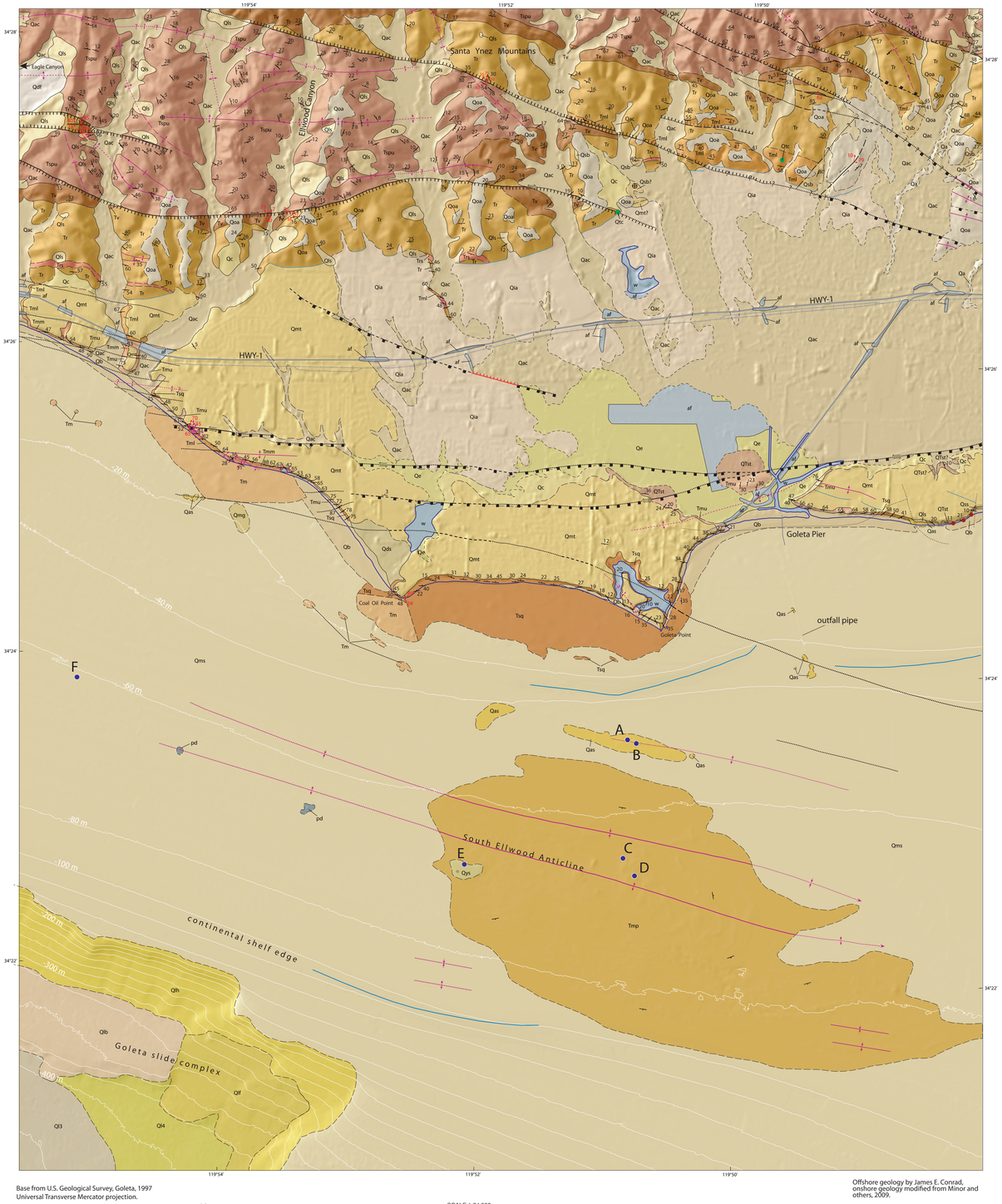
U.S. Department of the Interior
U.S. Geological Survey

Scientific Investigations Map 3124



Base from U.S. Geological Survey, Goleta, 1997
Universal Transverse Mercator projection.

