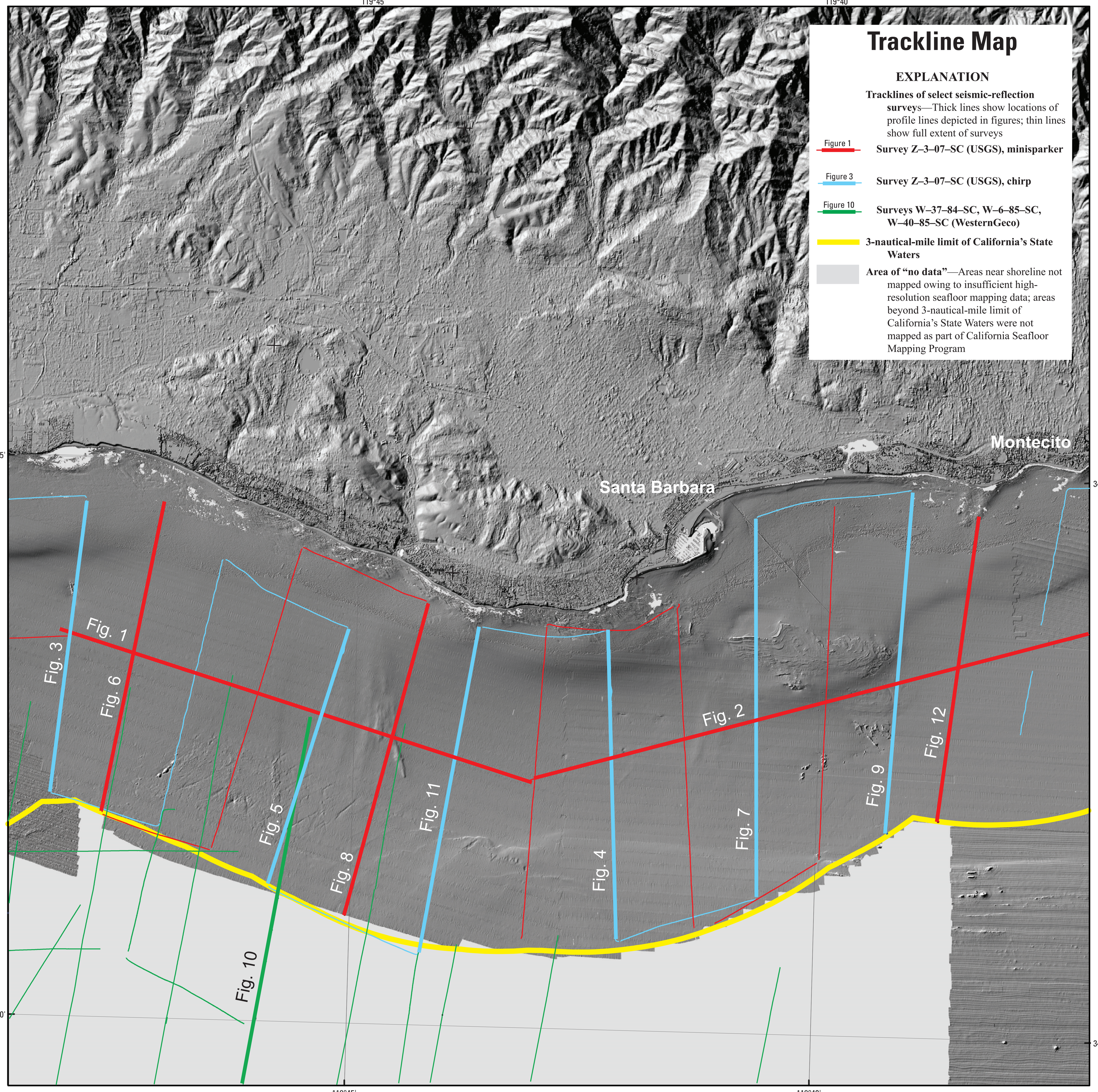
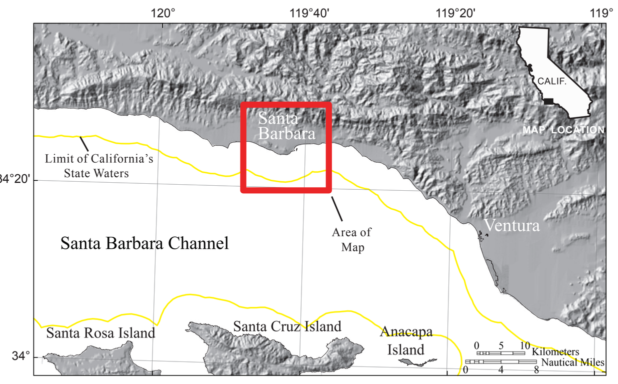
Scientific Investigations Map 3281
Sheet 8 of 11
Pamphlet accompanies map




Onshore elevation data from NOAA Coastal Services Center (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**

SCALE 1:50 000
ONE MILE = 0.869 NAUTICAL MILES


GIS database and digital cartography by Eleyne L. Phillips and Peter Dartnell
Edited by Taryn A. Lindquist
Manuscript approved for publication December 12, 2013



