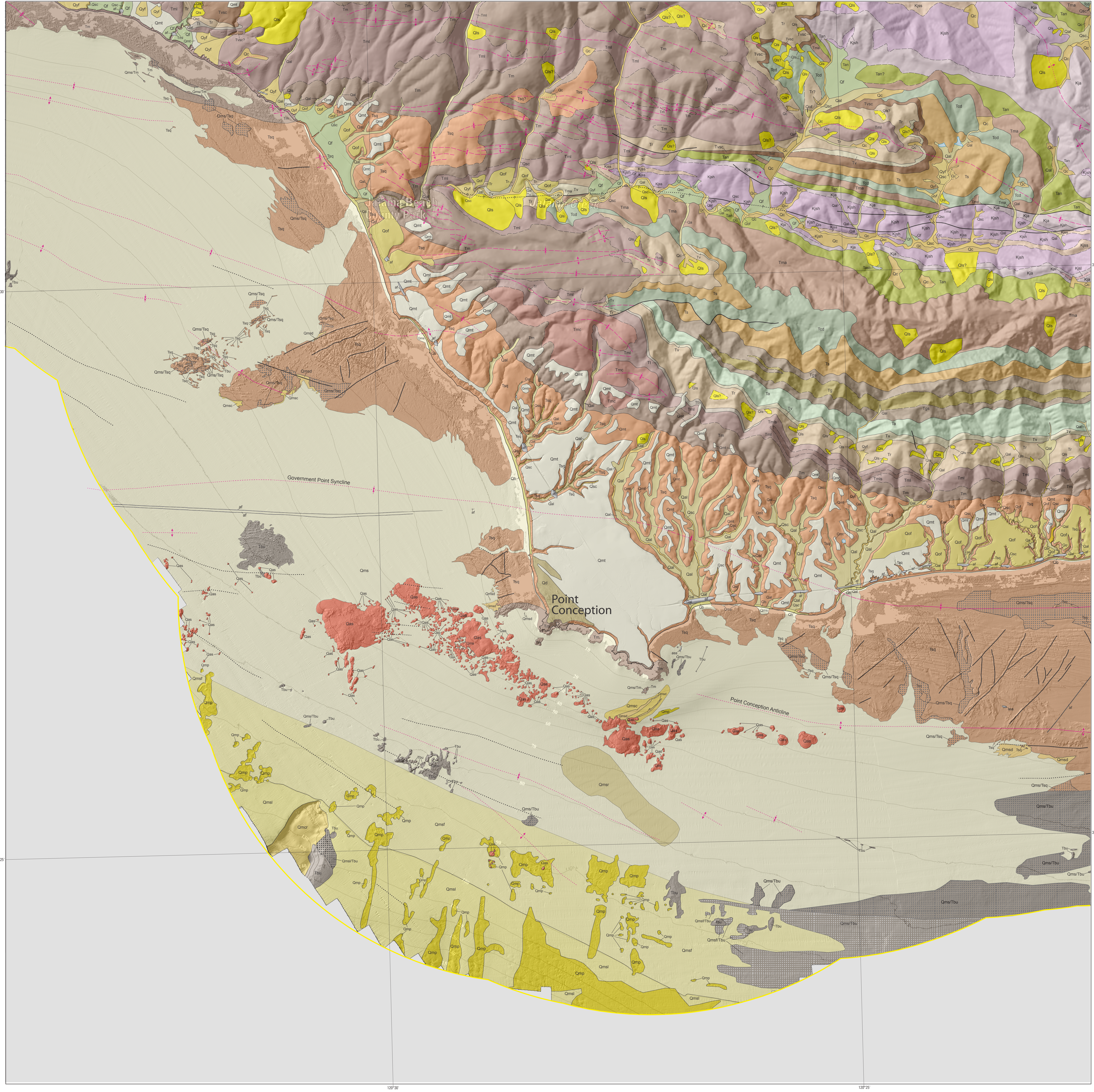
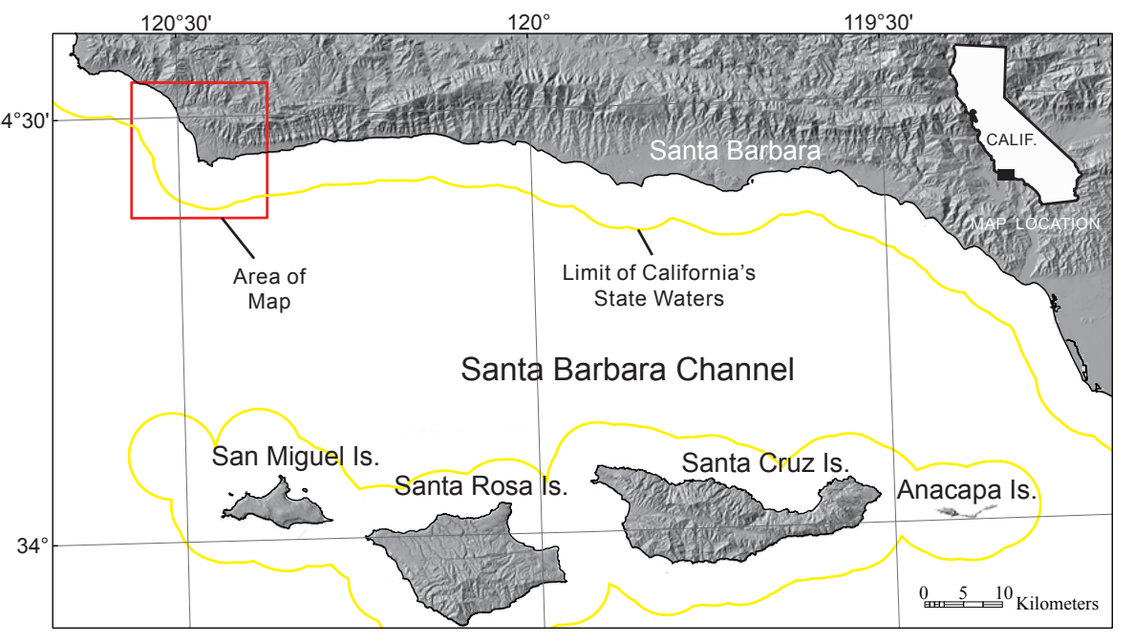
U.S. Department of the Interior
U.S. Geological Survey

