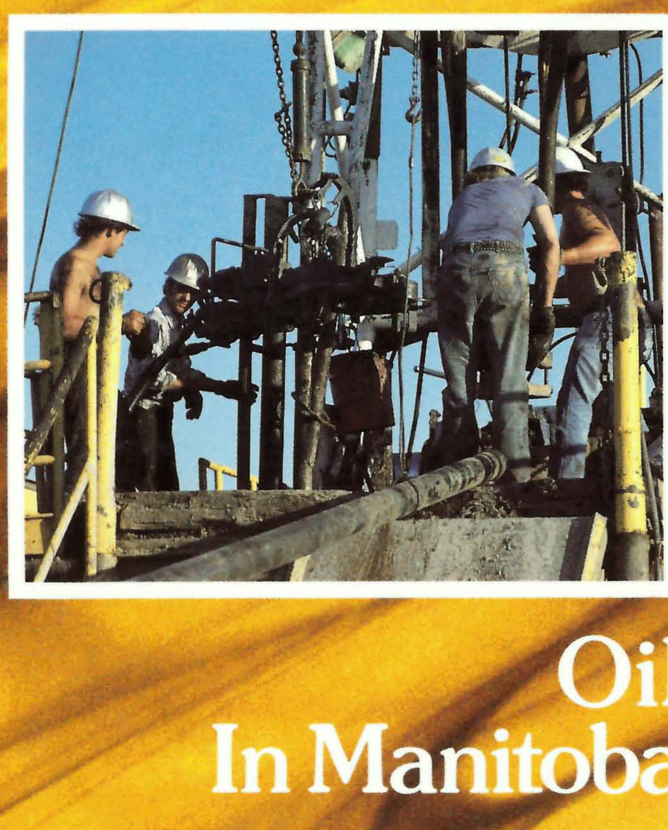
MINERAL EDUCATION SERIES



Oil In Manitoba

Manitoba
Energy and Mines

Message From The Minister Of Energy And Mines

Manitoba's abundant mineral resources form a vital part of our province's rich natural resource heritage. It is almost impossible to spend even a day in our province without using some item which contains a tiny part of this heritage. Your home or workplace, no doubt, has concrete which includes our abundant sand and gravel. Or perhaps it uses building stone from one of Manitoba's quarries. Somewhere in your home there is likely to be copper pipe or wire which may well have originated from a northern Manitoba mine. The same mines produce the zinc which is used to galvanize much of the metal in your car to retard rust. You probably sit down to dinner with stainless steel cutlery which require nickel — one of Manitoba's richest mineral resources. Your car may use gasoline refined from Manitoba oil. You may even use Manitoba's gold when you exchange rings on your wedding day.

In getting these resources out of the ground and into your life, Manitoba's mining, quarrying and oil industries create thousands of jobs for Manitobans, including everything from clerks to miners to executives. These people, in turn, spend their salaries on goods and services which provide the lifeblood for countless more employees and businesses. In total, these industries and their spin-off benefits make a major contribution to Manitoba's prosperity and stability.

These resources also provide a significant source of income for the provincial government. Royalties and taxes ensure that revenues from our natural resource heritage contribute to maintaining the level of services Manitobans expect. These revenues help pay for the quality schools, hospitals and roads which make Manitoba a fine place to live.

In the Mineral Education Series, we hope to increase Manitobans' awareness of the wealth and variety of our mineral resources and their importance. Each booklet in the series explains one aspect of our mineral industry, describing the mineral resources, the history of its development in Manitoba and the industry today. We hope the series will convey some of the importance and excitement of exploiting Manitoba's mineral resource heritage.

In **Oil in Manitoba** we look at a part of this heritage which is often overshadowed by the other provinces' vast petroleum industries. Yet, for over 35 years, the men and women who are part of Manitoba's petroleum industry have made a valuable contribution to the province's growth and prosperity. The story of the industry, from early exploration before the turn of the century to today's sophisticated production and exploration techniques, is a fascinating one.

Through this history, the staff of Manitoba Energy and Mines and its provincial predecessors have quietly worked to ensure the economical and safe development of our petroleum resources. In **Oil in Manitoba**, Andrew Galarnyk, a Resource Analyst with the Department, introduces us to the history, geology and technology of Manitoba's petroleum industry. I would like to thank him, and all the other staff in our Petroleum Branch, for sharing this part of Manitoba's mineral resource story.

Wilson D Parasiuk

Wilson Parasiuk
Minister
Energy & Mines

Metric Conversion Table

1 metre (m)	=	3.28 feet
1 cubic metre (m^3)	=	6.29 barrels (oil)
	=	220 imperial gallons
	=	35.49 cubic feet (gas)
1 hectare (ha)	=	2.471 acres
1 kilometre	=	0.62 miles
1 kilopascal (kPa)	=	0.145 pounds per square inch (psi)

PREFACE

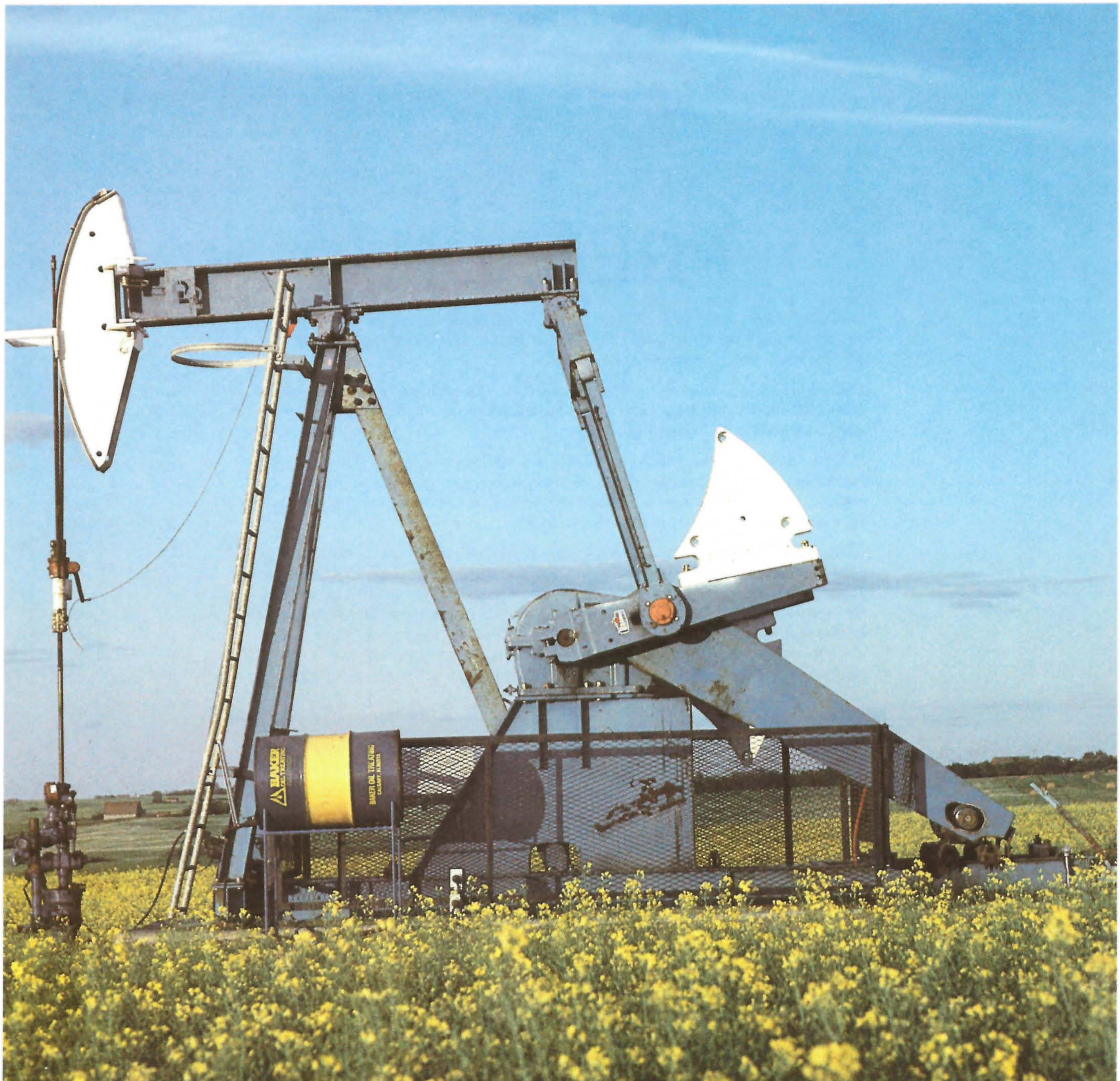
Did you know that back in April, 1877, oil and gas exploration began in Manitoba? In that year, the Manitoba Oil Company received a charter for petroleum exploration.

Did you know that in 1984, Manitoba produced approximately 800 000 cubic metres (5.0 million barrels) of crude oil valued at approximately $170 million?

When most people think of Canada's oil production, Alberta and Saskatchewan come to mind. While small compared to its neighbours, Manitoba is nevertheless an active and colourful participant in Canada's production of 'black gold'.

This publication offers an overview of Manitoba's petroleum industry, past and present. It provides a simple, non-technical explanation of how oil and gas were formed, where they are found and how they are explored for and developed. As well, the booklet looks at the role of the Manitoba Energy and Mines' Petroleum Branch in petroleum development. A Glossary, at the end of the booklet, explains some of the more technical terms which are necessary in a publication of this kind.

A comprehensive book has yet to be written about Manitoba's oil patch. It is a privilege to introduce the reader to this little known part of Manitoba's story, and to the general principles of petroleum geology, exploration and development.



Pump jack in Waskada oil field.

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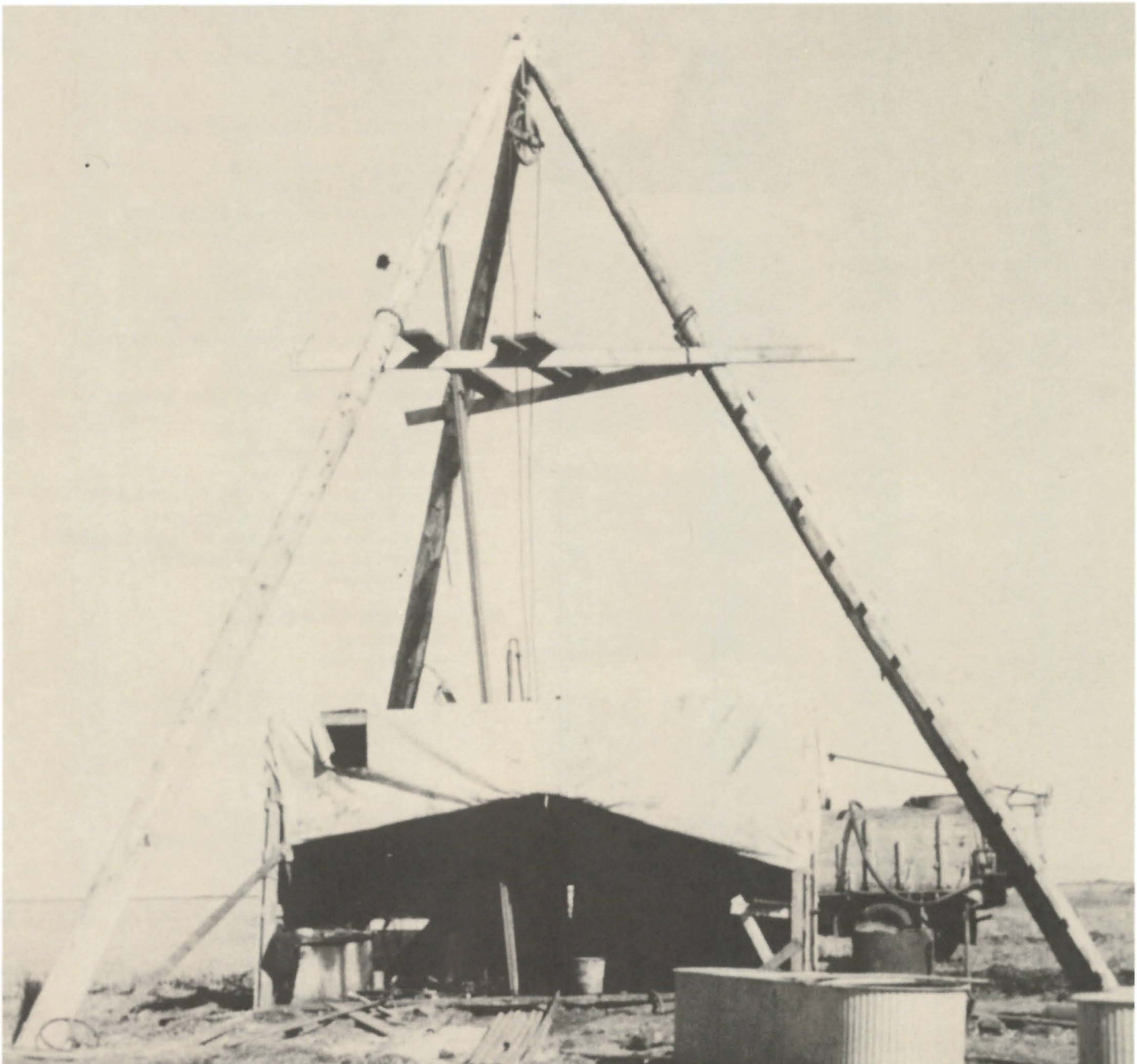
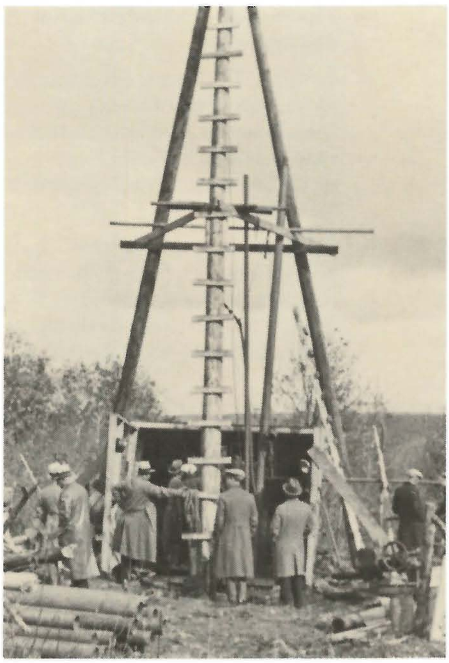


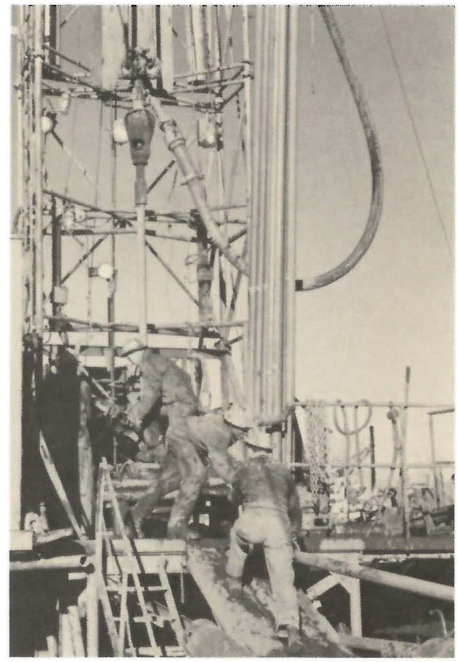
Cable tool rig drill site early 1940's.

Highlights From Manitoba's Oil Patch



Curious onlookers watch as cable tool rig punches out gas well near Manitou, Manitoba, 1933.

Geologist conducting preliminary geophysical survey.



'Roughnecks' at work.

1873 — The Geological Survey of Canada drilled wells to obtain geological information.

1877 — The Manitoba Oil Company was granted a charter to explore for oil in the province.

1912 — Local residents in the Waskada-Melita district drilled nine shallow wells which encountered pockets of natural gas. None of the wells were commercial producers.

1927 — A 209 metre well in the Grandview District was reported to have oil shows. It was later revealed that the promoters had brought oil from town in barrels and poured it down the well.

— North Star Oil built the first crude oil refinery in Manitoba.

1930 — Wells were drilled into deeper formations in the Paleozoic.

1934 — A well drilled by Canadian Industries Limited, near the Town of Neepawa, encountered salt brine at 455 metres. The deposit was commercially developed and produced 23 000 metric tons of salt per year until 1970, when production was discontinued.

1947 — The government passed the first regulations covering oil and natural gas exploration and development in the province. The Brandon Exploration Company, a subsidiary of the California Standard Company, was issued Oil and Natural Gas Reservations Numbers 1-9 by the provincial government. The company carried out the first major detailed geophysical survey, covering nearly all of the southwestern portion of Manitoba.

1949 — The Souris Valley Oil Company drilled two wells near Lyleton. The Gordon White No. 1 well, drilled to 1 573 metres, established the presence of Mississippian limestones. The Robert Moore No. 1 set a new provincial depth record of 1 838 metres.

1950 — Imperial Oil, the California Standard Company and Shell Oil of Canada had eight geophysical crews working in Manitoba. The eight wells drilled that year were all abandoned as dry holes, but perseverance started to pay off as oil shows began to appear.

1951 — The California Standard Oil Company discovered the first commercial oil-producing well in North America's prolific Williston Basin. The well, California Standard Daly, was located 15 kilometres west of Virden. It began production

Testing natural gas flow near Manitou, 1933.

February 1, 1951. Over an eight-month period it produced 135 cubic metres of oil from the Mississippian Lodgepole Formation. Before year end, development wells drilled around this discovery well confirmed the existence of Manitoba's first major oil field, the Daly Field.

1952 — Of 73 wells drilled, approximately half were development wells located in the Daly Field.

— Over 400 000 hectares were granted as exploration reservations. Major freehold leasing programs commenced.

— The Tilston, Waskada and Lulu Lake Fields were discovered.

1953 — After drilling 14 unsuccessful wells for the Anglo Canadian Oil Company, Hart and George McIvor decided to drill on their grandfather's old farmstead. Their efforts produced the province's first flowing oil well and led to the discovery of the Virden Field. The well located about 2 kilometres northwest of the Town of Virden, initially produced 21 cubic metres of oil per day.

— The Whitewater Field was discovered and the first known waterflood project in Canada was initiated in the Daly Field.

1954 — Of 310 wells drilled, 290 were completed as oil producers while 144 wells were classified as wildcat wells.

— The Pierson Field was discovered.

— An Act was passed which enabled the provincial government to assess taxes on producing privately-owned mineral rights.

— Manitoba's first crude oil pipeline gathering system was constructed in the Daly Field by the Northern Development Company.

1955 — A total of 554 wells produced 658 789 cubic metres of oil.

— Three hundred and fifty-nine wells were completed, setting an all time record for wells drilled in a single year.

— The West Butler Field was discovered in November.

1957 — Annual oil production reached 967 701 cubic metres, the highest level recorded to that date, with the Virden and Daly Fields producing 90% of this volume.

— The Kirkella Field was discovered.

1962 — Waterflooding was initiated in the Virden Field.

— As geophysical activity increased, the search for oil and gas extended to the onshore area of Hudson Bay, where Sogepet Limited received 12 exploration permits covering 200 000 hectares.

— The Souris-Hartney Field was discovered.

— Two 81 000 hectare helium exploration reservations in the Interlake area were granted to Hemisphere Helium Corporation. No commercial quantities were found.

