Sea-floor spreading caused the subsequent widening of the basin, and allowed the first marine transgression that formed a long and narrow embayment—the primitive South Atlantic Ocean. Here, due to restrictive conditions, an evaporitic section was deposited.

The combined effect of the enlargement of this embryonic ocean by eastward migration of the Mid-Oceanic Ridge since Late Cretaceous time, and basin tilting due to detumescence of the pre-rift arching, determined the deposition of a thick, predominantly marine section with deltaic sedimentation near the Doce River area, and of shallow-platform carbonates in the central and eastern parts of the basin.

This upper marine section, although only weakly structured by the progressively decreasing reactivation of the Early Cretaceous faulting, underwent adiastrophic movements by growth faulting and halokinesis.

Late Cretaceous to middle Eocene submarine volcanic activity built up the framework of a 30,000-sq km accretion to the preexisting continental shelf.

The process of origin and evolution, and the structural and stratigraphic characteristics of the Espírito Santo basin, cause consideration of the basin as potentially petroliferous, and warrant the exploration program that is being carried out.

The accumulated knowledge of the Espírito Santo basin, that reflects the regional situation of the whole Brazilian continental margin, affords an important clue to the study of continental drift of South America and Africa.

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Sedimentary Models, Cycles, and Deltas, Upper Cretaceous, Wyoming

Sedimentary models developed from modern sedimentation alone are of limited usefulness to the petroleum geologist because of (1) lack of variation resulting from deposition during a consistent trend of sea-level change; (2) poor control in the vertical dimension, particularly in intermediate and deeper water environments; and (3) the lack of direct association with petroleum accumulation. More widely useful models can be derived from certain ancient rock sequences, utilizing principles based on modern sedimentation. Good outcrops, abundant well control, bentonite marker beds, and dominantly stratigraphic oil and gas production make the Upper Cretaceous formations of Wyoming particularly useful in providing models pertinent to both industry and academic needs.

The Ericson Sandstone of southwestern Wyoming and its nonmarine and marginal-marine equivalents can be combined with marine elements of the model from eastern Wyoming to produce a complete, wide-shelf model consisting of fluvial, paludal, barrier-island, shelf, slope, and basinal facies. Significant differences between the resulting model and previously proposed models are the podlike configuration, the presence of thick slope deposits, and the significant submarine topography present at the epicontinental slope. A narrow-shelf model can be derived from the Lewis Shale, Fox Hills Sandstone, and Lance Formation of the Red Desert basin.

The complete sedimentary cycle consists of the same units as the complete model. Only regressive sedimentary cycles have been recognized. The maximum marine transgressive shift recognized is reflected in a basinal facies directly overlying the paludal facies of the Parkman in southwestern Powder River basin.

The complete model includes a distinct fluvial facies deposited at the mouth of a river and, by definition, a delta. An incomplete sequence consisting of paludal, barrier-island, and a thin shelf facies is interpreted to be interdeltaic. Several deltas can be delineated on this basis from the Ericson and time-equivalent rocks of Wyoming and adjacent states. When related to sequences interpreted as deltaic in older and younger Upper Cretaceous rocks of the area, a shifting pattern of deltaic sedimentation similar to that of the modern delta complex is suggested. If this pattern of shifting loci of deposition is correct, some stratigraphic concepts may require reexamination.

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A Method of Finding Oil—Unorthodox Thinking

Orthodox thinking proceeds in patterns established by past experience and is principally useful in solving the problem of why "other" people discover all the oil. Unorthodox thinking (as here used) is a deliberate pattern of denying (or doubting) the validity of each accepted basic concept and seeking new alternatives. In this sense unorthodox thinking is a method of generating new ideas in a regular and continuing stream.

The unorthodox approach challenges accepted ideas of oil generation and migration, suggesting new and untested trends for major oil accumulation. Similar trends, discovered largely by accident, already have produced vast quantities of hydrocarbons. Such accumulations, although a mystery to orthodox thinkers, are a challenge and an education to the unorthodox. Unorthodox thinking (a method of finding oil) is also a method of organizing and perpetuating creative energy.

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Concepts of Micropaleontology Applied to Petroleum Geology

Micropaleontologic correlations by means of planktonic microfossil zones, defined on either an evolutionary or paleoceanographic basis, show that there are major time-transgressive features for paleontologic zones based upon benthic forams. This problem is especially acute in tectonically active basins where rapid sedimentation is combined with differential subsidence rates. Stage boundaries based on benthic species may occur progressively down-section toward submarine fans; conversely, such boundaries are progressively higher in the section toward deep-water depositional areas that are far from sediment sources. Thus, the misidentification of stratigraphic objectives can lead to drilling errors of many hundreds of meters in exploring different depositional centers within a basin. This aspect of correlation precision is especially acute in areas of continental margins.

Paleoenvironmental logging of sections and wells, employing primarily benthic foram faunas, makes possible (1) definition of paleobathymetric cycles, (2) detection of areas with truncated cycles, (3) definition of principal depositional centers and their migration in time, (4) proper evaluation of sediment bodies such as turbidites and submarine landslides, and (5) definition of paleotectonic rates which lead to the definition of structural trends developing within a basin.

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Basic Disposal-Well Design

Abstract *in* Am. Assoc. Petroleum Geol. Bull., v. 55, no. 11, p. 2080.

