Gas Potential of Ouachita Facies, Atoka and Pushmataha Counties, Oklahoma

Atoka and Pushmataha Counties lie along the westernmost exposure of the Ouachita facies in southeast Oklahoma. Eight gas wells have been completed in this isolated exploration area, and six exploratory tests are in the drilling or completion stage. Seven of the completed wells are productive from the Mississippian Stanley sands, and produce at low daily rates. In mid-summer of 1980, a gas well was completed from the Arkansas Novaculite of Early Mississippian-Devonian-Silurian age, and from the Bigfork Chert of Ordovician age. Although a production history is not available on this well, an extensive lease play has resulted, and increased exploratory drilling has begun. The Novaculite-Bigfork production appears to be primarily fracture controlled, but will deliver gas at commercial rates. Only five tests in this general area were ever drilled deep enough to penetrate the Novaculite and/or Bigfork in the past, with three reporting commercial flows of gas, but owing to being in an isolated area with no gas pipeline, exploration has been at a lull since the late 1950s. With the new drilling technology known today, the greatly improved stimulation methods, and adequate gas market conditions, this area will provide new exploratory targets in the 1980s.

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Coal Geology of Northern Part of Northeast Oklahoma Shelf Area

Nine commercially important coal beds are present in the northern part of the shelf area of northeastern Oklahoma. Included in the area are parts of Craig, Mayes, Nowata, and Rogers Counties. The coal beds are of Desmoinesian (Middle Pennsylvanian) age. From oldest (lowest) to youngest (highest) they are: Rowe coal, Drywood coal, Bluejacket coal, Weir-Pittsburg coal, Mineral coal, Fleming coal, Croweburg coal, Iron Post coal, and Dawson coal.

Tonnages of resources and reserves were estimated for coal beds 10 in. (25 cm) or more in thickness for depths to 100 ft (30 m), and for coal beds 14 in. (35 cm) or more in thickness for depths greater than 100 ft (30 m). Methods used to calculate figures were adaptations of standard methods used by the U.S. Bureau of Mines and the U.S. Geological Survey. Remaining resources of coal for the four-county area total 1,063,466,000 short tons, of which 110,584,000 short tons are in the reserves category. In the entire four-county area the coal bed with the most remaining resources and reserves is the Weir-Pittsburg, with 490,869,000 short tons, and 31,055,000 short tons, respectively.

Coals of the area are predominantly of high volatile A-bituminous (hvAb) rank. Coal from the Croweburg bed has the highest overall quality and has an average sulfur content of less than 1%. Other coals in the study area have sulfur percentages averaging above 3.5%.

All coal produced in the four-county area during the time of the study was mined by surface methods. Production of coal peaked in the late 1970s, with 3,666,645 short tons reported mined in 1977, and 3,462,816 short tons reported mined in 1978. Rising production costs, a depressed market, and environmental restrictions have contributed to a decline in production in recent years.

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Anadarko Basin—A Model for Regional Petroleum Accumulations

Many basins being explored today can be viewed as regional petroleum accumulations. The Anadarko basin is used to describe how its depositional and orogenic history, its patterns of deposition and subsequent patterns of hydrocarbon accumulation, and its basic geochemical aspects all combine to make this basin a unique regional petroleum accumulation. The explorationist must view each basin as a unique entity and fully understand its regional characteristics to efficiently compete for the petroleum reserves therein.

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High-Constructive, Tidally Influenced Deltaic Sedimentation in Arkoma Basin: Desmoinesian Hartshorne Sandstone

The Hartshorne Sandstone and associated fine-grained facies of the Arkoma basin were deposited in a high-constructive, tidally influenced delta system which prograded longitudinally from east to west in an elongate, foreland basin during Ouachita suturing.

Prodelta facies (generally mapped as upper Atoka) consists of dark gray, nonfossiliferous shales. Delta front facies deposited near the mouth of an active distributary channel include interlaminated siltstones and sandstones of distal bar origin and ripple-bedded and trough cross-bedded sandstones of distributary-mouth bar origin. Delta front facies deposited in interdistributary areas consists of lenticular, wavy, and flaser-bedded sandstones, siltstones, and shales deposited under the influence of tidal currents. Delta plain facies is sandstone, siltstone, shale, and coal deposited in distributary channels, interdistributary bays, crevasse splays, marshes, and swamps. Distributary channel sandstone bodies display shoestring geometry (50 to 60 m thick), 1 to 3 km wide, tens of km long) and internally are unidirectionally trough cross-bedded. Their linear geometry and thickness relative to other delta facies suggest that channels were structurally localized, that the delta was elongate, or a combination of the two. Interdistributary bay facies comprise locally fossiliferous shale and silty shale. Crevasse splay facies coarsen upward from shale through ripple-bedded sandstone to trough cross-bedded sandstone. Marsh and swamp facies are carbonaceous shale and coal.

In Arkansas, the Hartshorne displays a single, progradational sequence of prodelta, delta front, and delta plain facies. In Oklahoma, the prodelta and delta front facies are capped by a complex assemblage of delta plain facies which records at least three episodes of active sedimentation followed by delta plain abandonment. Understanding the genesis of these delta plain facies will enhance petroleum and coal exploitation efforts within the Hartshorne of the Arkoma basin.

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Methane Production Potential from Hartshorne Coal Beds in Deep Parts of Pittsburg, Coal, and Hughes Counties, Oklahoma

Bureau of Mines investigations show the Hartshorne coal beds of the Arkoma basin are among the most gassy in the United States. The Hartshorne coal beds in Haskell and

LeFlore Counties, Oklahoma, contain 1.1 to 1.5 Tcf of methane; these coal beds are expected to contain a similarly high methane content in deep parts of the basin farther west in Pittsburg, Coal, and Hughes Counties.

