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Waskada Lower Amaranth an Overview

By Murray Rodgers and Bob Dubreuil

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1. INTRODUCTION:

The Waskada Field is situated on the northeast rim of the Williston Basin in southern Manitoba. It comprises a large portion of Townships 1 and 2, Ranges 25 and 26 (WPM) (Fig. 1).

Production is obtained from four stratigraphic intervals. The more commonly referenced "Red Beds" of the Jurassic Lower Amaranth (Spearfish) Formation currently provide the bulk of production. However, Mississippian production occurs in the Mission Canyon Formation from the three Mississippian members known locally as MC-1, MC-3a, and MC-3b.

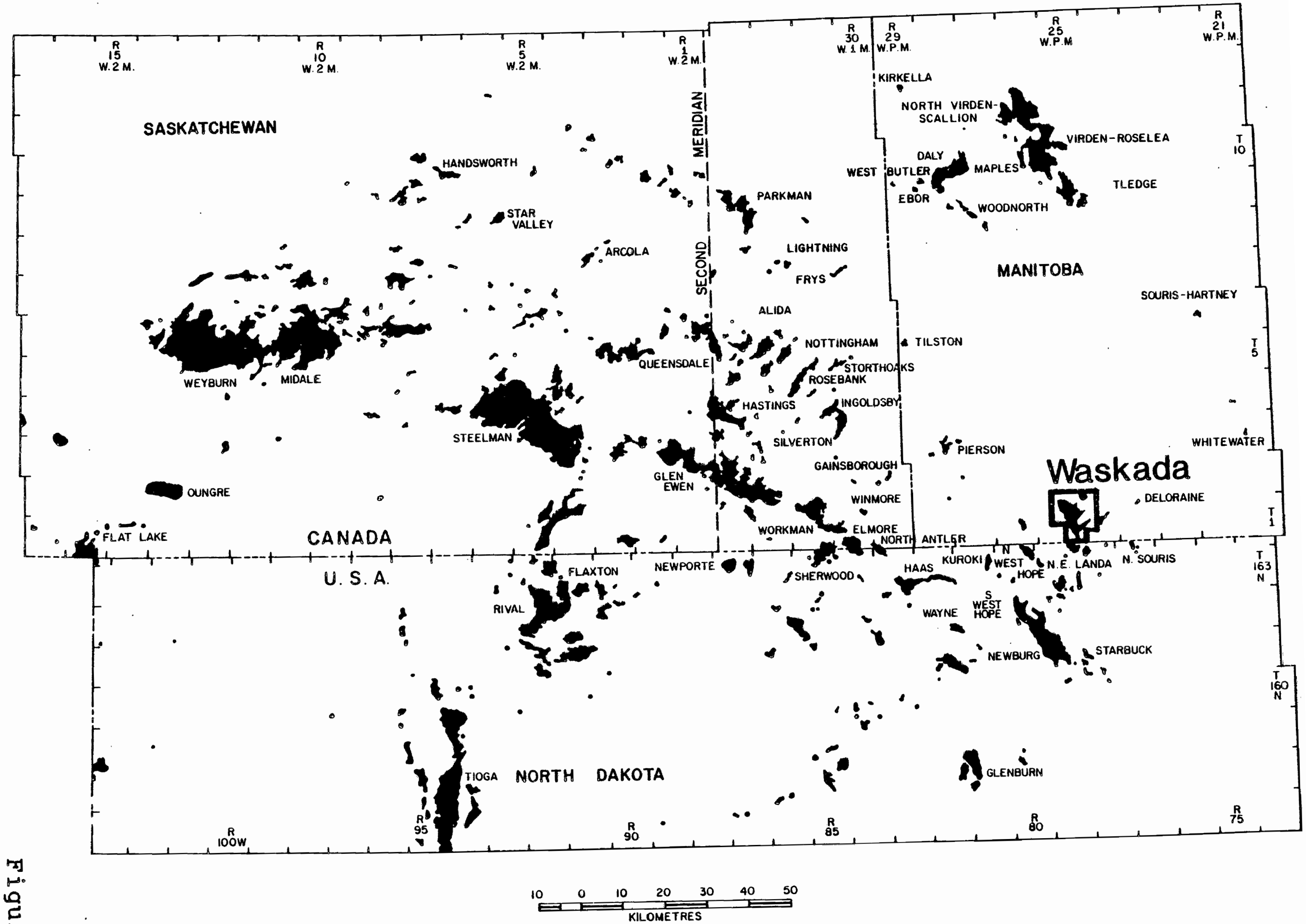
Initial skepticism regarding the potential of the Lower Amaranth reservoir has been silenced by the level of activity which followed the initial discovery in 1980 in that zone. There are now 261 producers in the area, 215 from the Lower Amaranth and 46 from the Mississippian. (Fig. 2). Production in June 1984 averaged 717.m^3 (4,500 bbls.) per day, over 84% of which is from the Lower Amaranth.

