bank and reef that existed along most of the margin. Facies C and D are common on the shelf, C being particularly significant on and seaward of Late Jurassic deltas. Two submarine-fan complexes formed off present Nova Scotia and the Middle Atlantic states. Seasonal upwelling plus fan development produced mixed B-C and C facies along the margin. Facies D dominated the deep basin.

The middle Cretaceous organic facies reflect profoundly changed conditions from those that existed in the Late Jurassic. The continent had a warm, humid, temperate-tropical climate producing abundant vegetation. Ancestral rivers carried large volumes of detrital plant material to the sea. Thus, facies C is virtually ubiquitous except for the inner shelf and isolated parts of the ocean basin. Active reefs and carbonate-bank development at the shelf break was limited to the low latitudes. In the early Cenomanian, a major transgression substantially broadened the shelf and upwelling probably occurred on the middle shelf. Facies B-C is postulated to exist on the upper slope, locally, and in the basin where anoxia prevailed.

Exploration targets for oil are the buried carbonate bank and reef and related fore-reef talus deposits. Secondary objectives are interreef channels and their seaward extensions, the upper parts of submarine fans. The shelf and margin basins are dominated by facies C source rocks. In the Late Jurassic, however, locally ideal conditions permitted deposition of facies B source rocks.

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Significance of EOM/TOC Ratios in Identifying Possible Migration Fairways, NPRA, North Slope, Alaska

Analyses of 958 samples from 54 wells in the NPRA (National Petroleum Reserve in Alaska) for TOC (total organic carbon) and EOM (extractable organic matter) have been made available as part of an extensive exploration program sponsored by the U.S. Geological Survey. In the present study, these data have been analyzed using the equation: EOM(wt. %)/TOC(wt. %) × 0.80 = Generation Index. The ratio of EOM to TOC is generally used as an indicator of thermal maturation. Work done by D. R. Baker demonstrates, however, that values in excess of 0.05 are indicative of migrated hydrocarbons in the sample.

Initial results of mapping these ratios for 11 structural zones in the NPRA indicate younger strata (i.e., Nannushuk, Torok, Pebble Shale, Kingak, and Sag River formations) have a significant probable migration fairway developed along the trace of the north-south-trending Meade arch, and toward the eastern margin of the NPRA. Older strata (i.e., Shublik, Ivishak, Echooka, Lisburne, Endicott formations and basement) generally show ratios in excess of 0.05 along the northern and northeastern margins of the NPRA. Although not enough data are available for detailed EOM/TOC mapping of these older trends, they may be related, in part, to the juxtaposition of younger source rocks that unconformably overlie these older strata.

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Reexamination of Middle Eocene Genus *Cubitostrea* Based on Collections from Central Virginia Coastal Plain

Three species of oysters from the middle Eocene *Cubitostrea* lineage are used for local and regional correlation and zonation of sediments in the Gulf coastal plain. However, oysters from the middle Eocene Piney Point Formation in Virginia also include the co-occurrence of specimens that exhibit the morphologic characteristics of these 3 Gulf Coast species.

Examination of approximately 150 specimens from 8 bulk samples collected in a vertical sequence along the Pamunkey River revealed that, in addition to co-occurring, a continium exists from one form to the next. The general shape of the forms is related to size, with juvenile oysters characterized by a triangular shape and prominent ribs, whereas the adults are oval with large auricles and a saddle-shaped form.

Results indicate that the morphologic variation of oysters in the middle Eocene sediments of Virginia does not represent an evolutionary lineage with each form a species, as proposed for the Gulf coastal plain. Rather, the forms are related to the growth stages of the species *C. sellaeformis*. Therefore, the Gulf model is not applicable to the middle Eocene sediments of Virginia and possibly not to other depositional areas.

Oysters from the underlying Nanjemoy Formation (lower Eocene) previously included within the species *C. sellaeformis* should not be so designated. This distinction is based on the coarser and fewer number of ribs on the Nanjemoy oyster as compared to *C. sellaeformis* from the Piney Point Formation.

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Exploration Applications Through Remote Sensing of Ice-Wedge Polygons

Petroleum exploration is facilitated through remote-sensing techniques such as Landsat digital data processing and aerial photointerpretation. These techniques were applied to reconstruct past geologic environments and to analyze the present geomorphic setting of the Colville delta on the North Slope of Alaska. By examining differences in the distribution of selected characteristics of ice-wedge polygons, the positions of former fluvial channels and lake beds and the relative age of the surface could be determined.

Characteristics of ice-wedge polygons such as size, shape, central relief, and rim condition were delineated using aerial photography of various scales and dates. Maps of selected characteristics assisted in identifying outcrops of the Pleistocene Gubik Formation, frequently flooded areas, and the locations of former distributary channels and lake beds. Although Landsat digital data were not as effective as aerial photography in geologic mapping, primarily due to pixel resolution being one order of magnitude larger than an individual polygon, major surface features and outcrops could be identified from variations in vegetation and the surface water content of ice-wedge polygons. In addition, tundra surface with ice-wedge polygons could be differentiated from that without.

