the Viscaino Desert of Baja California, a distance of 400 miles, the eastern extent of the Upper Cretaceous Rosario Formation can be plotted with the edge of a ruler. At several points the exhumed coast line is well exposed. In some places marine strata buttress directly against precipitous bedrock slopes. In other localities they interfinger with deltas of conglomerate which built from narrow gorges incised in the bedrock coast.

Westward from this paleocoast the Rosario thickens considerably in a short distance. At times, relatively deep water must have extended almost to the shore. The steep and straight paleocoast appears to have coincided with a hinge line, suggesting fault control. This tectonic line has continued to be active throughout the Cenozoic. Faults of Pleistocene age parallel the modern coast in several places.

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J.O.I.D.E.S. Ocean Drilling on Continental Margin off Florida

Most of the Tertiary section was sampled in six core holes drilled along a transect across the continental shelf, slope, and Blake plateau east of Jacksonville, Florida. Water depths at the drill sites ranged from 25 to 1,032 meters and penetrations into the bottom from 120 to 320 meters. Continuous coring was attempted at most of the sites, using a wire-line core barrel. Core recovery averaged 36 per cent overall, with best recovery (46%) in the soft formations of silt and clay and poorest recovery (22%) in hard layers of chert and dolomite. A generalized stratigraphic cross section, drawn from the coring results, reveals that the continental margin is a wedge-shaped constructional feature which becomes thinner seaward.

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Seismic Investigation of Eel Submarine Canyon, Humboldt County, California

Prior to and during the early 1960s several "sparker" and conventional survey lines were run across the head of Eel Canyon, which lies 7 miles west of the mouth of the Eel River, Humboldt County, California, and on the adjacent shelf area. The data from the surveys were utilized to discover if a "buried" canyon exists below the shelf sediments.

Interpretation of the seismic records indicates that a buried canyon does extend shoreward from the present-day canyon. Furthermore, this buried canyon consists of two branches; one branch is oriented toward Arcata Bay in the north Humboldt Bay area and the other branch is oriented toward South Bay in the south Humboldt Bay area.

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Seasonal Distribution of Magnetite and Ilmenite in Beach Sand of Malaga Cove, California

In 1961, 1962, and 1963, surveys of part of the "black sand" beach at Malaga Cove, California, included profiles for measuring seasonal variations in beach erosion and accretion, and sampling for grain-size, mineral composition, and magnetite percentage.

Profiles show maximum beach erosion during August and maximum accretion during January, contrary to the cycle of summer accretion and winter erosion for most beaches.

Mean grain-sizes, determined from analyses of samples extracted on October 19, 1963, are largest for all depth intervals within a narrow strip midway between the cliff and the swash. Particle size gradually decreases both oceanward and shoreward and increases northward. The average percentage of magnetite decreases with an increase in grain-size.

Magnetite, ilmenite, epidote, zircon, and quartz are the most abundant of 27 minerals identified petrographically in the very fine size.

For all samplings, the magnetite content in the beach sand increases with depth and shoreward; maximum concentrations are at the "slope break" near the cliff. During beach buildup, high-energy waves temporarily erode the foreshore, carry the lighter, fine materials offshore, and concentrate the magnetite and other heavy minerals as laminations and layers at depth in the beach. The magnetite concentration high on the beach reflects the superiority of onshore wave energy over other types of wave energy.

The magnetite and ilmenite in the sand at Malaga Cove are believed to have been transported from the western San Gabriel Mountains to Santa Monica Bay when the Los Angeles River channel followed the present course of Ballona Creek. The minerals were carried southward along the coast by predominant littoral movement in this direction and concentrated by wave action on the beach at Malaga Cove.

HERRON, ROBERT F., Edgerton, Germeshauser and Grier, Inc., Santa Barbara, California

Sub-Bottom Investigation Techniques

(No abstract submitted.)

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Structural Evolution of Santa Lucia Range, California

The rocks of the Santa Lucia Range are divisible into a bedrock complex and a superjacent series, separated by a major unconformity which represents early Late Cretaceous deformation ("Santa Lucia orogeny"). *Décollement* tectonics, involving gravity sliding of the Franciscan rocks over carbonate rocks of the Gabilan mesa, played an important role in the deformation of the bedrock complex during Late Jurassic and middle Cretaceous times (Hsu, 1965). The superjacent rocks were deformed by wrench faulting, and by folding during several Cenozoic orogenic episodes. Thrust faults have been observed in wrench-fault zones. Local changes from wrench to thrust faulting are related to slight changes in the magnitude of the vertical and horizontal principal stresses. These thrusts should not be confused with the *décollement* tectonics which affected only the bedrock complex.

The Franciscan-Recent succession of the region is illustrated and discussed. The stratigraphy of the superjacent sediments is based on the work of previous investigators. The stratigraphy of the bedrock complex is based mainly on the writer's structural interpretations.

Although the Franciscan rocks were deformed during late Mesozoic and denuded during early Tertiary, they furnished very little debris to the Cretaceous and early Tertiary sedimentary formations of California.

