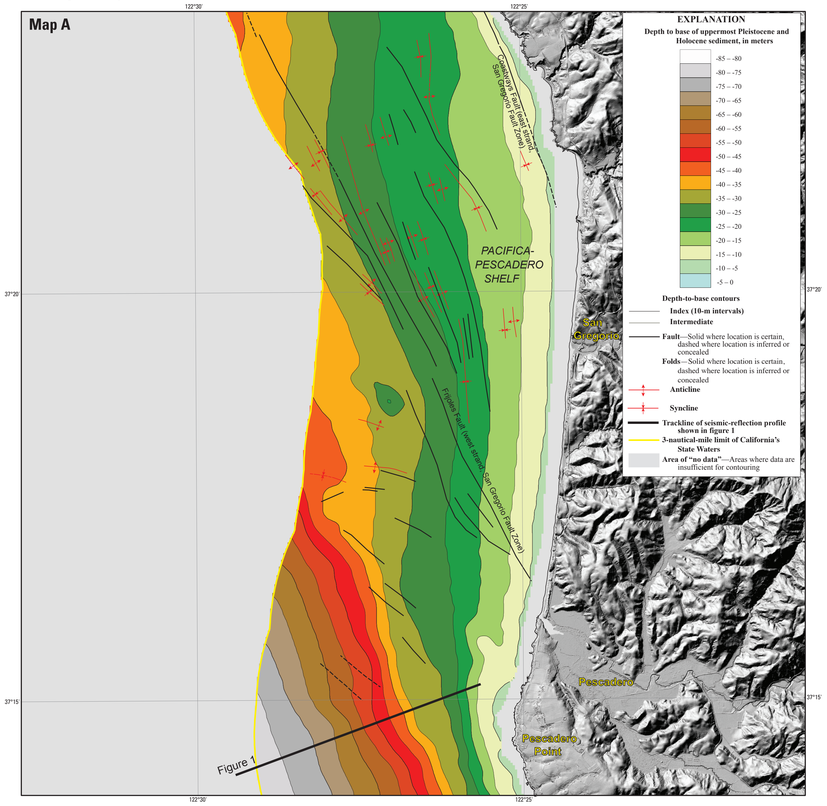
U.S. Department of the Interior
U.S. Geological Survey

Scientific Investigations Map 3306
Sheet 9 of 10
Pamphlet accompanies map



Onshore elevation data collected by Photoscience in 2005 for U.S. Geological Survey and County of San Mateo. California's State Waters limit from NOAA Office of Coast Survey
Universal Transverse Mercator projection, Zone 10N

APPROXIMATE MEAN DECLINATION, 2014

SCALE 1:50 000
2 0 2 MILES
7000 3500 0 7000 FEET
1 0.5 0 1 KILOMETER
1 0 1 2 3 4 5 KILOMETERS
ONE MILE = 0.869 NAUTICAL MILES

MAP LOCATION

Depth and thickness mapped by Janet T. Watt and Stephen R. Hartwell, 2011-2012
GIS database and digital cartography by Janet T. Watt., Stephen R. Hartwell, Eleyne L. Phillips, and Florence L. Wong

DISCUSSION

This sheet includes maps that show the interpreted thickness and the depth to base of uppermost Pleistocene and Holocene deposits in California's State Waters for the Offshore of San Gregorio map area (Maps A, B), as well as for a larger area that extends about 91 km along the coast from Bolinas to Pescadero (Maps C, D) to establish a regional context. This uppermost stratigraphic unit (blue shading in seismic-reflection profile of fig. 1; see also, figs. 6, 7, 8, 9, 11 on sheet 8) is inferred to have been deposited during the post–Last Glacial Maximum (LGM) sea-level rise in the last about 21,000 years (see, for example, Peltier and Fairbanks, 2006; Stanford and others, 2011). The unit commonly is characterized either by "acoustic transparency" or by parallel, low-amplitude, low- to high-frequency, continuous to moderately continuous, diffuse reflections (terminology from Mitchum and others, 1977). The acoustic transparency can be caused by extensive wave winnowing, which results in a uniform sediment grain size and the consequent lack of acoustic-impedance contrasts needed to produce seismic reflections. On the continental shelf, the contact with underlying units is a transgressive surface of erosion commonly marked by angularity, channeling, or a distinct upward change to lower amplitude, more diffuse reflections.

