BACKGROUND INFORMATION ON HEAVY OIL RESOURCES IN MISSOURI

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INTRODUCTION

The presence of so-called tar sands, asphaltic sandstone, or more properly, heavy oil deposits in Missouri has been known for over 100 years. The oil is contained within various sandstone layers of Pennsylvanian age that occur at the land surface or near-surface to depths of 600 feet, and except for very minor production, cannot be recovered by either "conventional" or secondary (waterfloods, etc.) methods. In the past few years research on new recovery methods (tertiary processes) has progressed to a point where deposits such as those in western Missouri may be exploited if economic conditions continue to be favorable.

"Heavy oil" as compared to ordinary crude oil is defined as oil whose gravity is 25° API or lower. In its natural state, this oil ranges in appearance from a brown, very viscous liquid to a nearly solid, black, "tar like" material. Although these oils are the products of natural alteration of lighter crudes, their quality is good with hydrocarbon content high and sulfer content low, as compared to typical Athasbasca tar sands/heavy oil deposits. (The Athabasca deposit in western Canada is the world's largest self-contained accumulation of hydrocarbons, estimated at between 600 and 900 billion barrels, which makes it at least four times as large as the largest oil field, Ghawas in Saudia Arabia).

Heavy oil deposits occur in several western Missouri counties (fig. 1), extending from Barton County in southwestern Missouri to Caldwell County, north of the Missouri River. The more concentrated and thicker deposits, and therefore the most promising for future development are in Barton, Vernon, and southern Bates Counties. It is in this latter area where industry has attempted to produce this oil by various methods; utilizing combinations of heat, pressure, and solvents since shortly after the turn of the century. The most notable attempts were conducted by Phillips Petroleum from 1955 to 1958, Carter Oil from 1955 to 1959, and Shell Oil in the early 1960's.

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Figure 1 – Heavy Oil Occurrences

Generalized area where heavy oil deposits occur

Counties where major concentrations of heavy oil occur and area of DOE Funded heavy oil study

PREVIOUS HEAVY OIL RECOVERY PROJECTS

Phillips Petroleum conducted a counterflow combustion project near Bellamy in Vernon County. Carter Oil operated a research project near Deerfield in Vernon County, following a limited core drilling program. Shell Oil conducted two projects near Richards in Vernon County following a large leasing and core drilling program that extended from Barton County northward to counties north of the Missouri River. It is estimated that Shell drilled over 600 core holes and had extensive lease holdings. Shell's pilot attempt consisted of a steam-flood on one 40-acre plot and a fire-flood on an adjoining 40-acre plot. Results of the pilot project were never released.

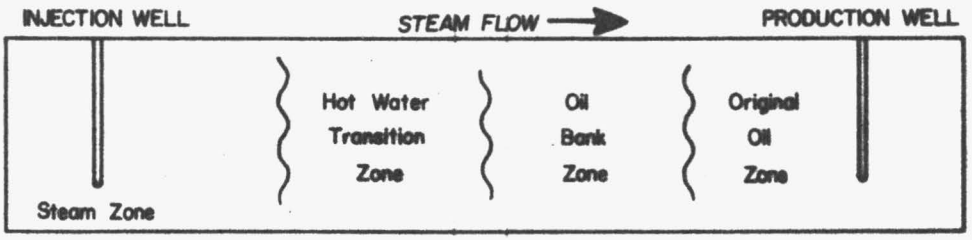

Figure 2 — Line-drive Steam Flood

THERMAL RECOVERY METHODS

Several thermal recovery methods have been tried (experimented with) in western Missouri. Basically these consisted of steam-floods and fire-floods, in which there are two basic modifications for each process.

In simplest form steam is injected into a producing zone through an oil well and allowed to soak after which the well is returned to production. This technique is referred to as a steam soak or "huff-and-puff." In another method steam is continuously injected into the producing formation through an injection well and the heated oil driven outward to producing wells. This is called a line-drive steam flood (fig. 2).

Fire floods or in-situ combustion are a fairly complicated process in which a fire is started in the producing zone and kept going by the injection of air. The two basic approaches are shown in figure 3 — Forward Combustion and figure 4 — Reverse Combustion.

