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WHAT ARE PROSPECTS IN WILLISTON BASIN'S EAST SIDE?

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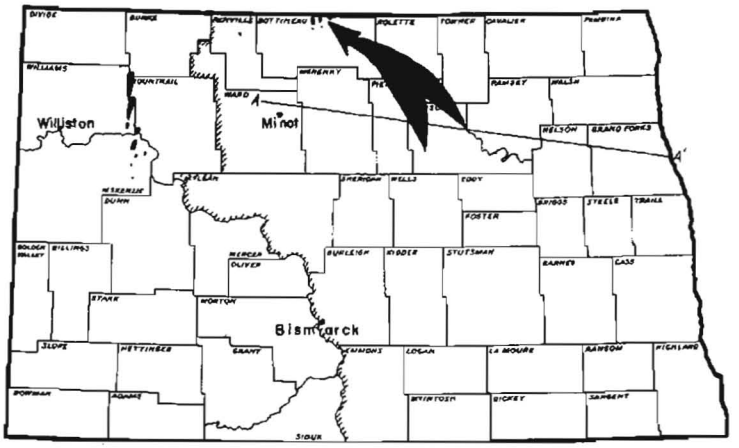

Fig. 1—Production on the east side of the Williston basin is limited to Bottineau and Renville counties.

What are prospects in

Williston Basin's EAST SIDE?

All the ingredients for a major oil province are present here to beckon the aggressive wildcatter, although to date only 11 out of 227 wildcats drilled have been successful. In Bottineau County, 8 out of 45 wildcats have scored.

by Clarence B. Folsom and Sidney B. Anderson

TERTIARY	RECENT	ALLUVIUM	
	PLEISTOCENE	GLACIAL DRIFT	
	PLIOCENE	PRE-PLEISTOCENE GRAVELS	
	MIOCENE		
	OLIGOCENE	WHITE RIVER	
	EOCENE	GOLDEN VALLEY	
	PALEOCENE	SENTINEL BUTTE	FORT UNION GROUP
		TONGUE RIVER	
		LUDLOW ? CANNONBALL	
CRETACEOUS		HELL CREEK (TREND)	
		FOX HILLS	MONTANA GROUP
		PIERRE	
		NIOBRARA	COLORADO GROUP
		CARLILE	
		GREENHORN	
		BELLE FOURCHE	
		MOWRY	DAKOTA GROUP
		NEWCASTLE "MUDDY"	
		SKULL CREEK	
		FALL RIVER	
		FUSON	
		LAKOTA	
JURASSIC		MORRISON	
		SUNDANCE	
		PIPER	
TRIASSIC		SPEARFISH	
PERMIAN		MINNEKAHTA	
		OPECHE	
PENNSYLVANIAN		MINNELUSA	
		"AMSDEN"	
MISSISSIPPIAN		HEATH	
		OTTER	BIG SNOWY GROUP
		KIBBEY	
		CHARLES	MADISON GROUP
		MISSION CANYON	
		LODGEPOLE	
		ENGLEWOOD	
DEVONIAN		LYLETON	QU'APPELLE GROUP
		"NISKU"	SASKATCHEWAN GP.
		DUPEROW	
		SOURIS RIVER	BEAVERHILL LAKE GROUP
		DAWSON BAY	
		PRAIRIE EVAP.	ELK POINT GROUP
		WINNIPEGOSIS	
		ASHERN	
SILURIAN		INTERLAKE GROUP	
ORDOVICIAN		STONY MOUNTAIN UPPER / LOWER	
		RED RIVER	
		WINNIPEG	
CAMBRIAN		CAMBRIAN	

Fig. 2—The North Dakota Geological Survey has published this preliminary stratigraphic chart.

ALONG the "east side" of the Williston basin, many possibilities for stratigraphic traps exist and some of them should be productive. Although very few structures have been plotted in the area, this is not final. The shallow depths, the low cost of wells, the number of possible productive beds, and market for new production should encourage a great many operators to explore in the area.

The "Williston basin" (Fig. 1) includes all of North Dakota except a very small portion in the southeast corner of the state. The term "east side" is generally used in referring to the eastern two-thirds of the state. Oil-exploration activity has been high in the area, but the only success to date has been along the northern borders of the state in Renville and Bottineau counties.