An understanding of ice-wedge polygon characteristics, which infer geologic environment and evolution, and the application of similar remote-sensing techniques can assist exploration geologist in determining past and present geologic environments in inaccessible periglacial regions.

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Williston Basin Seislog Study

This paper describes the results of Seislog® (trade name) processing and interpretation of an east-west line in the North Dakota region of the Williston basin. Seislog processing involves inversion of the seismic trace data to produce a set of synthetic sonic logs. These resulting traces, which incorporate low-frequency velocity information, are displayed in terms of depth and isotransit times. These values are contoured and colored, based on a standard stratigraphic color scheme.

The section studied is located just north of a dual producing oil pool from zones in the Ordovician Red River and Devonian Duperow Formations. A sonic log from the Long Creek 1 discovery well was digitized and filtered to match the frequency content of the original seismic data. This allows direct comparison between units in the well and the pseudosonic log (Seislog) trace nearest the well. Porosity development and lithologic units within the lower Paleozoic stratigraphic section can be correlated readily between the well and Seislog traces.

Anomalous velocity zones within the Duperow and Red River Formations can be observed and correlated to producing intervals in the nearby wells. These results emphasize the importance of displaying inversion products that incorporate low-frequency data in the search for hydrocarbons in the Williston basin. The accumulations in this region are local in extent and are difficult to pinpoint by using conventional seismic data or displays. Seislog processing and displays provide a tested method for identification and delineation of interval velocity anomalies in the Red River and Duperow stratigraphic sections. These techniques can significantly reduce risks in both exploration and delineation drilling of these types of targets.

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Use of Seislog for Basin Evaluation and Field Development

Generation of synthetic sonic logs (Seislogs) from seismic data can provide lithologic, porosity, and fluid-content identifications in a variety of geologic settings. Case studies illustrate the type of information that can be extracted from seismic data on carbonate rocks, including North Sea chalk, fractured limestones in Venezuela, and porosity development in regional limestones of western Canada. In the North Sea, 2 adjacent structures that appear similar on conventional seismic sections display porosity development and fluid content changes within the chalk reservoir on the Seislog section. In a South American example, the Seislog display demonstrates the ability of seismic data to locate vertical fracture zones. In western Canada, secondary porosity development within Devonian carbonates was identified on Seislog displays, which led to the extension of a gas field. Examples from southeast Asia display a variety of depositional environments in Miocene sediments. Shallow-marine and shoreline sands can be identified in a Malaysian example. An example from the Natuna Sea displays a lower delta-plain setting, with regional shale markers and thick clastic packages. An upper delta-plain example (Gulf of Thailand) displays more faulting, expansion of clastic packages, and discontinuous channel sands.

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Recognition of Paleosilcretes: Example from North Texas

Recognition of fossil silcretes may be hampered by weathering, erosion, or subsequent burial. Silcretes develop during periods of exposure and nondeposition and can represent cumulative sedimentation for geologically important periods of time.

The basal Cretaceous conglomerate in north Texas (Antlers and Twin Mountains formations) was deposited and lithified on the Wichita paleoplain. The silcrete formed in a tropical climate without seasonal variation. Outcrops are sporadic yet widespread and topographically prominant. The rock is a quartz and chert-pebble conglomerate with a variety of silica cements. It is recognized as a silcrete by the following criteria. (1) Both the detrital and authigenic components are composed primarily of silica. (2) Vadose quartz overgrowths are found in association with phreatic chalcedonic cements. Vadose silt occurs with both cement types. Zonation within the cements suggests intermittant cementation. (3) Reworked cemented grains indicate syndepositional cementation, necessarily a surface phenomenon. (4) Petrified wood is abundant. Abraded petrified wood further suggests recurring silicification and transportation.

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Shelf Sedimentation Across Precambrian-Cambrian Boundary: Chapel Island Formation, Southeastern Newfoundland

The upper Precambrian-Lower Cambrian Chapel Island Formation consists of medium- and fine-grained siliciclastics and minor limestones that record the early evolution of shelly fossils and complex trace fossils. Deposition of these Avalonian sediments occurred in a variety of shelf environments. Temporal and spatial changes in the conditions of sedimentation during the deposition of this sequence resulted in a wide spectrum of sedimentary and biogenic structures.

Facies transitional with underlying terrestrial and shallow-marine red beds were deposited in foreshore and upper-shoreface settings under tidal influence and display tidal channels, shrinkage cracks (desiccation and synaersis), abundant current ripples (bimodal-bipolar current distribution), and phosphatic nodules.