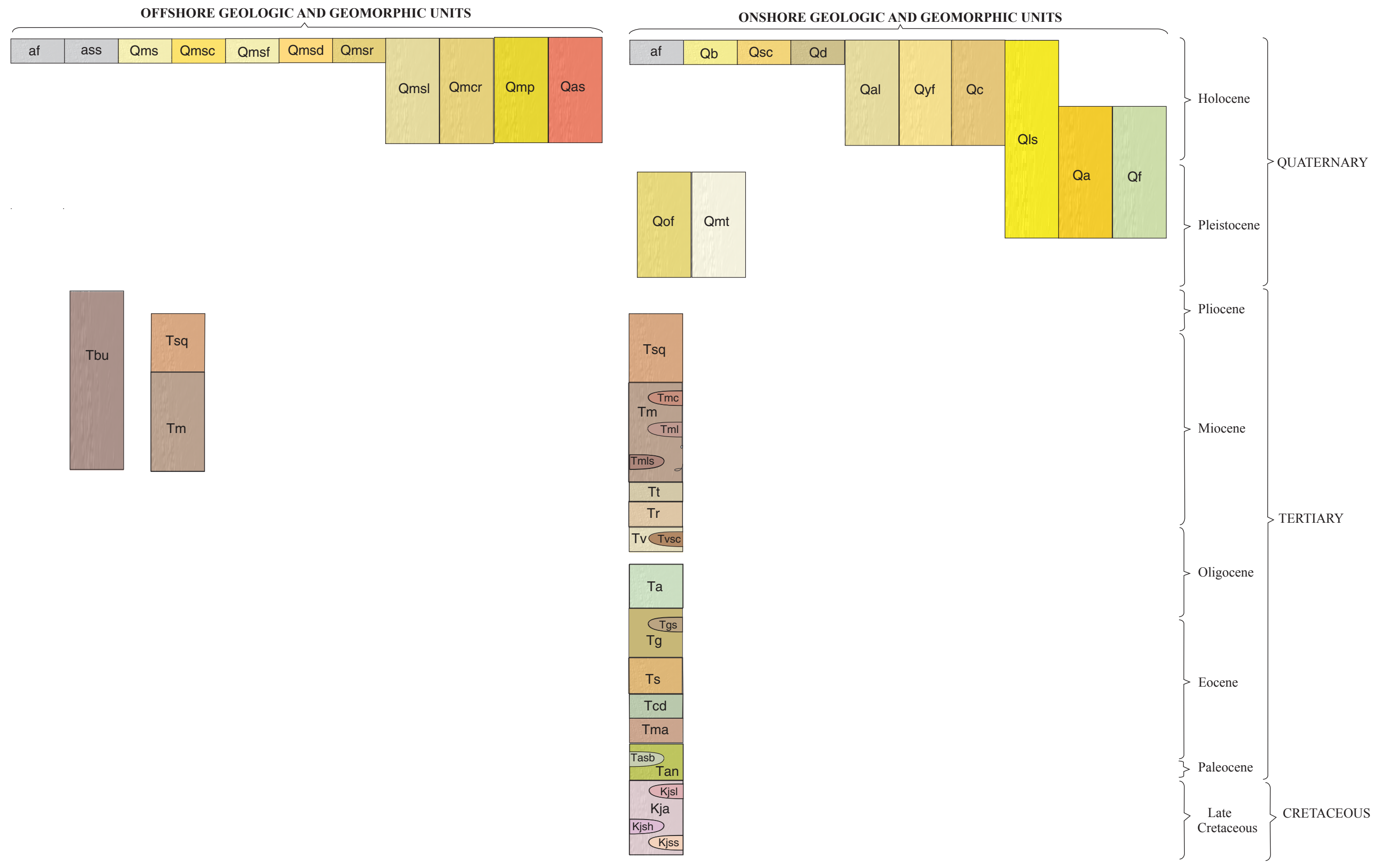
Open-File Report 2018–1024
Sheet 9 of 9
Pamphlet accompanies map





