U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-2212
SHEET 1 OF 2

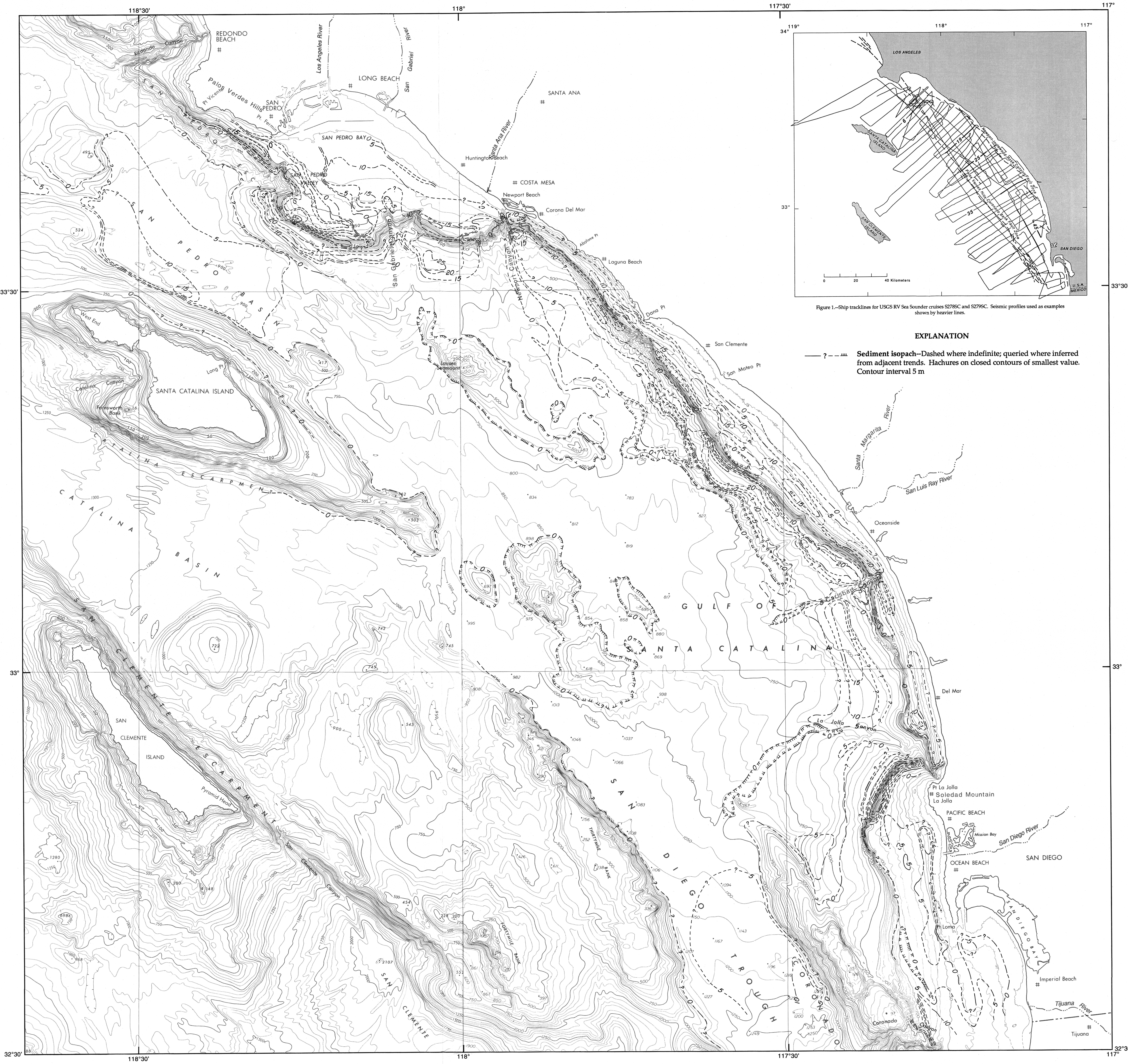

Figure 1.--Ship tracklines for USGS RV Sea Sounder cruises S278SC and S279SC. Seismic profiles used as examples shown by heavier lines.

