typical form live suspended deeper than about 50–100 m. Basing the beginning of the Pleistocene on planktonic foraminiferal criteria, benthic Foraminifera indicate that outer-shelf conditions prevailed at the beginning of the Pleistocene in some areas, upper-bathyal depths existed in other places, middle-bathyal depths in some areas, and lower-bathyal depths at still other locations. Thus, a boundary based on upper limits of benthic species (*Epistominella pacifica* and *Uvigerina peregrina*), and defined by comparing sections from different parts of the Los Angeles basin, differs hundreds of meters in stratigraphic position.

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LIVING PLANKTONIC FORAMINIFERA IN SOUTH ATLANTIC

The distribution of living planktonic Foraminifera from equatorial to Antarctic waters of the South Atlantic has been determined from plankton tows. Of 24 species recognized, the faunal diversity is greatest in subtropical and temperate waters and is least in the Antarctic region.

Four faunal zones were established. The tropical-subtropical fauna consists mainly of *Globigerinoides sacculifer, G. ruber, Globigerinella aequilateralis, Hastigerina pelagica, Globorotalia menardii,* and *Globigerinoides conglobatus.* Indicator species of the temperate fauna are *Globorotalia inflata, G. truncatulinoides,* and *G. hirsuta.* The sub-Antarctic fauna is characterized by *Globigerina bulloides,* and the Antarctic assemblages are dominated by left-coiling *Globigerina pachyderma.*

The relations between living populations and dead assemblages in bottom sediments were examined, and their implications for paleo-oceanographic interpretation are considered.

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WORLD OCCURRENCE OF PETROLEUM IN PRE-SILURIAN ROCKS

Marine sedimentary rocks of Precambrian, Cambrian, and Ordovician ages constitute a major frontier for petroleum exploration. In regions where appreciable thicknesses of such rocks exist, the distribution of test wells ranges from sparse in most Ordovician sections to virtually non-existent in Precambrian rocks. The prospects for petroleum occurrence within these strata appear to improve with decreasing age. However, the fact that the environment favorable for shelf sedimentation expanded progressively through the same space of time suggests that time is not the overriding factor and that no region of marine sedimentary rocks should be discounted simply on the basis of age.

Petroleum hydrocarbons in apparently commercial quantities are known from pre-Silurian rocks of four continents: North America, Africa, Asia, and Australia.

In Asia and Australia, pre-Silurian rocks have not been tested adequately, and production of petroleum to date is negligible. In Africa, although the presence of pre-Silurian petroleum has been established only recently, very significant production rates already have been achieved.

Approximately 94 per cent of all oil produced from pre-Silurian rocks has come from North America, where the lower Paleozoic rocks have been important petroleum reservoirs for many years. Trillions of cubic feet of gas and an estimated 4.8 billion barrels of oil had been produced by the end of 1963 from pre-Silurian rocks of North America. The most significant area of pre-Silurian oil production is a belt occupying parts of Kansas, Oklahoma, Texas, and New Mexico, where productive beds are found in the Arbuckle, Ellenburger, and Simpson. Elsewhere in North America, the Trenton Limestone of Ohio, Indiana, and Michigan has yielded more than a half billion barrels of oil and more than a trillion cubic feet of gas.

Only in North America has the pre-Silurian section been extensively explored, and it is in North America that most of the known pre-Silurian hydrocarbon accumulations have been found. It would seem reasonable to anticipate that newly discovered petroleum from pre-Silurian rocks in Africa, Asia, and Australia will lead to intensive exploration programs and result in significant discoveries.

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GEOLOGY OF LOWER PERMIAN MINNELUSA OIL FIELDS, POWDER RIVER BASIN, WYOMING

Upper Minnelusa sandstone reservoirs of the Powder River basin produce oil from structural and unconformity traps. This sandstone probably is Wolfcampian in age and was deposited in shallow-neritic to littoral environments which characterized eastern Wyoming. Post-Wolfcampian erosion left remnants of Minnelusa sandstone beds which were covered by red shales and evaporites of younger Permian age.

Minnelusa oil fields of the northeastern Powder River basin, such as Raven Creek and Halverson, are mainly unconformity traps. Updip truncation of the Minnelusa is reflected by abrupt thickening of the overlying Opeche red shale, basal member of the Goose Egg Formation. Minnelusa fields of the western Powder River basin, such as North Fork, are largely structural traps, but post-Wolfcampian truncation may account for as much as half of the closure. In these fields Minnelusa sandstone is preserved on top of structures, and truncation on the flanks is reflected by abrupt thickening of the entire overlying Goose Egg section.

More than 100 million barrels of oil has been found in the upper Minnelusa. As productive trends are revealed by drilling, more oil will be discovered in structural, unconformity, and combination traps throughout the Powder River basin.

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PHYLOGENETIC AND TAXONOMIC PROBLEMS OF SOME TERTIARY PLANKTONIC FORAMINIFERAL LINEAGES

The basic phylogeny and classification of five major lineages of Tertiary planktonic Foraminifera are considered and several revisions are suggested. The definition of *Globorotalia* is broadened to include keeled and non-keeled forms; its range is Danian to Recent. *Globorotalia pseudobulloides* (Plummer) is interpreted to be highly polytypic and ancestral to all later Tertiary members of the Globigerinacea with

the exception of the Heterohelicidae, which have had their own separate evolutionary development. *Globoconusa daubjergensis* (Brönnimann) is classified with the Guembelitriinae in this paper.