CORRELATION OF MAP UNITS

[See Description of Map Units (chapter 7, in pamphlet) for precise unit ages]



LIST OF MAP UNITS

[See Description of Map Units (chapter 7, in pamphlet) for complete map-unit descriptions]

OFFSHORE GEOLOGIC AND GEOMORPHIC UNITS

[Note that composite units (gray-, white-, and black-stippled areas) are designated on map by composite label indicating both overlying sediment cover and lower (older) unit, separated by a slash (for example, Qms/Tm indicates that thin sheet of Qms overlies Tm)]

af	**Artificial seafloor (late Holocene)**—Pipelines associated with offshore oil platforms
ass	**Artificially modified seafloor (late Holocene)**—Shipwreck(?)
Qms	**Marine nearshore and shelf deposits (late Holocene)**—Mostly sand; ripples common
Qmsc	**Coarse-grained marine nearshore and shelf deposits (late Holocene)**—Coarse sand and gravel to boulders
Qmsf	**Fine-grained marine shelf deposits (late Holocene)**—Mostly clay, silt, and very fine sand
Qmsd	**Marine shelf scour depressions (Holocene)**—Inferred to be coarse sand and gravel, in low-relief scour depressions
Qmsr	**Marine shelf sand ridges (Holocene)**—Field of low-relief (<60 cm) sand ridges and intervening troughs
Qmsl	**Marine upper slope deposits (Holocene)**—Mostly clay, silt, and very fine sand. Found below shelf break, at water depths of more than 100 m
Qmcr	**Marine slope canyons and rills (Holocene)**—Probably sand and mud; forms incised trough into shelf break and outer shelf southwest of Point Conception; one of five heads of informally named Arguello canyon
Qmp	**Marine pockmarks (Holocene)**—Sand and mud, in circular to elliptical pockmarks
Qas	**Asphalt deposits (Holocene)**—Asphalt (tar); weathered and biodegraded oil derived from underlying or nearby natural hydrocarbon seeps
Tbu	**Bedrock, undivided (Pliocene and Miocene)**—Mainly mudstone and siltstone. Probably consists of the lower Pliocene and upper Miocene Sisquoc Formation and the Miocene Monterey Formation
Tsq	**Sisquoc Formation (early Pliocene and late Miocene)**—Marine, tan- to white-weathering, diatomaceous mudstone and shale, conglomerate, and subordinate dolomite
Tm	**Monterey Formation (Miocene)**—Mainly siliceous and calcareous mudstone and shale

