Petrologic study of cores and well cuttings defined 3 major facies. The "deeper water" micrite is dark brown with scattered fossil fragments and was deposited in water from 50 to 200 ft deep. The biogenic bank facies is composed of biosparite to biosparudite containing platy algae, fusulines, bryozoans, gastropods, pelecypods, brachiopods, and some crinoid columnals. The "sheltered" micrite contains numerous small unidentifiable foraminifers deposited behind the bank, and a few very local biogenic mounds. These mounds seem to be analogous with the mangrove islands found in Florida Bay.

Bank development was confined to the west edge of an Atokan structural terrace where oscillation waves were impinging upon the rising sea floor. Turbulence, shallow water, and the associated supply of nutrients provided necessary ingredients for prolific growth of organisms which formed the biogenic bank.

Excellent hydrocarbon production has been obtained from the bank across 13 mi of its length. Recently production was extended 1¾-mi south and an extension is being drilled 1½-mi north. There is a good possibility of additional biogenic banks having developed on the broad Strawn shelf.

TILLMAN, R. W., Cities Service Oil Co., Exploration and Production Research, Tulsa, Okla.

Discriminant Analysis Versus Factor Analysis of Grain-Size Data from Different Environments and Sedimentary Structures

Grain-size data analyzed by multivariate computer techniques allows (1) discrimination of environment of deposition and (2) recognition of sedimentary structures. Multiple discriminant analysis where used in conjunction with variables derived from ¼-phi-sieve grain-size analysis was found to be the most useful multivariate technique.

Grain-size samples from 3 environments (Arkansas River, Great Sand Dunes National Monument, Colorado, and Gulf Coast beaches) were used as "known" environments in discriminant analysis. With the intention of classifying 49 samples from Bijou Creek, Colorado, they were listed in the discriminant analysis program as "unknowns." Thirty-six of 39 "unknowns" were correctly classified by the program as river sediments. Q/mode factor analysis correctly classified 32 of the Bijou Creek samples with known river samples.

Variations in grain-size distributions within a given environment were studied in an Arkansas River sand wave. Foreset beds, climbing ripples, and horizontal laminations were designated as "known" sedimentary structures. By use of multiple discriminant analysis 20 of 21 samples from a second sand wave were classified correctly. Using Q-mode factor analysis all but 3 samples were classified correctly.

By analyzing separately each of the 2 or 3 populations appearing as straight lines on cumulative plots on normal probability paper, greater discrimination between environments was obtained than by using standard grain-size parameters calculated by assuming each sample represented a single population.

TISSOT, B. P., Institut Français du Pétrole, Paris, France

Present Knowledge of Fundamental Processes of Oil and Gas Origin and Migration Applied to Petroleum Prospecting

There are 2 approaches to petroleum prospecting with organic geochemistry. The essential problems with direct methods are the process and the importance of migration to surface and the occurrence of hydrocarbons of superficial origin. Indirect methods are based on the knowledge of the laws of (1) distribution of organic matter as a function of paleogeographic and paleoclimatic conditions; (2) transformation of organic matter into petroleum under temperature and pressure conditions, as shown by laboratory analysis and experiments on samples from sedimentary basins; and (3) migration of petroleum from the source rocks to the reservoir and eventually alteration caused by temperature, pressure, and underground waters.

The foregoing knowledge may be applied to determine areas favorable to the transformation of organic matter into oil and/or gas and the time of formation of petroleum, compared with the time of sedimentary or structural trap formation.

These results may be obtained more particularly by mathematical models processed on computers.

VACHER, H. LEONARD, Bermuda Biological Station for Research, Bermuda, and FRED T. MACKENZIE, Dept. Geological Sciences, Northwestern Univ., Evanston, Ill.

Pleistocene Calcarenite Lithosomes of Bermuda

Bermuda's subaerially exposed limestones consist of eolianites, littoral calcarenite lithosomes, and accretionary soils deposited during Pleistocene high sea levels. The geometry and structure of these deposits were studied to evaluate sea-level fluctuations during Pleistocene high stands, and to provide criteria for recognizing the eolian-marine facies in surface and subsurface rocks of earlier age.

