UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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A SUMMARY REPORT OF THE REGIONAL GEOLOGY, PETROLEUM POTENTIAL, ENVIRONMENTAL GEOLOGY, AND OPERATIONAL CONSIDERATIONS IN THE AREA OF PROPOSED LEASE SALE NO. 68, OFFSHORE SOUTHERN CALIFORNIA

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This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards or nomenclature.

TABLE OF CONTENTS

Page

Summary.. 1

Introduction... 3

Regional Geological Framework.................................... 7

General Setting.. 7

Santa Barbara Channel.................................... 7

Borderland, inner basins and banks....................... 10

Borderland, outer basins and banks....................... 14

Petroleum Geology.. 21

Distribution and Characteristics of Petroleum in Adjacent Developed Areas............................... 21

Appraisal of the OCS Potential............................... 23

Santa Barbara Channel.................................... 23

Southern California Borderland (OCS)..................... 24

Petroleum Resource Appraisal................................. 29

Environmental Hazards.. 35

Santa Barbara Channel.................................... 35

Borderland, inner basins and banks....................... 39

Borderland, outer basins and banks....................... 41

Operational Considerations....................................... 44

Introduction... 44

Technological Needs.. 44

Drilling Rig Availability.................................... 51

Onshore Construction... 53

Manpower Availability.. 54

Availability of Investment Capital........................... 55

References Cited... 57

SUMMARY

This report reviews geological, geophysical and technological data that are pertinent to proposed OCS Lease Sale 68. Under consideration are 26,000 mi^2 (67,400 km^2) of the California Continental Borderland north of the U.S.-Mexico boundary. The area includes both leased and unleased tracts and lies adjacent to the highly productive coastal basins of southern California.

Factors that have contributed to petroleum generation in the onshore basins, such as thickness, burial depth and hydrocarbon content, are less favorable in parts of the offshore region. Nevertheless, regional geologic and geophysical mapping together with data from stratigraphic test wells and bottom samples suggest that source beds, reservoir rocks and traps are present beneath the borderland. Strata of Miocene age are widespread within the area of proposed OCS Lease Sale 68 and contain fair to excellent potential source rocks. Eocene and early Miocene sandstone beds in the Cortes Bank test well and late Miocene and Pliocene rocks in the Point Conception test well have porosities that are within the range of good reservoir rocks. Late middle Miocene through Pliocene sandy turbidites of reservoir quality possibly occur in some outer borderland basins. Additional prospective targets are fractured Miocene shale beds that may be present in the deeper basins and on the down-flank margins of major uplifts. Numerous structural and stratigraphic traps, which formed in response to late Cenozoic wrench tectonics, are distributed throughout the borderland.

Petroleum resources for the proposed sale areas are estimated in aggregate probability levels of 5 percent and 95 percent and are based in part upon volumetric and analog methods. Estimated undiscovered recoverable oil and gas resources at present technology and economics are at least these amounts at these probabilities:

	95 Percent Probability	5 Percent Probability	Statistical Mean
Oil (billions of barrels	2.2	7.6	4.4
Gas (trillions of feet^3)	3.2	7.7	5.4

Effects of active seismicity, seafloor instability, sediment erosion, subsidence susceptibility, and hydrocarbon seeps should be given careful consideration as potential environmental hazards. Unstable ground and active faults are evident along ridge and shelf areas throughout the borderland. The northern slope of Santa Barbara Channel, the western flank of Santa Rosa-Cortes Ridge, and the eastern edge of the San Diego Trough are particularly susceptible to slumping. Inundation of coastal lowlands and future installations on banks possibly could result from both locally generated and external tsunamis. Sparse sediment cover and rock outcrops devoid of sediment along the crest of the Santa Rosa-Cortes Ridge attest to strong current action.

Development of potential hydrocarbon resources is technically feasible within most of the proposed area of Lease Sale 68. By the mid-1980's exploratory drilling capability is expected to be in the range of 6,000 ft (1830 m) to 8,000 ft (2440 m) of water. Oil and gas production will be extended to 3,000 ft (915 m) of water using subsea production systems, and pipeline-laying technology will be available for comparable depths.

Development of southern California offshore reserves will depend not only on technical feasibility but also on equipment availability for exploration and production, refining capacity, and suitable manpower and capital. Availability of exploration drilling rigs will depend on offshore potential including previous lease sales and worldwide drilling activity. West coast construction and support bases are accessible in addition to those from the Gulf of Mexico and Japan. Refinery capability will be dependent on the future routing of Alaskan crude oil.

Manpower should be adequate in spite of the problems of industrial expansion offshore. If current trends in profits, crude prices and capital spending are not impeded or curtailed, investment capital should be obtainable for Lease Sale 68.

INTRODUCTION

This report is a summary of data that will affect exploration and development in the area of proposed OCS Lease Sale 68. The designated area extends from Point Conception to the United States-Mexico boundary and seaward to the foot of the continental slope (Fig. 1). As a result of the international treaty of May 4, 1978, the U.S.-Mexico boundary extends south of 32°N latitude and adds approximately 5,000 mi^2 (13,000 km^2) of new area to the 21,000 mi^2 (54,400 km^2) considered in the call for nominations for OCS Lease Sale No. 48.

Much of the geologic information in this report has been extracted from the summary reports prepared in advance of OCS Lease Sales No. 35 (Vedder and others, 1974a) and No. 48 (Vedder and others, 1976c). Significant new findings since transmittal of the summary report for OCS Lease Sale 48 are included herein. Tracklines for U.S. Geological Survey geophysical and rock sampling cruises since 1972 are shown in Figures 2 and 3. Available geologic data from the new territory south of 32°N latitude is limited to 5 widely spaced geophysical profiles and 7 dredge hauls.

As shown in Figure 1, the proposed lease sale area is divided into three regions: the Santa Barbara Channel, the inner basins and banks, and the outer basins and banks. Each subdivision is described separately under the sections of this report entitled regional geologic framework, appraisal of the OCS potential, petroleum resource appraisal, and environmental hazards.

Figure 1. Map of the region of proposed OCS Lease Sale 68. The three-mile line is shown by a solid line along the mainland coast and around the islands. The 200 meter and 750 meter depth contours are indicated by short-dashed curved lines. Boundaries of the area included in the Call for Nominations, OCS Lease 48 are depicted by short-dashed straight lines. Stratigraphic columns in Figures 4, 5, and 7 are located at the numbered circles 1 through 20.

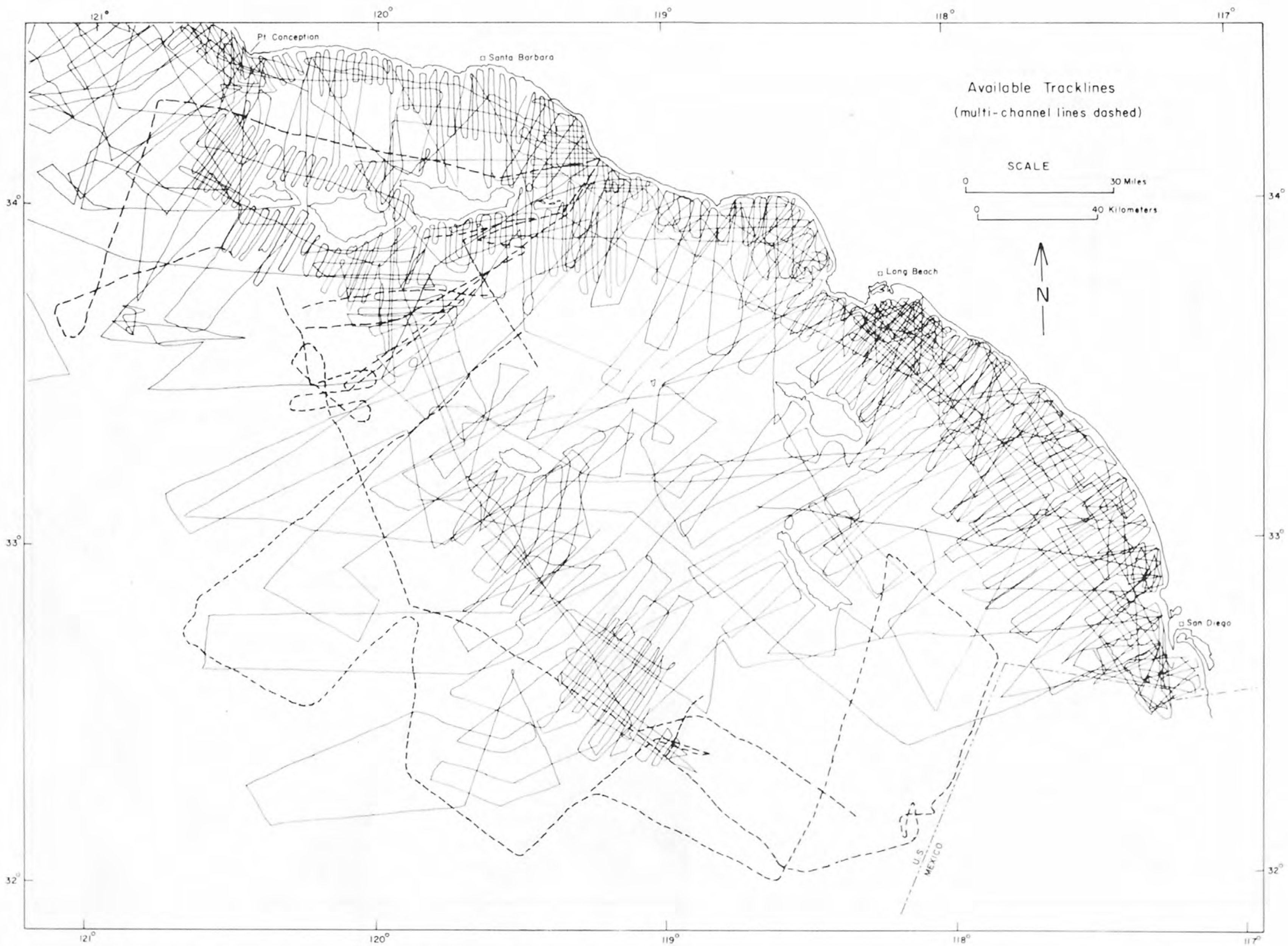


Figure 2. Ship tracklines along which nonproprietary geophysical data have been collected for the purpose of preparing the papers cited in this report.

Figure 3. Dredge sites and ship tracklines along which bedrock cores were taken for the purpose of preparing the papers cited in this report. Descriptions of samples are recorded in Vedder and others (1974, 1976a, 1976b, 1977, 1979).

REGIONAL GEOLOGIC FRAMEWORK

General Setting

Proposed OCS Lease Sale 68 lies offshore from the structurally complex part of California that includes the western Transverse Ranges province and the northern Peninsular Ranges province. This offshore region commonly is referred to as the southern California borderland. The Neogene geologic evolution of the region is attributed to tectonic instability of the continental margin along the boundary between the Pacific and North American plates. As a result of right-lateral shear, which began along the plate boundary about 30 m.y. ago, a network of ridge and basin structures developed. Rapid erosion of the ridges and thick accumulation of sediment in the basins accompanied by volcanism began about 20 m.y. ago. Subsequent deformation in response to continued right shear, which resulted in the formation of local en echelon zones of folds and faults, began about 12 m.y. ago and is continuing today.

Santa Barbara Channel. The geologic framework of the Santa Barbara Channel and Point Conception area has been described in reports by U.S. Geological Survey (1975), Campbell and others (1975) and Cook and others (1979). Basement rocks similar to some types of the Coast Range Franciscan have been penetrated in the Union Gherini No. 1 well on the east end of Santa Cruz Island, north of the Santa Cruz Island fault, where greenstone was cored and dated at 152 ± 8 m.y. (Howell, McLean, and Vedder, 1976). Exposed basement rocks south of this fault were described elsewhere (Hill, 1976).

The only reports of Cretaceous sedimentary rocks beneath the Santa Barbara Channel are from exploratory wells near the middle of the channel

(Vedder and others, 1969; Weaver, 1969). The Richfield Santa Cruz No. 1 well, located at the west end of Santa Cruz Island and north of the Santa Cruz Island fault, drilled 2,000 feet (610 m) of conglomerate, sandstone, and shale of Late Cretaceous age (Weaver, 1969; Howell, McLean, and Vedder, 1976). The Richfield Santa Cruz No. 2 well, located south of the fault, penetrated 2,260 feet (689 m) of sedimentary rocks of similar age and lithology. West of the channel, deep stratigraphic test well OCS-CAl 78-164 No. 1 (Fig. 4) drilled Upper Jurassic or Lower Cretaceous mudstone and siltstone between 10,000 feet (3050 m) and the total depth of 10,571 feet (3224 m).