The producing areas are rather remote and communications are not fully developed. Several all-weather roads traverse the area, but are not heavily traveled. Rail service is by spur lines from the main line farther south. No commercial facilities for air travel exist north of Minot and charter planes are required to use unsurfaced runways.

The largest city in the area is Minot with a population of 22,000 people. Several operators maintain offices in Minot and the state Geological Survey maintains a field inspector for the area there. Minot is 65 miles from the producing area.

The climate in the area is extremely rigorous. In the Westhope area, where present production is located, operators are faced with variations of temperature from 100° above to 45° below zero.

In 1907, gas was discovered at Westhope while drilling water wells. For several years, the town was supplied with gas from small wells nearby. Many people still heat homes and barns with gas from shallow water wells. The area became known as the Mouse River Loop gas field.

The first oil production occurred in 1953 when Zach Brooks Drilling Co. completed its 1 Edwin Berentson on New Year's Day. The well produced 60 bbl. of oil per day from the Madi-

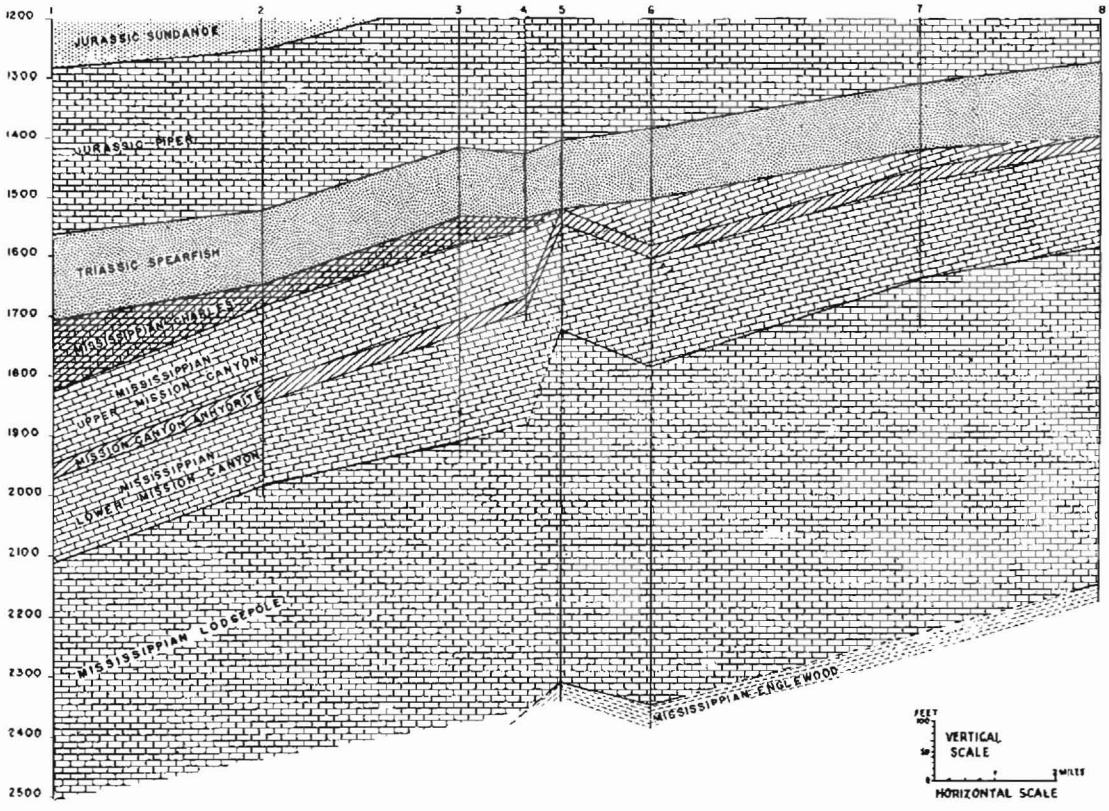

Fig. 3—In the Bottineau area the unconformity at the base of the Spearfish offers several possibilities for truncated stratigraphic traps.

