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SALT, POTASH AND PHOSPHATE IN MANITOBA

by

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INTRODUCTION

The material commonly called "salt" is known to the chemist as sodium chloride and has the chemical formula NaCl. Pure salt, or sodium chloride, contains by weight 39.34 per cent sodium and 60.66 per cent chlorine. Domestic salt, that is the salt used by nearly every householder in Canada, is not pure in the chemical sense as very minor quantities of other materials are added to the sodium chloride. Chemicals which may be added are (1) a non-hygroscopic material such as magnesium chloride which coats the salt grains and produces a "free running" product, (2) very minute quantities of a salt of iodine which is beneficial to the general health and greatly reduces the prevalence of goitre.

Most of our present day production of sodium chloride is obtained from one or other of the following sources:

1. Beds of rock salt.

2. Brines or saline waters where the salt is held in solution.

Where salt is obtained from beds it may be produced either by direct underground mining methods as used in metal or coal mining, or it may be obtained by pumping water which is allowed to circulate into the rock salt then returned, as brine, to the surface. In individual instances many steps may have to be taken, such as flotation, melting and regranulization. For both domestic and industrial uses, salt must be relatively pure. Most soluble impurities are removed from brines by chemical treatment, followed by evaporation.

Salt is widely distributed throughout the world and most countries are able to produce their own requirements. However, sodium chloride is an inexpensive commodity and in some cases it may be cheaper to use imported salt which has been carried as ships' ballast rather than domestic salt, which may be produced at a distance from the market. This situation is usually confined to seaports where no trans-shipment or railhaul is necessary in regard to the imported ballast salt.

Several grades and types of salt are marketed at present; some of the more important follow, in order of dollar value.

Evaporated salt (a) open pans or grainers
(b) vacuum pans
(c) solar process

Pressed blocks from evaporated salt.
Rock salt.
Pressed blocks from rock salt.
Fisheries grade salt.

The price of salt varies, depending upon the grade of product, quantity available, competition, etc., (in general $8.00 per ton is a maximum). Salt for home or domestic consumption must meet strict regulations as to purity, and is refined, made free running, iodized, packaged and sells on the retail market for a price ranging from 4 cents to 6 cents per pound. This price, of course, also includes all transportation charges.

The production of common salt (sodium chloride) by the evaporation of brines was the first mineral industry in what is now the province of Manitoba. Production started about the year 1800 from several springs along the west shore of Lake Winnipegosis. By 1876, Monkman's Springs, which had become the centre of the industry, was producing more than 1,000 bushels per year. Methods of production were primitive and the product was of poor quality compared with today's salt. Finally, imported salt from Ontario took the market from the local industry. Today there is no production from the brine springs, but deep wells at Neepawa are the basis of a sizable salt industry. Production from these wells began in 1932 and rose from a few thousand tons to over 27,000 tons per year during the recent war. At the present time the annual production varies between 24,000 tons and 26,000 tons of sodium chloride. In addition, there is a by-product production of both calcium and magnesium chloride.

Potassium salts, such as potassium chloride, have not been produced to date in Manitoba. Most of the brines in the province, from both wells and springs, contain potash but the salts are present in such minor quantities that they have not been considered of economic importance. This being so, potash will be considered only in so far as it is reported to occur in conjunction with sodium chloride. No separate section or report on potassium salts will be prepared.

Phosphatic material, to be used as the basis for the manufacture of phosphate fertilizers, would find a ready market in Manitoba today; the two occurrences of phosphatic shale known, or thought, to occur in the province, are therefore described in some detail in the section under phosphate. Neither of these occurrences appears to be of economic importance, but either might be useful as an indication of the presence of source beds.

SALT AND POTASH

BRINE SPRINGS

History

Many flowing brine springs are known along the west shore of Lake Winnipegosis. From about the year 1800, Indians, trappers, and freed men from the Hudson's Bay Company collected and evaporated these brines to produce salt. The iron pans or kettles used in the industry may still be found, half buried, adjacent to some of the springs. Monkman's Springs, located approximately 12 miles north of the present town of Winnipegosis became the main producing centre with production of close to 1,000 bushels of salt per year during the 1870's. The product was deliquescent, reddish in color and, by present day standards, not of high quality, but it found a ready market in the small scattered communities of southwestern Manitoba. The advent of the railway in 1875, bringing high-grade Ontario salt to the west, rang the death knell of the local industry and since 1876 there has been no commerical production from the brine springs, although an attempt to revive the industry was made in 1894.

