structures from submersibles in an area normally covered with prograding slope deposits. The concentration of relict shallow-water fossils in deep terrace zones and the rough topography can be confused with nonexistent structural features if not recognized during sampling programs.

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DEVELOPMENT OF LONG BEACH UNIT IN OFFSHORE PART OF WILMINGTON FIELD

Development of the Long Beach Unit, which includes most of the offshore part of the Wilmington field, was not begun until 1965. The city of Long Beach is the Unit Operator, directing THUMS Long Beach Company (field contractor) in the performance of day-to-day operations. The State of California oversees economic control through the State Lands Division in its Long Beach Operations office as determined by Chapter 138 (Senate Bill 60) of the State of California Statutes of 1964, First Extra Session. About 5% of the total revenues goes to the State of California for its Parcel II; about 9% is shared by 13,000 owners in the townlot area (downtown Long Beach) covering approximately 8,700 parcels. The remaining 86% is shared by the city of Long Beach and the State of California.

The field is a NW-SE-trending anticline broken by a complex system of mainly transverse faults. The field contains about 70 separate producing reservoirs which, for convenience, have been grouped into eight major zones defined by certain electric-log markers. They range in age from Pliocene to Miocene, and in depth from 2,000 to 8,000 ft. Shifts of the axial plane between fault blocks and with depth, variations in petrophysical characteristics, and large differences between the water tables between reservoirs indicate a complex depositional and postdepositional history. Oil gravity generally increases with depth, and also differs with structural position within the same producing reservoir.

The presently planned 650 wells are being drilled directionally from Pier J in the Long Beach harbor, and from four manmade offshore islands. Esthetic considerations have required extensive landscaping of the nearshore islands and the use of embellished towers which can move on a system of rails.

The general development plan requires a close interplay between geology, reservoir engineering, and economics because of certain unusual situations. At the start of the development, the reservoir pressure was found to be approximately hydrostatic on the south flank but considerably less than hydrostatic on the north flank. The water tables in many, but not all, sandstone members in the upper zones also were found to be less than hydrostatic on the north flank, as would be expected from hydrodynamic considerations. Moreover, free gas is disseminated in the oil zone along the crest and on the north flank in most fault blocks. It is believed that, originally, the reservoirs contained saturated oil with the bubble point at hydrostatic pressure, and that the present situation is attributable to large reservoir withdrawals before 1965, not only from the developed part of the Wilmington field, but also from the Seal Beach and the Long Beach-Signal Hill fields, the aquifer of these fields being in communication even across the Inglewood fault system. If so, the present hydrodynamic gradient is not a natural one but is the result of human intervention.

Exploitation of the field is governed by two major considerations: (1) returning maximum ultimate revenue to the Tidelands Fund. This has required sophisticated well-spacing studies using computerized mathematical modeling of both the production performance and the economics of the Unit; and (2) waterflooding without a primary depletion stage in order to maintain reservoir pressure to avoid any contribution toward ground subsidence. This creates complex problems because of the combining of many sandstone members in the same well bore, and also because faults are only partly sealing.

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ADVANCES IN INTERPRETATION OF OFFSHORE SEISMIC DATA

The recent advent of long recording spreads and the development of new programs for digital processing have yielded large quantities of detailed information on seismic velocities along each line of recording. These advances have multiplied the ability of the geophysical interpreter to convert his seismic time data properly to more accurate depth displays for proper integration with geologic data, thus narrowing the gap in interpretation of structure and lithology between the geologist and geophysicist.

In steep dip areas of offshore California, it is imperative that the individual segments of events appearing on seismic time sections be migrated to their proper original positions. This geometric reconstruction can be approximated successfully by the proper use of velocity data in seismic wave-front methods of migration. Two-dimensional plots of seismic depth sections can be produced economically at present; such plots incorporate changing vertical and horizontal velocity data. Various methods of two-dimensional representation of structure are available.

Much greater effort must be devoted to integrated geophysical-geological interpretation of the great masses of seismic data which are being accumulated if management is to realize full return on exploration investments.

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INTERNATIONAL LAW AND TECHNOLOGY FOR SEA FLOOR

The determination of who may own, lease, or explore the ocean floor must be reconciled first to precise means of defining the exact position of boundaries on the ocean floor. Definitions in terms of longitude and latitude at the surface cannot be used to determine on a slope on the sea floor where one company will cease drilling for oil and another will start.

A network of sonic transponders properly positioned on the sea floor by research submarines, guided by highly accurate underwater navigation equipment with X-Y plotters, will provide a 3-dimensional grid for locating fixed installations and tracking vehicles beneath the surface and on the surface. This network of transponders will correspond to "geodetic bench marks" on land.

Such catastrophes as the *Torrey Canyon* tanker, or crowded ports and zero weather conditions at ports, shorelines, or at sea require a new dimension in marine traffic control.

