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NUCLEAR POWER AND URANIUM

Nuclear power's role in supplying U.S. electrical energy needs will grow rapidly in the next few decades, becoming the principal electricity source by the end of the century. Chief nuclear fuel during the period will be the uranium isotope 235; however, some thorium reactors will be used and plutonium will have a role later to supplement uranium in water reactors and as fuel in breeder reactors. The current oversupply of uranium and the related soft market prices are likely to be short-lived considering the several fold increase in production capacity and large additions to reserves that will be needed. The U.S. has major low-cost uranium resources compared with other countries, but they are not large compared with projected needs. The few known large uranium areas will provide a basis for continued expansion of reserves, but indications are that new uranium areas will be needed. Filling future needs will be a challenge to the raw materials industry considering the time available, finances required, current prices, decreasing exploration activity, and the indicated resource expansion. Foreign supplies will be excluded from U.S. reactors until late in the 1970s, by which time the domestic industry should be in a strong position to supply a substantial part of U.S. needs and to withstand foreign competition.

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COST-CONSCIOUS GEOLOGY

The most valuable and least expensive tool used in exploring for oil is the time of a trained, creative exploration geologist. Unfortunately there are times when a geologist's job becomes so structured that he spends less time looking for oil than he would like. Ultimately we, as a profession, will be judged on whether we can find reserves of oil at a price per barrel less than the market price. In spending geological man hours, we must be acutely aware of costs and responsibility accounting. We must adapt our thinking to a principle of "reserve centered" accounting so that each unit of exploration is held accountable for finding reserves of oil at a reasonable price. With the tremendous demand for energy that our country now faces, it is more important than ever that we search for ways and means of getting the maximum creative effort from each geologist.

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GULF COAST SUBMARINE BANKS AS POTENTIAL HYDROCARBON TRAPS

The real possibilities of a serious energy shortage in the U.S. have been emphasized recently by economic and political events affecting the petroleum industry. As a result, many explorationists are pressing for new means and approaches by which to increase domestic reserves. As one example of the latter, interest in subtle traps resulting from facies changes, erosional processes, and paleogeomorphic features is increasing in the Gulf Coast as the more obvious structural features become exhausted. A group of calcareous banks along the outer edge of the northern Gulf continental shelf represents potential paleogeomorphic traps of a type that may have been common on ancient Gulf shelves since the Oligocene Epoch. Microfaunal and lithologic facies analyses, as demonstrated on and around the existing banks, provide powerful tools by which to recognize analogous features in the subsurface.

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SHELF-EDGE SUBMARINE BANKS IN GULF OF MEXICO—THEIR PALEOECOLOGY AND BIOSTRATIGRAPHY

A series of submarine banks along the outer edge of the northern Gulf continental shelf are occupied by reefal foraminiferal assemblages. The majority of specimens at these localities are dead, but a sparse living community is present on the shallowest banks. The reefal assemblages contain many species that have not been reported previously from the Gulf of Mexico, but most are well known from shallow reefs in the Caribbean. Cores recovered from the tops of the banks reveal the paleoecologic and biostratigraphic record of sea level fluctuations during the late Quaternary. The mutual presence of large planktonic and benthonic faunules in the same core samples provides direct means for equating paleobathymetric and paleothermal changes that resulted from glacial-interglacial climatic events.

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FACTORS WHICH CONTROL PETROLEUM ACCUMULATIONS

It has been established empirically that rapid deposition of sediment with abundant organic matter is required for the formation and accumulation of petroleum. Such conditions may have existed in any part of basins during different periods, therefore the kind of basin and position within the basin may have no close relation to depositional environments of any particular stratigraphic unit. The important thing is to determine for each formation the area which had optimum conditions for the development and preservation of petroleum source material and the deposition of sealed porous strata.