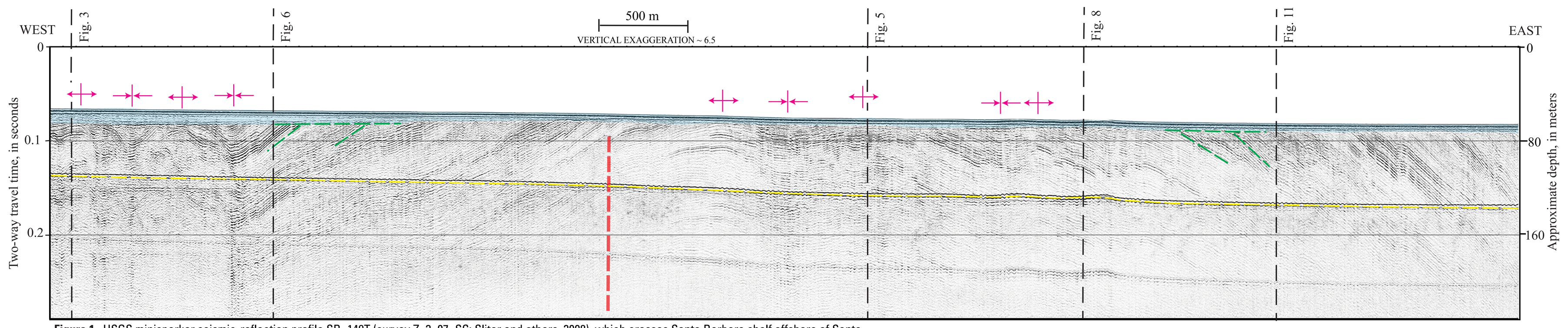




**Figure 1.** USGS minisparker seismic-reflection profile SB–149T (survey Z–3–07–SC; Sliter and others, 2008), which crosses Santa Barbara shelf offshore of Santa Barbara, subparallel to shoreline; see trackline map for location. Dashed red line shows fault. Magenta symbols above seafloor show fold axes (diverging arrows, anticlines; converging arrows, synclines). Both fault and folds are oriented highly oblique to predominant west-northwest structural trend. Blue shading shows inferred uppermost Pleistocene and Holocene nearshore and shelf deposits, which have maximum thickness of about 8 m at west end of profile. Lower contact of this stratigraphic unit is prominent angular unconformity; dashed green lines locally highlight this discordance. Folded strata beneath unconformity are undifferentiated Miocene to lower Pleistocene sedimentary rocks. Dashed yellow line is seafloor multiple (echo of seafloor reflector).

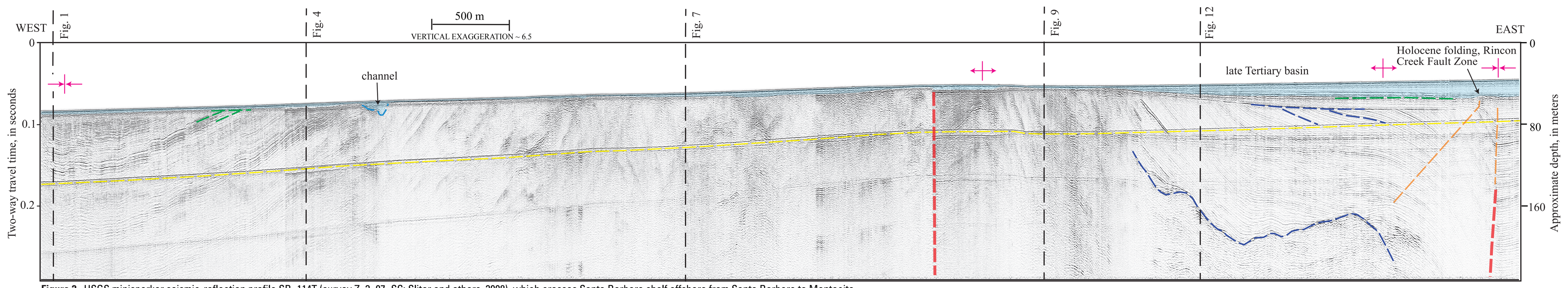



**Figure 2.** USGS minisparker seismic-reflection profile SB–114T (survey Z–3–07–SC; Sliter and others, 2008), which crosses Santa Barbara shelf offshore from Santa Barbara to Montecito, subparallel to shoreline; see trackline map for location. Dashed red lines show inferred faults. Magenta symbols above seafloor show fold axes (diverging arrows, anticlines; converging arrows, synclines). Both faults and folds have highly oblique orientation to predominant west-northwest structural grain. Easternmost fault is interpreted as structure associated with Rincon Creek Fault Zone (mapped onland by Minor and others, 2009), shown on this profile as "blind" fault that deforms young strata but does not rupture surface; dashed orange lines highlight shape of fold and "growth triangle" (Suppe and others, 1992) associated with this fault. Blue shading shows inferred uppermost Pleistocene and Holocene nearshore and shelf deposits, which have maximum thickness of about 14 m at east end of profile. Lower contact of this stratigraphic unit is prominent angular unconformity; dashed green lines locally highlight this discordance. Also highlighted (dashed purple lines) are two lower angular unconformities at east end of profile (see also, fig. 12): upper one probably results from local deformation within Rincon Creek Fault Zone; lower, more sinuous one is present at base of late Tertiary sedimentary basin that formed on east flank of anticlinal uplift. Dashed blue lines show small channel, possibly cut by Mission Creek (see fig. 1–2 in pamphlet) during last sea-level lowstand. Dashed yellow line is seafloor multiple (echo of seafloor reflector).

