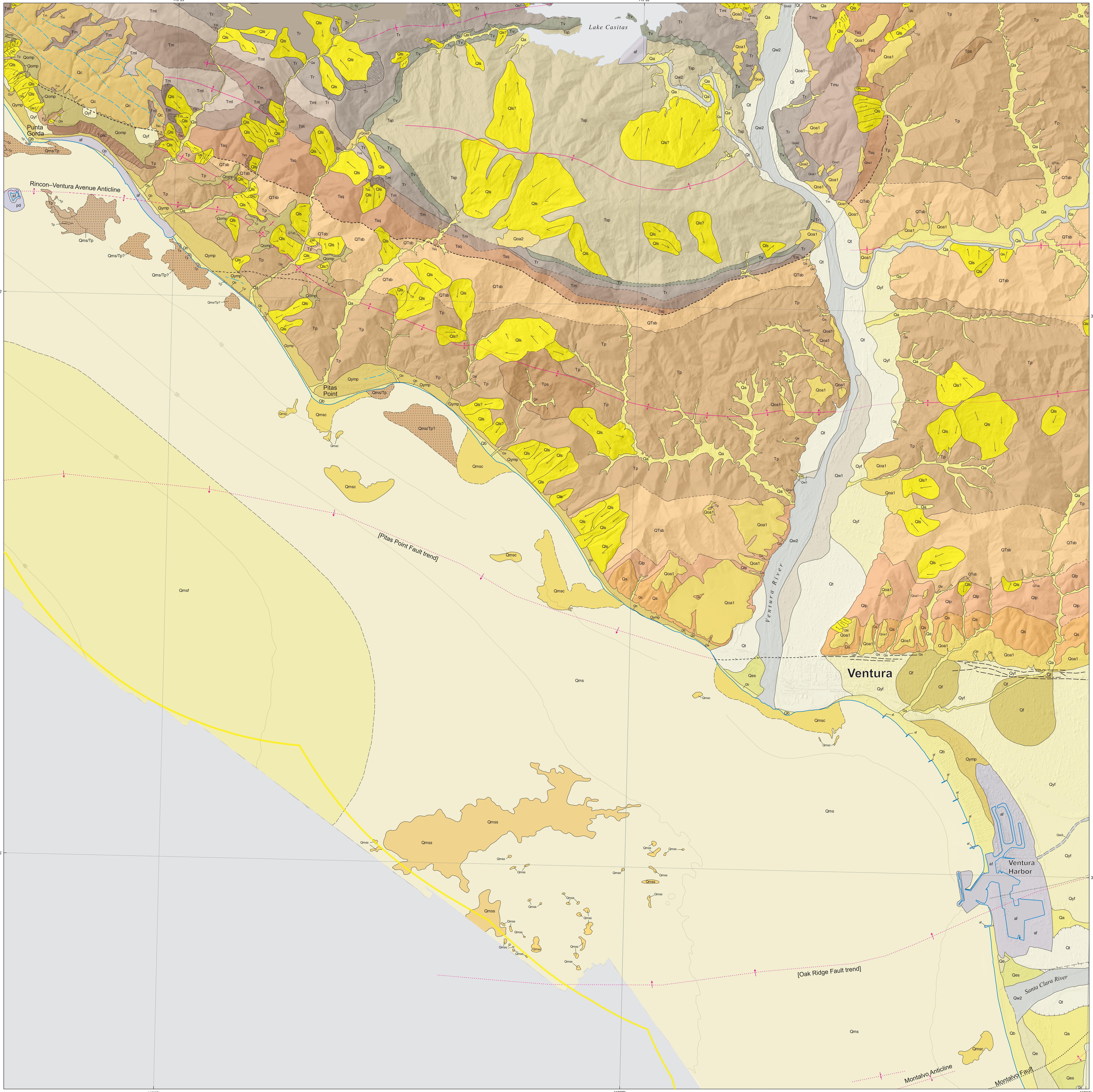
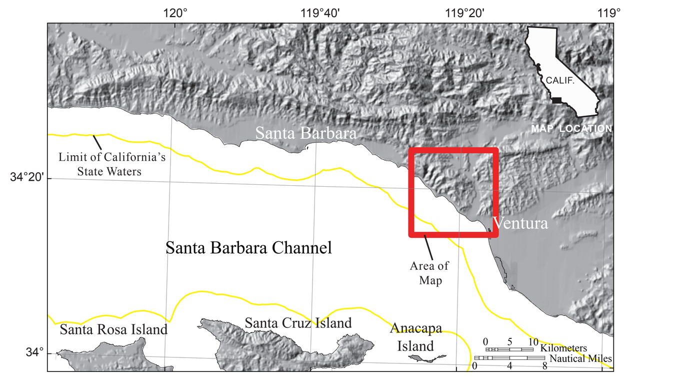