EXPLANATION

— — ?— — Sediment isopach--Dashed where indefinite; queried where inferred from adjacent trends. Hachures on closed contours of smallest value. Contour interval 5 m

Base compiled from NOAA, 1975
1206N-15, Santa Barbara to Huntington Beach;
1206N-16, Huntington Beach to Punta Sal Si Puede

Transverse Mercator Projection

TRUE NORTH
MAGNETIC NORTH
15°
APPROXIMATE MEAN DECLINATION, 1992

SCALE 1:250 000

5 0 5 10 15 20 STATUTE MILES

5 0 5 10 15 20 25 30 KILOMETERS

5 0 5 10 15 NAUTICAL MILES

BATHYMETRIC CONTOUR INTERVALS: 10 METERS TO THE 200 METER DEPTH, 50 METERS TO THE MAXIMUM DEPTH
DATUM: MEAN LOWER LOW WATER

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INTRODUCTION

The Gulf of Santa Catalina is part of the California Continental Borderland, an active transform margin characterized by narrow shelves, steep slopes, and deep closed basins separated by shallow banks and islands. The Gulf of Santa Catalina extends from Point Fermin south to San Diego. It is bounded on the west by prominent bedrock ridges, 30 to 45 km offshore, comprising Santa Catalina Island and Thirtymile Bank.

The predominant structural grain within the Gulf of Santa Catalina trends northwesterly. Two major fault zones bound a relatively undeformed structural block, the Catalina block (Clarke and others, 1983). The Newport-Inglewood-Rose Canyon Fault Zone forms the northeast boundary of the Catalina block, and the Palos Verdes Hills-Coronado Bank Fault Zone forms the southwest boundary (Figure 1). Both of these fault zones are characterized by discontinuous, right-stepping en echelon faults and associated folds. Major structural and physiographic features within and bounding the Catalina block are compatible with wrench-style tectonism (Harding, 1973; Wilcox and others, 1973; Nardin and Henyey, 1978). The distribution of seismicity, along with geophysical evidence showing local displacement of the sea floor and Holocene deposits, indicate that Newport-Inglewood, Palos Verdes Hills, and subsidiary faults are active (Clarke and others, 1983).

The distribution of Quaternary sediments (Pleistocene and Holocene) off the coast of southern California provides insight into recent sedimentation patterns and recency of faulting and tectonic deformation. This report focuses on the distribution of Quaternary sediments, particularly in the shelf and upper slope areas, the sources of detrial sediment, and the depositional environments of Holocene as well as relict deposits.

METHODS OF DATA COLLECTION AND INTERPRETATION

Much of the information presented on this map is based on interpretation of seismic-reflection records collected aboard the research ship *Sea Sounder* during 1978 and 1979 (Figure 1). High-resolution profiles, gathered with 3.5 kHz and Uniboom systems, were used to map the thickness and distribution of acoustically transparent sediment. The acoustic transparency or lack of subbottom reflectors results from the similarity of seismic velocity in young sediment to that in the overlying water column due to the poorly consolidated and water-saturated nature of the sediment. To convert the time profiles into thickness data, an average speed of 1,500 m/s (two-way travel time) was assumed for seismic energy in the acoustically transparent deposits. Based on this speed, subbottom penetration on the high-resolution reflection records varied from 150 to over 400 m and had a maximum resolution of 1.0 to 1.5 m.

Location accuracy of the seismic data was approximately ±15 m when a range-range precision triangulation system was used to determine ship's position. When the precision navigation equipment was not functioning (approximately 20 percent of the time), radar was used to determine ship's position with an accuracy of about ±500 m.

