

OIL EXPLORATION AND DEVELOPMENT IN THE NORTH DAKOTA

WILLISTON BASIN: 1980 UPDATE

by

Lee C. Gerhard, State Geologist
and
Sidney B. Anderson, Chief, Subsurface Section

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Lee C. Gerhard, State Geologist

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The rig on the cover is Cardinal Drilling's Rig 9, shown drilling the Al-Aquitaine/Coastal WJ 3-15 in Whiskey Joe Field, Billings County (SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec 15, T141N, R100W).

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INTRODUCTION

Every North Dakota citizen's life has been affected in some way by oil development in the Williston Basin (fig. 1). For some, development has meant great wealth. For some, it has disrupted a treasured life style. For others, it means tax relief. For still others, it may mean a new business, new housing, or new job. Some people regret the encroachment of drilling rigs upon grazing and game areas, while others marvel at the inherent grace of oil rig towers providing energy, chemicals, and lubricants for a vital economy.

Two years ago we wrote a history of oil exploration and development for the North Dakota portion of the Williston Basin (Gerhard and Anderson, 1979). Since that time, the rate of activity has ballooned beyond all predictions and the oil business has apparently become, or will soon become, the number one tax revenue producer for the state. In addition to development by domestic companies, foreign investment has greatly increased. In particular, Canadian political developments have caused a major influx of both money and equipment into North Dakota. For all of these reasons, it is time to reassess the status and future of the oil industry in North Dakota.

GENERAL

Oil development activity can be better understood by a study of graphs of activity and events. The total number of wells drilled since the 1951-1952 initial discovery period (fig. 2) rose between 1951 and 1958, dropped off rapidly to 1963 and then vacillated until 1977. Since 1977, an extremely rapid increase in total wells drilled has occurred. The number of wildcat wells drilled (fig. 3) has been more stable, however. Wildcat drilling during the initial discovery period peaked in 1954; the stratigraphic Mississippian play peaked in 1958; the Bowman County Red River play peaked in 1964; and the shallow "Muddy" Sandstone play (1967-1969) resulted in the highest number of wildcats during any year (1968) until 1980, even though no discoveries were made as a result of it. Since 1972, wildcat activity has generally been up.

When new pool discoveries are compared to the total wells drilled and wildcats drilled, the significance of the present development boom becomes obvious (fig. 4). Except for the "Muddy" drilling program, high levels of wildcat activity correspond quite well with new pool discoveries. However, the number of new pool discoveries per wildcat wells drilled rises dramatically during the last four years, a reflection of the high wildcat success ratios we have enjoyed recently.

Annual production levels also reflect drilling activity (fig. 5). Oil production from the original Nesson Anticline discoveries had already begun to level off when the Madison stratigraphic traps north and northeast of the Anticline began to produce in 1955. This additional production resulted in overall increases in production until 1962. The slight production decrease in 1963 was to be expected in view of the small total number of wells drilled and the lack of wildcats being drilled at that time. However, discovery of the Red River Formation production in southwestern North Dakota (Bowman County) gave a boost to production from 1964 to the 1966 peak.

Production in North Dakota reflected the declining national trends from 1966 until 1974. Continual decline of production here and elsewhere, coupled with increased consumption, necessitated increasing oil imports (the North Dakota production curve probably would have peaked much earlier were it not for prorationing). However, two events that occurred in rapid succession significantly changed Williston Basin production history. First, in 1972, the Red Wing Creek Field was discovered in McKenzie County. Second, OPEC imposed its 1973 embargo, along with price increases and production controls.

The Red Wing Creek discovery excited Williston Basin oil operators, partly because of the relatively high productivity of the wells, but especially because of the unusually thick pay sections. Since no one really understood the nature of the Red Wing Creek structure at that time, the only possible response was to gain a lease foothold in the area. The lease play initiated by the Red Wing Creek discovery set the stage for much additional development.

OPEC's actions resulted in the first substantial increase in the price of oil in 1973. Exploration for oil again became a profitable venture. Prior to the price increase, many companies found that exploration-risk money provided a better return in a regular bank saving account than in actual wildcat drilling. The price increases created risk capital, and exploratory drilling picked up.

The five-year term leases tended to increase exploratory activity as compared to the earlier ten-year leases. This, coupled with the sudden availability of venture capital resulting from OPEC's actions, caused exploratory drilling to increase in 1974 and 1975. As a result of this renewed activity, two major fields were discovered in 1976--the Mississippian Mondak and Little Knife Fields. It was immediately apparent that these two fields, especially Little Knife, were large Williston Basin discoveries, and the lease rush that occurred is still underway. This can be illustrated by looking at State Land Sale values. In 1970, the total bonuses paid for the year for state leases was \$294,000. In 1978, nearly \$20,000,000 was paid. In 1980, for the last quarter (November) sale only, over \$30,000,000 was paid (fig. 6).

The future for oil and gas production in the Williston Basin looks bright for the next several years. New rigs moving in, major exploratory programs underway, and high lease prices--all of these support a continuation of the present exploratory boom, with several more years of developmental drilling needed after exploratory drilling drops off (table 1).

DRILLING AND EXPLORATION HIGHLIGHTS

The continued successes on the Billings Nose and the Mondak Field are the highlights of 1979-1980. The success on the Billings Nose has vaulted Billings County into the number one producing spot in North Dakota in 1980. One of the major reasons for this was the discovery of the Big Stick Field in 1979 (figs. 7 and 8). The Big Stick Field is typical of other Billings Nose fields in that it is a multi-pay field producing from the Ordovician Red River, Devonian Duperow, Missis-

sippian Bakken, and Mississippian Madison with the Madison being the major producing interval. The field has many wells with I.P.'s exceeding 400 to 500 BOPD and several with I.P.'s above 2,000 BOPD. Current production is nearly equal to that of Little Knife.

Mondak Field is huge and growing steadily. It has encompassed Earl Field and currently shares a boundary with Poker Jim Field. It is also a multi-pay field with the Madison being the primary producing horizon. Its wells are not as prolific as those on the Billings Nose, but its size is currently over 110 sq. mi. in North Dakota alone.

The deep pool successes on the Nesson Anticline are the highlights of this older producing feature (fig. 8). Notable among them are Texaco's Silurian and Ordovician Red River discoveries near the southern end in Blue Buttes Field (an old Madison field) and Northwest Exploration's Dawson Bay and Red River successes along its western flanks near the north end. The Dawson Bay production is also notable because it has added a new producing formation to the state (fig. 9).

Two new counties have been added to the list of North Dakota producers, with Amoco's Red River discovery in Hettinger County (Tepee Butte Field) and Conoco's recent Red River success in Mercer County. This is now the easternmost Red River producer in North Dakota. It appears that a third new county will be added shortly when Home Oil's apparent Madison discovery is completed in McLean County (fig. 8).

In addition to the new counties, new discoveries were made in Golden Valley and Slope Counties far from already-existing production. Amerada Hess completed the southernmost Madison producer in North Dakota in Golden Valley County (Bull Run Field) and Terra Resources completed a Red River well in what is now the Marmarth Field in western Slope County.

To the north, in northern Williams County, Hunt completed a Lodgepole producer in the Corinth Field near the town of Wildrose. Even though this is not a big well, it is significant because it produces from a horizon that has been largely overlooked in the past. It appears that Shell has a Winnipegosis discovery in Renville County and, although this is not the first Winnipegosis well in the state, it is the

first in the Winnepigosis reef play in North Dakota.

