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Antietam Sandstone: Lower Cambrian Analog to Petroleum-Bearing Stringer Sands or Barrier Islands

The Lower Cambrian Antietam Sandstone crops out in southeastern Pennsylvania as many elongate, narrow ridges, commonly surrounded by lowlands thought to consist of shale and/or limestone. Most interpretations for this pattern have relied on complicated faulting to terminate the ridges. Mapping by the writer and his students suggests a simpler explanation: namely, this discontinuous series of sandstone ridges is an exhumed line of barrier islands that stood in front of the Early Cambrian continent. Barrier sands are surrounded by argillaceous units (the Harpers Phyllite) and calcareous marine units (the Vintage Dolomite), standing in front of sandy shoreline deposits (the Chickies Formation). Detailed stratigraphic studies, combined with petrologic analyses of related formations, grain studies, and comparisons of sedimentary features show the Antietam Sandstone to be very similar to such beaches as Fire Island, New York; Long Beach Island, New Jersey; and Pea Island, North Carolina. Very close similarities were found between the modern setting and the Early Cambrian formations, lending credence to this model for the Antietam Sandstone ridges. This porous sandstone, surrounded by less permeable lithologies, may be a potential reservoir in regions where metamorphism has not precluded the existence of hydrocarbons.

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Geologic and Commercial Evaluation of Heavy Oil Prospect in Maverick Basin, Texas

In December 1979, a 6,500 acre (2,631 ha.) farm-in prospect in the Maverick basin in Texas was offered to Shell as a potential field for heavy oil production using steam injection. Preliminary economic models from a limited data base were insufficient to evaluate this potentially profitable prospect. A test well was drilled and 100 ft (30 m) of the shallow Upper Cretaceous San Miguel sand (at about 2,000 ft or 610 m) was conventionally cored to obtain accurate data.

From the core description, thin-section, and grain-size analysis, the San Miguel basal sand is interpreted as a barrier-island deposit with the upper zone reworked by a transgressive marine cycle. Petrographic analysis indicated early calcite cementation in a complex pattern in the gross sand interval. Natural fracturing is present in the reservoir. The heavy oil is highly viscous with an extremely low API gravity. The relation of heavy oil to grain morphology was shown by SEM photographs.

The log and core data indicated 45 net ft (14 m) of oil sand. However, oil saturations and gross sand quality were inadequate to meet minimum requirements for a profitable project.

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Natural-Gas Hydrates of Blake Ridge Region, Atlantic Continental Margin

A strong acoustic reflection that parallels the sea floor has been observed in seismic profiles collected over the Blake Ridge region, off the southeastern United States. This anomalous reflection occurs at a subbottom depth of 400 to 700 m in water depths of 750 to 3,750 m and has been mapped over an area of at least 80,000 km^2. The reflection probably is due to the contrast between an upper high-velocity zone of sediment cemented by gas hydrates and an underlying low-velocity zone that does not contain gas hydrates.

Coring by the Deep Sea Drilling Project (DSDP) has shown that gas hydrates are present in this region. During DSDP Leg 11, high concentrations of gas were observed; gas was composed mainly of methane of light carbon isotopic composition (< -70 per mil relative to PDB standard) accompanied by minor amounts of heavier hydrocarbons and carbon dioxide. DSDP Leg 76 confirmed that high concentrations of methane are present in sediment from this region. Conclusive evidence for gas hydrates was obtained when a vigorously outgassing sediment sample with a matlike layer of white crystals was recovered. The volume of gas released from this sample was about 20 times the volume of pore fluid, a result clearly indicating gas hydrate. Results obtained by using a pressure core barrel also indicated that gas hydrate is present. The molecular composition of the hydrocarbon gases and the isotopic composition of the methane suggest that the methane is of biologic origin. This methane, if trapped beneath the gas hydrate in reservoir rocks, could represent a significant resource.

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Anomalous Sedimentary Features on Floor of Northern Hatteras Abyssal Plain

Analysis of approximately 700 km of high-resolution 3.5-kHz seismic profiles taken aboard the R/V *Endeavor* during the summer of 1980 indicates several distinct and sometimes puzzling features on the floor of the northern Hatteras Abyssal Plain. The basic pattern of echo character is perpendicular to rather than parallel with the axis of the plain, extending in bands across the plain almost to the Bermuda Rise. This banding may be the result of very low-relief fans extending across the basin from entry points at the Hatteras, Wilmington, and perhaps Hudson Canyon mouths. A series of terracelike features slopes gently seaward to form the western boundary between the abyssal plain and lower continental rise hills. Each terrace has a length of 5 to 10 km and an approximate relief of 5 m at its seaward boundary. Whether this 50-km wide boundary zone has been formed by boundary currents, intraformational faulting, or fan development is not clear. Distinct lensoidal deposits 200 to 500 m long and less than 5 m thick are sparsely distributed west of the Hatteras Canyon mouth. These acoustically transparent lenses lie in shallow channels and closely resemble debris-flow deposits; however, their small size and sparse distribution do not suggest that they are laterally continuous. These anomalous sedimentary features will be more intensively studied during the summer of 1981.

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Submersible-Mounted In-Situ Geotechnical Instrumentation

New miniaturized in-situ geotechnical instruments have been developed and field tested with the DSRV *Alvin* in various sedimentary features associated with mass movements of sediments on the U.S. East Coast slope and rise within the Wilmington geotechnical corridor. The instruments include a cone penetrometer, resistivity probe, miniature piezometer, and an inclinometer.

