MANITOBA
DEPARTMENT OF ENERGY AND MINES

MINERAL RESOURCES DIVISION

OPEN FILE REPORT OF83-3

DEVONIAN POTASH DEPOSITS IN MANITOBA

by

B.B. Bannatyne

1983

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(Parts of 62F/3, 6, 11 and 14, and
parts of 62K/3, 6, 11 and 14)

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Winnipeg, 1983

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DEVONIAN POTASH DEPOSITS IN MANITOBA

Introduction

Potash deposits containing sylvite occur in economically recoverable quantities in the Devonian Prairie Evaporite, which is located within the Elk Point Basin that covered much of the Plains area (Fig. 1). In 1980, production in Saskatchewan exceeded 7 million tonnes K_2O equivalent or 11.5 million tonnes KCl product.

The Prairie Evaporite is as much as 200 m thick in southern Saskatchewan, and consists of halite and some interbedded anhydrite, with beds rich in potash in the upper part. The potash mineralization extends as much as 25 km into Manitoba along the western border between Townships 1 and 22 (Fig. 2). The Manitoba deposits are the subject of this report. They have been explored extensively from north of St. Lazare to McAuley, where they were cored in 36 exploration holes drilled between 1956 and 1981. In addition mechanical logs, particularly gamma-ray logs, of several oil wells, indicate the potash extends southward to the International Boundary.

Geological formations present in Manitoba are listed in Figure 3. Units above the Prairie Evaporite consist predominantly of carbonate and shale, with some sandstone interbeds that include the Swan River Group, equivalent to the Mannville Group of Saskatchewan.

History of exploration for potash in Manitoba

Potash deposits of potential economic importance have been outlined along the western border of Manitoba. The potash beds occur within the Devonian Prairie Evaporite that extends across Saskatchewan and into Manitoba as far east as Assiniboine River in the St. Lazare-Russell area. The history of exploration and the development of the potash industry in Saskatchewan, where potash was first discovered in 1942 in salt core from the Norcanols Radville No. 1 well southwest of Weyburn, is described in "Potash in Saskatchewan" (Saskatchewan Department of Mineral Resources, 1973),and by Fuzesy (1982).

The occurrence of potash salts in brine was first reported in analyses of samples taken at salt springs issuing from Devonian rock in western Manitoba by J.B. Tyrrell (1892). Later, Kindle (1914), on the basis of the potassium content of the salt brines suggested that, based on association of rock salt with potash minerals at Stassfurt, Germany, the profits therefrom "should encourage systematic exploration for potash deposits in Manitoba" (p. 261). Potash salts in the subsurface in Manitoba were first reported in 1951 from the Calstan Daly 15-18-10-27W* well, 15 km west of Virden (this well was the first oil producer in Manitoba). A gamma-ray log for this well indicates two zones of moderate to high response in the Prairie Evaporite interval, at depths of 1155.3 - 1157.5 m and 1165.7 - 1166.5 m. Because of its high content of the radioactive isotope K^{40}, a potash bed causes a deflection in a gamma-ray log. Response is proportional to potash content, and a carefully run log can indicate grade and thickness of a potash zone (Fig. 4). By 1956, seven oil well tests had indicated the occurrence of potash beds in Manitoba, but in none of these had the potash interval been cored.

Following intensive exploration in Saskatchewan that outlined the largest known potash deposits in the world, interest developed in determining the eastward extension of the deposits into Manitoba. S.A.M. Explorations Ltd., a small company in Regina, obtained a potash permit from the Manitoba Government, and its first well, drilled in 7-15-19-29W in the Assiniboine River Valley, intersected potash beds at a depth of 780.2 m. The company drilled two other wells, one in 1957, and one in 1958. The property was acquired by Tombill Mines Limited of Toronto, and three more wells were drilled between 1959 and 1961. Sylvite of Canada Ltd., a subsidiary of Hudson Bay Mining & Smelting Co. Limited, acquired the potash lease, and drilled four more wells in 1966. All ten potash wells were successful in intersecting and coring a bed of potash. However, the company owned adjacent property in Saskatchewan that also was underlain by potash; when a decision was made in 1969 to establish a mine site only 5 km west of the Manitoba-Saskatchewan border, the lease area in Manitoba was cancelled.

In the meantime, Prairie Potash Mines Limited, a subsidiary of Inco Ltd. (62.1%) and Canadian Faraday Ltd. (37.9%), acquired a potash permit, part of which was later converted to a lease, for several townships south of the S.A.M.-Tombill leases. Between August 1964 and March 1966, the company cored the potash bed in 15 test holes. Feasibility studies were made, but development was not undertaken, and their lease lapsed in 1977. The company estimated it had outlined sufficient reserves to supply a plant with 1 million tonnes of muriate of potash annually for at least 50 years.

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* Legal subdivision 15, section 18, township 10, range 27 west of the Principal Meridian.

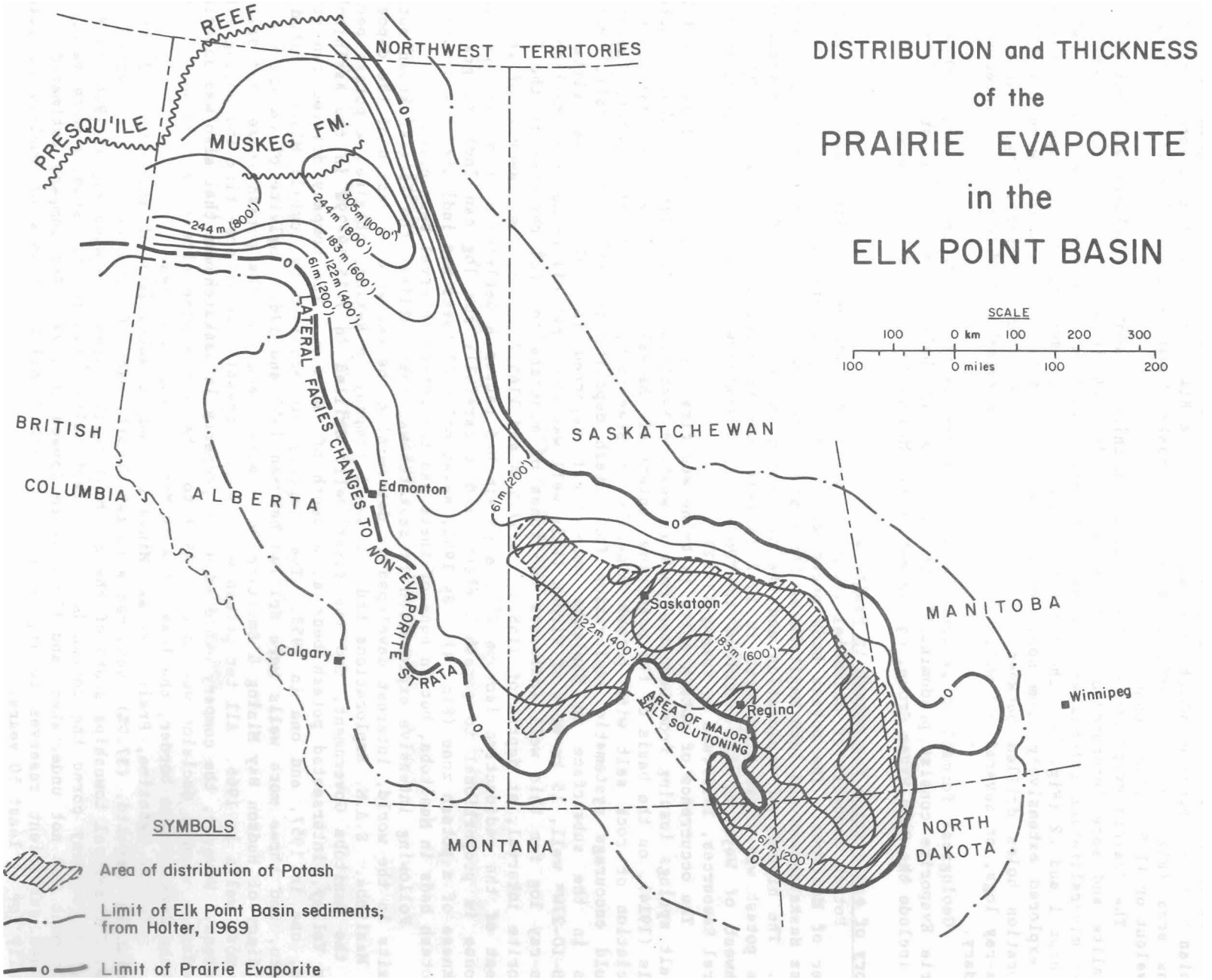


Figure 1: Distribution and thickness of the Prairie Evaporite in the Elk Point Basin