1963 — Annual oil production bottomed out at 599 276 cubic metres, before beginning to increase due to the initial effects of the waterflood in the Virden Field.

1964 — Oil exploration and development continued to show a marked increase, with drilling activity approaching twice that of the previous year (107 wells vs 56 wells). Production reached 701 909 cubic metres, an increase of 17% over the 1963 level.

— The first oil shale reservation in Manitoba was granted to a consortium of Sun Oil Company, Aquitane Company of Canada and the Atlantic Refining Company. Low oil concentrations and high development costs halted the program.

1965 — Oil production increased to 786 034 cubic metres, up 12% from 1964. Much of the increase was attributed to the continued expansion and success of waterflood projects.

1966 — The first exploratory drilling in the Hudson Bay on-shore area took place in September, when Aquitaine drilled to a depth of 896 metres, bottoming in the Precambrian. The stratigraphic information forecast better prospects for finding oil in the deeper portion of the Hudson Bay Basin, particularly offshore.

— Provincial oil production continued to increase.

— Bralorne Petroleums headed a consortium of five companies which was granted a 243 000 hectare helium exploration reservation in the Interlake area. Test holes revealed no commercial quantities of helium.

1967 — The original Waskada Field was further developed with a new Mississippian pool discovery by International Hydrocarbons Ltd.

1968 — Oil production reached 986 023 cubic metres, the highest annual level ever attained in Manitoba's oil patch.

— Exploration and development activity increased in the Waskada and Pierson areas.

— A second well was drilled, on-shore near Hudson Bay, by Houston Oils Limited.

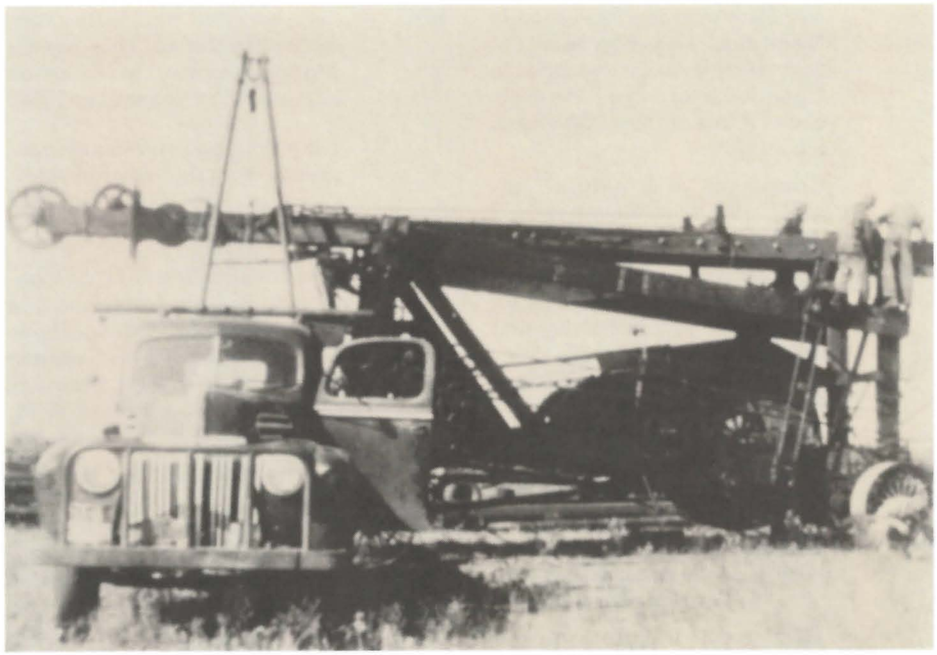
1969 — Thirty-eight structural test holes were drilled to evaluate the Ashville (Cretaceous) and Nisku (Devonian) Formations in the Brandon-Spruce Woods area.

— Aquitaine drilled the first off-shore well in Hudson Bay, Aquitane et al Hudson Walrus A-71, to a depth of 1 197 metres. The well, located approximately 225 kilometres east of Churchill, was later abandoned as a dry hole.

1970 — A third on-shore well was drilled just north of York Factory, near Hudson Bay, by Merland Explorations Ltd.

1974 — Asamera, in partnership with the provincial government, began a 25 well basement test drilling program in southwestern Manitoba.

— Provincial Crown oil royalties totalled $1.6 million, an increase of 300% from 1973. Freehold mineral taxes increased 3,500%, to $5.2 million. The increases resulted from higher crude oil prices and substantially increased provincial royalty and tax rates.



'Spudder' used in beginning a well prior to cable tool rig up.

— Two more unsuccessful wells were drilled off-shore in Hudson Bay by Aquitane Company of Canada.

1975 — The Gas Storage and Allocation Act, which provides for underground storage of natural gas, was introduced. The Oil and Natural Gas Conservation Board issued a permit to Daly Gas Storage Ltd, a subsidiary of Greater Winnipeg Gas Company, to evaluate the feasibility of an underground natural gas storage facility in the West Virden area.

1976 — Three small seismic surveys were conducted by Chevron Standard Limited, Francana Oil and Gas Limited and Shell Canada Resources Limited. This was the first petroleum-related geophysical work in Manitoba since 1969.

1977 — Interest in Manitoba's oil patch grew with the rise in oil prices and Shell Oil Company's announcement of a deep oil discovery in North Dakota, 40 kilometres southwest of the Manitoba-Saskatchewan border. Freehold oil leasing and geophysical activity increased significantly.

1979 — Manitoba's first Crown oil lease sale in over seven years generated more than $975,000 in revenue. Crown oil royalties, freehold oil taxes and lease sale revenue generated approximately $12 million for the province.

— Ten geophysical programs were licensed.

1980 — Omega Hydrocarbons Ltd. successfully recompleted a producing oil well in the Waskada Field, obtaining the first commercial production from a non-Mississippian formation in Manitoba. This was also the first recorded production in Canada from the Jurassic Lower Amaranth, or Spearfish Formation.

- Crown oil and natural gas lease sales generated over $1.9 million.

1981 — The discovery of the Lower Amaranth formation at Waskada fueled Manitoba's second 'oil boom', with 67 wells completed — an increase of 120% from 1980. Of the 67 wells drilled, 47 were completed as potential oil producers.

- Provincial oil production reached an all-time low of 542 695 cubic metres, having declined at approximately 4% per year since 1969.

- The federal government granted an exploration agreement to a consortium, with Canadian Occidental as operator, to carry out new exploration in Hudson Bay.

1982 — One hundred and ninety-five wells were drilled in Manitoba, the highest number in 24 years. Most of the activity resulted from the development of the Waskada Field.

- Manitoba's annual oil production increased for the first time since 1968 to 582 283 cubic metres, a 7% increase over 1981.

- The value of oil produced rose 57%, to over $100 million, due to increased production and higher oil prices.

- Remaining established crude oil reserves increased 6% to 8.2 million cubic metres.

- New seismic operations were conducted offshore in Hudson Bay.

1983 — Two hundred and forty-seven wells were drilled. This was the highest number in 27 years and a 27% increase over 1982.

- Oil production continued to increase for the second consecutive year reaching 738 300 cubic metres.

- The Oil and Natural Gas Conservation Board approved a plan by Omega Hydrocarbons Ltd. to construct a $3.5 million natural gas liquids recovery plant in the Waskada oil field, the first of its kind in Manitoba.

- The Surface Rights Act was passed by the Legislature on June 21, 1983. A six-member Surface Rights Board was appointed to arbitrate disputes between the petroleum industry and landowners in exploration and development operations.

1984 — Production increased for the third year in a row, reaching 793 284 cubic metres.

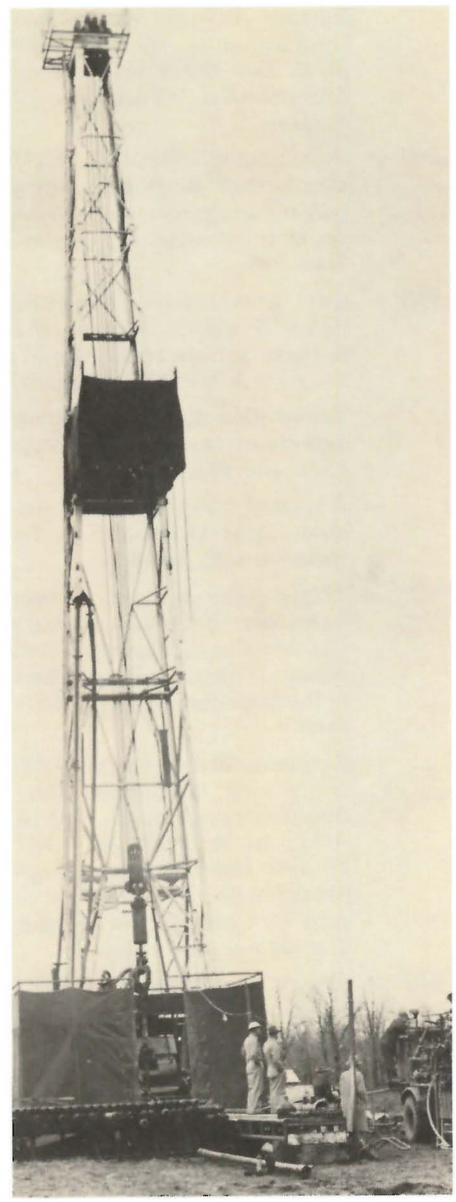
- Two hundred and forty-six wells were drilled.

- The October land sale established an all time record for an average bonus price per hectare of $1,411 for a 128 hectare parcel in the Lulu Lake area.

- The Waskada Gas Plant began operating in March.

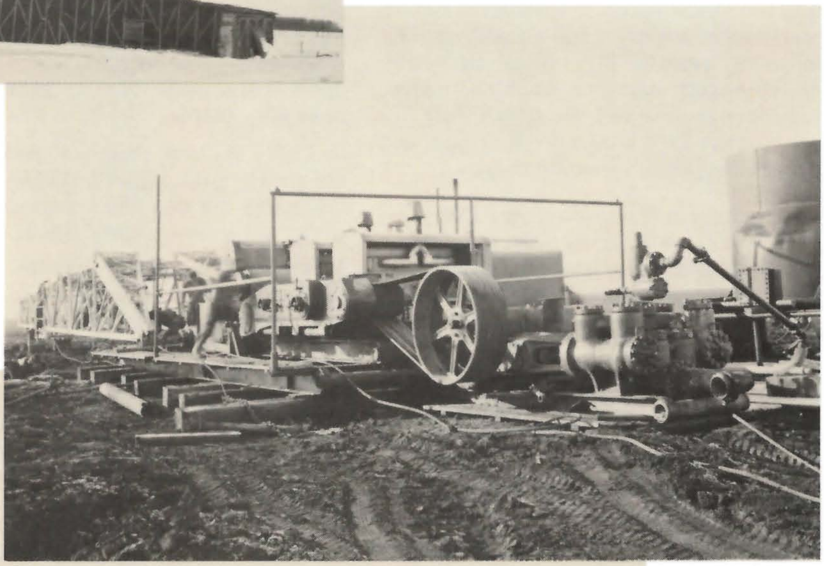
- The Oil and Natural Gas Conservation Board approved a plan to re-inject dry processed gas into the Waskada Field to aid in an enhanced oil recovery project.

- Inter City Gas Corporation's construction of the 90 kilometre Waskada Crude Oil Pipe Line, was completed in December.



Rotary drill rigs replaced the old cable tool rigs allowing drillers to drill deeper and more quickly.

Ross well located near Grandview, Manitoba, 1927.



Preparing to 'rig up' rotary drill - 1950s.

Drill crew unloading drilling mud.

Oil In Manitoba

Early Exploration

In 1873, the Geological Survey of Canada drilled wells in Manitoba near the proposed Canadian Pacific Railway line, to obtain information on ground water supplies, coal and other mineral deposits.

Petroleum exploration in Manitoba dates from April 1877, when the Manitoba Oil Company received a charter to explore for oil. That year, the company drilled a well in the Vermillion River Valley, about 20 kilometres southwest of Dauphin. The well reached a depth of 89 metres before mechanical problems halted drilling. The following year, a 226 metre hole was drilled a short distance down the valley, reaching Devonian formations (See fig. 1). Neither well showed oil or gas and subsequent drilling was cancelled.

Most drilling in Manitoba before 1900 was in search of water, with geological information of secondary importance. Prior to 1886 the Canadian Pacific Railway drilled a 316 metre well at Rosenfeld. In 1888, the town of Deloraine completed a 592 metre well. During 1889 and 1890, the town of Morden drilled a 183 metre well. All three wells provided important geological information.

Between 1900 and 1930, Manitoba granted several charters to companies searching for oil and gas. The charters were eventually cancelled with only a few wells drilled.

The first producing gas wells in the province were in the Waskada-Melita district. In 1912, local residents drilled four wells to depths of 60-75 metres, encountering shallow gas in the 100 kilopascals pressure range. Each well supplied enough gas to operate a small cookstove and light one home. Later, another five shallow gas wells were drilled in the same area, but none of the wells were considered commercially viable.

In 1921, the search for oil and gas continued when the Agassiz Oil Development Company drilled an unsuccessful 97 metre well near Ochre River.

Manitoba's oil patch has its share of stories about con men and 'get rich quick' artists. In early 1927, a controversial case of alleged oil shows arose over a 209 metre well in the Grandview district. Reports circulated that oil had been discovered. Hopes for a gusher died when it was revealed that the promoters had brought oil from town in barrels and poured it down the well.

In 1929 and 1930, the Dauphin Oil Company drilled a 396 metre well just southeast of Dauphin in an unsuccesful search for oil.

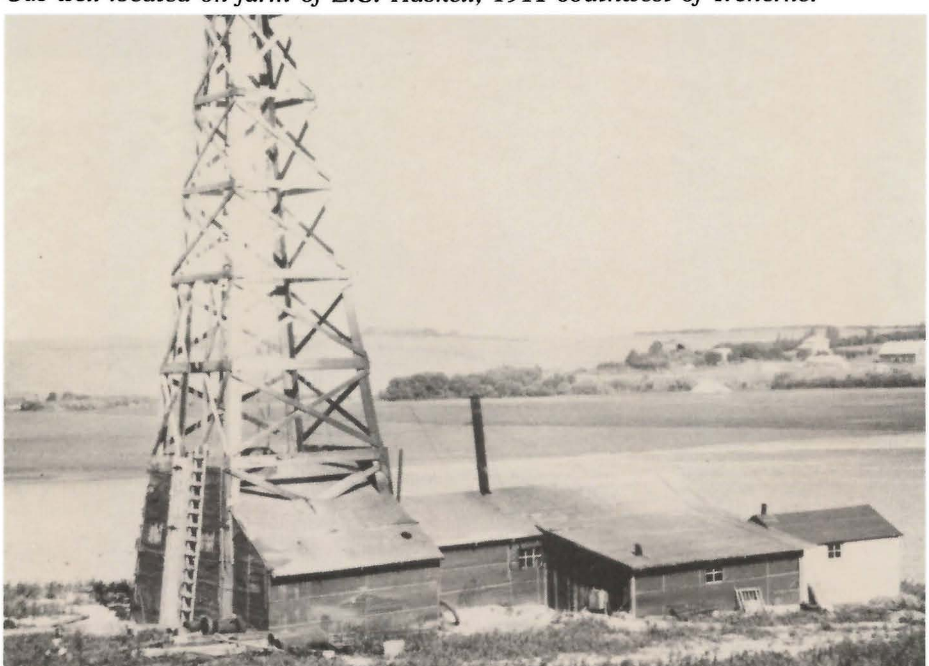
In 1930, the nine shallow wells in the Waskada-Melita districts produced an estimated 17 000 cubic metres of gas. All other wells in the province were plugged and abandoned.

The 1930's saw renewed interest in oil and gas exploration, with wells drilled into deeper formations in the Paleozoic (See figure 1). In 1931-32, Commonwealth Petroleum drilled a 366 metre and a 706 metre well south of Manitou for the Pembina Valley Gas and Oil Corporation. Both wells were abandoned as dry holes.

In addition to this oil and gas exploration, Canadian Industries Limited drilled two wells, one in 1933-34 and the second in 1936, in search of salt deposits. The first, in the Thunder Hills structure north of the Duck Mountain Forest Reserve, reached 131 metres. The second well, near the town of Neepawa, discovered salt brine at 455 metres. Canadian Industries Limited, which developed the deposit, operated a salt plant in Neepawa from 1935 until the well was abandoned in 1970. The plant produced approximately 23 000 metric tons of salt per year.

Other exploration activity during the late 1930s involved Lisgas Oil and Gas Company, Craydon Development Company,

Gas well located on farm of E.C. Haskell, 1911 southwest of Treherne.



Brandon Coutts No. 1 well, 1949 with Anglo Canadian Oil Refinery in background.

