

General view of shaft house and mill, Malagash Salt Company, Malagash, N.S.

**CANADA**  
**DEPARTMENT OF MINES**  
HON. W. A. GORDON, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

**MINES BRANCH**  
JOHN MCLEISH, DIRECTOR

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# The Salt Industry of Canada

BY  
L. Heber Cole



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## CONTENTS

	PAGE
<b>Introductory</b> .....	1
<b>Acknowledgments</b> .....	1

### CHAPTER I

<b>Salt occurrences in the Maritime Provinces</b> .....	2
<b>Nova Scotia</b> .....	2
Brine springs.....	2
Cape Breton district.....	3
Antigonish district.....	5
Kemptown district.....	7
Oxford district.....	7
Windsor district.....	10
Rock salt deposits.....	11
Malagash district.....	11
Windsor district.....	19
<b>New Brunswick</b> .....	19
Brine springs.....	19
Kings county.....	19
Rock salt deposits.....	21
Gautreau deposit.....	21

### CHAPTER II

<b>Salt occurrences in Ontario</b> .....	26
Introduction.....	26
Well records.....	27
History of the salt industry.....	31
Operating companies.....	34
Kincardine Salt Company, Ltd.....	34
Goderich Salt Company.....	36
Western Canada Flour Mills, Ltd.....	37
Dominion Salt Company.....	37
Western Salt Company.....	39
Exeter Salt Company.....	40
Canadian Industries, Ltd.....	40
Sandwich plant.....	41
Salt plant.....	41
Electrochemical plant.....	42

### CHAPTER III

<b>Salt occurrences in western Canada</b> .....	47
<b>Manitoba</b> .....	47
Early history.....	47
Winnipegosis district.....	49
Westbourne district.....	51
Winnipeg district.....	55
<b>Saskatchewan</b> .....	55
Rock salt deposits.....	57
<b>Alberta and the North West Territories</b> .....	58
Brine springs.....	58
La Saline.....	58
Salt river (Slave River district).....	61
Tar island (Peace river).....	63
Red Clay creek.....	63
On line of 5th meridian.....	64
Nahanni Butte-Liard river.....	64
Great Bear river, Mackenzie basin.....	64
Firebag river.....	64
Christina river.....	64

CHAPTER III—*Concluded*

	PAGE
<b>Salt occurrences in western Canada—Concluded</b>	
<b>Alberta and the North West Territories—Concluded</b>	
Rock salt deposits.....	65
Alberta Government wells.....	66
Alberta Salt Company.....	68
<b>British Columbia.....</b>	70
Kwinitza.....	70
Vancouver island and Saltspring island.....	73
Chilcotin valley.....	73
Maiden creek.....	73

## CHAPTER IV

<b>Mineralogy and technology of salt manufacture.....</b>	74
Salt and its associated minerals.....	74
Halite: sodium chloride or rock salt.....	74
Chemical composition.....	74
Physical properties.....	74
Occurrence.....	75
Technology of salt manufacture.....	76
Recovery of salt.....	77
Natural brines.....	77
Sea water.....	77
Brine springs.....	78
Rock salt.....	78
Mining.....	78
Artificial brines.....	78
Concentration of weak brines.....	79
Solar concentration.....	79
Wind concentration.....	79
Freezing concentration.....	80
Evaporation methods.....	81
Natural or solar evaporation.....	81
Artificial evaporation.....	82
Direct fire evaporation.....	82
Steam evaporation.....	83
Vacuum pan evaporation.....	84
Other methods of employing artificial heat.....	87
Alberger method.....	87
Hodgkinson process.....	87
Preparation of salt for the market.....	88
Uses of salt.....	89
In the home.....	89
Medicine.....	91
Agriculture.....	92
Industry.....	92
Public services.....	93

## CHAPTER V

<b>The allied industries using salt.....</b>	94
Sodium carbonate (soda ash).....	94
The Solvay process.....	95
Electrolytic process.....	96
Sodium sulphate.....	97
Electrolysis of salt.....	98
Products from the electrolysis of salt.....	99
Chlorine.....	100
Liquid chlorine.....	100
Uses of liquid chlorine.....	100
Caustic soda.....	102
Uses of caustic soda.....	102
Hydrogen.....	103
Hydrochloric acid.....	103

## CHAPTER VI

	PAGE
<b>The salt industry of Canada</b> .....	104
Introductory.....	104
Consumption.....	105
Marketing of salt.....	105
Imports.....	107
Exports.....	107
<b>Index</b> .....	113

## ILLUSTRATIONS

*Photographs*

PLATE	I	General view of shaft house and mill. Malagash Salt Company, Malagash, N.S.....	<i>Frontispiece</i>
	II	A. Flowing spring from drill hole, Bucklaw, Victoria county, N.S....	4
		B. Drift in the Malagash salt mine, Malagash, N.S.....	4
	III	A. Stope in salt, Malagash Salt Company, Malagash, N.S.....	12
		B. Drift in Malagash Salt Company's mine, Malagash, N.S.....	12
	IV	A. Evaporator building, the Malagash Salt Company, showing storage tanks in right foreground.....	14
		B. Salt crystallizing on the surface of brine in open pan evaporator. Malagash Salt Company, Malagash, N.S.....	14
	V	A. Typical brine-well building and derrick. Canadian Industries, Ltd., Sandwich, Ont.....	40
		B. Discharge end of grainers. Canadian Industries, Ltd., Sandwich, Ont.....	40
	VI	A. Oliver filter and conveying belt handling salt from vacuum evaporators. Canadian Industries, Ltd., Sandwich, Ont.....	42
		B. Rotary dryer, monel metal-lined and oil-fired, for drying salt. Canadian Industries, Ltd., Sandwich, Ont.....	42
	VII	A. Automatic weighing machine and carton filler. Canadian Industries, Ltd., Sandwich, Ont.....	44
		B. Automatic weighing, bagging, and sewing machines for table salt. Canadian Industries, Ltd., Sandwich, Ont.....	44
	VIII	A. Electrolytic cell room for the decomposition of brine. Canadian Industries, Ltd., Sandwich, Ont.....	44
		B. Flat car loaded with carboys of hydrochloric acid. Canadian Industries, Ltd., Sandwich, Ont.....	44
	IX	A. Drums of liquid chlorine, each containing 150 pounds, ready for shipment. Canadian Industries, Ltd., Sandwich, Ont.....	46
		B. Tank car for the shipment of liquid chlorine. Canadian Industries, Ltd., Sandwich, Ont.....	46
	X	Vacuum evaporators (Scott type) for the concentration of caustic soda solutions. Canadian Industries, Ltd., Sandwich, Ont....	46
	XI	A. Fusion pots for caustic soda.....	46
		B. Fusion pots for caustic soda showing in foreground both empty and filled drums.....	46
	XII	Salt flats, saline spring B. Winnipegosis district, Man.....	50
	XIII	A. Typical saline spring, saline spring B. Winnipegosis district, Man..	54
		B. Typical saline pond, saline spring B. Winnipegosis district, Man..	54
	XIV	A. View of La Saline flats, Alberta, looking north.....	58
		B. View of escarpment near southeast corner of La Saline, Alberta, showing incrustations of various salts.....	58
	XV	A. Salt springs near Fort Smith, North West Territories.....	64
		B. Brine tanks and evaporator buildings. Alberta Salt Company, McMurray, Alberta.....	64

Figure	<i>Drawings</i>	PAGE
1	Sketch map showing saline springs and salt occurrences in Nova Scotia.	2
2	Flow-sheet, crushing plant, Malagash Salt Co., Malagash, N.S. . . . .	17
2A	Flow-sheet, evaporator plant, Malagash Salt Co., Malagash, N.S. . . . .	18
3	Sketch map showing location of salt wells, Gautreau, N.B. . . . .	21
4	Log of salt well No. 1, Gautreau, N.B. . . . .	21
5	Log of salt well, No. 2, Gautreau, N.B. . . . .	22
6	Graph showing percentage of constituents in salt core from Hole No. 88, Gautreau, N.B. . . . .	<i>In pocket.</i>
7	Flow-sheet, Kincardine Salt Co., Kincardine, Ont. . . . .	35
8	Flow-sheet, Goderich Salt Co., Goderich, Ont. . . . .	36
9	Flow-sheet, Western Canada Flour Mills, Goderich, Ont. . . . .	37
10	Flow-sheet, Dominion Salt Co., Sarnia, Ont. . . . .	38
11	Flow-sheet, Western Salt Co., Courtright, Ont. . . . .	39
12	Flow-sheet, salt plant, Canadian Industries, Ltd., Sandwich, Ont. . . . .	43
13	Section of latest type Gibbs electrolytic cell. . . . .	45
14	Flow-sheet, chemical plant, Canadian Industries, Ltd., Sandwich, Ont. . . . .	46
15	Saline spring B, south side Salt point, Dawson bay, Man. . . . .	50
16	Sketch map showing saline springs in Manitoba. . . . .	55
17	La Saline lake, Athabaska river, Alberta. . . . .	59
18	Sketch map, McMurray district, Alberta. . . . .	65
19	Log, Provincial Government Well No. 1, McMurray, Alberta. . . . .	67
20	Log, Provincial Government Well No. 2, McMurray, Alberta. . . . .	67
21	Log of well of the Alberta and Great Waterways Railway, Waterways, Alberta. . . . .	68
22	Sketch map, salt works, Kwinitsa, B.C. . . . .	71
23	Salt crystal (after Dana). . . . .	74
24	Flow-sheet showing methods of salt recovery. . . . .	77
25	Single effect vacuum pan in operation. . . . .	84
26	Triple effect vacuum pans showing temperatures and vacuums. . . . .	85
27	Uses of salt. . . . .	90
28	Estimated distribution of soda ash to various industries. . . . .	91
29	Manufacture of soda ash by the ammonia soda process. . . . .	96
30	Relation of chlorinated water supplies to typhoid death rate. . . . .	101
31	Chart showing production of salt in Canada 1886-1928. . . . .	104

### *Maps*

No.		
717	Saline springs and salt areas in the Dominion of Canada. . . . .	<i>In pocket.</i>
718	The Michigan-Ontario salt basin. . . . .	"

### TABLES

Table	I Analyses of Nova Scotia brines. . . . .	8
	II Analyses of salt from Malagash salt deposit as compared with salt from other deposits. . . . .	15
	III Analyses of samples from salt formation in Hole No. 88, Gautreau, N. B. . . . .	24
	IV Showing thickness of beds and depth at which salt was encountered in Ontario salt basin. . . . .	30
	V Winnipegosis district—brine springs. . . . .	52
	VI Analyses of brines from northern Manitoba. . . . .	54
	VII Distribution of rock salt and brines. . . . .	75
	VIII Production of salt in Canada, by grades, 1924-28. . . . .	108
	IX World production of salt, 1913 and 1923-27. . . . .	109
	X Status of the salt industry in Canada. . . . .	110
	XI Principal statistics of the salt industry in Canada, 1924-28. . . . .	110
	XII Production, imports, exports, and consumption of salt in Canada, 1924-28. . . . .	111
	XIII Production of salt in Canada, 1886-1928. . . . .	111

# THE SALT INDUSTRY OF CANADA

## INTRODUCTORY

The salt industry of Canada is one of the oldest non-metallic industries of the country, dating back to the early years of the last century when the Hudson's Bay Company obtained their local supplies from the brine springs of the Mackenzie basin.

The discovery of salt in Ontario in 1866 was, however, the real beginning of the industry on a substantial basis, and production from the Ontario field has been continuous since that time. The opening of the Malagash deposits in Nova Scotia in 1918 inaugurated the first rock salt mine in the country, and has materially assisted in supplying the demands for salt in the Maritimes.

With the discovery of rock salt at McMurray in Alberta, the prospect of extending the industry to the western provinces is bright.

Salt finds a use in a large number of industries, and the consumption for domestic use forms a steady demand, depending on the population. The increasing use of salt in Canada for the manufacture of chemicals has in recent years caused a rapid rise in the production of salt, and there is every reason to look forward to a rapid expansion of the industry as the country grows.

The present report has been prepared to meet the demand for information relating to the Canadian salt industry. It is now over 14 years since the report *The Salt Deposits of Canada and the Salt Industry* was published by the Mines Branch, and a number of new deposits have been discovered and extensive development has been made in the industry in that time.

## ACKNOWLEDGMENTS

The writer takes the opportunity of formally expressing his gratitude to the officials of the various industrial corporations with whom he came in contact while collecting data for this report, for the courteous treatment received, for the many excellent photographs of plants furnished, and for the generous assistance rendered in reviewing the manuscript.

The analyses, unless otherwise specifically stated, were made by H. A. Leverin, of the Chemical Division of the Mines Branch.

## CHAPTER I

## SALT OCCURRENCES IN THE MARITIME PROVINCES

The occurrence in the Maritime Provinces of brine springs carrying varying small percentages of sodium chloride has been known for many years, but on account of the low saline content of these springs it was commonly thought that the finding of extensive beds of rock salt was improbable. The discovery in 1917 of a large deposit of rock salt at Malagash, Cumberland county, N.S., at a depth of 85 feet from the surface, and the later discovery in 1921 of a bed of salt over 500 feet in thickness in a drill hole at Gautreau, Westmorland county, N.B., have proved this theory to be erroneous.

Recent geological studies of parts of the Maritimes have also brought fresh evidence to bear on the subject, and a better knowledge of the Windsor series has enabled certain areas underlain by these measures, to be broadly delineated as fruitful districts for prospecting for salt strata. More intensive geological mapping of such areas will, however, have to be carried on, before the locations of the best sites for drilling operations are decided.

The occurrence of small quantities of potash salts in both of the above-mentioned rock salt strata, has been a great incentive to the search for further beds in the hope that an economic deposit of potash-bearing salt would be found. While the search for such deposits, to date, has not revealed a body of commercial size, the results so far obtained have been sufficiently promising to warrant further work.

## NOVA SCOTIA

## Brine Springs

With the exception of the Malagash deposits and a small occurrence of rock salt in a drill hole in the Windsor district, the salt occurrences so far known in this province consist wholly of brine springs and seepages. Although none of these springs contain brine of a high degree of salinity, it was thought that a detailed study of their occurrence with complete analyses of their saline contents would assist in determining the best localities for further prospecting. During the summer of 1928, therefore, as many as possible of these springs were visited and samples taken from each one for chemical analysis.

The localities in which the springs occur may be broadly divided into five separate districts.

*Cape Breton District.* This area runs from a point one mile southeast of Orangedale, Inverness county, in a northeasterly direction, following the north side of St. Patrick channel to springs at the head of Baddeck bay. An isolated occurrence of a spring at Glendyer, Inverness county, is included in this area.



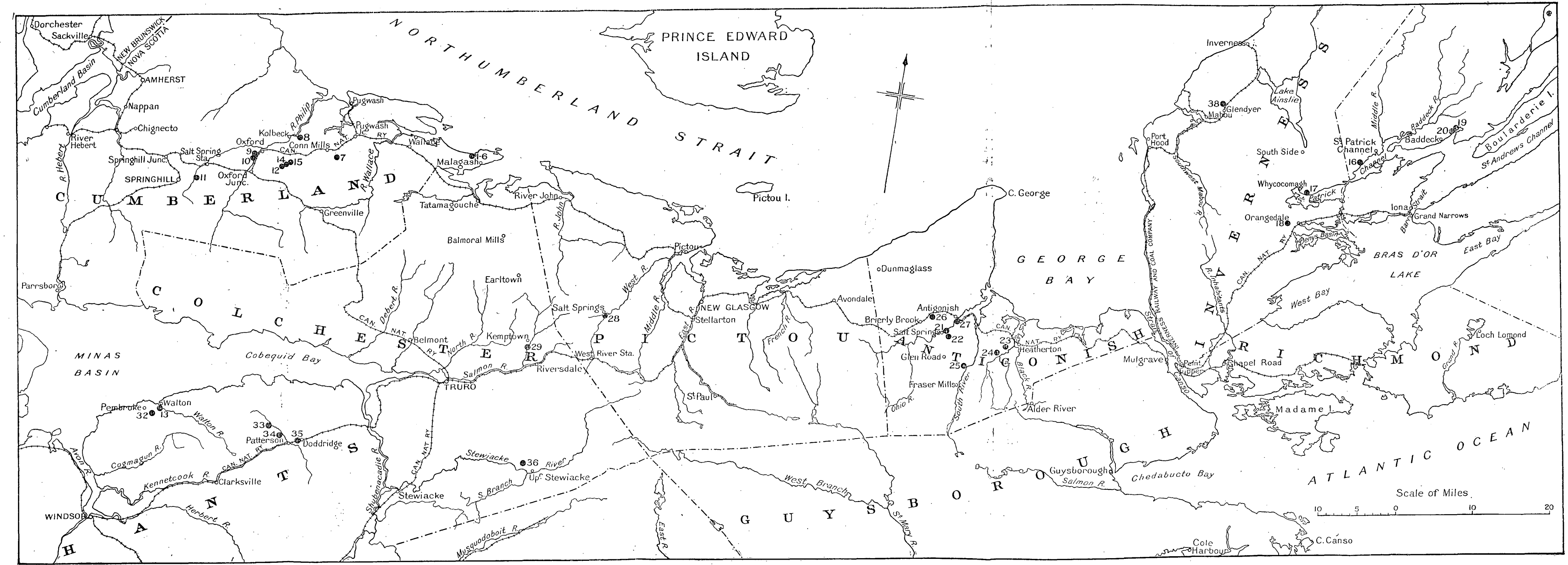


Figure 1. Sketch map showing saline springs and salt occurrences in Nova Scotia.

*Antigonish District.* The second district occurs within a radius of 5 or 6 miles with Antigonish as a centre, most of the springs lying to the east, south, and west of the town.

*Kemptown District.* There are a number of springs situated in a narrow belt running in a northeasterly direction from Kemptown, Colchester county, on the southwest, to Salt Springs, Pictou county, on the northeast. Only a couple of springs in this district were sampled, but it is probable that several others occur as saline water was encountered in a number of wells in the district.

*Oxford District.* The area included in this district runs in a narrow strip from Springhill, Cumberland county, in a northeasterly direction probably as far as the Malagash deposits in the Malagash peninsula.

*Windsor District.* The springs in this area are widely scattered and run from Windsor on the southwest to Otter brook on the east, a point 15 miles southeast of Truro. On the north the area is bounded by the south shore of the bay of Fundy.

#### *Cape Breton District<sup>1</sup>*

Six springs were sampled in this district.

*Orangedale Spring* (No. 18). About one mile true west of Orangedale station, Inverness county, a small saline spring occurs on the north side of a freshwater creek. Gas bubbles are coming up occasionally in the spring and the flow is approximately  $\frac{1}{2}$  gallon per minute. Several other seepages are to be seen in the same locality and taking all the springs into account there is a flow of about one gallon per minute.

*Whycocomagh Spring* (No. 17). A small stream which crosses the main road in Whycocomagh village, Inverness county, is slightly saline but the actual spring feeding this creek was not located. About 4 miles east of the village on the north shore of St. Patrick channel, three springs flow out of the base of the escarpment beneath the Whycocomagh-Baddeck highway. These springs have a combined flow of approximately 100 gallons per minute, but their salinity is low.

*Bucklaw Spring* (No. 16). The strongest spring found occurs at Bucklaw, 100 yards to the south of the Whycocomagh-Baddeck highway, just east of the boundary between Inverness and Victoria counties. Springs at this locality were noted by Charles Robb<sup>2</sup> as early as 1873. Robb in referring to these springs says that they

appear to issue from rocks lying towards the base of the Lower Carboniferous formation, and are situated on the north side of the Little Narrows of Bras d'Or lake, between the shore and the road, about 12 miles southwest of Baddeck, on land belonging to James Watson, miller. Here several saline springs of more or less strength occur in close proximity over an area of about 12 acres of flat marshy land. Much hydrated peroxide of iron is deposited in the water courses, the odour of sulphuretted hydrogen pervades the atmosphere in the vicinity, and the vegetation is destroyed around all the springs. The strongest spring, from which about a gallon was taken for analysis, appeared to me to discharge from 100 to 200 gallons per minute. It was stated by evaporating in two common iron pots, each containing about three gallons, from two to three bushels of salt were made per day. I was further informed that it had been proposed many years ago to establish works for the manufacture of salt at this place, and that machinery had actually been ordered for that purpose, but I am not aware for what reason the undertaking was abandoned.

<sup>1</sup> The figures after each spring name are the sample numbers and refer to these analyses in Table I, pp. 8 and 9.  
<sup>2</sup> Geol. Surv., Canada, Rept. of Progress 1873-4, pp. 180-181.

The sample taken by Mr. Robb from this locality was analysed by Mr. C. Hoffman, with the following results:—

The filtered brine contained in 1,000 parts:—

Sodium.....	19.9423
Potassium.....	0.1019
Calcium.....	1.6709
Magnesium.....	0.0403
Iron.....	absent
Alumina.....	traces
Chlorine.....	30.9585
Sulphuric acid (SO <sub>4</sub> ).....	4.0162
Silica.....	traces
or:—	
Chloride of sodium.....	50.6881
Chloride of potassium.....	0.1942
Chloride of magnesium.....	0.1593
Sulphate of calcium.....	5.6810
Alumina.....	traces
Silica.....	traces
	56.7226

In the early months of 1925 a well was drilled by a Provincial Government drill on this property to a depth of 470 feet, but no beds of salt were encountered, although at the present time brine is flowing from this drill hole.<sup>1</sup>

In the fall of 1927 the writer visited this locality and sampled the brine flowing from the drill hole. The analysis of this sample gave the following results:—

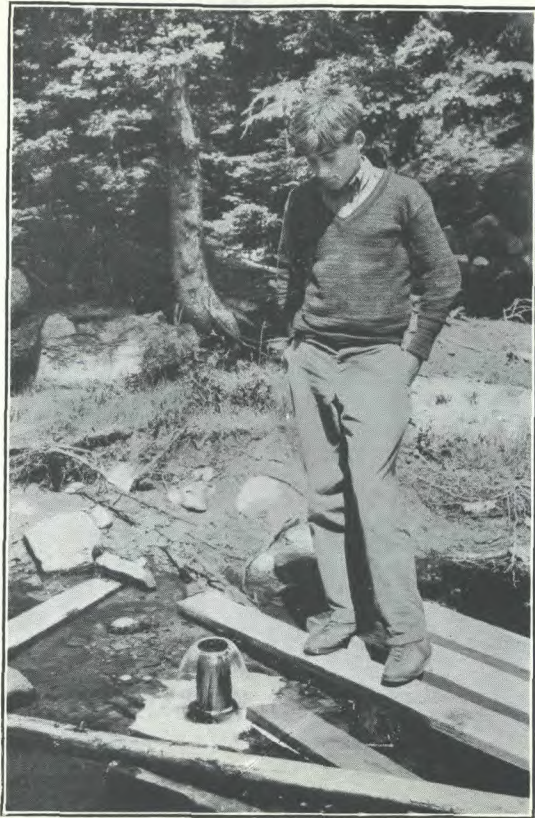
	Results expressed in percentages	Total solids calculated, per cent
Potassium.....	trace	trace
Sodium.....	2.307	32.86
Calcium.....	0.366	5.21
Magnesium.....	0.009	0.13
Sulphuric acid (SO <sub>4</sub> ).....	0.440	6.26
Chlorine.....	3.900	55.54
Bromine.....	trace	trace
Iodine.....	none	none
	7.022	100.00

Total dissolved saline matter by direct experiment, dried at 110°C = 7.18.  
Specific gravity at 15.5° C = 1.050.

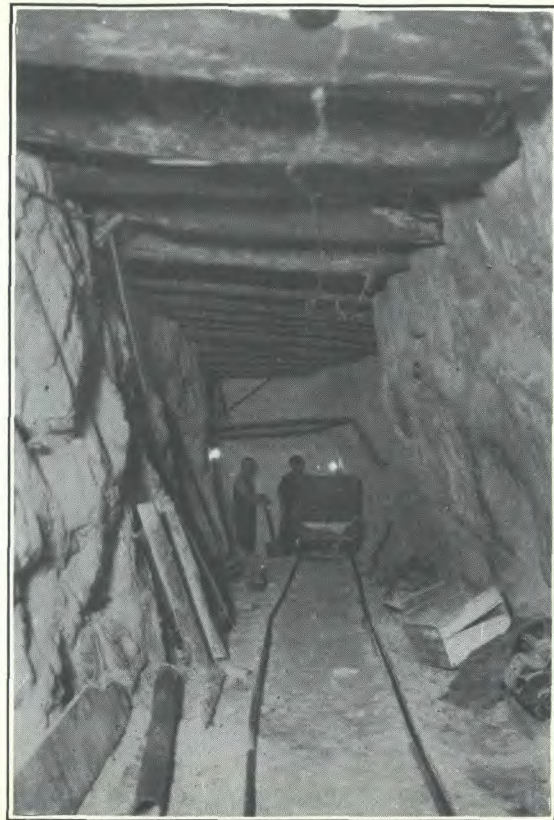
The 6-inch drill hole is cased and there is a steady flow from it of 18 gallons per minute. About 10 yards to the north of the drill hole a spring occurs from which there is an estimated flow of between 30 and 35 gallons per minute, so that there is a flow of at least 50 gallons per minute from the drill hole and spring. Taking the percentage of dissolved salts in this brine at 5 per cent there is being discharged from this spring and drill hole between 6,500 and 7,000 tons of salts each year.

The locality was again visited during the summer of 1928 and another sample (No. 16) taken for analysis. See Plate II A.

<sup>1</sup> The log of this drill hole is given in Rept. of Mines, Nova Scotia, 1925, p. 235.



A. Flowing spring from drill hole, Bucklaw, Victoria county, N.S.



B. Drift in the Malagash salt mine, Malagash, N.S.

*Baddeck Springs* (Nos. 19 and 20). There are two brine springs on the north side of the Baddeck-Ross Ferry highway about 3 miles east of Baddeck, Victoria county. The more easterly spring (No. 19) has a flow of about 1 gallon per minute. This spring occurs just off the north side of the road in a meadow swale and seeps up in a number of places. The shore of Baddeck bay for several acres in the vicinity is covered with the typical salt plant on the flat between the road and high tide level. The west spring (No. 20) has a flow estimated at 2 gallons per minute. This spring comes out of the side hill on the north side of the road 100 yards west of spring No. 19. It is situated 75 feet east of stand pipe and watering trough on the north side of road.

*Glendyer Spring* (No. 38). This spring was sampled by G. W. H. Norman in the course of mapping the geology of the Mabou sheet. In a private communication to the writer he says:—

It was not possible to make an accurate estimate of the flow as the springs issue from a limestone in the centre of the brook, so that some were not accessible. The one sampled would flow at the rate of 5-10 gallons per minute. Twenty feet to the west, another spring from the same limestone has a slight taste of  $\text{CaSO}_4$ , but not of  $\text{NaCl}$ .

The spring sampled flows out of a brown limestone 30 feet thick where it crosses Glendyer brook 3,000 feet upstream from Glendyer station, Inverness county, a station on the Inverness railroad, and about 1,000 feet downstream from the old Glendyer mills. The limestone belongs to the Upper Windsor series. The beds are massive though cut by joint-planes, while certain irregular layers are porous.

#### *Antigonish District*

Seven springs were sampled in this district. These springs have been known for a number of years and attempts were made at one time to recover salt from them. The late Hugh Fletcher made reference to these springs as follows<sup>1</sup>:—

Salt springs and ponds are found everywhere in the neighbourhood of the gypsum, as at Pomquet, and South rivers, Brierly brook, Addington Forks, and other places. Salt was made many years ago from the salt pond near the town of Antigonish. In May, 1866, a company called the Nova Scotia Salt Works and Exploration Company, was incorporated under the management of Mr. Josiah Deacon, to conduct boring operations to discover the source of the brine.<sup>2</sup> The first boring was sunk on Town Point, near the mouth of the harbour, a six-inch bore-hole, lined with iron tubing, being driven through a considerable thickness of soil and clay, then through a thick band of gypsum into sandstones, without finding any indication of brine; so that further operations in this locality were abandoned.

Encouraged by indications of salt water on the surface where the railway station now stands, a second bore-hole was put down here; and a nine-inch cast-iron pipe sunk through sixteen feet of gravel, full of weak surface brine. The auger then passed through red, blue, and brown marl, with thin bands of fibrous gypsum; then through several layers of magnesian sandstone, striking a bed of gypsum 141 feet from the surface.

After penetrating 18 feet into the gypsum, there was a flow of pure, strong, limpid brine from a cleft, which flowed nearly to the surface; it could be lowered only a few feet by pumping, and discharged a large volume of sulphuretted hydrogen gas. A steam engine was erected for pumping, and furnaces, tanks and evaporating pans of large dimensions, constructed for the production of salt. After the manufacture of a considerable quantity of salt, the strength of the brine became very much reduced. Another bore-hole was accordingly put through clays to a depth of 650 feet, but finding no indications of brine, that of the other boring being too weak for use, and working capital exhausted, the work was abandoned.

<sup>1</sup> Geol. Surv., Canada, Ann. Rept., pt. P, p. 124 (1886).

<sup>2</sup> Gesner's Geology, p. 92; How's Mineralogy of Nova Scotia, p. 145; Trans. Nat. Soc., vol. IV, p. 74; Acadian Geology, p. 350; Report of Commissioner of Mines for 1874, p. 58.

*Etheridge Springs* (Nos. 21 and 22). Two saline springs occur on the farm of Howard Etheridge, Salt Springs P.O., Antigonish county. The stronger one (No. 21) occurs on the east bank of West river. The flow is small but the water bubbles up quite freely on occasions. In the meadow back of the house there are several shallow saline ponds (No. 22) and, although no spring nor inlet is visible, they remain distinctly saline even after heavy rains.

*Pomquet River Spring* (No. 23). This spring is located on the south side of the first crossroad joining the Antigonish-Mulgrave highway west of where this highway crosses the Pomquet river, and 1.2 miles south on the crossroad from the highway. The flow is not appreciable but the seepage keeps the pond full even in the driest weather. The pond is nowhere more than one foot deep, with a length of 50 feet and a breadth of 20 feet. The bottom is soft black muck and if disturbed has a strong hydrogen sulphide smell.

*Pomquet River Intervale Spring* (No. 24). Another saline spring occurs in the meadow intervale through which Pomquet river flows, about  $2\frac{1}{2}$  miles upstream from where the Antigonish-Mulgrave highway crosses the river. The actual spring area covers about 30 feet square and the brine is coming up through gravel together with occasional gas bubbles. The gravel is all iron stained and on a dry day there are salt encrustations on the pebbles. The flow is hard to estimate but is probably not more than  $\frac{1}{4}$  gallon per minute.

A number of depressions in the meadow land resemble gypsum sink-holes and many of the larger ones are filled with water.

*Dunmore Spring* (No. 25). One mile west of Dunmore, Antigonish county, a post office on the west bank of the South Antigonish river, at a point 5 miles south of its mouth, a number of saline pools occur in the flats on the south side of a small creek. These springs have no appreciable flow and the salinity is low.

*Brierly Brook Spring* (No. 26). The most strongly saline spring of the district is found on the north side of Brierly brook,  $2\frac{1}{2}$  miles west south-west of Antigonish station, on the land of Martin Somers. The spring occurs at the west end of a small shallow pond at the base of a low escarpment and there is a flow out of this pond of about 5 gallons per minute. Another saline pond occurs 75 feet to the southwest of the main one, but there are no visible springs in it.

*Antigonish Spring* (No. 27). In the meadow land around the creek which runs along the southeastern outskirts of the town there is a brine pond in which several weakly flowing springs bubble up. The flow out of this pond is approximately 2 gallons per minute.

In addition to these springs there are a group of springs and seepages in the vicinity of Dunmaglass, Antigonish county. In the fall of 1919 three holes were drilled in the hopes of finding salt, but the results were negative. The first hole drilled to a depth of 130 feet ended in brown limestone, while the other two, drilled to 105 feet 3 inches and 85 feet 2 inches respectively, both ended in igneous rock. A fourth hole, finished in June 1920, reached a depth of 640 feet and ended in grey limestone but no salt was encountered.

### *Kemptown District*

Two springs were sampled in this district.

*Salt Springs Spring* (No. 28). On the west bank of West river, to the south of Salt Springs, Pictou county, a series of small springs or seepages occurs just above the river level. These springs are on the farm of D. M. McKay. No appreciable flow is present.

Attempts have been made to manufacture salt in this area and as early as 1813 a shaft 200 feet in depth was sunk in an endeavour to locate the source of the brine, but without success. A few years later a small amount of salt was made by evaporating the brine but the project was soon abandoned.

Dr. Henry How mentions a spring occurring at Salt Springs, Pictou county, of which the following is an analysis:—

Carbonate of lime .....	3.775	grain per Imp. gal.
Carbonate of magnesia .....	2.932	“ “
Carbonate of iron .....	0.181	“ “
Silica .....	0.560	“ “
Sulphate of lime .....	154.730	“ “
Chloride of magnesium .....	27.330	“ “
Chloride of calcium .....	51.910	“ “
Chloride of sodium .....	4,133.500	“ “
	4,374.918	“ “

Specific gravity at 53°F. = 1.04669

Sodium chloride, per cent = 5.9

*Kemptown Spring* (No. 29). Approximately one mile true south of Kemptown, Colchester county, a series of seepages occurs coming out of the steeply dipping rocks on the east bank of a small creek. These seepages have no appreciable flow but are distinctly saline to the taste.

### *Oxford District*

Nine springs were sampled in this district, and several other localities were visited.

*Conn Brook Spring* (No. 7). This spring occurs in the woods near Conn brook about  $1\frac{1}{4}$  miles southwest of Hartford, Cumberland county. The flow is hard to estimate since the springs consist of a number of seepages, none of which are very big of themselves but, if all combined, would probably amount to about 2 gallons per minute.

*Roslin Spring* (No. 8). This spring bubbles up in the centre of a pond on Plaster creek near Roslin post office, Cumberland county. The spring has a flow of about 2 gallons per minute.

*Oxford Springs* (Nos. 9, 10, and 10A). In the park to the southwest of Oxford, Cumberland county, there are a number of saline springs, ponds, and wells. At one place on the west side of the road about one mile to the south of the town of Oxford a concrete dam has been built which impounds the water back so that a lake covering several acres has been formed, the water in which is decidedly saline. In the intervalle to the east of the salt lake and between the highway and the railway there is a spring flowing at the rate of about 2 gallons per minute (No. 9). On the property of Laurin Thompson,  $\frac{1}{2}$  mile to the south of the salt lake, two wells have been drilled from which brine is flowing. These wells are about 100 feet apart and they flow into a saline pond of several acres in extent. The first well (No. 10) has a flow from a stand pipe of  $\frac{1}{2}$  gallon per minute, while the second well (No. 10A) has a flow of one gallon per minute.