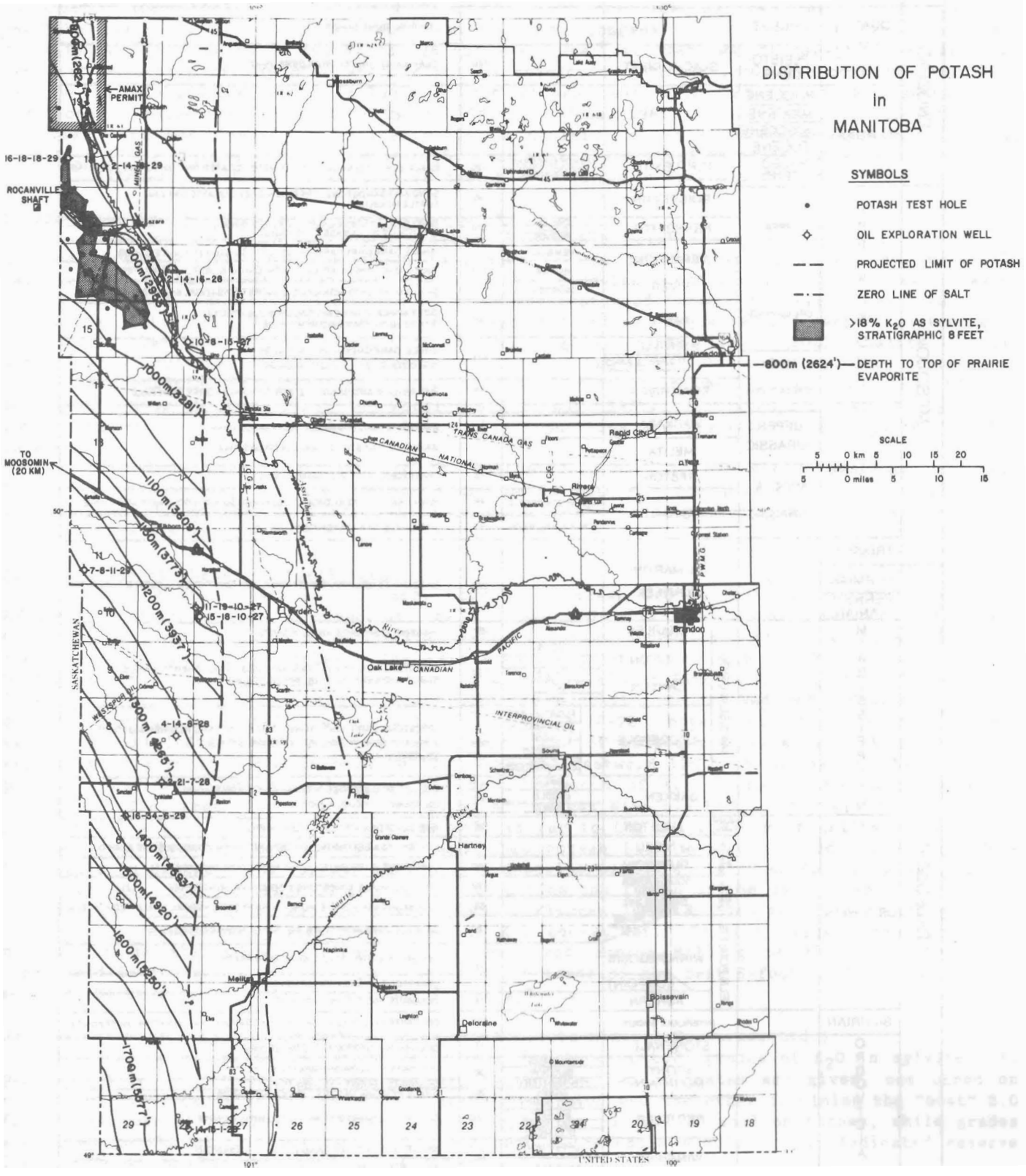


Figure 2: Distribution of potash in Manitoba

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				
		EOCENE				
		PALEOCENE	TURTLE MTN.	PEACE GARDEN	120	SHALE, CLAY AND SAND. LIGNITE BEDS LOCATED ONLY IN TURTLE MOUNTAIN
				GOODLANDS		
MESOZOIC	CRETACEOUS	UPPER CRETACEOUS	BOISSEVAIN		30	SAND AND SANDSTONE, GREENISH GREY, LOCATED ONLY IN TURTLE MOUNTAIN
			RIDING MTN.	COULTER	310	GREY SHALES – NON-CALC. LOCAL IRONSTONE BENTONITE NEAR BASE. GAS FOUND
				ODANAH		
				MILLWOOD		
			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 SAND AND SILT
			FAVEL		40	GREY SHALE WITH HEAVY CALCAREOUS SPECKS BANDS LIMESTONE AND BENTONITE
		LOWER CRETACEOUS	ASHVILLE		115	SHALE, DARK GREY, NON-CALC. SILTY
			ASHVILLE SAND			"SAND ZONE" 27m F.G. QTZ. S. OR SS.
			SWAN RIVER		75	SANDSTONE AND SAND, QTZ. PYRITIC SHALE – GREY, NON-CALC.
	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
	TRIASSIC					
PALEOZOIC	PERMIAN	(?)	ST. MARTIN COMPLEX		300	CARBONATE BRECCIA, TRACHYANDESITE (CRYPTO-EXPLOSION STRUCTURE)
	PENNSYLVANIAN					
	MISSISSIPPIAN		MADISON GROUP: CHARLES		20	MASSIVE ANHYDRITE AND DOLOMITE
			MADISON GROUP: MISSION CANYON	MC–5	120	LIMESTONE – LIGHT BUFF, OOLITIC, FOSS, FRAG., CHERTY, BANDS SHALE AND ANHYDRITE. OIL PRODUCTION
				MC–4		
				MC–3		
				MC–2		
				MC–1		
			MADISON GROUP: LODGEPOLE	FLOSSIE LAKE	185	LIMESTONE & ARG. LIMESTONE LIGHT BROWN AND REDDISH MOTTLED. ZONES OF SHALEY, OOLITIC, CRINOIDAL & CHERTY. OIL PRODUCTION
				WHITEWATER LAKE		
				VIRDEN		
				SCALLION / ROUTLEDGE		
			BAKKEN	UPPER	20	2 BLACK SHALE ZONES – SEPARATED BY SILTSTONE OIL SHOW HIGH R.A. KICK.
				MIDDLE		
				LOWER		
	DEVONIAN		SASK 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
			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	30	DOLOMITE – YELLOWISH – GREY SHALEY
				GUNTON		
				PENITENTIARY		DOLOMITE – DUSKY – YELLOW FOSS
				GUNN	20	SHALE RED-GREEN FOSS. LIMESTONE BANDS
			RED RIVER	FORT GARRY	170	DOLOMITIC LIMESTONE, MOTTLED AND DOLOMITE
				SELKIRK		
				CAT HEAD		
				DOG HEAD		
			WINNIPEG	UPPER UNIT	60	SHALE, GREEN, WAXY, SANDSTONE INTERBEDDED
				SANDSTONE		SAND, SANDSTONE, QUARTZOSE
	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 3: Geological formations in Manitoba

In 1980, interest in the possibility of developing the potash deposits was renewed, and in April, International Minerals and Chemical Corporation (Canada) Ltd. and the Province of Manitoba signed a letter of intent permitting the company to explore and evaluate potash deposits in Townships 15 to 18, Ranges 28 and 29W. The government was to retain the right to 25 per cent ownership of any mine which might be developed. During 1980, the company spent $1.6 million in exploration work, including three potash test holes and a seismic survey. An additional 5 holes were drilled by IMC in 1981. In June, 1980, a potash exploration permit for a 5-year term was issued to Amax Minerals, a division of Amax of Canada Limited, covering Townships 19 to 22, Range 29W. During 1980, Amax Minerals drilled three potash test holes.

Altogether, 36 potash test holes have been drilled in Manitoba to 1981.

Potash deposits in the Devonian Prairie Evaporite

The Prairie Evaporite was deposited in the Elk Point Basin that covered much of the northern Great Plains area, as shown in Figure 1. In northwestern Alberta, the Presqu'ile Barrier reef probably separated the basin from the Devonian ocean and restricted flow of water out of the basin. Evaporation of trapped brine and continued inflow of seawater resulted in its increasing salinity, and eventually in deposition of a sequence of evaporite-associated minerals: limestone ($CaCO_3$), dolomite ($CaCO_3 . MgCO_3$). anhydrite ($CaSO_4$), halite (NaCl), and finally sylvite (KCl) and carnallite ($KCl . MgCl_2 . 6H_2O$). During late stages of evaporite deposition, fluctuations in salinity of the seawater resulted in deposition of four potash-rich beds (Holter, 1969; and Worsley and Fuzesy, 1979), separated and overlain by layers consisting mainly of barren halite. Minor clay impurities are present, in some places as thin layers.

Potash beds are restricted to the southeastern part of the Elk Point Basin, and only halite is present west of the Saskatchewan-Alberta border. The potash layers, in ascending sequence, are named the Esterhazy, White Bear (not yet formally designated), Belle Plaine and Patience Lake Members (op. cit.).

Potash in the St. Lazare-Russell area

In the St. Lazare-Russell area, the main potash bed present is correlated with the Esterhazy Member, which is mined at the K-1 and K-2 shafts of International Minerals and Chemicals Corporation and the Rocanville shaft of Potash Corporation of Saskatchewan (formerly the Sylvite of Canada property). The salt back is about 25 to 30 m thick along the western border of Manitoba, decreasing in thickness toward Assiniboine River (see Fig. 6). In one hole, 7-15-19-29W, the potash bed is in contact with the overlying Second Red Bed. However, for two oil wells drilled in 1975, at 2-14-18-29 and 2-14-16-28, both east of Assiniboine River, gamma-ray logs indicate the presence of a potash bed of reasonable grade and thickness with a salt back of more than 8 m in both wells. Thus the eastward limit of the deposit has not been precisely defined, and the extent of the deposit north of the middle of township 19-29W is uncertain. That area has recently been explored by Amax Minerals Ltd., but their results are on confidential status. The nearest control well is far to the north; 70 m of halite was cored in the Imperial Bluewing Lake 13-4-24-27W well, but potash beds were not noted. Available data from wells in Saskatchewan suggest that potash deposits extend at least as far north as township 22, range 29W. More information is required to define the limits of the potash deposit.

Results of the potash tests are shown in Figures 7 and 8. The grade of potash shown is the amount present in sylvite, expressed as K_2O equivalent. In most holes, some carnallite occurs but as its potash content is not recovered during milling of the ore, it is not considered in ore grade calculations. The average grade of the best 8-foot (2.44 m) interval in most of the area is close to 20 per cent K_2O as sylvite.

Reserve Estimates: St. Lazare-McAuley area (by Manitoba Mineral Resources Ltd.)

Reserve estimates are shown in Table 1 for three cutoff grades of K_2O in sylvite - 16 per cent K_2O, 18 per cent K_2O and 20 per cent K_2O. Two estimates are given, one based on mining the 8.0 foot (2.44 metres) "stratigraphic" section and the other on mining the "best" 8.0 foot (2.44 metres) section. Tonnages are given to the closest 10 million tonnes, while grades are given to the closest one-tenth of a per cent. The table also shows an indicated reserve life predicted on assumptions discussed below.

