markedly dissimilar. A partial parallel in the 2 river systems is the upstream diversion of a sizable part of the Mekong's flow by the Bassac and of the Mississippi's flow by the Atchafalaya. Flood relief afforded by the Tonle Sap, a massive sump more than 200 mi upstream from the mouth of the Mekong has no counterpart in the Mississippi system. The effect of this sump in smoothing stage differences in the river downstream from the point of diversion may be one important reason for the differences between the river systems. The Tonle Sap also may affect sediment concentrations in the Mekong, concentrations which are not only lower than on the Mississippi but are also strikingly different from the standpoint of coarse-to-fine ratios. Two additional reasons for the dissimilarity in the amount and nature of sediment load reaching the sea are the marked difference in tidal variation affecting the river systems and the fact that the Mississippi essentially is confined between artificial levees. The Mekong largely is unleveed and a large proportion of its suspended fine sediments is deposited overbank before they reach the sea.

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Significant Studies of Modern and Ancient Deltaic Sediments

A critical analysis of the geologic literature of ancient deltaic sediments reveals that there has been a noticeable increase in the number of significant papers since 1959. During the 80-year period prior to 1959 only 8 papers on ancient deltas appeared in print. These early contributions were by Gilbert (1885, 1890), Barrell (1912), Barton (1930), Twenhofel (1932), Busch (1953), Pepper *et al.* (1954), and Nanz (1954). During a 5-year period beginning in 1959, 12 significant publications on ancient deltaic deposits of the United States, England, Scotland, and Brazil appeared in print. In the past 8 years an additional 14 papers have been published. Thus, during the 13-year period since 1959, the publication of significant delta papers has been at the rate of about 2 papers per year.

A review of the literature on the geology of modern deltas also is quite revealing. Prior to World War II only 7 papers on modern deltas of North America were published. These were: Johnson (1920, 1921) on the Fraser delta of northwest Canada; Trowbridge (1930), Russell (1936), and Russell and Russell (1939) on the Mississippi delta; and Sykes (1937) and McKee (1939) on the Colorado delta of southern California and Mexico.

Following World War II there was a steady increase in the studies of modern deltas beginning with Fisk's work on the Mississippi delta (Fisk, 1944, 1947, 1952, 1954, 1955, 1958, 1961). Other important studies of modern deltas were: Moore and Scruton (1957), Scruton (1960), and Welder (1959) on the Mississippi delta, and Kruit (1955), Van Straaten (1961), and Lajaaij and Kopstein (1964) on the Rhone delta of southern France.

Post-World War II research on the Mississippi and Rhone deltas and other studies of modern deltas provided reliable criteria for recognition of sedimentary rocks of deltaic origin and also established much needed concepts of deltaic sedimentation. The increase in the number of publications on ancient deltas since 1959 clearly reflects the extensive application of these criteria and concepts to the study of older rocks. This ability to interpret ancient deltaic sediments is one of the greatest achievements in the field of stratigraphy and sedimentology in the past several decades.

On the basis of the writer's 30 years of experience in the field of clastic sedimentology, he has selected what he considers to be the most significant contributions to our present understanding of modern deltas and ancient deltaic deposits.

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Environmental Modeling—Useful Exploration Tool in Carbonate Rocks

The areal distribution of hydrocarbon-producing fairways within any particular carbonate shelf results from the imprints left in the rocks by climate, wind, tide, and contemporaneous tectonic history. Carbonate shelves marginal to the oceanic basins are different from those which formed adjacent to the cratonic basins.

Combinations of the above factors produce a spectrum of environments which can be interrelated within the framework of an environmental model.

Holocene carbonate-depositional models such as Bahama-Florida, British Honduras, Persian Gulf, Shark Bay, and others have provided clues needed to analyze the ancient carbonates and to recognize the appropriate environmental model. The comparison of Holocene models provides a cause-and-effect relation between different factors.

During the early stages of exploration in a carbonate province one should attempt to select an appropriate environmental model from petrologic study of surface and subsurface data. Such a model can be molded to fit the tectonic framework of the basin. The resulting paleoenvironmental model is useful for extending productive fairways and for predicting new trends.

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Deltaic and Associated Facies of Difunta Group (Late Cretaceous to Paleocene), Parras and La Popa Basins, Coahuila and Nuevo Leon, Mexico

The Difunta Group is gray calcareous mudstone, siltstone, and sandstone that interfingers with wedge-shaped redbed units. These complexly interfingered units are divided into 13 formations and many members, tongues, and lentils; the group has a thickness of 10,000 ft.

Low-sinuosity, high-bedload streams transported volcanic and sedimentary rock debris from the Sierra Madre Oriental eastward to the ancestral Gulf of Mexico. Separate rivers fed the Parras and La Popa basins. Sediment accumulated in arcuate, wave-dominated deltas that prograded slowly into water several hundred feet deep. Some sediment was transported by marine processes to shallow delta-flank environments.

Delta-plain lake and interfluve deposits are bioturbated mudstones containing sparse leaves, charophyte oogonia, dinosaur bones, and oyster debris. Many beds were reddened by postdepositional oxidation of iron-bearing minerals. Delta-front sheet sands are 20–60 ft thick, well sorted, flat bedded, and have sparse *Ophiomorpha.* Delta-platform deposits are characterized by sequences of ball-and-pillow structure and a sparse molluscan fauna. Prodelta deposits are interbedded graded sandstone and bioturbated mudstone; the sandstone beds were deposited by turbidity currents generated at the delta front by hyperpycnal inflow.