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ZOOGEOGRAPHIC PROVINCES OF HOLOCENE PLANKTONIC FORAMINIFERIDA

Faunal provinces of planktonic Foraminiferida are delineated by oceanic water masses and available food supply. Species diversity decreases generally from tropical to polar waters, as well as from fertile to infertile areas. Productivity is probably higher and more continuous in tropical current systems than in subpolar regions. Test size and porosity decrease from low to high latitudes. These factors combine to yield higher accumulation rates of foraminiferal carbonate in tropical-subtropical than in subpolar-polar ocean basins (at depths above the $CaCO_3$ compensation depth).

The bipolar nature of the species distributions is evident from the reciprocal faunal zones in the northern and southern hemispheres. The Indo-Pacific fauna is richer than the Atlantic fauna. Most species (23) live in the warm-water region between approximately 40°N and 40°S lat. Tropical species, such as *Globigerinoides sacculifer* and *Globorotalia menardii,* inhabit the relatively eutrophic equatorial current systems and are transported to mid-latitudes by western boundary currents. Some subtropical species (*Globorotalia hirsuta, G. truncatulinoides, etc.*) live in the central oligotrophic areas of the oceans. Other species (*Globigerinoides ruber, Globoquadrina dutertrei, etc.*) are abundant in both tropical and subtropical latitudes, especially off continental margins. Salinity influences the distribution patterns of the 2 most successful species, *G. ruber* and *G. sacculifer.*

The northern and southern cold-water regions are inhabited by a total of only 8 species. The subpolar fauna is characterized by *Globigerina bulloides,* and left-coiling *G. pachyderma* is the sole representative of the polar provinces. Mixed assemblages of subpolar and subtropical species appear in convergence regions and areas of upwelling along eastern boundary currents.

Apparent species compositions and distribution patterns can be modified artificially by the mesh sizes of plankton net samplers.

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LATE NEOGENE STRATIGRAPHY (FORAMINIFERAL, COCCOLITH, AND PALEOMAGNETIC), UPPER COASTAL GROUP, JAMAICA, WEST INDIES

Late Neogene planktonic foraminiferal and calcareous nannofossil biostratigraphy of the Upper Coastal Group on the island of Jamaica is compared with the planktonic succession in the Gulf of Mexico and with the standard European stages and reference sections in Italy. Correlation of epoch boundaries and other paleontologic data from the Italian to the Caribbean and Gulf of Mexico regions utilizes restricted occurrences of planktonic foraminiferal and calcareous nannofossil species common to both regions. Species important for this intercontinental correlation and dating include: *Globorotalia acostaensis, Sphaeroidinellopsis sphaeroides, Discoaster challengeri,* and *D. extensus* in late Miocene; early Pliocene *Globorotalia margaritae* and *Discoaster quinqueramus;* middle and late Pliocene species of the *Globorotalia crassaformis* lineage, *Sphenolithus abies,* and *Reticulofenestra pseudoumbilica;* and appearance of *Globorotalia truncatulinoides, Helicopontosphaera* sp., and *Gephyrocapsa oceanica,* and faunal evidence for onset of climatic deterioration in early Pleistocene.

Climatic criteria obtained by analyses of the planktonic fauna provide a basis for recognition of the Pliocene-Pleistocene boundary within the most continuous and fossiliferous exposures of late Neogene marine sediments in the Gulf of Mexico and Caribbean region. On the basis of these data a sequence of planktonic foraminiferal zones and subzones is compared with the polarity reversal stratigraphy within the Gilbert, Gauss, and Matuyama geomagnetic epochs.

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CARBONATE POROSITY RELATED TO DEPOSITIONAL FABRIC —ZELTEN FIELD, LIBYA

Production from the Zelten field, Libya, is from the highly porous shelf carbonates of the Zelten Member (main pay) of the Paleocene and lower Eocene Ruaga Limestone. Fifteen facies are easily recognized, mapped, and predicted. In the Zelten field, primary and secondary porosities, recorded as high as 40%, are related to the original depositional fabric of the sediment and are, therefore, facies controlled. Porosity is best developed in the coralgal wackestone and packstone and *Discocyclina*-foraminiferal packstone and grainstone, which together form a northwest-southeast trend across the northern part of the field. Porosity is lowest in the miliolid-foraminiferal-wackestone and argillaceous bryozoan/echinoid-wackestone facies, both of which are blanketlike in distribution over the top of the field and form the cap for the reservoir. Porosity is also low in the argillaceous molluscan-wackestone facies south of and equivalent to the coralgal and *Discocyclina*-foraminiferal facies.

It is concluded that early compaction of the soft carbonate sediments determined the amount of porosity preserved in the reservoir today. The grain-supported facies were not compacted and much of the original primary porosity is presumed to have been enlarged later by leaching. However, the mud-supported facies were compacted; the original porosity was lost early and consequently, later leaching was inhibited.

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HILIGHT MUDDY FIELD—LOWER CRETACEOUS CHENIER PLAIN DEPOSITS IN POWDER RIVER BASIN, WYOMING

Thin sandstones and shales of the Muddy Formation produce large amounts of oil at Hilight field. The Muddy section is generally tight, and the best reservoir sandstones have effective porosity of 17% and average permeability of only 115 md. High production rates are caused primarily by extensive fractures, and the reservoir will yield an ultimate recovery of more than 80 million bbl of oil.

Sedimentary structures and petrographic analyses show that Muddy sands were deposited in littoral marine, lagoonal, and fluvial environments. Porous sandstones average 10 ft and rarely attain 20 ft in thickness. Lower Muddy sandstones are fluvial, whereas upper Muddy sandstones are mostly littoral or lagoonal in origin. Fluvial sandstones are associated with shales and siltstones that are highly carbonaceous and were deposited in poorly drained marshes. Lagoonal sand-