giving rise to much confusion and controversy. Attempts to compare these forecasts reveal that many of them were poorly documented and utilized different assumptions, definitions, methods, geographic boundaries, and data bases. During recent years increased effort has been directed toward resolving some of these major problems, and there is evidence that progress has been made.

Events triggered by the Arab-Israeli war of 1973 focused attention on the world's energy problems and on the inherent uncertainty of resource estimates. It is evident that many nations need forecasts of future petroleum supplies and that these should be based on reliable estimates of the distribution and magnitude of oil and gas resources throughout the world. This situation calls for a high level of domestic and international cooperation among resource appraisers. Communication lines need to be improved; how to accomplish this quickly and effectively is one of the major problems facing us today.

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Distribution of Clay in Recent Sands

Shallow cores and surface samples from a beach, point bar, and channel mouth near Pascagoula, Mississippi, were used to study clay distribution in sand-rich sediments. Air photos, permeability measurements, grain-size data, photomicrographs, and X-ray diffractograms provided the data base.

Data from clay-silt-sand separations show that, in general, the clay/silt ratio increases as the sand content increases. The clay/silt ratio increases from 0.12 to 5.92 in beach samples as the "percent sand" increases from 52.6 to 99.9, from 0.25 to 9.05 in point-bar samples as the "percent sand" increases from 48.5 to 98.8, and from 0.08 to 1.19 in channel-mouth samples as the "percent sand" increases from 59.9 to 97.8.

The highest clay/silt ratios are in subaerially exposed sediments with generally high vertical permeabilities. Clay/silt ratios in the berm crest of the beach increase to about 5 as permeability increases to about 5 darcys. Clay/silt ratios in the beach portion of the point bar increase to about 9 as the permeability increases to about 1.4 darcys.

Scanning electron microscope (SEM) photomicrographs show that the clay can occur as coatings on much larger grains and as composite grains (aggregates of clay, silt, and sand). Only one possible example of authigenic growth in the clay fraction was observed with the SEM.

It is concluded that clay may be deposited in sand-rich environments through the settling of large clay-coated grains, as composite clasts, and as floccules. In-situ percolation of clay suspensions and biogenic activity may add to the clay content of sediments.

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Sedimentology and Synergy of Deltaic Sandstone; Admire 650-Foot Sandstone, El Dorado Field, Kansas

The Permian Admire "650-ft" sandstone reservoir occurs at shallow depths (650 ft; 197 m), is thin (11 to 23 ft; 3 to 7 m), and has produced 48.7 million bbl of oil through primary and conventional secondary-recovery methods in the El Dorado field, Kansas. A micellar-polymer tertiary oil-recovery pilot project being conducted by Cities Service Oil Co. and DOE is aimed at recovering half of the 71.5 million bbl of oil still in the reservoir.

The 51-acre (20 ha.) block being tested for enhanced recovery at El Dorado field was initially assumed to be a generally homogeneous reservoir. A Phase 1 geologic analysis of seven slabbed and polished cores indicated the reservoir was, instead, heterogeneous and that it contained at least two vertically stacked layers with variable production characteristics. Considerable areal variability was also observed.

In Phase 2, a total of 24 cores was used to build a detailed geologic model. Various facies associated with a delta system were defined. Reservoir facies are distributary-channel sandstones, splay sandstones, and natural-levee deposits. Interdistributary-bay (in part intertidal), silty shales are present below, interbedded with and lateral to the sandstones. A classic subdelta model similar to that described by J. Coleman for West Bay in the Mississippi delta is demonstrated for the Admire. The deltaic model developed through geologic interpretation of cores allows prediction of the effectiveness of the tertiary oil recovery.

Pressure-transient analysis has been used to define sandstone trends further and to analyze directional properties of the reservoir. Interference tests yield directional pressure:transient ratios ranging up to 14 in areas of definite sandstone lineation. The high pressure:transient ratios result from strongly contrasting, mutually perpendicular transmissibility values. Many areas of strong, preferred transmissibilities are confined within geologic-facies boundaries.

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Radiolaria from Oman Mountains

Much of the Oman Mountains was formed from allochthonous thrust sheets of the Semail Ophiolite and Hawasina Series, remnants of a basin which existed north and east of the Arabian shield during most of Mesozoic time. Cherts and siliceous mudstones collected from the various formations of the mountains range from Late Triassic to Late Cretaceous in age. A 1,445-ft (440 m) measured section was made of sediments of the Halfa Formation, the most distal facies in the Hawasina Series. The lowest part of the section is no older than Middle Jurassic (Callovian), on the basis of presence of *Archaeospongoprunum* sp., and the highest well-preserved sample is Early Cretaceous (Valanginian) in age, on the basis of the presence of *Cecrops septemporatus*. Although Radiolaria are abundant throughout the section, preservation is strongly related to the color of the cherts and mudstones in which they are found—the green cherts and mudstones showing very poor preservation whereas the red show fair to excellent preservation. Halfa samples at other localities yielded Radiola-

ria associated with pectinacids (*Halobia* sp.) of Late Triassic age. In addition, samples of sediments interbedded with pillow lavas at the top of the ophiolite yielded well-preserved Late Cretaceous (Cenomanian to Turonian) Radiolaria.