Large deltas which were constructed in rapidly subsiding segments of oceans or large interior sea margins had all the requirements for oil and gas occurrence: plentiful organic remains; rapid deposition which preserved much of the organic matter; relatively slow compaction which allowed the hydrocarbons to escape from the fine-grained sediments and move into the more porous sediment bodies; many porous sands; abundant clay and silt to seal the sands laterally and vertically; and syndepositional development of local "highs." No other environment in the silicate clastic province had all of these favorable conditions.

Petroleum accumulations in carbonate rocks resulted from rapid deposition of organic-rich carbonate sediments in a fast subsiding area with shallow, restricted, marine environments that had periodic influx of fine-grained terrigenous sediments. Porous calcarenites or oolites which formed on shallow, open-sea platforms, or limestone reefs which grew far from shore and were never covered with terrigenous mud, had little organic material preserved to form petroleum.

Numerous undiscovered oil and gas accumulations are in stratigraphic and stratigraphic-structural traps in the favorable facies of terrigenous and carbonate formations. The basins or parts of the basins without the controlling factors should not be explored.

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LATE QUATERNARY CLIMATES INDICATED BY FORAMINIFERS FROM SOUTHWESTERN GULF OF MEXICO

Planktonic foraminiferal assemblages were examined in 22 deep-sea cores from the Bay of Campeche in the southwestern Gulf of Mexico. Analysis of these assemblages clearly indicates 3 distinct successive biofacies during the late Pleistocene and Holocene. The biofacies are defined by variations in the relative percentages of the *Globorotalia cultrata* group and *Turborotalia inflata*. Excellent correlation can be made between these biofacies and those found in a core from the continental shelf in the northern Gulf of Mexico. These biofacies are interpreted as representing climatic changes.

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EQUATORIAL ACCELERATION AND CONTINENTAL PATHS

A mantle weak enough for convection is also weak enough to

show zonal effects due to the earth's rotation. Zonal rotation—or equatorial acceleration—in a plastic mantle, underneath "rigid" crustal blocks, should have certain specific results.

For instance, major continental blocks in the Northern Hemisphere should, over the long term, describe counterclockwise loops. North America has had such a path, as has Europe. Present motions along the rim of the Pacific Ocean suggest that the North Pacific plate also has been following a counterclockwise loop.

Major continental blocks in the Southern Hemisphere should describe clockwise loops. This has been the pattern for Antarctica, Australia, and South America. Africa, located primarily in the Southern Hemisphere during Paleozoic time, traced a clockwise loop during that era; in Cenozoic time, largely in the Northern Hemisphere, it has been moving with counterclockwise curvature.

Further, major blocks close to the equator should have a greater west-to-east acceleration than major blocks located far from the equator. Hence, South America should be moving eastward relative to North America, and Africa should be moving eastward relative to Europe, North America, and South America. The northward paths of Europe and North America, relative to Africa and South America, also indicate major tensional effects in the Mediterranean and Gulf of Mexico-Caribbean areas.

The Northern Pacific block should be moving eastward faster than the North American block as it is closer to the equator, and should be turning in a counterclockwise sense. This movement provides a north-south zone of east-west compression along the western edge of North America and down the East Pacific Rise.

Reconstruction of block paths indicates that Gondwanaland, a hypothetical Paleozoic supercontinent, was more likely a convergence of individual blocks which had separate previous histories.

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NEGATIVE EVIDENCE AND PLEISTOCENE HISTORY

Studies of Florida, the Yucatán, and other nearby coastal areas have shown that (outside of tectonically disturbed belts), there are no Pleistocene reefs more than 10 m above present mean sea level. If interglacial times produced complete ice-cap melting, and a concomitant mean sea level rise, reef-building organisms should have flourished (a) farther north than now, and (b) higher above sea level than now. This distribution has not been found.

These studies also have shown that there are no obvious large pre-Sangamon coastal deposits away from major deltas. If the Sangamon and the Holocene were typical of Pleistocene interglacial times, then classical theory requires at least 2 more such deposits (Aftonian and Yarmouth). They either are not present or, if present, are not nearly as extensive as Sangamon accumulations.

