

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 angustumbilicata* 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;