**TABLE I**  
**Analyses of Nova Scotia Brines**

Sample No.....	7	8	9	10	10A	11	12	13	14	15	16	17	18	19	20
<b>FIELD NOTES AT TIME OF SAMPLING</b>															
Temperature of atmosphere, °F.	75	78	79	79	79	78	77	76	76	76	85	73	68	76	76
Temperature of brine, °F.....	62	47	46	50	48	54	50	47	65	47	56	43	47	60	51
Baumé degrees .....	1.5	1.0	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	6.25	0.5	5.0	6.0	5.0
Equivalent specific gravity ...	1.010	1.007	-	-	-	-	-	-	-	-	1.043	1.003	1.034	1.041	1.034
<b>LABORATORY NOTES</b>															
Specific gravity at 60°F.....	1.012	1.008	1.009	1.0100	1.0177	1.0533	1.0133	1.0163	1.0005	1.0139	1.049	1.0018	1.0239	1.0357	1.0177
Total solids at 110°C.....	1.63	1.13	1.32	2.25	2.45	7.40	1.89	2.14	0.71	1.84	5.83	0.33	3.26	5.00	2.36
Reaction.....	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
<b>ANALYSES OF SOLIDS—</b>															
Na..... Per cent	27.69	25.66	27.96	32.97	33.01	37.22	35.00	31.30	36.50	33.32	34.51	36.92	31.91	36.45	35.12
K..... "	0.32	0.31	0.09	0.12	0.08	0.15	0.01	0.19	0.22	0.18	0.07	0.08	0.06	0.21	0.21
Ca..... "	6.16	7.95	7.41	3.74	3.40	1.08	2.20	5.13	0.65	3.82	2.71	2.00	4.16	1.11	1.06
Mg..... "	0.33	0.21	0.11	0.15	0.14	0.06	0.21	0.09	0.13	0.16	0.11	0.28	0.26	0.17	0.18
SO <sub>4</sub> ..... "	15.94	18.65	16.97	8.44	8.10	1.55	2.00	11.24	0.21	9.23	6.10	0.90	9.27	1.65	11.48
Cl..... "	45.89	42.30	44.11	51.79	51.37	58.35	57.11	49.28	58.14	51.99	53.89	59.05	50.54	57.65	55.98
Br..... "	n.d.	n.d.	none	none	none	none	none	none	none	none	none	none	none	none	n.d.
I..... "	n.d.	n.d.	none	none	none	none	none	none	none	none	none	none	none	none	n.d.
Totals.....	96.33	95.08	96.65	97.21	96.10	98.41	96.53	97.23	95.85	98.70	97.39	99.21	96.20	97.24	94.03
<b>HYPOTHETICAL COMBINATION—</b>															
CaSO <sub>4</sub> ..... Per cent	20.94	26.42	24.04	11.94	11.56	2.20	2.83	15.92	0.30	13.06	8.64	1.28	13.13	2.34	2.09
CaCl <sub>2</sub> ..... "	3.21	0.49	0.94	0.65	.....	1.22	3.80	1.05	1.55	.....	0.47	4.49	0.83	1.16	1.25
MgSO <sub>4</sub> ..... "	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
MgCl <sub>2</sub> ..... "	1.29	0.82	0.43	0.59	0.56	0.24	0.61	0.35	0.51	0.62	0.43	1.02	1.02	0.67	0.71
K <sub>2</sub> SO <sub>4</sub> ..... "	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
KCl..... "	0.61	0.59	0.17	0.23	0.15	0.29	0.02	0.36	0.41	0.34	0.13	0.15	0.11	0.40	0.40
Na <sub>2</sub> SO <sub>4</sub> ..... "	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
NaCl..... "	70.27	66.77	71.07	83.80	83.89	94.48	89.28	59.55	93.08	84.68	87.72	92.27	81.11	92.67	89.58
Totals.....	96.32	95.09	96.65	97.21	96.16	98.43	96.54	97.23	95.85	98.70	97.39	99.21	96.20	97.23	94.03



TABLE I—*Concluded*  
 Analyses of Nova Scotia Brines—*Concluded*

Sample No.....	21	22	23	24	25	26	27	28	29	32	33	34	35	36	38
FIELD NOTES AT TIME OF SAMPLING															
Temperature of atmosphere, °F.....	72	72	65	65	65	65	73	75	75	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Temperature of brine, °F.....	50	72	64	51	62	48	55	n.d.	57	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Baumé degrees.....	6.5	1.5	1.5	4.0	1.75	6.75	3.5	5.5	2.5	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Equivalent specific gravity.....	1.045	1.010	1.010	1.027	1.012	1.046	10.24	1.037	1.016						
LABORATORY NOTES															
Specific gravity at 60°F.....	1.0335	1.0168	1.0155	1.0300	1.0055	1.0475	1.0277	1.0425	1.0214	1.0170	1.0066	1.0188	1.014	1.0033	1.023
Total solids at 110°C.....	4.41	2.13	1.88	4.07	0.80	6.55	3.77	5.86	2.88	2.41	0.79	2.43	2.08	0.60	3.25
Reaction.....	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
ANALYSIS OF SOLIDS—															
Na..... Per cent	33.22	32.18	31.35	33.35	33.21	34.53	34.07	35.08	36.62	30.83	23.77	32.24	32.15	18.64	34.77
K..... "	0.13	0.09	0.15	0.11	0.17	0.11	0.14	0.30	0.27	0.22	0.14	0.06	n.d.	n.d.	0.06
Ca..... "	3.28	3.87	3.08	3.44	2.22	2.50	3.00	2.14	1.09	4.89	10.58	3.90	4.00	12.33	2.04
Mg..... "	0.14	0.43	0.57	0.13	0.16	0.09	0.23	0.14	0.10	0.08	0.40	0.54	0.42	0.27	0.19
SO <sub>4</sub> ..... "	8.50	9.68	13.64	8.39	4.60	6.15	6.35	1.77	5.90	11.12	25.67	12.43	12.91	29.12	4.23
Cl..... "	51.65	50.60	45.51	51.69	52.35	53.61	53.94	57.60	54.58	48.34	37.74	48.72	46.06	29.38	54.02
Br..... "	none	none	n.d.	none	n.d.	none	none	none	none	none	n.d.	none	n.d.	n.d.	none
I..... "	none	none	n.d.	none	n.d.	none	none	none	none	none	n.d.	none	n.d.	n.d.	none
Totals.....	96.90	96.85	94.30	97.11	92.71	96.99	97.73	97.03	98.56	95.48	98.30	97.89	95.54	89.74	95.91
HYPOTHETICAL COMBINATION—															
CaSO <sub>4</sub> ..... Per cent	11.06	13.16	10.47	11.70	6.52	8.64	9.00	2.50	3.71	15.75	35.97	13.26	13.60	41.25	5.99
CaCl <sub>2</sub> ..... "	0.83				0.83		0.97	3.06		0.72					0.78
MgSO <sub>4</sub> ..... "		0.49	2.82	0.16					0.50		0.35	2.21	2.08	0.25	
MgCl <sub>2</sub> ..... "		1.24		0.27	0.62	0.35	0.90	0.54		0.18	1.29			0.86	0.65
K <sub>2</sub> SO <sub>4</sub> ..... "			0.34					0.60				0.12			
KCl..... "	0.12	0.17		0.21	0.32	0.21	0.26	0.57		0.42	0.27				0.11
Na <sub>2</sub> SO <sub>4</sub> ..... "			5.61						3.77			1.98	2.27		
NaCl..... "	84.85	81.79	75.03	84.77	84.40	87.78	86.60	89.47	89.98	78.37	60.42	80.32	77.58	47.38	88.38
Totals.....	96.86	96.85	94.30	97.11	92.69	96.98	97.73	97.04	98.56	95.44	98.30	97.89	95.53	89.74	95.91

*Salt Springs Spring* (No. 11). At Salt Springs, Cumberland county, 2 miles northeast of Springhill, a saline spring occurs on the east side of the road near a small freshwater creek. This spring, or really a series of seepages and springs, was the strongest spring encountered in the province. The main spring is boxed in about a 12-foot area in which bubbles are constantly rising. Attempts were made at one time to manufacture salt but the brine was too weak to make it profitable.

*Cook's Spring, Birchwood* (No. 12). One-half mile west of Birchwood, Cumberland county, a point on the Oxford-Wentworth highway, 4 miles east of Oxford, a strongly flowing saline spring occurs on the Cook farm.

*Mayne Spring* (No. 14). On the west side of the road from Birchwood to Hansford, Cumberland county, behind the barn on the farm of Hibbert Mayne there is a small saline seepage which occurs over perhaps half an acre. There is no distinct flow at any one place but the brine is quite saline to the taste.

*East Hansford* (No. 15). A fairly strong flow of saline water (about 1 gallon per minute) is to be found issuing from a spring on the west side of the road, about 75 yards from the road and about one-fifth mile north of the East Hansford schoolhouse. The brine bubbles up in a number of places.

#### *Windsor District*

Six springs were sampled in this district.

*Walton Spring* (No. 13). On the west bank of the river at Walton, Hants county, and about 500 yards to the south of the bridge there is a strongly flowing brine spring. The temperature indicates that it probably comes from considerable depth. The estimated flow is about 15 gallons per minute.

*Rainy Cove Spring* (No. 32). A salt spring occurs in a marshy area on the north side of Rainy Cove brook about  $1\frac{1}{2}$  miles southeast of Pembroke, Hants county. Sample collected by W. J. Wright, who also kindly collected the four samples following.

*Ettinger Salt Pond* (No. 33). This pond occurs on the property of Caleb Ettinger, approximately  $3\frac{1}{2}$  miles true north of Kennetcook Corner P.O., Hants county, N.S.

*Ettinger Brook Spring* (No. 34). On Ettinger brook, approximately  $1\frac{1}{2}$  miles upstream from where it joins the Kennetcook river at Patterson station, Hants county, there is a saline spring on the west side of the brook, near a gypsum outcrop.

*Willard Rine's Well* (No. 35). This well is situated on the north side of the railway, 2 miles northeast of Kennetcook Corner P.O., Hants county, N.S.

*Otter Brook Salt Spring* (No. 36). On the road approximately 1 mile east of Otter brook, Colchester county, there is a saline spring occurring at the west end of a small lake.

*Cheverie*. In two bore holes drilled at Cheverie, Hants county, strong brines were encountered at depths of 1,400 and 1,870 feet respectively. The brine from the bottom of the hole was reported as having a strength of 76 degrees by the salinometer, 100 degrees being saturation. The wells are not now accessible.

The location of all these springs is shown on Map No. 717 and Figure 1.

## Rock Salt Deposits

Rock salt has been discovered in Nova Scotia at only two localities, namely at Malagash, Cumberland county, and near Windsor, Hants county, although brine springs at a number of places indicate the possibility that salt beds are distributed over a wider area than at present known. For example, on the farm of Wilfred Brown, one-half mile east of Hartford, Cumberland county, a well was drilled to a depth of 90 feet in which a strong brine was obtained and it is said that rock salt was encountered in the bottom of the hole. No confirmation of this could be obtained as the well was closed up and its exact location unknown so that no sample could be obtained.

### Malagash District

*Location.* The Malagash salt mine is situated in the Malagash peninsula, Cumberland county, Nova Scotia, which lies between Northumberland strait on the north and Tatamagouche bay on the south. The nearest railway station is Malagash, on the Canadian National railway between Oxford Junction and Pictou. A standard gauge siding, 8.3 miles in length, connects the mine with the railway and also serves the company's shipping wharf, situated on Tatamagouche bay  $2\frac{1}{2}$  miles from the shaft, so that the mine is served with both rail and water transportation.

*Historical.* In 1912, Peter Murray, drilling a well for water on his farm on the Malagash road about 7 miles northeast of Malagash station, encountered a strongly saline water and sent a sample of the same to Dr. Frank T. Shutt, at the Dominion Experimental Farm at Ottawa. Dr. Shutt reported on this sample as follows:—

Our analysis of this water shows it to contain 28.83 per cent total solids, of which 28.32 per cent is common salt. It is in fact a very strong brine.

There are present very small quantities of sulphate of lime and possibly of allied compounds, but essentially this is a saturated, or practically saturated, solution of common salt.

No action was taken with regard to this discovery until the early months of 1917, when another sample was forwarded to Dr. Shutt, who reported 26.65 per cent common salt content. At this time Dr. Shutt referred the parties interested to the Mines Branch, Department of Mines. Steps were at once taken by the Mines Branch to obtain another sample for the purpose of having a fuller analysis made. It was found to be a nearly saturated brine, its analysis running as follows:—

	Grammes per litre	Hypothetical combination	Parts per thousand
Sodium (Na).....	99.50	Sodium chloride (NaCl).....	252.90
Potassium (K).....	0.55	Potassium chloride (KCl).....	1.04
Iron (Fe).....	0.07	Magnesium chloride (MgCl <sub>2</sub> )..	0.86
Calcium (Ca).....	1.37	Calcium chloride (CaCl <sub>2</sub> ).....	0.22
Magnesium (Mg)....	0.22	Calcium sulphate (CaSO <sub>4</sub> )....	4.42
Sulphuric acid (SO <sub>4</sub> )	3.11	Ferric oxide (Fe <sub>2</sub> O <sub>3</sub> ).....	0.10
Chlorine (Cl).....	154.70		
	259.52		259.54
		Specific gravity at 15.5° C. =	1.200.

As a result of this analysis it was suggested to the owners that further exploration was desirable in order to ascertain if the parent bed of rock salt could be located. When the district was examined by the writer, in June 1917, several more holes had been drilled and brine encountered in each one.

In the summer of 1917, A. R. Chambers and George McKay of New Glasgow, N.S., obtained an option on the property, and after drilling a series of holes, sank a shaft in June 1918. In this shaft rock salt was encountered at a depth of 85 feet from the surface. A diamond drill hole also encountered salt at a depth of 94 feet below the surface and was still in salt when stopped at a depth of 173 feet.

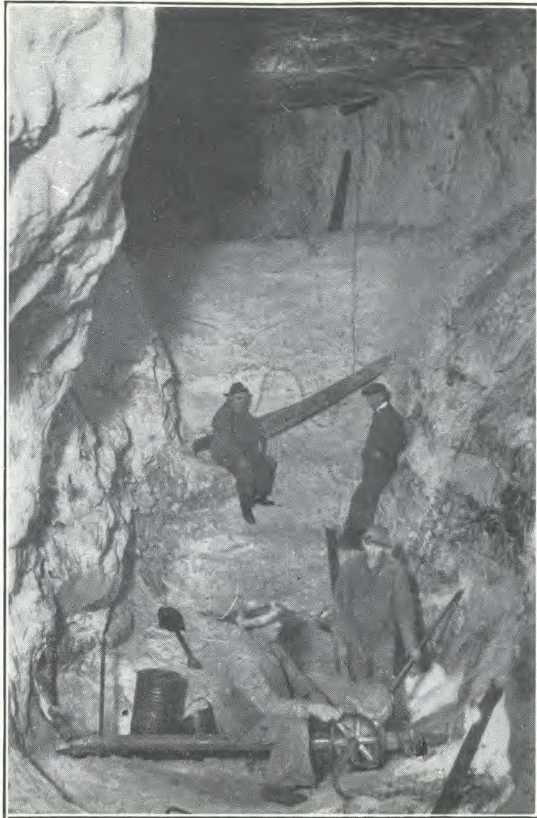
In 1919 the first production was made and operations have been continuous since that time, the following production reported for each year:—

**Production of Salt in Nova Scotia (Malagash)**

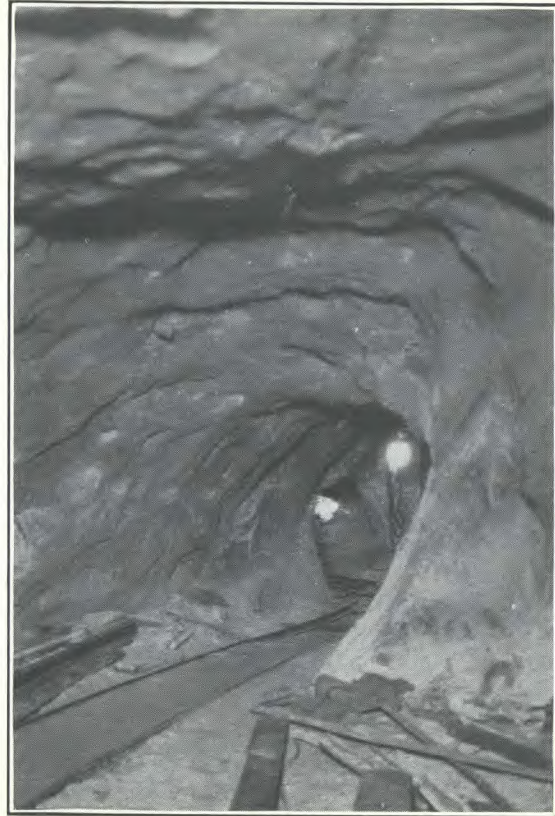
Calendar year	Federal Records		Provincial records as reported for the fiscal year ending September 30
	Short tons sold or used	Value	
		\$	tons
1919.....	174	2,188	.....
1920.....	3,023	32,000	3,095
1921.....	2,638	23,269	2,606
1922.....	5,053	54,666	5,250
1923.....	4,480	39,151	3,911
1924.....	4,551	37,469	5,239
1925.....	6,598	49,839	6,249
1926.....	8,165	68,781	7,985
1927.....	14,391	102,590	12,491
1928.....	19,604	118,342	19,671
1929.....	27,819	157,662	30,625

In June and July, 1919, A. O. Hayes, then of the Geological Survey, made a geological study of the district and his findings are published in Memoir 121, Geol. Series, Geol. Surv., Canada, No. 1828 (1920).

Later in the same year H. V. Ellsworth, of the Geological Survey, visited the mine and carefully sampled all the horizons in which potash had been noted up to that time. In 1924 he again visited the property and the results of his investigations are published in Geological Survey Summary Report 1924, part C.



A. Stope in salt mine, Malagash Salt Company, Malagash, N.S.



B. Drift in Malagash Salt Company's mine, Malagash, N.S. Note the folding of the seam of salt as indicated by winding of the track in the drift which has followed the seam.

*Geology of the Deposit.* A. O. Hayes<sup>1</sup> worked out the geology of the Malagash peninsula very thoroughly with respect to the salt deposit and his main conclusions are as follows:—

The salt at Malagash occurs as a stratified deposit interbedded with rocks of the Mississippian (Lower Carboniferous) period and apparently forms an integral portion of the Windsor (Carboniferous limestone) series.....

The salt strata were formed by evaporation of sea water in isolated lagoons and probably overlie limestone and gypsum measures which occur in the lower part of the Windsor series. The gypsum and salt may recur rhythmically interbedded, as do the limestone and gypsum on Smith island, Inverness county.

The Malagash salt horizon lies along the axis of an anticlinal fold, and may, therefore, be crumpled locally and perhaps thickened by isoclinal folding and duplication of its strata. It is impossible to state positively whether the salt strata continue to great depths with the attitude found in the mine workings or are folded so as to retain a more shallow position; but they probably continue with local crumplings for several hundred feet at least, and, as far as mining operations are concerned, no immediate difficulty may be looked for regarding depth.

Along the strike two important sets of faults or zones of faulting traverse the rocks exposed along the shore. Their extension inland is unknown since the rock outcrops are wanting, but if these faults are ever met in the mine they should be easily recognized. As indicated on the maps, one fault may cut the deposit about 500 feet east, and the other over 3,000 feet west of the present workings, so that they need occasion no immediate concern at the mine.

.....  
The dimensions of the salt deposit can only be roughly approximated..... Assuming that the beds have not been duplicated by folding or deleted by faulting the actual thickness of the original beds is probably more than 300 and less than 500 feet, measured at right angles to the dip.

Later developments in the mine have proved up the local crumpling in the salt strata as mentioned by Hayes, and the shaft has already penetrated over 200 feet of salt strata.

*Character of the Deposit.* The salt beds occur as steeply dipping strata on the south side of an anticline which can be traced for the whole length of the Malagash peninsula. The salt beds have been subjected to intense folding, minor faulting, crumpling, etc. Unlike coal seams when subjected to stress, they seem to flow rather than shatter and break off, and they alternately thin and thicken. This is well illustrated in the 200-foot level at the bottom of the shaft where one particularly white seam of salt is one foot in thickness, but on passing from the fault zone to a more undisturbed region, the section of pure salt is from 8 to 10 feet thick, and, farther on, much thicker. At certain places in the mine this bed has been worked 11 to 35 feet in section.

The salt occurs in a banded structure, the colour ranging from pure white to very dark grey with occasional bands of red. In the working seams the individual salt bands vary greatly in size, ranging from 2 inches in thickness upwards. In the more massive lower grade measures thin lenticular layers of clay<sup>2</sup> interbedded with the salt indicate, according to Hayes, the primary sedimentary nature of the deposit. In some cases even these layers are composed of clay and salt intimately mixed and grade off in both directions.

<sup>1</sup> Hayes, A. O.: "The Malagash Salt Deposit", Geol. Surv., Canada, Mem. 121 (1920).

<sup>2</sup> The term "clay" is used here to mean finely divided insoluble material. It may be anhydrite or a mixture of anhydrite and clay.

The salt mass, as a whole, is crystalline and it is probable that the variable colouring of the several kinds of salt is in part due to reflection of light and to the size of the crystal grain as well as to impurities in the salt.

Potassium chloride, so far as opened up, occurs in a number of definite bands in the salt mass, in the form of crystalline beds of pink and yellowish green sylvite in the matrix of halite. One of these zones has been penetrated at several points and found to be of varying thickness. These potash-bearing lenses were first noticed by their reddish colour, resembling some of the German potash deposits, and subsequent observations by Ellsworth<sup>1</sup> have shown that the red-coloured strata carry the most potash and that the sylvite lenses are associated only with the red-coloured salt.

Chambers,<sup>2</sup> in a paper on this deposit, describing the banded structure of the beds, says in part:—

To the south again are found thick beds of salt of all colours and purity, and where undisturbed by faults these strike north 60 degrees west and dip 45 degrees south, but for the most part are characterized by the above described 'year marks' with small bands of pure salt 2 to 3 inches thick. Where the workable seams of white salt occur the bands of pure salt are much thicker, the bands of impurities being reduced to mere streaks and in the best seam being mined the dark bands consist mostly of darker coloured salt. The colour of salt is affected by its crystal deposition and the reflection or transmission of light in much the same way that the colour of ice and snow is affected.

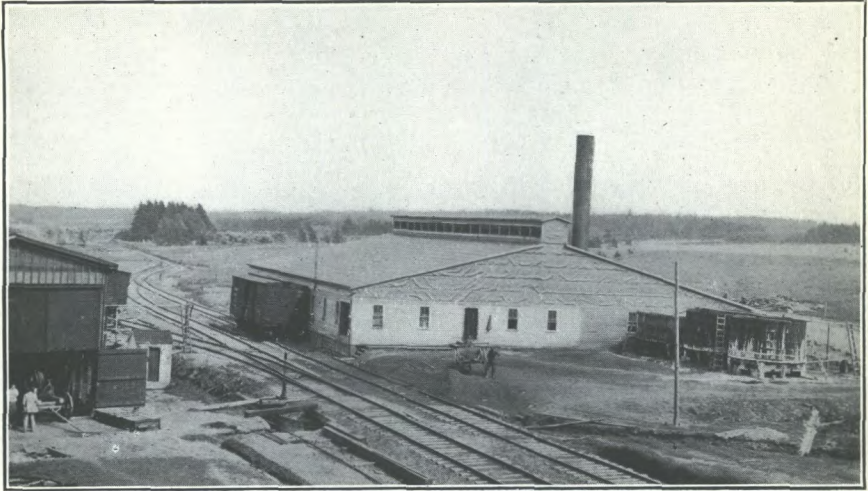
Proceeding still farther south, through the ever recurring 'year marks', and immediately adjacent to a fairly pure band of white salt are found one or two 2-inch bands of potash-bearing salt alternating with bands of white salt. Throughout the next 25 feet the 'year marks' disappear and the freshly mined face shows a bright red salt with darker red spots of leached salt and lumps of residual clay. On exposure to the air the iron colouring matter oxidizes to a brown limonite. Still going south we find a few bands of alternating potash and salt of about the same thickness, in one of which, small lenses of pure potassium chloride (KCl) are found. Continuing southward, the 'year marks' of alternating anhydrite and salt reappear for thirty feet or more, and then another potash zone is encountered. Then we come to a zone several feet thick of yellow clay with cracks filled with salt and potash-bearing minerals. In the opinion of a prominent Canadian geologist this zone indicates the evaporation of the Mississippian sea to actual dryness. If this be true it is evident that large deposits of potash in this horizon are a geological possibility, and further and careful study of the leached potash zone should be made to determine whether the leaching is primary or secondary, as this will indicate a method for proving the existence of potash in economic quantities. Farther south, the sequence of deposition, already described, recurs again and again and continues to the deposition of thick beds of pure salt.

*Composition of the Deposit.* The deposit consists essentially of sodium chloride with varying small percentages of other salts and impurities. Up to the present time it has been operated solely for the recovery of sodium chloride.

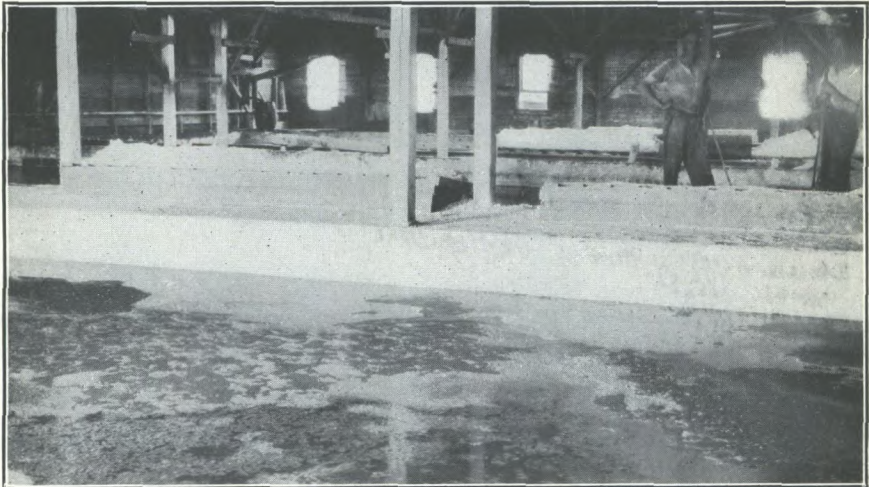
The sodium chloride content of the deposit varies from an impure salt, dark greyish in colour and containing considerable insoluble material, up to a high-grade white material running over 99 per cent sodium chloride. The following analyses will serve to give an idea of the character of the material found in the deposit.

<sup>1</sup>Ellsworth, H. V.: Geol. Surv., Canada, Sum. Rept. 1924, pt. C.

<sup>2</sup>Chambers, A. R.: "The Salt Deposits of Malagash, N.S." Trans. Can. Inst. Min. & Met., vol. XXVII, p. 248 (1924).



A. Evaporator building, Malagash Salt Company, showing storage tanks in right foreground.



B. Salt crystallizing on the surface of brine in open pan evaporator. Malagash Salt Company, Malagash, N.S.



TABLE II

## Analyses of Salt from Malagash Salt Deposit as compared with Salt from other Localities

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sodium (Na).....	38.45	38.57	23.15	37.42	38.983	39.15	38.72	37.66	37.70	38.52	38.01	37.69	38.57	n.d.	n.d.
Potassium (K).....	0.20	0.17	0.16	0.14	.....	.....	0.03	0.08	0.15	0.10	.....	.....	.....	0.195	0.136
Iron and aluminium (Fe & Al).....	none	.....	.....	.....	traces	traces	n.d.	n.d.	n.d.	n.d.	.....	.....	.....	none	none
Calcium (Ca).....	0.25	0.18	0.81	0.31	0.161	0.07	0.12	0.36	0.29	0.21	0.45	0.12	0.14	0.324	0.262
Magnesium (Mg).....	trace	0.01	0.06	0.03	0.006	0.02	0.04	0.03	0.03	0.02	0.16	0.65	0.17	0.005	0.011
Sulphuric acid (SO <sub>4</sub> ).....	0.61	0.64	3.05	1.07	0.283	0.22	0.29	0.63	0.49	0.61	1.72	1.40	0.65	0.952	0.656
Chlorine (Cl).....	59.35	59.58	35.85	57.85	60.207	60.50	59.30	58.40	58.50	59.33	58.51	59.22	59.83	59.845	59.855
Insoluble in water.....	1.05	1.40	35.36	3.01	0.360	0.04	0.10	1.81	1.78	0.83	0.13	0.15	0.06	0.347	0.010
Total.....	99.91	100.55	98.44	99.83	100.000	100.00	99.10	98.97	98.94	99.62	98.98	99.23	99.42	.....	.....
CONVENTIONAL COMBINATION															
Sodium chloride (NaCl).....	97.60	97.84	57.81	94.92	99.095	99.63	98.41	95.73	95.82	97.76	96.52	95.82	98.05	98.452	98.538
Potassium chloride (KCl).....	0.40	0.32	0.30	0.27	.....	.....	0.06	0.15	0.29	0.19	.....	.....	.....	0.372	0.259
Magnesium chloride (MgCl <sub>2</sub> ).....	trace	.....	.....	.....	0.026	0.03	0.12	0.11	0.11	.....	.....	1.19	.....	.....	0.016
Magnesium sulphate (Mg SO <sub>4</sub> ).....	.....	0.05	0.30	0.15	.....	.....	.....	0.27	0.25	0.10	0.80	1.75	0.82	0.025	0.033
Calcium chloride (CaCl <sub>2</sub> ).....	.....	.....	.....	.....	0.118	.....	.....	.....	.....	.....	.....	0.32	0.49	.....	.....
Sodium sulphate (Na <sub>2</sub> SO <sub>4</sub> ).....	.....	0.25	1.27	0.25	.....	0.06	.....	.....	.....	.....	.....	.....	.....	0.226	.....
Calcium sulphate (CaSO <sub>4</sub> ).....	0.86	0.61	2.76	1.06	0.401	0.24	0.41	0.89	0.69	0.71	1.53	.....	.....	1.103	0.892
Ferric oxide (Fe <sub>2</sub> O <sub>3</sub> ).....	.....	.....	.....	.....	trace	trace	.....	.....	.....	.....	.....	.....	.....	.....	.....
Insoluble in water.....	1.05	1.40	35.36	3.01	0.360	0.04	0.10	1.81	1.78	0.83	0.13	0.15	0.06	0.347	0.010
Total.....	99.91	100.47	97.80	99.66	100.000	100.00	99.10	98.96	98.94	99.59	98.98	99.23	99.42	100.525	99.748

## Description of Samples

- Sample of white rock from shaft at Malagash, N.S., taken in 1918. Analysis reported in Mines Branch Summary 1918, p. 71.
- Malagash shaft, from 16 to 17 feet in depth from top of salt.
- Malagash shaft, from 8 to 16 feet in depth from top of salt.
- Malagash shaft, from top of salt to 8 feet in depth. These three samples taken by A. O. Hayes in 1918 and analyses reported in Memoir 121, Geol. Surv., Canada.
- Average analysis of salt bed worked in 1924 at Malagash, N.S. Analysis furnished by A. R. Chambers in Trans. Can. Inst. Min. Met., vol. XXVII.
- Selected pure white salt marketed as table and grocery salt from beds worked at Malagash during 1924. Same reference as No. 5.
- Evaporator salt, Malagash Salt Co., July, 1928.
- Refrigerator salt, Malagash Salt Co., July, 1928.
- Fisheries salt, Malagash Salt Co., July, 1928.
- Hay salt, Malagash Salt Co., July, 1928.
- Turk's Island salt. Analysis from Bull. 919, U.S. Bureau Fisheries.
- Trapani Italian salt. Same reference as No. 11.
- Iviza Spanish salt. Same reference as No. 11.
- Malagash salt. Analysis by Dr. J. F. Logan, McGill University.
- Liverpool salt. Same authority as No. 14.

It will be seen from the study of these analyses that the Malagash deposit, by selective mining of the clear white bands, is capable of producing marketable salt of good grade, suitable for use in a number of industries in which salt is required. That its products in these markets are giving satisfaction is evidenced by the fact that the company has sold since 1918, 68,677 tons valued at \$528,345, and they have, to date, continued to increase at the rate of 50 per cent per annum.

*Marketing of the Salt.* At the present time the deposit is being operated solely for the manufacture of sodium chloride. A number of commercial grades are being prepared such as Hay salt, Refrigerator salt, Potash land salt, Cattle salt, Fishery salt, Coarse salt, and Evaporated Coarse and Grocery salts. A market for the products from this property has been developed throughout the whole of eastern Canada, and shipments by water and rail have been made to points on the east coast of Newfoundland to as far west as Edmonton, Alberta.

*Description of Plant.* The Malagash Salt Company's mine is operated from a 3-compartment, vertical shaft, 220 feet in depth. From this shaft two levels have been driven, one at a depth of 100 feet from the surface, the second at a depth of 180 feet. From the 180-foot level, at a distance of about 500 feet southwest of the vertical shaft, an inclined winze has been sunk with levels run off at depths of 230, 270, and 310 feet below the level of the collar of the shaft; and further sinking and levels are being projected. It is intended to connect the 270-foot level with the deepened main shaft and make this the main haulage way of the mine, and electric locomotive machinery is already on hand to equip this haulage level. Operations at the present time are confined to the 180-foot level and those off the winze.

The salt is at present being mined both by overhead and underhand stoping. But it is probable that mining will be done by the former, and development by the latter method.

The underground workings are lighted throughout by electricity and are perfectly dry, only a small pump being used to handle the drip down the shaft. No timbering is used in any part of the mine with the exception of the timbering in the shaft.

The drilling is done with electrically operated auger drills and a special dynamite is used in order to prevent dust from the blast contaminating the salt.

The loaded cars are trammed to the shaft and dumped into the 1½-ton skip which hoists the rock to the surface where it passes through the crushing and screening plant. A flow-sheet of this plant is shown in Figure 2.

The crushing and screening plant is housed in a building with the shaft house, the storage and shipping shed being situated to the west, the prepared products being transported to it by two 18-inch conveyer belts. A railway siding beside the shipping shed and the end of the crusher building affords easy transportation.

All the power used at the mine is electrical, the current being purchased from the local hydro-development in the Wallace district from which place a power line has been run.

For purpose of a reserve source of power two Diesel engines have been installed, 100 and 200 horse-power respectively, operating generators, and these are used in case of emergency and to supplement water shortage in dry weather.

An evaporator plant consisting of three open pans with necessary equipment was installed and put in operation during the early months of 1928.

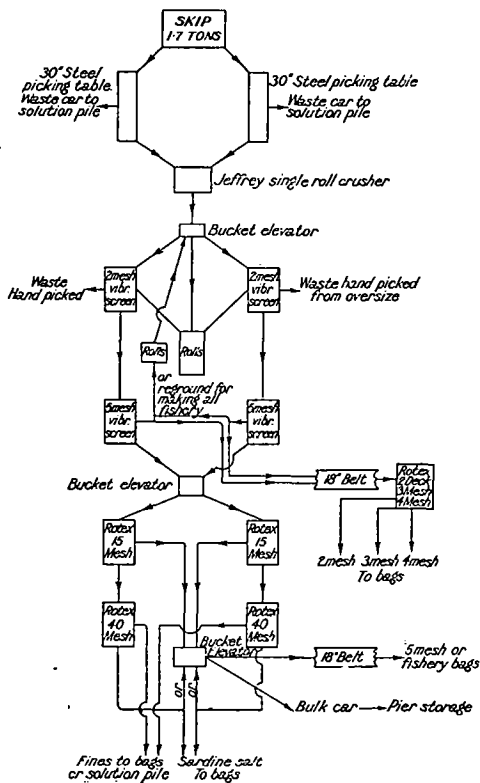


Figure 2. Flow-sheet of crushing plant, Malagash Salt Company, Malagash, N.S.

At the present time the fine salt screened out in the screening plant is dumped into solution ponds, of which there are several, and dissolved with fresh water; water is also allowed to play on the waste salt pile, the resulting brine being carried to the solution ponds. These solution and settling ponds are shallow excavations in the surface boulder clay with the sides boarded on a slope and the bottom paved with blocks of impure rock salt. These ponds, actually five in number, in addition to storage are provided with equipment to pump the brine from one to another as required.

From the ponds the brine (running 95 to 100 per cent saturation) is pumped to three wooden storage tanks just outside the evaporator building, each tank holding approximately 5,000 gallons of brine.

From the tanks the brine, treated to eliminate the small amount of impurity, is fed by gravity to the three evaporating pans which are 60 by 24 by 2 feet deep.

Each pan is fired separately, the flame and hot flue gases passing under the full length of the pan and then carried to one central stack. Coal is used for firing and there are four doors to fire each pan. The firing floor is on a lower level and entirely shut off from the pans so as to prevent any coal dust contaminating the brine or the finished salt.

The salt as it crystallizes in the pans is raked to the side by long rakes and then shovelled onto drainage boards where it is allowed to drain until all the excess moisture drips back into the pans. It is then transported to the drainage and storage shed where it is allowed to age before being bagged or shipped in bulk. A railway siding runs outside the full length of the building, allowing the salt to be loaded directly into cars. A flow-sheet of the evaporator plant is shown in Figure 2A.

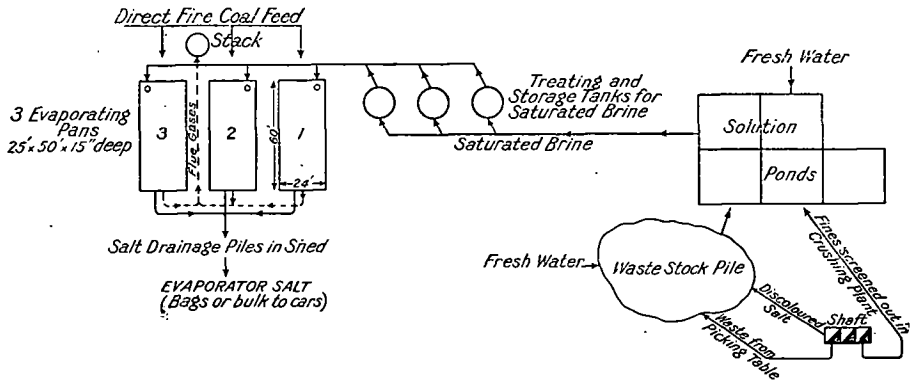


Figure 2A. Flow-sheet of evaporator plant, Malagash Salt Company, Malagash, N.S.

Two freshwater wells have been drilled and these with a 2,000,000-gallon reservoir furnish the water supply for the whole operation of the plant and for fire protection as well.

The products from the property are shipped by rail to the markets or to the shipping pier  $2\frac{3}{4}$  miles distant, where a 6,000-ton storage shed is built on the company's property adjacent to the Government wharf on Tatamagouche bay. Construction is now under way to double this capacity. From the storage shed it is loaded directly into steamers by means of a 3-foot belt conveyer, and 1,500-ton ships have been loaded in 12 hours; a simple speeding of the belt will increase this loading speed threefold. The company owns its own steamer which is of a type particularly suited for delivering salt in the shallow harbours, and carries 600 tons of salt.

