APPENDIX B

ONSHORE-OFFSHORE GEOLOGIC MAP
THE SHORELINE FAULT ZONE STUDY AREA, SAN LUIS OBISPO COUNTY

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1. INTRODUCTION

This appendix presents a comprehensive geologic map from a compilation of existing and new geologic mapping and geophysical data both onshore and offshore in the Shoreline fault zone study area. The study area extends from the western slope of the Irish Hills on the east to the edge of the continental shelf at the Hosgri fault zone on the west, and from Estero Bay on the north to Pismo Beach on the south (Figure B-1-1). The geologic map is presented in four plates at 1:12,000 scale (Plates B-1A to B-1D).

1.1 Purpose and Objectives

The purpose of creating an onshore-offshore geologic map of the study area is to place the Shoreline fault zone in its geologic context. The objectives of the mapping include:

1. Complete a geologic map of the study area using previous and new field mapping plus the newly acquired MBES and LiDAR images, dive samples, seismic-reflection profiles, and high-resolution helicopter magnetic field data;
2. Characterize the length, segmentation, style of faulting, and slip rate of the Shoreline fault zone;
3. Accurately locate the fault trace where it lies offshore of DCPP;
4. Assess the relation of the mapped traces of the Shoreline fault zone to the seismicity lineament that originally defined the Shoreline fault; and
5. Evaluate the evidence, if any, of late Quaternary displacements on the fault.

1.2 Previous Investigations

Existing onshore geologic maps within the DCPP site vicinity are shown on Figure B-1-1. Mapping of the Irish Hills (i.e., Point San Luis and Morro Bay topographic quadrangles) was completed at 1:24,000-scale by Hall (1973a) and later incorporated into a regional compilation by Hall et al. (1979) with minor revisions at 1:48,000 scale. Mapping of the Arroyo Grande topographic quadrangle at 1:48,000-scale by Hall (1973b) includes the Avila Beach and Pismo Beach area. These quadrangle maps were adopted with revisions for geologic maps included in the DCPP Final Safety Analysis Report (FSAR) (PG&E, 1975) and in the LTSP (PG&E, 1988; 1991) at 1:12,000 scale. A geologic map of the Morro Bay South topographic quadrangle was recently produced at 1:24,000 scale by the California Geological Survey and includes the northern part of the Irish Hills (Wiegers, 2009).

Detailed geologic maps (larger than about 1:6,000 scale) in the immediate area of DCPP include a map of coastline bedrock exposures from Discharge Cove to Green Peak completed in 1970 (PG&E, 1975). More recent geologic maps of the DCPP site are presented in the FSAR for the Independent Spent Fuel Storage Facility (PG&E, 2002).

Offshore geologic mapping in the DCPP vicinity was initiated by oil exploration efforts and was expanded during a comprehensive investigation performed for the LTSP (PG&E, 1988).

Bathymetric data available at that time were insufficient for evaluating submarine landforms, and offshore interpretations focused mainly on ship-borne seismic-reflection profile line data and point sampling campaigns using drop coring equipment and divers (Niemi et al., 1987; PG&E, 1989).

Areas of late Quaternary deformation and uplift in the Irish Hills are delineated on a map of onshore Quaternary deposits and marine terrace shoreline angles along the southwest coast of the Irish Hills, as well as a map of offshore wave-cut platforms using the bathymetric data available at the time (PG&E, 1988; 1991; Hanson et al., 1994).

1.3 New Base Map

An important advancement in geologic mapping of the study area has been the acquisition of accurate and detailed topographic and bathymetric data. Because of the benefits of a better geologic interpretation of the study area and adjacent areas, PG&E was permitted to use the San Luis Obispo County Interferometric Synthetic Aperture Radar (INSAR) Digital Elevation Model (DEM) that has an accuracy of 16 feet (5 meter) raster grid resolution. This dataset is a substantial improvement over the existing U.S. Geological Survey 40-foot topographic contour maps of the area (Morro Bay South and Port San Luis quadrangles, scale 1:24,000). The INSAR DEM was supplemented between Islay Creek and Point San Luis with newly acquired aerial photography (scale 1:12,000), and a LiDAR survey of the coastal strip at one of the lowest tides of the year (described in Appendix G). The LiDAR DEM has an accuracy of 5 centimeters with pixel resolution of 0.2 meters. Figure B-1-2 compares maps of a selected area at San Luis Hill that illustrates the improvement in the LiDAR-derived topography over the USGS topographic map.

The offshore bathymetry fronting the Irish Hills has been improved substantially with the Multibeam Echosounder (MBES) survey of the continental shelf between Estero Bay and Pismo Beach (described in Appendix F). The spatial resolution for this new bathymetry in water depths less than 50 meters is 1 meter, and in water depths greater than 50 meters the resolution is 2 meters. Figure B-1-3 illustrates the improvement in bathymetry in the area around Pecho Rock. Because of navigation hazards, shallow water, kelp beds, and submerged rocks, the bathymetry of the strip adjacent to the coastline as well as over and around shallow rocks was not obtained.

1.4 New Data Sources

High-resolution seismic-reflection profile data were obtained by the USGS along northeast-southwest transect lines within the Shoreline fault study area (described in Appendix H). The high-resolution seismic profiles provide a complementary dataset to deeper-penetrating common-depth point seismic-reflection profiles evaluated during the LTSP (PG&E, 1988). The seismic-reflection profile data were collected as close as the boat could safely approach the rocky coastline to offshore beyond the Hosgri fault zone. Trackline spacing is a nominal 800 meters (0.5 miles) with 400-meter spacing across the Shoreline fault zone. Data records extend to about 0.45 seconds two-way-travel time (338 meters at 1500 m/sec). Seismic signal depth penetration ranges from zero (in some areas of Franciscan Complex) to about 200 meters in areas of soft sediment cover (including within and adjacent to the Hosgri fault zone). Recent reprocessing of a few seismic-reflection profiles improved resolution and reduced spurious noise relative to the initial processing done by the USGS.

The magnetic field within the study area has been measured in several surveys to help identify rock units and structures having distinct magnetic signatures. Recently acquired magnetic field data by the USGS include an overland fixed-wing aerial magnetic survey and a marine magnetic survey with ship line spacing at 400 meters (details in Appendix D). These surveys were supplemented by a high-resolution helicopter magnetic survey across the Irish Hills coastline at 150 feet "above deck" to better define magnetic anomalies associated with the Shoreline fault zone and to gain detailed data in the gap between the onshore and offshore measurements (Appendix D).

2. METHODOLOGY

2.1 Onshore Mapping

Detailed onshore geologic mapping documents structural and stratigraphic relationships exposed in sea cliffs and wave-cut platforms along 17 kilometers of coastline to the northwest and southeast of DCPP. The objectives of this mapping effort were to identify and characterize the range and distribution of bedrock lithologies, to measure bedding attitudes, and to document structural discontinuities. Mapping was conducted during the spring months of 2009 and 2010 by Stephen Thompson, Michael Angell, Andrew Lutz, and Cooper Brossy of Fugro-William Lettis Associates (FWLA). The mapping was peer reviewed in the field by William Lettis (FWLA), Ray Weldon (Consultant, University of Oregon) and William Page (PG&E Geosciences Department).

Geologic mapping was conducted in accordance with standard field techniques described in sources such as Compton (1985). This included examination of natural outcrop exposures and road-cuts, and these observations were located spatially by inspection of geo-registered aerial photographs and commonly confirmed by recording positions with a handheld GPS unit. Orientations of bedding planes, fault planes, and joint planes and lineations were measured with a transit compass. Bedding features were considered carefully before measuring and were selected only when there was clear evidence of original horizontality, including consistent orientations of laminations and textural grading. Measurements of bedding attitudes (both strike direction and dip amount) are accurate to within 5 degrees. Bedding attitudes elsewhere in the DCPP site area were compiled from pre-existing sources (PG&E, 1975; 1988; 1991; 2002; Hall et al., 1979) and checked for accuracy by examining aerial photographs. These prior measurements were included after checking for consistency with structural fabric characteristics defined by other available data.

2.2 Offshore Mapping

2.2.1 MBES bathymetric data

The recently acquired MBES bathymetric data (Appendix F) allowed detailed interpretation of stratigraphic and structural relationships and seafloor geomorphology in the offshore area between Morro Bay and Pismo Beach. The bathymetric data with one- to two-meter pixel resolution covers large areas of nearly continuous rock exposure. The general quality of the 2008 and 2009 MBES bathymetric data is excellent. The bathymetry data generally extend from as close to the shoreline as the boat could safely approach out to the approximate seaward limit of bedrock outcrops. Sea floor features such as sediment bedforms (mobile sand sheets) and bedding ridges with a few tenths of a meter relative elevation change are imaged.

Where bedrock is imaged in the MBES bathymetric data, surface roughness and fabric allowed correlation and interpretation of different lithologies and structures. Derivative maps of the MBES data, particularly shaded-relief maps presented at different illumination angles and slope maps, enhanced the view of erosional patterns that are consistent with inclined bedding, folds, and structural and stratigraphic discontinuities (faults and unconformities) that truncate or cross-cut bedding and structures. Bedding strike of laterally continuous strata can be resolved in the MBES bathymetric data with a high degree of confidence, and dip direction may be recognized based on erosional patterns, local inclination or slope, and structural and stratigraphic position. Dip angle, however, is not well constrained from the MBES image. Estimated dips from the MBES bathymetric data were consistently lower when compared to measured dips on strike with the same beds onshore. The reason for this under-prediction is probably either (1) the data have too large a pixel size to measure dips on rather narrow bedding surfaces, or (2) erosion has modified original dip slopes. Identification of lithologic units in the bathymetric data was based on a number of criteria, including: (1) diver sample and drop-core data (see description below); (2) correlation with onshore data from existing maps and from recent coastline mapping (described above); and, (3) extrapolation of bathymetric texture from well-constrained lithologic areas to less well-constrained areas.

2.2.2 Sea floor samples

Direct observation of offshore lithology was performed by diver sample and drop core campaigns conducted for the LTSP (PG&E, 1991), and is supplemented by an additional diver sample campaign conducted in July 2010. Locations of drop cores collected for the LTSP were recorded using a LORAN C device and are assumed to be accurate within 10 to 20 meters. Locations of diver samples collected for the LTSP were calculated by using LORAN-C readings for the dive boat and then factoring divers' estimates of direction and distance from the vessel. The reported positions of these diver samples are assumed to be accurate within 50 to 100 meters. The LTSP samples (including descriptions) are compiled in Table B-1 for the drop cores and Table B-2 for the diver samples. Sample locations are plotted on Figure B-2-1 and are shown with revised interpretations on Plates B-1A to B-1D.

In the course of interpreting the MBES data, alternative lithologic interpretations were considered for these older samples in order to resolve inconsistencies between onshore and offshore data. Because the LTSP samples are not available to review, only those samples that were inconsistent with more recent samples or with the initial structural and stratigraphic interpretation of the MBES data were reviewed critically and often reinterpreted. In particular, several fine-grained samples previously interpreted as Pismo Formation were reinterpreted as fine-grained interbeds within Cretaceous sandstone, several sandstone samples classified as Franciscan greywacke were reinterpreted as Cretaceous sandstone, and several fine-grained samples classified as Monterey Formation were reinterpreted as fine-grained facies within the Obispo Formation.

Fifty new diver samples were collected under the supervision of Andrew Lutz (FWLA) who was knowledgeable of the stratigraphic units and their variation from detailed mapping along the coast described above. The July 2010 campaign used a targeted strategy to classify different areas of distinct bathymetric texture and specific locations where preliminary interpretations suggested a conflict of interpreted formations between the LTSP and the current mapping. Sample locations were recorded using a handheld GPS device on the dive vessel and are assumed to be accurate to within 10 to 20 meters. Samples from this most recent dive campaign are located on Figure B-2-1 and summarized on Table B-3. Sample descriptions and interpretations are in Attachment 1 to this Appendix.

2.2.3 High-resolution seismic-reflection profiles

The high-resolution sparker seismic-reflection profiles collected by the USGS in 2008 and 2009 were interpreted using the Kingdom Suite Program by Seismic MicroTechnology to delineate structural features. The sparker data provided improved resolution of shallow structures over previous datasets, and structures delineated from the seismic lines were integrated with the offshore geologic map.

2.2.4 Integration of onshore and offshore mapping

All the primary data sets used in the current map exist in digital format and were integrated into a GIS database. The interpretive information (e.g., geological units and contacts, fold axes, and fault traces) were compiled digitally or were hand-annotated on the base maps, scanned, and then digitized.

The detailed geologic map is presented in four sheets (Plates B-1A to B-1D) at a scale of 1:12,000. The map sheets cover the area from Morro Bay in the north to San Luis Obispo Bay in the south. The map sheets extend from the shoreline area on the east to 3 to 12 kilometers offshore. The maps show onshore topographic features, onshore geologic units and structures, offshore core and diver sample locations and units, MBES bathymetry images, and point locations where structures were observed in the seismic-reflection profiles. Geological features interpreted from the data sets and shown on the sheets include geological units and contacts, fold axes, and fault traces.

Offshore geologic mapping was correlated with existing onshore geologic maps by considering the projection of the geologic units, faults and contacts into the area covered by MBES bathymetric data. Tertiary rock contacts were mapped along prominent beds visible in the bathymetric data and bedding was traced through folds. Pre-Tertiary (basement) lithologic boundaries were mapped by following prominent changes in bathymetric fabric that are consistent with sea floor samples and magnetic susceptibility data (Appendix D). Stratigraphic units mapped southwest of the Shoreline fault are generally not identified to the member or subunit level due to reduced control on stratigraphic position and difficulty in identifying the rock type from texture alone without sufficient samples to confirm the selection of lithology.

The magnetic field data were interpreted by overlaying the total magnetic intensity and reduction-to-pole images (Appendix D) on a preliminary draft of the geologic map to help define the limits of the main magnetic rock types in the area, particularly diabase in the Obispo Formation, Franciscan Complex greenstone, and Jurassic pillow basalt. Several contacts were adjusted to better match the magnetic field data.

The high-resolution seismic-reflection profiles were used in the areas of the shelf covered with sediments to map folds and faults in the Tertiary rocks and to evaluate potential deformation of wave-cut platforms (see also Appendix I). The integrated map that exhibits the interpreted geology using all the data sources allows for a greatly improved geologic map offshore. As an example, Figure B-2-2 compares the geology mapped onshore and offshore near Olson Hill and illustrates the improvement in the geologic interpretation over previous efforts.

Folds and faults interpreted from the MBES bathymetric and seismic-reflection profile data sets are separately identified. Structures mapped primarily on the basis of MBES bathymetric imagery are shown as thin black lines. Folds are annotated with arrows indicating fold type and plunge if identified. Fault offsets are indicated by a UP/DN symbol for vertical displacement if that can be determined from the MBES bathymetric data. Solid lines indicate a feature observed in the MBES bathymetric imagery. Dashed lines indicate the inferred continuation of the structure (folds and faults) where sea floor evidence is not present due to sediment cover.

Folds and faults interpreted from the seismic-reflection data are shown as yellow squares at the intersection of the seismic line and the structural feature. Correlated structures are indicated by thin lines for older faults and all fold axes. If faults are interpreted as buried by 2 to 3 meters or more of sediment the fault is shown as a dotted line. Faults that are strands of the Hosgri fault zone are shown as thick black lines. Solid lines indicate that in at least one location the fault was interpreted to intersect the sea floor; dotted lines indicate the fault is everywhere interpreted as buried by 2 to 3 meters or more of sediment. Dashed lines with query marks indicate there is uncertainty about the line-to line correlation or continuation of the structural feature.

Buried wave-cut platforms and shoreline angles interpreted from the seismic-reflection profile data are presented in Appendix I.

Seismic reflection, side-scan sonar, and bathymetric data collected for the FSAR and LTSP between 1975 and 1988 were used to produce Structural Trend and Sediment Isopach maps in this area for the LTSP (PG&E, 1990). These maps were compared to the current maps but the previous data were not directly incorporated into the current mapping program as the basic data sets are currently in analog, not digital formats.

3. GEOMORPHOLOGY

The study area lies along the central California coast, between Morro Bay and Pismo Beach, southwest of San Luis Obispo. The geomorphic regions in the area include the Irish Hills, the marine terrace flanking the western margin of the hills, the continental shelf, and slope offshore. The continental shelf is subdivided into the Islay and Santa Rosa Reef shelves (Figure B-3-1). A third shelf, named the San Luis shelf, is located east of the Santa Rosa Reef shelf in San Luis Obispo Bay and is discussed in Appendix I.

3.1 San Luis Range

Irish Hills - The Irish Hills are an oval-shaped, northwest-trending range, 18 km long and 14 km wide, that form the northern end and highest part of the San Luis Range, a prominent west-northwest-trending topographic and structural high. The Irish Hills are bordered on the north and west by the Los Osos Valley and the coastal embayment formed by the Estero and Morro bays and on the south and east by San Luis Obispo Creek Valley and San Luis Obispo Bay. The crest of the Irish Hills reaches elevations of 1600 to 1800 feet (500 to 550 meters) with the highest ridges near the head of Diablo Creek, including Saddle Peak (554 m; 1819 feet). Point San Luis and San Luis Hill (660 feet) are separate from the Irish Hills and form a prominent point on the southwest side of the range. Islay, Coon, Diablo, See, and Pecho creeks originate near the center of the range and form a crude radial pattern dominated by reaches that follow the northwest structural grain as canyons cut into the hills. These creeks formed as consequent streams as the range emerged from the Pacific in the middle Pliocene; but as erosion continued, the creeks favored and eroded along the northwest structural grain of bedding along most of their lower reaches. The top of the range has a broad accordance of hilltops that form a surface that slopes gently east and southeast; this surface records a degraded late-Pliocene erosion surface (PG&E, 1988; 1991).

Marine terraces onshore - Bordering the Irish Hills and the coastline is a narrow, seaward-sloping terrace that is up to 1 kilometer wide. The east side is bordered by the steep slopes of the Irish Hills and the west side by the sea cliffs that form the coastline whose western-most extremity is Point Buchon. This terrace is underlain by alluvial fan deposits that are in turn underlain by multiple marine wave-cut platforms and paleostrandlines whose seaward edges are exposed in the sea cliffs and in some valleys. The landward side of the terrace in the north reaches up to 36 meters elevation but is at only 12 to 18 meters in elevation in the south. This terrace was carved into the Irish Hills by wave erosion during the late Pleistocene sea-level high stands at approximately 81,000 to 240,000 years ago (Hanson et al, 1994) and subsequently covered by alluvial fan deposits. This is discussed in more detail in Appendix I.

The western edge of the terrace consists of rugged headlands, sea cliffs, coves, arches, stacks, and a few pocket beaches, the largest of which is at the mouth of Islay Creek. The sea cliffs on the southeast side of Point San Luis approach 60 meters elevation but are only 12 to 24 meters elevation on northwest of Point San Luis to Islay Creek.

Where the northwestern Irish Hills north of Islay Creek terminate at Morro Bay, the marine terrace and lower slopes are covered by Pleistocene and modern sand dunes. The older dunes are stabilized by vegetation cover. In contrast, the marine terrace is nearly absent at the southern end of the Irish Hills between Point San Luis and San Luis Obispo Creek. Here, the coastline consists of a bluff on the west and a steep hillslope with a narrow beach on the east. Where San Luis Obispo Creek enters San Luis Obispo Bay there is a small filled estuary and Avila Beach.

3.2 Continental Shelf

The continental shelf offshore of the Irish Hills slopes gently westward. The shelf here is 5- to 10-kilometers wide and lies between the coastline and a prominent break-in-slope to the steeper (1.0° to 2.0°) inclined continental slope at water depths of 100 to 225 meters, which is generally coincident with the Hosgri fault zone. Numerous rocks extend above sea level close to the shoreline, including Lion Rock near of Diablo Canyon, and Pecho Rock west of Olson Hill. The Santa Rosa Reef and Wesdahl Rock are shallow bedrock projections west of Point San Luis that lie about 6 meters below mean sea level.

Niemi et al. (1987), who first described the offshore shelf for the LTSP, note that much of this "inner" shelf is a rocky near-shore zone corresponding to the general seaward limit of the sea floor bedrock outcrops at approximately 70 to 80 meters depth. They point out that the rocky near-shore shelf is buried to the north and south by on-lapping Quaternary marine sediments in Estero and San Luis Obispo bays and to the west by sediment of the outer shelf.

The inner shelf is underlain by folded, fractured and faulted bedrock of Cretaceous and Tertiary rocks that has been planed by wave activity and etched by differential erosion during multiple sea-level transgressions and regressions in the Quaternary. As a result, the upper surface of bedrock is essentially planar but with a rough relief generally less than 5 meters (Figure B-3-2). The rocky bedrock shelf is locally incised by stream channels and troughs eroded by marine processes into the less resistant rocks. The more resistant rocks preserved in many places are represented by submerged paleosea stacks, wave-cut platforms, paleosea cliffs, and paleostrandlines (former coastlines) that formed during one or more Pleistocene sea-level stillstands.

Islay and Santa Rosa Reef shelves – Analysis of the MBES bathymetry allows the division of the inner continental shelf off the Irish Hills into two parts, the Islay shelf on the north and the Santa Rosa Reef shelf on the south (Figure B-3-2). Both shelves have a rocky near-coast portion and a sediment-covered portion further offshore. The Islay shelf has a steeper slope than the Santa Rosa Reef shelf that is reflected in the structure contours on top of bedrock (Figure B-3-3). These are further described in Appendix I.

Paleo-stream Channels – Prominent submerged sediment-filled paleo-stream channels and narrow to moderately wide paleo-valleys are preserved in the near-shore shelf (Plates B-1A to B-1D; Figure B-3-3). Although generally covered by unconsolidated sediment (mobile sand sheets), the channels range up to several kilometers long and appear to broaden into valleys at their distal western ends. The unconsolidated deposits filling paleo-channels are part of the mobile sand sheets and other fine-grained marine deposits; one seismic-reflection profile indicates the depth of sediments in the Islay Creek channel is about 8 meters. Remnants of alluvium and older marine deposits may underlie the surficial sand deposits.

Four prominent submerged stream channels are preserved in the Tertiary sedimentary rocks in Islay shelf. The northern-most channel is the shortest at approximately 800 meters long; it is preserved completely within sedimentary rock of the Pismo Formation offshore and is aligned with the mouth of Hazard Creek on shore. The longest (approximately 4.5 kilometers long), channel with the largest and best developed meanders is the Islay Creek channel. This channel is located just offshore of Islay Creek where its headward parts appear to have eroded across a north-northwest striking fault zone. This channel extends west of a rocky shelf to where it is buried by a mobile sand sheet that fills a shallow bedrock valley. The third channel is approximately 2.5 kilometers long and approximately 75 meters wide at its mouth. In bedrock the channel has well-developed incised meanders. The channel is located just offshore of Coon Creek, north of Point Buchon. The fourth channel is a pair of short, approximately 1.5-kilometer-long channels that head toward a small cove south of Point Buchon, but do not appear to align with any onshore stream. These channels broaden to the west into what may have been a wide valley or lagoon. The two channels are structurally controlled with one aligned along a fault and the other eroded along bedding.

Three channels are carved into the Cretaceous sandstone in the Santa Rosa Reef shelf (Plate B-1B). All are 1 to 2 kilometers offshore and none have clear onshore equivalents. The northern channel is a narrow and weakly meandered channel that trends southwest. This channel is approximately 2.5 kilometers long and is roughly on trend with three small creeks: Irish, Pecho and Rattlesnake Creeks. At its landward end, the channel makes a right bend of approximately 200 meters along an interpreted fault. South of the channel is a network of intersecting channels that trend northeast, west-southwest and west. Individual channels are approximately 1 to 2.5 kilometers long with the southern-most channel being the longest. The southern west-trending channel has eroded along a fault in the sandstone. The third channel is a kilometer offshore of Point San Luis. It trends westerly and parallel to the coast. It is narrow and approximately 1 kilometer long.

The larger channels generally exhibit meanders showing that erosion occurred subaerially when the streams were near or at base level probably during one or more prolonged sea-level lowstands during the late Pleistocene. This interpretation is supported by the smooth concave-up profiles of the Islay Creek and Pecho Creek channels (Figure B-3-4). The absence of prominent knick points shows that these streams eroded their channels to a base level offshore during sea-level low stands.

The preservation of the paleo-channels below 20 meters water depth attests to the minimal erosion on the shelves during the rapid sea-level rise that began after the Last Glacial Maximum (LGM) 20,000 to 22,000 years ago. In contrast, the near-absence of paleo-channels above 20 meters water depth probably results from erosion since the rate of sea-level rise slowed about 7,000 years ago (Figure B-3-4 and Appendix I).

The gap between the head of the offshore channels and the onshore streams results from the Holocene erosion and cliff retreat that destroyed the channels since approximately 7,000 to 5,000 years ago (Figure B-3-4) . The amount of Holocene erosion on the northern Islay shelf may be estimated based on the preservation of the paleo-channel of Islay Creek. The Islay Creek paleo-stream channel is incised approximately 1 to 2 meters into the 800-meter-wide Holocene wave-cut platform and approximately 8 meters into Pismo Formation rock west of the Holocene platform. The 6 to 7 meters of differential stream incision may represent the amount of vertical lowering of Pismo Formation strata in approximately 7,000 years.

Sand Sheet 'Dunes' - Thin mobile sediment (sand) deposits cover parts of the near-shore continental shelf to water depths of 80 meters (Plates B-1A to B-1D). These are well-defined, low, less than one meter high, dune-like features with long wave-lengths, approximately 25 to 125 meters (Figure B-3-2). The sand sheets cover marine sediments, and on-lap low bedrock outcrops, partly fill low areas, including paleo-stream channels, in the exposed bedrock platforms, and undoubtedly cover shallow marine deposits from the post-LGM transgression and locally earlier transgressions or sea-level stillstands. The sand sheets are particularly well expressed on the outer, sediment-covered part of the Islay shelf, opposite Islay Creek to Diablo Canyon where sand sheet fronts (lee slope) are perpendicular to a S35°E direction. The morphology appears to be formed by strong southeast-flowing currents most likely generated from storm events and may vary seasonally, or from particularly severe storms. For example, sand sheets in the Point Buchon area bathymetrically imaged both in 2007 and 2009 have been reported to cover upwards of 80% of what was rocky habitat in 2007 in the 20 to 10 meter depth zone with half a meter of sediment (written communication, Rikk Kvitek to Sam Johnson, October 30, 2009).

Migration of the sand sheets northwest of Olson Hill is documented from MBES bathymetric surveys undertaken in 2009 and 2010 in which previously buried bedrock is exposed (Figure B-3-5). In addition, Figure B-3-5 shows two pockmarks on the 2009 bathymetry that are absent in the 2010 bathymetry. If the pockmarks are real (and related to episodic expulsion of gas or fluids) and not data artifacts, their disappearance also indicates the mobile, ephemeral nature of the sand sheet deposits. Presumably sand sheets located in deep water are mobilized during strong winter storms with large waves that mobilize the sands in the deeper waters. Their age is estimated to range from modern to less than a few hundred years.

Paleostrandlines - The rocky inner continental shelf is characterized by bedrock at the seafloor and thin, local deposits of Quaternary sediment. Numerous submerged paleostrandlines and features related to old shorelines along the coastline are preserved in the offshore bedrock, both exposed and where covered with sediment (Figure B-3-6). Offshore wave-cut platforms and associated paleostrandlines and their use as late Quaternary strain gauges are discussed in Appendix I.

4. STRATIGRAPHY

The sequence of bedrock lithologies mapped in the coastline sea cliffs and wave-cut platforms to the north and south of DCPP and the lithologies interpreted from diver samples and bathymetry data offshore are generally very consistent with the onshore map relationships described by Hall (1973a; 1973b), Hall et al. (1979), and PG&E (1988; 1991). The rocks described in this Appendix include two Mesozoic formations, Franciscan Complex and Cretaceous sandstone, which are considered basement rocks, and three Tertiary marine formations, Obispo, Monterey, and Pismo, each with basal unconformities. Plates B-1A to B-1D and the summary geologic map (Figure B-4-1) show the different formations and Figure B-4-2 is the stratigraphic column based on Hall (1973b). In addition, Quaternary marine terraces and their associated deposits and marine sediments occur in the area.

4.1 Mesozoic Formations

Pre-Tertiary rock is exposed between the Hosgri fault zone on the west and the San Miguelito fault on the east in the southern half of the Shoreline fault study area. These rocks consist of fault-bounded slices of the Jurassic-Cretaceous Franciscan Complex (JKf) and Cretaceous sandstone (Ks). This group of rocks was extensively deformed in a subduction zone accretionary prism. Tertiary strata on-lap and locally are faulted against the pre-Tertiary rock.

4.1.1 Franciscan Complex

Franciscan Complex rocks include a chaotic assemblage of various lithologies, including fine-grained metavolcanic rocks (greenstone, KJmv), sheared claystone (mélange, KJf), glaucophane schist, serpentinite, and chert. The greenstone is dark greenish gray with common very fine quartz and calcite veins, and the glaucophane schist is bluish to greenish gray with very fine quartz veins and a pervasive shear fabric. The greenstone and glaucophane schist are associated with a greenschist facies and strong magnetic-field anomalies observed offshore of San Luis Hill, along the south side of the San Miguelito fault, and elsewhere west of the Shoreline fault zone (Figure B-4-3). Onshore the mélange is black claystone with a pervasive shear fabric and includes pebble- to cobble-size angular clasts of fine-grained lithic sandstone (greywacke). The mélange is exposed in narrow bands along the coastline north and south of Olson Hill and is associated with chert and greywacke exposures. The chert is reddish brown to light brown with prominent banding (exposed at Olson Hill and Double Rock).

The texture of Franciscan Complex rocks in the MBES bathymetric data is variable, due to the highly variable levels of erosional resistance among the different rock types. Areas of the sea floor with diver samples or drop core samples identified as metavolcanic rock or glauconite schist (Plate B-1C) exhibit a hackled, isotropic texture in the MBES bathymetric image. The mélange is expressed as narrow to wide, easily eroded low areas with various-sized knockers of resistant greenstone and Cretaceous sandstone protruding above the general mélange surface. In the southern Santa Rosa Reef shelf the mélange separates large Cretaceous sandstone terranes and other rock types, but toward the north it is more localized near the shoreline and separates Tertiary strata from Cretaceous rocks along the coast south of Lion Rock. The mélange on the sea floor where exposed above the sand sheet is a low-relief, smooth surface with a shallow dimpled texture (Figure B-4-4). Some planar seafloor areas that are smooth but have a significant number of rocks three meters or higher above a low-relief bedrock plane or sand sheet are interpreted as underlain by mélange with rock knockers. Strong magnetic field anomalies are associated with the mélange. The South and Central segments of the Shoreline fault zone, discussed in Section 5.4.3, are located within the mélange.

4.1.2 Cretaceous sandstone

Cretaceous sandstone (Ks) exposed along the coast onshore south of DCPP is brown, thickly bedded, fine- to medium-grained greywacke. Grain lithologies are dominantly quartz with minor amounts of feldspar and lithic grains. Interbeds of siltstone and sandy siltstone included within the exposures of Cretaceous sandstone are rare.

Regionally, greywacke is the most abundant rock type within the Franciscan Complex (Hall, 1973b) but is only exposed in small pods in association with mélange along the coastline in the study area. This relative lack of onshore greywacke exposures is a leading motivation to reinterpret certain diver samples and drop core samples from the LTSP as Cretaceous sandstone instead of Franciscan Complex greywacke (Tables B-1 and B-2). Reinterpretation of these samples provides a simpler and more consistent geologic map that more closely resembles the local onshore geology. Silt beds within the greywacke deposits are locally extensive and samples of these silty interbeds were recovered offshore of Olson Hill during the most recent diver sampling campaign (Table B-3). Recognition of these silt interbeds in the offshore provided a good criterion to reinterpret fine-grained siltstones previously mapped as Pismo Formation and reclassify them as Cretaceous sandstone (Table B-3). The MBES bathymetry images the Cretaceous sandstone as a homogenous, rough textured outcrop with consistent differentially eroded beds. Locally the texture records crude bedding.

4.2 Tertiary Stratigraphy

Along the coastline and east of the Shoreline fault zone, the Tertiary section is exposed south of DCPP at the base of Green Peak and is continuously exposed as younger strata to the north-northwest beyond Islay Point and into Estero Bay (Plates B-1A and B-1B; Figure 4-1). West of the Shoreline fault zone, the offshore Tertiary section is exposed northwest of an unconformity with pre-Tertiary rocks that lies southeast of DCPP and becomes younger to the west and northwest towards the Hosgri fault zone (Plate B-1C). Additional Tertiary strata are exposed east of the southern end of the Shoreline fault zone, within San Luis Obispo Bay and onshore to the north and east (Plate B-1D). The majority of the Tertiary section is composed of three formations, the Miocene Obispo, the Miocene Monterey, and the Miocene-Pliocene Pismo Formations. Each of these formations is bounded with a basal unconformity.

4.2.1 Tertiary/basement contact

The basal contact of the Tertiary section is exposed in three locations: (1) in the Santa Rosa Reef shelf, southwest of San Luis Hill; (2) along the base of Green Peak south of DCPP; and, (3) offshore on the east side of San Luis Obispo Bay (Plates B-1B to B-1D). Along the base of Green Peak, the basal contact of the Tertiary section is generally concealed and is an intrusive contact between Obispo Formation diabase and basement rock (Hall, 1973a; Hall et al., 1979). Directly to the northeast this contact is a moderately dipping depositional contact with Rincon and Vaqueros Formations overlying basement rock (Hall, 1973a). Farther northeast the base of the Tertiary section is truncated by the San Miguelito fault. At an inaccessible coastline exposure south of DCPP, the base of the Tertiary section appears as a subvertical fault or possibly intrusive contact between Obispo Formation diabase and Franciscan Complex rocks (Plate B-1B). Farther west the base of the Tertiary is truncated along the Shoreline fault zone that juxtaposes Obispo diabase and basement rocks.

The lowermost Tertiary section in the San Luis Obispo region includes the Vaqueros Sandstone and Rincon Shale, locally representing a total of approximately 180 meters feet of marine conglomeratic sandstone and interbedded shale and tuff (Hall, 1973b). These units were not recognized along the DCPP coastline exposures, presumably because they (1) have been truncated by Tertiary faulting, (2) have been obscured by intrusion of the large diabase sill at the base of the Obispo Formation, (3) were not deposited in this portion of the Tertiary basin, or (4) have been mapped as lower Obispo Formation. However, offshore in the Santa Rosa Reef shelf, the basal Tertiary section is characterized by a package of thin, concordant beds that overlie weakly bedded Cretaceous sandstone (Plate B-1C). This may be thin Vaqueros Sandstone and/or Rincon strata that off-laps basement rock, but there are no samples to confirm this interpretation. For mapping purposes these rocks are included within the Obispo Formation.

Near the town of Avila Beach the base of the Tertiary section is constrained to lie between basement rocks on the west side of San Luis Obispo Creek and Obispo Formation exposures on the east side of San Luis Obispo Creek. The fault or unconformable contact can be projected offshore but is concealed beneath sand and is inferred to separate exposures of Obispo resistant tuff on the east side of San Luis Obispo Bay from basement rock of San Luis Hill. The degree of late Tertiary deformation of this contact is unclear and difficult to evaluate due to lack of exposure.

4.2.2 Obispo Formation

The Obispo Formation (Tmo) is a roughly 1300-foot-thick section of marine volcanic and volcaniclastic deposits (Hall, 1973a; Hall et al., 1979) and occurs throughout the Shoreline fault study area (Plates B-1A to B-1D). Lithologies and facies associations within the Obispo Formation vary considerably on a regional basis (e.g., Hall et al., 1979), but along the coastline of the Irish Hills three subunits within the Obispo Formation are recognized: resistant tuff (Tmor), fine-grained sandstone and claystone (Tmof), and intrusive diabase (Tmod). Tuff within the Obispo Formation has been dated at 15.5 to 15.3 million years before present (Ma) (Turner, 1970).

The resistant tuff subunit is exposed along the coastline from the base of Green Peak to the south headland of Discharge Cove, and is structurally repeated at the north headland of Discharge Cove. The resistant tuff subunit may be structurally repeated at Crowbar Hill, though these exposures may also represent a second, later episode of tuff deposition. The subunit includes multiple 15- to 45-meter-thick intervals of bedded and massive, well lithified, zeolotized tuff that forms prominent headlands, steep cliff faces, and sea stacks. These tuff deposits are intercalated with intervals of thinly bedded and laminated fine-grained sandstone and mudstone that differentially erode to form narrow surge channels at the coast. The massive tuff facies is most common and includes chaotic and unstratified deposits with basal scour features, rip-up blocks of shale and tuff, and evidence for soft-sediment deformation (indicating gravity flow transport). The bedded tuff facies includes packages of planar bedding continuous over tens of feet with weakly expressed textural grading and no large clasts or evidence for syn-depositional deformation (indicating suspension settlement). The intervals of laminated and thinly bedded sandstone and mudstone within the subunit of resistant tuff include common layers of tephra and are probably turbidite deposits, suggesting a deep marine depositional environment for the entire resistant tuff subunit.

The fine-grained sandstone and mudstone subunit is exposed along the coastline from the south headland of Discharge Cove to south of Crowbar Hill and is probably structurally repeated north of Crowbar Hill. This fine-grained subunit is a greater than 100 meter thick section of regularly bedded sandstone with minor shale and mudstone that coarsens gradually up-section. Bedding is laterally continuous over tens of feet, but packages of bedding are difficult to correlate between exposures in different shoreline coves and across Tertiary faults and folds, suggesting that there are significant lateral variations in the subunit. Along the coastline, lithologies include a basal interbedded shale and calcareous sandstone that overlies the resistant tuff subunit and grades up-section into laminated fine-grained sandstone and then into coarsely bedded medium- to coarse-grained sandstone. A package of diatomaceous sandstone has been recognized within the fine-grained subunit in the DCPP area of Diablo Canyon (PG&E, 2002), but only a small exposure of this lithology was found exposed in the sea cliffs south of Crowbar Hill. The well-bedded and generally coarsening-upward trend in the subunit records progradation of clastic sediments and filling of a distal marine basin during a period of local volcanic quiescence.

The diabase subunit has intruded into the resistant tuff subunit along approximately one kilometer of coastline south of DCPP, consistent with the onshore mapping by Hall (1973a) and PG&E (1988; 1991) that documented the subunit along the base of Green Peak. This dike/sill complex is also mapped on the modern wave-cut platform in the intertidal zone directly south of the breakwater at Intake Cove. Diabase was also identified north of Crowbar Hill where it is exposed as dikes and bedding-parallel sills within the fine-grained subunit. This exposure is a continuation of the diabase body mapped by Hall (1973a) and PG&E (1988; 1991) on the north side of Diablo Canyon. Texture of the diabase varies from aphanitic rock to phaneritic matrix with plagioclase porphyry up to 3 centimeters in diameter. Emplacement of the diabase may have begun coincident with the volcanism that produced the resistant tuff subunit and/or it may have intruded after deposition of the fine-grained subunit.

As imaged in the offshore MBES bathymetric data, the Obispo Formation is characterized by distinct and continuous beds that off-lap basement rock on the Santa Rosa Reef shelf southwest of San Luis Hill. Portions of this section appear more resistant to erosion, have higher seafloor relief, and are probably composed of the resistant tuff subunit. The well-bedded part is inferred to be the fine-grained subunit. However, in the area far offshore the few diver samples collected are insufficient to differentiate lithology, so the subunits are lumped together as undifferentiated Obispo Formation. Similarly, in San Luis Obispo Bay, much of the Obispo Formation on the sea floor is inferred to be either the resistant tuff subunit or the fine-grained subunit. Closer to the coastline, the geologic relationships observed onshore are extrapolated to offshore and the subunits are mapped based on the resistant texture of the resistant tuff subunit, the bedded habit of the fine-grained subunit, and the smooth, hummocky texture of the diabase subunit.

4.2.3 Monterey Formation

The Monterey Formation occurs onshore and offshore in the study area (Plates B-1A to B-1D). It overlies the Obispo Formation and is a roughly 600-meter-thick section of bedded dolomitic siltstone, diatomite, and cherty shale where it is exposed along the coast between Crowbar Hill and south of Coon Creek at Point Buchon (Hall, 1973a; Schwalbach and Bohacs, 1995). The Monterey Formation is thinly bedded and bedding packages are continuous over several tens of feet. The lower half of the Monterey section at Point Buchon records a gradual decrease in clastic deposits (dolomitic siltstone, similar to the fine-grained subunit of the Obispo Formation) and an increase in siliceous shale and porcelaneous chert. This trend reverses in the upper half of the Monterey section where the proportion of clastic strata increases gradually toward the basal unconformity at the base of the overlying Pismo Formation. The depositional environment for the Monterey Formation is deep marine, probably lower slope to distal basin (Schwalbach and Bohacs, 1995). Age dating analyses indicate an age of 11.4 to 10.5 Ma for the middle of the section at Point Buchon (Schwalbach and Bohacs, 1995).

Offshore exposures of the Monterey Formation were interpreted from MBES bathymetric data (Plate B-1A) assisted by projecting the strike of prominent bedding and the basal contact mapped onshore by Hall (1973a; 1973b) south of Point Buchon and west of the town of Pismo Beach. The basal contact of the Monterey Formation was mapped on the Santa Rosa Reef shelf by selecting a stratigraphic position that roughly divides bathymetric texture representing the Obispo Formation (thicker, less regular beds with intervals of resistant tuff) with texture representing the Monterey Formation (thinner, regular or rhythmically bedded layers with no resistant interbeds). The accuracy of this contact along the Santa Rosa Reef shelf is assumed to be within 10 to 15 meters of stratigraphic section in part because the diver and drop core samples near this contact were generally non-diagnostic and of little use in further constraining the contact location. Both the lower Monterey Formation and the upper Obispo Formation (subunit Tmof) include significant proportions of dolomitic sandstone and mudstone, but only the Monterey includes the unique lithology of chert or porcelaneous shale.

4.2.4 Pismo Formation

The Pismo Formation overlies the Monterey Formation and at the north end of the Irish Hills is an approximately 600-meter-thick section of marine sandstone and siltstone (Plates B-1A to B-1D) that includes five different members (Hall and Surdam, 1967; Hall, 1973a; 1973b, and Hall et al., 1979). The lower portion of the Pismo Formation includes the Miguelito and Edna Members, which interfinger and roughly define the extent of a Miocene-Pliocene subbasin that occupied the area of Irish Hills east to near Arroyo Grande. The Miguelito Member consists of basinal mudstone and diatomite, and the Edna Member consists of inner shelf sandstone (Stanley and Surdham, 1984). The Miguelito Member is exposed along the coastline north of Point Buchon in the south limb of the Pismo syncline and offshore in the Islay Shelf.

