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Potential for Discovery and Production from the Kansas Crude Oil Resource Base

by

Crude Oil Potential Committee

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Disclaimer

Executive Summary

Growing concern over the current and future health of the domestic petroleum industry has focused attention on the nature of the remaining undiscovered petroleum resource base. Development of appropriate policies for economic development and stability of this domestic industry also requires an understanding of the probable response of discovery rates to changes in economic conditions. This report presents current perspectives on these aspects of the crude oil resource potential in Kansas.

The ERC/KGS Crude Oil Potential Committee initially estimates the expected future discoveries of producible crude oil resources in Kansas to be approximately 2.2 billion barrels. This represents production expected from new oil producing leases, including discovery of new oil producing horizons on leases currently producing only natural gas. **Existing leases, with production reported by December 1991, are expected to produce 560 million barrels of additional crude oil** from current or new producing horizons.

Estimates of potential resource discoveries in new producing horizons on existing leases would <u>not</u> be included in estimates of proved reserves by the U. S. Geological Survey and other federal agencies. Because of the nature of production data available to the Committee for use in analysis of production trends it was decided to incorporate this component of future potential within the estimate of expected future production from existing leases. This difference accounts for some (but probably not all) of the extent to which the Committees estimate of 560 million barrels exceeds estimates of proved reserves by other agencies.

Several recent publications from the Energy Information Agency, the Interstate Oil and Gas Compact Commission and the U.S. Department of Energy, Bartlesville Project Office indicate that **cumulative production, through December 1991, of crude oil in Kansas is 5.6 billion barrels.** In these reports, **proved reserves in Kansas are estimated to be about 300 million barrels.** These reports estimate that 3 billion barrels of unrecovered mobile oil resources (UMO) will remain in Kansas reservoirs after completion of conventional recovery operations. Crude Oil Potential Committee estimates are related to conventional recovery techniques. Additional potential for recovery through the use of improved technologies in advanced secondary recovery (ASR) and enhanced oil recovery (EOR) are not considered in these estimates.

Discussion

Tables 1 and 2 present the overall results of the Committee's initial estimates of future discoveries and production for each of the major geologic provinces in Kansas (see Figure 1). The Midcontinent Rift System, listed in Tables 1 and 2 but not shown in Figure 1, is a Pre-Cambrian structural feature underlying the west flank of the northern half of the Nemaha Uplift and the east flank of the Salina Basin. Hydrocarbon shows have been identified in the Midcontinent Rift, but it remains an unproven but interesting province for potential hydrocarbon production.

Estimates for each province are divided into three mutually exclusive classes -- probable, possible and speculative. The confidence level for estimates in these classes are 90%, 50% and 10% respectively. Expected discoveries are calculated by multiplying estimated discoveries in each class by the confidence factor of that class and summing the results:

Expected = 0.9 x (Probable) + 0.5 x (Possible) + 0.1 x (Speculative).

In this initial round of estimates, it is the Committee's conclusion that 2.2 billion barrels is a reasonable estimate of expected future discoveries of producible crude oil resources in Kansas using conventional technology. A low-end estimate of 1.47 billion barrels is derived using 80% of probable and 25% of possible resources. A high-end estimate of 3.1 billion barrels is derived by summing 100% of probable, 75% of possible and 25% of speculative resources. The absolute extreme estimate would be 6.2 billion barrels, where crude oil discoveries within each province eventually match the full estimated quantity in each category.