*Windsor District*

Rock salt is reported<sup>1</sup> (probably only a few inches thick when the drill record is corrected for dip) in a driller's log from the Windsor district in the vicinity of Falmouth.

In this district there were four holes drilled to varying depths, two of which are reported to have encountered a bed of rock salt, 11 feet thick, at a depth of approximately 540 feet below the surface. Whether the bed of salt is lying horizontally or not is unknown so that its true thickness still remains to be proved.

## NEW BRUNSWICK

Saline springs have been known for many years in New Brunswick and in 1921 a thick bed of rock salt was discovered in a drill hole at Gautreau, Westmorland county, about 8 miles south of Moncton.

**Brine Springs**

Small quantities of salt were manufactured each year from brine springs but for the past 25 years operations have ceased. The best known springs are those located west of Sussex, and at Salina, Salt Springs brook, both in Kings county.

*Kings County*

*Sussex Spring.* Dr. L. W. Bailey<sup>2</sup> in referring to the springs in this locality says:—

As nearly as can be ascertained, the first operations for the manufacture of salt near Sussex were begun fully one hundred years ago, the quantity manufactured being, however, but small, very variable in amount, and employed wholly for local consumption. A similar description would, to a large extent, apply to more recent undertakings in the same direction. The present proprietor (Mr. Geo. N. Hendricks) commenced work in 1887, since which time, on an average, about 150 barrels of salt per year have been made, each barrel holding four bushels. During the year 1897, 140 barrels were made, at a cost of about \$2 per barrel. The salt is sold for \$3 per barrel, and is especially esteemed for table and dairy use.

The salt is made by evaporation, two furnaces being employed, side by side, and having over them one pan made of boiler-plate holding 2,000 gallons and one holding 400 gallons. There are also two kettles holding 200 gallons each, and four holding 150 gallons each. These latter kettles, weighing 1,000 pounds, and costing \$50 each, are found to be very liable to crack and sometimes last only a single season, thus increasing materially the cost of production, as well as giving uncertainty to the amount of product. Wood, in four-foot lengths, is burnt in one end of each furnace, and the fire is continued from Monday morning until Saturday night. Only two men are employed, one for the day and the other for the night, and great care is taken to secure a product which is pure and clean. Work is carried on in warm weather only. During the time the works were running in 1897, they turned out a little over twenty-four barrels per week; but there is plenty of brine to run a much larger plant, while, if by boring, a brine of greater strength were reached and more economical methods of concentration were employed, the yield could, no doubt, be very largely increased. There would be no difficulty in selling a larger quantity. The strength of the brine at present is twenty per cent.

<sup>1</sup> Bell, W. A.: Geol. Surv., Canada, Mem. 155, p. 88 (1929).

<sup>2</sup> Geol. Surv., Canada, Ann. Rept., pt. M., vol. X, p. 121.

The spring is situated on the west side of the St. John-Moncton highway, about 4 miles northeast of Sussex, Kings county. The old buildings in which salt was made in past years are still standing, and brine is flowing from a 1-inch pipe at the rate of 3 gallons per minute. A sample of this brine was taken for analysis:—

(August, 1928)

*Field notes—*

Temperature of air.....	78° F.
Temperature of brine.....	45° F.
Baumé reading.....	5.5°
Equivalent specific gravity.....	1.0394

*Laboratory notes—*

Specific gravity at 60° F.....	1.0328
Total solids at 110° C.....	4.45
Reaction.....	N

	Analysis of solids, per cent		Conventional combination, per cent
Na.....	33.62	CaSO <sub>4</sub> .....	8.67
K.....	1.24	CaCl <sub>2</sub> .....	0.50
Ca.....	2.73	MgCl <sub>2</sub> .....	0.43
Mg.....	0.11	KCl.....	2.36
SO <sub>4</sub> .....	6.12	NaCl.....	85.46
Cl.....	53.60		
Br.....	none	Total.....	97.42
I.....	none		
Total.....	97.42		

It is of interest to note the potash content from this brine.

*Salina Spring.* Another brine spring occurs on the south side of the road near a creek and about a quarter of a mile west of Salina post office, and about  $4\frac{1}{2}$  miles in a direct line southeast of Bloomfield station on the Canadian National railway. This spring was visited and sampled in August, 1928.

*Field notes—*

Temperature of air.....	74° F.
Temperature of brine.....	52° F.
Baumé reading.....	2°
Equivalent specific gravity.....	1.0140
Measured flow.....	6 gallons per minute.

*Laboratory notes—*

Specific gravity at 60° F.....	1.0157
Total solids at 110° C.....	1.96
Reaction.....	N

	Analysis of solids, per cent		Conventional combination, per cent
Na.....	30.47	CaSO <sub>4</sub> .....	18.56
K.....	0.63	MgCl <sub>2</sub> .....	1.14
Ca.....	5.46	KCl.....	1.20
Mg.....	0.39	NaCl.....	77.45
SO <sub>4</sub> .....	13.12		
Cl.....	48.30		98.35
Br.....	none		
I.....	none		
Total.....	98.37		

# D'ARCY EXPLORATION CO.

## TEST WELL GAUTREAU N°1

Location: On land of Cassimier Gautreau, Village of Gautreau  
Westmorland Co., N.B. on the north bank of Boyd Creek  
about 300' east of main highway from Moncton N.B. to Gautreau

Elevation of collar of hole 70.7 feet above sea level

Scale: 100 feet to 1 inch

Depth	Geologic Column	Strata Thickness	Explanation of Geologic Column
20		20'	No sample
70		30'	Surface Gravel - red to green
85		15'	Conglomerate - sandy red
97		12'	Sandstone and grit, quartz and pink feldspar
113		16'	Grit - reddish brown
191		78'	Sandstone and grit - red to brown
221		30'	Grit and sandstone - brown red quartz and feldspar
243		22'	Conglomerate - grey
248		5'	Sandstone and grit - brown
254		6'	Conglomerate - grey to brown
264		9'	Sandstone and grit - brown
285		21'	Conglomerate - red and grey sandstone - fine grained, cemented, hard
317		32'	Sandstone and grit - reddish brown with dark red sandstone - fine-grained, cemented hard, calcareous
363		46'	Sandstone - dark red, fine-grained, cemented hard, calcareous and conglomerate brown red bands and thin red marl
385		22'	Conglomerate - grey with dark fine-grained red sandstone
405		20'	Conglomerate - grey and grit
435		30'	Sandstone - red marly, fine-grained, cemented hard, calcareous and brown grey limestone and conglomerate bands
447		12'	Sandstone and grit - red
470		23'	Conglomerate and grit - red to grey
490		20'	Sandstone - dark red marly, fine-grained, cemented, calcareous
521		30'	Conglomerate and grit - brown red and thin dark red sandstone bands
570		50'	Conglomerate and grit and dark red, fine-grained, cemented marly sandstone
625		35'	Sandstone and grit - brown red with sandy marl or marly sandstone - dark red
625		20'	Limestone - grey to brown, sandy hard micaceous
678		53'	Marl - brown red, sandy
678			<b>BASE RED BEDS?</b>
744		66'	Shale - blue grey non-bituminous, calcareous and thin bands of light grey sandy limestone
774		30'	Shale - blue grey to light grey, calcareous, non-bituminous
825		51'	Limestone - brown to grey, sandy hard with little shale
900		75'	Shale - blue grey to light grey, non-bituminous, calcareous with thin bands grey limestone
987		87'	Limestone - brown sandy and thin shale blue grey, non-bituminous, calcareous
1027		40'	Shale - blue grey to light grey, non-bituminous calcareous and gypsum
1106		79'	Limestone - light grey sandy with thin bands blue grey to light grey shale - non-bituminous, calcareous
1126		20'	Limestone - brown hard sandy and thin shale - blue grey, non-bit. calc. and light grey sandstone - fine-grained micaceous, calc.
1236		110'	Shale - blue grey to light grey, generally non-bituminous calcareous with some light grey limestone bands and light grey cemented fine-grained, calcareous, micaceous sandstone and calcite veins
1295		59'	Shale - blue grey generally non-bituminous, calcareous, slightly carbonaceous some gypsum 1236-46. Traces of Na Cl 1236-56 Flame of Na 1280-89 Mixture of shale and white soluble salt (largely Na Cl traces A)
1784		489'	Rock Salt - generally large crystals and fine-grained cemented calcareous sandstone 1300-14, some efflorescence 1319-25, 1540-44 and 1771-84 and large crystals of Na Cl 1410-20
1863		75'	Shale - blue grey to light grey generally non-bituminous, calcareous, cherty, slightly carbonaceous and bands very slightly bituminous to bituminous 1806-11, slightly bituminous 1811-16, very slightly bituminous to non-bituminous 1816-20, slightly bituminous to non-bituminous 1820-25, slightly bituminous to very slightly bituminous 1825-35, non-bituminous to bituminous 1835-45, light brown to grey green. Some sandy limestone 1860-83 Na 1789-1808. Na colour in flame 1857-60
1878		15'	Shale - blue grey, non-bituminous and thin light grey fine-grained cemented sandstone
			Bottom of hole

Figure 4. Log of salt well No. 1, Gautreau, N.B.

Mention is also made in a number of the earlier reports of the Geological Survey of Canada of the existence of brine springs in the vicinity of the Tobique river, Victoria county, but exact locations of springs are not given nor were any analyses recorded.

## Rock Salt Deposits

### *Gautreau Deposit*

Near Gautreau village, in Westmorland county, about 20 miles south-east of Moncton, a well was drilled by the D'Arcy Exploration Company for the New Brunswick Gas and Oilfields, Ltd., in a search for gas and oil. Sketch map, Figure 3, gives location of this drill hole with respect to water and rail transportation. This drill hole at a depth of 1,295 feet

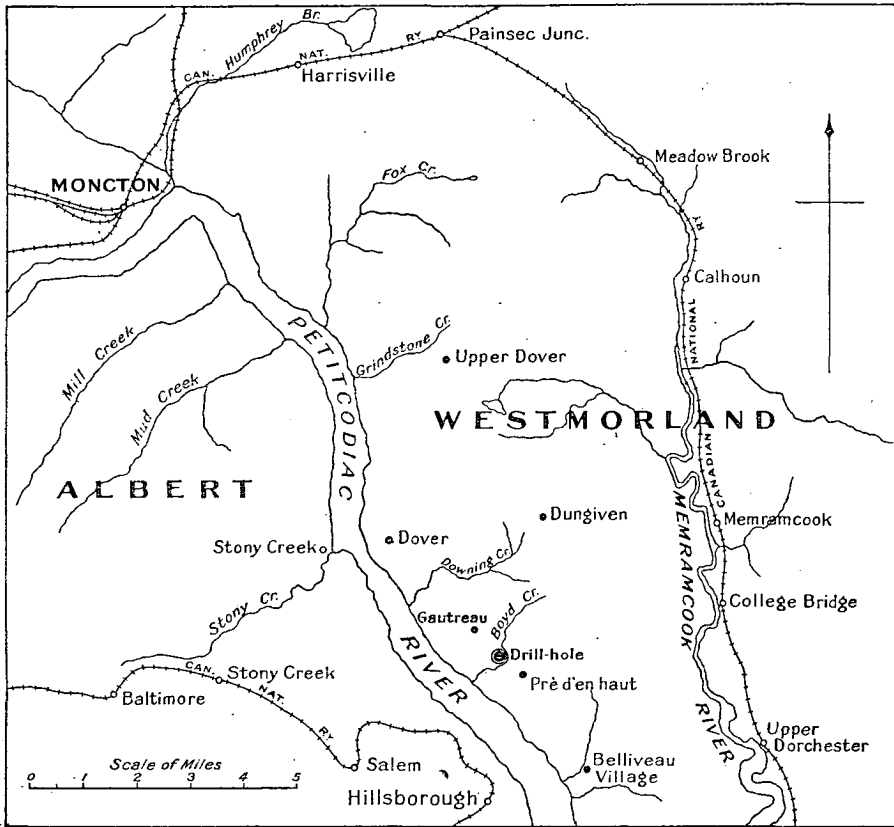


Figure 3. Sketch map showing location of salt wells, Gautreau, N.B.

below the collar of the hole entered beds of rock salt which had a total thickness at this point of 485 feet. The drilling was done by a standard churn drill so that no cores were recovered, but chip samples were taken every 5 feet. As far as known, no special precautions were taken to prevent the soluble salts being washed out from these cuttings. A log of this well is given in Figure 4.



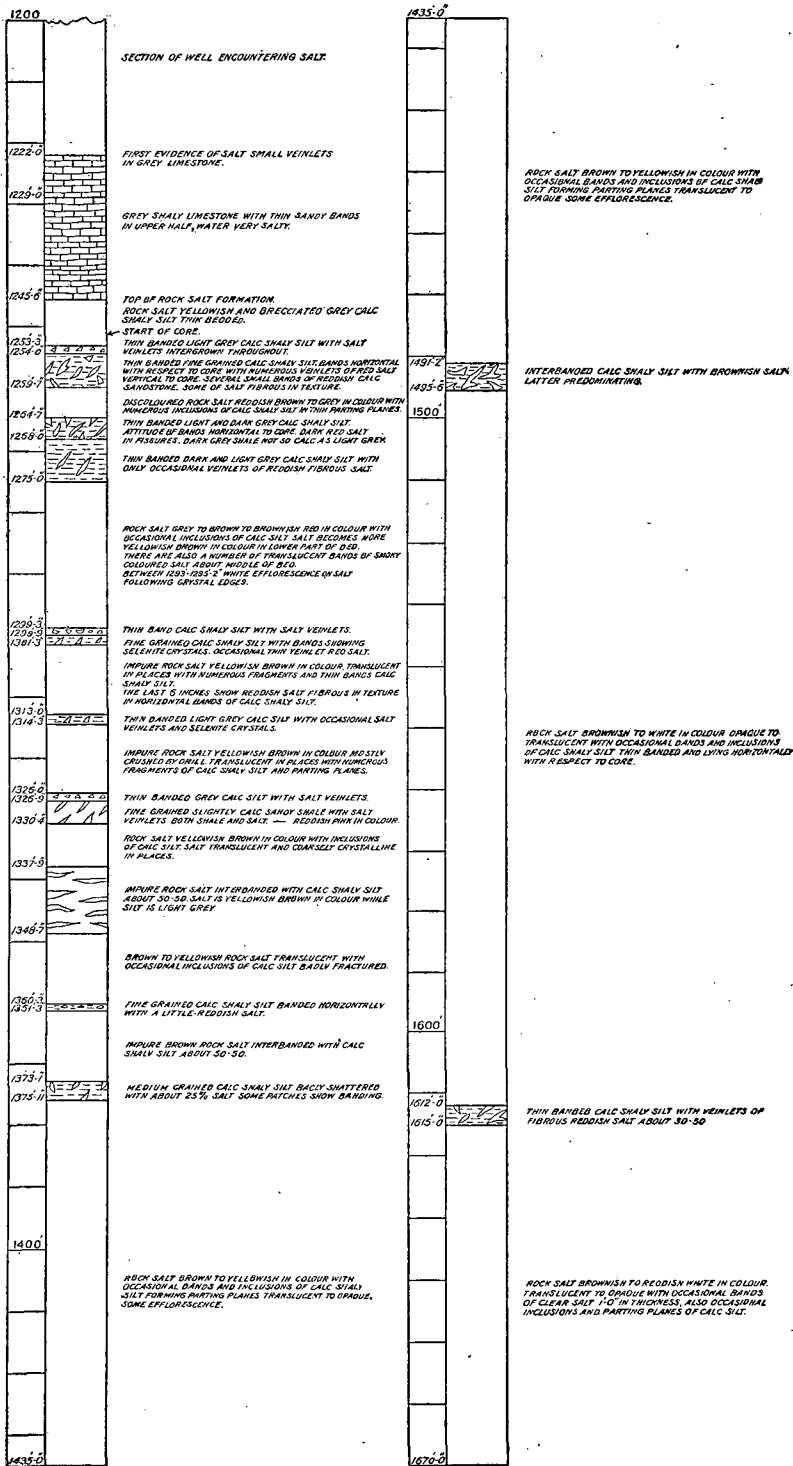


Figure 5. Log of salt well No. 2, Gautreau well No. 88.

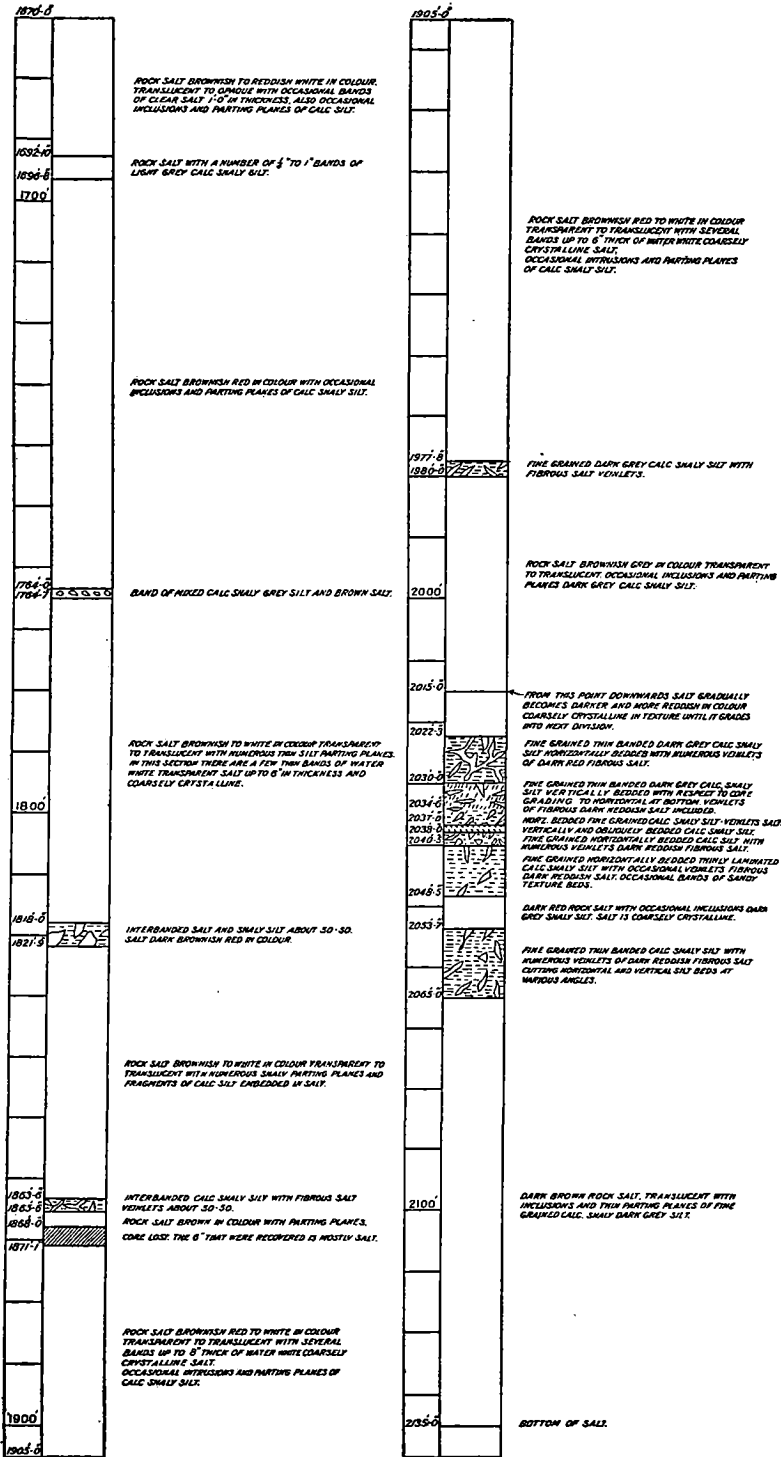


Figure 5—Continued.

A study of the chip samples in the laboratories of the Mines Branch revealed some interesting data, since all those obtained from that section of the hole embracing the salt showed the presence of small quantities of potassium. A number of the 5-foot chip samples showed quite a persistent potash coloration by the flame test, indicating that there is a possibility of concentration of potash salts in certain definite horizons in the salt strata, but only further drilling and sampling with a core drill will determine whether potash salts are present in this deposit in commercial quantities.

Composite samples, composed of several of the 5-foot chip samples, were made up for analysis.

Conventional Combination	1	2	3	4
NaCl.....	91.16	79.88	82.13	82.10
CaCl <sub>2</sub> .....			0.36	
MgCl <sub>2</sub> .....			0.20	
Na <sub>2</sub> SO <sub>4</sub> .....	0.36			0.39
CaSO <sub>4</sub> .....	2.50	6.08	6.70	7.58
MgSO <sub>4</sub> .....	0.36	0.30		0.39
Insoluble.....	5.35	11.70	8.66	7.20

H. A. Leverin, Analyst.

There was a trace of bromine in all samples but no iodine.

Sample No. 1 from a depth of 1,330-1,350 feet.  
 Sample No. 2 from a depth of 1,475-1,495 feet.  
 Sample No. 3 from a depth of 1,615-1,635 feet.  
 Sample No. 4 from a depth of 1,760-1,780 feet.

The chip samples obtained from the complete section of this well were examined by F. J. Fraser of the Borings Division of the Geological Survey and his summary of results is as follows:—

The position of the well on the map does not suggest the possibility of any great thickness of drift, and the occurrence of pebbles for the first 100 feet may indicate a conglomerate. Below this depth to 600 feet the samples are coarse reddish arkosic sandstones and fine-grained grits. The quartz content is low, and the feldspars are, in general, fresh. Optical examination of occasional feldspar grains shows absence of broad plagioclase twinning, and sodic rather than calcic composition. With the exception of 15 feet at 91-105 feet and 35 feet at 435-470 feet, the beds are calcareous. An intensive search for purple volcanic ash was made but only a few fragments were noted at 530-550 feet.

At 580 feet, the reddish colour commences to give way to grey. At 600 feet the reddish sandstone commences to change to a grey shale, the transition being quite complete at 625 feet. The colour change lags behind that of the lithology, the change to grey being complete at 670 feet.

The grey shale, with minor colour variations, continues down to 1,295 feet. The shale is compact and uniform in character throughout, and has a persistent content of anhydrite, usually pink, and gypsum, fibrous, granular and clear needles. The fragments of these sulphate minerals are sufficiently dissociated from the shale to suggest that they occur in numerous thin veinlets invariably associated with calcite. No fossils were seen in the shale. Sometimes gypsum needles up to 0.2 mm. are scattered throughout the shale in sufficient size and profusion to be plainly visible under low magnification. The greatest gypsum content is at 660-720 feet. From 1295 feet to 1325 feet rock salt is associated with the shale.

At 1325 feet there is a very sharp change from shale to a massive rock salt, colour impure white. The salt is very uniform in character, is persistently calcareous and contains soluble sulphates; the salt solution does not contain any soluble carbonates. The total depth of salt is 485 feet including the mixed salt and shale strata from 1,295 feet to 1,325 feet.

At 1,780 feet the salt reverts suddenly to a dark shale. A thin limestone probably rests on the top of this shale.



A second drill hole, put down about three-fifths of a mile to the north-west of the first hole during the summer of 1928, while not encountering the salt strata, has furnished valuable geological data which will be of great assistance in any further drilling contemplated.

During the summer of 1929 the New Brunswick Gas and Oilfields, Ltd., drilled another hole in an endeavour to prove up the extent of the salt deposit in this district. This hole was located on the north bank of Boyd creek just west of the main highway from Moncton to Gautreau, on the land of Anthony and Sifroid Gautreau. The elevation of the collar of the hole was 20 feet above sea-level. This hole was drilled by percussion tools and the first evidences of salt were encountered in small veinlets of grey limestone at a depth of 1,222 feet from the surface. The top of the rock salt formation was at 1,245 feet 3 inches. A special coring tool was used through the salt formation commencing at 1,251 feet below the surface. The salt formation continues to a depth of 2,135 feet giving a thickness of salt of 890 feet. Interbanded with the salt and at irregular intervals throughout are thin bands of a calcareous shaly silt of a bluish grey colour. These silt bands are in many cases penetrated by veinlets and thin seams of a reddish-coloured salt. The salt is of varying colour ranging from a dark red to a reddish grey, to brown and greyish white, several places showing transparent water-white bands of pure rock salt.

The salt formation was sampled every 10 feet by taking half of the core and quartering it down until a one-pound sample was obtained. These samples were analysed in the Mines Branch laboratories and the results are given in Table III. In order to show at a glance the relation of these analyses to the log of the well each analysis is graphically plotted opposite its proper location with respect to the log, and the results shown in Figure 6 (in pocket). A composite sample made up from the 80 pounds taken from this core was put into solution and an analysis made of the settled, clear brine reduced to a dry basis. The results obtained are as follows:

**Brine from Salt Samples Nos. 13-72, Taken from Drillings at Gautreau, N.B.**

*(Analysis of Settled Clear Brine reduced to a Dry Basis)*

	By radicals, per cent		By conventional combination, per cent
(HCO <sub>3</sub> ) <sub>2</sub> .....	0.051	Ca (HCO <sub>3</sub> ) <sub>2</sub> .....	0.069
CaO.....	0.616	R <sub>2</sub> O <sub>3</sub> .....	0.043
MgO.....	0.017	CaSO <sub>4</sub> .....	1.443
SO <sub>3</sub> .....	2.051	MgSO <sub>4</sub> .....	0.051
Cl <sub>2</sub> .....	58.489	Na <sub>2</sub> SO <sub>4</sub> .....	2.071
R <sub>2</sub> O <sub>3</sub> .....	0.004	NaCl.....	96.323
Na <sub>2</sub> O.....	0.904		
Na <sub>2</sub> .....	37.868		100.000
	100.000		

Br — none found  
K — none found.

Analysis by H. M. Gard, Sandwich, Ont., October 15, 1929.

Judging from the results of this hole and the previous D'Arcy well encountering salt in this district, there is probably a considerable tonnage of salt present in this area. The log of this latter well is shown in Figure 5.

## CHAPTER II

## SALT OCCURRENCES IN ONTARIO

## INTRODUCTION

Ontario, at the present time, is the centre of the salt industry of Canada. The salt obtained in this province is recovered by the evaporation of brine which has leached out rock salt from beds that occur in the Salina formation in the southwestern part of the province bordering on lake Huron, St. Clair river, lake St. Clair, and Detroit river. It is impossible, with our present knowledge, to determine definite boundaries of the salt basin; but, as far as it now stands proved, the area underlain by salt in Ontario is approximately contained within lines joining the towns of Inverhuron, Teeswater, Brussels, Seaforth, London, St. Thomas, on the east; and Thamesville, Dresden, across lake St. Clair, through Elmstead to a point on the Detroit river between Amherstburg and Sandwich. This approximate boundary of the salt basin has been shown on the accompanying map (No. 718). The area enclosed within this boundary in Canada is about 3,000 square miles.

The salt beds are known to vary in thickness. In some wells they occur in thin beds interstratified with dolomite and shale; the total combined thickness of all these beds varying from 100 to 200 feet. In other localities, as in the case of the beds at Windsor, the salt beds are of great thickness, one bed alone having a thickness of over 230 feet. The average depth at which the salt is found is in excess of over 1,000 feet, the depth gradually increasing towards the south.

The vast extent of this salt deposit in Ontario may probably be better realized when it is considered that a bed of salt one foot in thickness over the whole of this area would mean a quantity in excess of 6,000,000,000 tons. Taking a specific case, such as at Sandwich where a bed 230 feet in thickness is being exploited, if this continues over any considerable area, it means that in one square mile there is in excess of 400,000,000 tons of salt in this one bed alone. It can thus be seen that there is little danger of the supply of salt in Ontario being exhausted.

The production from a few wells has hitherto been sufficient to supply the domestic demand, and little exploration has been carried on by which the area underlain by salt can be definitely delimited. However, a great deal of exploratory work by bore holes has been done in connexion with the development of petroleum and natural gas fields. Where the bore holes extend below the salt horizon they give evidence of either the presence or the absence of salt. From the records available, it would appear that within the area mentioned, and outlined on the accompanying map, the salt beds are practically continuous; there are, however, some small areas within these boundaries where—according to the records of drill holes that have penetrated below the Salina—there are no salt beds.

The southeast boundary of the salt area is at present unknown, as no drill records are obtainable from the district along the north shore of lake Erie, between St. Thomas and Chatham. Records from a hole at Orford, Kent county, show 171 feet of salt at 1,510 feet below the collar of the hole; while another from Glencoe shows 104 feet of salt at 1,290 feet below the surface. These records lead one to believe that possibly the beds are dipping to the southeast and may be found by deeper drilling in the vicinity of lake Erie.

The southwestern boundary merely marks the dividing line between the area beneath which salt beds are encountered, and the area where brines of a more or less density were found, although no rock salt was obtained.

The salt beds are supposed to extend under the Detroit river, lake St. Clair, St. Clair river, and the southern part of lake Huron, since rock salt has been found in the Salina formation in the state of Michigan, on the opposite side of the International Boundary.

### WELL RECORDS

To give some idea of the depths at which salt occurs, the thickness of the beds, and other conditions, a number of logs are given of wells drilled in the salt basin. A table has been introduced to show the depths at which salt beds have been encountered in a number of the more prominent wells.

Among the earlier borings made in this region, the most important was the diamond drill hole put down by Mr. Henry Attrill in 1876, with a view to determine the nature and extent of the salt beds. The results<sup>1</sup> of the drilling, as interpreted from the log and the cores by Dr. T. Sterry Hunt, have been summarized by him as follows:—

Attrill's bore hole, Goderich, Huron county, Ont.	Thickness		Total depth	
	Ft.	In.	Ft.	In.
Clay, gravel and boulders.....	78	9	78	9
Dolomite, with thin limestone layers.....	278	3	357	0
Limestone, with corals, chert, and beds of dolomite.....	276	0	633	0
Dolomite with seams of gypsum.....	243	0	876	0
Variegated marls, with beds of dolomite.....	121	0	997	0
Rock salt, 1st bed.....	30	11	1,027	11
Dolomite, with marls towards the base.....	32	1	1,060	0
Rock salt, 2nd bed.....	25	4	1,085	4
Dolomite.....	6	10	1,092	2
Rock salt, 3rd bed.....	34	10	1,127	0
Marls with dolomite and anhydrite.....	80	7	1,207	7
Rock salt, 4th bed.....	15	5	1,223	0
Dolomite and anhydrite.....	7	0	1,230	0
Rock salt, 5th bed.....	13	6	1,243	6
Marls, soft, with anhydrite.....	135	6	1,379	0
Rock salt, 6th bed.....	6	0	1,385	0
Marls, soft, with dolomite and anhydrite.....	132	0	1,517	0

<sup>1</sup> Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, pp. 217, 222-226.

The drilling thus showed a total thickness of salt of 123 feet in a distance of 388 feet divided up into six beds, ranging from six feet to nearly thirty-five in thickness. Of these the first bed has intercalated with it layers of dolomite, and is stained by earthy matter. This bed would not be pure enough for mining.

The second and third beds which are separated by a layer of less than seven feet are very pure. They measure together over sixty feet, and represent practically one great mass of rock salt.

The fourth bed, measuring from 1,207 to 1,223 feet is uneven in purity, only the upper two feet and the lower two feet nine inches of the core were saved. The former was somewhat impure, the lower was white salt with layers of dolomite.

The fifth bed measures thirteen and a half feet, and from what can be judged from what was obtained of the core (five and a half feet) the salt is impure though white in portions.

The sixth bed is pure white and translucent and measures six feet.

### Clinton Well

(Stapleton Salt Works)

	Thickness	Total depth
	Feet	Feet
Drift.....	67	67
Limestone.....	413	480
Limestone, cherty, and dolomitic.....	204	684
Limestone.....	176	860
Limestone, cherty.....	36	896
Shale, limestone, gypsum, and marls.....	255	1,151
Rock salt (1st bed).....	15	1,166
Shale, gypsum, and salt.....	48	1,214
Rock salt (2nd bed).....	25	1,239
	1,239	

### Kincardine Well

(Kincardine Salt Company)

	Thickness	Total depth
	Feet	Feet
Drift.....	91	91
Limestone.....	509	600
Shale, red and blue.....	140	740
Limestone.....	30	770
Shale, red and blue.....	125	895
Rock salt.....	14	909
	909	

In both these wells distinct water courses were encountered at 250 and 500 feet respectively; the water from which supplies the solvent for the salt beds beneath.



*Petrolia Well*<sup>1</sup>

	Feet	Total depth	Formation
Drift.....	90	90	
Shale.....	240	330	Hamilton
Cherty limestone.....	190	520	Corniferous
Dolomite.....	690	1,210	
Salt.....	65	1,275	
Dolomite.....	20	1,295	
Salt, with dolomite.....	140	1,435	
Dolomite.....	30	1,465	
Salt.....	90	1,555	
Salt, with dolomite.....	50	1,605	Salina
Salt.....	25	1,630	
Dolomite.....	10	1,640	
Salt.....	138	1,885	
Dolomite, and shale.....	130	2,015	
Salt.....	90	2,105	
Dolomitic lime.....	275	2,380	Niagara
Shale.....	150	2,530	Clinton
Red shale.....	275	2,805	Medina
Light shales.....	205	3,010	Hudson River
Dark shales.....	165	3,175	Utica
Limestone.....	772	3,947	Trenton

<sup>1</sup> Ontario Bureau of Mines, vol. XX, pt I, p. 254.*Sarnia Well*

(Dominion Salt Co. Well No. 6)

Depths		Thickness	Material
Surface to 170 feet.....		170	Blue clay
170 feet to	190 feet.....	20	Quick sand
190	" 203 "	13	Shale
203	" 223 "	20	Soapstone
223	" 228 "	5	Lime (224 ft. 10-inch drive pipe).
228	" 503 "	275	Streaks of soapstone and shale. Gas at 230 ft., considerably more at 265 ft.
503	" 1,065 "	562	Limestone
1,065	" 1,575 "	510	Harder lime than above.
1,575	" 1,590 "	15	Salt
1,590	" 1,605 "	15	Streaks of shale and limestone
1,605	" 1,634 "	29	Salt
1,634	" 1,645 "	11	Salt and limestone (mostly salt)
1,645	" 1,695 "	50	Salt
1,695	" 1,705 "	10	Limestone
1,705	" 1,760 "	55	Salt
1,760	" 1,790 "	30	Limestone
1,790	" 1,816 "	26	Salt
1,816	" 1,825 "	9	Hard brown limestone
1,825	" 1,851 "	26	Salt
1,851	" 1,890 "	39	Hard grey limestone
1,890	" 1,895 "	5	Salt
1,895	" 1,900 "	5	Salt and brown lime—streaky.
1,900	" 1,911 "	11	Salt
1,911	" 1,917 "	6	Limestone—very hard
1,917	" 1,950 "	33	Salt
1,950	" 2,040 "	90	Limestone
2,040	" 2,058 "	18	Salt
2,058	" 2,061 "	3	Limestone
2,061	" 2,039 "	28	Salt
2,039	" 2,092 "	3	Shale

## Windsor Well

(Canadian Salt Works Well No. 4<sup>1</sup>)  
(Now Canadian Industries, Ltd.)

	Thickness	Total depth
	Feet	Feet
Drift.....	133	133
Limestone.....	922	1,055
Salt.....	30	1,085
Limestone.....	25	1,110
Break in record.....	35	1,145
Salt.....	75	1,220
Limestone.....	100	1,320
Salt.....	70	1,390
Limestone.....	30	1,420
Salt.....	252	1,672
Well ended in limestone.	1,672	

<sup>1</sup> Ont. Bureau of Mines, Sixth Report, p. 33 (1896).