AGE Millions of years before present	ERA	PERIOD	EPOCH	FORMATION	MEMBER	MAX. THICK (m)	BASIC LITHOLOGY
	CENOZOIC	QUATERNARY	RECENT				TOP SOIL, DUNE SANDS
			PLEISTOCENE	GLACIAL DRIFT		140	CLAY, SAND, GRAVEL, BOULDERS, PEAT
		TERTIARY	PLIOCENE				
			MIOCENE				
			OLIGOCENE				
50			EOCENE				
			PALEOCENE	TURTLE MTN.	PEACE GARDEN GOODLANDS	120	SHALE, CLAY AND SAND. LIGNITE BEDS LOCATED ONLY IN TURTLE MOUNTAIN
65	MESOZOIC	CRETACEOUS	UPPER CRETACEOUS	BOISSEVAIN		30	SAND AND SANDSTONE, GREENISH GREY, LOCATED ONLY IN TURTLE MOUNTAIN
				RIDING MTN.	COULTER ODANAH MILLWOOD	310	GREYSHALES—NON-CALC. LOCAL IRONSTONE BENTONITE NEAR BASE, GAS FOUND
				VERMILION RIVER	PEMBINA	155	SHALE DARK GREY CARBONACEOUS NON-CAL. BENTONITE BANDS
					BOYNE		SHALE GREY SPECKLED CALC. BENTONITIC SLIGHTLY PETROLIFEROUS
					MORDEN		SHALE DARK GREY NON-CALC. CONCRETIONS, LOCAL AND SILT
				FAVEL		40	GREY SHALE WITH HEAVY CALCAREOUS SPECKS BANDS LIMTESTONE AND BENTONITE
100				ASHVILLE		115	SHALE, DARK GREY, NON-CALC. SILTY
			LOWER CRETACEOUS	ASHVILLE SAND			"SAND ZONE" 27m F.G. QTZ. S. OR SS.
				SWAN RIVER		75	SANDSTONE AND SAND, QTZ. PYRITIC SHALE—GREY, NON-CALC
150		JURASSIC	UPPER JURASSIC	WASKADA		200	BANDED-GREEN SHALE AND CALC. SANDSTONE
				MELITA			BANDS OF LIMESTONE, VARI-COLORED SHALE
			MIDDLE JURASSIC	RESTON		45	LIMESTONE, BUFF, AND SHALES, GREY
				AMARANTH	UPPER: EVAPORITE	45	WHITE ANHYDRITE AND/OR GYPSUM AND BANDED DOLOMITE AND SHALE
					LOWER: RED BEDS	40	RED SHALE TO SILTSTONE-DOLOMITIC OIL PRODUCING
200		TRIASSIC	(?)	ST. MARTIN COMPLEX		300	CARBONATE BRECCIA, TRACHYANDESITE (CRYPTO-EXPLOSION STRUCTURE)
	PALEOZOIC	PERMIAM					
250		PENNSYLVANIAN					
300		MISSISSIPPIAN		MADISON GROUP: CHARLES		20	MASSIVE ANHYDRITE AND DOLOMITE
				MADISON GROUP: MISSION CANYON	MC—5 MC—4 MC—3 MC—2 MC—1	120	LIMESTONE—LIGHT BUFF, OOLITIC. FOSS. FRAG., CHERTY, BANDS SHALE AND ANHYDRITE, OIL PRODUCING
				MADISON GROUP: LODGEPOLE	FLOSSIE LAKE WHITEWATER LAKE VIRDEN SCALLION / ROUTLEDGE	185	LIMESTONE & ARG. LIMESTONE LIGHT BROWN AND REDDISH MOTTLED ZONES OF SHALEY, OOLITIC, CRINOIDAL & CHERTY. OIL PRODUCING
350				BAKKEN	UPPER MIDDLE LOWER	20	2 BLACK SHALE ZONES - SEPARATED BY SILTSTONE OIL SHOW HIGH R.A. KICK
		DEVONIAN		QU APPELLE GROUP: LYLETON		35	RED SILTSTONE AND SHALE DOLOMITIC.
				SASK. GROUP: NISKU		40	LIMESTONE & DOLOMITE, YELLOW-GREY FOSS. POROUS, SOME ANHYD.
				SASK. GROUP: DUPEROW		170	LIMESTONE & DOLOMITE. ARG. & ANHYDRITIC IN PLACES
				MAN. GROUP: SOURIS RIVER 1-ST RED		120	CYCLICAL SHALE, LIMESTONE & DOLOMITE ANHYDRITE
				MAN. GROUP: DAWSON BAY 2-ND RED		65	LIMESTONE & DOLOMITE, POROUS, ANHYDRITE—LOCAL SHALE RED & GREEN
				ELK POINT G.: PRAIRIE EVAP.		120	SALT POTASH & ANHYDRITE, DOLOMITE INTER—BEDDED
				ELK POINT G.: WINNIPEGOSIS		75	DOLOMITE, LIGHT YELLOWISH BROWN REEFY
				ELK POINT G.: ELM POINT			LIMESTONE—FOSS. HIGH CALCIUM
400				ELK POINT G.: ASHERN		12	DOLOMITE AND SHALE—BRICK RED
		SILURIAN		INTERLAKE GROUP		135	DOLOMITE YELLOWISH—ORANGE TO GREYISH—YELLOW FOSS. SILTY ZONES
		ORDOVICIAN		STONEWALL		15	DOLOSTONE, GREYISH YELLOW, BEDDED
				STONY MOUNTAIN	WILLIAMS GUNTON	30	DOLOMITE—YELLOWISH—GREY SHALEY
					PENITENTIARY		DOLOMITE—DUSKY—YELLOW FOSS.
					GUNN	20	SHALE RED—GREEN FOSS. LIMESTONE BANDS
450				RED RIVER	FORT GARRY SELKIRK CATHEAD DOG HEAD	170	DOLOMITIC LIMESTONE, MOTTLED AND DOLOMITE
				WINNIPEG	UPPER UNIT	60	SHALE, GREEN, WAXY, SANDSTONE INTERBEDDED
500					SANDSTONE		SAND, SANDSTONE, QUARTZOSE
550		CAMBRIAN		DEADWOOD		60	SAND, BLACK TO GREEN—GREY WAXY, GLAUCONITIC SILTSTONE & SHALE, GREEN—GREY TO BLACK, VERY EDGE OF S.W. MANITOBA ONLY.
	PRECAMBRIAN						ACID & BASIC CRYSTALLINES & METAMORPHICS

Figure 1 Geological formations in Manitoba.

the Waywasecapow Oil Syndicate and Gates Petroleum. These companies drilled wells in the Purves, Manitou, Birdtail, and Pilot Mound areas.

Drilling resumed in 1944-45, when the Manitoba and Saskatchewan Oil and Gas Development Syndicate drilled the Portage la Prairie No. 1 and Gilbert Plains No. 1 wells to depths of 469 and 418 metres. But it was only in the late 1940's that the first truly concentrated search for oil and gas began in Manitoba.

In 1947, the California Standard Company established the Brandon Exploration Company as a subsidiary. The provincial government later issued Oil and Natural Gas Reservation Nos. 1-9, covering several thousand hectares, to the Brandon Exploration Company. The company carried out the province's first detailed geophysical survey, covering nearly all of southwestern Manitoba.

The same year, the Langford Oil Syndicate drilled the Langford No. 1 well, eight kilometres east of Neepawa, down to the Precambrian at 765 m (See fig. 1). Although no oil or natural gas was discovered, rock samples from the Precambian confirmed the existence of an iron ore deposit in the area .

In 1949, two geophysical companies operated in Manitoba. In that year, the Souris Valley Oil Company drilled two wells near Lyleton. The Gordon White No. 1 well was drilled into the Devonian Winnipegosis Formation at 1 573 metres (See fig. 1). The deepest well in Manitoba to that date, it established the presence of Mississippian limestones. The second well, the Robert Moore No. 1, set a new depth record of 1 838 metres. Although no productive formations were discovered, these two wells plus two shallower ones set a new total annual drilling record of 3 875 metres.

In 1950, Imperial Oil, California Standard and Shell Oil of Canada operated eight geophysical crews in Manitoba. California Standard drilled the 1 566 metre California Standard Hartney well and the Souris Valley Oil Company drilled the Downey No. 1 well, near Lyleton, to a depth of 984 metres. Drilling on the latter was suspended for the winter because of mechanical difficulties. Also that year, the Manitoba Oil and Gas Syndicate drilled the Brandon Coutts No. 2 well to 1 087 metres. All eight wells completed in 1950 were plugged and abandoned as dry holes, but perseverance started to pay off as oil shows appeared. Manitoba was on the verge of its first oil boom.

In addition to drilling activity, 1950 saw the construction of the Interprovincial crude oil pipe line from Edmonton, Alberta to Superior, Wisconsin. The Winnipeg Pipe Line Company a subsidiary of Imperial Oil, built a branch line from Gretna to Winnipeg which supplied crude oil to the Imperial East St. Paul and North Star St. Boniface refineries.

First Oil Discovery

After spending several years and $10 million searching for oil and gas, the California Standard Oil Company made the first commercial oil discovery in Manitoba. The California Standard Daly well, 15 kilometres west of Virden, had been drilled to the Precambrian at a depth of 1 636 metres by November 16, 1950. After extensive tests, the well was plugged back to the Mississippian formation at 762 metres. It began producing on February 1, 1951.

Over an eight-month period the well produced 135 cubic metres of oil from the Mississippian Lodgepole Formation (671 metres — 712 metres) (See fig. 1). This was the first commercial oil well in North America's prolific Williston Basin. The Basin now yields production in Manitoba, Saskatchewan, North Dakota, South Dakota and Montana.

Before the end of the year, development wells drilled around the discovery well confirmed the existence of Manitoba's first major oil field, the Daly Field. By December 31, 1984, this field had produced approximately 3.65 million cubic metres or 23 million barrels of oil.

Service crew making adjustments on the casing head or 'Christmas Tree' of a pumping well in the Daly Field.

1950s Oil Boom

The California Standard discovery touched off a surge in drilling activity in Manitoba which continued throughout the 1950s. By the end of 1951 six of the eighteen wells drilled were completed as potential oil wells. These drilling results created a rush to lease oil and gas rights in southwestern Manitoba, from the Saskatchewan border to Portage la Prairie.

Continued exploration revealed three fields in 1952, Tilston, Waskada and Lulu Lake. Four more fields were discovered from 1953 to 1955. These included Virden and Whitewater in 1953, Pierson in 1954, and West Butler in 1955. Three new fields were developed in the following years as emphasis shifted from exploration to development.

Many stories were associated with the oil boom. In 1953, the Anglo Canadian Oil Company drilled 14 unsuccessful wells using the McIvor Drilling Company as their contractor. During a lull in activity, the two brothers that owned the Alberta drilling company, Hart and George McIvor, struck upon the idea of drilling on their grandfather's old farmstead. Just two kilometres northwest of the Town of Virden, the two native Manitobans drilled the first flowing oil well in the province. This became the discovery well of the Virden Field, and initially produced 21 cubic metres, or 130 barrels, per day.

Virden was soon proclaimed the 'Oil Capital of Manitoba'. At one point, the townsite contained 16 producing wells, including one in the middle of a playground.

As conventional primary oil recovery methods became less effective, the industry introduced Canada's first known waterflood pressure maintenance scheme into Manitoba's Daly Field in July 1953.

As an extension of successful petrolem development, the Northern Development Company constructed a crude oil pipeline and gathering system which began operating in January, 1954. The pipeline serviced the Daly Field, transporting oil to the Interprovincial Pipe Line pumping station at Cromer, Manitoba. Trans-Prairie Pipelines acquired the system in August, 1954 for approximately $500,000, and spent another $650,000 over the next two years connecting it to the Virden Field.

During the 1950s oil boom, two petroleum-related taxes were introduced. In 1954, the province introduced The Mineral Taxation Act, levied on producing, privately owned, oil and natural gas rights. This was followed in 1955 by the Oil Well Property Tax, which provided municipalities with revenue from petroleum facilities.

1960's — Oil Development Continues

Development work dominated Manitoba's oil patch during the 1960's. Waterflood pressure maintenance projects in the Virden Field helped to increase annual oil production, which peaked at 986 113 cubic metres, or 6.2 million barrels, in 1968. Another highlight of the 1960's was the development of the Waskada Field by International Hydrocarbons, which discovered a new Mississippian pool in January 1967. In the following twelve months, International Hydrocarbons, later known as Omega Hydrocarbons, drilled six more wells in the area, five of them producers. In 1968, other companies brought five more Waskada area wells into production.

The 1970's

The first half of the 1970's saw little oil activity in Manitoba. However, with the Organization of Petroleum Exporting Countries (OPEC) embargo in 1973 raising oil prices, and with improvements in exploration technology, the industry again actively looked at Manitoba.

An oil discovery by Shell Oil in 1977 in the deep Cambrian Formation in North Dakota, just 40 kilometres southwest of the Manitoba-Saskatchewan border, further stimulated interest in Manitoba. Various companies carried out geophysical exploration and freehold leasing programs. Exploration companies drilled from 10 to 25 wells a year in Manitoba during the 70s. The major new development was in the west Kirkella Field, where Rideau Petroleums discovered a new oil pool in 1978.

Rotary drill rig near Waskada, Manitoba, 1984.

1980's Oil Boom

After the uneventful 1970's, Manitoba's petroleum industry began the 1980's with a much-needed 'shot in the arm'. In 1980, Omega Hydrocarbons used the recompletion of a producing Mississippian well in the Waskada area to test the potential of the Jurassic Lower Amaranth Formation, known as the Spearfish Formation in North Dakota. After unsuccessfully swabbing the well for oil, the service crew left for the weekend, leaving the service rig in place. On Monday morning the crew returned to find the wellbore full of oil. The well was successfully recompleted in June of 1980, producing the first commercial oil from a non-Mississippian formation in Manitoba.

An extensive development program determined the size of the reservoir. By December 31, 1984 there were 313 producing wells at Waskada. Of these, 259 wells were completed in the Lower Amaranth Formation and 54 wells were completed from pools in the underlying Mississippian Mission Canyon Formation. This activity has stimulated Manitoba's oil industry to a point where it is aptly termed 'Manitoba's second oil boom'.

Petroleum exploration and development activity increased dramatically throughout Manitoba during 1982 and 1983, reaching the highest level in 25 years. Only in the four years of the mid-1950's oil boom had Manitoba's 'oil patch' seen such activity. Activity levels stayed high during 1984, with 246 wells drilled — compared with 247 in 1983, 195 in 1982 and 62 in 1981. Of the wells drilled in 1984, 218 were completed as potential oil wells — an 89% success rate!

The Waskada oil play takes much of the credit for this 'second boom' in Manitoba. During 1983 and 1984, approximately 48 percent of Manitoba's oil wells were drilled within 10 kilometres of Waskada.

Increased production at Waskada led to Manitoba's first natural gas liquids recovery plant, built at a cost of $3.5 million. The Omega Hydrocarbons plant went into operation in March, 1984. It recovers propane, butane and condensate by-products from gas produced in association with oil from Waskada. After processing, the 'dry' gas is injected back into the oil reservoir as part of a gas flood pressure maintenance operation.

Development of the Waskada Field also stimulated Inter City Gas Corporation's 1984 construction of a 90 kilometre, crude oil pipeline. The line, costing an estimated $5.0 million, is owned by ICG, Omega Hydrocarbons and Manitoba Oil and Gas Corporation. Operated by ICG, the 15 centimetre diameter line began moving crude oil north from Waskada to the Interprovincial Pipeline pumping terminal at Cromer, Manitoba in January, 1985.

Although much of Manitoba's increased oil activity has been in the Waskada Field, the Daly Field has also experienced a significant increase in development drilling, beginning in 1983. Other areas are stimulating increased interest, with several companies continuing to actively explore in the Oak Lake, St Lazare, Tilston, Virden and Pierson areas.

Hudson Bay Basin

During the 1966-67 season, Aquitane Company of Canada drilled the first exploratory well in Manitoba's Hudson Bay basin. The Sogepet Aquitane Kaskatama Prov. No. 1 well, located onshore approximately 300 kilometres southeast of Churchill, reached the Precambrian at 896 metres. In 1968, Houston Oils drilled another onshore well to a depth of 648 metres. In 1970, Merland Explorations Ltd. completed a 427 metre well just north of York Factory. Cores from the wells yielded valuable geological information.

Aquitane completed three offshore wells, more than 300 kilometres east of Churchill, in approximately 160 metres of water. The first well, Aquitane et al Hudson Walrus A-71, was drilled to 1 197 metres in 1969, but was later abandoned after reaching the middle Silurian formation (See figure 1). In 1974, two additional offshore wells reached the Precambrian formation at approximately 1 600 metres without finding commercial quantities of oil.

The Hudson Bay area experienced relatively little exploration work between 1974 and 1982. However, in 1981 the federal government granted oil and gas exploration rights covering 28.9 million hectares to a consortium comprised of Canadian Occidental Petroleum, Ontario Energy Corporation and Sogepet Ltd. Exploration plans called for 5 000 kilometres of offshore seismic work in 1982, followed by the commencement of drilling in 1986.

The Canada Oil and Gas Lands Administration approved a similar program by ICG Resources which conducted an extensive 3 000 kilometre seismic survey of the mid-Hudson Bay region in 1983. ICG's partners in this venture include Petro-Canada and Sogepet Ltd.

Promising seismac data led to a planned two well exploratory drilling program for the summer of 1985.

Helium and Oil Shale Exploration

In addition to the oil exploration and development work of the 1960's, three interesting ventures focussed on the search for helium and oil shales.

In 1962, Hemisphere Helium Corporation received two 81 000 hectare helium exploration reservations in the Interlake area, near Lundar. Later that year, Peerless Canadian Exploration joined Hemisphere in a joint helium exploration venture. Starting with 30 year old records which indicated a marginal helium find in a 30 metre well, the companies conducted a follow-up drilling program, without success. In 1966, Bralorne Petroleums headed a consortium of five companies receiving a 243 000 hectare reservation, also in the Interlake area. Five test holes again revealed no commercial quantities of helium.

In 1964, the Province granted the first oil shale reservations in Manitoba to Sun Oil Company (now Suncor Inc.), Aquitane Company of Canada, and the Atlantic Refining Company. Sun Oil's reservations extended north of Riding Mountain

WODECO II offshore drilling barge in Hudson Bay 1969.

Imperial Oil Refinery located in East St. Paul.

National Park up to and including the Porcupine Forest Reserve. Aquitane's holdings spread east and south of Riding Mountain National Park, while the Atlantic Refining Company's reservation extended south of Portage la Prairie to the Canada-U.S.A. border and west to just north of Spruce Woods Forest Reserve. Low oil concentrations and high development costs prevented the oil shale program from continuing.

Manitoba's Petroleum Refining History

Even before the discovery of oil in Manitoba, plentiful oil supplies from western Canada encouraged the construction of oil refineries in Winnipeg. By the 1950s the majority of oil products consumed in the province were refined locally. The price for petroleum products in Manitoba dropped as long rail hauls were eliminated . Opening refineries in the Province meant substantial savings for Manitoba consumers, and encouraged local business development.

North Star Oil built the first refinery in Manitoba in 1927, in St. Boniface (on Scott Block). In 1949, construction began on a new, expanded refinery which, when completed in 1955, had a rated capacity of 1 907 cubic metres/day. Crude oil refined here was delivered by pipeline from Alberta. In 1961 Shell Canada acquired North Star Oil. A Radio Oils refinery, built in East Kildonan in 1930, received crude oil by rail from East Texas, Alabama and Montana. With refining capacity limited to 79 cubic metres/day, the refinery operated until 1960. In 1938, Anglo Canadian Oil built a refinery in Brandon with a crude capacity rate of 509 cubic metres/day, which used crude oil from Alberta. In 1965 the Company changed its name to BA Petroleum, and in early 1969 Gulf Oil took over the refinery, closing it in April, 1969.

Four refineries operated in Manitoba during the 1950s — Radio Oils (East Kildonan), Imperial Oil Limited (East St. Paul), North Star Oil Co. (St. Boniface) and Anglo-Canadian Oil (Brandon) — with a combined output of 5 244 cubic metres/day.

The Imperial Oil Refinery was completed in 1951, with a crude oil refining capacity of 1 716 cubic metres/day. The refinery included the first fluid catalytic cracking unit in Western Canada. This refining process utilized the crude oil feedstock more efficiently in the production of high octane gasoline, gases and heating oils. In 1977, after 26 years of operation, the refinery shut down, converting to a petroleum products pipeline distribution terminal.

There are no refineries operating in Manitoba today. The Shell refinery which closed its doors in 1983 was the last refinery in Manitoba — a victim of surplus refining capacity and increased environmental standards in the country. The site is now used as a petroleum products pipeline distribution terminal. The Winnipeg Pipe Line from Gretna, Manitoba connects both the Shell and Imperial products terminals with the Interprovincial Pipe Line from Edmonton.

The Origin of Oil and Gas

How Oil and Gas Were Formed

Basic to modern life, crude oil and gas are still a mystery to most of us. What are they? Where do they come from? Where are they found?

Crude oil is a mixture of several fluid hydrocarbon compounds of organic origin. Natural gas, which is closely associated with crude oil, is a mixture of gases, such as methane, ethane, propane, butane and pentane. Most geologists believe hydrocarbons were formed from the remains of plants and animals.

The countless tiny plants and animals that make up oil and gas lived their brief lives in ancient seas or were washed down into the sea with silt from rivers or streams. Dying, they settled to the sea bottom, accumulating and mixing with other organic matter and sea floor sediments. This organic matter contained the essential building blocks of petroleum — hydrogen and carbon.

As new layers accumulated, their weight compressed earlier layers, eventually transforming them into rock. The pressure and resulting heat, along with chemical changes and the passing of time, converted these organic substances to minute bubbles of gas and liquid oil called 'petroleum' from the Latin words for rock, 'petra', and oil, 'oleum'.

Where Oil and Gas are Found

The pressure, heat, chemical changes and time which helped form petroleum also altered the associated sedimentary material. Known as 'source rocks', these are the compacted sediments which trapped the original organic tissue. Fine grained and relatively impervious, source rocks include shale, sandstone, carbonates, and evaporites. Shales are the most common sedimentary rock, often acting as source beds for hydrocarbons.