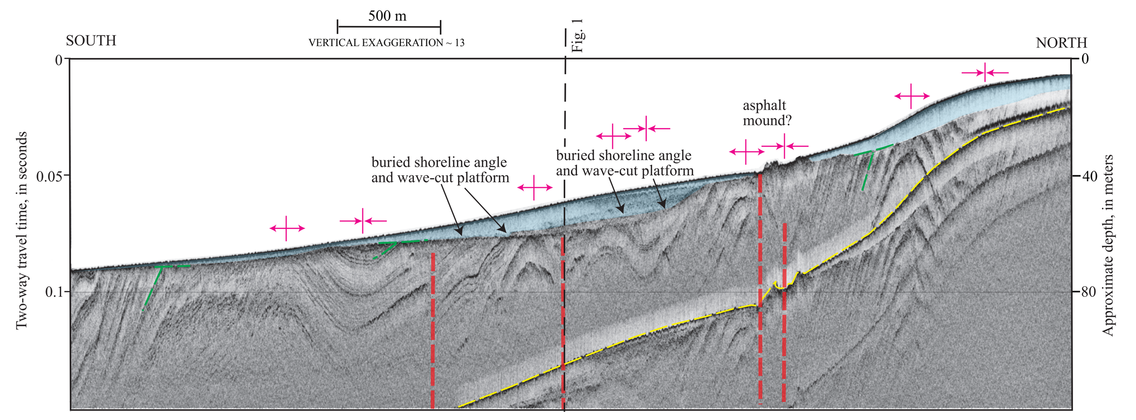



**Figure 3.** USGS chirp seismic-reflection profile SBC–122 (survey Z–3–07–SC; Sliter and others, 2008), which crosses Santa Barbara shelf offshore of Santa Barbara; see trackline map for location. Dashed red lines show inferred faults. Magenta symbols show fold axes (diverging arrows, anticlines; converging arrows, synclines). Blue shading shows inferred uppermost Pleistocene and Holocene nearshore and shelf deposits, which have maximum thickness of about 9 m on this transect but pinch out over offshore uplift and at south end of profile. Two buried wave-cut platforms and shoreline angles are present in center of profile, at depths of about 48 and 56 m. Upper stratigraphic unit is underlain by prominent angular unconformity; dashed green lines partly highlight this discordance. Folded strata beneath unconformity are undivided Miocene to Pleistocene rocks. "Mound" in seafloor, about 3 m high, is associated with zone of faulting, and it is tentatively interpreted as asphalt mound (see, for example, Keller and others, 2007). Dashed yellow line is seafloor multiple (echo of seafloor reflector).

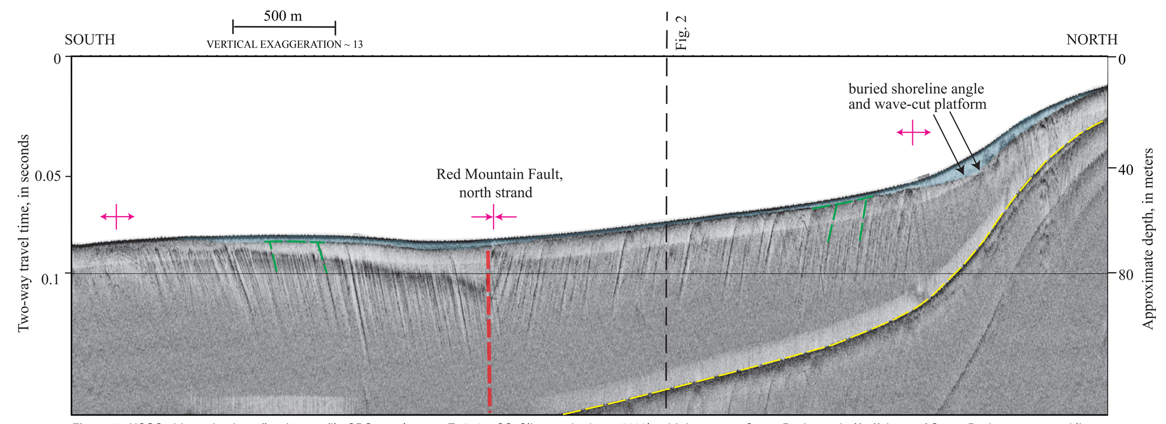



**Figure 4.** USGS chirp seismic-reflection profile SBC–111 (survey Z–3–07–SC; Sliter and others, 2008), which crosses Santa Barbara shelf offshore of Santa Barbara; see trackline map for location. Dashed red line shows fault. Magenta symbols show fold axes (diverging arrows, anticlines; converging arrows, syncline). Blue shading shows inferred uppermost Pleistocene and Holocene nearshore and shelf deposits, which are thin (typically 0 to 3 m) and of relatively uniform thickness across profile; maximum thickness (about 6 m) is at location of buried shoreline angle (depth about 42 m) and wave-cut platform. This upper stratigraphic unit is underlain by prominent angular unconformity; dashed green lines partly highlight this discordance. Folded strata beneath unconformity are undivided Miocene to Pleistocene rocks. Dashed yellow line is seafloor multiple (echo of seafloor reflector).