Background shaded relief image generated from publicly available multibeam and bathymetric side-scan data and onshore IfSAR digital elevation models, all merged at 10-m spatial resolution. See "Data Sources and Availability".

APPROXIMATE MEAN DECLINATION, 2009

SCALE 1:24 000

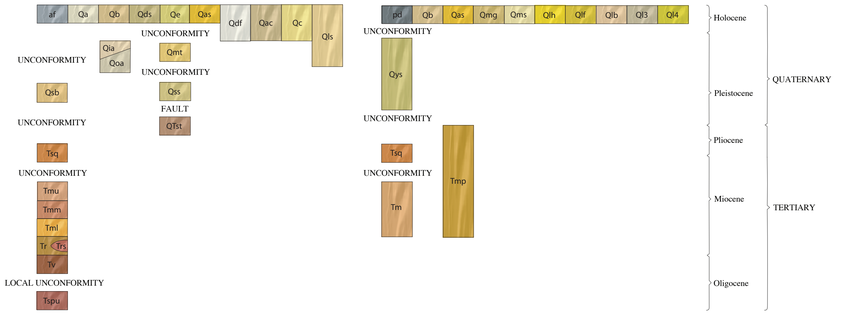
1 MILE
1 KILOMETER

Bathymetric contour interval 20 meters

Offshore geology by James E. Conrad, onshore geology modified from Minor and others, 2009.

MAP LOCATION

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

af — **Artificial fill (Holocene)**—Fill used for construction of highways, roads, buildings, airport runways, harbor facilities, breakwaters, and dams

pd — **Platform debris (Holocene)**—Mostly shelly debris shed off oil-platform structures, seep tents, and other equipment related to oil and gas recovery

Qa — **Active channel alluvium (Holocene)**—Unconsolidated sediments, primarily pebble to boulder gravel, in modern stream channels. Thickness less than 5 m

Qb — **Beach deposits (Holocene)**—Unconsolidated sand along coastal beaches. Thickness varies seasonally and rarely exceeds 5 m

Qds — **Dune sand (Holocene)**—Unconsolidated windblown sand forming coastal dunes northwest of Coal Oil Point

Qe — **Estuarine deposits (Holocene)**—Locally organic-rich clay, silt, and subordinate sand deposited primarily in peritidal environment in low-lying coastal areas of modern and historically active sloughs. Maximum thickness probably less than 20 m

Qas — **Asphalt deposits (Holocene)**—Black, tar-like asphalt that represents weathered and biodegraded oil derived from nearby natural seeps. Along modern shorelines typically found near asphalt-filled fractures in bedrock exposed in sea cliffs

Qmg — **Marine gravel deposit (Holocene)**—Unconsolidated gravel or shell debris, possibly of debris-flow origin, recognized on the basis of high reflectivity and sea-floor morphology

Qms — **Marine sedimentary deposit (Holocene)**—Unconsolidated marine sand, silt, and mud deposits

Qdf — **Debris flow deposits (Holocene and upper Pleistocene)**—Massive, weakly consolidated rock-debris breccia derived from rock units exposed upslope. Mainly located along lower flanks of Santa Ynez Mountains, where deposits estimated to be less than 5 m thick

Qac — **Alluvium and colluvium (Holocene and upper Pleistocene)**—Poorly consolidated silt, sand, and gravel deposits of modern drainages and piedmont alluvial fans and flood plains. Exposed thickness generally less than 10 m

Qc — **Colluvium (Holocene and upper Pleistocene)**—Poorly consolidated, poorly stratified, and poorly sorted deposits that mantle gentle to moderate slopes and are chiefly derived from weathering and down slope movement of nearby bedrock. Maximum thickness probably less than 15 m

Qls — **Landslide deposits (Holocene to middle Pleistocene)**—Deposits of diverse slope-movement processes ranging from poorly sorted, disrupted mixtures of rock fragments and soil to relatively intact bedrock slump blocks. Largest landslide deposits may be as thick as 60 m

Deposits of Goleta slide complex (Holocene)—Compound submarine slide complex, part of which is exposed in the southwest corner of map area. Source of slides is considered to be Pleistocene shelf-edge deltaic sediments deposited during glacial sea-level low stands, and age of the failure is 8 to 10 ka (Fisher and others, 2005). Subdivided by Greene and others (2006) into:

Qlf4 — **Fourth generation flow**—Youngest main flow of the Goleta slide

Qlf3 — **Third generation flow**—Third main flow unit of the Goleta slide

Qlf — **Head wall flow**—Secondary slides derived from the headwall that post-date the main slide complex

Qlb — **Head block**—Intact slump block at the base of the head wall

Qlh — **Head wall**—Intact marine sedimentary rocks (probably Tmp) exposed by slide

Qia — **Intermediate alluvial deposits (upper Pleistocene)**—Weakly consolidated, stratified silt, sand, and gravel that form low, rounded, moderately dissected terraces and piedmont alluvial fans that rest at higher elevations than the modern coastal piedmont surface underlain by unit Qac. Thickness probably locally exceeds 20 m

Qmt — **Marine-terrace deposits (upper Pleistocene)**—Weakly to moderately consolidated, variably stratified gravel, sand, and silt deposited as marine intertidal, beach, and estuarine deposits (fossiliferous in basal ~1 m) and overlying nonmarine eolian, alluvial, and colluvial deposits. Marine-terrace deposits rest on elevated marine wave-cut platforms and form single terraces or flights of terraces ranging in elevation from 10 to 90 m and in age from 45 ka (oxygen isotope substage 3a) to 105 ka (substage 5c). Maximum exposed thickness about 20 m

Qys — **Younger sedimentary rocks (upper Pleistocene?)**—Isolated outcrop of consolidated or semi-consolidated flat-lying sedimentary rocks, at least in part conglomeratic, unconformably overlying folded marine sedimentary rocks of Miocene and Pliocene age (Tmp). Deposit is 2 - 3 m thick

Qoa — **Older alluvial deposits (upper and middle Pleistocene)**—Moderately consolidated, erudely stratified, poorly sorted sand and sandstone, gravel, conglomerate, and breccia, and rare interbeds of clay, silt, and mudstone comprising proximal to distal facies of alluvial fans shed from the Santa Ynez Mountains. Unit forms dissected, gently south sloping elevated terraces, interfluvial caps, and other erosional remnants as thick as 35 m

Qsb — **Santa Barbara Formation (middle and lower Pleistocene)**—Chiefly marine, pale-gray, -buff, and -tan, friable, bioturbated and massive sandstone; includes subordinate interbeds and intervals of shale, siltstone, and silty to clayey sandstone. Contains diverse assemblage of marine invertebrate fossils. Rare conglomeratic lenses become more common up section, and uppermost part of unit locally interfingers with nonmarine conglomerates of the Casitas Formation (Qca) or older alluvial deposits (Qoa). Maximum exposed thickness approximately 300 m

Unnamed sedimentary rocks east of Goleta Pier (Pleistocene and Pliocene?)—Marine conglomerate, sandstone, siltstone, and mudstone mapped as two local unnamed, lithologically distinct units

Qss — **Sandstone unit (lower Pleistocene?)**—Laminated and bioturbated sandstone, siltstone, and subordinate mudstone and conglomerate. Contains marine fossils. Unit contains clasts derived from the Sisquoc Formation (Tsq) and (or) Monterey Formation (Tmu, Tmm, Tml). Exposed thickness 45 – 60 m

QTst — **Siltstone unit (lower Pleistocene and upper Pliocene?)**—Massive and extensively bioturbated siltstone, mudstone, and silty sandstone. Contains marine fossils. Exposed thickness about 45 m

Tmp — **Marine sedimentary rocks, undivided (Pliocene and Miocene)**—Marine well-bedded mudstone and shale. Includes rocks of the Monterey and Sisquoc Formations and younger strata bearing Repettian-age microfossils

Tsq — **Sisquoc Formation (lower Pliocene and upper Miocene)**—Marine, tan- to white-weathering, diatomaceous mudstone and shale, conglomerate, and subordinate dolomite. Unit distinguished by thick beds of conglomerate containing angular clasts (commonly as much as 1 m across; some blocks as large as 10 m) derived from the Monterey Formation. Both base and top of Sisquoc consist of erosional unconformities. Maximum preserved thickness of 300 m in sea cliffs