Oil and gas, however, are rarely found in large quantities in source rock. As pressure on the deeper sediment layers compressed the spaces between rock particles, oil and gas were squeezed into nearby layers of porous rock. It is here, in the more porous and permeable sedimentary rock, called reservoir rock, that large accumulations of oil and gas are found.

Sandstones are the most common type of reservoir rock. Younger sandstones are more porous than those which were buried deeper and subjected to greater compaction and cementing. Conglomerates, made of pebbles held together by clays or various cements, are also a common reservoir rock.

Carbonate rocks such as limestone and dolomite are another important group of sedimentary rocks which, along with sandstones, contain virtually all the world's petroleum reserves. Rocks of this type form Manitoba's most important reservoirs.

Lighter than the adjacent water, oil and gas migrate upward or laterally through tiny pore channels to more porous layers. Oil, gas and water continue to move through the reservoir rock until the migration is halted by a trapping mechanism or 'trap'. Traps form for numerous reasons such as earth movement and variations in rock types. Nevertheless, all traps consist of porous rock layers covered by non-porous rock (See figure 2). In the past, oil was thought to occur in underground lakes which were often referred to as 'pools' of oil. That portion of a trap containing oil is now more accurately referred to as a petroleum reservoir.

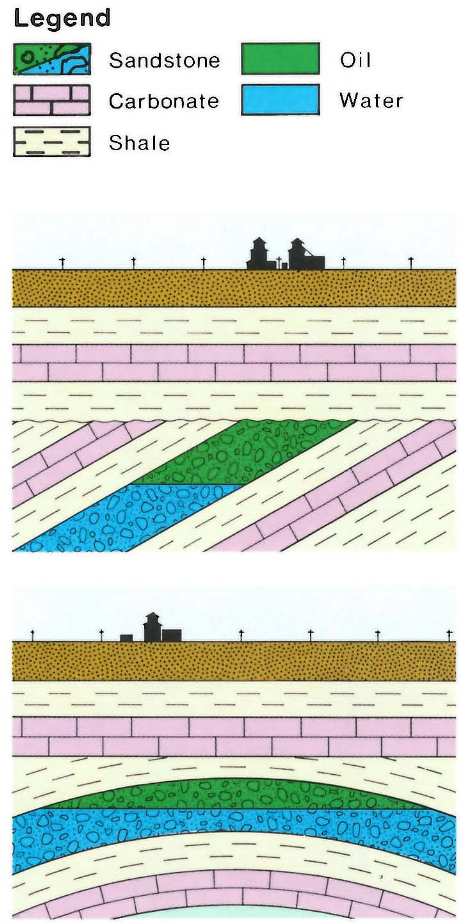


Figure 2
Common oil traps in Manitoba:

Top schematic shows stratigraphic trap.

Bottom schematic shows anticlinal trap.

Manitoba's Petroleum Geology Setting

Manitoba's sedimentary strata occur in two distinct regions. Our southwestern plains form part of the Williston Sedimentary Basin, while the Hudson Bay Lowlands lie on the western flank of the Hudson Bay Sedimentary Basin (See figure 3). Approximately 40% of Manitoba is underlain by sedimentary rock of the Paleozoic, Mesozoic, and Cenozoic ages.

Dominant rock types in the Paleozoic beds include limestones, dolomitic limestones and argillaceous limestones, but evaporites, sands and shales are also common, particularly toward the base of the Paleozoic. A major angular unconformity marks the contact between Paleozoic and Mesozoic beds in southwestern Manitoba (See figure 4).

Shale, silt and sand dominate the Mesozoic sequence above the unconformity. These Jurassic and Cretaceous beds dip more gently to the southwest than do the underlying Paleozoic beds. The total thickness of the sedimentary strata may exceed 2 300 metres in the southwest corner of the province.

Major reservoirs in southwestern Manitoba occur in carbonate rocks of the Mississippian Lodgepole and Mission Canyon Formations. These pools are found in reservoir rock below the Mississippian erosional surface, overlain by sedimen-

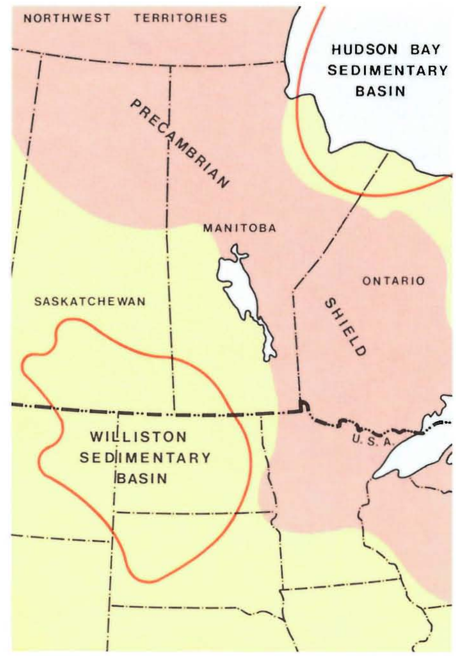


Figure 3 Williston and Hudson Bay Sedimentary Basins.

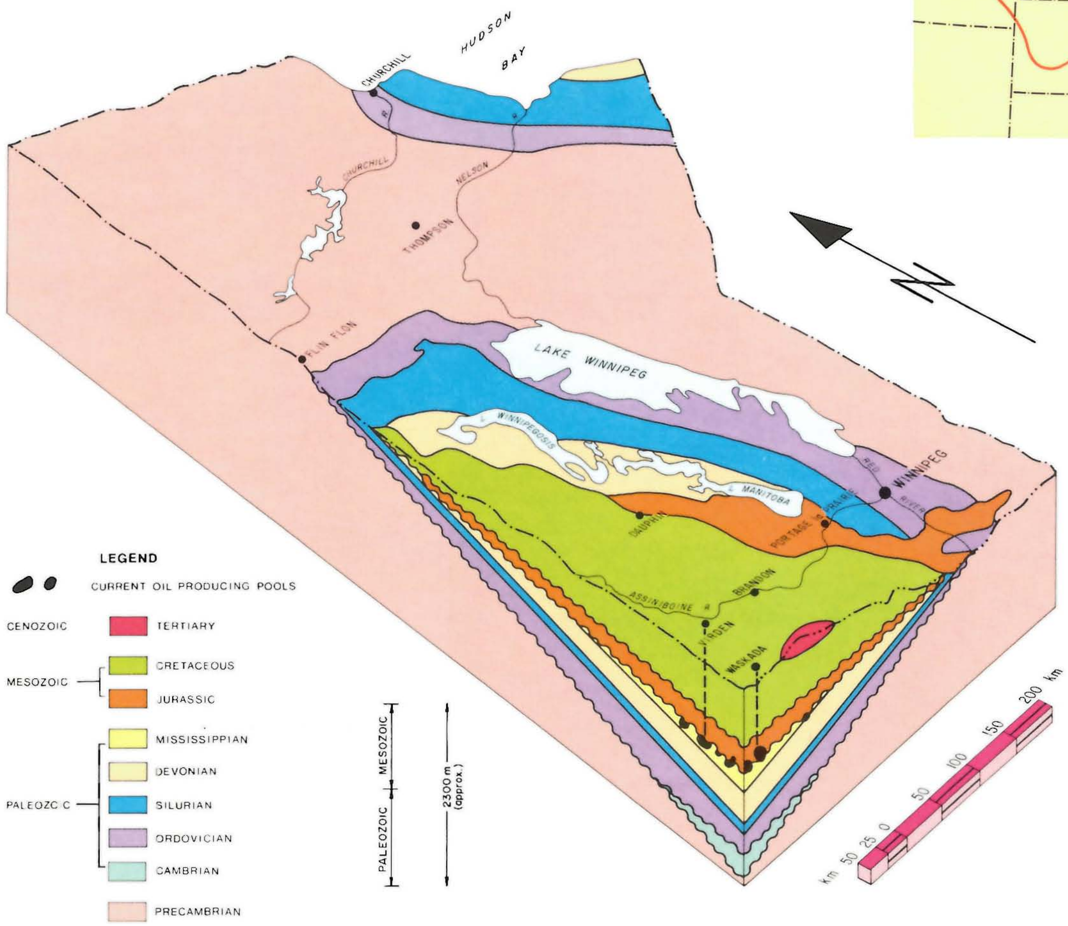


Figure 4 Stratigraphic cross section of southwestern Manitoba.

tary strata of Jurassic age. Potential zones of oil accumulation exist throughout Manitoba's southwestern sedimentary basin.

Until recently, Mississippian rock types produced all of Manitoba's oil. However, in June, 1980, a well in the Waskada Field proved capable of oil production from the Jurassic Lower Amaranth Formation. This productive horizon added significantly to provincial oil reserves. Seven deeper zones in the Devonian, Silurian, Ordovician and Cambrian Formation offer oil and natural gas potential, but they remain largely unexplored (see figure 5).

The Hudson Bay Lowland of northeastern Manitoba is the other potential oil producing area in the province, with potential reservoir beds in Ordovician and Silurian strata.

Pumping oil wells dot the Waskada area landscape.

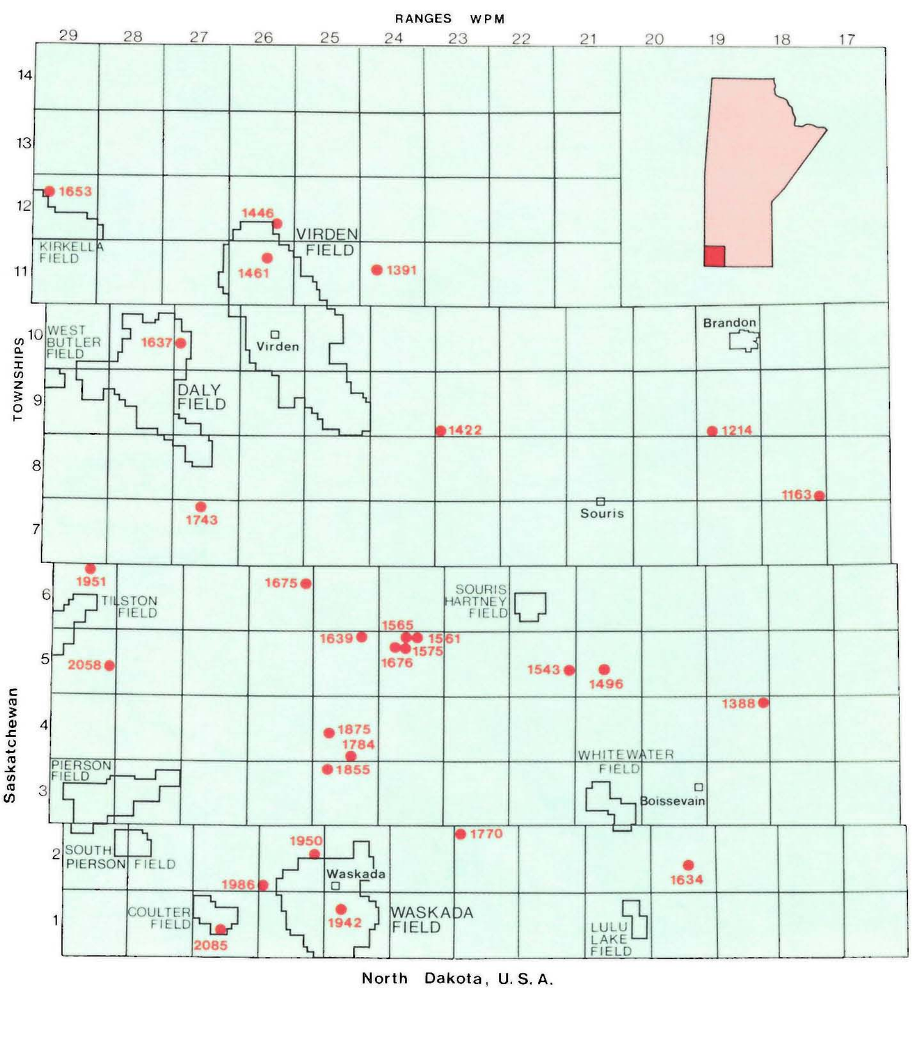


Figure 5
Deep test wells drilled to Precambrian in southwestern Manitoba.

Who Owns The Resource

Before January 11, 1890, settlers acquiring a homestead in Manitoba received a land title from the Dominion of Canada that included both surface and non-precious mineral rights. After 1890, the Crown retained mineral rights associated with land grants.

The transfer of natural resources from federal to provincial jurisdiction on October 1, 1930 vested these mineral rights in the province. The bulk of the province's oil lies in southwestern Manitoba, where most land grants included mineral rights. The Manitoba Government retains approximately 25% of the mineral rights in the area, with the remaining 75% held privately and commonly reerred to as 'freehold' mineral rights.

The following table illustrates land ownership variations in Manitoba.

Possible Land Ownership Situations*

	I	II	III	IV	V
Surface Owned By:	Party A	Party A	Party A	Crown	Crown
Minerals Owned By:	Party A	Party B	Crown	Party A	Crown

**Crown may be either the provincial or federal government.*
Party A or B may be an Indian band, corporation or individual.

In southwestern Manitoba, I and II cover about 80% of all cases while III and IV occur in the remainder. Nearly all of northern Manitoba falls into Category V.

Surface and Mineral Rights Leasing

Oil companies rarely own the land on which they explore for or develop oil or natural gas. Therefore, before entering the land the oil company requires the consent of the owner and occupant. This is normally negotiated with the land owner. When an agreement, or surface lease, cannot be obtained through negotiations, the province's Surface Rights Board may grant the oil company right-of-entry under an arbitration order.

Before drilling or production starts, the oil company must also acquire a lease interest in the oil and natural gas rights from the mineral rights owner(s). With a freehold mineral owner, the company negotiates a lease agreement, normally providing the owner with a percentage of the gross oil or gas revenues derived from these mineral rights. This is referred to as the 'freehold royalty'.

In the case of Crown-owned mineral rights, exploration rights are purchased for specified time periods as either Crown leases or exploration reservations. The industry commonly refers to Crown lease sales, where companies purchase leases and/or exploration reservations through sealed tender bidding, as 'land sales'.

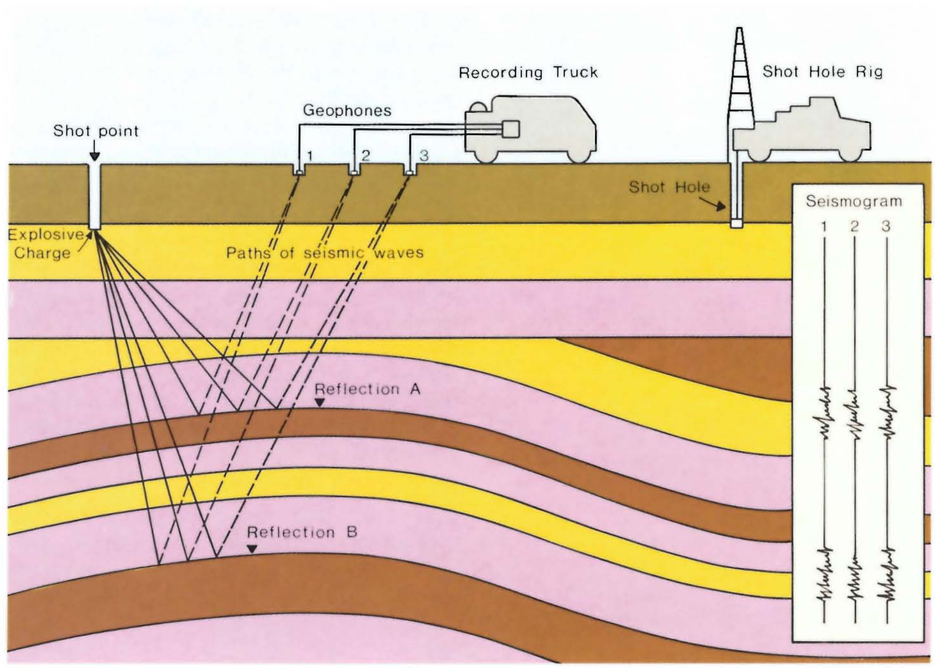
Exploration reservations must exceed three sections (768 hectares or 1,897 acres) and entitles the holder to exclusive exploration rights during the three-year term of the agreement. Drilling on the reservation allows the holder to select a specified lease area, determined by formula, from within the exploration reservation area. Only after a lease is obtained can oil be produced.

Crown leases are for a five year term. They are renewable, subject to certain conditions, if productive. Production obtained from Crown-owned mineral rights is subject to Crown royalty rates. Regulations prescribe these rates, depending on the monthly volume of oil or gas produced and its classification (new oil vs old oil).

Exploring For Oil

The first 'wildcatters', as they were called, found oil by drilling into hilltop and rock formations in unproved areas. Drilling sites were often chosen at random on a trial and error basis. The success rate of these wildcat wells may have been one in a hundred. However, geological data from these wells proved invaluable for future oil exploration, indicating rock formations and underground structures that might contain oil.

Today most oil is found through the efforts of geologists and geophysicists using the latest technology. Even with technological advances, oil and gas drilling remains a risky business.



Preliminary Evaluation

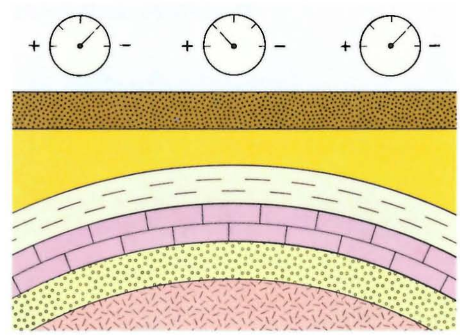
In Manitoba, geological traps containing oil reservoirs occur several hundred metres below the surface and can only be located by using geological and geophysical techniques.