Nevertheless, large volumes of Franciscan debris must have been removed from the Santa Lucia Range before the Miocene transgression. This debris probably was transported west and deposited as thick early Tertiary clastic sequences in offshore basins.

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Influence of Cascadia Channel on Abyssal Sedimentation

Cascadia channel is the most prominent and extensive deep-sea channel known in the northeastern Pacific Ocean. Preliminary results from a survey of this channel in the part of Cascadia abyssal plain off the Oregon coast and in the seamount province west of the plain are presented.

The bottom of the channel has a depth range of 1,565–1,830 fathoms and a slope of about 1:1,000. Relief ranges from 20 fathoms off northern Oregon to more than 400 fathoms in an abyssal gap in the seamount province. The width of the channel ranges from 1 to 4 nautical miles at the top and from less than ¼ to about 3 miles at the bottom.

Piston cores taken along a 6-mile profile extending from the western side (abyssal plain) to the eastern side (Astoria fan) of Cascadia channel exhibit a marked diversity in sediment texture and composition. On the western side the sediments are composed chiefly of gray clay interbedded with thin laminations of sandy silt. Planktonic Foraminifera predominate in the sandy material. Sediments in the axis of the channel consist of several cyclic depositional units. Each unit is made up of a basal fine sand grading upward into olive-brown silt and clay and overlain by gray clay. The sand and silt contain detrital minerals and organic debris derived from continental sources. On the eastern side the sediments are similar to terrigenous material found elsewhere on Astoria fan.

Sedimentation on Cascadia abyssal plain is controlled, to a large extent, by Cascadia channel. The channel apparently acts as a sediment trap and as an avenue of dispersal for terrigenous material transported along the sea floor.

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Recent Development in Wilmington-Long Beach Unit Oil Field

The Wilmington oil field is a broad, asymmetrical, anticlinal structure broken by a series of transverse normal faults which divide the producing zones into more than 50 separate pools. The seven producing zones in the field range in age from middle Miocene (Topanga) to early Pliocene (Repetto). Since the discovery of the field in 1936, cumulative production of the Wilmington oil field reached an estimated 1.049 billion barrels of oil at the end of 1965. Current daily production (exclusive of the Long Beach Unit) is approximately 102,000 BOPD, of which 65,000 barrels is estimated to result from salt-water injection. As of December 31, 1965, total cumulative salt-water injection in the Wilmington oil field was 1.2 billion barrels. Land subsidence has been arrested in most of the field except for a 4-square-mile area at the center of the bowl, where maximum subsidence has been reduced to approximately 0.2 feet per year.

Development of the Long Beach Unit (East Wilmington) started on July 16, 1965, when Thums Long Beach Company, under the terms of its contract with the City of Long Beach, spudded its first well, J-146, on the City's newly built Pier J site. By the end of 1965, Thums completed 24 wells (5 are water injectors) from Pier J and was producing approximately 11,000 BOPD. Geologic information from the recently completed wells confirms in general the structural interpretation based on the 1954 seismic survey and core holes drilled in 1962. Some horizontal lithologic changes are evident. It is estimated that 1,000 production and injection wells ultimately may be required to develop the estimated 1.2 billion barrels of oil reserves under a water-injection pressure-maintenance program during a 35-year period. These wells will be drilled from the harbor's Pier J locations and from four drill-site islands. The Long Beach Unit may reach a peak production of nearly 200,000 BOPD by 1970.

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Huntington Beach Offshore—Parcel 14

Union Oil Company of California has developed on California State Tidelands, PRC #3053, Parcel 14, an extension to the Huntington Beach offshore oil field. Union was awarded Parcel 14 by the State of California in 1962 for a bonus of $6,110,000.

Parcel 14 is located down the west plunge of a large east-west-trending asymmetrical anticlinal structure. This offshore structure extends from the shore westward approximately 3 miles. The south flank of the anticline is steep-dipping with known dips up to 65°. The north flank has an average dip of 10°. An axial hade of approximately 70° to the north is present.

Faulting is minor on Parcel 14 with only two 50-foot normal faults mapped. Oil is produced from the Upper Main division "C" sandstone reservoirs, defined as Upper Main and Main zones.

The maximum net oil-sand column penetrated to date is 510 feet. The Upper Main is composed of several sandstone bodies that are lenticular in nature, whereas the Main zone is more of a massive blanket sandstone body and holds the major part of the oil column.

California Division of Oil and Gas, "Summary of Operations," Volume 46, No. 2, contains a description of the Main-zone shale section located shoreward in Parcel 14. This main-zone shale section thickens seaward and new sandstone bodies appear, partly as a result of facies changes, and partly because of lensing. As a result, additional oil-productive zones are developed across Parcel 14 in both the Main and Upper Main intervals. Thirty wells on 10-acre spacing have been drilled directionally and completed from Union's Platform Eva. The wells are positioned on a five-spot waterflood pattern for future secondary operations.

Primary reserves of 23 million barrels and secondary reserves of 10 million barrels, a total of 33 million barrels, have been estimated for Parcel 14. Average daily production from Parcel 14 is 8,000 BOPD. All wells are pumped by hydraulic lift.

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Options for Geologists in Selecting a Professional Status

God helps those who help themselves, but state as-