The upper portion of the Pismo Formation includes the Gragg, Belleview, and Squire Members, all of which have a significantly smaller areal extent than the strata of the lower Pismo Formation and are composed of inner-shelf sandstone and sandy mudstone. The Gragg and Squire Members have basal unconformities. The basal portion of the Pismo Formation (Miguelito Member) at Point Buchon has been dated at about 10.4 to 9.0 Ma, and the upper strata exposed along the coastline to the north was dated at about 6.7 to 6.0 Ma (Keller, 1992; Keller and Baron, 1993). The base of the Gragg Member was estimated at 4.2 Ma by Stanley and Surdham (1984) through correlation to the global sea-level record, and the base of the Squire was similarly estimated at 3.8 Ma. Initial results of microfossil analysis of the Squire Member for our investigations indicate deposition at about 3.0 to 3.3 Ma (PaleoResource Consultants, Inc, personal communication, 2010).

No strata were recognized that would correlate with the Pismo Formation in the Santa Rosa Reef shelf, but a small section of the Miguelito Member strata is inferred to form the core of a syncline on the east side of San Luis Bay. Squire Member deposits directly overlie basement rock south of the San Miguelito fault northwest and north of San Luis Hill and in the sea cliff west of the town of Avila Beach. The Squire Member was also identified overlying basement rock in cores described from the Union Oil pier in San Luis Obispo Bay (PG&E, 1990), but is not evident on the flanks of San Luis Hill or offshore to the south or west of San Luis Hill.

Similarly to the Monterey Formation, the Pismo Formation was mapped in the offshore using MBES bathymetric images assisted by projecting along clear bedding trends the basal contacts as mapped onshore by Hall (1973a; 1973b) south of Point Buchon and west of the town of Pismo Beach.

4.3 Quaternary Stratigraphy

The major Quaternary deposits are included on the geologic map (Plates B-1A to B-1D): marine terrace and overlying deposits, alluvium, landslides, and marine sediments.

4.3.1 Onshore deposits associated with marine terraces

The onshore marine terraces (Figure B-3-6) (Qm) are described by Hanson et al. (1994). Between Morro Bay and Avila Beach, Hanson et al. (1994) map remnants of at least 12 marine terraces ranging from sea level to 247 meters elevation. The terraces generally consist of a wave-cut platform veneered by thin (1 to 2 meters) marine sand and gravel overlain by up to 30 meters of alluvium, alluvial fan deposits, colluvium, and eolian sand. The two lowest terraces of Hanson et al. (1994) are nearly continuous along the coast: the Q_1 terrace is correlated to Marine Isotope Stage 5a that formed about 80,000 years ago, and the Q_2 terrace is correlated with Marine Isotope Stage 5e that formed during the last interglacial interval about 120,000 years ago. For additional discussion of the terrace sequence, see Hanson et al. (1994) and Appendix I.

4.3.2 Eolian sand

Eolian sand deposits (Qe) in the form of dunes occurs on the northwestern end of the Irish Hills. These consist of reworked beach sands blown inland and deposited onshore as dunes behind the sand spit and beach north of Hazard Canyon as well as plastered on the hills facing the coast southeast of Estero Bay. The sand dunes are late Pleistocene and Holocene in age and are described in more detail by Wiegers (2009).

4.3.3 Beach deposits

Beach deposits occur along the coast of the Irish Hills but are not shown on the geologic map because they are too narrow. They consist of modern beach sands at the south end of Morro Bay and at the small beach at Islay Creek. To the south of Islay Creek the beach deposits are confined to the base of the sea cliffs and consist of rounded gravel, cobbles and boulders, locally sandy, concentrated in coves between headlands. More extensive beach sands are present at Avila Beach and at Pismo Beach in the southeast part of the study area.

4.3.4 Offshore marine deposits

The offshore marine deposits (Qs) are known from the drop cores taken during the LTSP. The thickness of these deposits is locally constrained by the high-resolution seismic-reflection profiles. They consist of sand and silty sand with minor gravel deposits that become finer grained progressively offshore. Thin dune-like sand sheets (Qsw) cover parts of the sea floor. Evidence for their mobile, ephemeral nature is discussed in Section 3.2 and shown in Figure B-3-5. At the base of the marine sand and silt, a gravel-cobble lag is inferred to overlie the top of bedrock. Paleo-beach deposits and talus or cliff-fall debris are interpreted from the MBES bathymetric images below submerged paleosea cliffs, particularly where they are concentrated along the leeward south and southeast sides of the cliffs.

5. STRUCTURE

The Shoreline fault zone study area is within the San Luis/Pismo structural block as described by Lettis et al., (1994; 2004). This block is bordered by three active fault zones: the Hosgri, Los Osos and Southwestern Boundary fault zones (including the San Luis Bay fault) (Figure B-4-1). The Hosgri fault zone borders the west side of the study area and separates the Islay and Santa Rosa Reef shelves from the outer continental shelf. The marine bedrock platform and geologic structures are truncated by the Hosgri fault zone (Plates B-1A to B-1C). The south- to southwest-dipping Los Osos fault is on the north and northeast side of the Irish Hills (Lettis and Hall, 1994). The Southwestern Boundary fault zone consists of the north-dipping San Luis Bay fault zone (which in turn includes the Olson and Rattlesnake faults) and the widely spaced Wilmar Avenue, Pecho, Los Berros, and Oceano faults (PG&E, 1988; Lettis et al., 1994). The Wilmar Avenue, Los Berros, and Oceano faults project offshore into San Luis Obispo Bay in the southeastern part of the Shoreline fault zone study area (Plate B-1D). Within these bounding faults are folds and fault zones that record one or more episodes of deformation since the Jurassic (Plates B-1A to B-1D; Figure B-4-1).

5.1 Tectonic History

The regional tectonic history includes several distinct tectonic events that are recorded in the geology of the study area. A recognition of the regional tectonic history helps put the faulting observed in the Shoreline fault zone study area in context; much of the structural fabric and faulting is inherited from one or more past episodes of deformation, and is not active in the current tectonic regime. On the other hand, faults that are currently active are probably, at least in part, reactivating older faults that formed under a different tectonic regime. In addition, ancestral faults and structures formed during a prior deformational episode have the potential to be offset markers where they cross currently active faults.

The earliest recorded tectonic event in the study area is the coast-parallel subduction that lasted during the Mesozoic and early Cenozoic and produced the chaotic Franciscan Complex (Atwater, 1970; 1998). This episode juxtaposed Jurassic ophiolite (including pillow basalt), various rock bodies within the Franciscan Complex (including serpentinite), and small to large blocks of Cretaceous sandstone within the study area. Localized deformation produced sheared zones of mélange and an overall highly anisotropic rock mass, and all pre-Tertiary rock boundaries are marked by mélange or narrower fault zones.

As the transform Pacific-North America plate boundary was established in central California in the Miocene, coast-parallel subduction was replaced by west-northwest-directed transtensional deformation (McCulloch, 1987). This episode of deformation is associated with the main Miocene depositional basins of the Obispo, Monterey, and lower Pismo Formations. Faults within the study area probably included basin-bounding or intra-basin normal, normal-oblique, and strike-slip faults, many of which may have reactivated pre-existing faults related to subduction. It is probable that the San Miguelito, Edna, and Hosgri were active basin-bounding normal faults at this time.

About 8 million years ago, the direction of relative Pacific-North America plate motion changed from west-northwest to about N37°W (Atwater and Stock, 1988). Later, about 5 million years ago, the major Pacific-North America plate boundary fault system stepped east and gradually initiated capture of Baja California and central coastal California within the Pacific Plate. Some time at or since about 5 million years ago, regional deformation switched from transtension to more coast-parallel strike-slip to transpression. A regional change to transpression in the middle to late Pliocene is recognized throughout coastal California (e.g., Page et al., 1998; Ducea et al., 2003) and may correlate with the progressive eastward development of the Pacific-North America plate boundary. In the study area, the transpressional deformation episode is associated with Tertiary unconformities, contractional folding of Tertiary strata including the Pismo syncline, and probably inversion of the formerly normal San Miguelito, Edna, and Hosgri faults as reverse, oblique, or strike-slip faults. Offshore mapping with MBES bathymetry and high-resolution seismic-reflection profile data clearly reveal folded and faulted Tertiary strata consistent with this episode of deformation (Plates B-1A to B-1D). The deformation also warps and folds pre-existing fault contacts or angular unconformities that separate the Tertiary section from the underlying Cretaceous basement section.

The most recent episode of deformation in the study area is characterized by near-uniform block uplift of the San Luis/Pismo block relative to adjacent blocks in the larger Los Osos/Santa Maria tectonic domain (PG&E, 1988; Lettis et al., 1994; 2004). The block uplift mode of deformation is recorded by flights of Pleistocene marine terraces along the flanks of the Irish Hills (Hanson et al., 1994) that demonstrate the mode of a coherently uplifting block over the past half-million years or more rather than tilting or folding as recorded in the Tertiary rocks. The estimated timing of the transition from folding-thrusting-dominated deformation to block uplift is broadly defined to between about 2 and 0.5 million years ago (Hanson et al., 1994).

5.2 Basement Structures

Deformation of Mesozoic and early Tertiary Formations - The Franciscan Complex basement rock in the Shoreline fault zone study area is a composite terrain with a high degree of structural and stratigraphic complexity. Faults within the Franciscan Complex are generally difficult to follow along strike but in outcrop are clearly recognizable as zones of intense localized shearing that separate different Franciscan lithologies. Deformation is generally localized and pervasive within zones of sheared claystone onshore and in the mélange offshore and is less penetrative in sandstone and greenstone rocks away from these mélange zones.

The Franciscan Complex rocks were faulted against overlying Cretaceous sandstone during one or more subsequent episodes of deformation during the early Tertiary (Wahl, 1995). The faulted contacts between the Franciscan Complex and separate blocks of Cretaceous sandstone onshore are generally narrow in outcrop, commonly less than a few meters wide. Offshore on the Santa Rosa Reef shelf, however, the sheared rock forms wide bands of mélange that separate large bodies of Cretaceous sandstone (Figure B-4-4).

Two northwest-striking faults interpreted to be in mélange displace broad outcrops of Cretaceous sandstone offshore (Figure B-4-4 and Plate B-1C). The westernmost is 3.4 kilometers west of Point San Luis and strikes N48°W. A strand of this fault may displace a paleo-stream channel right laterally about 80 meters; however, the data also allow the offset to be a bend in the channel and hence be erosional. The other fault is the South Segment of the Shoreline fault discussed in Section 5.4.3.2.

5.3 Tertiary Structures

Tertiary bedrock faults and folds commonly truncate or repeat stratigraphic section exposed along the coastline and are clearly imaged offshore in the MBES bathymetric data. The Tertiary strata record unconformities between formations and different styles of folding and faulting that represent one or more episodes of deformation. Within the study area, map relations suggest that structures vary from one formation to the next. Alternative interpretations of this are: (1) the structures record different tectonic episodes in the Tertiary, (2) the structures record different strain responses of the different rheologies, or (3) different structures formed in different locations within the map area due to differential movement of deeper crustal faults.

5.3.1 Deformation of the Tertiary/basement contact

Faulting and folding deform the basal contact between basement rocks and the overlying Tertiary strata. The base of the Tertiary section is probably late Oligocene to early Miocene, based on regional age estimates for the Rincon and Vaqueros Formations (Hall, 1973b). This basal contact records a broad-scale deformation evident in its outcrop pattern on the Santa Rosa Reef shelf and onshore (Plates B-1B and B-1C; Figure B-4-1). The northeast end of the contact west of DCPP is inferred from an interpretation of Tertiary rocks exposed through the mobile sand sheets and by seismic-reflection profile data that indicate a contact at depth between basement and bedded Tertiary rocks.

5.3.2 Deformation within the Obispo Formation

Coastline exposures of the Obispo Formation record several forms of syn- and post-depositional deformation. Syn-depositional deformation is recorded by the disruption of fine-grained intervals within the resistant subunit of the Obispo Formation and incorporation of these lithologies into the chaotic packages of tuff. There is also some evidence for post-depositional slumping. Post-depositional faulting of the Obispo Formation in the coastline exposures includes at least three different fault sets with clear cross-cutting relationships.

The oldest post-depositional deformation in the coastline exposures of Obispo Formation is a narrow zone of northeast-southwest-oriented faults that places the fine-grained subunit of the Obispo Formation against the resistant subunit at the south end of the Discharge Cove at DCPP (Plate B-1B; Figure B-5-1). This fault zone dips steeply southeast, has a reverse-sinistral sense of displacement, and is cross-cut by one or both of the adjacent east-west and approximately north-south bedrock fault systems described in the following paragraphs.

Bedrock faults striking about north-south displace an intrusive contact between the resistant subunit and the diabase subunit of the Obispo Formation exposed along the south breakwater at Intake Cove at DCPP (Plate B-1B; Figure B-5-1). A section of distinctive beds within the resistant Obispo subunit adjacent to the subunit contact is systematically displaced in a right-lateral sense several hundred feet along two faults in Intake Cove. Two additional north-south oriented faults separate resistant subunit strata on the west from fine-grained subunit strata on the east: one of these faults is at the northwest headland of Discharge Cove, and the other is about 300 meters southeast of Crowbar Hill and projects south to the east side of Lion Rock (Figure B-5-1). The sense of displacement along these north-south faults is dextral with no indication of the amount of vertical displacement. The north-south fault that crosses the northwest headland of Discharge Cove may continue for about 1.5 kilometers farther south, as suggested by an apparent right-lateral separation of two magnetic lineaments in the enhancement shown in Figure B-5-1. If so, this older right-lateral fault crosses the Shoreline fault and provides a limit to the total right-lateral displacement on the younger fault (described below with the Shoreline fault zone in Section 5.4.3.2).

East-west-striking faults in Discharge Cove and the next cove north truncate at least some of the faults that strike approximately north-south (Figure B-5-1). The sub-vertical east-west fault in Discharge Cove is observed in the sea cliff where it separates a sliver of resistant Obispo from fine-grained Obispo Formation. A northwest-southeast-striking fault that juxtaposes Obispo subunits at the south end of Discharge Cove projects northwest to the east bank of Diablo Creek. The lack of a similar fault near the mouth of Diablo Creek supports the interpretation that the northwest-striking fault is truncated by the east-west fault. In another example, the sub-vertical east-west fault in the cove north of Discharge Cove is clearly visible in the modern wave-cut platform and in the sea cliff where it truncates a fold and juxtaposes fine-grained subunits of the Obispo Formation. This east-west fault must truncate the north-south fault mapped at the northwest headland of Discharge Cove as this north-south fault is absent on the opposite side of the cove to the north.

Deformation of the Obispo Formation in the Santa Rosa Reef shelf (Plates B-1B and B-1C) includes small displacements (less than 3 meters) visible in the MBES bathymetric data along generally N20°W to N30°W striking faults. Folds in the Santa Rosa Reef shelf include the large-scale folds that deform the basal Tertiary contact and several other smaller-scale east-west oriented parasitic folds. Deformation of the Obispo Formation evident in the Islay shelf (Plate B-1A) includes several short, discontinuous, roughly east-west-oriented lineaments and faults that appear to terminate at the N40W fault (described in Section 5.4.2). Folding of the Obispo Formation in the Islay shelf is tight but mapable at a detailed scale from coastline exposures. However, this same folding is weakly expressed in the offshore MBES bathymetric data, probably because of the tight folding combined with extensive and complicated intrusion of diabase. Deformation of the Obispo Formation in San Luis Obispo Bay includes some east-west-oriented folding defined by MBES bathymetric data offshore similar to those in coastline exposures (Hall, 1973b). A series of discontinuous east-west-oriented lineaments in the Obispo Formation south of the town of Avila Beach may represent faults, joint discontinuities, or the dominant orientation of resistant beds within the Obispo Formation.

5.3.3 Deformation within the Monterey Formation

Late Tertiary deformation of the Monterey Formation has been primarily accommodated through folding, rather than through the brittle faulting that characterizes most of the deformation of the Obispo Formation. In the Islay shelf the Monterey Formation forms a moderately dipping homocline with abundant small, parasitic folds (Plate B-1A) such as the minor doubly-plunging syncline imaged in the MBES bathymetric data that appears to correlate with a small syncline mapped onshore near Point Buchon by Hall et al. (1979). Faults within the Monterey Formation appear to be caused by bedding-parallel shearing and drag folding within tight folds, and offset equivalents are difficult to identify. In the Santa Rosa Reef shelf the east-west folds recognized in the Obispo Formation generally continue east into the Monterey Formation. In one case, folding along the approximate Obispo-Monterey contact has been rotated into a northwest-southeast orientation by drag folding along a strand of the Hosgri fault zone (Plate B-1C). Deformation of the Monterey Formation in San Luis Obispo Bay includes the same approximately east-west-oriented folding described above in the Obispo Formation.

5.3.4 Deformation within the Pismo Formation

The Pismo syncline is a major structure that underlies the crest of the Irish Hills and plunges northwest toward the coast. At and southeast of the coastline, the Miguelito Member of the Pismo Formation is at the core of the syncline. In the Islay shelf along the northwest projection of the syncline axis, folds and faults are imaged on the MBES bathymetric data with growing complexity but are clearly correlative to folds mapped at the coastline (Plate B-1A). Bedding attitudes in the northern portion of the Islay shelf define a broad, northwest-plunging antiform that marks the end of the Pismo syncline and perhaps results from deformation related to the nearby Hosgri or Los Osos fault zones in southern Estero Bay.

Although folds, faults and fractures in the Pismo Formation are less pronounced than in the underlying Obispo and Monterey formations, they are clearly observed on the Islay shelf. Folds in the Pismo Formation strike N60°W to N70°W and associated with the folds are short faults that lie along and parallel to the fold axes. Other short faults striking N50°W slightly displace bedding. The largest fault zone in the Pismo strata lies northwest of the mouth of Islay Creek. This prominent fault zone strikes N25°W and trends onshore at the mouth of Islay Creek where Hall et al. (1979) maps a small anticline. Offshore it extends about 5.5 kilometers ending in a syncline. The 300-meter-wide fault zone appears to offset Pismo strata with possible right-lateral separation. The fault projection onshore does not deform the youngest emergent strandlines, associated with the 80,000- and the 120,000-year-old sea-level highstands (Hanson et al., 1994).

The LTSP analysis identified a group of northwest striking faults in the offshore that were collectively called the Crowbar faults (PG&E, 1988). In the analysis of the MBES bathymetric data and the high-resolution seismic-reflection profiles, a series of small, northwesterly striking faults associated with the folds were identified. These structures are more westerly striking than those mapped as the Crowbar faults in 1988. Most of these small faults are associated with the northwest folding in Monterey and Pismo Formation strata (Figure B-5-2) and are not the through-going, more northerly Crowbar faults extending between the coast and the Hosgri fault zone as interpreted in the LTSP. It appears that the LTSP-interpreted extension of faults between the widely spaced older seismic-reflection profiles crossed structures visible in the MBES bathymetric data.

5.4 Quaternary Structures

5.4.1 Hosgri fault zone

The Hosgri fault zone is an active transpressional right-slip fault zone that extends southeastward approximately 110 kilometers from 6 kilometers offshore Cambria in the north to a point 5 kilometers northwest of Point Pedernales in the south (Hanson et al., 2004). The fault zone lies offshore for its total length and separates two tectonic domains with contrasting styles of crustal deformation. These domains are the offshore Santa Maria Basin on the western side of the fault zone and the onshore Los Osos domain on the eastern side (PG&E, 1988; 1990; Lettis et al., 2004).

The Hosgri fault zone was mapped along its entire length using petroleum industry multichannel seismic-reflection profile data that imaged the fault planes to depths of 1.5 to 3 kilometers beneath the sea floor (PG&E, 1988; 1990). Part of the fault zone has been re-mapped for this study using the USGS single channel, high-resolution seismic-reflection profile data (Appendix H). The USGS data set provides improved near-surface resolution of the fault traces and associated structures but with limited depth penetration. The surface traces of the fault zone for an approximate 33-km long section are shown on three sheets of the geological map, Plates B-1A to B-1C, but the fault zone extends both northwest and southeast out of the Shoreline fault zone study area.

In the study area the fault zone strikes N25°W-N30°W and consists of many separate subparallel and en-echelon strands. It generally controls the shelf break and truncates many geologic structures east of the fault. With the exception of a few rock outcrops and changes in sea-floor slope, the fault zone has little surface expression. The fault zone appears to form a seaward limit to the Santa Rosa Reef and Islay shelves, restricting the sea-floor outcrops to the near-shore part of the continental shelf.

As mapped from the high-resolution seismic-reflection data, the Hosgri fault zone consists of multiple traces that are continuous for as long as 18 kilometers. The fault zone is 1- to 2.5-kilometers wide and contains strands that appear to extend to the sea floor and strands that are buried by sediment. Within the fault zone are several associated en-echelon faults and folds. On the relatively high-resolution seismic-reflection profiles the faults appear vertical to steeply dipping in the upper few hundreds of meters. On the common-depth point exploration seismic-reflection profiles with several seconds of signal penetration some of the faults dip steeply to the east within the upper 1 to 2 kilometers of Tertiary and pre-Tertiary rock (PG&E, 1988).

South of Estero Bay the Hosgri fault zone has three traces, A2, C, and C1 (Plate B-1A). The average strike is about N22°W. Trace A2 is buried, whereas both traces C and C1 appear to extend to the seafloor. Trace C1 is less than 7 kilometers long. Trace C extends south of Point Buchon where five other traces, A, A1, A2, B, and C2, are mapped (Plate B-1B). Southwest of DCPP the average strike changes from N22°W to N35°W to N40°W. Trace A is exposed at the seafloor over most of its length and associated with bedrock outcrops (probably Monterey Formation). The northern kilometer of trace A, most of trace A1, and traces A2 and B are buried. Trace C is exposed at the seafloor for all but its southern 2 kilometers. Trace C2 overlaps the southern 4 kilometers of trace C and is exposed at the seafloor for most of its length. Seafloor outcrops of the Monterey Formation are seen at several places along the eastern side of trace C2 and locally at the left bend (a restraining bend) between traces C2 and A.

West of Point San Luis the Hosgri fault zone has two main traces and several shorter traces between the two main traces (Plate B-1C). The two main traces are labeled the West and East traces (trace names are taken from the LTSP report, PG&E, 1988). The intermediate traces lie between the East and West traces and are generally buried by several meters of sediment. The general trend of the West and East traces is about N25°W. The seafloor outcrops along the eastern side of the East trace are mapped as Monterey and Obispo Formations. There are several folds that locally come to the seafloor in the 2.5-kilometer wide zone between the West and East traces.

Offshore (west) and south of DCPP, the Hosgri fault zone has a left restraining bend that is prominently exhibited in the zone's two major fault traces (Hosgri West and Hosgri East, Plate B-1B). East of this restraining bend, folds and faults in Tertiary strata also show a major shift in orientation with structural trends becoming more east-west (approximately N70°W) in orientation than those structures to the north. Typically, fold axes bend northward into the Hosgri East trace or are truncated by the fault.

Comparison with LTSP maps – Maps showing bathymetry, seafloor sediment thickness and geologic structural trends were prepared for the LTSP (PG&E, 1988; 1990). These maps were also at a scale of 1:12,000 and showed similar features and interpretations to those shown on Plates B-1A to B-1C. Although the LTSP maps used different projections and datums, the differences are very minor at this scale. The LTSP maps were based on single-beam echo sounder, side-scan sonar, high-resolution seismic reflection, and multichannel CDP exploration seismic-reflection data sets. In general the older survey tracklines did not approach as close to shore as the high-resolution seismic-reflection survey lines and the data were not in digital formats, making mapping a labor-intensive drafting effort.

A cursory comparison of the LTSP maps with Plates B-1A to B-1C was made by overlaying the former interpretations over those produced from the 2008 MBES bathymetry and high-resolution seismic-reflection data sets. Locations of the Hosgri Fault traces are in good agreement (generally within 5 to 10 meters) between the 1988 exploration and 2008-2009 seismic-reflection data sets, although the deeper data from the earlier surveys suggests a buried westerly trace not seen in the 2008 near-surface high-resolution profiles. The major differences are listed below for the individual plates.

On Plate B-1A, the major differences between the LTSP mapping and the new mapping are in the area east of the Hosgri fault zone (Plate B-1A and Figure B-5-2). The LTSP mapping of the "Crowbar faults" and offshore extension of the Los Osos fault zone are not imaged by the MBES bathymetric data. Although there are folds and short, older, bedrock faults in the area where the Crowbar faults were mapped, the through-going faults extending from the shoreline to the Hosgri fault zone are not seen in the upper rock units in the high-resolution seismic-reflection and MBES bathymetry data sets. The previously mapped area of the Los Osos fault zone appears to contain zones of continuous uninterrupted bedding outcrops as well as smaller structures trending across at angles to the previously mapped fault zone. A surface feature mapped as a fault on the 2008 high-resolution seismic-reflection profiles trends parallel to the former Los Osos fault trace, but lies about 1.5 kilometers to the northeast.

As on Plate B-1A, the locations of the traces of the Hosgri fault zone on Plate B-1B are in good agreement between the LTSP study and the traces imaged on the 2008 high-resolution seismic-reflection profiles. However, the earlier surveys did not approach close enough to the shoreline to map any of the lineaments that may be associated with the Shoreline fault zone. In addition, the Pecho fault mapped from the LTSP data (PG&E, 1988) intersects the Hosgri fault zone in the southern part of this plate. The 2008 MBES bathymetry and high-resolution seismic-reflection data do not clearly define a through-going Pecho fault in this area, suggesting it may be a blind fault.

On Plate B-1C, the traces of the Hosgri fault zone based on the 2008 high-resolution seismic-reflection profiles generally agree with the mapping based on the LTSP data (PG&E, 1988). Similar to the area farther north, the LTSP data provided little information regarding the details of the near-shore area including the Shoreline fault zone. Also, the southeastward extension of the Pecho fault cannot be confirmed in the MBES bathymetry or high-resolution seismic-reflection data.

5.4.2 N40W fault

The N40W fault parallels the coast 1 to 1 1/2 kilometers offshore north from Lion Rock and to the west of Point Buchon (Plate B-1A). Its characteristics are summarized in Table B-4 and described below.

The N40W fault is about 5 to 7 kilometers long and generally strikes about N40°W (N35° to 44°W). The fault cuts the Obispo, Monterey and Pismo Formations. It is expressed in the north by sharp linear truncations of rock strata in contact with the mobile sand sheets to the west. Based on its linearity, the N40W fault is assumed to be a steeply dipping to vertical fault. The N40W fault, and its northwestward projection, is crossed by a few deep Comap seismic-reflection profiles (Figure B-5-3) and several 2008 high-resolution seismic-reflection profiles (Appendix H). In general the images of the structures (folds and faults) on the eastern side of the Hosgri fault zone are better on the Comap profiles than the high-resolution profiles. Comap profile CM-21 and several 2008 high-resolution profiles show little coherence of reflectors across the N40W fault and thus provide little information about fault dip, structural characteristics, or estimated cumulative offset. The north end of the fault is determined based on the northwestern extent of the abrupt linear truncation of rock and the apparent absence of faulting in the Comap profile CM-23 (Figure B-5-3).

Comparison of the current map with the LTSP map (PG&E, 1988) for the northern portion of the N40W fault is shown in Figure B-5-2. The northern part of the N40W fault shown in this

Appendix is located along several traces of the more west-northwest- trending Crowbar faults than shown in the LTSP interpretation. The latter interpretations were based not only on the Comap data, but also on more closely spaced lines from the analog Aquatronics and BBN surveys. In areas covered by the MBES bathymetric data the structural trends are clear.

West of Crowbar Hill, the N40W fault juxtaposes contrasting sedimentary units in the Obispo Formation (Figure B-5-4). The southern end is interpreted to continue beneath a sand sheet for approximately 2 kilometers along a steep magnetic gradient (Appendix D) and end west of Lion Rock (Plate B-1B). The magnetic anomaly that crosses the N40W fault at a low angle is interpreted to be an Obispo diabase dike, but the N40W fault itself does not appear to have a magnetic anomaly associated with it. At its southern end, the N40W fault projects beneath a mobile sand sheet toward the Central segment (C-1) of the Shoreline fault zone with a 25 degree difference in strike. Based on the available data, the structural relationship between the Central segment and the N40W fault is unclear.

The N40W fault is crossed by a wave-cut platform that corresponds to the paleostrandline at 38 meters depth (Figure B-5-4). This platform is estimated to be approximately 49,000 to 60,000 years old (marine oxygen-isotope stage (MIS) 3) or older (Appendix I). Considering multiple bathymetric profiles across the fault and the natural variability of the wave-cut platform, the estimated vertical separation across the N40W fault is zero with a combined uncertainty of approximately 2 meters (Appendix I, Section 7.3.1). The limited amount of vertical deformation is similar to that observed on the Central segment of the Shoreline fault zone (discussed below in Section 5.4.3.5).

5.4.3 Shoreline fault zone

The Quaternary structural aspects of the Shoreline fault zone have been identified and characterized through an extensive program of onshore and offshore data acquisitions and analyses that commenced in late 2008 and continued through 2010. Preliminary results were presented in the PG&E (2010) Progress Report. Additional investigations completed since the Progress Report have led to an improved understanding of the Shoreline fault zone, including information on fault location, geometry, segmentation, slip rate, and relationship to the Hosgri fault zone, Southwestern Boundary fault zone, and older Tertiary structures.

The geologic characteristics of the Shoreline fault zone were developed from the following:

1. Geologic interpretation of MBES bathymetric imagery;
2. Assessment of submerged marine terraces from MBES bathymetric imagery (Appendix I);
3. Correlation of geologic units and structures onshore and offshore using a low-tide LiDAR base map (Appendix G);
4. Reinterpretation of offshore diver and core samples from the LTSP and collection of 50 additional offshore samples (Tables B-1 to B-3);
5. Interpretation of high-resolution seismic-reflection profiles acquired in 2008 and 2009 (Appendix H), and seismic-reflection profiles from the LTSP (PG&E, 1988); and
6. Analysis of magnetic field data from helicopter and ship-borne measurements (Appendix D).

This section describes the location, length, faulting style, dip, recency of activity, slip rate, and relationship of the Shoreline fault zone to other faults in the region. Characteristics of individual segments of the fault are summarized in Table B-5 for the North segment, Table B-6 for the Central segment, and Table B-7 for the South segment. Alternative interpretations and uncertainties in the fault characteristics are explicitly addressed to provide a clear rationale for seismic source characterization. Several comparative maps illustrate the interpretations of geology and submerged marine terraces with the MBES bathymetric imagery along the Central and South segments of the Shoreline fault zone at key locations along the fault zone at 1:12,000 scale. These comparative maps highlight the following areas: (1) west of Lion Rock, (2) directly west of DCPP, (3) directly south of DCPP, (4) southwest of Olson Hill, (5) west of Rattlesnake Creek, and (6) southwest of Point San Luis (Figures B-5-4 to B-5-9).

5.4.3.1 Location of the Shoreline fault zone and its relationship to older Tertiary structures

The Shoreline fault zone appears to involve local reactivation of a pre-existing fault. Although the pre-existing fault is not reflected in the regional gravity data, this older fault is associated with a distinct, linear magnetic anomaly as seen in the high-resolution helicopter magnetic field data (Appendix D and Figure B-4-3). The magnetic anomalies associated with the older fault zone between about Olson Hill and offshore Point San Luis probably result from serpentinite or greenstone lenses within Franciscan mélange (Plates B-1A to 1-C). Juxtaposition of magnetic (e.g., greenstone) against non-magnetic (e.g., sandstone) blocks of pre-Tertiary rock along the older fault zone also likely contribute to the strong signal in the magnetic field anomaly. This juxtaposition of distinct blocks of pre-Tertiary rock and the development of mélange has its origins in Cretaceous to early Tertiary coast-parallel subduction and development of the Franciscan accretionary wedge complex, and suggests the Shoreline fault zone represents at least local reactivation of an older well-developed fault zone that had significant cumulative displacement during prior episode(s) of deformation.

From a location northwest of Olson Hill to the area directly west of DCPP, the magnetic anomalies are spatially associated with intrusive diabase that is part of the Miocene Obispo Formation on the landward side of the older fault zone, and probable Franciscan Complex greenstone on the seaward side of the older fault zone (Plates B-1A to B-1C). Here, the pre-existing fault juxtaposes Franciscan Complex rocks against the Tertiary Obispo and Monterey Formations, which indicates a prior episode of faulting dating to late Miocene and perhaps Pliocene time. This Tertiary episode of deformation probably occurred either during a regionally recognized mid-Miocene to early Pliocene period of transtensional deformation or during a later middle to late Pliocene period of transpressional deformation (PG&E, 1988 and references therein). Other structural features in the DCPP area that were active during these regional episodes of deformation include the San Miguelito fault, Pismo syncline, and Edna fault, which originated as extensional faults and basins during the earlier transtensional tectonic regime. These structures were reactivated in a transpressional deformation episode in about the middle Pliocene coincident with reorganization of the Pacific-North America plate boundary (Lettis et al., 2004 and references therein). Many of these faults have been inactive since 1 to 2 million years ago when the mode of deformation in the Irish Hills switched from folding to block uplift (Lettis et al., 2004; Lettis and Hanson, 1992).

More recently, differential erosion along the pre-existing fault zone during periods of lower sea level produced a prominent series of bathymetric lineaments and associated scarps. The probable northern reach of the pre-existing fault zone includes a prominent escarpment off the coast of Point Buchon along the N40W fault (shown on Plate B-1A). The linear magnetic gradient (Figure B-4-3) associated with the N40W fault probably is derived from intrusive Tertiary diabase, as pre-Tertiary basement rocks are not mapped along the coast or in the near-shore bedrock platform north of the DCPP. Based on the linearity of the anomaly, it is likely that the geometry of the diabase is structurally controlled. The N40W fault is interpreted to cut across the diabase.

The central and southern seismicity sub-lineaments align with parts of the pre-existing Tertiary fault (within the half-kilometer location resolution of the seismicity comprising the lineament) (see main report, Plate 1), indicating that the older fault has been locally reactivated in the current stress regime. In particular, the central and southern seismicity sub-lineaments closely align with the pre-existing older Tertiary fault. The Central and South segments of the Shoreline fault zone are thus interpreted to represent reactivation of this part of the older Tertiary fault.

Seismicity along the northern sub-lineament trends northwest toward the Hosgri fault zone and lies west of the N40W fault (Figure 4-1). Late Quaternary marine sedimentary and ephemeral drifting sand sheets on the seafloor mask existing geomorphic expression of an active fault and any direct observation of youthful geologic structure that may be associated with the seismicity lineament. The origin of the northern seismicity sub-lineament and direct linkage to a bedrock fault, therefore, is less plausible than for the central and southern seismicity sub-lineaments and the older Tertiary faults. As described in the main report, Section 4.2.4, alternative structural origins of the northern seismicity sub-lineament include: (1) a steeply east-dipping Hosgri fault zone; (2) a sub-vertical fault (buried or emergent) coincident with the seismicity sub-lineament; and (3) the N40W fault, with a steeply west-dipping shallow crustal portion to link the surface trace of the fault with the seismicity trend.

Three methods were used to evaluate whether a direct structural geologic link can be made between the Hosgri fault zone and a distinct fault that could be associated with the northern seismicity sub-lineament: (1) re-examination of the USGS high-resolution seismic-reflection profiles that cross the northern seismicity sub-lineament to look for evidence of faulting; (2) reprocessing of three of these high-resolution seismic-reflection profiles to improve data resolution; and (3) re-examination of high-energy Comap seismic-reflection profiles interpreted during the LTSP (PG&E, 1990) that cross the northern seismicity sub-lineament and the N40W fault trend. The Progress Report (PG&E, 2010) concluded based on a preliminary examination of the 2008 and 2009 high-resolution sparker data that there was no evidence for a bedrock fault along the northern seismicity sub-lineament.

Re-examination of Comap line (CM-21) collected across the northern end of the seismicity lineament reveals gently folded Tertiary strata east of the Hosgri fault zone with no evidence of faulting across the northern seismicity sub-lineament within the resolution of the seismic-reflection profile (Figure B-5-3). In contrast, this line shows disruptions in reflectors consistent with faulting or tight folding across the nearby N40W fault.

Reprocessed high-resolution seismic-reflection profiles (PBS-22, PBS-26, and PBS-296) at the northern and southern ends of the northern seismicity sub-lineament provide significant improvement in overall data clarity compared to the basic processing by the USGS. Although the seismic-reflection data are presently insufficient to definitively evaluate the presence or absence of faulting, careful re-examination of the high-resolution profiles crossing the central part of the northern seismicity sub-lineament permits a preliminary interpretation of probable minor vertical separations across sub-vertical faults in Tertiary strata that were plotted on Plates B-1A and B-1B as two concealed, queried, en-echelon faults. The southwestern one follows the axis of a well-expressed syncline in Monterey(?) strata and the fault to the northeast is sub-parallel. These faults generally align with the northern seismicity sub-lineament (see main report, Plate 1). Preliminary estimates of vertical separations are on the order of 5 to 10 meters with the northeast side down. Direct correlation of Tertiary strata across the faults also suggests that the amount of cumulative lateral displacement is limited to a few tens of meters or less. These faults clearly lie west of the N40W fault, and are tentatively named the North segment of the Shoreline fault. Given the minor displacement of Tertiary strata, this newly-identified North segment of the Shoreline fault zone does not appear to be reactivating a well-developed older Tertiary fault similar to the Central and South segments of the Shoreline fault zone.

Based on the above evidence, the relative merits of the three alternative interpretations of the North segment of the Shoreline fault zone are assessed. The preferred alternative is that the newly-identified North segment of the Shoreline fault coincides generally with the northern seismicity sub-lineament (Figure B-4-1). The fault either has produced only minor displacement in the Tertiary strata in the near surface (similar to the small faults in the Monterey and Pismo Formation rocks imaged in the MBES bathymetric data), or is "blind" and does not extend to the near-surface. This location for the fault is preferred because it most closely aligns with the northern seismicity sub-lineament. The second alternative locates the North fault segment along the N40W fault. This alternative is less preferred because the N40W fault departs from the seismicity lineament, but the alternative does have the advantage of being associated with a recognizable pre-existing fault. The third alternative is that some or all of the northern seismicity sub-lineament is associated with an east-dipping Hosgri fault zone, in which case the North segment of the Shoreline fault does not exist or is limited to a few kilometers in length beyond the better-defined Central segment.

5.4.3.2 Length and segments

The Shoreline fault zone, including all three segments, has an overall strike of about N60°W and is up to 23 kilometers long (Plates B-1A to B-1C). The total length of individual segments and the continuity and integration of the fault as a whole are discussed below.

The North segment is up to 8 kilometers long. The uncertainty in the segment length encompasses the range of alternative locations described in Section 5.4.3.1 of the main report, ranging between zero length (with seismicity occurring on an east-dipping Hosgri fault zone at depth) and the maximum 8 kilometers length extending southeast from the Hosgri fault zone to south of Lion Rock (Table B-5). The alternative N40W fault trace also yields an 8 kilometer segment length (Table B-4). The North segment is at least partially concealed beneath marine sediments and the ephemeral drifting sand sheet on the seafloor and has no geomorphic expression. The alternative surface trace along the N40W fault coincides with a linear escarpment formed by a composite series of submerged paleostrandlines (Appendix I).

The two alternative locations of the North segment have different expressions in the magnetic intensity data (Figure B-4-3). The preferred trace that follows the seismicity sub-lineament does not coincide with a strong magnetic anomaly. The alternative N40W trace is subparallel to but crosses a linear magnetic anomaly associated with intrusive diabase (Section 5.4.2). The south ends of the North segment and the N40W fault are obscured by mobile sand sheets so the boundary between the North and Central segments is unclear. However, in this area magnetic anomalies are not continuous and appear complex. This complexity in the magnetic field is interpreted to represent structural complexity that suggests a segment termination and possible structural barrier to rupture.

The Central segment is approximately 8 kilometers long and follows an older reactivated Tertiary fault that is well expressed in the geology and as a magnetic anomaly (Plate B-1B; Figure B-4-3; Table B-6). The Central segment is further divided into three geomorphically and structurally defined en-echelon subsegments, C-1, C-2, and C-3. These subsegments are not considered to be rupture segments in the seismic source characterization of the Shoreline fault zone. Subsegment C-1 connects with C-2 at a change in strike and the boundary between C-2 and C-3 is a right step of 100 to 200 meters. Subsegment C-1 is west of Discharge Cove and its faulting appears to die out northward beneath the sand sheet directly south of Lion Rock. The northern end of C-1 does not follow the magnetic anomaly high that characterizes the majority of the Central and South segments but transitions into a magnetic trough. Subsegment C-1 forms a prominent and well-defined bathymetric lineament and, where mapped at the seafloor, juxtaposes Tertiary diabase against Franciscan mélange (Figure B-5-5).

Subsegment C-2 also forms a prominent, well-defined bathymetric lineament and juxtaposes Obispo diabase, Cretaceous sandstone and Franciscan mélange on the east against a thin mobile sand sheet covering Franciscan mélange on the west (Figures B-5-6 and B-5-7). The subsegment coincides with a linear peak in the magnetic anomaly data (Figure B-4-3 and B-4-4). West of Olson Hill, a moderate to strong, 900-meter-long geomorphic lineament is evident on the MBES bathymetric image. It lies within a shallow, 2- to 4-meter deep, 25-meter wide trough in Franciscan mélange and is likely accentuated by differential erosion (Figure B-5-7). To the south, subsegment C-2 ends near where the Olson Hill deformation zone (considered a part of the San Luis Bay fault zone) projects offshore. A direct structural or geomorphic linkage between the Central segment of the Shoreline fault zone and the bedrock faults near Olson Hill has not been established (Figure B-5-7). The step-over between subsegments C-2 and C-3 is southeast of Olson Hill where the linear magnetic anomaly high ends.

Subsegment C-3 also is expressed as a well-defined bathymetric lineament (Plates B-1B and B1-C; Figure B-5-8). The lineament is primarily in Cretaceous sandstone and Franciscan mélange and coincides with a magnetic anomaly high (Figure B-4-4). As shown on Figure B-5-8, the southern end of subsegment C-3 may bend to the east and follow a lineament (also interpreted to be a paleostrandline) that projects directly toward the Rattlesnake fault (the southern strand of the San Luis Bay fault zone). The apparent connection of the two faults suggests that there may be a kinematic link between these two structures (see main report, Section 5.4.4).