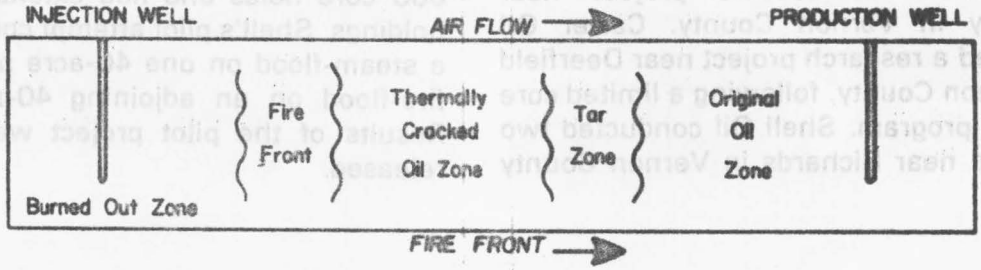

Figure 3 — Forward in-situ Combustion

In a forward combustion process the area nearest the injection well is the burned out zone which would be completely devoid of liquid saturation. The next zone downstream is the area of extreme reaction or the fire. The fire feeds on coke deposited on sand grains as the oil is thermally cracked just ahead of the fire front. The next zone can form when the heated and thinned oil is driven into the colder rock just ahead, resulting in a congealed or "tar zone." This can happen in those reserves where the original oil is essentially immobile and is not now generally used to produce the heavy oils, although the method is effective for medium gravity (22° to 28° API) oil reservoirs.

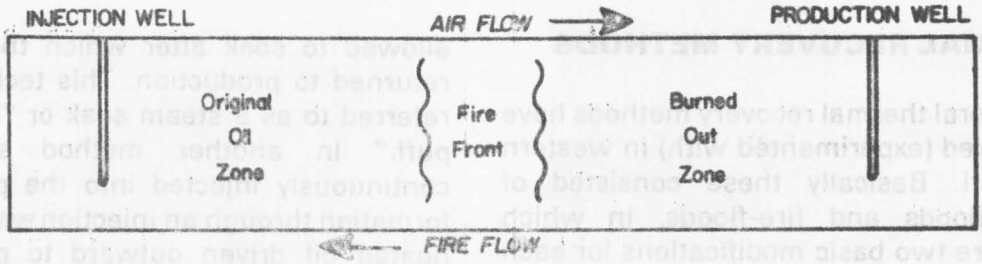

Figure 4 — Reverse in-situ Combustion

A reverse combustion method is particularly applicable to reservoirs that contain oil with little to no mobility. In this process the fire is made to burn from the producing well to the injection well. The heat-thinned heavy oil is driven back through the combustion zone where it is vaporized or thermally cracked with unburned coke deposited here and burned, yielding a produced product that has a higher gravity than the original oil in place.

TERTIARY OR ENHANCED RECOVERY METHOD

New processes referred to as tertiary or enhanced recovery methods other than the thermal methods just described have recently been initiated and are being tested in various parts of the United States.

These methods are most applicable to those oil fields containing medium to high gravity oil that have previously produced oil through primary and secondary cycles. It is an attempt to produce more of the oil that ordinarily would not be recoverable from secondary air repressuring or water-flood techniques, and would not be as applicable for the relatively immobile oils of western Missouri.

These methods include the use of chemicals and/or solvents to thin and free the oil from the rock or reservoir in which it is contained. This micellar solution is pumped into the reservoir through an injection well. Then after a calculated amount of the micellar solution has been injected another solution called polymer is injected. The polymer is in effect a thickening agent which does not readily mix with the fluids ahead of it, resulting in the polymer slug pushing the micellar slug of oil and water mixture ahead of it toward a producing well (see fig. 5).

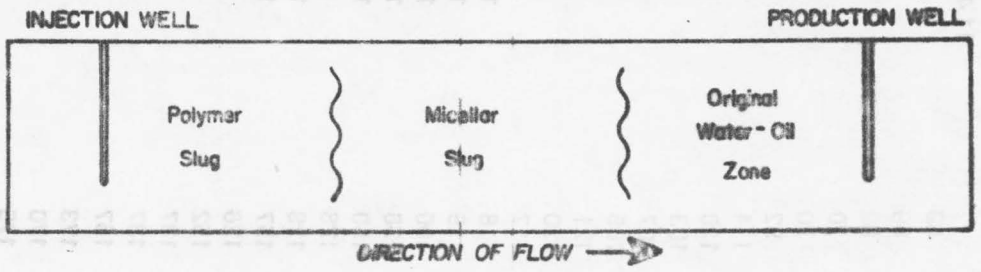

Figure 5 – Micellar & Polymer Flood

PRODUCTION HISTORY

The history of oil production in western Missouri, although undramatic in amounts, has been fairly consistent throughout the years — ranging from 20-40,000 bbls/year. All wells in Missouri are classified as stripper wells — that is, established production is less than 10 barrels of oil per day for a well. Total production of oil in Missouri to date is estimated to be between 2 and 2.5 million barrels, and has never approached 100,000 barrels in any year except for 1954 shortly after the discovery of the Florissant oil field in St. Louis County where 96,000 barrels were produced. Currently Missouri produces approximately 55,000 to 60,000 barrels of oil per year (Table 1).