Eolianites are dune ridges trending parallel with the present coastline and arranged in decreasing age from the center of the Bermuda islands outward. Eolianites are subdivided into 2 structural lithosomes: foreset wedge and windward-topset wedge. The foreset wedge is characterized by strata steeply inclined (35°) landward and concave seaward and downward. Foreset curvature is used to divide the wedge into a row of adjoining lobate bodies that represent the hillocky coastal dunes from which the dune ridge was constructed. The windward-topset wedge is characterized by complexly festooned cross-stratification in the seaward part and more regular, seaward-dipping, gently inclined (5–15°) cross-stratification near the dune crest.

Littoral calcarenites that overlie or are transitional with windward eolianite strata are termed "seaward shore" whereas those that onlap foresets are called "inland shore." Seaward-shore calcarenites are subdivided into (1) depositional coastline deposits that represent beaches fed by reef-derived detritus, and (2) erosional coastline deposits that represent pocket beaches fed by erosion of headlands. The former are wedge-shaped bodies of regular, seaward-dipping, gently inclined cross-strata and interfinger with eolianites. The latter are conglomeratic pods overlain by accretionary soils and found between eolianites.

Accretionary soil is unbedded, uncemented, organic-rich calcarenite containing land snails and rhizoconcretions. The soil records invasion of vegetation and land crabs onto freshly deposited calcarenite. Environments of soil development include the supralittoral of pocket beaches, interdune swales, and the seaward slopes of inactive, unlithified dune trains.

Analysis of the carbonate eolian-marine facies in Pleistocene and older rocks can provide data necessary to interpretation on a worldwide basis of (1) sea-level fluctuations, (2) shoreline position and physiography, (3) paleowinds and paleoclimates, and (4) sediment sources.

VISHER, GLENN S., Dept. Earth Sciences, Univ. Tulsa, Tulsa, Okla., SANDRO SAITTA-BERTONI, Texaco Maracaibo, Maracaibo, Venezuela, and RODERICK S. PHARES, Mobil Oil Corp., Tripoli, Libya

Pennsylvanian Delta Patterns and Oil Occurrences in Eastern Oklahoma

Data from modern deltas have made it possible to interpret the origin of the Pennsylvanian "shoestring sands" of Kansas and Oklahoma. Objective criteria from cores and outcrops are used to define specific areal and vertical depositional patterns. Criteria include: (1) vertical patterns of sedimentary structures, bedding, and grain size, (2) clay mineralogy and detrital clasts, (3) trace fossils, and (4) detailed analysis of textures.

The historic development of a delta provides the insight for interpreting the deposition patterns observed in ancient deltaic sandstone bodies. The processes of progradation and maturation are used to develop a 4-dimensional deltaic model. Six subdivisions are distinguishable: (1) lower alluvial plain, (2) upper deltaic plain, (3) lower deltaic plain, (4) subaqueous sand sheet, (5) marginal basin, and (6) marginal plain.

The lower alluvial plain is characterized by stream meandering, point bars, and unidirectional channel flow. Development of the lower deltaic plain is controlled by crevassing of natural levees, by tides, and by floods. The subaqueous sand sheet is developed by shallow-water currents, modified by progradation and commonly replaced by deltaic-plain environmental units. The marginal basin and depositional plain are produced by longshore drift, and reflect a balance between subsidence, sediment supply, and wave energy. These environmental units may be modified or replaced by other deltaic elements.

The Bluejacket-Bartlesville Sandstone of eastern Oklahoma was selected as a model because of its importance as an oil reservoir, the large amount of available subsurface data, and the simplicity of the stratigraphic and structural framework. The model is used for interpreting many other oil-productive Pennsylvanian sandstones in eastern Oklahoma.

