Trace Fossil Assemblages of Upper Cretaceous Sand Units, Delaware and New Jersey

Siliciclastic formations of Upper Cretaceous age on the Delaware-New Jersey coastal plain contain diverse trace fossil assemblages. When used with physical sedimentary structures and textural data, the assemblages can differentiate intertidal and shallow subtidal depositional environments. Most close modern analogs can be recognized for the Cretaceous trace makers.

The Englishtown Formation (Campanian) crops out along the C & D Canal in Delaware. The basal part of the unit is characterized by mottling due to dense concentrations of gently meandering, essentially horizontal *Planolites* burrows outlined by rims of dark organic-rich material. Other zones are mottled primarily by small-diameter branched shafts of *Chondrites*. Clumps of quartz sand-lined tubes of *Terebellina* are dispersed throughout. These tubes have gently curved shafts which form tunnels with distinctive feeding-probe structures at their distal ends. At the top of the unit, the assemblage is dominated by stacked *Ophiomorpha nodosa* systems with basal mazes. Also present are several types of *Chondrites*, which commonly surround and/or infest the walls of *Ophiomorpha* shafts, and delicate *Skolithos* shafts.

In New Jersey, the Wenonah Formation, Mt. Laurel Formation, and Shrewsbury Member of the Red Bank Formation (all Maestrichtian) each contain a distinctive trace fossil assemblage. The Wenonah Formation is characterized by *Cylindrichnus*, large concentrically laminated, subvertical, and tapering clay tubes. The Mt. Laurel Formation exhibits two facies, one characterized by small-diameter *Ophiomorpha* shafts and associated *Chondrites* forms and the other containing an *Ophiomorpha, Chondrites, Skolithos,* and *Cylindrichnus* assemblage. Large-diameter *Ophiomorpha nodosa* systems and associated *Chondrites* characterize sands of the Shrewsbury Member of the Red Bank Formation.

The trace fossil assemblages and primary sedimentary characteristics suggest the following depositonal environments: Englishtown Formation, shallow subtidal shoals transitional to lower foreshore; Wenonah Formation, subtidal, inner shelf; Mt. Laurel Formation, shoreface and transition zones to shallow shoal complex; and Shrewsbury Member of Red Bank Formation, offshore bar complex.

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Advances in Radon Exploration Techniques for Uranium

In an effort to evaluate several radon measurement methods, Bendix Field Engineering Corp., as part of the Department of Energy's National Uranium Resource Evaluation (NURE) program, has performed radon measurements using a variety of new techniques at a uranium occurrence located in the Red Desert area of south-central Wyoming. The site had 100 sampling locations over a 1.5-sq km area.

The radon techniques used were: a prototype microprocessor-controlled emanometer; alpha-track detectors with two types of detector material, with and without membranes for thoron separation; radon adsorption on activated charcoal with the measurement of the gamma-emitting radon decay products; thermoluminescence detectors; partial extraction of lead-210 from soil samples; and an established emanometer. The radon measurements obtained by these techniques at the sample locations are compared for their sensitivity, variability, signal enhancement, and the correlation between the radon techniques. The radon techniques were also correlated to the equivalent uranium in the soil samples.

The prototype emanometer was found to exhibit less variability than the established emanometer. One alpha-track material was 15 times more sensitive than the other material. The thoron membranes decreased the number of alpha tracks by 47% in the more sensitive material and increased the number of alpha tracks in the less sensitive material by 27%. Signal enhancement obtained for all the radon techniques was similar for this research site and ranged from 2.5 to 3.5. Correlation coefficients between the techniques ranged from 0.32 to 0.70 and from 0.3 to 0.9 with equivalent uranium.

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Application of Regional Geochemical Data to Uranium Exploration

Hydrogeochemical and stream-sediment reconnaissance data generated by the U.S. Department of Energy's National Uranium Resource Evaluation program can be used to identify geologic environments favorable for uranium or base metal deposits.

Open-filed analytical data for 1 × 2° NTMS quadrangles are obtained on magnetic tape from Oak Ridge National Laboratory and transferred to disk for interactive computer use. Data may then be organized into subsets according to sample type, geologic, or physiographic units; smoothed using block or nearest-neighbor averaging techniques; and power transformed to normalize frequency distributions. Multivariate statistical techniques, including principal component, discriminant, and multiple regression analyses, aid in interpretation. A contrast filter may be used to identify areas that are significantly different from their local background.

Machine-generated color or black and white maps are produced from raw elemental analyses, elemental ratios, and statistical parameters such as factor scores and multiple regression residuals. The data may be represented at any scale, using a variety of symbol or color schemes designed to cartographically enhance the appearance of anomalous areas.

Results of the geochemical interpretation are used to select target areas several tens of square kilometers in size. Examples from the Colorado Plateau and other areas illustrate how the interpretive techniques are used.

