cene stand of sea level at 120–140 ft altitude, an Aftonian stand at 90–100 ft, a Yarmouthian stand at 40–70 ft, and a Sangamonian stand at about 25 ft.

The classic exposures of the Fort Thompson and Caloosahatchee Formations on the Caloosahatchee River are the best sections for correlation. Cooke's four marine units in the Plio-Pleistocene sequence are confirmed by detailed tracing of fossiliferous beds, fresh-water marl, and caliche crust related to unconformities. Faunas in the four marine beds show distinct biostratigraphic and paleoecological trends. The ratio of extinct to extant molluscan species indicates a Pliocene age for unit 1 (the lowest marine bed). The presence of Pleistocene land vertebrate remains and the ratio of extinct to extant molluscan species indicate a Pleistocene age for units 2, 3, and 4. For mapping purposes, the lower two units, 1 and 2, are included in the Caloosahatchee Formation. Units 3 and 4 are included in the Fort Thompson Formation. The following bathymetric interpretations were made on the basis of molluscan and foraminiferal faunal assemblages: unit 1—maximum depth 15–20 fm; unit 2—maximum depth 10–15 fm; unit 3—maximum depth 5–10 fm; and unit 4—less than 5 fm.

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SHALE DIAPIRS OF LOWER TEXAS GULF COAST AS TYPIFIED BY NORTH LAWARD DIAPIR

Most geologists who have worked the Oligocene-Frio trend of the Gulf Coast have encountered shale or salt diapirs in their subsurface mapping. Much has been written about salt diapirs or salt domes but little emphasis has been placed on pure shale diapirs.

The purposes of this paper are to acquaint the reader with a typical example of a shale diapir and to point out the possible economic and geologic significance of these features in future exploration for buried lower Frio structures. The North LaWard diapir was chosen because of the large number of wells drilled into the shale stock. This shale diapir has intruded into the lower Frio to a depth approximately 1,100 ft above the base of the Frio Formation. The intrusion appears to have taken place as late as late Frio time and most of the lower Frio reservoirs have been truncated and displaced by the shale. Shale diapirs that have not intruded the lower Frio are believed to have formed many of the lower Frio buried structures such as Una West, Potilla, and Copano fields.

The timing and extent of intrusion by the diapiric shale seem to be critical factors in determining the economic success or failure on these structures.

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WORLD-WIDE EXPLORATION EFFORT AND ITS EFFECT ON GULF COAST GEOLOGIST

(No abstract submitted)

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PALEOCLIMATIC SIGNIFICANCE OF BRYOZOAN METRARABDOTOS

The cheilostome bryozoan genus *Metrarabdotos* occurs abundantly in late Eocene to Recent sediments in the Gulf and Atlantic coastal provinces, the Caribbean region, Europe, and northern and western Africa. The tropical distribution of Recent populations is apparently a consequence of a temperature tolerance of 61° to 82°F. This stenothermy and the distinctive generic morphology of fossil and Recent species provide a basis for identifying tropical faunal provinces on the sublittoral margins of both sides of the Atlantic during late Paleogene and Neogene times.

The northern limit of the genus, congruent in Recent seas with the 70°F. isocryme for surface water, has fluctuated during late Paleogene and Neogene times. The amplitude of latitudinal fluctuation has been 8° in the New World and 34° in Eurafrica. The synchronous latitudinal shifts of this line on both sides of the Atlantic probably reflect variations in Atlantic marine climate. The northern boundary of the genus lay at 31° N. Lat. in the Gulf and Atlantic Coastal Plain and at 40°–48° N. Lat. in Europe from late Paleogene to middle Miocene, at about 26° in America and 28° in Europe in late Miocene, and at its northern maximum of 34° in America and 51° in Europe in the Pliocene; it now lies at 29° in the Gulf of Mexico and at 17° in Africa. The greater amplitude in Eurafrica is probably the result of a surface-current gyre similar to the modern one. The pattern of increasing amplitude of fluctuation does not agree with a paleo-climatic model of cooling from early to late Tertiary time.

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DIAPIRS IN SOUTHWESTERN GULF OF MEXICO

Recent surveys have traced the belt of diapiric structures, first observed in the Sigsbee deep, through the Bay of Campeche to within about 60 mi of the saline basin of southeastern Mexico. This prompts a further examination of the structure of the Gulf of Mexico with particular attention to the possibilities that the diapirs are salt.

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DEPOSITIONAL SYSTEMS IN WILCOX GROUP OF TEXAS AND THEIR RELATIONSHIP TO OIL AND GAS OCCURRENCE

Regional investigation of the lower part of the Wilcox Group in Texas in outcrop and subsurface indicates seven principal depositional systems. These include: (1) Mt. Pleasant fluvial system developed updip and in outcrop north of the Colorado River; (2) Rockdale delta system, present primarily subsurface between the Guadalupe and Sabine River; (3) Pendleton lagoon-bay system in outcrop and subsurface largely on the southern flank of the Sabine uplift; (4) San Marcos strandplain-bay system, found in outcrop and subsurface mainly on the San Marcos arch; (5) Cotulla barrier bar system in subsurface of South Texas; (6) Indio bay-lagoon system developed updip and in outcrop of South Texas; and (7) South Texas shelf system, an extensive system entirely subsurface in South Texas. The Rockdale delta system, consisting of large lobate wedges of mud, sand, and carbonaceous deposits, is the thickest and most extensive of the lower Wilcox depositional systems. It grades updip to the thinner terrigenous facies of the Mt. Pleasant fluvial system Deposits of the Rockdale delta system were the source of sediments redistributed by marine processes and deposited in laterally adjacent marine systems. Delineation of depositional systems and, more specifically, delineation of component facies of the various systems, permit establishment of regional oil and gas trends which show relationship to

producing fields and distribution of potentially productive trends.

