NURKOWSKI, JOHN R., Alberta Geol. Survey, Edmonton, Alberta, Canada

Coal Quality and Overburden Reconstruction of Upper Cretaceous and Tertiary Coal-Bearing Formations, Plains Area, Alberta

Statistical analyses of chemical data obtained from 685 coal samples have been carried out to determine the distribution of coal quality in the Alberta plains. Distributions of components of proximate and ultimate analyses and heating value for each of the major Upper Cretaceous and Tertiary coal-bearing units, namely Belly River Group, Wapiti Formation, Horseshoe Canyon Formation, and Scollard Formation, were investigated.

A least-squares regression analysis of all data, regardless of formation, of calorific value, CV (Kcal/kg), corrected to a moist mineral matter free basis, on equilibrium moisture, MEQ, yielded the equation

$$CV = 7599\text{-}105.58\ MEQ.$$

The maximum depth of coal seam burial, D (meters), was reconstructed on the basis of published graphs relating equilibrium moisture loss to depth of burial of coal seams. The resulting equation was

$$\log_{[10]}MEQ = 1.865\text{-}0.000416(D).$$

This equation facilitated reconstruction of both the maximum paleotopographic elevation and the amount of sediment removal from the plains area of Alberta. Near surface coals (shallower than 300 m) varied in rank from subbituminous to high volatile bituminous C, with rank increasing in a west-southwest direction (i.e., toward the foothills and mountains region) because of the progressively greater amounts of overburden that existed in that direction during Tertiary time. Erosion has since removed between 880 and 1,900 m of sediment, with the greatest amount of removal occurring in a west-southwest direction. An average coalification gradient of 1.67 of Kcal/kg/m (0.91 BTU/lb/ft) was determined by using the reconstructed overburden.

OAKS, ROBERT Q., JR., Magellan Petroleum Corp. and Utah State Univ., Logan, UT, KEITH T. CONRAD,* Mobil Exploration and Producing Services, Dallas, TX, and JAMES A. DECKELMAN, Magellan Petroleum Corp., Brisbane, Australia

Salt-Induced Growth Structures and Subsequent Overthrusts, Northeastern Amadeus Basin, Central Australia

Thicknesses of the late Proterozoic-Early Cambrian Arumbera Sandstone and Middle Cambrian Giles Creek Formation show initiation of growth of the Brumby anticline during the Middle Cambrian. Growth probably resulted from flowage of bedded salt in the late Proterozoic Bitter Springs Formation, possibly due to uneven deposition of fluvial sediments of the Arumbera. Such early growth structures are more likely to be oil prone than anticlines that formed later, during the Alice Springs orogeny (Late Devonian-Early Carboniferous), because adjacent source rocks were not buried as deeply. Positive source-rock analyses are known from several late Proterozoic units in the Northeast Amadeus basin.

Four major tectonic elements formed during the Alice Springs orogeny: (1) the N'Dahla nappe in the north, (2) the Phillipson nappe in the center, (3) tectonic windows (autochthon?) southward in the Phillipson nappe, and (4) the Camel Flat nappe in the south. Isopach maps drawn for each tectonic element suggest a minimum of 10 to 20 km of southward movement for each of the two northern nappes. A strike-slip fault along the east side of Todd River anticline, with 1 to 1.5 km of left-lateral offset, forms a prominent north-trending lineament across the dominant east-northeast trend of most of the folds in the Northeast Amadeus basin. It is paralleled on both sides by closed, doubly plunging anticlines. Major strike-slip faults and north-trending anticlines were not widely recognized previously in the Amadeus basin.

OBELENUS, THOMAS J., Univ. North Dakota, Grand Forks, ND

Depositional Environments and Diagenesis of Frobisher-Alida Interval, Madison Group (Mississippian, North Dakota Williston Basin

The Frobisher-Alida interval is a well log-marker-defined interval, not lithologically based, which extends across middle and upper Mission Canyon carbonates into lower Charles evaporite from the basin center toward the eastern basin margin. The interval represents a regressive sequence with superimposed minor transgressive pulses. A wide spectra of depositional and diagenetic environments with associated fabrics and porosities are represented in these carbonates.