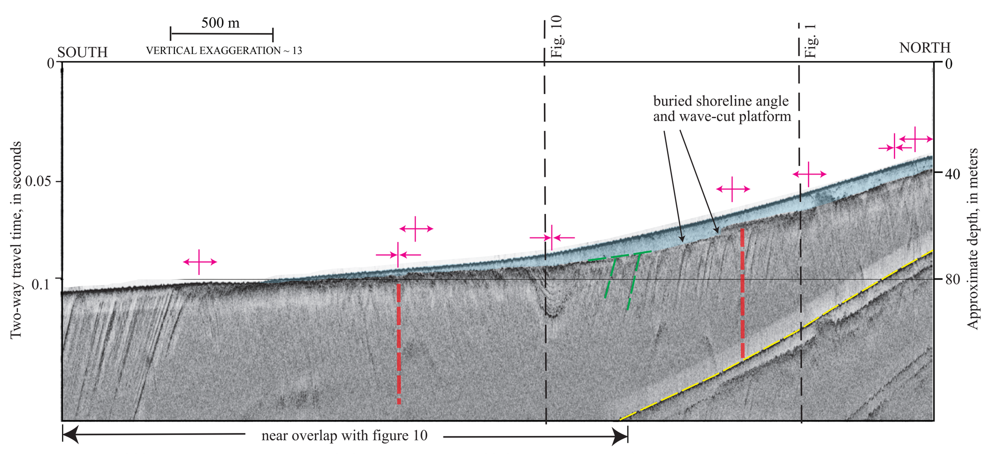



**Figure 5.** USGS chirp seismic-reflection profile SBC–118 (survey Z–3–07–SC; Sliter and others, 2008), which crosses Santa Barbara shelf offshore of Santa Barbara; see trackline map for location. Dashed red lines show inferred faults. Magenta symbols show fold axes (diverging arrows, anticlines; converging arrows, synclines). Blue shading shows inferred uppermost Pleistocene and Holocene nearshore and shelf deposits, which have maximum thickness of about 7 m on this transect but pinch out over offshore uplift at south end of profile. Upper stratigraphic unit is underlain by prominent angular unconformity; dashed green lines partly highlight this discordance. Folded strata beneath unconformity are undivided Miocene to Pleistocene rocks. Note near overlap with figure 10 (see trackline map), which has much lower resolution but much greater depth penetration. Dashed yellow line is seafloor multiple (echo of seafloor reflector).

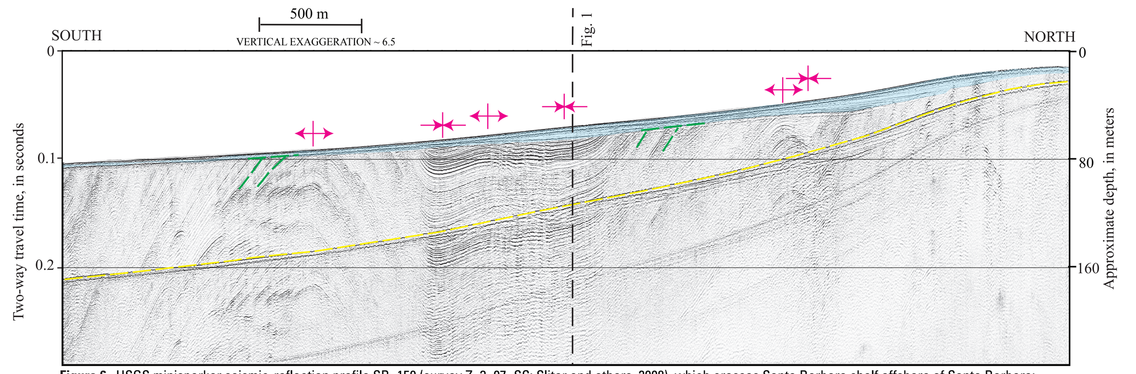



**Figure 6.** USGS minisparker seismic-reflection profile SB–150 (survey Z–3–07–SC; Sliter and others, 2008), which crosses Santa Barbara shelf offshore of Santa Barbara; see trackline map for location. Magenta symbols show fold axes (diverging arrows, anticlines; converging arrows, synclines). Blue shading shows inferred uppermost Pleistocene and Holocene nearshore and shelf deposits, which have maximum thickness of about 12 m on this transect but thin markedly at south end of profile. Upper stratigraphic unit is underlain by prominent angular unconformity; dashed green lines partly highlight this discordance. Folded strata beneath unconformity are undivided Miocene to Pleistocene rocks. Dashed yellow line is seafloor multiple (echo of seafloor reflector).

