patchily distributed spar most common at grain-contacts, change abruptly across the water table to phreatic cements, displaying a uniform rim of rhombohedrons surrounding each grain. Vadose cements preserve primary porosity and increase variation in permeability more than phreatic cements.

The updip Smackover grainstone reservoirs in southern Arkansas are characterized by (1) early cements that predate hydrocarbon emplacement and that resemble the Joulter Cays freshwater cements, (2) preserved primary intergranular porosity, and (3) leached moldic porosity. Vadose imprint is characterized by poorly developed cement rims around grains, a grain-contact meniscus fabric producing rounded pores, and a patchy distribution of block spar with crystals that increase in size away from the grains. The meniscus fabric is only partly preserved where grain interpenetration has occurred during burial. Phreatic cements occur as moderately to well-developed non-isopachous rims around most or all of the grain margins. They line pores forming jagged boundaries, and are patchy to extensively developed showing an increase in crystal size away from the grain. The cement rims are commonly broken and separated from the grains during compaction. Compaction features and late cements are not distributed uniformly in the grainstones, owing perhaps to heterogeneous porosity and permeability patterns established by early cements.

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False River Field

On August 14, 1975, Chevron Oil Co. spudded the No. 1 Alma Plantation in Sec. 87, T6S, R11E, Pointe Coupee Parish, Louisiana. The objective was in Cretaceous rocks at a projected total depth of 22,500 ft (6,858 m). This became the discovery well for False River field. To this date, nine wells have been completed in the field from the Tuscaloosa Formation of early Late Cretaceous age at a depth of 19,800 ft (6,035 m). In addition, seven wells are being drilled or tested, and two have been completed as dry holes. The No. 1 Alma Plantation flowed at the rate of 20 MMcf of gas per day with a flowing tubing pressure of 11,600 psig (79,878 kPa). The initial shut-in reservoir pressure was 16,806 psig (115,776 kPa). From subsurface and seismic data, a structure appears to be buried below the base of the Austin Chalk. This structure is 20-mi (32 km) long and 10-mi (16 km) wide at a depth of approximately 19,000 ft (5,791 m), and is situated adjacent to the south side of a Cretaceous hinge line. This hinge line extends from Lake Bornge northwesterly across south-central Louisiana into southern Vernon Parish. From subsurface and seismic data it appears that the structure is depositional in origin.

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Authigenic Quartz in Devonian Black Shale

The Antrim Shale (Devonian, Michigan basin) contains a large volume of authigenic quartz. The shale contains appproximately 50% quartz by weight of which, in the >500 mesh-size fraction, 56% is polycrystalline. This is approximately twice the amount of quartz in most shales and 10 times the amount of polycrystalline quartz in the silt-size fraction of sandstones and shales. Scanning electron microscopy reveals an authigenic surface composed of hexagonal tabular plates which coalesce to form smooth grain surfaces. These plates have not been previously reported on quartz grains. Oxygen isotopes of quartz and carbonate phases are interpreted to indicate a gradual isotopic lightening of the pore fluids, from approximately −4 to −9 or −10 ppm. Most of the authigenic quartz has a $\delta^{18}O \approx$ 22 ppm (SMOW).

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Petroleum Geology in 1980s

At no time in the history of petroleum geology has the need for marshaling our scientific knowledge and professional skill been more necessary than it is today. As a result of the mature stage of development in most United States petroleum-producing areas and recent concentration on close-in exploration targets, the barrels of oil equivalent (BOE) discovered per foot of new-field wildcat drilled has declined from 350+ in the late 1940s to 53 in the late 1970s.

If the decline in discovery per unit of drilling continues, and approximately the same rate of drilling is maintained, by 1990 the discoveries per foot in new-field wildcat wells are projected to be 24 BOE. If the rate of exploratory drilling is increased in the early 1980s, the discovery rate will decline more drastically.

Our knowledge of oil and gas source materials, source-bed maturation, mechanisms and time of primary migration has expanded greatly during past decades and new insights will be added in the 1980s. Stratigraphic and sedimentational concepts, methods of identifying depositional environments, tectonic and structural principles, and details of geologic history will continue to play prominent roles in our intensive probing of the frontiers of geologic knowledge. Pressure-temperature relations, origins of abnormally high or low pressures, and the delineation of hydrodynamic versus hydrostatic conditions have become increasingly important in understanding trap formation; more precise measurements and interpretation are essential in future exploration.

The role of the geologist in interpreting geophysical measurements, especially in seismic stratigraphy and mechanical logs, will grow in importance. Knowledge of the principles of petroleum geology will continue to be important in oil- and gas-field development, in enhanced recovery, and in uranium, coal, geothermal, and tar-sands exploration or exploitation.

With these increasing complexities and the resulting professional opportunities, it is unfortunate that so few universities have a meaningful program specifically designed for educating petroleum geologists. The developing surplus of bachelor-level geology graduates probably will be followed in the late 1980s by a shortage, i.e., another supply/demand cycle. The opportunities for advanced-degree graduates probably will continue during this decade and the energy crisis should guarantee a long and exciting professional career.