Since the turn of the century the brine springs have been investigated and sampled several times, with particular reference to their potassium content. In every case, however, the analyses have shown that the concentration of dissolved salts is too low for economical recovery of either sodium or potassium compounds.

Geology and Chemical Analysis

The salt springs occur throughout a narrow strip of country extending roughly from the Carrot River on the north to the Red River on the south and bordering Lakes Winnipegosis and Manitoba. The more important springs are to be found along the west shore of Lake Winnipegosis and for a short distance up the Red Deer River. According to Wallace (2)[1], the springs issue from Devonian limestones and dolomites and most are found close to the base of the escarpment which extends from the Pasquia to the Pembina Hills. The more important springs occurring along the west side of Dawson Bay and on Red Deer River issue from the upper beds of the Manitoban formation of the Devonian.

The salt spring locations are all similar in appearance but range in size from a few hundred square feet to more than 50 acres.

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1 Numbers in parentheses refer to bibliography at end of report.

All appear as a barren flat completely devoid of any vegetation, except the red salt plant salicornia heribacea. Within this barren flat a flowing spring will be found if one issues at surface; otherwise, there may be a moist area or saline seepage. If a spring exists, a shallow ditch or drainage channel will be found leading to a creek or lake. Surrounding the barren salt flat there is a large lush salt grass meadow, and beyond, normal vegetation of deciduous or coniferous trees. Most of the springs can readily be located, however, by the large barren flat. Sea gulls, terns and shorebirds are usually to be found in vast numbers on the larger salt flats.

The different salt springs have been sampled several times since Tyrrell's first survey of the area in 1888 or 1889 (1). Analyses of the samples collected by the different investigators show that the salt content of the different brines is very low, although, in the aggregate it is probable that between 50,000 and 100,000 tons of dissolved salts reach the surface each year from this source. However, the individual springs have been found to be within the following limits with regard to salt content:

Sodium Chloride	39-50 grams per litre *
Calcium Sulphate	3-6 grams per litre
Potassium Chloride	± 0.3 grams per litre
Other Salts	4-8 grams per litre
Total Dissolved Salts	50-60 grams per litre

Calculated from these analyses the constitutent salts of the brines, on a dry basis, would be approximately

Sodium Chloride	75-85 per cent
Calcium Sulphate	6-8 per cent
Potassium Chloride	±0.6 per cent
Other Salts	6-12 per cent

Tyrrell showed potassium chloride content somewhat higher than these results, but analyses of samples since that time have indicated that on the average the lower value is probably more nearly correct. The flow and salt content of the brines vary depending upon the time or season of the year, general water level in the area, etc., and hence considerable variation in reported results should

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* grams per litre are equivalent to parts per thousand

be expected where samples were taken over a period of several years. It is felt, however, that on the average, most of the flowing brine springs will fall within the above limits.

Mines Branch Investigations, 1948

A Manitoba Mines Branch field party spent part of the summer of 1948 in the Dawson Bay area and re-examined several of the brine springs. Very few of the springs were actually flowing, although several showed continuous brine seepage. Unfortunately, the analyses of the various samples collected showed considerable variation from all previous analyses and the results could not be correlated. However, the analyses did show that the total dissolved salts were present in the brines in quantities varying from 48 to 62 grams per litre. This is a very low concentration when compared with the Neepawa brines which contain 170 to 180 grams per litre, or the brines of southern Ontario which contain 200 to 230 grams per litre of dissolved salts.

Spring Areas Investigated and/or Sampled [1]

Spring No. 1: South end Pelican Bay

This spring was not visited during 1948 owing to difficulty of access; however it is understood to be a small spring, and to be as low in total dissolved salts as the springs in the Dawson Bay area.

Spring No. 2: West side Pelican Bay adjacent to winter road across the point from Shoal River Post

There was no spring at this location but a large grass meadow indicated the location. A Forest Service timber cruising party located on this shore of Pelican Bay reported that this meadow was the nearest approach to a salt spring that they had encountered in their timber survey. A search was made along this shore but no further evidence of salt springs could be located.

Spring No. 3: West side of Dawson Bay

A small salt flat was located at this site and a shallow drainage channel showing salt incrustation was identified. No spring or seepage was noted however.

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[1] For location of springs, see map 48-9 in folder attached to back cover of report.

Spring Nos. 4 and 5: Adjacent to mouth of Shoal River, located in Indian Reserve

Two small salt flats were identified at this general location. No springs were found but at location No. 4, east of the river, there was a slight seepage. Indians at Shoal River Post reported that this was the only brine occurrence on the east shore of Dawson Bay.