ONSHORE GEOLOGIC AND GEOMORPHIC UNITS

[Units compiled and modified from Dibblee (1988a,b); unit ages, which are from these sources, reflect local stratigraphic relations. In addition, some Quaternary units modified by C.W. Davenport on basis of analysis of 2004 ifSAR and 2009 lidar imagery]

af	**Artificial fill (late Holocene)**—Engineered and (or) nonengineered material deposited by humans
Qb	**Beach deposits (late Holocene)**—Unconsolidated, fine- to coarse-grained sand, pebbles, and boulders. Mapped in coastal band from shoreline to highest elevation of swash zone
Qsc	**Active stream-channel deposits (late Holocene)—**Active stream channels that contain unconsolidated sand, silt, and gravel deposits
Qd	**Dune-sand deposits (late Holocene)—**Very well sorted, fine to medium sand; forms active dunes along coast
Qal	**Alluvial deposits, undivided (Holocene)—**Sand, gravel, and silt deposits, adjacent to or near active stream channels
Qyf	**Alluvial fan deposits (Holocene)**—Unconsolidated, heterogeneous layers of sand, silt, and gravel; relatively undissected. Internal contacts delineate individual alluvial fans
Qc	**Colluvium (Holocene)**—Loose to firm, unsorted sand, silt, clay, gravel, rock debris, and organic material; includes slope wash and valley fill; may contain numerous small landslides and (or) coalesced alluvial fans
Qls	**Landslide deposits (Holocene and Pleistocene)**—Deposits of diverse slope-movement processes; queried where identity is uncertain. Internal contacts delineate individual landslide bodies
Qa	**Alluvial deposits, undivided (Holocene and Pleistocene)**—Sand, gravel, and silt deposits. Mapped on gently sloping to level surfaces near stream channels
Qf	**Alluvial fan deposits (Holocene and Pleistocene)**—Poorly consolidated silt, sand, and gravel deposits. Mapped either where older age is indicated by greater degree of dissection or where elevations are higher than that of adjacent Holocene alluvial fans
Qof	**Alluvial fan deposits (Pleistocene)**—Discontinuous or highly dissected deposits of semiconsolidated, moderately to poorly sorted layers of silty clay, silt, sand, and gravel
Qmt	**Marine-terrace deposits, undivided (Pleistocene)**—Semiconsolidated sand and local gravel deposits; on uplifted marine-abrasion platforms along coast
Tsq	**Sisquoc Formation (early Pliocene and late Miocene)**—Marine shale, claystone, and diatomite; queried where identity is uncertain
Tm	**Monterey Formation, undivided (Miocene)**—Marine, predominantly well-bedded, siliceous chert, mudstone, shale, diatomite, and conglomerate breccia. Locally divided into three subunits
Tmc	**Chert (Miocene)**
Tml	**Light-gray diatomite (Miocene)**
Tmls	**Semisiliceous shale (Miocene)**
Tt	**Tranquillon Volcanics (Miocene)**—Rhyolitic tuff breccia
Tr	**Rincon Shale (early Miocene)**—Marine shale or claystone; queried where identity is uncertain
Tv	**Vaqueros Formation (late Oligocene)**—Marine calcareous sandstone. Includes one subunit
Tvsc	**Sandstone and pebble conglomerate (late Oligocene)—**Queried where identity is uncertain
Ta	**Alegria Formation (Oligocene)**—Marine, arkosic sandstone and greenish-gray siltstone; locally fossiliferous (Dibblee, 1988a)
Tg	**Gaviota Formation (Oligocene and Eocene)**—Marine arkosic sandstone, locally fossiliferous; includes one subunit
Tgs	**Concretionary siltstone and claystone (Oligocene and Eocene)**
Ts	**Sacate Formation (Eocene)**—Marine arkosic sandstone that contains interbeds of micaceous, clayey shale
Tcd	**Cozy Dell Shale (Eocene)—**Marine micaceous shale
Tma	**Matilija Sandstone (Eocene)**—Marine arkosic sandstone
Tan	**Anita Shale (Eocene and Paleocene)**—Marine, micaceous, clayey shale; includes foraminiferal claystone (informally known as "Poppin shale"); queried where identity is uncertain. Also includes one mappable subunit
Tasb	**Sierra Blanca limestone (Eocene and Paleocene)**—Algal limestone lens
Kja	**Jalama Formation (Late Cretaceous)**—Marine arkosic sandstone; includes three subunits
Kjsl	**Siltstone (Late Cretaceous)**
Kjsh	**Micaceous shale and siltstone (Late Cretaceous)**
Kjss	**Arkosic sandstone with interbeds of micaceous shale (Late Cretaceous)**

