

penetration of hard formations in order to recover the oldest rocks in the eastern Caribbean Sea; (2) Curaçao to Kingston, dedicated primarily to geochemical studies of the interstitial waters and to organic geochemical analysis of anoxic sediments from the Cariaco trench; (3) Kingston to Balboa, where attempts were made to reach the oldest rocks in the western Caribbean adjacent to Panama and to establish biostratigraphic standard sections. Paleontologists were looking for deep-sea evidence for the final closing of the Isthmus of Panama through the isolation of the Caribbean fauna from the Pacific fauna.

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SEDIMENTOLOGY OF RESERVOIR SANDSTONES IN EL-MORGAN FIELD, GULF OF SUEZ, U.A.R.

Well cuttings and core samples from 17 wells in El-Morgan field were studied for grain-size distribution, degree of roundness, and feldspar content. The sandstones are Miocene and generally are arkose or subarkose. Mechanical analysis indicates that the sand mode achieved good sorting in a high-energy beach environment, and then was transported en masse by strong waves and currents to a neritic environment where it became mixed with finer sand and clay. The sandstones are leptokurtic and positive skewed indicating a nearby source area. Study of roundness of the sand grains reveals a mixed source, mainly plutonic, with minor contributions from a preexisting sedimentary source, presumably a Cretaceous or Nubian sandstone.

Maps showing the variation in average grain size, feldspar content, and percent of sand in the formation, clearly indicate a source area south and southwest of the field. It is believed to be the nearby Zeit Range. The lack of feldspar alteration is attributed to rapid erosion as a result of the high relief attained by large-scale block faulting in pre-Miocene and early Miocene times and to conditions of extreme aridity.

The sands were deposited from traction currents. The bottom topography of the Miocene sea controlled the amount of turbulence and determined the size, shape, and distribution of the sands.

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ORDOVICIAN GRAPTOLITE FACIES AND NORTH ATLANTIC CONTINENTAL DRIFT

Pre-Caradoc graptolite faunas of North America and Europe are believed to indicate a significant divergence into 2 major facies associations: a "Pacific" fauna which is characteristic for Australia and most of North America, and an "Atlantic-Baltic" fauna which is documented in British and Scandinavian sequences, and which has been reported recently from Newfoundland.

Pelagic graptolites have not received much attention for their potential as facies indicators, but studies of Appalachian and European graptolite occurrences have demonstrated that two contrasting faunal developments existed during the Early Ordovician with both facies occurring on both sides of the Atlantic.

North American circumcratonic pelagic seas apparently provided a prevalent west-to-east current pattern which is indicated by periodic waves of immigrant Pacific graptolites in the northern Appalachians of Quebec and western Newfoundland, as well as in western Ireland and the Atlantic Norwegian Caledonides. This facies is in contrast with penecontemporaneous grap-

tolite congregations of epicratonic black shales in the Oslo region, southern Sweden, Wales, eastern Ireland, and northernmost Newfoundland.

The juxtaposition of both facies in both North America and Europe suggests the existence of a continuous physical barrier during part of the Early Ordovician. The axis of this barrier extended from Newfoundland to central Norway. Only a pre-drift continental plate margin association of North America and Europe makes this assumption tenable.

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FORAMINIFERAL STUDIES: WILKINSON BASIN, GULF OF MAINE

Sediment samples from a 280-m core taken in the Wilkinson basin, Gulf of Maine, have been studied for foraminiferal content. The sediments are dusky yellowish-brown silty clay and presumably represent particles carried by glacial meltwater into the Atlantic Ocean during the latest period of continental deglaciation.

Several features set the foraminiferal fauna apart from the normal open-shelf fauna. There is a distinct lack of arenaceous species in these sediments. *Eggerella advena*, customarily abundant, is lacking, and only *Hyperammina elongata* and *Trochammina inflata* are present in trace quantities.

*Bolivina fragilis* and *B. pseudoplicata* dominate the calcareous fauna, with fewer *Glandulina laevigata*, *Guttulina glacialis*, and *Nonionella labradorica* present. The species abundance and diversity are large and compare favorably with other northern areas.

The faunal list from the basin does not compare with species found at comparable depths on normal shelves. The fauna appears mixed with shallow-water elements derived from relict sediments on the shelf and bordering the basin. By far the majority of species found are from depths of 60-75 m. A few ubiquitous species, *Bulimina marginata* and *Cassidulina norcrossi* are found at greater depths.

Planktonic/benthonic ratios increase upward attesting to an influx of planktonic forms associated with rising sea level.

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LATE PLEISTOCENE-HOLOCENE SEDIMENTATION HISTORY OF CAPE KENNEDY INNER CONTINENTAL SHELF

Lithologic analyses of 91 cores averaging 10 ft in length, radiocarbon dates of *in situ* peat deposits from the shelf, and interpretation of 360 mi of high-resolution continuous seismic profiling indicate a complex sedimentation history for the Cape Kennedy inner continental shelf.

Two prominent and continuous acoustical horizons in the upper subbottom can be traced throughout the 200 sq mi grid studied. The lower reflector lies at -60 to -110 ft MLW and is characterized by an irregular surface probably resulting from erosive processes during long-term subaerial exposure. The upper horizon lies at depth of -40 to -90 ft MLW and generally 2-15 ft below the existing bottom. This horizon is relatively smooth and dips seaward at a low angle. Internal reflectors between the upper and lower horizons suggest prograding beds. Cores penetrating the upper reflector contain subaerially cemented sands and recrystallized shells.