The acoustically transparent sediment is inferred to be of late Quaternary age (Nardin and Henyey, 1978; Nardin, 1983; Ponti, 1989). In the shelf and upper slope areas, the base of the upper Quaternary deposits is well defined by an angular unconformity (Line 25) related to glacio-eustatic fluctuations (Moore and Curray, 1964; Lajoie, 1986). This angular unconformity is thought to have been cut about 600 ka during the isotope-stage 16 glacial maxima (Ponti, 1989). Subsequent cycles of Quaternary deposition and erosion on the shelf are inferred to have preserved a patchwork of post-600 ka deposits. On the lower slope and in the basin areas, where underlying strata are conformable, this boundary between Quaternary and pre-Quaternary deposits is more difficult to discern (Lines 19 and 35).

DISTRIBUTION AND CHARACTER OF UPPER QUATERNARY DEPOSITS

The thickness of acoustically transparent sediment in the Gulf of Santa Catalina region is shown on this map. The mapped deposits unconformably overlie pre-Quaternary bedrock on the shelf and upper slope (Nardin and Henyey, 1978; Clarke and others, 1983; Kennedy and others, 1987) where they probably represent the total thickness of Quaternary sediment. However, acoustically transparent sediments conformably overlie older strata of presumed Quaternary age (Teng and Gorsline, 1989) on the lower slopes and in the basins of this region. The total thickness of upper Quaternary deposits in these areas is likely greater than indicated on the map (Emery, 1960; Emery and Bray, 1962; Fleischer, 1970; Malouta and others, 1981; Nardin, 1983; Teng and Gorsline, 1989).

SHELF DEPOSITS

The seaward shelf boundary in the Gulf of Catalina area is defined by a sharp increase in slope gradient (increasing from 1° to 4° which generally occurs near the 100-m isobath. Shelf width is typically less than 5 km, except in the northern San Pedro and southern San Diego areas where the shelf extends as far as 20 km offshore. In these two areas, the wide shelf is associated with large headlands formed by upfaulted structural blocks.

San Pedro Shelf Area

The distribution of Quaternary deposits in the northern San Pedro shelf area is controlled by a bedrock ridge that extends from Point Fermin southeastward along the west side of San Gabriel Canyon. This ridge, formed by displacement along the Palos Verdes Hills Fault, appears to have acted as a barrier to sediment dispersal from the Los Angeles and San Gabriel Rivers during late Quaternary time. Upper Quaternary sediment is thin or non-existent over the bedrock ridge, but locally, on the landward side of the fault, ponded sediment is more than 15 m thick.

The thickest deposits (30 m or more) in the northern shelf area occur near the shelf edge between San Pedro Valley and San Gabriel Canyon (Line 6) These deposits were likely derived from erosion of the adjacent bedrock ridge, which was emergent during late Pleistocene glacio-eustatic low stands. Thick deposits (20 m or more) also occur near the shelf edge southwest of Point Fermin and between the San Gabriel and Newport Canyon systems. The Point Fermin deposits were probably derived from southward littoral drift of sediment eroded from Palos Verdes Hills, and the San Gabriel-Newport deposits were probably derived from outbuilding of the shelf edge by sediment supplied by the Santa Ana River during periods of lowered sea level.

Bedrock is exposed on the inner shelf along Palos Verdes Hills, in the heads of San Pedro Valley, San Gabriel and Newport submarine canyons, and along the upfaulted ridge west of San Gabriel Canyon. The ridge is a bathymetric high isolated from transport of modern sediment, and the other regions are inferred to be areas of active transport and scour of sediment.

The San Pedro shelf area is relatively well studied owing to its proximity to the University of Southern California. Most of the sediments exposed on the sea floor are mixtures of Holocene and late Pleistocene detrital sediment (Gorsline and Grant, 1972). Pure relict deposits are rare—exposed on the sea floor only in areas isolated from recent detrital sedimentation, such as the sand and gravel deposits surrounding the bedrock ridge (Emery, 1952), and exposed locally along the shelf edge. Modern detrital sediment grades from fine- and very fine-grained sand in the nearshore area to sandy silt at the shelf edge (Moore, 1954; Stevenson and others, 1959; Uchupi and Gaal, 1963; Bandy and others, 1964; Gorsline and Grant, 1972; Karl and others, 1980).