Sandstones and siltstones deposited in shoreface to outer-shelf settings contain evidence of storm and wave reworking. Features present include: gutter casts, thin granule lag zones, phosphate nodules, slump-fold zones, hummocky cross-stratified beds, and thin to medium-grained sandstones with sharp bases and gradational tops, wave-rippled upper surfaces, climbing wave ripple laminations, and draping laminations. These features indicate deposition on a storm- and wave-dominated shelf with locally variable topography. Thick massive siltstone beds and pebbly mudstones are interpreted as debris flows formed on a gentle slope.

Red and green mudstones, nodular limestones, and medium to thick (up to 60 cm) limestones were deposited during periods of low siliciclastic input. The limestone beds—micrites to packed biomicrites—contain oncolitic and planar stromatolites, sheet-crack cavities (containing the oldest known coelobiontic fauna), iron-manganese encrusted surfaces, authigenic barite, mudcracks, intraformational and extraformational conglomerate layers, and small channels. These are interpreted as intertidal and supratidal deposits.

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Fission-Track Dating and Its Application to Thermal History of Sedimentary Basins

Fisson tracks are zones of intense damage formed when fission fragments of ^{238}U pass through a solid. Spontaneous fission of ^{238}U takes place at a constant rate. Therefore, the age of a mineral can be calculated by determining the number of tracks and the amount of uranium the mineral contains. Once formed, fission tracks are stable in most minerals at temperatures below about 80°C. However, if a mineral is heated to a high enough temperature, the tracks fade and disappear, resulting in an anomalously young fission-track age. The temperature at which this "annealing" occurs depends on the mineral and the duration of heating.

The two minerals most commonly used in fission-track annealing studies are apatite and zircon. Fission tracks in apatite are totally annealed at temperatures of about 150°C to 105°C over periods of 10^5 to 10^8 yr, respectively. Annealing temperatures of fission tracks in zircon are not as well known, but are probably in the range of 200°C ± 25°C for heating lasting longer than 10^6 yr. The annealing temperatures of apatite and zircon span the main temperature range of oil generation, and both minerals are present in the heavy-mineral suites of many sediments. Consequently, fission-track dating is a valuable method for studying the time-temperature history of sedimentary basins.

In the southern San Joaquin Valley, California, fission-track ages of apatite from drill-hole samples of Eocene to Miocene sandstones suggest that sediments in the rapidly subsiding basin northwest of the active White Wolf fault have been near their present temperature for about 10^6 yr, whereas those in the Tejon platform southeast of the fault have been near their present temperature for about 10^7 yr. These estimates agree with estimates based on other thermal history indicators in these rocks.

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In-Situ Rock/Water Geochemistry of Holocene Radial and Tangential Ooid Sediment, Baffin Bay, Texas

The crystal fabric in ooids from the shoreline of Kleberg Point (Baffin Bay) is predominantly tangentially oriented aragonite; however, multiple fabric elements (radial and tangential crystals) occur in ooids with mineralogies of both aragonite and 10.3-mole % magnesium calcite. Aragonite occurs as both radial and tangentially oriented crystals, whereas, high Mg-calcite exists only in a radial crystal orientation. High Mg-calcite occurs as an outermost coating surrounding aragonite, and also as an envelope about aragonite that encloses quartz nuclei.

Seasonal diurnal measurements were made in ambient bay water and water in the ooid sediment. Cyclic diurnal changes occurred in both the ambient and pore water, with the largest change occurring during the summer. Measured extremes for the summer ambient waters are: day = 32.7°C, pH of 8.22, Alk_C of 3.14 meq, and H_2CO_3* of $10^{-5.07}$; and night = 28.3°C, pH of 8.11, Alk_C of 2.54 meq, and H_2CO_3* of $10^{-4.88}$. Chlorinity (27.93 ‰), $A_{Ca^{2+}}$ (2.7×10^{-3} moles/L), and $A_{Mg^{2+}}$ (2.8×10^{-2} moles/L) showed little diurnal variation. Aragonite saturation was greatest during the day with $\Omega_{ARAG\text{-}ambient} = 3.25\text{-}1.95$; and $\Omega_{ARAG\text{-}pore} = 4.07\text{-}2.52$. Both pH and Alk_C decrease with depth, whereas H_2CO_3* increases. The Ω_{ARAG} increases in the uppermost 10 cm of sediment and decreases with depth. Both ambient and pore waters are supersaturated with respect to a 10.3-mole % Mg-calcite.

Maximum ΣCO_2 in the ooid sediment occurs during the mid-afternoon, and increases with increasing sediment depth. A decrease in H_2CO_3*, produced through respirative processes with increasing sediment depth, indicates that precipitation is taking place in the sediment column, as the greater proportion of H_2CO_3* with increasing sediment depth is caused by precipitative processes. The differing mineralogy and ooid fabric is a product of changes in both water chemistry and energy.