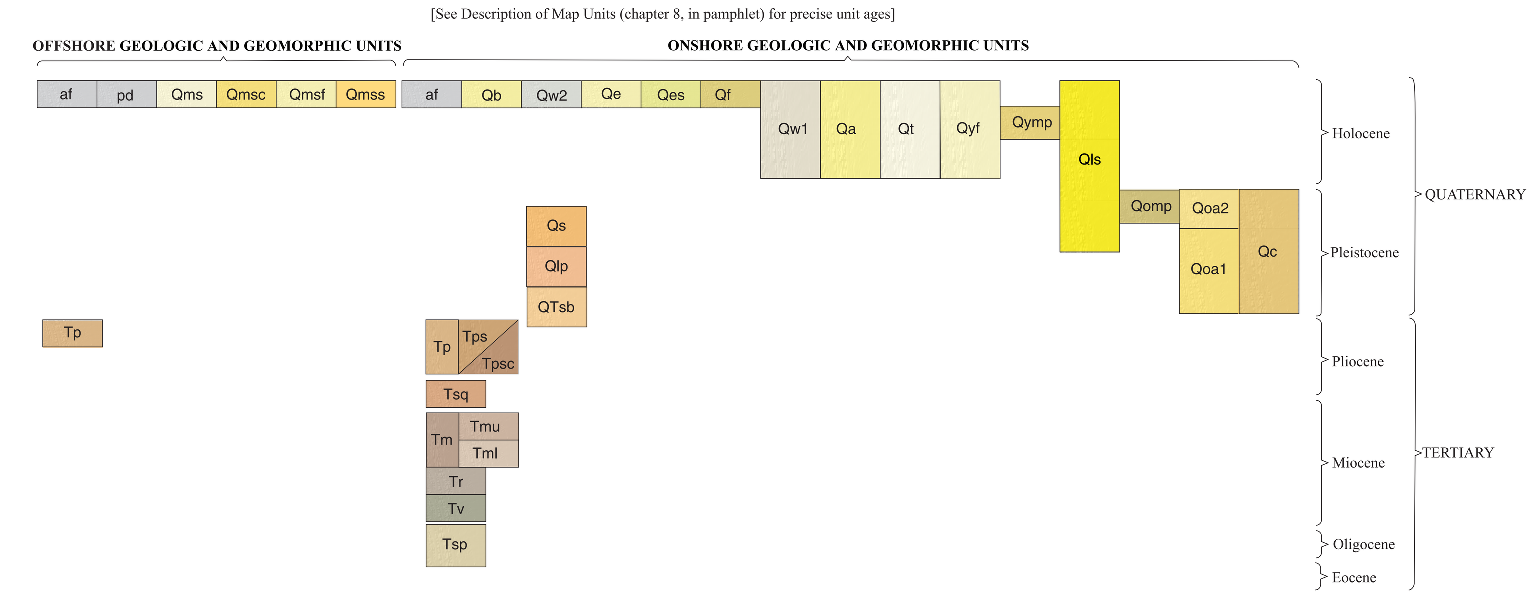