Paleogene rocks beneath the channel are believed to be widespread and may attain thicknesses of as much as 10,000 feet (3050 m) or more nearshore (Curran, Hall, and Herron, 1971; Campbell and others, 1975). Along the mainland coast, marine sandstone and claystone beds form the bulk of the Paleocene and Eocene sequences and locally are interlayered with conglomerate. The Oligocene section on shore grades westward from nonmarine to marine and is composed primarily of sandstone and siltstone (Dibblee, 1950; Curran, Hall, and Herron, 1971; Vedder and others, 1974). Much of the insular platform west of San Miguel Island is underlain by Upper Cretaceous and Paleogene strata (Junger, 1979). Folds occur in well defined trends, and individual anticlines commonly are arranged in echelon. High-angle faults, with apparent normal and reverse separations, are interspersed with those that have strike-slip components of movement (Lee and Vedder, 1973); Ellsworth and others, 1973; U.S. Geological Survey, 1975; Greene, 1975; Yerkes and others, 1979). Older structures may have controlled sediment dispersal as early as Eocene time, and at some places faults cut strata no younger than late Miocene and early Pliocene, particularly along the southern margin of the channel (Junger, 1979). On the other hand, domed late Pleistocene alluvium, uplifted

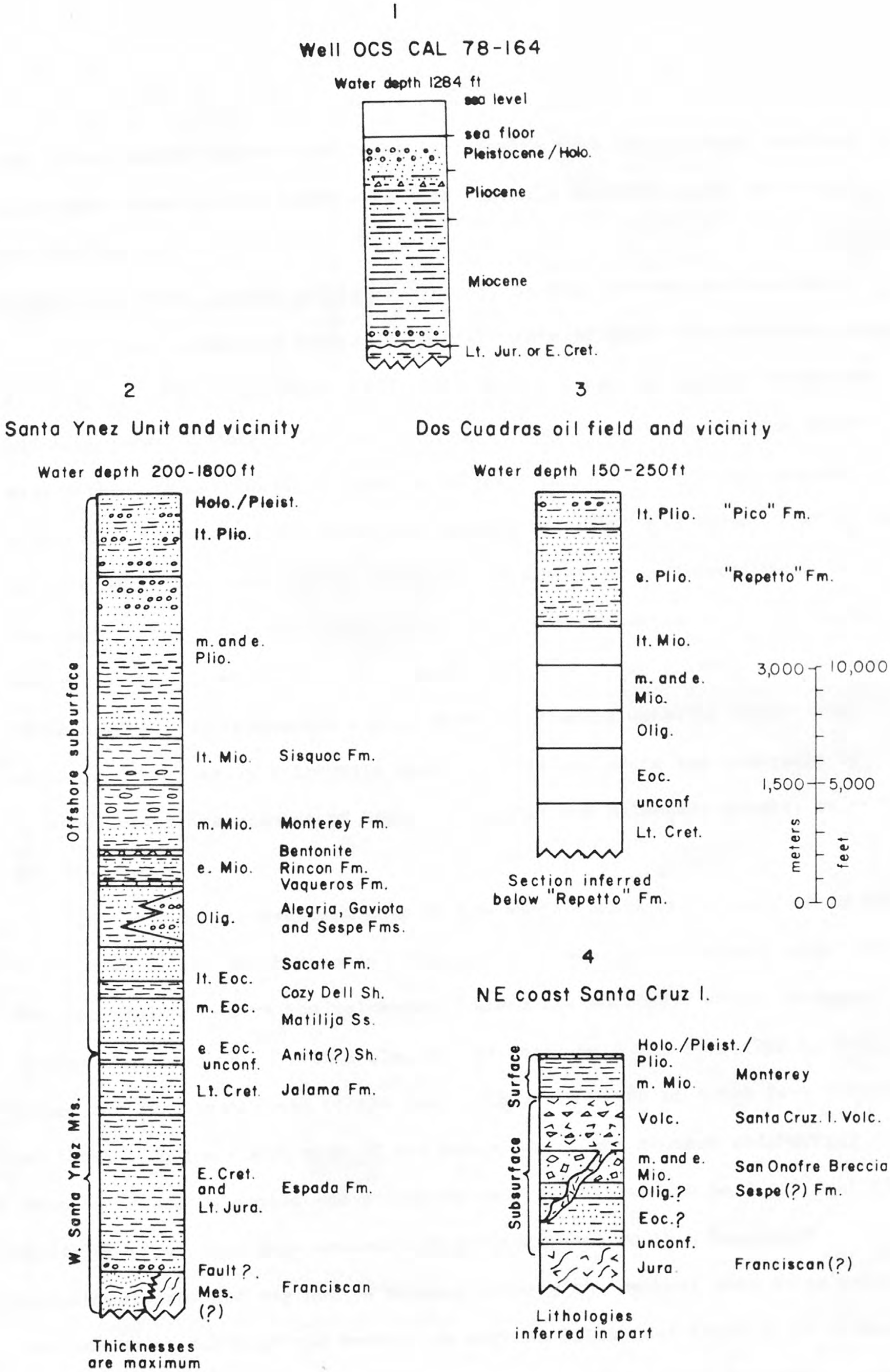


Figure 4. Stratigraphic columns, Santa Barbara Channel region. Provincial chronologies and named stratigraphic units are shown to the right of each column. The rock types, where known, are generalized and depicted by lithologic symbols.

and tilted marine terrace platforms, and faults that cut Holocene seafloor sediments attest to the youthfulness of tectonic activity along the mainland edge of the channel.

Borderland, inner basins and banks--The region that extends southeastward from Anacapa Island and inboard from the crests of Santa Cruz-Catalina Ridge and Thirtymile Bank contains at least three large basins, each of which has had a somewhat different geologic history. The Santa Monica and San Pedro Basins seem to be floored by Miocene volcanic rocks and/or schist basement with little or no strata beneath the volcanics (Junger and Wagner, 1977). The Gulf of Santa Catalina and San Diego Trough probably are underlain by Peninsular Ranges basement rocks along their easternmost edges and by schist and volcanics elsewhere (Fig. 5) (Howell and Vedder, in press). Unlike the western edges, where Miocene strata directly overlie Catalina Schist and volcanic rocks, as at Thirtymile Bank, the eastern edges are underlain by relatively thick sequences of Upper Cretaceous and Paleogene strata, as on the San Diego shelf.

In the deep northwestern part of the Santa Monica Basin, as much as 8,000 feet (2438 m) of latest Miocene, Pliocene and younger sedimentary rocks may have accumulated above the volcanics. Along the northeast slope, Miocene strata, composed chiefly of shale, are as thick as 2,600 feet (792 m) and along the southeast flank of the basin, they are 1,300 to 1,800 feet (396-549 m) thick. On the north edge of San Pedro Basin, the Miocene sedimentary section rests on schist and volcanics and is estimated to be 3,000 feet (914 m) thick (Fig. 3). This sedimentary section seems to thin basinward (southwestward) and may not be present beneath the central deep or on parts of the southwest flank of the basin. As much as 5,000 feet (1586 m) of Pliocene strata are believed to overlie volcanic rocks and/or schist basement in the

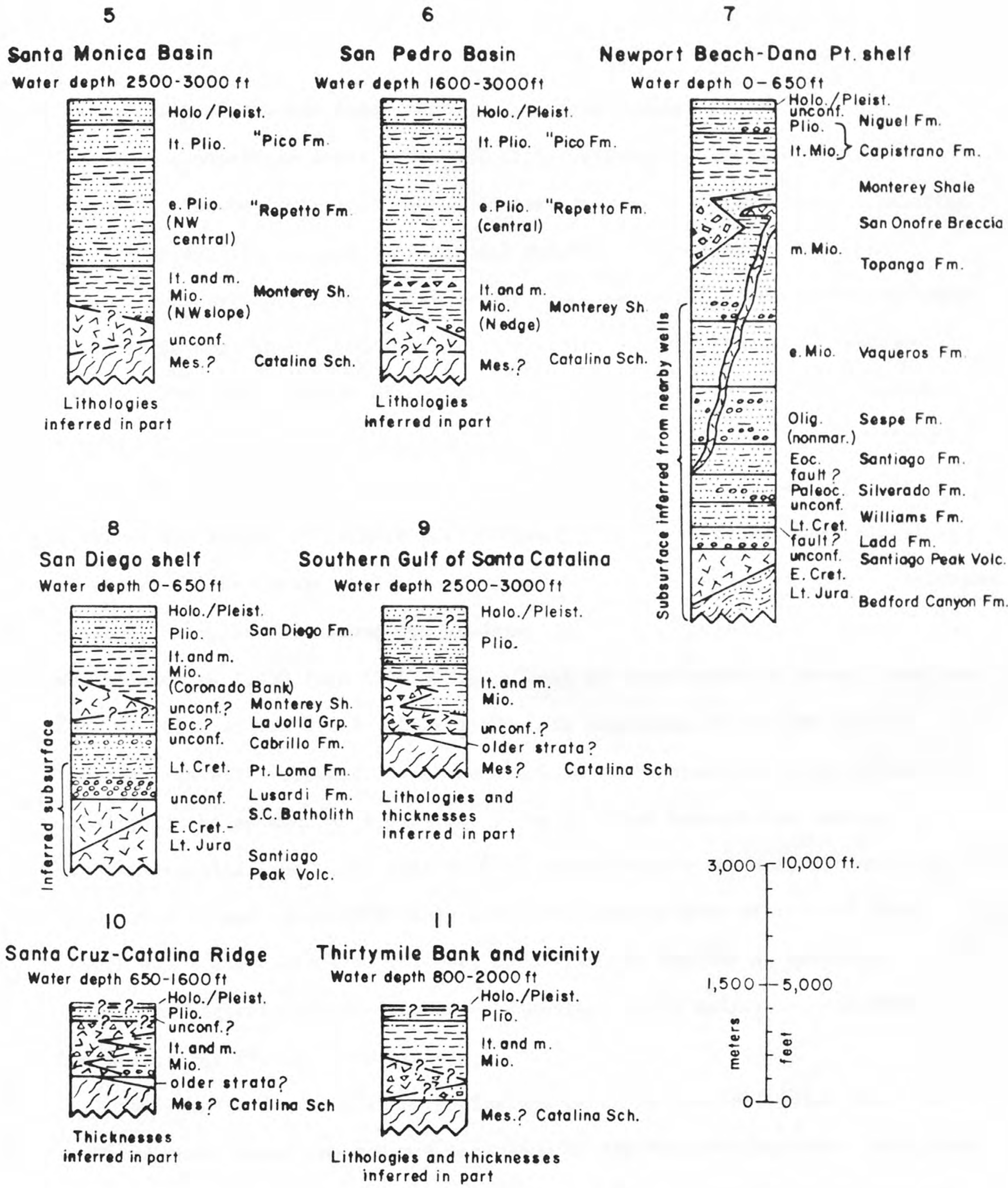


Figure 5. Stratigraphic columns, inner basins and banks. Provincial chronologies and named stratigraphic units are shown to the right of each column. The rock types are generalized and depicted by lithologic symbols.

central part of the San Pedro Basin (Junger and Wagner, 1977).

In the nearshore shelf area east of the offshore extension of the Newport-Inglewood fault zone, Upper Cretaceous and Paleogene strata consisting chiefly of sandstone, conglomerate, and mudstone unconformably overlie crystalline basement rocks. Near Laguna Beach, this pre-Miocene stratigraphic sequence is more than 7,000 feet (2134 m) thick in the subsurface sections on shore; and in the vicinity of San Diego, approximately equivalent strata are estimated to have a maximum thickness of 5,000 feet (1524 m). Nearly 11,000 feet (3353 m) of Miocene sandstone, shale, conglomerate, and breccia beds underlie the shoreline between Newport Beach and Laguna Beach, but equivalent strata on the San Diego shelf are thin or absent as a result of post-depositional erosion. Pliocene siltstone and sandstone units with minor conglomerate lenses are as much as 1,000 feet (305 m) thick east of Dana Point and about 1,250 feet (381 m) thick at San Diego. Relatively thin sequences of Miocene shale interlayered with volcanic flows are overlain by Pliocene silts and sands that locally may be as much as 4,000 feet (1219 m) thick beneath the central Gulf of Santa Catalina and 2,000 feet (610 m) thick beneath the central San Diego Trough. A Bouguer gravity anomaly along the eastern part of the San Diego Trough and western flank of Coronado Bank (Fig. 6) implies an eastward-thickening sequence of pre-Pliocene sedimentary rocks and/or low-density basement rocks (Beyer, in press).

The structure of the inner basins and banks is complex; folds near the mainland coast along the seaward extension of the Newport-Inglewood fault zone are comparatively small and steep-flanked, and faults occur both as zones of en echelon breaks or as single traces. Most folds and faults are oriented northwest. Some large, fault-bounded antiform structures, such as Coronado Bank, are broad and nearly symmetrical but little is known about their

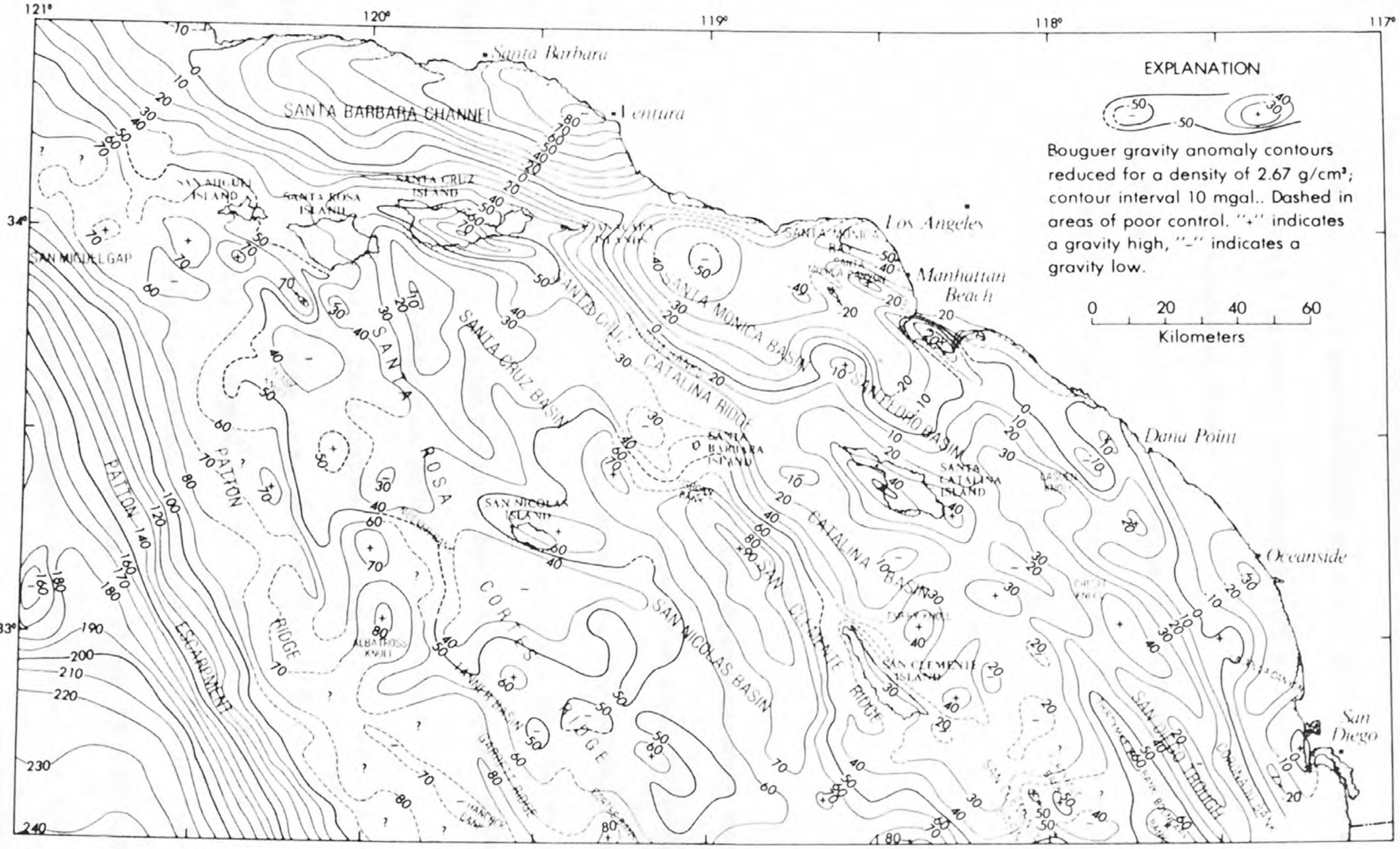


Figure 6. Bouguer gravity map of offshore southern California. From Beyer (in press).

development. Faults range in age from middle Miocene to Quaternary and presumably include those with strike-slip as well as dip-slip separations. The age of the small folds probably is restricted primarily to post-late Miocene to pre-late Pleistocene time.