MISSOURI'S EXPLORATION HISTORY

The first oil well west of the Mississippi was drilled in 1855 near Paola, Kansas just a few miles west of the Missouri border. Shortly after the Civil War drilling and prospecting started in western Missouri with one of the first wells drilled in Kansas City near the old Union Depot. By 1932 some 2,500 wells were estimated to have been drilled in the state. Of these, 320 were reported as oil wells, 1,140 as gas wells, and 1,040 as dry holes. Since this time

PRODUCTION AND VALUE DATA – MISSOURI OIL AND GAS

Year	Oil in Barrels	Value of Oil	Number of Wells	Gas in Thousands of Cubic Feet	Value of Gas	Number of Wells (Commercial)
1865-1947	531,621	$607,002		11,430,115	$1,241,080	
1948	30,700	68,994	89	31,110	4,159	11
1949	32,028	54,356	99	23,340	3,257	11
1950	33,000	62,000	89	81,589	7,144	14
1951	22,525	46,013	70	17,295	1,961	6
1952	19,830	38,050	70	13,272	1,593	2
1953	38,733	83,917	92	15,160	1,655	3
1954	96,021	270,078	114	15,479	1,683	3
1955	74,022	192,160	120	14,915	1,626	2
1956	65,212	176,723	103	7,000	1,750	3
1957	65,151	171,512	107	30,668	7,667	3
1958	83,953	242,383	105	42,399	10,600	4
1959	75,471	214,174	121	64,928	16,232	7
1960	74,694	210,306	120	75,702	18,925	9
1961	65,252	186,697	117	96,000	25,000	12
1962	55,856	159,635	118	103,425	24,542	6
1963	55,295	148,644	115	103,139	24,239	10
1964	65,281	163,203	100	103,464	25,875	11
1965	72,392	184,610	136	112,669	25,748	10
1966	75,310	189,690	150	113,348	26,496	26
1967	73,542	183,775	128	97,068	22,345	26
1968	65,508		128	115,052	26,365	26
1969	66,510		157	125,574		26
1970	66,251		126	87,131		
1971	65,449		152	31,902		2
1972	59,501		137	9,073		
1973	59,796		137	24,739		2
1974	55,974		157	32,592		2
1975	56,973		173	31,660		12
1976	60,828		170	29,201		
1977	59,535		175			
1978	53,583					
1979						
1980						

drilling has been sporadic and cyclic with several hundred wells being drilled in some years and virtually only a handful in other years.

In 1966 Missouri enacted legislation that among other things requires permits to be obtained through an Oil and Gas Council for any wells drilled for oil or gas. Since this time the actual number and kind of wells drilled as well as reliable drilling and plugging records is available to the public through the Division of Geology and Land Survey.

HEAVY OIL RESEARCH

Despite the exploratory drilling by industry in the past, information on the heavy oil deposits has been fragmentary. Numerous surface occurrences of oil-impregnated rock have been reported in the tri-state area of Oklahoma, Kansas, and especially in Missouri, but no attempt had been made to demonstrate the connection of these occurrences with reported heavy oil encountered in shallow borings of subsurface rocks. Lack of reliable subsurface control has prevented correlation of subsurface occurrences with each other or with deeper producing oil fields farther west.

Due to the lack of coordinated study, estimates of the size of this potential oil resource have ranged from a few billion barrels to as much as 75 billion barrels in the tri-state area. Uncertainty about the size of the resource was one factor that has contributed to the delay in development of these deposits and is an area of concern that has been addressed by this Division. Other factors such as economics and development of new recovery processes, although just as important, are outside the scope of this Division.

A Department of Energy research, development, and demonstration (RD&D) program was initiated which had as its objectives verification of this potential resource base and improvement in subsurface and reservoir data. The resource evaluation included surface and subsurface mapping, structural studies, geochemical studies, and data acquisition and processing. The Missouri project was one of three conducted by Geological Survey organizations within the states of Kansas, Missouri, and Oklahoma, and was a coordinated program to define the heavy oil deposits in the area contiguous to the three states. This project has recently been completed with the final report to be published and distributed by the U.S. Department of Energy.