Basin-margin carbonates are dominated by supratidal sediments with lesser amounts of intertidal and subtidal sediments. Major fabric types of important producing zones consist of major developments of hypersaline, and minor development of caliche and vadose, ooid and pisolite wackestones to grainstones. Intercalated with these are fenestral mudstones to laminated dolomudstones, gastropod mudstones, and evaporite "mush" dolomudstones. In addition, desiccation cracks and minor occurrences of karst breccias and laminated crusts indicate periods of subaerial exposure. Porosities associated with the supratidal-subaerial realm include well-developed interparticle, fenestral, vuggy, and intercrystal types, and in places are filled with clear spar and/or void-filling clear anhydrite cement.

Basinward, subtidal sediments dominate the interval. These consist of cyclic, shallow open-marine bioclastic mudstones to packstones-grainstones and, partly restricted marine burrowed peloidal mudstones to bioclastic wackestones. Upsection, noncyclic burrowed bioclastic peloidal mudstones to wackestones indicate increasingly restrictive conditions. Interparticle porosity is exhibited in the bioclastic grainstones. Intercrystal porosities are developed from selective dolomitization of burrows and mudstones.

O'DONNELL, SHARON ROSE, Univ. Maryland, College Park, MD

Coal Geology of Eastern McCreary and Western Whitley Counties, Kentucky

On the southern flank of the Pocahontas basin, Kentucky, Lower to Middle Pennsylvanian sedimentary rocks contain the coal-bearing strata of eastern McCreary and western Whitley Counties. These strata are divided into two major formations, the Lee and the Breathitt, each composed of quasi-cyclic sequences of sandstone, siltstone, coal, and shale, which have been interpreted as paralic lithogenetic units reflecting depositional environments that periodically intertongued laterally.

Cores from six exploratory drill holes penetrating the formations are described, and analyses of basic lithologies in conjunction with geophysical logs are integrated into detailed stratigraphic columns. Correlation using key beds is established, producing geologic sections and a stratigraphic framework to which the coal beds could be referred for specific correlations. Isopach maps of the major coal seams and a structure contour map of the unconformity at the base of the Corbin sandstone were prepared. A fence diagram incorporating the six core holes illustrates a detailed interpretation of the subsurface stratigraphic record, including depositional sequences, distribution, and thickness of the strata. A brief review of the general geologic history of the coal zones is presented.

ORR, WILLIAM N., and PAUL R. MILLER, Univ. Oregon, Eugene, OR

Mid-Tertiary Carbonates, Western Oregon

The distribution of marine limestones in the Oregon Tertiary is an important facet of the paleoenvironmental setting. Although the most extensive deposits of Tertiary limestones in the state are found in the middle Eocene Yamhill Formation in the coast range, several smaller exposures of late Eocene and Oligocene limestones occur in the Western Cascades east of Salem, Oregon.

All of these accumulations are of limited stratigraphic and areal extent. Much of the carbonate content is invertebrate shell material which accumulated in shallow-water environments during periods of limited terrigenous sedimentation. A significant amount of the limestones, however, reflects an offshore or open-ocean environment, such as a bank or seamount.

Porosity in the carbonates ranges from extremely low values, where sparry calcite has precipitated in pore spaces, to values of 5% where solution has extensively removed shell calcite.

A recently drilled well near Lebanon, Oregon, produced gas for a short time before being abandoned. That well was completed at 3,000 ft (914 m) near the top of the Spencer Formation at approximately the same stratigraphic level as Eugene carbonate-bank deposits in northern Marion and southern Clackamas Counties.

OTTMANN, JEFFRY D., Exxon Co., U.S.A., Houston, TX, and DEWITT C. VAN SICLEN, Univ. Houston, Houston, TX

Evolution of Formation Fluids in "J" Sandstone, Denver, Basin, Colorado

Hydrodynamic flow is a major factor in the entrapment of petroleum in the Cretaceous "J" sandstone of the Denver basin. Two distinct fluid potential minima trend northeast across the geographic center of the basin. The downdip flow of water toward these minima has enhanced holding capacities of oil traps on the eastern and southeastern flanks of the basin and made possible gas entrapment at the Wattenburg field in the basin deep.