The amount of gas being found from the deep Red River pays in the central part of the basin, as well as the amounts of associated gas being produced in western North Dakota, are also significant factors in the 1979 and 1980 development in western North Dakota. Other significant developments on the North Dakota oil scene in 1979-80 include the completion of two new gas plants, several gas pipelines, and an oil pipeline. The Koch gas plant, with a capacity of 60 MCFGPD, was completed in southwestern McKenzie County. The recently completed Western Gas Processors Plant in Billings County had its capacity increased to 40 MCFPD. Koch completed an 8-inch, 30 MCFPD gas line from the Billings Nose to the gas plants in the Sidney, Montana area, and recently looped the line with a 16-inch, 70 MCFPD line to serve its new plant. The capacity of the 16-inch line can be increased to about 100 MCFPD with additional compressors, and any excess gas can be sent to the Shell Oil Company and Perry Petroleum plants near Sidney, Montana. The addition of these plants, complete with the increased line capacity, should take care of the gas flaring problems in the Billings Nose fields.

The addition of Amoco's 10-inch 40,000 barrel per day oil pipeline from the Billings Nose to its main line should greatly facilitate the handling of crude from the area. These new developments will have a big impact on the oil and gas industry in western North Dakota.

NORTH DAKOTA'S OIL ROLE IN THE NATION

In order to compare North Dakota to the rest of the nation and thereby assess the role played by the state's oil production in the national energy picture, we have tabulated statistics provided by the Independent Petroleum Association of America (table 2). These statistics are for 1979; even though some of the numbers do not agree with official North Dakota Geological Survey figures, they should be accurate (or at least consistent) when they are compared to IPAA statistics for other states.

Estimates of employees involved in

exploration are also of interest. IPAA estimates 4,259 employees for 1979 in North Dakota. Additional rigs that have come into the state since those figures were current swell the total by 1,625 employees to a total of 5,884. During the last year many new service companies were either formed or moved into North Dakota; many others added staff. The probable current, direct oil field employment for exploration and production can now be calculated at about 7,500 jobs.

Finally, the ratio of oil production to oil usage has always been of interest. The IPAA figures closely approximate those used by the North Dakota Geological Survey: North Dakota's 1980 production was about 40,000,000 barrels; the state's 1979 usage was 22,259,000 barrels; 1980 usage was probably no more than 1 percent higher than in 1979. Unfortunately, national oil usage is so high that North Dakota production supplies only about 4 days worth of U.S. usage, a little over 1 percent of national needs.

FUTURE POSSIBILITIES

In a recent article, the Director of the United States Geological Survey proved statistically that the Little Knife and Mondak Fields and the several Billings Nose oil fields don't exist because they statistically couldn't be discovered (Menard, 1981). Fortunately for the North Dakota State budget, oil is being produced from these Class A (giants: 100,000,000+ barrels) oil fields. In addition, current discovery rates in North Dakota are as high as last year, greatly exceeding the national discovery average of one in seven. One could say that it is fortunate that oil companies use geologists and geophysicists instead of statisticians to find oil.

Statements such as Menard's, expressing a lack of confidence in future exploration efforts in the continental United States, are typical of those who have had little practical experience. The Williston Basin has a long exploration future, proven by the expansion of production and producing areas over the last two years.

Several areas of North Dakota are still virtually undrilled. The central basin area east of the Nesson Anticline is now proved by the Stanley Field, but most of that region is untouched

by the drill. Structure mapping by the North Dakota Geological Survey suggests that several major structural lineations and elements present in the eastern basin have not been tested. All of the area overlying the boundary of the Churchill and Superior provinces of the Canadian Shield (fig. 1) is potentially productive. East of that line little drilling has been done, although several large drilling programs are planned.

Industry sources and trade journals list about eight major drilling programs scheduled for North Dakota in the next year. In addition, much of the acreage leased in 1976-1978 is near expiration so that large numbers of farmout deals are likely to stimulate considerable activity by independents. Two years ago major oil company estimates for rig counts in 1980 went as high as 120 rigs, approximately the number now drilling. The same sources and trade journals, consultants, and others (Lenzini, 1980) predict that the upheaval in the Canadian oil industry caused by their federal government nationalization attempts will drive 200 rigs and much capital across the border into the Rocky Mountains.

All of this is apparently an accurate assessment of events. Many Canadian and other foreign companies were represented at the last North Dakota State Land Sale, which grossed over \$30 million. Quite a few new rigs in North Dakota are from Canada. Estimates are that about 75 rigs from Canada will end up in North Dakota. More conservative estimates support a total rig count of 150-165 rigs in North Dakota within the next two years.

One of the most significant advances in the last two years was the successful infill drilling of the Glenburn Field; additional infill drilling and deeper horizon drilling in older fields may add substantially to production. For Glenburn, it appears that over 4,000,000 barrels of additional oil may be recovered. As better engineering data becomes available and is processed, optimum spacing for development of existing reservoirs may be reappraised. It is likely that the State Industrial Commission may have to encourage unitization of major fields in order to maximize primary recoveries and prepare for secondary recovery procedures.

Two years ago high-intensity shallow gas exploration appeared to be

imminent. It has not materialized for two reasons. First, although several shows have been informally reported, none have been commercially proven on acreage not already held by production. Second, the general shortage of rigs precludes such a drilling program until the oil play wanes.

During the next two years, there will undoubtedly be new gas discoveries in North Dakota. Predictably, deeper drilling results in the discovery of more gas. As the Red River deep play continues, new facilities for handling, treating, and transporting natural gas will be needed. Perhaps the greatest problem facing the North Dakota petroleum industry is transportation of crude oil and natural gas. Production limits (prorationing) for North Dakota may be necessary unless these problems are solved. To a lesser extent, the same is true of oil. Despite the increased capacity of the Portal Pipeline and the new Amoco line from the Billings Nose, oil collection and transportation systems are inadequate for present production. Lack of refining and pipeline capacity will be a problem until production either drops or new capacity catches up with new production.

A comparison of production with production tax revenues for the last few years clearly shows the impact oil development is having in North Dakota (figs. 10 and 11). It is the extrapolation of these graphs that is most significant, however. During the 1981-83 biennium, with the additional revenues incurred by the new oil extraction tax added to the gross production tax, tax revenues of \$288 million are forecast on production of 95 million barrels. In addition, lease bonuses on state land in 1979 were \$22,014,111 and in 1980 they were \$68,495,566 (fig. 6). During the same period, royalties paid on state minerals were \$2,960,515 in 1979 and \$9,090,840 in 1980. Combining these figures with annual rentals and projecting some increase over the next biennium, additional state revenues from these sources could be in the range of 130 to 150 million dollars. These revenues, combined with the income taxes paid on lease bonuses, rentals, royalty interests, and by the supporting service industry, will make the oil industry an even more important revenue producer for North Dakota.