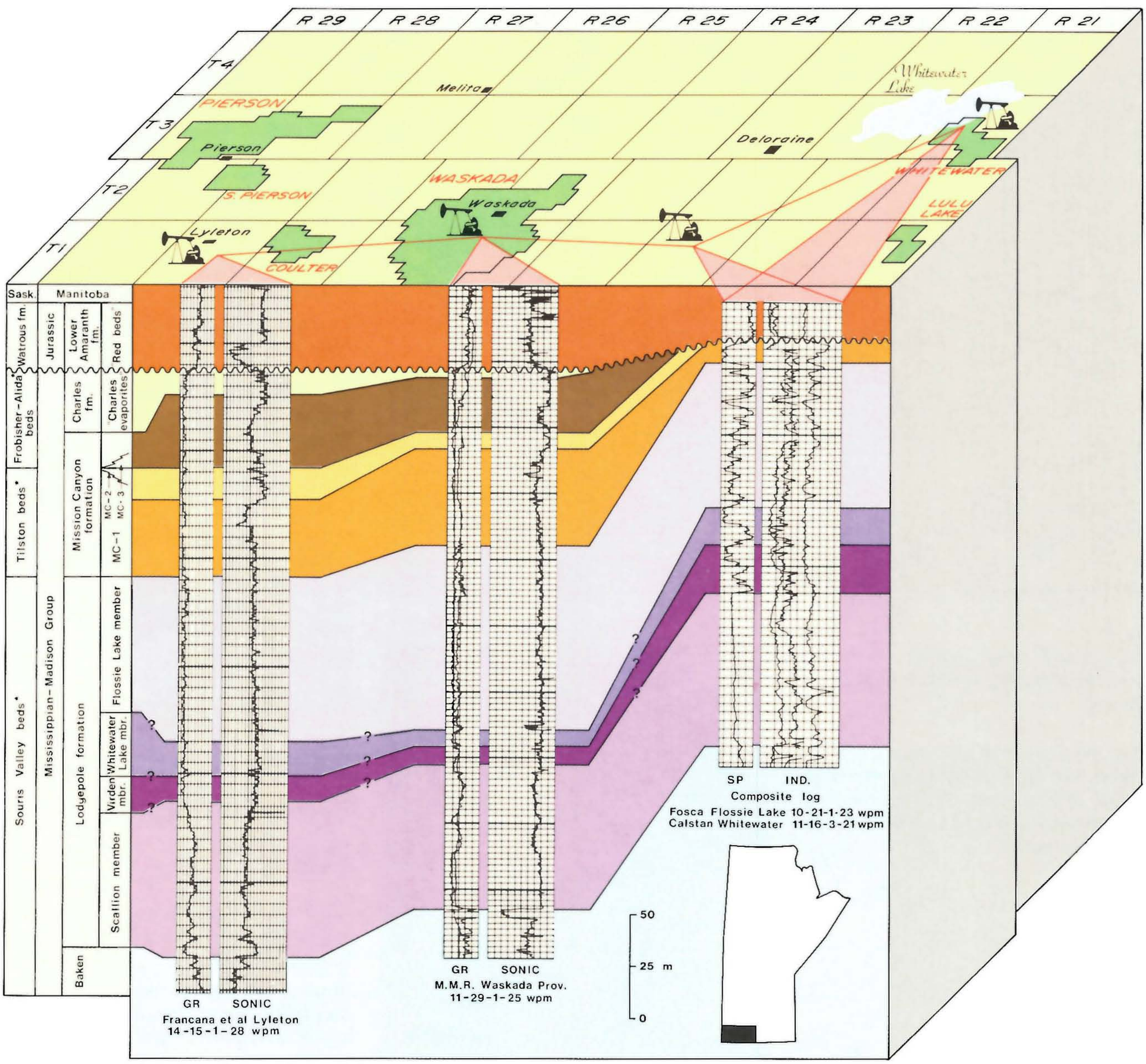
The science of geophysics is used extensively when geological data is scarce. It allows the geophysicist to use physical forces such as shock waves, gravity and magnetism to outline subterranean structures.

Seismic surveying is the most common method in geophysical exploration. Shock waves are produced by exploding dynamite in small, shallow holes (See figure 6). These shock waves penetrate the subsurface formation and reflect back to the surface where they are recorded with geophones or seismometers (seismographs). A geophone or seismometer is similar to a microphone, picking up vibrations and converting them into electric impulses.

The time that it takes shock waves to reach the rock formations and reflect back to the surface is correlated with their intensity to help calculate the depth and shape of subsurface strata. Sound waves are also produced by using vibration or percussion methods. In these instances, there is no need to drill holes and use explosives. These modern methods help minimize environmental damage caused by drilling and blasting.

The gravity meter or gravimeter also helps locate potential oil bearing formations. This instrument measures the variations in gravitational pull caused by the varying densities of subsurface formations. A potential oil trap may show high gravity readings because of upward arching of underlying beds (See figure 7). The gravimeter is most useful in preliminary exploration.





* Saskatchewan Geological Society, 1956

Figure 6
Seismic survey using 'shot hole' method.

Figure 7
Gravimeter recording high gravity reading in anticlinal trap.

Vibroseis method of seismic surveying creates sound waves at the surface without drilling or using exploding charges.

Magnetometers measure variations in the earth's magnetic field. Sedimentary rocks, for example, generally have a lower magnetic attraction than underlying formations. Magnetometer surveys help geologists plot the contours of rock formations underlying sedimentary rocks. The ability to cover large areas with limited time, equipment and personnel makes this geophysical technique valuable for preliminary survey work.

Figure 8
Stratigraphic cross section using 'control points' in southwestern Manitoba; previously drilled wells provide valuable stratigraphic information which helps the geologist piece together the location of potential oil bearing formations.

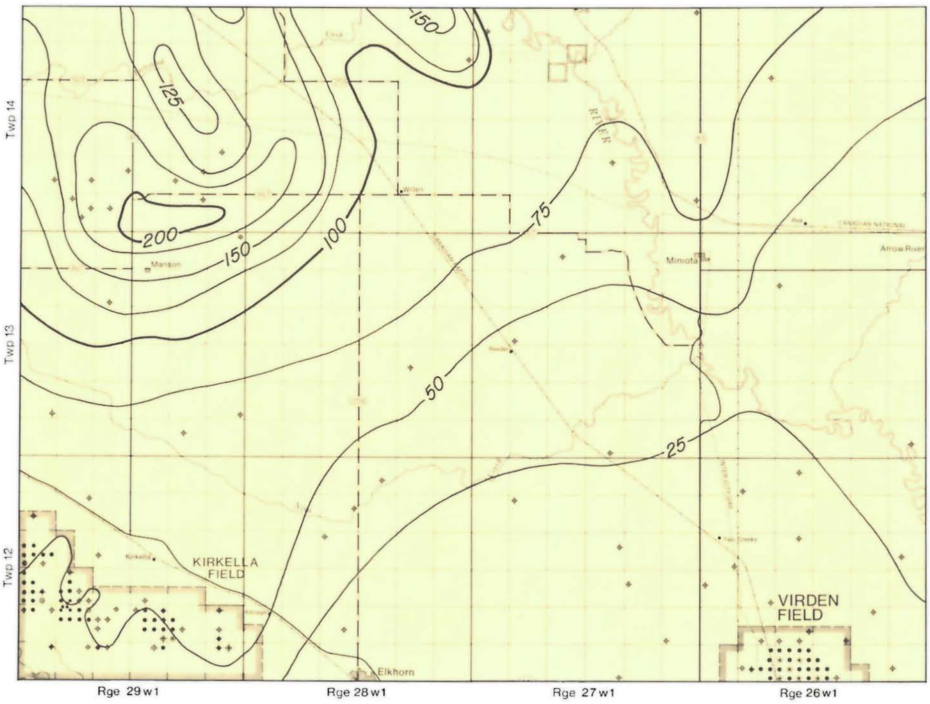


Figure 9
Typical isopach map; Isopach contours are used in showing formation or zone thicknesses.

Logging truck on drill site near Pierson, Manitoba; Electric logging is used to determine the nature and amount of fluids in formations and their locations (in terms of depth).

Exploration Techniques

Once preliminary geophysical work identifies favourable oil and gas structures, a geological study is undertaken. The geophysical data and any available geological information are studied for indications of reservoir, source and cap rocks. At this stage one of the major problems for a geologist is correlating rock information from a number of areas. Information from previous wells drilled in the area, called 'control points' (See figure 8), provide the data for such correlations.

Examining the well core data, the geologist attempts to identify rock units capable of containing oil. By observing the rock characteristics, the units are traced to the next control point. Once rock units have been correlated, stratigraphic, isopach or cross-sectional maps are drawn to help establish an exploration model (See figure 9).

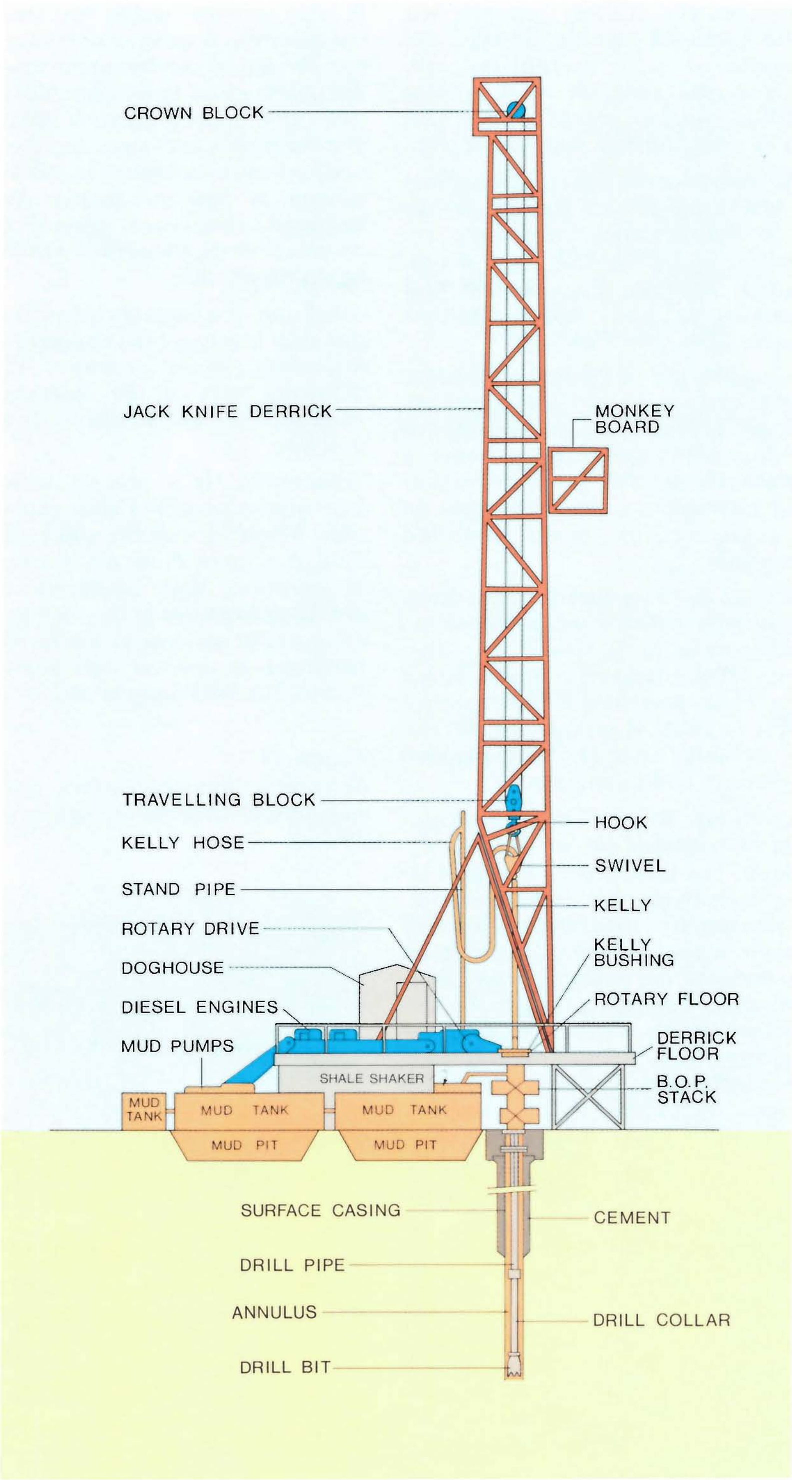
Occasionally, geophysical surveys miss suitable structures such as 'sand lenses' or 'pinch outs' of porous beds. For this and other reasons, geophysical data must be cross checked with available geological data.

Drilling Exploratory and Development Wells

After a potential site is chosen, the drilling crews move in and set up a drill rig (See figure 10).

Rotary drilling is the most common method in the 'oil patch'. This type of rig has a removable steel mast and an experienced crew can move and 'rig up' in less than a day. The rotary drill rig, with its ability to drill deeper and faster, has replaced the original cable tool rigs, which used a pounding action to make holes.

The first stage in drilling is referred to as 'spudding in'. A hole is drilled through loose glacial till. Steel surface casing is run to reach a minimum depth of thirty



metres below the base of the glacial drift or ten percent of the estimated total depth of the well, whichever is greater, with an overall minimum of 100 metres. This surface casing is then cemented in the hole to prevent the well bore from caving in. The surface casing and cement form a firm anchor for other equipment in the hole to prevent 'blowouts' and also to prevent the contamination of fresh water near the surface.

Various types of drill bits are used to grind and cut through different rock formations.

Drilling 'mud', consisting of water, oil or diesel fuel mixed with clay and chemicals, is pumped down the drill pipe to the bottom of the hole and out through the drill bit. The mud is returned to the surface through the space between the outside of the drill pipe and sides of the hole, also referred to as the annulus. The drilling mud lubricates and cools the drill bit while brining drill cuttings to the surface. It also prevents fluid loss into the formations by forming a filter cake on the walls. The weight of the mud in the hole also controls any oil or gas encountered and exerts pressure against the wall of the hole, preventing cave-ins.

Once the surface casing has been set, drilling continues around the clock, stopping only for bit changes or equipment breakdowns. As bits wear out the entire 'drill string' must be pulled out and disconnected. Once the bit is changed the drill pipe is threaded back on and drilling commences again. This pulling out and threading back in of the drill pipe is referred to as 'tripping'.

Drilling time varies with the type of well, depth to producing formations, and nature of the rock. An exploratory well usually takes longer to drill than a development well, as frequent testing is required to ensure that potential producing formations are not overlooked. In

Figure 10
Major components of a rotary drill, including mast assembly, substructure, power drive system, rotary table, mud system, drill string and draw works assembly.

Manitoba, an average 1 000 metre development well can be drilled in three to four days.

To prevent spectacular but wasteful blowouts, wells are equipped with blowout preventers (BOPs) located at the surface of the wellbore. If unexpected high pressure is encountered, the BOP quickly and effectively seals off the well.

Transmitting power and rotation to the drill bit can create several problems during drilling. Downhole bit motors apply drilling power directly to the bit at the bottom of the hole. The motor helps relieve drill pipe stress, reduces damage to the hole and casing and improves penetration rates in deep, hard rock situations. Because of relatively shallow oil well depths, downhole bit motors are seldom used in Manitoba.

When total depth is reached, the well is tested to determine if it is likely to be a producer.

Service rigs are used to prepare wells for production and any subsequent workovers.

Well Evaluation and Completion

Throughout the drilling process, the wellsite geologist records the type and thickness of rock formations encountered and analyzes rock cuttings and drilling mud for traces of oil or gas. If traces exist, further tests are made.

Testing may take the form of electric logging. These tests provide a graphical picture of the different formations encountered, including rock type, depth, thickness, porosity, fluid content and composition, and other related characteristics (See figure 8).

Core samples provide valuable information on rock formations. Using a core bit, a cylinder of rock is cut and brought to the surface where the geologist examines its characteristics as a potential producing formation. Laboratory tests on the core reveal more detailed information.

A drill stem test may also be run to determine the rate of flow from the formation and pressures in it, while providing samples of the fluids produced. These various tests determine whether or not a well is capable of production. An unsuccessful well, or 'dry hole', is plugged with cement and abandoned.

If the well is considered capable of producing oil or natural gas, production casing is run. The crew lowers steel pipe into the well, lining the entire wellbore. After running the production casing, they cement it in place by pumping a cement slurry between the casing and well bore from the bottom of the casing to the surface. Once the cement has set, the crew begins rigging down and the drill rig is moved to the next site. A service rig is then moved on to the well to complete the well and prepare it for production.

Perforations are made through the casing into the producing formation, using bullet or sharp charge perforators, or sand jets, which allow the oil and gas to flow into the casing.

The service crew now lowers production tubing into the casing. It is through this suspended tubing that fluids are actually produced. At the surface, the crew install a wellhead, or 'Christmas tree', which controls oil or gas flow, using a series of chokes and valves.

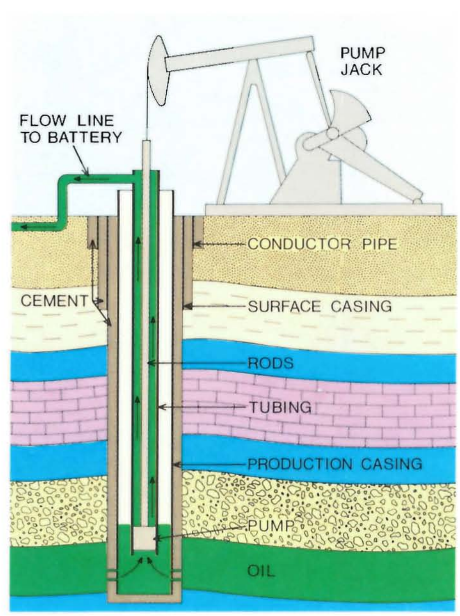
Production and Production Rate Regulation

Producing oil wells fall into two categories — flowing or pumping. Reservoir conditions determine the type of production method to be used. Oil production rates depend on rock characteristics, formation pressures and the volume and type of hydrocarbons. When a formation is less productive than anticipated, there are several possible chemical or physical methods of stimulating production.

'Acidizing' is a form of chemical stimulation that involves injecting acid into the formation, under pressure. The acid dissolves part of the formation and enlarges the oil flow channels into the wellbore.

'Fracturing' is a process which uses hydraulic pressure to stimulate production. Material, usually silica sand and fluid, is pumped down into the formation at extremely high pressures, creating cracks or fractures in the rock that allow oil or gas to move more freely. When the wellhead is opened and pressure released, the fluid that carried the sand in-

Figure 11
Schematic showing surface and subsurface components of a producing oil well.



to the fractures flows out, followed by the formation fluid, which uses the sand filled fractures as a path to the wellbore. Most wells in Manitoba require some form of stimulation prior to production.

When the crew has perforated and stimulated the well, they install the necessary valves, gauges and flowline connections. With all the connections made and the well ready for production, the service rig leaves and the clean-up begins. Only the wellhead and pumpjack remain above the surface (See figure 11).

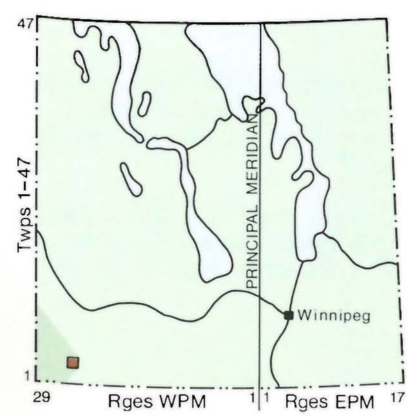
Most crude oil contains dissolved gas and salt water that must be removed. As the oil is pumped, the decrease in pressure from sub-surface to surface releases some gas (similar to removing the cap from a bottle of pop). If gas and water remain in the pumped oil, the mixture (emulsion) is passed through a 'production separator'. The separator holds the oil for a short period of time at a slightly reduced pressure. This allows the gas to come out of solution and gather at the top of the vessel. The gas is piped off into a flare pit where it is burned, or to a gas processing plant. Up until 1984, recovery and processing of gas produced in association with oil was not considered economical in Manitoba. However, in March, 1984 Omega Hydrocarbons began operating a natural gas liquids recovery plant in the Waskada area.

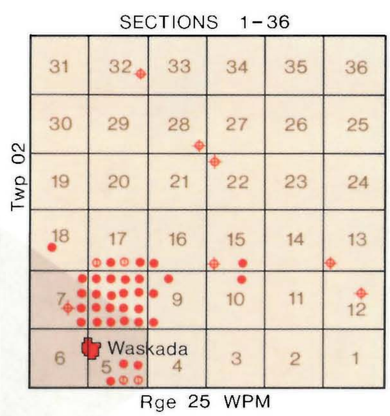
Manitoba's oil fields often produce a large volume of salt water combined with the oil emulsion. To remove the water from the crude oil before transportion to market, the emulsion is sometimes left in a holding tank where gravity differences separate the water from the oil. As water collects at the bottom of the tank, it is piped off through a valve at the base of the tank. In most instances, however, the water is so finely mixed with the oil that the emulsion requires the use of a treater utilizing either heat, chemicals, electric current or a combination of the three. After the salt water is separated, it is usually pumped back into the reservoir from which it was produced through a saltwater disposal well.