Spring No. 6: Base of Salt Point, west side of Bell River

This is presumed to be spring No. "A" of Tyrrell's report. This location was a large barren salt flat on the slope of a hill. Channels were noted down which the brine presumably flowed to the lake. No flowing springs could be found but holes dug in the area barren of all vegetation slowly filled with brine. An analysis of a sample of this seepage indicated 52.4 grams per litre total dissolved salts.

Spring Nos. 7 and 8: East side of salt point near north end

These springs would seem to be spring No. "B" or "C" of Tyrrell's Report. The barren area was very large and appeared to be the result of two or three smaller areas having increased in size and overlapped. There were numerous pools of slightly brackish water and a few drainage channels leading to the lake. The whole area was coated with a white salt incrustation but no flowing springs were noted. Owing to the fact that for several days immediately prior to the visit it had rained steadily, the brine standing in shallow pools was not sampled. No flowing springs could be located in this large barren area.

Spring No. 9: West side of salt point adjacent to previous two springs

The barren area surrounding this spring was relatively small compared with the previously investigated salt flat. However, a very small seepage of brine was noted.

Spring Nos. 10 and 11: West side of salt point south of Spring No. 9

These two springs which were very close together and probably could be classed as one, were by far the most important brine springs located, at least with regards to rate of flow. Both springs were on a steep section of the lake shore in an area that had very recently been the scene of active logging operations. These springs issued at surface at a point lower in elevation, than the salt flats surrounding springs Nos. 7, 8 and 9 and it may well be that the flow originally issuing from these areas is now all reaching the surface at location 10 and 11.

Spring No. 10, the more northerly of the two, flowed a measured 2 gallons per minute, the brine analysing 53 grams per litre of total dissolved salts. Spring No. 11 flowed a measured 58 gallons per minute, the brine containing 62 grams per litre of total dissolved salts. In addition, there was an estimated flow of 2 or 3 gallons per minute in subsidiary channels, seepages, etc., which could not be controlled sufficiently to obtain an accurate measure of rate of flow.

The ground surrounding these springs was deeply channeled by run-off of the brines and/or surface water from the recent rains. However, the whole area was stained an iron or rust brown. There was no sign of the red salt plant at this location which is considered a strong indication that the spring is of recent origin in so far as surface outlet is concerned.

Spring No. 12: North bank of Red Deer River, bisected by Mafeking-The Pas Highway

This area showed several run-off channels covered with salt incrustation and the red salt plant but no brine springs were noted. On both sides of the highway several seepages were in evidence with total run-off of approximately 1 or 2 gallons per minute. A sample of the run-off analysed 55.6 grams per litre total dissolved salts, but there was no way of proving whether or not this sample truly represented the brine seepages.

Spring No. 13: North bank of Red Deer River upstream from Spring No. 12

There was a very slight flow at this spring but the run-off was so diluted with surface water running down the river bank that the spring was not sampled.

Other Salt Flat Marshes:

South from the Red Deer River several small salt flats were located. Most of these consisted of grass meadows without the usual barren area in the centre and appeared to be the location of springs which have ceased to flow and have now become overgrown with vegetation. Many areas, with or without barren sections, are to be found along the west shore of Lake Winnipegosis, several being noted within a few miles of the town of Winnipegosis.

In the area between Lake Winnipeg on the east and Lakes Manitoba and Winnipegosis on the west a few salty meadows may be found. In one or two places the red salt plant was noted but nowhere was a flowing brine spring located.

Conclusions

From the evidence gained during 1948 it would appear that the flowing brine springs issue at surface relatively indiscriminately. In some cases the flow will be reduced to a seepage or stopped altogether, but in all probability the brine will reach surface at a nearby point. The total weight of dissolved salts reaching surface is probably more or less constant but its point of issuance may vary over the years.

Investigations completed in the past two or three years indicate that there has been practically no change in salt concentration of the brines during the past 50 or 60 years. The low concentration of dissolved salts in these brines caused cessation of production of sodium chloride in 1876 and would not at the present time warrant re-opening of the industry. Concentrations of dissolved salts in the range of 50 to 60 grams per litre would not be economical compared with brine concentrations of 200 grams per litre or more.

The potash content of the brines averages less than 1.0 per cent of the total dissolved salts. With brines containing ± 0.3 grams of potassium salt per litre, 3.4 litres would have to be evaporated to obtain 1 gram of potassium salt. In other words it would be necessary to evaporate 665,000 imperial gallons of the brine to obtain approximately 183 tons of salt. From this weight of salt one ton of potassium salts could be recovered. Thus, it would appear that the flowing brine springs would not be an economic source of potassium salts.