Estimates of probable, possible and speculative categories of crude oil discoveries and production are based on analysis of lease production histories and reserve estimates aggregated by year of initial production and location within geologic provinces. This information is integrated with evaluations of the extent of existing exploration for petroleum resources, reservoir characteristics, stratigraphy, structure and other geologic factors typical of each province. A more detailed explanation of methodology will be presented in a separate report.
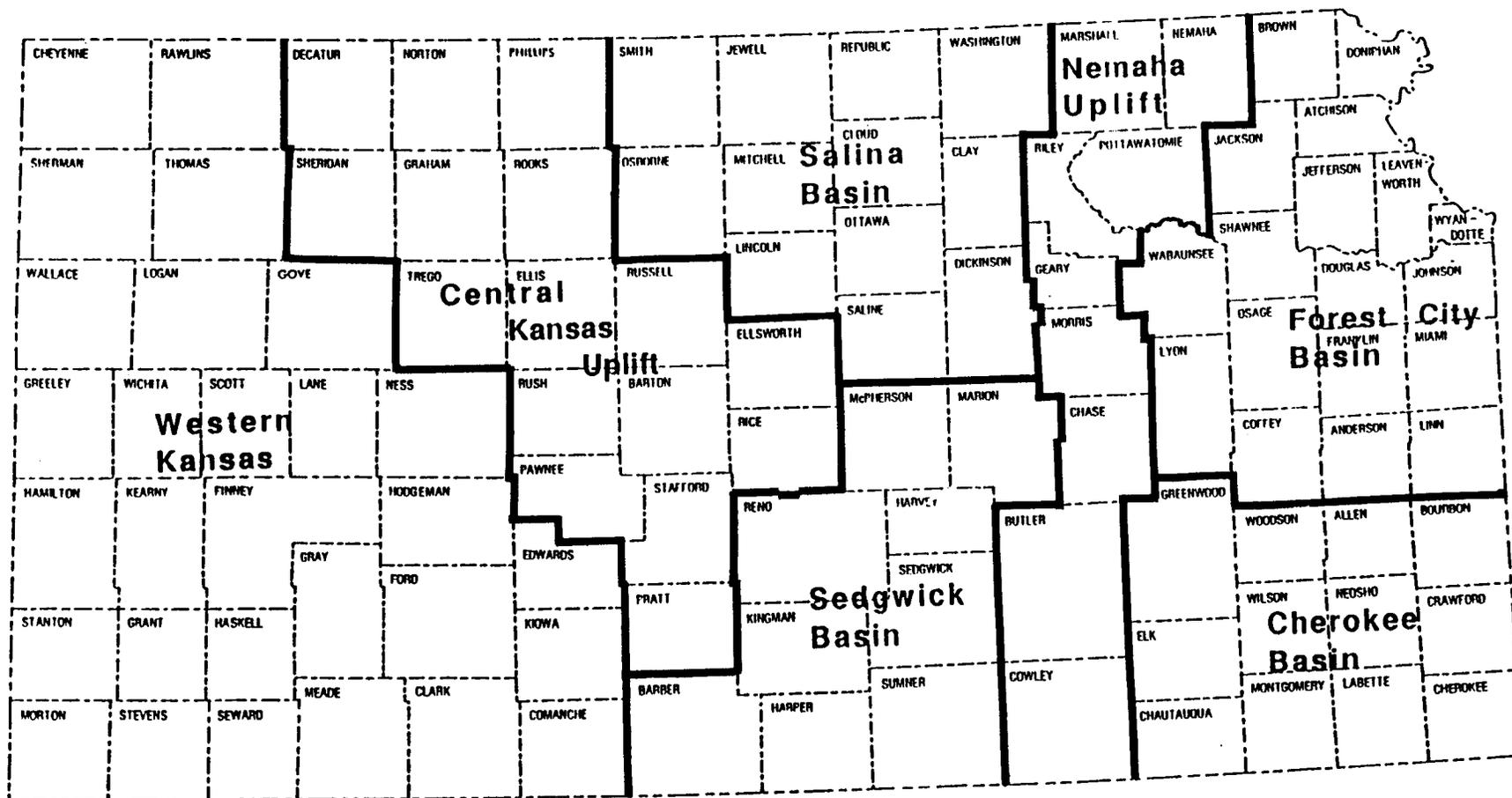
Geologic Provinces of Kansas

| CHEYENNE | RAWLINS | DECATUR | NORTON | PHILLIPS | SMITH | JEWELL | REPUBLIC | WASHINGTON | MARSHALL | NEMAHA | BROWN | DONIPHAN |
| SHERMAN | THOMAS | SHERIDAN | GRAHAM | ROOKS | OSBORNE | MITCHELL | CLOUD | CLAY | RILEY | POTTAWATOMIE | JACKSON | ATCHISON |

Nemaha Uplift

Salina Basin

Central Kansas Uplift

Western Kansas

Forest City Basin

Sedgwick Basin

Cherokee Basin

Figure 1

Table 1: Estimated future new lease discoveries of producible crude oil from Kansas' crude oil resource base (in millions of barrels).