To make these maps, water bottom and depth to base of the post-LGM horizons were mapped from seismic-reflection profiles (fig. 1; see also, sheet 8 of this report). The difference in the two horizons was exported for every shot point as XY coordinates (UTM zone 10) and two-way travel time (TWT). The thickness of the post-LGM unit (Maps B, D) was determined by applying a sound velocity of 1,600 m/sec to the TWT. The thickness points were interpolated to a preliminary continuous surface, overlaid with zero-thickness bedrock outcrops (sheet 10 of this report), and contoured, following the methodology of Weng and others (2012).

The thickness data points are dense along tracklines (about 1 m apart) and sparse between tracklines (1 km apart), resulting in minor contouring artifacts. To incorporate the effect of a few rapid thickness changes along faults, to remove irregularities from interpolation, and to reflect other geologic information and complexity, minor manual editing of the preliminary thickness contours was undertaken. Contour modifications and regridding were repeated several times to produce the final sediment-thickness maps. Information for the depth to base of the post-LGM unit (Maps A, C) was generated by adding the sediment-thickness data to water depths determined by multibeam bathymetry (sheet 1 of this report).

The thickness of the post-LGM unit in the Offshore of San Gregorio map area ranges from 0 to 23 m (Map B), and the depth to base of the unit ranges from less than 10 to 76 m (Map A). The relatively thin sediment cover over most of the area suggests a lack of sediment "accommodation space" (Catuneanu, 2006), consistent with regional uplift expressed by the young, high topography of the Santa Cruz Mountains and Coast Ranges, as well as nearby uplifted marine terraces (Weber, 1990; Lajoie and others, 1991; Brabb and others, 1998). The uplift raises and, therefore, exposes much of the shallow shelf to the high wave energy that is characteristic of this region (Barnard and others, 2007), so that sediments are efficiently reworked and then transported off the inner shelf and midshelf areas to deeper water. This uplift has been attributed to the northwest-transpressional bend in the San Andreas Fault about 15 to 25 km northeast of the map area (see, for example, Zoback and others, 1999). The San Gregorio Fault Zone, which cuts through the Offshore of San Gregorio map area, consists of an east strand ("Coastways Fault" or "Seal Cove Fault"), a west strand ("Frijoles Fault"), and related splay faults (fig. 2). McCulloch (1987) and Weber (1990) suggested that these faults divide the area into three separate blocks, distinguished by different basement rocks (fig. 2): the Santa Cruz Mountains block (east of the Coastways Fault), the Pomponio block (between the Frijoles and Coastways Faults), and the Pigeon Point block (west of the Frijoles Fault). Minimal amounts of sediment are present on the Santa Cruz Mountains and Pomponio blocks, whereas the thickest accumulation of sediment in the map area is on the west-dipping, wave-cut surface of the Pigeon Point block.

Five different "domains" of sediment thickness are recognized on the regional sediment-thickness map (Map D): (1) the Bolinas shelf, located west of the east strand of the San Gregorio Fault Zone, in the northwestern part of the regional map (Map D); (2) the San Andreas graben, located between the San Gregorio Fault Zone and the Golden Gate Fault, east-southeast of the Bolinas shelf and both southwest and southeast of the Marin shelf; (3) the Marin shelf, located both northeast and northwest of the San Andreas graben and north of the San Francisco ebb-tidal delta paleovalley; (4) the northeast-trending San Francisco ebb-tidal delta paleovalley, located outside the Golden Gate at the mouth of San Francisco Bay, between the Marin shelf and San Andreas graben on the north and the Pacifica-Pescadero shelf on the south; and (5) the Pacifica-Pescadero shelf, which is located south of the San Francisco ebb-tidal delta paleovalley and which extends south all the way to Pescadero Point (including all of the Offshore of San Gregorio map area).

The five sediment-thickness domains have distinct geologic controls. The Bolinas and Pacifica-Pescadero shelves are uplifting and are relatively sediment poor (mean sediment thicknesses of 0.8 and 3.6 m, respectively). Thicker sediment accumulations (as much as 20 m) on the western margins of the Pacifica-Pescadero shelf (within California's State Waters) are associated with west-side-down slip on the west strand of the San Gregorio Fault Zone and with deposition on the outboard, west-dipping Pigeon Point block (McCulloch, 1987; see also, fig. 2) farther south, offshore of Pescadero Point. The San Andreas graben is a rapidly subsiding, fault-controlled sedimentary basin that has sediment thicknesses of as much as 57 m; the Marin shelf forms the uplifted northeastern and northwestern margins of this basin. The San Francisco ebb-tidal delta is filling a paleovalley that formed during the last sea-level lowstand, with sediment thicknesses of as much as 32 m along the trough axis. Although the southern part of the San Andreas graben may extend into the paleovalley, the north flank of the paleovalley is used here as the boundary when calculating sediment volumes for the five sediment-thickness domains (see table 7–1 in accompanying pamphlet). Subsidence in the San Francisco ebb-tidal delta paleovalley and the San Andreas graben can be partly attributed to the northward change in strike of both the San Andreas and San Gregorio Fault Zones offshore of San Francisco, which has resulted in the local change from contractional deformation to extensional deformation (Zoback and others, 1999).

