bedded pelagic limestones and clastic limestones containing locally derived shallow-water carbonate debris. The carbonaceous-tuffaceous sequence is overlain by cyclic interbeds of green, gray, and pink limestone. The organic-rich strata on southern Hess Rise are dark-olive laminated limestone with a few clay-rich intervals that may contain altered volcanic ash. The association of volcanogenic sediments with organic-rich strata on Hess Rise is not as striking as in the Mid-Pacific Mountains, but the occurrences do suggest a coincidence of mid-plate volcanic activity and accumulation of organic matter at intermediate water depths in the tropical North Pacific during the middle Cretaceous. These organic-rich rocks are equivalent in age to organic-rich lithofacies elsewhere in the world ocean.

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Generation and Occurrence of Hydrocarbons Related to Structural and Geothermal History of Onshore Perth Basin, Western Australia

The Perth basin, an elongate rift basin along the southwestern coast of Australia, contains over 15,000 m of mainly continental clastic sediments which range in age from Silurian to Holocene. Organically rich sediments are widely distributed throughout the Permian, Triassic, and Jurassic sections of the basin. However, as a result of the proximity of the Precambrian shield in the east and the predominance of terrestrial organic matter in the largely continental to marginal-marine sedimentary fill of the basin, the kerogen type is mainly humic and gas-prone. Hydrocarbon accumulations are therefore mainly gas and/or condensate, although a secondary light, highly paraffinic oil is of economic significance. Present commercial fields are restricted to the northern part of the basin and appear to be related to Permian, Triassic, and Jurassic mature source beds in the Dandaragan trough. In the Bunbury trough in the south, mature source beds are limited to a very deeply buried Permian coal measures sequence 2,000 m thick, from which significant but noncommercial gas flows and some condensate have been recorded.

Vitrinite reflectance data suggest that the uplift and erosion of the northwestern flank of the Perth basin were accompanied by higher geothermal gradients than are measured today in exploratory boreholes. In contrast, low geothermal gradients in the axis of the Dandaragan and Bunbury troughs ($<2.0°C/100$ m) mean that generative temperatures are reached in these areas at relatively great depths. Producible accumulations often depend on a delicate balance between depth needed to generate hydrocarbons and the level at which porosity declines to unacceptable levels for gas production.

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Applications of Scanning Electron Microscopy to Hydrocarbon Exploitation

The Scanning Electron Microscope (SEM), which became available commercially in the mid 1960s, has added a new dimension to exploitation during the decade of the 1970s. Of primary importance are studies of pore geometry and diagenetic history, which influence the type, distribution, and flow of fluids in the lithosphere.

The SEM provides a means of evaluating the abundance and location of micropores relative to macropores, which influence fluid distribution. If a rock contains a significant percentage of authigenic clay minerals or other fine particles, bound water may be retained in the micropores and cause a high irreducible water saturation. The reservoir may produce water-free hydrocarbons, but wireline-log calculations may indicate water saturations greater than 60%.

The SEM is useful for examining the effect of fluids and chemical additives on rocks during enhanced oil recovery. For example, laboratory tests have shown decreasing permeability during flow tests using a specific micellar fluid. SEM examination of "before and after" rock samples revealed that smectite, an expandable clay, was reacting to the fluid and plugging pore throats, yielding reduced permeability.

Reservoir studies using the SEM have shown that varying distributions and morphologies of clay minerals can be directly related to productivity of sandstones. Clay distribution, in order of decreasing reservoir quality and decreasing mean-pore-aperture size, is (1) discrete loosely packed clay particles, partially filling pores; (2) clay lining pores; and (3) clay bridging from one sand grain to an adjacent sand grain. Reservoir quality due to clay distribution types 1 and 2 is exemplified by Mesaverde sandstones in southwestern Wyoming. Measured porosities for the two types of reservoirs are similar, but permeability and, hence, productivity are markedly dissimilar.

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Forecasting—Fact or Folly?

Many dire forecasts about future hydrocarbon potential in the United States culminated in the pessimistic Club of Rome forecast and recent statements by officials of DOE that, "we cannot substantially increase our domestic production." Forecasts can be self-fulfilling, can impact the shape of the future, and should be examined in these terms.

A look at energy supply and demand predictions made over the last 6 years in the United States is instructive. Forecasts made in 1973 for a 1990 energy demand of 67 million BCOE (barrels crude oil equivalent) and a domestic supply of 45 million BCOE indicated a short fall of 22 million BCOE. Today, forecasts indicate a demand of 50.4 million BCOE and a domestic supply of 37.3 million BCOE producing a short fall of 13.1 million BCOE. Because we appear to be in a domestic-supply-limiting situation, we must examine very carefully the supply analysis used in the forecast.

Most forecasts contain a failure of imagination usually due to relying on today's "logic." This disallows the possibilities of breakthroughs which are the real future. Most important in looking at the future is to (1) describe its "volume," (2) determine what changes could affect the limits of the "volume," (3) do research in ar-

eas where positive changes to the limits might be expected, and (4) obtain "directionality" from the forecast.