The South segment is approximately 7 kilometers long and, like the Central segment, follows a reactivated older bedrock fault (Table B-7). It is expressed as a poor to moderate bathymetric lineament inferred to be in a band of mélange covered by a thin mobile sand sheet. Locally, the South segment truncates bedding in Cretaceous sandstone along a low, northeast-facing escarpment (Plate B-1C; Figure B-5-9). It is also associated with a strong linear magnetic high (Figure B-4-3). In detail, the fault trace defined on the MBES bathymetric data follows the west flank of the magnetic anomaly high rather than the crest. The northern end of the South segment lies within a broad zone of Franciscan mélange that is covered by a mobile sand sheet, so its exact location is uncertain. The junction between the Central and South segments is interpreted as either a right stepover of 100 to 500 meters, or the two segments meeting at the north end of the linear magnetic anomaly southeast of Rattlesnake Creek. The south end of the South Segment projects beneath a mobile sand sheet southwest of Point San Luis (Figure B-4-1).

5.4.3.3 Faulting style

The Shoreline fault zone is inferred to be primarily a right-lateral fault based on earthquake focal mechanisms, vertical alignment of seismicity, and the linear geologic expression of the fault on the seafloor along the Central and South segments. However, some focal mechanisms along the North and Central segments show right-oblique or right-reverse motion, and one focal mechanism along the South segment shows right-normal motion. These oblique mechanisms suggest that the fault may accommodate some vertical displacement as well as lateral displacement. In earthquake rupture scenario models considered in the seismic hazard analysis where the Central and North segments are linked with the San Luis Bay fault zone, the fault zone forms an uplift rate boundary and is considered to have a significant northeast-side up vertical component (see main report, Section 5.1.1).

5.4.3.4 Geometry

The seismicity defines a nearly vertical seismic source zone and is discussed in the main report, Section 4.2). A vertical fault zone is consistent with the linear geologic and geomorphic expression of the fault on the seafloor along the Central and South segments, but geologic data (including high-resolution seismic-reflection profiles) are lacking to independently measure the dip of the Shoreline fault zone. Local 2D modeling of the helicopter magnetic data across the Central segment of the Shoreline fault zone shows that magnetic anomalies coincident with the Shoreline fault zone can be explained by a vertical fault in the shallow crust, but the solutions are not unique (Appendix D).

5.4.3.5 Evidence of activity

This subsegment addresses only the geologic or geomorphic evidence for recency of activity of the Shoreline fault zone; the seismicity lineament as evidence for activity is discussed in the main report (Section 4.2). The Shoreline fault zone lies entirely offshore and thus it is difficult to evaluate its activity with direct evidence. The MBES bathymetric images were extensively probed to identify geologic or geomorphic features that would record late Quaternary activity. Such features include potentially datable sediments that appeared offset, or geomorphic features such as paleostrandlines, wave-cut platforms, or channels on both sides of the fault zone that could be used to constrain cumulative slip. No geologic or geomorphic features were found that definitively prove or disprove activity of the Shoreline fault zone. Two lines of evidence are available to qualitatively assess the recency of activity of the Shoreline fault zone: (1) the geomorphic expression of the fault zone, and (2) vertical deformation of submerged wave-cut platforms that cross the fault zone.

The well-expressed geomorphic scarps along certain sections of the fault zone described in Section 5.4.3.2 are indirect indicators of activity of the fault. These scarps include the southwest-facing fault-line scarps along the Central segment (Figures B-5-5 to B-5-7) and the northeast-facing fault-line scarps along parts of the Southern segment (Plates B-1C and B-1D). Most of the scarps are expressed as a juxtaposition of rock against mobile sand sheets, and in one location (sub-segment C-2) there is a fault-line scarp within bedrock interpreted as mélange. All the scarps are interpreted to result from differential erosion. Their size and locally sharp expression is suggestive of a contrast in erodability of rock on opposite sides of the fault; this sharp expression is probably accentuated by easily eroded fault rock within the fault zone. Additionally, it is reasonable that the existence and linearity of a scarp with vertical separation across it is maintained by cumulative movement on the fault, even if the amount of vertical separation is attributed to both differential erosion and long-term cumulative deformation. However, with the current lack of detailed understanding of the geology along the scarps, differential erosion alone is sufficient to produce the observed geomorphic expression, and thus the existence and sharpness of the fault-line scarps does not require the fault zone to be active.

The second line of evidence available to evaluate activity of the Shoreline fault zone comes from three locations where the Central and South segments cross late Quaternary wave-cut platforms, and one location where a correlated paleostrandline is mapped on opposite sides of the South segment. These locations are described in detail in Appendix I, Section 7.3, and are summarized from north to south below:

- *Central segment, subsegment C-2 near intersection with subsegment C-1*– In the stepover region between the C-1 and C-2 subsegments of the Shoreline fault zone the Shoreline fault zone locally is buried by a mobile sand sheet that is thought to cover a wave-cut platform associated with a -25 meter (m) paleostrandline (Figure B-5-5). Based on its depth, the wave-cut platform is estimated to have developed during MIS 5 or earlier, and hence is older than approximately 75,000 years (Appendix I). Contours of the top-of-rock surface are interpreted from high-resolution seismic-reflection profiles, and an elevation profile across the contours shows a 1-m-high scarp (with northeast-side up) with a combined uncertainty of 2.5 m (Appendix I, Section 7.3.2). The preferred interpretation is that this scarp is a fault-line scarp formed by differential erosion that was not completely removed during development of the -25 m wave-cut platform. The basis for the preferred interpretation is the presence of fault-line scarps northwest and southeast of the -25 m wave-cut platform and the lack of evidence for vertical separation on subsegment C-2 where it crosses the -21 m wave-cut platform (discussed below). However, we cannot preclude the scarp is vertical separation on the Shoreline fault zone and is caused by late Quaternary tectonic deformation. Along strike to the southeast, the Shoreline fault zone appears to follow a sediment-filled trough etched in bedrock, indicating local differential erosion along the fault trace (Figures B-5-5 and B-5-6). Therefore, we conclude that vertical offset on the Shoreline fault zone since approximately 75,000 years is either zero (from the preferred interpretation that the apparent scarp is due to differential erosion) or 1 ± 2.5 meters with the center value having a northeast-side up vertical separation (Section 5.4.3.5 and Appendix I, Section 7.3.2). Using the vertical separation and the estimated minimum age of 75,000 years for the wave-cut platform yields a vertical separation rate of 0 or 0.01 ± 0.03 mm/yr.
- *Central segment, subsegment C-2* – South and southwest of the entrance to DCPP the Shoreline fault zone locally crosses a wave-cut platform associated with a -21 m paleostrandline (Figure B-5-6). Based on its depth, the wave-cut platform is estimated to have developed at least 75,000 years ago (Appendix I). Analysis of elevation profiles across the wave-cut platform suggests there is zero vertical separation across the mapped fault trace with a combined uncertainty of approximately ±1.5 m (Appendix I, Section 7.3.2).

- *South segment* – South of Point San Luis, the South segment of the Shoreline fault zone locally crosses a wave-cut platform associated with a -31 m paleostrandline (Figure B-5-9). Although the paleostrandline itself is not preserved for approximately 100 meters directly adjacent to the fault zone, sections of the paleostrandline several hundred meters long are mapped on either side of the fault zone and are correlated. Based on its depth, the wave-cut platform is estimated to have developed at least 75,000 years ago (Appendix I). Analysis of elevation profiles across the wave-cut platform suggests there is zero vertical separation across the mapped fault trace with a combined uncertainty of approximately ± 1.5 m (Appendix I, Section 7.3.3).

The results summarized above suggest that there is no strong evidence for activity on the Shoreline fault zone in the last 75,000 years. Although the buried wave-cut platform along the C-1 sub-segment has an apparent scarp, a preferred interpretation for this scarp is that it is not due to late Quaternary surface-fault rupture, and the wave-cut platform located approximately 1.3 km to the southeast along the C-2 sub-segment shows no evidence for vertical separation across the fault zone with a lower combined uncertainty. Given the measurement and geologic context uncertainties in the data, however, we cannot preclude that the approximately 75,000-year-old wave-cut platforms are offset by the Shoreline fault zone.

5.4.3.6 Slip rate

Similar to assessing activity, the offshore location of the Shoreline fault zone makes it difficult to develop direct quantitative estimates of slip rate. The MBES bathymetric data were extensively probed to identify piercing points (i.e., potentially datable geomorphic features such as paleostrandlines or submerged channels on both sides of the fault zone that could be used to constrain cumulative slip and slip rate). No geomorphic features that could be reliably used as offset markers were observed, hence no conclusive piercing points were identified. In the absence of more direct information, important constraints to slip rate are provided by four qualitative and indirect quantitative estimates of slip rate. These are summarized below:

(1) *Comparison to the Hosgri-San Simeon fault system.* The Hosgri-San Simeon fault system has a slip rate in the range of 0.5 to 6 mm/yr, with a preferred rate of 1 to 3 mm/yr (PG&E, 1988; 1990; Hanson and Lettis, 1994; Hall et al., 1994; Hanson et al., 2004). Onshore, the San Simeon fault is well expressed geomorphically and clearly displaces late Pleistocene and Holocene deposits at numerous locations. Offshore, the Hosgri fault zone locally produces scarps on the sea floor, and, along the reach of the fault directly west of the Irish Hills, abruptly truncates the westward extent of the offshore bedrock platform. In addition, individual fault strands within the Hosgri fault zone produce linear escarpments in bedrock that appear to be pressure ridges on the sea floor. All of these features on the Hosgri fault zone occur in water depths shallower than 120 meters, and thus if present at the time of the last transgression, were subject to erosion. The Shoreline fault zone is not associated with similar geomorphic or geologic features identified on the Hosgri fault zone offshore or with the San Simeon fault zone onshore, with the exception of the distinct lineament west of Olson Hill (Figure B-5-7) and the lineament and scarp west of the Intake Cove (Figure B-5-5) discussed above. Elsewhere along the Shoreline fault zone, geomorphic features of high slip-rate faults are lacking, even in locations where the fault zone extends into deeper water where the rapid rise in sea level since the last glacial maximum would not have destroyed significant fault features (Appendix I).

In addition, if the Shoreline fault zone had a slip rate comparable to the Hosgri-San Simeon fault system, it is likely that it would have maintained a seafloor expression southwest of Point San Luis, and evidence of higher slip-rate faults in the associated Southwest Boundary zone would be evident onshore in the vicinity of San Luis Obispo Bay or the Santa Maria Valley. Despite extensive onshore mapping in this area both during the LTSP and during this study, no faults with comparable geomorphic expression to the San Simeon fault have been identified.

Based on these observations, the slip rate on the Shoreline fault zone is qualitatively estimated to be an order of magnitude less that the slip rate on the Hosgri-San Simeon fault zone. This qualitative comparison yields an estimate of slip rate in the range of 0.05 to 0.6 mm/yr for the Shoreline fault zone.

(2) *Estimates of vertical separation*. Two approaches are used to constrain the amount of vertical separation on the Shoreline fault zone. Along the North segment (associated with the northern seismicity sub-lineament), possible displaced Tertiary strata from high-resolution seismic-reflection profiles are interpreted to constrain the cumulative amount of vertical separation on the segment to be about 5 to 10 meters, with a northeast-side down vertical separation. The northeast-side down sense of vertical separation is opposite the expected northeast-side up vertical separation if the fault is partially accommodating uplift of the San Luis/Pismo block. In addition to the apparent limited vertical stratigraphic separation, the similarity in the seismic stratigraphy across the fault zone observed at these two locations probably indicates limited lateral displacement as well. These interpreted faults are similar to the faults imaged in the MBES bathymetric data that are associated with seafloor-exposed folds in the Monterey and Pismo Formations west of Point Buchon.

The second approach to constrain vertical separation rates across mapped traces of the Shoreline fault zone is based on evaluation of the submerged wave-cut platforms that are mapped across the N40W and Central and South segments as described above in Section 5.4.3.5 and in Appendix I, Section 7.3. Estimates of vertical separation rate at the four sites are summarized from north to south below:

- *N40W fault* – The estimated vertical separation of the wave-cut platform associated with the -38 m paleostrandline across the N40W fault is zero with an uncertainty of approximately ± 2 meters (Section 5.4.3.5 and Appendix I, Section 7.3.1). Using the vertical separation and the estimated age of 49,000 to 60,000 years for the wave-cut platform yields a vertical separation rate of 0 ± 0.04 mm/yr (i.e., with either a northeast- or southwest-side up sense of vertical separation).
- *Central segment, sub-segment C-1* – The estimated vertical separation of the buried wave-cut platform associated with the -25 m paleostrandline across the C-1 sub-segment of the Shoreline fault zone is either 0 (from the preferred interpretation that the apparent scarp is due to differential erosion) or 1 ± 2.5 meters with the center value having a northeast-side up vertical separation (Section 5.4.3.5 and Appendix I, Section 7.3.2). Using the vertical separation and the estimated minimum age of 75,000 years for the wave-cut platform yields a vertical separation rate of 0 or 0.01 ± 0.03 mm/yr.
- *Central segment, sub-segment C-2* – The estimated vertical separation of the wave-cut platform associated with the -21 m paleostrandline across the C-2 sub-segment of the Shoreline fault zone is zero with an uncertainty of approximately ± 1.5 mm/yr (Section 5.4.3.5 and Appendix I, Section 7.3.2). Using the vertical separation and the estimated

minimum age of 75,000 years for the wave-cut platform yields a vertical separation rate of 0 ± 0.02 mm/yr.

- *South segment* – The estimated vertical separation of the wave-cut platform associated with the -31 m paleostrandline across the South segment of the Shoreline fault zone is zero with an uncertainty of approximately ± 1.5 mm/yr (Section 5.4.3.5 and Appendix I, Section 7.3.3). Using the vertical separation and the estimated minimum age of 75,000 years for the wave-cut platform yields a vertical separation rate of 0 ± 0.02 mm/yr.

The results summarized above suggest that the vertical separation rate on the Shoreline fault zone is indistinguishable from zero. In order to estimate a maximum horizontal slip rate from the wave-cut platform data, the maximum vertical separation rates are considered with a fault having an assumed 10:1 horizontal to vertical slip ratio. This assumption yields maximum horizontal slip rates on the order of 0.2 to 0.4 mm/yr.

(3) Estimates of cumulative right-lateral strike-slip displacement. Toward the northern end of the Central segment of the Shoreline fault zone, directly west of Discharge Cove, two west-northwest-trending, subparallel magnetic anomaly highs show an apparent right-lateral step of about 300 meters (Figure B-5-1). Although not a unique interpretation, the apparent right-lateral step occurs across a N15°E striking basement fault whose north end aligns with the north-south to N25°W striking fault mapped in the headland at the northwest end of Discharge Cove. The mapped fault onshore and in the rocks at low tide juxtaposes two Obispo Formation units: resistant tuff against bedded sedimentary rock in a broad zone of shearing that is associated with hydrothermal alteration. The N15°E fault is truncated to the north by an east-west-striking fault that is clearly mapped in the intertidal zone and in the sea cliff (Plate B-1B; Figure B-5-1). This east-west fault does not displace an approximately 80,000 year-old wave-cut platform exposed in the sea cliff. Similarly, approximately north-south-striking faults mapped elsewhere in the direct vicinity of DCPP exhibit right-lateral separation, supporting the interpretation that the right-lateral separation in the magnetic anomaly highs reflects offset bedrock structure. The interpreted N15°E fault provides a possible piercing line or strain gauge from which to estimate cumulative right-lateral displacement where the Central segment of the Shoreline fault crosses the N15°E fault. Alternative interpretations of possible traces of the N15°E fault through the MBES bathymetric data that satisfy the right-lateral separation in the twin magnetic anomaly highs, limits the possible offset to less than 100 meters (possibly 200 meters) right-lateral, and possibly zero (Figure B-5-1). Estimating an onset of deformation at between 1 and 2 million years ago (coinciding with the estimated onset of block uplift recorded by emergent marine terraces on the adjacent coast (Hanson et al., 1994) the horizontal slip rate of the fault would be no more than about 0.05 to 0.2 mm/yr, and could be zero.

(4) *San Luis Bay fault zone.* An alternative structural interpretation of the Shoreline fault zone is that it is kinematically linked to the San Luis Bay fault zone such that the slip on the North and Central segments of the Shoreline fault zone continues onshore and follows the Rattlesnake fault of the San Luis Bay fault zone and forms part of a strike-slip restraining bend (Plates B-1C and 1D; Figure B-5-8). In characterizations based on this linked structural model, the slip rate on the San Luis Bay fault zone can be used to provide information on the slip rate of the Shoreline fault zone. The San Luis Bay fault zone has a cumulative rate of vertical separation of 0.14 mm/yr as recorded in the emergent marine terraces at the coast, with about half of that vertical rate occurring on the Rattlesnake fault (PG&E, 1990; Hanson et al., 1994). In addition, detailed mapping along the coastline shows steeply (approximately 70 degrees)

north-dipping beds of Cretaceous sandstone and siltstone across the Rattlesnake fault (Figure B-5-10). Tentative correlation of an approximately 35- to 40-meter-thick sequence of resistant sandstone beds on the modern wave-cut platform across the Rattlesnake fault yields an estimate of about 70 ± 20 meters of apparent right-lateral separation across the fault, indicating that the Rattlesnake fault does not have significant cumulative deformation across it. Because the beds dip steeply to the north, the apparent right-lateral separation is consistent with pure north-side up dip-slip motion on a vertical fault of about 190 meters. Oblique motion of the Rattlesnake fault would yield a range of horizontal displacements up to approximately 70 meters (consistent with pure strike-slip displacement). An estimated onset of deformation of 1 to 2 million years ago and a maximum horizontal displacement of 70 meters yields a limiting lateral slip rate of about 0.14 to 0.07 mm/yr. The absolute maximum lateral slip rate on the fault would be obtained by considering the limiting horizontal offset of 70 meters and a minimum age of 120,000 years, the age of the marine terrace that records the offset of the Rattlesnake fault. In this very unlikely consideration, the extreme maximum lateral slip rate would be about 0.6 mm/yr. Given the roughly equal distribution of vertical separation between the Rattlesnake fault and Olson deformation zone, the lateral slip rate is also assumed to be equally distributed, giving a cumulative absolute maximum lateral slip rate for the entire San Luis Bay fault zone of 1.2 mm/yr. As described earlier, given the absence of geomorphic expression onshore along the San Luis Bay fault zone similar to the San Simeon fault, a slip rate of over 1 mm/yr is not credible. Thus, this analysis concludes that a lateral slip rate of up to 1 mm/yr may branch from the San Luis Bay fault onto the Shoreline fault zone.

Given the above four lines of reasoning, the slip rate on the Shoreline fault zone ranges from 0.05 to possibly 1 mm/yr, with a preferred value of about 0.2 to 0.3 mm/yr. The slip rate could also be zero.

5.4.3.7 Relationship to other structures

The Shoreline fault zone lies between the active Hosgri fault zone on the west and faults of the Southwest Boundary fault zone on the south and east: the Los Berros, Oceano, Wilmar Avenue, and San Luis Bay faults. Two alternatives are considered for the kinematic relationship of the Shoreline fault zone to adjoining structures. One alternative, named herein the "independent fault" alternative, is that the Shoreline fault zone is an independent strike-slip fault that may or may not branch from the Hosgri fault zone. In this alternative, the Shoreline fault zone does not accommodate uplift of the Irish Hills but rather is a strike-slip fault within the uplifting block and occurs in the hanging wall of the Hosgri, Los Osos, and San Luis Bay fault zones that are responsible for uplift of the range. In the second alternative, named herein the "linked fault" alternative, the Shoreline fault zone is kinematically linked to the San Luis Bay fault zone, and possibly to other faults of the Southwest Boundary fault zone to the south (i.e., the Los Berros, Wilmar Avenue, and Oceano faults). In this scenario, the Shoreline fault zone is part of a system of strike-slip and oblique-slip faults that border the southwestern margin of the uplifting San Luis/Pismo structural block, and slip rate on the San Luis Bay fault zone may be used to provide information on slip rate on the Shoreline fault zone, as discussed above.

In the "independent fault" alternative, the western extent of the San Luis Bay fault zone would cross the Shoreline fault zone and extend to the Hosgri fault zone to accommodate uplift of the Irish Hills portion of the San Luis/Pismo block. In the "linked fault" alternative, the San Luis Bay fault zone proper likely ends or merges with the Shoreline fault zone and does not extend farther west to the Hosgri fault zone. In this case, the Shoreline fault zone is predicted to be an uplift rate boundary and accommodate a significant oblique component of slip. This alternative is not consistent with the evidence from wave-cut platforms that are crossed by the Shoreline fault zone and show minor, if any, vertical separation. However, within the "linked fault" alternative there may be other kinematic models that do not require the Shoreline fault zone to be an uplift rate boundary. For example, the Shoreline fault zone may act as a strike-slip fault as part of the Southwestern Boundary fault zone, and differential uplift between the Islay and Santa Rosa Reef shelves may be accommodated by other structures, including the steeply east-dipping Hosgri fault zone and the southwest-dipping Los Osos fault zone.

5.4.4 San Luis Bay fault zone

The San Luis Bay fault zone is part of the longer Southwestern Boundary fault zone that forms the southwestern boundary of the uplifting San Luis/Pismo structural block (PG&E, 1990; Lettis et al., 1994; 2004). The late Quaternary-active and approximately east-west-striking San Luis Bay fault zone contains one or more fault strands and accommodates north-side-up vertical displacement and an unknown amount of horizontal displacement. At a minimum, the San Luis Bay fault zone is located between the Pacific coast near Rattlesnake Creek, across a low saddle separating San Luis Hill from the rest of the Irish Hills, and eastward to the mouth of San Luis Obispo Creek (Avila Beach) where a strand of the fault zone is exposed faulting Franciscan rocks over alluvium (Figure B-4-1). Detailed mapping of the stream exposure and radiocarbon dating of faulted fluvial terrace deposits shows approximately 20 centimeters of apparent vertical separation since about 20,000 years ago (PG&E, 1990). Along the sea cliff directly west of San Luis Obispo Creek (exposures now covered), the fault juxtaposes Franciscan Complex rocks over the Squire Member of the Pismo Formation. At these two locations, fault exposures suggest a moderate dip to the north, and, in one location, striations are consistent with dip-slip movement. The continuation of the San Luis Bay fault zone across the saddle north of San Luis Hill without a significant deviation in trend suggests the average dip of the San Luis Bay fault zone is probably steep (70 degrees or higher) rather than moderate (PG&E, 1988; 1990).

As the extent of the fault has not been directly observed, the eastern and western ends of the fault zone must be inferred based on structural and geomorphic observations. East of San Luis Obispo Creek, the San Luis Bay fault zone probably continues to about Mallagh Landing (Figure B-4-1). Here, geologic mapping suggests a complex intersection between the northwest-striking San Miguelito fault zone and the northeast-striking Avila fault (PG&E, 1990). Interpretation of MBES bathymetric data and integration with mapping performed during the LTSP suggest that the San Miguelito fault probably continues to the southeast from Mallagh Landing and juxtaposes Obispo Formation on the southwest against a syncline of Monterey and Pismo Formation strata on the northeast (Plate B-1D). Thus the eastern limit of the San Luis Bay fault is considered to be at the intersection with the through-going San Miguelito fault and conjugate Avila fault near Mallagh Landing.

The western end of the San Luis Bay fault zone and its relationship with the Shoreline fault zone is also uncertain. At the coast, the San Luis Bay fault zone consists of two separate structures, the Rattlesnake fault and the more northerly Olson Hill deformation zone (called the Olson fault in the LTSP reports) (Plate B-1C) (PG&E, 1988; 1990). These structures were identified based on the analysis of longitudinal profiles of emergent marine terrace shoreline angles that show down-to-the south offsets of the 80,000 and 120,000 year old marine terraces dating to sea-level highstands during the last interglacial interval (MIS 5a and 5e, respectively) (PG&E, 1990; Hanson et al., 1994). Borehole and survey data define a narrow warp or step in the buried

120,000 year-old wave-cut platform directly west of Rattlesnake Creek (PG&E, 1990). Likewise, borehole and map data show down-to-the south deformation of the 80,000 and 120,000 year old shoreline angles across Olson Hill (Figure B-5-7). The current elevations of these terraces and estimates of paleosea level at the time of their formation provide estimates of uplift rate north of Olson Hill (0.2 mm/yr), between the Olson Hill deformation zone and Rattlesnake faults (0.14 mm/yr), and south of the Rattlesnake fault (0.06 mm/yr). The differential uplift rate across the San Luis Bay fault zone is about 0.14 mm/yr, with about 0.08 mm/yr uplift rate across the Rattlesnake fault and 0.06 mm/yr uplift rate across the Olson Hill deformation zone (PG&E, 1990; Hanson et al., 1994). In this report, we informally name the portion of the San Luis/Pismo block uplifting at 0.2 mm/yr north of the San Luis Bay fault zone the Irish Hills sub-block, and the portion uplifting at 0.06 mm/yr south of the San Luis Bay fault zone the Point San Luis sub-block.

5.4.4.1 Bedrock exposures of the San Luis Bay fault zone

Although the geomorphic evidence for and quantification of differential uplift rates at the coast are clear, the exact location of the faults in bedrock at the coastline is not. A primary objective of the coastline geologic mapping was to identify and characterize the active Rattlesnake fault and bedrock faults near Olson Hill within the sea cliff and/or modern wave-cut platform exposed at low tide.

Rattlesnake fault

The bedrock geology at the coast across the Rattlesnake fault consists of steeply dipping and bedded Cretaceous sandstone (Figures B-5-8, B-5-10, and Plate B-1C). The strata in the direct vicinity of the active fault generally strike approximately east-southeast and bedding-up indicators within the siltstone and sandstone sequence consistently suggest the beds are overturned with steep dips to the north-northeast of about 70 degrees. Brittle, penetrative fabric within siltstone interbeds record significant bedding-parallel shear within the unit, and detailed mapping shows several minor faults and sub-vertical-axis folds cutting and folding bedding. Based on the step or warp in the buried wave-cut platform, the exact location of the Rattlesnake fault is constrained to be within a southwest-facing cove that has a coarse sandy beach and a combination of bedrock and shallow slide/slump debris covering the sea cliff (Figure B-5-10). Structural bedrock mapping and observations of the emergent paleo-wave-cut platform suggest the Rattlesnake fault may intersect the sea cliff at one or both of two locations, labeled "Rattlesnake fault #1" and "Rattlesnake fault #2" on Figure B-5-10. The exact fault planes were not identified in the field as they are obscured by shallow slide debris derived from deposits capping the wave-cut platform. In addition, slumping or sliding has obscured the contact between bedrock and overlying deposits (the wave-cut platform) so that it could not be directly evaluated whether the wave-cut platform was discretely offset across one or both of the alternative fault strand locations. At the base of the sea cliff at the location of the "Rattlesnake fault #1" trace is a narrow zone of saturated clayey gouge and seeps, although it is unclear whether the sheared rock represent older bedding-parallel shears that are common in the strata or the active fault strand. South of the "Rattlesnake fault #2" trace is a clear wave-cut platform with overlying marine sands, but north of the trace the equivalent wave-cut platform with overlying marine deposits was not exposed. A higher wave-cut platform with no capping marine deposits is visible as discontinuous fragments, but this higher surface may represent paleo-sea-stacks and not the offset equivalent wave-cut platform surface. Both traces project seaward towards the lineament mapped in the MBES bathymetric data and suggest a branching relationship between the Rattlesnake fault and the Shoreline fault (Figure B-5-8).

The similarity of Cretaceous strata across the Rattlesnake fault suggests that cumulative offset of the Rattlesnake fault is limited, and the Rattlesnake fault here is not reactivating a pre-existing fault. One possible measure of the cumulative offset comes from a sequence of similar thick sandstone beds with thin sandy and silty interbeds that are observed on either side of the fault (Figure B-5-10). These sequences are about 35 to 40 meters thick, overturned with an approximately70 degree dip to the north, bounded on the landward side by a sequence of thin sandstone and siltstone beds that record significant bedding-parallel shear, and bounded on the seaward side by a row of eroded sea stacks that may represent a correlative resistant bed. These sedimentary packages, if correlatives, show right-lateral separations on the order of 50 to 70 meters (Figure B-5-10). Because the beds dip steeply to the north, the apparent right-lateral separation is consistent with end-members of pure strikes-slip or pure north-side up dip-slip motion. If the apparent right-lateral separation is caused by dip-slip motion, the total amount is estimated based on a vertical fault to be about (70 meters * tan(70°) = 190 meters). Thus, cumulative displacement between about 70 and 190 meters in about 0.5 to 2 million years yields slip rates that are on the same order as the 0.08 mm/yr vertical rate on the Rattlesnake fault calculated based on the offset 120,000 year old marine terrace.

Olson Hill deformation zone

Exposed in the bedrock geology near Olson Hill are several faults that juxtapose Franciscan complex greenstone, chert, and mélange and blocks of Cretaceous sandstone (Figure B-2-2, B-5-7, and Plate B-1C). The narrow wave-cut platform and sea cliff north and south of Olson Hill provide excellent and almost continuous exposure of bedrock under low tide conditions, with very limited reaches of the coastline that cannot be accessed safely. The bedrock faults near Olson Hill include the North Olson fault north of Olson Hill, the South Olson fault directly south of Olson Hill, an unnamed fault zone farther south exposed near the mouth of Deer Creek, and the Double Rock fault exposed southeast of Double Rock. These bedrock faults are all clearly exposed in the sea cliff, dip subvertically, juxtapose Cretaceous sandstone and Franciscan Complex rocks, and contain several meters of penetrative, fissile fault rock indicating that these are pre-existing faults with significant cumulative displacement that may date to coast-parallel subduction. The North Olson, South Olson, and Double Rock faults all strike east-northeast, and their offshore projections do not correlate with well-defined lineaments observed in the MBES bathymetric data and thus do not clearly connect with the Shoreline fault zone (Figures B-2-2 and B-5-7). Furthermore, these faults do not appear to offset the overlying wave-cut platform. The fourth fault zone located near the mouth of Deer Creek between Olson Hill and Double Rock has ambiguous structural relationships such that it is unclear whether the fault is itself tightly folded or whether it cross-cuts a fold. This unnamed fault is observed beneath the coastal terraces to strike in a coast-parallel northwest-southeast trend and sub-parallel to the Shoreline fault zone. The relationship between this bedrock fault and the overlying wave-cut platform is ambiguous and partially obscured by vegetation that exists within the mouth of Deer Creek. Nevertheless, no clear and direct observations were made in the field to correlate the offset Pleistocene marine terraces across the Olson Hill area with discrete bedrock fault offsets. Based on the data points defining the shoreline angle of the 120,000 year old terrace (Figure B-5-7) (PG&E, 1990; Hanson et al., 1994), it is probable that the deformation across the Olson Hill area occurs as a southwest-facing monoclinal fold, herein named the Olson Hill deformation zone, between north of Olson Hill and Double Rock and not as a discrete fault offset.

5.4.4.2 Westward offshore extent of the San Luis Bay fault zone

The offshore extent of the San Luis Bay fault zone is uncertain. As stated above, there is a reasonable connection between the likely intersection of the Rattlesnake fault at the coast and a lineament mapped in the MBES bathymetric data that suggests a branching relationship between the Rattlesnake and Shoreline faults (Figure B-5-8). Therefore, one reasonable western limit of the San Luis Bay fault zone is at the Shoreline fault zone. This endpoint and the eastern endpoint at Mallagh Landing yields an 8 km-long fault (Figure B-4-1). In this scenario, the Shoreline fault zone may be considered a part of the Southwestern Boundary fault zone that accommodates relative uplift between the Irish Hills and Point San Luis sub-blocks. However, as described above in Section 5.4.3 and in Appendix I, there is evidence suggesting a zero to low vertical displacement rate across the Shoreline fault zone.

Alternatively, multiple lines of evidence suggest that a broad structural boundary separating two sub-blocks with different uplift rates exists in the offshore west of the Shoreline fault zone along the westward continuation of the onshore San Luis Bay fault zone. The lines of evidence suggesting the westward continuation of the San Luis Bay fault zone include: (1) a west-northwest-trending magnetic intensity anomaly that continues along trend with the San Luis Bay fault zone west of the Shoreline fault (Appendix D); (2) the broad boundary in the offshore geologic map between pre-Tertiary bedrock to the north and Tertiary deposits to the south (particularly the northern limit of Obispo Formation southwest of the Shoreline fault), suggesting north-side-up structural relief (Figure B-4-1 and Plates B-1B and B-1C); (3) permissible correlation of submerged marine terraces south and north of the magnetic anomaly consistent with an uplift rate boundary separating the Santa Rosa Reef and Islay shelves there (Appendix I, Section xx); and (4) apparent deformation of the approximately 80,000 year old (MIS 5a) wave-cut platform in the nearshore across the Rattlesnake fault and Olson Hill deformation zone (Appendix I, Section 7.3 and Figure I-7-1). The offset MIS 5a wave-cut platform suggests that deformation of the terraces onshore documented in the LTSP (PG&E, 1990) continues offshore and across the Shoreline fault zone.

The geologic map indicates a west-northwest trending structural grain between the coastline and the Hosgri fault zone along this possible westward continuation of the San Luis Bay fault zone, but the MBES bathymetric data do not show a through-going fault zone at the seafloor along this trend. This finding is consistent with the westward continuation of the San Luis Bay fault zone as a south-facing monoclinal flexure separating the Irish Hills and Point San Luis sub-blocks west of the Shoreline fault zone and extending to the Hosgri fault zone. This alternative relationship is generally consistent with the findings near Olson Hill that the 120,000-year-old (MIS 5e) terrace may be deformed in a monoclinal warp instead of as a discrete offset across a mapped fault, and would imply that the San Luis Bay fault zone may be partially blind at the coast and offshore, with only some strands (such as the Rattlesnake fault) intersecting the surface.

6. CONCLUSIONS

The following conclusions are based on the data and analyses presented above.

Data bases

1. The low-tide LiDAR and concurrent air photos of the coastal strip allowed detailed geologic mapping of the stratigraphy and structure of the nearly continuous exposures to be correlated with the detailed MBES bathymetry offshore and topography onshore. This allowed interpretation and correlation of geologic units and structures onshore and offshore referenced to a GIS database.

2. MBES bathymetric images provided, in places, continuous coverage of bedrock and permitted accurate depiction of geologic structures and separation of rock types by textures.

3. The offshore high-resolution seismic-reflection profiles at 800- and 400-meter spacing provided limited interpretations of structures in the areas covered by marine deposits and mobile sand sheets.

4. The detailed magnetic-field maps from the marine survey and particularly the helicopter surveys helped delineate bedrock structures and differentiate rock types in the Obispo Formation and Franciscan Complex.

5. Reinterpretation of the LTSP diver samples and drop cores combined with the new diver samples clarified some questionable stratigraphic and structural relationships offshore.

Integration to make onshore-offshore geologic map

1. Combining all the information allowed for the interpretation of the geology and the creation of a nearly seamless onshore-offshore geologic map. This detailed geologic map illustrates what can be accomplished using the various types of data acquired for this study.

Shoreline fault zone

1. The Central and South segments of the Shoreline fault zone are clearly expressed as a strong lineament on the MBES bathymetric image and have distinct magnetic-field signatures.

   a. Vertical displacement is less than 1 to 2 meters in the past 75,000 years providing a vertical separation rate of zero to < 0.02 mm/yr.

   b. Horizontal displacement is difficult to measure as no definitive geologic or geomorphic piercing points were identified. However, an inferred, north-south striking fault mapped based on apparent offsets of magnetic anomalies across the Central segment of the Shoreline fault zone suggests limited right-lateral offset of the Shoreline fault zone (range is 0 to less than 200 meters and probably less than 100 meters). If this deformation has occurred in the past 1 to 2 million years, this possible piercing line indicates an estimated slip rate of zero to less than 0.05 to 0.2 mm/yr.

2. Some important characteristics remain uncertain, including:

   a. The relationship between the Shoreline fault zone and the Southwestern Boundary zone, in particular the San Luis Bay fault zone.

b. The geologic character of the North segment of the Shoreline fault zone. It may or may not be expressed as the small faults in Tertiary strata that overlie the seismicity trend; an alternative interpretation that it coincides with the N40W fault is permissible but not preferred.
c. The connection between the N40W fault and the Central segment of the Shoreline fault; and,
d. The late Quaternary horizontal slip rate on the Shoreline fault zone. Current best estimates of horizontal slip rate are based on comparisons to other faults with measured slip rates and constraints on offset of inferred structures based on magnetic anomaly trends.