LEGEND

1. Ward Williston Drilling Co. 2-A State, 36-164n-80w.
2. Murray-Monson-Murry 1 Olaf Staveheim, 33-164n-79w.
3. Hunt Oil Co. 1 Iver Gravseth, 31-164n-78w.
4. Kingwood Oil Co. 1 Peterson, 32-164n-78w.
5. Lion Oil Co. 1 Erickson, 32-164n-78w.
6. Calvert Exploration Co. 1 Anderson, 34-164n-78w.
7. Calvert Exploration Co. 1 Kornkven, 32-164n-77w.
8. Lion Oil Co. 1 Magnuson, 2-163n-77w.

son formation and opened Westhope field. The oil was 37° A.P.I. Within the year three additional fields had been discovered. In 1955 three new fields were discovered and interest in the area increased.

General Geology

The area covered by this report has been glaciated with the glacial cover ranging from a few feet to 300 ft. or more in thickness. This, of course, makes surface structure mapping impossible. Therefore, exploration is based largely on subsurface geology and seismic work.

The correlation chart (Fig. 2) represents the normal stratigraphic section in North Dakota except on the east side of the basin, where the Triassic Spearfish rests unconformably on formations of Mississippian age. Farther east, the Jurassic rests unconformably on formations of Devonian and Silurian age and in the 1 A. J. Scott, 18 miles west of Grand Forks, the Cretaceous sands of the Dakota group rests unconformably on the Ordovician Red River.

This unconformity is very interesting in view of the fact that in Renville County and North Westhope, Westhope, unnamed (Ekrehaugen), Landa fields in Bottineau County, oil is being produced from the Mississippian Charles, which is immediately overlain by the Spearfish. In Northeast Landa and North Souris pools, oil is being produced from the Mississippian Mission Canyon formation where it is overlain by the Spearfish. The Spearfish is the producing horizon in Newburg field.

In view of this, it is conceivable that production may be possibly found in the Mississippian Lodgepole and may extend to the Devonian and Silurian intervals where they pinch out and are unconformably overlain by beds of Triassic or Jurassic age.

Structure . . . As has been mentioned, it is impossible to do surface structure mapping in eastern North Dakota because the area has been glaciated. However, there is subsurface structure in the area as is shown in Fig. 3. With the increase in drilling activity on the east side, more of these structures are being found.

Well No. 5 in Fig. 3 represents a rather unusual condition. It is so high structurally that the Mississippian Charles to upper Mission Canyon formations are eroded. These formations are, with the exception of the Triassic Spearfish in the Amerada 1 Beauchamp, the only horizon currently producing in this area.

The producing fields in the Bottineau area appear to be on small noses that are not structurally as high as well No. 5 in Fig. 3. These fields seem to be a combination of structural and stratigraphic traps. The generalized cross-section in Fig. 6 and the Bottineau cross-section in Fig. 3 are indicative of the possibilities for the occurrence of oil and gas on the east side.

Stratigraphy

Ordovician . . . The Winnipeg formation is made up of two members which are in ascending order—the Winnipeg sand and the Winnipeg shale.

The Winnipeg sand rests on the pre-Cambrian. It is composed of fine-grained, well-consolidated, slightly calcareous quartz sand. It has been tested

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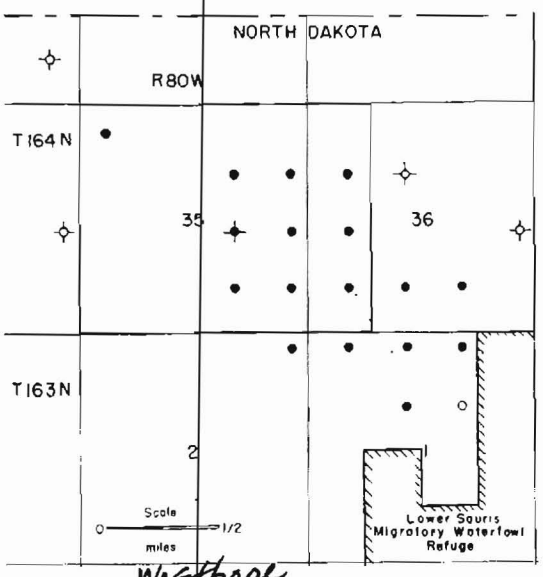

Fig. 4—Northeast Lindahl produces about 300 bbl. of oil per day from 10 wells.