The present regime of downdip hydrodynamic flow in the "J" sandstone resulted from subhydrostatic pressures created by regional Pliocene uplift and erosion of approximately 600 m of sediment proximal to the Front Range. Subhydrostatic pressure development is the result of cooling which contracted the fluids more than the pore volumes, and elastic expansion of the pores which exceeded that of the water.

Present hydrodynamic conditions do not adequately explain the unusually low formation water salinities throughout the "J" sandstone. Artesian flow conditions during the Eocene flushed the "J," replacing connate water with meteoric water, conditions similar to those occurring east of the Black Hills today. Growth of the Golden fault during the Oligocene terminated the artesian flow.

Hydrodynamic effects have not been commonly recognized, due partly to the fact that it requires analyzing data which are not usually obtained. The need to understand and evaluate hydrodynamic flow is essential to the explorationist searching for subtle traps, particularly in the Rocky Mountain region.

OUTLAW, B. D., and G. G. BENNET, British National Oil Corp., Glasgow, Scotland

Geology and Hydrocarbon Potential, United Kingdom Sector, Western Approaches Basin

The Western Approaches basin covers an area of approximately 20,000 mi^2 (52,000 km^2) and lies along the median line between the British and French sectors of the northwest European continental shelf. About 40% of the basin lies within United Kingdom designated waters. Seismic coverage of this area is extensive, but only four deep holes have been drilled.

The basin was initiated toward the end of the Carboniferous and then underwent rapid fault-controlled subsidence, accumulating a thick succession of Permo-Triassic red beds and evaporites. Marine conditions became widely established during the Rhaetic and Early Jurassic but block faulting and uplift then led to widespread erosion, with the result that Jurassic and Lower Cretaceous sediments are now largely confined to the deeper parts of the basin. These vertical crustal movements were the result of Atlantic rifting and appear to have been accompanied by strike-slip faulting and localized volcanism. A marine transgression tentatively dated as Barremian/Aptian marked the end of rifting activity and is visible on seismic records as a conspicuous angular unconformity. The basin then underwent gradual subsidence throughout the Late Cretaceous and early Tertiary until Alpine compressional movements led to further uplift and erosion.

Several different structural trapping mechanisms have been identified and potential reservoirs exist in the Permo-Triassic and Jurassic to Lower Cretaceous intervals. Rhaetic and Lower Jurassic claystones have source potential, and maturation studies, though not conclusive, suggest that locally they will be mature for hydrocarbon generation. The timing of migration and the effectiveness of seals remain speculative due to lack of stratigraphic information.

PARDO, GEORGES, Gulf Oil Exploration & Production Co., Houston, TX

Petroleum Exploration on Niger Delta

The Nigerian continental shelf, covering over 40,000 km^2 to a water depth of 200 m has been extensively explored since 1962. Most of the shelf is a submarine extension of the Niger delta where the first discovery was made in 1956. The section is a typical delta, where the prodelta shales of the Akata Formation prograde over Paleocene and Upper Cretaceous sediments and are overlain by interbedded sands and shale of the Agbada Formation of the deltaic facies proper. The deltaic facies are overlain by the massive freshwater alluvial-plain sands of the Benin Formation. These are lithostratigraphic units that, depending on the position on the delta, range in age from Eocene to Holocene. The delta is deposited over the boundary between continental and oceanic crusts and, in large part, overlies the oceanic crust of the Gulf of Guinea. The Akata Formation is thought to be, in part, the source of hydrocarbons. The reservoirs are found in the Agbada Formation and the Agbada shales act as seals. The dominant trapping is by down-to-the-basin growth faulting and the accumulation seems to be the result of migration updip along the major faults. As of January 1978, the Niger delta initial recoverable oil was estimated at 18.76 billion bbl. The major production occurs in a belt that runs approximately east-northeast to west-southwest, with the result that prolific production offshore has mostly been found in two places (east and west of the delta)