HISTORY:

The first oil discovered at Waskada was in 1952 by The California Standard Company (9-13-1-26 WPM). This well produced from the Mission Canyon Formation and the Field was gradually developed to include four small Mississippian pools with production from the MC-1, MC-3a and MC-3b members.

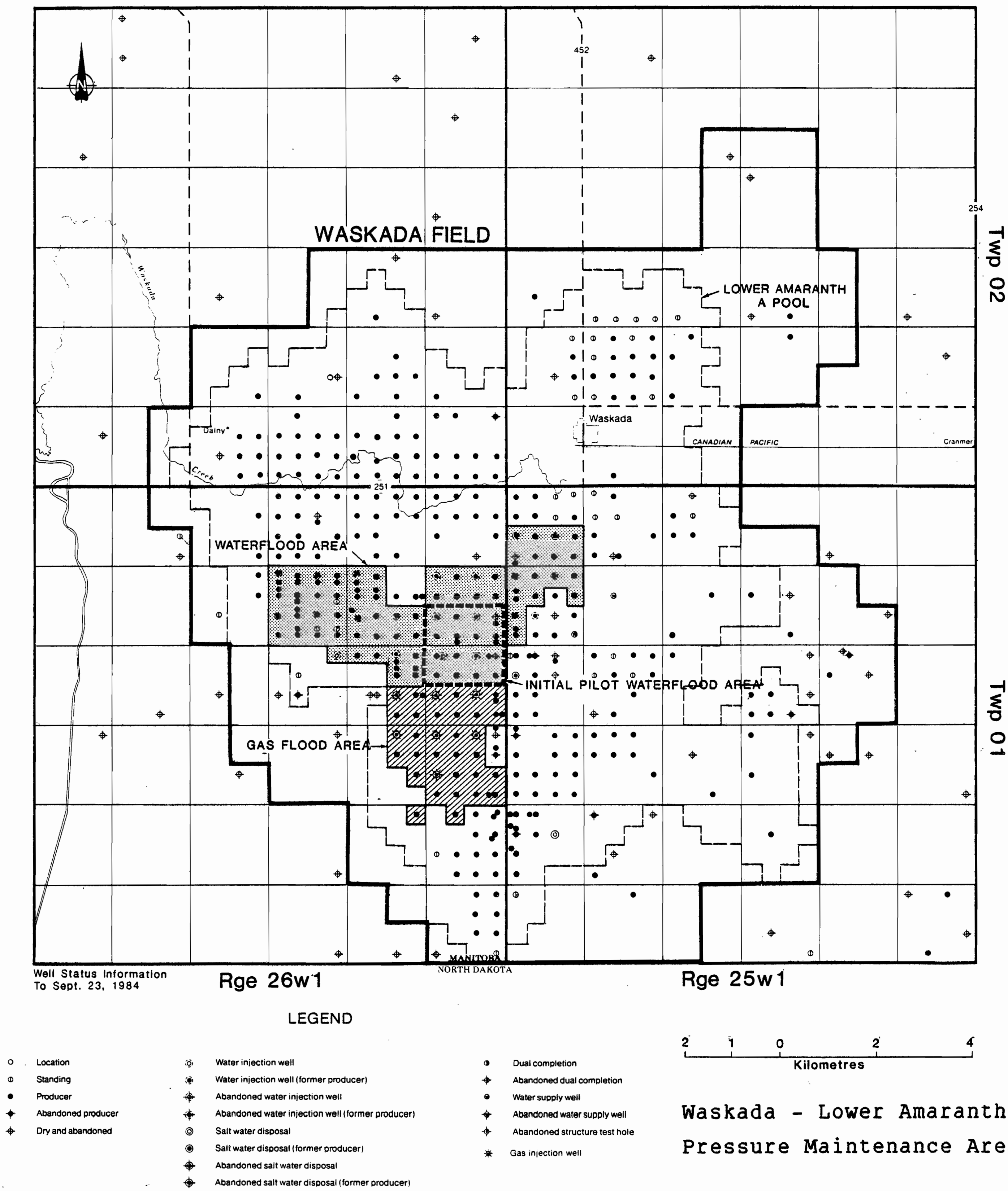
Although Triassic Spearfish strata at Newburg and South Westhope in North Dakota were produced since the mid-fifties, its Manitoba equivalent was not regarded as a prime target.

