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OFFSHORE ALGERIA—A GROWING INFANT

Exploration of the continental margin of Algeria is a natural result of the search for additional production and reserves by SONATRACH, the national Algerian oil company. The narrow shelf along much of the Algerian coastline discouraged exploration until 1965, but the rapid development of deep-water-drilling and completion techniques during the last 4 years has greatly increased interest in this area. The first offshore studies by SONATRACH, made in 1967, involved a comparison between the costs of exploring the offshore area and those of exploring the Algerian coastline. These studies indicated that the most economical method of exploring the coastline was to conduct offshore exploration first. In this manner, areas of interest suggested by the offshore results could provide leads to the most attractive areas of the coastline. A reconnaissance marine-seismic survey was completed in 1968. The results of this survey, and the rapid progress in marine drilling and completion techniques, indicate that exploration along the continental margin of Algeria may be much more rewarding than had been supposed.

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CARBONATE FACIES AND CORAL ZONATION, MISSISSIPPIAN, KOGRUK FORMATION, LISBURNE GROUP, DE-LONG MOUNTAINS, BROOKS RANGE, NORTHWESTERN ALASKA[1]

The Kogruk Formation, 1,500 to 2,000 ft thick, is composed of marine carbonate rocks deposited in normal-marine to shoal-water environments. Carbonate rock types typically are bryozoan, echinoderm packstone and wackestone, and lesser amounts of calcareous mudstone, and oöid grainstone and packstone. Dolomite and other carbonate sedimentary rocks characteristic of intertidal and supratidal environments are absent in the sections studied. The Kogruk Formation was deposited in an open-marine environment on a subsiding shelf on which carbonate deposition and subsidence were near equilibrium. Only minor oscillations in environments of deposition are seen in a typical section. Lithostrotionid coral faunas are best developed adjacent to the shoal-water facies.

Two major coral faunas are recognized. The older, 600–800 ft above the base of the Kogruk Formation, consists of *Lithostrotion* (*Siphonodendron*) *sinuosum* (Kelly), *L.* (*S.*) *warreni* (Nelson), *Lithostrotionella mclareni* (Sutherland), *Thysanophyllum astraeiforme* (Warren), *Thysanophyllum orientale* Thomson, and *Sciophyllum lambarti* Harker and McLaren. This fauna is of middle Meramecian age. The younger coral fauna is in the highest 600–800 ft of the Kogruk Formation and contains many of the species of lithostrotionids which are present in the lower beds, plus *Lithostrotionella* aff. *L. macouni* (Lambe), *L. banffensis* (Warren), a new species each of *Lithostrotionella* and *Sciophyllum,* and two species of *Faberophyllum.* This fauna is of late Meramecian age.

[1] Publication authorized by the Director, U.S. Geol. Survey.

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ORGANIC GEOCHEMISTRY AND PETROLEUM DISTRIBUTION ON CHEROKEE PLATFORM, KANSAS AND OKLAHOMA[2]

In southeastern Kansas and northeastern Oklahoma rocks of the Cherokee Group (Desmoinesian, Middle Pennsylvanian) were deposited across the Cherokee platform—a part of the Mid-Continent craton. These sediments are a clastic sequence of the coal-cycle association. Cyclothems composed of several thin, persistent lithosomes characterize the section. The sedimentary sequence indicates a depositional model of fluctuating conditions which, from a tectono-environmental viewpoint, may be regarded as an *unstable shelf* dominated by nonmarine and shallow-marine environments (*e.g.,* fluvial, swamp, lagoonal, and littoral).

The Cherokee platform is flanked by other Middle Pennsylvanian tectonic features. The mildly positive Ozark dome on the east, the active Nemaha ridge on the west, and the cratonic shelf area on the north affected significantly the depositional history of the platform. The most important influence was the adjacent Arkoma basin on the south. The Arkoma basin was an actively subsiding *marginal basin* between the craton and the orogenic Ouachita system. Rocks of Desmoinesian age in the Arkoma basin are a clastic wedge whose principal source area was the Ouachita orogenic region. Rapid sedimentation in the Arkoma basin kept pace with subsidence. As a result, the basin floor generally was close to sea level. Hence, most of the clastic wedge consists of coarse terrigenous clastic strata, shale, and coal, and was deposited under nonmarine conditions. Desmoinesian strata of the clastic wedge are partly continuous with Cherokee platform rocks. Much of the detritus deposited on the platform (including carbonaceous matter) was derived from the south and transported across the nonmarine Arkoma basin. Although the strandline fluctuated widely, its average position was near the craton-marginal basin hingeline.

Organic geochemical aspects of the Cherokee platform sediments were influenced by the tectono-environmental setting. This influence is displayed by regional contour maps of organic geochemical properties. For example, contour maps of organic carbon, hydrocarbon, and carbon-isotope data display regional variations related to the clastic wedge on the south and more persistent marine depocenters on the shelf. Most regional geochemical variations of the Cherokee section can be related to variations in the proportion of the different rock types making up the section. However, some rock types display smaller but significant regional organic geochemical variations, which also appear to be a response to differences in the tectono-environmental setting across the platform. Perhaps the most important single aspect that controlled the organic composition of these sediments was the interplay between marine (*in situ*) and terrestrial (detrital) organic sources. Rate of sedimentation, rate of burial, and postdepositional effects were less important in causing observed variations.