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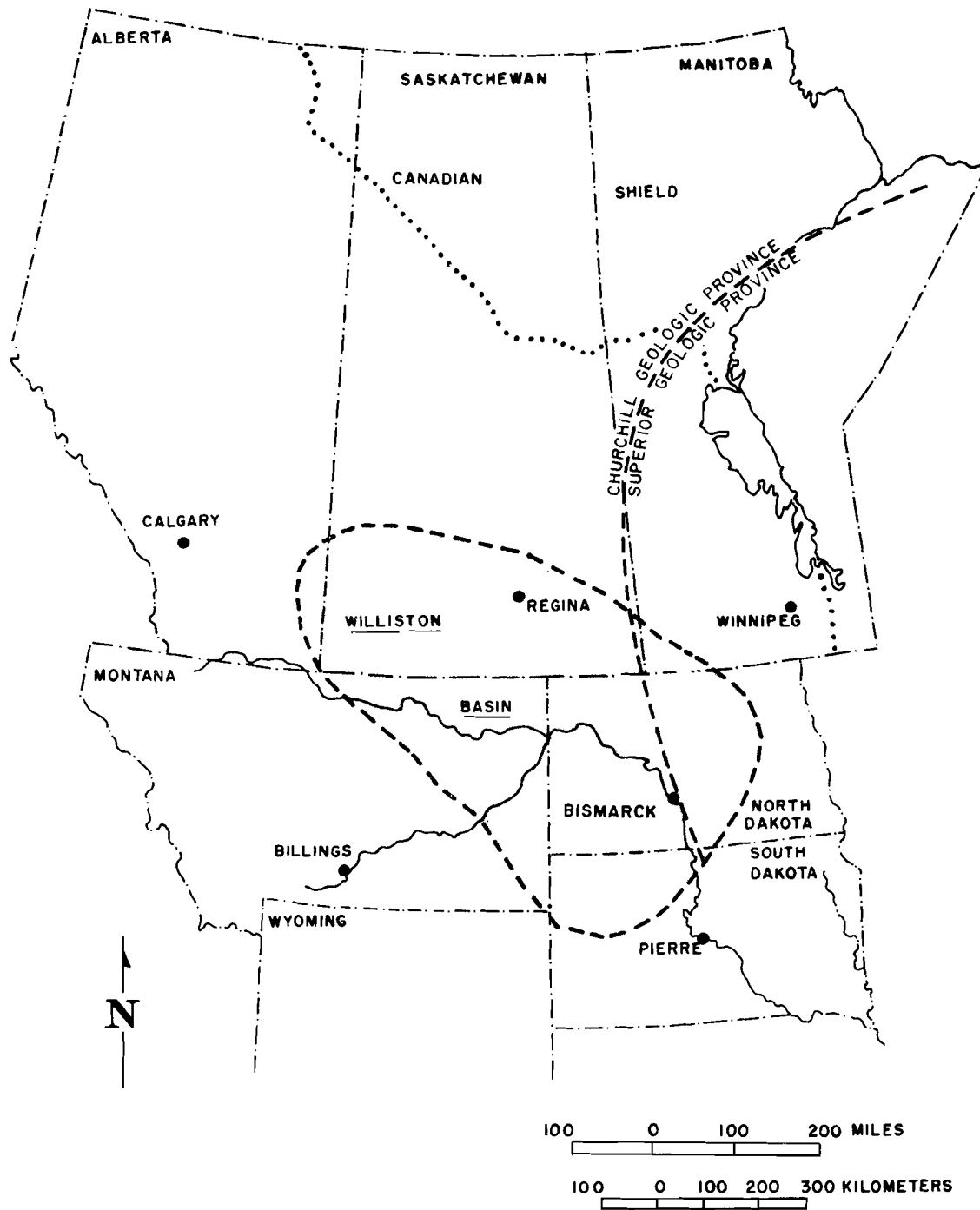


Figure 1. Location of the Williston Basin.

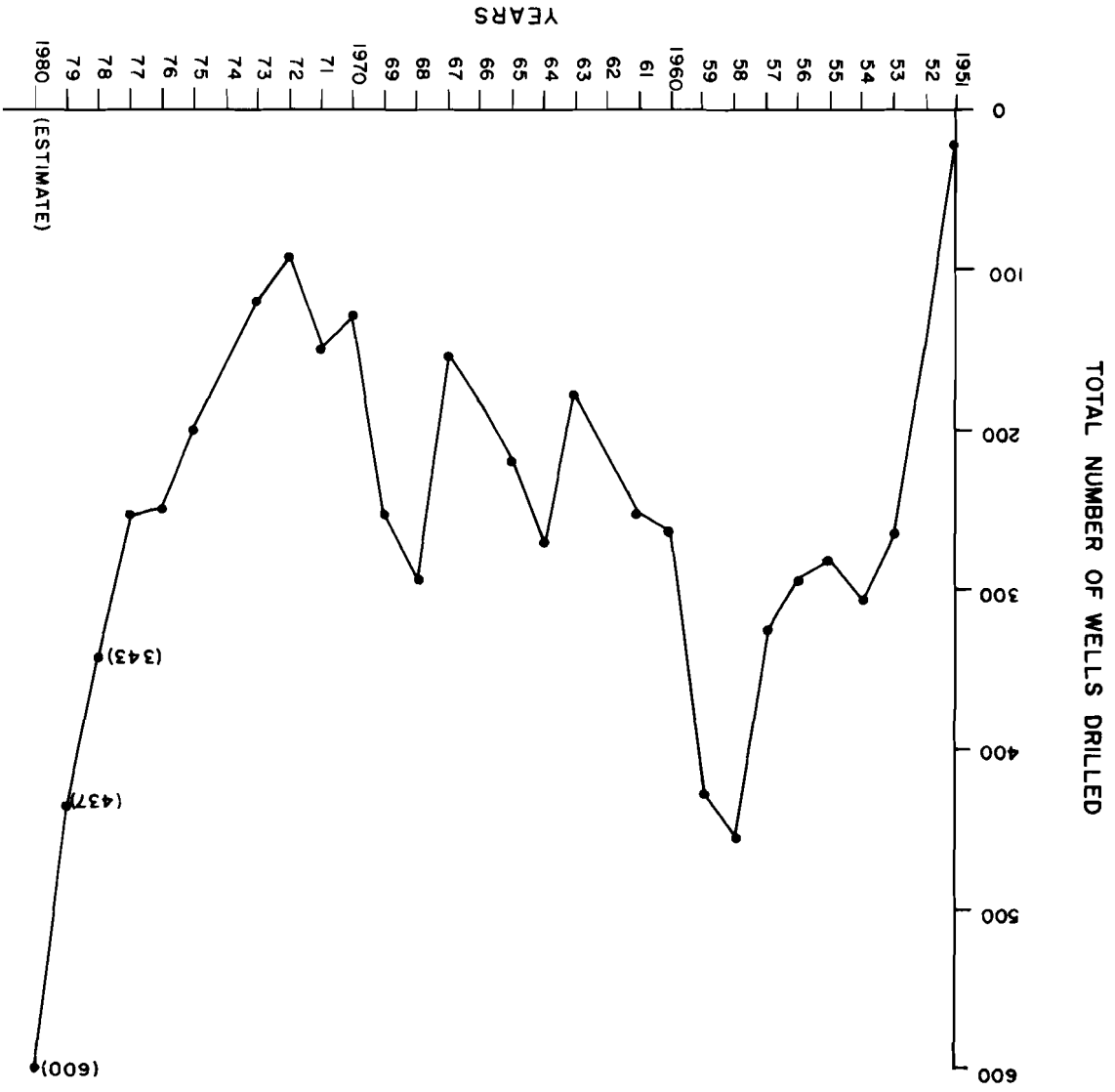


Figure 2. Total number of wells drilled for oil and gas each year in North Dakota since 1951.