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Effects of an Offshore Drilling Mud on Selected Corals

Seven species of coral—*Dichocoenia stokesii, Montastrea annularis, Agaricia agaricites, Acropora cervicornis, Porites furcata, P. astreodes,* and *P. divercata*—were experimentally exposed to three concentrations of drilling mud obtained from an offshore oil well in the Gulf of Mexico. The whole mud, collected from the mud pit of a well at a drilling depth of 4,000 m, was diluted with seawater to produce concentrations of 100, 316, and 1,000 μL/L. Corals were exposed to each of the three concentrations and control seawater for 96 hours to observe behavioral response. Response to drilling-mud concentrations was measured as percent of polyps retracted. Some experiments were conducted in laboratory aquaria with Gulf Stream water, but the most significant experiments were conducted at Carysfort Reef, Florida Keys, using similar aquaria located in 3 m of water. Polyp behavior was determined with serial close-up photography which allowed counting of retracted, partially retracted, and nonretracted polyps in each colony.

All species except *Montastrea annularis* and *Agaricia agaricites* survived exposure to 1,000-μL/L mud during the period of testing. In two tests with *Acropora cervicornis,* one group survived exposure to the mud and the other died. All other corals except *Dichocoenia stokesii* and *Porites divercata* showed significant ($p<0.05$) polyp retraction during exposure to 100-μL/L mud concentration, whereas 316-μL/L mud was the minimum concentration which induced significant polyp retraction in *Porites divercata.* Polyps of *Dichocoenia stokesii* did not react to any of the three concentrations.

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Light Hydrocarbons of Petroleum; Internal Evidence of Thermal History

A diverse suite of 76 oils was analyzed for light C_4 to C_7 hydrocarbons (LHC). Indices of paraffinicity, termed the "heptane value" (HV) and "isoheptane value" (IV) were examined. These paraffin-to-naphthene concentration ratios had provided reliable measures of the catagenetic grade of sedimentary rocks, also a means of determining paleotemperatures, employing autochthonous LHC. The goal of the present study was an assessment of the conditions of generation of oil.

Heptane values in the sampled oils range from 0.5 to 60.9, but possess a near-normal distribution. The principal group (31 samples, 41%) is within the range 18.0 to 22.0. The modal class (HV 19.0 to 20.0) comprises 14%. The isoheptane value is similarly distributed about a modal class (18%) of 0.90 to 1.0. It is concluded that most oils retain evidence of generation in an extremely limited range of subsurface temperatures. The temperatures are of the order of 280 to 300°F (138 to 149°C), assessed from curves relating HV and IV to maximum-attained subsurface temperature for sediments bearing aliphatic, petroleum-source kerogens.

The oils of the principal group (HV 18.0 to 22.0) are termed "normal, paraffinic." Twenty percent of the analyzed oils are naphthenic (HV 0.0 to 18.0). Their compositions differ from those of low-temperature sediment extracts: they are identified as biodegraded, not immature, oils. Forty percent of the oils have an HV exceeding 22.0 (mature oils); some exceed 30.0 (supermature oils). Both classes have undergone protracted heating. The analytic methods and parameters provide a scheme of oil classification containing substantial geologic information. In addition, the plot of HV versus IV for sediment extracts provides clear distinction between aromatic, coaly kerogens and aliphatic, sapropelic kerogens.

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Exploration Research Along Ardmore-Anadarko Basin Trend

Consideration of southern Oklahoma geologic history in the context of plate-tectonic analogies to present continental margins suggests several avenues of investigation that help explain some oil and gas accumulations and could lead to more discoveries. Postulated origin as the abandoned arm (aulacogen) of a rift triple junction in the late Precambrian and early Paleozoic suggests the potential for fault-controlled sedimentation and early generation of oil and gas by magmatic heating. Collision-related late Paleozoic deformation suggests displacement of early Paleozoic reservoirs by wrench faulting and the formation of traps by wrench-controlled thrust faulting. The search for fracture reservoirs involves facies relationships to the precollision continental margin, fracturing during collision, and prediction of open fractures based on stress orientation related to formation of the Gulf of Mexico. Position of the early Paleozoic continental margin with its unrealized potential for oil and gas accumulation remains an enigma concealed by late Paleozoic emplacement of the Ouachita thrust complex unknown distances over the edge of the early Paleozoic continental edge and subsequent burial by Mesozoic sediment during formation of the Gulf of Mexico.

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Oil and Gas Resource Appraisal—State of the Art

The art of appraising oil and gas resources has been maturing rapidly during the past few years. This welcome development has come about because of a growing awareness that petroleum resource estimates are required for the development of reasonable energy policies and long-range plans.

Published appraisals of oil and gas resources in the United States date back at least 70 years. Since that time many estimates have been made available to the public. In the 20-year period following 1955 the amounts resulting from these appraisals varied widely,