abrasion by thick algal coatings acquired before introduction into the high-energy oolitic environment. The fauna is robust (not dwarfed, as is common in oolites) and is taxonomically diverse. The ooliths formed in association with small bryozoan-algal banks on a shallow subtidal shelf. Mountainous regions to the south, and lowlands to the northeast and southeast, provided terrigenous sediments to the study area through deltaic processes before, during, and after Drum deposition.

Diagenetic alteration of the oolite has created much moldic and oomoldic porosity, but isolation of the molds has resulted in extremely low permeabilities. Wholesale leaching and cementation began (1) when deltaic distributaries eroded into the oolite soon after its deposition, allowing fresh water into the pore system of the oolite; and (2) perhaps when the oolite shoaled and formed islands which may have served as conduits for fresh rainwater. Similar rocks with higher permeabilities, resulting from less cementation or late fracturing, would be well-suited for hydrocarbon accumulation.

Because many modern and ancient oolites have thickened by upward shoaling and accentuation of preexisting topography, potential oolitic petroleum reservoirs in the subsurface have been sought on paleobathymetric highs. Oolitic accumulations in paleobathymetric lows should not be neglected in the search for petroleum.

STOUT, JOHN, and RETA BRADLEY, Petroleum Information, Denver, CO

United States Province Overviews

Basin folios which compile computerized well data, updated biannually, serve as a ready reference in the event of a new discovery.

Folios are available for the following basins: Appalachian, Arkoma, Black Warrior, Denver-Julesburg, Bend–Fort Worth–Strawn, South Georgia–North Florida, Great Basin and Range, Green River, Overthrust, Powder River, San Juan, Williston, and Lower Great Lakes.

In each folio is a list of exploratory wells with basic information and geologic tops, including a statistical analysis of formations penetrated in the basin. Additional statistics include the discovery-success percentage and hydrocarbon shows tabulated by formation name. An index map shows the states and counties included in the geologic province accompanied by a computer-posted and contoured map to represent the productive horizon of the basin. A thickness or structural datum corrected to sea level is given with each control point.

STOW, DORRIK A. V., STEPHEN J. MILLS, and CLIVE D. BISHOP, British Natl. Oil Corp., Glasgow, Scotland

Fan Models for Hydrocarbon Exploration with Examples from the North Sea

Important hydrocarbon discoveries have been made in submarine fan facies of Devonian to Tertiary age. A large number of controls on fan development include the nature of the sediment source and supply systems, tectonic style and activity, sea-level variation, oceanic conditions, and internal fan geometry. Several fan models have been proposed; the four best-documented models are outlined and then compared with North Sea fans.

Upper Jurassic objectives are important in the North Sea and include both nearshore sandstone and submarine-fan reservoirs. The submarine fans commonly developed close to the active fault-controlled margins of small basins and overlapped laterally to form a base-of-slope sediment apron. Jurassic intervals of the Brae field are believed to be of this type.

Detailed core, electric log, dipmeter, and seismic data from the Brae field have been examined. Conglomerates and poorly sorted sandstones and mudstones are arranged in fining-upward cycles and megacycles and appear to have been deposited by gravity-flow mechanisms in a marine environment. There is no evidence of a single feeder canyon or radial-channel pattern. The Jurassic fan of the Brae field differs in certain respects from the classic fan models but is closely analogous to Upper Jurassic shallow-water fans from east Greenland.

STUCKLESS, JOHN S., U.S. Geol. Survey, Denver, CO

Interpretation of Thorium to Uranium Ratios in Granitic Rocks and Implications for Uranium Exploration

Ratios of thorium to uranium for granitic rocks within the range of 3 to 5 are generally thought to be normal. Possible economic significance has been attached to granitic rocks that have thorium to uranium ratios either higher or lower than the normal range. Interpretations are commonly based on measurements of surface or shallow bore-hole samples that may have been affected by near-surface processes, such as uranium loss by leaching. The thorium to uranium ratios that existed prior to changes produced by near-surface processes can be calculated from lead isotope data, provided that certain limitations and boundary conditions are met, such as closed-system behavior and large ratios of thorium and uranium to lead relative to the age of the system.

Lead isotope analyses for several suites of Precambrian peraluminous granites and granite gneisses show that the calculated thorium to uranium ratios for most of the suites are in the range of 1 to 3. The range of calculated thorium to uranium ratios within each suite is generally smaller than the range of measured values. The mean thorium to uranium value for the measured ratios is generally larger, in some places by more than an order of magnitude. The difference between measured and calculated thorium to uranium ratios tends to increase with increasing thorium. Finally, the difference between calculated and measured thorium to uranium ratios is smallest in the granite gneisses.

The difference between calculated and measured thorium to uranium ratios is interpreted to be the result of recent and variable uranium loss in response to incipient weathering. By analogy, other peraluminous granite suites with large and variable thorium to uranium ratios are possible sources for low-temperature uranium deposits. Peraluminous suites with small and uniform thorium to uranium ratios are unlikely sources for low-temperature deposits. Present data do not preclude association of these suites with high-temperature or mechanically concentrated uranium deposits.

SUCHECKI, ROBERT K., Univ. Texas at Austin, Austin, TX

Diagenesis in Volcanogenic Rocks of Great Valley Sequence, Northern California—Isotopic and Chemical Data

Diagenesis of volcanogenic sandstone and mudstone of the 8,500 m thick Great Valley sequence (Tithonian to Hauterivian) involved extensive mass transfer during burial in the outer-arc basin.