The lack of appreciable shows and characteristic "tight" appearance on logs led local operators to conclude that these red beds were a top seal to the Mississippian rather than



SASKATCHEWAN
MANITOBA
CANADA
U. S. A.
NORTH DAKOTA
SECOND MERIDIAN
R 15 W.2 M.
R 10 W.2 M.
R 5 W.2 M.
R 1 W.2 M.
R 30 W.1 M.
R 29 W.P.M.
R 25 W.P.M.
R 21 W.P.M.
T 10
T 5
T 1
T 163 N
T 160 N
R 100W
R 95
R 90
R 85
R 80
R 75
HANDSWORTH
STAR VALLEY
ARCOLA
WEYBURN
MIDALE
STEELMAN
QUEENSDALE
OUNGRE
FLAT LAKE
GLEN EWEN
PARKMAN
LIGHTNING
FRYS
ALIDA
NOTTINGHAM
STORTHOAKS
ROSEBANK
HASTINGS
INGOLDSBY
SILVERTON
GAINSBOROUGH
WINMORE
WORKMAN
ELMORE
NORTH ANTLER
KIRKELLA
NORTH VIRDEN-SCALLION
VIRDEN-ROSELEA
WEST
DALY
BUTLER
MAPLES
EBOR
WOODNORTH
TLEDGE
SOURIS-HARTNEY
TILSTON
PIERSON
WHITEWATER
Waskada
DELORAINE
FLAXTON
NEWPORTE
RIVAL
SHERWOOD
HAAS
KUROKI
N WEST HOPE
N.E. LANDA
N. SOURIS
S WEST HOPE
WAYNE
NEWBURG
STARBUCK
TIOGA
GLENBURN
10 0 10 20 30 40 50
KILOMETRES

Figure 1



Waskada - Lower Amaranth Pressure Maintenance Areas

Figure 2

reservoirs in their own rights. This view was commonly held until 1980.

In June of that year, Omega Hydrocarbons Ltd. achieved a break-through by successfully recompleting a former Mississippian producer, 11-30-1-25 (WPM) in the stratigraphically higher Lower Amaranth Formation. Since that date, the Waskada Field has been the focus of considerable attention and debate regarding reserves. The bulk of Lower Amaranth production is from the Lower Amaranth A Pool, and it is from this pool that the following data is derived.

3. GEOLOGY:

The sedimentary sequence is part of the basinward-thickening segment of Paleozoic and Mesozoic strata on the northeastern flank of the Williston Basin. These two sections are marked by a major angular unconformity, and most oil exploration has been oriented towards regional truncation traps in Mississippian strata.

The Lower Amaranth, the oldest Mesozoic unit is a clastic red bed sequence lying directly on the Paleozoic erosion surface. It is equivalent to the Lower Watrous Formation of Saskatchewan. This unit consists of a series of dolomitic siltstones and sandstones interbedded with argillaceous siltstones and shales. The section is usually subdivided into a lower sandy unit and an overlying shale unit. The lower sequence is the oil production zone. The bulk of pay is found in the laminated sandstone/siltstone facies. Porosity is both primary intergranular and secondary intercrystalline in the recrystallized dolomite matrix. In contrast, massive sandstones in the section have poor reservoir quality as virtually all primary intergranular porosity has been destroyed by anhydrite cementation (Barchyn, 1982).

4. <u>Oil in Place</u>:

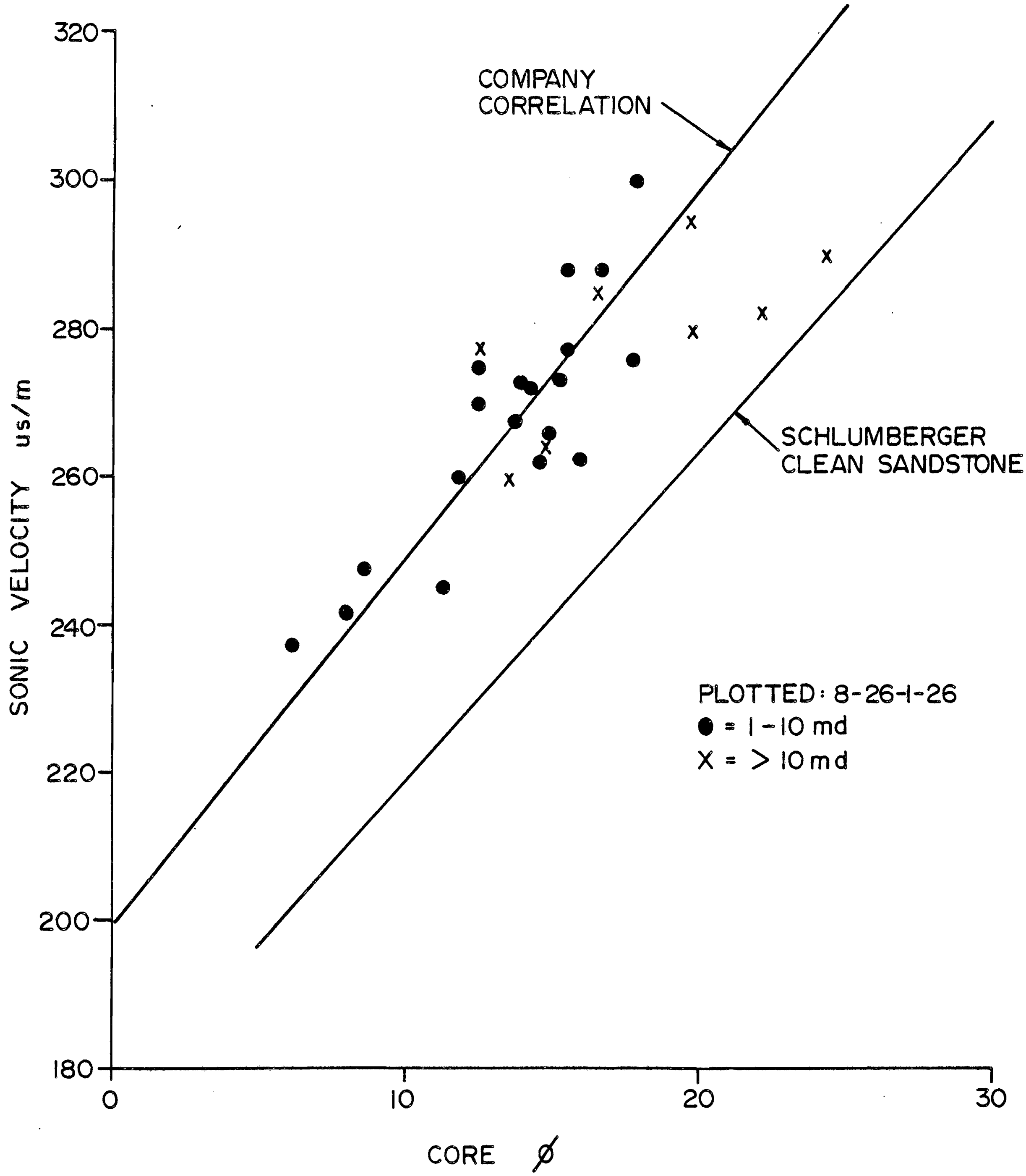
Oil in place in the Lower Amaranth A Pool is estimated volumetrically.

a) <u>Determination Of Effective Pay</u>

The most consistent and reliable method of determination of net pay in the Lower Amaranth Formation is core analysis. In the absence of core data, however, net pay is determined from logs.

Because of the "tight" nature of the reservoir, characteristic responses of Resistivity and Sonic logs do not automatically yield diagnostic measurements of pay as they would in most conventional reservoirs. A method has been developed by which reasonably consistent readings may be obtained. The method consists of inverting the Gamma-Ray and overlaying it on the Sonic curve using the 100 - 500 u-s scale. The curves are normalized on the upper shaly section of the Lower Amaranth. When the sonic lies to the left of the inverted gamma ray, incremental permeabilities of 1 md. for each 10 u-s division separation may be assumed.

Once pay thickness has been determined, using a 1md. cut-off, porosity for each corresponding pay interval is derived from the Sonic curve using a Sonic-porosity relationship calibrated from existing core data. The porosity values derived using this method are consistently lower than those derived using the Schlumberger charts for clean sandstones. A comparison between red beds and clean sands has been provided in Figure 3. Effective pay is expressed in terms of porosity-metres for purposes of reserve calculation. This method is workable but is not without problems which relate specifically to the quantitative accuracy of the values derived. The cross-plot shown in Figure 3 reveals a "cloud" scatter which makes for difficult determination of a best-fit line. The positioning of



COMPANY
CORRELATION
SCHLUMBERGER
CLEAN SANDSTONE
PLOTTED: 8-26-1-26
● = 1-10 md
X = > 10 md
SONIC VELOCITY us/m
320
300
280
260
240
220
200
180
0
10
20
30
CORE Ø

Figure 3

the Gamma-Ray overlying the Sonic is not always consistent as there is a certain amount of subjectivity involved in normalizing the curves. This can lead to unreliable net pay values. Also, resolution of logs may not be sufficient to identify thin (less than 0.2m) zones of pay.