TABLE IV<sup>1</sup>  
Showing Thickness of Beds and Depth at which Salt was Encountered in Ontario  
Salt Basin

Locality	Salt struck at depth of		Thickness of salt	
	Ft.	In.	Ft.	In.
Bruce county, Kincardine:—				
Total depth, 1,007 feet.....	993	..	13	..
Huron county, Goderich, Attrill's diamond drill:—				
Total depth, 1,517 feet.....	997	..	30	11
	1,060	..	25	4
	1,092	..	34	10
	1,027	7	15	5
	1,230	..	13	6
	1,379	..	6	..
Huron county, Goderich, International well:—				
Total depth, 1,170 feet.....	1,054	..	19	..
	1,103	..	24	..
	1,130	..	32	..
Huron county, Wingnam:—				
Total depth, 1,185 feet.....	1,090	..	30	..
Huron county, Brussels:—				
Total depth, 1,244 feet.....	no salt		.....	..
Huron county, Brussels, $\frac{1}{4}$ mile southwest of above well:—				
Total depth, 1,000 feet.....	970	..	.....	..
Huron county, Blyth:—				
Total depth, 1,215 feet.....	1,125	..	90	..
Huron county, Clinton:—				
Total depth, 1,239 feet.....	1,151	..	15	..
	1,214	..	25	..
Huron county, Seaforth:—				
Total depth, 1,135 feet.....	1,035	..	110	..
Huron county, Hensall:—				
Total depth, 1,206 feet.....	1,090	..	116	with shale
Huron county, Exeter:—				
Total depth, 1,251 feet.....	1,135	..	.....	..
Middlesex county, Ailsa Craig, McGillivray tp., lot 29, con. VII:—				
Depth of salt, 1,005 ft.....	.....	..	215	..
Middlesex county, London, Asylum well:—				
Total depth, 2,250 ft.....	1,400	..	100	with shale
Middlesex county, Glencoe:—				
Total depth, 1,510 feet.....	1,290	..	104	with shale

TABLE IV—*Concluded*

Showing Thickness of Beds and Depth at which Salt was Encountered in Ontario  
Salt Basin—*Concluded*

Locality	Salt struck at depth of		Thickness of salt	
	Ft.	In.	Ft.	In.
Middlesex county, Nissouri West tp., Con. Dundas Road E. lot 3, Salt at depth of 938 feet.....	.....	..	35	..
Lambton county, Port Franks:—				
Total depth, 1,355 feet.....	1,245	..	110 with shale	
Lambton county, Petrolia:—				
Total depth, 1,505 feet.....	1,180	..	105 with shale	
	1,365	..	140 with shale	
Lambton county, Courtright:—				
Total depth, 1,665 feet.....	1,630	..	22	..
Lambton county:—				
Dawn tp., lot 19, con. XIII.....	1,290	..	240	..
lot 20, con. VII.....	1,380	..	180	..
lot 24, con. V.....	1,750	..	15	..
lot 24, con. II.....	1,488	..	112	..
Enniskillen tp., lot 18, con. I.....	1,325	..	500	..
lot 19, con. II.....	1,235	..	555	..
lot 6, con. VII (four beds).....	1,260	..	40	..
	1,650	..	145	..
	1,965	..	70	..
Oil Springs (three beds).....	1,252	..	13	..
	1,350	..	270	..
	1,763	..	37	..
Bosanquet tp.....	1,165	..	55	..
Arkona.....	1,550	..	150	..
Moore tp., lot 23, RR.....	1,728	..	17	..
	1,820	..	30	..
	1,878	..	239	..
Essex county, Windsor:—				
Total depth, Well No. 1, 1,167 ft.....	1,127	..	40	..
Essex county, Windsor:—				
Total depth, Well No. 4, 1,672 ft.....	1,055	..	30	..
	1,110	..	75	..
	1,320	..	70	..
	1,420	..	252	..
Kent county:—				
Thamesville, Zone tp., lot 5, con. III.....	1,485	..	200	..
Rondeau Park well.....	1,660	..	165	..

<sup>1</sup> Geol. Surv., Canada, Ann. Rept., vol. XV, pt. S, p. 226; and Ont. Dept. of Mines, 34th Rept., pt. II, p. 49 (1925).

## HISTORY OF THE SALT INDUSTRY IN ONTARIO

The discovery of salt in Ontario dates back to the year 1866. In that year, when the oil excitement was at its height in western Ontario—due to oil having been discovered to the south—a company was formed at Goderich, organized by a Mr. Samuel Platt, with the object of drilling for oil. This company, with a subscribed capital of \$10,000, commenced drilling on the north bank of the Maitland river, to the east of the bridge. The drill passed through a series of layers of greyish limestone of varying hardness, to a depth of 686 feet, without encountering any indications of oil; so the stockholders decided to abandon the enterprise. Mr. Platt, however, decided to continue drilling at his own expense, especially since the County Council had offered a bonus of \$1,000, and the city a bonus of

\$500 providing drilling was continued to a depth of 1,000 feet. His efforts were amply rewarded, for, at a depth of 964 feet from the collar of the hole, he encountered a solid bed of rock salt into which he bored for a distance of 60 feet, thus completing 1,000 feet, and securing the above-mentioned bonuses.

Upon encountering salt, the shareholders who previously had abandoned the work, expressed a desire to pay up their assessment and were allowed to do so by Mr. Platt. The capital of the company was increased to \$14,000, and was incorporated as the Goderich Petroleum Company, and in September, 1866, pumping of brine commenced. The salt made from this brine was sold to George Rumball & Co., who marketed it.

The record of the hole was carefully kept by Mr. Platt, who furnished the information to Dr. T. Sterry Hunt<sup>1</sup> who worked out the record as follows:—

*Goderich Well (1866)*

	Thickness	Total depth
	Feet	Feet
Surface gravel.....	25	25
Limestone (blue, white and grey).....	335	360
Sandstone.....	85	445
Limestone (blue, white and grey).....	175	620
Sandstone.....	40	660
Limestone (blue, white and grey).....	26	686
Sandstone (traces of oil).....	27	693
Chert (with calcspar).....	12	725
Magnesian limestone (white and yellowish).....	75	800
Shales (bluish and reddish with several beds of white gypsum).....	164	964
Rock salt* (interstratified with soft blue clay. Salt in layers of 1 foot or more in thickness).....	41	1,005
Hard limestone.....	5	1,010
Total depth.....		1,010

\*Rock salt formed 30 feet of this thickness.

At the time the first salt was encountered Mr. Platt furnished a sample of the brine to Dr. Hunt who reported on it as follows<sup>2</sup>:—

	In 1,000 parts by weight	In 100 parts of solid residue
Chloride of sodium.....	259.000	99.018
Chloride of calcium.....	0.432	.165
Chloride of magnesium.....	0.254	0.097
Sulphate of lime.....	1.882	0.720
	261.568	100.000

<sup>1</sup> See Geol. Surv., Canada, Rept. of Prog., 1866, pp. 268-269.

<sup>2</sup> Geol. Surv., Canada, Rept. of Prog., 1866, p. 269.

It was colourless and transparent, and its temperature was about 50°F. Its specific gravity, at 60°F., was 1.205.

It is therefore a saturated brine, a wine-pint of it weighing 8,783 grains, and containing 2,274 grains of pure salt. . . . This brine is remarkable for its purity, the solid matters from its evaporation containing over 99 per cent of salt. . . . It results from this that the salt manufactured from the Goderich brine must be of exceptional purity, since it will hold less than one per cent of foreign matters, while the Onondaga solar salt contains 1.15, the Saginaw 2.0 and the Turk's Island 2.34 per cent of impurities. In all of these, a portion of the foreign matter is taken away in the process of manufacture, while no draining or other mode of purification will be needed with the Goderich brine, to make from it salt surpassing the finest hitherto known.

As soon as the well was in shape for pumping the brine, the Goderich Salt Company (as it was later called) constructed two blocks of 52 kettles each; the kettles ranging in capacity from 120 to 140 gallons. Thus the total capacity of the plant was in the neighbourhood of 100 barrels per day.

The salt produced found a ready market, so that at the end of the first year's operation the profits were considerable, dividends totalling 51 per cent being distributed among the shareholders. The price then obtained for the salt was \$1.25 per barrel at the works.

The kettle method was soon found to be expensive; hence it was discarded in favour of the pan method of evaporation.

The success attending this pioneer company gave great impetus to this infant industry, so that by the next summer the valley of the Maitland from the bridge to the town was the scene of extensive drilling operations. About the year 1872, the following blocks with the enumerated capacity in barrels per day were in full operation: "The Goderich," 200 bbls. (this was the pioneer well); "Maitland," 100; "Prince," 100; "Victoria," 100; "Huron," 100; "Dominion," 200; "Ontario," 150; "Tecumseh," 150; "Hawley's," 200; "Inniskillen," 200; "International," 600; and "Platt's," 150 (Platt having severed his connexion with the original company and erected works of his own).

In the meantime, drilling operations had been carried on with good success at Clinton and Seaforth, and at both places salt was encountered and plants erected. The fact that wood fuel was cheaper at these latter places enabled them to supply the Canadian market at lower prices than from the Goderich wells, and in consequence a number of the plants at the latter place were forced to close down.

In the year 1879, there were only four of the Goderich plants in operation: namely: "Platt's"—making 150 barrels per day; "Tecumseh"—owned by A. Hodge, 75 barrels; "Hawley's"—200 barrels; and the "International"—600 barrels. This last-mentioned company was operated by the Seaforth Syndicate and was, up to that time, the largest salt works in Canada.

The salt industry in Ontario was, from the very first, met by competition from the salt manufacturers of the state of New York; who, up to that time, had controlled the whole of the Canadian market. All reductions on the part of the American manufacturers were met by the Canadian producers, and in time the superior quality of the Canadian product secured the whole of the Canadian trade.

Since the year 1876, salt has been encountered in other wells both north and south of Goderich, so that now the area under which salt is to be found is fairly well defined. (See Map No. 718).

In the year 1878, the first shipment of Canadian salt—consisting of 200 barrels—was made to Winnipeg, *via* Duluth, Pembina, Emerson, and by boats down the Red river.

Since that time (1878), the industry has had a varied career, showing, on the whole, a gradual increase. Many "Associations"—formed from time to time—have obtained control of the selling of the products from all the different wells; agreements being made, in each case, to take a certain quantity from each manufacturer yearly. In the last few years, however, these associations have become defunct, and now each plant does its own selling.

Improvements in the methods of evaporating the brine and handling the salt have been introduced into a number of the works, so that several of the plants now compare very favourably with the best on the continent.

The year 1911 marked the start of the chemical industry using salt as one of the raw materials, the Canadian Salt Company in that year placing its chemical plant for the manufacture of caustic soda and bleaching powder in operation at Sandwich. In the fall of 1918 a further extension to the chemical branch of the industry was made when the Brunner Mond Company at Amherstburg commenced making soda ash by the Solvay process using brine derived from wells a few miles north of that town. These two operations have provided an increasing outlet each year for brine, and at the present time, caustic soda, soda ash, liquid chlorine, and hydrochloric acid are being successfully manufactured and marketed with prospects that other related products will in time be added to this list.

## OPERATING COMPANIES

At present five companies are producing salt in the Ontario field.

### Kincardine Salt Company, Limited<sup>1</sup>

*Location.* Kincardine, Ont. *Head Office*—Cleveland, Ohio.

*Transportation Facilities.* Canadian National railway, and wharf on lake Huron from which shipments can be made by water.

*Operations.* The company obtains its brine from a well 1,115 feet deep; the top of the first bed of salt is encountered at 967 feet from the surface, with a thickness of 31 feet; the second bed of salt is encountered at 1,005 feet from the surface, with a thickness of 115 feet. The water required for the brine is obtained from an underground water channel, so that it is unnecessary to pump water down to dissolve the salt.

The brine from this well, practically saturated with respect to sodium chloride, is pumped to two settling-tanks, 20 by 20 by 5 feet deep. From these tanks it is piped to two grainers, each 12 by 120 by 2 feet deep, or to one 8-foot vacuum pan according to the grade of salt desired.

The grainers are employed to manufacture coarse salt. They are heated by a series of 4-inch steam pipes running lengthwise and kept at least 2½ inches below the surface of the brine, a depth of 18 inches of brine

<sup>1</sup>Early in April 1930, this company was taken over by Canadian Industries, Ltd.

being maintained. The salt as it is formed is automatically removed by mechanical rakes, which scrape it over the inclined end of the grainer from where it is conveyed to the draining floor; here it remains for a certain period before being prepared for shipment.

The vacuum pan is employed in the manufacture of fine salt. This pan was installed in 1923 and has been in continuous service ever since. The pan is operated under a vacuum of 28 inches in consequence of which the brine boils at a temperature of about 130° F.

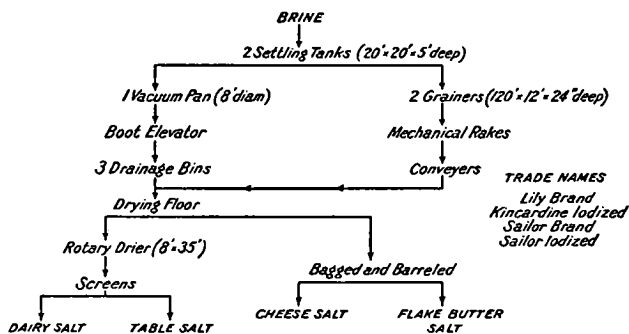


Figure 7. Flow-sheet, Kincardine Salt Company, Kincardine, Ontario.

The salt from the pan is removed by means of a boot elevator to three drainage bins where it is allowed to drain for about 6 hours before being conveyed to a drying-floor where it stands from 10 days to 3 weeks before being bagged or barreled. A part of this salt is passed through a rotary dryer 8 feet in diameter and 35 feet long; the dried material after screening is marketed as table and dairy salt. Some is further treated to make it "free running" by the addition of 1 per cent magnesium carbonate. An "iodized" salt is also prepared by the addition of 0.01 per cent potassium iodide added to the dried table salt. These two last products are packed in cardboard cartons.

A flow-sheet of this plant is shown in Figure 7.

Analyses<sup>1</sup> of three of the products produced by this company are as follows:—

	No. 1 Fine Vacuum, not dried	No. 2 Coarse Grainer, not dried	No. 3 Dairy Vacuum, fine, dried
Moisture.....	1.75	6.50	0.22
Insoluble.....	0.014	0.028	0.010
CaSO <sub>4</sub> .....	0.897	0.586	0.731
CaCl <sub>2</sub> .....	0.075	0.120	0.061
MgCl <sub>2</sub> .....	0.041	0.126	0.068
Phosphate.....	none	none	none
Carbonate.....	none	none	none
Fe and Al.....	none	none	none
<i>Calculated on dry basis</i>			
CaSO <sub>4</sub> .....	0.914	0.626	0.731
CaCl <sub>2</sub> .....	0.076	0.128	0.061
MgCl <sub>2</sub> .....	0.042	0.130	0.068
NaCl.....	98.96	99.09	99.13

<sup>1</sup> Analyses furnished by company.

MINES BRANCH  
LIBRARY

The boiler capacity of the plant is 940 h.p.; equipped with underfeed stokers using Pennsylvania bituminous coal for fuel.

The capacity of the plant is 45 tons fine and 25 tons of coarse per day. Free running and iodized salt is marketed by this company.

### The Goderich Salt Company

*Location.* Goderich, Ontario.

*Transportation Facilities.* Canadian National railway and Canadian Pacific railway; also by water.

*Operations.* This company is now pumping brine from two wells, the first one, 1,168 feet deep, has passed through the first bed of salt and has been operated continuously since 1880. The second well, 450 feet from the first was drilled in 1919 and reached a depth of 1,270 feet. No water has to be forced down these wells which, in common with many others in the northern part of the salt basin, encounter a water fissure in the first few hundred feet, and this supplies sufficient water for all the brine pumped.

The brine is pumped to three settling-tanks from which it is piped to the vacuum pans and open pans for evaporation.

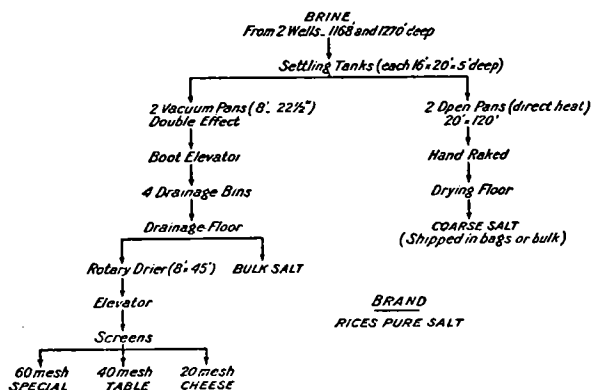


Figure 8. Flow-sheet, Goderich Salt Company, Goderich, Ontario.

There are two vacuum pans, live steam being used for the first pan. The fine salt produced in these pans is removed by boot elevators to drainage bins from which it is conveyed to the drainage floors. Part of the salt is dried in a rotary dryer and after screening is packed and shipped in several grades, such as table, cheese, and special salt.

The two open pans produce the coarse salt for which there is a considerable demand.

Free flowing and iodized salt is produced by the addition of 1 per cent magnesium carbonate and 0.01 per cent potassium iodide, and these are marketed under the trade name of 'Rice's Pure Salt.'

Salt from this plant finds a ready market throughout practically the whole of Canada, approximately 15 per cent going to Quebec and the Maritimes, 65 per cent to Ontario, and 20 per cent to western Canada.

Figure 8 is a flow-sheet of this plant.

HOWARD ZIMM  
VANALU



## Western Canada Flour Mills, Ltd.

*Location.* Goderich, Ont.

*Transportation.* Canadian National railway, Canadian Pacific railway, also wharfage on lake Huron.

*Operations.* This company operates two wells from which it obtains a saturated brine. The first well, drilled over 60 years ago, is still in operation.

The brine from these wells is pumped into settling-tanks and from them piped into a vacuum pan or two open pans according to the grade of salt desired.

In the vacuum pan fine salt is manufactured. This is removed from the pan by a boot elevator and conveyed to the drying floor where the surplus brine drains off. It is then passed through a rotary dryer after which it is screened and prepared for the market in a number of standard grades. Automatic baggers, carton fillers, and boxes handle the dried salt so that it is not touched by human hands until it reaches the consumer.

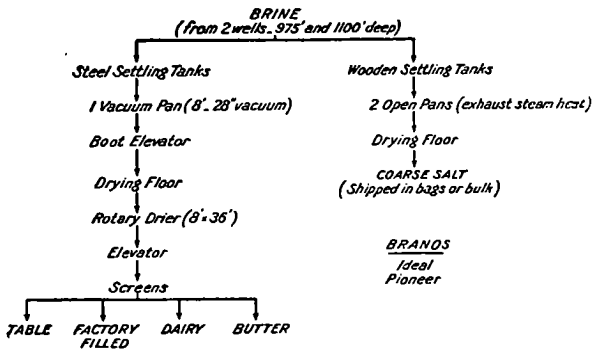


Figure 9. Flow-sheet, Western Canada Flour Mills, Ltd., Goderich, Ontario.

The open pans prepare coarse salt which is bagged or shipped in bulk. Free flowing and iodized salt is also prepared.

The products from this plant find a ready market throughout Canada, an analysis of their sales for the three months of May, June, and July, 1926 shows the following distribution:—

Maritimes and Quebec.....	3.1 per cent
Ontario.....	76.6 "
Manitoba.....	12.4 } "
Saskatchewan.....	5.7 } " = 20.3 per cent
Alberta.....	2.2 }

Figure 9 gives the flow-sheet of this plant.

## Dominion Salt Company.

*Location.* Sarnia, Ontario.

*Transportation Facilities.* The works are connected with the Canadian National railway by a siding; also with the Pere Marquette railway and water shipment.

*Operations.* This company at present is operating four wells, the depths of which are: 2,104, 2,097, 2,173, and 2,092 feet. Water is pumped down these wells from the St. Clair river, and the brine is recovered both by direct pumping and pumping by compressed air.

The brine pumped from the wells goes to storage or settling-tanks from which it is piped to the vacuum pans or the grainers.

There are three vacuum pans, 10 feet in diameter, run triple effect and the fine salt formed is removed by pumps and fed into an Oliver continuous filter (4 by 4 feet) which dries the salt down to approximately  $2\frac{1}{2}$  per cent moisture.

From the Oliver filter the salt is conveyed to the packing house floor where it is shipped in bulk, or else passed through a rotary dryer for the dairy plant. A portion of the fine salt is also used for the pressed blocks which are made in 50-pound size with or without iodine, and these blocks find a ready market wherever there are cattle. For convenience in differentiating between the blocks with or without iodine, a small percentage of iron oxide is added to the iodized blocks to give them a slight reddish colouring.

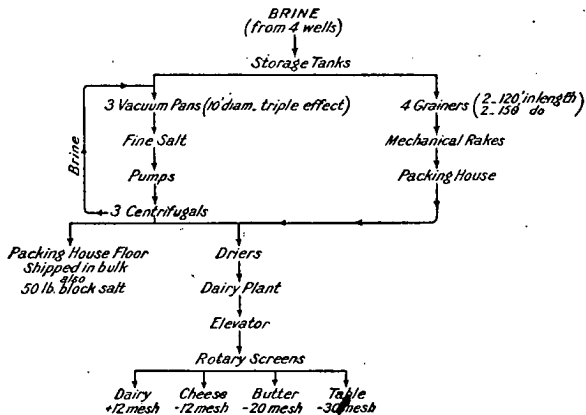


Figure 10. Flow-sheet, Dominion Salt Company, Sarnia, Ontario.

The fine salt passed through the dryer is screened, the coarse being used for dairy purposes while the fine is prepared for table use.

Some of the fine material has 1 per cent magnesium carbonate added to make it free flowing and some has 0.010 per cent potassium iodide incorporated to make an iodized salt of standard grade. The dairy salt is shipped in 100-pound bags, while the table salt is marketed in bags or cartons.

For the manufacture of coarser-grained salt four grainers are employed, two 120 feet in length and two 150 feet in length by 2 feet deep. Brine to a depth of 18 inches is kept in each of the grainers. Mechanical rakes remove the salt from the grainers and it is then conveyed from the packing house to the dryers. This coarse salt is sold as dairy salt and for use in packing houses.

Analyses furnished by the company are as follows:—

	Dry salt		Saturated brine
CaSO <sub>4</sub> .....	0.23	CaSO <sub>4</sub> .....	0.42
CaCl <sub>2</sub> .....	0.03	CaCl <sub>2</sub> .....	0.11
MgCl <sub>2</sub> .....	0.00	MgCl <sub>2</sub> .....	0.00

A flow-sheet of this plant is given in Figure 10. The capacity of the plant is 1,500 to 1,600 barrels per day.

## Western Salt Company

*Location.* Courtright, Ontario.

*Transportation Facilities.* Michigan Central railway, Pere Marquette railway, and water shipment from wharf on St. Clair river.

*Operations.* This company operates two wells, 1,800 and 2,200 feet deep. River water is used for dissolving the salt, the surface water being cased off.

The brine is pumped into wooden storage tanks and from these it is piped to the vacuum pan or the grainers.

The vacuum pan is an 8-foot single effect, using live steam at 100 pounds pressure. A vacuum of 28 inches is maintained. The fine salt is removed from the pan by means of a boot elevator and allowed to remain in drainage bins until the entrapped brine drains off. From these bins it is conveyed to the stock-piles. For the finer grades, part of the salt is put through a rotary steam dryer after which it is screened into the various grades. Free flowing and iodized salts are also prepared. The products are put up in cartons, bags and sacks, and barrels. Mechanical baggers and carton fillers are employed.

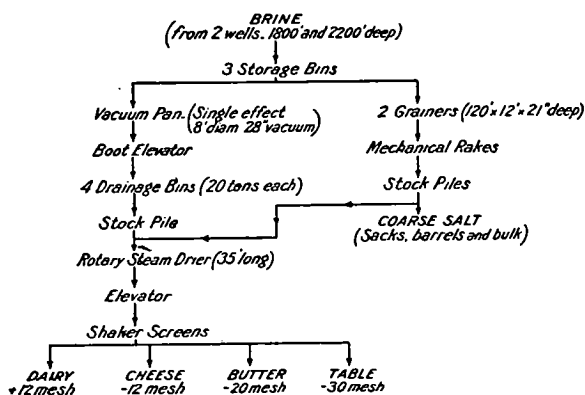


Figure 11. Flow-sheet, Western Salt Company, Courtright, Ontario.

Coarse-grained salt is produced in two grainers. These grainers are mechanically raked and the salt is allowed to drain in stock-piles before being marketed.

The salt from this plant is marketed under the trade name of "Purity" and a typical analysis furnished by the company is as follows:—

	Per cent
Insoluble matter.....	0.002
Calcium sulphate.....	0.871
Calcium chloride.....	0.076
Magnesium chloride.....	0.003
Sodium chloride.....	99.044
	99.996

Salt from this plant is distributed throughout the whole of Canada in approximately the following ratios:—

	Per cent
Ontario.....	54
Quebec.....	9
Maritimes.....	1
Western Canada.....	36

The company manufactures its own barrels for shipping the salt.

The capacity of the plant is 700 barrels per day. Figure 11 gives the flow-sheet of the plant.

### Exeter Salt Company

*Locality.* Exeter, Ont.

*Transportation Facilities.* Canadian National railway.

*Operations.* One well, 1,225 feet deep, is operated by this company. The brine is pumped into a settling-tank from which it flows to a direct-fired open pan, divided into sections by partitions, the brine flowing from one to the other. By this means the different grades are kept separate. The trade is mostly local and the plant is only run from three to four months each year.

### Canadian Industries, Ltd.

(Salt and Chemical Division)

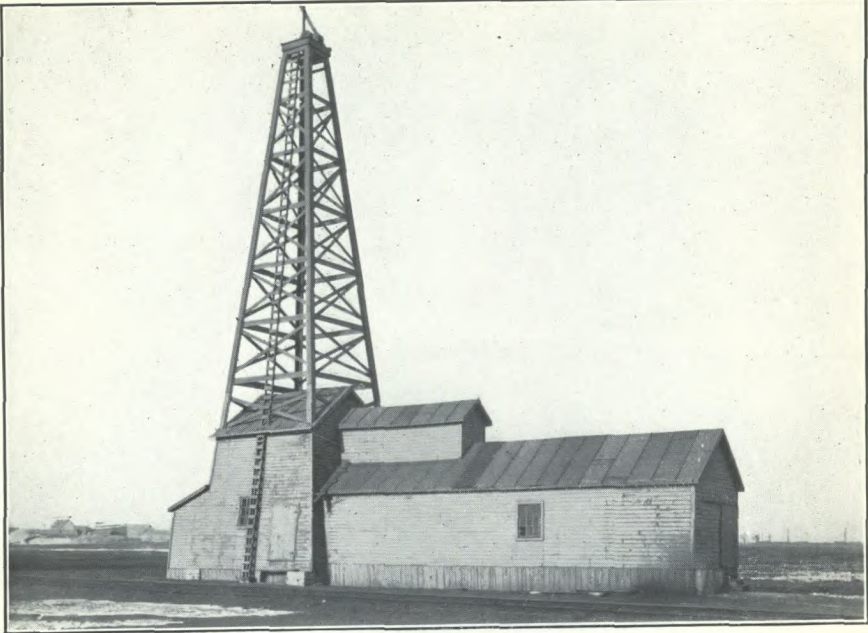
*Location.* Sandwich, Ontario.

*Transportation Facilities.* The Essex Terminal railway has a siding directly into the plant; connexions are also made with the Canadian Pacific, Canadian National, and Michigan Central railways and as the plant is situated on the bank of the Detroit river where it has its own private wharf, water transportation is also available.

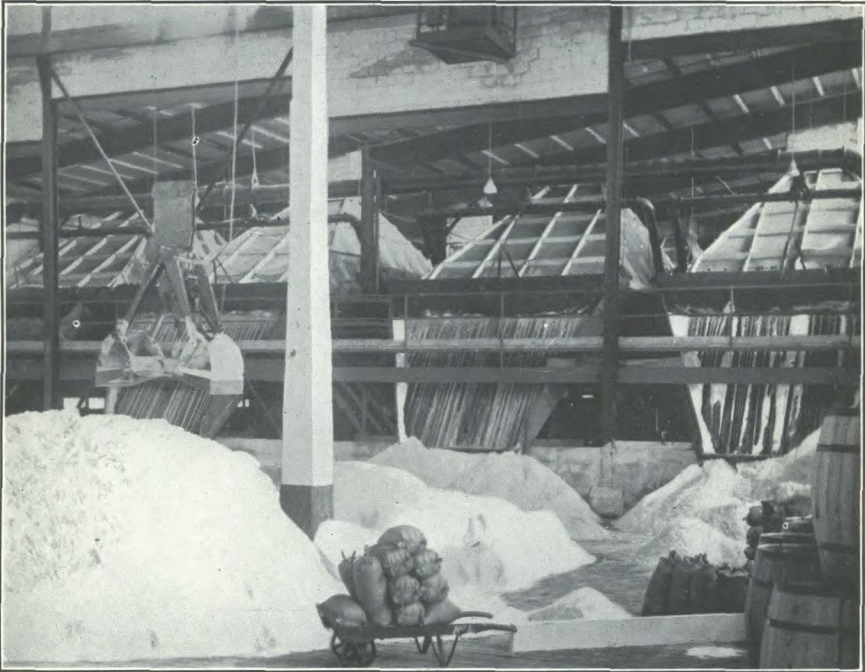
#### *Historical*

In the year 1891 a well drilled near the Canadian Pacific railway station at Windsor encountered a 30-foot bed of rock salt at a depth of 1,138 feet, thus greatly extending the area in Ontario known to be underlain by salt. Construction of a plant for the manufacture of salt was soon commenced under the name of the Windsor Salt Company and production started late in the year 1893. The original plant consisted of open pans and grainers, but soon two 12-foot, single effect, vacuum pans were installed and these were the first vacuum pans operating on salt brine in Canada. In April 1901 the Canadian Salt Company was incorporated and took over the assets of the Windsor Salt Company. Under the new management a third vacuum pan was added, larger than the other two, the two smaller ones being run alternately as first effect with the larger one as second effect. An additional plant for this company was later built at Sandwich, Ont., where four grainers were operated.

In 1911, this company commenced the operation of its chemical plant at Sandwich, for the manufacture of caustic soda and bleaching powder, later additions being made to produce liquid chlorine and hydrochloric acid.



A. Typical brine-well building and derrick. Canadian Industries, Limited, Sandwich, Ontario.



B. Discharge end of grainers. Canadian Industries, Limited, Sandwich, Ontario.

In 1928, excavations were started for a new and modern salt plant adjacent to the chemical plant at Sandwich and this plant was put in operation early in 1929.

During the fall of 1928 the Canadian Salt Company was purchased by the Canadian Industries Limited, and operations are now carried on by the Salt and Chemical Division of that company.

The plant at Windsor is completely dismantled and all operations are conducted at Sandwich.

### *Sandwich Plant*

The plant of this company at Sandwich consists of two distinct units—the salt plant and the chemical plant. Eight wells are being operated, the depth of salt ranging from 1,400 to 1,600 feet, and these wells supply brine for both plants.

### **Salt Plant**

This plant is probably one of the most modern salt plants on the continent and is housed in buildings as nearly fireproof as possible, an automatic sprinkler system ensuring additional protection. The salt coming to the plant in the form of a brine is handled in all the operations by machinery in such a way that it is not touched by human hands until it reaches the consumer.

The brine from the wells is pumped to storage tanks where it is allowed to settle and is then treated to remove any dissolved calcium sulphate. From the storage tanks the brine is pumped to the grainers and vacuum pans for evaporation.

*Grainer Process.* The grainers, five in number, are steel tanks 150 by 16 by 2 feet deep, the heat being furnished by steam pipes immersed in the brine. The salt as it forms is removed automatically from one end of the grainer by hydraulic rakes which move back and forward on the bottom of the grainers. The salt rests for a short time on the draining board to permit the superfluous brine to drain off. It is then conveyed to storage piles where the remaining moisture drains out. A clam shell bucket operated on a crane over the storage shed enables the easy handling of the salt.

Four of the grainers are operated by the exhaust steam from high pressure Parsons turbines generating power for the Electrochemical plant, while the fifth utilizes the condensate from the other four grainers in order to produce a coarser-grained salt due to evaporation of the brine at a lower temperature.

This process produces medium, fine, and coarse salt and the product is shipped in bulk, bags of various sizes, or barrels, with a moisture content not exceeding 3 per cent. A portion of the grainer salt as required is further processed by drying and screening to produce cheese and butter salt.

*Vacuum Pan Process.* For the manufacture of fine salt, vacuum evaporators are employed. These pans are three in number, 18 feet in diameter, manufactured by the Manistee Iron Works, Manistee, Mich. The pans are run in triple effect, the first effect utilizing exhaust steam from the

high pressure Parsons turbines previously mentioned. The steam belt is composed of 2,256 vertical copper tubes,  $2\frac{1}{2}$  inches diameter and 4 feet 6 inches long. Running triple effect, the vapour from the brine in the first effect furnishes the heating medium for the second effect, the vapour from which passes through the steam chest of the third effect. The vapour from the third terminates in a condenser which maintains the vacuum on the third effect.

The salt, as quickly as it is formed, drops down the cone-shaped bottom where it collects and is then pumped to the washing tank which removes impurities. From the washer, the salt which contains over 50 per cent moisture passes on to an Oliver continuous filter which filters and dries the salt to a moisture content of between 2 and 3 per cent.

From the filter it is conveyed by belt to the undried fines warehouse or else directly to the rotary dryer.

*Preparation of Special Grades.* In preparing dairy, table, free running, and iodized salt, the vacuum pan salt is taken either directly from the Oliver filter or from the warehouse, and passed through a monel metal-lined, oil-fired rotary dryer in order to remove the last trace of moisture. It is then cooled and screened through Rotex screens into the different meshes for the various grades. Where free flowing and iodized salt is desired, the salt goes through special mixers in which the necessary ingredients are added in proper proportions. Gravity flow is used wherever possible.

Automatic filling, labelling, and sewing and sealing machines are used throughout the plant, and handling of the finished products from the machines is reduced to a minimum. Electric trucks handle the product to storage and from storage to cars or boats.

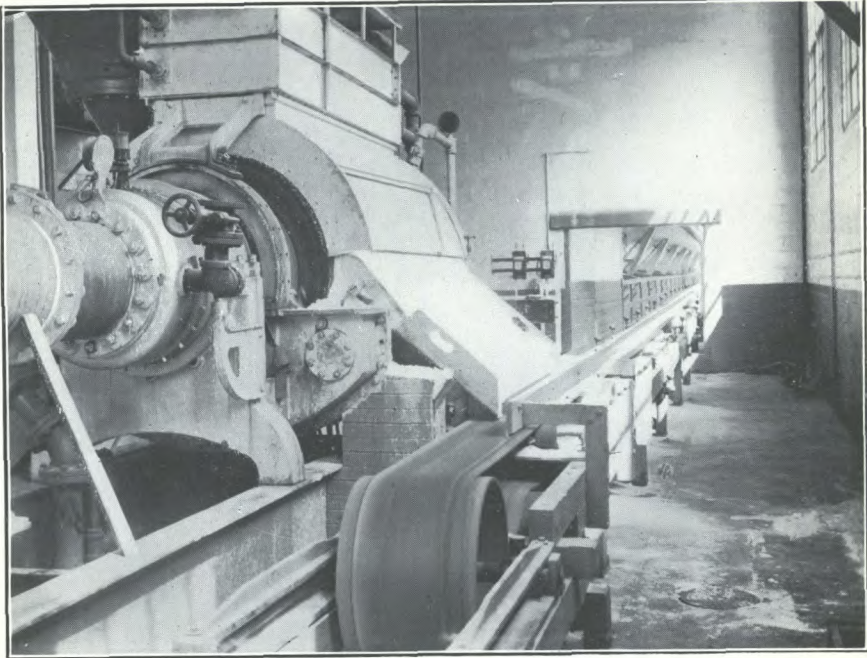
Pressed blocks, 50 pounds in weight, are made from the fine salt from the Oliver filter. Iodized blocks are also prepared and these have a small percentage of iron oxide added in order to distinguish them from the ordinary block. A cooperage plant makes all the barrels needed.

The salt from this plant is marketed under the trade name of "Windsor Brand" and as such has become internationally known. Over 160 grades and packages of salt are made to meet the demands of consumers in all parts of the world.

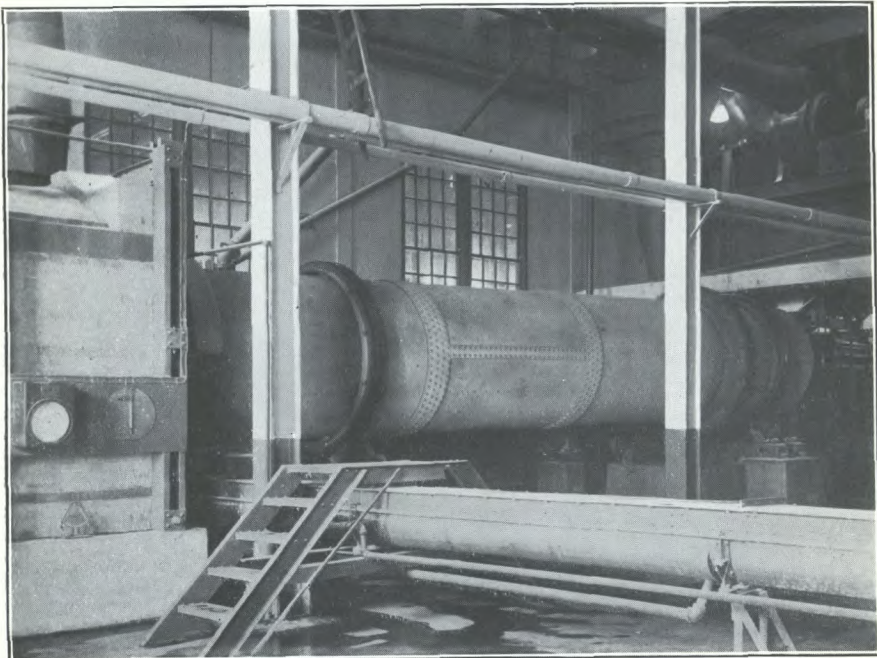
#### Electrochemical Plant

A chemical plant was erected at Sandwich in 1911 for the manufacture of bleaching powder and caustic soda. Additions have since been made so that the plant is now manufacturing liquid chlorine, hydrochloric acid, synthetic ammonia, and several other chemicals.