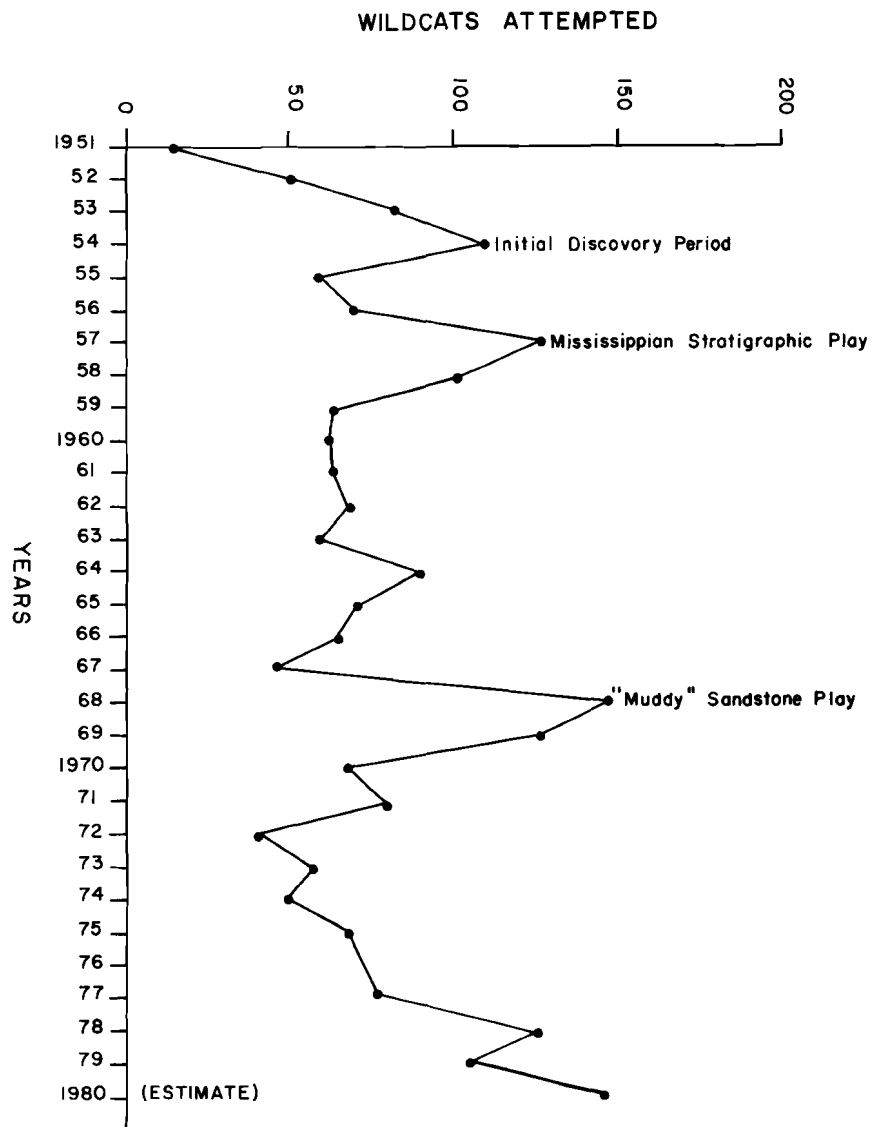


Figure 3. Total number of wildcat wells drilled each year for oil and gas in North Dakota since 1951.

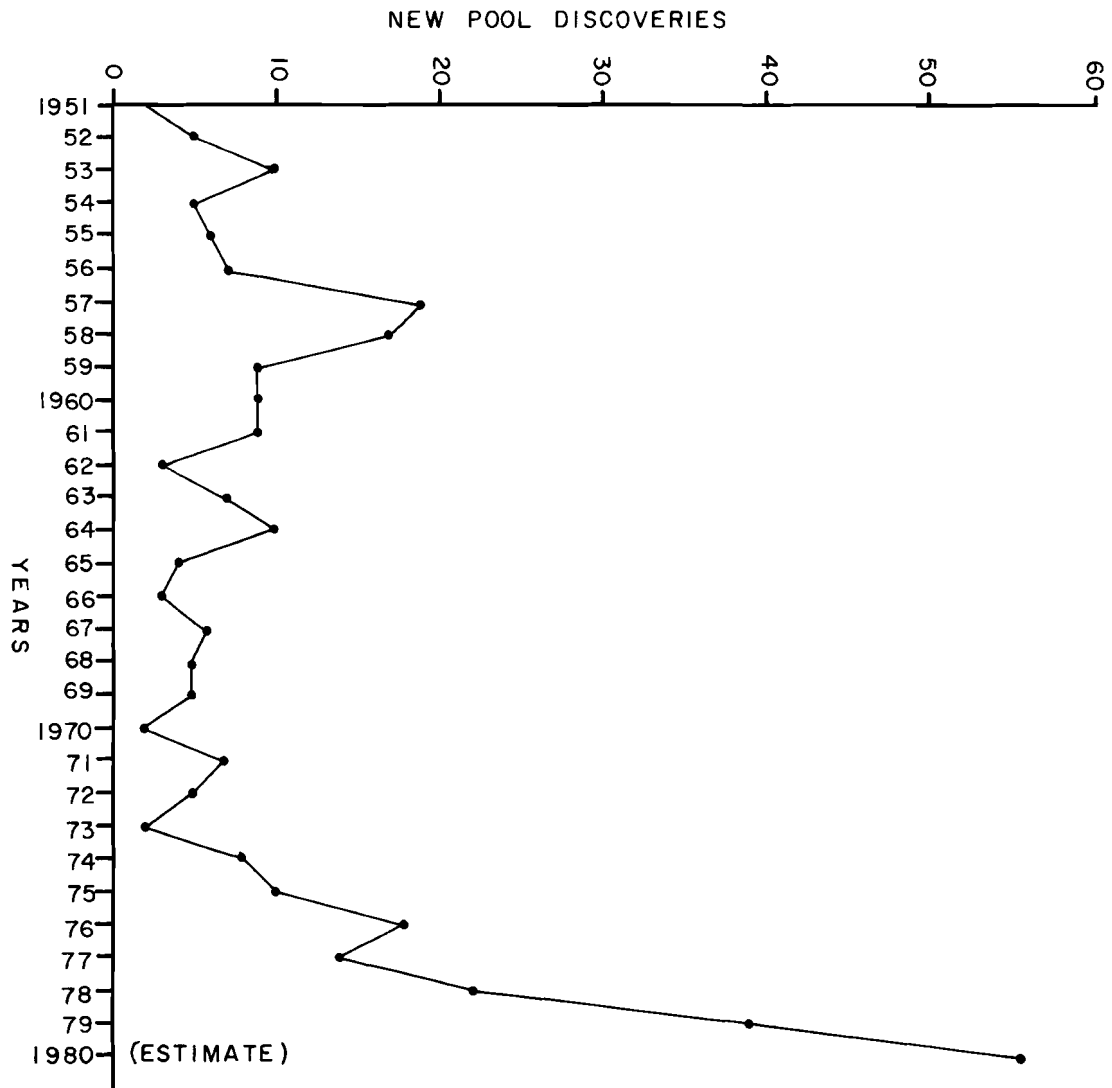


Figure 4. Total number of oil pools discovered each year in North Dakota since 1951.

