Micropaleontologic studies were undertaken to establish the burial temperature of the Paleozoic sedimentary sequence in southern Ontario through investigation of color alteration of conodonts and palynomorphs. Over 500 samples were used from surface localities and several hundred from 20 wells that penetrated various units of Ordovician, Silurian, and Devonian age in the subsurface.

The results showed the existence of at least two thermal alteration zones defined along the surface and in the subsurface. The first identifiable thermal alteration zone extends from the top of the Paleozoic sedimentary sequence to depths coinciding with the base of the Silurian and possibly extending into uppermost Ordovician strata. In this zone, the conodont alteration index (CAI) is 1.5 and reflects a burial temperature of 50 to 90°C. The second zone includes the remainder of the Ordovician section in southwestern Ontario and part of the Ottawa Valley in eastern Ontario. The CAI values for this zone lie in range 2 to 2.5 and suggest burial temperatures of about 60 to 140°C.

Superimposed on this broad scale thermal alteration pattern that reflects burial depth, are several areas with higher alteration indices of 2.5 to 3 in the Ottawa Valley. These are interpreted as being the result of unusually high heat flow occurring after the main burial phase of alteration and probably related to Cretaceous rifting that produced the Ottawa-Bonnechere graben.

Study of palynomorphs (acritarchs) shows a change in color from light yellow to dark yellow in the first zone and to brown in the second zone. These paleontologic studies of thermal maturation are being integrated with studies of the isotopic composition of natural gases (by J. F. Barker and P. Fritz, Univ. Waterloo) and of the organic geochemistry of the oils (by T. G. Powell, Geol. Survey Canada) for southwestern Ontario hydrocarbon deposits.

LEHMANN, PATRICK J., Exxon Production Research Co., Houston, TX

Porosity Evolution of Niagaran Pipe Creek Jr. Reef, Grant County, Indiana

Tarry residues within porous zones in the upper 15 m of the erosionally truncated Pipe Creek Jr. reef attest to it being a fossil oil reservoir. The radially arranged, steeply dipping (25 to 40°) flank beds of this large (1.4 km diameter) limestone buildup are composed of crinoidal grainstone, packstone, and wackestone with minor stromatoporoid and coral boundstone. Interparticle, intraparticle and shelter pores of all sizes accounted for depositional porosity of 60 to 80%. Syndepositional submarine and marine phreatic cementation, including palisade and monocrystalline syntaxial overgrowth-cements, reduced depositional porosities to 5% or less. The abundance of hardgrounds, isopachous palisade-cemented grainstones, and lithoclasts indicate the syndepositional genesis of these cements. Syndepositional and younger fractures, some extending at least 215 m laterally, cut through the tightly cemented reef. Sedimentary dikes resulted as these fractures were filled with syndepositional reef sediment and later with Devonian quartzarenites. The tightly cemented dikes form permeability barriers that may inhibit lateral fluid flow altering reservoir quality. Dolomite selectively replaced the finer sediment and partly replaced many skeletal grains in zones within the reef-interreef transition and along the present unconformity. Leaching of the remaining calcite in dolomitized skeletal grains produced localized porous zones (up to 15%). Meteoric phreatic sparry calcite cementation further reduced reef porosity to under 2%. Further quarrying of this beautifully preserved limestone reef will insure its value to geologists studying reef facies, diagenesis, and porosity evolution for many decades.

LEKAS, MITCHELL A., Geokinetics Inc., Concord, CA

Lofreco Process—Tailoring Shale Oil Extraction Method to Available Geology

Geokinetics Inc., in cooperation with the Department of Energy, is developing an in-situ process for extraction of shale oil from shallow deposits of oil shale. The oil shale is fragmented by explosives emplaced in surface drill holes. The fragmented zone constitutes the in-situ retort. The fragmented zone is ignited and the generated heat releases the shale oil which drains to the bottom of the retort and flows along the sloping bottom to the oil production wells.

The Mahogany oil shale zone at this location is 30-ft (9 m) thick and averages 23 gal/ton. The beds strike east-west and dip to the north at 120 ft/mi (36.6 m/km). Groundwater in the oil shale zone is very limited. Field work was initiated in April 1975 at a test site 70 mi (113 km) south of Vernal, Utah, and has continued without interruption to date. Twenty-four test retorts have been blasted and 15 retorts have been burned. By June 1982 the R & D phase will be completed, and construction of a commercial plant will begin.

LEVEY, R. A., J. C. HORNE, J. K. BALSLEY, et al, Univ. South Carolina, Columbia, SC

Wave-Dominated Deltas—Important Economic Depositional Setting in Upper Cretaceous of Western Interior

In the western interior basin, wave-dominated, deltaic deposits provide an important economic model for exploration of oil and gas and thick, laterally extensive economic coals. Recent studies in the Upper Cretaceous Mesaverde Group (Rock Springs Formation of southwestern Wyoming and Blackhawk Formation of eastern Utah) provide insight to the characteristics of wave-dominated, deltaic environments. Widespread, delta-front, sheet sandstones provide significant reservoirs for oil and gas and a platform upon which thick laterally continuous coals can develop.