*Manufacturing Cycle.* The process employed at this plant is the electrolytic process, whereby the salt brine is decomposed into chlorine gas, caustic soda solution, and hydrogen gas. The chlorine gas is utilized to manufacture liquid chlorine, bleaching powder, and hydrochloric acid, while the caustic soda solution is concentrated to produce liquid, solid, flaked and crushed caustic. The hydrogen gas enters into the manufacture of hydrochloric acid and synthetic ammonia.



A. Oliver filter and conveying belt handling salt from vacuum evaporators. Canadian Industries, Limited, Sandwich, Ontario.



B. Rotary dryer, monel metal-lined and oil-fired, for drying salt. Canadian Industries, Limited, Sandwich, Ontario.



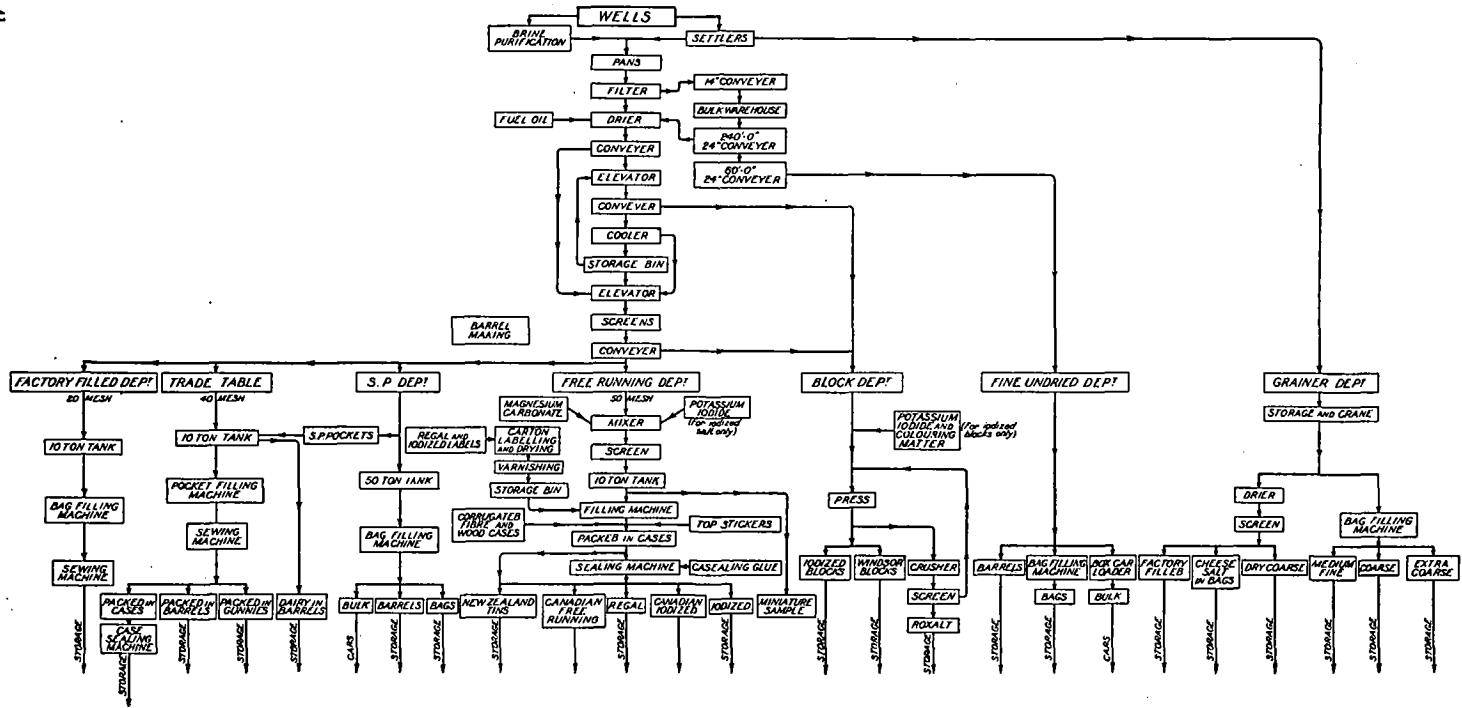


Figure 12. Flow-sheet of salt plant, Canadian Industries, Ltd., Sandwich, Ontario.

*Power.* The power required for the chemical and salt plants is generated in the company's power plant at the works.

The plant consists of six high pressure boilers, capacity 2,000 h.p., and three high pressure boilers with a capacity of 6,000 h.p., fired by powdered fuel, and generating a steam pressure of 350 pounds per square inch. This steam is used to drive three 2,000 h.p. Parsons turbo-generators, the exhaust steam being utilized for the salt plant evaporators and the evaporators concentrating the caustic solution. The complete plant is capable of supplying as high as 12,500 h.p.

The fuel supply is bituminous coal from the United States and is brought in by boat and unloaded at the company's own wharf on the Detroit river.

Power is also purchased from the Ontario Hydro-Electric Commission, transmitted from Niagara Falls over a distance of 276 miles at 110,000 volts. It is delivered to the plant at 26,500 volts and stepped down or converted into direct current as required. The company takes 5,000 h.p. from the Commission.

*Brine Supply.* The brine supply for the chemical plant is obtained from the eight wells previously mentioned. Before being used in the process this brine has to be treated or purified by the removal of any lime compounds present which would tend to precipitate in the diaphragm of the cell and thereby increase the resistance.

In the purification plant the brine is first heated to 180°F. after which the calculated amount of soda ash necessary to neutralize the calcium salts present is mechanically added, the resulting precipitate of calcium carbonate being removed by means of Dorr thickeners.

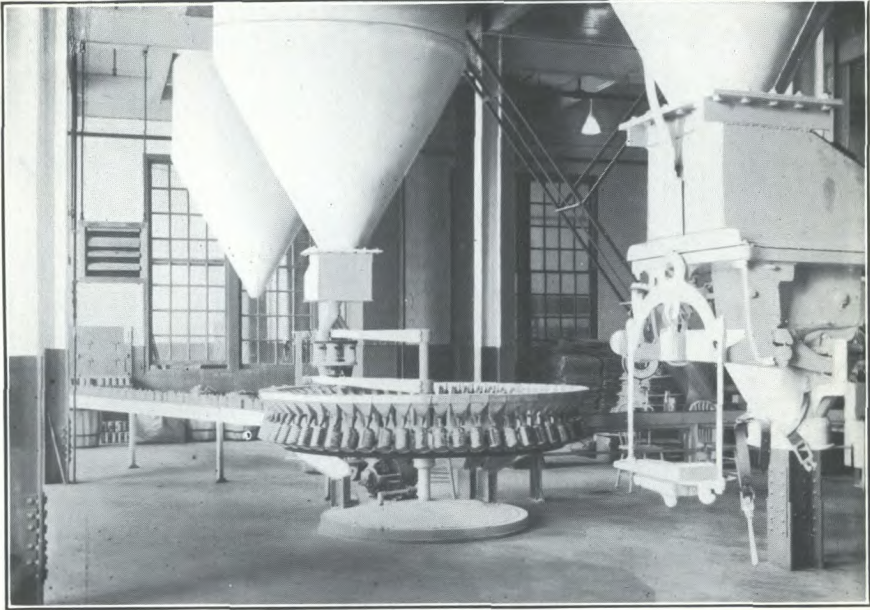
The clear hot brine is then fed by gravity to the electrolytic cells where it is decomposed by an electric current into its component parts, sodium and chlorine. The sodium immediately reacts with the excess water present to form a weak solution of caustic soda with the evolution of hydrogen gas.

*The Electrolytic Cells.* The cells used in the Sandwich plant are a modified form of the Gibbs cell, first patented in Canada by Arthur E. Gibbs on March 31st, 1908, under patent No. 110604. Figure 13 is a drawing of the cell. Pritchard and Hubel<sup>1</sup> describe this cell as follows:

The electrolytic cells, or decomposers, used at Sandwich are of the cylindrical diaphragm type and are the invention of an Englishman, Arthur E. Gibbs. The process is one of the most efficient of its kind in operation today. A large plant consuming about 10,000 h.p. is located at Wyandotte, Mich., and possibly the largest installation in the world today is that of the United Alkali Company of Great Britain, both using the Gibbs cell.

The cell itself is inclosed in an upright iron container, cylindrical in shape, and is assembled by placing inside this container a cylindrical and perforated cathode sheet on the inner side of which is secured a diaphragm of a special grade of long-fibre asbestos paper. Inside the cylindrical cathode and as near to it as practicable are placed 24 graphite sticks, 2 x 2 x 36 inches long, suspended in a circle from a dome-shaped head. The head, the ring it fits, and the bottom around which the cathode with its diaphragm is formed are made by the company from a mixture of cement and asbestos. The joints between the various divisions of the cell are so designed that they can be made gas-tight by a chlorine-resistant putty. These cells are arranged in a series of seventy individual cells

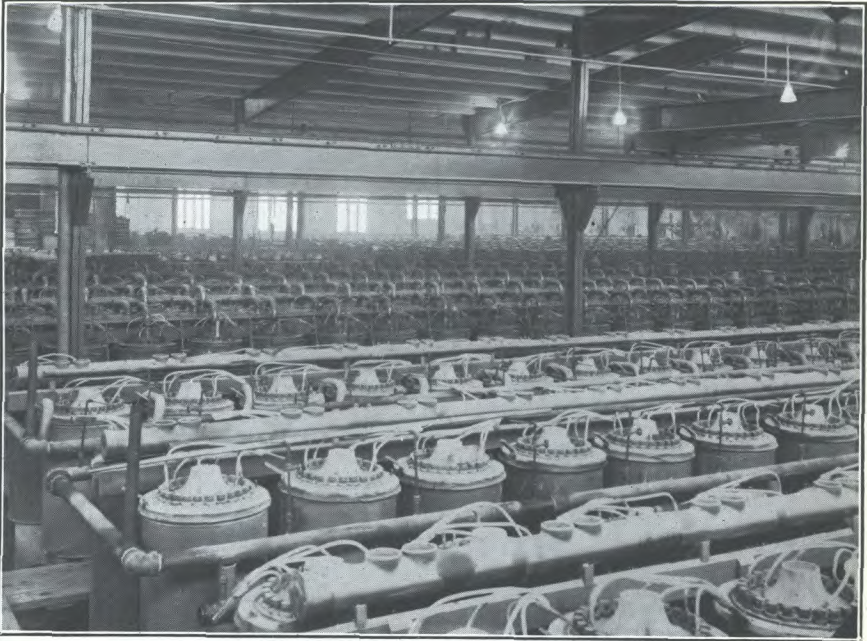
<sup>1</sup> Pritchard, D. A. and Hubel, J. H.: "Liquid Chlorine, Its Manufacture and Use;" Canadian Chemistry and Metallurgy, April 1927, p. 81.



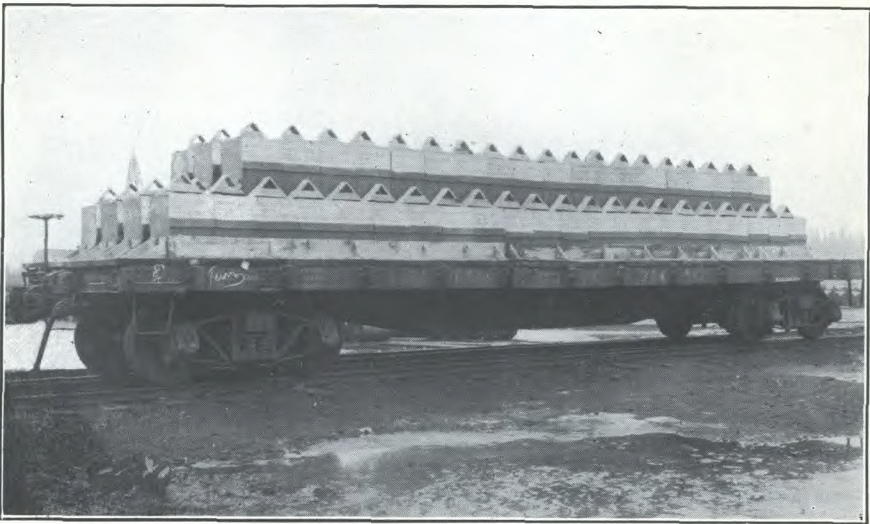
A. Automatic weighing machine and carton filler. Canadian Industries, Limited, Sandwich, Ontario.



B. Automatic weighing, bagging, and sewing machines for table salt. Canadian Industries, Limited, Sandwich, Ontario.



A. Electrolytic cell room for the decomposition of brine. Canadian Industries, Limited, Sandwich, Ontario.



B. Flat car loaded with carboys of hydrochloric acid. Canadian Industries, Limited, Sandwich, Ontario.

placed in two parallel rows of thirty-five each, and are connected so that the current must travel in series through the whole seventy under an applied voltage of 250 volts. Each cell will take approximately 3.57 volts and a current of 1,000 amperes. Practically the only departure from the original design has been in the manner of feeding the brine. By an ingenious arrangement, the cell is kept full of hot brine and at the same time the continuity of the brine fed to the cell is broken in an effective manner, thereby eliminating electric current losses.

The chlorine gas generated is removed through a stoneware pipe connection into a gas main kept under slight suction. The caustic soda, together with some undecomposed brine, trickles down the outside of the cathode sheet to the bottom of the cell container and thence into a receiving line into storage tanks which supply the evaporator department.

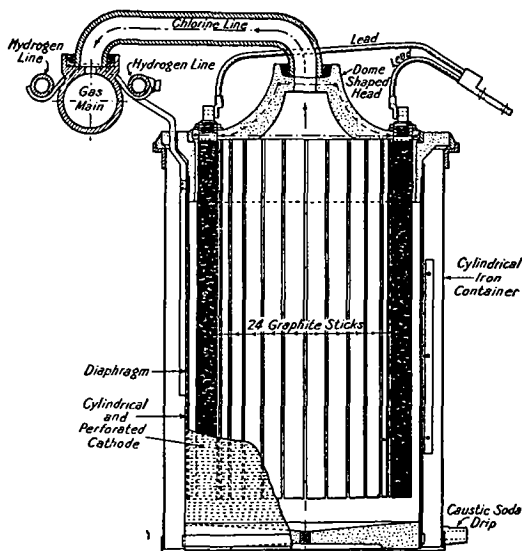


Figure 13. Section of latest type of Gibbs electrolytic cell.

The cell operates at a current efficiency of 93 to 95 per cent over the anode life of better than a year, a power efficiency of 56 to 57 per cent and a voltage efficiency of 60 to 61 per cent. It will produce in 24 hours, per square foot of floor space taken, 5 pounds of caustic soda and 4.43 pounds of chlorine. The caustic will run 120 grams per litre of sodium hydroxide, and the chlorine 95 per cent or better. The cell itself is remarkably simple, while the ease of its assembling and replacement does not demand expensive labour in building or supervising while in operation.

Plate VIII A gives a view of the cell room in this plant.

*Chlorine.* The chlorine gas generated in the cells is first cooled after which it has its moisture removed by passing through 4 to 40 drying towers. The chlorine gas is passed counter-current to a flow of strong sulphuric acid which removes the last trace of moisture present, and thus enables the gas to be liquefied in iron equipment since dry chlorine does not attack iron. The cooling and drying system removes as high as 50 pounds of moisture per ton of gas passed through them.

The dry chlorine is passed into compressors and cooled to produce liquid chlorine, which is shipped in 15- or 30-ton tank cars or 150-pound cylinders. (See Plates IX A and B.)

In the manufacture of bleaching powder the chlorine is passed through the bleaching chambers in which lime is placed on the floor to a depth of 3 inches, or through a Rudge mechanical bleach machine.

**Caustic Soda.** The dilute caustic soda solution from the cells is pumped into storage tanks from whence it is fed into the evaporators. There are two Scott vacuum evaporators run double effect and in these the solution is concentrated to 50 per cent strength, while the salt is removed, cleaned, redissolved, and the resultant brine returned to the cells. This concentrated solution of caustic may be either shipped as liquid caustic or else further concentrated in a Swenson, single effect evaporator to 65 per cent strength. From this evaporator it is fed to the finishing pots and further concentrated so that it solidifies on cooling. From these pots it is poured into moulds for lump or crushed caustic, directly into drums for solid caustic, or poured on a flaker for flaked caustic. A specially purified salt-free caustic is prepared for certain industries.

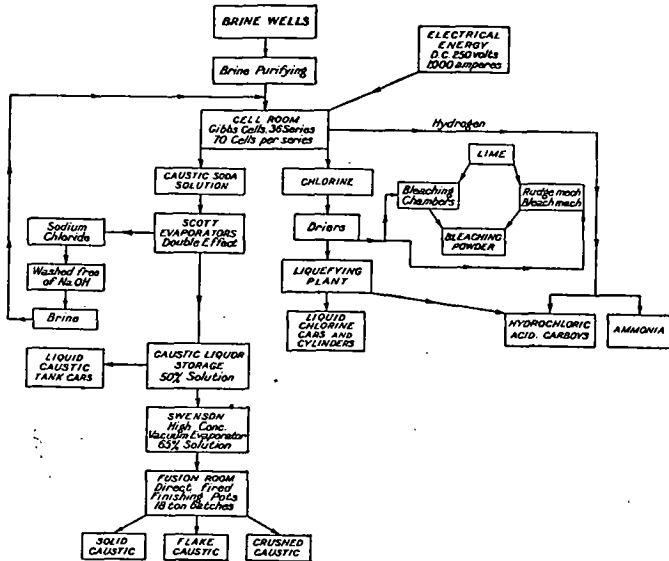
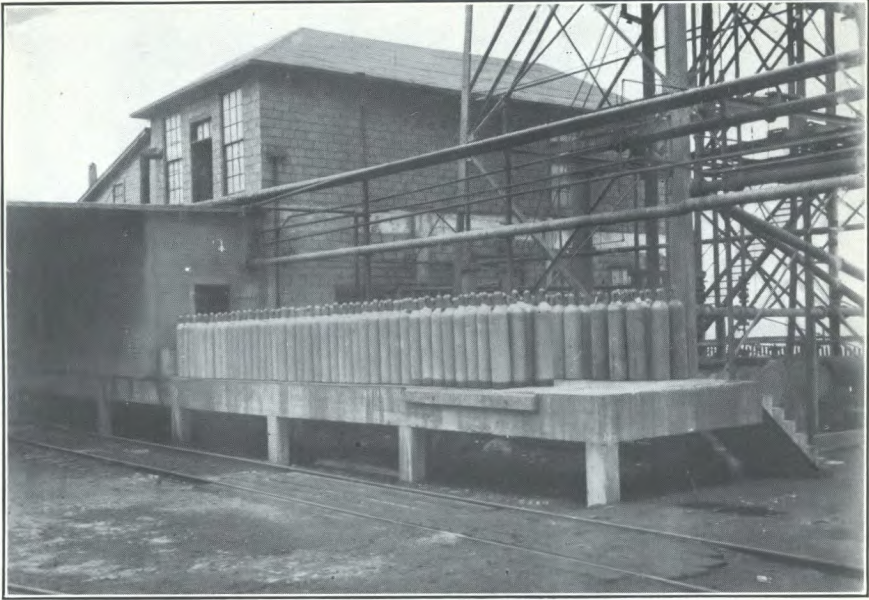


Figure 14. Flow-sheet of chemical plant, Canadian Industries, Ltd., Sandwich, Ontario.

**Hydrogen.** A certain amount of hydrogen gas is generated in the cells and part of this is burned in the hydrochloric acid plant in an atmosphere of chlorine to form synthetic muriatic acid. The burners and condensers for the acid are made of fused silica; the acid is condensed to 22° Baumé and shipped in carboys. The product is pure and water white and finds a ready market. The hydrogen gas is also being employed to manufacture synthetic ammonia.

The whole plant of the Canadian Industries, Limited, at Sandwich, Ont., is modern in every respect and is laid out in such a manner that enlargements to increase production of any of its products can be made at any time when conditions warrant.



A. Drums of liquid chlorine each containing 150 pounds ready for shipment. Canadian Industries, Limited, Sandwich, Ontario.



B. Tank car for the shipment of liquid chlorine. Canadian Industries, Limited, Sandwich, Ontario.

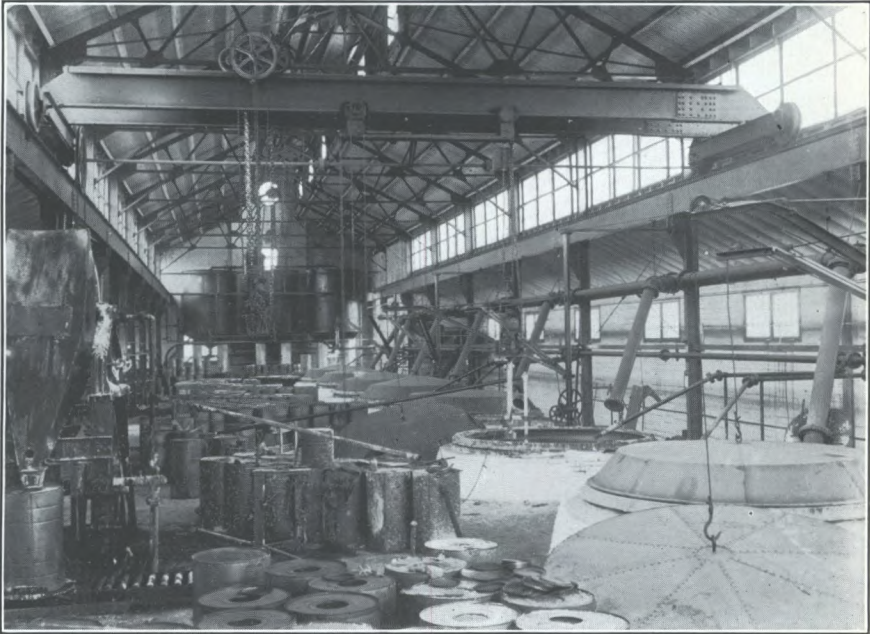


Vacuum evaporators (Scott type) for the concentration of caustic soda solutions. Canadian Industries, Limited, Sandwich, Ontario.





A. Fusion pots for caustic soda showing in right foreground the moulds in which the caustic solution is cast preparatory to shipment.



B. Fusion pots for caustic soda showing in foreground both empty and filled drums. The caustic when finished is poured into these drums and allowed to solidify.

## CHAPTER III

## SALT OCCURRENCES IN WESTERN CANADA

In the western provinces of Canada salt has been recovered from brines from a number of places, but at only two localities, namely, the McMurray district, Alberta, and in a deep well at Unity, Saskatchewan, are salt strata definitely known to occur.

With the extensive drilling campaigns at present being carried on by the several oil companies in western Canada in a search for oil and gas, excellent chances of discovering beds of salt at depth exist, especially if the drilling is carried into the northern parts of the Palæozoic area in the three provinces.

## MANITOBA

Beds of rock salt have not, as yet, been discovered in Manitoba, but many brine springs are known, and from these, in past years, salt has been recovered by evaporation. When these springs first became known, the area in which they occurred seemed to be limited to the district lying to the west of lake Winnipegosis, and this still remains the only district in which natural flowing springs occur. Of late years, however, in drilling operations in the vicinity of Winnipeg and the district to the west as far as the boundary line between Saskatchewan and Manitoba, brines have been encountered in holes and wells. Further drilling will most likely demonstrate a considerably larger area under which brine waters may be found.

*Early History.*

For a complete record of the early history of the discovery of salt and its manufacture from the brine springs of Manitoba, an extensive search would have to be made through the past records of the Hudson's Bay Company.

To the Indians of the Plains the springs must have been known for many years, and use made of them for domestic needs. In the early years of the nineteenth century—about the year 1820—at the brine springs situated on Red Deer peninsula in the southern part of lake Winnipegosis, active operations were commenced by James Monkman in the manufacture of salt. The production then obtained was small, and the product used only for local demands. When these springs were visited in 1858 by Prof. H. Y. Hind, operations were being conducted by James Monkman's sons, on a more extensive scale, and with some degree of profit, as the salt was in greater demand owing to the influx of settlers in the neighbourhood of the Red River valley. In his report<sup>1</sup>, Prof. Hind gives the following description of these "Monkman Salt Works" as they then existed:—

The soil at the Salt Springs is a very retentive yellowish white clay, containing small limestone boulders and pebbles, with boulders of unfossiliferous rocks. The wells, for obtaining a supply of brine, are sunk wherever a small bubbling spring is observed to issue from this retentive clay. The springs are constantly changing their position, and as

<sup>1</sup> Report on Assiniboine and Saskatchewan Exploring Expedition, by H. Y. Hind, 4to., Toronto, 1859, pp. 94-95.

the wells become exhausted from time to time, a fresh excavation is made where a new spring is observed to issue. No doubt boring, or deeper wells, would prevent these changes, and not only secure a larger flow of brine, but insure its permanency. The wells at present are twenty-five in number; but some of them appear to have been lately abandoned, and others have long since ceased to yield brine. They are situated 400 yards from the lake shore, and were first worked 40 years since by James Monkman. This enterprising individual struggled for many years against the importation of English salt which was sold in the settlements at a cheaper rate than he could afford to manufacture salt on lake Winnipegosis. He has made salt at Swan river and Duck river. The manufacture is now carried on with profit for the Hudson's Bay Company, at Swan river, and at Winnipegosis lake by Monkman's sons.

At the 'Works' there are two small, log houses and three evaporating furnaces. The kettles, of English construction, are well-made, rectangular vessels of iron, 5 feet long, 2 feet broad and 1 foot deep. They are laid upon two rough stone walls, about twenty inches apart, which form the furnace. At one extremity is a low chimney. The whole construction is of the rudest description; and at the close of the season the kettles are removed, turned over, and the furnace permitted to go to ruin, to be rebuilt the following spring.

The process of making salt is as follows: When a spring is found, a well, 5 feet broad and 5 feet deep, is excavated and near it an evaporating furnace erected. The brine from the well is ladled into the kettles, and the salt scooped out as it forms, and allowed to remain for a short time to drain before it is packed in birch bark roggins for transportation to Red river, where it commands twelve shillings sterling a bushel, or one hundred weight of flour, or a corresponding quantity of fish, pemmican, or buffalo meat, according to circumstances.

The brine is very strong. From one kettle two bushels of salt can be made in one day in dry weather. There are nine kettles at the 'Works', seven being in constant use during the summer season. The half-breeds engaged in the manufacture complained of the want of fuel—in other words, of the labour and trouble of cutting down the spruce and poplar near at hand, and the difficulty of hauling it to the furnaces. An objection of no moment, but characteristic of some of the people, who are generally unaccustomed to long-continued manual labour. Unfortunately I had no instrument with me for ascertaining the specific gravity of the brine, and a supply which I took to Red River for that purpose, as well as with a view to its analysis, still remains in the settlements. It will be seen that the processes employed in the manufacture of salt are of the rudest description, so that without any outlay beyond a few days' labour, the quantity might be largely increased. I spoke to John Monkman, who now makes salt here, of pumps and solar evaporation. Of a pump he knew absolutely nothing. He had heard that such an apparatus had been contrived, but had never seen one. He readily comprehended the advantage to be derived from pumping the water into shallow troughs, dug in the retentive clay near the springs, and strengthening the brine by solar evaporation.

Mr. T. W. Spencer, who, during the summer of 1874, made a brief exploratory trip into the region where these brine springs occur, found that the manufacture of salt was still being carried on, in a small way, at the springs at the south end of lake Winnipegosis; presumably the same springs where the Monkman's carried on operations. He gives the following description of the operations as carried on at the time of his visit:—

The salt springs at the south end of lake Winnipegosis have been worked for a long time. At these springs the saline waters percolate through the drift, which in this region covers but thinly the Devonian limestones, and destroys vegetation for some distance around. The manufacture of the salt is conducted in a crude manner. Pits are dug four or five feet deep, and into them the waters infiltrate. Beside these, temporary furnaces are erected, on which are placed evaporating pans made of iron plate one-eighth of an inch thick and five or six feet long, by about three feet wide and eight or ten inches deep. Beside the pans, are trays on which the salt is raked. No pumps are used, the water being lifted directly from the pits by means of pails. The operation is conducted entirely in the open air. The manufactured salt is put into birch bark boxes, or "mocoeks," holding about 100 pounds each, and is then ready for market. During the season Mr. McKay, the only person engaged in the business, made about 500 bushels, or less than half the quantity which had been manufactured in some previous years.

<sup>1</sup> Geol. Surv., Canada, Rept. of Prog., 1874-75, p. 69.

Mr. Spencer made the following analysis of a sample of the salt which he brought from the works:—

	Per cent
Sodium chloride.....	95.123
Magnesium chloride.....	0.600
Calcium sulphate.....	3.400
Sodium sulphate.....	0.394
Moisture.....	0.044
Residue.....	0.439
	100.000

The residue, he found to consist of silica, alumina, iron, and lime. The salt had a light brown tint, and was very coarse-grained.

From the time of Spencer's visit in 1874, the manufacture of salt from these springs seems to have gradually waned, so that when they were visited in 1889 by Mr. J. B. Tyrrell—then of the Geological Survey—there was no salt being manufactured, other than, perhaps, a small production made from time to time by wandering Indian families for their own use. This falling-off and final abandonment of all operations is readily understood, since the advent of the railway into Manitoba made the better and more cheaply produced salt of the Ontario and Michigan districts available at a price which negated competition at that time.

Since 1890, attempts to manufacture salt on a commercially profitable scale have been made locally but with little success, and now, operations have been entirely abandoned.

In the fall of 1913 the writer visited and sampled a number of the springs and wells.<sup>1</sup>

The localities where saline waters have been found have been divided tentatively into three districts. This division is in no way based on geological or chemical considerations, hence the division is purely for convenience of references.

#### *Winnipegosis District*

In this district the saline waters all appear in the form of flowing springs. The area in which these springs occur is approximately confined to the west shore of lake Winnipegosis, and the district between lake Winnipegosis and Porcupine and Duck mountains on the west. The southern boundary is Dauphin lake; and the northern boundary the northern shore of Dawson bay. In this area, as outlined, saline springs are known to rise to the surface through the till which covers the district in question.

The topography of the district is that of a low-lying country, at an average elevation of only a few feet above the level of the water of lake Winnipegosis. To the west the prominent ridge of the Manitoba escarpment rises to a height of from 1,000 to 1,500 feet above the surrounding country. The whole area is, with the exception of small parts of the southern portion, covered with a growth of small pine, spruce, and poplar, which increase in size farther to the north.

<sup>1</sup> A complete report on these occurrences, covering 33 pages together with maps, sketches, tables, and photographs, was made in Mines Branch Report No. 325 (1915), "The Salt Deposits of Canada". For the purpose of this report, therefore, the data contained therein has been tabulated and the analyses recalculated to correspond to the method used in presenting the analyses of the brines from the Maritimes. For the detailed descriptions the reader is referred to the above report.

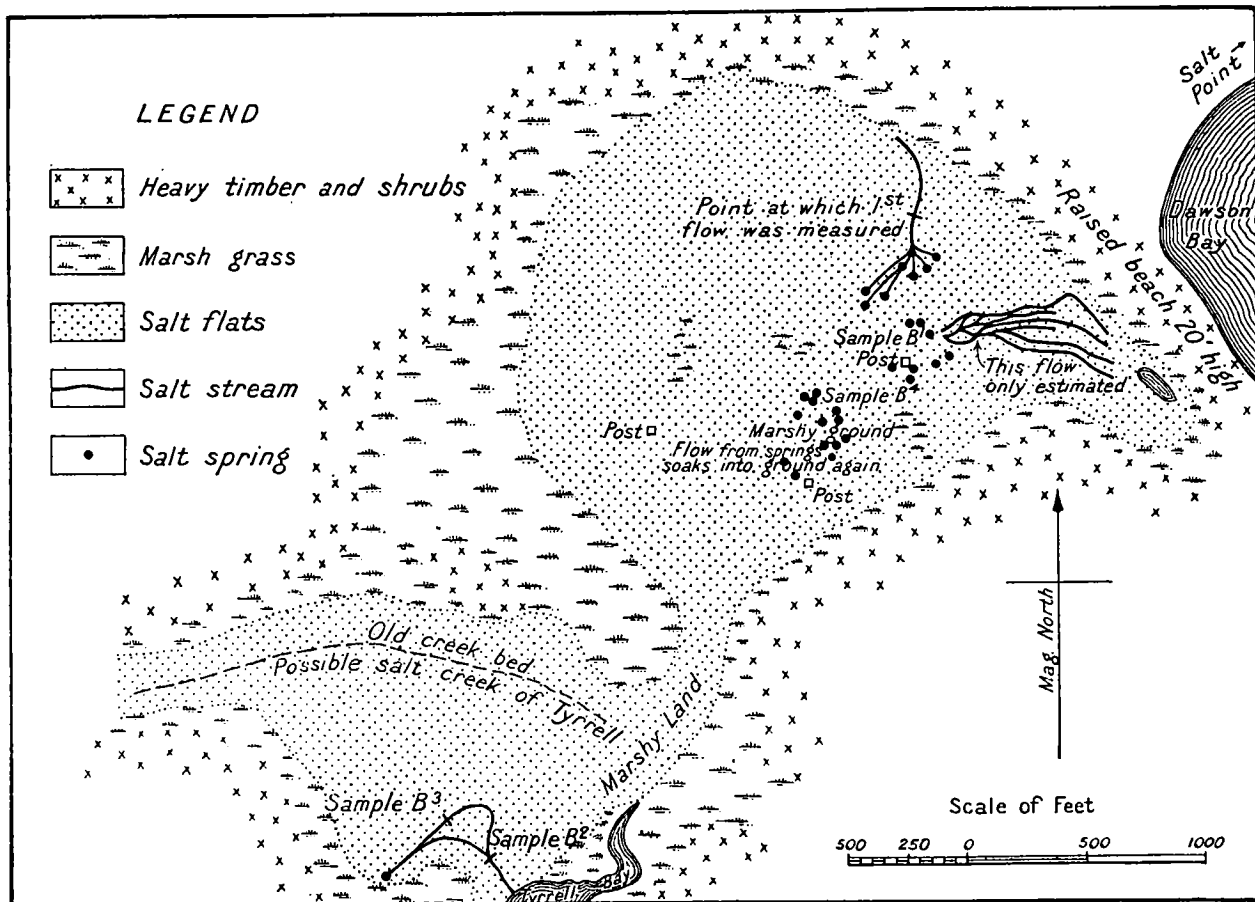
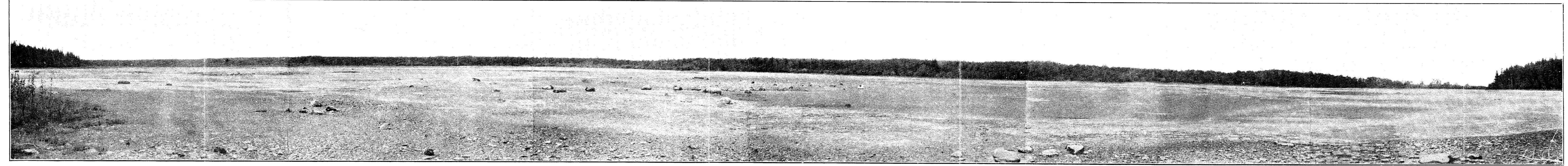


Figure 15. Saline spring B, south side of Salt point, Dawson bay, Manitoba.



Saline flats, saline spring B, Winnipegosis district, Manitoba.

The saline springs throughout this district are very numerous, and many small saline areas can be noticed where the brine oozes up through the overlying drift.

Mr. J. B. Tyrrell, who visited a number of these springs during the summer of 1889, gives the following list of some of the principal places where saline springs have been observed<sup>1</sup>:—

1. Salt creek, west of lake Dauphin.
2. Banks of Mossy river.
3. Salt point, south end of lake Winnipegosis.
4. Monkman's Salt springs, Red Deer peninsula, Saline spring J.
5. Pine creek. Saline springs H and I.
6. Pelican bay, mouth of Pelican creek.
7. Pelican bay, west side.
8. Mouth of Bell river. Saline spring A.
9. Salt point.
10. Salt Point peninsula, wide salt area near its base. Saline spring B.
11. Salt Point peninsula, north side of its base. Saline springs C and CC.
12. Mouth of Steeprock river.
13. Lower Red Deer river, many places. Saline springs E, F, and G.
14. Banks of Shoal river.
15. Mouth of Swan river.

The writer visited the more important of these saline areas during the fall of 1913. The springs then visited are indicated by distinguishing letters opposite the corresponding localities in Tyrrell's list. Data referring to these localities together with chemical analyses are given in Tables V and VI.

#### *Westbourne District*

The region included, tentatively, in this report, covers the area lying to the west of Portage la Prairie and the western boundary of Manitoba and south of the town of Dauphin. In this district several saline areas occur, and a number of drill holes have encountered saline waters.

