

plane parallel with bedding plane and the minimum reflectance axis is perpendicular to the bedding plane. If maximum reflectance is achieved prior to folding, the minimum reflectance is always perpendicular to the bedding regardless of the subsequent folding and the attitudes of the coal beds. Thus, the attitude of the minimum reflectance is a good parameter for evaluating whether maximum thermal maturation is achieved prior or after folding or other structural changes. Twenty-five samples were collected from coal-bearing strata from Monkman's Pass north to Sparwood, British Columbia, in the Canadian Rockies. Most of the coal beds sampled were highly disturbed by folding and faulting with dips ranging from a few degrees to overturned. Analysis results indicate distinctive groupings of the samples with the minimum reflectance deviating a few degrees to more than 30° from the normal of the bedding. This suggests a varied thermal history for the coal fields studied. The technique can be applied not only to the investigation of coal-bearing strata but also to the study of source rocks of petroleum as to whether thermal maturation occurs before or after a trap has been developed.

TRICE, E. L., Baylor Univ., Waco, TX

Depositional History of Strawn Group (Pennsylvanian), Fort Worth Foreland Basin, Colorado River Valley, Central Texas

In the Colorado River Valley of central Texas about 1,200 ft (366 m) of Pennsylvanian (Desmoinesian) terrigenous clastic and carbonate facies were deposited in the Fort Worth basin. Paleocurrent and petrographic data indicate that the clastic provenance, to the west and northwest, was the rising Ouachita orogenic foldbelt.

Surface study suggests that the Strawn Group includes two main stratigraphic divisions: (1) a lower sequence representing basin and submarine fan sediments deposited as active tectonic subsidence substantially increased water depths in the Fort Worth basin; and, (2) an upper progradational sequence of fluvial-deltaic and carbonate platform sediments deposited as passive isostatic subsidence or regional uplift to the east accompanied progressive shoaling of the sediment surface. The lower Strawn is characterized by sediment gravity flows suggestive of submarine fan deposition. It is subdivided into four facies (from proximal to distal): (1) massive channeled sandstone; (2) massive amalgamated sandstone; (3) turbidite; and (4) shale facies. The upper Strawn constitutes a delta-platform assemblage that includes: (1) delta facies including channel-mouth-bar sands, delta-front sands, delta-slope shales, and interdistributary fine clastics; and (2) carbonate platform facies that includes phylloid algal mounds and perideltaic bioclastic limestones.

The lower Strawn basinal shale and submarine fan sequence is gradational with the underlying basinal Smithwick Shale (Atokan) and records foreland basin subsidence synchronous with orogenesis in the Ouachita foldbelt. In contrast, the basal contact of the upper Strawn is variable. Generally, the upper Strawn is gradational with the lower Strawn but locally it rests disconformably on the Marble Falls Formation (Morrowan-Atokan). This stratigraphic relationship suggests that regional compressive forces from the Ouachitas were positionally more important than previously supposed.

TROGER, UWE, Technical Univ. Berlin, West Berlin, West Germany

Resource Appraisal and Environmental Problems Associated with Oil-Shale Deposits in Morocco

The best-known oil-shale deposit in Morocco occurs in the

Middle Atlas region at an elevation of 5,000 ft (1,525 m), and contains total estimated reserves of 3.5 billion bbl. Approximately 1 billion bbl is amenable to open-pit mining techniques, having an overburden ratio of 0.8. Yields from this deposit reach maximum values of 45 gal/ton and average more than 20 gal/ton. Questionable infrastructure and extreme climatic conditions are important considerations, but do not represent major obstacles to development. Run-off of precipitation is very important in this region because the water is used for field irrigation. Major changes from the present hydrologic pattern could easily destroy the dominantly cedar vegetation and adversely affect the most important inland recreational area in the region.

Conditions are much more favorable for developing the 100 billion bbl deposit situated near Tarfaya. This oil shale averages 19 gal/ton and approximately 60% of the deposit has an overburden ratio of 0.8 and thus could be mined in an open pit. Suitable infrastructure conditions exist in this area, including a harbor, an airport, and asphalt roads. Proximity to the Atlantic Ocean, stable climate, and low precipitation conditions help resolve problems which exist for other oil-shale deposits worldwide. Under these conditions, this particular deposit could be exploited by above-ground retort technology.

Development of these two deposits would be in contrast to current United States operations which tend to favor in-situ processing because of environmental considerations.

TROTTER, SHERRY F., Wichita State Univ., Wichita, KS, and ROD E. ANDERSON, Petro-Dynamics, Wichita, KS

Utopia Algal-Bank Complex and Its Potential in Shallow Gas Exploration in South-Central Kansas

The Utopia Limestone (Upper Pennsylvanian) was deposited as a series of algal banks forming a narrow arcuate band approximately 25 mi (40 km) long on the shelf margin of Sedgwick basin in south-central Kansas. Utopia banks may attain a maximum thickness of 70 ft (21 m) and are encased in a dark gray shale, creating excellent reservoirs for hydrocarbon accumulation. Having porosities of up to 22%, the Utopia produces economic quantities of gas from depths of 2,000 to 2,500 ft (610 to 762 m).

The Utopia contains three distinct facies: (1) biomicrite, the "core" facies; (2) calcilitite, an *Osagia*-coated biosparite, the mound facies; and (3) an oolitic facies associated with the mound. The facies distribution was controlled by basin geometry and the variations in the subtidal and intertidal environments of the shelf. Sedimentation rate approximately equaled subsidence rate, maintaining the position of the bank tops within the shallow intertidal range. The banks are slightly asymmetrical and thicken basinward. The initial mound accumulation began with the deposition of a biomicritic mound "core," in a quiet-water environment. The major constituents of the calcilitite facies are green algae (*Osagia* and *Epimastopora*), along with a wide assortment of shallow-water biota. The oolite shoal facies formed contemporaneously beside the mound facies.

Subaerial exposure and subsequent leaching of the banks during successive marine transgressions created the intraparticle and oomoldic porosity. Locally, dolomitization of the algal fragments occurred.

Results of this study indicate that further exploration in this area and basinward should prove profitable.

UKAZIM, EMENIKE O., and D. A. FAHLQUIST, Texas A&M Univ., College Station, TX

Hydrocarbon Migration and Accumulation as Influenced by Growth-Fault Building Mechanism