Geologic Province	Probable (90%)	Possible (50%)	Speculative (10%)	Expected
Cherokee Basin	37.0	100.0	90.0	92.3
Forest City Basin	27.0	27.0	10.0	38.8
Nemaha Uplift	39.0	30.0	30.0	53.1
Salina Basin	5.0	25.0	50.0	22.0
Midcontinent Rift	0.0	100.0	2400.0	290.0
Sedgwick Basin	65.0	90.0	120.0	115.5
Central KS Uplift	420.0	400.0	100.0	588.0
Western Kansas	600.0	800.0	600.0	1000.0
State Totals	1193.0	1572.0	3400.0	2199.7

Table 2: Estimated future production of crude oil from leases in Kansas with established crude oil production by December 1991 (in millions of barrels).

Geologic Province	Probable (90%)	Possible (50%)	Speculative (10%)	Expected
Cherokee Basin	32.0	13.8	0.0	35.7
Forest City Basin	20.0	4.2	0.0	20.1
Nemaha Uplift	31.0	12.8	0.0	34.3
Salina Basin	3.0	1.2	0.0	3.3
Midcontinent Rift	0.0	0.0	0.0	0.0
Sedgwick Basin	44.0	22.0	0.0	50.6
Central KS Uplift	205.0	99.0	0.0	234.0
Western Kansas	165.0	67.0	0.0	182.0
State Totals	500.0	220.0	0.0	560.0

Analysis of the probable response of discovery rates to changes in economic conditions requires an evaluation of the timing of actual additions to ultimate recovery in relation to economic conditions. For this report, the Crude Oil Potential Committee has conducted this analysis on a statewide basis. The real (constant dollar) price of crude oil has been used in this initial effort as the exclusive indicator of economic incentive for exploration.

Table 3 shows the production of crude oil from Kansas leases grouped by the year in which each lease first began production. Each row gives the annual production from 1970 to 1991 obtained from all leases beginning production in the year or years indicated in the left-hand column. The first row gives total annual production from all leases which began producing oil prior to 1971. Annual production declines each year across this row. The continuation of this decline, even through 1979 when the price of crude oil jumped to $40 per barrel and 1981 when all domestic crude oil prices were deregulated, indicates the lack of sensitivity of existing production capacity to changing economic conditions.

Production from each new group of leases for the years 1971 through 1990 shows an increase in the second year and then begins to decline. This initial increase occurs because some leases within each group produce for only part of the first calendar year. The second year of production in each row is the first year with established production in all leases from the beginning of the year. There is also a short lag between the initial production from the first oil well on a lease and the completion of other development wells on the same lease.

Although the added production from new leases during each of the years from 1971 to 1978 is not extremely large, by 1978 the production from all post-1970 leases has increased to almost 32% of total production and is more than 46% of the production level from the remaining pre-1971 leases. During this time period (1971-1978) total annual production in Kansas, as shown on the bottom row, is declining.

The years 1979-1985 cover the period of peak oil prices, yet the production from any single group of previously established leases (any previous row) continues to decline through these years of rising or high prices. However, a dramatic change occurs in the amount of new oil production coming from each new year's group of leases, peaking at 6.8 million barrels of oil from new leases in 1981. By 1982, production from pre-1971 leases (32.5 million barrels, shown in the top row) is less than half of the total state production (69.7 million barrels, shown in the bottom row). Because of the dramatic increase in production from new leases,

TABLE 3:   Kansas Crude Oil Production (1970-1991), aggregated by initial year of lease production