Various geophysical logs from gas wells were used to analyze thickness and sedimentary facies of the Hartshorne formation in the Arkoma basin. Bulk density and sonic logs indicate the presence of lower and upper Hartshorne coal beds with an apparent thickness of up to 8 ft (2.4 m), flanking a linear body of Hartshorne Sandstone in Pittsburg and Coal Counties. The natural gas produced from wells along this and other linear trends of thick Hartshorne Sandstone probably originated in the associated coal beds.

The depth of the coal (up to 4,000 ft or 1,219 m) and its proximity to several gas fields producing from the Hartshorne Sandstone suggest a high methane content (200 to 600 cu ft/ton) for the Hartshorne coal beds in the western parts of the Arkoma basin. However, methane content is not as high as in coal beds farther east at similar depths because of the lower rank (less thermal maturation and therefore lower gas generation) of coal beds in Pittsburg, Coal, and Hughes Counties. Effective placement of gas drainage wells should take into consideration the thickness and depth of coal, possible communication with the natural gas-bearing Hartshorne Sandstone, and rank of associated coal beds.

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Harrisburg Trough, Stephens County, Oklahoma—An Update

On the northeast edge of the Wichita Mountain uplift, northwest of Loco, Oklahoma, is a depositional syncline with Pennsylvanian sediments from Atokan through Virgilian. This depositional syncline was named the Harrisburg trough by Harlton. Sedimentary onlap relations within the Harrisburg trough suggest that it formed as a topographic valley that was at times partly above and below sea level. Seismic evidence indicates that this buried valley (canyon?) has paleotopographic relief of more than 10,000 ft (3,048 m). Atokan drainage in the Harrisburg trough was from the southeast to the northwest. Continued erosion of the highlands of Mississippian through Ordovician rocks, and located mainly to the south but also present to the north, provided the clastics deposited in the trough.

The compression that probably caused the uplifted source areas continued through Virgilian time and folded the northeast flank of the Harrisburg trough into the Northwest Velma and West Velma anticlinal hydrocarbon traps. Future hydrocarbon discoveries will probably find production in stratigraphic traps of Atokan sands that pinch out or onlap the flanks of the trough.

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Ouachita Facies, an Overview

Since the discovery of oil in the Arkansas Novaculite in Marshall County, Oklahoma, in February 1977, several significant wells have been drilled in southeastern Oklahoma and in Grayson County, Texas. Sands in the Stanley formation and parts of the Bigfork formation have proven to be productive. An unnamed sand zone in the Womble that occurs about 200 ft (60 m) below the Bigfork has had significant shows and indicates that it too will be productive.

Structural problems and stratigraphic surprises will probably be exposed as wildcat drilling continues.

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Geothermal Energy Resources in Mid-Continent

Awareness of the energy availability problems in the United States has led to increasing curiosity about and interest in geothermal energy. The U.S. Department of Energy has contracted with state agencies in several Mid-Continent states to evaluate geothermal prospects in the Mid-Continent region. The data being gathered will augment and update the data published by the AAPG from their geothermal survey conducted about 10 years ago. The DOE program not only includes support for accurate geothermal gradient and heat flow measurements, but also includes programs in gravity, aeromagnetics, and geochemistry.

This program will not discover any new "Old Faithful" type of geothermal resource. However, preliminary indications are that heat pump applications for space heating may be economically viable in this decade, especially in southeastern Kansas and northeastern Oklahoma. Geothermal gradients in that region are in the 50°C/km (2.8°F/hundred ft) range in the upper 300 m of the sedimentary section. The gradients decrease drastically below this relatively shallow depth to about 15 to 20°C/km (0.8 to 1.1°F/hundred ft). It is not yet clear whether this change in gradient is due to changes in thermal conductivity in the sediments or to hydrothermal convection.

Low-grade geothermal energy could be produced from brine that comes to the surface as a by-product of oil production. Such energy could be used for space heating or even to eventually drive oil well pumps as low-temperature-differential engines are developed. The energy that could be extracted from such brine is six times the energy required to pump it if initial temperature is 150°F/km (66°C) and final temperature is 100°F (38°C) and a lift of 3,000 ft (915 m) with 50% pump efficiency is assumed.

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Statistical Relations Between Borehole and Surface Data

Reconciliation of measurements made on the surface and in the borehole is often difficult. The most prevalent practice is visual alignment and evaluation of forward synthetics. Recently inverse seismograms have generated more direct involvement and vertical seismic profiles provide more positive information on correlation.

For relations between the forward log synthetic and the well-site seismic trace, normalized cross-correlation is the most obvious statistic. Time alignment, polarity, and the coefficient of correlation can often (but not necessarily) be determined. Log editing may be required as well as multiple studies. General scaling curves for seismic data can be derived from the log instead of simple exponentials. Time variant coherency measure quantifies the degree of similarity between the seismic well-site trace and the synthetic. The coherency points out problem areas to be corrected or edited to improve the match. Used as a weighting function on both signals, editing can be automated to make wavelet extraction practical. Extracted wavelets provide a good quality control for statistical wavelet processing of seismic data.

Similar procedures may be used between the VSP and log or VSP and seismic data. Time-depth relations are often clarified as the VSP provides a reliable time-depth curve. While poorly sampled relative to the sonic log, it may be used to correct problem zones in the log. The VSP also shows which multiples interfere constructively and which interfere destructively. This