Borderland, outer basins and banks--The outer borderland consists mainly of paired, northwest-trending, pre-Neogene lithologic belts that are blanketed by Miocene and younger strata. These two paired belts are correlated with the Franciscan complex and Great Valley sequence of northern and central California (Vedder and others, 1976; Crouch, 1978, 1979; Howell and Vedder, in press). Franciscan rocks form the acoustic basement underlying the continental slope and Patton Ridge and are characterized by compressional velocities of 5.1 to 6.1 km/s, discordant and discontinuous seismic reflectors, and diverse rock types that range from zeolite-bearing sandstones to blueschists. The Great Valley belt underlies the Santa Rosa-Cortes Ridge and Santa Cruz and San Nicolas Basins. In contrast to the Franciscan rocks, the Great Valley rocks are characterized by compressional velocities of 4.5 to 4.6 km/s, concordant and continuous seismic reflectors, and thick turbidite sequences of unmetamorphosed Cretaceous and Paleogene strata.

Low-grade metamorphic rocks that presumably are related to those exposed on and around Santa Catalina Island and in the Palos Verdes Hills have been sampled at numerous localities within the borderland south of the northern group of Channel Islands and west of Santa Catalina Island and the San Diego Trough. These schistose rocks are known to be present as far south as Sixtymile Bank. Arkosic wacke and argillite similar to Coastal belt Franciscan and "Knoxville" rock types occur southeast of San Nicolas Island, west of Tanner Basin, and from the northern Patton Ridge. Schistose rocks that resemble the Catalina Schist form the crest of a low, northwest-trending ridge about 5 miles southwest of Santa Rosa Island. Serpentine and metamorphosed ultramafic intrusive rocks much like those on Santa Catalina Island were recovered from the northern Patton Escapment and from the saddle on the ridge between Santa Barbara Island and San Clemente Island. On Santa Cruz Island, south of the median fault, greenschist-facies rocks of the Santa Cruz Island Schist are intruded by plagiogranite and diorite that have been dated at about 140 and 160 m.y; respectively.

South of the northern group of Channel Islands, seafloor outcrops of Cretaceous strata are sparse, and definite Lower Cretaceous samples have not been reported. Inasmuch as Upper Cretaceous strata were penetrated in wells on Santa Cruz and Santa Rosa Islands, they probably are present in the subsurface section immediately south of these islands. Mobil Santa Rosa No. 5 well drilled south of the median fault on Santa Rosa Island spudded in Eocene strata and bottomed in Upper (?) Cretaceous sedimentary rocks at a depth of 11,003 feet (3356 m). It seems likely that an Upper Cretaceous sedimentary section underlies Eocene strata on the San Nicolas Island platform. From there, these strata probably continue southeast beneath the Santa Rosa-Cortes Ridge into West Cortes and Velero Basins. Siltstone of Late Cretaceous age recently was sampled near the northwest end of Cortes Bank (Vedder and others, 1979). Nearly 4,000 feet (1219 m) of Late Cretaceous turbidites (Fig. 7) were penetrated in a deep stratigraphic test well (OCS-CAL 75-70 No. 1) near the southeast end of Cortes Bank. Cretaceous sedimentary rocks also are present in the vicinity of Nidever Bank and on Garrett Ridge.

Lower Tertiary rocks are sparsely distributed as seafloor outcrops on the outer borderland. Paleocene strata occur on the northwesternmost part of the Santa Rosa-Cortes Ridge and may be exposed on the shelf west of San Miguel

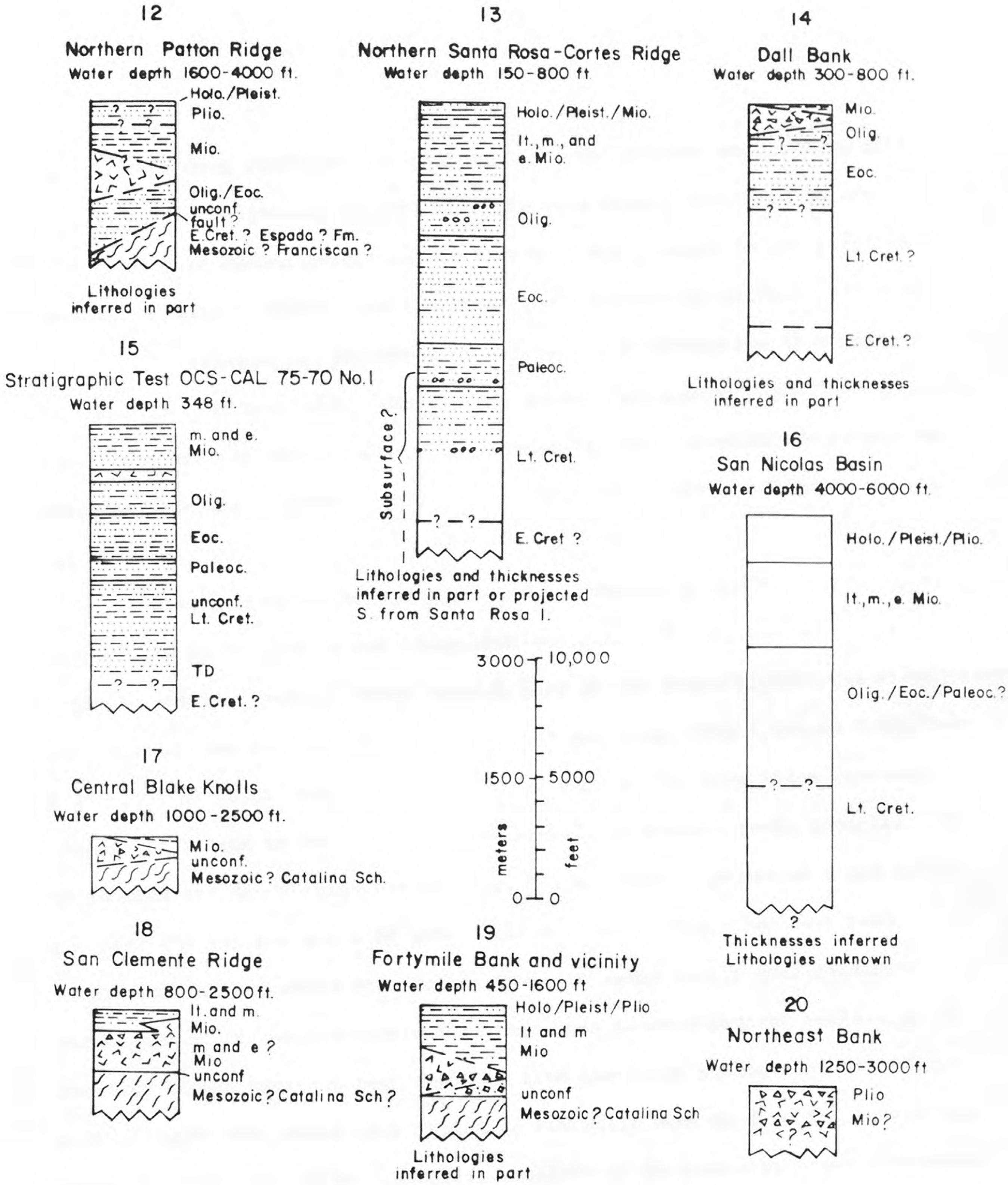


Figure 7. Stratigraphic columns, outer basins and banks. Provisional international chronologies are shown to the right of the columns. Most stratigraphic units are unnamed. Rock types, where known, are generalized and depicted by lithologic symbols. Except for the OCS-CAL 75-70 No. 1 well, thicknesses are estimated from acoustic-reflection profiles.

Island. The deep stratigraphic test well on southeastern Cortes Bank drilled through marine Oligocene, Eocene, and Paleocene strata (Paul and others, 1976). Beds of Eocene sandstone and claystone are present on the platform west of San Miguel Island, and the broad shelf around San Nicolas Island is underlain by interbedded sandstone and siltstone of Eocene age that extends northwest beyond Begg Rock. Correlative strata undoubtedly constitute a thick subsurface section southward from Santa Rosa Island. Oligocene sandstone and mudstone beds are exposed on Cortes and Tanner Banks and at places along the Patton Ridge.

The distribution of Eocene rocks in the subsurface section of the outer part of the borderland is not known with certainty, but strata of this age probably underlie younger rocks beneath most of the Santa Rosa-Cortes Ridge northwest of San Nicolas Island, where they may range from 4,000 to 7,000 feet (1219-2134 m) thick, and they extend under much of the same ridge southeast beneath Dall Bank to Tanner and Cortes Banks. Equivalent rocks underlie both Santa Cruz and San Nicolas Basins (Fig. 7), and they thin eastward and wedge out near the eastern edges of these basins. Even though they have been sampled no farther south than Cortes Bank, it seems likely that Paleogene strata extend far southeastward from that area beneath younger rocks. Early Tertiary strata have not been reported from the ridge system that extends southeastward from Santa Cruz Island to Sixtymile Bank or from the basins and banks directly east of it. However, remnants of Paleogene or Upper Cretaceous siltstone, sandstone, and conglomerate are intruded by Miocene igneous rocks at the southeast end of Santa Catalina Island (Vedder and Howell, 1979).

Much of the crest of the Santa Rosa-Cortes Ridge southward from Santa Rosa Island and northward from Begg Rock is composed of silty claystone of early Miocene age. Strata of the same age and similar composition are present on the shelf west of San Miguel Island and in the vicinity of Tanner and Cortes Banks. Correlative sedimentary rocks presumably blanket most of the Santa Rosa-Cortes Ridge southeast of the San Nicolas Island salient and underlie parts of Patton Ridge and the intervening basins. Sandstone of possibly early Miocene age occurs at Sverdrup Bank, Dall Bank, and the Cortes-Tanner Banks area.

Fine-grained strata of middle Miocene age, predominantly shale and claystone, form large expanses of the Santa Rosa-Cortes Ridge southeast of Santa Rosa Island and between San Nicolas Island and Santo Tomas Knoll. Shaly beds of the same age occur on the shelf west and northwest of San Miguel Island, on Santo Tomas and Shepard Knolls, on Garrett and Patton Ridges, and on ridges east of the northwestern part of Long Basin. Diatomaceous shale of middle and late Miocene age is locally present on and around San Clemente Island, in the vicinity of Santa Barbara Island, at Santa Catalina Island, and near Fortymile Bank. Coarse-grained sedimentary rocks of middle Miocene age seem to be sparse seaward of the mainland and northern island shelves. Strata of late Miocene age, chiefly diatomaceous mudstone, are more restricted than the middle Miocene strata along the outer ridges but are inferred to drape the slopes and pass beneath younger sediments that floor the outer basins.

These Miocene sedimentary sequences may attain thicknesses of 5,000 feet (1525 m) or more in some of the larger outer basins and may contain turbidite sands (Crouch and others, unpublished data). Some of the thinnest sections of Miocene strata are believed to be in the Southern end of the Catalina Basin and in the region of Thirtymile and Fortymile Banks, where volcanic and basement rocks are exposed on the seafloor or are shallowly buried.

One of the commonest rock types on the borderland is volcanic rock, most of which is early and middle Miocene in age. Because these igneous rocks represent diverse conditions of emplacement ranging from aquagene tuffs and thick, extensive flows to local narrow, near-vertical intrusions and sill-like bodies, it is difficult to predict their volume and distribution. They are widespread along Santa Cruz-Catalina Ridge and San Clemente Ridge and around Santa Barbara Island and Fortymile Bank. Volcanic rocks are not as abundant on the Santa Rosa-Cortes Ridge although they form Northeast Bank and parts of Cortes and Tanner Banks. Along the Patton Ridge-Patton Escarpment, volcanics have been dredged at a number of sites, and their abundance seems to increase southward.

Exposures of Pliocene sedimentary rocks are much less common than Miocene strata on the outer borderland shelves and slopes and seem to be restricted primarily to the deep basins. Seaward of the islands, Pliocene strata have been recorded at only a few places in water less than 1,500 feet (457 m) deep. Estimates of thickness range from close to 2,000 feet (610 m) in the central parts of Santa Cruz and San Nicolas Basins to less than 500 feet (152 m) on the flanks. Thicknesses of Pliocene strata in the Catalina Basin generally are less than 1,000 feet (305 m). At DSDP Site 467 in San Miguel Gap, early Pliocene sands are overlain by Pliocene and younger hemipelagic strata. The predominant rock types among Pliocene samples are semiconsolidated mudstone, unconsolidated mud, and minor amounts of sand. Redeposited sediment in the form of slumped material or turbidites derived from bordering ridges, banks, and islands probably is present in the Pliocene sections of many of the basins.

Faults on the outer borderland show different kinds of slip and have varying ages. The dominant trend is northwest, but there are two conspicuous east-west zones; one in the vicinity of the northern group of Channel Islands, and the other south and east of San Nicolas Island. Strike-slip is indicated on some, such as the San Clemente fault; and normal and reverse displacements are indicated on many, such as faults along the southeastern edge of Santa Cruz Basin (Junger 1976, 1979). The ages of movement interpreted from acoustic-reflection profiles range from pre-Pliocene to Quaternary. Recurrent movement probably has occurred on many of these offshore faults. Pre-middle Miocene thrust faults are inferred in the basement rocks of Santa Catalina Island.

In general, large anticlines trend west-northwest at angles oblique to the major fault zones and at places seem to be arranged en echelon. Many are very large and symmetrical and have low dips on their flanks. Examples are those that underlie Tanner Bank and the San Nicolas Island platform. Along major upwarps such as the Santa Rosa-Cortes Ridge, numerous small folds are superimposed on the larger feature but seem to die out basinward. In many places, topographic highs reflect anticlinal structures. Broad, downwarped structural lows form both Santa Cruz and San Nicolas Basins. Some anticlines deform sediments as young as Pleistocene, as in the central San Nicolas Basin; others probably are as old as Miocene, as the main anticlinal structure on northwestern Santa Rosa-Cortes Ridge, where Miocene strata truncate Paleogene strata on both limbs. An unconformity between middle Miocene and late middle Miocene sequences on the flanks of central Santa Rosa-Cortes Ridge and on the crest of Patton Ridge suggests a widespread episode of deformation in middle Miocene time in the outer borderland.

