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 annihilated Mesozoic calcareous nannoplankton floras. Highly diversified assemblages of Maastrichtian coccoliths were replaced by early Danian assemblages having only a few genera and species. Species diversity increased rapidly during the Paleocene, and by the middle Paleocene had reached a level comparable to that in the late Mesozoic. Discoasters, which due to their large size are very easy to observe and use stratigraphically, first appeared in the middle Paleocene. Late Paleocene, early and middle Eocene pelagic sediments contain a remarkable succession of rapidly evolving calcareous nannoplankton assemblages, culminating in a diversity maximum in the early Lutetian. Later in the Lutetian, a sudden decline in the number of species occurred, and the late Eocene is characterized by relatively monotonous, slowly evolving calcareous nannoplankton floras. Many species characteristic of the late Eocene became extinct in the very late Eocene or early Oligocene. Large calcareous nannofossils, particularly discoasters, are rare in the Oligocene, but forms bearing smaller coccoliths evolved rapidly. Early Miocene calcareous nannofloral assemblages were dominated by an abundance of stout asteroliths belonging to the *Discoaster deflandrei* plexus. In the middle Miocene, these were replaced by rich asterolith assemblages with many delicate forms having long, thin arms. The number of species of asteroliths and coccoliths again reached a maximum in the early Pliocene. During the Pliocene a number of species, particularly discoasters, declined and became extinct. The last asterolith, *Discoaster brouweri*, became extinct at the Nebraska-Aftonian boundary in the Gulf Coast region. During the Pleistocene, species bearing small coccoliths evolved rapidly, and modern assemblages are dominated by a species which first appeared in the Wisconsinan.

The zonation based on calcareous nannoplankton fossils, proposed here, approximates the stratigraphic resolution which can presently be achieved using planktonic Foraminifera. However, monographic studies have been completed only for the Paleocene-lower Eocene, and uppermost Pliocene-Pleistocene-Recent intervals. Stratigraphic resolution should be considerably improved when detailed studies of the middle Eocene-upper Pliocene interval, now in progress, are completed.

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Hypothesis Concerning Origin and Development of Salt Structures in Gulf of Mexico Sedimentary Basin

Geologic and geophysical surveys conducted by Texas A & M University and Lamont Geological Observatory have established the existence of an extensive fold belt on the continental shelf and slope of eastern Mexico.

Indirect evidence suggests that evaporites are present beneath the fold belt and that they played a significant role in the origin and development of the fold belt.

The writers believe that the presence of the folds on the Mexican shelf and slope support Murray's (1966, p. 475) suggestion that the initial deformation of the salt was in the form of anticlines.

Based on the assumption that the initial deformation of the salt was in the form of anticlines, the writers suggest a possible sequence of events in the Gulf sedimentary basin: (1) the folds developed under only a relatively thin cover of sediments; (2) anticlinal ridges blocked sediment transport until they were completely buried; (3) secondary growth began from the crests of the anticlines when there was sufficient overburden to cause salt movement; (4) the development of secondary growth on the anticlines may have triggered the development of other salt stocks which are not directly related to the anticlines.

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Groundwater Flow and Geothermal Regime of Florida Plateau

Temperature surveys in oil-exploratory wells indicate that the geothermal profile underlying the Floridan Plateau is modified anomalously to a negative geothermal gradient (*i.e.*, the ground water becomes colder) to a depth of about 3,000 ft below sea level. The anomaly is related to cold ocean water below the thermocline in the Gulf of Mexico and the Florida Straits. At 3,000 ft below sea level the ground water has a temperature of about 70°F near the edge of the deep sea water bodies, and warms to more than 108°F toward the central axis of the Floridan Plateau. The horizontal and vertical temperature distributions suggest the possibility that cold, dense sea water flows inland through the cavernous dolomite in the deep part of the aquifer where it progressively becomes heated by upward geothermal heat flow. The reduction in density produces an upward convective circulation which brings the sea water into contact with fresh water recharged through sinkholes in the karst region of central Florida. The mixing with fresh water further reduces the density and the diluted salt water then flows seaward and discharges by upward leakage through confining beds into shallow aquifers and thence back to the sea or by discharge through submarine springs on the continental shelf and slope.

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Stratigraphic Utility of Sphaeroidinella Cushman in Louisiana

The evolutionary line which leads to the living *Sphaeroidinella dehiscens* (Parker and Jones) has been divided into two genera, at least six species, and several subspecies. The sequence of forms is discussed here as a temporal cline.

Irrespective of nomenclature, the evolutionary forms of *Sphaeroidinella s. l.* have proved stratigraphically useful in the upper Miocene and younger sediments of Louisiana. Development progressed from a trochospiral form with discrete, inflated chambers and a single aperture, to the living form in which the coiling pattern is obscure, the chambers are merged, and multiple apertures are present. Single aperture forms (*Sphaeroidinellopis* of Banner and Blow) disappeared at the end of the Pliocene. Late Miocene and earliest Pliocene specimens have a thickened apertural lip at maturity. Pleistocene and Recent specimens resemble irregularly ruptured spheres. The lips of the several apertures tend to be recurved and are never thickened. The coiling spiral becomes lower with time. Whereas there is a trend in the direction of fewer chambers in the final whorl of stratigraphically younger forms, this feature must be used with great caution as juveniles always have fewer chambers than adults. The safest single index to stratigraphic age is the degree of chamber separation. All stages of gradation between "species" can be observed.