EXPLANATION OF MAP SYMBOLS

―	**Contact**—Solid where location is certain or well located, dashed where location is approximate or inferred
━	**Fault**—Solid where location is certain, dashed where location is inferred, dotted where location is concealed, queried where uncertain
	Folds—Solid where location is certain, dashed where location is inferred, dotted where location is concealed
↕	**Anticline**
⇅	**Syncline**
―	**Approximate modern shoreline**—From National Oceanic and Atmospheric Administration's Shoreline Data Explorer (National Geodetic Survey, 2016)
━	**3-nautical-mile limit of California's State Waters**
▭	**Area of "no data"**—Areas beyond 3-nautical-mile limit of California's State Waters were not mapped as part of California Seafloor Mapping Program

DISCUSSION

Marine geology and geomorphology were mapped in the Offshore of Point Conception map area from the shoreline to the 3-nautical-mile limit of California's State Waters. The location of the shoreline, which is from the National Oceanic and Atmospheric Administration's (NOAA's) Shoreline Data Explorer, is based on their analysis of lidar imagery (National Geodetic Survey, 2016). Offshore geologic units were delineated on the basis of integrated analyses of adjacent onshore geology with multibeam bathymetry and backscatter imagery (sheets 1, 2, 3), seafloor-sediment and rock samples (Reid and others, 2006), digital camera and video imagery (Golden and Cochrane, 2013), and high-resolution seismic-reflection profiles (sheet 7). Bathymetric lidar and aerial photographs taken in multiple years were used to map the nearshore area (0 to 10 m water depth) and to link the offshore and onshore geology.

The onshore geology was compiled and modified from Dibblee (1988a,b); unit ages, which are derived from these sources, reflect local stratigraphic relations. In addition, some Quaternary units were modified by C.W. Davenport on the basis of analysis of 2004 ifSAR and 2009 lidar imagery.

The offshore part of the map area largely consists of a gently offshore-dipping shelf underlain by Neogene bedrock, as well as by Holocene sediments that are derived primarily from relatively small coastal watersheds that drain the Santa Ynez Mountains. The dip of the shelf gradually changes from about 1.1° south and east of Point Conception to about 0.7° on the broader shelf west of Point Conception. Holocene nearshore and shelf deposits are primarily sand (unit Qms). A distinct field (about 1.15 km^2) of northeast-trending (about 60° azimuth) low-relief sand ridges (unit Qmsr) is present in the midshelf area about 1.5 to 3.0 km south of Point Conception, at water depths of 65 to 80 m; the crests of the sand ridges are as high as 60 cm and as long as 750 m long, and they are spaced at intervals of about 125 to 200 m.