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Table B-1. Drop Core Samples from LTSP

Table B-1. Drop Core Samples from LTSP						
Sample ID	Date	Location	LTSP Sample Description	LTSP Unit Interpretation	2010 Re-interpretation	Additional Comments
ANTI-1-2DC	1974	SE of Point Estero	"Greywacke"	Cretaceous Sandstone (Ks)	**n/a**	Not located in area mapped for this study
AQ-24	1974	SW of Morro Bay	"Argillite"	Not determined	**Tmpm**	Consistent with Miguelito Member of the Pismo Formation, mapped along coastline
AQ-34	1974	W of Pt. San Luis	Argillaceous carbonate	Probably Monterey Formation	**Tmm or Tmof**	Consistent with Monterey Formation or fine-grained subunit of the Obispo Formation
AQ-101	1974	Estero Bay	Ultramafic rock	Mesozoic	**n/a**	Not located in area mapped for this study
AQ-103	1974	W of Morro Bay	Silty argillite	Probably Monterey Formation	**n/a**	Not located in area mapped for this study
AQ-104	1974	W of Morro Bay	Silty argillite	Not determined	**n/a**	Not located in area mapped for this study
AQ-108	1974	W of Morro Bay	Argillite	Not determined	**n/a**	Not located in area mapped for this study
AQ-110	1974	W of Morro Bay	Argillite	Not determined	**Tmpm**	Consistent with Miguelito Member of the Pismo Formation, mapped along coastline
AQ-111	1974	W of Morro Bay	Silty argillite	Not determined	**Tmpm**	Consistent with Miguelito Member of the Pismo Formation, mapped along coastline
AQ-113	1974	SW of Morro Bay	Argillite	Probably Monterey Formation	**Tmpm**	Consistent with Miguelito Member of the Pismo Formation, mapped along coastline
AQ-115	1974	SW of Morro Bay	Argillite	Not determined	**Tmpm**	Consistent with Miguelito Member of the Pismo Formation, mapped along coastline
AQ-118	1974	San Luis Obispo Bay	Greywacke	Not determined	**Ks**	Bedded habit in bathymetric data is consistent with Cretaceous Sandstone (Ks)
NCAL-75-1G	1975	SW of Pt. San Luis	Siltstone	Not determined	**n/a**	Not located in area mapped for this study

Table B-1. Drop Core Samples from LTSP						
Sample ID	Date	Location	LTSP Sample Description	LTSP Unit Interpretation	2010 Re-interpretation	Additional Comments
NCAL-75-1I	1975	SW of Pt. San Luis	Sandstone	Not determined	**Ks**	Bedded habit in bathymetric data is consistent with Cretaceous Sandstone (Ks)
NCAL-75-1J	1975	SW of Pt. San Luis	Sandstone	Not determined	**Ks**	Bedded habit in bathymetric data is consistent with Cretaceous Sandstone (Ks)
NCAL-75-1K	1975	SW of Pt. San Luis	Sandstone	Not determined	**Ks**	Bedded habit in bathymetric data is consistent with Cretaceous Sandstone (Ks)
NCAL-75-1L	1975	SW of Pt. San Luis	Sandstone	Not determined	**Ks**	Bedded habit in bathymetric data is consistent with Cretaceous Sandstone (Ks)
NCAL-75-1M	1975	SW of Pt. San Luis	Sandstone	Not determined	**Ks**	Bedded habit in bathymetric data is consistent with Cretaceous Sandstone (Ks)
NCAL-75-1Q	1975	SW of Pt. San Luis	Sandstone	Not determined	**Ks**	Bedded habit in bathymetric data is consistent with Cretaceous Sandstone (Ks)
NCAL-75-2A	1975	W of Pt. San Luis	Sandstone/siltstone	Early to middle Miocene	**Tmo**	Stratigraphic position and lithology is consistent with Obispo Formation
NCAL-75-2B	1975	W of Pt. San Luis	Sandstone/shale	Middle Miocene	**Tmo**	Stratigraphic position and lithology is consistent with Obispo Formation
NCAL-75-2C	1975	W of Pt. San Luis	Sandstone/siltstone	Early to middle Miocene	**Tmo**	Stratigraphic position and lithology is consistent with Obispo Formation
NCAL-75-2D	1975	W of Pt. San Luis	Siltstone/shale	Early to middle Miocene	**Tmo**	Stratigraphic position and lithology is consistent with Obispo Formation
NCAL-75-2H	1975	W of Pt. San Luis	Sandstone/mudstone	Middle (?) Miocene	**Tmo**	Stratigraphic position and lithology is consistent with Obispo Formation
NCAL-75-2K	1975	W of Pt. San Luis	Mud over shale	Not determined	**Tmo**	Stratigraphic position and lithology is consistent with Obispo Formation
NCAL-75-2M	1975	W of Pt. San Luis	Siltstone or shale	Not determined	**Tmo**	Stratigraphic position and lithology is consistent with Obispo Formation

Table B-1. Drop Core Samples from LTSP						
Sample ID	Date	Location	LTSP Sample Description	LTSP Unit Interpretation	2010 Re-interpretation	Additional Comments
NCAL-75-2O	1975	W of Pt. San Luis	Sand over shale	Not determined	**Tmm**	Stratigraphic position and lithology is consistent with Monterey Formation
NCAL-75-2Q	1975	W of Pt. San Luis	Clay/siltstone/limestone	Monterey type lithology	**Tmm**	Stratigraphic position and lithology is consistent with Monterey Formation
NCAL-75-3A	1975	W of Pt. San Luis	Siltstone/tuff	Miocene (?)	**Tmo**	Stratigraphic position and lithology is consistent with Obispo Formation
NCAL-75-3E	1975	W of Pt. San Luis	Shale	Not determined	**Tmm**	Stratigraphic position and lithology is consistent with Monterey Formation
NCAL-75-3I	1975	W of Pt. San Luis	Siliceous shale	Not determined	**Tmm**	Stratigraphic position and lithology is consistent with Monterey Formation
NCAL-75-3J	1975	W of Pt. San Luis	Siltstone	Not determined	**Tmo**	Stratigraphic position and lithology is consistent with Obispo Formation
N-3K	1975	W of Pt. San Luis	Siltstone or shale	Not determined	**Tmm**	Stratigraphic position and lithology is consistent with Monterey Formation
NCAL-75-3L	1975	W of Pt. San Luis	Siltstone/chert	Miocene type lithology	**Tmm**	Stratigraphic position and lithology is consistent with Monterey Formation
NCAL-75-3N	1975	W of Pt. San Luis	Siltstone	Miocene type lithology	**Tmm**	Stratigraphic position and lithology is consistent with Monterey Formation
NCAL-75-3O	1975	W of Pt. San Luis	Mudstone/siltstone/chert	Middle or late Miocene	**Tmo**	Stratigraphic position and lithology is consistent with Obispo Formation
NCAL-75-4P	1975	W of Pt. San Luis	Mud over mudstone	Not determined	**Tmm**	Stratigraphic position and lithology is consistent with Monterey Formation
NCAL-75-5A	1975	W of Pt. San Luis	Mud/sandstone	Not determined	**Tmm**	Stratigraphic position and lithology is consistent with Monterey Formation
NCAL-75-5D	1975	W of Pt. San Luis	Siltstone	Not determined	**Tmm**	Stratigraphic position and lithology is consistent with Monterey Formation

Table B-1. Drop Core Samples from LTSP

Sample ID	Date	Location	LTSP Sample Description	LTSP Unit Interpretation	2010 Re-interpretation	Additional Comments
NCAL-75-8C	1975	W of Morro Bay	Mudstone/siltstone/shale	Not determined	**Tmpm**	Consistent with Miguelito Member of the Pismo Formation, mapped along coastline
NCAL-75-8G	1975	W of Morro Bay	Clay/silt	Miocene (?)	**Tmpm**	Consistent with Miguelito Member of the Pismo Formation, mapped along coastline
NCAL-75-8H	1975	SW of Morro Bay	Mudstone	Not determined	**Tmpm**	Consistent with Miguelito Member of the Pismo Formation, mapped along coastline
NCAL-75-8I	1975	SW of Morro Bay	Shale	Miocene type lithology	**Tmpm**	Consistent with Miguelito Member of the Pismo Formation, mapped along coastline
NCAL-75-8O	1975	SW of Morro Bay	Clay over shale	Not determined	**Tmpm**	Consistent with Miguelito Member of the Pismo Formation, mapped along coastline
NCAL-75-8Q	1975	SW of Morro Bay	Mudstone/chert	Middle (?) Miocene	**Tmpm**	Consistent with Miguelito Member of the Pismo Formation, mapped along coastline
NCAL-75-8S	1975	SW of Morro Bay	Mudstone	Not determined	**Tmpm**	Consistent with Miguelito Member of the Pismo Formation, mapped along coastline
NCAL-75-8T	1975	SW of Morro Bay	Mudstone	Not determined	**Tmpm**	Consistent with Miguelito Member of the Pismo Formation, mapped along coastline
NCAL-75-9B	1975	W of Morro Bay	Mudstone	Not determined	**Tmpm**	Consistent with Miguelito Member of the Pismo Formation, mapped along coastline
NCAL-75-9C	1975	W of Morro Bay	Clay over mudstone	Not determined	**Tmpm**	Consistent with Miguelito Member of the Pismo Formation, mapped along coastline
NCAL-75-9I	1975	W of Morro Bay	Clay over shale/siltstone	Middle to late Miocene	**Tmpm**	Consistent with Miguelito Member of the Pismo Formation, mapped along coastline
NCAL-75-9K	1975	W of Morro Bay	Sand over mudstone	Not determined	**Tmpm**	Consistent with Miguelito Member of the Pismo Formation, mapped along coastline
NCAL-75-9N	1975	W of Morro Bay	Sand over mudstone	Not determined	**Tmpm**	Consistent with Miguelito Member of the Pismo Formation, mapped along coastline

Table B-1. Drop Core Samples from LTSP

Sample ID	Date	Location	LTSP Sample Description	LTSP Unit Interpretation	2010 Re-interpretation	Additional Comments
NCAL-75-9P	1975	W of Morro Bay	Siltstone	Not determined	**Tmpm**	Consistent with Miguelito Member of the Pismo Formation, mapped along coastline
NCAL-75-10B	1975	W of Morro Bay	Shale or siltstone	Not determined	**n/a**	Not located in area mapped for this study
NCAL-75-10E	1975	W of Morro Bay	Clay over siltstone	Quaternary coccoliths	**n/a**	Not located in area mapped for this study
NCAL-75-12F	1975	S of Pt. Estero	Sand over clay	Quaternary coccoliths	**n/a**	Not located in area mapped for this study
NCAL-75-17C	1975	W of Pt. Estero	Siltstone	Late Miocene or early Pliocene	**n/a**	Not located in area mapped for this study
NCAL-75-18A	1975	NW of Pt. Estero	Sand over shale	Not determined	**n/a**	Not located in area mapped for this study
NCAL-75-18E	1975	NW of Pt. Estero	Sand over sandstone	Not determined	**n/a**	Not located in area mapped for this study
NCAL-75-18F	1975	NW of Pt. Estero	Sandstone and shale	Not determined	**n/a**	Not located in area mapped for this study
NCAL-75-18G	1975	NW of Pt. Estero	Shale or sandstone	Not determined	**n/a**	Not located in area mapped for this study
NCAL-75-23A	1975	W of Cambria	Clay	Late Miocene or early Pliocene	**n/a**	Not located in area mapped for this study
NCAL-75-25A	1975	S of San Simeon Pt.	Siltstone	Middle Miocene, Relizian (?)	**n/a**	Not located in area mapped for this study
NCAL-75-25E	1975	S of San Simeon Pt.	Siltstone	Middle Miocene, Relizian (?)	**n/a**	Not located in area mapped for this study
NCAL-75-25F	1975	S of San Simeon Pt.	Siltstone in clay matrix	Middle Miocene, Luisian	**n/a**	Not located in area mapped for this study

Table B-2. Diver Samples from LTSP

Table B-2. Diver Samples from LTSP

Sample ID*.	Date	Location	LTSP Sample Description	LTSP Unit Interpretation	2010 Re-interpretation	Additional Comments
D1/S1	10/30/1980	Santa Rosa Platform	"Black shale with albite (?) veinlets"	Franciscan Complex (KJfm)	**Ks**	Franciscan Complex rock is not mapped along coastline within 1800 meters of this location, this sample is probably from fine-grained interbeds within Cretaceous Sandstone
D1/S2	10/30/1980	Santa Rosa Platform	"Massive, medium-gr. greywacke; attitude on good planar surface, but may not be bedding"	Cretaceous Sandstone (Ks) or Franciscan Complex (KJfg)	**Ks**	Franciscan Complex rock is not mapped along coastline within 1800 meters of this location, this sample is probably Cretaceous Sandstone
D2/S3	10/30/1980	Santa Rosa Platform	"Massive medium-gr. greywacke, abundant biotite, resembles Dive 1, Sta. 2"	Cretaceous Sandstone (Ks) or Franciscan Complex (KJfg)	**Ks**	Franciscan Complex rock is not mapped along coastline within 1800 meters of this location, this sample is probably Cretaceous Sandstone
D2/S4	10/30/1980	Santa Rosa Platform	"Same as Dive 2, Sta. 3"	Cretaceous Sandstone (Ks) or Franciscan Complex (KJfg)	**Ks**	Franciscan Complex rock is not mapped along coastline within 1800 meters of this location, this sample is probably Cretaceous Sandstone
D3/S5	10/30/1980	Santa Rosa Platform	"Slickensided black shale similar to Dive 1, Sta. 1"	Franciscan Complex (KJfm)	**KJfm**	Consistent with Franciscan Complex rock mapped along the coastline
D3/S6	10/30/1980	Santa Rosa Platform	"Red and green chert"	Franciscan Complex (KJfm)	**KJfm**	Consistent with Franciscan Complex rock mapped along the coastline
D3/S7	10/30/1980	Santa Rosa Platform	"Medium-gr. greywacke"	Cretaceous Sandstone (Ks) or Franciscan Complex (KJfg)	**KJf**	Consistent with Franciscan Complex rock mapped along the coastline
D4/S8	10/30/1980	Santa Rosa Platform	"Greenstone"	Franciscan Complex (KJfm)	**KJf**	Consistent with Franciscan Complex rock mapped along the coastline
D4/S9	10/30/1980	Santa Rosa Platform	"Very fine-gr, Microgreywacke"	Franciscan Complex (KJfm)	**KJf**	Consistent with Franciscan Complex rock mapped along the coastline
D4/S10	10/30/1980	Santa Rosa Platform	"Serpentinite"	Franciscan Complex (KJfm)	**KJf**	Consistent with Franciscan Complex rock mapped along the coastline
D5/S1	10/30/1980	Islay Platform	"Vesicular, zeolitized tuff; attitude may be on loose block"	Obispo Formation (To)	**Tmor**	Consistent with resistant subunit of Obispo Formation mapped at Crowbar
D5/S2	10/30/1980	Islay Platform	"Orange-brown zeolitized tuff; attitude probably on car-sized block"	Obispo Formation (To)	**Tmor**	Consistent with resistant subunit of Obispo Formation mapped at Crowbar
D5/S3	10/30/1980	Islay Platform	"White zeolitized tuff"	Obispo Formation (To)	**Tmor**	Consistent with resistant subunit of Obispo Formation mapped at Crowbar
D6/S4	10/30/1980	Islay Platform	"Basalt; attitude may be on flow or dike surface, or on joint"	Unnamed volcanic rocks (Tvr)	**Tmod**	Consistent with diabase mapped along the coastline
D6/S5	10/30/1980	Islay Platform	"Coarse-gr, Diabase"	Unnamed volcanic rocks (Tvr)	**Tmod**	Consistent with diabase mapped along the coastline

Table B-2. Diver Samples from LTSP

Sample ID*	Date	Location	LTSP Sample Description	LTSP Unit Interpretation	2010 Re-interpretation	Additional Comments
D7/S6	10/30/1980	Islay Platform	"Chert breccia"	Monterey Formation (Tmm)	**Tmm**	Consistent with Monterey Formation mapped along the coastline
D7/S7	10/30/1980	Islay Platform	"Fractured, siliceous claystone/chert"	Monterey Formation (Tmm)	**Tmm**	Consistent with Monterey Formation mapped along the coastline
D8/S8	10/30/1980	Islay Platform	"Massive brown mudstone"	Miguelito Member of the Pismo Formation (Tpm)	**Tmpm**	Consistent with Pismo Formation mapped along the coastline
D8/S9	10/30/1980	Islay Platform	"Laminated opaline claystone"	Miguelito Member of the Pismo Formation (Tpm)	**Tmpm**	Consistent with Pismo Formation mapped along the coastline
D9/S10a	10/30/1980	Islay Platform	"No sample taken; sand/rock contact may be Los Osos fault (?)"	-	**n/a**	No sample, not reinterpreted
D9/S10b	10/30/1980	Islay Platform	"No sample taken; sand/rock contact may be Los Osos fault (?)"	-	**n/a**	No sample, not reinterpreted
D10/S11	10/30/1980	Santa Rosa Platform	"Gray, medium-gr, sandstone well-sorted sandstone"	Pismo, Squire, or Edna(?) Members of the Pismo Formation (Tp)	**Ks or Tpp**	This sample is probably from fine-grained interbeds within Cretaceous Sandstone, but may be Tertiary-age (Pismo or Obispo Formations)
D11/S1	11/1/1989	Santa Rosa Platform	"Gray, fine-gr, well-sorted sandstone"	Squire Member of the Pismo Formation (Tps)	**Ks or Tpp**	This sample is probably from fine-grained interbeds within Cretaceous Sandstone, but may be Tertiary-age (Pismo or Obispo Formations)
D11/S2	11/1/1989	Santa Rosa Platform	"Brown with white mottles, dolomitic siltstone"	Miguelito Member of the Pismo Formation(?) (Tpm)	**Ks or Tpp**	This sample is probably from fine-grained interbeds within Cretaceous Sandstone, but may be Tertiary-age (Pismo or Obispo Formations)
D11/S3	11/1/1989	Santa Rosa Platform	"Brown, crudely bedded siltstone"	Miguelito Member of the Pismo Formation(?) (Tpm)	**Ks or Tpp**	This sample is probably from fine-grained interbeds within Cretaceous Sandstone, but may be Tertiary-age (Pismo or Obispo Formations)
D12/S4	11/1/1989	Santa Rosa Platform	"Fine-gr. , tuffaceous white sandstone, outcrop trend measured on 2 large blocks"	Obispo Formation(?) (To)	**Tmor/Tmof**	Stratigraphic position above basal Tertiary contact (recognized in bathymetric data) is consistent with resistant or fine-grained subunits of Obispo Formation
D13/S5	11/1/1989	Santa Rosa Platform	"Orange-brown, vesicular tuff"	Obispo Formation (To)	**Tmor/Tmof**	Stratigraphic position above basal Tertiary contact (recognized in bathymetric data) is consistent with resistant or fine-grained subunits of Obispo Formation
D14/S6	11/1/1989	Santa Rosa Platform	"Greenstone with minor pyrite"	Franciscan Complex (KJfmv)	**KJfmv**	Sample may be slightly mis-located, should be from Pecho Rock

Table B-2. Diver Samples from LTSP

Sample ID*	Date	Location	LTSP Sample Description	LTSP Unit Interpretation	2010 Re-interpretation	Additional Comments
D15/S7	11/1/1989	Santa Rosa Platform	"Gray, very fine-gr, Sandstone"	Squire Member of the Pismo Formation (Tps)	**Ks or To/Tpp**	This sample is probably from within Cretaceous Sandstone, but may be Tertiary-age (Pismo or Obispo Formations)
D15/S8	11/1/1989	Santa Rosa Platform	"Brownish gray, dolomitic siltstone; resembles Dive 11, Sta. 2"	Miguelito Member of the Pismo Formation(?) (Tpm)	**Ks or To/Tpp**	This sample is probably from fine-grained interbeds within Cretaceous Sandstone, but may be Tertiary-age (Pismo or Obispo Formations)
D15/S9	11/1/1989	Santa Rosa Platform	"Dark brown, bedded, siltstone calcareous"	Miguelito Member of the Pismo Formation(?) (Tpm)	**Ks or To/Tpp**	This sample is probably from fine-grained interbeds within Cretaceous Sandstone, but may be Tertiary-age (Pismo or Obispo Formations)
D16/S10	11/1/1989	Santa Rosa Platform	"Dark grayish brown, dolomitic siltstone; resembles Dive 15, Sta. 9"	Miguelito Member of the Pismo Formation(?) (Tpm)	**Ks or To/Tpp**	This sample is probably from fine-grained interbeds within Cretaceous Sandstone, but may be Tertiary-age (Pismo or Obispo Formations)
D17/S1	11/2/1989	mislocated	"Highly sheared greywacke greenstone"	Franciscan Complex (Kjf)	**n/a**	sample mislocated
D18/S2	11/2/1989	mislocated	"Dark green, medium-gr, hard greywacke; surfaces measured may be joints"	Cretaceous Sandstone (Ks) or Franciscan Complex (KJfg)	**n/a**	sample mislocated
D18/S3	11/2/1989	mislocated	"Same as Dive 18, Sta. 2"	Cretaceous Sandstone (Ks) or Franciscan Complex (KJfg)	**n/a**	sample mislocated
D19/S4	11/2/1989	mislocated	"Tan, fine-gr, mod. sorted greywacke"	Cretaceous Sandstone (Ks)	**n/a**	sample mislocated
D19/S5	11/2/1989	mislocated	"Greenish brown, greywacke fine-gr, Micaceous"	Cretaceous Sandstone (Ks)	**n/a**	sample mislocated
D19/S6	11/2/1989	mislocated	"Greenish gray, fine-gr, greywacke Grayish tan, fine-gr, Greywacke"	Cretaceous Sandstone (Ks)	**n/a**	sample mislocated
D20/S7	11/2/1989	mislocated	"Grayish tan, fine-gr. Greywacke"	Cretaceous Sandstone (Ks)	**n/a**	sample mislocated
D20/S8	11/2/1989	mislocated	"Olive brown, fine-gr. Greywacke"	Cretaceous Sandstone (Ks)	**n/a**	sample mislocated
D21/S1	11/3/1989	Islay Platform	"Very dark brown, bedded siliceous mudstone; tar in fractures"	Monterey Formation (Tmm)	**Tmm**	Sample located outside of the area discussed in this report
D21/S2	11/3/1989	Islay Platform	"Very dark brown, laminated mudstone (same color as Dive 21, Sta. 1)"	Monterey Formation (Tmm)	**Tmm**	Sample located outside of the area discussed in this report
D21/S3	11/3/1989	Islay Platform	"Very dark brown, laminated chert and siliceous mudstone;	Monterey Formation (Tmm)	**Tmm**	Consistent with Monterey Formation mapped along the coastline

Table B-2. Diver Samples from LTSP

Sample ID*	Date	Location	LTSP Sample Description	LTSP Unit Interpretation	2010 Re-interpretation	Additional Comments
			tarry"			
D22/S4	11/3/1989	Islay Platform	"Med, to dark brown, siliceous mudstone laminated"	Monterey Formation (Tmm)	**Tmm**	Consistent with Monterey Formation mapped along the coastline
D22/S5	11/3/1989	Islay Platform	"Med. to dark brown, siliceous mudstone with contorted laminations"	Monterey Formation (Tmm)	**Tmm**	Consistent with Monterey Formation mapped along the coastline
D23/S6	11/3/1989	San Luis Bay	"White vitric tuff"	Obispo Formation (To)	**Tmo**	Consistent with Obispo Formation mapped along the coastline
D24/S7	11/3/1989	San Luis Bay	"Light gray vitric tuff to E; brownish black, mottled, hard siltstone to"	Obispo or Rincon(?) Formations To/Tr	**Tmor**	Stratigraphic position above basal Tertiary contact is consistent with interbedded tuff and siltstone as observed onshore in subunit Tmor of the Obispo Formation
D25/S8	11/3/1989	San Luis Bay	"Gray to orange, zeolitized, vesicular tuff with chalcedony veins"	Obispo Formation (To)	**Tmor**	Consistent with Obispo Formation mapped along the coastline
D26/S1	11/8/1989	Santa Rosa Platform	"Fine-gr, fractured greywacke"	Franciscan Complex(?) (KJfg) or Cretaceous Sandstone (Ks)	**Ks or KJf**	Mapped as Cretaceous Sandstone based on low magnetic values in aerial survey data, could be Franciscan Complex rock
D26/S2	11/8/1989	Santa Rosa Platform	"Fine-gr, biotite-rich greywacke"	Franciscan Complex(?) (KJfg) or Cretaceous Sandstone (Ks)	**Ks or KJf**	Mapped as Cretaceous Sandstone based on low magnetic values in aerial survey data, could be Franciscan Complex rock
D26/S3	11/8/1989	Santa Rosa Platform	"Fine-gr, slickensided metagraywacke"	Franciscan Complex (KJfg)	**Ks or KJf**	Mapped as Cretaceous Sandstone based on low magnetic values in aerial survey data, could be Franciscan Complex rock
D27/S4	11/8/1989	Santa Rosa Platform	"Med-gr, micaceous greywacke with slickensided shaly interbeds"	Franciscan Complex(?) (KJfg) or Cretaceous Sandstone (Ks)	**KJf or Ks**	Mapped as Franciscan greywacke based on high magnetic values in aerial survey data, could be Cretaceous Sandstone
D27/S5	11/8/1989	Santa Rosa Platform	"Fine-gr, fractured greywacke"	Franciscan Complex(?) (KJfg) or Cretaceous Sandstone (Ks)	**KJf or Ks**	Mapped as Franciscan greywacke based on high magnetic values in aerial survey data, could be Cretaceous Sandstone
D27/S6	11/8/1989	Santa Rosa Platform	"Slickensided metagraywacke with albite (?)"	Franciscan Complex (KJfg)	**KJf or Ks**	Mapped as Franciscan greywacke based on high magnetic values in aerial survey data, could be Cretaceous Sandstone
D28/S7	11/8/1989	Santa Rosa Platform	"Fine-gr, tuffaceous sandstone"	Obispo Formation(?) (To)	**Tmor**	Stratigraphic position above basal Tertiary contact (recognized in bathymetric data) is consistent with resistant subunit of Obispo Formation
D28/S8	11/8/1989	Santa Rosa Platform	"Fine- to med-gr, tuffaceous, vesicular	Obispo Formation(?)	**Tmor**	Stratigraphic position above basal Tertiary contact (recognized in

Table B-2. Diver Samples from LTSP						
Sample ID*	Date	Location	LTSP Sample Description	LTSP Unit Interpretation	2010 Re-interpretation	Additional Comments
			sandstone"	(To)		bathymetric data) is consistent with resistant subunit of Obispo Formation
D28/S9	11/8/1989	Santa Rosa Platform	"Vesicular, zeolitized tuff; based on trend of ridges strike"	Obispo Formation (To)	**Tmor**	Stratigraphic position above basal Tertiary contact (recognized in bathymetric data) is consistent with resistant subunit of Obispo Formation
D29/S10	11/8/1989	Santa Rosa Platform	"Light gray, moderately indurated, fine-gr, sandstone"	Squire Member of the Pismo Formation (Tps)	**Ks or To/Tpp**	This sample is probably from within Cretaceous Sandstone, but may be Tertiary-age (Pismo or Obispo Formations)
D29/S11	11/8/1989	Santa Rosa Platform	"Gray, fine-gr, well-sorted sandstone"	Squire Member of the Pismo Formation (Tps)	**Ks or To/Tpp**	This sample is probably from within Cretaceous Sandstone, but may be Tertiary-age (Pismo or Obispo Formations)
D29/S12	11/8/1989	Santa Rosa Platform	"Very dark brown mudstone, laminated with tan blebs < 1 mm across"	Monterey Formation, Phosphatic (Tmm)	**Ks or To/Tpp**	This sample is probably from within Cretaceous Sandstone, but may be Tertiary-age (Pismo or Obispo Formations)
D30/S1	11/9/1989	Santa Rosa Platform	"Fine- to med-gr, greywacke"	Franciscan Complex (KJfg)	**KJf or Ks**	Mapped as Franciscan Complex rock based on high magnetic values in aerial survey data, could be Cretaceous Sandstone
D30/S2	11/9/1989	Santa Rosa Platform	"Dark gray to black, sheared greywacke (strike to NE-SW)"	Franciscan Complex (KJfg)	**KJf or Ks**	Mapped as Franciscan Complex rock based on high magnetic values in aerial survey data, could be Cretaceous Sandstone
D31/S3	11/9/1989	Santa Rosa Platform	"Coarse-gr, crystalline albite (?), and greenish black, sheared metagraywacke"	Franciscan complex (KJfm)	**KJf or Ks**	Mapped as Franciscan Complex rock based on high magnetic values in aerial survey data, could be Cretaceous Sandstone
D31/S4	11/9/1989	Santa Rosa Platform	"Orange-brown, foliated, aphanitic silica-carbonate (?) rock"	Franciscan Complex (KJfm)	**KJf or Ks**	Mapped as Franciscan Complex rock based on high magnetic values in aerial survey data, could be Cretaceous Sandstone
D31/S5	11/9/1989	Santa Rosa Platform	"Weathered/altered serpentinite"	Franciscan Complex (KJfm)	**KJf or Ks**	Mapped as Franciscan Complex rock based on high magnetic values in aerial survey data, could be Cretaceous Sandstone
D32/S6	11/9/1989	Santa Rosa Platform	no data	no data	**n/a**	No sample, not reinterpreted
D32/S7	11/9/1989	Santa Rosa Platform	"Dark green, med-gr, diabase"	Unnamed volcanic rock (Tvr)	**Kv or Tmod**	Could be Cretaceous volcanic rock with sandstone, or diabase subunit of the Obispo Formation
D33/S8	11/9/1989	Santa Rosa Platform	"Cobble of dark brown, faintly bedded mudstone with abundant forams"	Monterey Formation, Phosphatic (?) (Tmm)	**Ks or To/Tpp**	This sample is probably from fine-grained interbeds within Cretaceous Sandstone, but may be Tertiary-age (Pismo or Obispo Formations)
D33/S9	11/9/1989	Santa Rosa Platform	"Same as Dive 33, Sta. 8"	Monterey Formation, Phosphatic (?) (Tmm)	**Ks or To/Tpp**	This sample is probably from fine-grained interbeds within Cretaceous Sandstone, but may be Tertiary-age (Pismo or Obispo Formations)

Table B-2. Diver Samples from LTSP

Sample ID*	Date	Location	LTSP Sample Description	LTSP Unit Interpretation	2010 Re-interpretation	Additional Comments
D34/S1	11/10/1989	Santa Rosa Platform	"Med. to dark brown, siliceous mudstone with silica-filled fractures"	Monterey Formation (Tmm)	**Ks or To/Tpp**	This sample is probably from fine-grained interbeds within Cretaceous Sandstone, but may be Tertiary-age (Pismo or Obispo Formations)
D34/S2	11/10/1989	Santa Rosa Platform	"Orange-brown, pyrite dense, hard tuff with"	Obispo Formation(?) (To)	**Tmor**	Stratigraphic position above basal Tertiary contact (recognized in bathymetric data) is consistent with the resistant subunit of Obispo Formation
D34/S3	11/10/1989	Santa Rosa Platform	"Black, flow-banded, vesicular basalt"	Unnamed volcanic rock (Tvr)	**Tmod**	Stratigraphic position above basal Tertiary contact (recognized in bathymetric data) is consistent with the diabase subunit of Obispo Formation
D35/S4	11/10/1989	Santa Rosa Platform	"Greenish black, med. porphyritic diabase to coarse gr"	Unnamed volcanic rock (Tvr)	**Tmod**	Stratigraphic position above basal Tertiary contact (recognized in bathymetric data) is consistent with the diabase subunit of Obispo Formation
D35/S5	11/10/1989	Santa Rosa Platform	"Gray-brown, aphanitic tuff with pyrite"	Obispo Formation(?) (To)	**Tmor**	Sample may be slightly mislocated, stratigraphic position above basal Tertiary contact (recognized in bathymetric data) is consistent with the resistant subunit of Obispo Formation
D35/S6	11/10/1989	Santa Rosa Platform	"Gray-brown, massive siltstone (could also be Monterey or Pt. Sal. fms.)"	Rincon(?) (Tr), Monterey(?) (Tmb), or Point Sal formations(?) (Tpsa)	**Tmo or Tr**	Sample may be slightly mislocated, stratigraphic position consistent with Obispo or Rincon Formations
D36/S7	11/10/1989	Santa Rosa Platform	"Fine- to med-gr greywacke; near T/K ctc., clasts of To, diabase observed nearby"	Franciscan Complex(?) (KJfg), or Cretaceous Sandstone (Ks)	**KJf or Ks**	Mapped as Franciscan Complex rock based on high magnetic values in aerial survey data, could be Cretaceous Sandstone
D36/S8	11/10/1989	Santa Rosa Platform	"Fine-gr greywacke with abundant lithic grains"	Franciscan Complex(?) (KJfg), or Cretaceous Sandstone (Ks)	**KJf or Ks**	Mapped as Franciscan Complex rock based on high magnetic values in aerial survey data, could be Cretaceous Sandstone
D36/S9	11/10/1989	Santa Rosa Platform	"Like Dive 36, Sta. 8 with scattered, 700 SE flattened lithic grains"	Franciscan Complex(?) (KJfg), or Cretaceous Sandstone (Ks)	**KJf or Ks**	Mapped as Franciscan Complex rock based on high magnetic values in aerial survey data, could be Cretaceous Sandstone
D37/S10	11/10/1989	Santa Rosa Platform	"Dark greenish gray, very fine-gr, highly sheared greywacke"	Franciscan Complex (KJfg)	**KJf or Ks**	Mapped as Franciscan Complex rock based on high magnetic values in aerial survey data, could be Cretaceous Sandstone
D38/S11	11/10/1989	Santa Rosa Platform	"Fine- to med-gr, greywacke with rare lithic clasts; like Dive 36, Sta. 7"	Franciscan Complex(?) (KJfg), or Cretaceous Sandstone (Ks)	**KJf or Ks**	Mapped as Franciscan Complex rock based on high magnetic values in aerial survey data, could be Cretaceous Sandstone

Table B-2. Diver Samples from LTSP						
Sample ID*	Date	Location	LTSP Sample Description	LTSP Unit Interpretation	2010 Re-interpretation	Additional Comments
D38/S12	11/10/1989	Santa Rosa Platform	"Very fine-gr, sheared micrograywacke; shears give rock laminated appearance"	Franciscan Complex(?) (KJfg), or Cretaceous Sandstone (Ks)	**KJf or Ks**	Mapped as Franciscan Complex rock based on high magnetic values in aerial survey data, could be Cretaceous Sandstone
D39/S1	11/11/1989	Santa Rosa Platform	"Greenish-black, greywacke fine-gr, sheared"	Franciscan Complex (KJfg)	**Ks or KJf**	Mapped as Cretaceous Sandstone based on low magnetic values in aerial survey data, could be Franciscan Complex rock
D39/S2	11/11/1989	Santa Rosa Platform	"Yellow-brown, med-gr sandstone with black shale rip-up clasts (turbidite)"	Rincon Formation(?) (Tr), Vaqueros sandstone(?) (Tv) (turbidite)	**Tmo or Tr**	Sample may be slightly mislocated, stratigraphic position consistent with Obispo or Rincon Formations
D39/S3	11/11/1989	Santa Rosa Platform	"Gray, v. fine- to fine-gr tuff"	Obispo Formation (To)	**Tmor**	Sample may be slightly mislocated, stratigraphic position consistent with resistant subunit of the Obispo Formation
D40/S4	11/11/1989	Santa Rosa Platform	"Sheared red chert"	Franciscan Complex (KJfm)	**KJf**	Consistent with Franciscan Complex rock mapped along the coastline
D40/S5	11/11/1989	Santa Rosa Platform	"Serpentinite, plus low ridge of pervasively sheared black shale"	Franciscan Complex (KJfm)	**KJf**	Consistent with Franciscan Complex rock mapped along the coastline
D40/S6	11/11/1989	Santa Rosa Platform	"Serpentinite, Sta. 5 same as Dive 40"	Franciscan Complex (KJfm)	**KJf**	Consistent with Franciscan Complex rock mapped along the coastline
D41/S7	11/11/1989	Santa Rosa Platform	"Massive, dark, fine-gr greywacke with rare crystal-lined vugs"	Franciscan Complex(?) (KJfg), or Cretaceous Sandstone (Ks)	**Ks or KJf**	Mapped as Cretaceous Sandstone based on low magnetic values in aerial survey data, could be Franciscan Complex rock
D41/S8	11/11/1989	Santa Rosa Platform	"Gray, v. fine-gr. to aphanitic tuff, with scattered phenos, zeolitized pumice; possible depositional K/T contact"	Obispo Formation(?) (To) or Cambria Felsite	**Tmor**	Stratigraphic position above basal Tertiary contact (recognized in bathymetric data) is consistent with the resistant subunit of Obispo Formation
D41/S9	11/11/1989	Santa Rosa Platform	"Gray, very fine-gr, slightly vesicular tuff, zeolite-lined vugs"	Obispo Formation (To)	**Tmor**	Stratigraphic position above basal Tertiary contact (recognized in bathymetric data) is consistent with the resistant subunit of Obispo Formation
D41/S10	11/11/1989	Santa Rosa Platform	"Dark gray, massive mudstone (Dive 41, Sta. 8 -10 crossed synclinal axis)"	Rincon Formation(?) (Tr)	**Tmor**	Stratigraphic position above basal Tertiary contact is consistent with interbedded tuff and siltstone as observed onshore in subunit Tmor of the Obispo Formation
51	9/19/1986	San Luis Bay	"Gry to tan tuff"	Tmor	**Tmor**	Stratigraphic position above basal Tertiary contact (recognized in bathymetric data) is consistent with the resistant subunit of Obispo Formation

Table B-2. Diver Samples from LTSP						
Sample ID*	Date	Location	LTSP Sample Description	LTSP Unit Interpretation	2010 Re-interpretation	Additional Comments
52	9/19/1986	San Luis Bay	"wht tuff"	Tmot	**Tmot**	Consistent with tuffaceous subunit of Obispo Formation mapped along the coastline
53	9/19/1986	San Luis Bay	"blk slt"	Tmr	**Tr**	Sample may be slightly mislocated, consistent with Rincon Formation mapped along the coastline northwest of the Wilmar Avenue fault
54	9/19/1986	San Luis Bay	"md gr diabase"	Tmod	**Tmod**	Consistent with diabase subunit of Obispo Formation mapped along the coastline southeast of the Wilmar Avenue fault
55	9/19/1986	San Luis Bay	"md-fn gr diabase"	Tmod	**Tmod**	Consistent with diabase subunit of Obispo Formation mapped along the coastline southeast of the Wilmar Avenue fault
56	9/19/1986	San Luis Bay	"md-fn gr diabase"	Tmod	**Tmod**	Consistent with diabase subunit of Obispo Formation mapped along the coastline southeast of the Wilmar Avenue fault
57	9/19/1986	San Luis Bay	"gry diabase"	Tmod	**Tmod**	Consistent with diabase subunit of Obispo Formation mapped along the coastline southeast of the Wilmar Avenue fault
58	9/19/1986	San Luis Bay	"dk gry-grn diabase"	Tmod	**Tmod**	Consistent with diabase subunit of Obispo Formation mapped along the coastline southeast of the Wilmar Avenue fault
59	9/19/1986	San Luis Bay	"gry blk slt"	Tmr	**Tr**	Sample may be slightly mislocated, consistent with Rincon Formation mapped along the coastline northwest of the Wilmar Avenue fault
60	9/19/1986	San Luis Bay	"gry-grn diabase"	Tmod	**Tmod**	Consistent with diabase subunit of Obispo Formation mapped along the coastline northwest of the Wilmar Avenue fault
61	9/19/1986	San Luis Bay	"diabase"	Tmod	**Tmod**	Consistent with diabase subunit of Obispo Formation mapped along the coastline northwest of the Wilmar Avenue fault
62	9/19/1986	San Luis Bay	"wht tuff, might be somewhat calcified"	Tmo/Tmor?	**Tmot/Tmor**	Consistent with tuffaceous or resistant subunit of Obispo Formation mapped along the coastline northwest of the Wilmar Avenue fault
63	9/19/1986	San Luis Bay	"lt brn tuff, might be slight sil."	Tmo/Tmor?	**Tmot/Tmor**	Consistent with tuffaceous or resistant subunit of Obispo Formation mapped along the coastline northwest of the Wilmar Avenue fault
64	9/19/1986	San Luis Bay	"gry tuff, might be slight sil. or calcified"	Tmo/Tmor?	**Tmot/Tmor**	Consistent with tuffaceous or resistant subunit of Obispo Formation mapped along the coastline northwest of the Wilmar Avenue fault

Table B-2. Diver Samples from LTSP						
Sample ID*	Date	Location	LTSP Sample Description	LTSP Unit Interpretation	2010 Re-interpretation	Additional Comments
65	9/19/1986	San Luis Bay	"gry blk slt"	Tmr	**Tr**	Sample may be slightly mislocated, consistent with Rincon Formation mapped along the coastline northwest of the Wilmar Avenue fault
66	9/19/1986	San Luis Bay	"dk-gry diabase"	Tmod	**Tmod**	Consistent with diabase subunit of Obispo Formation mapped along the coastline northwest of the Wilmar Avenue fault
67	9/19/1986	San Luis Bay	"gry tuff"	Tmot	**Tmot**	Consistent with tuffaceous subunit of Obispo Formation mapped along the coastline
68	9/19/1986	San Luis Bay	"Lt gry tuff"	Tmot	**Tmot**	Consistent with tuffaceous subunit of Obispo Formation mapped along the coastline
69	9/19/1986	San Luis Bay	"gry tuff"	Tmot	**Tmot**	Consistent with tuffaceous subunit of Obispo Formation mapped along the coastline
70	9/19/1986	San Luis Bay	"lam gry-blk sft slt to dk brn sh"	Tmo/Tmm?	**Tmo**	Consistent with Obispo Formation mapped along the coastline
71	9/19/1986	San Luis Bay	"gry-blugry tuff"	Tmot	**Tmot**	Consistent with tuffaceous subunit of Obispo Formation mapped along the coastline
72	9/19/1986	San Luis Bay	"gry, hard fin gr tuff"	Tmot	**Tmot**	Consistent with tuffaceous subunit of Obispo Formation mapped along the coastline
73	9/19/1986	San Luis Bay	"gry tuff"	Tmot	**Tmot**	Consistent with tuffaceous subunit of Obispo Formation mapped along the coastline
74	9/19/1986	San Luis Bay	"gry sil cavities fin gr tuff"	Tmor	**Tmot/Tmor**	Consistent with tuffaceous or resistant subunit of Obispo Formation mapped along the coastline northwest of the Wilmar Avenue fault
75	9/19/1986	San Luis Bay	"gry blk soft slt to dk brn sh"	Tmo	**Tmor/Tmof**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation
76	9/19/1986	San Luis Bay	"blu gry masshrd fine gr tuff, could be fine gr ss"	Tmot/Tmo	**Tmo**	Consistent with Obispo Formation mapped along the coastline
77	9/19/1986	San Luis Bay	"blu gry tuff"	Tmot	**Tmot/Tmor**	Consistent with tuffaceous or resistant subunit of Obispo Formation mapped along the coastline
78	9/19/1986	San Luis Bay	"gry brn Slt, blocky fract, hard"	Tmo	**Tmor/Tmof**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation
79	9/19/1986	San Luis Bay	"Blu gra fn gr slt, could be tuff"	Tmo/Tmot	**Tmor/Tmof**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation
80	9/19/1986	San Luis Bay	"gry hard mass v fine gr ss/slt"	Tmo	**Tmor/Tmof**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation
81	9/19/1986	San Luis Bay	"blu gry tuff"	Tmot	**Tmot/Tmor**	Consistent with tuffaceous or resistant subunit of Obispo Formation mapped along the

Table B-2. Diver Samples from LTSP						
Sample ID*	Date	Location	LTSP Sample Description	LTSP Unit Interpretation	2010 Re-interpretation	Additional Comments
						coastline
82	9/19/1986	San Luis Bay	"blu-gry fine gr tuff w/xls"	Tmo	**Tmor/Tmof**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation
83	9/19/1986	San Luis Bay	"lt gry brn silt/sh; not typical of Tmm"	Tmm	**Tmor/Tmof or Tmm**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation, could be Monterey Formation
84	9/19/1986	San Luis Bay	"lt gry to brn lam slt/sh"	Tmm	**Tmor/Tmof or Tmm**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation, could be Monterey Formation
85	9/19/1986	San Luis Bay	"Lt gry blk slt"	Tmm	**Tmor/Tmof or Tmm**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation, could be Monterey Formation
86	9/19/1986	San Luis Bay	"brn silty sh; similar to sample 83"	Tmm	**Tmor/Tmof or Tmm**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation, could be Monterey Formation
87	9/19/1986	San Luis Bay	"fry to blk lam sdy sh"	Tmm	**Tmor/Tmof or Tmm**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation, could be Monterey Formation
88	9/19/1986	San Luis Bay	"gry brn fossil sndy? slt/sh"	Tmm	**Tmor/Tmof or Tmm**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation, could be Monterey Formation
89	9/19/1986	San Luis Bay	"blk lam sh"	Tmm	**Tmor/Tmof or Tmm**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation, could be Monterey Formation
90	9/19/1986	San Luis Bay	"blk sil sh highly fractured"	Tmm	**Tmor/Tmof or Tmm**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation, could be Monterey Formation
91	9/19/1986	San Luis Bay	"blk lam sil sh"	Tmm	**Tmor/Tmof or Tmm**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation, could be Monterey Formation
92	9/19/1986	San Luis Bay	"blk lam sil sh"	Tmm	**Tmor/Tmof or Tmm**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation, could be Monterey Formation
93	9/19/1986	San Luis Bay	"lt gry to brn lam sil sh"	Tmm	**Tmor/Tmof or Tmm**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation, could be Monterey Formation
94	9/19/1986	San Luis Bay	"lt and dk gry lam sil sh/slt"	Tmm	**Tmor/Tmof or Tmm**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation, could be Monterey Formation
95	9/19/1986	San Luis Bay	"lt gry lam sh; slightly sil and locally dolomitic"	Tmm	**Tmor/Tmof or Tmm**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation, could

Table B-2. Diver Samples from LTSP						
Sample ID*	Date	Location	LTSP Sample Description	LTSP Unit Interpretation	2010 Re-interpretation	Additional Comments
						be Monterey Formation
96	9/19/1986	San Luis Bay	"lt and dk lam sh and v. fn gr ss"	Tmpm/Tmm?	**Tmor/Tmof or Tmm**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation, could be Monterey Formation
97	9/19/1986	San Luis Bay	"dk gry slightl sndy slt"	Tmpm	**Tmor/Tmof or Tmm**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation, could be Monterey Formation
98	9/19/1986	San Luis Bay	"gry and brn massive slt"	Tmpm	**Tmor/Tmof or Tmm**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation, could be Monterey Formation
99	9/19/1986	San Luis Bay	"gry to wht tuff, surrounded by 'ided' Tpp"	Tmpm	**Tmor/Tmof or Tmm**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation, could be Monterey Formation
100	9/19/1986	San Luis Bay	"dk gry mass slt/sh; also in bag is soft dk fn gr ss"	Tmpm	**Tmor/Tmof or Tmm**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation, could be Monterey Formation
101	9/19/1986	San Luis Bay	"gry mass f gr tuff ss"	Tmpm	**Tmor/Tmof**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation
102	9/19/1986	San Luis Bay	"lt gry to blue sil tuff"	Tmor	**Tmot/Tmor**	Consistent with tuffaceous or resistant subunit of Obispo Formation mapped along the coastline
103	9/19/1986	San Luis Bay	"dk gry blk, gry brn sh (tar on jts)"	Tmo	**Tmor/Tmof**	Stratigraphic position is consistent with resistant or fine-grained subunits of Obispo Formation
104	9/19/1986	San Luis Bay	"gry brn hard sil slt or Tuff"	Tmm	**Tmor/Tmof or Tmm**	Consistent with resistant or fine-grained subunits of Obispo Formation mapped along the coastline, could be Monterey Formation
105	9/19/1986	San Luis Bay	"dk gry fn gr ss, hard"	Tmo	**Tmot/Tmor**	Consistent with tuffaceous or resistant subunit of Obispo Formation mapped along the coastline
106	9/19/1986	San Luis Bay (onshore?)	"gry-wht tuff, hard"	Tmor	**Tmot/Tmor**	Consistent with tuffaceous or resistant subunit of Obispo Formation mapped along the coastline
107	9/19/1986	Santa Rosa Platform	"dk gry to grn aphanitic, meta volcanic or qtz mix"	KJfmv	**KJf**	Consistent with Franciscan Complex rock mapped along the coastline
108	9/19/1986	Santa Rosa Platform	"dk gry to grn aphanitic grnstn"	KJfmv	**KJf**	Mapped as Franciscan Complex rock based on high magnetic values in aerial survey data
109	9/19/1986	Santa Rosa Platform	"gry grn med gr ss"	Ks	**Ks**	Consistent with Cretaceous Sandstone mapped along the coastline

