

dard Space Flight Center (GSFC) to adjust for the detector response of the Multispectral Scanner (MSS). Because illumination conditions and landscape characteristics vary considerably and detector response changes with time, the radiometric adjustments applied at GSFC are seldom perfect and detector striping remains in LANDSAT data. Therefore, adjustments are applied to minimize the effects of striping, and to adjust for bad data lines, line segments, and lost individual pixel data. Rotation of the earth under the satellite and movements of the satellite platform introduce geometric distortions in the data which must be compensated for if image data are to be correctly displayed to the data analyst. Adjustments to LANDSAT data are made to compensate for variable solar illumination and for atmospheric effects. Geometric registration of LANDSAT data involves determination of the spatial location of a pixel in the output image and determination of the new value of the pixel in the output image.

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#### Late Quaternary Foraminiferal Record in Eastern Caribbean Cores—Paleo-Oceanographic Implications

Oxygen-isotope variations in planktonic Foraminifera (*Orbulina universa*, *Globorotalia menardii*, and *Globigerinoides sacculifer*) indicate that, in two Grenada Basin cores, paleontologic datum planes do not coincide with isotope boundaries. The time lag is greater when the boundaries are transitional from glacial to interglacial phases.

Recurrent-groups analysis of benthic foram assemblages led to the recognition of five groups. Only one of these, containing *Osangularia culter*, *Bulimina buchiana*, and *Chilostomella oolina*, appears to have any stratigraphic significance. The group shows its best development during interglacial times. In accordance with Weyl's paleo-oceanographic model, this group is associated with colder bottom waters and can be used to draw inferences about the influx of such waters. Periods of cold-water influx ranged from before 367,000 to 210,000 years B.P., from 139,000 to 81,000 years B.P., and from 22,000 to 8,600 years B.P. Cessation of influx 8,600 years B.P. is further substantiated by heat-flow calculations.

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#### Environmental Assessment of In-Situ Leaching of Uranium

Maintenance of water quality during and following in-situ leaching of uranium is the fundamental problem which must be considered in an environmental assessment of such operations. Prior to any leaching activity, a realistic baseline by which to judge the groundwater quality must be established for any given operation. Monitoring programs will be required to evaluate subsurface restoration efforts and to assess the containment of the lixiviant and the solubilized ions essentially within the mining area of the ore-bearing aquifer of the

leaching operation. Disposal of leach-mining wastes may prove a greater threat to the environment than the mining.

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#### Oceans and Climate During Cenozoic

Ten years of deep-ocean drilling have helped to assemble an enormous body of new data about the evolution of the physiography and sedimentary processes of the Cenozoic ocean basins. The formation of the Southern Ocean isolated Antarctica and allowed the evolution of the circum-Antarctic oceanic current regime during mid-Tertiary time. The opening of the Norwegian-Greenland sea during the early Tertiary and the final subsidence of the Iceland-Faroe Ridge during the late Miocene connected the main North Atlantic with the Arctic basin. This seaway was the final step in the formation of an ocean basin connecting the cold, polar water bodies of both hemispheres. The construction of the middle American land bridge and the interruption of the Tethys into separated shallow and deep basins led to a segmentation of the old global, equatorial seaway into different current regimes in the Indian, Atlantic, and Pacific Oceans. This physiographic-tectonic evolution of the ocean basins and the deterioration of the earth's climate during the Cenozoic led to important changes of the depositional regime in the deep oceans because of the initiation of a vigorous polar bottom-water formation and because of the generation of steep zonal hydrographic gradients in the surface-water masses. The effects of these changes on pelagic sedimentation cannot be separated easily, but they have resulted in many deep ocean basins and in lithofacies distributions along their continental margins that are asymmetric along zonal profiles. The DSDP data from the North Atlantic are a prominent example of this Cenozoic evolution of the pelagic depositional environment.

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#### Middle Cretaceous Oxygen-Deficient Paleoenvironments in Mid-Pacific Mountains and on Hess Rise, Central North Pacific Ocean

Cores collected during Leg 62 of the Deep Sea Drilling Project recovered organic-rich rocks of early Aptian age in the Mid-Pacific Mountains and of late Albian age on the southern Hess Rise. Concentrations of organic carbon in these rocks range from a few tenths of 1% to more than 9%. The organic-rich strata in the Mid-Pacific Mountains are in a 45-m-thick sequence of carbonaceous and tuffaceous limestone that lies on inter-

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 ( $<2.0^{\circ}\text{C}/100\text{ m}$ ) mean that generative temperatures are reached in these areas at relatively great depths. Producing 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 de-

cade 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-