A rectangular block centred on test hole 5-10-17-29W is not included in the estimates and separates the explored potash deposit into two parts designated the"northern" and "southern" areas. The rectangular block was omitted because it may be an area of potential mining problems.

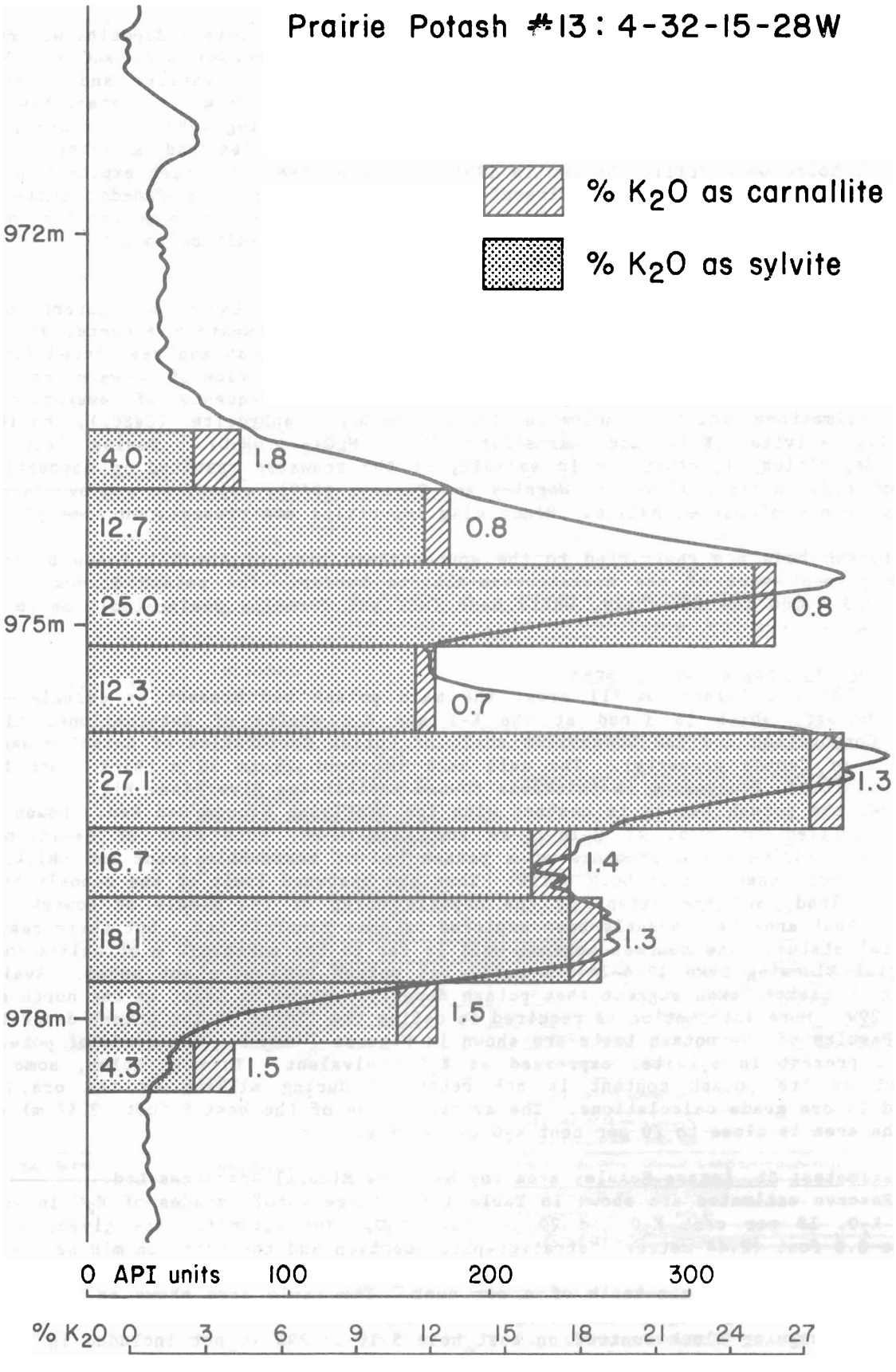
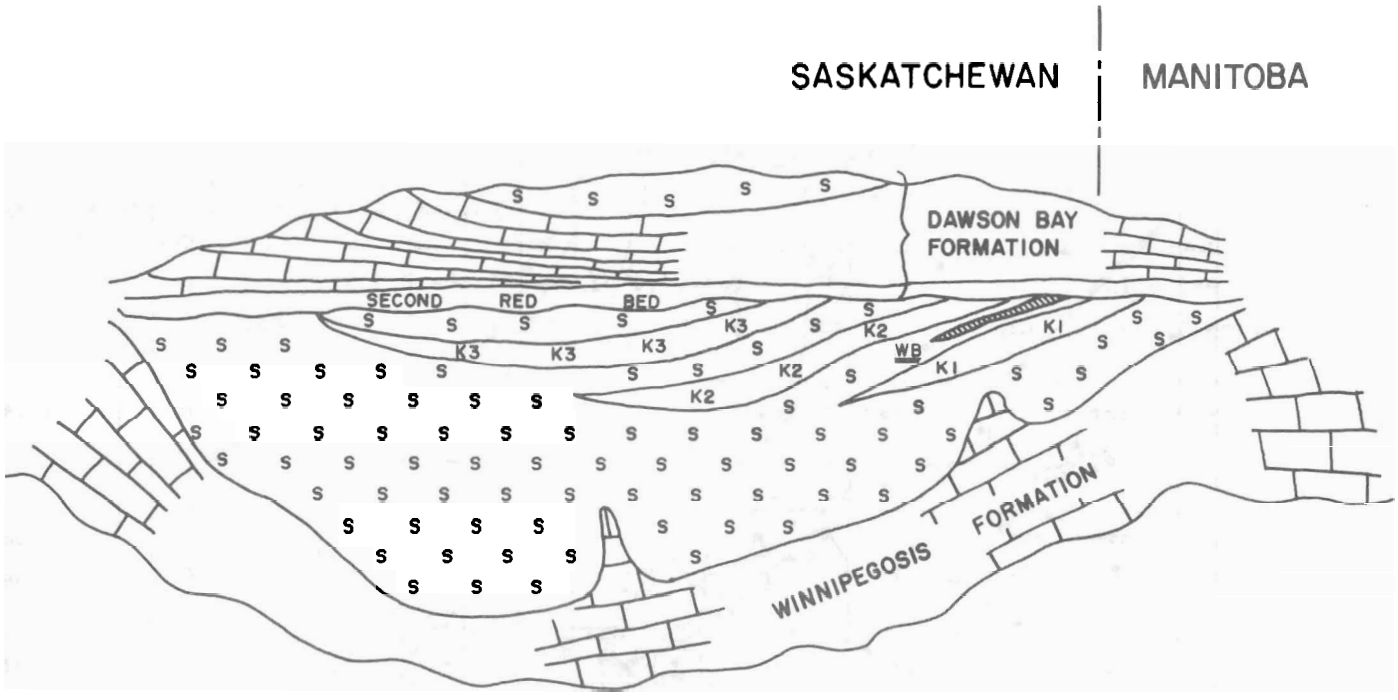


Figure 4: Correlation of gamma-ray log with chemical analyses



LEGEND

K1,K2,K3	ESTERHAZY, BELLE PLAINE AND PATIENCE LAKE MEMBERS
S	SALT
	LIMESTONE, DOLOMITE
WB	WHITE BEAR

Figure 5: Idealized east-west section through the Prairie Evaporite and adjacent rock units

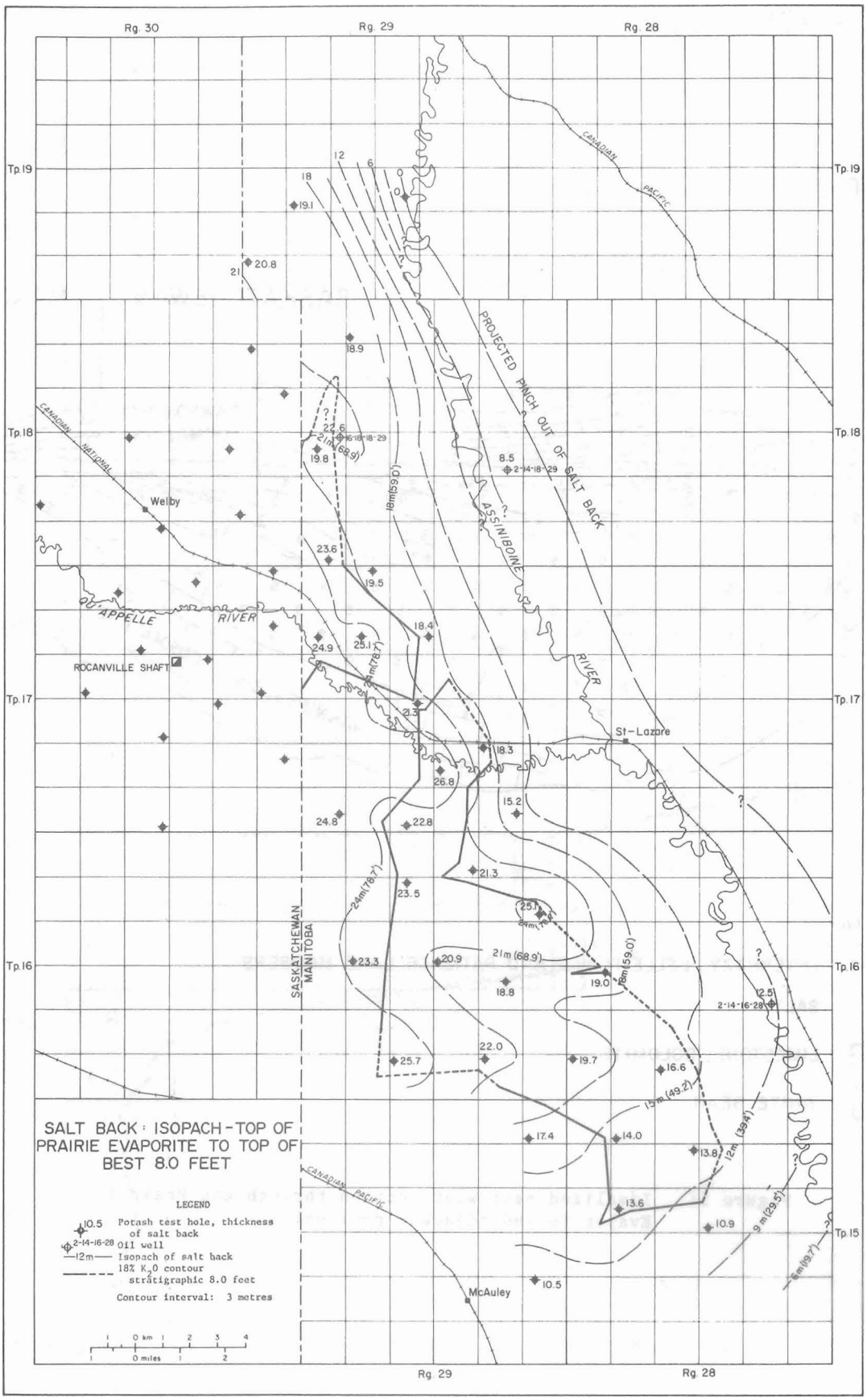


Figure 6: Salt back: isopach - top of Prairie Evaporite to top of best 8.0 feet

Assumptions used in the reserve calculations are listed below:

1. Grade variations between test holes are linear
2. Optimum mining height including dilution is 8.0 feet (2.44 metres)
3. Specific gravity of the potash unit is 2.0
4. "Dummy" test holes having an assumed grade of zero per cent K_2O in sylvite are positioned two miles (3.2 kilometres) distant from peripheral test holes containing values above a cutoff grade of 16.0 per cent K_2O in sylvite.

Assumptions used in calculating the life of the different reserve estimates are:

1. Production rate of 1.8 million tonnes of product per annum grading 61 per cent K_2O (2.0 million short tons)
2. Extraction of 35 per cent of the calculated reserve
3. 87 per cent mill recovery

TABLE 1
RESERVE AND LIFE ESTIMATES

Stratigraphic 8.0 Feet (2.44 Metres)

	Cutoff Grade (% K_2O in Sylvite)						Life (years) Cutoff grade		
	16%		18%		20%				
Area	Tonnes x 10^6	% K_2O	Tonnes x 10^6	% K_2O	Tonnes x 10^6	% K_2O	16%	18%	20%
South	480	21.5	390	22.5	290	23.8	28	24	19
North	170	19.5	120	20.5	70	21.7	9	7	4
Total	650	20.9	510	22.0	360	23.4	37	31	23

Best 8.0 Feet (2.44 Metres)

	Cutoff Grade (% K_2O in Sylvite)						Life (years) Cutoff grade		
	16%		18%		20%				
Area	Tonnes x 10^6	% K_2O	Tonnes x 10^6	% K_2O	Tonnes x 10^6	% K_2O	16%	18%	20%
South	560	21.6	450	22.7	360	23.6	33	28	23
North	190	19.2	120	20.5	70	21.6	10	7	4
Total	750	21.0	570	22.2	430	23.3	43	35	27

A comparison of the two reserve estimates, "stratigraphic" 8.0 feet (2.44 metres) versus "best" 8.0 feet (2.44 metres), shows that the grades are nearly identical but the tonnage of the "best" 8.0 feet (2.44 metres) is somewhat higher than that of the "stratigraphic" 8.0