CORRELATION OF MAP UNITS

[See Description of Map Units (chapter 8, in pamphlet) for precise unit ages]



LIST OF MAP UNITS

[See Description of Map Units (chapter 8, in pamphlet) for complete map-unit descriptions]

OFFSHORE GEOLOGIC AND GEOMORPHIC UNITS

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

af **Artificial fill (late Holocene)**—Rock, sand, and mud; placed and (or) dredged

pd **Platform debris (late Holocene)**—Mixed coarse sediment and construction debris surrounding Rincon Island

Qms **Marine nearshore and shelf deposits (late Holocene)**—Mostly sand; ripples common

Qmsc **Coarse-grained marine nearshore and shelf deposits (late Holocene)**—Coarse sand, gravel, and cobbles

Qmsf **Fine-grained marine shelf deposits (late Holocene)**—Mostly mud to muddy sand

Qmss **Marine shelf scour depressions (late Holocene)**—Inferred to be coarse sand and gravel in low-relief scours

Tp **Pico Formation (Pliocene)**

ONSHORE GEOLOGIC AND GEOMORPHIC UNITS

[Units are compiled from Dibblee (1986), Tan and others (2003a,b), and Tan and Clahan (2004). Unit ages, which are from Tan and others (2003a,b) and Minor and others (2009), reflect local stratigraphic relations]

af **Artificial fill (late Holocene)**—Engineered and (or) nonengineered

Qb **Beach deposits (late Holocene)**—Unconsolidated, loose, fine- to coarse-grained sand; well sorted

Qw2 **Wash deposits (late Holocene)**—Unconsolidated silt, sand, and gravel. Located in major active river channels

Qe **Coastal eolian sand dune-deposits (late Holocene)**—Well-sorted, loose sand and silt

Qes **Coastal-estuarine deposits (late Holocene)**—Silty clay

Qf **Alluvial fan deposits (late Holocene)**—Moderately to poorly bedded sandy clay with some gravel

Qw1 **Wash deposits (Holocene)**—Unconsolidated silt, sand, and gravel

Qa **Alluvium and colluvium, undivided (Holocene)**—Primarily sandy clay with some gravel

Qt **Stream-terrace deposits (Holocene)**—Clayey sand and sandy clay with gravel

Qyf **Alluvial fan deposits (Holocene)**—Moderately to poorly sorted sandy clay with gravel

Qymp **Paralic deposits of Sea Cliff marine terrace (Holocene)**—Sandy clay with some gravel

Qls **Landslide deposits and colluvium, undivided (Holocene and Pleistocene)**—Weathered rocks and soil

Qomp **Paralic deposits of Punta Gorda marine terrace (late Pleistocene)**—Clayey sand with gravel lenses

Qoa2 **Older alluvial deposits (late and middle Pleistocene)**—Silt, sand, clay, and gravel

Qoa1 **Older alluvial deposits (middle and early Pleistocene)**—Gravel, sand, silt, clay, and boulders

Qc **Colluvium (Pleistocene)**—Silt, sand, clay, and gravel

Qs **Saugus Formation (Pleistocene)**—Sandstone and siliceous shale, gravel, and cobbles

Qlp **Las Posas Formation (Pleistocene)**—Sandstone and gravelly sand

QTsb **Santa Barbara Formation (Pleistocene and Pliocene)**—Claystone; locally contains shale fragments

Tp **Pico Formation, undivided (Pliocene)—**Claystone, siltstone, and sandstone; locally pebbly

Tps **Sandstone**

Tpsc **Sandstone and conglomerate**

Tsq **Sisquoc Formation (Pliocene and Miocene)**—Silty shale and claystone

Tm **Monterey Formation, undivided (Miocene)**—Siliceous and diatomaceous shale, sandstone, and limestone

Tmu **Upper unit (late Miocene)**—Mainly diatomaceous mudstone and shale

Tml **Lower, calcareous unit (middle and early Miocene)**—Predominantly mudstone and shale

Tr **Rincon Shale (Miocene)**—Shale and siltstone

Tv **Vaqueros Formation (Miocene)**—Sandstone; locally calcareous

Tsp **Sespe Formation (Oligocene to late Eocene)**—Sandstone, siltstone, and claystone; locally pebbly