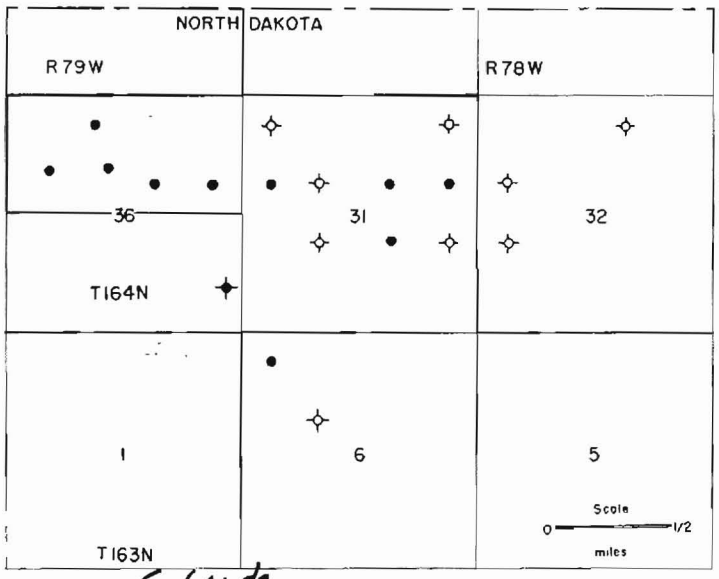

Fig. 5—North Westhope produces from the Madison and the 16 wells have a total daily output of 850 bbl.

a number of times, but as yet, only a few slight shows have been reported. The sand should, however, make a very good reservoir.

The Winnipeg shale overlies the Winnipeg sand and is immediately overlain by the Ordovician Red River. It is predominantly a green waxy shale which should make a good source bed.

In the A. J. Scott well 18 miles west of Grand Forks, a sand and limestone unit was found in the Winnipeg shale. This unit has not been observed in any other Winnipeg tests. Some small oil cuts were made from the limestone unit in this well. However, they were not considered to be commercial. In the General Atlas 1 Ketterling, McIntosh County, and in several other wells in the southeast part of the state, a sand of 15 to 20 ft. in thickness has been observed at the top of the Winnipeg shale. This is a fine-grained clean sand and should make a good reservoir.

● **The Red River formation** is a carbonate section which is predominantly limestone. This formation has some good porosity near the top and should be a good prospect on the east side where the depths encountered are not so great. The Herman Hanson 1 Billey well near Ellendale in Dickey County had some gas shows at the top of the Red River; however, they were not commercial.

● **The Stony Mountain formation** is composed of two members. They are the upper and lower Stony Mountain. The formation is underlain conformably by the Ordovician Red River and is overlain conformably by the Silurian Stonewall. Both members are very fossiliferous and highly argilaceous limestone.

Silurian . . . The Stonewall formation is a dolomite and limestone section underlain conformably by the Ordovician Stony Mountain and overlain by the Devonian Ashern. In eastern North Dakota, the Siluran has some excellent porosity. This formation was cored extensively in The California Co. 1 Blanche Thompson in Bottineau County, also several cores were cut by Union Oil in the Devils Lake area. **These cores show excellent vugular porosity and should make very good reservoir rocks.**

Also, since there are reefs known to be present in the Silurian in Manitoba, there is good reason to suspect that they may also be present in North Dakota.

Devonian . . . The Devonian of North Dakota consists of the following units in ascending order: Ashern, Winnipegosis, Prairie Evaporites, Dawson Bay, Souris River, Duperow, Nisku, and Lyleton. This is predominantly a carbonate section with some shales. Further west, the Prairie Evaporite is a salt section.

Considerable difficulty has been encountered in distinguishing several of the Devonian formations on the eastern edge of the Williston basin due to the regional thinning and similarity of the formations. However, the Ashern, Duperow, Nisku, and Lyleton can be distinguished quite easily.

The Winnipegosis, Duperow, and Nisku seem to present the best possibilities for the production of oil from the Devonian in eastern North Dakota.

Bioherms are present on outcrop in the Winnipegosis of Manitoba, Canada, so quite probably there may be reefs present in the subsurface of North Dakota. The Nisku and Duperow exhibit excellent intergranular porosity in eastern North Dakota and should also make good reservoir rocks.