PETROLEUM GEOLOGY

Distribution and Characteristics of Petroleum in Adjacent Developed Areas

The offshore areas in proposed OCS Lease Sale 68 are adjacent to the two largest petroleum basins in the California coastal province west of the San Andreas fault. The borderland south of 34°N latitude has an inner basin area that is, in part, an extension of the Los Angeles basin. The Santa Barbara Channel between 34° and 34°30'N latitude is the offshore continuation of the Ventura basin. Other offshore basins, however, have stratigraphic and structural characteristics that differ from those that have onshore counterparts.

As of January 1, 1975, the cumulative production from all onshore California coastal basins totaled 9.9 billion barrels of oil (11.8 billion barrels of oil + gas expressed as BOE [Barrels of Oil Equivalent]). The remaining oil reserves, plus indicated reserves, from proven fields are estimated at 2.3 billion barrels (API, 1975). Production from the coastal basins is more than half of all the petroleum found in onshore California. According to Taylor (1976), the distribution of oil resources decreases from south to north as follows: Los Angeles basin (6.7 billion bbls.); Ventura basin (2.0 billion bbls.); Santa Maria (0.6 billion bbls.); Cuyama (0.3 billion bbls.); and Salinas and the north coastal basins (0.3 billion bbls.). Petroleum is concentrated in young reservoirs with 87 percent from late Miocene or younger rocks, 5.3 percent from middle Miocene, 4.7 percent from early Miocene, 2.8 percent from Oligocene, and 0.2 percent from Eocene strata. In each of the basins, most of the known petroleum occurs in a few fields. Five giant fields account for over 52 percent of all the petroleum produced from these basins, and 24 fields, each with cumulative production greater than 75 million barrels, account for over 86 percent (8.5 billion bbls. of oil). Approximately 80 percent of the petroleum is from turbidite sandstone reservoirs, 10 percent from shallow-water sandstone, 5 + percent from fractured siliceous shale, and 5 percent from nonmarine sandstone and conglomerate beds and fractured schist basement. Most of the fields are in faulted anticlinal traps of post-Miocene age; a few are in homoclines against major faults. Only two fields (of those larger than 20 million bbls.) are stratigraphic traps; both are in the Santa Maria basin.

The Ventura basin and its seaward extension, the Santa Barbara Channel, produce from reservoirs of Eocene through Pleistocene age. Total production amounts to 2.0 billion barrels of oil (2.6 billion barrels oil + BOE). The basin differs from both the Santa Maria and Los Angeles basins in that a thick section of Upper Cretaceous and lower Tertiary beds underlies younger strata. These older rocks are believed to contain the source beds for dry gas and account for the high gas-oil ratios that are nearly twice as high in this basin as those in other California basins (Taylor, 1976). Furthermore, almost all of the petroleum in the coastal basins from Eocene and Oligocene reservoirs is from the Ventura basin, but this amounts to only 0.35 billion barrels oil plus gas as BOE. Over half of all production in the basin has come from an anticlinal trend over 25 miles long that includes the Ventura field on the east and the Dos Cuadras field in the Federal OCS to the west. Most of the production from this structural trend is from turbidite sandstone reservoirs of early Pliocene age.

The Los Angeles basin has produced 66 percent of the petroleum in the California coastal basins. The source of this oil is believed to be the thick, organically rich Miocene and younger strata that extend throughout most of the basin. Eight of the ten largest fields in the coastal basins are in the Los Angeles basin (Wilmington, Long Beach, Huntington Beach, Santa Fe Springs, Brea-Olinda, Inglewood, Dominguez, and Coyote West). Of these, two extend offshore, and produce from deep-water turbidite sandstone sequences with net sand thicknesses exceeding 1,000 feet (305 m). All are structural traps, either anticlinal or homoclinal against major faults, and many are situated along regional structural highs such as the Newport-Inglewood trend.

Appraisal of the OCS Potential

Santa Barbara Channel--As a result of exploratory drilling following the OCS sale in 1968, the Santa Barbara Channel is relatively well known. Large areas leased in OCS Lease Sale 48 are in the central and deep parts of the channel and in the waters to the west. Twenty-four tracts along the south edge of the channel were eliminated from OCS Lease Sale 48 by the Secretary of the Interior, primarily because of environmental concerns. Shows of oil and gas in deep stratigraphic test well OCS-CAL 78-164 No. 1 west of Point Conception (Menard, 1978) attest to the presence of petroleum source rocks at or near the well site. In addition, high temperature gradients measured in the well, coupled with data on vitrinite reflectance and organic geochemical studies indicate a high oil-generating capacity.

Reservoirs, chiefly sandstone beds in the Sespe Formation, that produce from beneath the Oxnard Plain east of the channel, are potential reservoirs south of the seaward extension of the Oak Ridge fault. Other possible reservoirs benath the channel are sandstone zones in the early Miocene section, fractured shales of the Monterey Formation, and inferred post-late Miocene sandstone zones. Eocene and older sandstone zones are present but may not be primary objectives. Well data on recently discovered reservoirs in the offshore Santa Clara and Oak Ridge units are confidential.

In the central deep part of the channel and westward to the 750-meter (2461 feet) isobath potential reservoirs are expected to be similar to the late Miocene or older reservoirs in the Santa Ynez Unit. Some potential reservoirs may be present in Pliocene rocks west of Point Conception and in some of the outer basins. Thick sandstone beds in the Rincon Formation, known only in the South Elwood field (Dames and Moore, 1974), form the main reservoir in that field. The fractured shale there is less important, yet is a significant prospect because of its widespread occurrence. The nonmarine Sespe Formation grades westward into a shallow-marine facies in which potentially high quality sandstone reservoirs may be present. In the same area, the early Miocene Vaqueros Formation, the main sandstone reservoir in the coastal area west of Santa Barbara, generally is thin, but local thickening may occur. Eocene sandstone zones probably are thin-bedded distal turbidites with low reservoir potential; similar sandstones have poor productive history onshore.

Within the channel, the main Pliocene turbidite reservoirs are believed to be restricted to the northeastern edge in the Dos Cuadras field and areas to the east of it. Because these sandstone zones thin abruptly southward and westward, they are considered poor prospective reservoirs in the central part of the channel.

The main source rocks are believed to be the Miocene shales that are buried deeply enough over most of the basin to have become thermally mature. Structural traps similar to those in leased areas may be present in the unleased areas.

Southern California Borderland (OCS)--OCS Lease Sales 35 and 48 held in December, 1975, and June , 1979, respectively, included much of the available area to and beyond the 750-meter (2460 feet) water depth. Much of the nearshore area adjacent to the Los Angeles basin has been leased with the exclusion of Santa Monica Bay. However, only one field, Beta in San Pedro Bay, has been developed. Twenty-six tracts offshore from San Diego County were eliminated from OCS Lease Sale 48 by the Secretary of the Interior, primarily because of environmental concerns. Appraisals of the petroleum potential of the entire borderland recently have been prepared (Vedder and others, 1976; Taylor, 1976) and supplemented by information from the deep stratigraphic test wells, OCS-CAL 75-70 No. 1 at Cortes Bank (Paul and others, 1976) and OCS-CAL 78-164 No. 1 west of Point Conception (Cook and others 1979).

In the outer basin area seaward of the Channel Islands, the deep test well at Cortes Bank provided data that seemed to enhance the petroleum potential of this part of the borderland; yet exploratory drilling done since OCS Lease Sale 35 at Dall Bank, Tanner Bank, and Cortes Bank has been discouraging. The distribution of potential reservoir sandstones seaward from Cortes Bank is unknown. Potential source rocks occur in strata of late Eocene and Miocene age in OCS-CAL 75-70 No. 1 well. Organic matter in all analyzed Tertiary rocks is immature, but the same rocks might have generated petroleum in adjacent basins if sufficiently buried to have been subjected to high temperatures. Upper Cretaceous strata, known only from three widely scattered seafloor areas of the borderland, are more than 5,000 feet (1524 m) thick in the OCS-CAL 75-70 No. 1 well at Cortes Bank; but reservoir-quality rocks are present only in the upper part, and the source-rock potential is low. The lower 3,000 feet (914 m) of section in the well, below an unconformity or fault within the Upper Cretaceous strata, contains small amounts of mature organic matter. An exploratory well drilled 8 nautical miles (15 km) northwest of Santa Barbara Island proved unproductive.

Acoustic-reflection profiles and sonobuoy refraction data (Fig. 8) (Crouch and others, 1978) indicate that thicknesses of Miocene strata may be 5,000 feet (1525 m) or more in some of the larger outer basins and geochemical analyses of Miocene samples from DSDP Site 467 and scattered bottom samples (Taylor, 1976) indicate that these strata may have a high source rock potential. Moreover, late middle Miocene through Pliocene strata within these basins may include potential reservoir rocks in the form of sandy turbidites., For example, DSDP site 467 in San Miguel Gap penetrated late middle Miocene and early Pliocene sands (Haq, Yeats, and others, 1979). Pliocene and younger hemipelagic strata that overlie these potential reservoir rocks are as much as 3600 feet (1100 m) thick at places in the outer basins (Fig. 9). Water depths in these basins, however, generally are more than 3,600 feet (1100 m).

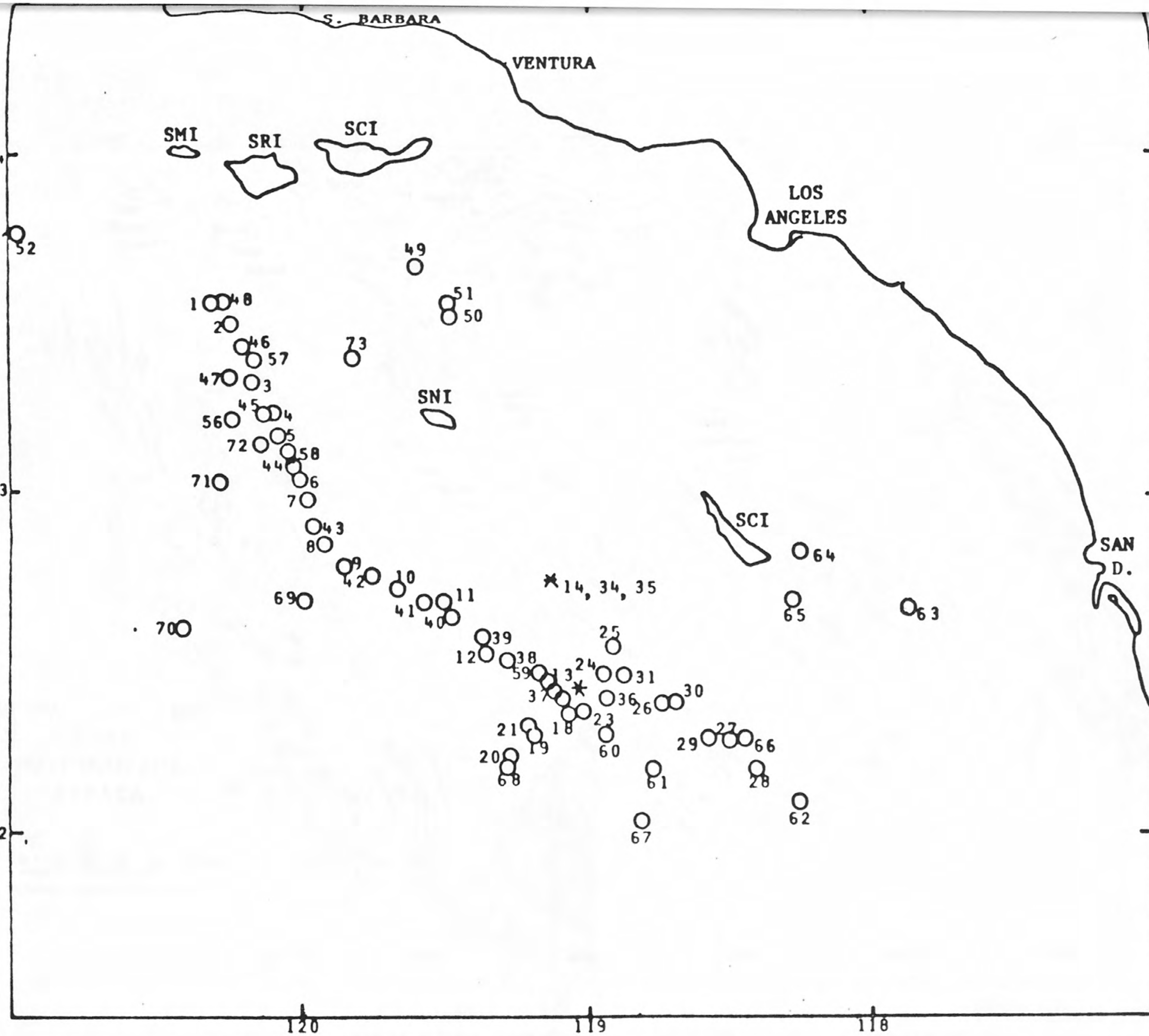


FIGURE 8 Location of sonobuoy refraction stations southern California borderland.