The vicinity around the south end of lake Manitoba is very marshy, and the water in the swampy land is, in some cases, distinctly saline to the taste.

The main localities at which saline waters are found in this district are:—

1. Gladstone, Tom Smith farm. Well K.
2. Gladstone, James McBride farm. Well L.
3. Saline spring, Westbourne. Well M.
4. Neepawa. Well O.

The brine from the Neepawa well was the strongest brine encountered in any of the wells or springs in Manitoba, and is the only one which at present holds out any promise of being of commercial importance. For data regarding these wells and springs see Tables V and VI.

<sup>1</sup> Geol. Surv., Canada, Ann. Rept., vol. V, pt. I, p. 219E.

TABLE V

## Winnipegosis District—Brine Springs

Spring letter	Approximate location west of Principal Meridian			General location; Description	Approximate area (acres)		Flow of brine, Imp. gals. per min.	Degree of salinity, B6.	Remarks
	Section	Township	Range		Salt flat	Meadow			
A.	33	24	43	To northwest of mouth of Bell river—Dawson bay—lake Winnipegosis.	30	7	17½	26	About 15 springs are to be noticed in this area forming two streams which unite at end of meadow land and flow into Dawson bay.
B.	23	24	44	On west shore of Dawson bay, about 1 mile south of Salt point, lake Winnipegosis.	140	25	7½	26	Numerous springs are to be found dotted over barren area. Only main flows could be measured. Probably 25 per cent can be added to cover rest of flow.
C.	17	24	44	On south shore of Dawson bay, 1 mile to east of mouth of Steeprock river, lake Winnipegosis.	16	2	45½	26	Situated on sloping ground and brine flows directly into Dawson bay. Salt manufactured from this spring about 10 years ago for local use.
CC.	17	24	44	On south shore of Dawson bay, lake Winnipegosis. About 300 yards to east of Salt spring "C."	5	10	1½	26	Probably a part of spring C. Ground marshy and brine seeping out forming a small stream near lake edge where it was measured.
D.	11	25	44	On south bank of Steeprock river, about 1 mile from mouth, Dawson bay, lake Winnipegosis.	2	115	15½	12	The greater part of this spring is boggy and covered with a thick growth of marsh grass through which the brine finds its way to the surface. Probably about 30 per cent can be added to amount of flow to cover loss by seepage.



**TABLE V—Concluded**  
**Winnepegosis District—Brine Springs—Concluded**

Spring letter	Approximate location west of Principal Meridian			General location; Description	Approximate area (acres)		Flow of brine, Imp. gals. per min.	Degree of salinity, Bé.	Remarks
	Section	Township	Range		Salt flat	Meadow			
E.	16	25	45	On north bank of Red Deer river, 1 mile from mouth Dawson bay, lake Winnepegosis.	10	60	1	.....	Flow estimated. Consisted of seepage from marshy flat. No definite spring could be seen.
F.	18	25	45	On north side of Red Deer river, about 2½ miles from mouth Dawson bay, lake Winnepegosis.	.....	20	3½	21	Brine spring coming from low limestone ridge flowing in two directions into Red Deer river.
G.	11	26	45	On south side of Red Deer river, about 4 miles from mouth. Dawson bay, lake Winnepegosis.	105	10	7¼	24	On flat ground brine flows two directions into Red Deer river.
H.	2	20	35	About 4 miles to southwest of Camperville on west shore of lake Winnepegosis.	12	.....	14½	15	This spring is situated in meadow land extending for several miles with occasional clumps of bushes and trees, locally called bluffs.
I.	1	20	35	About 3½ miles to southwest of Camperville, on Pine creek, lake Winnepegosis.	1	.....	14½	10	Spring situated on steep bank of river and brine flows directly into river.
J.	21	18	32	On west shore of lake Winnepegosis, 12 miles north of town of Winnepegosis.	60	.....	No flow measure	15	Brine at this spring is found in wells or pits but no flow sufficient to be measured. Monkman's old spring from which salt was manufactured over 50 years ago for use of the Hudson's Bay Co. Situated in meadow land similar to spring "H."

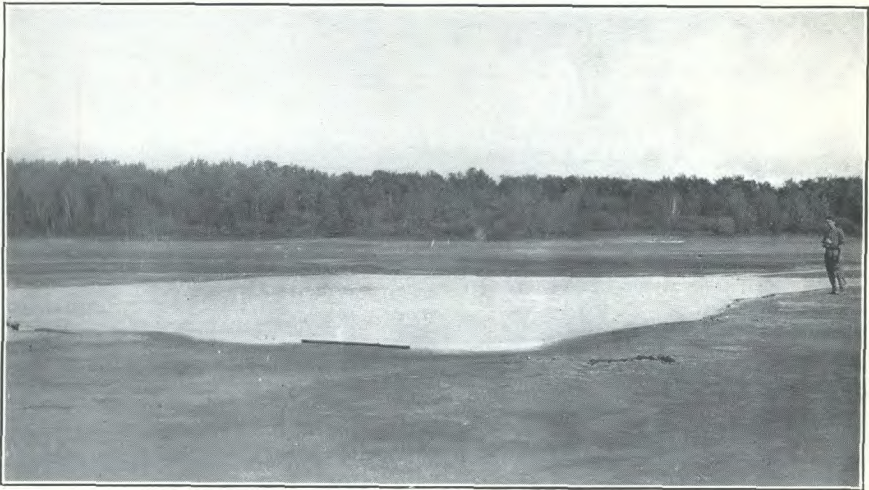
NOTE.—Salinity was measured in the field to gain an approximate idea as to the strength (NaCl) of the brine. A salinometer was used on which 100 degrees = a saturated solution of NaCl.  
 The amount of flow was measured by a right-angled V notch taking the measurement 2 feet from notch.

TABLE VI  
Analyses of Brines from Northern Manitoba  
(Percentages calculated on dry basis)

	A <sub>1</sub>	A <sub>1</sub>	B <sub>1</sub>	B <sub>2</sub>	B (Tyrrell)	C	C (Tyrrell)	CC	E	F	G	G Tyrrell	H	I	J	J (Tyrrell)	J (Tyrrell)	K	L	M	O	Win- nipeg well	Peli- can bay	Salt point	Steep- rock river	Swan river
K.....	0.16	0.25	0.56	0.37	1.81	0.19	2.21	0.03	1.84	0.02	0.01	2.20	0.21	0.01	0.11	1.54	0.34	tr.	tr.	tr.	0.01	0.02	2.20	0.07	2.74	1.94
Na.....	34.58	34.70	35.03	34.74	34.34	34.35	34.19	35.23	33.47	36.06	36.46	34.46	36.00	33.59	37.89	31.86	34.38	30.99	30.68	31.35	37.39	36.10	34.04	36.42	33.45	33.96
Ca.....	2.21	2.17	2.23	2.32	2.17	2.02	2.10	2.07	2.42	2.18	2.23	2.15	2.54	2.72	2.43	3.63	2.55	4.53	3.97	4.09	2.14	1.92	2.12	1.89	2.18	2.31
Mg.....	0.53	0.56	0.55	0.55	0.57	0.51	0.54	0.67	0.78	0.66	0.62	0.51	0.63	0.91	1.25	1.02	1.01	2.48	2.83	2.45	0.62	0.39	0.53	0.54	0.65	0.53
Fe and Al.	0.01	0.01	.....	0.01	.....	0.18	.....	0.03	.....	0.01	0.01	.....	0.02	0.02	0.01	.....	.....	0.01	0.03	0.14	.....	0.01	.....	.....	.....	.....
SO <sub>4</sub> .....	5.16	5.15	5.21	5.21	5.04	5.04	5.16	5.67	5.05	5.01	5.03	5.23	6.31	6.56	6.72	9.22	5.03	10.93	7.96	7.42	1.51	6.16	5.29	4.77	5.25	5.32
Si.....	0.01	0.01	0.03	0.01	.....	0.01	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Cl.....	57.16	57.04	56.23	56.66	56.07	57.63	55.80	56.30	56.42	56.03	55.60	55.45	54.24	56.09	51.53	52.73	56.69	50.96	54.16	54.55	58.27	55.36	55.82	56.31	55.73	55.94
Br.....	0.18	0.11	0.16	0.12	.....	0.07	.....	.....	.....	0.03	0.04	.....	0.05	0.10	0.04	.....	.....	0.06	0.29	.....	0.05	0.04	.....	.....	.....	.....
I.....	nil	nil	nil	nil	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.04	0.08	.....	0.01	.....	.....	.....	.....	.....
Total....	100.0	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
KCl.....	0.31	0.49	1.06	0.73	3.44	0.38	4.20	0.06	3.51	0.03	0.02	4.14	0.39	0.02	0.19	2.92	0.65	tr.	tr.	tr.	0.02	0.03	4.19	1.29	5.22	3.71
Na Cl.....	89.80	89.68	89.23	88.94	87.02	89.90	86.55	89.12	85.15	90.11	90.33	86.60	88.47	86.79	86.56	80.66	87.03	75.64	76.07	77.52	91.48	89.59	86.47	90.18	84.83	86.39
Ca Cl <sub>2</sub> ....	0.19	0.07	0.35	0.42	0.19	.....	.....	.....	0.87	0.26	0.35	.....	.....	.....	.....	.....	1.24	.....	1.77	2.71	4.05	.....	.....	.....	.....	0.28
Mg Cl <sub>2</sub> ....	2.02	2.21	1.94	2.17	2.24	2.05	2.00	2.67	3.10	2.54	2.30	1.95	2.38	3.60	4.50	3.50	3.99	9.35	10.73	9.41	2.34	1.53	1.90	1.88	2.54	2.09
Mg Br <sub>2</sub> ....	0.21	0.12	0.19	0.15	.....	0.08	.....	tr.	.....	0.03	0.05	.....	0.06	0.12	0.04	.....	.....	0.07	0.33	.....	0.05	0.04	.....	.....	.....	.....
Ca SO <sub>4</sub> ....	7.45	7.41	7.23	7.56	7.11	7.10	7.10	7.06	7.37	6.96	6.94	7.22	8.38	9.40	7.52	12.26	7.09	14.80	10.99	10.22	2.05	6.52	7.19	6.36	7.38	7.53
Fe and Al.	0.01	0.01	tr.	0.01	.....	0.19	.....	0.03	.....	0.07	0.01	.....	0.02	0.02	0.01	.....	.....	0.01	0.03	0.14	.....	0.01	.....	.....	.....	.....
Si.....	0.01	0.01	tr.	0.02	.....	0.01	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Mg SO <sub>4</sub> ....	.....	.....	.....	.....	.....	.....	0.15	.....	.....	.....	.....	0.09	.....	.....	.....	0.66	.....	.....	.....	.....	.....	.....	0.25	0.29	0.03	.....
Na <sub>2</sub> SO <sub>4</sub> ....	.....	.....	.....	.....	.....	0.29	.....	1.06	.....	.....	.....	.....	0.30	0.05	1.18	.....	.....	0.08	.....	.....	.....	2.28	.....	.....	.....	.....
Mg I <sub>2</sub> ....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.05	0.08	.....	0.01	.....	.....	.....	.....	.....
Total....	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00



A. Typical saline spring, saline spring B, Winnipegosis district, Manitoba.



B. Typical saline pond, saline spring B, Winnipegosis district, Manitoba.

## Winnipeg District

A Winnipeg syndicate drilled seven wells within a radius of 20 miles of the city of Winnipeg and in five of them encountered waters of varying degrees of salinity. It was noted by the drillers that whenever a certain kind of coarse white sandstone was drilled into, water was encountered. One well at Elmwood was sampled and results obtained are recorded in Tables V and VI.

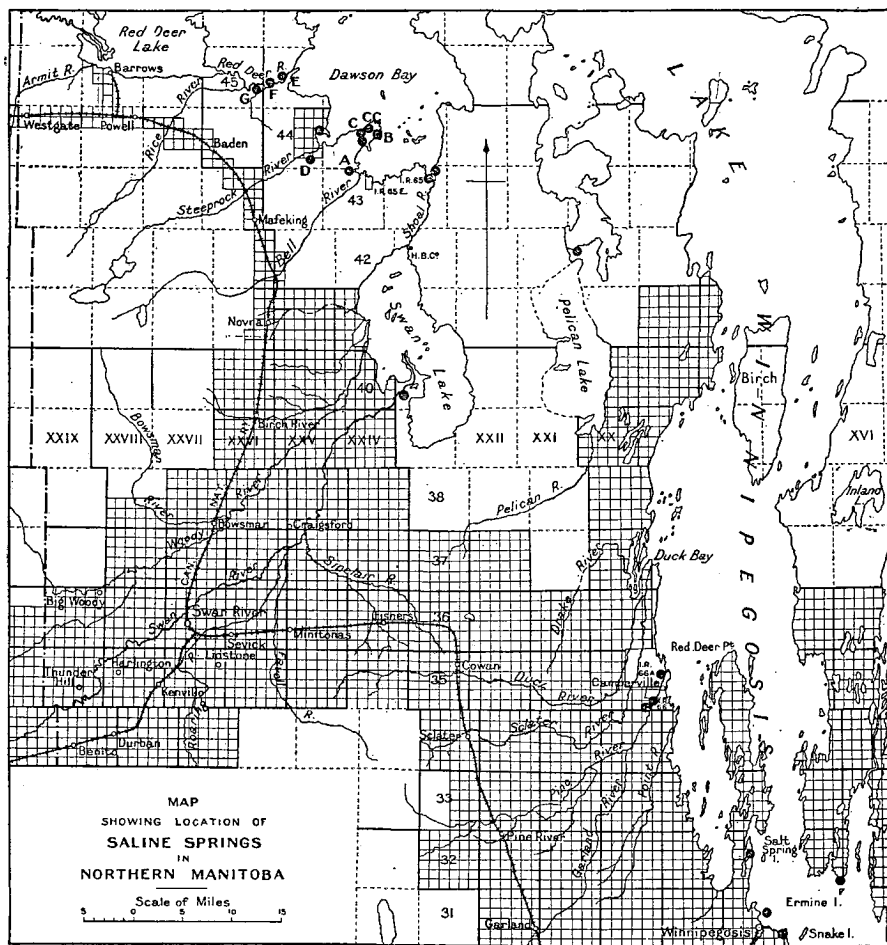


Figure 16. Sketch map showing saline springs in Manitoba.

## SASKATCHEWAN

In the province of Saskatchewan only one deposit of rock salt has as yet been found. Small percentages of salt, however, have been noted in the numerous alkali lakes<sup>1</sup> which occur throughout the province, but, with the exception of Senlac lake, the percentage of sodium chloride has been small.

<sup>1</sup> See Report No. 646, Mines Branch, Dept. of Mines, Ottawa (1926).

### Senlac Lake

This lake is situated in sec. 19 and 30, tp. 39, range 25, west of the 3rd. meridian, Saskatchewan, and is midway between the Macklin-Kerrobot branch and the Macklin-Unity branch of the Canadian Pacific railway, and 13 miles by road from either Senlac, Macklin, or Denzil, the nearest railway stations. The wagon roads from the lake to these towns are fairly good.

*Topography.* The country is somewhat hilly, and the shores of the lake have gentle slopes which rise gradually to hillocks 100 to 150 feet high. The drainage basin is small. The lake is nearly 1 mile in length in a northwesterly and southeasterly direction and is approximately 1,200 feet wide. The area of the lake is 185 acres and, unlike many of the other lakes examined, the predominant salt is sodium chloride.

On the south shore there is a narrow neck of land jutting out into the lake some 800 feet and on this point a small plant has been erected.

*Springs.* The lake is fed by numerous springs in various parts of the lake bottom and along the shore, but none of them seem to have a very strong flow. When the lake was visited in September, 1923, the specific gravity of the waters in four of these springs varied from 1.007 to 1.047. The brine at that time had a specific gravity of 1.067. A sample of the brine taken in March, 1924, analysed as follows:—

Ca (HCO <sub>3</sub> ) <sub>2</sub> .....	267
CaSO <sub>4</sub> .....	4,335
NaCl.....	50,053
CaCl <sub>2</sub> .....	1,854
MgCl <sub>2</sub> .....	15,932
Total.....	72,446
Specific gravity at 15° C.....	1.055
(Results expressed in parts per million.)	

*Crystal Bed.* No crystal bed was found under the mud in any part of the deposit, and the brine is the only source of salts in the lake. The depth of brine varies from 6 inches to 1 foot, according to the season of the year. Two samples of brine were collected in September, 1923, one from the lake and the other from the spring on the northeast shore. These brines were evaporated to dryness and the salts analysed as follows:—

	Lake brine		Spring brine	
	Per cent		Per cent	
Insoluble.....	0.25		4.53	
Al <sub>2</sub> O <sub>3</sub> , Fe <sub>2</sub> O <sub>3</sub> .....	3.87		2.10	
NaHCO <sub>3</sub> .....	1.69		1.26	
NaCl.....	79.60		63.02	
MgCl <sub>2</sub> .....	3.66		14.92	
CaCl <sub>2</sub> .....	1.86		10.40	
CaSO <sub>4</sub> .....	6.70		0.99	
Totals.....	97.62		97.22	

*History of the Deposit.* The lake was staked early in 1918 and work on it was commenced the following year.

Wooden cribbing was placed around eight of the springs and the water pumped to shallow mud vats laid out on the shore of the lake. Solar evaporation caused the deposition of sodium chloride in the vats. The crystals were then shovelled and scraped to drying platforms, where they were drained and afterwards bagged for shipment. Two samples, furnished by the operators, analysed as follows:—

	No. 1 Coarse	No. 2 Fine
	Per cent	Per cent
Na.....	38.13	36.87
Mg.....	0.23	0.45
Ca.....	0.05	0.13
SO <sub>4</sub> .....	0.08	0.35
Cl.....	59.43	58.14
Insoluble in water.....	0.34	0.09
Loss at 110° C.....	1.02	2.24
Loss above 110° C.....	1.18	2.00
Totals.....	100.46	100.32

In November, 1920, control of the property was obtained by the Senlac Salt Company (Head office, Calgary, Alta.), and a large building was put up to house three iron evaporating pans approximately 35 by 6 feet by 8 inches deep. The three pans were placed side by side about 6 feet apart and rested on brickwork. The three pans had heating space underneath them, the two outside ones being heated directly by coal fires, fired from the east end. The flues from the two outside pans each passed into the heating space under the centre pan. The hot gases thus passed beneath the two outside pans from east to west and returned beneath the centre pan from west to east before passing up the stack at the end of the centre pan. The brine evaporated in these pans and the crystal was gathered on drying-boards placed on the side.

The material produced was sold locally to the farmers.

Operations did not continue for very long, and there has been no production since 1921.

### Rock Salt Deposits

It is interesting to note that according to Prof. F. H. Edmonds,<sup>1</sup> University of Saskatchewan, rock salt has been encountered in a drill hole near Unity, Saskatchewan. In speaking at Winnipeg in March, 1929, he called attention—

.....to the record of a well drilled in western Saskatchewan, namely, the Unity Valley No. 2 well, where, a few weeks before, salt was encountered at a depth of 3,110 feet. About 18 inches of rock salt were penetrated before boring was discontinued. In this particular well, dolomite limestone of Devonian age was struck at a depth of 2,100 feet and continued for about 800 feet. At 2,940 feet a thin band of gypsum was met, and from this depth occasional gypsum seams occur; also, threads or veinlets of gypsum are to be seen penetrating the dolomite.

<sup>1</sup>Can. Inst. Min. & Met. Bull. No 206, June 1929, p. 787.

## ALBERTA AND NORTH WEST TERRITORIES

Brine springs have been known in Alberta and North West Territories for many years.

The utilization of salt deposited from brine springs in the Mackenzie River district in the early years of the nineteenth century marks the beginning of the salt industry in Alberta. Thus the salt industry is probably one of the oldest mineral industries of the province. Salt river, where one of the strongest springs occurs, was visited by Sir James Richardson in 1820, and in the same year D. W. Harmon states that<sup>1</sup>:—

.....down Slave river, there are several places, where almost any quantity of excellent clean white salt may be taken, with as much ease as sand along the seashore. From these places the greater part of the northwest is supplied with this valuable article.

Salt from this locality and several others in the district is still harvested in a small way each year even to the present time. It is customary to sack the salt in the summer time and transport it to Fort Smith when the ground freezes.

Rock salt was not discovered in the province until 1907, when thick beds were reported to have been drilled through in two wells sunk by the Northern Alberta Exploration Company several miles from the townsite of McMurray. That there is an extensive bed of rock salt occurring at a depth below 600 feet has later been proved by a number of wells drilled by the Alberta Government in the McMurray district.

### Brine Springs

At present none of the springs in the Mackenzie River district are sufficiently close to transportation and markets to make them commercial. Their occurrence is of interest, however, inasmuch as they probably indicate that salt-bearing strata lie underneath a considerable area. A few of the better known localities will be described.

#### *La Saline*

At La Saline, 26 miles north of McMurray, numerous saline springs have from time to time been noted by the several explorers. S. C. Ells, of the Mines Branch, during his work on the bituminous sands of the district, made the following notes on the occurrence of these springs:—

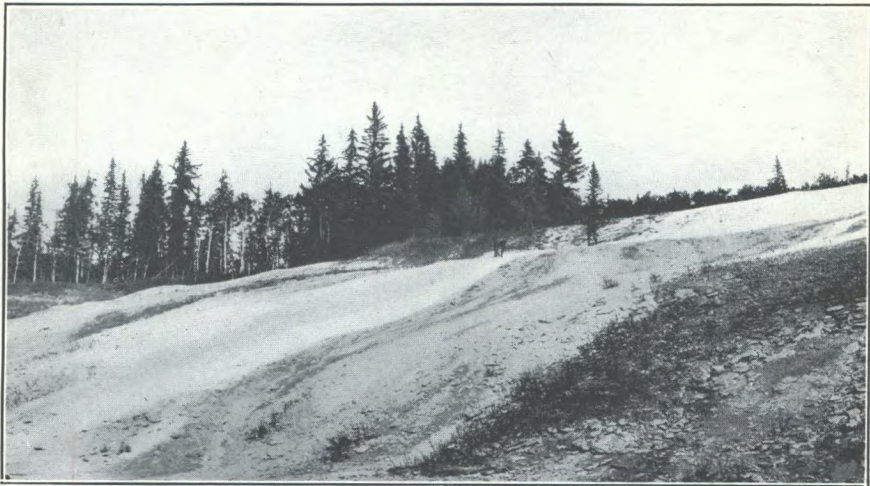
The occurrence of saline springs has long been recognized in many parts of the Athabaska-Mackenzie basin, while wells north of McMurray and on both banks of the Athabaska discharge quantities of saline water. Within a radius of 75 miles of McMurray, saline springs have been recognized on the Wabiskaw, Firebag, Christina, and other streams. The water from these springs is usually clear and bright.

The most important spring recognized in the McMurray district occurs at Saline, 26 miles north of McMurray. (See Figure 17.) At this point the eastern bank of the Athabaska valley swings away from the present shore line, the intervening area being now occupied by a typical clay flat several hundred acres in extent. In this flat, the lake, known as La Saline, occurs. A trail 250 yards long leads from the Athabaska and meets the lake near its southern extremity.

<sup>1</sup> Harmon, D. W.: "A Journal of Voyages and Travels in the Interior of North America," p. 17 (1820).



A. View of La Saline flats, Alberta, looking north.



B. View of escarpment near southeast corner of La Saline, Alberta, showing incrustations of various salts.



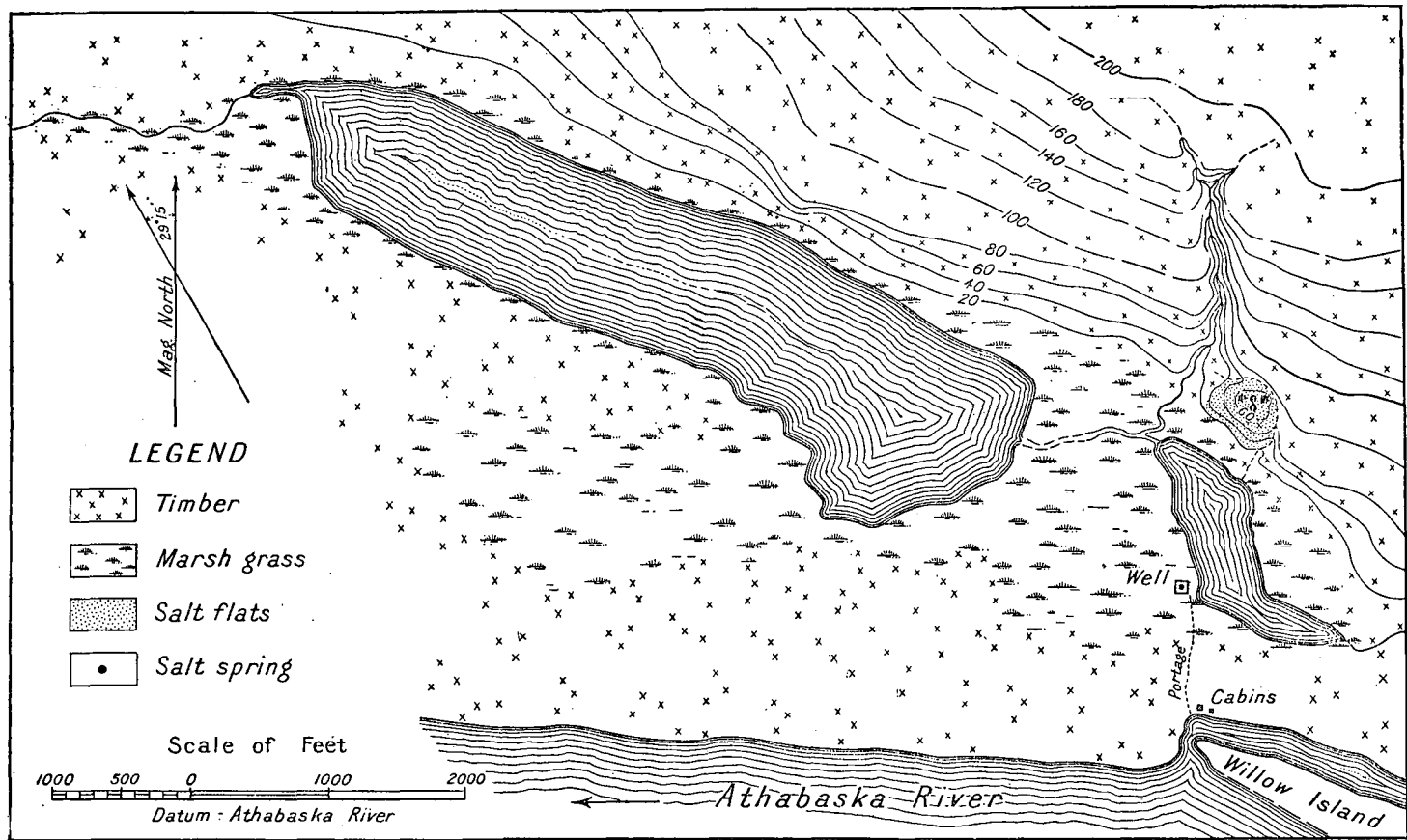


Figure 17. La Saline lake, Athabaska river, Alberta.

Surveyed by S.C. Ellis, 1914

At periods of high water, the lake itself is of considerable extent. During the driest seasons, however, only occasional large and shallow ponds remain. (See Plate XIV A.) At such times it is possible to cut a considerable tonnage of marsh hay, particularly towards the north end of the flat. (See Plate XIV B). Along the eastern edge of the lake the ground rises rapidly in a series of narrow terraces to an elevation of quite 200 feet. Russell brook, a small fresh water stream, rises in the muskeg some two miles to the east and enters the flat near the southeastern corner.

At the mouth of Russell brook, and on the south side, a number of small springs, of which four or five are at present active, and of which the largest is probably 8 or 10 feet in diameter, rise through the limestone and overflow down the escarpment. The waters, in depositing their mineral matter have formed a cone several feet in thickness and of considerable extent.

Allan,<sup>1</sup> who visited this locality about 1920, in describing the deposit says:—

About 75 feet above the mud flats, and on the side of the escarpment, several saline springs occur. The largest has a basin 12 feet in diameter and 2 feet in depth. The water is extremely clear, and when visited had a temperature of 40 degrees Fahrenheit. The salts from these springs form a cone-shaped deposit of tufa, 12 feet high and 200 to 250 feet wide, on top of a limestone ridge which is part of the escarpment. A white coating of salt, gypsum, and sulphur has been deposited over the surface of the rocks in the face of the escarpment and extending to the edge of the mud flats below. The tufa is chiefly calcareous, but is intermixed more or less with gypsum, sulphur, and a small percentage of common salt.

Analysis of the brine collected by Allan and the analysis of brine from the same locality collected by McConnell<sup>2</sup> in 1890 are given below:—

	Allan	McConnell
Total solids, per cent.....	7.28	7.00
Specific gravity, 15.5° C.....	1.052	1.052
Per cent of Total Solids—		
K.....	0.52	1.24
Na.....	30.16	34.18
Ca.....	2.38	2.25
Mg.....	2.57	0.71
SO.....	6.31	6.71
Cl.....	54.00	54.91
Ignition loss.....	4.06	.....
	100.00	100.00
<i>Hypothetical Combination</i>		
KCl.....	0.98	2.36
NaCl.....	76.55	86.86
MgCl <sub>2</sub> .....	9.58	1.50
CaSO <sub>4</sub> .....	8.11	7.64
MgSO <sub>4</sub> .....	0.72	1.64
Ignition loss.....	4.06	.....
	100.00	100.00

<sup>1</sup>Allan, J. A.: "Salt and Gypsum in Alberta"; Can. Inst. Min. & Met. Bull. No. 206, June, 1929, pp. 773-4.

<sup>2</sup>McConnell, R. G.: Geol. Surv., Canada, Ann. Rept., vol. VI, pt. R, pp. 79-80.

*Salt River (Slave River District), Mackenzie Basin*

One of the most strongly saline and perhaps the most noted of the saline spring areas in the Mackenzie basin is that occurring on the bank of Salt river which flows into Slave river about half way between Athabaska and Great Slave lakes. Referring to this stream and these springs, Sir J. Richardson writes<sup>1</sup>:—

The Salt river flows in from the westward, a short distance below the portages. We ascended it for twenty-two miles, including its windings, but not above half that distance in a straight line, for the purpose of visiting the salt springs from whence it derives its taste and name. Seven or eight copious saline springs issue from the base of a long even ridge about 600 feet high, and spreading their waters over an extensive clayey plain, deposit a considerable quantity of very pure common salt in large cubical crystals. The *mother water*, flowing into the Salt river, gives it a very bitter taste, which it retains until near its junction with the Slave river when the addition of some fresh water streams renders it only slightly brackish. A few patches of greyish compact gypsum were exposed on the side of the ridge from whence the springs issue.

Sir J. Richardson visited these springs in the summer of 1820. Captain Back who accompanied him on that expedition again visited these springs in 1833. He notes<sup>2</sup> three springs:—

.....varying in diameter from four to twelve feet, and producing hillocks of salt, from fourteen to thirty inches in height. The streams were dry, but the surface of the clayey soil was covered, to the extent of a few hundred yards towards the plain, with a white crust of saline particles.

Mr. McConnell, of the Geological Survey, in the summer of 1887, ascended Salt river as far as the brine springs and gives a full account in his report<sup>3</sup> for that year. He says in part:—

Near the springs the river forks, and while one branch turns off to the south, the other pursues a winding way through the salt plains. These plains are four or five miles in width, and are bounded to the west and north by swelling ridges, covered with spruce and aspens, the leaves of which at this date, 26th August, were already turning yellow. The plains are well grassed, and in former days were the favourite feeding grounds of the buffalo. .... The springs have been visited and described by both Back and Richardson. They are situated near the base of the ridge mentioned above, are three or four in number, and are surrounded for some hundreds of yards by a salt-sprinkled and desolate looking clay flat, through which numerous briny streamlets make their way to the river. The springs are enclosed by small evaporating basins, the largest of which is about fifteen feet in diameter, and is crusted with a remarkably pure deposit of sodic chloride. The salt obtained here is of excellent quality, and has been used in the Mackenzie River district for many years.

This district was again visited in 1902 when Camsell, of the Geological Survey, made a trip up the Salt river about 20 miles above the salt springs. He states<sup>4</sup>:—

The brine springs which occur near the forks of the river and from which the Hudson's Bay Co. gets its supply of salt, were located and an observation for latitude taken to determine their position more accurately. Other brine springs were also discovered about six miles southeast of the forks. A much larger accumulation of salt occurs here, but on account of their being some distance from navigable waters, the salt from these springs has never been utilized. All these springs are situated along the base of the escarpment and at the time of our visit were nearly dry. They generally rise from among an accumulation of granite boulders and flow thence into shallow basins, where the water is evaporated, leaving a deposit of coarse salt. The stumps of trees, the boulders and the ground in the neighbourhood of the springs are all incrustated with the salt.

<sup>1</sup> Narrative of a Journey to the Polar Sea, 1819-22, p. 518.

<sup>2</sup> Narrative of the Arctic Land Expedition, p. 80.

<sup>3</sup> Geol. Surv., Canada, Ann. Rept., vol. IV, pt. D, pp. 62-63.

<sup>4</sup> Geol. Surv., Canada, Ann. Rept., vol. XV, pt. A, p. 153.

Probably the most extensive description of these springs is that given by Allan<sup>1</sup> as follows:—

The strongest and most saline springs known in Alberta are situated on Salt river about twenty-five miles west of Fitzgerald and Smith. Salt river rises about 25 miles south of the 60th parallel of latitude, which is the northern boundary of the province. It flows south and enters Slave river 20 miles north of Smith. This river, in some places not more than 10 feet wide and 3 to 5 feet deep, has a very tortuous course. The East fork meanders across a broad flat known as 'Salt prairie'. This flat is a true playa basin, in that it is covered with a briny slime at certain seasons of the year. On the west of Salt prairie, which here has a width of two to five miles, there is an escarpment rising five to six hundred feet above the plain. The rock in the escarpment belongs to the 'Fitzgerald dolomite limestone', which according to Cameron<sup>2</sup> is of Silurian age.

The saline springs are situated along the base of this escarpment, which here consists largely of anhydrite, gypsum, and dolomitic limestone. Only five of the numerous springs were examined by the writer in 1920. Sir James Richardson, who visited Salt river in 1820, records "six or seven copious saline springs". The brine from these springs spreads out over the playa east of the escarpment. There is no vegetation on the prairie here except a small salt plant, *Salicornia rubra*. Projecting from the prairie are a few islands and peninsulas sparsely covered with spruce and poplar. These islands, rising two to fifteen feet above the plain level, were probably formerly more numerous, but the vegetation has been killed by the brine, and erosion has obliterated the gravel and sand. Evidence of this erosion is seen in the presence of stumps of trees and boulders strewn about the prairie.

When the saline mud on the surface of the prairie dries, mud cracks develop. Some of the cracks are very shallow, while others observed are as much as an inch in depth. Kindle states that mud cracks formed in the more saline clays are shallower than those formed in the less saline clays. The corrugated surface of the mud-crack polygons on the salt plains at Salt river is very common. Referring to this feature, Kindle is of the opinion that "This peculiar surface is due to a species of algæ which evidently grows over large areas of the plain when it is covered with water". Large areas of the surface of the mud on the salt plains, especially near the banks of the small stream draining the plain, are covered with a white incrustation of salt. Individual crystals of salt are numerous on the freshly dried mud surface. Another noticeable feature on this salt plain is the presence of many cavities in the saline mud that has been baked in the sun. These cavities, once filled with salt crystals in the desiccated muds, are very similar to those observed in the dolomitic limestones penetrated by drilling at McMurray, and it is probable that in both cases the cavities have been formed under similar conditions. Clay moulds not more than six or eight inches high, openly spaced, were observed along the margin of the Salt River playas. Kindle holds that these moulds indicate patches of grass which "were later overwhelmed with saline efflorescence and incrustations, and turned gradually into mounds of clay....."

The salt springs occur in alignment with the escarpment of dolomitic limestone and gypsum rock, and in several places the saline waters come to the surface close to the base of the escarpment. It is not known how many saline springs there are, but five of the stronger ones were examined.

The quantity of brine coming from the spring varies. In some it forms a bubbling spring, in others it flows out as a very small streamlet. When the brine reaches the surface, salt crystals are formed, and these collect about the orifice of the spring or are carried down in the small streamlet and accumulate on the mud plains adjoining the spring.

At the time of our visit to Salt river in 1920, the quantity of salt that had accumulated about the springs was estimated at about 400 tons. At the Mission spring, which is situated about six miles south of the forks of Salt river, the deposit of sodium chloride had a depth of three feet and measured less than 100 feet in diameter. At the 'New salt spring' about a mile south of the Mission spring, the brine at the time of our visit was rising in a small basin so fully saturated that salt crystals were forming on the surface of the pool, and were floating down the streamlet to add to the deposit nearby. At another spring observed, about 150 tons of salt had accumulated on the surface, but the flow had practically ceased at that time of the year, which was in mid-summer. Small salt mounds have in some places been formed around the orifice of the spring. The diameter of the basin within the mound varied up to about 25 feet.