Tm — **Monterey Formation, undivided (Miocene)**—Marine, predominantly well-bedded, siliceous and calcareous mudstone and shale with subordinate porcelanite and dolomite. Contains abundant microfossils. Unit deposited at water depths ranging from upper to lower bathyal (150–2,000 m). Maximum composite thickness of Monterey estimated to be about 830 m. On land, the Monterey Formation is divided into three subunits that are distinguished from each other by lithology and age:

Tmu — **Upper siliceous unit (upper Miocene)**—East of Eagle Canyon, unit consists mainly of white- to tan-weathering diatomaceous mudstone and shale with subordinate dolomite and porcelanite. West of Eagle Canyon, consists mainly of thin-bedded, light-brown-weathering, siliceous mudstone and shale, porcelanite, and subordinate dolomite. Thickness ranges from about 50 m to 250 m

Tmm — **Middle shale unit (upper and middle Miocene)**—White-weathering shale, mudstone, dolomite, porcelanite, phosphorite, and subordinate tuff. Unit includes a prominent, at least 20- to 30-m-thick, submarine slump deposit in sea cliff in western part of map area. Thickness estimated to range from 70 to 180 m

Tml — **Lower calcareous unit (middle and lower Miocene)**—Calcareous, siliceous, and phosphatic, white- to tan-weathering mudstone and shale, with subordinate dolomite, porcelanite, breccia, glauconitic sandstone, and tuff. In places unit is characterized by intraformational deformation that may have formed by gravitational slumping shortly after deposition. About 250 m thick in far western part of map area

Tr — **Rincon Shale (lower Miocene)**—Marine, primarily massive and thick-bedded, light-brown-weathering mudstone, with subordinate dolomite, siliceous shale, sandstone, and tuff. Mudstone is bioturbated and massive, pervasively hackly fractured, and locally contains abundant microfossils. Single or multiple white-weathering tuff layers limited to upper 10 m of Rincon section. Thickness ranges from about 400 m to 460 m

Trs — **Siliceous shale interval (lower Miocene)**—Thin-bedded, white- to pale-gray-weathering siliceous shale that resembles siliceous shale intervals within Monterey Formation. Unit about 60 m stratigraphically below top of Rincon Shale and has a thickness of 35 to 45 m

Tv — **Vaqueros Formation (upper Oligocene)**—Shallow marine, massive and bioturbated, resistant, light-tan-weathering sandstone. Uppermost part consists of thinly interbedded sandstone, siltstone, and mudstone; base typically marked by a 50- to 150-cm-thick, thinly bedded, calcareous conglomerate containing abundant fossil shell fragments. Unit gradually decreases in thickness eastward from more than 150 m to about 75 m

Tspu — **Sespe Formation (upper Oligocene)**—Interbedded sandstone, siltstone, and mudstone that weather to various shades of maroon, buff, pale green, tan, and gray. Proportions of different sedimentary rock types vary both laterally and vertically through the section. Sandstones commonly broadly lenticular, laminated, and thin- to thick-bedded. Upper unit thickens eastward across map area from about 500 m to more than 1,000 m

w — **Water**

Contact—Solid where certain; long-dashed where approximately located; short-dashed where inferred; dotted where concealed

65, a36 — **Fault**—Solid where certain; long-dashed where approximately located; short-dashed where inferred; dotted where concealed; queried where uncertain; small red arrow shows direction and angle of dip; red diamond-headed arrow shows bearing and rake of slickenlines and inferred slip direction of hanging-wall block

Strike-slip fault—Opposing arrows show sense of strike-slip movement, queried where uncertain; bidirection arrows indicate superimposed dextral and sinistral slip on same fault

Normal Fault—Bars on apparent downthrown side

Reverse Fault—Boxes on apparent upthrown side

Fault-line scarp

Anticline—Solid where certain; long-dashed where approximately located; short-dashed where inferred; dotted where concealed

Syncline—Solid where certain; long-dashed where approximately located; short-dashed where inferred; dotted where concealed

Arrow showing direction of fold plunge

Modern shoreline

Paleo-shoreline

Horizontal bedding

31 **Inclined bedding**—Showing strike and dip

Inclined bedding—Showing approximate strike and dip direction

Overturned bedding—Showing strike and dip

Asphalt deposits—Unit Qas too small to show at scale of map

Travertine and/or caliche deposits—Unit Qtc too small to show at scale of map

A ● Location of selected seafloor images from video and still photographs used to help make geologic interpretations

Data Sources and Availability

U.S. Geological Survey—2006 and 2007, partial 10 m data available in this report.