Map E shows the regional pattern of major faults and of earthquakes occurring between 1967 and April 2014 that have inferred or measured magnitudes of 2.0 and greater. Fault locations, which have been simplified, are compiled from our mapping within California's State Waters (see sheet 10 of this report) and from the U.S. Geological Survey's Quaternary fault and fold database (U.S. Geological Survey and California Geological Survey, 2010). Earthquake epicenters are from the Northern California Earthquake Data Center (2014), which is maintained by the U.S. Geological Survey and the University of California, Berkeley, Seismological Laboratory. Map E also shows the inferred location of the devastating great 1906 California earthquake (M7.8, 4/18/1906), thought to have nucleated on the San Andreas Fault offshore of San Francisco (see, for example, Bolt, 1968; Lomax, 2005). Map E clearly shows that the largest number of earthquakes in the region occur within the broad San Andreas Fault Zone between Pacifica and Bolinas; events west of the east strand of the San Gregorio Fault Zone and east of the Golden Gate Fault are much less common. Epicentral data indicate that recent seismicity in the Offshore of San Gregorio map area has been notably minimal.

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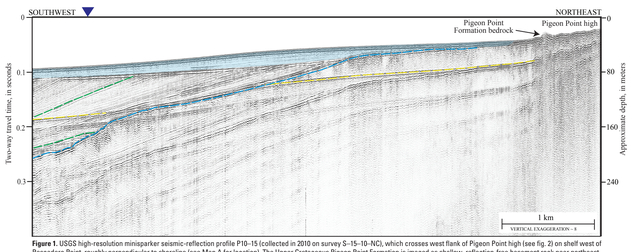


Figure 1. USGS high-resolution minisparker seismic-reflection profile P10–15 (collected in 2010 on survey S–15–10–NC), which crosses west flank of Pigeon Point high (see fig. 2) on shelf west of Pescadero Point, roughly perpendicular to shoreline (see Map A for location). The Upper Cretaceous Pigeon Point Formation is imaged as shallow, reflection-free basement rock near northeast end of profile. To southwest, these basement rocks are unconformably overlain by west-dipping strata inferred to be of Neogene and Pleistocene age that are, in turn, unconformably overlain by 2- to 20-m-thick layer of shelf strata (blue shading), inferred to be of latest Pleistocene and Holocene age (that is, deposited since last sea-level lowstand about 21,000 years ago). This uppermost unit thins to northeast and to southwest, suggesting deposition within shallow basin (see Map B). Dashed green lines highlight continuous, southwest-dipping reflections on west flank of Pigeon Point high. Dashed blue line shows erosional unconformity. Dashed yellow line is seafloor multiple (echo of seafloor reflector). Purple triangle shows location of California's State Waters limit (yellow line on Maps A, B, C, D, E).