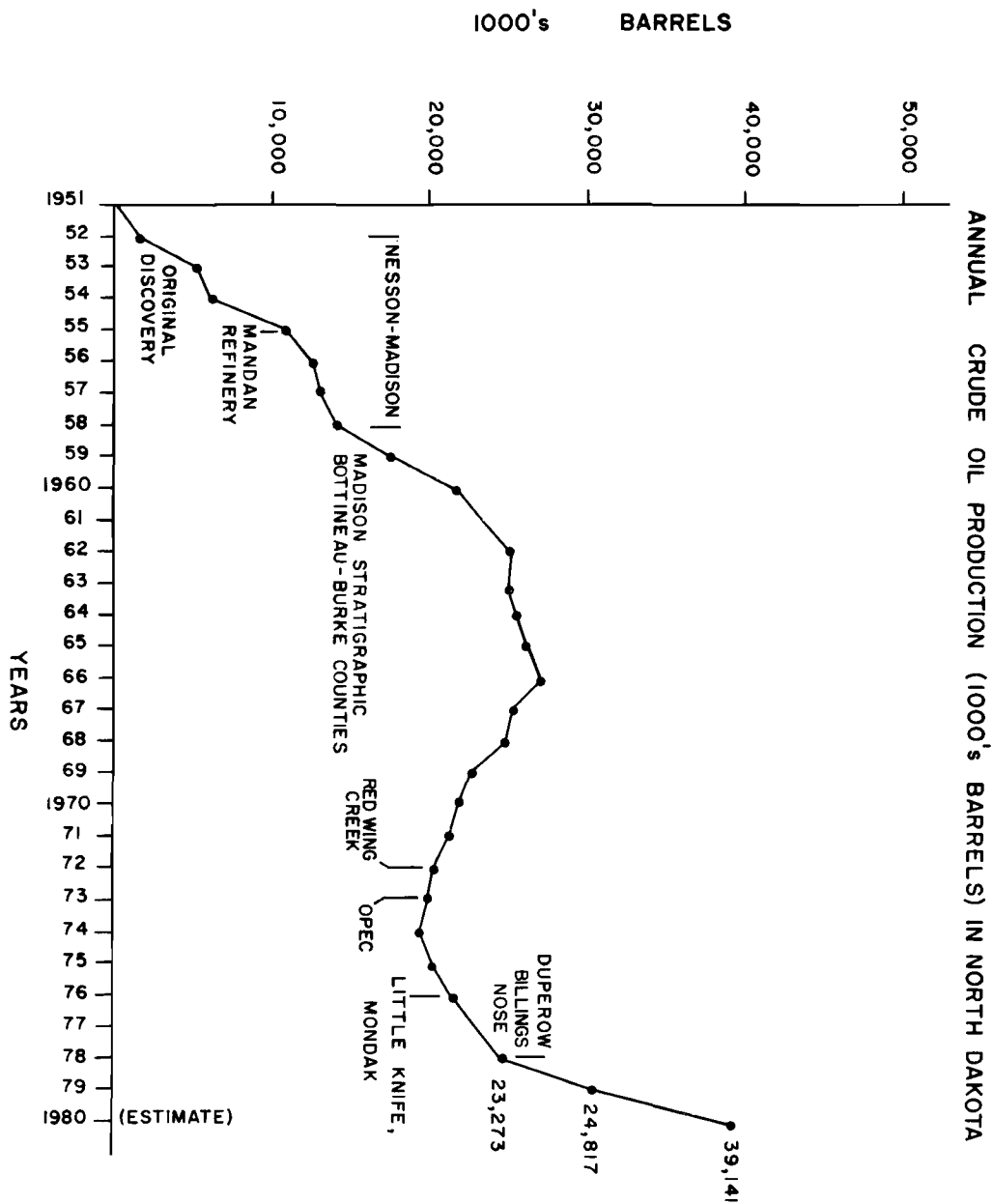


Figure 5. Crude oil production in millions of barrels each year since 1951. Major events affecting oil production history are noted on the graph.

OIL AND GAS LEASE BONUS INCOME FROM STATE LANDS

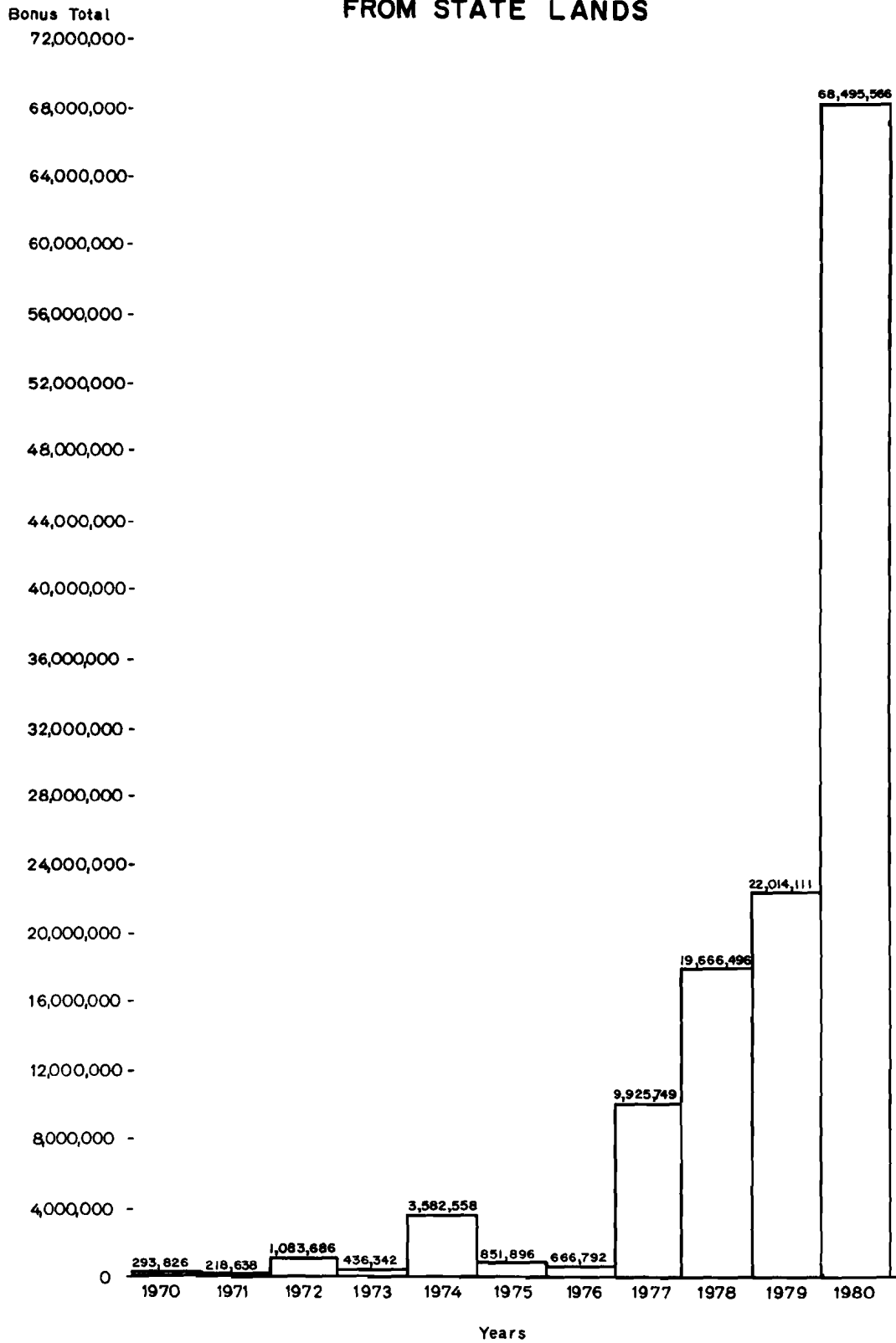
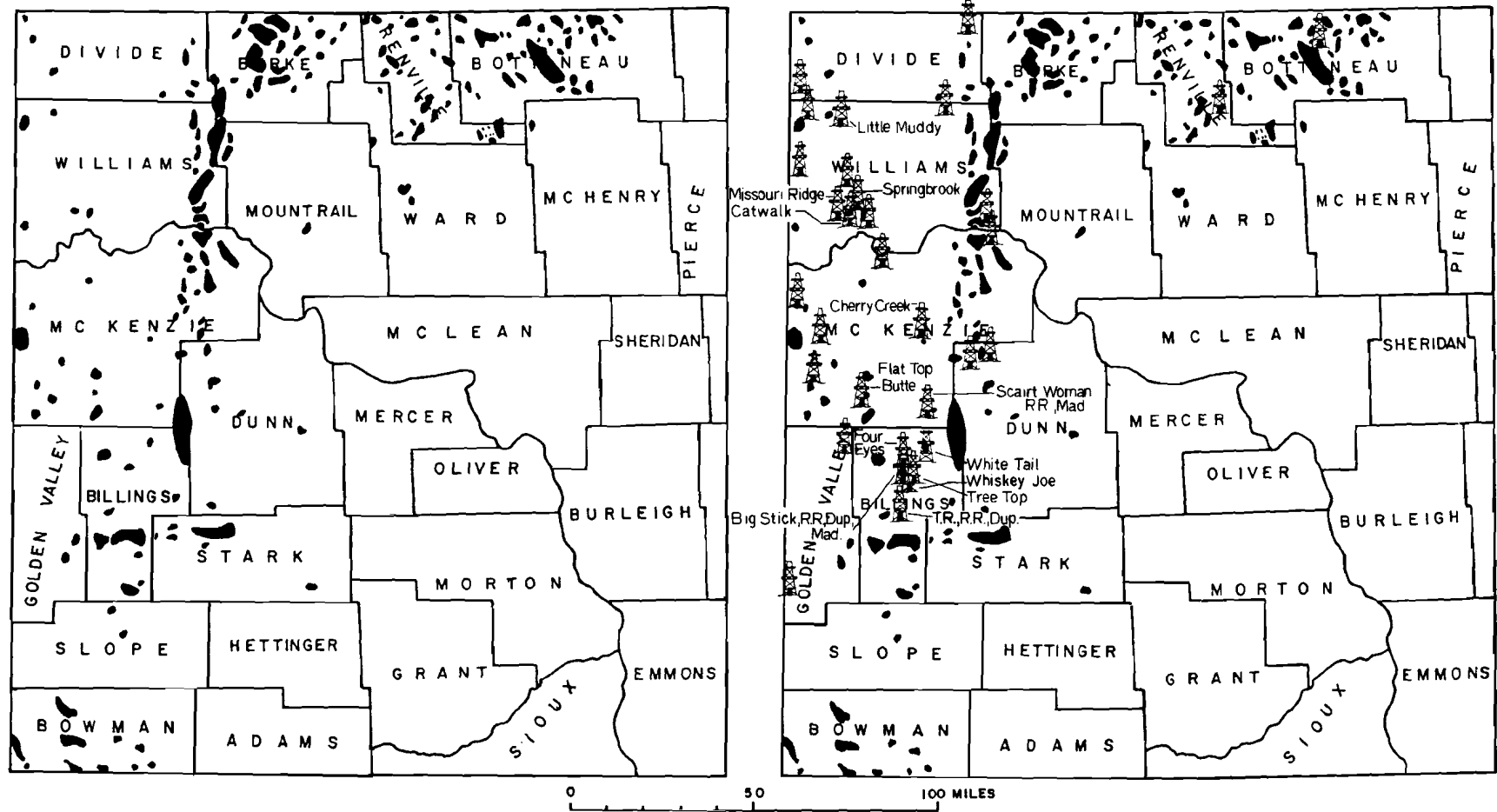