The geochemical results support the "shelf principle" of petroleum origin. Specifically, the regional organic geochemical contour maps suggest a rational explana-

[2] Presented with permission of Marathon Oil Co.

tion for the distribution and compositional variations of the petroleum across the platform. In addition, material balance calculations of oil-in-place *versus* indigenous sediment hydrocarbons provide a quantitative insight into petroleum migration problems.

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IMPORTANCE OF STORM ACTIVITY IN DEPOSITIONAL HISTORY OF WESTPHALIA (PENNSYLVANIAN) LIMESTONE MEMBER OF NORTHERN MID-CONTINENT EXPOSURES

The Westphalia Limestone Member (Stranger Formation, Douglas Group, Virgilian, Pennsylvanian) crops out from northern Osage Co., Oklahoma, on the south to southern Buchanan Co., Missouri, on the north. In most Kansas outcrops, the Westphalia is essentially continuous. South of east-central Chautauqua Co., Kansas, and north of southernmost Franklin Co., Kansas, discontinuous lenses comprise Westphalia outcrops.

Two very different rock types, a fusulinid, calcareous packstone and an ostracod, coaly, calcareous mudstone, are believed to represent the effects of storm deposition. These facies form most northern Mid-Continent Westphalia outcrops. Inner parts of the intertidal zone are postulated as the depositional site of the sediment that now forms the fusulinid calcareous packstone. Either a marsh or a supratidal tract was the probable site of the ostracod, coaly, calcareous mud deposition.

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IDENTIFICATION OF *Catapsydrax stainforthi* ZONE IN UPPER PART OF LOWER SAUCESIAN STAGE, CALIFORNIA

Samples from the upper part of the lower Saucesian Stage represented in Reliz Canyon, California, reveal populations of *Catapsydrax stainforthi* Bolli, Loeblich, and Tappan together with specimens of *Turborotalia opima nana* (Bolli) and *Globorotalia scitula praescitula* Blow. The concurrence of these planktonic foraminiferal indices suggests a correlation of the upper part of the lower Saucesian of Reliz Canyon with the *Catapsydrax stainforthi* Zone of tropical areas and with the fossil fauna exposed on Erben Guyot, Pacific Ocean. Associated planktonic species include *Globigerina angustiumbilicata* Bolli, *Globigerina woodi woodi* Jenkins, *Globigerina praebulloides* Blow, *Turborotalia mayeri* (Cushman and Ellisor), and *Turborotalia opima continuosa* (Blow). Critical benthonic species include *Planulina appressa* Kleinpell and *Rectuvigerina kleinpelli* (Cushman).

Equation of the *Catapsydrax stainforthi* Zone with the upper part of the lower Saucesian indicates that the underlying *Catapsydrax dissimilis* Zone of the tropics probably is equivalent in large part to the lowermost Saucesian; the superjacent *Globigerinatella insueta* Zone of the tropics is equivalent to the upper Saucesian and perhaps to the lowermost part of the Relizian Stage of California.

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YATES (PERMIAN) CARBONATE RESERVOIR, WINKLER COUNTY, TEXAS

Backreef Yates (Permian) carbonate stringers in producing wells of the Hendrick field area, Winkler County, Texas, have lithologic and environmental characteristics which are very similar to equivalent-age outcrops in the Guadalupe Mountains of New Mexico.

Extensive dolomitization of the pay zones has not destroyed the original carbonate textures which appear to reflect oscillations of intertidal to supratidal environment in a narrow, relatively sheltered lagoon of predominantly carbonate deposition. These discrete carbonate units merge basinward with the massive Capitan reef complex and interfinger shelfward with quartz sandstone.

Stylolitic algal material alternates repeatedly with calcareous mudstone pellets, aggregate grains or "lumps," pisolites, and calcarenite beach deposits. Selective leaching of pellets, aggregate grains, and pisolitic textures accounts for most of the effective porosity development. Shelfward termination of this facies and consequent termination of porosity aid in the entrapment of hydrocarbons across a low-relief anticlinal trend.

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SUMMARY OF OFFSHORE EXPLORATION AND PRODUCTION

During the last decade, the continental offshore has emerged as a major petroleum-producing province and the leading area for future growth. The petroleum industry has invested more than $7 billion in exploration of the shelves of the continental United States. Major offshore areas produce approximately 1 MM b/d of oil, more than 10% of U.S. production. Spurred by increased demands, gas production will assume a more important role in future offshore operations. In 1968, gas gatherers filed six major pipeline applications for 1969 construction of 800 mi of big-inch pipeline that will cost $290 million.

Early offshore activity adapted onshore techniques to shallow-water installations. Gradual evolution to greater water depths and more hostile environments followed. Industry has developed designs for offshore structures and spent more than $5 million to gather oceanographic data; several major programs currently are active.

Exploration technology has been sharpened because of intense competition and high costs. New sources of seismic energy for marine exploration have almost supplanted dynamite. To improve exploratory drilling, many types of mobile rigs have been developed, the first of which became operational in 1950. Industry continually has extended its capability and in 1968 drilled in 1,300 ft of water.

Although production facilities take many forms, including single-well templates, the most common is the large multiwell platform. During 1967, a 12-well platform was installed in 340 ft of water. Current designs suggest that platform construction is feasible to depths of 1,000 ft. Through continued development, underwater completions may evolve as a major producing method.

The large amount of bidding at 1968 offshore sales emphasized industry's need to develop new reserves. This need will continue into the foreseeable future;