In spite of limitations relating to the actual quantitative values derived using logs, the relative pay values can be applied on a well-to-well basis as a indicator of relative productivity.

For purposes of oil in place determination, an average porosity thickness of 0.91 porosity metres has been determined from core analyses in 61 wells.

b) Connate Water Saturation

Determination of connate water saturation from logs is very difficult because of the silty nature of the sand (affects the Gamma-Ray) and the presence, in some instances, of anhydrite (affects the Sonic porosity and the resistivity). As discussed above, a correction factor relating sonic porosity to core porosity has been determined empirically and appears to be consistent within the limits of the Pool (Sonic porosity ÷ core porosity = ± 1.5). Water saturations ranging from 30% to 70% are determined using sonic porosites with this factor applied. A connate water saturation of 50% is assumed for oil in place estimation.

c) Shrinkage Factor

Reservoir fluid properties were derived from a bottom hole sample taken at Omega Waskada 8-26-1-26 (WPM). Results of this sample indicate a flash formation volume factor at initial conditions of 1.17 RV/STV (1/Boi=0.84).

d) Productive Area

Productive area for the Pool has been determined by considering spacing units (legal subdivisions) that have been completed and have obtained production from the Lower Amaranth Formation. Spacing units that are bounded on two sides by productive or formerly productive wells are also included. Using this procedure, a productive area of 373 drilling spacing units (5 968 ha) is determined for the Pool. An outline of the Waskada Lower Amaranth A Pool as designated on January 1, 1985 is included on Figure 2.