Figure 6. Oil and gas lease bonus income from state lands since 1970.



1952 - 1978
Oil Fields


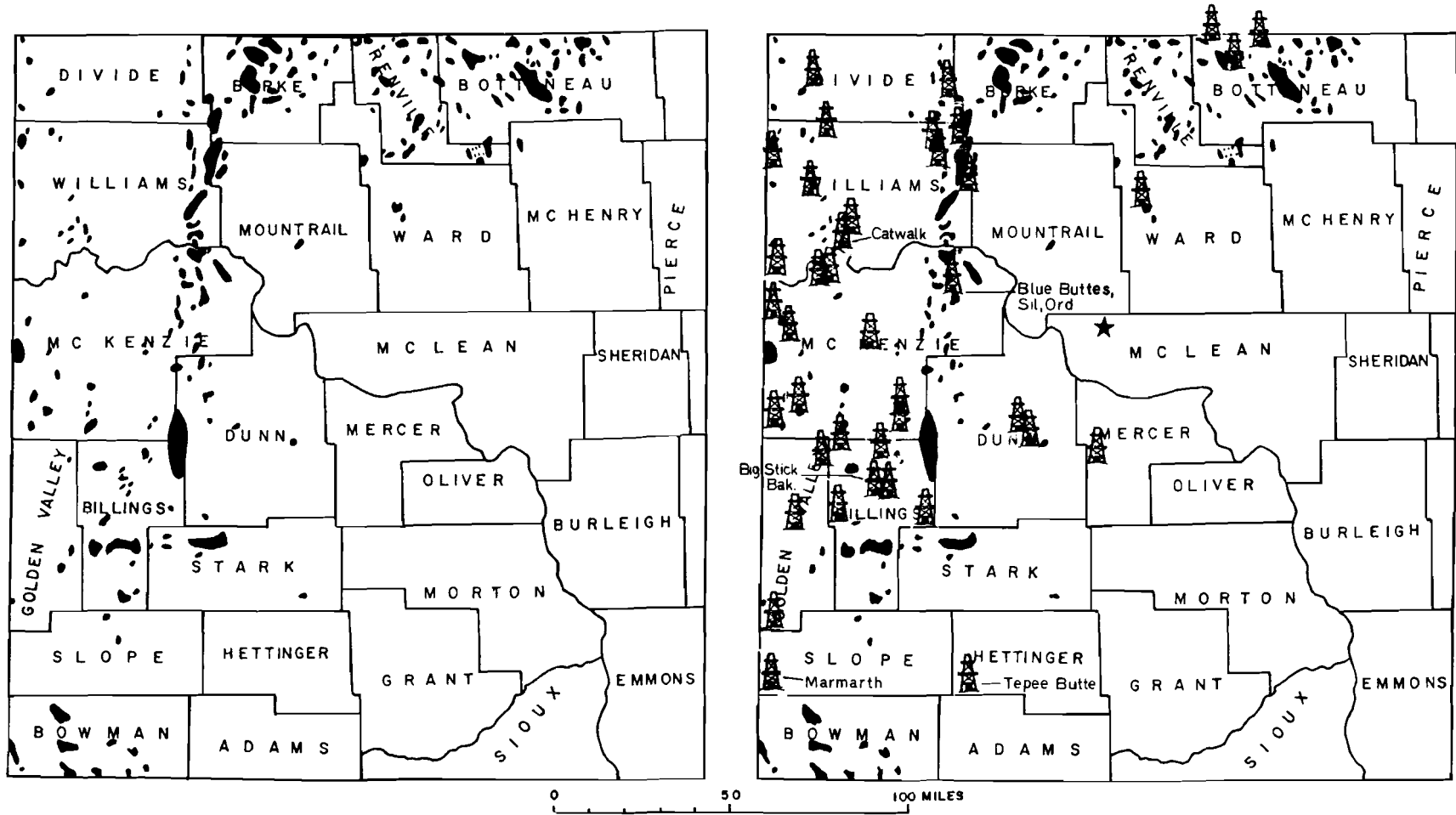
 - New field discoveries for 1979

Figure 7. Oil fields in 1978 (left diagram); 1979 discoveries (right diagram).



1952 - 1979 Oil Fields



 - New field discoveries for 1980
 - Apparent new discovery

Figure 8. Oil field development, 1979 compared to 1980. Star represents several apparent discoveries in northwest McLean and southeast Mountrail Counties.