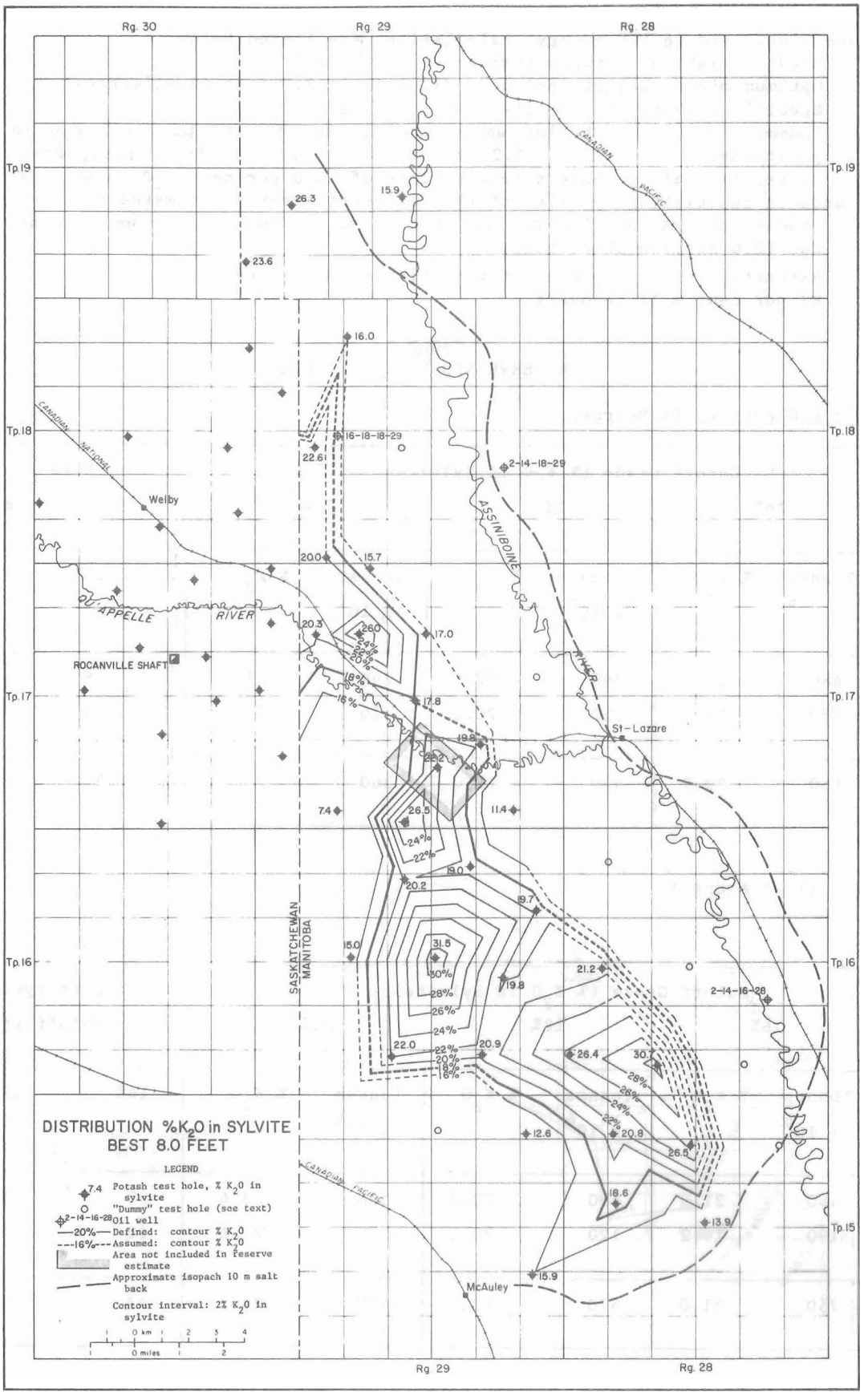


Figure 7: Distribution of $\%K_2O$ in sylvite, best 8.0 feet

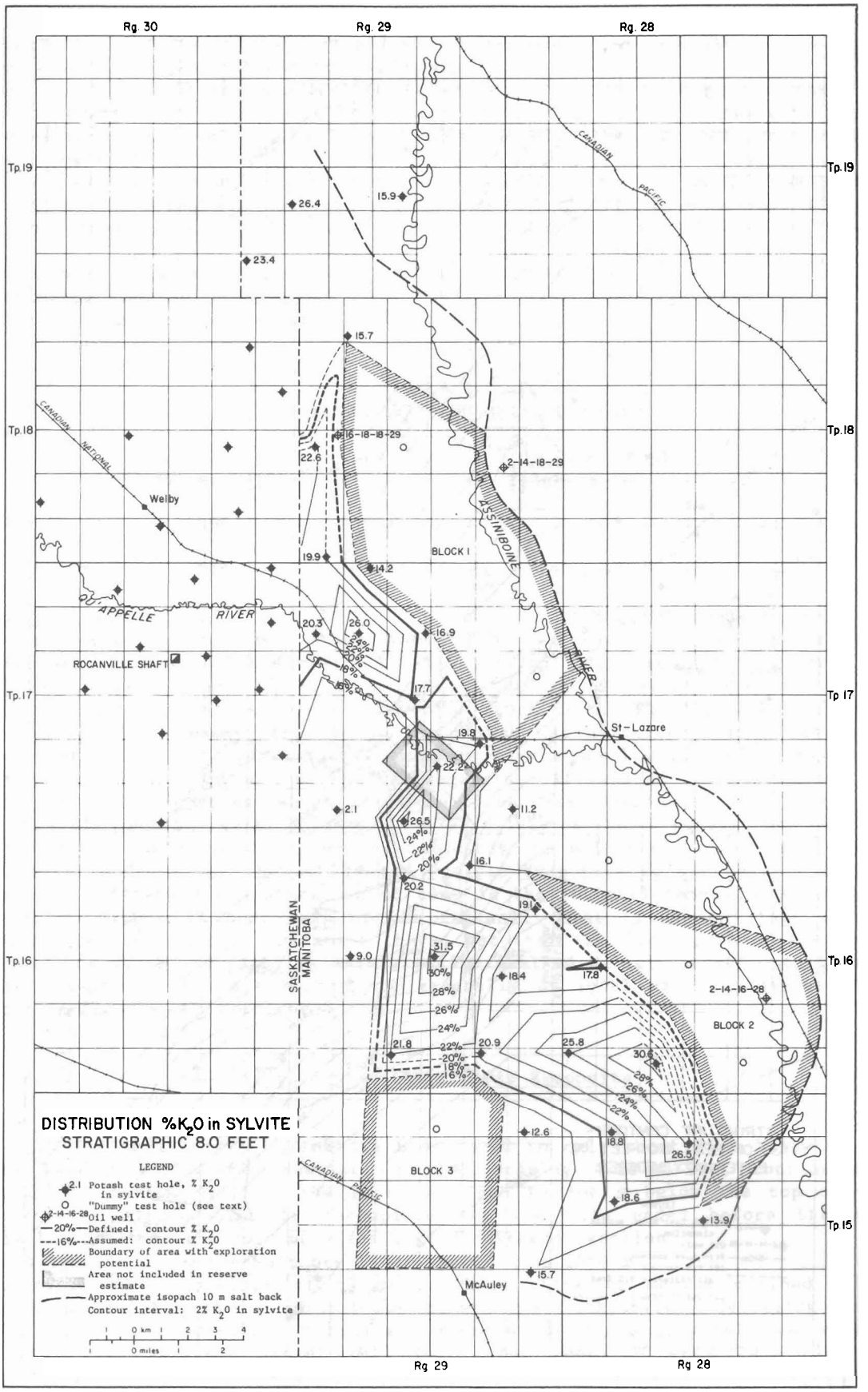


Figure 8 Distribution of $\%K_2O$ in sylvite, stratigraphic 8.0 feet

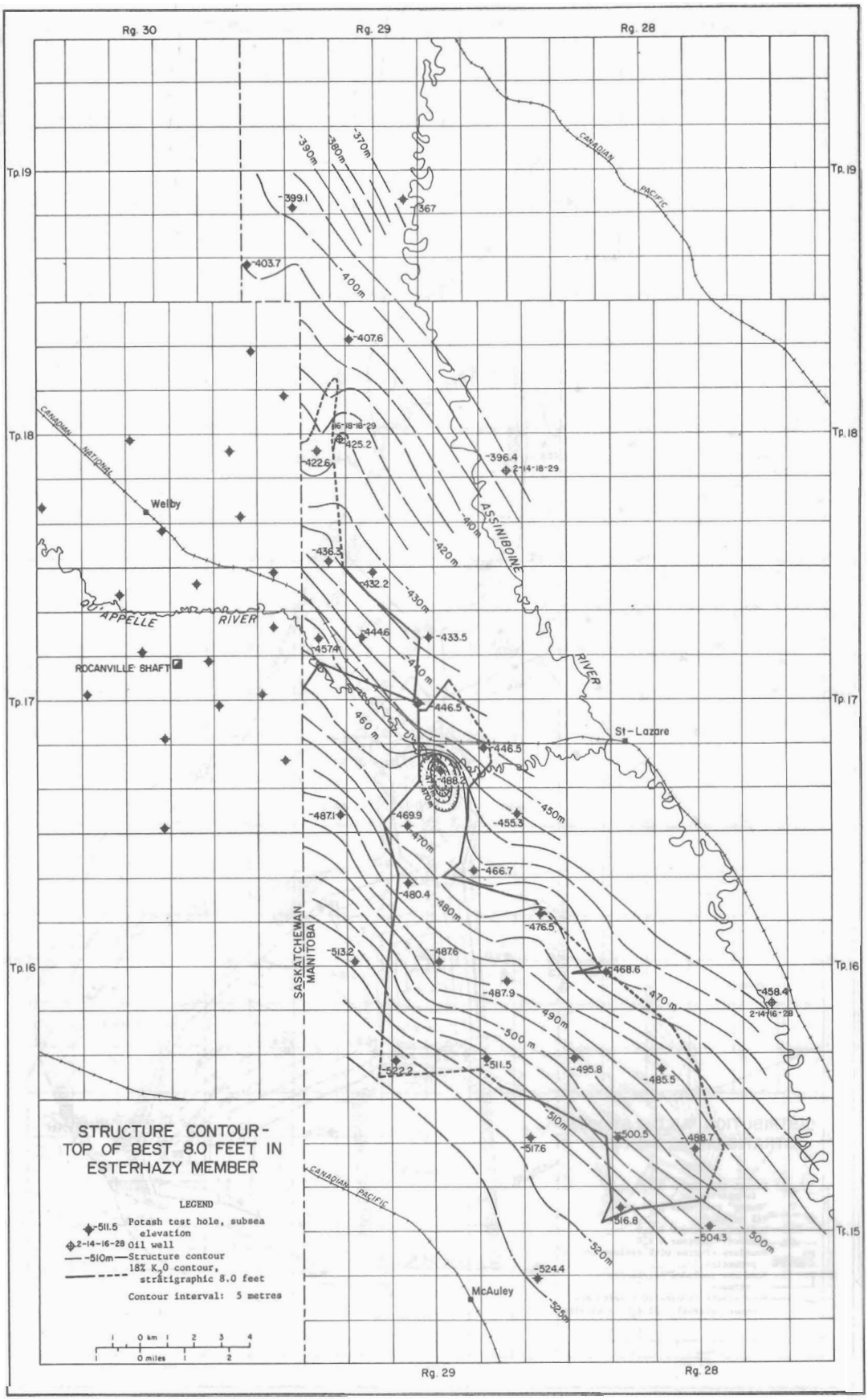


Figure 9: Structure contour - top of best 8.0 feet in Esterhazy Member

feet (2.44 metres). The "stratigraphic" reserve is the preferred estimate on geological grounds and is the more conservative with respect to tonnage.

Three blocks outlining prospective reserves are shown in Fig. 8. The blocks cover areas in which "dummy" test holes were required to define cut-off grade contours where data are absent. The eastern limits of Blocks 1 and 2 coincide with the inferred position of 32.8 foot (10 metre) salt back isopach.

Two oil exploration wells add incentive to explore Blocks 1 and 2. Gamma-ray logs from 2-14-18-29 indicate a total K_2O content over the best 8.0 feet (2.44 metres) of about 18 per cent, while logs from 2-14-16-28 indicate a grade of about 20 per cent total K_2O over the same interval.

Tonnages of potential reserves in the three blocks are given in Table 2. Table 2 also shows an estimated reserve life based on a tonnage equal to 50 per cent of the calculated prospective reserve grading 20 per cent K_2O in sylvite.

TABLE 2
POTENTIAL RESERVE AND ESTIMATED LIFE

Block	Calculated Tonnes x 10^6	50% Calculated Tonnes x 10^6	Life (years)
1	300	150	8
2	230	115	6
3	170	85	5

Salt solution and salt horses

The structure contour map shows that, with one exception, the potash bed extends throughout the area with a gentle slope of about 7.5 m/km. The exception is Prairie Potash test hole 5-10-17-29W, where the section of rock between the top of the Devonian and the top of the Prairie Evaporite shows an increase in thickness of about 21 m. The most likely explanation for this is that about 21 m of salt from below the potash was dissolved during the deposition of overlying Devonian beds. This particular area could pose a problem in mining, as the potash bed could be either bent downward, or faulted into segments; if faulted, associated brecciation may be present in the overlying rocks, which are known to be water-bearing.

In Prairie Potash test hole 8-6-17-29W, only a thin potash bed (16.4% K_2O as sylvite/0.6 m) was cored. Comparison of the gamma-ray log with those of adjacent wells shows a completely normal section from the top of the Prairie Evaporite to the base of the 0.6 m bed. Chemical analyses indicate a concentration of clay in the interval immediately below the potash (6% insolubles vs. about 1% over much of the region). Thus is appears that the potash was originally deposited in its full thickness there, but that the lower part of the bed, possibly as much as 2 m, was dissolved, leaving mainly halite (called a 'salt horse' when found in potash mines in Saskatchewan). As salt horses are generally of local extent, chances of finding a normal ore section nearby are considered good.

Mineralogy of the Prairie Evaporite

Reference section

Most of the potash test holes have been cored to only about 15 m below the potash ore zone of the Esterhazy Member. However, in IMC McAuley 4-22-16-29W, continuous core was recovered from the bottom part of the First Red Bed to 106 m below the top of the Prairie Evaporite section. Although it is incomplete, as the hole ended before the Winnipegosis Formation was intersected, the core provides a good reference section.

a) Salt and anhydrite below the main ore layer: 966.8 m to 1050 m

The basal 40 m consists of clear to white, fine to medium grained clean halite, interlayered with bluish grey to amber-brown dense, hard anhydrite. Overlying the anhydrite zone is a 44 m section consisting of halite, in medium to coarse crystals and clear to smoky white or dirty, with a variable amount (nil to 10 per cent) of grey-green clay, either as disseminated blebs or in thin layers. Deep red to pinkish red carnallite occurs disseminated throughout the upper 20 m of this section, forming 10 to 12 per cent of the core. A 2.6 m layer containing 5 to 10 per cent of large irregular masses of creamy white sylvite occurs 10 m below the main potash zone.

b) The Main Potash zone

The mineralogy of the main potash zone, as determined from chemical analyses, is listed in Table 3. Included are the analyzed sections above and below the main ore zone, which is correlated with the Esterhazy Member.

TABLE 3

Mineral Composition: IMC #2, 4-22-16-29

Interval	Sylvite	Carnallite	Halite	$CaSO_4$	Insol.	Total
1	17.7	10.9	68.4	0.04	2.5	98.84
2	26.5	10.9	63.0	0.03	0.09	101.33
3	25.8	10.1	54.3	0.08	10.2	100.48
4	8.4	10.7	74.1	0.05	5.9	99.15
5	6.5	9.9	75.3	0.14	6.8	98.64
6	5.6	10.6	82.1	0.07	2.5	100.87
7	19.8	9.6	70.1	0.04	1.8	101.34
8	26.3	11.3	60.0	0.29	2.6	100.49
9	58.5	13.3	27.0	0.18	1.8	100.78
10	55.2	9.4	35.1	0.07	1.1	100.87
11	41.9	8.8	44.4	0.14	4.1	99.34
12	26.2	7.5	64.6	0.04	2.2	100.54
13	1.4	4.2	91.0	0.06	1.2	97.86
14	0.14	4.6	81.6	0.41	10.1	96.85
15	0.19	6.3	87.3	0.45	4.9	99.14
16	0.46	8.6	86.4	1.02	1.9	98.38
17	0.11	6.9	87.7	0.58	0.7	95.99
18	0.02	6.5	88.5	0.45	1.3	96.77

The main ore zone in 4-22-16-29 occurs at 965.7 m to 968.14 m (intervals 9, 10, 11, and part of 12) and is relatively simple mineralogically. The zone consists primarily of a mixture of halite and sylvite, with carnallite as the major accessory mineral. Only small amounts of $CaSO_4$ are present, and the average content of insolubles is 1.84 per cent. The insolubles consist of finely disseminated greyish green clay. The halite occurs as coarse grained crystals enclosed in an irregular matrix of sylvite.

c) The salt back

The salt back extends from the top of the main ore zone at 965.7 m to the top of the Prairie Evaporite at 944.13 m. The dominant mineral is halite in clear, medium to coarse grained crystals. However, both carnallite and sylvite occur sporadically throughout the salt back, and in places are concentrated in thin layers. The insoluble clay content is variable from almost nil to more than 40 per cent in one carnallite-rich bed.