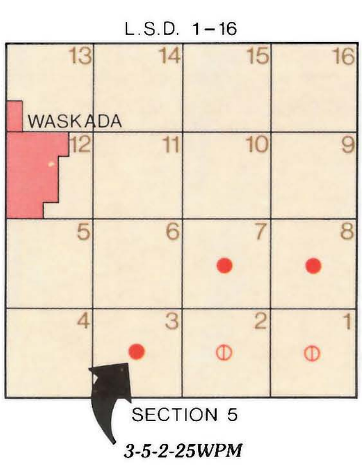
In Manitoba, regulations governing oil production restrict the amount of oil a producer can pump from the ground, thereby protecting the oil reservoir from damage caused by over production. Over production causes oil that would normally be produced to be left behind in the reservoir. When over-production continues for an extended period of time, the damage is usually irreparable. Manitoba's regulated production rates allow oil to be pumped efficiently and economically. Oil production is recorded in cubic metres (formerly barrels) of oil per day and the normal maximum allowable production per day averages approximately eight cubic metres (50 barrels).

Well spacing regulations also maximize economic oil recovery without damage to the reservoir. They discourage unnecessary drilling and prevent drainage of oil reserves from surrounding land. The Oil and Natural Gas Conservation Board establishes well spacing regulations. Normal oil well spacing in Manitoba is one well to each pool in each legal subdivision, or every 16 hectares with a maximum of 16 wells per section for each developed pool (See figure 12).

Figure 12
Legal description system used in locating a well. By knowing the township, range, section and legal subdivision in which a well is drilled, it is possible to pinpoint its location on a map (i.e. 3-5-2-25WPM) refers to a well located in legal subdivision 3, section 5, township 2, range 25 west of the principal meridian.







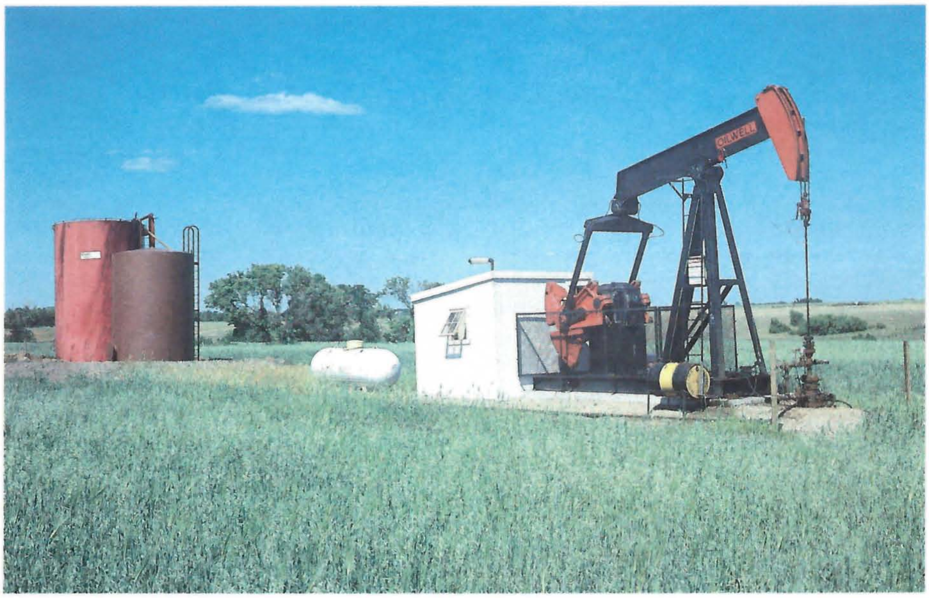
Enhanced Recovery

Natural pressures, rock permeability and oil viscosity all limit the amount of oil pumped from a reservoir. The four types of natural pressures pushing oil to the well include water drive, fluid expansion drive, solution gas drive, and gas cap drive. Oil obtained from these drive forces is referred to as primary recovery. An oil field at this stage is in the primary production phase or under primary depletion.

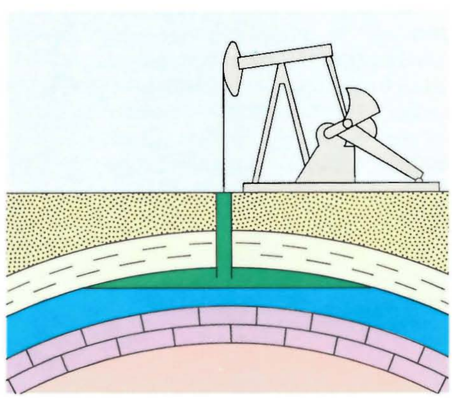
Solution gas and water drive are the major natural mechanisms in Manitoba's oil fields (See figure 13). As oil is pumped, these reservoir pressures decrease, reducing the production rate. Under natural conditions, 10-15% of the oil in place is normally recovered.

As primary production produces only a small percentage of the oil in a reservoir, the industry has developed enhanced recovery or artificial techniques to coax more oil from the ground. Of the various enhanced recovery techniques available, waterflooding is the most widely used in Manitoba because of the rock formations, natural drive characteristics and economic feasibility. The technique may increase oil recovery to 30-40%. Most wells in Manitoba today use this enhanced recovery method. (See figure 14).

Simply stated, pumps inject water under pressure into the reservoir rock through regularly spaced injection wells. This pressurizes the reservoir, forcing the oil through the formation into nearby producing wells. Controlling the injection rate according to variations in formation permeability avoids trapping and leaving large quantities of oil behind. Water flooding is most effective in reservoirs where permeability is fairly uniform.



Pumping well with production tanks used for storing oil and water before transport to pipe lines (oil) and salt water disposal or injection wells (near Lyleton, Manitoba).



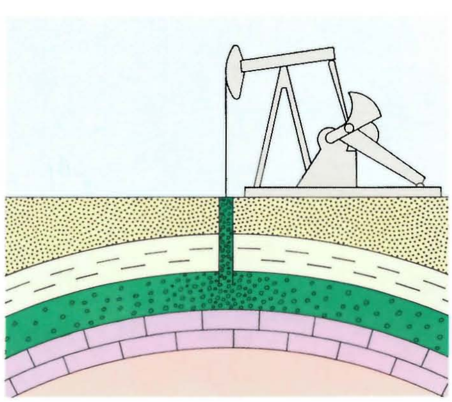


Figure 13
In a water drive mechanism, oil is produced by the upward expansion of underlying water that forces oil into the wellbore.

A solution gas drive mechanism forces oil into the wellbore as a result of the expansion of dissolved gases in the oil.

Unitization

Several operators may produce oil from a reservoir extending over several thousand hectares. With a number of operators working an oil pool, production and decline rates may vary. Unnecessary production facilities may have to be built and operated individually.

Unitization permits efficient operation of a pool and maximum oil recovery. The first major unitization was introduced to Manitoba in 1962, permiting operation of the Virden area pools as single properties rather than numerous smaller individual properties. Under this system the majority of operating companies and their royalty owners agree to operate their area of a pool as a single property (unit) and share in the unit's total production. Each share is based on a formula agreed to by the majority of the participants at the time of unitization.

Consolidating operations into a single unit reduces the total number of wells and other production facilities to a more practical number. The advantage of this is clear — individual producers reduce their overall operating costs and maximum economic recovery of oil reserves is achieved. Interest owners in the field may also work out an agreement to introduce a pressure maintenance scheme.

When an agreement is reached, The Oil and Natural Gas Conservation Board must approve the unitization scheme. If a majority of the participating parties agree to unitization, the Board may issue a unitization order.

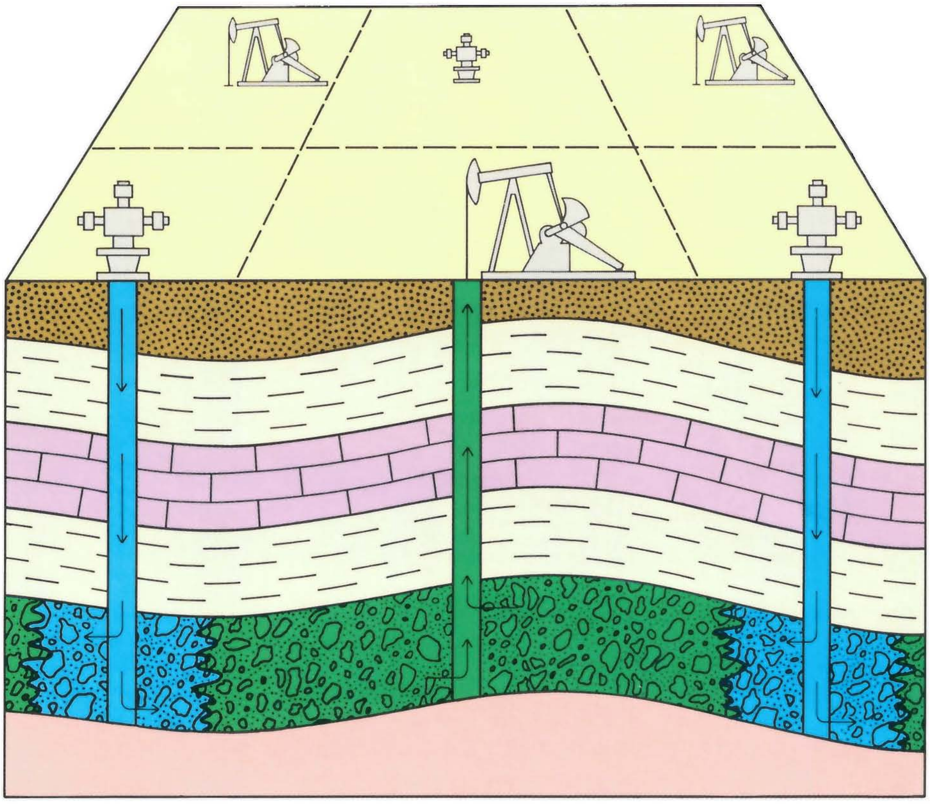
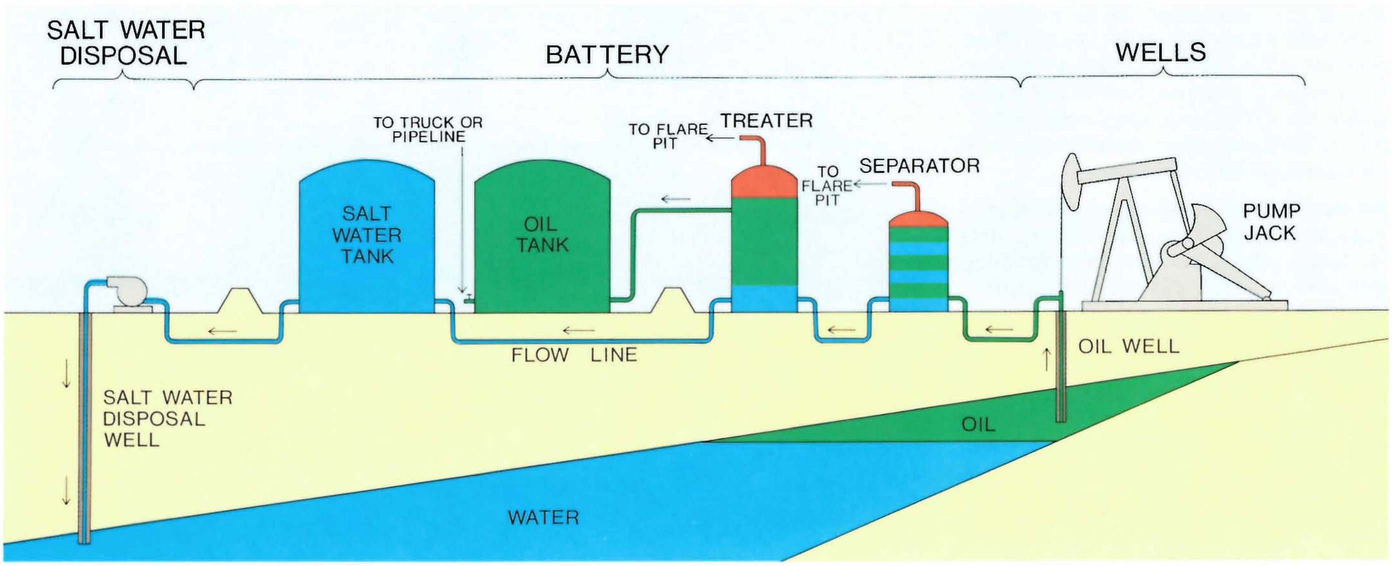


Figure 14
Typical waterflood pressure maintenance scheme whereby water is injected through wells into the producing formation. Water pushes the lighter oil remaining in the reservoir towards the wellbore of the producing well.

Area being waterflooded near Waskada, Manitoba. Water injection well located in foreground.

After The Oil Is Pumped

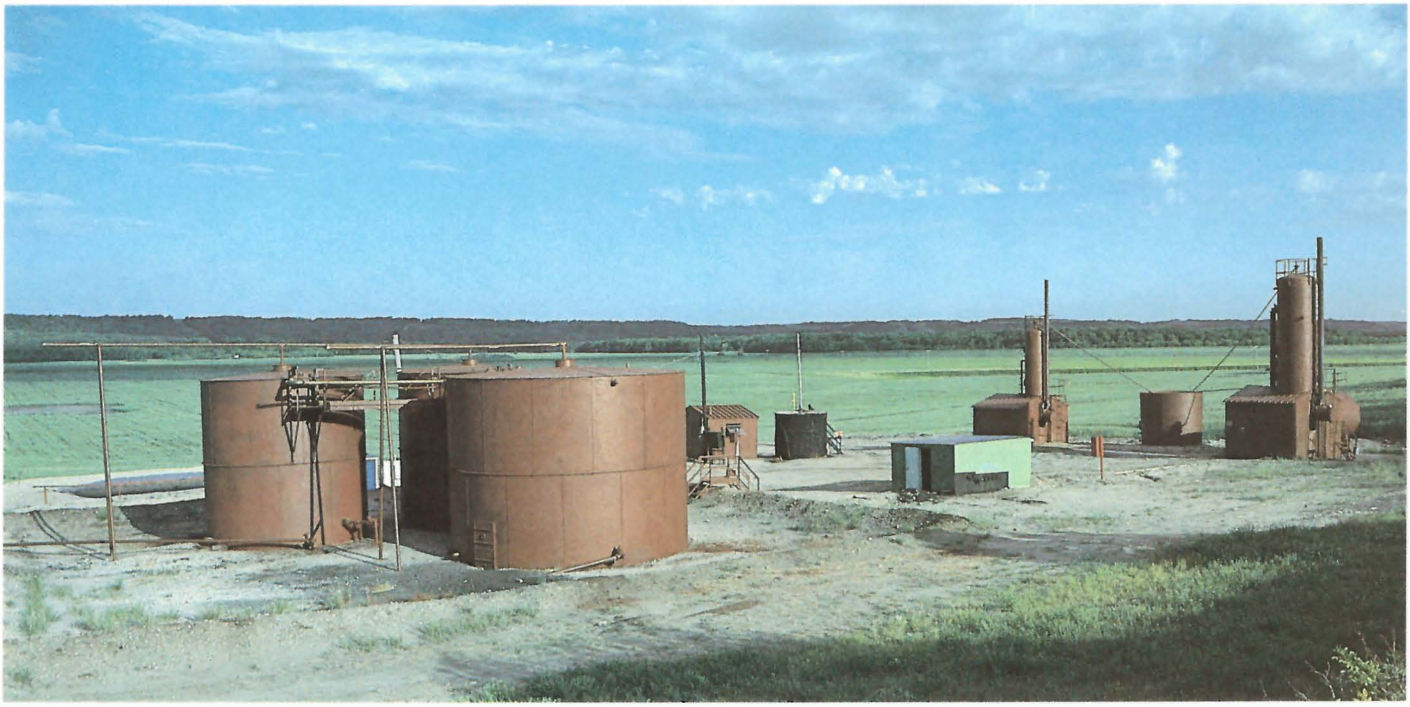
Oil Storage



Once pumped from the ground and separated from dissolved gases and water, shipping tanks at the 'battery site' store the oil until transport to refineries. A 'battery' is the field facility which separates the gas and salt water from the oil. It includes the oil and salt water storage tanks (See figure 15). Producing wells feed the centralized battery by small pipelines, or 'flowlines'. Battery size varies with the number of wells and volume of production.

Figure 15
Schematic of oil field production, battery and disposal facilities.

Battery located in Virden Field.



Oil Transport

In Manitoba, tanker trucks, or larger pipelines called 'gathering lines', transport oil from field batteries to the Interprovincial Pipeline pumping station at Cromer, Manitoba.

The gathering system delivers oil from field storage tanks to 'spur' lines connecting several oil fields, and from there to the main line, or common carrier, which delivers the oil to refineries. The two gathering systems currently operating in Manitoba connect about 70% of the oil wells in Manitoba with the common carrier, Interprovincial Pipelines. These wells produce approximately 80% of Manitoba's crude oil. Fields not serviced by gathering systems must transport oil by tanker truck to the truck unloading terminals on the two systems, at Cromer or Waskada. A pipeline with a capacity of approximately 1 500 cubic metres of oil per day was built in late 1984, connecting the Waskada Field to the Interprovincial Pipeline pump station at Cromer.

Pumping stations which move the oil are strategically placed to maintain a steady pressure along the length of the pipeline. The distance between pumping stations, and their size, vary according to oil volume, pipe size, topography, oil viscosity and gravity.

Tanker truck loading oil at battery for transport to Interprovincial Pipelines at Cromer, Manitoba.

Gathering line construction near Waskada, Manitoba

The Industry In Manitoba Today

Exploration and Development

The number of producers working in Manitoba fluctuates with the level of exploration and development activity. Throughout the the 1950's boom, approximately 125 companies were involved in oil and gas development.

Since 1982, Manitoba is again experiencing a second oil boom. In 1984, oil companies completed 246 wells with a combined total depth of 220 631 metres. This equaled 1983 levels and exceeded 1982 levels by 26% and 1981 levels by 297%. Of the wells drilled, 86% were development wells, while 14% were exploratory. Eighty nine percent of the 246 wells drilled were completed as potential oil wells (See figure 16).

Of the 31 oil companies that drilled wells in 1984, three accounted for 54% of all wells drilled. Omega Hydrocarbons drilled 72 wells, Resman Holdings 34 wells and New Scope Resources 26 wells.

For the fourth consecutive year, the Waskada area, located approximately 100 kilometres south of Virden, Manitoba, dominated drilling activity. One hundred wells, or 41% of all wells drilled in 1984, were located in that area. Ten of the companies operating in Manitoba have oil interests there. Although the Waskada area saw most of the past four years' exploration and development work, the Daly Field has also experienced significant recent development. Exploration activity also increased in the Virden, Pierson, Lulu Lake, St. Lazare, and Oak Lake areas of the Province.

