To overcome seismic data problems associated with the high-speed Tertiary section, navigational problems due to the size of the area, drilling problems associated with geo-pressured shales and the highly porous Tertiary beds, new techniques constantly were required and introduced.

To integrate the interpretation of the large volume of data and to apply the maximum amount of geologic rationalization require the cooperation and mutual support of competent geologists and geophysicists. Large areas to be mapped and steadily increasing volume of data from this area required the utilization of computer-assisted mapping.

By mid-1971 approximately 40,000 mi of seismic data were in the files. At the same time wells 11 (Scott Reef No. 1) and 12 (North Rankin No. 1) were drilling and located what promise to be commercial accumulations of hydrocarbons. However, feasibility studies still are being evaluated and step-out wells have yet to be drilled. Since completion of these wells, other wildcats have been drilled resulting in several discoveries.

Future potential in the area looks very bright with source, reservoir, and cap rocks in Triassic, Jurassic, and Cretaceous rocks. The potential of the Paleozoic section is as yet virtually unknown.

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Systematic Geophysical Mapping of Continental Shelves and Deep Ocean Areas

The National Oceanic and Atmospheric Administration's National Ocean Survey program is mapping systematically the geophysical characteristics of the continental shelves of the U.S. and certain deeper ocean areas. Properties measured are bathymetry, geomagnetics, gravity, and seismic reflection profiles. The purpose of the program is to provide maps, data lists, reports, *etc.*, to meet requirements stated for coastal zone management and exploitation.

The map scales produced are 1:250,000 on shelves and 1:1,000,000 in deeper areas. Coverage now includes parts of the east and west coasts and Alaska. Work is underway off Oregon and Washington. The next year's program includes the west coast, Gulf of Alaska, and part of the Atlantic east of Bermuda.

The program objective is to produce data packages for each map unit. Survey control, line spacing, instrumentation, and collection accuracies vary according to the scale, area, and characteristics found. Critical to program development are the known and stated area and data requirements of major segments of the national economy such as the petroleum and other mineral industries, and fisheries. Recreational and environmental aspects are likewise important.

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Facies and Paleocurrents of Gallup Sandstone: Model for Alternating Deltaic and Strand-plain Progradation

The Upper Cretaceous Gallup Sandstone of northwestern New Mexico, is a regressive, shallow-marine to alluvial sequence up to 140 ft thick. Vertical and lateral facies sequence and orientation of current- and wave-produced structures show that the shoreline advanced by episodes of delta progradation, followed by minor erosional transgression and subsequent seaward accretion of surf-zone and beach deposits. Each episode is thought to be a reaction to stream positions on a broad coastal plain. In a 200-sq mi area, 2 delta progradations and 3 strand plains are recognized, each with some important variations.

The deltaic deposits consist of: (1) distributary-channel sandstones, entrenched in older beach deposits; and (2) more widespread marine sandstones, thinning and grading seaward. The marine deltaic sandstones are in tabular beds deposited from short-duration currents; these beds vary in thickness and bioturbation, depending upon distance from dispersal centers. There is little evidence of sand transport or reworking by waves.

The strand-plain units consist of: (1) coarser sandstones with high-angle cross-strata in trough-shaped sets and minor interbeds of siltstone, overlain by (2) finer sandstones with low-angle cross-strata in wedge-shaped sets and local seaward-sloping heavy mineral placers. The coarser sandstones rest on a basal scour surface cut on older deltaic deposits, probably representing adjustment of profile with decrease in sand supply and increased effectiveness of wave action. Cross-strata dip directions record sand transport parallel with shore but in frequently reversing directions, suggesting the influence of surf generated by seasonal or more frequent weather changes. Upward gradation to sandstones with the characteristics of beach foreshore deposits indicates beach progradation.

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Theory of Crustal Development Based on Analysis of Vertical Uplift Experiments

One of the most important concepts resulting from oceanographic data is the segmented nature of the oceanic ridge and rise areas. These segments are separated by transverse faults. Continental orogenic areas both past and present possibly may exhibit this same phenomenon.

Model studies using vertical uplift were conducted in an effort to duplicate the segments. The forces involved in the development of the individual segments were analyzed, as well as those caused by the interaction between segments resulting from differential uplift. By applying principles observed in the modeling, known first-order orogenic areas were modeled. These areas include parts of the Rocky Mountain system and the California system.

A theory is developed which mechanically relates the orogenic events of the past with those of the present. A proposed corollary relates the major transgressions and regressions of past geologic seas to the geographic distribution of the orogenic belts. During times of extensive oceanic orogenic activity, the belts were distended and the water was displaced onto the continents. The distention was followed by extrusion and collapse which resulted in regression of the seas.

The theory is applied to the continental United States, and a series of sketches shows the possible tectonic development of the southern part of the North American continent from the late Precambrian to the present.

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Relation between Texas Barrier Islands and Late Pleistocene Depositional History

The 400-mi-long Texas shoreline is characterized by barrier islands separated from the mainland by la-

goons, bays, and estuaries up to 8 mi wide. Regional studies indicate that barrier morphology and texture and composition of beach sediment, although largely unrelated to modern rivers, are related to the distribution of sand-rich late Pleistocene facies on the inner continental shelf. For example, Matagorda Peninsula, near the Brazos River, is narrow, receding, and has a high oyster-shell content.