Iron-stained elongate sand lobes on San Pedro shelf (Welday and Williams, 1975) subparallel the present shoreline and probably represent paleo-shorelines deposited during lowered sea level. A buried channel, representing the paleo-San Gabriel River (graded to a low sea-level stand and subsequently backfilled), extends from near the mouth of the San Gabriel River across the shelf to the San Pedro Valley (Moore, 1954) (Line 6).

Central Shelf Area

Upper Quaternary deposits in the central shelf area between Newport Beach and Point La Jolla are thin, generally less than 10-m thick. Locally, off Dana Point, upper Quaternary deposits reach 20 m or more in thickness. The shelf slopes evenly seaward in this region, therefore this accumulation of sediment represents fill of a subsurface low (Line 19).

Detrital sediment blankets most of the central shelf area. In general, well-sorted, fine-grained sand in the nearshore region (Stevenson and others, 1959; Welday and Williams, 1975) grades to mud at the shelf edge (Welday and Williams, 1975). Medium-grained sand is present locally adjacent to the mouths of streams (Wimberley, 1964). Relict beach or marine-terrace sand is exposed locally along the shelf edge (Stevenson and others, 1959).

San Diego Shelf Area

The southern San Diego shelf area is defined by a fault-bounded, emergent bedrock high which extends southward from Point La Jolla to Point Loma and continues offshore south of Point Loma as a submerged bedrock ridge. Coronado Bank, another bedrock ridge approximately 15 km to the east, reaches shelf depths (less than 150-m water depth) between La Jolla and Coronado Canyons. Upper Quaternary sediment cover is thin, commonly less than 5 m thick, over most of the San Diego shelf area. Buried paleobathymetric features (such as channels and terrace scarps) create local thinning and thickening of shelf sediment cover (Line 25). The thickest shelf deposits (30 m or more) are found along the shelf edge, west of Point La Jolla. These deposits are likely derived from erosion of the adjacent Soledad Mountain.

Bedrock is exposed on the shelf in the nearshore area between Point La Jolla and Point Loma, and on the ridge extending south from Point Loma. High-resolution seismic data indicate no sediment cover on Coronado Bank, which reaches shelf depths in places, but sampling data by others (Emery, 1952; Stevenson and others, 1959; Welday and Williams, 1975) indicate at least a thin cover of sediment, apparently below the resolution of seismic data (less than 2-m thick).

Well-sorted, fine- to medium-grained sand blankets the nearshore San Diego shelf area and grades to sandy silt at the shelf edge (Stevenson and others, 1959; Henry, 1976). Medium- to coarse-grained sand is present in the nearshore area adjacent to the southern seacliff area (Emery, 1952).

Relict, iron-stained gravel and sand are exposed adjacent to the bedrock ridge south of Point Loma and adjacent to the mouth of the Tijuana River (Emery, 1952; Stevenson and others, 1959). South of Point Loma, sand extends to 90-m water depth, 10 to 15 km offshore, which suggests a relict origin, in contrast to the adjacent central shelf area where sand extends to only 15-m water depth (Wimberley, 1964).

SLOPE DEPOSITS

The continental margin slopes steeply from the shelf edge at about the 100-m isobath to the 250-m isobath along the central, narrow portion of the Gulf of Santa Catalina margin and in the northern part of the San Diego area. Off the northern San Pedro shelf area, the margin slopes steeply from the the shelf break to the 500-m isobath. Off Coronado Bank, the margin slopes steeply to about the 1,000-m isobath.

The continental slope is cut by five major submarine canyon systems and several minor ones. The northernmost canyon, San Pedro Valley, comes within 4 km of shore and cuts into the shelf to a water depth of about 50 m. This canyon system empties into San Pedro Basin. Two other canyons cut the San Pedro slope; San Gabriel Canyon (which comes within 7 km of shore to a water depth of approximately 40 m) and Newport Canyon (which comes within 0.5 km of shore to a depth of approximately 20 m). These two canyons empty into the central Gulf of Santa Catalina area which in turn spills over into the San Diego Trough.