Coarser grained sediments (units Qmsc, Qmsd) are mapped on the basis of their high backscatter and, in some cases, their moderate seafloor relief. Unit Qmsc, which ranges from coarse sand and gravel to possibly boulders, is found as (1) a southwest-trending lens about 650 m south of Point Conception, at depths of 15 to 40 m, and (2) along the margins of seafloor bedrock outcrops between Point Conception and Point Arguello, at depths of about 30 to 50 m. Unit Qmsd, inferred to consist of coarse sand and possibly gravel, is found as single depressions or in groups of depressions interspersed with elevated shelf sediments (unit Qms) adjacent to seafloor bedrock outcrops, at water depths of about 15 to 40 m. Areas in which unit is found are not likely to change substantially, but the boundaries of unit(s) and locations of individual depressions (and intervening flat sheets) likely are ephemeral, changing during significant storm events.

Finer grained sediment—the very fine sand, silt, and clay of unit Qmsf—is mapped between depths of about 80 m and the shelf break, which is present only in the southwesternmost part of the map area, at a depth of about 100 m. The boundary between units Qms and Qmsf is based on observations and extrapolation from sparse sediment sampling (for example, Reid and others, 2006) and camera ground-truth surveying (Golden and Cochrane, 2013). Thus, the boundary between units Qms and Qmsf should be considered transitional and approximate and is expected to shift as a result of seasonal- to annual- to decadal-scale cycles in wave climate, sediment supply, and sediment transport.

Fine-grained deposits similar to unit Qmsf also are found below the shelf break on the upper slope at water depths greater than 100 m, where they are mapped as a separate unit (unit Qmsl) on the basis of their location and geomorphology. Both the shelf break and upper slope are incised by a 600-m-wide, 20- to 30-m-deep, south-facing trough, probably filled with sand and mud (unit Qmcr), that is one of the five heads of the informally named Arguello submarine canyon (Greene and others, 1991; Eichhubl and others, 2002; Monterey Bay Aquarium Research Institute, 2002).

Bedrock exposures along the shoreline both north and east of Point Conception primarily consist of marine shale, claystone, and diatomite of the upper Miocene and lower Pliocene Sisquoc Formation (unit Tsq). Adjacent Tsq seafloor outcrops commonly have a "ribbed" appearance, reflecting the differential erosion of variably resistant interbeds. Unit Tsq overlies the Miocene Monterey Formation (Tm), which crops out on the seafloor in the nearshore on the west flank of Government Point, as well as in the nearshore to inner shelf areas in the northwestern part of the map area. Because of the lack of sampling and their relative lack of distinctive seafloor morphology, some seafloor bedrock outcrops cannot be confidently assigned to either unit Tm or unit Tsq; these areas are mapped as the undivided Tertiary bedrock unit (Tbu).

The Santa Barbara Channel region is a mature hydrocarbon province (Kunitomi and others, 1998) that is well known for hydrocarbon-induced seafloor topography (Keller and others, 2007). Geomorphic features associated with petroleum seepage on the shelf and upper slope, which are prevalent near Point Conception (Draut and others, 2009; Lorenson and others, 2009, 2014), include fields of dense pockmarks (unit Qmp) and asphalt mounds (unit Qas). In the Offshore of Point Conception map area, pockmarks are predominantly grouped or, less commonly, solitary; are circular to elliptical; range in size from 50 to 150 m along their long axis; typically are 20 to 40 cm deep; and commonly have a central cone as much as 150 cm high. Grouped pockmarks cover about 4.2 km^2 of the map area (see table 7–1 in pamphlet). The largest mapped asphalt mounds cover 675,856 m^2 and 168,950 m^2, and they have as much as about 12 m of relief above the seafloor. Draut and others (2009) noted that such large mounds likely consist of a mix of tar and sediment, and Lorenson and others (2014) calculated areas and volumes of asphalt in the Point Conception area and the larger Santa Barbara Channel region. The asphalt mounds in the Offshore of Point Conception map area, which are mainly found on the south flank of the Point Conception Anticline, cover about 2.6 km^2 (table 7–1 in pamphlet).