DEEP WELLS

History and Geology

No salt beds have been located in Manitoba to date but several deep wells south of Lake Manitoba have encountered brine or salt water horizons. Wells at Jamestown, Deloraine, Morden, Manitou and Rathwell are thought to have tapped a brine flow in the Dakota (Lower Cretaceous) sandstone whereas at Neepawa three horizons were encountered, the uppermost in the Dakota sandstone, the lower two in the Ordovician or possibly Silurian strata. Wallace (4) has suggested the following as a possible source of the brines issuing from the Dakota sandstone: "Whenever the Dakota sandstone is tapped at any considerable depth in Manitoba a strong flow of brine is obtained. This has been explained as being due to connate sea water, but the brines contain a greater percentage of salt, a smaller percentage of sulphate and a much smaller percentage of magnesium than does sea water. Moreover the Dakota sandstone represents in the main a fresh water deposition. More in accord with the facts is the theory that the volume of the flow is from the Dakota sandstone water horizon but the dissolved salts from isolated crystals in Devonian strata. The shales capping the sandstone are impervious. Hence, in order to escape, water from the Dakota sandstone must penetrate downwards into the Devonian, leach out isolated salt crystals, and travel laterally through the fissures and openings which characterize the Devonian limestones and dolomites and offer little resistance to the passage of water." If this theory is correct there would appear to be five horizons or strata in Manitoba, from which brine flows may be obtained; namely, (a) Winnipeg sandstone, (b) Upper mottled limestone, (c) Gypsum zone of the Silurian, (d) Devonian series and (e) Dakota sandstone.

The brines encountered in the different wells, with the exception of the wells at Neepawa, are very similar in chemical composition to the brine from Lake Winnipegosis springs, but are even lower in total dissolved salts content. The brine from some of the wells have a high sulphate content, but in general these brines have a total dissolved salts content of only 30 grams to 40 grams per litre which compares unfavorably, even with the 55 to 65 grams per litre contained in the brines from the springs to the north.

Neepawa Wells

In the Neepawa area two wells encountered strong flows of brine which rose to within 300 feet of the surface. Brine flows at 1,185 feet and 1,460 feet, probably from the Upper Mottled limestone formation, analysed 17 per cent dissolved salts, over 85 per cent of which was sodium chloride. Typical well brine analyses are as follows:

	% By Weight[1]	Gms. Per Litre[1]	Gms. Per Litre[2]
Sodium Chloride (NaCl)	15.40	174.2	181.528
Calcium Chloride ($CaCl_2$)	0.66	7.5	8.042
Magnesium Chloride ($MgCl_2$)	0.41	4.6	4.603
Potassium Chloride (KCl)	0.36	4.0	0.031
Calcium Sulphate ($CaSO_4$)	0.36	4.0	4.073
Bicarbonate, Ammonia, Lithium and Bromide	Traces		
Total Solids	17.2		
Specific Gravity (15° C)	1.1305		

1 Analyses supplied to the writer by Mr. M. F. O'Day, Works Manager, Neepawa Salt Plant, April, 1949.

2 Analysis from Wallace and Greer (4)

These analyses show that there has been little change in the composition of the brines from the time they were tested as reported by Wallace in 1927 to the present, except for an increase in the potassium chloride content.

The Neepawa Salt Company was formed in 1932 to develop the wells and erect a plant for the production of salt. In 1935 Canadian Industries Limited purchased control of the Company and now operate the Neepawa plant as one of the units of their salt division.

During the years 1932 to 1940 the production from the plant averaged 3,000 tons of salt per year. However, in 1940 production was increased to over 13,000 tons and rose to a maximum of 27,133 tons in 1945. Output now ranges between 24,000 and 26,000 tons per year, the brine being treated by the vacuum pan process which produces a full range of fine salt products including table, dairy, and pressed blocks. Any of these products may be obtained iodized if desired. In addition to sodium chloride the Neepawa operations include the recovery of the chlorides of calcium, magnesium and potassium, in dry form, which are marketed as flaked chlorides for dust control and for the filling of tractor tires.

Conclusions

All commercial production of salt in Manitoba at the present time is obtained from the two wells at Neepawa. To date, these wells have been the only source of a brine containing economic quantities of dissolved salts. However, it would appear that, during the next few years, several wells will be drilled in the province in the expanded search for oil and it is quite possible that one or more of these wells will encounter brine of salt concentrations comparable to those encountered in the wells at Neepawa.