Further studies of these areas have shown that there are no high flights of Pleistocene marine terraces. Those terraces within the study area commonly mapped as Pleistocene are very low features of Sangamon and Holocene age, or are higher features of Pliocene and Miocene age, or cannot be dated.

Several conclusions were made from these studies.

1. The cooling which brought on late Cenozoic ice ages must have occurred in the late Tertiary, rather than in the Quaternary.

2. Melting of the full set of ice caps, during Quaternary time, was never complete, including the present.

3. Sea level, in Quaternary time, never stood much higher than it is today.

4. Aftonian and Yarmouth sea levels were (a) slightly lower than in Sangamon and Holocene time, or (b) did not maintain a position, similar to now, long enough for significant deposits to be made, or (c) maintained such a position for so long that almost all deposits were removed by erosion.

5. The next long-term trend—barring short-term fluctuations—must be one of climatic cooling and a marked drop in mean sea level.

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PETROLOGY AND DIAGENESIS OF TERTIARY AQUIFER CARBONATES, NORTH CAROLINA

Superior stone quarry near New Bern, North Carolina, exposes 9.2 m of Eocene Castle Hayne Limestone that is disconformably overlain by 2 m of an unnamed Oligocene carbonate unit. Both form part of the most important aquifer system in eastern North Carolina.

The Eocene Castle Hayne strata are divisible into 2 massively bedded facies: (A) a sandy, pelecypod-mold biomicrudite with microspar and pseudospar matrix, and (B) a sandy, pelecypod-mold biosparite and biosparrudite, which grades westward into calcareous quartz sand. Facies A consists of unabraded pelecypod valves (dominantly molds of aragonite *Macrocallista* shells) and 20% by volume of moderately well-sorted, fine quartz sand that are set in microspar and pseudospar. Facies B consists of pelecypod valves (chiefly molds of worn, fragmented, and unabraded *Macrocallista*) and 27% of well-sorted, fine quartz sand. Sparry calcite cement forms 41% of this facies. Subordinate allochems in both are gastropods, foraminifers, bryozoans, echinoderms, ostracods, intraclasts, peloids, glauconite, and bone. Facies A is a low-energy, shallow-marine bank that accumulated seaward of Facies B, which was deposited in a higher energy nearshore environment.

The Oligocene stratum is a sandy, molluscan-mold biomicrudite consisting of pelecypods, turritellid and naticid gastropods, and scaphopods (all as molds of unabraded aragonite shells) that are set in micrite. Fine, moderately well-sorted quartz sand forms 3% of the unit. Other allochems are echinoderms, foraminifers, peloids, ostracods, and bone. This is an inner or middle-shelf deposit that accumulated below wave base.

Upon subaerial exposure, the following diagenetic changes occurred: (1) high-Mg calcite skeletons, mainly echinoderms, recrystallized to low-Mg calcite, (2) most aragonite skeletons dissolved to form molds, and the carbonate either precipitated nearby as low-Mg calcite cement, or neomorphed to spar, (3) molds were reduced or filled with low-Mg spar, and (4) micrite and pelmicrite aggraded to microspar and pseudospar.

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HIGH-RESOLUTION, SUBBOTTOM PROFILES AND SEDIMENT CHARACTERISTICS OF MISSISSIPPI DELTA

High-resolution subbottom profiling and sediment coring within a 100-sq mi area off South Pass of the Mississippi delta have resulted in: (1) a detailed bathymetric chart of the area; (2) a three-dimensional structural chart of the sediments to a subbottom depth of 100 m; and (3) characterizing the surface sediments in terms of lithology, shear strength, water content, bulk density, and compressibility.

The bathymetric chart was constructed on a 1/2 mi grid supplemented by surveys of the area of other agencies. One of the more interesting features of the area was the delineation of a series of gullies. These features are compared with those contoured by F. P. Shepard in 1940.

The seismic data revealed that the subbottom structure of the delta front and of the area seaward is characterized by numerous slump features. The sediment in the area is classified as a high water content, low shear strength, underconsolidated, rather homogeneous silty clay.