Examination of 16 shallow core borings from the Great Bahama Bank reveals that coral-coralline algal deposits of Pliocene-Pleistocene age line the margins of the bank. These reefal deposits extend up to 5 km bankward from both windward and leeward edges of the platform. Those along leeward margins are framestones and grew in relatively deep water. Those along the windward margins are a mixture of framestone and bafflestone formed in water of various depths probably including low intertidal. A similar assymetric distribution of depositional textures may be indicative of windward versus leeward margins on ancient platforms.

The margins of the bank evolved upward through the Pliocene-Pleistocene. This evolution may be divided into three stages. In stage I, the lowermost, discrete depositional units average 8 m in thickness and contain an abundance of species of corals now extinct, including *Stylophora affinis.* In stage III, depositional units average 3 m in thickness and corals such as *S. affinis* are rare or absent. Stage III is marked by accumulation of nonskeletal sands (beach and eolian dune deposits) along inner-bankward parts of the margins. The distribution of reefal sediments was reduced to a narrow belt similar to that of the present. The change from stage I to II is of uniform time, apparently coinciding with the initiation of major Northern Hemisphere glaciation at the beginning of the late Pliocene; that from stage II to III is more variable, occurring from the middle to late Pleistocene.

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Stratigraphy and Resource Assessment of Mississippian and Devonian Oil Shales of Northeastern Kentucky

Heightened interest in the organic carbon-rich shale of Mississippian and Devonian age as a source of oil has resulted in intensive leasing along the shale outcrop belt in Kentucky. Twelve cores of shale from Lewis and Fleming Counties were examined and analyzed in an effort to relate details of stratigraphy to the oil-rich horizons and to outline areas of minable potential resources.

Formations of interest are the Sunbury Shale (Lower Mississippian) and the Ohio Shale (Upper Devonian). The generalized stratigraphy (Lower Mississippian through Upper Devonian) is, in descending order: Borden Formation, Sunbury Shale, Berea Sandstone, Bedford Shale, and Ohio Shale. Useful key markers in the sequence are the Three Lick Bed and the *Foerstia* zone, which are both in the Ohio Shale. The Three Lick Bed divides the Ohio Shale into the Cleveland Member, above, and the Huron Member, below. The Ohio Shale is underlain by Silurian Bisher Limestone and Crab Orchard Formation.

Organic content is high in the Sunbury Shale and in the upper part of the Cleveland Member of the Ohio Shale. In cores, the total thickness of the Sunbury ranges from 12.0 to 18.4 ft (3.7 to 5.6 m). The combined thickness of Berea Sandstone and Bedford Shale ranges from 28 to 122 ft (8.5 to 37.2 m). The Cleveland shale ranges from 50 to 65 ft (15.2 to 19.8 m).

Assuming a stripping ratio of 2.5 to 1, more than 2.9×10^6 acre-ft (3.6×10^3 cu hm) of shale having a Fischer-assay oil yield greater than 11 gal/ST (38 l/MT) is minable by means of existing methods. A conservative estimate of the amount of the potential strippable shale-oil resource in these two counties is more than 2×10^9 bbl.

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Geopressured Geothermal Energy—Geological Setting and Constraints to Development Along Northwestern Gulf Coastal Plain

Wide-ranging estimates of the magnitude and economic viability of the geopressured geothermal resource along the Gulf Coast have resulted in the establishment of significant research efforts in Texas and Louisiana. The energy resource consists of the heat and pressure of water, and the dissolved methane. The amount of methane in solution is directly related to the temperature, pressure, and salinity. Major questions being addressed by this research relate to prediction of subsurface fluid salinity and reservoir deliverability (size of contiguous sandstone unit, permeability, rock compressibility).

Success of the geopressured geothermal resource development is dependent upon identifying large, geopressured sandstone reservoirs with high permeability (20 md or greater), high temperature (higher than 250°F or 121°C), and low salinity (lower than 60,000 ppm). Extensive studies in Texas and Louisiana show that areas with favorable combinations of all these parameters are difficult to find. Subsurface data indicate that thick sandstones of the main-sand depocenters are, in most areas, not geopressured. Geopressured reservoirs, for the most part, lie gulfward within growth-faulted, delta-front sequences consisting of thick shales and thinner sandstones. Most wells which penetrate this delta-front section show that fluid temperature and pressure increase, and salinity decreases, with depth; sandstone reservoir thickness and permeability decrease with depth. Therefore, the ideal geopressured geothermal reservoir is an exception and a compromise must be made.

Despite the limitations of locating an ideal reservoir, several short-term deep tests by industry have provided encouragement. More extensive long-term testing, now underway through the U.S. Department of Energy geopressured-geothermal Designed-Well Program, is providing answers to some of the questions.

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Alisitos Terrane, Baja California: Sedimentation Within Early Cretaceous Island Arc

The Alisitos terrane is a thick accumulation of mainly volcaniclastic sediments that were deposited in an island arc setting related to late Mesozoic subduction along the southwest margin of North America. A diverse suite of depositional facies can be related to various environments of a marine volcanic arc. The recognition of facies associations and thermal histories characteristic of specific paleoenvironments within the Alisitos terrane provides a model which to some extent is applicable to arc terranes in general. Important features of sedimentation in an arc setting include discrete point sediment sources, high sedimentation rates, and the maintenance of steep slopes, and abrupt lateral facies changes.

Development of shallow-water environments within the Alisitos terrane was related to major volcanic centers. Characteristic facies include coarse proximal volcaniclastic rocks, locally interspersed with rudist limestone bodies, and relatively abundant hypabyssal rocks and associated thermal alteration.