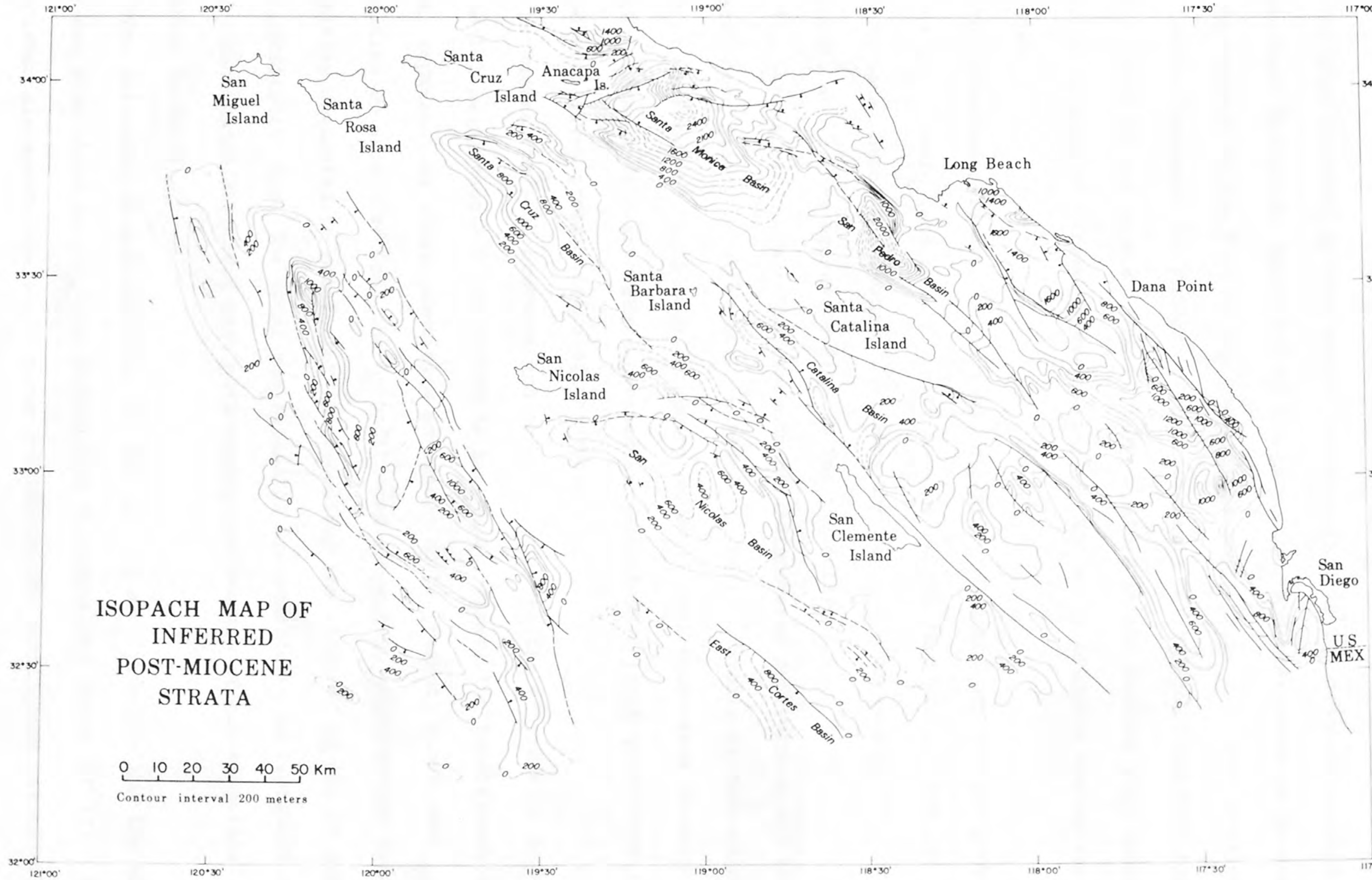


Figure 9. Revised isopach map of inferred post-Miocene strata. Modification and extension of an earlier map (Vedder and others, 1974) are based upon revisions in the San Diego Trough area and new data in the Patton Ridge-Patton Basin area. May include late Miocene and late Middle Miocene strata in some places.

Petroleum Resource Appraisal

The area included in this report, as described in the sections devoted to the geologic framework, appraisal of OCS potential, and environmental hazards, extends seaward to the foot of the continental shelf (Fig. 1). That portion specifically assessed for undiscovered recoverable oil and gas resources has a seaward limit at the 2500 m isobath, and therefore at the western edge excludes a very small area of extremely deep water (> 2500 m) of probable negligible potential.

The proposed sale area is divided into three distinct oil and gas provinces: (1) the Inner basin (and banks), (2) the Outer basins (and banks), and (3) the Santa Barbara Channel. Resource estimates are reported for each of the three provinces, as well as aggregate figures for the entire area.

The estimates represent assessments of undiscovered recoverable oil and gas, and are those quantities that are considered to be recoverable at current conditions of economy and technology, assuming an additional short-term technologic growth. These assessments are expressed as estimated of least quantities associated with given probabilities of occurrences.

Estimates for each province and the aggregate for the entire area are given on the following page and are stated in two ways: first, the conditional estimates, representing those quantities estimated to be present, given that commercial quantities do exist; second, the unconditional estimates, representing those quantities estimated to exist, but incorporating the risks of no oil or gas. In this particular case, the total gas estimates are considered to represent essentially associated/dissolved gas, with negligible amounts of non-associated gas expected to occur.

The estimates of undiscovered oil and gas for each province and the entire area are also shown as complete probability distributions (Figs. 10-13). Where two curves are shown, the solid curve represents the conditional estimates, and the dashed curve the unconsolidated estimates.

Estimates of Undiscovered Recoverable Resources

Southern California, OCS Sale 68

UNCONDITIONAL ESTIMATES

		Oil (Billion bbls.)				Total Gas (TCF)			
		.95	.05	$\bar{x}$	M.P.	.95	.05	$\bar{x}$	M.P.
Inner Basins	0-2500 m	.6	2.8	1.4	1.0	.6	2.9	1.4	1.0
Outer Basins	0-2500 m	0	1.4	.4	.5 *	0	1.5	.4	.5 *
Santa Barbara Ch.	0-2500 m	.5	4.2	1.8	1.0	1.4	4.8	2.8	1.0
Total	0-2500 m	1.7	6.5	3.6	1.0	2.6	6.8	4.6	1.0

(* The odds of finding commercial quantities of hydrocarbons are particularly uncertain in frontier areas, and a marginal probability is assigned to express this risk. In this case, it is estimated that there is a 50% chance of finding commercial quantities of hydrocarbons.)

CONDITIONAL ESTIMATES

		Oil (Billion bbls.)			Total Gas (TCF)		
		.95	.05	$\bar{x}$	.95	.05	$\bar{x}$
Inner Basins	0-2500 m	.6	2.8	1.4	.6	2.9	1.4
Outer Basins	0-2500 m	.4	2.7	1.2	.3	2.7	1.2
Santa Barbara Ch.	0-2500 m	.5	4.2	1.8	1.4	4.8	2.8
Total	0-2500 m	2.2	7.6	4.4	3.2	7.7	5.4

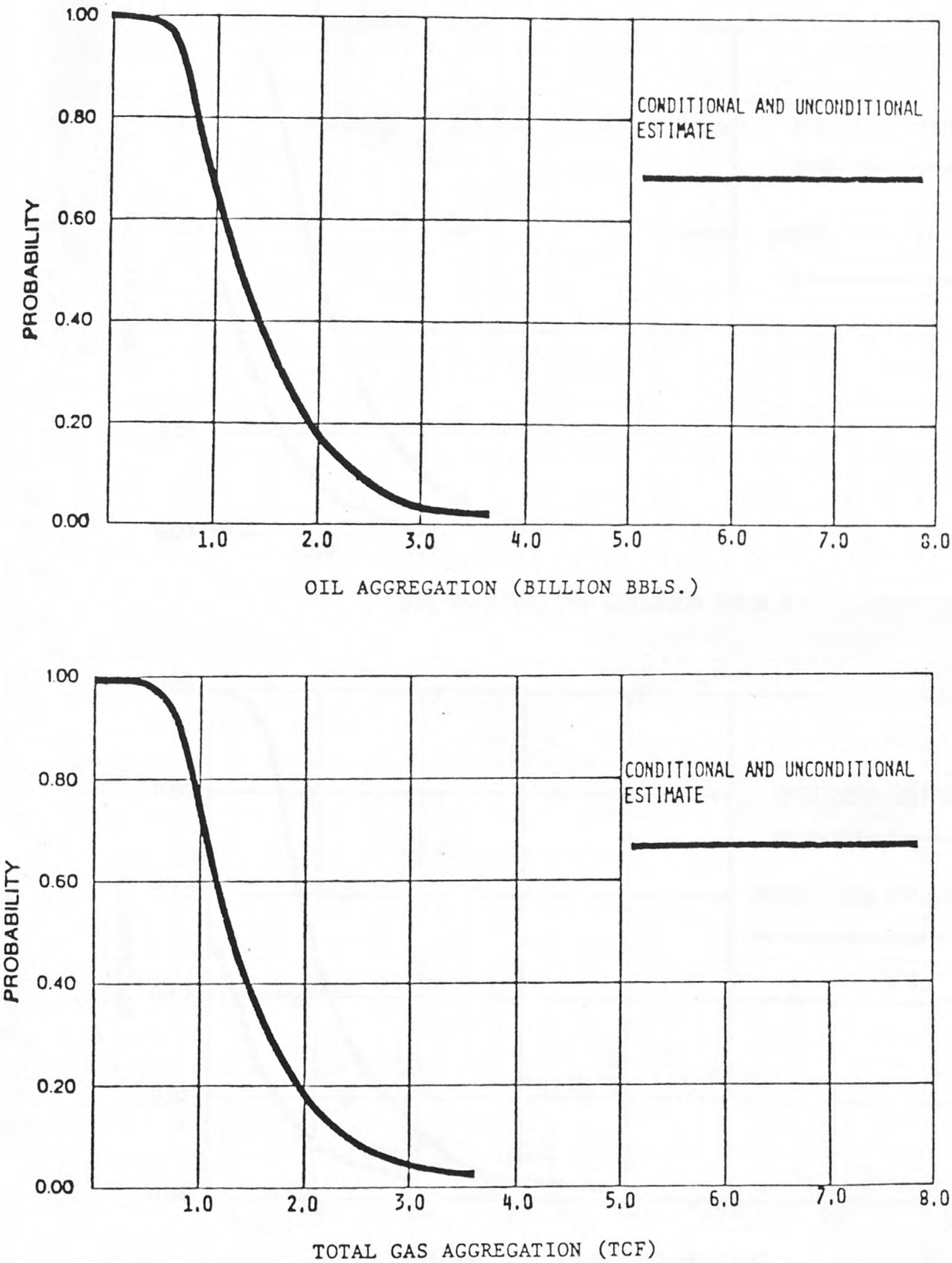


Figure 10. Probability distribution of undiscovered recoverable resources for So. California Borderlands Inner Basins (0-2500 m).

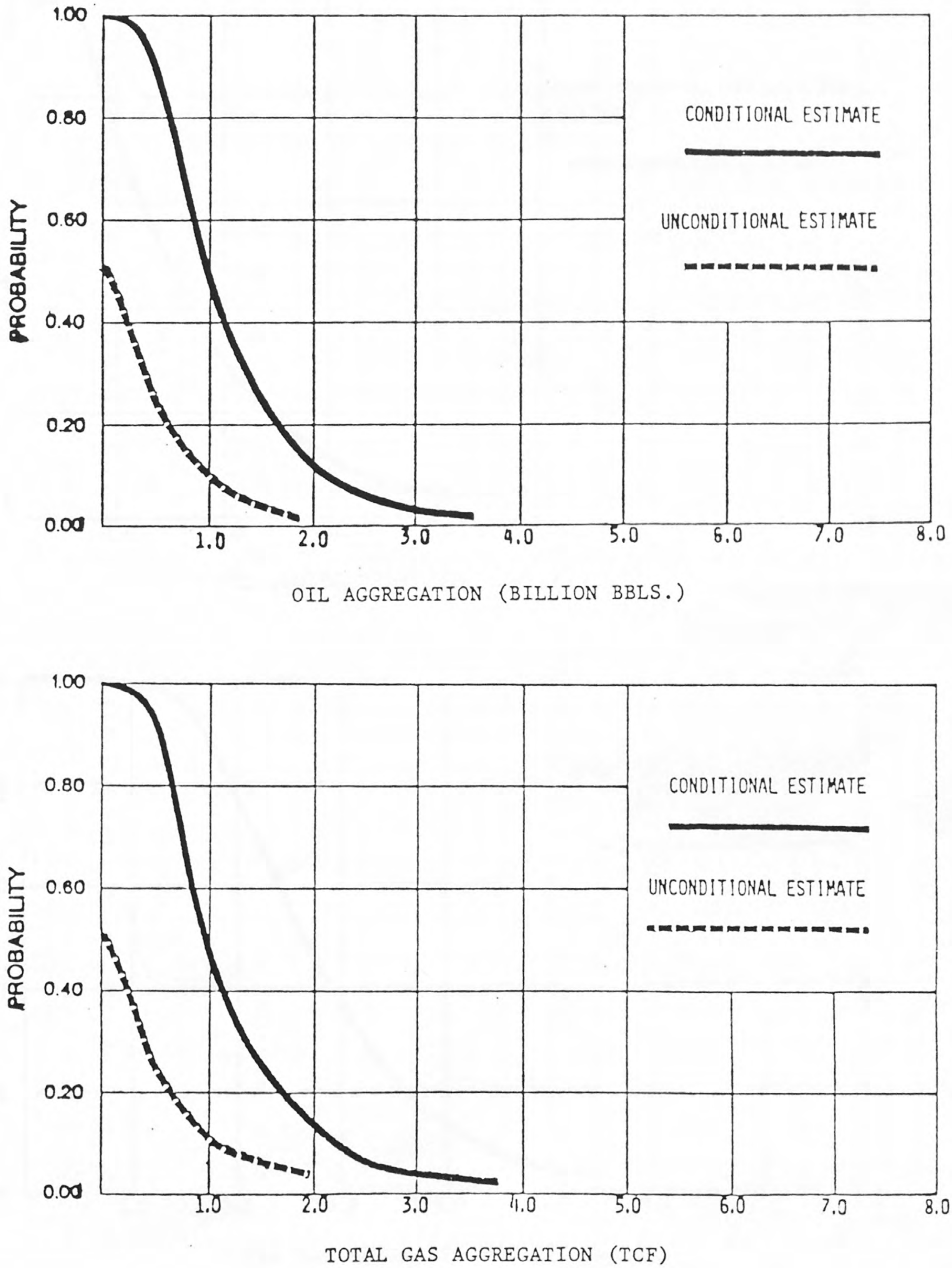
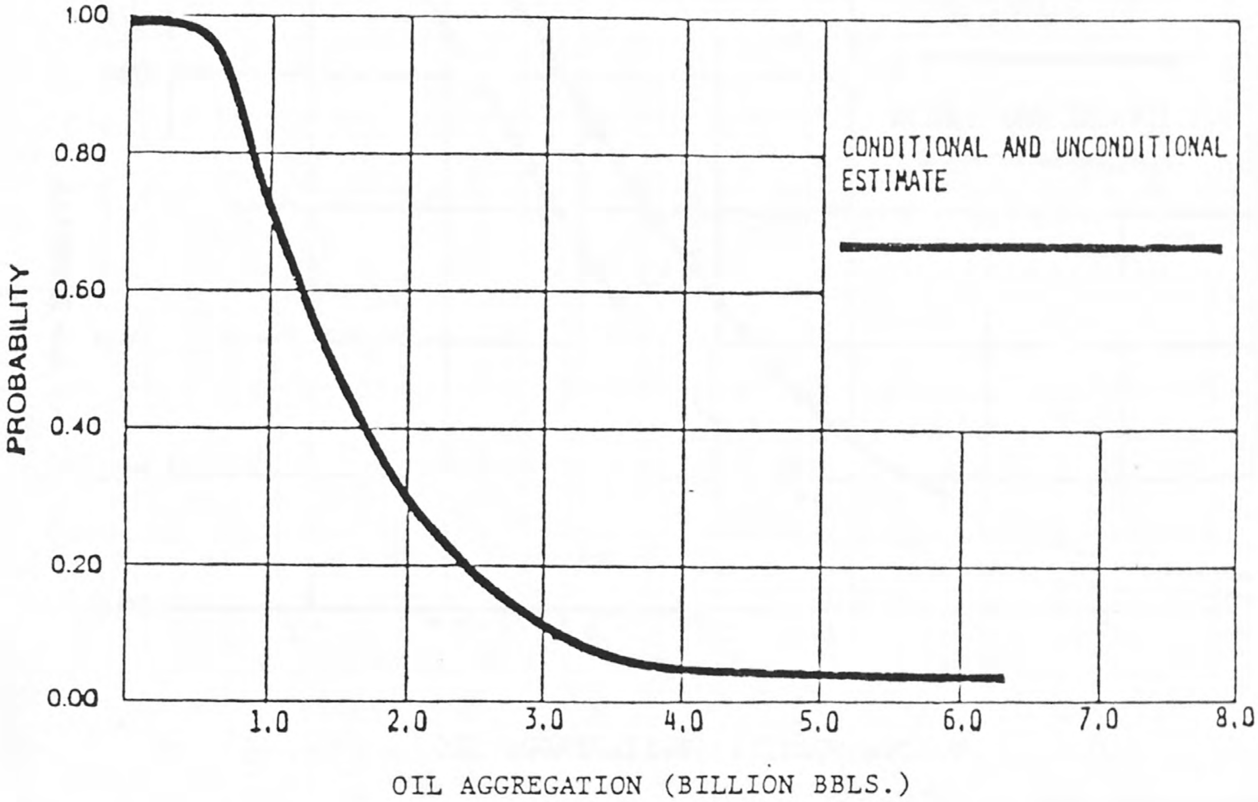