Table B-2. Diver Samples from LTSP						
Sample ID*	Date	Location	LTSP Sample Description	LTSP Unit Interpretation	2010 Re-interpretation	Additional Comments
110	9/19/1986	Santa Rosa Platform	"grnstn"	KJfmv	**KJf**	Mapped as Franciscan Complex rock based on high magnetic values in aerial survey data
111	9/19/1986	Santa Rosa Platform	"gry brn to gry grn metavolcanic"	KJfmv	**KJf**	Mapped as Franciscan Complex rock based on high magnetic values in aerial survey data
112	9/19/1986	Santa Rosa Platform	"gry grn cr gr ss"	Ks?/KJfss?	**KJf**	Mapped as Franciscan Complex rock based on high magnetic values in aerial survey data
113	9/19/1986	Santa Rosa Platform	"Wht tuff, fn gr"	Tmot	**Tmor**	Consistent with resistant subunit of Obispo Formation mapped at Crowbar
114	9/19/1986	Santa Rosa Platform	"grn med-fn gr tuff"	Tmot	**Tmor**	Consistent with resistant subunit of Obispo Formation mapped at Crowbar
115	9/19/1986	Santa Rosa Platform	"Diabase"	Tmod	**Tmod**	Consistent with resistant subunit of Obispo Formation mapped at Crowbar and with high magnetic values in aerial survey data
116	9/19/1986	Santa Rosa Platform	"dk gry biotite tuff"	Tmor	**Tmor**	Consistent with resistant subunit of Obispo Formation mapped at Crowbar

Table B-3. Diver Samples Collected July 2010

Table B-3. Diver Samples Collected July 2010

Sample ID*	Date	Location	Sample Description	Unit ID
DS001	7/12/2010	Santa Rosa Platform	Dark grayish brown sandy SILTSTONE	**Ks (fine-gr)**
DS002	*7/12/2010*	*Santa Rosa Platform*	*Greenish gray METAMORPHIC ROCK and light bluish gray SANDSTONE*	***Kjf***
DS003	7/12/2010	Santa Rosa Platform	Grayish brown SANDSTONE	**Ks**
DS004	7/12/2010	Santa Rosa Platform	Light brown sandy MUDSTONE	**Ks (fine-gr)**
DS005	7/12/2010	Santa Rosa Platform	Medium gray SANDSTONE	**Ks**
DS006	7/12/2010	Santa Rosa Platform	Dark gray VOLCANIC ROCK	**Ks/Kv**
DS007	7/12/2010	Santa Rosa Platform	Grayish brown SANDSTONE	**Ks**
DS008	7/12/2010	Santa Rosa Platform	Dark grayish brown silty SANDSTONE	**Ks (fine-gr)**
DS009	7/12/2010	Santa Rosa Platform	Light gray SANDSTONE	**Tmor**
DS010	7/12/2010	Santa Rosa Platform	Orange brown TUFF	**Tmor**
DS011	7/12/2010	Santa Rosa Platform	Medium gray SANDSTONE	**Ks**
DS012	7/12/2010	Santa Rosa Platform	Dark gray VOLCANIC ROCK	**KJfmv**
DS013	7/12/2010	Santa Rosa Platform	Grayish brown SANDSTONE	**Ks**

Table B-3. Diver Samples Collected July 2010				
Sample ID*	Date	Location	Sample Description	Unit ID
DS014	7/12/2010	Santa Rosa Platform	Grayish brown SANDSTONE	**Ks**
DS015	7/12/2010	Santa Rosa Platform	Grayish brown SANDSTONE	**Ks**
DS016	7/12/2010	Santa Rosa Platform	Medium gray TUFF	**Tmor**
DS017	7/13/2010	Santa Rosa Platform	Dark greenish brown VOLCANIC ROCK	**KJfmv**
DS018	7/13/2010	Santa Rosa Platform	Dark greenish gray VOLCANIC ROCK	**KJfmv**
DS019	7/13/2010	Santa Rosa Platform	Medium gray SANDSTONE	**Ks**
DS020	7/13/2010	Santa Rosa Platform	Dark greenish gray VOLCANIC ROCK	**KJfmv**
DS021	7/13/2010	Santa Rosa Platform	Dark greenish gray VOLCANIC ROCK	**KJfmv**
DS022	7/13/2010	Santa Rosa Platform	Dark gray SANDSTONE	**Ks**
DS023	7/13/2010	Santa Rosa Platform	Grayish brown SANDSTONE	**Ks**
DS024	7/13/2010	Santa Rosa Platform	Light grayish brown SANDSTONE	**Ks**
DS025	7/13/2010	Santa Rosa Platform	Greenish gray METAMORPHIC ROCK	**KJf**
DS026	7/13/2010	Santa Rosa Platform	Dark grayish brown sandy SILTSTONE	**Ks (fine-gr)**

Table B-3. Diver Samples Collected July 2010				
Sample ID*	Date	Location	Sample Description	Unit ID
DS027	7/14/2010	Santa Rosa Platform	Dark grayish brown sandy SILTSTONE	**Tmof/Tmor**
DS028	7/14/2010	Santa Rosa Platform	Light brown sandy SILTSTONE	**Tmof/Tr**
DS029	7/14/2010	Santa Rosa Platform	Olive brown SANDSTONE	**Ks**
DS030	7/14/2010	Santa Rosa Platform	Dark brown sandy SILTSTONE	**Tmof/Tmor**
DS031	7/14/2010	Santa Rosa Platform	Dark brown sandy SILTSTONE	**Tmof/Tr**
DS032	7/14/2010	Santa Rosa Platform	Greenish gray METAMORPHIC ROCK	**KJf**
DS033	7/14/2010	Santa Rosa Platform	Dark bluish green VOLCANIC ROCK	**KJfmv**
DS034	7/14/2010	Santa Rosa Platform	Medium gray SANDSTONE	**Ks**
DS035	7/14/2010	Santa Rosa Platform	Greenish gray METAMORPHIC ROCK	**KJf**
DS036	7/15/2010	Santa Rosa Platform	Dark bluish green VOLCANIC ROCK	**KJfmv**
DS037	7/15/2010	Santa Rosa Platform	Grayish brown SANDSTONE	**Ks**
DS038	7/15/2010	Santa Rosa Platform	Very dark gray sheared CLAYSTONE	**KJfm**
DS039	7/15/2010	Santa Rosa Platform	Dark gray SANDSTONE	**Ks**

Table B-3. *Diver Samples Collected July 2010*				
Sample ID*	Date	Location	Sample Description	Unit ID
DS040	7/15/2010	Santa Rosa Platform	Grayish brown SANDSTONE	**Ks**
DS041	7/15/2010	Santa Rosa Platform	Dark gray SANDSTONE	**Ks**
DS042	7/15/2010	Santa Rosa Platform	Dark gray SANDSTONE	**Ks**
DS043	7/15/2010	Santa Rosa Platform	Dark gray SANDSTONE	**Ks**
DS044	7/15/2010	Santa Rosa Platform	Dark brown sandy SILTSTONE	**Ks (fine-gr)**
DS045	7/15/2010	Santa Rosa Platform	ARTIFICIAL FILL	**AF**
DS046	7/17/2010	San Luis Bay	Greenish and reddish brown VOLCANIC ROCK	**KJfmv**
DS047	7/17/2010	San Luis Bay	Greenish gray METAMORPHIC ROCK	**KJf**
DS048	7/17/2010	San Luis Bay	Grayish brown SANDSTONE	**Ks**
DS049	7/17/2010	San Luis Bay	Greenish and reddish brown VOLCANIC ROCK	**KJfmv**
DS050	7/17/2010	San Luis Bay	Grayish brown SANDSTONE	**Ks**
DS051	7/17/2010	San Luis Bay	Greenish gray VOLCANIC ROCK	**KJfmv**

TABLE B-4 Characteristics of the N40W fault.

Location / fault Characteristics	Seismicity	Geomorphic (Bathymetric) Expression	Lithology	Structure	Potential Field
Location Offshore of Point Buchon to Lion Rock **Strike, Dip** N40°W (N35°-44°W), 90° **Length** 7 to 8 km **Width (down dip)** 12 km (+3/-2 km) **Activity** Possible evidence of late Quaternary activity because of (1) probable structural connection to Central segment and (2) possible association with seismicity lineament	No clearly associated seismicity lineament, but northern sub-lineament may connect up-dip to N40W fault. Epicenters of about 7 events associated with the southern end of the North segment Shoreline fault occur at the south end of the N40W fault and two events plot near the central part of the fault.	Fault crosses the Islay shelf without apparent vertical offset. Moderate geomorphic expression. North part has discontinuous straight fault-line scarps accented by paleo-sea cliffs in contact with sand sheets. Central part is a lineament in exposed Obispo Formation rocks. South part covered by sand sheet west of Crowbar Hill. Pleistocene wave-cut platform in Obispo Formation rocks crosses fault with no vertical separation of platform with an uncertainty of about 2 meters.	Fault cuts Miocene strata (Obispo, Monterey, lower Pismo Formations). South part covered by sand sheet but inferred to be contact between Obispo Formation sedimentary rock on west with Obispo diabase on east based on magnetic field.	Fault truncates structures and strata of Obispo, Monterey and Pismo Formations. Middle part where exposed on wave-cut platform west of Crowbar is straight lineament juxtaposing contrasting Obispo rock units. Consists of two traces in zone 50 meters wide. The fault may be imaged in several high-resolution seismic-reflection profiles along middle and south part, but evidence is ambiguous. North end is covered with sand sheet but continues along the 'linear' margin of the rocky platform for up to 3 km. Deep seismic-reflection profiles (from LTSP) may show north end of fault offshore Point Buchon where N40W fault intersects previously identified "Crowbar" faults. South part interpreted to continue beneath sand sheet for 2 km along magnetic gradient west of Lion Rock. It may connect with the Central segment (C-1) of the Shoreline fault zone where the two faults have a 25° strike difference. Alternatively, the fault may splay to the east and end west of Lion Rock.	No gravity anomaly at south end, but north end of fault follows north plunge of gravity high in the northern Islay shelf. Follows the east side of a prominent magnetic high in the north; crosses the high and follows the west side of the anomaly in the south. Magnetic high believed to be associated with Obispo diabase.

TABLE B-5 Characteristics of the North segment of the Shoreline fault zone.

Location / Fault Characteristics	Seismicity	Geomorphic (Bathymetric) Expression	Lithology	Structure	Potential Field
Location Northwest end is the Hosgri fault zone west of Point Buchon; southeast end is Lion Rock. **Strike, Dip** N45°W, 90° **Length** Up to 8 km **Width (down dip)** 12 km (+3/-2 km) **Activity** Treated as active because of associated seismicity lineament.	Sub-lineament is 8 km long, 2 to 15 km deep. A reverse and a composite right-lateral focal mechanism for events at the north end and two right-lateral focal mechanisms near Lion Rock.	No surface expression in Quaternary sediments that overlie bedrock on the Islay shelf.	Inferred offset in Miocene rocks (Obispo or Monterey Formation) in high-resolution seismic-reflection profiles.	Distinct from N40W fault. Two short en-echelon faults cutting Miocene strata tentatively interpreted in shallow seismic lines: the southwestern fault may offset the core of a syncline (northeast-side down vertical separation); the northeastern fault may offset the east limb of the syncline (also northeast-side down vertical separation). Deep seismic line at the north end of the segment, near the intersection with the Hosgri fault zone, shows the absence of faulting within the resolution of the seismic line.	Northern end terminates within steep gravity gradient associated with Hosgri fault zone. Fault is between linear magnetic intensity highs.

TABLE B-6 Characteristics of the Central segment of the Shoreline fault zone.

Location / Fault Characteristics	Seismicity	Geomorphic (Bathymetric) Expression	Lithology	Structure	Potential Field
Location Lion Rock to west of Rattlesnake Cr. **Strike, Dip** N65°W, 90° **Length** 7 to 9 km **Width (down dip)** 8 to 10 km (seismicity sub-lineament) **Activity** Treated as active because of association with seismicity lineament; possible 1-meter-high fault scarp in ~75,000 wave-cut platform.	Two earthquakes near Green Peak have right-lateral focal mechanisms; another earthquake has an oblique right-lateral reverse focal mechanism, and a composite focal mechanism yields a right-lateral solution.	Prominent to moderately prominent geomorphic expression, with fault-line scarps in resistant rock units, shallow troughs, and lineament in mélange. Locally sharp morphology with right-stepping, en-echelon traces.	Fault located within mélange in middle and south parts. Fault juxtaposes Obispo diabase against Franciscan mélange in north part.	Fault segment consists of three geomorphically and structurally defined sub-segments C-1, C-2, and C-3 (see separate tables below). Sub-segments C-3 and C-2 are separated by a 50 to 150 meter right stepover and sub-segments C-2 and C-1 appear to merge with a change in strike. North end buried by sand sheet but trends toward the North segment; alternatively, central segment may merge with the N40W fault with 25° difference in strike. South end defined by an east-trending splay that trends toward the onshore Rattlesnake fault (San Luis Bay fault zone). Alternatively, Central segment dies out in sand sheet south of Rattlesnake Creek. Central and South segments either merge with a 4° strike change or are separated by a right step of up to 400 to 500 meters beneath the sand sheet that covers the north part of the South segment. Age of faulting is post middle Miocene.	Fault follows strong linear magnetic high that lies within the Franciscan mélange except at northern end where fault coincides with a magnetic low.

TABLE B-6 (*continued*). Sub-segment C-1, Central segment of the Shoreline fault zone.

Location / Fault Characteristics	Seismicity	Geomorphic (Bathymetric) Expression	Lithology	Structure	Potential Field
Location of C-1 Lion Rock to Green Peak **Strike, Dip** N68°W, 90° **Length** 1.8 to 3.4 km		Moderately prominent, linear southwest-facing fault-line scarp approximately 5 meters high on east side of fault with sand sheet and scattered rocks to southwest. Follows shallow trough and generally covered with sand sheet with local rock streaks parallel to fault protruding above sand. Shallow seismic-reflection profiles show a Pleistocene wave-cut platform (≥ 75 ka) with a ~1-m-high scarp that is interpreted as erosional but may be from northwest-side up fault displacement. Sub-segment C-2 is interpreted to cross a Pleistocene wave-cut platform and merge with sub-segment C-1 from high-resolution seismic-reflection lines west of Intake Cove.	Sub-segment is the contact between Obispo Formation diabase and Obispo resistant tuff to the east and Franciscan mélange(?) containing numerous knockers to the west along a zone generally covered by sand sheet.	Sub-segment truncates bedding. South end partly covered by sand sheet and appears to merge with north end of C-2 with an 8° change in strike offshore of the Intake Cove, or may end with right stepover of 150 meters. Alternatively, but unlikely, the south end may change strike and trend onshore west of Green Peak. A north-south fault imaged in the magnetic field data in bedrock at the Discharge Cove does not appear displaced but 100 to 200 meters displacement is permissible. Estimated slip rate in past is less than 1 to 2 million years is 0.05 to 0.2 mm/yr	North end where buried by sediments sub-segment follows a magnetic low. Sub-segment crosses magnetic high interpreted to be Obispo diabase on the northeast and Franciscan mélange on southwest. North part follows the east flank of a magnetic high interpreted to be mélange.

TABLE B-6 (*continued*). Sub-segment C-2, Central segment of the Shoreline fault zone.

Location / Fault Characteristics	Seismicity	Geomorphic (Bathymetric) Expression	Lithology	Structure	Potential Field
Location of C-2 Green Peak to Olson Hill **Strike, Dip** N65°W (N43°-62°W), 90° **Length** 4.5 to 5.8 km		North part has moderate to locally strong expression as a shallow trough and as a wide half-trough with small rocks within the zone; fault lies west of a bedrock scarp and where constrained is 15 to 20 meters wide; generally covered with sand sheet in trough. South of the DCPP entrance the Pleistocene wave-cut platform (> 75 ka) crosses sub-segment C-2 and shows no vertical separation within 1.5 meters resolution. In the south part, west of Olson Hill, sub-segment has strong geomorphic expression as a shallow, 2- to 4-meter-deep, 25-meter-wide trough. A moderate to strong, 900-meter-long lineament is located within mélange.	In the north part, sub-segment is the contact between Obispo diabase and mélange In the south part, sub-segment is the contact within mélange and between Cretaceous sandstone and mélange.	North part is generally straight, striking N61°W, in zone of mélange containing small resistant knockers; separates Cretaceous sandstone from Franciscan mélange; analysis of shallow seismic data indicates that the north end continues on strike beneath the sand sheet and merges with sub-segment C-1 offshore of the Intake Cove. Middle part is straight, strikes N68W; truncates bedding and bedrock faults South end may branch into several splays, one of which strikes easterly toward the late Quaternary deformation zone at Olson Hill that is part of the San Luis Bay fault zone; the other may continue south for 130 meters on strike following a narrow trough generally in Cretaceous sandstone.	C-2 fault follows a strong linear magnetic high within Franciscan mélange. Analysis of magnetic anomaly gradient indicates that fault likely has a steep dip.

TABLE B-6 (*continued*). Sub-segment C-3, Central segment of the Shoreline fault zone.

Location / Fault Characteristics	Seismicity	Geomorphic (Bathymetric) Expression	Lithology	Structure	Potential Field
Location of C-3 West of Olson Hill to west of Rattlesnake Creek. **Strike, Dip** N57°W (N43°-62°W), 90° **Length** 2.4 to 3.5 km		Weak to moderate expression as a shallow trough bounded by alignment of small rock knockers within the zone. Southeast end (intersection with Rattlesnake fault) has strong to moderate expression as a fault-line scarp and a shallow, approximately 5-meter-deep, 25-meter-wide trough. Prominent paleostrandline is controlled by the fault, but no lineament is detected within deposits (talus and paleo-beach sediments) at the base of the submerged cliff.	Sub-segment is the contact along the trough between Cretaceous sandstone and mélange containing numerous greywacke knockers. Southeast end is within Cretaceous sandstone.	Middle part is moderately straight, 2.6 km long, strikes N55°to 62°W; the south end may change strike gradually to N70°E; fault appears to lie within a narrow zone of mélange with only small knockers. South end of sub-segment splays into two traces: one splay continues southeast along strike for 400 meters before becoming covered by a sand sheet; the other splay curves easterly toward the Rattlesnake fault (San Luis Bay fault zone).	Northern end of sub-segment crosses west-trending magnetic low; southern part of fault follows steep magnetic gradient that curves along the eastern splay toward Rattlesnake Creek where magnetic high ends; the fault is interpreted to separate Cretaceous sandstone from greenstone and supports the interpretation that the fault changes strike easterly.

TABLE B-7. Characteristics of the South segment of the Shoreline fault zone.

Location / Fault Characteristics	Seismicity	Geomorphic (Bathymetric) Expression	Lithology	Structure	Potential Field
Location West of Rattlesnake Creek to south of Point San Luis. **Strike, Dip** N47°W (N43°-50°W), 90° **Length** 6 to 7 km **Width (down dip)** 8 to 10 km (seismicity sub-lineament) **Activity** Treated as active because of association with seismicity lineament.	Weakest expression of three segments. Has trend that is 10° to 15° more westerly than the associated bedrock fault. Largest event (ML 3.5) is part of a cluster of four events at the southeast end. Composite focal mechanism is right lateral; one earthquake yields normal focal mechanism.	Fault traverses the wide, flat Santa Rosa Reef shelf. North part covered by wide sand sheet, location uncertain. Middle part has moderate expression; near south end the fault occupies a shallow, ~5 meter deep, 50 meter wide trough, but to north the fault is marked by a linear fault-line scarp between resistant sandstone and sand sheet. Near south end a Pleistocene wave-cut platform and strandline (≥ 75 ka) cross the fault and are not displaced vertically within ~1.5 meter resolution. South end covered by sand sheet.	Fault generally covered by sand sheet but inferred to lie within Franciscan mélange. In places fault forms the lithologic contact between Cretaceous sandstone and Franciscan mélange.	North part of fault lies beneath sand sheet. Fault either is continuous with south end of the Central segment or is located to the west where it would have a right step of 400 to 500 m to the Central segment. South part of fault is in a narrow zone of Franciscan mélange; trend is generally straight over 2½ to 3 km near the south end. Locally sharp truncation of rock and strata on west side of fault and slices of bedrock parallel to fault within the mélange. Rock structure southeast of Point San Luis terminates at fault. South end projects beneath sand sheet near the seismicity cluster. Ambiguous evidence for continuation of fault to southeast on high-resolution seismic-reflection profiles. Age of faulting is post Cretaceous.	North part of segment coincides with subparallel linear magnetic highs. Middle part of the segment follows the southwest side of a linear magnetic high.

ATTACHMENT 1 – 2010 DIVE SAMPLE DESCRIPTIONS

Below are the detailed descriptions of the samples collected with Andy Lutz, FUGRO-William Lettis & Associates, in July 2010 by divers in the Shoreline fault zone study area.

Sample ID: DS001

Collected: 07/12/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.18836 W120.82535 (WGS84)

Sandy siltstone, dark grayish brown, visible grains in silty matrix are fine-grained, subangular, quartz or carbonate (very slight reaction to HCl). Stratification defined by thin (1 to 2 mm) discontinuous fine-grained sand laminations. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with few fractures and does not part readily along lamination planes. Sample is fine-grained and may be suitable for microfossil analysis.

Notes: Sample collected from a low-relief outcrop with no prominent indication of bedding or jointing.

Interpretation: **Fine-grained variant of Cretaceous Sandstone** (Ks)

Sample ID: DS002

Collected: 07/12/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.18914 W120.82446 (WGS84)

This sample includes two different lithologies

Metamorphic rock, greenish gray, medium-grained with weakly developed foliation. Crystal composition dominantly quartz and feldspar with common pyrite and trace chlorite. Rock is strong (multiple hammer blows to fracture) with few fractures. Trace fine (1 to 2 mm) quartz veins.

Also: **Sandstone**, light bluish gray, fine- to medium-grained, subangular, dominantly quartz grains with minor feldspar and lithic grains. Samples are unstratified and shear fabric, joints, and fractures are not present. Rock is strong (multiple hammer blows to fracture) with few fractures.

Notes: Sample collected from a low-relief area below a high escarpment; thick kelp created very low visibility conditions.

Interpretation: **Franciscan Complex mélange with greywacke and greenschist metamorphic rock** (KJf)

Sample ID: DS003

Collected: 07/12/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.18780 W120.82180 (WGS84)

Sandstone, grayish brown, fine- to medium-grained, subangular, dominantly quartz and lithic grains with minor feldspar, carbonate cement (vigorous reaction to HCl). Weakly expressed laminations are defined by grain size variation. Rock is strong (multiple hammer blows to fracture) with few fractures, no veins, and does not part regularly along lamination planes. Not suitable for microfossil analysis.

Notes: Sample collected from prominent hog-back ridges oriented roughly normal to the coastline (i.e., east-west).

Interpretation: **Cretaceous Sandstone** (Ks)

Sample ID: DS004

Collected: 07/12/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.18459 W120.81917 (WGS84)

Mudstone, sandy, light brown, visible grains in muddy matrix are very fine-grained, subangular, quartz (no reaction to HCl). Weakly expressed laminations are defined by grain size variation. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow), unfractured, no veins, and does not part readily along lamination planes. Possibly suitable for microfossil analysis.

Notes: Sample collected from prominent hog-back ridges, orientation information not available.

Interpretation: **Fine-grained variant of Cretaceous Sandstone** (Ks), possibly fine-grained subunit of Obispo Formation (Tmof)

Sample ID: DS005

Collected: 07/12/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.18093 W120.80783 (WGS84)

Sandstone, medium gray, fine- to medium-grained. Dominantly subangular quartz and lithic grains with minor feldspar, minor carbonate cement (very slight reaction to HCl). Weakly expressed laminations are defined by grain size variation. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with few fractures, no veins, and does not part regularly along lamination planes. Not suitable for microfossil analysis.

Notes: Sample collected from a roughly 5-ft-high outcrop with east-west oriented bedding or jointing and boulders along the base of the exposure.

Interpretation: **Cretaceous Sandstone** (Ks)

Sample ID: DS006

Collected: 07/12/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.18314 W120.80647 (WGS84)

Volcanic rock, dark gray, generally aphanitic with very fine euhedral quartz crystals in a dark matrix. Rock is unstratified and unsheared, strong (multiple hammer blows to fracture) with thin (1 to 2 mm) quartz veins (no reaction to HCl), and few fractures.

Notes: Sample collected from the south side of a roughly 8-ft-high outcrop.

Interpretation: **Diabase within Cretaceous Sandstone** (Kv)

Sample ID: DS007

Collected: 07/12/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.17736 W120.80093 (WGS84)

Sandstone, grayish brown, fine- to coarse-grained, subangular to subrounded, dominantly quartz and lithic grains with minor feldspar (no reaction to HCl). Minor fine lithic gravel up to 6 mm diameter. Thin (1 cm) beds are defined by grain size variation and textural grading. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with few fractures, no veins, and does not part regularly along lamination planes. Not suitable for microfossil analysis.

Notes: Sample collected from one of several low (3-ft-high) exposures, flat and unlayered.

Interpretation: **Cretaceous Sandstone** (Ks)

Sample ID: DS008

Collected: 07/12/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.18018 W120.81248 (WGS84)

Sandy siltstone, dark grayish brown, visible grains in silty matrix are fine-grained, subangular, quartz or carbonate (very slight reaction to HCl). Stratification defined by thin (1 to 2 mm) discontinuous fine-grained sand laminations.

Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with few fractures and does not part readily along lamination planes. Rare thin (<1 mm) quartz veins. One block is pervasively sheared with abundant quartz veins. Sample is fine-grained and may be suitable for microfossil analysis.

Notes: Sample collected from one of several 5-ft-high exposures.

Interpretation: **Fine-grained variant of Cretaceous Sandstone** (Ks)

Sample ID: DS009

Collected: 07/12/2010

Diver: Craig Porter, Location: Santa Rosa shelf, N35.18294 W120.81994 (WGS84)

Sandstone, light gray, fine- to very fine-grained. Dominantly subangular quartz and lithic grains with minor feldspar, minor carbonate cement (very slight reaction to HCl). No pumice or other volcaniclastic grains. Laminations are absent and there are no preferred grain orientations to suggest bedding. Rock is strong (multiple hammer blows to fracture) with few fractures and no veins. Not suitable for microfossil analysis.

Notes:

Sample collected from a roughly 10-ft-high outcrop with a 20-ft-long overhang, very hard to break.

Interpretation: **Cretaceous Sandstone** (Ks), possibly resistant subunit of Obispo Formation (Tmor)

Sample ID: DS010

Collected: 07/12/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.18380 W120.82711 (WGS84)

Tuff, orange brown, fine- to medium-grained. Dominantly tuffaceous matrix with trace perlite and pumice clasts (up to 0.5 mm diameter), silicate cement (no reaction to HCl). Laminations are absent, and there are no preferred grain orientations to suggest bedding. Rock is strong (multiple hammer blows to fracture) with few fractures and no veins. Not suitable for microfossil analysis.

Notes: Sample collected from a prominent overhanging outcrop with layering oriented roughly east-west.

Interpretation: **Resistant subunit of Obispo Formation** (Tmor)

Sample ID: DS011

Collected: 07/12/2010

Diver: Craig Porter, Location: Santa Rosa shelf, N35.18719 W120.82443 (WGS84)

Sandstone, medium gray, very fine-grained. Dominantly subangular quartz and lithic grains with minor feldspar, silicate cement (no reaction to HCl). Weakly expressed laminations are defined by grain size variation. Rock is strong (multiple hammer blows to fracture) with few fractures and common thin quartz veins. Possibly suitable for microfossil analysis.

Notes: Sample collected from one low rise surrounded by sand, kelp bases covered by sand.

Interpretation: **Cretaceous Sandstone** (Ks)

Sample ID: DS012

Collected: 07/12/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.18969 W120.83016 (WGS84)

Volcanic rock, dark gray, aphanitic with very fine euhedral quartz crystals in a dark matrix. Rock is strong (multiple hammer blows to fracture) with abundant very thin quartz veins (no reaction to HCl), and a pervasive shear fabric.

Notes: Sample collected from a highly fractured, roughly 10-ft-high outcrop.

Interpretation: **Franciscan Complex metavolcanic rock** (KJfmv)

Sample ID: DS013

Collected: 07/12/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.18817 W120.82663 (WGS84)

Sandstone, grayish brown, fine- to very fine-grained. Dominantly subangular quartz and lithic grains with minor feldspar, no reaction to HCl. Prominent laminations are defined by grain sorting. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with few fractures and no veins. Possibly suitable for microfossil analysis.

Notes: Sample collected from a prominent hog-back ridge.

Interpretation: **Cretaceous Sandstone** (Ks)

Sample ID: DS014

Collected: 07/12/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.18623 W120.82546 (WGS84)

Sandstone, grayish brown, fine- to medium-grained, subangular to subrounded, dominantly quartz and lithic grains with minor feldspar (no reaction to HCl). Gravel and coarse-grained sand absent. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with few fractures and no veins. Not suitable for microfossil analysis.

Notes: Sample collected from one of several 10-ft-high, upward-tapering pinnacles, unlayered.

Interpretation: **Cretaceous Sandstone** (Ks)

Sample ID: DS015

Collected: 07/12/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.18647 W120.82335 (WGS84)

Sandstone, grayish brown, fine- to medium-grained, subangular to subrounded, dominantly quartz and lithic grains with minor feldspar (no reaction to HCl). Gravel and coarse-grained sand absent. Rock is medium strong (cannot be scraped with knife, fracture with hammer blow) with few fractures and no veins. Not suitable for microfossil analysis.

Notes: Sample collected from an unlayered, 5-ft-high outcrop.

Interpretation: **Cretaceous Sandstone** (Ks)

Sample ID: DS016

Collected: 07/12/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.18263 W120.82531 (WGS84)

Tuff, medium gray weathered to orange brown, very fine-grained. Dominantly tuffaceous matrix with trace perlite and pumice clasts (up to 0.5 mm diameter), silicate cement (no reaction to HCl). Laminations defined by oxide staining, may indicate textural variation. Rock is strong (multiple hammer blows to fracture) with few fractures and no veins. Not suitable for microfossil analysis.

Notes: Sample collected from a flat surface with deep cracks spaced about 30 ft apart.

Interpretation: **Resistant subunit of Obispo Formation** (Tmor)

Sample ID: DS017

Collected: 07/13/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.19645 W120.84567 (WGS84)

Volcanic rock, dark greenish brown, aphanitic with few visible crystals in a dark matrix. Rock is unstratified, highly sheared, and medium strong (cannot be scraped with knife, fractures with hammer blow) with abundant thin (1 to 2 mm) quartz veins (no reaction to HCl), and common fractures.

Notes: Sample collected from a very tall, unlayered, jagged pinnacle, 10-15 ft wide; base of pinnacle beyond visible range.

Interpretation: **Franciscan Complex metavolcanic rock** (KJfmv)

Sample ID: DS018

Collected: 07/13/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.19796 W120.84905 (WGS84)

Sample description: **Volcanic rock,** dark greenish gray, aphanitic with few visible crystals in a dark matrix. Rock is unstratified and strong (multiple hammer blows to fracture) with abundant thin (1 to 2 mm) quartz veins (no reaction to HCl). Shears and fractures are common but do not impart a pervasive fabric.

Notes: Sample collected from one of several hogback ridges, water very murky.

Interpretation: **Franciscan Complex metavolcanic rock** (KJfmv)

Sample ID: DS019

Collected: 07/13/2010, Diver: Carson Porter

Location: Santa Rosa shelf N35.19952 W120.84960 (WGS84)

Sandstone, medium gray, very fine-grained. Dominantly subangular quartz and lithic grains with minor feldspar, silicate cement (no reaction to HCl). Weakly expressed laminations are defined by grain size variation. Rock is strong (multiple hammer blows to fracture) with common fractures and rare thin quartz veins. Possibly suitable for microfossil analysis.

Notes: Sample collected roughly 8 ft from the top of a tall, rounded pinnacle.

Interpretation: **Cretaceous Sandstone** (Ks)

Sample ID: DS020

Collected: 07/13/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.20623 W120.86724 (WGS84)

Volcanic rock, dark greenish gray, aphanitic with few visible crystals in a dark matrix. Rock is unstratified and strong (multiple hammer blows to fracture) with abundant thin (1 to 2 mm) quartz veins (no reaction to HCl). Shears are common but do not impart a pervasive fabric, and fractures are common.

Notes: Sample collected from an unlayered, steep-sided pinnacle with a rounded top.

Interpretation: **Franciscan Complex metavolcanic rock** (KJfmv)

Sample ID: DS021

Collected: 07/13/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.20452 W120.86454 (WGS84)

Volcanic rock, dark greenish gray, aphanitic with few visible crystals in a dark matrix. Rock is unstratified and strong (multiple hammer blows to fracture) with abundant thin (1 to 2 mm) quartz veins (no reaction to HCl). Shears are common but do not impart a pervasive fabric, and fractures are common.

Notes: Sample collected from a relatively smooth, unlayered, 50 ft tall pinnacle.

Interpretation: **Franciscan Complex metavolcanic rock** (KJfmv)

Sample ID: DS022

Collected: 07/13/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.19457 W120.83265 (WGS84)

Sandstone, dark gray, fine- to medium-grained, subangular, dominantly quartz and lithic grains with minor feldspar. Gravel and coarse-grained sand absent. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with common fractures and common thin quartz and very thin calcite veins (moderately strong reaction to HCl). Common shears disrupt any sense of laminations or bedding. Not suitable for microfossil analysis.

Notes: Sample collected from a large, rounded, unlayered, outcrop.

Interpretation: **Sheared Cretaceous Sandstone** (Ks)

Sample ID: DS023

Collected: 07/13/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.19526 W120.83474 (WGS84)

Sandstone, grayish brown, fine- to medium-grained, subangular, dominantly quartz and lithic grains with minor feldspar. Gravel and coarse-grained sand absent. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with common fractures and common thin quartz veins (no reaction to HCl), rare shears. Not suitable for microfossil analysis.

Notes: Sample collected from a thickly layered, angled outcrop.

Interpretation: **Cretaceous Sandstone** (Ks)

Sample ID: DS024

Collected: 07/13/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.18413 W120.81735 (WGS84)

Sandstone, light grayish brown, fine- to medium-grained, subangular, dominantly quartz and lithic grains with minor feldspar. Gravel and coarse-grained sand absent. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with common fractures and common thin quartz veins (no reaction to HCl), rare shears. Not suitable for microfossil analysis.

Notes: Sample collected from a flat outcrop with 2-3 feet of relief and cracks oriented roughly NE-SW, 30 ft toward shore from boat.

Interpretation: **Cretaceous Sandstone** (Ks)

Sample ID: DS025

Collected: 07/13/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.18515 W120.81595 (WGS84)

Metamorphic rock, greenish gray, medium-grained with moderately well developed foliation. Crystal composition dominantly quartz and feldspar with trace pyrite and common chlorite staining. Rock is strong (multiple hammer blows to fracture) with common fractures. Trace fine (1 to 2 mm) quartz veins and trace calcite veins (weak reaction to HCl).

Notes: Sample collected from a 10 ft tall pinnacle with several rounded knobs and rough areas. Sample thoroughly penetrated by boring clams.

Interpretation: **Franciscan Complex greenschist metamorphic rock** (KJf)

Sample ID: DS026

Collected: 07/13/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.18653 W120.81631 (WGS84)

Sandy siltstone, dark grayish brown, visible grains in silty matrix are fine-grained, subangular, quartz or carbonate (very slight reaction to HCl). Stratification defined by faint thin (1 to 2 mm) sand laminations. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with few fractures and no shears and does not part readily along lamination planes. Sample is fine-grained and may be suitable for microfossil analysis.

Notes: Sample collected from a pinnacle with a large crack in it, with knobs but no ridges, unlayered.

Interpretation: **Fine-grained variant of Cretaceous Sandstone** (Ks)

Sample ID: DS027

Collected: 07/14/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.17552 W120.82388 (WGS84)

Sandy siltstone, dark grayish brown, visible grains in silty matrix are fine-grained, subangular, quartz or carbonate (very slight reaction to HCl). Rock is unstratified, medium strong (cannot be scraped with knife, fractures with hammer blow) with few fractures and no shears. Sample is fine-grained and may be suitable for microfossil analysis.

Notes: Sample collected from a 5 ft tall ridge above a bedrock platform, very little sand.

Interpretation: **Fine-grained variant of Cretaceous Sandstone** (Ks)

Sample ID: DS028

Collected: 07/14/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.17681 W120.82335 (WGS84)

Sandy siltstone, light brown, visible grains in silty matrix are fine-grained, subangular, quartz. Matrix is dolomitized (very slight reaction to HCl). Stratification defined by faint thin (1 to 2 mm) sand laminations. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with few fractures, no veins, and no shears. Sample is fine-grained and may be suitable for microfossil analysis.

Notes: Sample collected from a prominent linear ridge on a bedrock platform.

Interpretation: **Fine-grained subunit of Obispo Formation** (Tmof), or possibly Rincon Shale (Tr)

Sample ID: DS029

Collected: 07/14/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.17631 W120.82138 (WGS84)

Sandstone, olive brown, fine-grained, subangular, dominantly lithic grains with quartz and minor feldspar. Gravel and coarse-grained sand absent. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with no fractures, shears, or veins (no reaction to HCl), rare shears. Not suitable for microfossil analysis.

Notes: Sample collected from a 4 ft tall linear ridge on a bedrock platform.

Interpretation: **Cretaceous Sandstone** (Ks), or possibly Franciscan Complex greywacke (KJfg)

Sample ID: DS030

Collected: 07/14/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.16707 W120.81110 (WGS84)

Sandy siltstone, dark brown, visible grains in silty matrix are fine-grained, subangular, quartz or carbonate (very slight reaction to HCl). Stratification defined by thin (1 to 2 mm) discontinuous fine-grained sand laminations. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with few fractures and does not part readily along lamination planes. Sample is fine-grained and may be suitable for microfossil analysis.

Notes: Sample collected from one of several low raised ridges trending NW-SE across a larger bedrock platform.

Interpretation: **Fine-grained subunit of the Obispo Formation** (Tmof) or fine-grained beds within the resistant subunit of the Obispo Formation (Tmor)

Sample ID: DS031

Collected: 07/14/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.16839 W120.80853 (WGS84)

Sandy siltstone, dark brown, visible grains in silty matrix are fine-grained, subangular quartz with carbonate cement (strong reaction to HCl). Stratification defined by faint very thin (< 1 mm) sand laminations. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with few fractures, no veins, and no shears. Sample is fine-grained and may be suitable for microfossil analysis.

Notes: Sample collected from 20 ft tall exposure, rounded on top.

Interpretation: **Fine-grained subunit of Obispo Formation** (Tmof), or possibly Rincon Shale (Tr)

Sample ID: DS032

Collected: 07/14/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.17303 W120.80612 (WGS84)

Metamorphic rock, greenish gray, medium-grained with weakly developed foliation. Crystal composition dominantly quartz and feldspar with trace chlorite. Rock is strong (multiple hammer blows to fracture) with common fractures and pervasive shearing. Trace fine (1 to 2 mm) quartz veins.

Notes: Sample collected from a large, amorphous stack with no indication of layering.

Interpretation: **Franciscan Complex greenschist metamorphic rock** (KJf)

Sample ID: DS033

Collected: 07/14/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.17780 W120.80675 (WGS84)

Volcanic rock, dark bluish green, aphanitic with few visible crystals in a dark matrix. Rock is strong (multiple hammer blows to fracture), unstratified with common shears, common thin (1 to 2 mm) quartz veins (no reaction to HCl), and common fractures.

Notes: Sample collected from a broad, unlayered rock platform roughly 5 ft high with low relief on top.

Interpretation: **Franciscan Complex metavolcanic rock** (KJfmv)

Sample ID: DS034

Collected: 07/13/2010, Diver: Carson Porter

Location: Santa Rosa shelf N35.17864 W120.80451 (WGS84)

Sandstone, medium gray, fine- to very fine-grained. Dominantly subangular quartz and lithic grains with minor feldspar, carbonate cement (strong reaction to HCl). Weakly expressed laminations are defined by grain size variation. Rock is strong (multiple hammer blows to fracture) with common fractures, rare thin quartz veins, and no shearing. Possibly suitable for microfossil analysis.

Notes: Sample collected from a prominent riser on a small bedrock platform, surrounded by boulders.

Interpretation: **Cretaceous Sandstone** (Ks)

Sample ID: DS035

Collected: 07/14/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.17845 W120.82071 (WGS84)

Metamorphic rock, greenish gray, medium-grained with weakly developed foliation. Crystal composition dominantly quartz and feldspar with trace chlorite. Rock is strong (multiple hammer blows to fracture) with common fractures and pervasive shearing. Trace fine (1 to 2 mm) quartz and calcite veins (moderately strong reaction to HCl).

Notes: Not available.

Interpretation: **Franciscan Complex greenschist metamorphic rock** (KJf)

Sample ID: DS036

Collected: 07/15/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.20062 W120.85300 (WGS84)

Volcanic rock, dark bluish green, aphanitic with few visible crystals in a dark matrix. Rock is strong (multiple hammer blows to fracture), unstratified with common shears, common thin (1 to 2 mm) quartz veins (no reaction to HCl), and common fractures.

Notes: Sample collected from a large steep-walled pinnacle with a flat top.