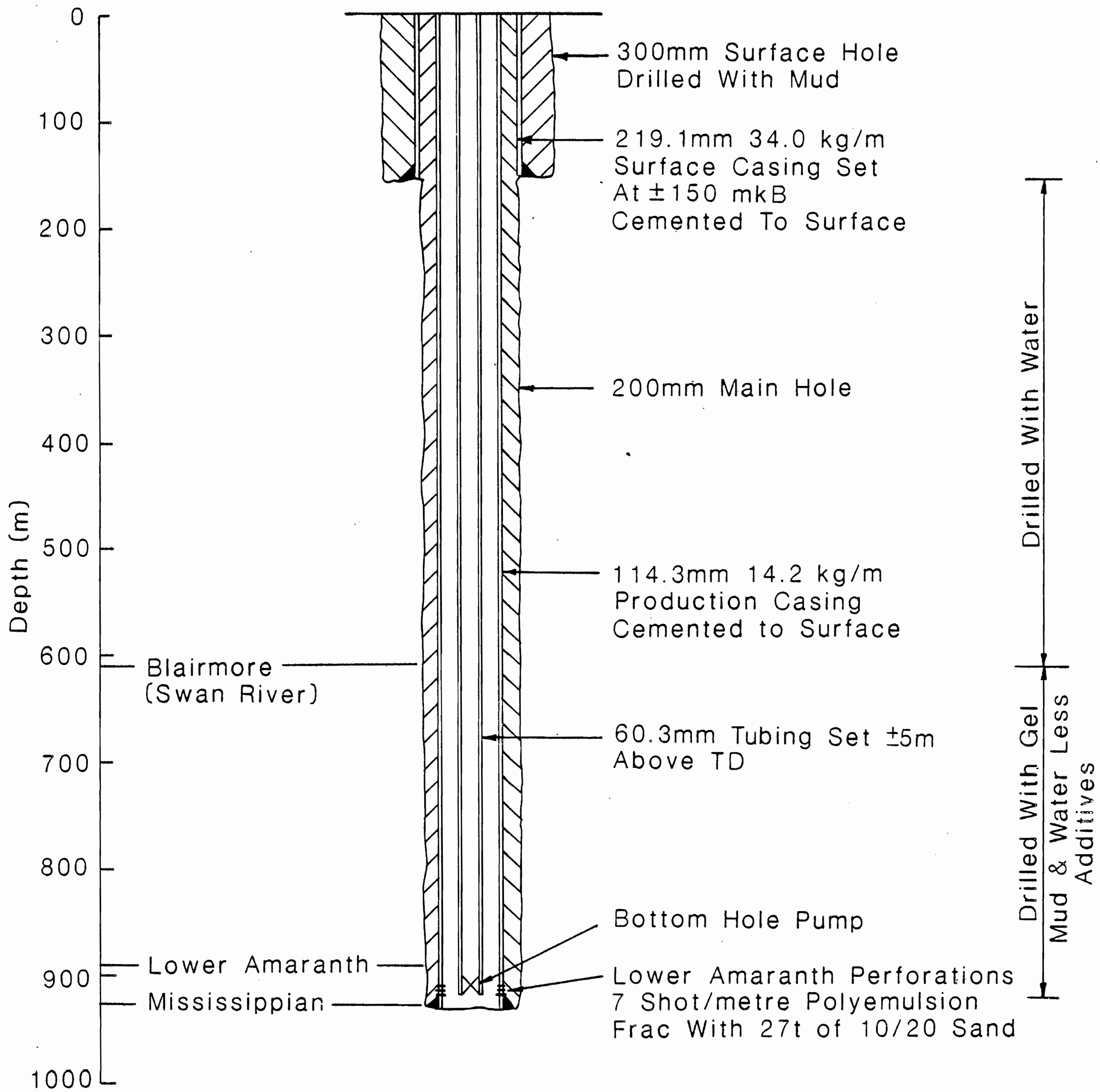
e) Oil In Place

Based on the above factors, an original oil in place of 23 110 000 m^3 (145,358,000 bbl) is calculated for the developed portion of the Lower Amaranth A Pool. The productive area of the Pool does not take into account expansion due to future development drilling.

Well Completion

Figure 4 shows a cross-section of a typical Lower Amaranth Waskada well. A 311 mm surface hole is drilled to a depth of 120 m to 150 m (depending on the depth of bed rock) and 219.1 mm surface casing is set and cemented to surface. After pressure testing the BOP's, the plug is drilled out with water. At the Swan River Formation, the hole is mudded up with gel and drilled to total depth. The well is logged, typically using a Dual Induction Log and a Bore Hole Compensated Sonic Log. If logs indicate potential in the Mississippian zones, the well may be tested using conventional drill stem test tools. Production casing (normally 114.3 mm) is run and cemented to surface and the drilling rig released.

A typical Lower Amaranth completion involves perforation of a 9 -10m interval and a polyemulsion fracture treatment using 27 tonnes of 10/20 sand. Upon fracturing, many wells will flow at



Typical Well Completion

Figure 4

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relatively high rates (up to 15 m^3/day) for a few days. After this flow period, a conventional bottom hole pump is run on sucker rods.