Narrow, regressive barriers occur where Pleistocene strand plains are absent, where Pleistocene deltas are mud-rich, and in Pleistocene interdeltaic areas. These regressive barriers have a high shell content (dominantly estuarine species), and varying amounts of caliche, siderite, beach rock, and sandstone fragment gravel. Beaches retreat 7–40 ft/yr in erosional areas. Dunes are rare on narrow barriers, and shell ramps extend several hundred feet bayward ending abruptly as steep avalanche faces.

Terrigenous sand is the dominant sediment type of wide barriers such as Matagorda Island; no modern stream contributes sand to this barrier. Broad barriers develop where sand-rich Pleistocene deltas and strand plains are present and the sand budget is large. Morphologic features of these barriers are fore-island dunes, beach ridges, and broad barrier flats. Beach ridges, indicating rapid accretion, are characteristic of the older barrier segments. Today, fore-island dunes, suggesting cessation of accretion, are relatively well developed on these barriers.

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EVIDENCE OF MIGRATING HYDROCARBONS IN DEEP SEA DRILLING PROJECT CORES

To date the Deep Sea Drilling Project has revealed migrated liquid hydrocarbons in 3 widely separate areas of the globe. The first occurrence was the highly publicized, visually observed accumulation of immature petroleum in sediments on the Challenger Knoll in the Gulf of Mexico. Subsequent to the discovery of this obvious saturation, chemical analyses revealed 2 more possible examples of migration. The first was a low-grade bitumen saturation in a thin porous zone in Pleistocene sediments on the Shatsky Rise in the western Pacific Ocean. The second and latest was a small but geochemically significant quantity of wet gas and gasoline-range hydrocarbon that apparently seeped upward into Miocene rocks in the Balearic basin of the western Mediterranean Sea. These migrated hydrocarbons—in addition to the methane gas commonly encountered in deep ocean cores—reveal that hydrocarbon source beds are present, and that liquids as well as gases have begun to migrate, at least locally, in deep-ocean sediments.

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ANATOMY OF DISTRIBUTARY CHANNEL-FILL DEPOSITS IN RECENT MUD DELTAS

Recent distributary channel-fill deposits (of various sizes) were studied in three mud-rich deltas of the Gulf Coast: the Mississippi, the Colorado-Matagorda, and the Trinity. Although the deltas differ markedly in size, they show similar geomorphology, depositional processes, and patterns of sand accumulation. Data were obtained from 2 major sources: (1) continuously cored borings with electric logs to study the depositional sequence of filled channels, and (2) fathometer surveys to study bed forms in modern channels.

Deposition within distributary channels reflects major depositional stages during the development of the channel. A complete depositional sequence consists, from the base upward, of an active-channel fill (deposited when the channel carried its full flow), a partial-abandonment fill (flow through the channel was reduced), and an abandoned-channel fill (deposited in essentially a still-standing body of water when channel was abandoned).

There is good agreement between cross bedding direction and sand-body elongation, *i.e.*, crossbedding foresets dip downstream parallel with the channel axis. The dip azimuths for accretion beds in the upper part of the channel are too variable in their orientation to be useful trend indicators. The shoestring channel-fill deposits generally trend subnormal to the regional depositional strike, but can show a wide directional scatter.

Because delta channels scour 20–200 ft below sea level, channel-fill sands are commonly positioned stratigraphically lower than their contemporaneous delta-front sands. Although distributary channel-fill and point-bar sands show a similar sedimentary sequence, some sedimentologic and stratigraphic features are helpful in distinguishing the 2 sand types.

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GEOCHEMICAL STUDY OF CRUDE OILS FROM GHADAMES BASIN, WESTERN LIBYA

Twenty-five crude oils from the Ghadames basin, western Libya, were analyzed to distinguish genetically distinct oil families and to attempt identification of different geologic processes that have affected the oils. The oils came from reservoirs ranging in age from Cambrian to Triassic. The samples were analyzed by mass spectrometry to identify molecular types of compounds present and to determine the stable carbon isotope values for the heavy saturate and heavy aromatic fractions. Gas chromatography was used to analyze the light gasoline fractions and the heavy saturate fractions of the oils.

Significant differences were noted between oils from different parts of the basin. At least 4 different Paleozoic oil families were distinguished. The oils from Triassic reservoirs appear to have migrated from Paleozoic strata. Alteration of some of the oils by water flushing and by bacterial degradation is evident. A study of the hydrodynamic flow of formation waters in the major reservoir zones supports the chemical evidence that flushing has affected the compositions of some of the oils.

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JOHANNES WALTHER'S LAW OF CORRELATION (OR SUCCESSION) OF FACIES

The writings of Johannes Walther (1860–1937) have been neglected in the west and his law of the correlation (or succession) of facies has been ignored or misstated in many text books of stratigraphy. Walther should be recognized as a pioneer stratigrapher-sedimentologist, important both as a world traveler and explorer of modern sedimentary environments (deserts, reefs, laterites) and as a theorist. His main theoretical contributions were his championing of the