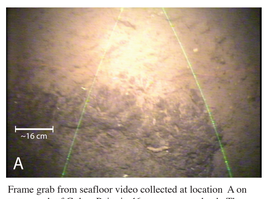
California State University, Monterey Bay—http://seafloor.csumb.edu/. 2007, Data used in this study were acquired, processed, archived, and distributed by the Seafloor Mapping Lab of California State University Monterey Bay.

Monterey Bay Aquarium Research Institute—http://www.ngdc.noaa.gov/mgg/bathymetry/multibeam.html. 1998, Chief Scientist: David Clague, Simrad EM300.

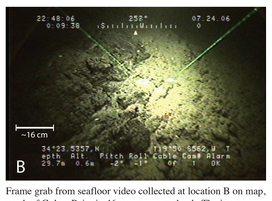
National Geophysical Data Center (NOAA)—http://www.ngdc.noaa.gov/mgg/bathymetry/hydro.html. 1985, Survey H10165, NOAA Ship Fairweather.

Topography data, NOAA Coastal Service Center—http://www.csc.noaa.gov/digitalcoast/. 2002/2003 IfSAR data for Southern California: Digital Elevation Model

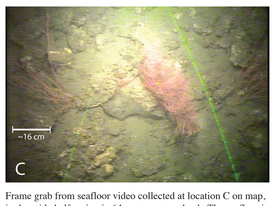
Index map of southern California showing location of map and other geographic features.



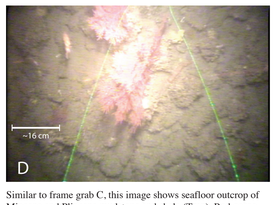
Frame grab from seafloor video collected at location A on map, south of Goleta Point in 46 meters water depth. The image shows asphalt deposits that form a tar mound (Qas) with a thin sediment cover at the top of the image. Green diagonal lines are paired lasers used for scale.



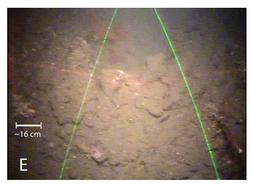
Frame grab from seafloor video collected at location B on map, south of Goleta Point in 46 meters water depth. The image shows a relatively recent tar mound (Qas) as evident by minimal sediment cover and no encrusting organisms. Green diagonal lines are paired lasers used for scale.



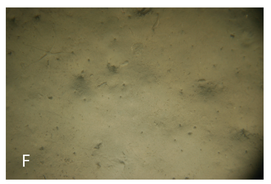
Frame grab from seafloor video collected at location C on map, in the mid-shelf region in 64 meters water depth. The seafloor in this region is comprised of Miocene and Pliocene mudstone and shale of the Monterey and Sisquoc Formations and unnamed younger marine sedimentary rocks (Tmp). Red gorgonian are attached to the rocks. Green diagonal lines are paired lasers used for scale.



Similar to frame grab C, this image shows seafloor outcrop of Miocene and Pliocene mudstone and shale (Tmp). Red gorgonian are attached to the rocks. Green diagonal lines are paired lasers used for scale.



Frame grab from seafloor video collected at location E showing cobble conglomerate near the top of a thin (2 - 3 m thick) flat-lying sequence of sedimentary rocks (Qys) that lie unconformably on folded Miocene and Pliocene rocks (Tmp). Green diagonal lines are paired lasers used for scale.



Seafloor photograph taken at location F on map. This region is sediment covered with fine-grained material. Images such as these help characterize unconsolidated marine sand, silt, and mud deposit (Qms) on the geologic map. Frame is approximately 1 m wide.

Onshore and Offshore Geologic Map of the Coal Oil Point Area, Southern California

By
Peter Dartnell, James E. Conrad, Richard G. Stanley, and Guy R. Cochrane,

2010

CALIFORNIA OCEAN PROTECTION COUNCIL

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