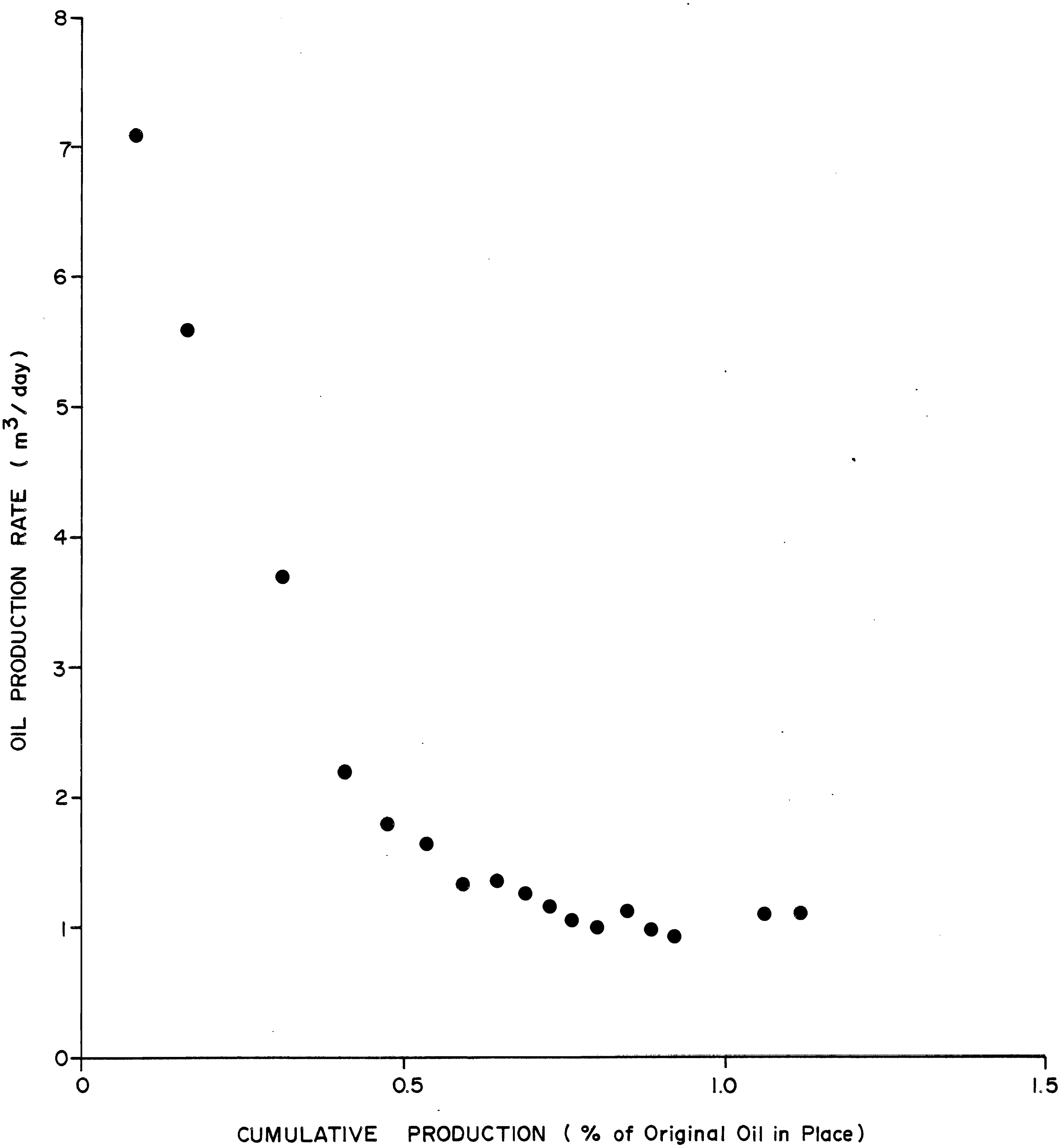
6. Primary Production:

Primary production is characterized by relatively high initial rates (up to 15 m^3/d), a very rapid initial drop, followed by a more gradual decline. This performance is characteristic of a low energy reservoir (initial production due to an expansion drive above the bubble point pressure). At pressures below the bubble point, the primary recovery mechanism is a solution gas drive. Figure 5 illustrates a typical production rate decline and indicates that primary reserves are not expected to exceed 5% of the original oil in place. Primary water production appears to be quite limited (except in the extreme western and southern parts of the Pool). In many instances, initial water cuts are quite high but decline rapidly over the first few months of production, probably indicating depletion of limited water laden zones.

Pressure data obtained in the central part of the Pool prior to initiation of water injection confirms the rapid pressure decline to the bubble point.

7. Secondary Recovery:

As a result of these rapidly declining rates and pressures, Omega Hydrocarbons Ltd. (the major operator in the Field) proposed a pilot waterflood project in the Pool in mid 1982. The project consisted of a one section area in the central part of the Pool (see Fig. 2) and involved conversion of four wells to water injection on an inverted nine spot pattern. Injection began in February 1983. Peformance of the pilot scheme shows a definite waterflood response (increasing rate and declining



8
7
6
5
4
3
2
1
0
0
0.5
1.0
1.5
OIL PRODUCTION RATE (m3/ day)
CUMULATIVE PRODUCTION (% of Original Oil in Place)

Figure 5

GOR) beginning 5 to 8 months after injection was initiated. Production rates, gas-oil ratios, water-oil ratios and reservoir withdrawal/replacement ratios for one of the injection patterns included in the pilot waterflood area is shown on Figure 6. Although recent data indicate a declining production rate, this may be due to under injection over the period January 84 to July 84, rather than premature water breakthrough (note - stable WOR).

Cumulative production to May 31, 1984 in the area of the original pilot waterflood totals 61 124.0 m^3 (384,458 bbl) or approximately 5.2% of the original oil in place.

The success of the pilot has encouraged Omega to expand its pressure maintenance operations in the Pool to include an area totalling 1 776 hectares. (4,440 acres), which includes a gas injection project in the south central part of the pool. (see Figure 2). Production performance from the initial waterflood expansion indicates response comparable to the pilot waterflood area. Meaningful results from the subsequent pressure maintenance projects are not yet available.

