accretion and the nature of deformation associated with accretion and dispersion. Such data are needed for further define specific exploration targets in the circum-Pacific region.

HOWER, JOHN, Univ. Illinois, Urbana, IL

Clay Mineral Reactions in Clastic Diagenesis

Studies of clastic sediments have documented the formation and transformation of clay mineral assemblages during burial diagenesis. The transformation of smectite to illite in shale by its reaction with the decomposition products of detrital K-feldspar and mica results in the production of new pore water at depth. The overall reaction mobilizes all the major chemical components in the shale, most of which are consumed in the formation of the diagenetic assemblage illite/smectite + chlorite + quartz. However, part of all the components is undoubtedly transported from the shale to sandstone units and is involved in cementation, replacement, and diagenetic clay mineral formation in these reservoir rocks.

In contrast to burial diagenetic reactions in shale, where the sequence is monotonic and reasonably predictable, diagenetic reactions in sandstone are frequently variable. This variability is probably attributable to the fact that sandstones are open systems in which the reactions that proceed are controlled in part by the influx of new pore water, the chemistry of which is determined by an outside source.

The useful understanding role of clay minerals in hydrocarbon exploration will follow from a determination of the system shale/sandstone/organic material. We need to tie in the nature and timing of shale mineral reactions and their control on the fluid and mass transfer from shale to sandstone.

HU CHAOYUAN, China Nat. Oil and Gas Exploration and Development Corp., Beijing, China

Petroleum Exploration Characteristics of Small Depressions, East China

In eastern China there are more than 100 Mesozoic-Cenozoic continental depressions; some of these have areas ranging from several hundred square kilometers to 2,000 km^2 (772 mi^2). Many oil fields have been discovered in these depressions.

From the geologic and exploration histories of the Qianjiang, Miyang, and Damintun depressions the writer has summarized five essential features in exploring small depressions.

(1) Because the distance of oil migration is less than 50 km (31 mi) in continental basins, exploration in small depressions should be guided by the idea that source beds control hydrocarbon distribution.

(2) Locate the deep part of the depression by gravimetric and magnetic prospecting with some seismic profiling and drill stratigraphic wells in the deeper part to evaluate the capacity of oil generation and to record other geologic and geophysical parameters.

(3) Drill wildcats not only on the anticlines but also on structural noses and monoclines, because nonanticlinal pools commonly predominate (about 70% or more of reserve) in small depressions.

(4) If a few wildcats are dry holes and no sand beds are encountered during the early stages of exploration, negative conclusions should not be made in a hurry. If a possible source bed exists, further exploration should be conducted even if the area of the depression is less than 1,000 km^2 (386 mi^2).

(5) In mature small depressions, exploration should be directed mainly to finding various subtle traps in the same way as exploring in large depressions.

HUNTER, GAMAL, GUPCO, Cairo, Egypt

Belayim Marine Oil Field of Egypt: A Case History

Belayim Marine 1 drilled in 1961 encountered oil in a Miocene sand-shale section. The well logged a clear oil-water contact in the lowest sand bed which at the time was believed to be the common oil-water contact for all the interbedded sequence. Based on the results of this well and other subsequent wells drilled inside the oil-water contour, the oil reserves were volumetrically calculated and a development program was effected. In 1978, when the field came back under the Egyptian control, a number of reservoir studies indicated that the oil in place is at least double the amount calculated. The additional reserves could not be accommodated in the rock volume sitting above the logged oil-water line. It was suggested then that the logged oil-water line is valid only for the lowest sand bed and higher sand beds can have their own oil-water lines. The concept when checked by drilling proved to be valid. The additional reserves are now under development.

If the actual size of the field has been known at an earlier stage, a different and more rational development program could have been adopted. It is therefore highly recommended that in similar reservoirs in interbedded successions possible oil-water lines be thoroughly defined for the different sands at an early stage of development.

IBE, A. CHIDI, Nigerian Inst. Oceanography and Marine Research, Lagos, Nigeria

Organic Geochemistry of Recent Marine Ooids as a Key to Origin of Petroleum in Oolite Reservoirs

Organic geochemical investigation of recent marine ooids (457 ± 76 to $1,516 \pm 86$ years) from the Schooner Cays area, Bahamas, has yielded data that suggest a probable source bed function for their ancient equivalents. Chromatographic analysis of gas desorbed from the ooids reveals the presence of C_1 to C_{5+} compounds believed to be authigenic. These include between 1.7 and 3.6×10^{-5} gm C_1 to C_4 saturated hydrocarbons per gram organic carbon. Total organic carbon (TOC) content varies between 1.23 and 4.13 wt. %, depending on the purity of the sample, with the lowest values reflecting an increased contribution of skeletal debris to the ooids. Total organic extract (TOE) values range from 550 to 650 ppm and show a slight transformation in the direction of oil formation. The organic matter isolated from ooids (termed protokerogen) is dominantly of algal facies. Elemental composition of this protokerogen showed mean atomic H/C, O/C, and N/C ratios of 1.76, 0.24, and 0.19, respectively. Following pyrolysis, CR/CT ratios were found to be very low, with a mean of 0.18. All the results, including a thermal alteration index (TAI) of 1 to 1.5 on Staplin's scale and a very strong green to blue-green fluorescence under ultraviolet light excitation, point toward an immature, high grade, kerogen-type material with enormous potential for generating hydrocarbons. Additional experiments using a high pressure cell to simulate diagenesis in the ooids showed profound changes in their organic geochemistry with the contained organic matter following the predicted evolution path for type II kerogen. There is strong evidence that with deeper burial and prolonged exposure to higher temperatures, and perhaps to catalytic influence of the clay minerals (0.05%) and traces of metals (e.g., Ti, Mn, Sr, V) found in ooids, the organic matter will generate significant amounts of hydrocarbons. In those oolites with a favorable history of porosity development, the hydrocarbons would migrate along the continuous groundmass of organic matter within the ooids and into the pore spaces to accumulate as petroleum.