Wave-dominated deltas are characterized by thick, prodelta deposits composed of graded, bedded siltstones and mudstones. Capping the prodelta deposits are distributary-mouth, bar sandstones at the mouth of distributary channels. In the interchannel areas, delta-front, sheet sandstones accumulate owing to high wave energy. They are laterally continuous along depositional strike as well as dip. Coeval, distributary channels tend to be straight or have a low sinuosity with sediment fills ranging from fine mudstones to coarse-grained sandstones. Delta-plain deposits consist of lagoonal, bayfill mudstones and small-splay or bayhead-delta sandstones formed in areas behind and marginal to the delta front. Numerous coarsening-upward sequences are capped by localized coals. Fluvial and upper delta-plain areas consist of channel, levee, and backswamp materials that are laterally discontinuous.

Features such as those observed in these wave-dominated delta deposits are easily recognizable on seismic lines. The seismic lines can be used to target favorable areas of hydrocarbon and coal accumulation.

LEVIN, DAVID M., Gulf Energy and Minerals Company–U.S., Houston, TX

Hydrocarbon Exploration in Western Approaches, Offshore England

The North Sea has matured into its production phase and explorationists are now searching for hydrocarbons on the Atlantic continental margin west of England. The Western Approaches, one of these new exploration frontiers, is currently the subject of drilling to test hydrocarbon potential.

The Western Approaches forms an ENE-WSW trending structural trough southwest of England extending from the mouth of the English Channel westward to the edge of the continental shelf. The basin is believed to be the failed arm of a triple junction which originated in Permian-Triassic rifting associated with separation of the North American continent from western Europe and the opening of the Atlantic.

Seismic and gravity data indicate good sediment thickness in which Permian-Triassic, Jurassic, Cretaceous, and Tertiary sequences have been interpreted. Structure of the basin has been strongly influenced by Hercynian related tectonism in basement rocks. Four wells have been drilled within the last 18 months as the first exploratory attempts in this basin.

LINK, MARTIN H., Los Angeles Harbor College, Wilmington, CA, and JOANN E. WELTON, Chevron Oil Field Research Co., Brea, CA

Hydrocarbon Potential of Matilija Sandstone, an Eocene Sand-Rich, Deep-Sea Fan and Shallow-Marine Complex, California

The Matilija Sandstone Member, exposed in the Santa Ynez Mountains, California, records a major regressive event in the Eocene Santa Ynez basin in which turbidites were deposited in the basin and subsequently covered by shallow-marine complexes. Despite thick favorable source beds and generally good initial reservoir characteristics, the Matilija sandstone is not a productive unit in the basin. Lowered reservoir rock permeability (<1 md) and porosity (0-10%) are due to early compaction, cementation, and diagenesis.

The lower part of the Matilija sandstone is a 700-m-thick sand-rich deep-sea fan complex which overlies basin plain and turbidite deposits (Juncal shale). The Matilija sandstone consists of anastomosing outer-fan depositional lobes overlain by channelized middle- and inner-fan deposits. Cross-bedded sandstone, red-bed, and carbonate-evaporite sequences overlie the turbidites. Matilija sandstone deposition closed with rapid transgression which culminated in the deposition of basin plain and turbidite deposits (Cozy Dell shale).

The Matilija sandstone lower deep-sea fan complex has a high sandstone and shale ratio (4:1) and consists of submature arkoses of facies B. The average sandstone is medium grained, moderately sorted, subangular, massive, and contains 40% quartz, 35% feldspar (about equal amounts of potassium and plagioclase feldspars), 10% lithic fragments (mostly granitic and volcanic types), and smaller amounts of mica, chert, and heavy minerals. Early compaction, carbonate cementation, and authigenic pore-lining chlorite, albite, and quartz have reduced the initial porosity and permeability. Minor secondary fractures are the only effective porosity in these rocks now.

LORSONG, J. A., Saskatchewan Geol. Survey, Regina, Sask.

Nearshore Lithofacies of Mannville Group, Lloydminster Heavy Oil Area, Saskatchewan

The Lower Cretaceous Mannville Group comprises a 200-m succession of poorly consolidated, fine-grained sandstones and shales in the Lloydminster heavy oil producing area of west-central Saskatchewan. Detailed study of closely spaced cores from several oil fields indicates the presence of six major lithofacies (here denoted by letters), and suggests some provisional interpretations of depositional environments.

Facies L consists of well-sorted sandstone characterized by low-angle cross-lamination and hummocky lamination. Nearly all oil production is from multistory facies L sandstone bodies, which average 5 m in thickness and commonly pinch out over a few hundred meters. Facies T includes moderately sorted sandstones with multidirectional trough cross-lamination. Facies M is composed of massive, fine to medium-grained, poorly sorted sandstone. Facies B comprises bioturbated sandstone-shale sequences with abundant oscillation ripples, desiccation cracks, and flaser, lenticular, and wavy bedding. Facies S includes two subfacies: massive shales (S_1) are commonly associated with laminated shales (S_2) that display desiccation cracks as well as flaser, pinstripe, and tidal bedding. Facies C comrises thin lignite beds composed of terrestrial plant debris.

Sedimentary structures in facies B and S indicate shallow-water deposition with intermittent exposure typical of tidal flats. Characteristic structures of facies L and T suggest beach, offshore bar, or sand-flat depositional environments. Facies M may represent thin channel fills. Intimate association of the lithofacies in vertical section indicates a nearshore depositional setting for the Mannville Group. A substantial number of petroleum reservoirs in the Lloydminster area appear to be intertidal sand bodies rather than the fluvial channel fills suggested in some previous studies.

LORSONG, J. A., Saskatchewan Geol. Survey, Regina, Sask.