Carbonate banks up to 1,000 ft thick developed in distal prodelta (shelf) environments on submarine highs that were sea-floor expressions of rising evaporite diapirs.

At least 4 major regressive-transgressive cycles developed in response to episodic basin subsidence. In contrast to the Rocky Mountain Cretaceous transgressions, the Difunta accumulated sheet sandstone units 20–60 ft thick. Parts of the transgressive units are delta-destructional deposits, but many are coalesced progradational sheet sands.

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RECENT SEDIMENT DISTRIBUTION IN COLORADO DELTA AREA, NORTHERN GULF OF CALIFORNIA

Deposition in the northern Gulf of California is a battle between 2 giants: the Colorado River which supplies approximately 150 million tons of mud and sand a year to the area, and the Gulf with its strong tidal currents (up to 4 knots) which control depositional patterns in the coastal and marine environments. The river is winning; during the Quaternary a cone of sediment has prograded basinward covering more than 4,000 sq mi, of which Holocene sediments form only a broad lens in the southern margin of the delta wedge.

A group of 14 continuously cored borings supplemented by surface observations of sediment distribution and processes document both sedimentologic attributes and facies relations of genetic-sand types in the Holocene. These sand facies include (1) tidal bars in the marine environment; (2) barriers, cheniers, sand-tidal flats, tidal deltas, and tidal and estuarine channels in the coastal environment; and (3) fluvial channels, alluvial bars, and dunes in the continental environment.

The late Holocene depositional record typically is characterized by a single regressive section except along the western margin of the basin where multiple regressive sequences, each separated by a transgressive sand, are common as a result of river shifting. The regressive sections either overlie a thin transgressive sand deposited during an early Holocene rising sea-level stage or lie directly on Pleistocene strata.

In a complete offlap sequence the lower part is characterized by marine bar sands and/or marine clays. This lower marine part of the sequence thins northward under the deltaic cone and is absent in the northernmost areas. The upper part of the sequence is much more variable, consisting predominantly of coalescing, upward-fining channel (estuarine, tidal, and fluvial) deposits in the northern and central parts, upward-coarsening coastal-barrier sands along the eastern margin, and mud-flat and coarse alluvial-fan deposits on the western margin of the basin.

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GROWTH RATES OF BEACH RIDGES ON SANIBEL ISLAND, FLORIDA

Sanibel Island, a barrier island located approximately 100 mi south of Tampa along the southwest Florida coast, is about 13 mi long with a curved axis, and comprises a land area of about 18 sq mi with a convex shore facing seaward.

At least 7 distinct sets of beach ridges are present on the island. These are separated by lines of truncation causing the older sets to intersect younger sets at angles ranging from nearly 90° to about 10°. The sets consist of varying numbers of individual sub-parallel-beach ridges with the total number in a set ranging from 10 to over 80.

Elevation of the beach ridges differs with regard to comparison of whole sets and individual ridges differ systematically within each set. Mangrove peat and intertidal marsh cover the oldest sets, which were deposited at an elevation below present mean sea level. The highest beach ridges occur in the Wulfert Ridge set, which has maximum elevations near 10 ft above present mean sea level.

The second highest ridge set has a radiocarbon age of 2,375 ± 75 years, and the Wulfert Ridge set has an average age of 2,131 ± 100 years. Other radiocarbon dates show the chronologic depositional history of the island and rates of sedimentation. The geometry and elevation of the Wulfert Ridge set indicate a possible higher stand of sea level 2,000 years ago.

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PETROLEUM-DERIVED HYDROCARBONS IN GULF OF MEXICO WATERS

Petroleum-type hydrocarbons occur in waters of the Gulf of Mexico principally as particulate material floating on the surface of the water (tar balls) and as dissolved components in the water column. Gas-chromatographic, mass-spectrometric, and carbon isotopic analytical methods have been used to characterize the hydrocarbons in tar balls from western Gulf beaches. These analyses provide a "fingerprint" which indicates that the source of some of the tar ball materials is from seeps.

Dissolved hydrocarbons have been measured both near producing platforms and in the open Gulf. The amounts of dissolved hydrocarbons in the water near producing platforms have been measured to provide basic data useful for interpreting the possible impact of oil production on marine ecology. Samples were taken approximately 20 ft below the surface to eliminate any effects of surface films, although none were visible at the time of sampling. Gaseous hydrocarbons (C_1-C_4) were less than 1 microgram/kg, light-liquid hydrocarbons (C_5-C_{10}) were less than 0.7 microgram/kg, and heavy hydrocarbons (C_{15}^+) were less than 5 micrograms/kg.

These values are not different significantly from values measured on samples from the open Gulf. There does not appear to be an increase in dissolved hydrocarbons in the water near producing platforms.

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SUBMARINE CURRENT MEASUREMENTS, NORTHWEST GULF OF MEXICO

In February 1966, Exxon Corporation undertook a geophysical and geologic survey of the continental slope of the Gulf of Mexico from Texas to Florida. They were joined in May by Standard Oil Company of California and in August by Gulf and Mobil Oil Companies.

As part of this survey the *Caldrill* 1 was to drill 42 coreholes at 36 sites. Submarine current measurements were to be recorded while the vessel was on station. Because of technical difficulties, submarine-current records were obtained at only 6 northwestern sites.

Vertical current profiles at 5 of the 6 stations show two prevailing directions which may represent distinct water masses. The upper current flows generally east or northeast, increasing from about 0.2 knots in the west to about 0.4 knots in the east. Below this system is a current that flows west or northwest at similar rates. The interface between these water masses deepens