volcanic rocks. At the south end of San Diego Bay, a gravity anomaly of —36 mgals. and well data indicate the presence of a sedimentary basin ±6,000 feet deep. A +4 mgal. anomaly at Point Loma and near-zero anomalies at La Jolla reflect a positive westerly gradient.

At the surface, Santiago Peak volcanic rocks, a discontinuously exposed belt of Upper Jurassic and Lower Cretaceous(?) meta-volcanic and meta-volcaniclastic rocks, roughly separate mid-Cretaceous batholithic rocks at the northeast from Upper Cretaceous, Eocene, and Pliocene clastic sedimentary rocks at the southwest. The Campanian-Maestrichtian Rosario Formation crops out at La Jolla and Point Loma. Most surface exposures of undifferentiated Eocene rocks are north of Mission Valley. At the south, the Pliocene San Diego Formation overlaps the Eocene.

An irregular basement surface (batholith and older) dips west; it is elevated slightly under Point Loma and flattened under La Jolla. The Rosario Formation reaches a maximum thickness of ±4,000 feet at La Jolla and Point Loma. Undifferentiated Eocene sedimentary rocks attain a maximum thickness of ±2,500 feet south of San Diego Bay where they are overlain by more than 2,000 feet of the San Diego Formation.

Four distinct post-batholith structural blocks are delimited by an east-west Mission Valley hinge line and the north-south-trending Rose Canyon fault. The northeast stable block (Kearny mesa) received mostly Eocene sediments. The northwest block (La Jolla) and southwest block (Point Loma), separated by synclinal Mission Bay, received mostly Upper Cretaceous and Eocene sediments, and later were uplifted, faulted, and tilted. The southeast block (San Diego mesa) probably subsided continuously, receiving more than 2,000 feet of Upper Cretaceous, Eocene, and Pliocene sediments.

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Authigenic Silicates in Marine Spencer Formation at Corvallis, Oregon

Segments of the petroleum industry are actively exploring the Tertiary rocks of offshore Oregon and Washington; several wells are being drilled and others are projected. It is noteworthy (1) that amphibole and pyroxene occur in sandstone beds of one of the potential reservoir formations under conditions that require an authigenic origin and (2) that the rocks have not been metamorphosed. These minerals, which usually are presumed to have formed in conditions of much higher temperatures than those of diagenesis, are found in the Spencer Formation of late Eocene age at Corvallis, Oregon. The best-preserved examples of these minerals are found in a graded sedimentation unit rich in molluscan fossil fragments, basic volcanic glass, and zeolitic concretions. The marine shell fragments are replaced by thomsonite which contains many idiomorphic crystals and tangled needles of actinolite and clinopyroxene.

Reconstruction of the diagenetic environment suggests a formation temperature near 140°F., solutions somewhat less saline than sea water, a pH of slightly less than 7.0, and an Eh near —0.2.

Formation of thomsonite, actinolite, clinopyroxene, and rare analcime, rather than a suite such as clinoptilolite or heulandite, orthoclase, and abundant analcime, is thought to have been caused by a supply of basic volcanic glass and molluscan calcite rather than acid glass and soda-rich brines.

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Diving Geology

A remarkably large amount of "surface geology" has been done in the California offshore areas using both "Hard Hat" and "SCUBA" divers. Considerable oil has been found as a result of this work, but there have been some notable failures.

In the areas where the diving method is applicable, it is a very effective and relatively inexpensive way to explore for oil. In areas of steep dip and in shallow water, it has some distinct advantages over conventional seismic techniques.

Future use will be dependent on the choice of suitable areas for exploration and on improvements in the technique. Suggested improvements include the use of (1) sonar bottom-scanning devices and (2) submersibles to extend the depth of observation.

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Stratigraphy of Montesano Formation, Washington

The Montesano Formation is known to occur over about 250 square miles of Grays Harbor basin. Eight stratigraphic sections were measured along the branches of the Wishkah and Satsop Rivers, the Wynoochee River, and the Canyon River. Exposures of the Montesano Formation along the Middle Fork of the Wishkah River are designated the type section. There it is 2,500 feet thick and is composed of 1,500 feet of fine-grained sandstone, with small amounts of pebble conglomerate and mudstone, overlain by 1,000 feet of tuffaceous mudstone and sandy siltstone. Toward the east the thickness of the formation averages only 1,800 feet, and it is composed principally of fine- to medium-grained sandstone, pebbly sandstone, and conglomerate. Along the West Fork of the Satsop River, an abnormally thick sequence of thin-bedded to laminated, tuffaceous mudstone and very fine-grained sandstone at least 1,100 feet thick contributes to a formation thickness that may exceed 3,000 feet.

Deposition took place in a sea which was transgressing eastward across a broad, east-west-trending embayment. Estimated water depths ranged from sea-level to more than 3,000 feet. The upper parts of the eastern sections apparently represent a regressive phase. Turbidite deposition in a partly closed basin was the principal cause of the abnormally thick accumulation of the thin-bedded sequence mentioned previously.

Foraminiferal evidence places the Montesano Formation mainly in the upper Miocene. It is unconformable on the lower Miocene Astoria and Oligocene Lincoln Formations. A unit sometimes referred to as the Satsop Formation, and questionably considered to be Plio-Pleistocene, overlies the Montesano unconformably.

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An Upper Cretaceous Fault-Line Coast

From northern San Diego County, California, to 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.

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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.