Carlsbad Canyon, which cuts the central slope and shelf area west of Oceanside, reaches within 1.5 km of shore to a depth of about 40 m. La Jolla Canyon extends to within 0.5 km of shore to a depth of about 10 m. Coronado Canyon, west of Tijuana River, reaches a water depth of about 50 m, within 11.5 km of shore. These three canyon systems empty directly into the San Diego Trough.

San Pedro Valley, and La Jolla and Coronado Canyons have submarine fans at their bases (Emery, 1960) that were active during the late Pliocene and Quaternary (Teng and Gorsline, 1989). Some subsidiary canyons are filled with deposits, but the upper segments of the main distributary channels are generally devoid of sediment. This lack of deposits suggests that the larger channels are actively transporting sediment, not storing it; or conversely, that the canyons are currently starved. In regions with steeply inclined shelves and slopes, such as off Palos Verdes Hills and Soledad Mountain, detrital sediment apparently is transported directly across the shelf and downslope as mass flows, which form large outbuilding sediment wedges (Line 45).

Many steeper slopes appear devoid of upper Quaternary sediment other than a thin hemipelagic drape, such as along San Pedro Escarpment and Coronado Bank. Upper Quaternary upper slope deposits are thin (characteristically less than 10-m thick) except downslope from regions of Quaternary outbuilding at the shelf edge. In contrast, upper Quaternary deposits at the base of the slope commonly reach 25 m or more in thickness. Some base-of-slope deposits are inferred to be mass-failure deposits because of their irregular surfaces. In general, slope deposits are thickest near major sediment sources, such as between San Gabriel and Newport Canyons. These deposits may have resulted from the Santa Ana River debouching directly on the shelf edge during lowered sea level. The thick deposit (25 m or more) between San Mateo Point and Carlsbad Canyon is ponded behind an upfaulted ridge on the lower slope.

Little sample data exist for the distribution of grain size on the continental slope in the Gulf of Santa Catalina. In general, detrital sediment that accumulates below wave-base (typically deeper than the shelf break at 100-m isobath) is fine-grained silt, which settles out from suspension. Coarser grained deposits on the upper slope are probably relict from shallower depositional environments and were transported over the shelf edge during periods of lowered sea level.

BASIN DEPOSITS

The two main sediment sinks in the Gulf of Santa Catalina area are San Pedro Basin in the north and San Diego Trough in the south. Their basin perimeters are defined by adjacent uplifted structural blocks.

Upper Quaternary deposits thicken basinward from nearshore slopes and ultimately conformably overlie lower Quaternary and older Neogene strata. In the basin centers, upper Quaternary deposits could not be distinguished from underlying Neogene deposits using high-resolution seismic profiles. Late Pliocene-Quaternary sediment accumulation rates of 20-60 cm/1,000 yr are inferred for San Pedro and San Diego Basins (Malouta and others, 1981; Nardin, 1983; Teng and Gorsline, 1989); clearly the thicknesses shown here do not represent the total upper Quaternary deposits but only the depth to the first strong seismic reflector.

San Pedro Basin receives sediment predominantly from the Redondo Canyon system (Teng and Gorsline, 1989) from north of the Gulf of Santa Catalina, and the San Pedro Valley. Minor amounts of sediment are contributed from mass failure on the San Pedro Escarpment (Nardin, 1983) and from erosion of Santa Catalina Island. San Pedro Basin has accumulated a relatively small amount of sediment in late Quaternary time, considering its nearshore location, because its main sediment source, the Redondo Canyon system, empties first into the Santa Monica Basin to the north (Teng and Gorsline, 1989). Also, during the late Quaternary, the Los Angeles-San Gabriel River system has alternately emptied into San Pedro Basin and San Diego Trough, reducing the cumultative sediment influx to San Pedro Basin (Teng and Gorsline, 1989).