The same devices for definition of sea floor boundaries—the "transponder" geodetic bench marks—could be used for FAA type monitoring of surface or submerged vehicle movements first at ports, and then throughout coastlines and into the deep ocean waters.

The state of the art of technology with both battery powered transponders (for temporary fixes and short life) and atomic powered transponders (for long-life and long-range capability) makes the installation economical and reasonable at this time.

Areas such as the North Sea, the Black Sea, the Red Sea, the Adriatic, the Gulf of Aqaba, and others could be surveyed and temporarily zoned in a technically accurate manner. A plan for five or six such pilot surveys will be proposed to the United Nations.

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WHAT'S AHEAD ON O.C.S. IN PACIFIC

(No abstract submitted)

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Glomar Challenger AND DEEP-SEA DRILLING PROGRAM

Glomar Challenger has been engaged in its unique assignment of investigating the character of deep-ocean-floor sediments since August, 1968 and at year end was well into the third of four Atlantic Ocean segments. The very comprehensive documentation of this effort includes the film that is presented with this paper, which was taken during the sea trials and first leg of the voyage.

A geologic summary of the status and goals of the program and some of the findings developed during the *Challenger*'s initial efforts is presented by courtesy of Scripps Institution of Oceanography, operators for the program. Both the technical and academic results of the coring program have been very gratifying to date.

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ADAK "PALEOZOIC" SITE, ALEUTIANS—IN FACT OF EOCENE AGE[1]

In 1946 several specimens of the plant genus *Annularia* [cf. *A. stellata* (Schlotheim) Wood], a primitive horsetail of Pennsylvanian or Permian age, were found by Robert R. Coats of the U.S. Geological Survey in tuffaceous sandstone exposed near Andrew Lake, northern Adak Island, Alaska. Because of the geographic position of these upper Paleozoic fossils near the middle of the Aleutian insular chain, it has been a challenging if not a vexing problem to fit the enclosing rocks into a structural scheme for the development of the Aleutian ridge. In view of this, the enigmatic upper Paleozoic section was restudied during July 1968 to enlarge the fossil collection and to determine its depositional environment and stratigraphic setting.

The *Annularia*-bearing beds are associated with a sequence of sedimentary rocks that is more than 850 m thick, and that consists mainly of northwest dipping tuffaceous sandstone, siltstone, and shale, and siliceous and calcareous siltstone and shale interbedded with basaltic flows and/or penecontemporaneous sills a few tens of meters thick. Specimens of *Annularia* have been found only within the basal 5–10 m of this section, which lies with apparent depositional contact on the massive and intensely altered andesitic and basaltic flows and pyroclastic rocks of the Finger Bay Volcanics that form most of Atak Island. The top of the section is not exposed. The section is uncomplicated structurally and dips homoclinally northwestward between 40° and 65°; it is exposed across an area of about 2.5 km² (approximately 1 sq mi).

Mollusks, Foraminifera, sponge spicules, fish scales, and skeletal remains were found by the writers in the lower 350 m of the section just above the basal *Annularia*-bearing beds. Included in this fauna is the mud pecten *Propeamossium* [cf. *P. stanfordensis* (Arnold)], indicating a probable Eocene age; the associated foraminiferal fauna is of definite Eocene (most likely late Eocene) age, and the fish scales are similar to those found in the Refugian and Narizian (Eocene-Oligocene) of California. The microfossils imply a paleobathymetry of 1000 meters or deeper. In consideration of these new findings, the rock matrix surrounding specimens of *Annularia* was searched for microfossils. A substantial dinoflagellate flora was found —establishing that the *Annularia*-bearing beds are themselves marine units of early Tertiary age. The paleontologic and stratigraphic significance of *Annularia* is now being reevaluated.

The Adak findings clearly establish that at least a portion of the structural framework of the Aleutian Ridge was in existence by early Tertiary time.

[1] Publication authorized by the Director, U.S. Geological Survey.

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AIR FORCE WESTERN TEST RANGE OPERATIONS

(No abstract submitted)

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RAPID CHANGES IN HEAD OF RÍO BALSAS SUBMARINE CANYON, MEXICO

The Río Balsas submarine canyon heads in or near the surf zone of Mexico's Pacific coast, 280 km northwest of Acapulco. One of its tributaries is related directly to the main distributary of a large river of the same name. Seaward, the canyon terminates in the Middle America Trench.

The intricately bifurcated heads of the tributaries were investigated by divers. They are cut into poorly consolidated deltaic sediments. The walls commonly slope more than 30°, and are vertical to overhanging where sedimentary strata are exposed. The tributaries apparently are not controlled tectonically.

Shifts in river discharge cause formation of new tributaries and filling of old ones. The easternmost tributary heads in an embayment formerly associated with the main river discharge. Sediments exposed in three