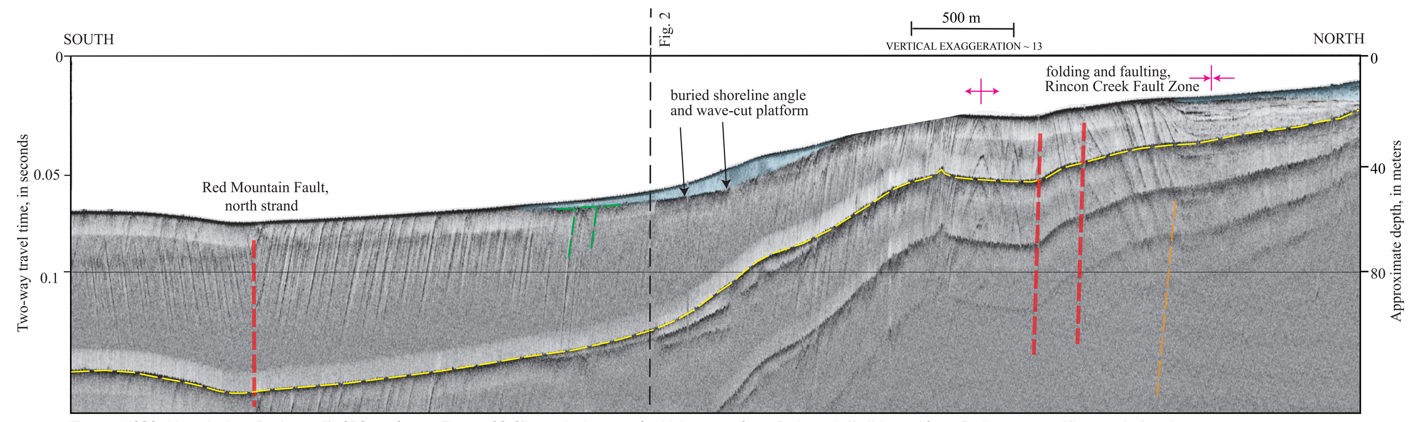



**Figure 7.** USGS chirp seismic-reflection profile SBC–109 (survey Z–3–07–SC; Sliter and others, 2008), which crosses Santa Barbara shelf offshore of Santa Barbara; see trackline map for location. Dashed red lines show faults. Magenta symbols show fold axes (diverging arrows, anticline; converging arrows, syncline); dashed orange line shows axis of syncline within Rincon Creek Fault Zone. Blue shading shows inferred uppermost Pleistocene and Holocene nearshore and shelf deposits, which are very thin to absent over much of profile; maximum thickness of about 7 m is at location of buried shoreline angle (depth about 47 m) and wave-cut platform. This upper stratigraphic unit is underlain by prominent angular unconformity; dashed green lines partly highlight this discordance. Folded strata beneath unconformity are undivided Miocene to Pleistocene rocks. Dashed yellow line is seafloor multiple (echo of seafloor reflector).

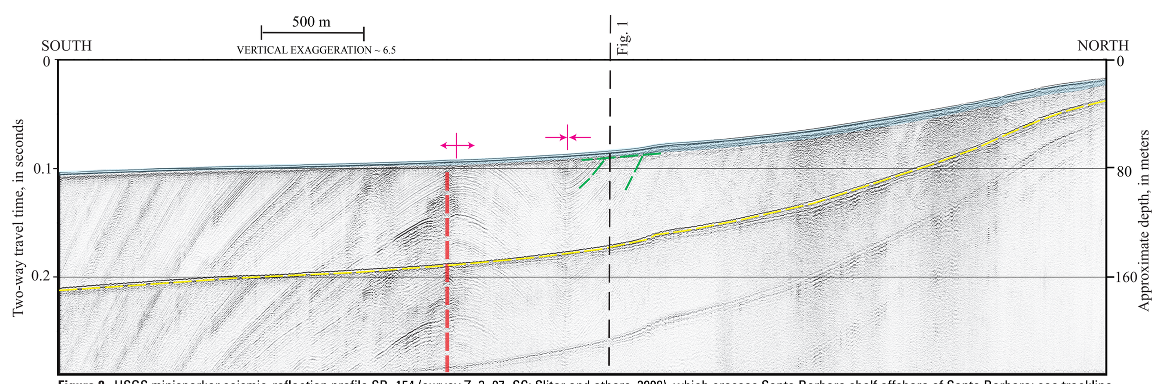



**Figure 8.** USGS minisparker seismic-reflection profile SB–154 (survey Z–3–07–SC; Sliter and others, 2008), which crosses Santa Barbara shelf offshore of Santa Barbara; see trackline map for location. Dashed red line shows fault. Magenta symbols show fold axes (diverging arrows, anticline; converging arrows, syncline). Blue shading shows inferred uppermost Pleistocene and Holocene nearshore and shelf deposits, which are thin (less than 1 to 5 m) and have fairly uniform thickness across profile. This upper stratigraphic unit is underlain by prominent angular unconformity; dashed green lines partly highlight this discordance. Folded strata beneath unconformity are undivided Miocene to Pleistocene rocks. Dashed yellow line is seafloor multiple (echo of seafloor reflector).