Subsurface sediments in the Cape Kennedy area are widely diversified in sorting, texture, composition, and macrofauna. Major lithologic types are commonly correlative between cores; however, individual cores commonly contain several distinct changes in sediment type. Lithologic characteristics and thickness of strata suggest rapid changes of depositional environment; marsh, lagoon, littoral, and open-shelf facies are represented. Most of the sediments studied were produced by bottom erosion of Pleistocene surfaces and by shoreward migration and mixing of an outer-shelf oolitic sand with an inner-shelf quartzose-molluscan sand during the Holocene transgression.

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#### PROBLEMS OF CHERT IN OCEAN

Mesozoic-Cenozoic pelagic sedimentary cherts exposed in mobile belts or recovered from the deep sea are diagenetic alteration products of a variety of primary sediments rich in opaline skeletons.

The abundance of skeletal opal in fresh sediments depends on its rate of production, losses to solution during transport and before burial, and dilution by other sediment. The chief effect of volcanism on silica deposition is probably one of inhibiting solution. Maximal quantities of silica are buried in the shallower pelagic sediments, but the percentage of organic silica is normally highest near the carbonate compensation depth, where dilution by carbonate is slight. These normally deep sediments are most susceptible to wholesale silicification (radiolarites). Widespread cherts in otherwise noncherty sequences (Reflectors A and B in the North Atlantic) record chemical changes from a regime of silica solution to one of silica retention and back.

Predilection of chert for permeable beds indicates localization along zones of water movement. Paragenesis may be complicated. In normal abyssal sediments, complete conversion of skeletal opal requires 30–60 m. y., but in areas of rapid burial, high heat flow, and faster connate water flow, the rate must be more rapid.

Two organic events have greatly affected patterns of chert sedimentation. First was the rise, in the early Paleozoic, of organisms with siliceous skeletons; prior to that time silica had been precipitated inorganically. Second was the rise of planktonic carbonate producers during the Jurassic, resulting in restriction of highly opaline sediments to great depths (radiolarian oozes) or to areas of unusual circulation (diatom oozes).

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#### VARIATIONS IN HEAVY MINERAL COMPOSITION DURING TRANSPORT OF SHORT-HEADED STREAM SANDS

Past studies on variation in heavy minerals along large streams have shown that progressive change, or lack of it, during transport is due to abrasion, dilution, hydraulic conditions, and sorting on the basis of size, density, and shape. In the light of these studies assessment of the variation in heavy minerals was made along the short-headed Canadaway and Cattaraugus Creeks in western New York. In that area the glacial drift and moraine deposits are ready sources of heavy minerals. Major annual erosion and transportation of these materials occur during peak streamflow in March–April and deposition during decreased flow in the succeeding months. Thus, during the summer of

1968, efforts were made to collect part of the bedload deposited during the interim period of optimum and minimum streamflow.

Analyses of samples of similar size distributions show that variation in heavy minerals during transit occurs along these creeks and the relation is best developed in the coarse fractions. Results show a decrease in garnet and complementary increase in hypersthene, hornblende, and tourmaline downstream. Comparison of variation in heavy minerals reveals that although overall difference in weight percent exists, the relation of these minerals and the transport direction do not differ significantly between the two creeks.

Consideration of the possible causes of heavy mineral variation indicates that it is not due to dilution and abrasion. This modification may result from progressive sorting on the basis of size, density, and shape as produced by the annual current-flow fluctuations.

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#### MINERAL DEPOSITS FOUND IN EXPLORING FOR PETROLEUM

The greater part of the world's supply of mineral commodities, both in monetary value and tonnage, is obtained from strata lying within or near petroliferous regions. Commercial deposits of many metals as well as nonmetallic minerals are present in such sediments.

Serendipity has been responsible for the discovery of numerous valuable deposits of various nonhydrocarbon minerals as a by-product of exploration for petroleum. Such discoveries include enormous reserves of aluminum ore in northern Australia; a major copper deposit in New Guinea; saline deposits comprising various magnesium, potassium, and/or sodium minerals in many parts of the world; most of the sulphur deposits produced by the Frasch process in the USA and Mexico; and uranium in Texas. Hundreds of other valuable deposits probably have been found but were not recognized.

Making full use of all the geologic information that can be derived from petroleum operations inevitably will lead to discovery of additional mineral deposits with little extra cost, and thus increase the return on investment. Conversely, thorough study of stratigraphic zones containing commercially valuable minerals commonly will improve the interpretation of geophysical data and thereby assist in petroleum exploration.

In order to attain maximum profit from exploration, companies should: (1) itemize all mineral possibilities in the area of operations; (2) train personnel to recognize and report all minerals of economic interest; (3) collect and examine cuttings from all shot-holes and wells, from surface to total depth; and (4) take full advantage of the wealth of geologic and geophysical data already in the files.

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#### MAGNESIUM-RICH WATER FROM EVAPORITE-BEARING SHALES, AND DIAGENESIS OF SUBJACENT CARBONATES—KEUPER-MUSCHELKALK, IBERIAN RANGE, SPAIN

Triassic rocks of the Iberian Range consist of a succession of continental sandstones (Buntsandstein), peritidal carbonates and shales (Muschelkalk), and continental claystones and evaporites (Keuper).

Dolostone, which comprises 75% of Muschelkalk