Interpretation: **Franciscan Complex metavolcanic rock** (KJfmv)

Sample ID: DS037

Collected: 07/15/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.19980 W120.84680 (WGS84)

Sandstone, grayish brown, fine- to medium-grained, subangular, dominantly quartz and lithic grains with minor feldspar and carbonate cement (moderately strong reaction to HCl). Gravel and coarse-grained sand absent, faint bedding defined by grain sorting. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with common fractures, rare shears. Not suitable for microfossil analysis.

Notes: Sample collected from one of several 10 ft high hogback ridges, spaced roughly 10 ft apart with boulders between.

Interpretation: **Cretaceous Sandstone** (Ks)

Sample ID: DS038

Collected: 07/15/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.19777 W120.84507 (WGS84)

Claystone, very dark gray, highly sheared. No visible grains, common very thin (< 1 mm) calcite veins (strong reaction to HCl), laminations if present are obscured by shear fabric. Rock is weak (can be scraped with a pocketknife, cannot be scratched with fingernail) with common fractures. Possibly suitable for microfossil analysis.

Notes: Sample collected from a low exposure 30-35 ft across and 6 ft high, surrounded by sand.

Interpretation: **Franciscan Complex mélange**

Sample ID: DS039

Collected: 07/15/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.19663 W120.83983 (WGS84)

Sandstone, dark gray, fine- to medium-grained, subangular, dominantly quartz and lithic grains with minor feldspar. Trace coarse-grained lithics. Weak sense of bedding defined by grain size variation. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with rare fractures and common thin quartz and very thin calcite veins (moderately strong reaction to HCl). Not suitable for microfossil analysis.

Notes: Sample collected from one of several low ridges on a bedrock platform.

Interpretation: **Cretaceous Sandstone** (Ks)

Sample ID: DS040

Collected: 07/15/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.17373 W120.80077 (WGS84)

Sandstone, grayish brown, fine- to medium-grained, subangular, dominantly quartz and lithic grains with minor feldspar. Trace coarse-grained lithics. Weak sense of bedding defined by grain size variation. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with rare fractures and common thin quartz and very thin calcite veins (moderately strong reaction to HCl). Not suitable for microfossil analysis.

Notes: Sample collected from a low relief exposure surrounded by boulders.

Interpretation: **Cretaceous Sandstone** (Ks)

Sample ID: DS041

Collected: 07/15/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.17063 W120.79643 (WGS84)

Sandstone, dark gray, fine- to medium-grained, subangular, dominantly quartz and lithic grains with minor feldspar. Gravel and coarse-grained sand absent, no sense of bedding or laminations. Rock is strong (multiple hammer blows to fracture) with rare fractures and common thin quartz and very thin calcite veins (moderately strong reaction to HCl). Not suitable for microfossil analysis.

Notes: Sample collected from a jagged, unlayered pinnacle above a low bedrock platform.

Interpretation: **Cretaceous Sandstone** (Ks)

Sample ID: DS042

Collected: 07/15/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.16778 W120.79129 (WGS84)

Sample description:

Sandstone, dark gray, fine- to medium-grained, subangular, dominantly quartz and lithic grains with minor feldspar. Trace coarse-grained lithics. Weak sense of bedding defined by grain size variation. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with rare fractures and common thin quartz and very thin calcite veins (moderately strong reaction to HCl). Not suitable for microfossil analysis.

Notes: Sample collected from a 20 ft long bedrock platform with 3-4 ft wide ridges.

Interpretation: **Cretaceous Sandstone** (Ks)

Sample ID: DS043

Collected: 07/15/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.18023 W120.80299 (WGS84)

Sandstone, dark gray, fine- to medium-grained, subangular, dominantly quartz and lithic grains with minor feldspar. Trace coarse-grained lithics. Weak sense of bedding defined by grain size variation. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with rare fractures and common thin quartz and very thin calcite veins (moderately strong reaction to HCl). Not suitable for microfossil analysis.

Notes: Sample collected from a long bedrock platform with short ridges.

Interpretation: **Cretaceous Sandstone** (Ks)

Sample ID: DS044

Collected: 07/15/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.18852 W120.83092 (WGS84)

Sandy siltstone, dark brown, visible grains in silty matrix are fine-grained, subangular quartz with carbonate cement (strong reaction to HCl). Stratification defined by faint very thin (< 1 mm) sand laminations. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with few fractures, no veins, and no shears. Sample is fine-grained and may be suitable for microfossil analysis.

Notes: Sample collected from 20 ft tall exposure, rounded on top.

Interpretation: **Fine-grained variant of Cretaceous Sandstone** (Ks) (preferred), Fine-grained subunit of Obispo Formation (Tmof), or possibly Rincon Shale (Tr) (alternatives)

Sample ID: DS045

Collected: 07/15/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.18864 W120.82881 (WGS84)

Sample description: No sample taken.

Notes: No bedrock exposed, feature targeted from bathymetric data is an artificial reef of broken tribars.

Interpretation: **Artificial fill** (AF)

Sample ID: DS046

Collected: 07/17/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.14159 W120.75490 (WGS84)

Volcanic rock, greenish and reddish brown, aphanitic with few visible crystals in a dark matrix. Rock is highly weathered, medium strong (cannot be scraped with knife, fractures with hammer blow), unstratified with common shears, and abundant fractures.

Notes: Sample collected from a hummocky, low relief exposure with many cracks and fractures.

Interpretation: **Franciscan Complex metavolcanic rock** (KJfmv)

Sample ID: DS047

Collected: 07/17/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.14303 W120.75242 (WGS84)

Metamorphic rock, greenish gray, medium-grained with weakly developed foliation. Crystal composition dominantly quartz and feldspar with trace chlorite. Rock is strong (multiple hammer blows to fracture) with common fractures and pervasive shearing. Trace fine (1 to 2 mm) quartz and calcite veins (moderately strong reaction to HCl).

Notes: Sample collected from one of several low, rounded exposures surrounded by cobbles and boulders (no sand).

Interpretation: **Franciscan Complex greenschist metamorphic rock** (KJf)

Sample ID: DS048

Collected: 07/17/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.14304 W120.74387 (WGS84)

Sandstone, grayish brown, fine- to medium-grained, subangular, dominantly quartz and lithic grains with minor feldspar. Trace coarse-grained lithics. Weak sense of bedding defined by grain size variation. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with rare fractures and common thin quartz and very thin calcite veins (moderately strong reaction to HCl). Not suitable for microfossil analysis.

Notes: Sample collected from one of several hogback ridges, 10-15 ft wide and about 20 ft apart with sand between.

Interpretation: **Cretaceous Sandstone** (Ks)

Sample ID: DS049

Collected: 07/17/2010, Diver: Carson Porter

Location: Santa Rosa shelf, N35.14619 W120.74639 (WGS84)

Volcanic rock, greenish and reddish brown, aphanitic with few visible crystals in a dark matrix. Rock is highly weathered, medium strong (cannot be scraped with knife, fractures with hammer blow), unstratified with common shears, and abundant fractures.

Notes: Sample collected from a hummocky, low relief exposure with many cracks and fractures.

Interpretation: **Franciscan Complex metavolcanic rock** (KJfmv)

Sample ID: DS050

Collected: 07/17/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.16093 W120.74426 (WGS84)

Sandstone, grayish brown, fine- to medium-grained, subangular, dominantly quartz and lithic grains with minor feldspar. Trace coarse-grained lithics. Weak sense of bedding defined by grain size variation. Rock is medium strong (cannot be scraped with knife, fractures with hammer blow) with rare fractures and common thin quartz and very thin calcite veins (moderately strong reaction to HCl). Not suitable for microfossil analysis.

Notes: Sample collected from a long, flat bedrock exposure with low ridges.

Interpretation: **Cretaceous Sandstone** (Ks)

Sample ID: DS051

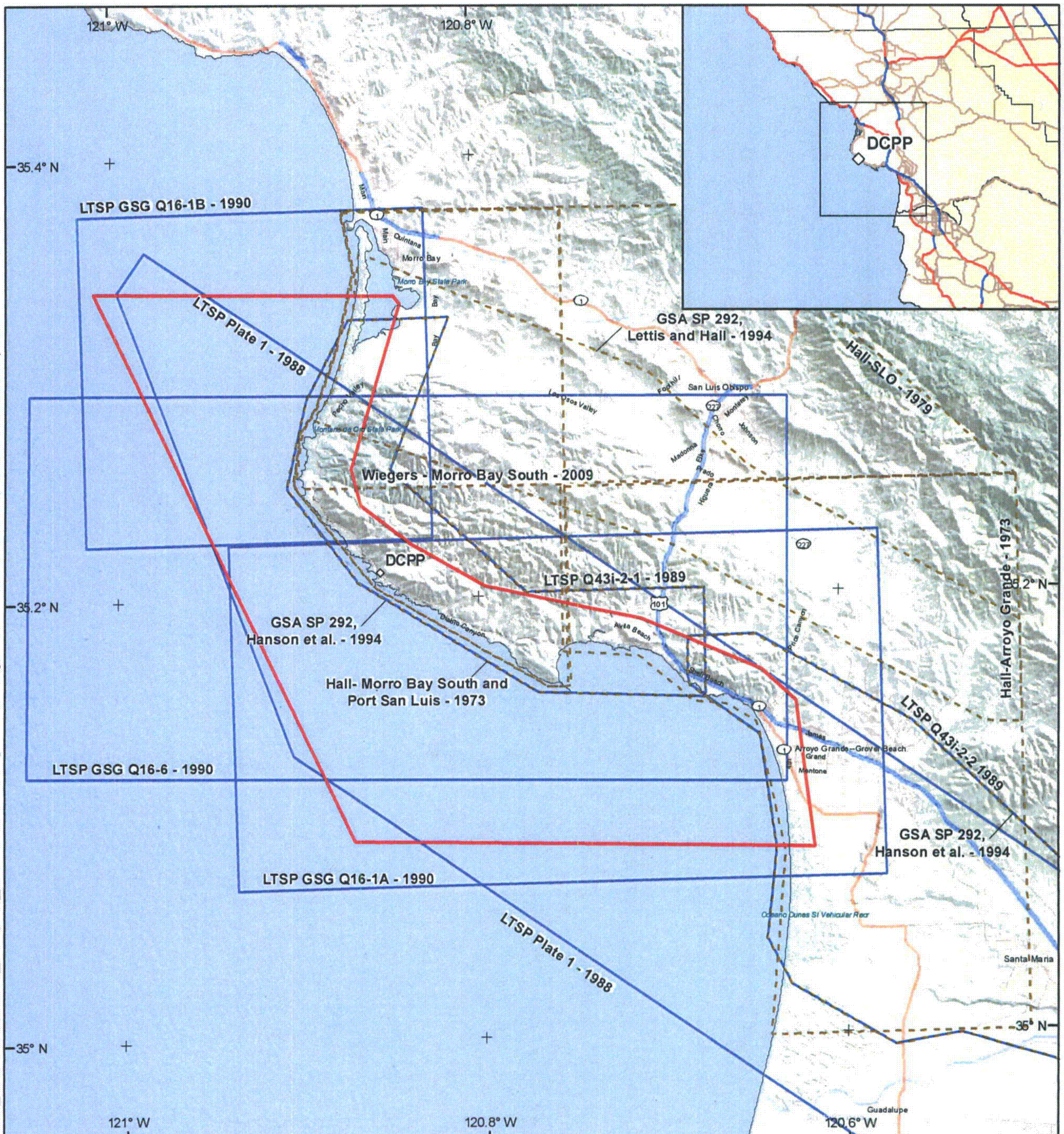
Collected: 07/17/2010, Diver: Craig Porter

Location: Santa Rosa shelf, N35.16041 W120.74676 (WGS84)

Volcanic rock, greenish gray, aphanitic with no visible crystals. Rock is strong (multiple hammer blows to fracture), unstratified with common fractures and no shears.

Notes: Sample collected from a roughly 7 ft high, rounded, overhanging exposure.

Interpretation: **Franciscan Complex metavolcanic rock** (KJfmv)



LEGEND

Study area

LTSP geologic maps (PG&E, 1988, 1989, 1990)

Published geologic maps (Hall, 1973a and 1973b; Hall, 1979; Hanson et al, 1994; Lettis and Hall, 1994; Wiegers, 2009)

Base map: Project DEM (2010), ESRI Data & Maps (2009)

N W E S

0 2 4 Miles

0 4 8 Kilometers

Map projection and scale: NAD 1983, UTM Zone 10N, 1:300,000

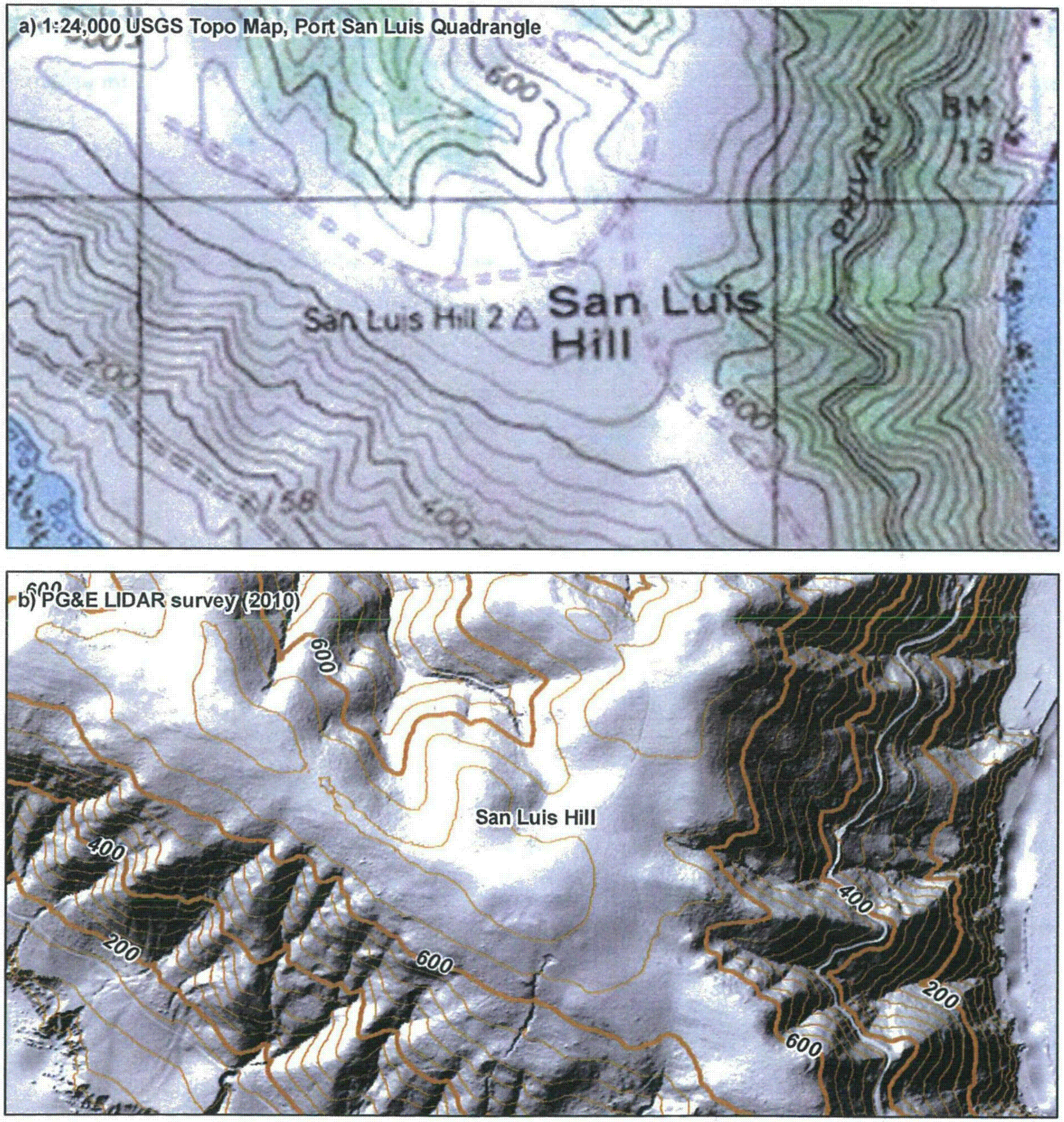
Areas of previous geologic mapping

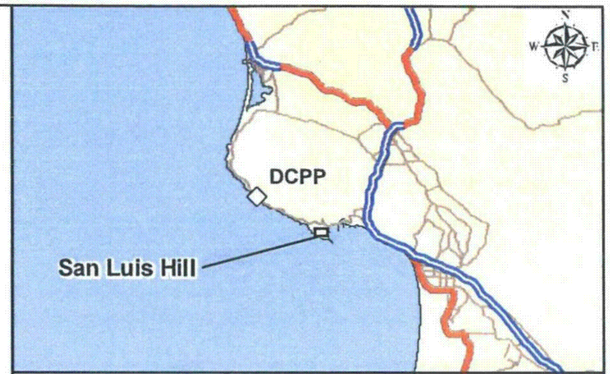
SHORELINE FAULT ZONE STUDY

Pacific Gas and Electric Company

Figure **B-1-1**

File path: S:\13800\13838\13838.002\Figures\20101112_Report\Appendix_B\Figure_B-1-1.mxd; Date: [12/20/2010]; User: Serkan Bozkurt, AMEC Geomatrix, Inc.





Note: Contours are generally in agreement, but details between contours in DEM allow much better geomorphic/geologic interpretation of features.

Contour interval: 20 feet
Map scale: 1:10,000
Map projection: NAD 1983, UTM Zone 10 North

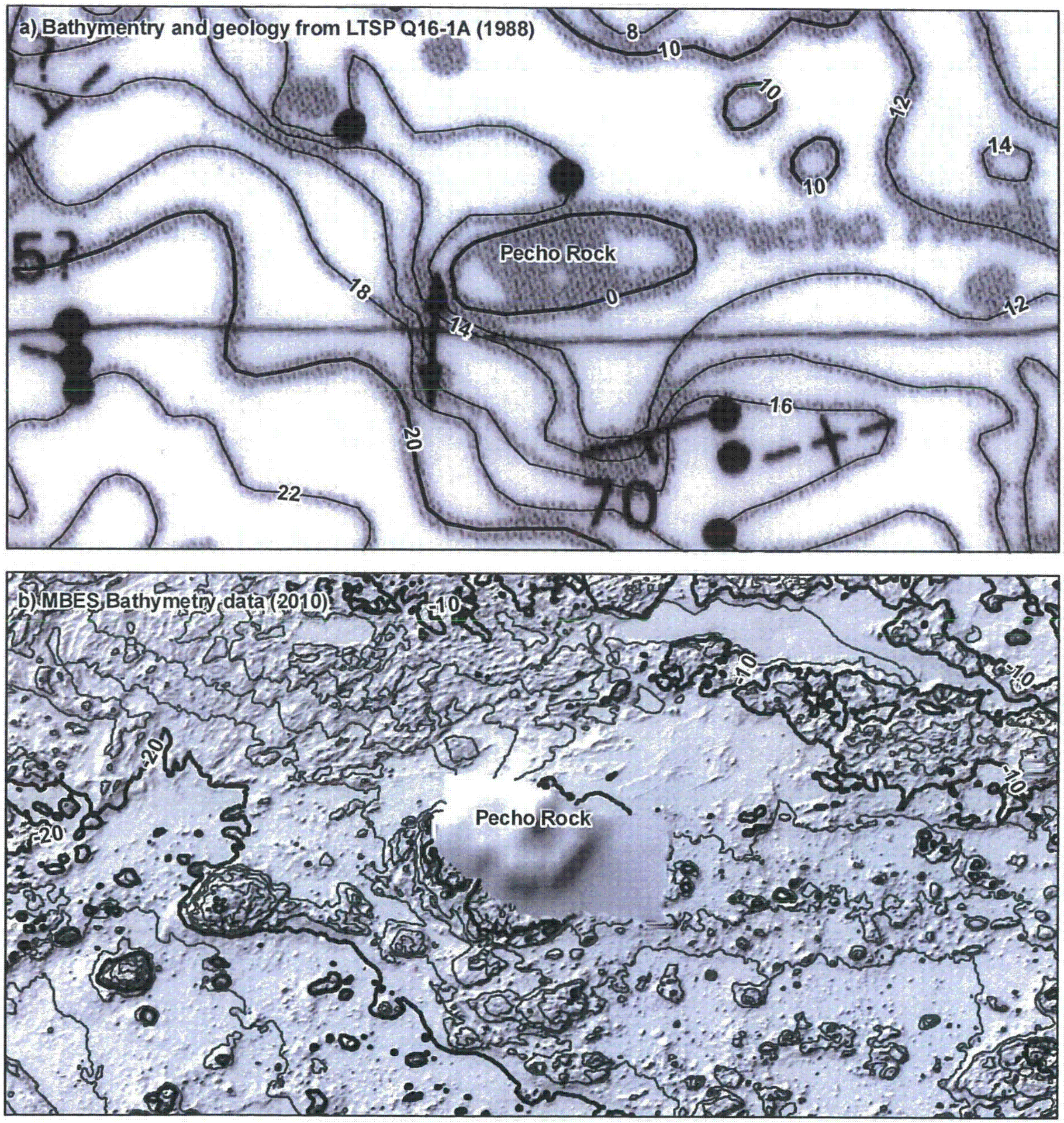
0 500 1,000 Feet
0 100 200 Meters

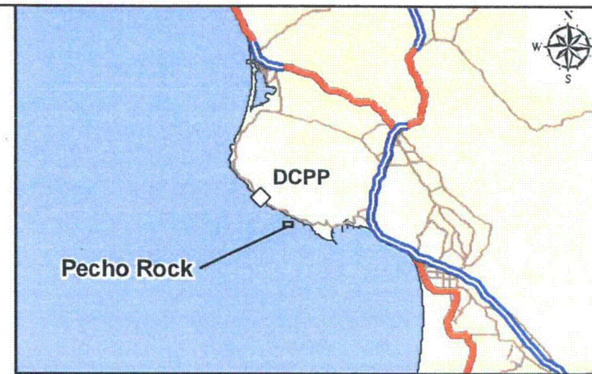
Comparison of (a) USGS topography with the (b) new LIDAR topography at San Luis Hill

SHORELINE FAULT ZONE STUDY

Pacific Gas and Electric Company | Figure **B-1-2**

File path: S:\13800\13838\13838.002\Figures\20101112_Report\Appendix_B\Figure_B-1-2.mxd; Date: [12/20/2010]; User: Serkan Bozkurt, AMEC Geomatrix, Inc.





Notes: Bathymetric contours generally agree, but are much more detailed in MBES bathymetric data. The texture of the sea floor in the MBES bathymetric image allows for detailed geomorphic/geologic interpretation.

Flanks and top of Pecho Rock not surveyed in MBES data because of navigation hazard.

The flat area at the top of Pecho Rock in the MBES bathymetric image is a wave-cut platform, possibly the MIS 5e sea-level high stand.

Depth contours in meters (NAVD-88)
Map scale: 1:7,000
Map projection: NAD 1983, UTM Zone 10 North

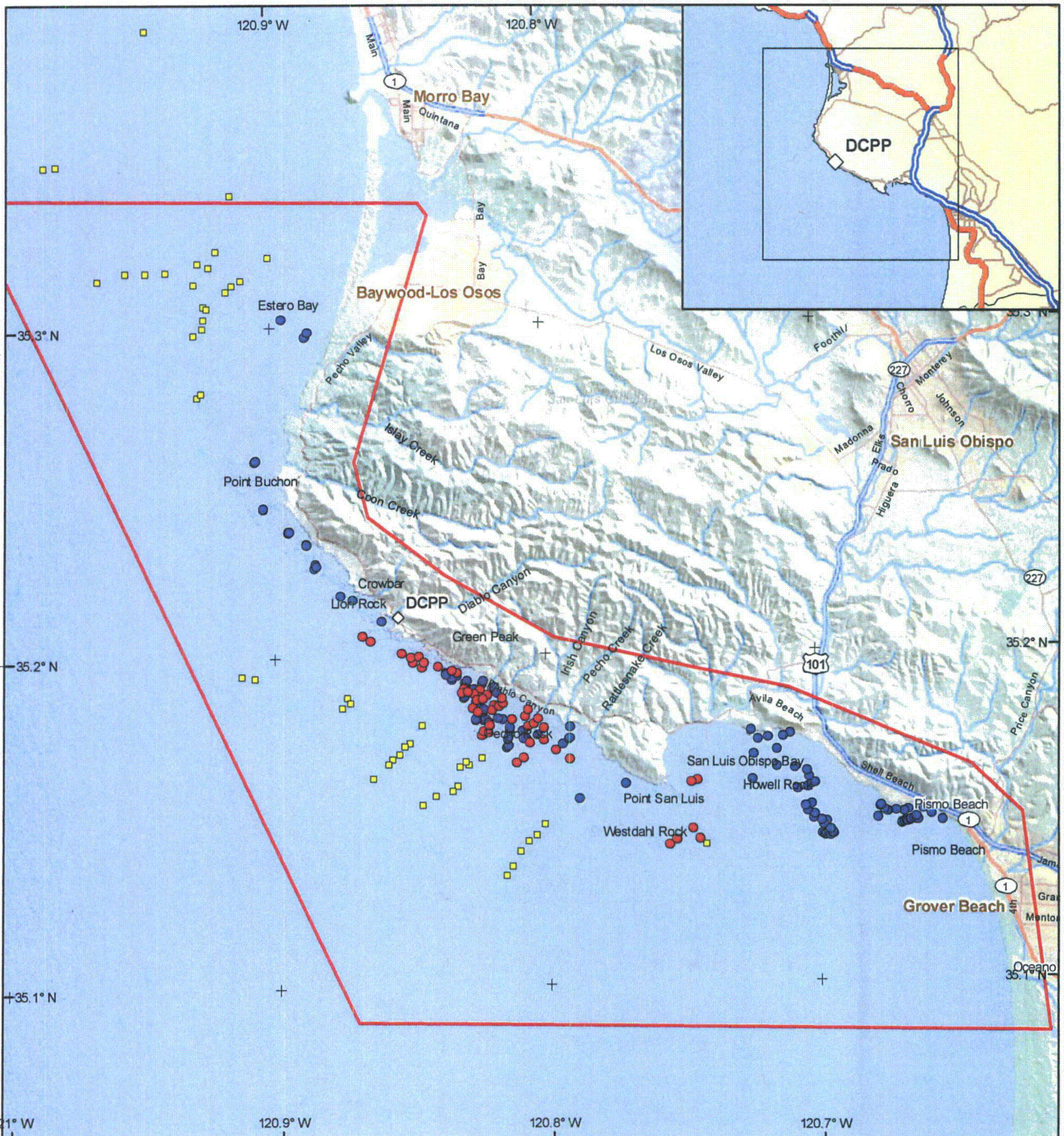
0 500 1,000 Feet
0 100 200 Meters

Comparison of (a) LTSP bathymetry with the (b) new MBES bathymetry at Pecho Rock

SHORELINE FAULT ZONE STUDY

Pacific Gas and Electric Company | Figure **B-1-3**

File path: S:\13800\13838\13838.002\Figures\20101112_Report\Appendix_B\Figure_B-1-3.mxd; Date: [12/20/2010]; User: Serkan Bozkurt, AMEC Geomatrix, Inc.



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LEGEND

Study area

Diver Samples (This Study)
See Table B-3 and Attachment 1 for descriptions

Diver Samples (LTSP, 1986)
See Table B-2 for descriptions

Drop-core Samples (LTSP, 1988)
See Table B-1 for descriptions

Base map: Project DEM (2010),
ESRI Data & Maps (2009)

0 1 2 Miles
0 2 4 Kilometers

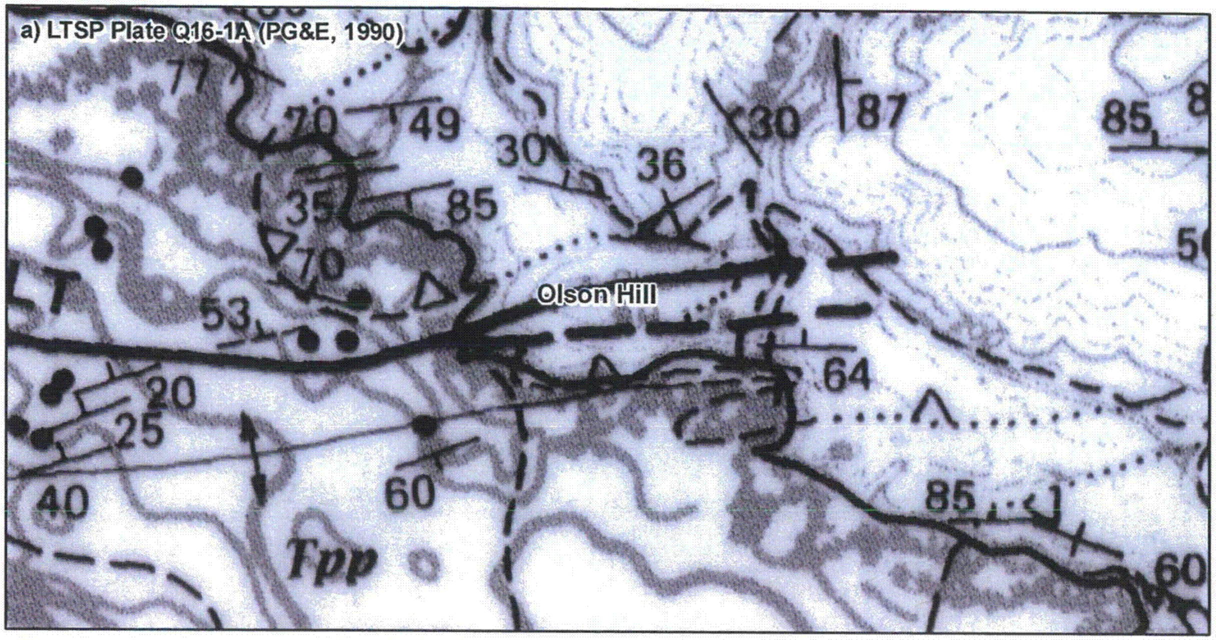
Map projection and scale: NAD 1983, UTM Zone 10N, 1:200,000

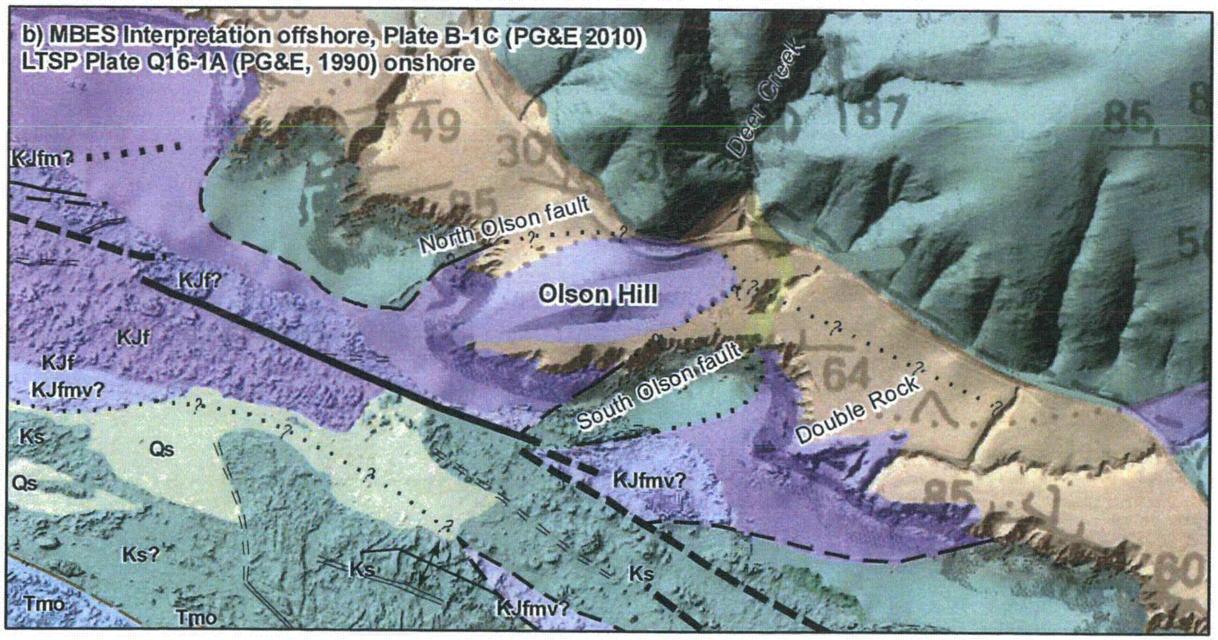
Offshore samples obtained during the LTSP and in 2010 for this study

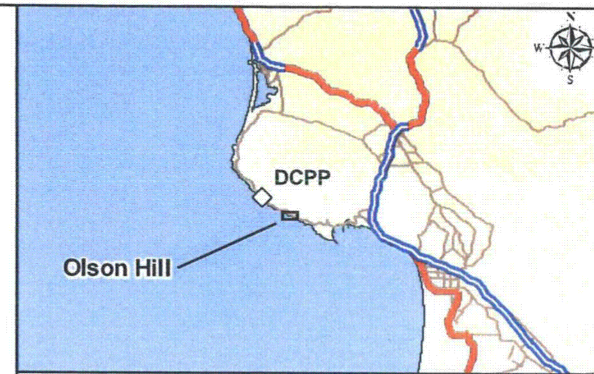
SHORELINE FAULT ZONE STUDY

Pacific Gas and Electric Company

Figure **B-2-1**







Notes: The new MBES bathymetric data offshore with the low-tide LIDAR and airphotos onshore allows better interpretation and correlation of geology onshore to offshore.

See Plate B-1A for geology legend.

Map scale: 1:12,000
Map projection: NAD 1983, UTM Zone 10 North

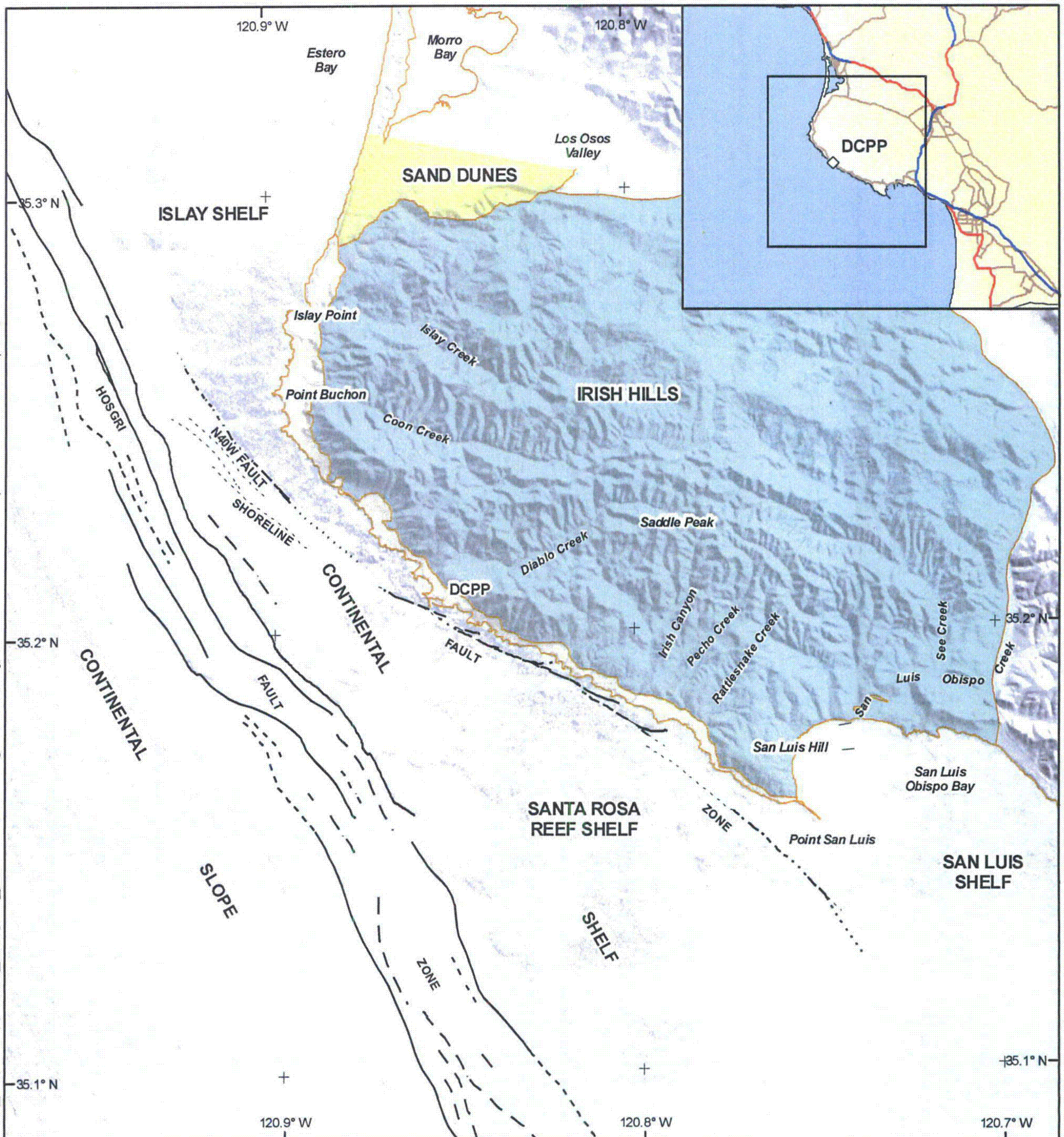
0 500 1,000 Feet
0 100 200 Meters

Comparison of (a) LTSP geology map with the (b) new geologic map near Olson Hill

SHORELINE FAULT ZONE STUDY

Pacific Gas and Electric Company | Figure **B-2-2**

File path: S:\13800\13838\13838.002\Figures\20101112_Report\Appendix_B\Figure_B-2-2.mxd; Date: [12/20/2010]; User: Serkan Bozkurt, AMEC Geomatrix, Inc.



LEGEND

- PG&E Faults database (2010)
- Marine Terraces
- Irish Hills
- Sand Dunes

Note: Boundary between the Islay and Santa Rosa Reef shelves is uncertain and not shown. The Hosgri fault generally separates the continental shelf and continental slope.