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RECENT DELTAIC DEPOSITS OF MISSISSIPPI RIVER: THEIR DEVELOPMENT AND CHRONOLOGY

Fifteen separate delta lobes have been formed by the Mississippi River in the past 6,000 years. Fourteen are included in the Teche, St. Bernard, and Lafourche deltaic complexes; the fifteenth includes the present birdfoot delta, which is an extension of the initial lobe of the Plaquemines-Modern complex. Each deltaic complex is genetically related to a major Mississippi River trunk stream, whereas delta lobes within each complex are the result of different distributary networks extending from the trunk stream.

The delta lobes were defined by detailed facies analyses of sediment cores from hundreds of shallow borings combined with lithologic and faunal data from several hundred additional borings. Each lobe consists of a basal fine-grained prodelta facies, an overlying sandy delta-front facies, and an uppermost fine-grained delta-plain facies. The latter deposits include peat accumulations and nonorganic flood-basin and natural-levee deposits.

More than 100 radiocarbon age determinations have been used to establish the chronology of major deltaic complexes and their subsidiary delta lobes. These data, together with the facies relations, indicate that growth of each deltaic complex was sporadic; progradational phases were interrupted by transgressions resulting from local shifting of sediment influx and from subsidence.

Similar deltaic sequences, prevalent in Tertiary outcrops along the northern flank of the Gulf Coast geosyncline, extend basinward as massive subsurface clastic wedges, which constitute a major part of the peripheral basin fill.

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A LOCAL GEOLOGIST TRIES TO EXPLAIN SAN ANTONIO

(No abstract submitted)

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HIDDEN TRENDS AND FEATURES

Most of the easy-to-find accumulations of petroleum in this country have been found. As a result our domestic exploratory successes during the past decade have been declining not only in numbers of fields found annually, but also in quality or economic worth.

This has come about because the petroleum industry is still confining most of its exploratory efforts to the search for the obvious types of traps which it *knows* are becoming more scarce and thus harder to find.

Geologists have made relatively little effort to search purposefully for the obscure traps—stratigraphic or paleogeomorphic—because of (1) a motivation to continue looking for structures which can be found with present-day tools and ideas, and (2) the pressure exerted on explorationists by their knowledge that anticlines, domes, and fault structures are more acceptable and saleable to management.

Hidden trends may occur below unconformities, at undrilled depths in productive trends, and in relatively unexplored regions. Hidden features may be ancestral anticlines and domes, faults, stratigraphic traps, and buried geomorphic features. The differences between these hidden and the obvious type features is that the former are *not obvious* to present-day exploratory methods and thinking. Many of these probably can now be found, but only if we point our methods and thinking toward them, not around them.

The large domestic reserves required for the future are contained in hidden trends and features. If we are to succeed in finding them, geologists and management will have to place greater emphasis on the search for the obscure trap. In this search, the geologist will be required to emphasize greater study and research on stratigraphy, paleogeomorphology, paleogeography, and paleostructure. Management, on the other hand, will have to be reoriented in its exploration thinking and policies so that the geologist will be encouraged to look for the obscure as well as the obvious trap; also the explorationist must be assured by management that to search for the subtle trap will be welcomed instead of discouraged.

The Gulf Coastal Province contains many geological environments which offer possibilities for production from subtle or hidden traps—among these are (1) sand pinchouts in the lagoonal environment of the Frio (Oligocene) of South Texas, (2) buried structures and sand buildups in the Hackberry embayment (Oligocene) of southeast Texas and southwest Louisiana, (3) possibilities for localized favorable sand distribution patterns in the downdip Wilcox (Eocene) in an area extending from Mexico to Alabama, (4) buried, undiscovered accumulations of petroleum in ancient traps around salt domes which were formed when the domes were shaped or positioned differently than at the present time, and (5) in the entire Gulf Coastal Province where there is no doubt that paleogeomorphological features exist.

The time has come when domestic explorationists must make a turn in the direction of *purposefully* looking for the obscure trap. Since the start in that direction necessarily must begin through management, who must be convinced that the search for the subtle hidden trap is necessary to the future welfare of the industry and the national economy, it is up to the geologist and geophysicist to sell management on the idea of directing a sizeable portion of the exploration effort toward the less obvious traps. If management exploratory policies can be oriented in this direction, the industry will be rewarded with a new era of successful exploration

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CALCAREOUS NANNOPLANKTON ZONATION OF CENOZOIC OF GULF COAST AND CARIBBEAN-ANTILLEAN AREA, AND TRANSOCEANIC CORRELATION

Calcareous nannoplankton organisms evolved rapidly during the Cenozoic, and are of great value as stratigraphic indicators. Many species exhibit world-wide distribution, so that this group of fossils is very useful in transoceanic correlation. Many calcareous nannofossils may be recovered from relatively shallow-water sediments, permitting the zonation established in pelagic sediments to be used in shelf deposits.

The event which ended the Cretaceous almost anni-