Figure 11. Probability distribution of undiscovered recoverable resources for So. California Borderlands Outer Basins (0-2500 m).



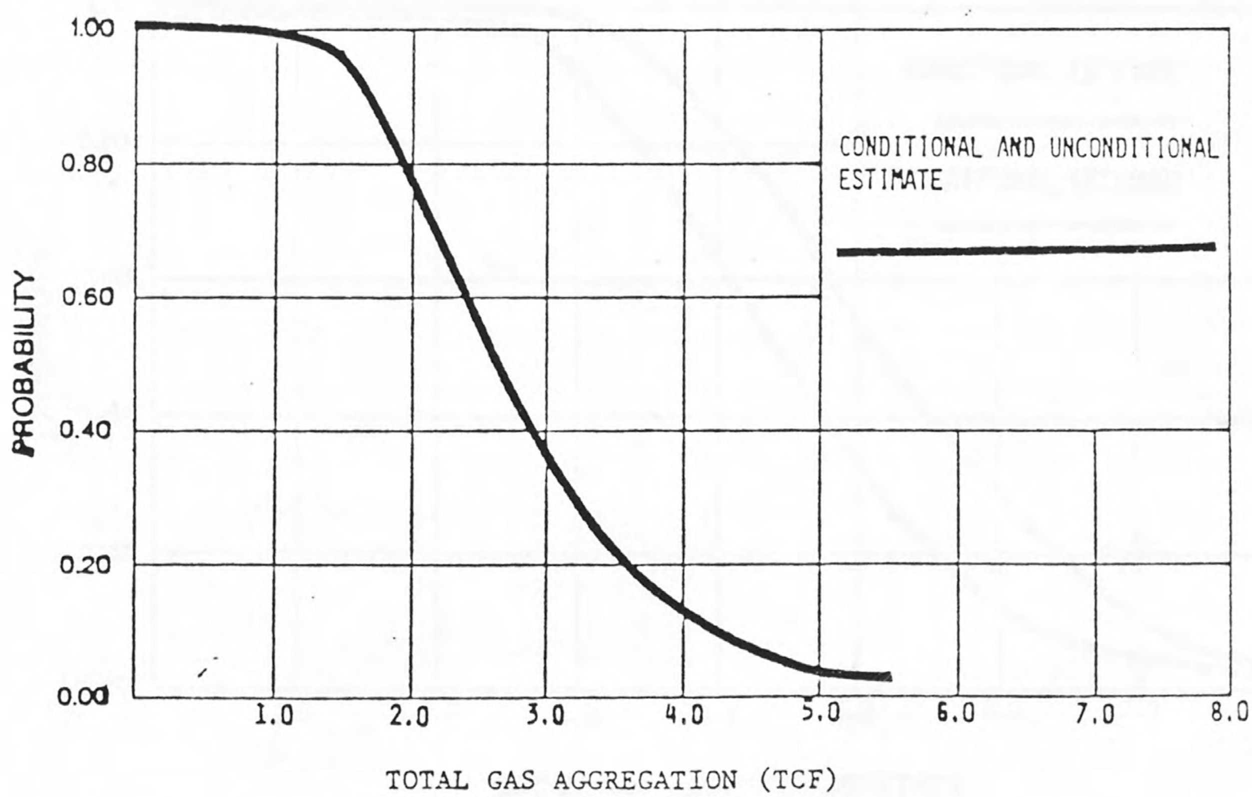
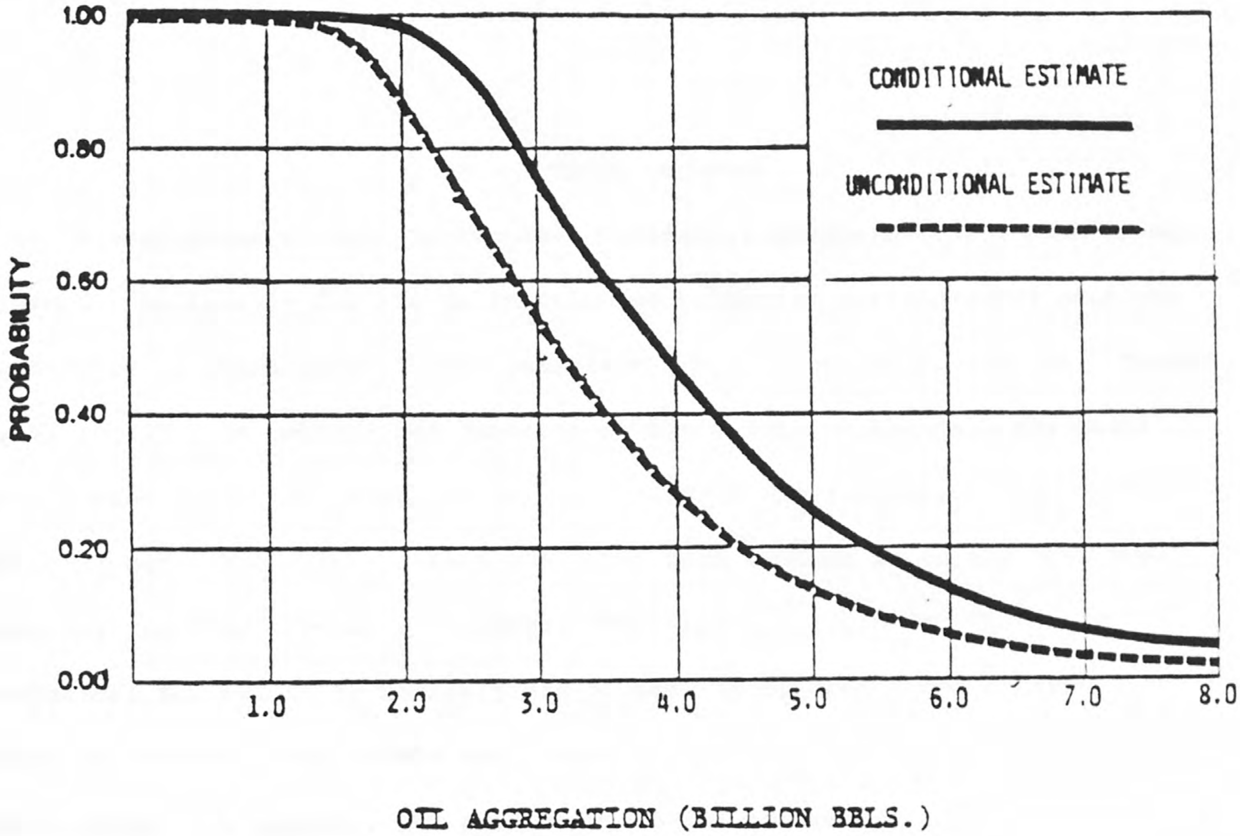


Figure 12. Probability distribution of undiscovered recoverable resources for Santa Barbara Channel (0-2500 m).



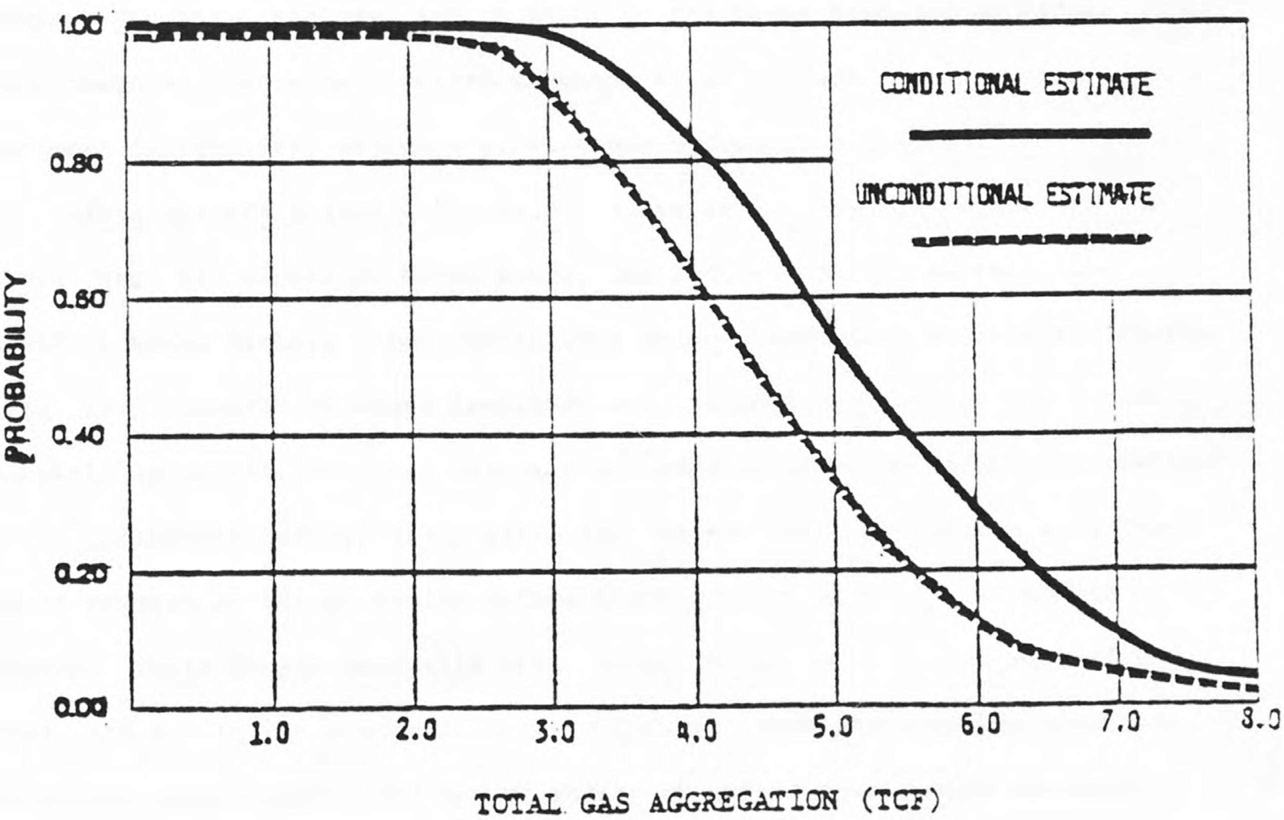


Figure 13. Probability distribution of undiscovered recoverable resources for the entire So. California Borderlands and Santa Barbara Channel (0–2500 m): OCS Sale 58, Southern California.

ENVIRONMENTAL HAZARDS

Several areas within the southern California borderland have been investigated specifically for the delineation of potential environmental problems that could be detrimental to OCS petroleum exploration and production. These areas include the western and easternmost Santa Barbara Channel, the Santa Rosa-Cortes Ridge, Santa Monica Bay, the Gulf of Santa Catalina and the San Diego Trough. Most of the areas that have been studied in detail have been publicly reported (Vedder and others, 1969; Ziony and others, 1974; U.S. Geological Survey, 1975; Campbell and others, 1975; Greene and others, 1975; Green and others, 1978; Field and others, 1977) or are being prepared for publication. In general, the published studies are restricted to the shallow parts of the Santa Barbara Channel, to the Mugu-Santa Monica, San Pedro, and Newport-San Diego shelves, and to parts of the Santa Rosa-Cortes Ridge. The environmental phenomena assessed in these areas include faults, seismicity, sediment instability, sediment erosion and hydrocarbon seeps.