EXPLANATION OF MAP SYMBOLS

Contact—Solid where location is certain, long-dashed where location is approximate, short-dashed where location is inferred, dotted where location is concealed

Fluvial-terrace scarp—Denotes fluvial terrace within unit Qt; in places, also forms terraced alluvial contact between units Qt and Qa. Dashed where location is approximate, queried where uncertain. Hachures point downscarp

Landslide complex—Arrow(s) show direction of downslope movement; pattern shows area of slip surface and direction of slip

Fault—Long-dashed where location is approximate, short-dashed where location is inferred, dotted where location is concealed, queried where uncertain

Folds—Solid where location is certain, long-dashed where location is approximate, short-dashed where location is inferred, dotted where location is concealed

Antiform

Synform

Monoform

Former shoreline or marine limit

Approximate modern shoreline—Defined as Mean High Water (MHW) (+1.33 m), North American Vertical Datum of 1988 (NAVD 1988)

3-nautical-mile limit of California's State Waters

Area of "no data"—Areas beyond the 3-nautical-mile limit of California's State Waters were not mapped as part of the California Seafloor Mapping Program

DISCUSSION

Marine geology and geomorphology was mapped in the Offshore of Ventura map area from approximate Mean High Water (MHW) to the 3-nautical-mile limit of California's State Waters. MHW is defined at an elevation of 1.33 m above the North American Vertical Datum of 1988 (NAVD 88) (Weber and others, 2005). 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 (sheet 6), and high-resolution seismic-reflection profiles (sheet 8).

The onshore geology was compiled from Dibblee (1986), Tan and others (2003a,b), and Tan and Clahan (2004). Unit ages, which are from Tan and others (2003a,b) and Minor and others (2009), reflect local stratigraphic relations.

The offshore part of the map area largely consists of a relatively shallow (less than about 40 m deep), gently offshore-dipping (less than 1°) shelf underlain by recent deltaic deposits of the Santa Clara and Ventura Rivers. The mean annual sediment load of these two rivers exceeds 3.25 kilotons per year (Warrick and Farnsworth, 2009a), and the area is largely part of an extensive Quaternary deltaic depocenter (Dahlen, 1992; Slater and others, 2002; Sommerfield and others, 2009). Shelf deposits are primarily sand (unit Qms) at depths less than about 25 m and, at depths greater than about 25 m, are more fine-grained sediment (very fine sand, silt, and clay) of unit Qmsf. The boundary between units Qms and Qmsf is based on observations and extrapolation from sediment sampling (see, for example, Reid and others, 2006) and camera ground-truth surveying (see sheet 6). Given that this is an area of abundant sediment supply and active sediment transport (Barnard and others, 2009; Warrick and Farnsworth, 2009a), it is important to note that 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.

Offshore of the mouth of the Ventura River, at water depths of between 20 and 30 m, the sandy shelf (unit Qms) includes an area of irregular arcuate depressions floored by coarser sediment (coarse sand and possibly gravel; unit Qmss). Such features have been referred to as "rippled-scour depressions" (see, for example, Cacchione and others, 1984) or "sorted bedforms" (see, for example, Goff and others, 2005; Trembanis and Hume, 2011). Although the general area in which unit Qmss depressions are found is not likely to change substantially, the boundaries of the unit(s), as well as the locations of individual depressions and their intervening flat sand sheets, likely are ephemeral, changing during significant storm events.