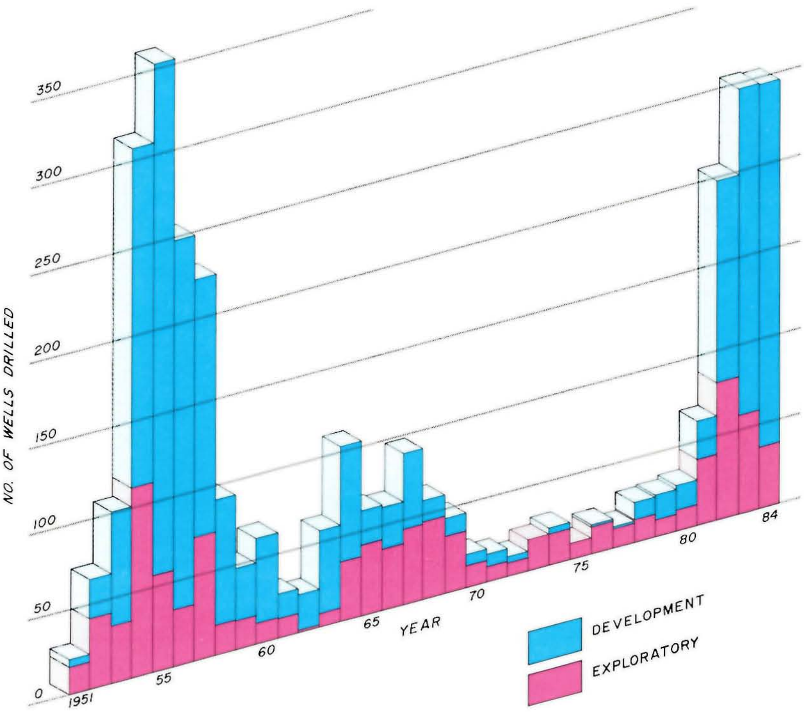


Figure 16
Exploratory and development wells drilled in Manitoba 1951 - 1984.

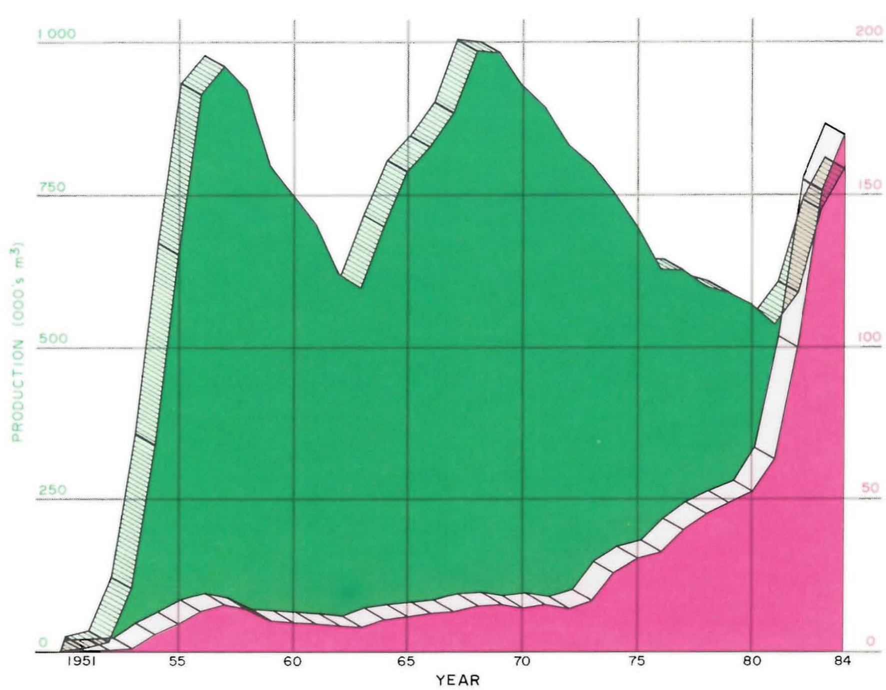


Figure 17
Manitoba crude oil production and value of production 1951-1984.

Oil Production

Oil production has varied significantly in Manitoba since 1951. During the early 1950s, intensive exploration and development work steadily increased oil production to a 1957 peak of 967 721 cubic metres (See figure 17).

However, as the industry completed development of known oil fields, oil production declined, reaching a low of 599 276 cubic metres in 1963. Successful waterflood pressure maintenance projects in the fields around Virden increased production by the mid-1960s, and in 1968 oil production peaked for a second time at 986 024 cubic metres. After 1968, the lack of sufficient new discoveries to replace declining oil reserves led to production declines until 1982. During 1982, extensive exploration and development activity, mainly in the Waskada area, increased oil production for the first time in 14 years.

In 1982, oil production increased to 582 322 cubic metres, 7% more than 1981. In 1983, production rose 26% to 736 934 cubic metres. Development of the Waskada Field during this period increased its share of the Province's total annual production from 2.4% in 1981 to 15% in 1982 and 35% in 1983. Total production increased in 1984 for the third consecutive year, reaching 793 284 cubic metres, with 34% of the oil coming from the Waskada Field.

Oil Pricing

Throughout the 1950s and 1960s, oil prices in Manitoba remained relatively stable, ranging from $14.00 to $16.50/cubic metre (see figure 18). One reason for the cheap, stable prices was that during these two decades, a principal concern of oil producers was finding markets for this abundant energy supply. To encourage rapid expansion of the use of petroleum, prices were kept low.

This way of thinking, however, began to change with the onset of the 1970s. The change was signalled by the Organization of Petroleum Exporting Countries (OPEC) in October 1973, when the price of Persian Gulf Oil began increasing dramatically. Further increases followed, but it was the OPEC embargo which marked a permanent change in the world energy picture.

In Manitoba, this meant that oil prices increased from $15.80/cubic metre in 1970 to $118.03/cubic metre in 1981. In 1982, the federal government introduced a two-price system for oil. Two classifications of crude oil formed the basis of Manitoba's and Canada's oil pricing structure. Effective January 1, 1982, pricing was based on oil which was classified as either 'old' or 'new' oil.

'New' oil prices were to provide an oil producer with prices equal to the equivalent world price. From 1982 to 1984, the average wellhead price increased from $172.66/cubic metre (average price of 'old' and 'new' oil combined) to $213.41/cubic metre.

As of June 1, 1985, the federal government did away with this two-price system in favour of a one price system dictated solely by market influences.

Value of Production

In 1984, the total value of Manitoba's crude oil production increased to $170 million, compared with $153 million in 1983 and $101 million in 1982. Despite declining production before 1982, higher selling prices steadily increased the value of oil production since 1973 (See figure 17).

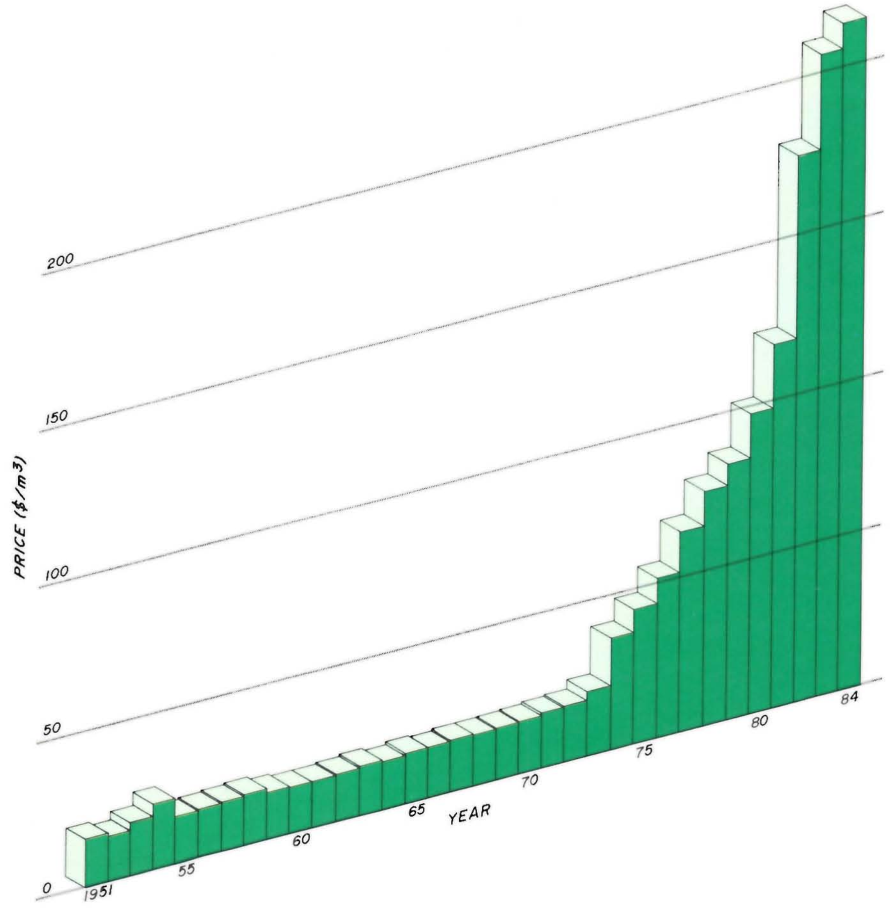


Figure 18 Manitoba average crude oil prices 1951-1984.

How Much More Oil And Gas

Current Established Oil Reserves

After the 1950's boom, remaining established recoverable oil reserves were approximately 9.9 million cubic metres. These reserves declined throughout the late 1950's, but in the early 1960s, waterflooding projects in older fields increased recoverable reserves to 12 million cubic metres.

The lack of new oil discoveries in the 1970's led to a decline in remaining reserves, which continued until the 1980 oil discoveries in the Kirkella area. In 1981, new discoveries in the Waskada area further arrested the decline. In 1982, Manitoba experienced its first increase in established reserves in more than 15 years. As of December 31, 1984, the province's total estimated recoverable reserves were 31.2 million cubic metres, with remaining established recoverable reserves estimated to be 8.02 million cubic metres.

Current Gas Reserves

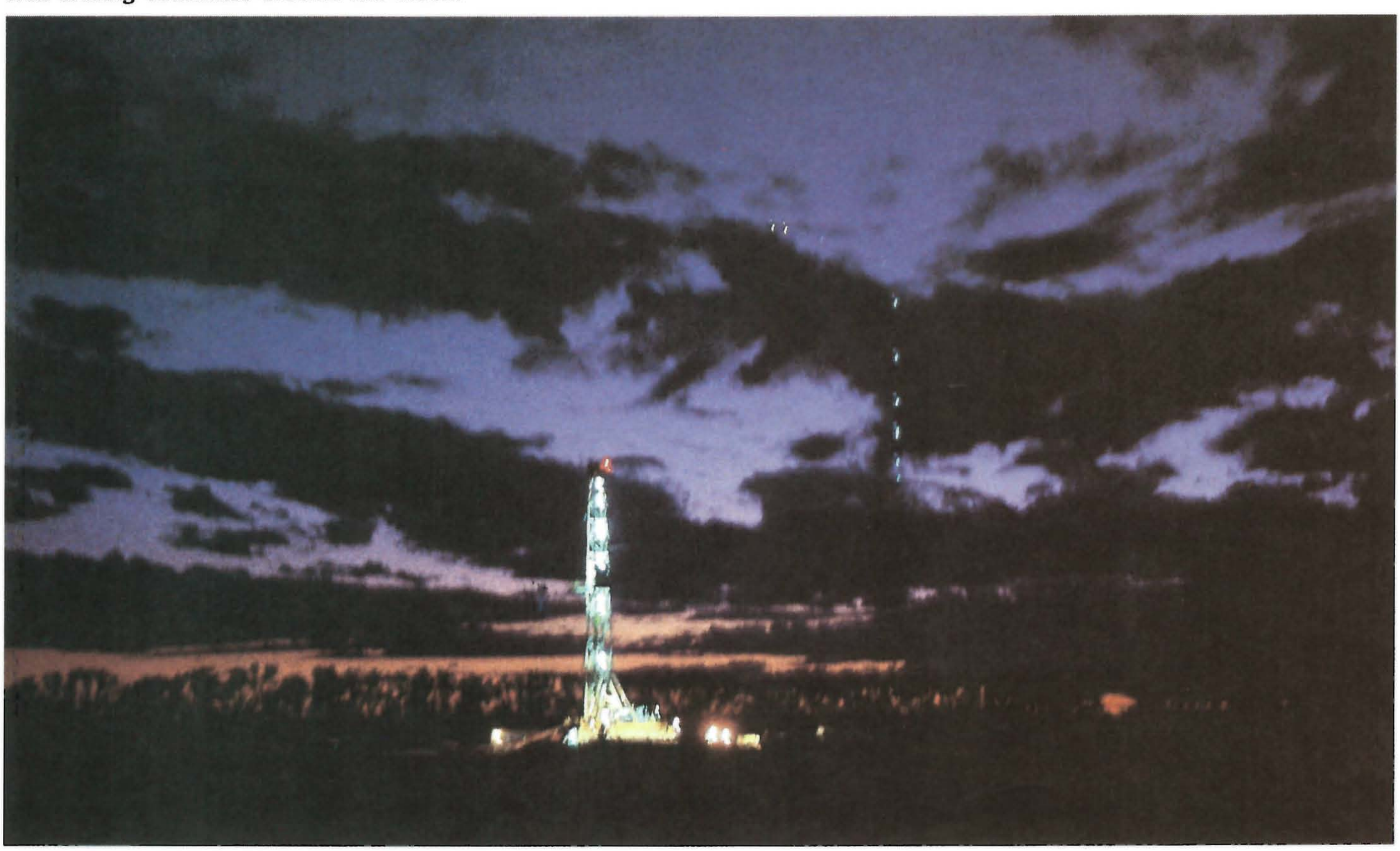
Natural gas discoveries in Manitoba have been limited to uneconomical shallow gas occurrences. There are no gas wells producing in the province. However, Omega Hydrocarbons operates a gas processing plant which recovers natural gas liquids (propane, butane and condensates) from natural gas produced in association with crude oil from the Waskada Field. The plant, the first of its kind in the province, began operating in 1984 and has a maximum processing capability of 85 000 cubic metres per day.

Oil and Gas Potential

While most oil in Manitoba comes from carbonate rocks of the Lodgepole and Mission Canyon Formations (Mississippian period), in 1981 the first non-Mississippian oil was pumped from the Lower Amaranth Formation (Jurassic period) in the Waskada area.

In addition to currently producing formations, several other pre-Mississippian formations in southwestern Manitoba have hydrocarbon potential. They include the Cambrian Deadwood, the Ordovician Winnipeg and Red River, the Silurian Interlake, and the Devonian Winnipegosis, Dawson Bay, Duperow, and Nisku Formations (See figure 1). Many of these formations are productive elsewhere in the Williston Basin, but relatively few wells have tested these formations in Manitoba, and their potential remains largely unexplored.

Well drilling continues around the clock.



Manitoba's Oil Future

Forecast For the 1980's

Drilling will likely continue at a significantly higher rate than the 1970's. A number of positive factors support this forecast. The continuation of the Manitoba Drilling Incentive Program to the end of 1986 will provide oil producers with netbacks competitive with other provinces. Discoveries will likely be oil, rather than less marketable natural gas. Increased geophysical activity in the early 1980's could spark interest in several areas of the province, while expiring leases will either prompt drilling or free up land for other developers. High drilling success rates in recent years should encourage oil producers to continue development drilling in established areas as well as exploratory drilling in other areas. Elimination of certain federal taxes and the phasing out of exploration grants in the frontier areas will also attract more interest and competition to the western producing provinces.

Further development of the Waskada, Daly, Pierson and Tilston areas, and new discoveries in Turtle Mountain Provincial Park, should maintain or increase established oil reserves. Recently oil and gas companies have become active in the St. Lazare and Oak Lake areas. More drilling will determine if these areas, together with further development of the Waskada and Daly areas, will continue to fuel Manitoba's current oil boom.

Benefits to Manitoba

Oil remains a valuable stimulant to Manitoba's economy. Recent estimates indicate that the oil industry spent approximately $125 million in the province during 1984, a 7% increase over 1983. Expenditures include exploration, development and operating costs, plus payments to the provincial and municipal governments through royalties, taxes, lease sales and rentals. Surface owners and private mineral rights owners in the province benefit from the oil industry through surface rentals and oil royalties.

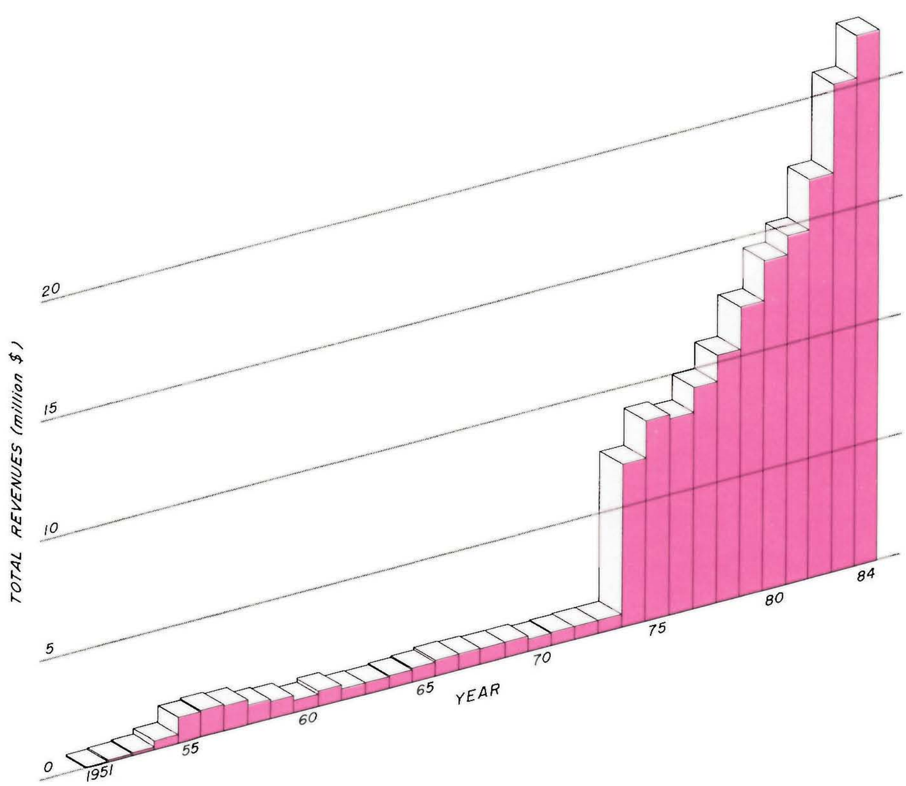
In 1984, the provincial government collected approximately $4.0 million in Crown oil royalties, $15.6 million in freehold oil taxes, $2.5 million in Crown lease sale bonuses, rentals, and fees, and $0.4 million as the province's share of the crude oil export tax (see figure 19). These figures do no include provincial revenues in the form of corporate capital taxes, sales taxes, and corporate or individual income taxes.

Some municipal governments in southwestern Manitoba also receive oil industry revenues through municipal taxes on oil field equipment and pipelines. For the assessment year from September, 1983 to September, 1984, the municipal assessment amounted to approximately $6.5 million.

With over 80% of oil production coming from freehold mineral rights, the owners received an estimated $18.0 million in gross freehold royalties in 1984. This excludes signing bonuses and delay lease rental payments for new and non-producing leases. Surface rights owners also received revenues of approximately $2.6 million in 1984 — about $ 1.0 million in new lease bonus payments and $1.6 million in annual rental fees.

As well as providing an estimated 250 person years of direct employment in exploration and development in 1984, the industry generates several indirect or spin-off benefits for local economies. These are primarily in the service sector, such as restaurants, motels, stores, and garages. Recent increases in activity have substantially improved many local economies.

Figure 19
Provincial government revenues from oil production 1951-1984 (includes Crown oil royalties, freehold oil taxes, Crown lease sales and rentals.