The clay mineral assemblage of mudstone is characterized by (1) disappearance of discrete smectite at a relative stratigraphic depth of 6,600 m, and (2) a gradational increase of illite/smectite with increasing stratigraphic depth over the lowermost 4,500 m of strata. $\delta^{18}O$ for illite/smectite changes with descending stratigraphic position from 21.9 to 15.5 ppm and is temperature dependent. Potassium and sodium enrichment and uniform aluminum composition in the clay-size fraction of the mudstone relative to the whole rock indicates that the dominant reaction was: smectite + potassium $\rightarrow$ illite/smectite + silica. Authigenic quartz with $\delta^{18}O \cong$ 21.6 ppm throughout the sequence indicates that this reaction is temperature triggered. Calcite derived from primary biogenic carbonate acquired $\delta^{18}O$ values from +0.2 to −10.5 ppm PDB during successive mobilizations as temperature increased with burial.

In sandstones, the sequence of mineral authigenesis is: (1) chlorite cutans ($\delta^{18}O$ = 13.2 to 13.9 ppm) around framework grains formed during shallow burial; (2a) precipitation of radiating pore-fill chlorite ($\delta^{18}O$ = 11.1 to 13.3 ppm) as iron and magnesium were released from mudstone by illitization of smectite at temperatures as low as 60°C, or (2b) precipitation of calcite ($\delta^{18}O$ = −4.2 to −10.8 ppm PDB) as calcium was released from nearby shales and albitized plagioclase; (3) late replacement of framework grains by chlorite ($\delta^{18}O$ = 6.5 to 13.0%) or by calcite ($\delta^{18}O$ = −8.3 to −12.7 ppm PDB) at more elevated temperatures.

Prehnite, laumontite, and quartz veins ($\delta^{18}O$ = 17.2 to 20.5 ppm) are found only in the most basal strata, and were derived from the ophiolitic basement. These phases do not imply zeolite-grade burial metamorphism of the basal sediment.

SUMMERHAYES, C. P., Exxon Production Research Co., Houston, TX

Organic Facies of Mid-Cretaceous Black Shales in Deep North Atlantic

The mid-Cretaceous black shales of the deep North Atlantic consist of alternating layers of sediment rich in total organic carbon (TOC) that contain abundant amorphous types of organic matter, and sediment poor in TOC that contain mostly woody and coaly types of organic matter. The amorphous materials are derived mostly from marine organisms in the eastern North Atlantic off Africa, in the Caribbean, and on the Demarara Rise off Surinam, and from higher land plants in the western North Atlantic and off Europe. Marine amorphous material is important off Africa because this was an area of upwelling and highly productive surface water. Amorphous marine organic matter was deposited across the entire North Atlantic basin in the Cenomanian in response to an ocean-wide upwelling event connected with the opening of the equatorial Atlantic. The difference between the TOC-rich and background TOC layers reflects deposition of the former under reducing conditions, which allowed the preservation of labile amorphous materials of marine and terrestrial origin, and of the latter under oxidizing conditions, when all that was preserved was refractory organic material.

SUNDERMAN, JACK A., Indiana Univ.-Purdue Univ. at Ft. Wayne, Ft. Wayne, IN

Submarine Carbonate Cementation and Pisolith Growth in Silurian Reefs of Northern Indiana

Peloidal grainstone and pisolite fill crevices on the flanks of several Silurian reefs in northern Indiana, producing intersecting dikes and veins. Internal dike structures and cross-cutting show that the cycle of crevice formation, sediment trapping, and lithification was repeated several times during the life of the reefs. Significantly, where younger dikes cut across older dike material, their walls have sharp boundaries and matching wall structures, showing that each earlier crevice sediment became lithified before the next fracturing event occurred.

The grainstone clasts appear to have been mechanically swept into the crevices and initially lithified by the precipitation of sparry calcite cement around the grains. Most of the crevice fill now consists of calcite or dolomite pisoliths, however, some exhibit concentric structure, suggesting concretionary growth. Other pisoliths exhibit radial structure in which blades of cloudy calcite encroach on peloids and fossil fragments of the grainstones, suggesting growth by replacement. Petrographic evidence thus favors in-situ growth of the pisoliths, and suggests that lithification of the grainstone was completed by this process.

Evidence favoring vadose cementation of the grainstone, or favoring vadose origin of the pisoliths, is absent, and fresh-water phreatic cementation is considered unlikely. However, the repeated alternation of cementation events with marine reef sediment-producing conditions strongly suggests that initial grainstone cementation and pisolith growth occurred under shallow-water marine conditions.

SURDAM, R. C., Univ. Wyoming, Laramie, WY, C. A. HALL, Univ. California at Los Angeles, Los Angeles, CA, and J. MURPHY, Univ. Wyoming, Laramie, WY

Diagenesis in Monterey Formation, Pismo Syncline, Coast Ranges of California

A predictive model of diagenesis, involving hydrocarbon migration, for the Monterey Formation in the Pismo syncline, Coast Ranges of California, includes (1) diagenetic history, (2) lithofacies relations, and (3) tectonic setting. The diagenetic reactions control mineral-