Lease Groups	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	Total
											(million barrels)												
pre'71	85.2	75.7	67.1	58.0	52.2	47.9	45.1	41.7	38.6	36.2	35.1	34.3	32.5	31.3	30.7	29.5	25.7	24.1	22.8	22.3	21.7	20.9	878.8
1971	.0	2.8	4.1	3.2	2.6	2.0	1.7	1.5	1.3	1.1	1.1	1.0	1.0	.9	.8	.8	.7	.6	.6	.6	.6	.6	29.4
1972	.0	.0	2.4	3.2	2.5	2.2	1.8	1.6	1.4	1.3	1.2	1.1	1.0	.9	.9	.8	.7	.6	.6	.5	.5	.4	25.4
1973	.0	.0	.0	1.8	2.3	2.0	1.8	1.5	1.1	1.0	.9	.8	.7	.6	.6	.6	.5	.5	.5	.4	.4	.4	18.3
1974	.0	.0	.0	.0	2.0	2.7	2.1	1.7	1.4	1.3	1.1	1.1	1.0	.9	.9	.9	.7	.6	.6	.6	.5	.5	20.7
1975	.0	.0	.0	.0	.0	2.4	3.4	2.8	2.3	2.2	2.1	1.9	1.8	1.6	1.5	1.5	1.4	1.3	1.2	1.1	1.2	1.0	30.8
1976	.0	.0	.0	.0	.0	.0	2.7	3.5	2.5	2.2	1.8	1.6	1.5	1.4	1.4	1.3	1.1	1.0	.9	.9	.8	.8	25.3
1977	.0	.0	.0	.0	.0	.0	.0	3.1	4.5	3.5	2.9	2.4	2.1	2.0	1.7	1.6	1.3	1.2	1.1	1.0	1.0	1.0	30.3
1978	.0	.0	.0	.0	.0	.0	.0	.0	3.4	4.6	3.7	3.1	2.6	2.2	2.0	1.8	1.5	1.3	1.2	1.2	1.1	1.1	30.7
1979	.0	.0	.0	.0	.0	.0	.0	.0	.0	3.5	5.3	4.4	3.4	2.7	2.2	2.0	1.6	1.4	1.3	1.2	1.1	1.1	31.4
1980	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	4.6	7.5	5.9	4.6	4.0	3.3	2.6	2.2	2.0	1.8	1.7	1.7	42.0
1981	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	6.8	9.6	7.4	6.3	5.5	4.4	3.5	3.1	2.9	2.6	2.4	54.5
1982	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	6.6	8.8	7.0	5.4	4.0	3.4	3.0	2.8	2.5	2.3	45.8
1983	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	5.9	8.6	6.2	4.5	3.7	3.2	2.7	2.4	2.0	39.2
1984	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	6.3	7.8	5.0	3.6	2.9	2.6	2.4	2.2	32.8
1985	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	6.3	7.5	5.4	4.4	3.7	3.1	2.8	33.3
1986	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	3.4	3.7	2.8	2.3	2.3	2.0	16.6
1987	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	2.5	3.7	2.6	2.3	1.8	12.9
1988	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	2.7	3.7	2.6	2.2	11.2
1989	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.9	3.1	2.8	7.8
1990	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	2.7	4.0	6.7
1991	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	2.4	2.4
All leases	85.2	78.5	73.5	66.2	61.6	59.2	58.7	57.4	56.5	56.7	59.7	66.0	69.7	71.4	75.0	75.2	66.7	60.5	58.6	56.8	56.8	56.3	1426.3

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total state production reverses its long decline, beginning to climb in 1979 and rising to a peak of 75.2 million barrels in 1985.