The study area in Missouri covers an area of approximately 1¼ million acres or 1950 square miles (fig. 1). A total of 50 test wells were drilled within this area to evaluate existing subsurface data and to obtain data in areas where no data existed. Unfortunately, due to the discontinuous nature of the various potential reservoir horizons this number of test holes could not adequately evaluate the potential of the area.

The sandstone layers or beds in which the heavy oil occurs were originally deposited in what is referred to as a fluvial-deltaic origin which would be somewhat analogous to the modern Mississippi Delta area that has many small meandering streams forming a distributary system, with all of the varying types of specialized deposits that can occur within such a depositional environment. The end result was the development of a series of about four different sand horizons as long, narrow, lenticular bodies which are limited in areal extent and easily missed by a

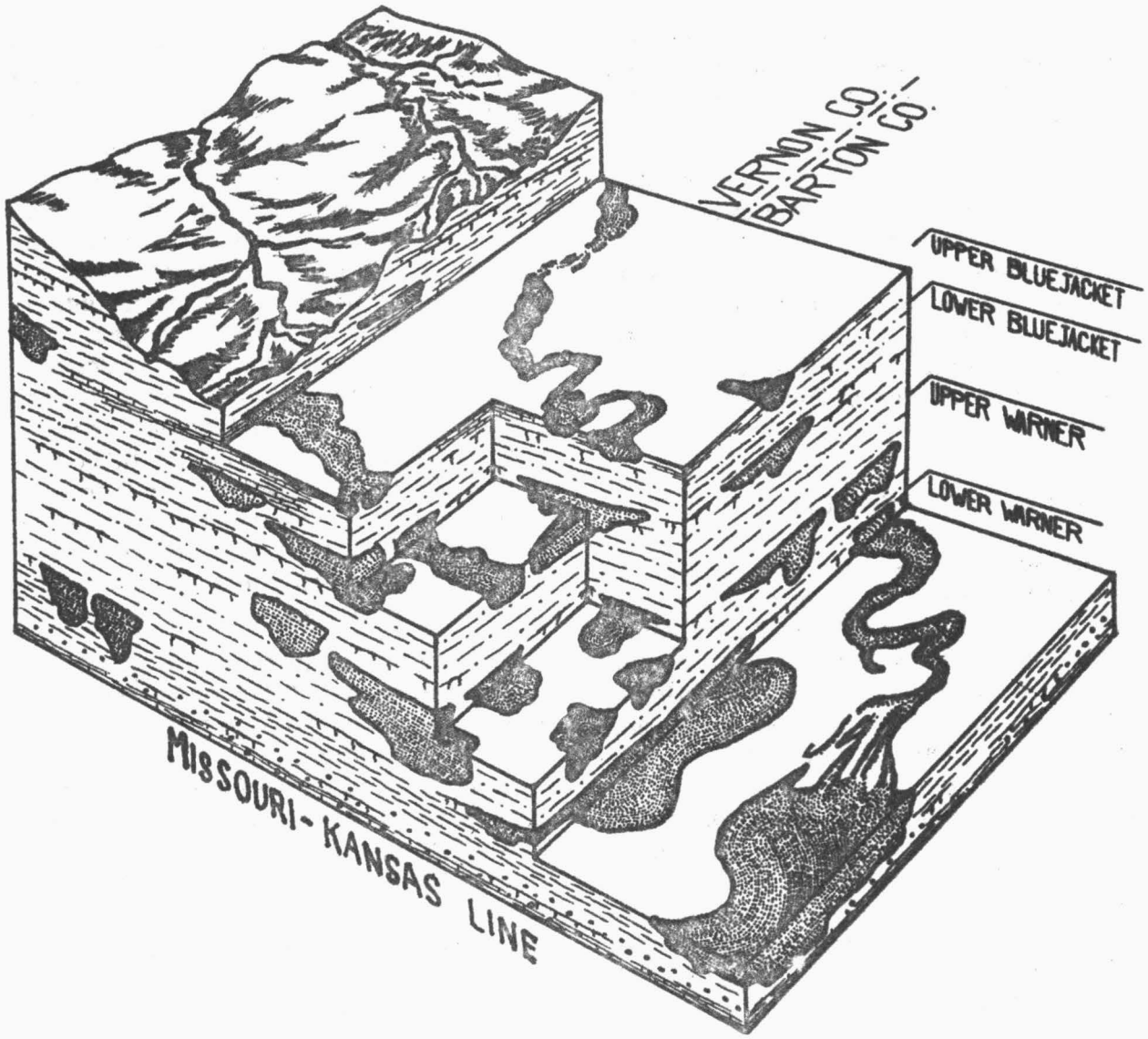

Figure 7 — Block diagram showing heavy oil deposits of Fluvial-deltaic origin

scattered drilling program (see fig. 7). However, a series of maps showing the extent and thickness of four potential reservoir horizons as well as the areas of hydrocarbon occurrences from each unit was constructed. Shows of hydrocarbons were evaluated by selecting core samples from analyses that represented the various kinds and qualities of hydrocarbons most commonly encountered. Values from these analyses were utilized in conjunction with the maps in calculating a resource base figure.

The final report will show that a total of 1.5 to 1.9 billion barrels of oil is projected for an area previously estimated to contain from 8 to 50 billion barrels of heavy oil. Of

this 1.9 billion barrels calculated, 20% or .4 billion barrels is present in sands, the tops of which are less than 50 feet from the ground surface. The remaining 80% or 1.5 billion barrels occur at depths greater than 50 feet and would be recoverable by means other than stripping or mining methods. Unfortunately, none of the 1.9-billion-barrel resource base can be considered in the reserve category under present economic and technologic parameters.

RECENT ACTIVITY

During the past year Carmel Energy, Inc., Houston, Texas has — with the Department of Energy funding — conducted a pilot recovery project in Vernon County, Missouri to demonstrate the efficiency and economics of recovering oil from a heavy-oil reservoir, using their patented "Vapor Therm" process. This process utilizes a mixture of combustion gases (CO_2) and water vapor (steam) to stimulate the production of low-gravity crude oil. The mechanism for recovery of the crude-bearing formation and oil-in-place by forcing hot vapors into the formation. Heat transfer is effected through both condensation of water and sensible-heat exchange between the hot gases and surrounding formations.