Mississippian . . . The Englewood formation in North Dakota is predominantly a black carbonaceous shale. This formation forms the base of the Mississippian system. It overlies the Devonian Lyleton conformably and is conformably overlain by the Mississippian Lodgepole. The Lion Danielson 1 well in Rolette County recently had a show of oil in the Englewood. However, it is not particularly favorable for the production of oil inasmuch as it is predominantly a shale, but it should be an excellent source bed.

● The Mississippian Lodgepole overlies the Mississippian Englewood conformably and is conformably overlain by the Mississippian Mission Canyon, except where the Mission Canyon is absent by erosion. The Lodgepole is then overlain unconformably by the Triassic Spearfish as is the case in Rolette, Towner, eastern Pierce, Benson, Eddy, Foster, and eastern Stutsman County.

The Lodgepole as yet has produced no oil in North Dakota. However, oil is being produced from it in southern Manitoba in Lulu Lake area, just across the North Dakota boundary. Lodgepole production in the Lulu Lake area is from a crinoidel zone in the upper part of the formation.

● The Mission Canyon in North Dakota is the most prolific oil-producing formation in the state. On the east side it produces in Northeast Landa and North Souris fields in Bottineau Coun-

ty. While the production from the Bottineau fields is not high, it is relatively shallow which makes it attractive to independent operators.

The Mission Canyon on the east side is characterized by two zones of porous limestone separated by a thin anhydrite. The production in the Bottineau area is from the upper porous zone. There is no production yet from the lower zone, but it should also be an excellent prospect especially since it is capped by an anhydrite zone.

● The Charles formation in North Dakota is largely an evaporitic section with salt, anhydrite, and limestone. The salt sections in the western part go out to the east and the section becomes more anhydritic.

In the Bottineau area, the Charles section consists of interbedded anhydrites, and limestones. Westhope, North Westhope, unnamed (Ekrehaugen), and Landa fields produce from several pays.

In Renville County, the Sohio 1 Ritter was recently completed in the Charles with an initial production of 374 bbl. of oil per day from a very porous oolitic limestone.

According to a personal communication from LaVerne Nelson, geologist of the North Dakota Geological Survey, some of the anhydrite zones in the Bottineau area became zones of oolitic limestone to the west. This is an interesting facies change that could form good reservoirs for structural or stratigraphic traps.

Triassic . . . The Spearfish rests unconformably on Paleozoic rocks on the east side of the basin and is overlain conformably by the Jurassic Piper.

The Spearfish consists largely of siltstone with some sandstone beds. Numerous oil shows have been found in the Spearfish in this area. However, to date only one well, the Amerada 1 Beauchamp in Bottineau County, has been completed in it.

Drilling Problems and Practices

The usual drilling program includes spudding in with 13¾-in. bit or 15-in. reamer, or with 8¾-in. bit and reaming to 15-in. The surface hole is carried below the glacial drift or about 200 ft. from the surface.

Surface casing is set and cemented to the surface. The common sizes are 10¾-in., 32.75-lb. Rt. H-40 or 8⅝-in., 24-lb. J-55. The cement is allowed to set for at least 12 hours, after which drilling is resumed with an 8¾ or 7⅞-in. bit. In case production is encountered, the production string is 5½-in., 15.5-lb. J-55 cemented to the top of Mississippian.

In rotary drilling, 20 to 22 points of weight are kept on the bit with 500 to 700 psi. on the pumps and rotary speeds of 75 to 100 r.p.m.