New lease groups in the years 1986 through 1991 show a sharp drop in the amount of new production capacity being added each year. This is a direct response to the collapse of crude oil prices in 1986 and the corresponding decline in drilling shown in Figure 2.
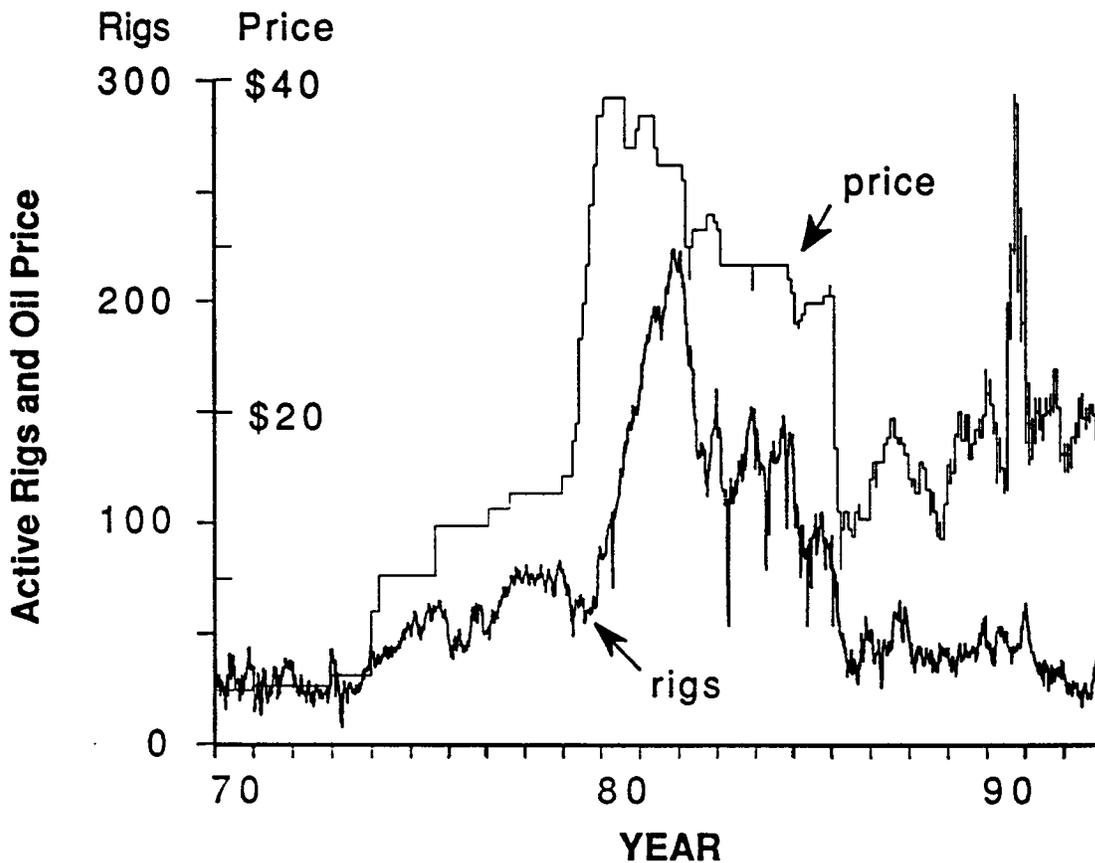
Drilling in Kansas

Figure 2

Table 4 presents estimates of expected ultimate recovery for each group of new leases corresponding to the years 1971 through 1991 from Table 3. The average real price of crude oil (based on the value of 1992 dollars) is also shown. If a one year lag is assumed between the price of oil and the response in discovery and development of new producing leases, the recent history indicates a discovery response to economic incentives which holds closely to a trend from 20 million barrels of new

production capacity developed at $10 per barrel of oil to 70 million barrels of new capacity developed at $60 per barrel of oil (Figure 3). **At oil prices in the range of $18 per barrel, this trend suggests that the price elasticity of supply of new oil reserves in Kansas is about 0.75** (that is, a 0.75% increase in the rate of new reserve additions per 1% increase in price).

Table 4:   Expected ultimate recovery estimates in Kansas for lease groups, with leases aggregated by initial year of production from 1971 to 1991 (in millions of barrels).