The main concentration of potash minerals in the salt back is in the interval between 950 and 956 m. Carnallite is enriched at the top of this zone, and some sylvite occurs lower down. The concentrations are sufficient to cause prominent peaks on the gamma-ray logs, and these have been termed the White Bear marker beds.

d) White Bear: "marker beds" and "member"

Persistent thin layers of potash occur within the salt back, some 12 to 15 m above the Esterhazy Member. These layers are called the White Bear marker beds by Holter (1969). Later work by Worsley and Fuzesy (1979) suggested the beds thicken in southeastern Saskatchewan, and they have proposed naming them the White Bear Member.

In Manitoba these beds have been cored in most of the potash test holes. The most persistent unit is the lowermost bed. It has a thickness ranging between 1.52 and 2.44 m. Portions of the marker beds that have been analyzed show a variable mineralogical content (Table 4).

TABLE 4

COMPOSITION OF WHITE BEAR MARKER BEDS

	Sylvite	Carnallite	Thickness
Sylvite holes, 9 analyses	19.4 to 58%	0.11 to 30.66%	0.3 to 1.1 m
Prairie Potash holes, 4 analyses	6.8 to 45%	0.3 to 58%	0.3 to 1.5 m
IMC holes, 3 analyses	0.6 to 36%	4.4 to 36%	0.75 to 1.11 m

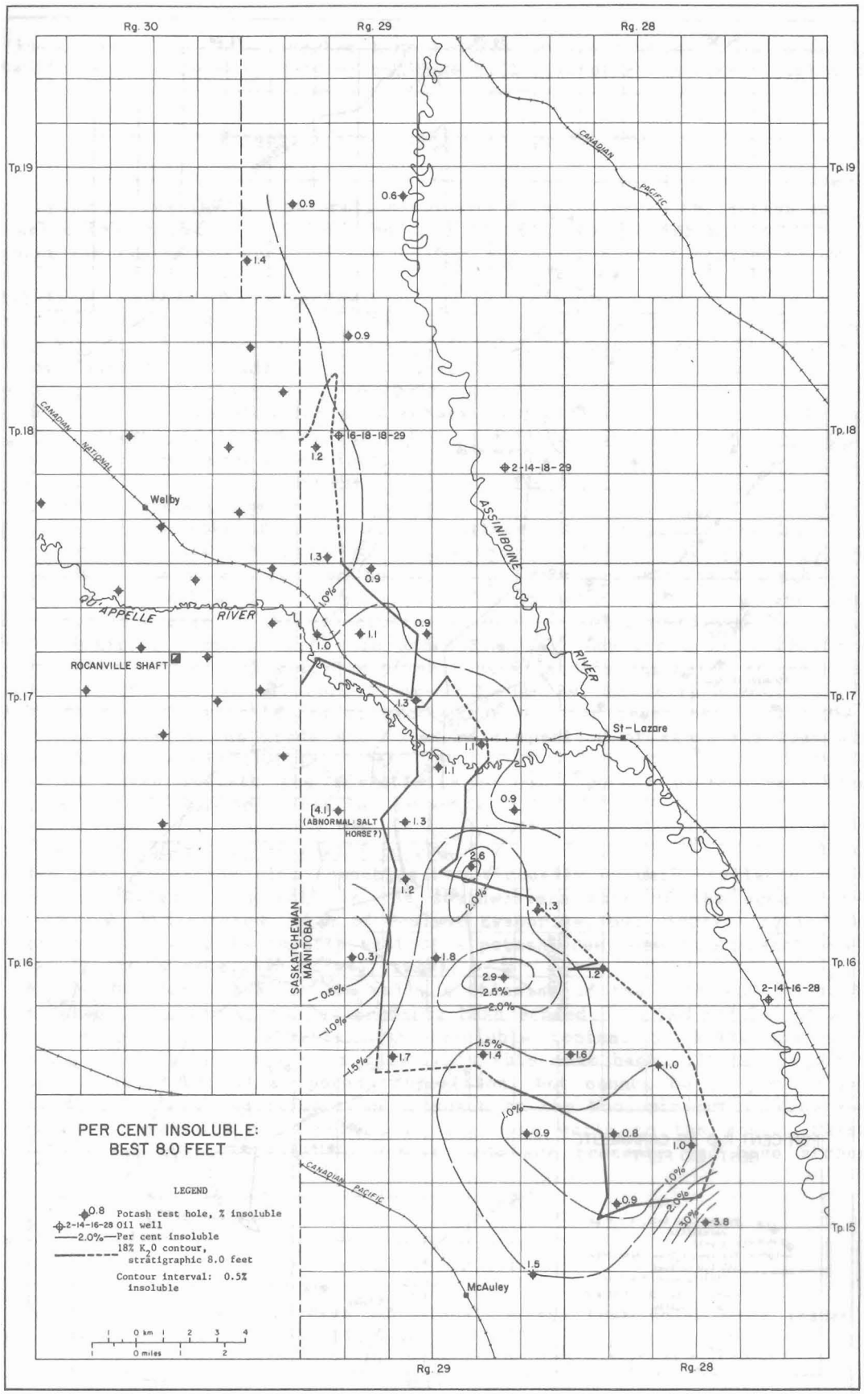


Figure 10: Per cent insoluble: best 8.0 feet

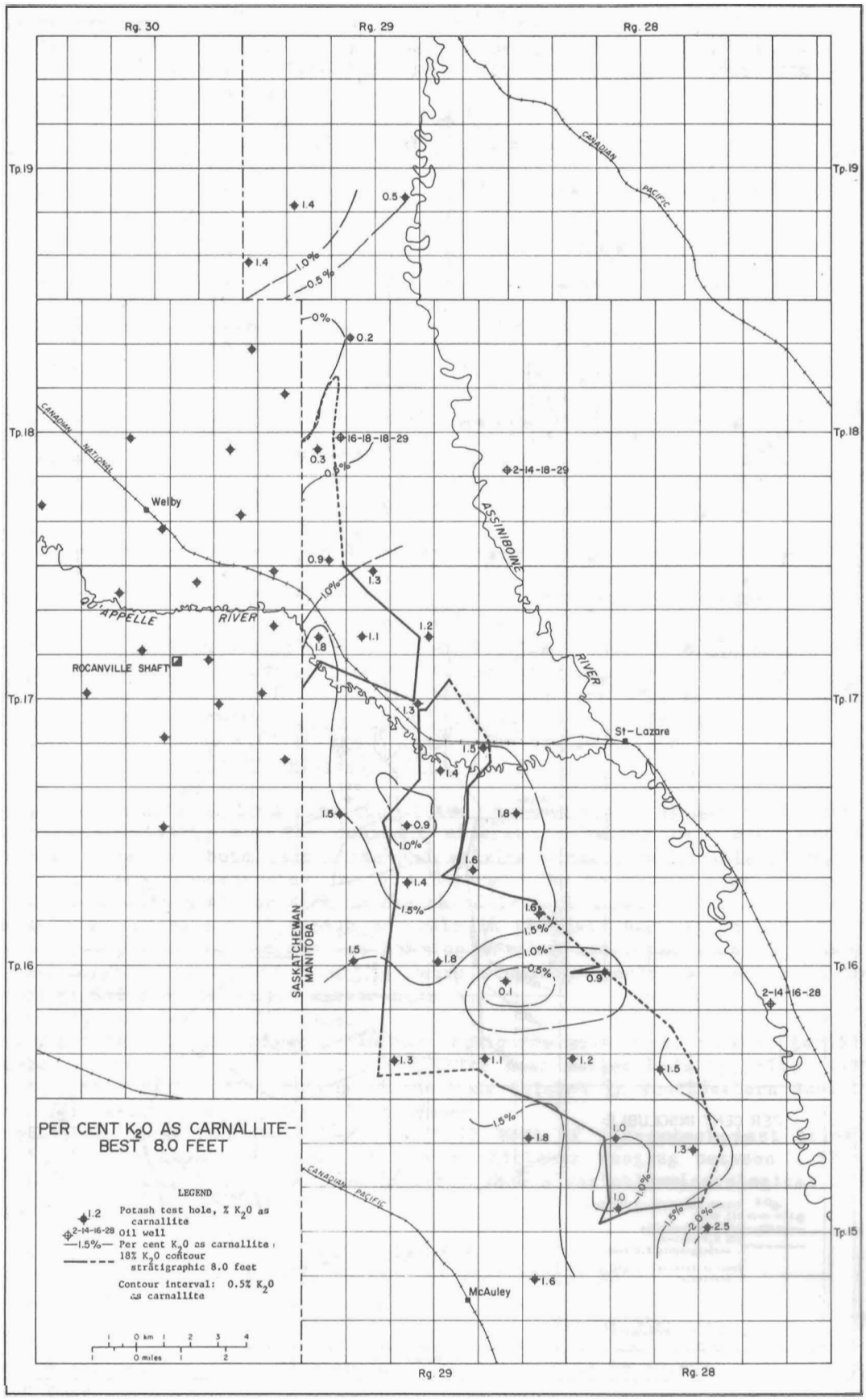


Figure 11: Per cent K_2O as carnallite - best 8.0 feet

Thus the unresolved question is whether the potash zones in the McAuley area are connected southeastward to the zones in the Daly-Elkhorn area, or whether the Moosomin zero-area extends eastward to the Assiniboine River. Additional drilling in that area would be useful.