NORTH DAKOTA STRATIGRAPHIC COLUMN

SYSTEMS	GROUPS	ROCK UNITS
QUATERNARY		GLACIAL
TERTIARY	WHITE RIVER	GOLDEN VALLEY
	FORT UNION GROUP	SENTINEL BUTTE
		BULLION CREEK
		SLOPE
		CANNONBALL
		LUDLOW
		HELL CREEK
CRETACEOUS	MONTANA GROUP	FOX HILLS
		PIERRE
		JUDITH RIVER
		EAGLE *
		NIOBRARA
	COLORADO GROUP	CARLILE
		GREENHORN
		BELLE FOURCHE
		MOWRY
	DAKOTA GROUP	NEWCASTLE ss
		SKULL CREEK
INYAN KARA		
JURASSIC		MORRISON
		SWIFT
		RIERDON
		PIPER
TRIASSIC		SPEARFISH ●
PERMIAN		MINNEKAHTA
		OPECHE
	MINNELUSA GROUP	BROOM CREEK
PENNSYLVANIAN		AMSDEN
		TYLER ●

	BIG SNOWY GROUP	OTTER	
MISSISSIPPIAN	MADISON GROUP	KIBBEY ●	
		INFORMAL INTERVALS	POPLAR INTERVAL
			RATCLIFFE INTERVAL ●
			FROBISHER ALIDA INTERVAL ●
			TILSTON INTERVAL ●
			BOTTINEAU INTERVAL ●
			BAKKEN ●
			THREE FORKS ●
		BIRDBEAR ●	
		DEVONIAN	
	SOURIS RIVER		
	DAWSON BAY ●		
	PRAIRIE		
	WINNIPEGOSIS ●		
SILURIAN		INTERLAKE ●	
ORDOVICIAN	BIG HORN GROUP	STONEWALL ●	
		STONY MTN. ●	
	WINNIPEG GROUP	RED RIVER ● *	
CAMBRIAN		DEADWOOD *	
PRECAMBRIAN		●	

● OIL PRODUCTION

* GAS PRODUCTION

Figure 9. North Dakota stratigraphic column. Black dots and stars denote geologic horizons that produce oil or gas.

ANNUAL CRUDE OIL PRODUCTION (BARRELS) IN NORTH DAKOTA

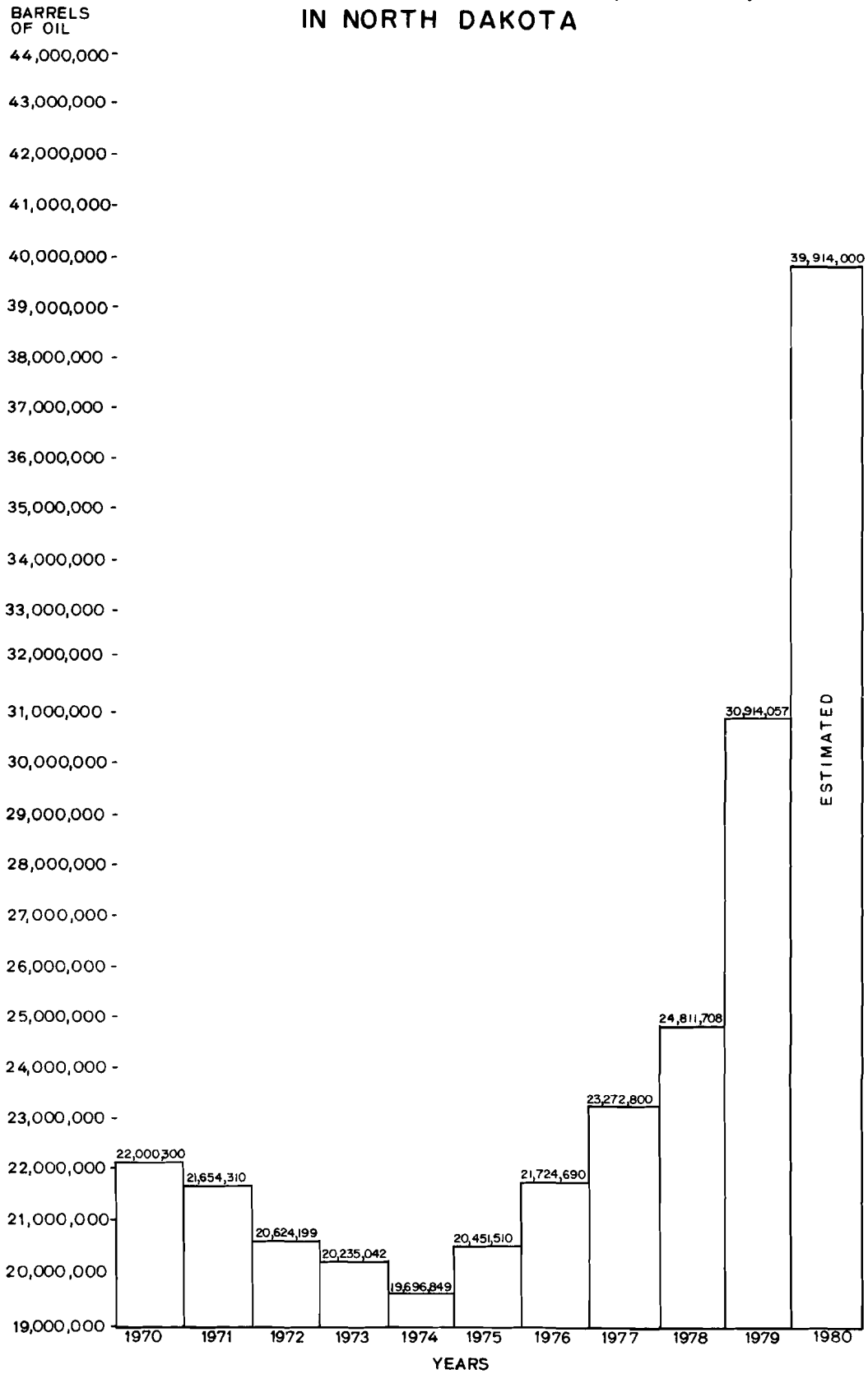


Figure 10. Annual crude oil production in North Dakota since 1970.