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Paleoenvironment and Petroleum Potential of Mid-Cretaceous Black Shales in Atlantic Basins

Cores from the Deep Sea Drilling Project in the Atlantic Ocean have permitted recognition of widespread organic-rich black shales in the mid-Cretaceous. However, geochemical studies have proved that the origin and petroleum potential of this organic matter is highly variable. Three main types of organic material can be recognized in these sediments from kerogen studies: (a) marine planktonic, deposited in a reducing environment; (b) terrestrial higher plants, moderately degraded; and (c) residual organic matter, either oxidized in subaerial environments and/or recycled from older sediments.

Vertical and horizontal variations of these three types of organic matter are illustrated by geochemical logs in each main basin of deposition. Paleogeography and environment of deposition of organic deposits are deduced from these data. The petroleum potential of the sediments is therefore a consequence of the paleogeographic setting. Thus, the zones favorable for oil and gas (given adequate maturation), or those devoid of any potential, can be delineated. Complementary studies of wells on the continental shelf of the North American continent tend to show that the organic characters in the deep basins can be correlated with those recognized in nearshore locations.

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Paleoenvironments of Middle Devonian Sandstones of Upper Mississippi Valley

The Dutch Creek, Beauvais, Lupus, and Hoing Sandstones are supermature quartzarenites associated with transgressive carbonate sequences. They generally have gradational upper and lower contacts. Fossils are mostly fragmentary crinoids, brachiopods, and trilobites. Complete fossils are mostly corals that settled during periods of temporary bottom stability and slow sedimentation.

Unidirectional, planar cross-bedding dominates part of the Dutch Creek, Beauvais, and Lupus Sandstones, indicating paleocurrent movement to the northwest. Local herringbone cross-stratification with associated reactivation surfaces indicates tidal action. Lenticular bodies of Hoing and Lupus sandstone enclosed in calcilutite contain graded sequences and basal conglomerates, suggesting tidal-channeling of banks and shoals. Parallel lamination and cylindrical structures in the Hoing Sandstone indicate high intertidal environments.

These sandstones all consist of bimodally distributed fine- and medium-sized quartz grains. Medium-sized grains are well rounded to rounded, contrasting with angular fine-grained quartz. Cementation is mostly by sparite and microcrystalline calcite. Locally, secondary silica replaces carbonate. Near faults, quartzitic texture probably results from pressure solution. Interlocking secondary overgrowth locally provides cementation.

Bimodal grain-size distribution, seaward thickening of the sandstone, and an apparently inadequate source suggest eolian transport to the sea across a carbonate terrane prior to marine deposition. This does not require a sabkha, but depends on aridity and sparse plant cover. Subsequent tidal, wave, and current action is believed responsible for ultimate transport and deposition of the sand.

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Shallow-Submarine Seismic Stratigraphy, Mississippi River Delta Front

High-resolution seismic, and engineering borehole data were integrated to interpret the shallow seismic stratigraphy of the Mississippi River delta front. Three seismic stratigraphic units have revealed the transgressive-regressive depositional sequences associated with late Pleistocene glacio-eustatic changes in sea level. Each of the stratigraphic groups was found to consist of a lower clayey unit and an upper fine-sand and shell unit. Paleotopographic maps of the stratigraphic units reveal the morphology of the former continental shelves. Structural features observed within the delta front area include shelf-edge growth faults, a salt diapir, and an extensive erosional unconformity which is believed to be the result of a large slide mass of early Holocene age.

The modern, prodeltaic sedimentary wedge includes up to 100 m of soft, underconsolidated, gas-bearing silty clays, deposited during the past 500 years. The thickness of this unit within the delta-front area has been mapped.

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Computer Applications of Petroleum Data System

The Petroleum Data System, a collection of general field and reservoir information, has been available for public use for approximately 3 years. Data have been used in a variety of studies by oil companies, consultants, and government agencies. In particular, many studies have been done in an effort to determine the potential of specific basins for future exploration and drilling, the feasibility of certain types of enhanced recovery techniques, and future reserves from existing fields. The different types of output are histograms, scatterplots, bargraphs, correlations, simple listings, and summary reports obtained by manipulation of the data in the file. These examples illustrate problems that have to be faced in working with large data bases, such as