Pipelines through California's State Waters, which are associated with petroleum platforms located farther offshore in federal waters, are mapped as unit af. The remains of two large (about 75 and 60 m long) ships, mapped as unit ass, are located about 550 m northeast of Government Point, at a water depth of 10 m, and about 5.8 km east of Government Point, at a depth of 22 m.

Neogene strata are deformed in a fold belt that, on a regional scale, is located within a large, east-west-striking, south-dipping homocline that extends from the south flank of the Santa Ynez Mountains into the offshore to the south and west. Nearby regional cross sections (Redin and others, 2005) and industry seismic-reflection profiles (see fig. 10 on sheet 7; see also, Sorlien and Nicholson, 2015) showed that the homocline formed above the blind Pitas Point–North Channel Fault system, which in the offshore extends westward for more than 100 km, from Pitas Point (10 km northwest of Ventura) to beyond Point Conception. South of Point Conception, the tip of the Pitas Point–North Channel Fault is inferred to be buried beneath the slope about 5 to 6 km offshore, to a depth of about 2 to 3 km below sea level.

In the offshore part of the map area, closely spaced seismic-reflection profiles (see sheet 7) image many shallow, west-northwest-striking folds that have variable geometries, lengths, amplitudes, degrees of continuity, and wavelengths. The Government Point Syncline, which is the most prominent fold, has been mapped both onshore at Point Conception (Dibblee, 1988a) and in the offshore both to the west and east; it has a cumulative length of more than 22 km. Local thickening of post-LGM sediments along the axis of the Government Point Syncline (see figs. 2, 3, and 4 on sheet 7) could reflect syn-tectonic sedimentation. Onland at Point Conception, Rockwell and others (1992) also documented active folding of late Pleistocene marine terraces in the Government Point Syncline. This regionally extensive syncline and many shorter, east-west-striking folds and faults probably are rooted in blind thrust faults and back-thrust faults in the hanging wall above the Pitas Point–North Channel Fault system.

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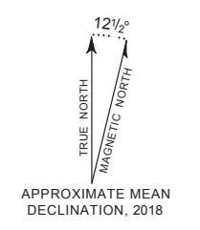
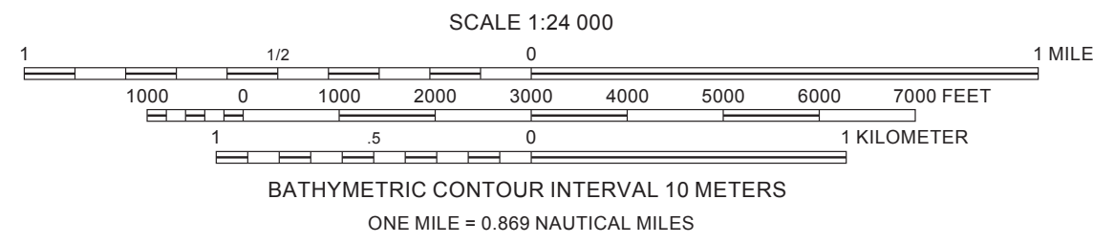
Onshore elevation data from National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management's Digital Coast (available at http://www.csc.noaa.gov/digitalcoast/data/coastallidar/) and from U.S. Geological Survey's National Elevation Dataset (available at http://ned.usgs.gov/). Offshore shaded relief bathymetry from map on sheet 2, this report. California's State Waters limit from NOAA Office of Coast Survey

Universal Transverse Mercator projection, Zone 10N

NOT INTENDED FOR NAVIGATIONAL USE





Offshore geology and geomorphology mapped by Samuel Y. Johnson and Stephen R. Hartwell, 2016. Onshore geology and geomorphology compiled and modified by Clifton W. Davenport, 2014, from Dibblee (1988a,b). Bathymetric contours by Peter Dartnell, 2014

GIS database and digital cartography by Stephen R. Hartwell and Peter Dartnell

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Offshore and Onshore Geology and Geomorphology, Offshore of Point Conception Map Area, California

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