NET OIL AND GAS GROSS PRODUCTION TAX COLLECTIONS AND PROJECTIONS

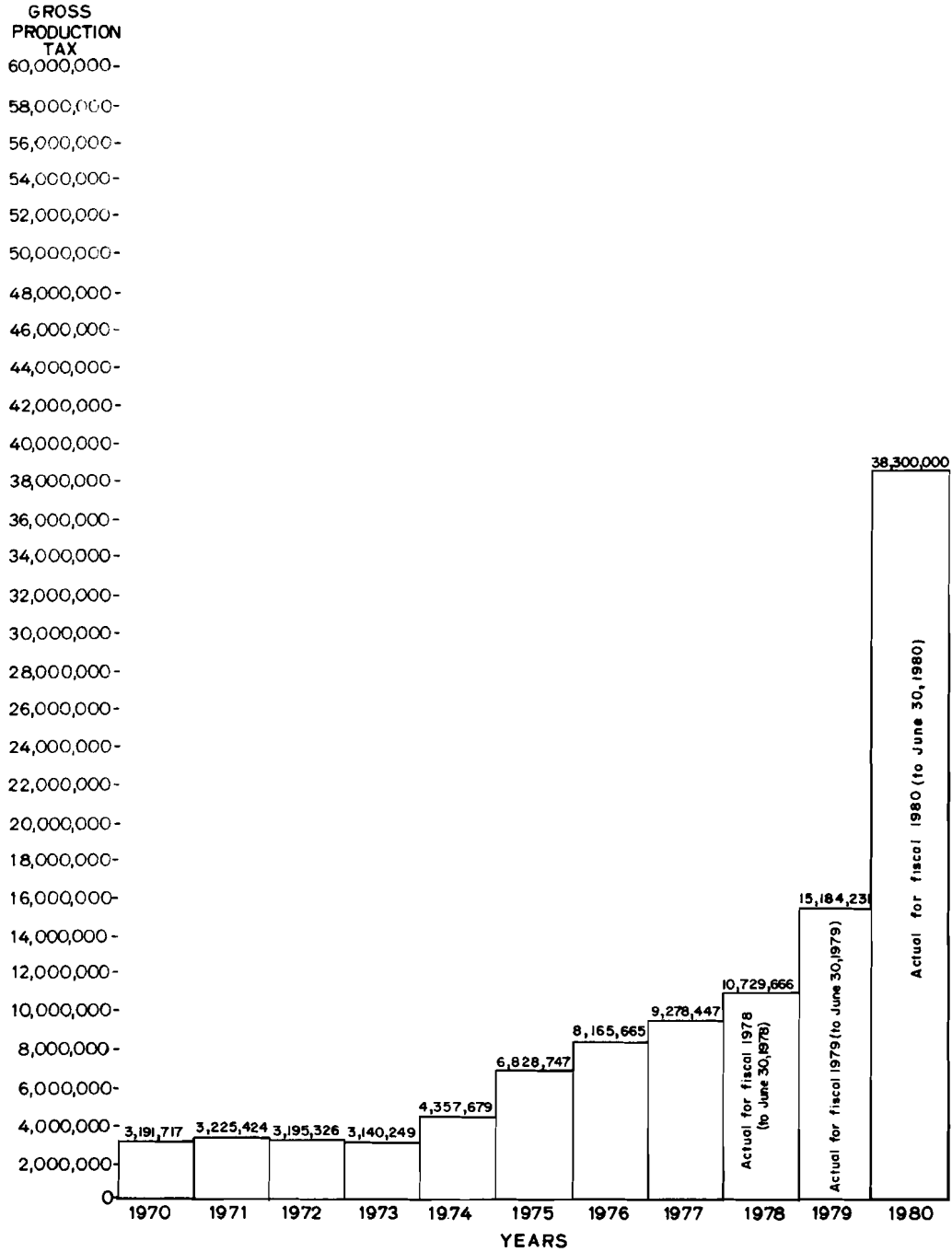
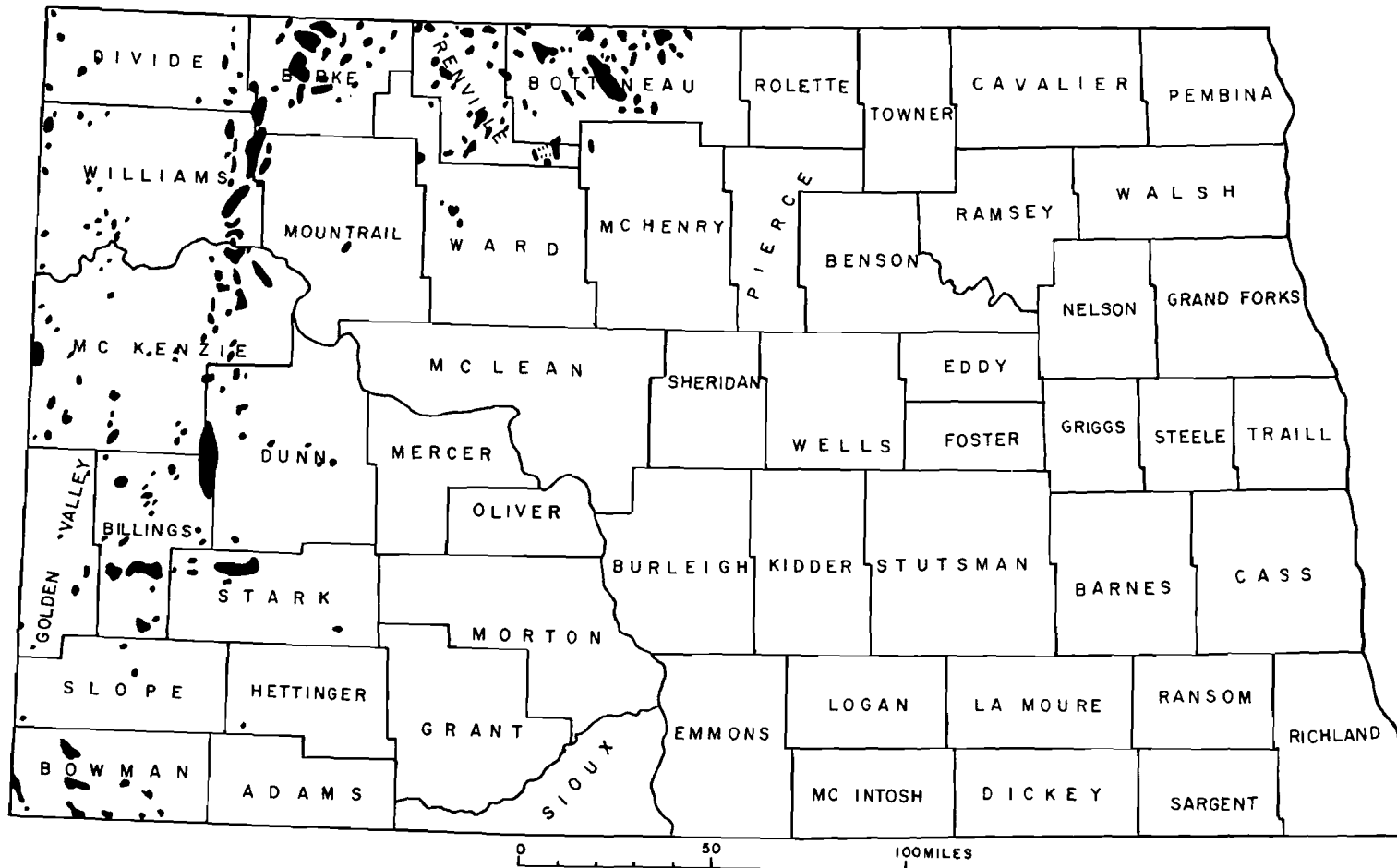


Figure 11. Net oil and gas gross production tax collections and projects.



1980
Present Fields

Figure 12. North Dakota oil fields.

TABLE 1.--Activities of Geological Survey/Industrial Commission

	YEAR											
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	
OIL & GAS CASES HEARD / INDUSTRIAL COMMISSION	38	45	41	60	51	82	106	108	115	164	250	
NEW PERMITS ISSUED FOR:												
OIL /GAS	171	134	103	129	174	264	246	351	417	644	766	
COAL						46	33	76	37	33	37	
SALT							3	0	0	0	1	
URANIUM							10	5	4	0	2	
OIL & GAS WELLS COMPLETED	134	151	90	117	153	202	251	254	343	439	540*	
NUMBER OF FEET DRILLED/ OIL & GAS (1000's)	873	979	606	814	1,139	1,348	1,802	1,928	2,882	3,945	5,009*	
COAL TESTHOLES DRILLED						3,761	2,139	3,817	2,483	2,300*	2,200*	
TEST HOLES FOR OTHER SUBSURFACE MINERALS:												
SALT							3	0	0	0	1	
URANIUM							91	620	640	0	18	

Estimated*

TABLE 2.--North Dakota drilling statistics

<u>For 1979:</u>	<u>North Dakota</u>	<u>National Rank</u>
Geophysical Crew-months	269	4th
Percent Total Acreage Under Lease	51.3%	6th
Average Rigs Operating (1)	56	8th (1)
New Field Wildcats	99	12th
Total Exploratory Wells	144	16th
Total Wells Drilled (2)	364	21st (2)
Average Depth (1978)	8496 feet	7th
Average Cost/Foot	\$59.22	12th
Number of Stripper Wells	1196	19th
Daily Crude Production	83,800 BBL (3)	12th (3)
Proved Reserves	228,950,000 BBL	10th (of 34)

(1) NDGS figures: 67, thus 6th in Nation

(2) NDGS figures: 439, thus 20th in Nation

(3) November, 1980, figures: 110-115,000, 9th in Nation

Source:

Mesnard, M. L., 1980, The Oil Producing Industry in Your State: Independent Petroleum Association of America, Washington, D.C., 132 p.

These data demonstrate that drilling levels in North Dakota are considerably less than in many of the other 34 oil-producing states. The figures are somewhat misleading since the average North Dakota well depth is greater than in other basins and our carbonate rocks drill slowly so completions are necessarily fewer. More significant is the ranking of North Dakota in seismic crew-months, percent of acreage leased, and the average number of rigs in operation. The high rankings in these categories strongly suggest that North Dakota is poised for major development at a time when it is short of drilling-rigs.