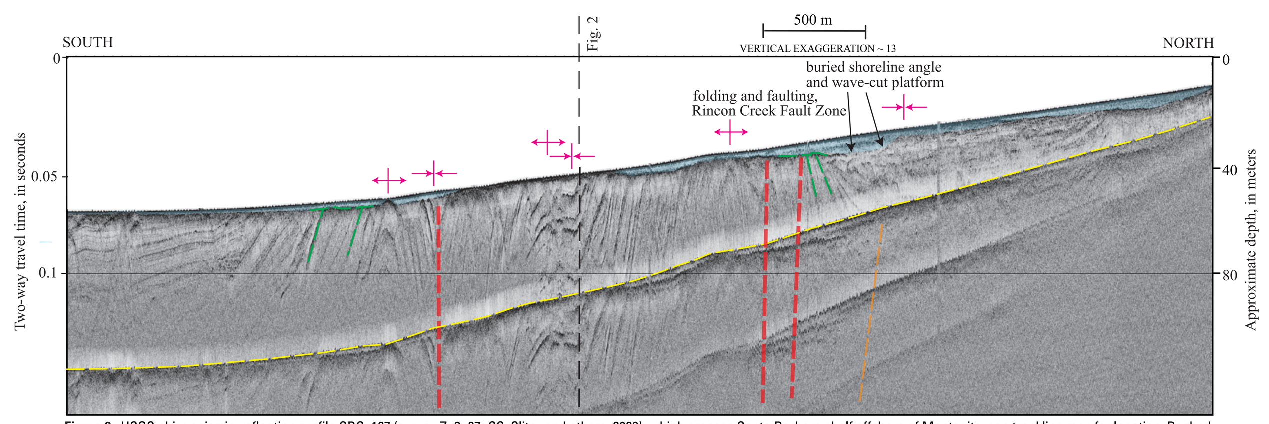



**Figure 9.** USGS chirp seismic-reflection profile SBC–107 (survey Z–3–07–SC; Sliter and others, 2008), which crosses Santa Barbara shelf offshore of Montecito; see trackline map for location. Dashed red lines show inferred faults. Magenta symbols show fold axes (diverging arrows, anticlines; converging arrows, synclines). Dashed orange line shows axis of syncline within Rincon Creek Fault Zone. Blue shading shows inferred uppermost Pleistocene and Holocene nearshore and shelf deposits, which have maximum thickness of about 6 m on profile. This upper stratigraphic unit is underlain by prominent angular unconformity; dashed green lines partly highlight this discordance. Folded strata beneath unconformity are undivided Miocene to Pleistocene rocks. Dashed yellow line is seafloor multiple (echo of seafloor reflector).

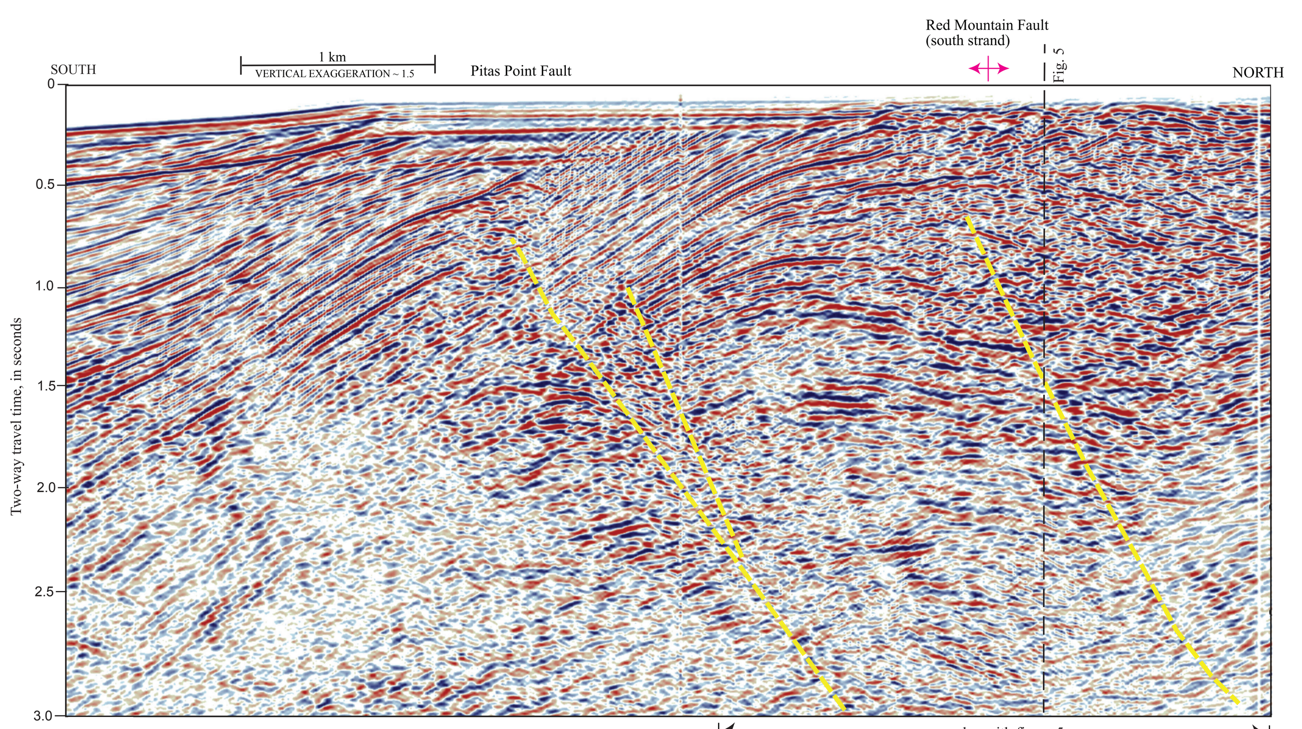



**Figure 10.** Industry 2-D, migrated multichannel air-gun seismic-reflection profile WC–84–212 (collected in 1984 on survey W–37–84–SC), which extends south across Santa Barbara shelf offshore of Santa Barbara; see trackline map for location. Note that profile has similar horizontal scale to USGS high-resolution seismic-reflection profiles shown in figures 1 through 10, but it has much less vertical exaggeration (about 1.5:1). Note also that profile has not been depth converted and so no depth scale is shown, but it probably extends to depths of 4 to 5 km. Note near overlap with figure 5 (see trackline map). Pitas Point Fault Zone and Red Mountain Fault (south strand) are shown by dashed yellow lines; magenta symbol above profile shows axis of anticline. Faults are "blind" at this resolution; they appear to fold but not rupture upper reflections in profile.