Both the data and data analysis techniques have wide application in mineral exploration. Because of the extensive suite of elements represented, the data can be

beneficial to any organization involved in frontier exploration for uranium or base metals.

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Internal Structures of Shallow-Marine Tidal Sand Waves

Asymmetric sand waves (average height 0.86 m, and average wavelength 46.6 m) with superimposed megaripples 0.05 to 0.2 m high, occur commonly in medium to coarse sand on tidal sandbars in the Bay of Fundy. Their internal structures are complex, but three main types can be distinguished: (1) *inclined sets* of descending and ascending cross-bedding (0.1 to 0.3 m thick) that have set boundaries dipping at an average angle of 9° in the dominant transport direction; (2) *large-scale foresets* having set thicknesses comparable to the sand wave lee-face height and average inclinations of only 20°; and (3) *complex cosets* up to 0.5 m thick of thin (0.05 to 0.15 m thick) cross-bedded sets with abundant herringbone cross-stratification. Types 1 and 2 are formed during sand wave lee-face migration, whereas type 3, which overlies the lee-face structures, is produced by the superimposed megaripples during vertical growth of the sand waves following degradation by storms or winter ice.

Inclined sets are the most common lee-face deposit in the Bay of Fundy. Their formation is favored by the high current speeds, low to intermediate sediment transport, and the migration of large megaripples (relative to the sand waves) which characterize this area. Large foresets are relatively rare, and extensive development of large-scale, angle-of-repose cross-bedding has never been observed. Large-scale foresets may be more abundant in other areas where there are larger sand waves, lower current speeds, and higher sediment transport, but they should contain numerous reactivation surfaces, and be overlain by vertically accreted complex cosets. The internal structures of tidal sand waves should differ significantly from those in aeolian dunes.

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Shallow Oil Shale Deposits of Southern Uinta Basin, Utah

In the southern part of the Uinta basin of northeastern Utah, the Mahogany zone of the Green River Formation occurs at or near the ground surface. This shallow Mahogany zone represents a resource of oil shale at depths of up to 200 ft (61 m), developable by horizontal in-situ methods such as demonstrated by Geokinetics Inc., which is operating in the study area. The geologic sections potentially attractive for near-surface oil production are described. The Mahogany zone is divided into seven correlatable units. Three cross sections constructed from oil-yield histograms detail the correlations. Thickness, average oil yield, and oil resource in place are used to create contour maps defining the resource.

Production of shale oil from near-surface horizontal retorts involves creating permeability by blasting. This method lifts the surface, providing subsurface void space. Horizontal in-situ production of shale oil uses this void space to permit passage of air and product gasses. To this date, successful experimental horizontal retorts have been created to depths of about 60 ft (18 m) and further experimentation is expected to increase that depth limit.

To determine and define the resource characteristics of this potentially developable section of the Green River Formation, the Laramie Energy Technology Center has drilled 12 core holes in the southern Uinta basin during the past 3 years. Data for 10 of these core holes are included. Information from 12 other cores taken by private companies is incorporated and 18 other test holes provided some data used in construction of structural contour and overburden maps.

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Dineh-Bi-Keyah Field, Apache County, Arizona

The Dineh-Bi-Keyah oil field is located on the Navaho Indian Reservation in northeastern Apache County, Arizona, and is situated on the northwest end of the Toadlena anticline, a surface feature on the northeast flank of the Defiance uplift. The field is producing from a syenite sill which intruded Lower Pennsylvanian rocks. The discovery well was completed in January 1967 and as of October 1, 1979, the field has produced a total of 15,386,725 bbl of oil.

The sill is of Tertiary age and contains both intercrystalline and fracture porosity. Primary minerals are sanidine, biotite, diopsidic augite, glass, and minor magnetite. Glass is the primary cementing material. The porosity, permeability, and oil-saturation values measured in the igneous rock are similar to the reservoir parameters of many oil-producing carbonate rocks.

The sill is comparable in general appearance and mineral composition with plugs, dikes, and sills that crop out in the area. However, the igneous rocks exposed at the surface in the area are very fine grained and dense and have little, if any, porosity. Samples from the two igneous plugs which crop out at Roof Butte, 1 mi (1.6 km) southeast of the discovery well, are difficult to distinguish from core chips from the dense parts of the producing formation.

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Graphic Representation of Subsurface Data by Computer

A subsurface stratigraphic study of terrigenous Miocene sediments along the south Texas Gulf coast was undertaken to determine the possible existence of a major, uranium-bearing, fluvial system that may be related to a paleo-Nueces River. The Nueces River in south Texas flows in a southeasterly direction toward the Texas Gulf coast. In southeastern LaSalle County, the Nueces River makes an abrupt 90° turn and flows northeast for 56 mi (90 km). The Neuces River joins with the Frio and Atascosa Rivers to flow southeasterly,