The intense search for non-Arab, non-OPEC oil-producing areas in the world will continue. The present 28/1 reserves/production ratio of world oil probably will not decline rapidly as long as OPEC nations restrict production to levels significantly below capacity. Other nations with recently expanded oil-production capacity may choose also to maintain moderate export levels. High import prices, supply insecurity, and balance-of-payments problems will keep extreme pressure on production of domestic oil and gas, coal, atomic energy, hydroelectric power, synthetic fuels, and other energy alternatives. In addition, strong compulsory conservation measures probably will be imposed. Rapidly rising leasing, exploration, and production costs and their relation to wellhead prices (minus tax) may result in a deterrent to U.S. oil and gas production.

The outcome of environmental, political, and economic constraints on domestic energy production is more problematic than are the scientific and technologic questions. Three-fourths of our oil and gas reserves and production are in giant fields. Most future discoveries of large fields will be in the frontier areas, largely offshore and in Alaska. National energy policy should encourage exploration in frontier areas, in addition to conservation and development of other energy sources.

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Paleogeography of Eustatic Model for Deposition of Mid-Continent Upper Pennsylvanian Cyclothems

The hypothesis that eustatic sea level changes formed Upper Pennsylvanian cyclothems in Mid-Continent North America has been supported by recent documentation of many episodes of Mississippian through Permian glaciation in Gondwanaland. Changes in Mid-Continent paleogeography and sedimentation during a single eustatic advance and retreat are described in 6 phases. (1) At maximum transgression, deep water promoted development of a thermocline, quasi-estuarine circulation, and upwelling, all leading to widespread deposition across the Mid-Continent of phosphatic black shale, which graded in shallower peripheral areas to gray marine shale and carbonates. (2) Progressive shallowing during early regression destroyed the thermocline, restored bottom oxygenation, and caused deposition of gray shale, and then algal-skeletal calcilutite. Deltas began prograding from Oklahoma and the Appalachians, and shoreline carbonates began prograding southward from the Dakotas. (3) During late regression extensive shoal-water calcarenites developed over most of Kansas, carbonate shoreline facies prograded into southern Nebraska and Iowa, and deltas of Appalachian origin prograded across Illinois. (4) At maximum regression, the sea was confined to the deep basins of west Texas and Oklahoma. Karst, caliche, and residuum developed on the exposed carbonate terrane to the north. The extensive deltaic deposits to the east underwent channeling, alluviation, and soil formation. (5) Expansion of the sea during early transgression restored shoal-water calcarenite deposition across western Kansas, caused gray shale deposition in embayments and lagoons along the inundated deltaic terrane to the east, and impounded Appalachian-derived streams flowing westward across the immense alluvial plain to form widespread coal swamps in Illinois. (6) During late transgression deeper seas restored skeletal calcilutite deposition across the Mid-Continent, caused marine shell accumulations over coals in Illinois, and shifted coal swamp formation eastward into the Appalachian region.

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Stratigraphy and Depositional History of Powell Formation (Uppermost Canadian) in Northern Arkansas

Subsurface geologic data reveal that uppermost Canadian carbonate rock units previously designated as the Smithville and Black Rock Formations in northeastern Arkansas are intertonguing lithofacies of the Powell formation, which trends east-west across northern Arkansas, and do not overlie the Powell as tabular formations. Therefore, these units are considered members of the Powell.

The Powell of northeastern Arkansas was deposited in and marginal to a transgressing epeiric sea along the hinge line of the Reelfoot basin, which lay to the east. Transgression, coupled with subsidence, resulted in Black Rock wedging to the northwest, onlapping the Smithville. Numerous minor regressions superimposed interfingering upon the overall transgressive pattern. Influx of quartz sand terminated Powell deposition, initiating deposition of the Everton Formation without interrupting sedimentation.

Constantly shifting environments resulted in complex intertonguing of carbonate lithofacies, with nonmarine lithofacies in the west progressively giving way to marine lithofacies toward the east. The Powell of northwestern and north-central Arkansas is characterized by nonfossiliferous, unburrowed cryptalgalaminate dolostone deposited above the strand on occasionally inundated algal mudflats. The Smithville Formation of northeastern Arkansas is characterized by fenestral carbonates and an abundant gastropod fauna, deposited above the strand on frequently inundated algal mudflats. The Black Formation is characterized by two distinct marine lithofacies: burrow-mottled cryptalgalaminates, deposited below the strand but above wave-base in a low-energy, schizohaline environment; and abundantly fossiliferous sponge-bearing biomicrudite, deposited below the strand but above wave-base in a moderately agitated, normally saline marine environment.

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Scientific Ocean Drilling near United States

Deep sea drilling by the *Glomar Challenger* is scheduled to phase out in October 1981. Plans are being made to phase in the *Glomar Explorer* or a drill ship with more capabilities after that time. These additional capabilities include longer drill string, a riser, a blow-out