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

DALRYMPLE, ROBERT W., Brock Univ., St. Catharines, Ontario

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.

DANA, G. F. (PETE), J. WARD SMITH, and LAURENCE G. TRUDELL, U.S. Dept. Energy, Laramie, WY

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.

DANIE, T. C., Kerr-McGee Corp., Oklahoma City, OK

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.

DAUB, GERALD J., Plateau Resources Ltd., Grand Junction, CO, and ROGER K. GREENALL, JR., Univ. Rhode Island, Kingston, RI

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, debouching in Corpus Christi Bay. It has been theorized that the Neuces River once flowed southeasterly crossing northwest Webb and central Duval Counties and then into Baffin Bay.

A subsurface stratigraphic study was initiated to determine the existence of stacked fluvial sequences within the confines of the proposed former course of the Neuces River. Four hundred and three electric logs were examined to determine the formation tops, bottoms, thickness, percent sand, net sand, and maximum sand of both the Oakville and Catahoula Formations.

The electric log data were reduced to acceptable form for use with the University of Rhode Island SYMAP program. The SYMAP program is capable of producing a map of any dimension using a conventional line printer. Data base, cross section location, percent sand, net sand, and maximum sand maps were produced by this method. An advanced University of Rhode Island program known as SYMVU was used in conjunction with a CalComp plotter to display the data as a colored, graphic, three-dimensional map.

DELGADO, DAVID J., Univ. Wisconsin-Madison, Madison, WI

Submarine Diagenesis (Aragonite Dissolution, Cementation by Calcite, and Dolomitization) in Ordovician Galena Group, Upper Mississippi Valley

The Galena Group is a fossiliferous, dominantly carbonate unit about 85 m thick, which was deposited in a broad epeiric sea mostly below wave base.

Submarine dissolution of aragonite and cementation by calcite appear to have proceeded simultaneously in Galena sediments. Commonly, the enclosing sediment (mostly carbonate mud) lithified before shell aragonite dissolved, resulting in moldic voids. Most of these voids were later cemented with block calcite spar; some were filled by bioturbation.

Some burrow fills became lithified but the enclosing matrix remained soft. Where this occurred, sparry replacements of aragonitic bioclasts now exist only within these burrow fills; lithification preserved bioclast outlines. Where scouring later exhumed lithified burrow fills, they produced topographic highs on scoured surfaces or intraclasts with meniscus-fill fabric.

Hardgrounds very commonly occur in most exposures of the Galena; many are bored. Sparry calcite fills cracks in some hardgrounds, and is transected by borings or by the overlying bed. Spar-filled voids suggestive of former aragonitic clasts are preserved in the upper centimeters beneath hardgrounds in some strata which otherwise lack these fossils.

Fine to very fine crystalline dolomite fills burrows extending downward from many hardgrounds. Individual dolomite crystals are abraded at scoured surfaces and at margins of intraclasts. These features suggest that dolomitization occurred on the seafloor.

DEMAISON, G. J., Chevron Overseas Petroleum, Inc., San Francisco, CA, and G. T. MOORE, Chevron Oil Field Research Co., La Habra, CA

Anoxic Environments and Oil Source Beds

The anoxic, aquatic environment is a mass of water so depleted in oxygen that virtually all aerobic biologic activity has ceased. Oxygen demand relates to surface biologic productivity, while oxygen supply largely depends on water circulation, which is governed by global climatic patterns and the Coriolis force.

Organic matter in sediments below anoxic water is commonly more abundant and more lipid-rich than under oxic water mainly because of the absence of benthic scavenging and bioturbation. Geochemical and sedimentologic evidence suggests that oil source beds are and have been deposited in four main anoxic settings.

1. Large anoxic lakes. Permanent stratification promotes development of anoxic bottom water, particularly in lakes not subject to seasonal overturn such as Lake Tanganyika. Warm, equable, paleoclimatic conditions favored lacustrine anoxic settings.

2. Anoxic silled basins. Only those landlocked silled basins with positive water balance tend to become anoxic. Typical are the Baltic and Black Seas. In arid region seas, such as the Red Sea and the Mediterranean Sea, evaporation exceeds river inflow, causing negative water balance and well-oxygenated bottom waters. Hence, silled basins do not necessarily imply the presence of oil source beds.

3. Anoxic layers caused by upwelling. These develop when the oxygen supply in deep water cannot match demand due to high surface biologic productivity. Examples are the Benguela current and Peru upwellings. No systematic correlation exists between upwelling and anoxic conditions because deep oxygen supply can commonly match strongest demand. Anoxic sediments resulting from upwelling are found preferentially at low paleolatitudes.

4. Open-ocean anoxic layers. These are found in the oxygen-minimum layers of the Pacific and northern Indian Oceans, far from deep, oxygenated, polar water sources. They are analogous to worldwide "oceanic anoxic events" during global climatic warm-ups and major transgressions, as in Late Jurassic and middle Cretaceous times.

DEMATHIEU, GEORGES R., Inst. Sciences de la Terre, Univ. Dijon, Dijon, France

Use of Trace Fossils for Interpretation of Triassic Depositional Environments, Northeast Border of French Massif, Central France

A variety of trace fossils occur in Triassic sediments of the northeast border area of the French massif as follows:

1. Vertebrate tracks: numerous species (approx. 30) that point to the existence of: (a) numerous large herbivorous reptiles (*Isochirotherium*) accompanied by small ones (*Rhynchosauroïdes, Rotodactylus*); rare carnivorous reptiles of relatively small size (*Coelurosaurichnus, Sphingopus, Anchisauripus*); common omnivorous or necrophagous reptiles (*Brachychirotherium*); (b) very small insectivorous or herbivorous reptiles or amphibians (small *Rhynchosauroïdes, Prolophonichnium, Platipes, Furcapes*).

2. Invertebrate trace fossils: *Isopodichnus, Planolites, Cochlichnus.*

3. Plant imprints: *Voltzia* sp.

4. Associated primary sedimentary structures: ripple