The penetrometer produced a continuous profile of sediment cone resistance and was useful in determining recent sediment thicknesses to 1.3 m at several sites. The resistivity probe produced a continuous profile of sediment electrical resistance/conductivity, which is related to sediment wet unit weight and porosity when pore water salinities, temperatures, and average grain densities are constant. The miniature piezometer is a prototype 8-mm diameter probe which measures sediment excess pore water pressures and the dissipation of pressures induced during insertion at various depths below the sediment-water interface. An inclinometer was also mounted on the submarine and continuously measured the sediment slope as the submersible traversed the sea floor.

The use of in-situ geotechnical instruments with a manned submersible provides the opportunity to select sites for detailed geotechnical analysis of specific sea-floor features such as previously slumped blocks, their slump scars, and sediment gravity flow deposits. Although depth of penetration of the submersible-mounted probes is limited to ~1.3 m, valuable detailed in-situ geotechnical data were obtained.

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High Potential Gas Production and Fracture-Controlled Porosity in the Upper Devonian Kane Sandstone, Central-Western Pennsylvania

Cush Cushion field is a small gas-producing tract in central-western Pennsylvania. It lies physiographically within the Pittsburgh Plateau section of the Appalachian Plateau province. The Allegheny Front, which forms the border between the Appalachian Plateau province and the Valley and Ridge province, is 23 mi (37 km) east of the field. Cush Cushion is developed across the Brush Valley synclinal axis in eastern Indiana County. The Conemaugh Group is exposed at the surface and production is from the multistory sandstone reservoirs of the Bradford Group (Upper Devonian) at depths ranging from 2,600 to 3,924 ft (792 to 1,196 m).

The Kane sandstone of the lower Bradford Group is the principal reservoir at Cush Cushion field. The Kane is interpreted as a distributary-channel sandstone associated with the westward progradational Catskill clastic wedge.

Kane sandstone production is fracture controlled at Cush Cushion field. Fracture porosities as high as 13.8% occur along a limited east-west trend. Natural open flows of up to 13.8 MMcfgpd are known from the fractured Kane interval.

A zone of structural discontinuity is recognized at Cush Cushion field. Fracture porosity in the Kane may be related to the local disruption of the regional structural grain. This disruption could represent the extension of a documented cross-structural discontinuity from the overthrust belt into the undetached foreland.

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Future of Uranium Mining in Atlantic Margin

Good prospects exist for the discovery of mineable uranium ore bodies in a variety of geologic environments in the Atlantic margin. Development is farthest along in the Canadian Maritimes, at Kitts-Michelin in Labrador, through extensive exploration in New Brunswick, at Johan Beetz and other pegmatite areas on the Quebec north shore, and in the South Mountain batholith in Nova Scotia. Targets of interest in the United States include Precambrian crystalline rocks in the Green Mountain massif in Vermont, the Reading Prong-Hudson River Highlands in New York-New Jersey, and Grandfather Mountain in North Carolina-Tennessee. Paleozoic granitic intrusives in the Piedmont province commonly are enriched in uranium, and some have potential for discovery of episyenite, pegmatite, authigenic, and contact metasomatic deposits. Triassic sedimentary basins are being explored for sandstone-type ore bodies, and are being considered for vein-type deposits related to the border faults, or to the basal unconformity. The potential of the Coastal Plain is almost unknown although there are good source rocks nearby, and substantial uranium is moving in the present hydrologic regime. Gorceixite occurrences in Aiken County, South Carolina, are of some interest. The Department of Energy is continuing to review areas and evaluate data generated under the National Uranium Resource Evaluation program.

Exploration and development of resources in the Atlantic margin are hampered by large metropolitan areas, high population density, higher priority uses of land, and the difficulty of negotiating leases. Environmental and antinuclear concerns have resulted in legislation restricting exploration and development in Vermont and New Jersey. Publich sentiment is divided on the issue of mining. Where these obstacles can be overcome, there are good opportunites and worthwhile prospects for further work.

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Petroleum Geology of Southern Appalachian Foreland Basin: Black Warrior Basin of Alabama

Because much of the petroleum contained in giant structure traps in the United States has been discovered, the petroleum resources of the future will be from complex petroleum traps involving structure, lithofacies distribution, and diagenetic alteration. The Black Warrior basin of northwestern Alabama is an excellent basin to prospect for combination petroleum traps; to date 35 petroleum fields have been discovered. The key to successful prospecting in this basin involves the delineation of local structure and determination of reservoir size, morphology, and quality. Mississippian sandstone reservoirs presently have the greatest petroleum potential, the Carter and Lewis sandstones being the most economic of these reservoirs. The Carter was deposited as part of a high-constructive, elongate to lobate delta which prograded from northwest to southeast into the basin. Specific deltaic environments identified include distributary channel and mouth bar, distal-bar, prodelta, and interdistributary bay. The Lewis accumulated as a series of elongate, northwest to southeast trending sand bodies on a shallow marine shelf. Specific environments identified include central-bar, interbar, and shelf.

Carter distributary-mouth bar and distal-bar lithofacies and Lewis central-bar lithofacies constitute the primary Mississippian reservoirs in the basin. These sandstones are usually fine grained, well sorted, subangular to subrounded quartzarenites or sublitharenites. Primary interparticulate porosity has been reduced through the development of quartz overgrowths and/or calcite cementation. Porosity is principally secondary and involves leaching of carbonate allochems, calcite cement, and/or matrix. The Carter prodelta and interdistributary-bay shales and the Lewis marine shales make excellent petroleum source rocks. These shales contain amorphous, algal, and herbaceous kerogen. The state of alteration of the kerogen indicates that the thermal history of the basin has been favorable for the generation and preservation of hydrocarbons. The hydrocarbon-trapping capabilities of these strata have been enhanced because of their association with normal faults.