Lower Pennsylvanian strata were deposited during an overall transgression; but, the transgression is marked by extensive regressions. These are represented by widespread sandstone sheets commonly underlain and overlain by marine shale or limestone. Particular sandstone units are distributed across thousands of square miles, but locally the sands are lenticular. Each regression is in response to the outbuilding of sediment under static sea-level conditions. The supply of sediment is related genetically to a river system, and deltaic patterns from the same river can be traced through Morrowan, Atokan, and Desmoinesian strata.

WALKER, ROGER G., Dept. Geology, McMaster Univ., Hamilton, Ont., and J. C. HARMS, Marathon Oil Co., Denver, Colo.

Thin Marine-Nonmarine Alternations in Upper Devonian "Catskill Delta"

Upper Devonian strata, totaling 1,000–3,000 m in Pennsylvania and New York, record the shift from marine turbidity current to alluvial-plain deposition. Few detailed descriptions of the interval of transition have been published, and there is no adequate discussion of depositional environments based on modern sedimentologic principles.

In the Susquehanna Valley, south-central Pennsylvania, the turbidite sequence is followed by several hundred meters containing numerous thin marine-nonmarine alternations. These alternations, commonly as thin as 6 m, are composed from bottom to top of (1) sharp basal surface; (2) green, bioturbate, fine sandstone with brachiopods or crinoids; (3) green-gray fissile shale; (4) red, thin-bedded to massive mudrock or very fine sandstone with root marks, cracks, and small wave ripples; and (5) red massive mudrock with root marks, and tan calcitic nodules. Cross-stratified sandstone beds a few meters thick and with erosional bases are found rarely within units 4 and 5. Above the highest band of marine fossils is a thick sequence of red alluvial-plain cycles, composed of sediments which become finer toward the top of each cycle (Catskill). These characteristics suggest that the shift from marine to nonmarine deposition was broken by many abrupt transgressions (1 and 2). Shorelines prograded mainly by mud deposition (3 to 4), implying that wave energy was slight. Because coarser sediments with channeled bases are absent in unit 3 and rare in unit 4, tidal channels and tidal fluctuations must have been absent. The large volume of mud represented by each alternation must have been supplied mainly by longshore drift or overbank flooding from large, widely spaced streams, and the alternations probably are controlled by local tectonic pulses or tectonically influenced sedimentation rates.

WALKER, ROGER G., Dept. Geology, McMaster Univ., Hamilton, Ont., and F. J. PETTIJOHN, Dept. Earth and Planetary Sciences, Johns Hopkins Univ., Baltimore, Md.

Archean Turbidite Basin, Northwestern Ontario

The importance of the study of Archean sedimentary sequences in unraveling the early history of the earth and continental development is self-evident. To this end we made a detailed stratigraphic and sedimentologic analysis of an Archean basin typical of the many found in the Slave and Superior provinces of the Canadian shield. The sedimentary sequence chosen, probably between 5,000 and 10,000 ft thick, is exposed on the shores of East Bay of Minnitaki Lake in northwestern Ontario. The lower 4,400 ft was studied in detail.

The entire section consists of turbidites, the indigenous sediment being fine mudstone and siltstone commonly forming graded couplets 1 or 2 cm thick with distal aspect. Interbedded with this predominantly pelitic facies are proximal facies. These consist of coarse, graded graywacke and, in places, graded conglomerate, the latter with cobbles up to 40 cm in diameter. The conglomerate near the base of the section consists of quartz-porphyry debris with numerous large sedimentary intraclasts; that near the middle of the section is of "granitic" provenance and contains cobbles of "granitic" aspect.

The study demonstrates the dominant role of turbidity currents in the deposition of Archean sediments—even of coarse conglomerates—and establishes the nonvolcanic origin of these sediments and a sialic plutonic source for most of the basin fill. The strata are not intra-volcanic but are, instead, a true epiclastic sequence deposited in a turbidite basin—perhaps similar to the younger turbidite basins of southern California.