Larsen, 1948. *Digital preparation by*: Paul Garcia and Rachel M. Hauser.

Pechanga Quadrangle

Hanley and Jahns, 1950; Irwin and Greene, 1970; Jahns and Wright, 1951; Kennedy, 1977; **Kennedy, 2000b**; Larsen, 1948. *Digital preparation by*: Brad L. Nelson and Rachel M. Hauser.

Rancho Santa Fe Quadrangle

Larsen, 1948; Nordstrom, 1970; Tan, 1987; Tan and Giffen, 1995; **Tan and Kennedy, 1996**; Weber, 1963. *Digital preparation by*: Diane Burns.

San Clemente Quadrangle

Blanc and Cleveland, 1968; Boss and others,1958; Ehlig and Farley, 1976; Kern, 1996a; Kern, 1996b; Morton and Miller, 1981; **Tan, 1999b**; Tan and Weber, 1984; Vedder, 1975. *Digital preparation by*: Anne G. Kennedy and Amy C. Zach.

San Luis Rey Quadrangle

Tan and Kennedy, 1996; Tan and Giffen, 1995; Weber, 1982; Wilson, 1972. *Digital preparation by*: Diane Burns and Geoff Faneros.

San Marcos Quadrangle

Herzig, 1991; **Tan and Kennedy, 1996**; Larsen, 1948; Tan and Giffen, 1995; Weber, 1963, 1982. *Digital preparation by*: Diane Burns.

San Onofre Bluff Quadrangle

Boss and others, 1958; Ehlig and Farley, 1976; Kern, 1996a; Kern, 1996b; **Tan, 1999c**. *Digital preparation by*: Amy C. Zach and Kelly R. Ruppert.

Temecula Quadrangle

Kennedy, 1977; Larsen, 1948; Mann, 1955; **Tan and Kennedy, 2000**. *Digital preparation by*: Brad L. Nelson and Gary W. Patt.

Valley Center Quadrangle

Kennedy, 1999; Larsen, 1948; Merriam, 1953. *Digital preparation by*: Anne G. Kennedy and Kelly R. Ruppert.

Offshore Region

Clarke and others, 1987; Ryan and others, (in preparation, in review). *Digital preparation by*: Rachel Alvarez and Carlos I. Gutierrez.

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