Four lineages within the genus *Globorotalia* are differentiated: one leading toward low-conical, keeled and non-keeled forms (*G. spiralis-pusilla-convexa-broedermanni*) became extinct during the middle Eocene; a second leading toward compressed, keeled, and non-keeled forms (*G. compressa-ehrenbergi-pseudomenardii-chapmani-planoconica-pseudoscitula*) became extinct at the end of the middle Eocene; a third is postulated as having led from low- to high-conical forms ("conical globorotaliids") which became extinct at the end of the middle Eocene; and a fourth lineage is postulated as having led to the Neogene and Recent globorotaliid faunas.

The acarininids appear to be characterized by species which are distinguished from *Subbotina* and *Globorotalia* by a strongly spinose wall texture. Two, and possibly three, branches within this lineage appear to lead independently, through parallel trends, to the development of the polytypic, but monophyletic, genus *Truncorotaloides*. In terms of normal criteria of divergence (gaps) and monophyly, there seems to be justification for recognition of the acarininids as a genus, provided the genus were emended to include primarily spinose forms. The genus *Truncorotaloides* also is accepted as valid, although it seems unlikely that it warrants a separate subfamily.

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CHEMICAL DIAGENESIS OF SOME MODERN CARBONATE SEDIMENTS

Mineralogical determinations and pore-water chemical analyses have been conducted on fine-grained carbonate sediments from Bermuda and southern Florida. For the pore waters of normal marine sediments, the results clearly demonstrate no change within experimental error of the ratios Mg^{++}/Cl^{-} and Sr^{++}/Cl^{-} from values found in the overlying sea water. Also, there is a lack of consistent change in carbonate mineralogy with depth. No evidence was found for the recrystallization of metastable aragonite or high-Mg calcite to low-Mg calcite and dolomite in sediments which have been in contact with sea water since deposition. Carbonate saturometer measurements indicate equilibrium of the pore waters with low-Mg calcite, even though it is a minor phase in many samples. This conclusion is corroborated by calcium, alkalinity, and pH determinations, and by laboratory studies of the solution behavior of the sediments. Values of dissolved Ca^{++} lower than those expected for simple $CaCO_3$ solution by dissolved CO_2, in sediments rich in H_2S, can be explained partly by the addition of excess HCO_3^{-} from bacterial sulfate reduction and partly by the precipitation of calcium phosphate.

Pore waters from the brackish mangrove-swamp sediments of the Everglades contain a slight excess of dissolved Mg^{++} over that expected from the Mg^{++}/Cl^{-} ratio of the overlying brackish waters and of sea water. This suggests that transformation of high-Mg calcite to low-Mg calcite takes place in these sediments by interaction with fresh water. Loss of Mg from calcite in fresh water is directly demonstrated by the chemistry of Bermuda cave waters.

The lack of diagenetic transformation of carbonate minerals in sea water may be caused mainly by the interaction of dissolved Mg^{++} with the surfaces of the mineral grains.

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GEOTECHNICAL PROPERTIES OF MARINE SEDIMENTS FROM GULF OF MEXICO

Sediment cores collected from three areas of the Gulf of Mexico—the Louisiana continental shelf, the Mexican shelf-slope, and the abyssal plain—were examined to determine their geotechnical properties.

As these three areas have diverse sedimentation rates ranging from rapid in proximity to the Mississippi delta to very slow on the abyssal plain, the cores were studied with the expectation that a correlation would be evident between rate of deposition and the following properties: shear strength, wet density, water content, grain-size distribution, and porosity.

The cores examined from the Louisiana and Mexican shelves and the abyssal plain exhibited similar characteristics, with shear strength in the upper 10 feet of the cores averaging about 90 lbs./sq. ft.

The shear-strength values of the cores taken on the Mexican slope average much higher (170 lbs./sq. ft.), with some zones having a shear strength as high as 800 lbs./sq. ft. Such a high shear strength is caused by authigenic cementation and the presence of volcanic shards.

Statistically speaking, the remaining parameters measured showed less correlation between zones than did shear strength.

It is assumed from this study that, although the shelf and abyssal zones are being subjected to different sedimentation rates, the processes of sedimentation are such that sediments on the Louisiana and Mexican shelves and the abyssal plain are underconsolidated as opposed to the slope sediments, which are in a normal to overconsolidated state.

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MIDDLE JURASSIC TROUGH OF CENTRAL TUNISIA

Upper Jurassic rocks are widespread in the surface outcrops of Tunisia and adjacent areas in Algeria and Libya. Deep drilling in central Tunisia during the past 15 years has revealed the presence of a thick rock sequence of limestone and calcareous shale which are recognized as Middle Jurassic (Callovian, Bathonian, and Bajocian), and which, in some places, are 1,500 meters thick.

To facilitate better understanding and appreciation of the geological framework and setting for the depositional trough which accommodated this thick series of sediments, maps showing the areas of Triassic outcrops and the thickness of these beds at the surface and in the subsurface are presented. The environment and nature of Triassic sediments are presented, followed by a discussion of the entire Jurassic System in Tunisia. Emphasis is placed on the Middle Jurassic and on the possible role of "Dogger" beds of early Middle Jurassic age serving as reservoir or source beds for oil and gas.