Lease Group	Cumulative Production (thru '91)	Expected Ultimate Recovery	Average Real Price (1992 dollars)
1971	29.4	34.2	11.47
1972	25.4	28.6	10.97
1973	18.3	21.5	12.22
1974	20.7	24.7	28.81
1975	30.8	38.8	31.33
1976	25.3	31.7	27.97
1977	30.3	38.3	30.60
1978	30.7	39.5	26.47
1979	31.4	40.2	40.61
1980	42.0	55.6	57.67
1981	54.5	73.7	55.19
1982	45.8	64.2	44.42
1983	39.2	55.2	39.43
1984	32.8	50.4	37.19
1985	33.3	55.7	32.44
1986	16.6	32.6	17.49
1987	12.9	27.3	21.00
1988	11.2	28.8	16.94
1989	7.8	30.2	20.26
1990	6.7	38.7	24.79
1991	2.4	30.0	20.36
Totals ('71-'91)	547.5	839.9	

Response of Oil Discoveries to Price
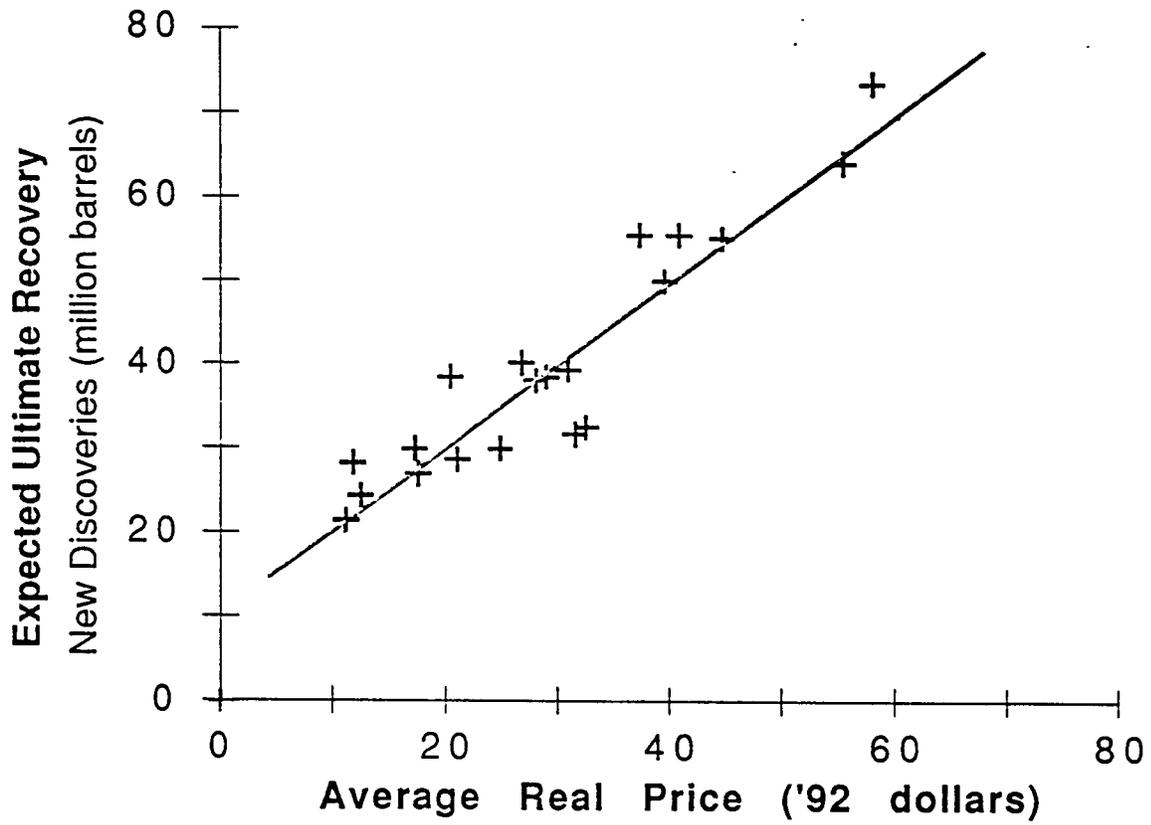## (annual Kansas data, 1971-1991)

Figure 3