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 subparallel-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

westward, from about 400 to about 600 m. The deeper mass may be related to the Yucatan Current.

At 5 sites the meter was maintained for up to 9 hours a short distance off the sea floor to determine the sustaining nature of the currents. Records obtained at 3 locations are consistent in both velocity and direction with the short-term measurements.

These few scattered measurements would not seem to warrant broad conclusions regarding the movement and structure of the water masses over the upper continental slope. However, the data clearly document certain water movements in the spring of 1966. Most of these data are internally consistent, and the velocities are sufficient at times to transport fine to medium sand.

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DEEP-WATER TURBIDITE CHANNELS AND THEIR POTENTIAL VALUE IN PETROLEUM LOCALIZATION

Recent geophysical surveys delineated the characteristics and distribution of turbidites on the proximal parts of deep-sea fans. Turbidite channels generally normal to depositional strike are concentrated near the apexes of deep-sea fans and may be potential reservoirs of petroleum. Migration of the major channels can dissect older turbidite sequences and in places create stratigraphic traps. Deformation such as slumping that is symmetrical to the fan can provide a structural mechanism for entrapment of migrating petroleum.

As the petroleum industry explores for hydrocarbons in turbidite sequences, it is paramount to understand the sedimentation and subsequent deformation associated with this depositional environment.

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WAVE-POWER GRADIENT—APPROACH TO HOLOCENE DEPOSITIONAL HISTORY

Wave-power gradient studies along the mainland in the St. Joseph Bay area (panhandle coast of Florida) indicate that the dominant wave approach direction, responsible for littoral drift toward the south-southeast, is from the west. Using this information, attempts have been made to arrive at a relative depositional sequence in this region consisting of: bay, shoal, spit with beach ridges, and mainland beach ridges.

On a smoothed coast without the beach ridges, but with the present bathymetric conditions, the wave-power gradient was determined. There was no noticeable drift component indicating deposition. Then, the bathymetry was made smooth by the removal of the offshore shoal, the longshore component of wave power was computed and plotted to get an idea of the littoral drift. As a third stage, successive beach ridges were deleted from the spit one after the other and the drift component was determined in each case. At a certain stage, after the removal of a specific number of ridges in the spit and making the bathymetry smooth, the longshore component showed a strong south-southeast drift, accounting for deposition, and in turn leading to the growth of the mainland beach ridges (which originally had been smoothed out).

This model produced one possible depositional history of this region: initially, the simultaneous growth of the mainland beach ridges after the closing of the channel east of Cape San Blas and the northern part of the spit and associated beach ridges extending northward from the cape. This growth is followed by the development of the remaining part of the spit and the formation of the shoal attached to it; and finally the termination of growth of the mainland beach ridges. The age of the beach ridges on the mainland is thought to be between 400 and 600 years.

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EVOLUTION OF BELLE ISLE SALT DOME, LOUISIANA

The Plio-Miocene subsurface geology of Belle Isle dome in coastal Louisiana was studied using electrical logs. The pattern of syndepositional folding, faulting, and sand distribution at this shallow-piercement salt structure reflects variations with time in the configuration of the paleotopographic mound and indicates contemporaneous intrusive movement and sedimentation. Intrusive growth proceeded from an elongate shale and salt mass (ridge stage) to a buried cylindrical salt plug (deep-plug stage) to a plug which maintained a near-surface position (shallow-plug stage).

Each growth stage has a particular style of folding and normal growth faulting that is related to the shape and burial history of the intrusive. The ridge stage is characterized by movement on tangential faults and intrusive-coincident peripheral faults. The highly convergent beds of the deep-plug stage record the main episode of radial faulting. Shallow-plug-stage sediments are rarely faulted, and have low-sedimentary convergence rates. During both plug stages the salt-sediment interface acted as a vertical circular fault.

The shallow-plug stage is associated with slowly deposited nonmarine sediments, whereas the deep-plug stage is associated with rapidly deposited deltaic sediments. It is postulated that deposition rates largely determined burial depth of plug and that changes in absolute rate of salt movement during plug stages were minor.

Because of the large topographic mound present during the ridge stage and deep-plug stage, sandstones grade to shale near the salt, thereby creating numerous stratigraphic traps.

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JAY FIELD—JURASSIC STRATIGRAPHIC TRAP

The first Jurassic oil discovery in Florida was made in June 1970, near Jay, 35 mi north of Pensacola. Current estimates indicate recoverable reserves in the Smackover Formation should exceed 300 million bbl of oil and 300 Bcf of gas. Production is on the south plunge of a large subsurface anticline with the updip trap formed by a facies change from porous dolomite to dense micritic limestone.

The Smackover consists of a lower transgressive interval of laminated algal-mat and mud-flat deposits and an upper regressive section of hardened pellet grainstones. Early dolomitization and freshwater leaching have created a complex, extensive, high-quality reservoir. Irregular distribution of facies presents difficult problems in development drilling, unitization, and planned pressure-maintenance programs.

Hydrogen sulfide content of the hydrogens requires expensive processing facilities and wellhead equipment. A typical completed well costs $650,000 with an additional $200,000 for flowline and inlet separation facilities. Add to this $550,000 for plant facilities to sweeten the oil for market, and each well investment approaches $1,400,000. Daily production from Jay field will approach 85,000 bbl from approximately 85 wells. This rapid development results from a coordinated development program with modular plant design.