N / W / E / S

0 2 4 Miles

0 2 4 Kilometers

Map projection and scale: NAD 1983, UTM Zone 10N, 1:150,000

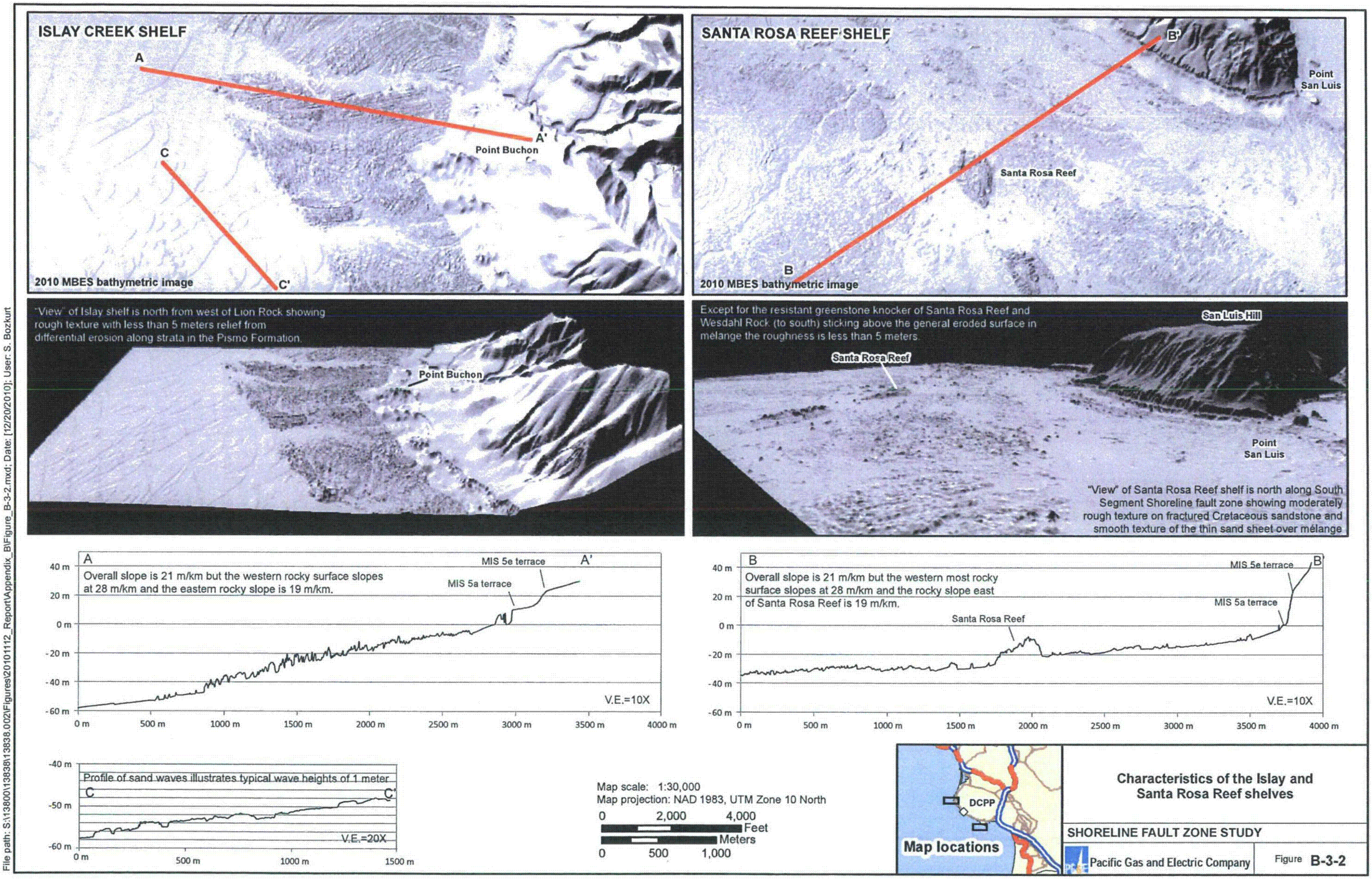
Geomorphic regions in the Shoreline fault zone study area

SHORELINE FAULT ZONE STUDY

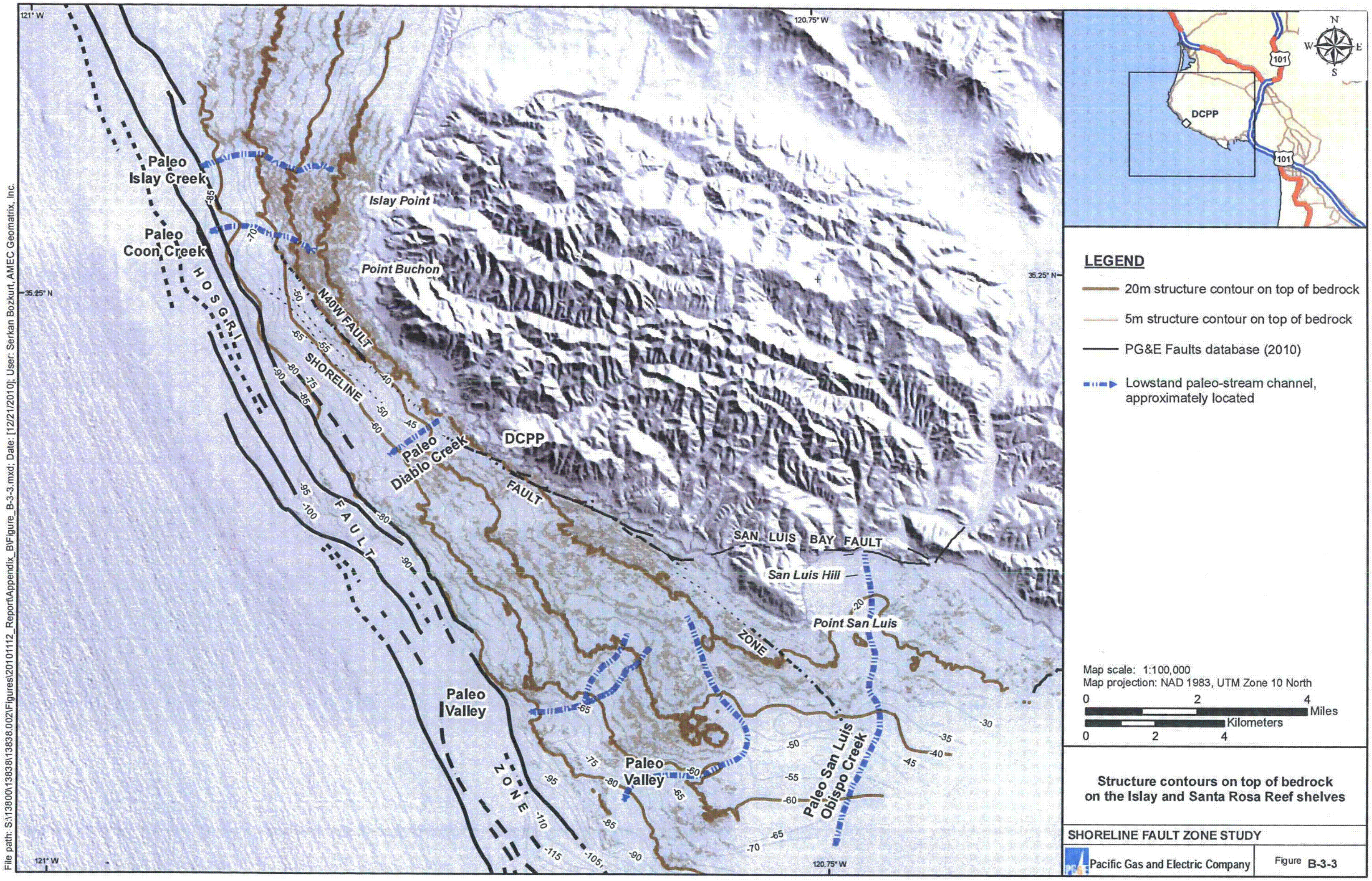
Pacific Gas and Electric Company

Figure **B-3-1**

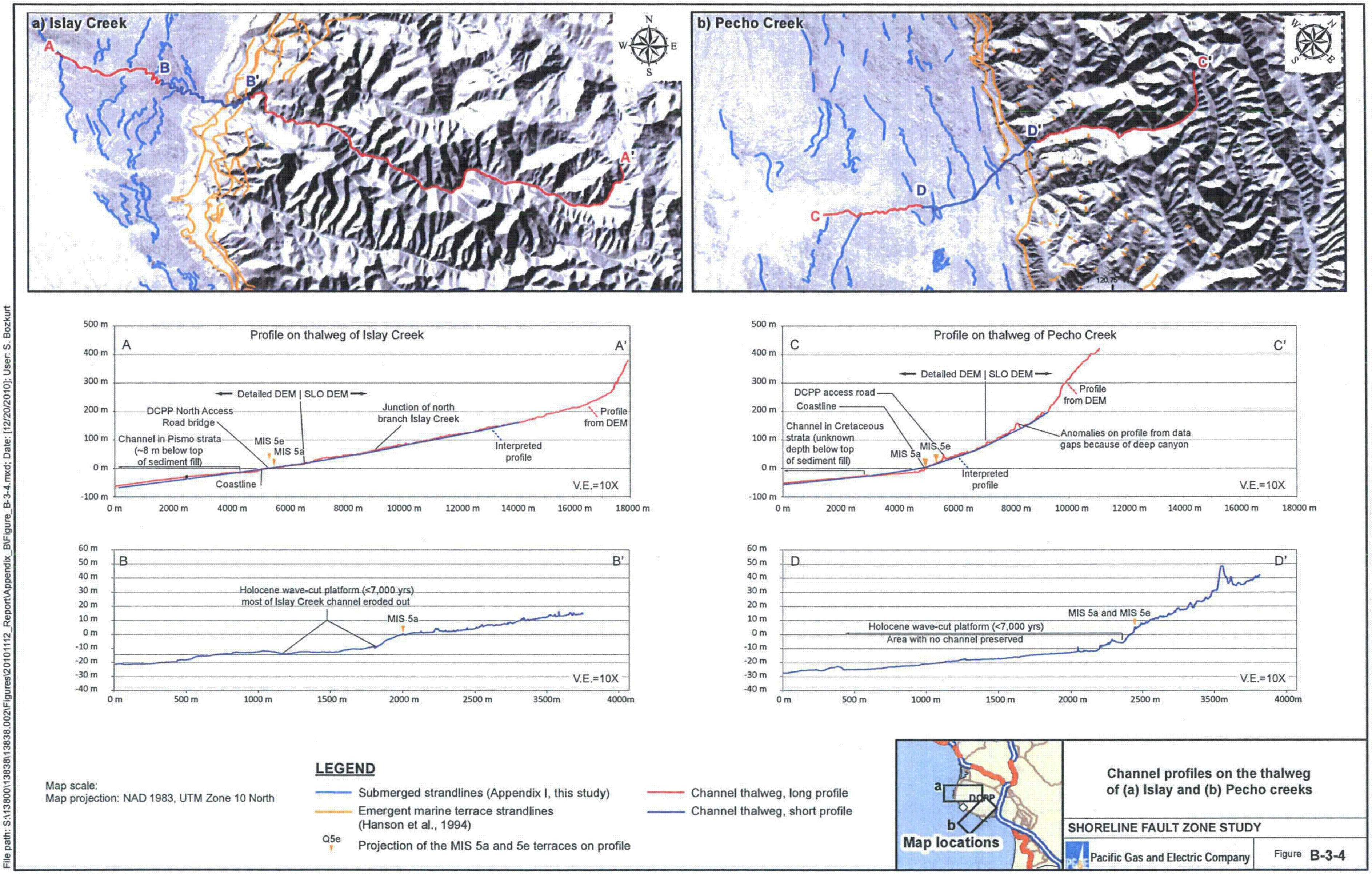
File path: S:\13800\13838\13838.002\Figures\20101112_Report\Appendix_B\Figure_B-3-1.mxd; Date: [12/20/2010]; User: Serkan Bozkurt, AMEC Geomatrix, Inc.



ISLAY CREEK SHELF
A
A'
Point Buchon
C
C'
2010 MBES bathymetric image
SANTA ROSA REEF SHELF
B'
Point San Luis
Santa Rosa Reef
B
2010 MBES bathymetric image
"View" of Islay shelf is north from west of Lion Rock showing rough texture with less than 5 meters relief from differential erosion along strata in the Pismo Formation.
Point Buchon
Except for the resistant greenstone knocker of Santa Rosa Reef and Wesdahl Rock (to south) sticking above the general eroded surface in mélange the roughness is less than 5 meters.
San Luis Hill
Santa Rosa Reef
Point San Luis
"View" of Santa Rosa Reef shelf is north along South Segment Shoreline fault zone showing moderately rough texture on fractured Cretaceous sandstone and smooth texture of the thin sand sheet over mélange
A
A'
MIS 5e terrace
MIS 5a terrace
Overall slope is 21 m/km but the western rocky surface slopes at 28 m/km and the eastern rocky slope is 19 m/km.
40 m
20 m
0 m
-20 m
-40 m
-60 m
V.E.=10X
0 m
500 m
1000 m
1500 m
2000 m
2500 m
3000 m
3500 m
4000 m
B
B'
Overall slope is 21 m/km but the western most rocky surface slopes at 28 m/km and the rocky slope east of Santa Rosa Reef is 19 m/km.
MIS 5e terrace
MIS 5a terrace
Santa Rosa Reef
40 m
20 m
0 m
-20 m
-40 m
-60 m
V.E.=10X
0 m
500 m
1000 m
1500 m
2000 m
2500 m
3000 m
3500 m
4000 m
-40 m
Profile of sand waves illustrates typical wave heights of 1 meter
C
C'
-50 m
-60 m
V.E.=20X
0 m
500 m
1000 m
1500 m
Map scale: 1:30,000
Map projection: NAD 1983, UTM Zone 10 North
0 2,000 4,000 Feet
0 500 1,000 Meters
DCPP
Map locations
Characteristics of the Islay and Santa Rosa Reef shelves
SHORELINE FAULT ZONE STUDY
Pacific Gas and Electric Company
Figure B-3-2
File path: S:\13800\13838\13838.002\Figures\20101112_Report\Appendix_B\Figure_B-3-2.mxd; Date: [12/20/2010]; User: S. Bozkurt



Paleo Islay Creek
Paleo Coon Creek
Islay Point
Point Buchon
HOSGRI FAULT ZONE
N40W FAULT
SHORELINE FAULT ZONE
Paleo Diablo Creek
DCPP
SAN LUIS BAY FAULT
San Luis Hill
Point San Luis
Paleo Valley
Paleo Valley
Paleo San Luis Obispo Creek
121° W
120.75° W
35.25° N
LEGEND
20m structure contour on top of bedrock
5m structure contour on top of bedrock
PG&E Faults database (2010)
Lowstand paleo-stream channel, approximately located
Map scale: 1:100,000
Map projection: NAD 1983, UTM Zone 10 North
Miles
Kilometers
Structure contours on top of bedrock on the Islay and Santa Rosa Reef shelves
SHORELINE FAULT ZONE STUDY
Pacific Gas and Electric Company
Figure B-3-3
File path: S:\13800\13838\13838.002\Figures\20101112_Report\Appendix_B\Figure_B-3-3.mxd; Date: [12/21/2010]; User: Serkan Bozkurt, AMEC Geomatrix, Inc.



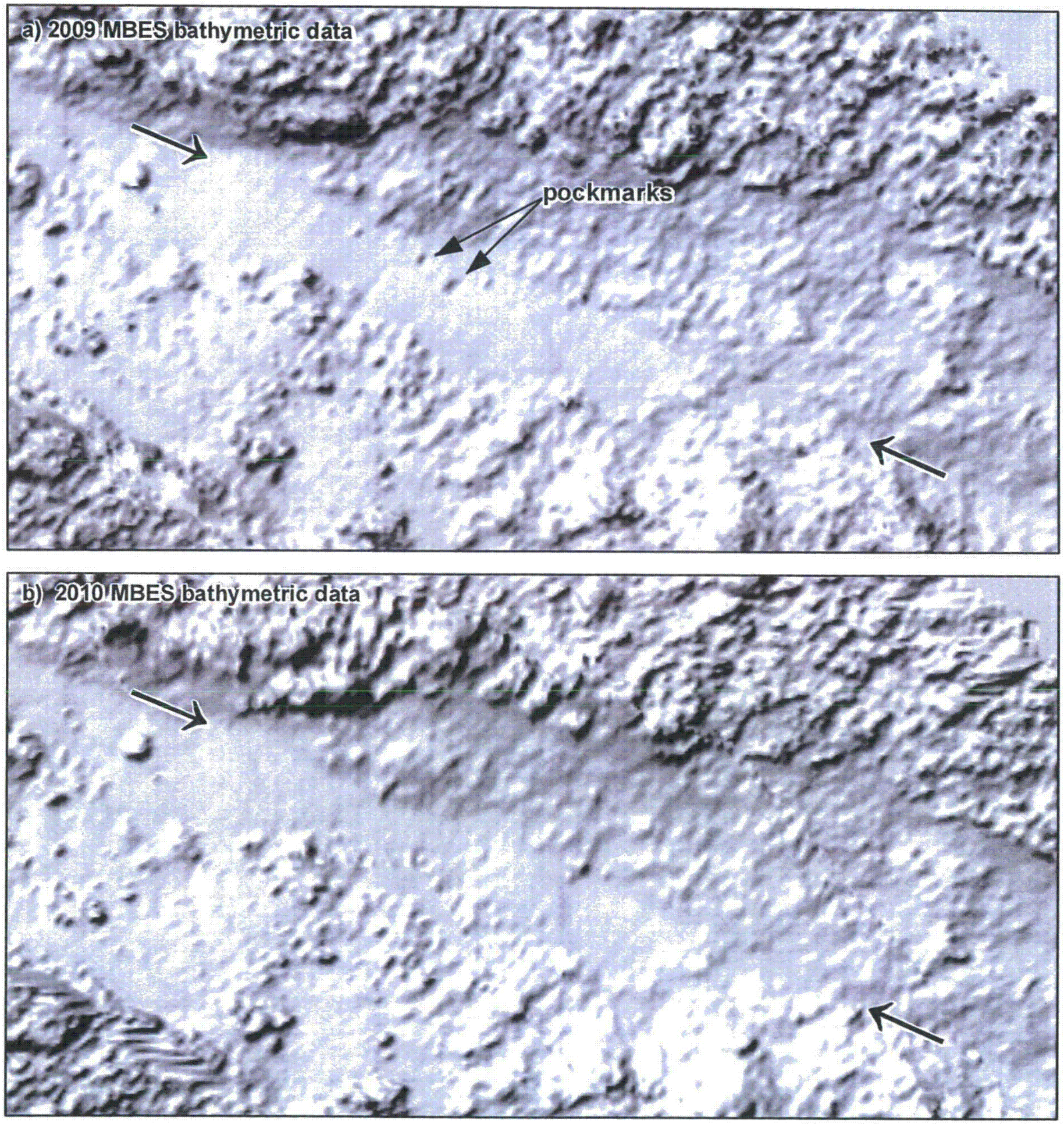
Channel profiles on the thalweg of (a) Islay and (b) Pecho creeks

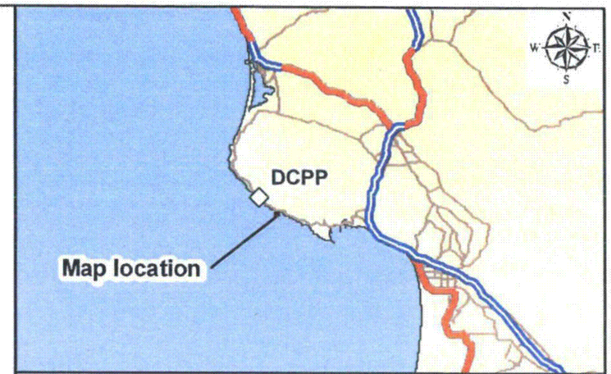
SHORELINE FAULT ZONE STUDY

Pacific Gas and Electric Company

Figure B-3-4

File path: S:\13800\13838\13838.002\Figures\20101112_Report\Appendix_B\Figure_B-3-4.mxd; Date: [12/20/2010]; User: S. Bozkurt





LEGEND

Lineament of Central segment (sub-segment C-2) of the Shoreline fault zone

Notes:
a) The 2009 MBES bathymetric image shows two small pockmarks in the sand sheet that may have been formed by gas or fluid release along the Central segment of the Shoreline fault zone.
b) 2010 MBES bathymetric image of the same area shows the loss of the pockmarks and thinning of the sand sheet, with more bedrock exposed along the fault at the sea floor.

Map scale1:2,000
Map projection: NAD 1983, UTM Zone 10 North

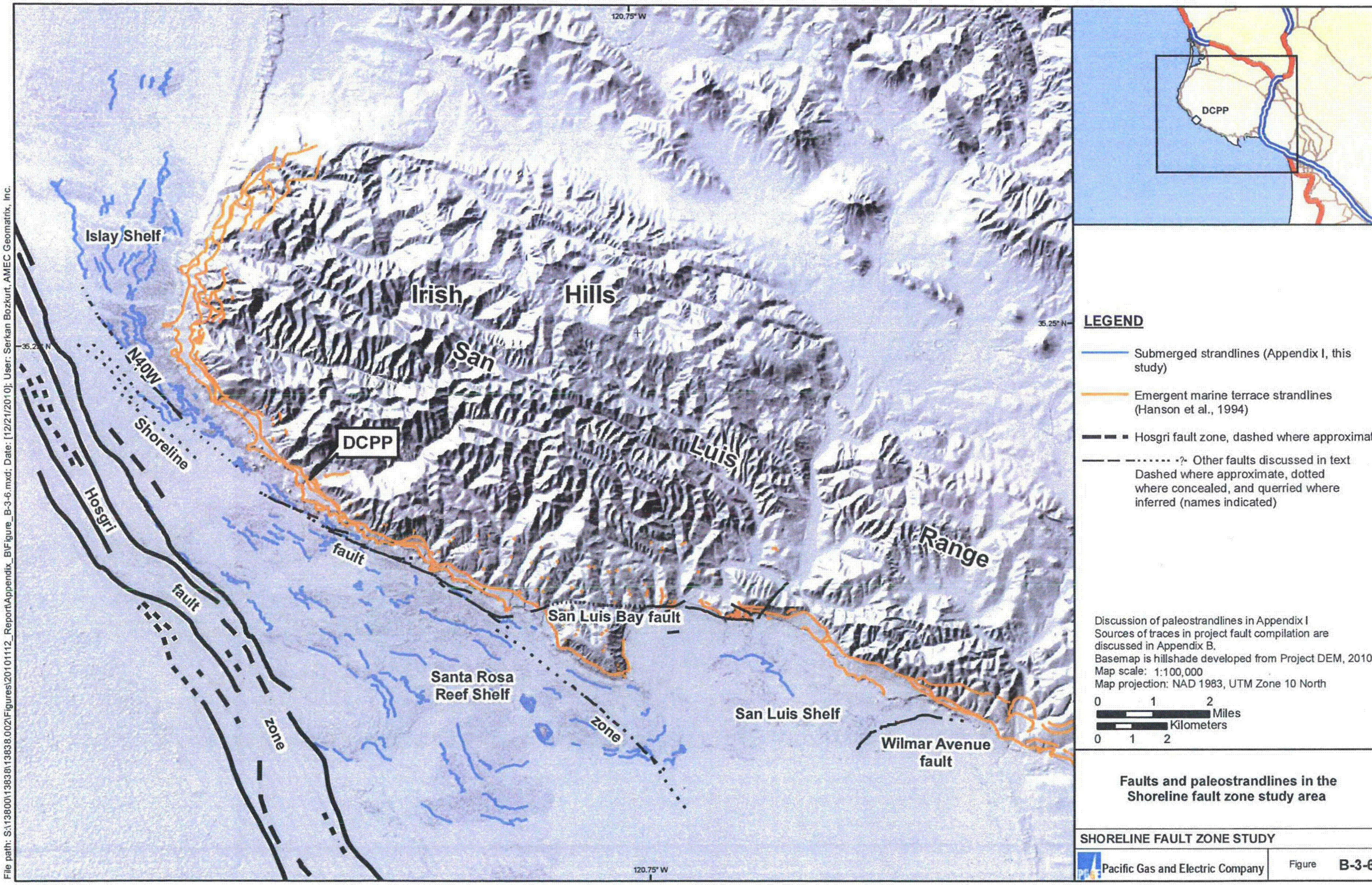
0 200 400 Feet
0 50 100 Meters

Migration of sand sheet along the Central segment (C-2) of the Shoreline fault zone between the (a) 2009 and (b) 2010 MBES surveys northwest of Olson Hill

SHORELINE FAULT ZONE STUDY

Pacific Gas and Electric Company | Figure **B-3-5**

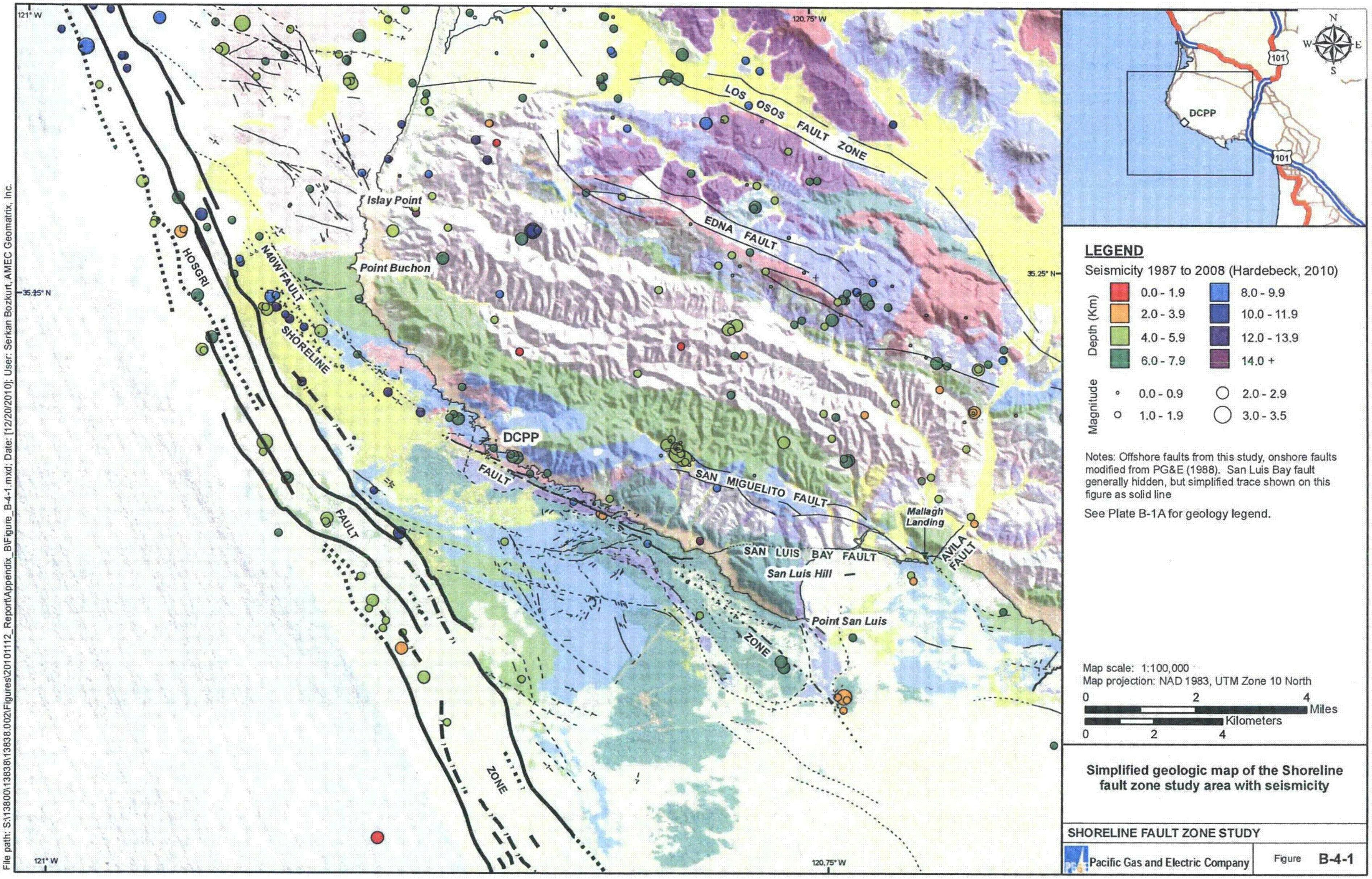
File path: S:\13800\13838\13838.002\Figures\20101112_Report\Appendix_B\Figure_B-3-5.mxd; Date: [12/22/2010]; User: Serkan Bozkurt, AMEC Geomatrix, Inc.



Faults and paleostrandlines in the Shoreline fault zone study area

SHORELINE FAULT ZONE STUDY

Pacific Gas and Electric Company Figure B-3-6

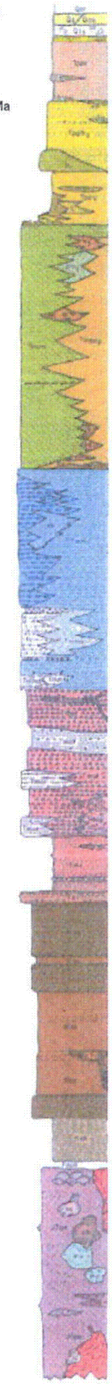


Simplified geologic map of the Shoreline fault zone study area with seismicity

File path: S:\13800\13838\13838.002\Figures\20101112_Report\Appendix_B\Figure_B-4-1.mxd; Date: [12/20/2010]; User: Serkan Bozkurt, AMEC Geomatrix, Inc.

File path: S:\13800\13838\13838.002\Figures\20101112_Report\Appendix_B\Figure_B-04-02.ai; Date: [12/20/2010]; User: S. Bozkurt

Unit	Age		Unit Thickness	Description
Surficial Deposits	Quat. Pleist.	~0.5 Ma to present	10 to 80 ft	**Surficial deposits:** stream alluvium, marine terraces, fluvial terraces, landslides, beach sand, and sand waves, unlithified.
unconformity				
Pismo Formation (upper): Squire Member	Tertiary, Pliocene		550 ft	**Squire Member of the Pismo Formation (Tpps):** unstratified white fine- to medium-grained silty sandstone, poorly lithified, fossiliferous horizons, rare pholad-bored cobbles where Squire Member unconformably overlies basement rock. Basal contact with Belleview Member is generally conformable.
unconformity		3.3 to 3.0 Ma		
Pismo Formation (upper): Belleview Member			650 ft	**Belleview Member of the Pismo Formation (Tppb):** interbedded buff to light gray claystone and fine-grained sandstone, weakly to moderately well lithified, fossiliferous horizons, diatomaceous horizons, claystone fractures spheroidally. Basal contact with Gragg Member is generally conformable.
Pismo Formation (upper): Gragg Member			550 ft	**Gragg Member of the Pismo Formation (Tppg):** unstratified white to buff fine- to medium-grained sandstone, poorly to moderately well lithified, rare diatomaceous siltstone, pebble conglomerate, and bituminous sandstone. Basal contact with lower members of the Pismo Formation is unconformable.
unconformity		~4.2 Ma		
Pismo Formation (lower): Miguelito Member / Edna Member	Tertiary, Miocene		1450 ft	**Edna Member of the Pismo Formation (Tmpe):** thickly bedded to unstratified gray to brown fine- to coarse-grained sandstone, moderately well lithified, common bituminous horizons, basal chert pebble conglomerate and tuffaceous sandstone hroizons. Grades laterally into the Miguelito Member to the west and south.
		10.4 to 9.0 Ma	2250 ft	**Miguelito Member of the Pismo Formation (Tmpm):** thinly bedded brown siltstone and claystone, moderately well lithified, rare to common intervals of siliceous and dolomitic siltstone, opaline and porcelaneous shale, and bituminous sandy siltstone. Basal contact with Monterey Formation at Point Buchon is relatively gradual but is described by Hall (1973a; 1973b) as unconformable elsewhere in San Luis Obispo County.
unconformity				
Monterey Formation	Miocene	11.4 to 10.5 Ma	> 2000 ft	**Monterey Formation (Tmm):** thinly bedded white, gray, and brown chert, weathers to chalky white, well lithified with a conchoidal fracture habit, fractured and sheared. Includes intervals of diatomite with opaline chert, tuff, and tuffaceous sandstone and siltstone, rare to common intervals of siliceous and dolomitic siltstone, opaline and porcelaneous shale, and bituminous sandy siltstone. Basal contact along the coastline is very gradual, grading from interbedded fine-grained diatomaceous and tuffaceous sandstone of the Obispo Formation into interbedded chert and sandstone/siltstone.
progressive unconformity				
Obispo Formation	Miocene	15.5 to 15.3 Ma	1350 ft (1000 to 2000 ft on map)	**Obispo Formation (Tmo):** Resistant subunit (Tmor) is crudely bedded to unstratified, orange-brown to gray fine-grained zeolitized tuff, very well lithified, chaotic, unstratified intervals with basal scour and rare intervals of black silty sandstone. Fine-grained subunit (Tmof) is well bedded light brown to gray sandstone and silty sandstone, coarsening gradually up-section, including abundant invervals of dolomitic sandstone and common intervals of diatomaceous and tuffaceous sandstones. Diabase subunit (Tmod) is brown aphanitic to phaneritic intrusive dikes and sills. Tuffaceous subunit (Tmot) is grouped with Tmor subunit along the coastline at DCPP but is mapped by Hall (1973a; 1973b) elsewhere in San Luis Obispo County. Basal contact with Rincon Formation is not exposed along coastline but is mapped as conformable in the Irish Hills by Hall (1973a). Contact with basement rock along coastline may be depositional, intrusive, or faulted.
unconformity				
Rincon Formation	Miocene		500 ft	**Rincon Formation (Tmr):** thinly bedded dark brown siltstone and silty claystone with interbeds of dolomitic sandstone. Not exposed along coastline but mapped as conformable by Hall (1973b).
unconformity				
Vaqueros Formation	Oligocene		100 ft	**Vaqueros Formation (Tov):** tan to gray conglomerate and sandstone. Not exposed along coastline but mapped in the Irish Hills by Hall (1973b).
unconformity/intrusive/faulted				
Sandstone	Cretaceous		> 2500 ft	**Cretaceous Sandstone (Ks):** well bedded brown fine- to coarse-grained sandstone, moderately to very well lithified, generally quatrz grains with minor feldspar and lithic grains. Also includes yellowish brown to black fissile shale, and dark brown fine- to medium-grained, unstratified vesicular basalt and diabase. Abuts Franciscan Complex rock along faulted contacts.
faulted				
Franciscan Complex (also serpentine)	Jurassic-Cretaceous		> 2000 ft(?)	**Franciscan Complex (KJf):** choatic, unstratified assemblage of varying lithologies, including fine-grained metavolcanic rocks (with strong magnetic resistivity values), sheared claystone (melange matrix), glaucophane schist, and chert. Serpentine is included in Francsican Complex. Regionally, graywacke sandstone is a prominent component of the Franciscan Complex but is not common within the mapped area described in this report.

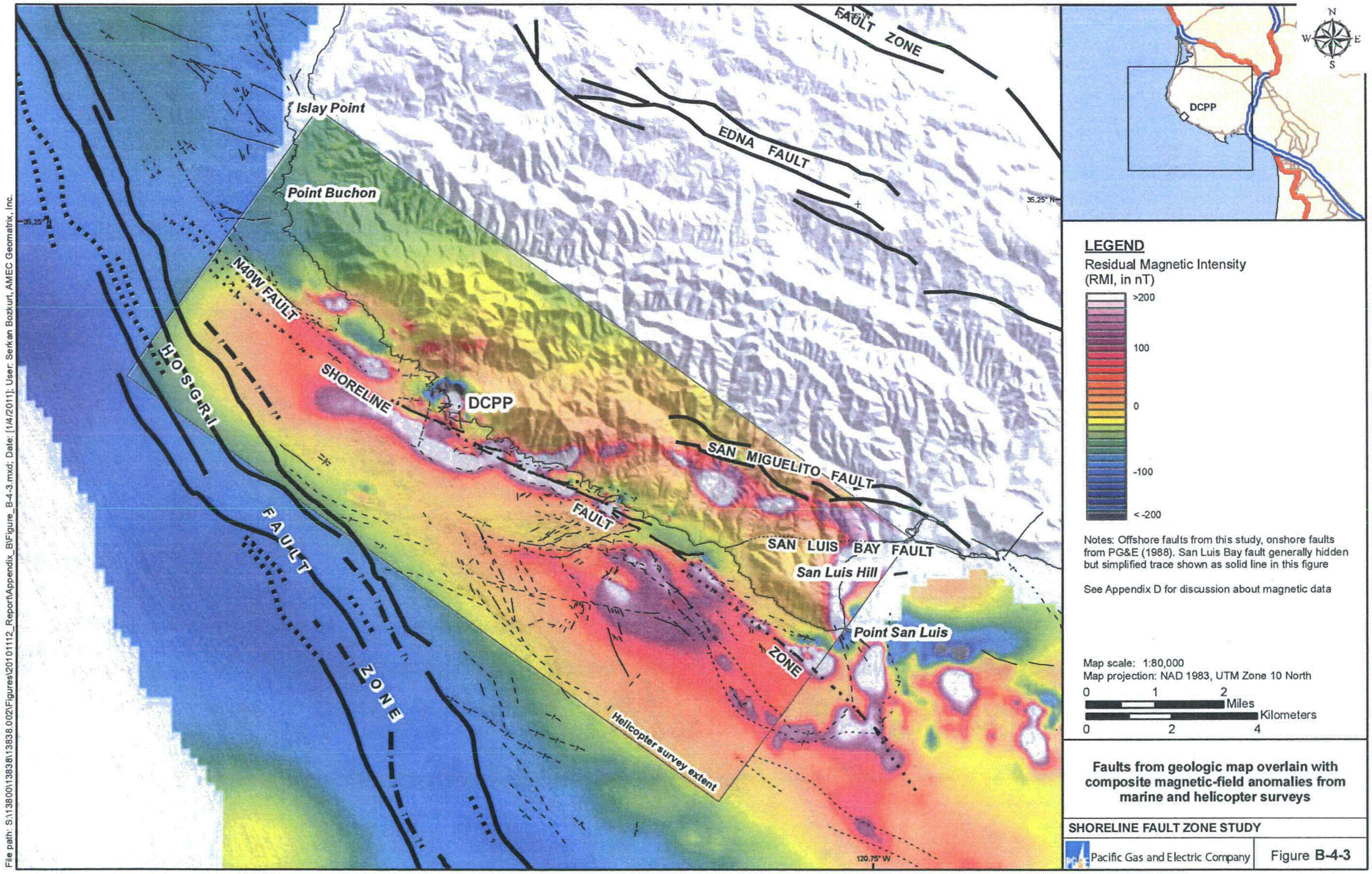


Note: Figure modified from Hall (1973b)

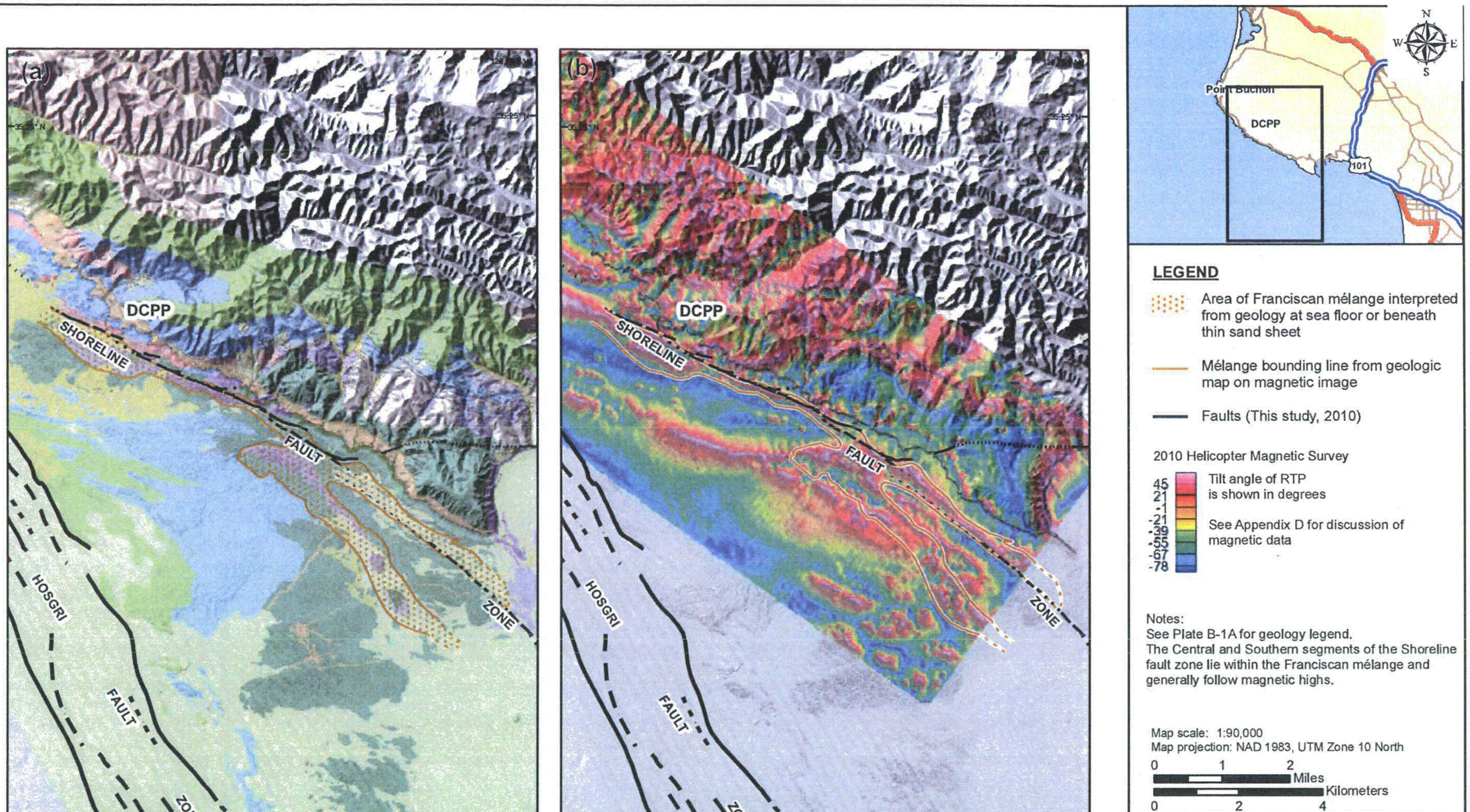
Stratigraphy of the coastline exposures and offshore area adjacent to the Irish Hills

SHORELINE FAULT ZONE STUDY

Pacific Gas and Electric Company | Figure **B-4-2**



Faults from geologic map overlain with composite magnetic-field anomalies from marine and helicopter surveys

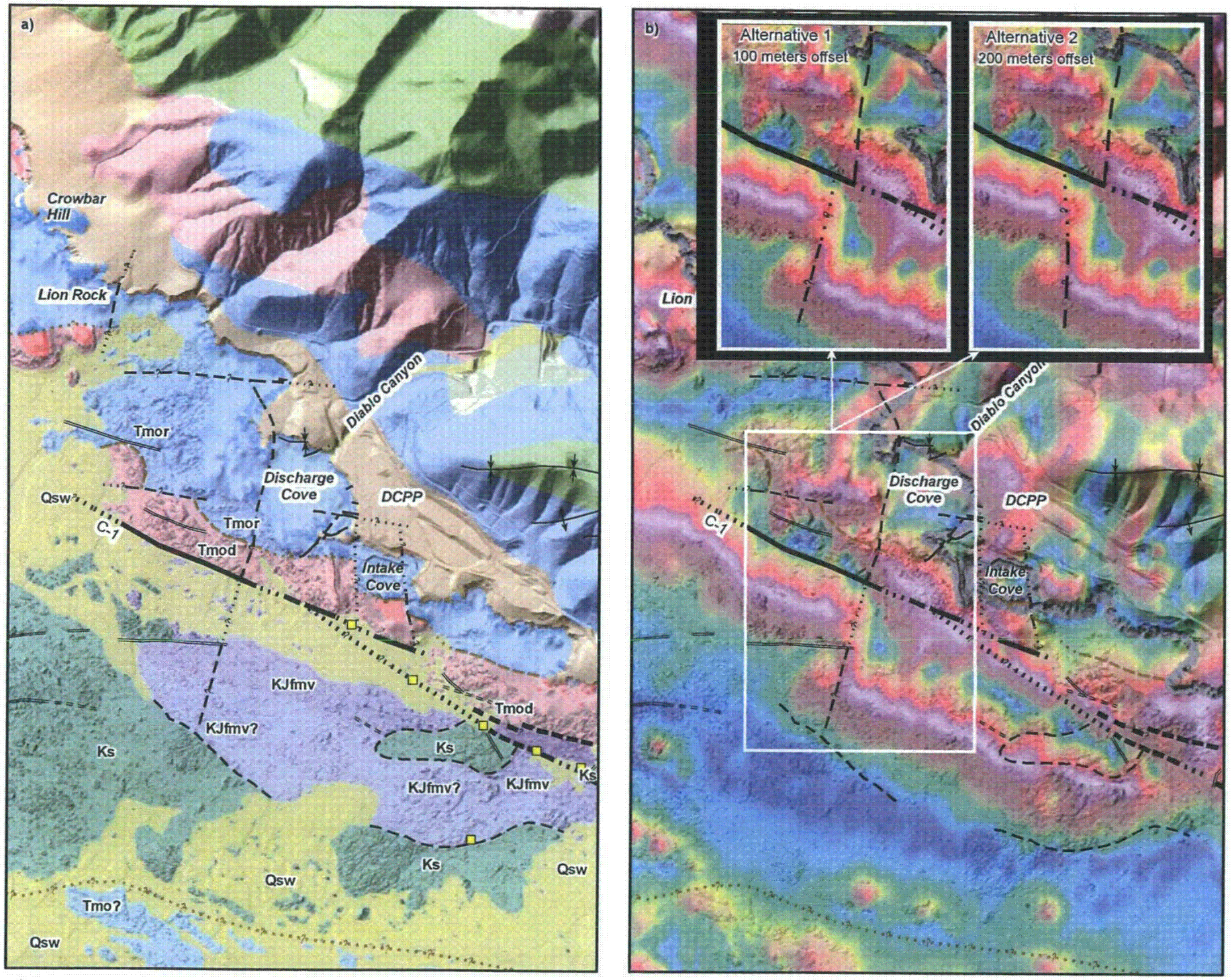


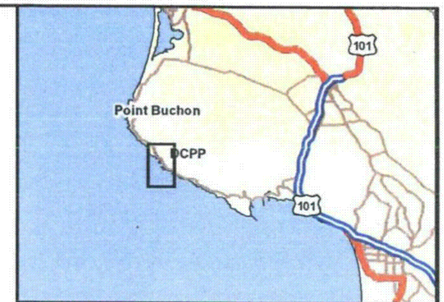
Generalized area of (a) Franciscan mélange offshore compared to (b) magnetic-field anomalies

SHORELINE FAULT ZONE STUDY

Pacific Gas and Electric Company | Figure B-4-4

File path: S:\13800\13838\13838.002\Figures\20101112_Report\Appendix_B\Figure_B-4-4.mxd; Date: [12/20/2010]; User: Serkan Bozkurt, AMEC Geomatrix, Inc.