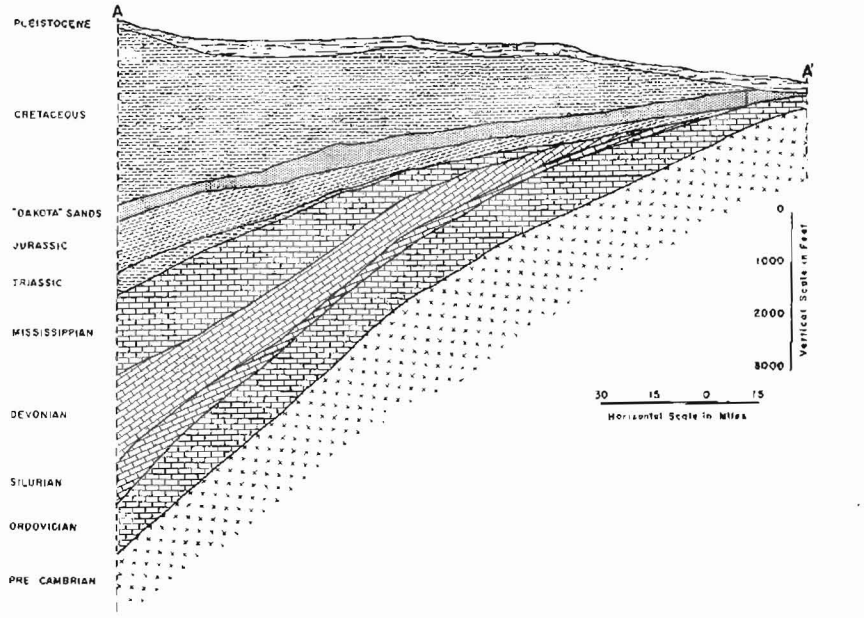

Fig. 6—Cross-section A-A' (see Fig. 1) shows several possible oil traps where porous limestone units pinch out against the post-Mississippian unconformity.

The early completions involved perforation and acidization with approximately 2,000 gal. of regular acid. Four perforations per foot is the usual practice. However, recently operators set casing on top of the producing zone and tail and well in with cable tools, making only enough hole to provide reasonable production. Acid treatments have been reduced to 500 gal. or less. Some completions were made without acid and the results, insofar as initial production is concerned, are inconclusive as to which is the better prictice.

Problems . . . Some difficulties are encountered in drilling operations. Salt water is often encountered in the Spearfish, but this can be best overcome by conditioning the mud. Gyp-base muds with viscosity of 40, weight of 10.4 lb. per gallon, and water loss less than 10 cc. are considered optimum. Some operators drill to the Dakota sand with fresh water before preparing mud.

Some instances of lost circulation have been encountered, particularly in the south and east parts of the basin. This generally occurs near the unconformity at the base of the Triassic and in some instances has resulted in the loss of the hole. Ordinary lost-circulation materials are generally successful in overcoming this obstacle.

A general problem in the area is the extreme winter weather. Almost all of the operators maintain a boiler to provide steam for use is thawing lines and hoses. When the kelly is set over to make a connection, steam is connected to it to prevent it from freezing in the hole.

Material handling and deliveries are difficult during the winter months. During the period of the spring thaw, the State Highway Department puts restrictions on truck loads which hamper the movement of rigs from location to location as well as delivery of other heavy materials.

Some contractors move rigs both ways across the Canadian border and in such cases the border authorities have been extremely cooperative in making these movements easy for the contractors.

The cost of drilling wells in the area was estimated at $54,000 in 1954 with an additional $8,000 for lease equipment on producing leases.

Production

Production in Bottineau County amounted to 268,582 bbl. of oil on September 1, 1955. During the month of August, 38,426 bbl. was produced. Although a producing well has been completed in Renville County with a potential of 374 bbl. of oil per day, no production had been recorded prior to September 1, 1955.

In the eight producing fields, there were 32 wells on the first of September. Half of these were in North Westhope field which is the largest producer, having produced 166,183 bbl. or about 62 per cent of all the oil produced at that time.

The average gravity of the oil was 36.7° A.P.I. for the fields in Bottineau County. The Renville County well produces oil with a gravity of 28.1° A.P.I. from a different interval.

TABLE 1—OIL PRODUCTION IN BOTTINEAU COUNTY, NORTH DAKOTA
(Barrels)

	Westhope	Unnamed (Ekrehaugen)	Northeast Landa	Landa	North Westhope	Newburg	North Souris	Bluell
1953—								
January	293							
February	251							
March	231	490	600		185			
April	227		1,871		150			
May	174		1,663		180			
June	163		2,024		180			
July	145		1,144		220			
August	68	510	1,588					
September	115	341	1,287		890			
October	178	240	1,302		910			
November	131	234	1,275		715			
December	89	147	1,131		710			
1954—								
January	91		1,050		494			
February	148		460		540			
March	114		720		707			
April	120		961		408			
May	90	390	1,662		707			
June		330	1,632		2,047			
July	96	224	1,370		2,548			
August	107	264	1,159	22	2,688			
September	121	245	855		1,920			
October	97	178	1,706		2,403			
November	135		1,855		2,607			
December	93		2,233		5,547			
1955—								
January	102	202	2,160		10,469			
February	69		5,064		7,548			
March	63	82	6,627		13,603			
April	76	238	7,712		11,652			
May	79	174	8,765		19,590			
June	62	574	8,442		23,557		161	
July	33	160	10,924		26,958	176	1,686	
August		158	9,912		26,048	207	2,101	
September	63	120	9,050		25,604	102	4,145	678
Total	3,824	5,301	98,154	22	191,787	485	8,093	678