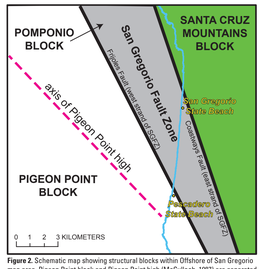
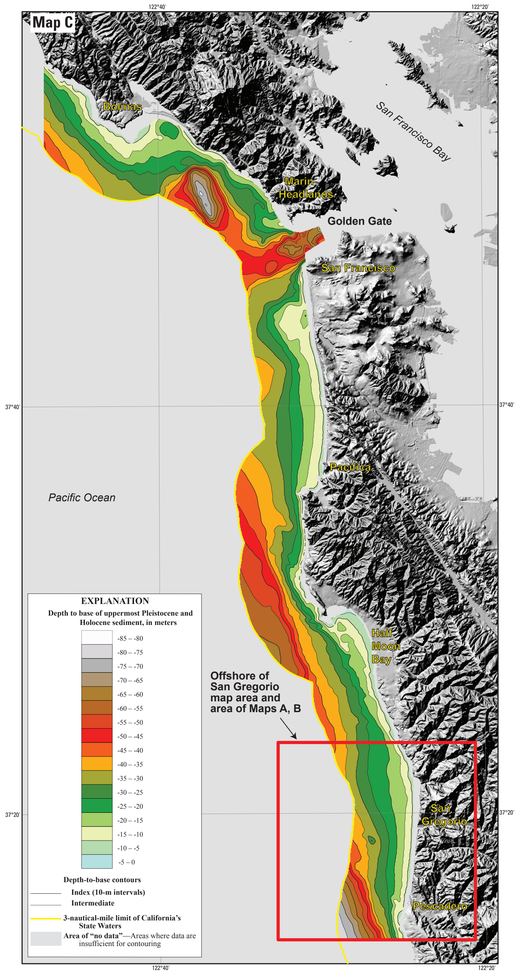
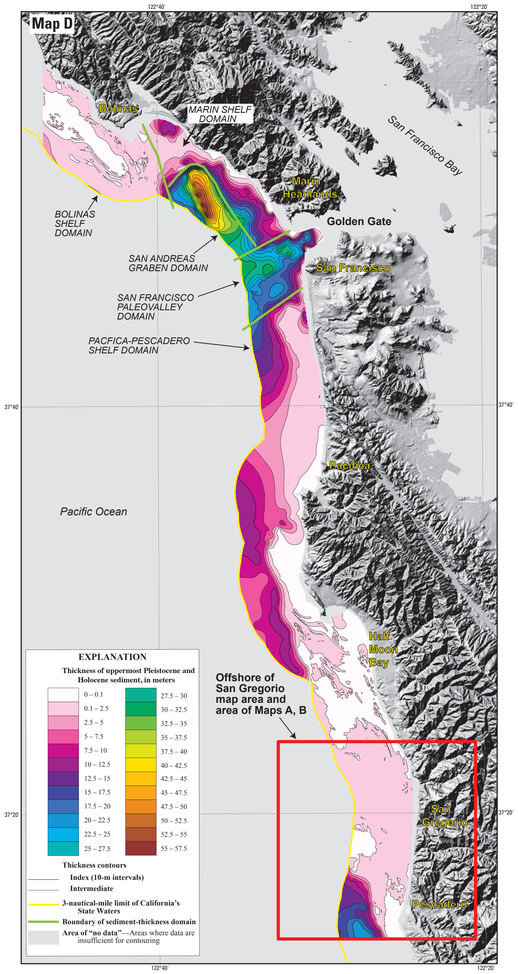
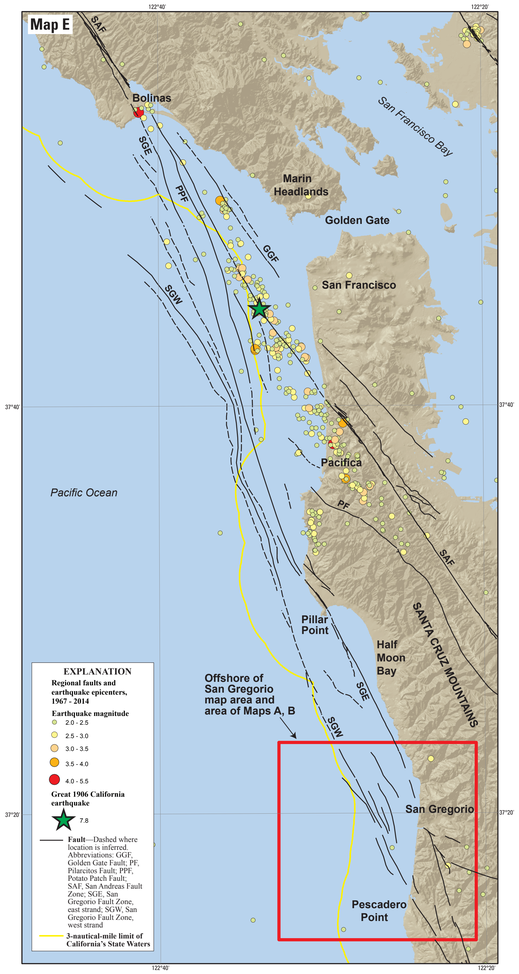


Figure 2. Schematic map showing structural blocks within Offshore of San Gregorio map area. Pigeon Point block and Pigeon Point high (McCulloch, 1987) are separated from Santa Cruz Mountains block by Pomponio block, which is bounded by Frijoles Fault (to west) and Coastways Fault (to east), two strands of San Gregorio Fault Zone (SGFZ). Blue line shows coastline. Modified from Weber (1990).







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Edited by Taryn A. Lindquist
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Local (Offshore of San Gregorio Map Area) and Regional (Offshore from Bolinas to Pescadero) Shallow-Subsurface Geology and Structure, California

By
Janet T. Watt, Stephen R. Hartwell, Samuel Y. Johnson, Ray W. Sliter, Eleyne L. Phillips, Stephanie L. Ross, and John L. Chin

2014

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