The Petroleum Branch

The Petroleum Branch of Manitoba Energy and Mines administers provisions under The Mines Act, The Pipe Line Act and The Gas Storage and Allocation Act relating to exploration, development, production and transportation of crude oil and natural gas. The Branch also assists the Department of Finance in administering The Oil and Natural Gas Tax Act.

The Branch develops, recommends, implements and administers policies and legislative changes, which encourage exploration and development of the province's crude oil and natural gas resources in a safe, efficient and environmentally sensitive manner. The Branch also conducts studies and provides technical assistance to The Oil and Natural Gas Conservation Board in matters relating to well spacing, production allowables, pool designations, salt water disposal, enhanced recovery projects, unitization agreements and other Board responsibilities.

Collection and analysis of petroleum industry statistics, as well as monitoring of federal-provincial policies, enables the Branch to evaluate the effects of these policies on the province's petroleum industry. It releases several reports each year, providing the public, industry and government with information on the petroleum industry in Manitoba.

The Branch is comprised of three Sections — Administration, Geology, and Engineering and Petroleum Inspection.

Administration Section

The Administration Section administers regulations under The Mines Act governing the disposition of Crown oil and natural gas rights and the collection of Crown oil and natural gas royalties. These responsibilities include Crown lease sales, the enforcement of provisions under these agreements, and the collection of annual rentals and Crown royalties on oil and natural gas.

The Section administers the Manitoba Drilling Incentive Program, and accumulates and publishes monthly production and disposal/injection data on active wells in the Province. It also assists the Department of Finance in the collection of taxes from producing freehold mineral rights under The Oil and Natural Gas Tax Act and oil exports.

In addition to internal administrative functions, the Section handles all financial functions of the Branch, including collection of fees and technical service charges.

Geology Section

The Geology Section evaluates geological data and provides consultation to the petroleum industry and the public. It assists The Oil and Natural Gas Conservation Board in the designation of field and pool boundaries and the administration of Geophysical Regulations. It also prepares reports on Manitoba's petroleum geology and hydrocarbon potential.

Engineering and Inspection Section

The Engineering component administers regulations under The Mines Act relating to petroleum exploration, drilling and production operations. As part of this responsibility, it processes drilling licence applications as well as applications to recomplete, suspend or abandon wells. Technical support is provided to The Oil and Natural Gas Conservation Board in the processing of salt water disposal, pressure maintenance, gas conservation and unitization applications.

Through its studies of oil and gas reserves and enhanced recovery potential, the Engineering component offers consultation services and information to the petroleum industry and the public. Administration of The Pipe Line Act and The Gas Storage and Allocation Act are also the responsibility of the Engineering component. In performing its duties, the component encourages the recovery of Manitoba's petroleum resources while minimizing the environmental impact.

The Inspection component of the Section, with district offices in Virden and Waskada, enforces Mines Act regulations relating to geophysical, drilling, production and pipe line operations. Staff inspect field facilities, investigate complaints and interpret and communicate regulatory requirements to industry personnel.

The Inspection component also evaluates various techniques of reclaiming soil contaminated by oil or salt water spills.

Further Information

The Branch offers information in the form of publications, reports, maps, and other technical data, including a complete core and sample library. A comprehensive catalogue lists available information and services. This material is available for inspection at the Branch or may be reproduced and forwarded at cost. The Branch attempts to answer both general and technical questions. Inquiries regarding the catalogue or other services should be directed to:

Manitoba Energy and Mines
Petroleum Branch
555 — 330 Graham Avenue
Winnipeg, Manitoba R3C 4E3
Ph: (204) 945-6577

Glossary

Allowable- the amount of oil per day that an operator is permitted by law to take from a given well.

Battery- the field facility in which the oil, water and gas are separated and stored, including such equipment as separators, treaters and tanks.

Bit- the cutting or boring element attached to the bottom end of the drill pipe when drilling oil and gas wells.

Blowout- an uncontrolled flow of gas, oil and other well fluids from a well.

Cap Rock- the impermeable rock overlying an oil or gas reservoir that prevents migration of the reservoir fluids from the reservoir.

Casing- a steel pipe cemented into a well as drilling progresses.

Christmas tree- a term applied to the control values, pressure gauges, and chokes assembled at the top of a well to control the flow of oil and gas.

Complete a well- to finish work on a well and bring it to productive status.

Condensate- a light liquid obtained by the condensation of hydrocarbon vapors. It consists of varying proportions of butane, propane, pentane, and fractions heavier than these, and contains little ethane and methane.

Core- a cylindrical rock sample taken from the formation for the purpose of examination.

Coring- the act of obtaining a core, for geological information, from the formation being drilled.

Crude oil- any produced liquid petroleum, other than condensate, before it is refined — customarily described in terms of its density and sulfur content.

Development well- a well drilled for oil or gas within a proven field for the purpose of completing the desired pattern of well spacing.

Dry Hole- any well that does not produce oil or gas.

Enhanced recovery- various methods which can be used to increase the percentage of oil ultimately recovered from a given reservoir. This process can involve injection of fluids, chemicals or heat into the reservoir.

Field- a designated geographical area in which a number of oil or gas wells produce from one or more continuous reservoirs which may be at varying depths.

Flowing well- a well that produces oil or gas by its own reservoir pressure without employing an artificial lift.

Flow line- the small diameter pipeline through which oil travels from the well to the battery.

Formation- a bed, stratum or deposit composed substantially of the same minerals throughout.

Formation fracturing- a method of stimulating production by increasing the permeability of the producing formation through application of hydraulic pressures.

Gas drive- An oil recovery process wherein expansion of gas in the reservoir moves the oil to a wellbore. May also refer to a form of enhanced recovery, wherein gas is injected through a well into the reservoir and sweeps oil to a producing well.

Impermeable- not allowing the passage of fluid. A formation may be porous, yet impermeable, owing to the absence of connecting passages between the voids within it.

Isopach map- a geological map of a given formation underlying an area, showing the formation's varying thickness. It is widely used in the calculation of reserves, planning secondary recovery projects, and exploration work.

Lease- a legal document executed between the surface and mineral rights owners or lessors and the operator or lessee, granting the right to explore and develop the land for minerals or other products; also applies to a tract of land undergoing mineral development on which a lease has been obtained.

Limestone- a type of sedimentary rock rich in calcium carbonate; sometimes serves as a reservoir rock for petroleum.

Log- a systematic recording of various parameters within the wellbore which can be used to estimate properties (porosity, water saturation, type of rock, etc.) of the formation.

Migration- the natural movement of oil and gas from the area in which it was generated to a reservoir where it can accumulate.

Mineral rights- right of ownership of gas, oil and other minerals beneath the surface.

Mud- a preparation of water, clays and chemicals circulated through the wellbore during drilling and workover operations. Drilling mud brings cuttings to the surface, cools and lubricates the bit and drill string, protects against blowouts by counter balancing subsurface pressures and deposits a mud sheath on the borehole wall to prevent loss of fluids and cave-ins.

Netback- the amount of net revenue earned from the production of oil or natural gas.

Oil field- surface area overlying an oil reservoir or reservoirs. In common usage, it may include the oil reservoir, the surface, and the wells.

Perforate- to pierce the casing wall and cement to provide holes through which formation fluids may enter the casing, or to provide holes in the casing so that materials may be introduced into the annulus between the casing and the wall of the borehole.

Perforations- holes made through the casing wall and cement.

Permeability- a measure of ability of a porous rock to permit flow of fluids.

Porosity- the quality or state of being porous. That percentage of the total bulk volume of a rock sample that is composed of pore spaces or voids is its absolute porosity. The effective porosity is the percentage of the bulk volume that is composed of interconnected pore spaces, allowing the passage of fluids through the sample.

Porous- containing voids or other openings which may or may not interconnect.

Pressure maintenance- a method for increasing ultimate oil recovery by injecting gas, water, or other fluid into the reservoir to reduce or eliminate the decline in reservoir pressure or to repressure a reservoir in which the pressure has dropped appreciably.

Primary recovery- oil production in which only naturally occurring reservoir energy sources provide for movement of the well fluids into the wellbore.

Producing zone- the zone or formation from which oil or gas is produced.

Production- that phase of the petroleum industry that has to do with bringing the well fluids to the surface and separating, storing, gauging and otherwise preparing the product for the pipeline; also the amount of oil or gas produced in a given period.

Production tank- a tank used in the field to receive crude oil as it comes from the battery; also referred to as a lease tank.

Pump jack- the unit in motion and visible at the surface of a pumping well that transmits the energy from the motor drive to the rodstring and downhole pump.

Recompletion- an operation whereby an existing well is modified to produce oil or natural gas from a different formation.

Recovery factor- the percentage of oil or gas originally in the reservoir that will be ultimately produced.

Reservoir- a porous and permeable rock body in which oil and/or gas is stored.

Reservoir pressure- the pressure that exists in a reservoir under equilibrium conditions.

Rig- the derrick, draw works and attendant surface equipment of a drilling or workover unit.

Rigging down- the act of dismantling the drilling rig and auxiliary equipment following the completion of drilling operations.

Rotary- the component in a drill rig which rotates the drill pipe while at the same time permitting vertical movement of pipe for rotory drilling.

Rotary Drilling- the method of drilling a hole using a rotary bit to which a downward force is applied. The bit is fastened to and rotated by the drill string. New joints of drill pipe are added as drilling progresses.

Royalty- the share of oil or gas production paid by the lessee to the lessor or to the possessor of the royalty rights, based on a percentage of the value of gross production from the property.

Sandstone- a sedimentary rock consisting of individual grains of sand cemented together by silica, calcium carbonate, iron oxide, etc,; a common rock in which petroleum and/or water accumulate.

Secondary recovery- restoring an essentially depleted reservoir to a producing status by the injection of liquids or gases into the reservoir. This restores reservoir pressure and moves the formerly unrecoverable reserves through the reservoir to the wellbore. Usually synonymous with pressure maintenance.

Seismograph- a device for detecting vibrations in the earth; used in prospecting for probable oil-bearing structures.

Separator- a low pressure vessel used for separating mixed streams of fluids into their components.

Shale- a fine-grained sedimentary rock composed of silt and clay particles; ranges in composition from pure clays to calcareous or siliceous clays. It is the most common sedimentary rock.

Spud- to commence actual drilling operations.

Stimulation- the descriptive term used for several processes which enlarge old channels or create new ones in the producing formation of a well; ie., acidizing, fracturing, or explosive treatments.

Swabbing- operating a swab on a wireline to bring well fluids to the surface when the well does not flow naturally. This process results in a slight vacuum being formed in the wellbore. This is a temporary operation to evaluate the productivity of a well.

Tank battery- a group of production tanks located at a point in the field for the storage of crude oil.

Total depth (T.D.)- the maximum depth reached in a well.

Trap- a configuration of permeable and impermeable rock necessary to result in formation of an accumulation of oil or gas. A structure trap is a convolution of a porous and permeable formation that will catch and retain oil and gas underground.

Treater- a vessel at a battery in which produced well fluids (oil, gas and water) are separated into their component parts usually through the addition of chemicals or heat or both.

Unconformity- a buried, irregular eroded surface separating an older and younger rock mass.

Water drive- the type of drive mechanism whereby oil is produced by the expansion of underlying water, which forces the oil into the wellbore.

Water flood- a secondary-recovery operation in which water is injected to displace additional oil to wellbores where it can be recovered.

Well completion- the operations performed to bring a well to productive status following drilling.

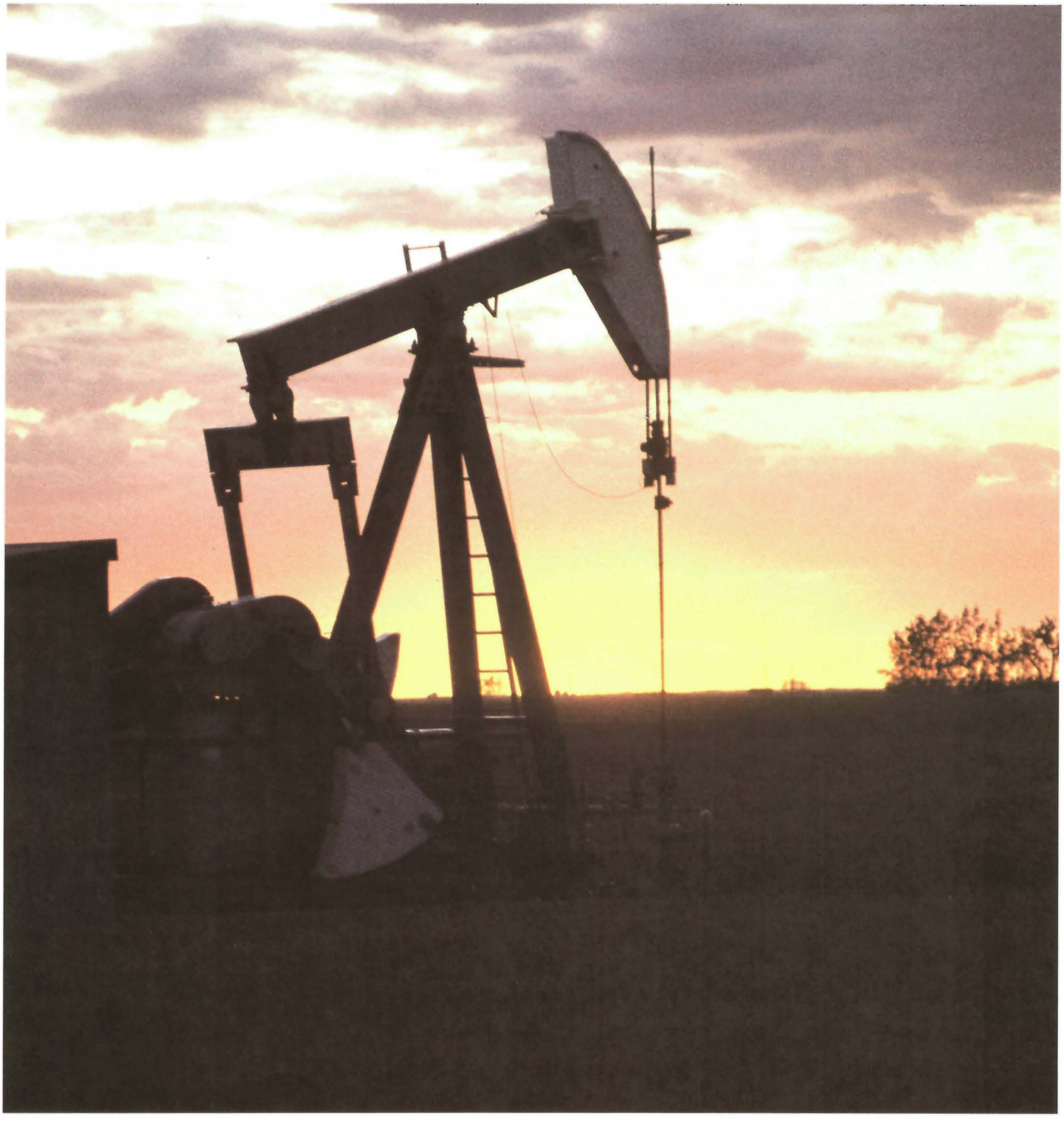
Wellhead- the equipment, comprised of the casing head, tubing head and Christmas tree, used to maintain surface control of a well.

Well logging- the recording of information about subsurface geologic formations. Logging methods include records kept by the driller, mud and cutting analyses, core analysis, drill-stem tests and electric and radioactivity procedures.

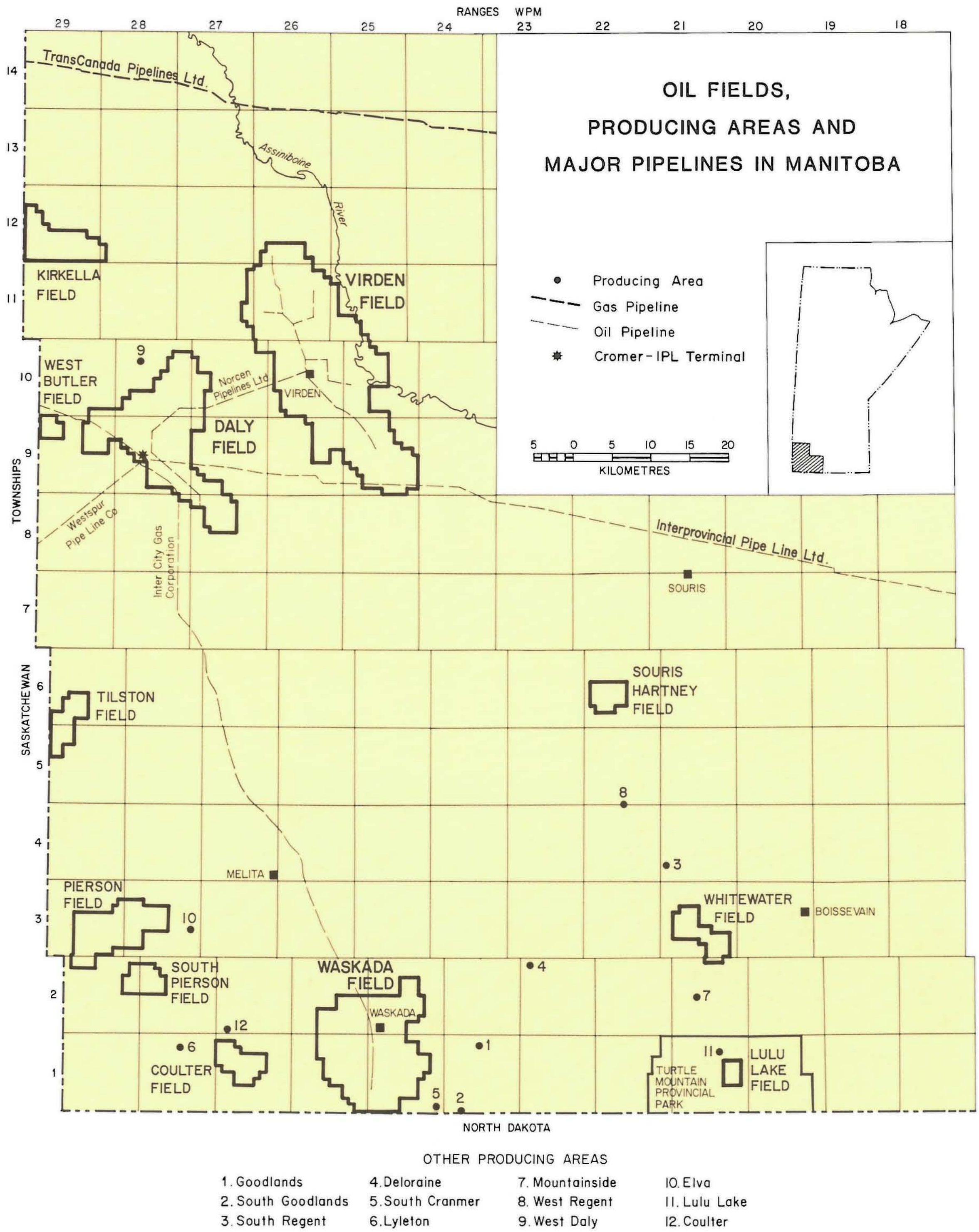
Well servicing- maintenance work performed on an oil and gas well to improve or maintain production from a formation already producing in the well.

Wildcat- a well in unproved territory. With present-day exploration methods and equipment, about one wildcat out of every nine proves to be productive, though not necessarily profitable.

Work over- to perform a variety of remedial operations to change the producing interval in a well.



Map showing location of oil fields and major gathering lines and pipe lines in southwestern Manitoba.



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