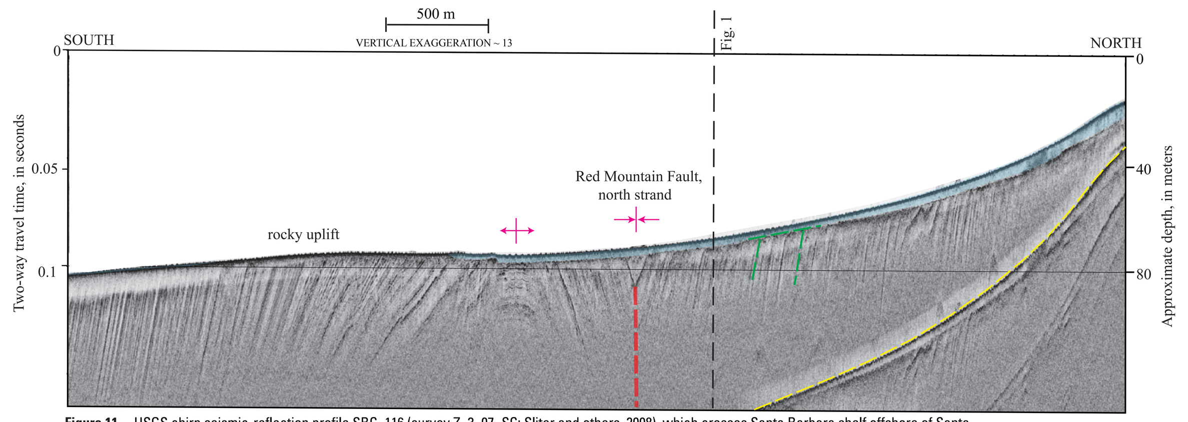



**Figure 11.** . USGS chirp seismic-reflection profile SBC–116 (survey Z–3–07–SC; Sliter and others, 2008), which crosses Santa Barbara shelf offshore of Santa Barbara; see trackline map for location. Dashed red line shows north strand of Red Mountain Fault, near where it disappears westward in axis of syncline. Magenta symbols show fold axes (diverging arrows, anticline; converging arrows, syncline). Blue shading shows inferred uppermost Pleistocene and Holocene nearshore and shelf deposits, which have maximum thickness of about 5 m on profile but are not present over rocky uplift south of anticline axis. This upper stratigraphic unit is underlain by prominent angular unconformity; dashed green lines partly highlight this discordance. Folded strata beneath unconformity are undivided Miocene to Pleistocene rocks. Dashed yellow line is seafloor multiple (echo of seafloor reflector).

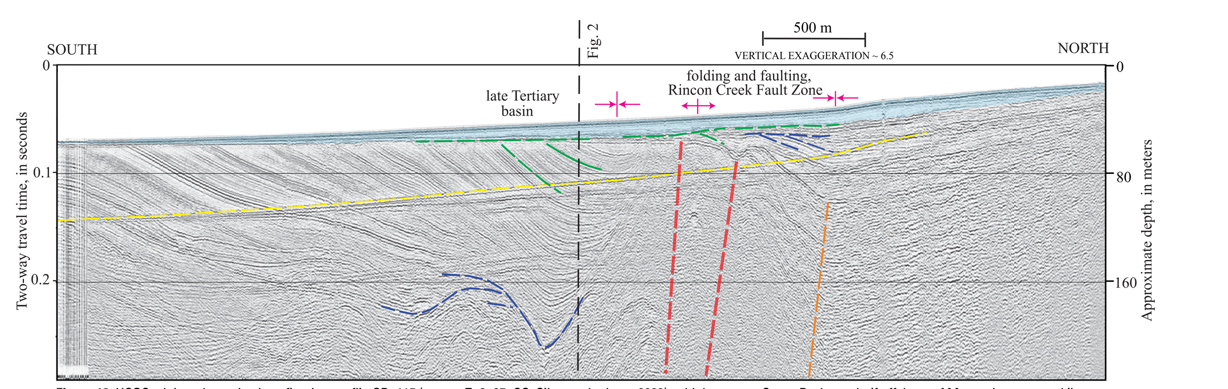



**Figure 12.** USGS minisparker seismic-reflection profile SB–115 (survey Z–3–07–SC; Sliter and others, 2008), which crosses Santa Barbara shelf offshore of Montecito; see trackline map for location. Dashed red lines show faults. Magenta symbols show fold axes (diverging arrows, anticline; converging arrows, synclines); dashed orange line shows axis of syncline within Rincon Creek Fault Zone. Blue shading shows inferred uppermost Pleistocene and Holocene nearshore and shelf deposits, which have maximum thickness of about 11 m on profile. Lower contact of this stratigraphic unit is prominent angular unconformity; dashed green lines locally highlight this discordance. Also highlighted (dashed purple lines) are two lower angular unconformities: upper one is related to local deformation; lower one is present at base of late Tertiary sedimentary basin that formed on south flank of late Tertiary anticlinal uplift (see also, fig. 2). Dashed yellow line is seafloor multiple (echo of seafloor reflector).