<sup>1</sup> Allan, J. A.: "Salt and Gypsum in Alberta"; Can. Inst. Min. & Met. Bull. No. 206, June, 1929, pp. 768-772.

<sup>2</sup> Cameron, A. E.: Geol. Soc. Am., vol. 29, p. 486 (1918).

<sup>3</sup> Kindle, E. M.: Geol. Surv., Canada, Sum. Rept. 1921, pt. B., p. 13.

The flow from the springs varies with the time of year. In the strongest spring observed, it was about seven gallons per minute, and the temperature of the brine was approximately 40 degrees F. at the surface of the pool, although the atmospheric temperature was about 65 degrees.

Samples of brine and salt collected by the writer, and analysed by J. A. Kelso in the Industrial Laboratories at the University of Alberta, gave the following results:—

	1	2	3
Sodium chloride.....	98.65	98.51	95.50
Calcium carbonate.....	0.07	0.08	.....
Calcium sulphate.....	1.14	1.09	.....
Magnesium chloride.....	0.14	.....	.....
Magnesium sulphate.....	.....	0.32	.....
Sodium sulphate.....	.....	.....	3.96
Lime.....	.....	.....	0.00
Magnesite.....	.....	.....	0.00
Insoluble.....	.....	.....	0.14
Ignition loss.....	.....	.....	0.20

1. Brine from "New salt spring," specific gravity 1.203.
2. Brine from Mission spring, specific gravity 1.193.
3. Salt from "New salt spring."

There are other springs owned by the Hudson's Bay Company and situated near the forks of Salt river. Conditions of deposition are similar to those described above.

This salt has been used in a small way for the trading posts and missions in the Lower Mackenzie district and at Fort Smith. About five tons of salt from these springs, and from the salt springs owned by the Hudson's Bay Company at the forks of the Salt river, are collected annually. It is the custom to sack the salt in the summer time and transport it to Fort Smith when the ground becomes frozen.

#### *Tar Island, Peace River*

McConnell speaks of the occurrence of a saline spring at this place as follows<sup>1</sup>:—

A saline spring, emitting natural gas and carrying up small quantities of tar, occurs on the boulder bench at the upper end of Tar island, about thirty miles below the Smoky River forks..... A second spring is noted to occur on an island opposite the mouth of Whitemud river, but this was not seen.

#### *Red Clay Creek*

McConnell noted<sup>2</sup> and examined a saline spring on Athabaska river 2 miles above the mouth of Red Clay (Red Earth) creek. Here a copious saline spring bubbles up about 100 feet from the west bank of the river and feeds a considerable stream. Large quantities of hydrogen sulphide gas escape at the same place and taint the air for half a mile around. An analysis of the water is here given<sup>3</sup>:—

<sup>1</sup> Geol. Surv., Canada, Ann. Rept., vol. V, pt. D, p. 49.

<sup>2</sup> Geol. Surv., Canada, Ann. Rept., vol. V, pt. D, p. 36.

<sup>3</sup> Geol. Surv., Canada, Ann. Rept., vol. VI, pt. R, p. 80.

	Analysis Per cent total solids		Hypothetical combination
K.....	0.22	KCl.....	0.43
Na.....	29.82	NaCl.....	75.69
Ca.....	5.90	CaSO <sub>4</sub> .....	20.03
Mg.....	0.76	MgSO <sub>4</sub> .....	3.85
SO <sub>4</sub> .....	17.20		
Cl.....	46.10		100.00
	100.00		

Total solids, per cent = 1.604  
Specific gravity at 15.5° C = 1.012

#### *Salt Occurrences on Line of 5th Meridian*

Mention is made by Mr. A. W. Ponton, D.L.S., of encountering saline creeks crossing the survey line of the 5th meridian. He says<sup>1</sup>:—

A long saline slough, sixty feet wide, occurs in section 25, township 106, and a river 125 feet wide, in section 1, township 107, which shows a slight current; it is also saline. This river joins Birch river and is no doubt the Stinking creek shown on maps of the district. Both the salt water courses referred to have channels as regular as artificial canals, and their sources are no doubt salt springs situated west of the meridian.

Another saline creek is reported to cross the 5th meridian near the point where the Wabiskaw river crosses this meridian.

#### *Nahanni Butte-Liard River*

A salt spring is reported to occur in this district by Sir J. Richardson. He did not ascend the Liard river himself, but was informed by Mr. McPherson that 75 miles from its mouth there is a high hill, called "Nohanni Butte," on the summit of which is a salt spring. Mr. McConnell, in August, 1887, visited this locality, but was unable to locate the spring mentioned. He states that<sup>2</sup>:—

A salt spring, with a basin fifteen feet in diameter, is reported by Sir J. Richardson on the authority of Mr. McPherson, as existing on the top of the mountain, but this I did not succeed in finding. A neighbouring mountain, however, showed a white patch on its steep side which is plainly marked due to the deposits of a mineral spring of some kind, and may be the one referred to.

#### *Great Bear River, Mackenzie Basin*

Near the mouth of the Great Bear river, a river flowing from the lake of the same name and emptying into the Mackenzie river at Norman, there is reported<sup>3</sup> to be a small stream flowing in from the southward near the sources of which the Indians procure an excellent common salt, which is deposited from the springs by natural evaporation.

Numerous other springs have been noted from time to time in the country tributary to the Mackenzie and among these there may be noted the following:—

*Firebag River.* On north bank 14 miles from mouth and also on south bank 11 miles from mouth.

*Christina River.* On southeast bank 14 miles from mouth.

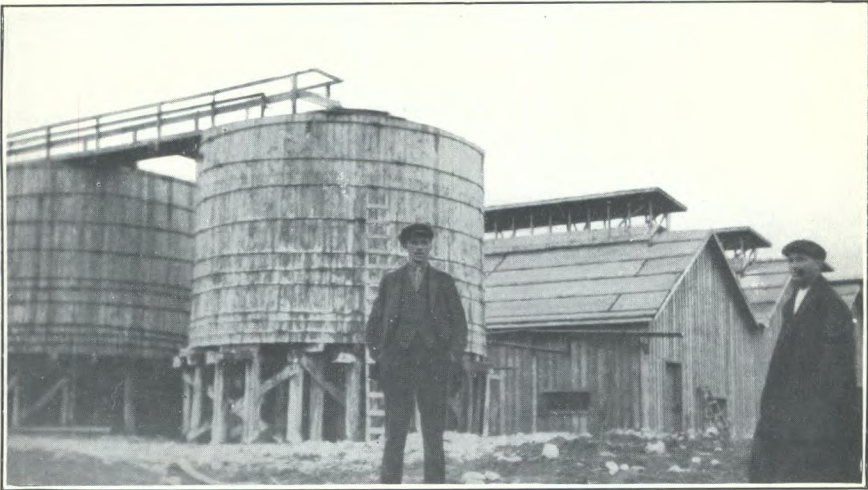
<sup>1</sup> Ann. Rept., Topog. Surv. Branch, Dept. Interior, 1908-1909. Appendix No. 36, p. 171.

<sup>2</sup> Geol. Surv., Canada, Ann. Rept., vol. IV, pt. D, p. 57.

<sup>3</sup> Geol. Surv., Canada, Ann. Rept., vol. II, pt. R, p. 20.



A. Salt springs near Fort Smith, North West Territories.



B. Brine tanks and evaporator buildings, Alberta Salt Company, McMurray, Alberta.

## Rock Salt Deposits

An extensive deposit of rock salt is known to occur at depth in the vicinity of McMurray. At the mouth of Horse creek, two wells were drilled to a reported depth of 1,406 and 1,475 feet respectively. These wells drilled by the Northern Alberta Exploration Company, between 1907 and 1912, are reported to have penetrated thick beds of rock salt, but unfortunately the wells were drilled with a churn drill so that no core was obtained.

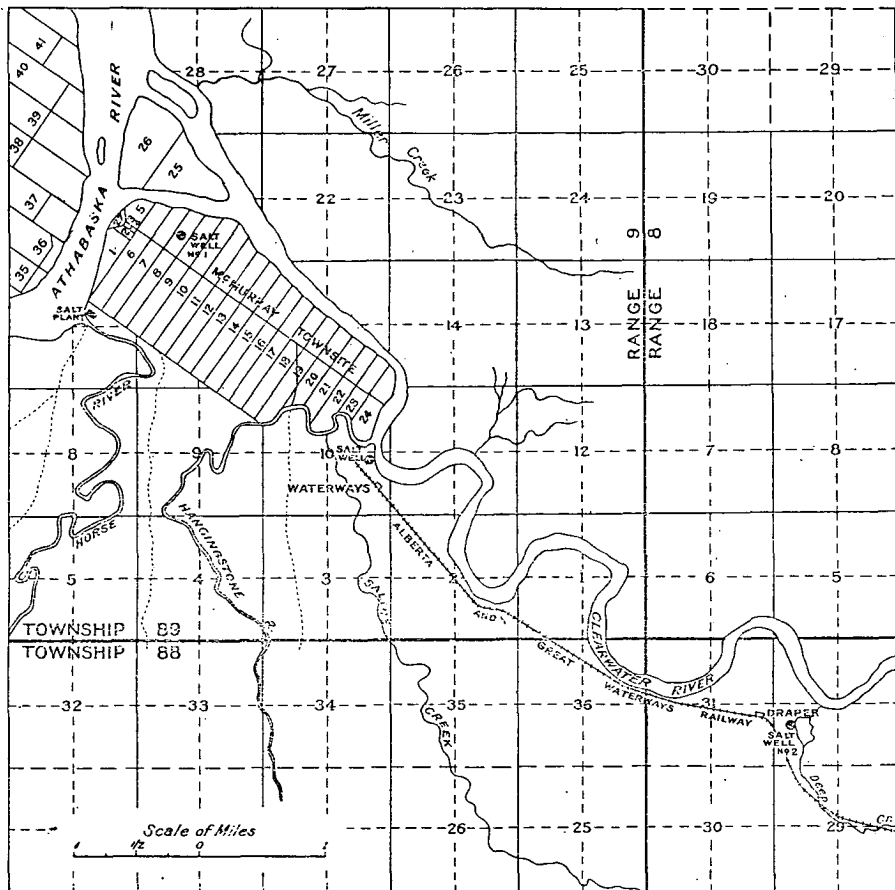


Figure 18. Sketch map, McMurray district, Alberta, showing position of salt plant and Alberta Government salt wells.

McMurray is situated on the east bank of the Athabaska river in township 89, range 9, west of the 4th meridian, at the junction of the Clearwater with the Athabaska. Horse creek enters the Athabaska about a mile south of the townsite (upstream).

Brine from one of these wells was used in 1911 or 1912 to manufacture a small tonnage of salt, but no commercial developments followed immediately.



*Alberta Government Wells*

In 1919, with the Alberta and Great Waterways railway completed to Waterways, a few miles from McMurray, the Provincial Government investigated the possibility of procuring salt from this locality for consumption in the western provinces.

Dr. Allan, of the Department of Geology, University of Alberta, made a survey of the situation and recommended that a test well be drilled with a core drill on a site selected in the valley of the Clearwater river, in the townsite of McMurray and about one mile from the site of the two wells at Horse creek. This well was subsequently drilled with a rotary Davis Calyx drill, during the summer of 1920, salt beds being penetrated in November of the same year. The complete core of this well is preserved in the University of Alberta at Edmonton. The log as prepared by Allan is shown in Figure 19. The well reached a depth of 685½ feet and stopped in anhydrite. The part of the core of chief interest was as follows:—

Depth 631 feet.

Feet	
10	Rock salt and saline mud.
7	Salt and anhydrite (part of core lost).
14	Transparent rock salt.
4	Anhydrite and gypsum.
8	Rock salt and anhydrite.
5	Limestone and rock salt.
6.5	Compact, hard anhydrite.
54.5	Salt-bearing horizon.

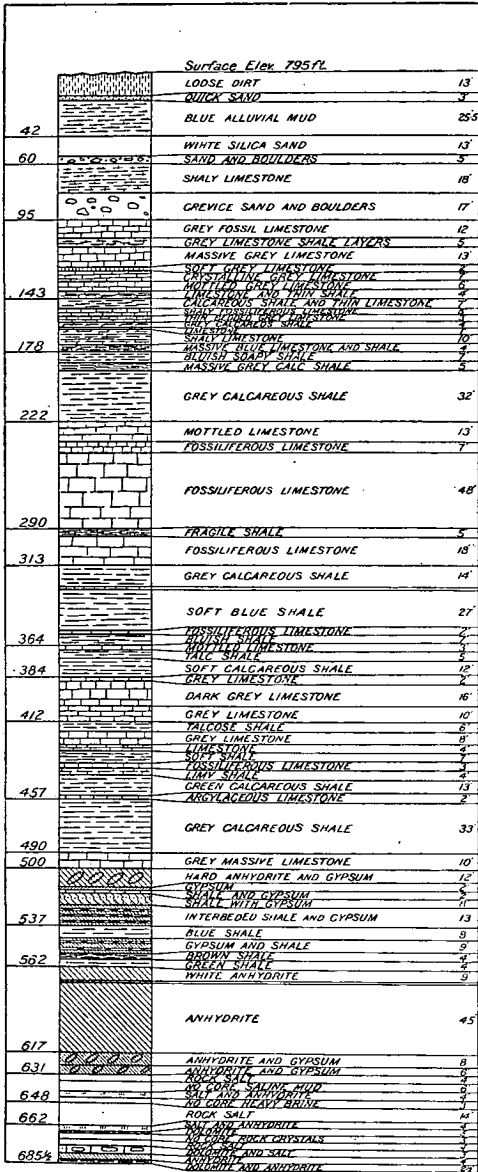
A second well was drilled by the Alberta Government in 1923, in an endeavour to prove the extent of the salt bed in this district. In a description of this drilling Allan<sup>1</sup> says:

In 1922, the end of steel on the A. & G.W. railway was at Waterways, in the Clearwater valley, about six miles above McMurray. It was decided to drill a second test-well for salt, and the writer located this, No. 2, site near the junction of Deep creek and the Clearwater. This well also was drilled with the Calyx, and a complete core retained. The log as prepared on this core is shown in Figure 20. The well was drilled to a depth of 789 feet. Precambrian granite was encountered at 785 feet, but as the writer was beyond the reach of the telegraph for about a week at that time, the driller penetrated the granite about five feet. Immediately above the granite contact is conglomerate breccia, consisting largely of sub-angular fragments of anhydrite and dolomitic limestone. By comparing the logs of these two wells, considerable difference in the succession will be noted. At 415 feet there is a sharp contact, with no sign of unconformity, between the limestone-shale Upper Devonian formation above, and the anhydrite-gypsum-dolomitic limestone series below. No beds of pure rock salt were encountered, but at various horizons the strata contain cavities and lenses of salt. A strong flow of saline water was encountered at 666 feet, the flow being 24 gallons per minute. This brine, on analysis, was found to have a salinity of 16 per cent, which represents an output of 6.2 tons of salt in 24 hours, or 2,263 tons or 22,630 barrels of salt per year. This is approximately 15 per cent of the present consumption of salt in Alberta. In 1926, the consumption of salt in Alberta was about 30,000 tons, as calculated from the per capita consumption of salt for all purposes in the whole of Canada, which in 1926 was approximately 100 pounds. An analysis of the salt obtained by the evaporation of the brine is as follows:—.....

Sodium chloride.....	97.2 per cent
Calcium sulphate.....	2.1 “
Magnesium sulphate.....	0.5 “

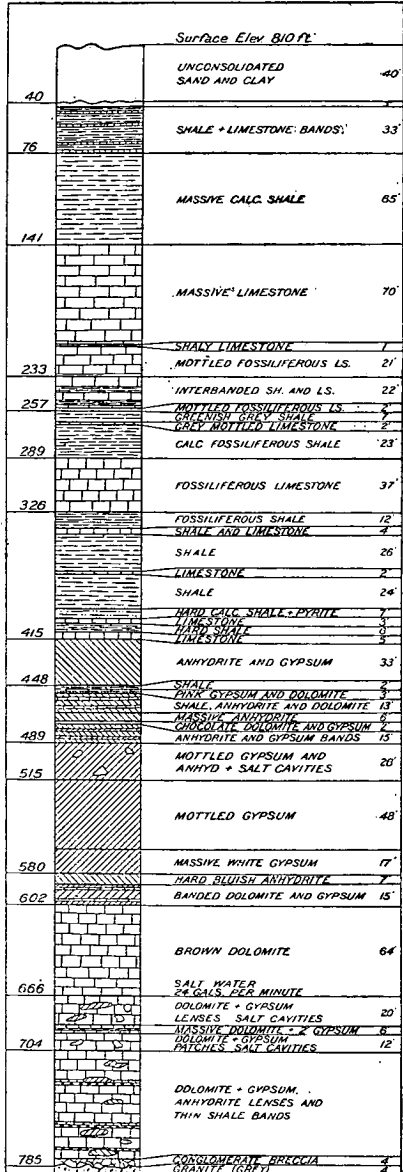
The results of No. 2 well indicate that the workable beds of rock salt proved at McMurray in Well No. 1 do not extend six miles to the east. In other words, the margin of the basin of salt deposition lies nearer Well No. 2 than Well No. 1.

<sup>1</sup> Allan, J. A.: "Salt and Gypsum in Alberta"; Can. Inst. Min. & Met. Bull. No. 206, June 1920, pp. 778-780.



Compiled by J. A. Allan, Geologist, 1920.

Figure 19. Log of salt well No. 1 drilled by Alberta Government, at McMurray. (River lot 8, sec. 21, tp. 89, R. 9, west 4th mer.).



Compiled by J. A. Allan, Geologist, 1923.

Figure 20. Log of salt well No. 2 drilled by Alberta Government at Waterways. (Sec. 32, tp. 88, R. 8, west 4th mer.).

During the year 1928, the Alberta and Great Waterways railway was extended along the Clearwater valley to the mouth of the Hangingstone river, where a new town of Waterways has sprung up, the old townsite of that name being abandoned. In October, 1928, another test well was drilled by the company close to the railway at the new town of Waterways and in this well it is reported that a thick bed of rock salt was encountered at a depth of 670 feet. The log of this well shown in Figure 21 was compiled from notes kindly furnished the writer by John Callaghan, General Manager of the Alberta and Great Waterways Railway.

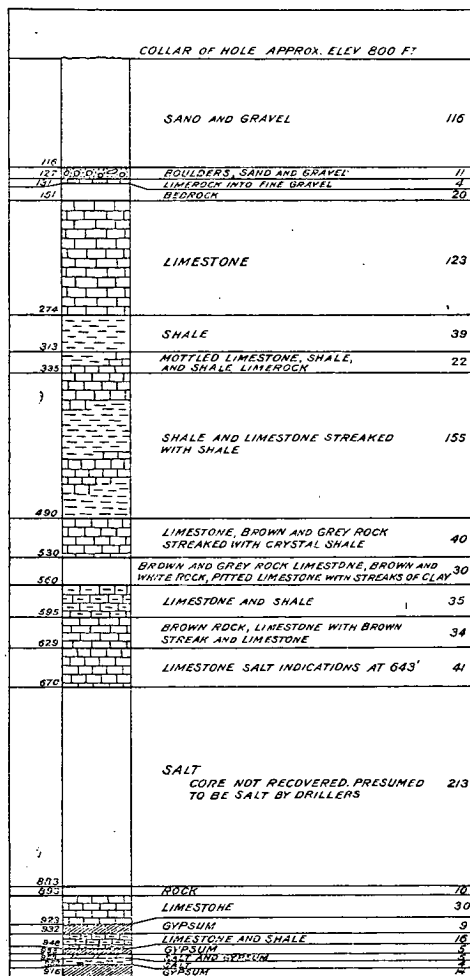


Figure 21. Log of well at Waterways, Alberta, for Alberta and Great Waterways Railway Company. (SE.  $\frac{1}{4}$  sec. 10, tp. 89, R. 9, west 4th mer.) 1928.

Three large tanks of 30,000 gallons each are used for settling-tanks for the brine before being fed to the grainers.

From the work done at and near McMurray it has been proved that there is an important deposit of rock salt at a depth of about 650 feet or more, in this vicinity, which should be of great value to the province in the years to come.

#### Alberta Salt Company

In 1924, the Alberta Salt Company, Ltd., was formed by J. Gillespie and associates of Edmonton, to exploit the salt discovered in brine at Horse creek. A grainer plant was erected and the first production made in 1925 during which year 833 tons of salt were manufactured. In 1926 the plant produced 2,037 tons while in 1927, 100 tons production was recorded. The plant was closed down during the latter part of 1927 and has been idle since that time, due to the failure of the company to induce the railway to put a siding from the end of steel to the plant, and also to the heavy cost entailed in bringing the salt from the plant to the railway either by road or barge.

The plant of the company consists of two open grainer pans, 105 feet long by 11 feet wide for fine salt, and one exhaust steam low-temperature grainer the same size, producing coarse salt. Space is left for two additional grainers in the building.

The salt coming from the grainers is passed through a dryer and screens, after which it is bagged in the several grades for the market.

Two 150 h.p. boilers are used to supply steam to the grainers and the dryer as well as to operate an engine supplying power to the plant. Coal is used for fuel.

*Analysis of Brine used by Alberta Salt Company, 1926.*

1,000 parts by weight were found to contain:

Na.....	142·800 parts	NaCl.....	363·21
K.....	trace	KCl.....	trace
Li.....	none	CaCl <sub>2</sub> .....	4·33
Al.....	0·055	CaSO <sub>4</sub> .....	3·34
Fe.....	0·082	MgSO <sub>4</sub> .....	2·21
Ca.....	2·538	Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> .....	0·35
Mg.....	0·442	Fe <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub> .....	0·29
Cl.....	223·200		
Br.....	none		373·73
SO.....	4·632		
	<u>373·749</u>		

Suggested hypothetical combination

Cl found in excess of that in above combination = 0·02

Total solids, by direct experiment 374·4  
Specific gravity at 15·5°C. = 1·20

E. A. Thompson, Mines Branch, Analyst.

Analyses of salt solutions obtained from Alberta and Great Waterways Railway well drilled at Waterways in 1928:—

	1	2	3
Total solids—per cent by weight.....	14·18	14·20	14·03
Specific gravity.....	1·105	1·105	1·105
Total solids—pounds per gallon.....	1·566	1·568	1·550
<i>Analysis of total solids—</i>			
Sodium chloride.....	98·90	99·04	99·00
Calcium sulphate.....	0·76	0·74	0·78
Calcium chloride.....	0·09	0·07	0·08
Magnesium carbonate.....	0·06	0·06	0·06
Magnesium chloride.....	0·07	0·07	0·07

NOTE.—Sample No. 1 contained no iron.  
Samples Nos. 2 and 3 contained slight sediment of iron oxide.

James A. Kelso, Analyst (Provincial Analyst, Alberta).

Analyses furnished by John Callaghan, Manager, A. & G. W. Ry.

From the material from No. 1 hole, drilled by the Alberta Government in the townsite of McMurray, a number of analyses were made in the Industrial Laboratories of the University of Alberta.<sup>1</sup>

—	1	2	3	4	5	6
Water soluble.....	53.78					
Insoluble matter.....	46.32	0.24	0.46		0.30	
<i>Analysis of water soluble—</i>						
Calcium sulphate.....	1.94	4.74	0.90	2.48	2.78	1.84
Sodium chloride.....	97.28	94.78	98.46	97.01	96.53	97.64
Ignition loss.....	0.40			0.21	0.18	0.28
Magnesia.....	0.00	0.00	0.00	0.00	0.00	0.00
Potash.....	0.00	0.00	0.00	0.00	0.00	0.00

1. Transparent rock salt from 660 feet.
2. Rock salt from 14-foot bed.
3. Transparent rock salt from 650 feet.
4. Brine taken from well at 660 feet.
5. Rock salt with anhydrite lenses from 645 feet.
6. Brine from bottom of the well at 685 feet when drilling ceased.

These analyses show that the chief impurity present is calcium sulphate, which is not present in sufficient quantity to be detrimental to the salt for market purposes.

### BRITISH COLUMBIA

Previous to 1911 the only known occurrence of salt in British Columbia was in the form of a number of saline or mineral springs, the waters of which are more or less saline.

#### *Kwinitsa*

In August, 1911, reports came in of the discovery of a strong saline spring 45 miles from Prince Rupert, situated on the banks of the Skeena river, at Kwinitsa, on the line of the Canadian National railway. That year the location of the spring was staked and recorded. Experiments were carried on in a small way and it was found that the brine was strong enough to collect considerable quantities of a good quality of salt by evaporation methods.

Early in 1913 a syndicate started drilling operations in an endeavour to locate rock salt at this point, and in April of the same year, their efforts were rewarded—according to reports—by encountering salt in five different holes.

Donald G. Forbes, M.E., made the following report on this property for the British Columbia Government.<sup>2</sup>

The Kwinitsa salt deposit, owned by the British Columbia Salt Works, Limited (D. Whiteford, manager), is located in a basin in the Coast range of mountains between the 45th and 47th mile-posts on the Grand Trunk Pacific railway. It is surrounded by high mountains, the Skeena river crossing the southeast end of the basin. The basin is bounded on the southwest side by granite and on the northeast by basic schists. The Skeena river is navigable for shallow-draught vessels during the greater part of the year from this point to the sea, being closed for a few months in winter.

This salt was discovered by Mr. Whiteford in 1910-11, his attention being attracted to it on account of there being no snow on the ground in midwinter near the rim-rock on the southwest side of the basin, where a natural seepage of brine occurs.

<sup>1</sup> Second Annual Report — Mineral Resources of Alberta, p. 109.

<sup>2</sup> Annual Report Minister of Mines for B.C. 1913, pp. K85-86.

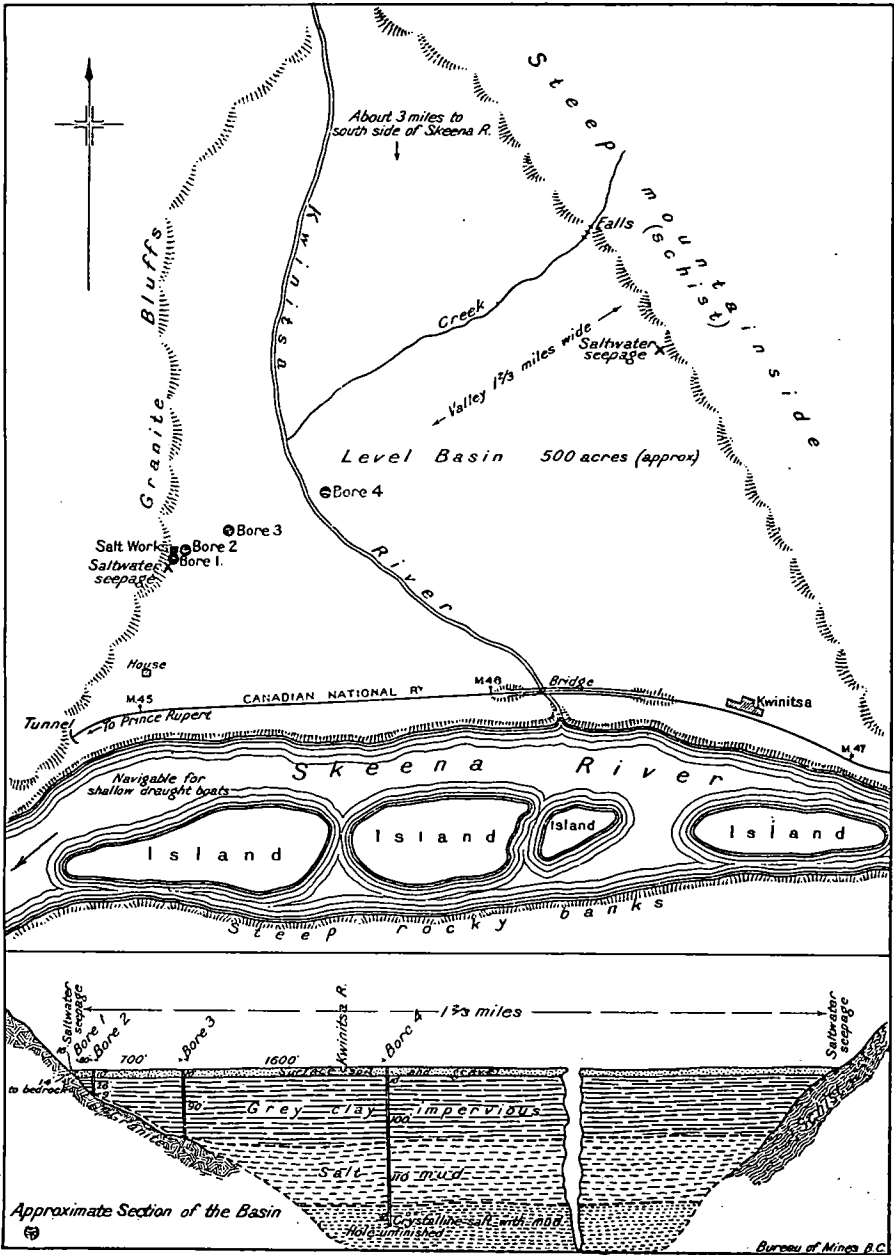


Figure 22. Approximate sketch of the property of British Columbia Salt Works, Ltd., at Kwinitsa, Skeena mining division, B.C.

A 2-inch pipe was driven down 14 feet and a hand-pump attached to the pipe, and a considerable amount of brine, containing  $\frac{1}{2}$  lb. of salt to the gallon, pumped without reducing the quantity or density of the water.

Last winter a drilling plant, operated by a gasoline engine, was installed and 80 feet from the southwest rim-rock No. 2 hole was driven. In this hole the drill is said to have passed through 10 feet of surface soil and gravel, 26 feet of impervious grey clay, and 9 feet of salt-mud; bed-rock being found at a depth of 45 feet.

A heavy flow of brine was struck at bed-rock which slacked off after the hole had been open a short time. There was no apparent flow last June, but the water at the collar of the hole was still salt.

No. 3 hole was put down 600 feet from the rim-rock, with similar results. The hole passed through 10 feet of surface material, clay 90 feet, and 6 feet of salt-mud to the granite bed-rock at a depth of 106 feet.

No. 4 hole was driven 1,600 feet northwest from rim-rock, a 6-inch casing being used. Salt-mud was struck at 110 feet after passing through 10 feet of surface and 100 feet of clay. The hole was continued to a depth of 250 feet, when the casing stuck. As no smaller casing had been provided, work was discontinued. The last 30 feet of this hole contained salt crystals mixed with the mud. Close to the rim-rock on the northeast side of the basin, another seepage of brine occurs, being distant about one and two-thirds miles from the first discovery.

The distance from southeast to northwest across the basin from rim to rim is about three miles, but no natural seepages of salt have been located near either rim.

While there is undoubtedly a deposit of salt in the basin, its thickness and the area it covers cannot be determined without further systematic prospecting with the drill.

A small experimental evaporating plant, consisting of open galvanized-iron pans with a fire underneath, has been erected at No. 1 hole, and a few tons of salt have been produced to demonstrate the possibilities of the deposit.

The detail of the bore holes and the information from which the sketches are prepared were supplied by Mr. Whiteford, the company's manager. The writer during his visit started up the Cyclone drill at No. 4 hole, and obtained some crystalline salt discoloured with grey clay from the bottom of the hole.

A sample of the salt as evaporated in the temporary plant mentioned, gave the following analysis, showing it to be quite up to the commercial standard of table-salt:—

*Analysis made on Dry Sample*

Sodium chloride.....	98.15 per cent
Calcium sulphate.....	1.82 "
Magnesium sulphate.....	trace
Insoluble matter.....	"
Iron and alumina.....	nil
Magnesium chloride.....	"
Calcium chloride.....	"
Sodium sulphate.....	"
Calcium carbonate.....	"
Magnesium carbonate.....	"

During 1913, 15 tons of salt were produced from this deposit, which were either sold or given away.

No further development or work is known to have been done and the property is now idle.

Of the saline springs known to occur elsewhere in the province, none are of any great importance as a source of sodium chloride. The most strongly saline are those at Nanaimo, and Saltspring or Admiral island; but the flow of these is not so copious, nor the strength of the brine sufficient, to warrant a belief in their economic importance. Brief descriptions of several of these localities are here given.

### *Vancouver Island and Saltspring Island*

*Nanaimo.* A salt spring issues from the Cretaceous coal-bearing strata near the Douglas seam, and according to Mr. Richardson has a flow of two to three gallons a minute. The Hudson's Bay Company at one time attempted the manufacture of salt here, but it was soon abandoned. The brine has been analysed by Mr. Hoffman who found it to contain 52.154 parts of saline matter in 1,000. Of this thirty-nine parts were common salt and the remainder largely calcium chloride. According to an analysis quoted by Pemberton, it contained 49 parts of salt to 1,000 in 1854. (Report 1872-73, p. 82. Facts and Figures relating to Vancouver Island, etc., p. 159).

*Saltspring (formerly Admiral) Island.* According to analysis quoted by Pemberton in the place above cited, the spring contains 65 parts of saline matter to 1,000, but with more impurities than the last.<sup>1</sup>

### *Chilcotin Valley*

Small saline lakes were noticed in the locality by G. M. Dawson, in 1875.

### *Maiden Creek, Bonaparte Valley, Northwest of Ashcroft*

Dr. G. M. Dawson, in his report on British Columbia, makes reference to several localities in which saline springs occur. Of the principal district, he says<sup>2</sup>:—

Many small saline springs occur in this district which are due merely to the accumulation of salts in the superficial deposits of the drier valleys, and a number of the small pools and lakelets without outlets are charged with similar salts, but the only known mineral spring of any possible importance is situated on Maiden creek, four or five miles west of Mundorf's. This is described by Mr. A. Bowman as being charged with carbonic acid.

The analysis of water from this spring shows the presence of a small quantity of sodium chloride.

<sup>1</sup> Geol. Surv., Canada, Ann. Rept., vol. III, pt. R, p. 162.

<sup>2</sup> Geol. Surv., Canada, Ann. Rept., vol. VII, pt. B, p. 347.



## CHAPTER IV

## MINERALOGY AND TECHNOLOGY OF SALT MANUFACTURE

## SALT AND ITS ASSOCIATED MINERALS

**Halite: Sodium Chloride or Rock Salt***Chemical Composition*

Common salt or rock salt is composed of chlorine and sodium, and is represented by the formula  $\text{NaCl}$ .

100 per cent sodium chloride ( $\text{NaCl}$ ) = sodium ( $\text{Na}$ ) 60.6 per cent + chlorine ( $\text{Cl}$ ) 39.4 per cent.

Sodium chloride is very seldom found pure in nature, being commonly mixed with small quantities of calcium sulphate, calcium chloride, magnesium chloride, and, occasionally, with sodium sulphate, magnesium bromide, or iodide, and magnesium sulphate, or one or more of the potash compounds.

*Physical Properties*

It has a hardness, according to Moh's scale, of 2.5, and a specific gravity of 2.1 to 2.6—pure crystals, 2.135. Its lustre is vitreous. It is generally colourless, or white, sometimes yellowish, reddish, bluish, or purplish.<sup>1</sup> When found in the crystalline form it is transparent to translucent. It is one of the minerals readily soluble in water, and imparts to the solution a decided—or what is commonly known as—a saline taste.

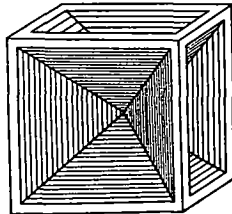


Figure 23. Salt crystal (after Dana).

*Crystallization.* It crystallizes in the cubic system; the most characteristic form being the cube. These crystal forms are often distorted, or with hopper-shaped faces. (See Figure 23). The cleavage is cubic and the fracture conchoidal.

*Blow-pipe Analysis.* A very characteristic reaction when fused on a platinum wire is the brilliant yellow colour (sodium flame) given to the blow-pipe flame.

<sup>1</sup> Dana's Mineralogy, 6th Edition, 1906, p. 154.

## Occurrence

It is commonly found in massive or in granular, compact aggregates known as rock salt.

In nature, salt occurs also in the form of brines which are more or less saturated solutions of rock salt in water; also in the waters of the ocean.

Beds of rock salt, and brines, are common in nearly every country in the world. The localities in which the mineral occurs are too many to mention in detail, the largest producing countries being the United States, United Kingdom, Germany, Russia, India, France, Spain, Japan, Italy, Hungary, Canada, Greece, and Algeria.