TABLE 5
POTASH IN OIL EXPLORATION WELLS

Well	Potash Member	Thickness Feet	Thickness Metres	Gamma-ray Response	Salt Back to Top of Potash Member Feet	Salt Back to Top of Potash Member Metres
7-8-11-29W	White Bear	26	7.9	Strong	20	6.1
	Esterhazy	17	5.2	Moderate	67	20.5
15-18-10-27W	White Bear	23	7.0	Strong	17	5.2
	Esterhazy	11	3.4	Moderate	60	18.3
11-19-10-27W	White Bear	7	2.1	Moderate	0	0.0
	Esterhazy	15	4.5	Moderate	15	4.6
4-14-8-28W	White Bear	29	8.8	Strong	17	5.2
	Esterhazy	22	6.7	Moderate	64	19.5
2-21-7-28W	Belle Plaine	7	2.2	Weak	12	3.6
	White Bear	37	11.2	Strong	39	11.9
	Esterhazy	25	7.6	Moderate	85	25.9
16-34-6-29W	Belle Plaine	4	1.2	Weak	15	4.6
	White Bear	20	6.1	Strong	45	13.7
	Esterhazy	9	2.7	Very weak	102	31.1
14-15-1-28W	White Bear (?)	7	2.2	Strong	1.6	0.5

4. Southern area: townships 11 to 6

In the area extending from west of Virden to the Saskatchewan border, and south to Reston, six oil wells have been drilled through the Prairie Evaporite (Table 5). Two potash zones are present in these wells, and can be tentatively correlated with the White Bear and Esterhazy Members, as defined by Worsley and Fuzesy (1979). The Belle Plaine Member also is thought to be present in 2-21-7-28W and 16-34-6-29.

In township 10, the potash is at a depth of less than 1200 m and may possibly be recoverable by conventional mining methods, although most ore reserve calculations to date have been based on a limit of 1066 m (3500 feet). Farther south, the potash is assumed to be recoverable only by solution mining methods. As very large deposits of potash in Saskatchewan are available for solution mining, little attention has been directed toward the possibility of this method of recovery in Manitoba. However, the occurrences deserve to be considered on their own merits. In the Calstan Ewart 4-14-8-28W and the Calstan Linklater 2-21-7-28W wells, both the White Bear and Esterhazy Members are present, separated by a thin layer of halite.

Potash mineralization of undetermined grade but showing a moderate to strong response on gamma-ray logs, occurs over a thickness of about 25 m. The salt back in the two wells is 3 and 8 metres, respectively.

5. Area from township 5 to International Boundary

In the area comprising Townships 1 to 5, Ranges 28 and 29W, results of only one deep exploration well are available and a potash bed with a strong gamma-ray response is present in the 14-15-1-28W well near Lyleton. This may be the White Bear Member, rather than the Esterhazy. The bed is 7.2 feet (2.2 metres) thick and has a salt back of only 1.6 feet (0.5 metres).

Anderson and Swinehart (1979) indicate a thickness of 3 m of the Esterhazy Member is present in a well about 10 km southeast of the southwestern corner of Manitoba, in the northwestern part of Bottineau County, North Dakota. It occurs at a depth of 1717m, and the Prairie Evaporite there is between 60 and 90 m in thickness.

It is possible that these marker beds thicken in the area south of township 12; such an interpretation has been made by Worsley and Fuzesy (1979) for southeastern Saskatchewan.

Potential extension of the potash area

The review of results of exploration work to date indicates the potash zone in Manitoba is more extensive than previously known, and that its full extent has not yet been determined. Five areas where the limits and grade of the deposit are unknown are discussed below.

1. Area north from township 19, range 29W

The northern area, from township 19 to 22 in range 29W, is held under a potash permit issued to Amax Minerals.* Based on the results in Saskatchewan on the adjoining property that was explored by Canberra Oils Limited, this area in Manitoba has good potential. Potash has been intersected in Canberra Langenburg 16-29-22-30W, where a 2.44 m (8-foot) zone with a total K_2O content of 22.85% is present under a salt back 14.6 m thick. Deposits of halite more than 100 m thick are believed to extend as far north as township 28, although the extent of potash north of township 22 has not been determined.

2. East of the explored area, townships 15 to 18

Based on early results of drilling, the eastern limit of potash was once believed to be close to or along the Assiniboine River (Bannatyne, 1971). That position was based on extrapolation between S.A.M. Exploration No. 1, 7-15-19-29 and Homestead Birdtail 10-8-15-27, where the potash bed in each well is in contact with the Second Red Bed. However, wells drilled in 1975 a short distance east of the Assiniboine River both indicated the potash bed extended at least several kilometres farther east. In ASM-BTS et al. Gambler 2-14-18-29W, the Esterhazy Member potash zone is present below 8.53 m of salt back, and is estimated to grade about 18 per cent total K_2O. In ASM-BTO et al. Fort Ellice 2-14-16-28W, the potash zone is present under 12.5 m of salt back, and is estimated to grade about 20 per cent total K_2O. The zones were not cored, and the estimates of grade are based on comparison of gamma-ray logs with those of wells for which analyses are available.

These two wells suggest the possibility of more potash of economic interest being present to the east of the explored area in townships 15 to 18.

3. Area from townships 15 to 12, ranges 27 to 29W

A large area totalling nine townships has virtually no data available on which potash reserves can be estimated. One well in the southwestern part of the area, ASM-BTO et al. Kirkella 16-29-12-29W, intersected 100 m of Prairie Evaporite, but without any indication of the presence of potash. The well is located east of a potash-free zone in Saskatchewan surrounding Moosomin (Holter, 1969; Worsley and Fuzesy, 1979).

In the IMC McAuley 14D-12-15-29W well, a thinning of the salt back is evident; also, the White Bear Member is absent, and has probably been eroded. In IMC McAuley 4B-22-15-28 well, the main potash zone has a relatively high insoluble content of 3.84% and a high K_2O as carnallite content of 2.5%, as well as a relatively thin salt back. These factors may suggest an approach to the edge of initial potash deposition, but cannot be considered as conclusive evidence. For example, they may reflect an approach to the Moosomin potash-free zone, but the potash could thicken again to the south. In the next wells to the south, Calstan Elkhorn 7-8-11-29 and Daly Gas #2, 11-19-10-27, potash beds are present, and have strong gamma-ray deflections.

*In the fall of 1983, licenses for five additional potash test holes were issued to Canamax Resources Inc. (formerly Amax of Canada Limited).

Sources of information and acknowledgements

The basic material for this report has been derived from the 33 drill holes listed in the Appendix. Geological reports for each of the wells contain the chemical analyses of the potash beds, and are in non-confidential assessment work files. They are available through the Geoscience Data Section, Mineral Resources Division, 993 Century Street, Winnipeg, Manitoba, R3H OW4.

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APPENDIX: DATA FROM NON-CONFIDENTIAL POTASH WELLS

(All depth measurements are in metres)

Company	SYLVITE #7	SYLVITE #1	SYLVITE #3	SYLVITE #10	SYLVITE #8
Well Name	Francana Millwood	S.A.M. Exploration No. 1	(Boundary) S.A.M. Binscarth	Sylvite Madeline	Sylvite Madeline
Location	4-17-19-29	7-15-19-29	13-6-19-29	4-32-18-29	11-18-18-29
K.B.	489.51	412.09	486.98	480.06	485.55
Ground	485.55	411.48	483.11	476.1	481.58
Prairie Evap.:					
Top	869.59	779.07	869.90	868.68	888.42
Subsea	-380.05	-368.04	-382.92	-388.62	-402.94
White Bear:	Anomalous γ				
Top/Bottom	875.08/876.91	ABSENT	870.81/872.33	873.86/875.39	895.20/897.33
Subsea	-385.57	-	-383.83	-393.80	-409.65
Isopach	1.83	0	1.52	1.53	2.13
Esterhazy:					(γ-peak-917.95-919.43 cored; no analysis)
Top/Bottom	?886.36/891.54	779.07/782.12	?888.79/894.89	882.09/890.63	903.13/910.74
Subsea	-396.85	-366.98	-401.81	-402.03	-417.57
Isopach	5.18	3.05	6.1?	8.54	7.62
Top of best 8.0 ft.	888.64	779.07	890.65	887.61	908.18
% K_2O as Sylvite	26.3	Much >16%	23.6	16.0	22.6
% K_2O as Carn.	1.4	0.45	1.4	0.2	0.3
% Insoluble	0.92	0.63	1.4	0.86	1.2
Top Strat. 8.0 ft.	888.43	779.07	890.65	887.70	980.18
% K_2O as Sylvite	26.37	n.r. (36.3/3.5)=15.88	23.41	15.72	22.58
TOTAL Depth	1006.45	814.43	902.8	930.86	924.46
P.E. Core	870.8 - 901.9	779.07 - 814.43	878.7 - 902.8	868.68 - 898.55	906.78 - 924.46
Salt back to:					
Best 8.0 ft.	19.05	0	20.76	18.93	19.76
Top Strat. 8.0 ft.	18.84	0	20.76	19.02	19.76