San Diego Trough recieves sediment predominantly from the San Gabriel, Newport, and La Jolla Canyon systems, and smaller amounts from the Carlsbad and Coronado Canyon systems. San Diego Trough has accumulated only a relatively small amount of sediment because most detrital sediment is derived from the San Gabriel and Newport Canyon systems and this sediment is entrapped upslope in the central Gulf of Santa Catalina area (Teng and Gorsline, 1989).

Most of the sediments entering these nearshore basins are sand and silt with a fluvial-turbidite source (Emery, 1960; Fleischer, 1970; Schwalbach and Gorsline, 1985). Minor nephaloid-hemipelagic basin sediments consisting of silt and clay were probably derived from suspended sediment plumes associated with large flood events (Fleischer, 1970; Welday and Williams, 1975; Karl and others, 1980; Drake and others, 1985).

BANKS

Some of the fault-bounded ridges, such as Lausen Seamount and Coronado Bank, form shallow banks which were emergent during extreme low sea-level stands (approximately 100 m below modern sea level). Welday and Williams (1975) recovered sand, presumed residual, from some of these bank tops. Mixed authigenic and biogenic (foraminiferal tests) sediments have been recovered from the top of Coronado Bank (Emery, 1952). Sand recovered from Thirtymile Bank is probably authigenic or biogenic, as the bank top is at 250-m water depth and has been below wave base throughout Quaternary time (assuming moderate to low tectonic subsidence).

SUMMARY

The role of Quaternary tectonism in the distribution of unconsolidated sediment in the Gulf of Catalina area is limited by the short span of time (less than 600 ka) represented, resulting in only modest changes in relief. The most obvious effects of tectonism are the ponding of sediment behind actively rising fault blocks, increased sediment influx resulting from erosion associated with uplifted coastal areas, and the channeling of sediment around structural barriers. In a broader sense however, the distribution of Quaternary deposits and the location of sediment sinks are controlled by existing structures such as fault-bounded banks and headlands.

Slope and basin depositional environments have remained fairly constant during the late Quaternary. The most significant changes in depositional environment are associated with sea-level fluctuations which controlled the rate of detrital sediment influx and the relative proportions between the various sediment components. The shelf, in contrast, has experienced dramatic changes in depositional environments associated with sea-level fluctuations. During a sea-level cycle, the shelf changes from an emergent coastal plain, fluvially transporting unconsolidated sediment to the shelf edge, to a submerged shelf below short-period wave base with sediment transport controlled principly by ocean currents and long-period waves.

Modern detrital sediment on the shelf and upper slope is currently burying relict sediment and filling topographic lows. Coarse relict sediment still exposed at the shelf edge is attributed to the last major sea-level low stand approximately 18 ka (Lajoie, 1986). The relatively thick deposits exposed in the central, mid-shelf area probably pre-date this low stand and represent multiple, intermediate sea-level high stands (such as occurred at 40 ka and 60 ka). Stream channels filled with gravels are superimposed on the mid-shelf beach deposits (Greene and others, 1975). These channels were presumably cut and backfilled during the most recent low stand and subsequent Holocene transgression.

The elongate shape of some relict shelf deposits resemble shoreline bar or dune morphologies. The iron-stained sands in the northern and southern mid-shelf areas, for instance, may be analogous to emergent paleo-beach ridges between San Mateo Point and San Diego Bay, which are also iron stained and have similar linear morphologies. The emergent beach ridges apparently represent dune sands which accumulated on sea cliffs above the paleo-strandline (Lajoie, oral communication, 1989). Beach ridges are generally found in regions with broad coastal plains composed of easily eroded material that has yielded abundant sediment to the beach zone where it formed sand dunes. Both the northern and southern coastal areas in the Gulf of Santa Catalina provide such settings.

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ISOPACH MAP

ISOPACH MAP SHOWING QUATERNARY DEPOSITS IN THE GULF OF SANTA CATALINA AREA, CALIFORNIA

By

Patricia A. McCrory

1993

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