The indigenous origin of petroleum in oolites, which obviates a long and wasteful primary migration process, affords an explanation for the exceptionally rich petroleum accumulations in such reservoirs. It is proposed that with the exception of leached oolites with oomoldic porosity, other petroleum-bearing oolites could be viewed as integrated source-reservoir beds. The prolific oolite reservoirs of the Arab Formation in Saudi Arabia were selected as natural case studies and the result found to be consistent with the hypothesis.

ILLICH, HAROLD A., Sun Exploration Division, Dallas, TX

Stratigraphic Implications of Geochemistry of Oils from Middle Magdalena Valley, Colombia

Seventeen oils from the Middle Magdalena Valley of Colombia were studied for the purpose of acquiring an improved view of the number and nature of hydrocarbon sources in the region. Oils from this basin possess a range of bulk compositions (API gravity, sulfur content, gasoline content, etc) and occur mainly in Tertiary reservoirs developed in nonmarine sediments. Several explanations have been informally offered regarding the origin of the oils. Most of these explanations have depended on a concept of the "immature" oil.

Examination of the chemistry of the oils and comparison of these data to oils from other basins lead to the conclusion that the Magdalena oils were derived from a single source or series of closely related sources. The sources for the oils are believed to be stratigraphic units deposited in marine environments. This conclusion is based mainly upon the isoprenoid, normal paraffin, and polycyclic alkane composition of the oils. A marine source virtually eliminates the possibility of the source occurring within the Tertiary section.

Study of lithologic descriptions of the Cretaceous sediments stratigraphically underlying the Tertiary allows the nomination of several units that may have been the source for the oils: the La Luna, Simiti, and Paja formations. Each of these formations was deposited under anoxic marine conditions, and some of them contain enough organic debris to be described as "carbonaceous."

Differences in the bulk compositions of the oils are interpreted to be related to secondary alteration processes. Altered oils from the Magdalena possess compositional attributes similar to oils that have been modified during in-vitro bacterial degradation experiments. There is little evidence that collectively the oils represent a range of maturities; consequently, the idea that the more dense fluids are examples of immature oils is rejected.

The Middle Magdalena oils are derived from a single source or a series of closely related sources that are probably Cretaceous in age. Some of the oils have experienced secondary alteration that is believed to account for the range of bulk compositions observed in the region.

The complicated source-reservoir relationships suggested by knowledge of the oil chemistry are undoubtedly contributory to protracted exploration history of the Magdalena. Improved knowledge of these relationships should be of assistance in the search for new reserves that may be obscured by the complex structural features characteristic of the Magdalena and adjacent terrain.

IVERSON, WILLIAM P., and SCOTT B. SMITHSON, Univ. of Wyoming, Laramie, WY

Termination of Southern Appalachian Overthrust

Autochthonous sediments equivalent to Valley and Ridge formations are interpreted to exist beneath crystalline rocks of the entire Blue Ridge and western portion of the Piedmont. Although hydrocarbon potential has not been determined, we have defined the southeastern extent of sediments beneath the allochthonous southern Appalachians. Truncation of underlying sediments by a subsurface fault occurs at 10 km (6 mi) depth approximately 55 km (34 mi) southeast of the Brevard zone. Farther southeast, a basal detachment might exist, but it would be within mylonitized Grenville basement. Blue Ridge basement rocks probably originated from this area. The interpretation is primarily based on detailed analysis of reprocessed COCORP seismic data, modeling potential fields, and the undisputable fact that Grenville rocks must be cut by a deep fault someplace beneath the southern Appalachians. All previous theories which attempted to correlate with the original interpretation of a regional detachment underlying the entire southern Appalachians should be reexamined. Although detachments and major thrust faults undoubtedly exist throughout the southern Appalachians, they do not form one continuous overthrust sheet and are not underlain by sediments deposited on the ancient continental margin of North America.

Geophysical studies of the southern Appalachians have determined them to be largely allochthonous. Seismic data show that a continuous master decollement underlies the Valley and Ridge, Blue Ridge, and Piedmont provinces. Other forms of geophysical data are consistent with the hypothesis of an extensive overthrust system. The question remains, however, how far east can we define a continuous master decollement? This question has been debated in many conferences in recent years where two extreme positions have developed. One side believes that the Brevard zone represents a cryptic suture continuing to depth beneath the inner Piedmont and terminating the master decollement at depth. The alternative position draws a detachment continuous from the western Valley and Ridge, beneath the entire Appalachians to the southeast, deep beneath the coastal plain, and possibly out to the edge of the continent in the Atlantic Ocean. In this paper, a moderate position is presented which places a sloping master decollement root zone beneath the eastern Piedmont. The adjoining province of island arc assemblages is thus regarded as an accreted terrain which is generally regarded as autochthonous. Evidence for such a model is primarily from reflection profiles across Georgia. Additional support comes from gravity, aeromagnetics, magnetotellurics, and surface geology.