LEGEND

45, 21, -1, -21, -39, -55, -67, -78

2010 Helicopter Magnetic Survey Enhancement

Tilt angle of RTP is shown in degrees

See Appendix D for discussion of magnetic data

Notes:
The onshore right-lateral north-south fault north of Discharge Cove aligns with a north-south offset of two northwest-trending magnetic highs. The magnetic anomalies are interpreted to be offset by the same north-south fault. The Shoreline fault does not appear to displace the north-south fault laterally within the limits of resolution (estimated to be about 100 meters per "Alternative 1" but clearly less than 200 meters per "Alternative 2").

See Plate B-1A for geology legend.

Map scale: 1:20,000
Map projection: NAD 1983, UTM Zone 10 North

0 1,000 2,000 Feet

0 500 1,000 Meters

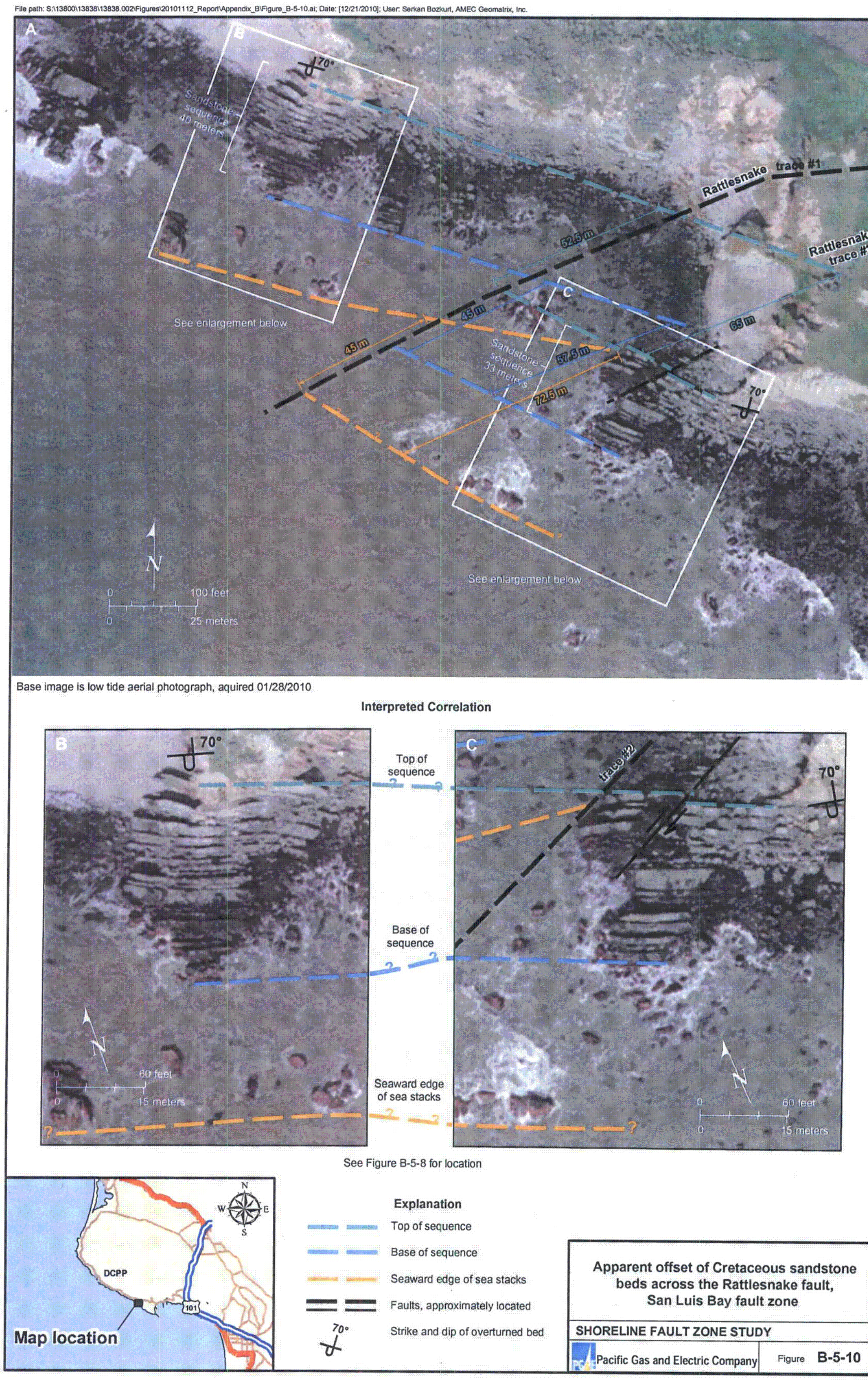
Comparison of (a) the geology with (b) the magnetic-field anomalies in the DCPP area

SHORELINE FAULT ZONE STUDY

Pacific Gas and Electric Company

Figure **B-5-1**

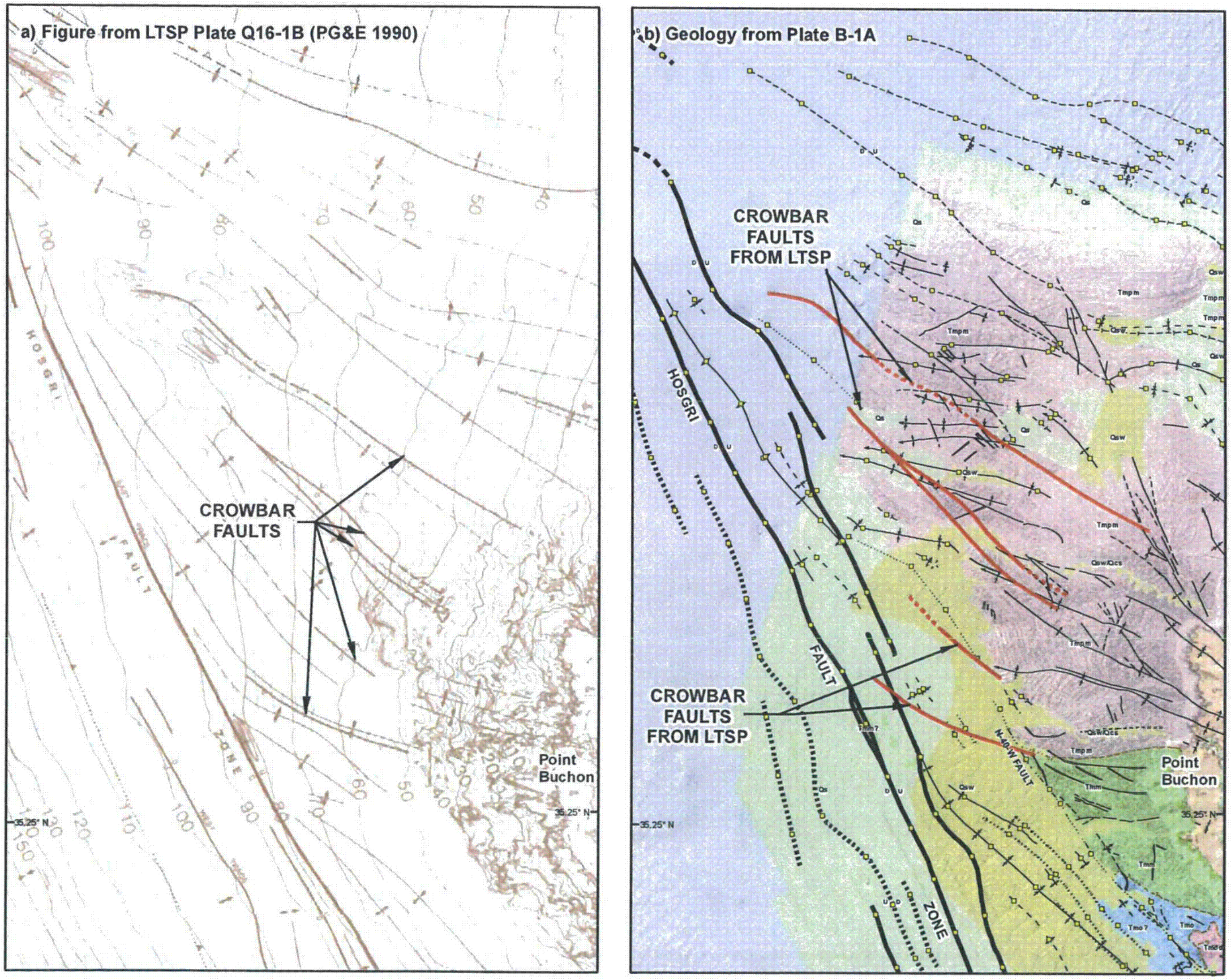
File path: S:\13800\13838\13838.002\Figures\20101112_Report\Appendix_B\Figure_B-5-1.mxd; Date: [12/20/2010]; User: S. Bozkurt

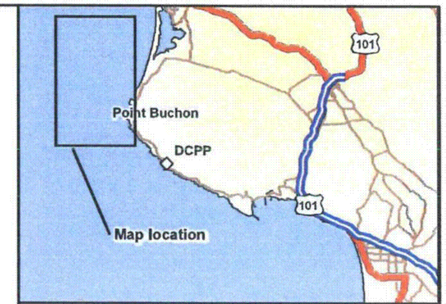


Apparent offset of Cretaceous sandstone beds across the Rattlesnake fault, San Luis Bay fault zone

SHORELINE FAULT ZONE STUDY

Pacific Gas and Electric Company Figure B-5-10





Notes: The Crowbar faults follow the general axes of folds interpreted from seismic-reflection profiles from the LTSP (PG&E, 1990). Geologic interpretation using the MBES bathymetric image also shows that faults along fold axes but the folds trend more westerly than those interpreted for the LTSP.

See Plate B-1A for geology legend.

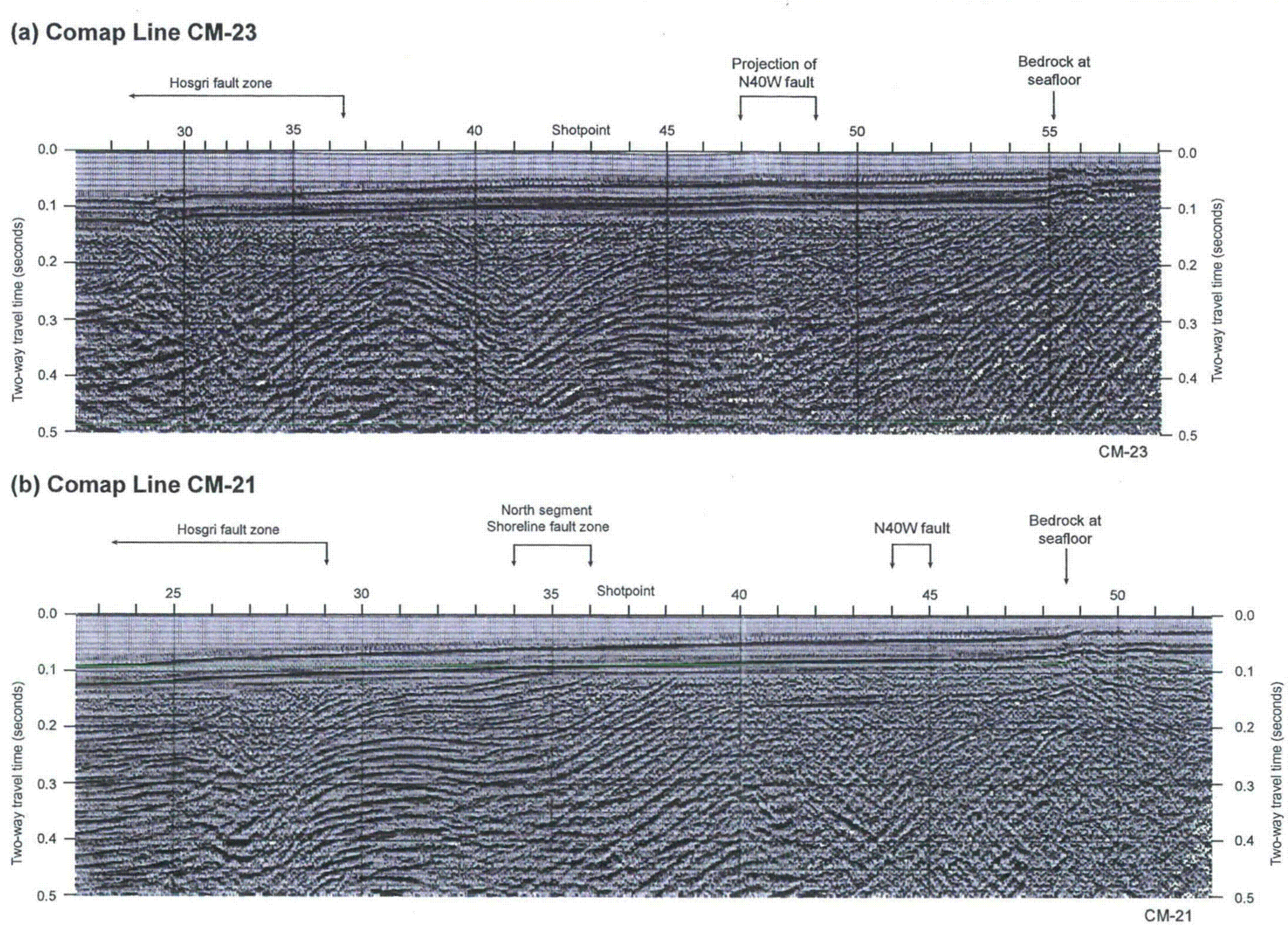
Map scale: 1:60,000
Map projection: NAD 1983, UTM Zone 10 North

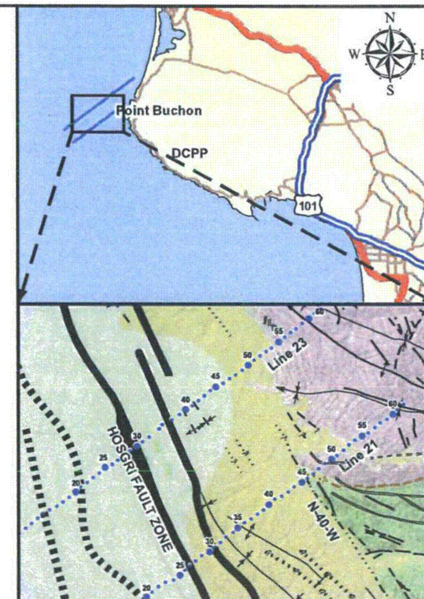
0 1 2 Miles
0 1 2 Kilometers

Comparison of (a) Crowbar faults interpreted from the LTSP with (b) faults from this study

SHORELINE FAULT ZONE STUDY

Pacific Gas and Electric Company | Figure **B-5-2**





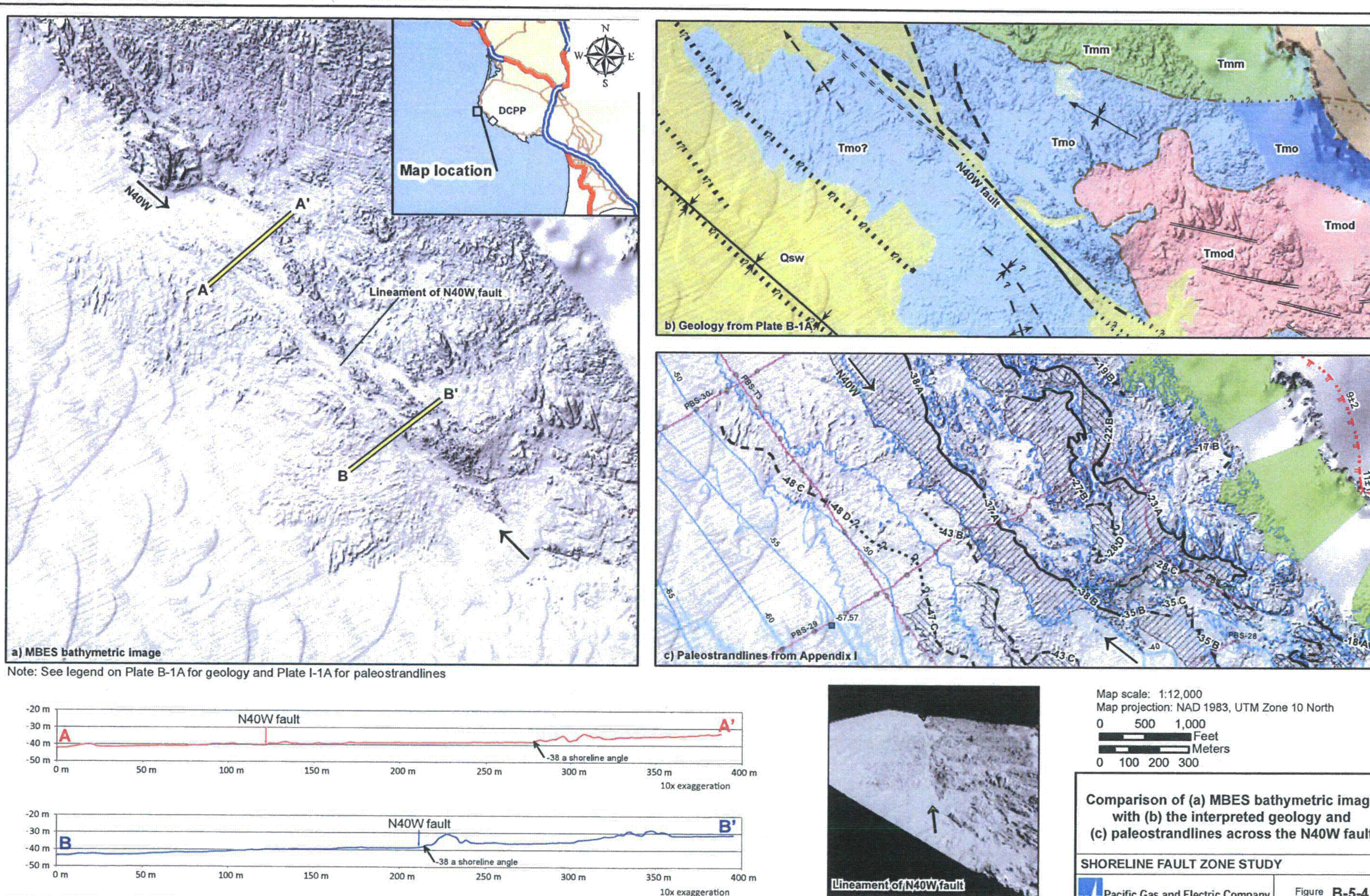
Note: Comap profiles (upper 0.5 seconds) (PG&E, 1988). CM-23 images the eatern part of the Hosgri fault zone but not the N40W fault. CM-21 images the eastern part of the Hosgri fault zone and the N40W fault. No fault is detected in the seismic-reflection profile across the northern Shoreline seismicity lineament.

Comap seismic-reflection profiles (a) CM-23 and (b) CM-21 across the Hosgri fault zone, North segment of the Shoreline fault zone and the N40W fault.

SHORELINE FAULT ZONE STUDY

Pacific Gas and Electric Company | Figure **B-5-3**

File path: S:\13800\13838\13838.002\Figures\20101112_Report\Appendix_B\Figure_B-5-3.ai; Date: [12/21/2010]; User: S. Bozkurt



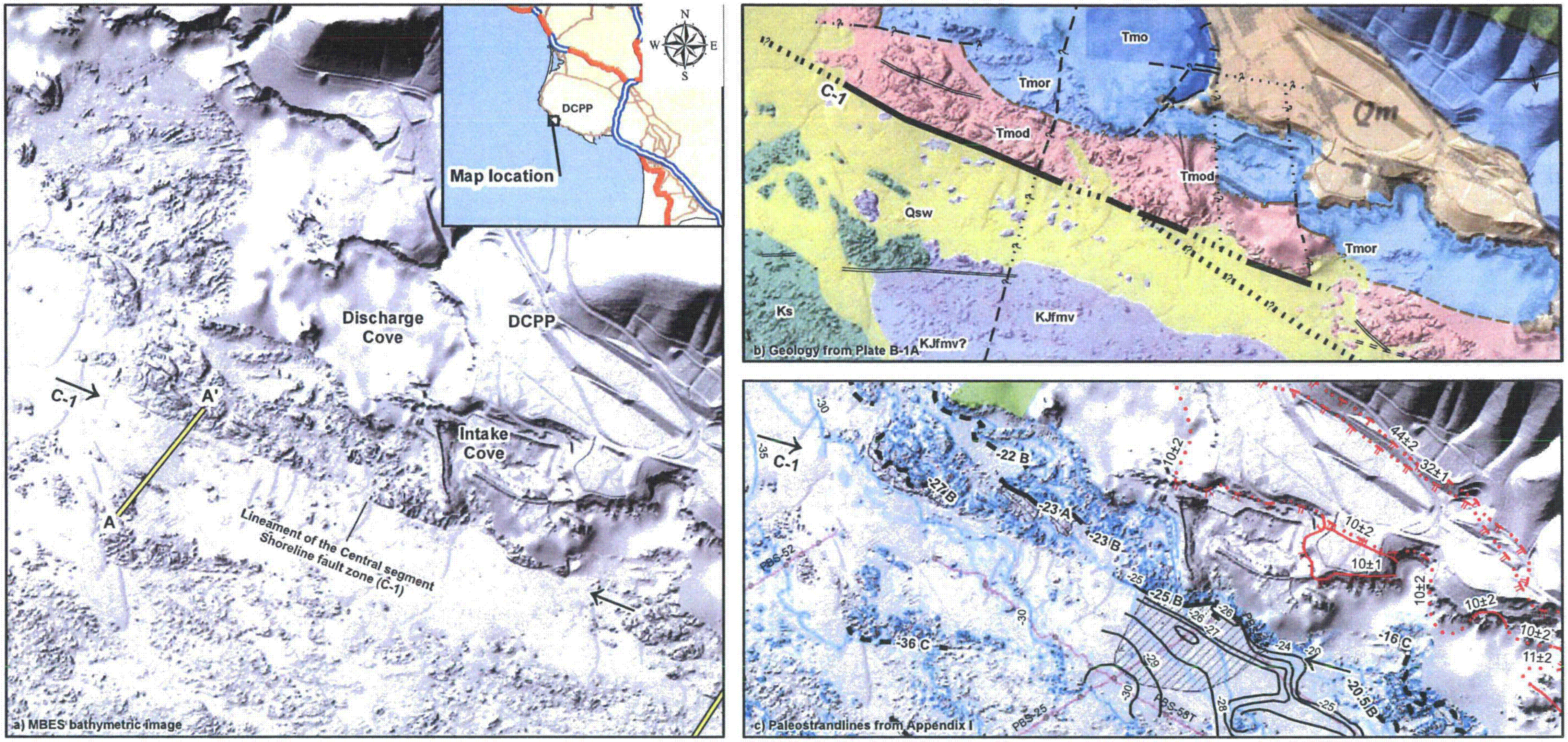
Note: See legend on Plate B-1A for geology and Plate I-1A for paleostrandlines

Comparison of (a) MBES bathymetric image with (b) the interpreted geology and (c) paleostrandlines across the N40W fault

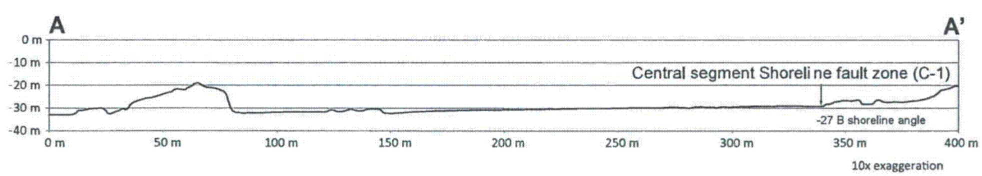
SHORELINE FAULT ZONE STUDY

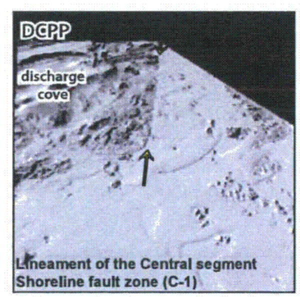
Pacific Gas and Electric Company | Figure B-5-4

File path: S:\13800\13838\13838.002\Figures\20101112_Report\Appendix_B\Figure_B-5-4.mxd; Date: [12/20/2010]; User: S. Bozkurt



Note: See legend on Plate B-1A for geology and Plate I-1A for paleostrandlines





Map scale: 1:12,000
Map projection: NAD 1983, UTM Zone 10 North

0 500 1,000 Feet
0 100 200 300 Meters

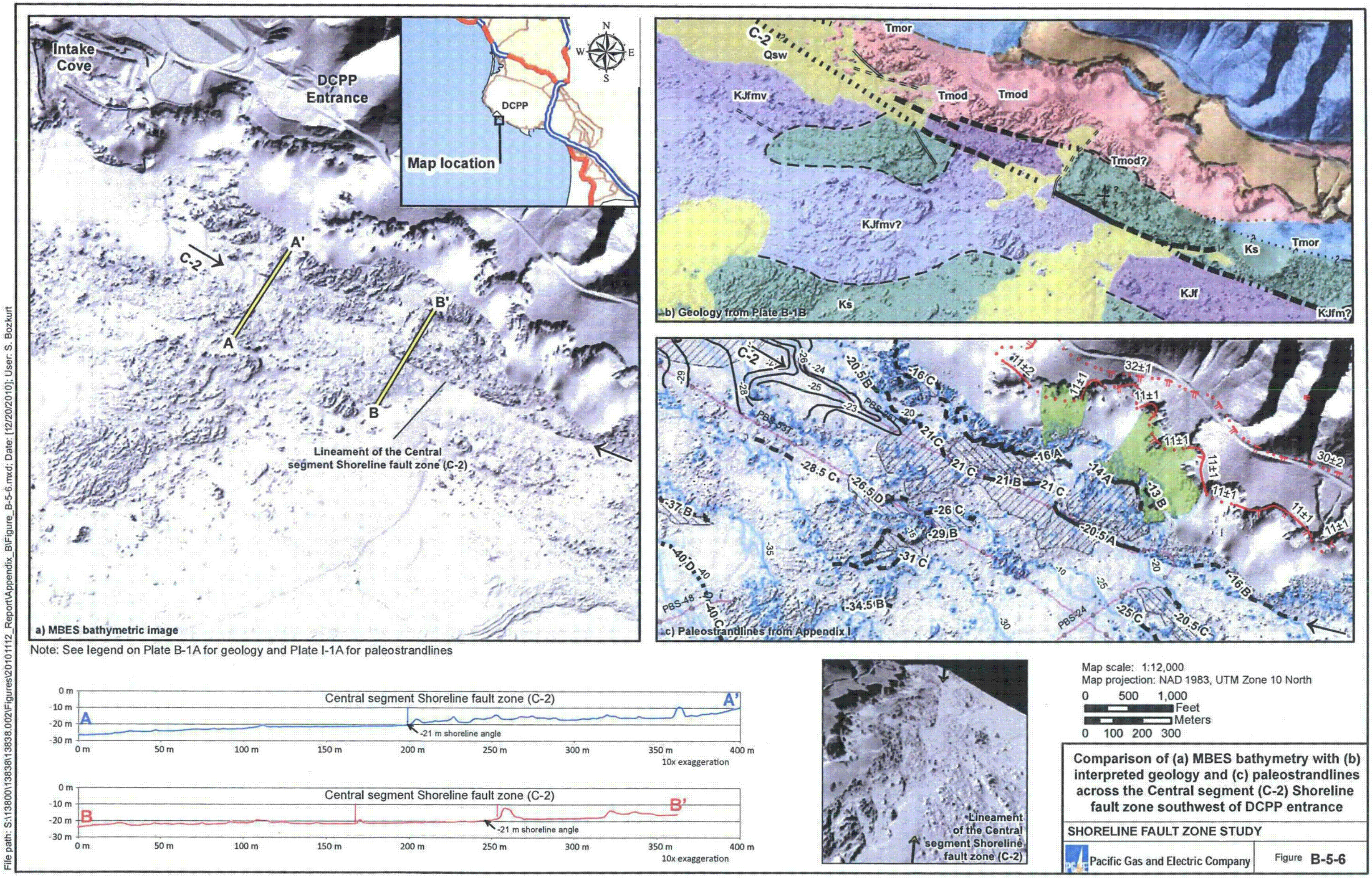
Comparison of (a) MBES bathymetry with (b) interpreted geology and (c) paleostrandlines across the Central Segment (C-1) Shoreline fault zone west of DCPP

SHORELINE FAULT ZONE STUDY

Pacific Gas and Electric Company

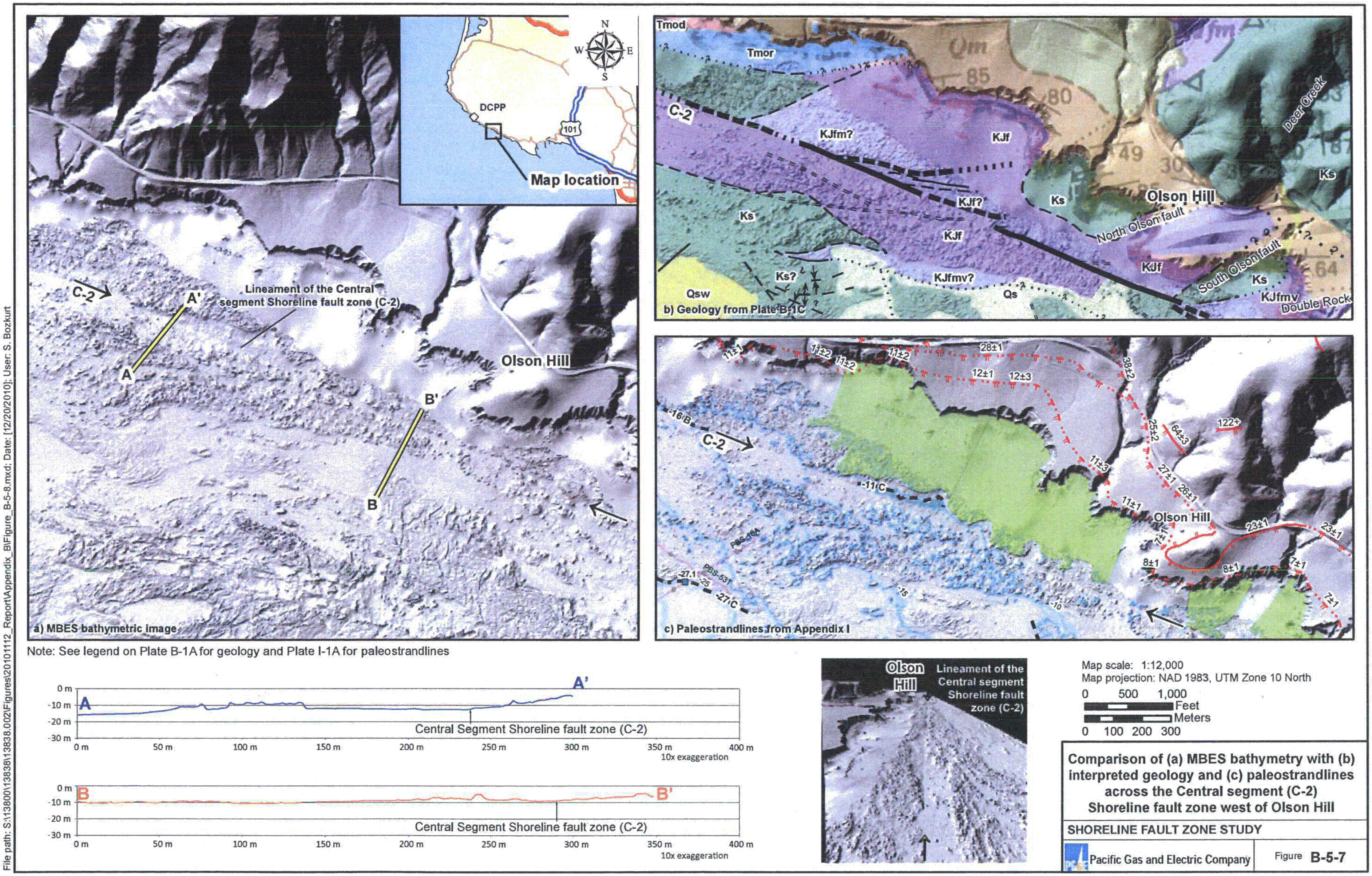
Figure **B-5-5**

File path: S:\13800\13838\13838.002\Figures\20101112_Report\Appendix_B\Figure_B-5-5.mxd; Date: [12/20/2010]; User: S. Bozkurt



Note: See legend on Plate B-1A for geology and Plate I-1A for paleostrandlines

Figure B-5-6. Comparison of (a) MBES bathymetry with (b) interpreted geology and (c) paleostrandlines across the Central segment (C-2) Shoreline fault zone southwest of DCPP entrance



Comparison of (a) MBES bathymetry with (b) interpreted geology and (c) paleostrandlines across the Central segment (C-2) Shoreline fault zone west of Olson Hill

SHORELINE FAULT ZONE STUDY

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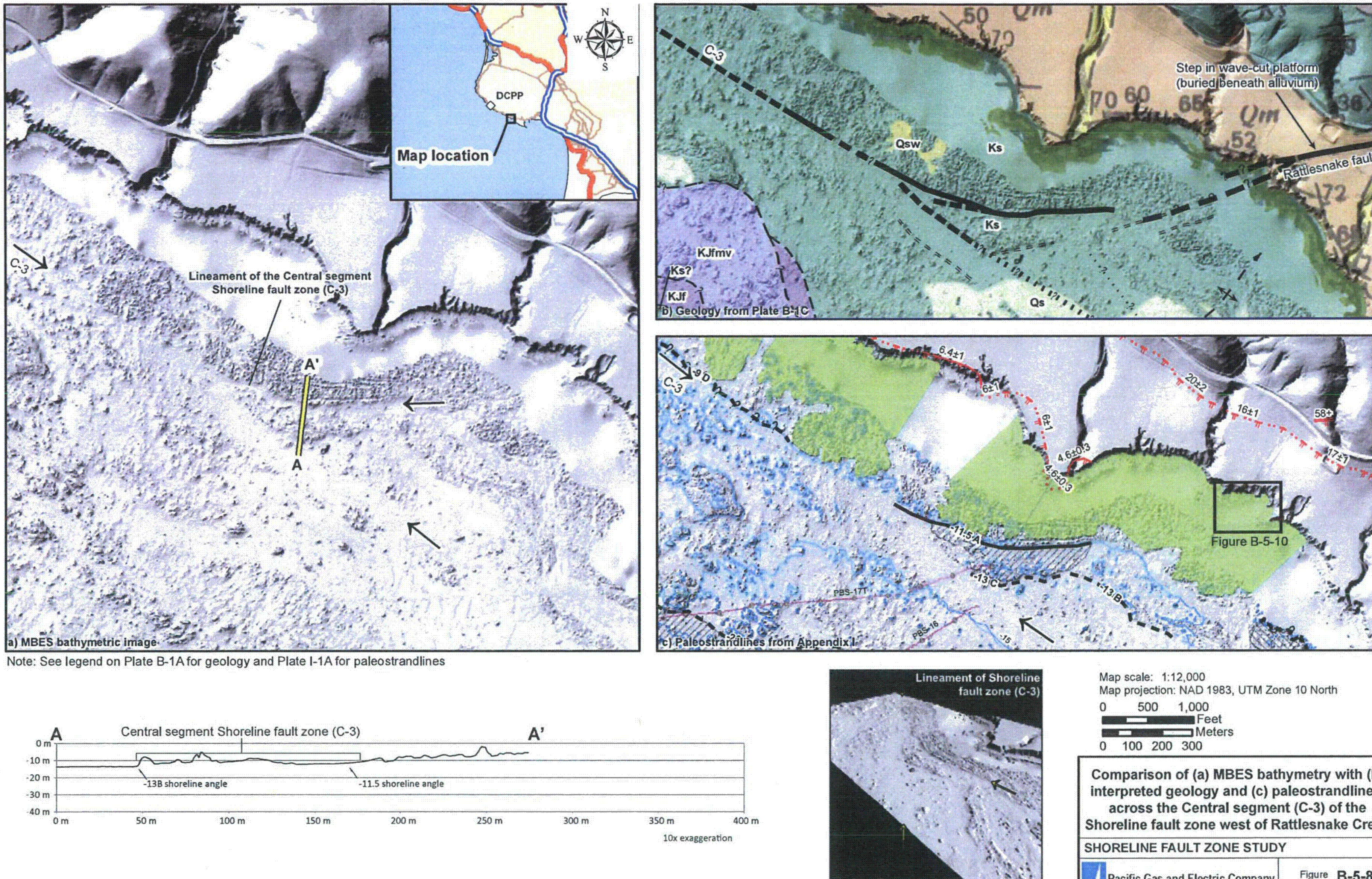
Figure **B-5-7**

File path: S:\13800\13838\13838.002\Figures\20101112_ReportAppendix_B\Figure_B-5-8.mxd; Date: [12/20/2010]; User: S. Bozkurt



Note: See legend on Plate B-1A for geology and Plate I-1A for paleostrandlines

Map scale: 1:12,000
Map projection: NAD 1983, UTM Zone 10 North

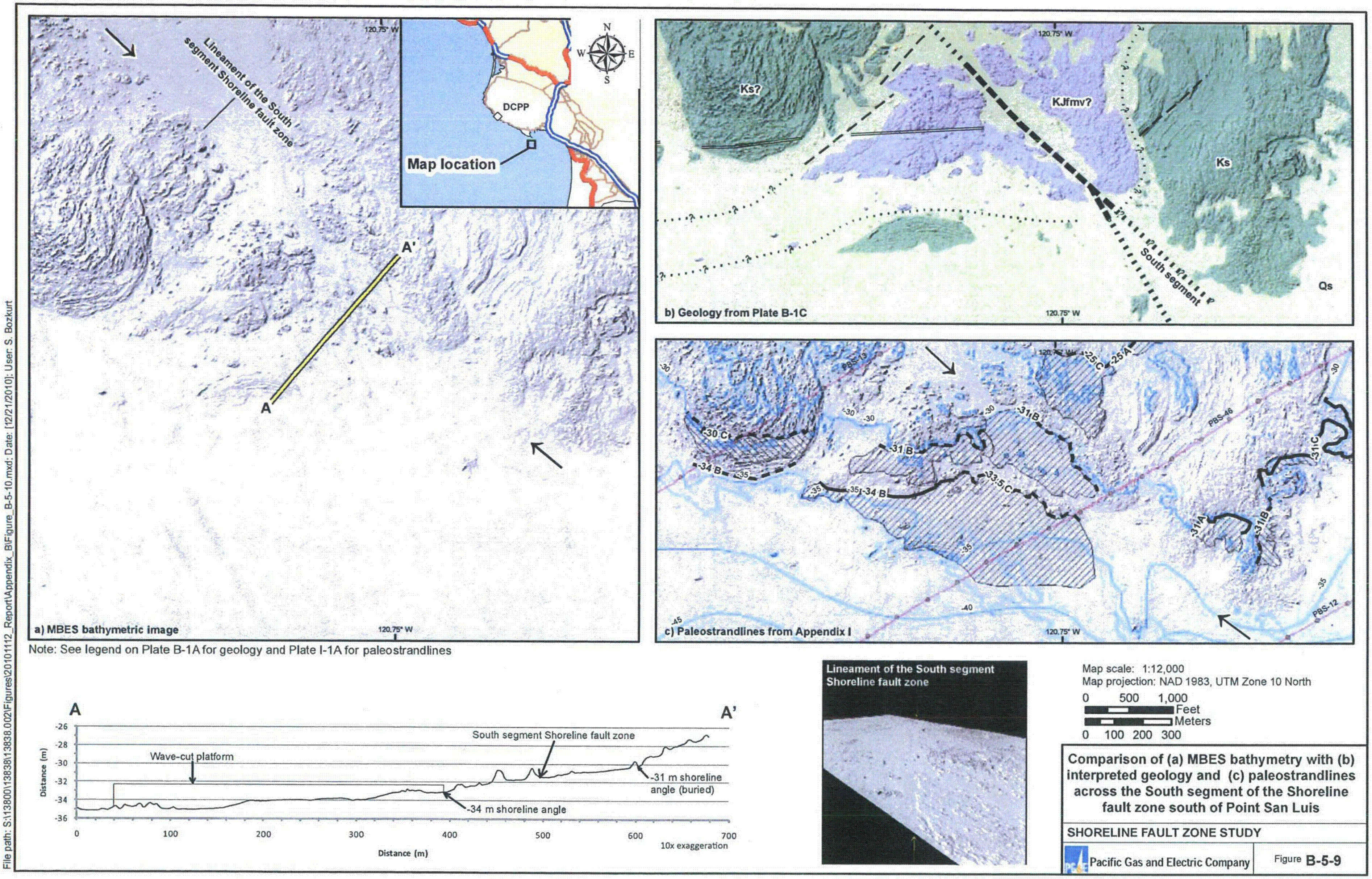
0 500 1,000 Feet
0 100 200 300 Meters

Comparison of (a) MBES bathymetry with (b) interpreted geology and (c) paleostrandlines across the Central segment (C-3) of the Shoreline fault zone west of Rattlesnake Creek

SHORELINE FAULT ZONE STUDY

Pacific Gas and Electric Company | Figure **B-5-8**

File path: S:\13800\13838\13838.002\Figures\20101112_Report\Appendix_B\Figure_B-5-9.mxd; Date: [12/20/2010]; User: S. Bozkurt



Comparison of (a) MBES bathymetry with (b) interpreted geology and (c) paleostrandlines across the South segment of the Shoreline fault zone south of Point San Luis

SHORELINE FAULT ZONE STUDY

Pacific Gas and Electric Company — Figure B-5-9