Santa Barbara Channel--The major faults in the channel region are the Santa Ynez, Red Mountain, Pitas Point, Oak Ridge--McGrath, northern and southern Santa Barbara slope, Santa Cruz Island, and Santa Rosa Island faults (Fig. 14). Several of these faults or associated faults either are active or potentially active, for they displace Holocene sediment or offset the seafloor (U.S. Geological Survey, 1975, plate 7). In the Point Conception area low-angle reverse or thrust faults define three or more major thrust sheets or nappes. These faults generally trend NW-SE in the northwestern part of the area, and E-W in the southwest part, suggesting that the area has undergone east-west compression. The thrust sheets or nappes were pushed westward during late Pliocene time. Seafloor displacement along conjugate faults and

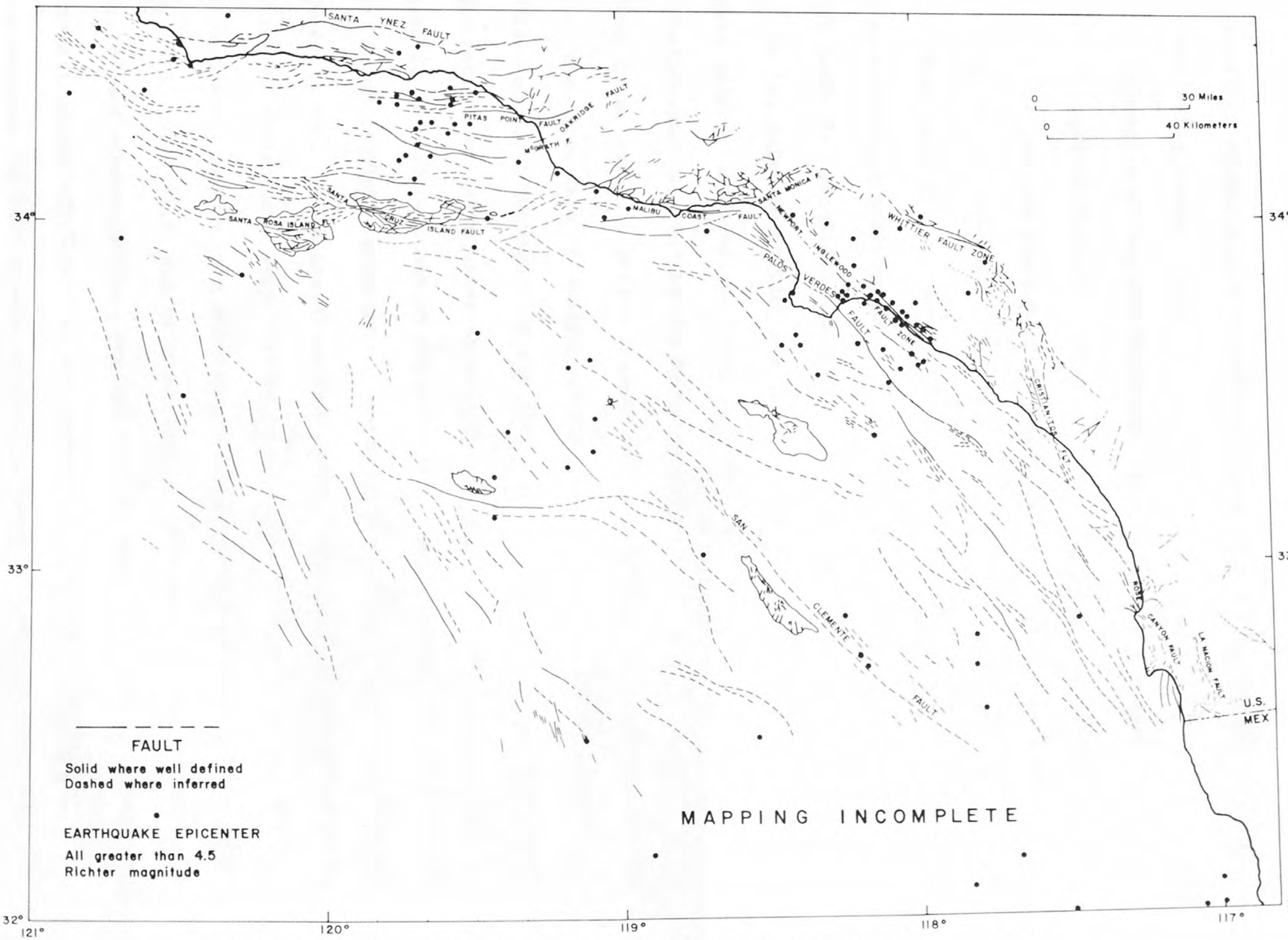


Figure 11. Map showing known and inferred faults in the coastal zone and borderland of southern California. Epicenters of earthquakes greater the Richter magnitude 4.5 are shown by solid circles for the period 1932-1973. Sources: Vedder and others, 1969; Hileman, Allen and Nordquist, 1973; Campbell and others, 1975; Greene and others, 1975; Jennings, 1975; Yerkes and Lee, 1979a; Lee and Yerkes, 1979; U.S. Geological Survey, unpublished data.

possible offset of Quaternary sediments suggest that thrusting of these nappes may be continuing today.

Many submarine slumps and landslides are present on the seafloor slopes of the Santa Barbara Channel. Most of these features are located along the mainland slope and are especially prominent between Point Conception and Goleta Point and in Hueneme Canyon (U.S. Geological Survey, 1975, fig. II-17; Greene, 1976, Fig. 4). In addition, buried disturbed strata observed in acoustic-reflection profiles at the foot of the Channel Islands platform suggest probable landsliding in the past (U.S. Geological Survey, 1975, p. II-145). In the Point Conception area a thick veneer of Pleistocene sediments is actively undergoing downslope creep and sliding.

Earthquakes recorded in the Santa Barbara Channel region indicate that the area is seismically active (Yerkes and Lee, 1979a,b; Lee and others, 1978, 1979). The epicenters of seismic events greater than Richter magnitude 4.5 that have occurred between 1932 and 1978 are shown in Figure 14. Location determinations of earthquakes in the channel prior to 1969 are imprecise because of limited coverage of the network of seismographic stations at the time. Prior to 1969, epicenter locations were probably accurate to within ± 7 miles (± 11 km). After installation of additional seismometers since 1969, location determinations were refined to ± 3 miles (± 5 km). In the Santa Barbara Channel region, six destructive earthquakes have occurred; in 1812, 1821, 1925, 1927, 1941, and at Point Mugu in 1973 (U.S. Geological Survey, 1975; Lee and others, 1979). The two largest events occurred on December 21, 1821, (est. magnitude 7 to 7.5) and November 4, 1927 (est. magnitude 7.3). The epicenters for both events are poorly known. Reports of tsunamis associated with these events indicate that they were centered somewhere in the western Santa Barbara Channel and that dipslip or landsliding occurred at the seafloor (Yerkes, written commun., 1979). Previously the maximum credible earthquake predicted for the area is one of Richter magnitude 6 with a recurrence interval of approximately 20 years (U.S. Geological Survey, 1975), however, if the estimated magnitudes of the 1821 and 1927 events are correct, this estimate is probably to low. The study by Lee, Yerkes, and Simirenko (1979) shows that epicenters are distributed along the east-trending reverse faults with clusters of relatively high seismicity in the central and northeast parts of the channel. Locally, well-located earthquakes and well-constrained fault plane solutions can be associated geometrically with specific east-trending reverse faults such as the mid-channel, Pitas Point-Ventura, Red Mountain and Anacapa faults.

Although the Santa Barbara Channel lies in a seismically active region and the physiography is such that inundation by run-up is possible, especially in the Oxnard Plain area, few tsunamis are documented. Prior to 1967, only five locally generated tsunamis had been recorded in the channel region; these were reported in Santa Barbara in 1812, 1821, 1854, 1896?, and 1927 (Iida and others, 1967; Yerkes, written commun., 1979). No extensive property damage or loss of lives were reported.

Natural hydrocarbon seeps are reported offshore from Coal Oil Point and Point Conception in the Santa Barbara Channel (U.S. Geological Survey, 1975). More than 900 individual seeps have been mapped in a 7 mi (18 km^2) area off Coal Oil Point (Fischer and Stevenson, 1973), and additional seeps occur on the northern shelf of the northern Channel Islands (Wilkinson, 1971).

Quaternary sediments apparently are being actively eroded along the mainland shelf off Carpinteria, Coal Oil Point near Gaviota, and Point

Conception (U.S. Geological Survey, 1975). Erosion and transport of Holocene sediments seems to be taking place along the sill that separates the Santa Barbara Basin from the Santa Monica Basin (Greene and others, 1978; Edwards and Gorsline, 1978).

Borderland, inner basins and banks--In the Mugu-Santa Monica and San Pedro shelf areas, detailed geophysical investigations of geology, structure, and geologic hazards have been made, and the findings are reported by Wagner and Junger (1977), Greene and others (1975), Field and others (1977). Geological environmental studies are underway for the Newport-San Diego shelf.

Two major fault zones transect the inner basins and banks area; they are the Palos Verdes Hills-Coronado Bank and Newport-Inglewood-Rose Canyon fault zones (Fig. 14). Based on offsets in the seafloor and young (Holocene) sediments, many faults associated with these zones may be active (Ziony and others, 1974; Jennings, 1975; Greene and others, 1979). Most of the active faults in the Mugu-Santa Monica shelf area are short and discontinuous. The Malibu Coast fault in the northern part of the area probably is the longest and most likely to generate major earthquakes. In the San Pedro shelf area, active faults seem to be a major geologic hazard. Probably the most important is the offshore extension of the Palos Verdes Hills-Coronado Bank fault zone, branches of which extend for 110 miles (177 km) across the Palos Verdes peninsula, San Pedro shelf and Gulf of Santa Catalina, and locally offset the seafloor. Earthquake epicenters along this zone verify its continuing activity. Many other faults that extend upward to the seafloor must be considered environmentally hazardous, as they cut beds of Holocene age (Wagner and Junger, 1977; Greene and others, 1975, plate 13; Greene and others, 1979; Fig. 1).

Areas known to be prone to submarine sliding occur in the submarine canyons and mainland slope of the entire coast from Pt. Mugu to San Diego. Large zones of mass movement have been documented on the slopes of the Hueneme-Mugu shelf (Greene and others, 1978), Santa Monica Bay (Haner and Gorsline, 1978), off Point Fermin (Greene and others, 1975) and off Dana Point. (Field and Edwards, in preparation). Unconsolidated Quaternary deposits are as much as 600 feet (183 m) thick in the vicinity of Santa Monica Bay, and most of the San Pedro shelf is covered with similar flat-lying sediments.

The inner basin and banks area is moderately active seismically (Fig. 14), and seismicity is most prominent in the offshore area between Point Mugu and Point Dume, in the vicinity of the Malibu Coast fault, along the offshore parts of the Palos Verdes Hills-Coronado fault zone, and in areas adjoining the Newport-Inglewood-Rose Canyon fault zone (Greene and others, 1975, plates 10, 13). Predictions of maximum credible earthquakes and their recurrence intervals have not been made for the inner basins and banks. Only a few locally generated tsunamis have been recorded along the coast between Point Mugu and the Mexican border and none of these caused major damage; one was noted in 1879 at Santa Monica, and two others were reported in 1925 (uncertain) and 1933 at Long Beach (Iida and others, 1967). The 1933 seismic seawave resulted from the March 10, 1933 Long Beach earthquake. Because the area is seismically active, inundation of the coastal lowlands possibly could result from tsunamis generated locally or distantly.

Oil and gas seeps have been reported in the northen part of Santa Monica Bay, along the probable extension of the Malibu Coast fault, in southern Santa Monica Bay along the probable extension of the Palos Verdes fault, and offshore between Point Vicente and Point Fermin (Greene and others, 1975, plates 10, 13). Wilkinson (1971) shows two oil seeps and one gas seep in the San Pedro shelf area.

Borderland, outer basins and banks--Few reports have been published on geological environmental problems on the outer part of the borderland and the area south of 32°N, which is included in a proposed lease sale for the first time, is largely unsurveyed. Geological hazards on the northern part of the Santa Rosa-Cortes Ridge and Tanner-Cortes Banks are described by Greene and others (1975), Field and Clarke (1979), Field and Richmond (in press), and Nardin and others (1979); a detailed analysis of the central part of Santa Rosa-Cortes Ridge and San Nicolas platform is in preparation.

The longest Quaternary fault mapped in the outer basins and banks area is the San Clemente fault; the northwestern segment is 50 miles (80 km) long and the southeastern segment, more than 15 miles (24 km) long (Jennings, 1975). Recent submersible dives in the vicinity of this fault, off the southern end of San Clemente Island provided data on recent seafloor breaks that may be associated with movement on the San Clemente fault. Many other smaller faults cut the area, and some apparently are active (Fig. 14). The Santa Rosa-Cortes Ridge in particular seems to be tectonically unstable. Faults are common along the ridge crest where relatively small apparent vertical separations are characteristic (Greene and others, 1975, plate 5; Field and Richmond, in press). Beneath the flanks of the ridge, faults are less numerous but are longer and have greater apparent vertical separations than those on the crest. Seafloor offsets above displaced seismic reflectors suggest that some faults are active. In the Tanner-Cortes Banks area, faults are concentrated along the northern flank of Cortes Bank and along the southern edge of the ridges and troughs between the two banks (Greene and others, 1975, plate 2). Many of these faults displace either Holocene sediments or the sea floor.

Numerous submarine slumps and sediment slides have occurred along the flanks of the Santa Rosa-Cortes Ridge from Santa Rosa Island to Tanner-Cortes Banks. Recurrent slumping is likely because slopes are relatively steep (4°-7°), and unconsolidated Holocene sediments are locally thick. The failure zones vary in size from large slumps measuring several km^2 (Field and Richmond, in press) to small features measuring hundreds of m^2 (Field and Clarke, 1979). The bank and ridge tops are characterized by exposures and subcrops of pre-Quaternary bedrock locally overlain by a thin veneer or small pockets of unconsolidated Holocene sediments, and sediments in these areas are generally stable.

The Santa Rosa-Cortes Ridge area is moderately active seismically. Most of the earthquake epicenters in this area are randomly scattered, but there is some clustering south of South Point on Santa Rosa Island (Hileman and others, 1973; Greene and others, 1975, Plate 5). Most of the earthquakes in this region have been estimated to be between 2.5 and 4.5 Richter magnitude. During a four-year period betwen 1970 and 1973, the USGS seismic network recorded 11 earthquakes beneath the northern ridge ranging from less than 2.5 to greater than 3.5 Richter magnitude (Greene and others, 1975). Several earthquakes have been reported in the vicinity of the San Clemente fault. In 1941, a Richter magnitude 5.9 to 6.0 earthquake was recorded from an area near the southeastern extension of this San Clemente fault (Lamar and others, 1973). Significant earthquakes also have been reported from the vicinity of San Nicolas Island. Because Tanner and Cortes Banks lie beyond the limits of the seismographic network there are no reliable epicenter data and thus no estimates of maximum credible earthquakes and recurrence intervals. Tsunamis have not been reported in the outer basins and banks region of the borderland. However, some of the ridges, banks, and island platforms lie in shallow water, and the generation of seismic seawaves in this region could pose a hazard to engineering structures or coastal facilities.