8. <u>Recoverable Reserves</u>:

Total proved recoverable reserves from the Pool have been estimated assuming a 5% recovery factor for areas currently under primary production (note if spacing unit is undrilled but is adjoined by two or more drilled spacing units, 1% recovery is assumed), a 25% recovery factor where pressure maintenance response has been observed and a 15% recovery factor where pressure maintenance has been initiated but response has not yet been observed. Based on these assumptions, total proved ultimate recoverable oil reserves of 1 921 000 m^3 (12,083,000 bbl) is calculated. Based on a cumulative production from the Pool of 348 415 m^3 (2,191,464 bbl) through May 31, 1984, remaining reserves are 1 572 585 m^3 (9,891,000 bbl)

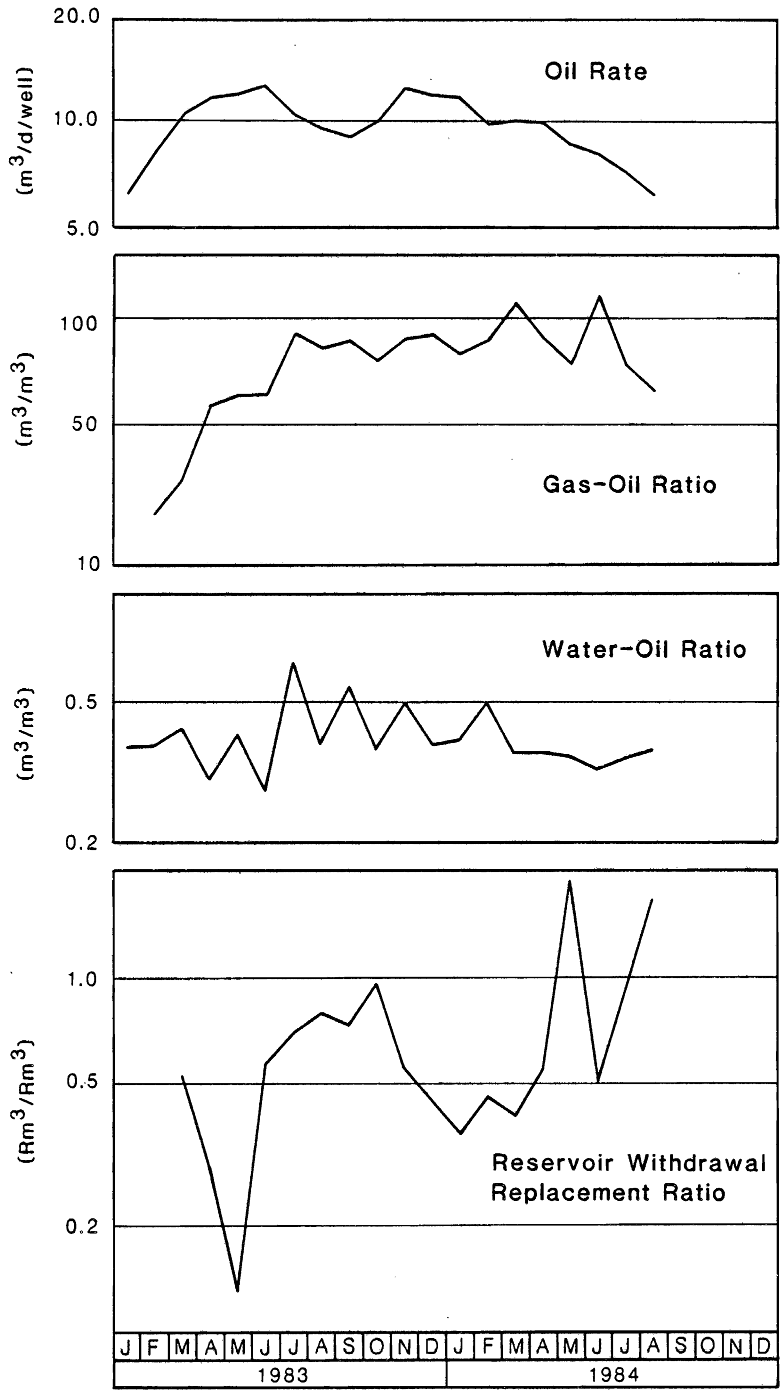


Figure 6

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9. Future Development

It is anticipated that development drilling in the Waskada Lower Amaranth A Pool will continue at an active pace for at least another year. The northeast and eastern limits of the reservoir have not been sufficiently delineated and it is in this area that much of the development drilling is anticipated. In view of the success of waterflooding operations to date, it appears likely that more of the pool will be waterflooded.

A combination of these development activities is expected to result in a significant increase in the recognized recoverable reserves for the Pool.

10. References

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