PHOSPHATE IN MANITOBA

INTRODUCTION

The continued harvesting of grain crops from the Canadian prairies has greatly diminished the supply of available minerals in the soil. To partially counteract this, in recent years, the farmers have been using larger and larger tonnages of chemical fertilizers, particularly super and tri-basic phosphates. These fertilizers are obtained by treating phosphatic material with sulphuric acid.

At the present time neither of these necessary ingredients are produced in Manitoba. The metallurgical operations of the Hudson Bay Mining and Smelting Co., Limited at Flin Flon are a potential source of sulphuric acid however so that if economic deposits of phosphatic material were discovered in the province it would be possible to establish a phosphate fertilizer manufacturing plant in Manitoba.

PHOSPHATIC SHALE

Phosphatic material has been reported in two widely separated areas in Manitoba:

1. On Wilson River southeast of the town of Ashville;

2. In the Pembina River Valley south and west of Kaleida.

Location No. 1

J. B. Tyrrell, in his report on northwestern Manitoba (1), recorded the presence of phosphatic shale on the bank of Wilson River in section 18, township 25, range 20, W.P.M. The small deposit containing a large number of fragments of fish bones could not be traced for any great distance but samples analysed 17.27 per cent phosphoric acid.

S. R. Kirk, in his report on the Cretaceous Stratigraphy of the Manitoba Escarpment (5), recorded the presence of a thin, black, highly phosphatic band in the shales of the Ashville formation, exposed on the banks of the Wilson River, one-half mile southeast of the town of Ashville. The band was jet black and made up entirely of teeth, vertebrae and other bones of fishes. Cone-in-cone structure was strongly developed and was, in places, covered by an incrustation of brown iron oxide. The black bed or band had a maximum thickness of only 2 inches but the phosphatic material analysed 18.41 per cent P_2O_5.

Officers of the Manitoba Mines Branch have endeavoured, several times during the past two years, to locate this black bed on the bank of Wilson River. The most recent attempt was in November, 1948, when the river was frozen but the ground was clear of snow. These conditions allowed an excellent opportunity to travel and examine the river banks in the vicinity of Ashville. Owing to extensive slumping of the banks, however, the bed could not be located.

Location No. 2

Blue incrustation, thought to be vivianite (hydrous ferrous phosphate), has been noted at the junction of a small creek with the Pembina River in section 27, township 1, range 8, west principal meridian. This material was noted in the fall of the year but could not be found during the summer of 1947 when the district was last visited. It is possible that spring floods had removed all traces of the blue coloured material. However, a short search of the area failed to locate any shale beds analysing as high in phosphate (P_2O_5) as the soil in the fields above the river.

W. M. Tovell, in his report on the Pembina Valley, Deadhorse Creek Area (8) does not mention the presence of phosphatic shale but diagram 47-7B of that report shows vivianite at location 5 in the Pembina Member, Vermilion River formation. Reference to Map 47-7A of the same report shows location 5 in section 23, township 2, range 9, west principal meridian.

SUMMARY

1. The phosphatic shales reported by Tyrrell and Kirk as occurring on the banks of the Wilson River are probably the same occurrence. The descriptions are very similar and the recorded locations approximately the same.

2. A two-inch thick bed of highly phosphatic material would not be economical to operate owing to the high cost of removing the overburden.

3. Remains of fish have been noted in several horizons in the Ashville area and it would therefore appear as though the two-inch bed was due to a local condition at time of deposition. Because of the general dispersion of fish remains throughout the beds of the area, it would appear unlikely that any large source bed would be located.

4. The vivianite noted at two locations in the Pembina River Valley could be assumed to indicate a highly phosphatic source bed in the vicinity. To date this bed has not been located, although the area has been investigated and/or surveyed by several geologists. It is also possible that blue incrustation is due solely to weathering action on the shales with a very local concentration of the phosphate from the weathered material.

CONCLUSIONS

The possibilities of locating an economic source bed of highly phosphatic material in Manitoba would not appear to be very great. The two most promising areas, Pembina and Wilson Rivers, have been surveyed at various times and have given no indications of deposits of any quantity. At the present time no showings of phosphatic material can be easily located although trenching through the slumped beds of the Wilson River bank would probably locate the two-inch thick bed.

There is a good market for phosphate fertilizers, however, and the production of sulphuric acid could readily be undertaken if sufficient quantities of phosphate were available.

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