Although no oil and gas seeps have been reported on the Santa Rosa-Cortes Ridge and Tanner-Cortes Banks areas, the combined presence of hydrocarbons in the sediments and a large number of faults suggest that surface seeps and subsurface gas-charged sediments may be present. Proprietary data tend to confirm this possibility.

Distribution of sediment types on the northern part of the Santa Rosa-Cortes Ridge (clastic sands on the edges, foraminiferal sands in the center) suggests that bottom currents may be strong on the perimeter and weaker in the center. Both the sparse sediment cover on the ridge top, due to the isolation from sediment sources, and the abundance of rocky outcrops devoid of sediment along the axis of the ridge suggest the influence of strong current activity (Greene and others, 1975, plates 8, 9; Field and Richmond, in press). On Tanner and Cortes Banks, strong current activity is suggested by areas of exposed bedrock and by the thinness of the sediment cover over much of the nearby area (Greene and others, 1975, plates 1, 2, 4). The low silt and clay content, relatively good sorting, and coarseness of bank-top sediments also suggest current action, although the coarseness is partly a reflection of the abundant supply of coarse biogenic debris.

Secondary effects, such as seafloor subsidence resulting from fluid withdrawal should be investigated before oil field development, but are beyond the scope of this report.

OPERATIONAL CONSIDERATIONS

Introduction

Offshore oil and gas resources development activities involve a wide spectrum of operations, extending from exploration to hydrocarbon processing. Offshore technology is one of the fastest progressing fields in the petroleum industry with continuous innovation and application of exotic techniques. The following is a list of the main items for technological consideration in hydrocarbon resource development offshore:

i) geophysical and geological exploration methods,

ii) exploratory, delineation and development drilling,

iii) installation of platforms, floating facilities and/or underwater completions

iv) separation, treatment, disposal, transportation, storage and processing of produced fluids,

v) well stimulation and production acceleration projects at a later stage of field development, and

vi) supportive onshore bases.

Technological Needs

Geophysical exploration is not limited by water depth nor distance from shore. Geological exploration involves, among other activities, obtaining samples of formation from below the ocean floor and the technological requirements increase with water depth. When drilling a deep stratigraphic test, the techniques and limitations applicable are the same as those involved in drilling exploratory and delineation wells, which are discussed later in this section.

Offshore operations for the proposed area of Lease Sale No. 68 could be at distances in excess of 150 miles (240 km) from California mainland and at water depths exceeding 6000 ft (1830 m). With present technology hydrocarbon deposits could be technically feasible to develop at most of the proposed sale area which extends from Point Conception to the United States Mexico boundary and seaward to the foot of the continental slope (Fig. 1). Economic feasibility will be the deciding factor in developing the undiscovered hydrocarbon resources in most of the area. Controlling economic criteria will be:

i) hydrocarbon trap size,

ii) reservoir quality,

iii) water depth,

iv) distance from shore,

v) conditions and land use restriction on adjacent coastal zones; and

vi) new hydrocarbon discoveries in the California OCS.

Exploratory wells have been drilled and tested in water depths exceeding 4000 ft (1219 m) and close to 5000 ft (1524 m) (See Table 1). Deepwater exploration wells exceeding 5000 ft are scheduled for 1979 (2). Capability to drill in 8000 ft of water depth will be available by the early 1980's (1).

Well drilling capabilities are available to 30,000 ft (9,144 m) from jackup rigs and semisubmersibles and to 25,000 ft (7620 m) in deepwater using dynamically positioned drillships (3).

Fixed-leg platforms have been used in the majority of cases for development drilling and production facilities. The tallest of such structures at the present time is the Congnac at a water depth of 1025 ft (312 m) in the Gulf of Mexico. Current technological capabilities for deeper water platforms are available, either in the form of fixed leg platforms or alternative designs such as tension leg platforms, guyed towers, and concrete columns. In the last few years, some scaled models of these alternative designs have been successfully tested by oil companies at different regions. It is expected that some of these exotic types of platforms in the range of 1000 ft to 3000 ft (305-914 m) will eventually be constructed if the size of discovered resources justify economic development of prospects.

Several variations of the original tension leg platform (TLP) design by Deep Oil Technology of Long Beach, California have been proposed as feasible for water depths up to 3000 ft. The advantages of the TLP for Southern California are its deepwater capabilities and insensitivity to earthquake forces. Exxon has taken into consideration use of a guyed tower platform for its development of the Santa Ynez Unit.

"By 1985 we will be producing oil and gas in 3,000 ft (914 m) of water using subsea production systems." (4). These opinions were expressed by experts in subsea production technology to "Ocean Industry" reporters. "By 1990, the depth range should be extended to 5,000 to 6,000 ft (1524-1829 m)". The majority of the new subsea completions installed (1979) were made with single, non-TFL wet trees (5). Single, non-TFL wet trees are currently being installed in 600 ft of water with future capability dependent on diving limits [current experimental dives are being carried out at 1000 to 1500 ft (305-457 m)]. Remote control hydraulic wet trees and the wellhead cellar encapsulated dry tree system should extend the subsea capabilities to 3000 ft within the next five years. Utilization of these systems in remote areas (those not close to an existing pipeline) will be made possible by modular systems such as offshore storage and treatment vessels.

Despite the success of pipeline laying projects in water depths as deep as 2200 ft (670 m) (2), the construction industry is facing a great challenge in the installation and repair of deepwater pipelines in the range of 1000-2000 ft (305-610 m). Presently consideration is being given to proposals for such projects as the one from Algeria to Spain in water depths to 5600 ft (1707 m). See Table 3.

	COUNTRY	WATER DEPTH, FT. (METERS)
First Well	Ivory Coast	362 (110)
Second Well	Egypt	1,848 (563)
Third Well	Egypt	2,060 (628)
Fourth Well	Congo	4,346 (1325)
Fifth Well	Spain	3,755 (1145)
Sixth Well	Italy	3,133 (955)
Seventh Well	Ghana	2,927 (892)
Eighth Well	Spain	4,441 (1354)
Ninth Well	Newfoundland	4,876 (1486)

DEEPWATER DRILLING STATISTICS
TABLE 1 - (DISCOVERER SEVEN SEAS' STATISTICS).[1]

OPERATOR	LOCATION	WATER DEPTH (FT)	MOBILE RIG
Esso Canada	Flemish Pass	3,700	Sedco 709
Esso Canada	Baffin Island	2,800	Sedco 709
Texaco-Shell	Newfoundland	5,300	Discoverer Seven Seas
British Petroleum	Newfoundland	850	Sedco 707
Total-Eastcan	Labrador	-----	Pelerin
Total-Eastcan	Labrador	-----	Pelican
Total-Eastcan	Labrador	1,200	Petrel
Chevron	Labrador	-----	Glomar Atlantic
Aquitaine	Labrador	-----	Ben Ocean Lancer
Shell-Petrocan	Baffin Island	2,000 plus	-----
Getty	Exmouth Plateau	2,200	Penrod 74
Esso-Broken Hill	Exmouth Plateau	3,896	Sedco 472
Woodside	Exmouth Plateau	-----	-----
Phillips	Exmouth Plateau	3,000	Sedco 471
Phillips	Exmouth Plateau	-----	Sedco 471
Phillips	---------------	1,800	Discoverer 534
Phillips	---------------	-----	Discoverer 534

TABLE 2 - DEEPWATER WELLS SCHEDULED FOR 1979.[2]

AREA	WATER DEPTH	PIPE SIZE	CONTRACTOR
CURRENT			
Mediterranean	1,850 ft	16-in	Saipem
Lake Geneva	1,100 ft	10-in	O.T.P.
Gulf of Mexico	1,000 ft	12-in	Santa Fe
North Sea	550 ft	30-36 in	Brown & Root, ETPM, Santa Fe
UNDER CONSTRUCTION			
Mediterranean	2,300 ft	20-in	Saipem
PROPOSED			
Mediterranean (Algeria to Spain)	5,600 ft		
North Sea (Statfjord to Norway)	1,100 ft		

TABLE 3 - DEEPWATER PIPELINES CURRENT, UNDER CONSTRUCTION AND PROPOSED AS OF JUNE 1979.[2]

Drill Rig Availability

As of October 1979, the disposition of drill rigs in Southern California waters is as follows:

OWNER & RIG NAME	DESCRIPTION	DRILLING DEPTH CAPABILITY	WATER DEPTH CAPABILITY	LOCATION
1) Global Marine Coral Sea	Drillship	25,000'	1500'	Exxon Santa Ynez Unit, Santa Barbara Channel
2) Diamond M General	Semi-Submersible	30,000'	1200'	Chevron Santa Clara Unit, Santa Barbara Channel
3) Odeco Ocean Prospector	Semi-Submersible	25,000'	600'	Chevron, Santa Clara Unit, Santa Barbara Channel
4) Marine Drilling & Coring Caldrill I	Drillship	6,000' or	5000'+	Idle Long Beach
5) Global Marine Challenger	Drillship	25,000' or	Unlimited	Scripps Pacific

An itemized accounting of current drill rigs is as follows:[12]

Under Construction	68
Working	409
Idle	24
En Route	4

The utilization rate from the above figures out to 94.5%. This compares with the April 1979 rate of 90.2%, and the October 1978 rate of 93.1%.

Current construction activity should have a positive impact on rig availability for Southern California. The construction figures are as follows:

Drillships	3
Jackups	61
Semisubmersibles	3
Submersibles	1

Half of the jackup units on order are slated for the Gulf of Mexico. This will release semisubmersibles currently working in the Gulf for deepwater work such as the California OCS.

The future refinery availability for Sale 68 crude oil is dependent on the following factors:

(1) sale 68 crude properties - particularly sulfur content and gravity

(2) refinery capacity for sour versus sweet crude

(3) Alaskan oil northern tier pipeline - construction date relative to Sale 68 production

(4) heavy oil decontrol - possible resurgence of heavy California production warranting investment in refinery processing for heavy crude (Gravity <20°API).

Onshore Construction

Recent platform construction and support activities indicate probable future sites for the Southern California OCS. Past and present construction activities are summarized as follows:

(1) Platform Grace — Santa Barbara Channel — Chevron

Jacket Fabrication - IHI Nagoya, Japan

Deck Fabrication - Snelson-Anvil Co., Anacortes, WA

Installation - Alaska Constructors (Subsidiary of Brown & Root)

Two-Rig Drilling Operation - Global Marine, Los Angeles, California, Houston, Texas

(2) Platform Hondo — Santa Barbara Channel — Exxon

Jacket Formation - Kaiser Napa, Fontana, California

Deck Fabrication - McDermott Morgan City, Louisiana

Production Facilities - Hudson Engineering Houston, Texas with field construction at Bayou Black Yard, Morgan City, Louisiana

(3) Platform Ellen/Elly — San Pedro — Shell

Jacket Fabrication - Alaska Constructors Brown & Root Labuan, Malaysia

Production Deck Fabrication - Mitsubishi Heavy Industries; Yokohama, Japan

Facilities Ellen/Elly - Brown & Root Houston, Texas

Other West Coast construction sites are located at San Diego, Long Beach and San Pedro, California; Portland, Oregon; Vancounver, Tacoma, and Seattle, Washington; and Vancouver, British Columbia. Smaller ports which have served as construction support, supply and delivery areas are Oxnard, Port Hueneme, and Ventura, California.

Manpower Availability

The expansion in exploration, development and production of the Gulf of Mexico and the Rocky Mountain areas could create a strain on availability of manpower for exploration and development drilling in less active areas, such as the OCS of California. However treatment and processing sectors of the oil industry may not suffer a shortage of manpower because of the different nature of employment in these industries.

Current manpower problems do exist in offshore drilling. A recent study shows a 100% turnover rate for offshore crews per year. The main reason cited was the equivalence of work offshore with an onshore job with 50% away-from-home travel. The manpower problems faced by the industry could be exacerbated by high turnovers and the ever increasing complexity of equipment for deepwater drilling. This equipment will need more highly trained personnel for maintenance.(6)

The oil industry is highly competitive in the recruitment of experienced personnel. The success of the industry in coping with the shortage in professionals is evidenced in the nationwide increase of enrollment in petroleum engineering departments as well as the intensive training of non-petroleum engineers for working in the petroleum engineering field.

The overall expectations for manpower for Lease Sale No. 68 are favorable.

Availability of Investment Capital

The availability of investment capital for proposed Lease Sale 68 will depend on the future trends of oil industry profits, capital spending, crude prices, and taxes. Interest in the Southern California OCS vs. other regions is also a factor to be considered.

Profits are a major source of investment capital for large oil companies. A good earnings performance is a positive factor for the company that must borrow capital. The Oil and Gas Journal analyzes the performance of 24 oil companies which together comprise a significant force in the total industry. The profits of this group were up 10.2% in 1978.(7) Expectations for 1979 are highly optimistic. According to the Wall Street Journal oil company stocks have so far turned in a strong performance in 1979.(8)

Decontrol of domestic crude prices should expand investment opportunities for the oil industry. The Department of Energy estimates domestic prices should at least double by 1995.(9) Decontrol will enhance the value of prospects under evaluation by a company. The Oil and Gas Journal points out that planned capital spending increased by 14.4% in 1979.(10) A windfall profits tax will reduce to some extent the favorable impact on earnings of oil price decontrol.

The Chase Manhattan Bank's 1977 study of 27 national and multinational oil companies indicates that the United States is an area of prime interest for investment.(11)

According to Chase Manhattan, areas outside the United States are declining in interest. This has resulted from discouraging drilling results in some countries, loss of crude through nationalization and purchase, and increasing costs.

Investment capital will probably be available for the total United States. How that capital will be allocated within the U.S. is a question for Lease Sale 68. Large discoveries of crude in regions other than the Southern California OCS might limit the availability of capital for Lease Sale 68. The extent of this potential capital drain is impossible to reliably forecast.

Significant crude discoveries in the Lease Sales 48 and 53 areas could increase the attraction of the Southern California OCS for capital investment. Increased drilling should produce more information and thus reduce risk in the general area. As Sale 68 development proceeds equipment and manpower already in place for operations on Sale 48 and 53 leases may be utilized. The overall result is an increased return on investment.

In conclusion, investment capital will probably be available for Lease Sale 68 provided that profits, capital spending, and crude prices continue their recent trends.

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