Sediment was dispersed into deep water by both epiclastic and pyroclastic processes. Epiclastic transport was dominantly by mass-flow processes, removing coarse volcanic sediment from the flanks of volcanic edifices to intra-arc and fore-arc basins. Sediments also reached these sites by pyroclastic processes. Criteria for distinguishing deposits of pyroclastic and epiclastic origin in these basins include recognition of Bouma sequences (graded bedding characterizes both facies), and single versus multiple clast types.

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Extractable Geothermal Energy in Benue Area, Nigeria

An episodic mobile belt underlies the zone of geothermal springs in the Benue area of Nigeria. The close resemblance between the transverse gravity profiles for the Benue depression and profiles of the central Red Sea depression may indicate a similar origin for the depression. The Benue depression is an expression of a spreading ridge generated from a RRR triple junction which was active in the Early Cretaceous. Separation in the Benue trough ceased in the Late Cretaceous, and the spreading ridge is now defunct and at least partly obscured. In Neogene time, there was predominance of igneous activity in the Cameroon-Adamawa volcanic zone which has many attributes of an embryonic spreading ridge. Many of the Neogene alkaline volcanics in the Benue depression and on the Jos plateau trend northwest-southeast, roughly perpendicular to both the Benue depression and the Cameroon-Adamawa volcanic zone, and may mark the sites of future transform faults.

It is postulated that the geothermal springs in the Benue area are surface expressions of a convective hydrothermal system associated with an embryonic spreading ridge or hot spot. It is also suggested that extraction of energy from this convective hydrothermal system, either for direct heat application or for conversion to electricity in the Benue area, is feasible.

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Late Cenozoic Paleo-oceanography of Norwegian Greenland Sea and Northeast Atlantic: Benthic Foraminiferal Evidence

Analysis of late Cenozoic deep-sea benthic foraminifera from DSDP Legs 12 and 38 was conducted to determine faunal patterns and relate them to the evolution of bottom-water circulation. In the Norwegian Greenland Sea, middle to late Miocene sites from 1,200 to 1,800 m present water depth have an agglutinated benthic foraminiferal assemblage dominated by *Martinottiella communis* and *Spirosigmoilinella* sp.; shallower and deeper sites are barren. A regional unconformity appears to span an interval from within the late Miocene to the early Pliocene. A sparse early Pliocene calcareous assemblage is dominated by *Cassidulina teretis.* Intervals interpreted to represent colder episodes within the late Pliocene-Pleistocene are either barren or contain an assemblage dominated by *Oridorsalis tener.* These alternate with a more diverse assemblage dominated by *Cibicides wuellerstorfi* (> 1,500 m) or *C. teretis, Islandiella norcrossi,* and *Melonis barleeanum* (< 1,500 m) that represent interstadial or interglacial intervals.

North Atlantic sites show higher benthic foraminiferal diversity and better preservation throughout most of the late Cenozoic than the Norwegian Greenland Sea sites. The Norwegian Greenland Sea does not appear to have been a source of North Atlantic deep water during the Miocene to early Pliocene interval because conditions were not conducive to the preservation of calcareous foraminifera. Late Pliocene-Pleistocene assemblage changes in the Norwegian Greenland Sea are interpreted to represent changes in bottom- and surface-water circulation. Episodes of ice cover inhibited bottom-water formation and affected the food supply to the benthos. These intervals alternated with times of more productive ice-free conditions, some of which may have been conducive to bottom-water formation.

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Drilling-Mud Emanometry, a New Technique for Uranium Exploration

Bendix Field Engineering Corp., as a part of the Department of Energy's National Uranium Resource Evaluation (NURE) program, has investigated the feasibility of measuring radon in recirculating drilling mud, and whether the radon variations might be useful for uranium exploration. To implement this program, a prototype instrument was developed and tested. The system works by degassing the drilling mud as it recirculates and by continuously measuring the radon activity of the evolved gas. A record of the relative radon activity, as related to borehole depth, is obtained.

Radon data were obtained at two sites: Sand Wash basin in northwestern Colorado, and the Great Divide basin in south-central Wyoming. At both sites it was found that radon could be measured in the recirculating mud, and the downhole radon profiles paralleled gamma logs obtained from the same drill holes. At the Sand Wash site, the radon content in the mud varied with the lithology encountered. The conglomeratic member of the Browns Park Formation had the highest radon content, twice that of the sand member. The shale of the Mancos Formation had much lower radon levels than either of the other two lithologies. At the Great Divide basin site, the lithology was not as well delineated by the radon profiles.

From this study it was found that radon can be detected in drilling mud and that anomalous radon zones can correspond to uranium concentrations and to variations in lithology. It may also be possible by this method to detect the presence of nearby uranium concentrations.

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Dip-Profile Method of Constructing Structural and Stratigraphic Cross Sections

Dip profiles are graphs that show apparent dip as a function of distance along selected horizontal, vertical, or inclined lines on cross sections. Such profiles not only serve to integrate structural control of all kinds (surface dips, dipmeter dips, and dips derived from contour maps and migrated seismic sections) into a single numerical package, but they also provide a foundation for sophisticated geometric constructions based on the concepts of curvature trajectories and dip isogons. A curvature trajectory is a smooth line that connects points on a cross section where the bedding curvature has a distinctive property not shared by points on either side. (The trace of an axial plane is a familiar example.) Eight kinds of curvature trajectories (of which two relate to dip-slip faults) occur in nature. Each kind is distinguished on dip profiles by a specific, mathematically-defined special point. A dip isogon is a smooth line that connects points of equal apparent dip on those parts of a cross section where the bedding is curved. (The trace of a crestal plane is a familiar example.) Reliable procedures for extrapolating and interpolating curvature trajectories and dip isogons (based on the known or deduced tectonic style) can be used to establish a network of primary and secondary dip profiles—thereby insuring structural and stratigraphic interpretations that are statistically and