Coarser grained deposits (unit Qmsc), which are recognized on the basis of high backscatter (sheet 3), camera observations (sheet 6), and sampling (Reid and others, 2006; Barnard and others, 2009), are found locally in water depths less than about 15 m. These units are concentrated at the mouths of the Santa Clara and Ventura Rivers and a few smaller coastal watersheds to the northwest, and they are inferred to represent wave-winnowed lags of deltaic sediment. It is likely that these deposits are ephemeral and are commonly covered by finer grained sediment. However, a few areas of unit Qmsc between Ventura and Pitas Point are not obviously tied to coastal watersheds. One large area in particular is characterized by high rugosity (see Box A on sheet 5) and high backscatter (see sheet 3); camera ground-truth surveying (see fig. 2 on sheet 6) reveals that this area consists of boulders, cobbles, gravel, and sand. The area lies immediately offshore of steep slopes underlain by variably consolidated Pliocene and Pleistocene deposits (sand, gravel, cobbles) of the Pico, Santa Barbara, and Saugus Formations (onshore units Tp, QTsb, and Qs, respectively), which are highly susceptible to landsliding (Tan and others, 2003a,b); thus, this area most likely represents wave-winnowed landslide deposits. It is also possible that these high-backscatter areas are partly underlain by bedrock, as is inferred on sheet 7. The steep onshore slopes are immediately north of, and in the hanging wall of, the active Pitas Point Fault, a location that undoubtedly has contributed to slope instability.

The seafloor bedrock exposures south and west of Punta Gorda are inferred to consist of the Pico Formation (unit Tp; Tan and others, 2003a,b), on the basis of their backscatter, rugosity, and relief, as well as adjacent exposures of unit Tp in coastal bluffs and platforms and their similar location along the axis of the Rincon–Ventura Avenue Anticline (Tan and others, 2003a). A few shallow (less than 10 m deep) areas offshore between Punta Gorda and Pitas Point are inferred to be underlain by a composite unit (Qms/Tp) consisting of the Pico Formation overlain by a thin (probably ephemeral) marine-sediment layer.

The Offshore of Ventura map area is in the Ventura Basin, in the southern part of the Western Transverse Ranges geologic province, which is north of the California Continental Borderland (Fisher and others, 2009). This province has undergone significant north-south compression since the Miocene, and recent GPS data suggest north-south shortening of about 6 to 10 mm/yr (Larson and Webb, 1992; Donnellan and others, 1993). The active, north-verging Oak Ridge Fault and the south-verging Pitas Point Fault (continuous with the onshore Ventura Fault) are two of the structures on which this shortening occurs (see, for example, Sorlien and others, 2000; Fisher and others, 2005, 2009). High-resolution seismic-reflection profiles (sheet 8) reveal that neither fault ruptures the surface; instead, the surface expression of each fault is a narrow, asymmetric fold that involves the uppermost Pleistocene and Holocene (younger than 21 ka) sedimentary section. Both structures are inferred to be parts of long fault systems that extend for more than 100 km, representing important potential earthquake hazards (see, for example, Fisher and others, 2009). Shortening is also occurring on the Montalvo Fault and Anticline system along the southeast edge of the map area (part of the broader Oak Ridge Fault Zone; Yeats, 1998) and on the Rincon–Ventura Avenue Anticline (see, for example, Rockwell and others, 1988), which crosses the northwest edge of the map area.

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Onshore elevation data from NOAA Coastal Services Center (data collected by EarthData International in 2002-2003). 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 11N

NOT INTENDED FOR NAVIGATIONAL USE

APPROXIMATE MEAN DECLINATION, 2013

SCALE 1:24 000

BATHYMETRIC CONTOUR INTERVAL 10 METERS
ONE MILE = 0.869 NAUTICAL MILES

MAP LOCATION

Offshore and Onshore Geology and Geomorphology, Offshore of Ventura Map Area, California

By
Samuel Y. Johnson,[1] Andrew C. Ritchie,[1] Gordon G. Seitz,[2] and Carlos I. Gutierrez[2]
2013

[1]U.S. Geological Survey;
[2]California Geological Survey

Offshore geology and geomorphology mapped by Samuel Y. Johnson and Andrew C. Ritchie, 2010-2011. Onshore geology and geomorphology compiled by Gordon G. Seitz and Carlos I. Guiterrez from Dibblee (1986), Tan and others (2003a,b), and Tan and Clahan (2004). Bathymetric contours by Andrew C. Ritchie, 2011
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