Company	SYLVITE #4	SYLVITE #9	SYLVITE #6	SYLVITE #2	SYLVITE #5	PR. POT #4
Well Name	Tombill Madeline	Sylvite Lazare	Tombill Lazare	S.A.M. Victor	Tombill Lazare	Pr. Pot. et al
Location	2-6-18-29	15-32-17-29	6-30-17-29	6-29-17-29	8-28-17-29	15A-16-17-29
K.B.	485.85	484.94	400.20	482.19	479.4	477.01
Ground	482.19	481.28	396.54	479.15	475.7	473.35
Prairie Evap.:						
Top	898.55	897.64	832.71	901.60	894.59	902.21
Subsea	-412.70	-412.70	-432.51	-419.41	-415.13	-425.20
White Bear:						
Top/Bottom	908.91/910.74	904.65/906.48	834.99/846.12	913.49/915.92	902.51/904.65	909.83/911.96
Subsea	-423.06	-419.71	-443.79	-431.3	-423.06	-432.82
Isopach	1.83	1.83	2.13	2.43	2.14	2.13
Esterhazy:						
Top/Bottom	919.58/927.20	914.70/920.50	852.83/860.76	922.63/930.55	912.88/918.97	921.72/926.59
Subsea	-433.73	-429.76	-452.63	-440.44	-433.43	-444.71
Isopach	7.62	5.80	7.93	7.92	6.09	4.87
Top of best 8.0 ft.	922.11	917.11	857.64	926.74	912.97(+3.0?)	923.48
% K_2O as Sylvite	20.0	15.7	20.3	26.0	17.0	17.8
% K_2O as Carn.	0.92	1.3	1.8	1.1	1.2	1.3
% Insoluble	1.3	0.9	1.0	1.1	0.9	1.32
Top Strat. 8.0 ft.	922.11	917.84	857.64	926.90	913.06	923.54
% K_2O as Sylvite	19.93	14.23	20.28	25.97	16.89	17.68
Total Depth	934.21	925.68	866.24	932.69	934.21	948.54
P.E. Core	898.55 - 934.21	906.78 - 925.68	823.71 - 866.24	904.34 - 932.69	896.11 - 934.21	902.21 - 948.54
Salt back to:						
Best 8.0 ft.	23.56	19.47	24.94	25.14	18.38	21.27
Top Strat. 8.0 ft.	23.56	20.20	24.94	25.30	18.47	21.33

Company	PR. POT. #5	PR. POT. #12	PR. POT. #3	PR. POT. #1	PR. POT. #6	PR. POT. #7
Well Name	Pr. Pot. et al.	Lazare	Lazare	Lazare	St. Lazare	St. Lazare
Location	13D-11-17-29	5-10-17-29	8-6-17-29	3-4-17-29	8-2-17-29	1-34-16-29
K.B.	414.53	397.15	482.50	480.67	472.74	478.23
Ground	410.87	393.50	478.72	476.98	469.09	474.57
Prairie Evap.:						
Top	842.77	+858.62	944.88	927.81	912.88	923.54
Subsea	-428.24	-461.47	-462.38	-447.14	-440.14	-445.31
White Bear:						
Top/Bottom	848.56/850.39	869.90/872.34	957.38/958.90	937.26/939.70	915.01/917.14	932.99/934.82
Subsea	-434.03	-472.75	-474.88	-456.59	-442.97	-454.76
Isopach	1.83	2.44	1.52	2.44	2.13	1.83
Esterhazy:						
Top/Bottom	858.62/864.41	880.87/887.58	969.57/975.06	949.45/953.72	925.07/931.16	942.14/949.45
Subsea	-444.09	-483.72	-487.07	-468.78	-452.33	-463.91
Isopach	5.79	6.71	5.48	4.27	6.09	7.31
Top of best 8.0 ft.	861.06	885.38	969.63	950.60	928.08	944.88
% K_2O as Sylvite	19.8	22.2	7.4	26.5	11.4	19.02
% K_2O as Carn.	1.49	1.39	1.5	0.9	1.77	1.61
% Insoluble	1.14	1.12	4.1	1.27	0.87	2.58
Top Strat. 8.0 ft.	861.06	885.38	971.40	950.60	928.42	946.92
% K_2O as Sylvite	19.82	22.20	2.13(n.r.)	26.46	11.21	16.05
Total Depth	885.44	893.37	988.77	979.32	945.18	968.04
P.E. Core	842.77 - 885.44	858.62 - 893.37	944.88 - 988.77	928.12 - 979.32	912.88 - 945.18	923.54 -968.04
Salt back to:						
Best 8.0 ft.	18.29	26.76	24.75	22.79	15.2	21.34
Top Strat. 8.0 ft.	18.29	26.76	26.52	22.79	14.54	23.38

Company	PR. POT. #2	PR. POT. #8	IMC #6	IMC #6	PR. POT. #9	IMC #7
Well Name	Lazare	St. Lazare	IMC McAuley	IMC McAuley	St. Lazare	IMC McAuley
Location	14-28-16-29	3-25-16-29	4C-22-16-29	4B-20-16-29	10-14-16-29	13C-4-16-19
K.B.	478.23	477.93	477.40	475.64	472.44	477.85
Ground	474.57	474.27	473.81	471.94	468.78	474.15
Prairie Evap.:						
Top	935.13	929.33	944.1	965.6	941.53	974.4
Subsea	-456.90	-451.40	-466.7	-490.0	-469.09	-496.6
White Bear:						
Top/Bottom	945.49/947.47	940.92/942.59	950.6/952.2	976.8/978.7	950.06/951.59	986.2/988.7
Subsea	-467.26	-462.99	-473.2	-501.16	-477.62	-508.35
Isopach	1.98	1.67	1.6	1.9	1.53	2.5
Esterhazy:						
Top/Bottom	956.77/962.25	949.76/956.46	958.0/966.8	988.6/992.0?	958.75/964.39	996.9/1003.0
Subsea	-478.54	-471.83	-480.6	-512.96	-486.31	-519.05
Isopach	5.48	6.70	8.8	3.5?(incomplete?)	5.64	6.1
Top of best 8.0 ft.	958.64	954.42	965.0	988.88	960.33	1000.05
% K_2O as Sylvite	20.23	19.7	31.50	14.97?	19.8	21.96
% K_2O as Carn.	1.42	1.6	1.80	1.49	0.1	1.33
% Insoluble	1.20	1.3	1.84	0.31	2.9	1.65
Top Strat. 8.0 ft.	958.64	954.85	969.8	990.36	961.52	1000.34
% K_2O as Sylvite	20.23(revised)	19.13	31.49	9.04?	18.36	21.83
Total Depth	977.49	973.53	1050	992	983.89	1010
P.E. Core	940.92 - 977.49	929.33 - 973.53	944.13 -1050	956.6 - 992	941.53 - 983.89	974.4 - 1010
Salt back to:						
Best 8.0 ft.	23.51	25.09	20.9	23.28	18.80	25.65
Top Strat. 8.0 ft.	23.51	25.52	21.5	24.76	19.99	25.94

Company	PR. POT. #15	PR. POT. #10	PR. POT. #11	IMC #1	PR. POT. #14	IMC #8
Well Name	IMC McAuley	Lazare	Lazare	IMC McAuley	McAuley	IMC McAuley
Location	13-2-16-29	16-18-16-28	13-6-16-28	12D-4-16-28	4-36-15-29	14D-12-15-29
K.B.	469.70	475.49	474.88	471.76	470.92	479.37
Ground	466.04	471.83	471.22	468.17	467.26	475.67
Prairie Evap.:						
Top	959.21	925.07	950.98	940.6	971.09	993.3
Subsea	-489.51	-449.58	-476.10	-468.84	-500.17	-513.93
White Bear:						
Top/Bottom	966.67/968.81	931.16/933.30	956.46/958.60	946.2/948.2	976.27/978.10	NOT PRESENT
Subsea	-496.97	-455.67	-481.58	-474.44	-505.35	-
Isopach	2.14	2.14	2.14	2.0	1.83	-
Esterhazy:						
Top/Bottom	977.80/984.20	941.83/948.54	965.91/972.62	956.8/963.0	987.25/991.97	1000.8/1006.4
Subsea	-508.10	-466.34	-491.03	-485.04	-516.33	-521.43
Isopach	6.40	6.71	6.71	7.2	4.72	5.6
Top of best 8.0 ft.	981.21	944.06	970.67	957.24	988.47	1003.7
% K_2O as Sylvite	20.9	21.2	26.4	30.7	12.6	15.87
% K_2O as Carn.	1.13	0.9	1.19	1.5	1.75	1.64
% Insoluble	1.4	1.18	1.6	1.02	0.9	1.50
Top Strat. 8.0 ft.	981.21	945.34	970.79	957.41	988.47	1003.94
% K_2O as Sylvite	20.85	17.76	25.75	30.64	12.64	15.74
Total Depth	989.08	968.04	993.65	973.25	1011.02	1032
P.E. Core	959.21 - 989.08	925.07 - 968.04	950.98 -993.65	940.6 - 973.25	971.09 -1011.02	996 - 1032
Salt back to:						
Best 8.0 ft.	22.00	18.99	19.69	16.64	17.38	10.47
Top Strat. 8.0 ft.	22.00	20.27	19.81	16.81	17.38	10.64

Company	PR. POT. #13	IMC #3	IMC #4	IMC #5
Well Name	McAuley	IMC McAuley	IMC McAuley	IMC McAuley
Location	4-32-15-28	16A-28-15-28	4B-22-15-28	12B-20-15-28
K.B.	474.27	470.85	465.30	468.78
Ground	470.61	467.26	461.60	465.08
Prairie Evap.:				
Top	960.73	945.8	958.7	972.0
Subsea	-486.46	-474.93	-493.4	-503.2
White Bear:				
Top/Bottom	961.34/963.47	949.2/951	958/959.7	972.6/974.4
Subsea	-487.07	-478.35	-492.7	-503.82
Isopach	2.13	1.8	1.7	1.8
Esterhazy:				
Top/Bottom	971.40/978.71	959.2/965	967.2/972.7	982.5/988.6
Subsea	-497.13	-488.35	-501.9	-513.72
Isopach	7.31	5.8	5.5	6.1
Top of best 8.0 ft.	974.75	959.55	969.62	985.56
% K_2O as Sylvite	20.8	26.5	13.9	18.6
% K_2O as Carn.	1.0	1.25	2.5	0.98
% Insoluble	0.75	0.96	3.84	0.87
Top Strat. 8.0 ft.	976.00	959.55	969.62	985.56
% K_2O as Sylvite	18.80	26.50	13.86	18.58
Total Depth	993.04	980	992	1008
P.E. Core	960.73 - 993.04	945.8 - 980	958.7 - 992	972 - 1008
Salt back to:				
Best 8.0 ft.	14.02	13.75	10.92	13.56
Top Strat. 8.0 ft	15.27	13.75	10.92	13.56