All production in the area is now on the pump. Some wells flowed their production initially. Average daily rates of production vary from 8.8 bbl. in the 1 Ekrehaugen to 60.7 bbl. in North Souris field. The average for the eight fields was 33 bbl. per well.

General practice on pumping wells includes 30 to 44-in. stroke at 12 to 22 s.p.m. The working barrel is generally 1½ or 1¾-in. run on 2 or 2⅜-in. tubing.

Bottom-hole pressures have not been taken on many wells since the wells would have to be swabbed after the shut-in period. In lieu of bottom-hole-pressure tests, static and pumping fluid levels have been taken.

Very little core information is available but tests of the Charles formation indicate that horizontal permeabilities of the order of 10 to 20 md. might be expected. In Bluell field, a visual inspection would indicate that the pay interval would have unusually high permeability. Isolated cores have tested from 68 to 616 md. of horizontal permeability with vertical permeability from 2 to 207 md. The Mission Canyon pay interval will be much tighter.

Porosity of the order of 20 per cent is indicated for the Charles with somewhat comparable porosity expected in the Mission Canyon.

Conservation

Spacing for the development of these fields has been set at 40 acres for a period of 18 months. These problems will be reviewed before final spacings are established next year. In the case of North Westhope field, wells are drilled on the northeast quarter of each 40-acre tract in order that smaller spacing can be instituted if found necessary.

In the spring of 1954, the state-wide rules were amended to provide for a discovery allowable of 200 bbl. per day for new wells. Under this rule, the first four wells in a field are allowed to produce at the higher rate for 18 months, or until the completion of the fifth well, provided there is a market for the oil and the production can be had without damage to the reservoir. It was hoped that this step would encourage development in the eastern basin. Since the adoption of this rule, three new fields have been discovered but none of the wells have been able to take advantage of the higher allowable.

Summary

The lack of success outside of Bottineau County cannot be considered to condemn the entire area since the wells have been widely scattered. (Several wells were drilled primarily for stratigraphic information and some were drilled on the basis of nontechnical data.) Considering the great bulk of sediments present, the actual percentage of the area tested has been very small. (There is no reason why the same conditions that exist in Bottineau and Renville counties areas do not extend southward where Mission Canyon and Charles are overlain unconformably by the Spearfish. However, it will probably take much more drilling and seismic work to find these areas. Also it seems probable that the Devonian, Silurian, and Ordovician may produce on the east side at the unconformity.)

Acknowledgments

Permission to publish this report was granted by Dr. Wilson M. Laird, director of the North Dakota Geological Survey. Much of the information contained herein was found in the files of the North Dakota Geological Survey and the North Dakota State Industrial Commission.

TALE 2—MADISON POOL DATA

Field—	Discovery date	Top of pay	°A.P.I.	Res. temp. (°F.)	Pay thickness (ft.) Max.	Min	Avg.	Acres	Mds. horizontal permeability Max.	Min.	Avg.	Porosity (per cent) Max.	Min.	Avg.	Deepest test (ft.)
Westhope	1- 1-53	3,350	37.0		15			1,440							3,633
Unnamed (Ekrehaugen)	1-30-53	3,054	38.0		16			40							3,084
Northeast Landa	3-20-53	3,073	36.0		41	4	13	1,000							3,150
Landa	5- 3-53	3,202						1,440							3,594
North Westhope	8-25-53	3,248	36.9	109	50	7	25	1,160	228		11.25	17.3	2.16	9.68	3,330
Newburg	7-10-55	3,403	35.1	110	8			1,920							4,080
North Souris	6-26-55	3,248	37.0	114	7	4	5	1,400							3,018
Bluell*	9-25-55	4,500	28.1		18			40							5,180

*Charles formation.