The DOE contract with Carmel ended on April 15, 1979 and a final report should be published within a few months. Total project cost was $1,455,737 with the DOE share $1,071,123 and the contractor's share $384,614.

With the "apparent success" of this project, future phases of Carmel include expansion of the pilot area into a commercial-sized venture and further testing of this process in different oil-bearing sandstone horizons within the Vernon County area.

CONCLUSIONS

The DGLS-DOE study, while indicating somewhat disappointing amounts of oil to many, in that this is obviously not a Midwestern Athabasca, has provided industry and government with the first published estimates for these deposits, based on specific geologic parameters rather than generalized and often erroneous data. In addition, the published maps, while revealing the irregular distribution of heavy oil within discontinuous sandstone reservoirs, do show several areas where further drilling and evaluation could be conducted by industry. Core descriptions and mechanical or electric logs of the test holes are included in the final report as an additional aid to industry of any evaluation and exploration programs that might be conducted.

With new economic incentives such as allowing heavy oil to be sold at world prices, and the apparent successful recovery project currently underway in Vernon County by Carmel Energy, this area is expected to undergo yet another period of leasing and production attempts that has characterized the exploration and production history of western Missouri.

BIBLIOGRAPHY

Ebanks, W.J., Jr., James, G.W., and Livingston, N.D., *1977, Evaluation of heavy oil and tar sands in Bourbon, Crawford, and Cherokee Counties, Kansas — Final Report: Kansas Geological Survey, U.S. Department of Energy, BERC/RI-77/20, 110 p.*

Harrison, W.E., and Roberts, J.F., *1979, Evaluation of heavy-oil potential of northeastern Craig and northwestern Ottawa Counties, Oklahoma: Oklahoma Geological Survey, U.S. Department of Energy, BETC/1812-1, 46 p.*

Searight, W.V., *1957, Asphaltic rocks in western Missouri: Missouri Geological Survey and Water Resources, Inf. Circ. 13, 26 p.*

Wells, J.S., *1977,Inventory of strippable tar sands in southwestern Missouri: Missouri Department of Natural Resources, Division of Geology and Land Survey, Report, 55 p.*

Wells, J.S., *1979, Inventory of heavy oil in western Missouri: Missouri Department of Natural Resources, U.S. Department of Energy, BETC/in press).*

Wells, J.S., and Anderson, K.H., *1968, Heavy oil in western Missouri: Am. Assoc. Petroleum Geologists Bull., vol. 52, No. 9, p. 1720-1731.*