## DISCUSSION

This map sheet shows seismic-reflection profiles from two different surveys of the Offshore of Santa Barbara map area, providing imagery of the subsurface geology. The area extends from the nearshore across the inner shelf to the midshelf, with maximum water depths of about 75 m in California's State Waters. The shelf is underlain largely by upper Pleistocene and Holocene marine sediments (blue shading in profiles; Sommerfield and others, 2009; Draut and others, 2009) deposited in the last about 21,000 years, following the last major glaciation and sea-level lowstand (see, for example, Fleming and others, 1998). This postglacial stratigraphic unit has a maximum thickness of about 14 m (fig. 2) at the east edge of the map area and a mean thickness of 3.1 m, and it locally pinches out over bedrock uplifts. Two or three submerged and buried shoreline angles and wave-cut platforms (see, for example, Kern, 1977) may have formed during relative stillstands during late Quaternary sea-level fluctuations (figs. 3, 4, 5, 6, 7, 9). Nearshore and shelf sediment is derived mainly from eastward littoral drift, bluff erosion, and local coastal watersheds (see fig. 1–2 in pamphlet).

The seismic-reflection profiles on this map sheet show significant folding and faulting. The east-west-striking, south-dipping Rincon Creek Fault Zone forms the north edge of a northwest-trending uplift of complexly deformed Monterey Formation, due south of Santa Barbara (figs. 7, 9, 12; see also, sheet 10 of this report). The fault zone is "blind" in this map area because it does not appear to rupture to the surface or to clearly offset the uppermost Pleistocene and Holocene stratigraphic unit. Instead, it is characterized by a zone of deformation that includes an upward-narrowing asymmetric syncline that has a gently south-dipping north limb and a steeply north-dipping south limb. The east-west-striking, steeply south-dipping north strand of the Red Mountain Fault Zone lies about four km south of the Rincon Creek Fault Zone, coincident with the axis of a prominent tight syncline (figs. 4, 7, 11). Although the syncline can be mapped across the entire map area, the fault tip appears to be buried below the depth of the high-resolution seismic-reflection profiles in the western part of the map area. Both the east-west-striking, north-dipping south strand of the Red Mountain Fault Zone and the Pitas Point Fault extend westward just south of the map area, as indicated in the industry seismic-reflection profile in figure 10.

Both the Red Mountain and Rincon Creek Fault Zones are inferred to include several splays and to be complex at depth, on the basis of the irregular pattern of near-surface folding in the map area, as well as the variable fold presence, geometry, length, amplitude, continuity, and wavelength between closely spaced seismic-reflection profiles (figs. 1 through 11).

All but one of the profiles displayed on this map sheet (figs. 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12) were collected in 2007 on U.S. Geological Survey (USGS) cruise Z–3–07–SC (Sliter and others, 2008). Single-channel seismic-reflection data were acquired using two different sources, the EdgeTech 512 chirp (figs. 3, 4, 5, 7, 9, 11) and the SIG 2Mille minisparker (figs. 1, 2, 6, 8, 12). The EdgeTech 512 chirp subbottom-profiling system consists of a source transducer and an array of receiving hydrophones housed in a 500-lb fish towed at a depth of several meters below the sea surface. The swept-frequency chirp source signal was 500 to 4,500 Hz and 50 ms in length, and it was recorded by hydrophones located on the bottom of the fish. The SIG minisparker system used a 500-J high-voltage electrical discharge fired 1 to 4 times per second, which, at normal survey speed of 4 to 4.5 nautical miles per hour, gives a data trace every 0.5 to 2.0 meters. The data were digitally recorded in standard SEG-Y 32-bit floating-point format, using Triton Subbottom Logger (SBL) software that merges seismic-reflection data with differential GPS-navigation data. After the survey, a short-window (20 ms) automatic gain control algorithm was applied to both the chirp and minisparker data, and a 160- to 1,200-Hz bandpass filter was applied to the minisparker data. The vertical scale on the high-resolution seismic-reflection profiles (figs. 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12) is shown as two-way travel time in seconds, as well as in meters on the basis of an inferred velocity of 1,600 m/sec for near-surface sediments.

Figure 10 shows a deep-penetration, migrated, multichannel seismic-reflection profile collected in 1984 by WesternGeco on cruise W–37–84–SC. This profile and other similar data were collected in many areas offshore of California in the 1970s and 1980s when these areas were considered a frontier for oil and gas exploration. Much of these data have been publicly released and are now archived at the USGS National Archive of Marine Seismic Surveys (U.S. Geological Survey, 2009). These data were acquired with a large-volume air-gun source that has a frequency range of 3 to 40 Hz and recorded with a multichannel hydrophone streamer about 2 km long; shot spacing was about 30 m. These data can resolve geologic features that are 20 to 30 m thick, down to subbottom depths of about 4 km.

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# Seismic-Reflection Profiles, Offshore of Santa Barbara Map Area, California

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2013

ISSN 2329-132X (online)
http://dx.doi.org/10.3133/sim3281