The following table of the distribution of rock salt and brines is taken from many reliable sources, among which might be mentioned: Dana's Mineralogy; Geikie's Geology; Rock Salt, by Harris; and many others:—

TABLE VII  
Distribution of Rock Salt and Brines

Geological formation	Localities	
	Brine	Rock Salt
Recent.....	California (sea water); Utah; Arabia; South American States (sea water); shores of Dead sea; Algeria; Mexico (sea water); Portugal (sea water).	Utah; Nevada; New Mexico; Kirghiz steppes; Arabia; Chile; Colombia.
Tertiary.....	Armenia; State of Tamaulipas, Mexico; Java, East Indies.	Louisiana; California; Cordova, Spain; Wieliczka; Kalusz and Bochnia; Poland; Asia Minor; Armenia; Lungro and Volterra, Italy; Rumania; Transylvania; Caucasus mts; Salt Range, India (?); Persia.
Cretaceous.....	Westphalia; Algeria; Kansas; Texas; States of Puebla and Coahuila, Mexico.	
Jurassic.....		Rodenburg on the Deister; Bex, Switzerland; Cerro de Pasco, Peru.
Triassic.....	Upper. Worcester, England; Cheshire, England.	Nancy, France; Halle, Berchtesgaden, Germany; Hallein, Aussee, Tyrol; Cheshire, England; Antrim, Ireland; Isle of Man.
	Middle.....	Wurttemberg; Thuringia, Ernsthall, Stottenheim; Canton of Aargau, Switzerland.
	Lower.....	Schoeningen, near Brunswick, Salzderhelden.
Permian.....	Russian salines.	Hanover, Heilsbronn, Stassfurt, Germany; Texas, Oklahoma, U.S.
Carboniferous.....	Nova Scotia, New Brunswick, Canada; Michigan, Ohio, West Virginia, Texas, Pennsylvania, Nebraska, U.S.	Durham and Bristol; Nova Scotia, New Brunswick, Canada; Kansas, Texas, Virginia, Oklahoma, U.S.
Devonian.....	New York (Ordovician to Devonian); Alberta, Canada (?); Manitoba, Canada (?); Yeneseisk, and Irkutsk, Siberia.	
Silurian.....	Manitoba, Canada (?); Szeewan Province, China (?).	Ontario, and Alberta (?) Canada; Michigan, New York, Ohio, U.S.

NOTE.—The sign (?) after a locality means that the age of the deposit is not definitely determined.

Associated with sodium chloride in nature, both in brines and rock form, are a number of other salts. Of these, by far the commonest are the carbonates of lime and magnesia in the form of limestone-dolomites and marls; the sulphates of lime, magnesia and soda, and the chlorides of potassium and magnesium. These are seldom found in the same deposit, although in the Stassfurt deposits of Germany some thirty or more different minerals have been recognized in the same deposit. The following list by Harris<sup>1</sup>, after Precht, gives the more important minerals found in these deposits:—

#### Primary Group

Rock salt.....	NaCl
Anhydrite.....	CaSO <sub>4</sub>
Polyhalite.....	2CaSO <sub>4</sub> .MgSO <sub>4</sub> .K <sub>2</sub> SO <sub>4</sub> + 2H <sub>2</sub> O
Kieserite.....	MgSO <sub>4</sub> + H <sub>2</sub> O
Carnallite.....	KCl.MgCl <sub>2</sub> + 6H <sub>2</sub> O
Boracite.....	Mg <sub>7</sub> B <sub>10</sub> O <sub>30</sub> Cl <sub>2</sub>
Douglasite.....	2KCl.FeCl <sub>2</sub> + 2H <sub>2</sub> O

#### Secondary Group

Kainite.....	K <sub>2</sub> SO <sub>4</sub> .MgSO <sub>4</sub> .MgCl <sub>2</sub> + 6H <sub>2</sub> O
Sylvite.....	KCl
Schoenite.....	K <sub>2</sub> SO <sub>4</sub> .MgSO <sub>4</sub> + 6H <sub>2</sub> O
Langbeinite.....	K <sub>2</sub> SO <sub>4</sub> .2MgSO <sub>4</sub>
Reichardtite.....	MgSO <sub>4</sub> + 7H <sub>2</sub> O
Jarosite.....	K(FeO) <sub>3</sub> (SO <sub>4</sub> ) <sub>2</sub> + 3H <sub>2</sub> O
Krugite.....	K <sub>2</sub> SO <sub>4</sub> .MgSO <sub>4</sub> .4CaSO <sub>4</sub> + 2H <sub>2</sub> O
Glauberite.....	Na <sub>2</sub> SO <sub>4</sub> .CaSO <sub>4</sub>
Blodite.....	Na <sub>2</sub> SO <sub>4</sub> .MgSO <sub>4</sub> + 4H <sub>2</sub> O
Glaserite.....	K <sub>2</sub> SO <sub>4</sub>
Bischoffite.....	MgCl <sub>2</sub> + 6H <sub>2</sub> O
Tachyhydrite.....	CaCl <sub>2</sub> .2MgCl <sub>2</sub> + 12H <sub>2</sub> O
Pinnoite.....	MgB <sub>2</sub> O <sub>4</sub> .3H <sub>2</sub> O
Ascharite.....	3Mg <sub>2</sub> B <sub>2</sub> O <sub>5</sub> .2H <sub>2</sub> O
Heintzite.....	K <sub>2</sub> O.4MgO.9B <sub>2</sub> O <sub>3</sub> .16H <sub>2</sub> O
Magnesite.....	MgCO <sub>3</sub>
Iron pyrite.....	FeS <sub>2</sub>
Sulphur.....	S

Of these minerals only five are being used commercially, to any great extent. These are carnallite, kainite, kieserite, magnesite, and rock salt.

### TECHNOLOGY OF SALT MANUFACTURE

The recovery of salt from nature has been practised from the earliest times. The first methods were very crude, and consisted either of excavating it in its native state or else evaporating the brine of the salt springs or sea water by means of natural or artificial heat.

The earliest processes consisted either of allowing sea water to evaporate in shallow basins near the seashore, by means of the heat of the sun; or else evaporating the brine, obtained from springs, in small earthenware pots, or by burning brush, throwing the brine over it, and collecting the salt deposited thereon. It was not until the end of the eighteenth and the

<sup>1</sup> "Rock Salt in State of Louisiana", by Harris: Bull. No. 7, Rept. of 1907, Geol. Surv. of Louisiana.

beginning of the nineteenth centuries that much improvement was made in methods used. The common method of solar evaporation was greatly improved, and put on a more economical basis. The kettle and pan processes were gradually evolved; and in late years, with the advent of steam evaporation in the "grainer" process, and the vacuum process, production increased rapidly. Figure 24 shows at a glance the principal methods employed at the present time for the production of commercial salt. These various methods will now be described under their different headings.

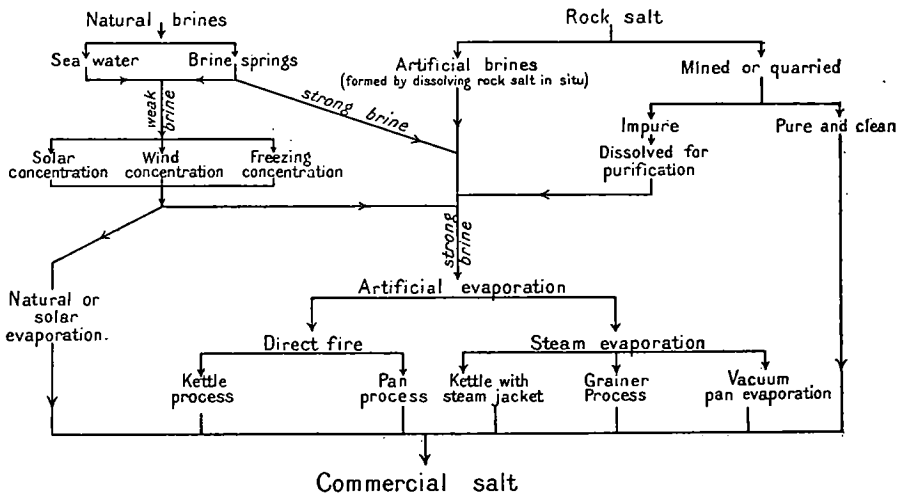


Figure 24. Flow-sheet showing methods of salt recovery.

## RECOVERY OF SALT.

Commercial salt is obtained from two sources in nature: (1) natural brines, (2) rock salt.

### Natural Brines

Natural brines may be divided into two classes: (1) sea water, (2) brine springs.

#### *Sea Water*

Sea water has been, from the earliest times, one of the commonest sources of salt for domestic use. Of late years, however, owing partly to the discovery of beds of rock salt and saturated brine springs, and to improved methods of artificial evaporation, the recovery of salt from sea water has gradually decreased, and now manufacture is practically limited to the seaboard and salt lakes where the climate is dry and warm for long seasons in the year.

In the recovery of salt from sea water, solar evaporation is almost exclusively relied upon.

Inland lakes and seas—such as the Great Salt lake, Utah, and the Dead sea, Palestine—also furnish a source for the production of domestic salt by means of solar evaporation.

### *Brine Springs*

In many countries brine springs have been—until the last 50 years—the chief source from which salt was obtained. With the discovery of rock salt beds, the springs—unless of great concentration—have been gradually abandoned, on account of the greater cheapness of the direct mining of the salt, or preparing salt from the saturated brines. In Canada, at present, no salt is being manufactured from the natural brines, except that recovered in a small way in the Mackenzie basin by the Hudson's Bay Company, where the salt deposited from brine springs is harvested and bagged each year for local use.

### **Rock Salt**

Rock salt is found in many countries in beds of such extent as to allow of its being mined or quarried; or else recovered by dissolving the beds with water and pumping the resultant brine to the surface to be evaporated.

### *Mining*

Where the salt beds are sufficiently near the surface to enable the salt to be recovered directly, the common practice is either to quarry it or mine it by the pillar and chamber method. In the former case it is taken from an open quarry, possibly with very little stripping. Mining is generally carried on from a shaft sunk to tap the deposits. Galleries are run and chambers mined out on each side of the gallery, leaving pillars at regular intervals. Where the beds are narrow ordinary stoping methods are employed.

The salt from both quarry and mine is generally crushed by rolls, after which it is screened. The coarse lumps are sold as lump salt; the material passing through the coarse screens is fed into other types of crushers. The ground salt from these crushers is passed through screens which take out the dust and separate the salt into its several marketable grades. Where the salt is too impure to handle in this manner, it is dissolved in large tanks, and the saturated brine is evaporated by one of the several methods hereinafter described.

### *Artificial Brines*

Where the beds of rock salt are at too great depth to be worked economically by mining methods, the common practice is to recover the salt by putting a drill hole down to the beds and dissolving the salt by means of water, afterwards pumping the saturated brine to the surface and evaporating it.

The drilling of the wells is accomplished by the ordinary churn drill, common to oil drilling practice; the diameter of the holes at the collar being between 8 and 10 inches. It is customary to carry the hole several feet through the salt bed, and to blast or torpedo the bottom in order to form a collecting chamber for the brine when formed. The hole is then encased to ensure that the brine will not escape through some of the overlying porous strata.

There are several methods employed in the pumping of the brine.

In the northern part of the Ontario salt field, where underground waters form the solvent for the salt, the most common practice is to pump the brine through the casing of the hole by means of a plunger pump—after the Cornish pump pattern—with walking beam. In the southern part of this field, where water has to be forced down the hole, the common method adopted is to case the hole down to the top of the salt strata, and then to put down an inner piping, almost to the bottom of the hole. The case pipe has a diameter of from 6 to 8 inches, and the inner pipe from 3 to 4 inches. The joint between case pipe and the hole is made tight by a heavy rubber washer. Fresh, pure water is then forced down the space between the outer casing and the inner pipe under sufficient pressure to cause the brine to flow up the inner tube. The brine pipe reaching to the bottom of the cavity ensures a saturated solution ascending to the surface.

A third method, sometimes adopted, is to pump the brine by means of compressed air. In this method the double tubing is also required, air being forced down the inner tube and allowed to rise through the outer tube, carrying with it the brine.

The brine coming from the wells is piped to settling-tanks where it is allowed to stand for a certain length of time, in order to allow any sediment or mechanically suspended matter to settle. In these tanks the brine is sometimes treated with lime to precipitate any gypsum present; and in some plants it is partially heated by means of exhaust steam, so that time will be gained when the brine is fed into the evaporators.

### Concentration of Weak Brines

In the case where the natural brines are low in sodium chloride content, they can be concentrated into strong or saturated brines by one of the three following methods:—

- (a) Solar concentration.
- (b) Wind concentration or Graduation process.
- (c) Freezing concentration or Congelation method.

(a) *Solar Concentration.* In this method the excess water is removed by the natural heat furnished by the sun, and the weak brine brought to the point of saturation, and then further evaporated either by natural or artificial heat. The complete method employed in the production of salt by this means is fully described later in this chapter, under Solar Evaporation.

(b) *Wind Concentration or Graduation Method.* A method which has, to some extent, found favour in the concentration of the weak brines, which occur in many places in France and Germany, consists in allowing the brine to trickle slowly in a continuous stream over walls of thorns or brushwood exposed to the sun and wind. This process is called the method of graduation, and is carried on in what are called "graduation houses." These houses consist of large wooden trestles covered in on the top, to exclude the rain, but left open at the ends to allow of free circulation of air through the building. The plant consists of a long shallow cistern, built of wooden planks, above which is arranged a wall of thorns and brushwood built up between the two wooden walls, to the height of 30 to 50 feet. Above this wall is a reservoir for the weak brine, or else a long trough furnished with stopcocks. The weak brine is pumped into this reservoir or trough, and allowed to flow either over the surface or through

the brushwood wall, and is collected in the vat or cistern situated on the floor of the building. The building is built lengthwise in the direction of the prevailing wind of the region, with its ends left open. The brine thus trickling through the brushwood, affords a tremendous evaporating surface to the wind circulating through the building, so that a considerable concentration is effected. The brine must be more frequently pumped up and allowed to flow through the brush wall according to the weakness of the original brine. This is accomplished by making the brine flow down over the thorns in different compartments of the building called the first, second, and third graduation. The arrangement is so made that the brine resulting from the third, or last graduation, is of sufficient strength to be economically evaporated by one of the methods of artificial evaporation.

The success of this process is naturally dependent on the state of the atmosphere, and its use is consequently limited to certain districts, and to the favourable time of the year.

(c) *Freezing Concentration or Congelation Method.* The theory upon which this process is based takes into consideration the fact that when a solution of salt and water solidifies, or partially solidifies, it does so in a definite manner, depending upon the proportion of NaCl in the water. For example<sup>1</sup> if a solution of common salt in water, with a definite composition of 23.6 per cent of NaCl in the mixture, which freezes at 22°C., is cooled to that temperature, then the entire mass of salt and water solidifies as a whole. If less than that proportion of salt is present, ice will crystallize first and will continue to separate out until the proportion above stated is reached.

If, on the other hand, salt is in excess of 23.6 per cent, its hydrate, NaCl. 2H<sub>2</sub>O, will first appear and continue to be deposited until the point of equilibrium has been attained.

The whole mass will then solidify as above stated.

This minimum temperature, with its definite, corresponding concentration of salt and water, is known as the eutectic point and at that point the solution and the solid will have the same composition.

Above this eutectic point, one may have either salt or water crystallizing out, according as to which substance is present in the solution in excess of the eutectic ratio, i.e. 23.6 NaCl to 76.4 H<sub>2</sub>O. Thus in the freezing of sea water or a weak brine the separation of nearly pure ice takes place, because the water is largely in excess of the eutectic proportions, and the remaining solution is correspondingly stronger in NaCl.

In the northern part of Europe this method of concentrating brines has met with some degree of success. The weak brine, contained in large reservoirs, is submitted to successive partial congelations, the ice being removed as fast as it forms. The resultant mother liquor containing a higher percentage of sodium chloride is again submitted to the freezing process until finally a saturated solution is obtained which can then be treated by one of the methods of artificial evaporation, and commercial salt prepared. In districts where the atmosphere is dry, and a constant temperature below freezing prevails for any length of time, this method should prove a cheap means of producing a saturated brine suitable for the preparation of salt on an economically commercial scale.

<sup>1</sup> See "Data of Geochemistry", U.S. Geol. Surv., Bull. No. 770, p. 303 (1924).

## Evaporation Methods

A great number of different methods have been used at various times for the recovery of salt from brines, each one being adapted to suit local conditions. These different processes can be conveniently divided into two groups according to the heat employed and the mode of application: (1) Natural evaporation, (2) Artificial heat evaporation.

### *Natural or Solar Evaporation*

The recovery of salt from sea water and weak brines has, in nearly all cases, been made by the solar method, employing the agency of the heat of the sun and wind. No salt is being made at the present time in Canada by this method and it is doubtful if there is any locality in the country where it would be feasible since solar evaporation is practical only in districts where evaporation greatly exceeds precipitation.

This method is employed with success on the Pacific coast of the United States at San Diego and around San Francisco bay, and when it is considered that an evaporation of 1 inch means the evaporation of 113 tons of water per acre, the advantage of this cheap method of evaporation is at once apparent.

The method of operation at the various places where solar evaporation is employed varies little. Sea water is admitted into large storage ponds at high tide. A certain amount of evaporation takes place in these ponds but they are mainly settling ponds to allow any suspended material to settle out. From these ponds the water is pumped to another pond from which it flows to the rest of the system by gravity. In the first of the evaporating ponds, called the concentration ponds, the brine is allowed to remain until a specific gravity of about 1.208 is reached, i.e. when the brine is practically saturated with respect to sodium chloride. In these ponds most of the calcium sulphate in the brine is deposited, hence these ponds are sometimes called the lime ponds. When crystals of salt commence to form the concentrated brine is run by gravity into the crystallizing ponds. Salt crystals separate out in these ponds as evaporation goes on, and a deposit of as much as 5 to 8 inches of salt is obtained in a season. When the evaporating season is over, the crystallizing ponds are drained of the mother liquors which contain high percentages of calcium and magnesium chlorides as well as varying percentages of potassium chloride. These salts being more soluble than sodium chloride remain in solution during the precipitation of the sodium chloride. In some plants the mother liquor (or bitters) is further treated for the recovery of magnesium chloride or some of the other salts they contain, but usually they are wasted.

The salt deposited in the crystallizing ponds is harvested by hand or machinery methods. It is stacked in large piles in the ponds where some of the entrapped bitters drain off and it is then hauled in small cars to the storage piles for further purification. This treatment consists of preliminary crushing and washing with a pure salt brine after which it goes to storage piles for final drainage and drying preparatory to shipment. It has been found that the salt produced by this process does not make the highest grades required for table and dairy use, so that a number of



companies using this process have installed modern types of artificial heat evaporators, and for these the salt is dissolved and the brine used for the production of the finer grades for the market. 'Solar salt' or 'Bay salt' are names given to the product produced by this process.

### *Artificial Evaporation*

From the earliest times salt was recovered from brines by means of artificial heat applied to vessels in which brine was contained. The earliest methods were naturally crude, but improvements have been gradually made and in late years the industry has made rapid progress in the line of machinery for cheap evaporation. Evaporation methods in which artificial heat is employed fall naturally into two groups, according to whether the heat is applied directly, as in the case of the open pan or kettle process, or indirectly, in the form of steam circulating through pipes or jackets.

#### DIRECT FIRE EVAPORATION

*Kettle Process.* One of the earliest methods employed in the salt industry consisted in evaporating the brine in large hemispherical kettles, over an open wood fire. An improvement was shortly made in this method by setting the kettle in an arch of masonry. Later, two kettles were employed, then four, using the same fire, and finally, the kettles were placed in long rows, as many as 30 or 40 in each row; with one common fire-box and a common stack for several rows. The salt formed was removed by hand and placed in baskets to drain. The method was, at best, very wasteful of fuel, since in order to heat the kettles farthest away from the fire-box heavy fires had to be made, and this caused an excessive heat under the nearest kettles. Naturally, on account of this difference in heat under the different kettles, a uniform grade of salt could not be obtained. Due, therefore, to these, and several other drawbacks, the kettle method of evaporation was gradually replaced by the English open pan method.

*Pan Process.* As first adopted in Canada—upon rejection of the kettle method—the pan employed consisted of a long shallow pan placed upon two walls, with a fire-place at one end and a chimney at the other. These pans were made of  $\frac{1}{4}$ -inch boiler plate, and were from 40 to 50 feet long, 12 to 20 feet wide, and 10 to 12 inches deep. One fire grate was used, and the products of combustion passed under the pan, and directly up the chimney. The best practice of the present at plants where the open pan method is still employed is to have two or four pans in one "block," as these salt plants are called. If, for example, four pans are employed, they are arranged in pairs, side by side; the pairs being placed end to end, so that one common chimney or stack is utilized for all four pans. Where the furnace gases pass under the length of the pan, and are then allowed to escape, the pan is generally divided into two compartments, two grades of salt being made in each pan: fine salt in the compartment nearer the fire grate, and coarse salt in the compartment farther from the fire, where evaporation is much slower. An arrangement by which an even grade of salt is made throughout the pan is, to divide the space underneath the pan into three chambers, and to allow the furnace gases to pass through the two outside ones, and return to the stack by the middle flue. The stack in this case is located beside the fire grate. This

system has, in the case of a "block" of four pans, the advantage that all the fire-boxes are situated on either side of one passage way, and can be attended to much more easily than if two were at either end.

The pans are made of  $\frac{1}{4}$ -inch boiler plate riveted together. The length varies from 90 to 120 feet, and the width from 18 to 24 feet, with a depth of 12 to 14 inches. The salt is removed as fast as it is formed by means of long scrapers. Between the two pans a walk, 6 to 8 feet wide, is placed from which the man operates the rake. The sides of the pan are generally sloping, and bolted to the drainage boards (6 feet wide). The salt can then be raked directly from the pans on to the boards, and left there until thoroughly drained, before being removed in two-wheeled carts to the drying bins. It is necessary that the salt be removed at frequent intervals, so that it will not cake on the bottom of the pan, and thus retard the conduction of the heat through the pan to the brine, or injure the quality of the product. If the brine is not agitated frequently by the removal of the salt by these rakes, there is a tendency for a film of crystallized salt to form on the surface of the brine as a scum, and thus prevent the escape of the steam of evaporation. The open pan method is still employed in some of the Canadian plants.

#### STEAM EVAPORATION

The fact that the preparation of salt by the open pan system was extravagant in fuel, and that the product obtained varied considerably, led to the adoption of other methods which utilized either exhaust or live steam.

*The Steam Jacket.* The earliest use of steam in the salt industry was in steam jackets surrounding the kettles or pans of the kettle and open pan processes. A second bottom was placed under the kettle or pan, through which steam, either live or exhaust, was allowed to circulate. This produced a constant temperature in the evaporator, and thus an even product was obtained. The grainer system and the vacuum pan, however, produce the same results, and are much more economical; so that in nearly all the best plants these processes are employed.

*Grainer System.* Grainers consist, in general, of shallow vats of various shapes, near the bottom of which a series of steam pipes are placed, through which steam is allowed to circulate and heat the brine. These vats are generally rectangular in shape, with a depth of from 18 to 24 inches, a width of from 8 to 16 feet, and a length of from 60 to 120 feet. They may be built either of wood (lined with tile for protection), cement, or steel.<sup>1</sup>

The pipes are arranged after the manner of ordinary heating coils, so that the steam entering at one end passes through the whole series of coils before leaving the grainer. The pipes are generally 2 inches in diameter.

In the best practice the salt is removed from the grainers by some continuous, operating form of mechanical rake. The two types most commonly used are the endless chain raker, and the reciprocating raker. In the former style of rake the lugs on the chain drag along the bottom of the grainer, carrying the salt with it, and deposit it on the inclined draining board at the end. This rake has the disadvantage of having the chain exposed to the corrosive action of the air while returning to the front of the

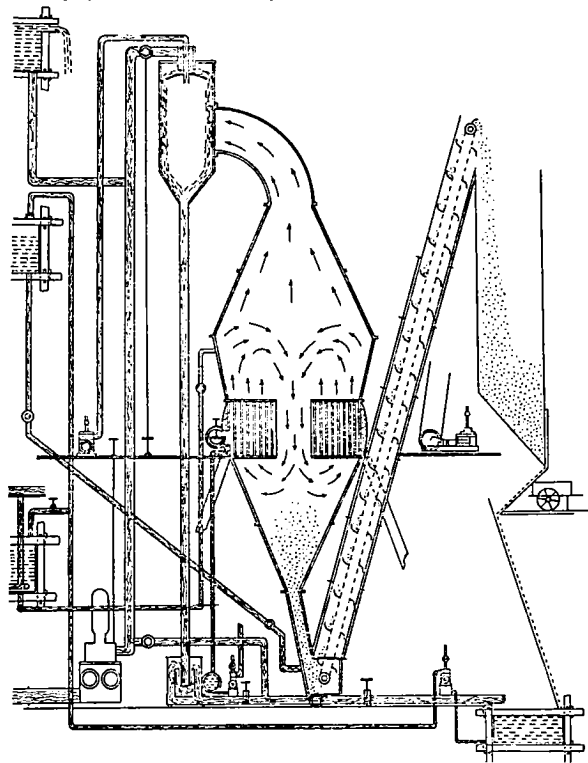
<sup>1</sup> One variation in the grainer type that is quite common is the shaped grainer. In this type a scraper conveyer runs along the bottom of the vat and scrapes the salt as formed to the end of the evaporator, where it is removed by an elevator. The pipes are placed above this conveyer.

grainer and the rust so formed is liable to discolour the salt. In the reciprocating rake, a rigid frame is operated back and forth on angle ledges on the sides of the grainer, the lugs on which frame are so fastened that on the back stroke they trail over the top of the salt and only push the salt along the bottom and up the incline on the forward stroke. The reciprocating motion is obtained by means of a hydraulic cylinder placed at the end of the grainer. The salt is thus shoved gradually up the draining board, from the top of which it falls into a trough, through which a conveyer runs, and carries it to the drying bins.

These grainers may use either live or exhaust steam. The temperature can be regulated at will, so that the grainer can be made to produce whatever grade of salt is required.

#### VACUUM PAN EVAPORATION

The application of the vacuum pan process to the manufacture of salt is a comparatively new departure. Although vacuum pans had been employed for many years in the sugar and other similar industries, it was



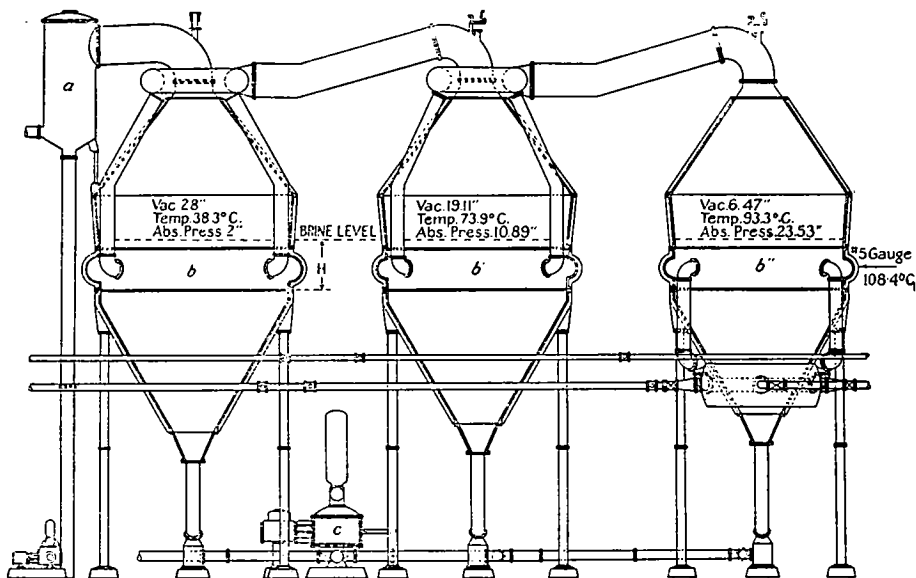
(Manistee Iron Works, Mich., U.S.)

Figure 25. Single effect vacuum pan in operation.

not until the year 1887 that the first vacuum pan for the manufacture of salt was placed in operation. This pan was erected by Mr. Joseph Duncan at Silver Springs, N.Y. From that time their use has extended, with gradual improvements, to all the more modern plants on the American continent.

The principle upon which the vacuum pan process is based is, that, when the pressure on the surface of the brine is decreased, the boiling point of the brine is correspondingly lowered. The brine can then be evaporated with a great saving in the amount of heat required. The heating medium employed in evaporation of the vacuum type, is steam, either live or exhaust. No vacuum evaporators have been, so far, designed to successfully operate by direct heat.

Vacuum evaporators may be operated in series as double effect, triple effect, quadruple effect, etc. When the pans are employed in this manner, the steam formed by the evaporation of the brine in the first pan is conducted to the heating chamber in the second pan, in which a greater vacuum is carried. Likewise, the steam generated from the brine in the second pan is led to the steam chamber in the third pan, where a still greater vacuum is maintained. Similarly, each pan is heated by the steam produced in preceding pan, for as many pans as are operated in series. The steam from the last pan is carried to a condenser. The vacuum in each pan is created by the condensation of the steam in each succeeding steam chamber, the vacuum in the last pan being produced by a vacuum pump.



(Manitowoc Iron Works, Mich., U.S.)

Figure 26. Triple effect vacuum pans, showing temperatures and vacuums.

The construction of the several types of evaporators employed in the salt industry varies only in a few minor details. They consist essentially of four parts, namely:—

- (1) the evaporating and condensing chambers,
- (2) the heating element,
- (3) the coned bottom,
- (4) salt filter, or barometric leg.

*Evaporating and Condensing Chambers.* The main body of the evaporator may be built of steel, cast iron, or copper, generally circular in cross-section, and either cone- or dome-shaped at the top. The height of this chamber varies with the diameter, and is made sufficiently high to prevent the escape of any of the brine by entrainment, or foaming. In order to prevent a loss of heat by radiation, the evaporation chamber is covered completely (as well as all other parts of the evaporator) with a heavy coating of asbestos packing. The condensing chamber is of the usual type, furnished with a vacuum pump.<sup>1</sup>

*The Heating Element.* Two methods of applying heat to evaporate the brine are employed. In the first, a steam chamber is placed between the evaporating chamber and the coned bottom, in which a series of copper tubes, varying from 2 to 4 inches in diameter, are fastened vertically in the top and bottom plates of the chamber. These tubes are open at either end, and thus permit free circulation of the brine between the cone-shaped bottom and the evaporating chamber. The steam is passed into this chamber and circulates in and out around the tubes, thus heating the brine circulating within them. The condensed steam is drawn off by suitable means from the bottom of the steam chest. The second method employed in heating the brine is to have the steam pass through a series of coils or tubes around which the brine has free circulation. In this method of heating special means have to be adopted to properly dispose of the condensed steam, and the coils of pipe have to be so arranged as not to impede the salt, as it is formed, from descending into the cone-shaped bottom.

One of the great difficulties encountered in the application of vacuum pans to salt manufacture is the scale which deposits upon the heating surface.<sup>2</sup> This has to be removed at frequent intervals, or else the evaporative capacity of the pan will be greatly reduced. In order to facilitate the removal of this scale, the heating element should be either removable from the pan, or else easily accessible.

The bottom of the pan is sharply coned, so that the salt crystals, as formed, may readily fall to the bottom, clear of the heating tubes, and can then be drawn off from time to time. The pipe for the entry of the brine is generally attached to this cone.

*The Salt Filter, Barometric Leg, or Centrifugal Pump.* In order that the operation may be continuous, there must be some means of removing the crystals of salt as fast as they are formed. This is accomplished in three ways, (1) by a salt filter, (2) by a barometric leg, or (3) by means of a centrifugal pump. In using a salt filter, the salt is drawn off into a filter or chamber, connected with the cone bottom. The connecting valve is closed when the filter is filled, and the salt is removed without stopping the operation of the evaporator. Sometimes two pipes lead from the cone to two filters, so that when one filter is being emptied the valve to the second is opened and allowed to fill. This prevents any possibility of clogging of the salt crystals in the bottom of the cone. In the barometric leg the salt falls continuously down, and is removed from the bottom by a closed elevator. While this method has been in common use for a number of years,

<sup>1</sup> When working in double or multiple effect, the heating element or steam chest of the succeeding unit is the condensing chamber for the preceding evaporator.

<sup>2</sup> This scale is, in most cases, composed of calcium sulphate, which is present in the original brine, and in the best practice this is largely removed before the brine enters the evaporators.

the method considered to be the latest practice in the removal of salt from the cone-shaped bottom is to attach a centrifugal pump directly to the bottom of the cone. The mixture of salt and brine removed by this pump is carried to a washing apparatus which eliminates impurities, after which the excessive moisture is removed by some form of continuous filter.

The salt made in vacuum pan evaporators is mostly of a very fine grain, and, consequently, has not entirely succeeded in replacing the grainer, the latter being able to produce varying grades of salt, according to the amount of heat supplied.

#### *Other Methods of Employing Artificial Heat*

There are several other processes for the production of salt from brine, which are worthy of mention. None of these methods are, however, being employed in Canada at present.

#### ALBERGER METHOD

The principle of the Alberger process is to heat a saturated brine under pressure, and then on releasing this pressure evaporation takes place.

The actual operation of this process is complicated and consists in heating the brine under pressure in stages in a number of heaters run in series, the brine leaving the last heater of the series at a temperature approximately 300° F. The brine is then passed through an apparatus called the graveller in which the calcium sulphate is removed, the brine still being under pressure. From the graveller the brine passes to three steel cylinders called flashers in which the pressure is released in successive stages, the brine coming from the last flasher at atmospheric pressure. Vapour is given off from each flasher which is used to heat the heaters in the first part of the operation. By the time the brine reaches the last flasher enough vapour has been removed to cause seed crystals of salt to commence to form, which are suspended in the brine as it passes from the last flasher to the collecting pan. The temperature of the brine passing to this pan is over 230°F. and due to this high heat surface evaporation goes on and these crystals so formed are collected, together with the seed crystals already formed, passed through a centrifuge and then a dryer, and the finished salt passed to storage bins.

#### HODGKINSON PROCESS

A process that has found some favour in England is called the Hodgkinson process. A. F. Calvert<sup>1</sup> in describing this process says in part:—

The essential features of the Hodgkinson plant consist of (a) a mechanically-stoked furnace for the production of heat; (b) a primary closed evaporating pan, 30 ft. in diameter; (c) two secondary circular pans, 25 ft. in diameter; (d) four open rectangular pans, 60 ft. by 25 ft.; (e) a series of folded steam-jacketed pipes for heating the inflowing brine by the waste steam; and (f) a condensing arrangement to produce a partial vacuum in the closed pans.

The Hodgkinson furnace is not placed under the pan, as in the old system, but in front of the plant, and the heated gases pass under the primary pan, where the temperature ranges between 1,800 and 2,000 degrees F. In this primary pan is made a finer and better salt than can be produced by any other system in the world. Moreover by means of the mechanically stoked furnace, and the consequent uniform temperature, it is possible, for the first time, to control the character of the salt produced. Where the temperature varies, as in the open-pan system, crystals of varying shapes and sizes are produced, and this mixed salt must be ground to make it suitable for table purposes. Where steam heat is

<sup>1</sup> Calvert, A. F.: Salt in Cheshire, London, 1915, pp. 978-989.

employed, as in the vacuum process, the temperature is not high enough to make crystals of the smallest size. By the Hodgkinson system the primary pan produces a precipitation which requires no grinding, which flows in a cascade of salt from the pan, and can be delivered to the consumer without having come into contact with the hand of man in the whole course of the operation.

The heated gases having passed under the primary pan, are then divided and sent under the two secondary pans, and from thence they pass under the open rectangular pans, the gases being distributed by the broken columns of brickwork on which the pans stand. The temperature of the gases passing under the open pans commences at about 600 degrees F., and gradually decreases to about 200 degrees F. under the farthest pans. By the automatic regulation of the temperature, the waste gases are utilized to produce salts of the various degrees of coarseness required for the dairy, the stockyard, and fishery purposes. In the two secondary closed pans, finely divided table salt is also produced, but it is possible, by opening the manhole traps in the covers, to increase the size of the crystal and make dairy salt in these pans. The coarser crystals and flake salts are made in the open pans in which the crystallization is at the lowest rate. The grain of the salt can be altered at will. In order to meet any change in the market requirements, coarser salt can be produced at a moment's notice in the secondary pans. The very marked superiority of the whole system over all other processes is seen in the fact that a change in the type of salt produced can be immediately effected, and a constant and uniform output of any combination of products can be absolutely guaranteed.

Under the old system, the heat having been employed to make the first quality salt, the gases were allowed to escape up a chimney and poison the air with clouds of smoke. In the Hodgkinson process the chimney is dispensed with, and a mechanical draught, regulating the waste gases, carries them on to complete the production of the coarser varieties of salt.

## PREPARATION OF SALT FOR THE MARKET

The salt as it comes from the evaporators, no matter what form of evaporator is employed, contains varying percentages of moisture in the form of brine which has to be removed by some means before the salt is ready for the market. In the case of salt coming from vacuum pans the greater portion of this moisture is removed either by means of a centrifuge or some type of mechanical filter which leaves between 2 or 3 per cent moisture in the salt. If the salt is to be shipped in bulk or in 100-pound bags it is placed on the warehouse floor where it is allowed to stand until dry before shipping. Where special grades are to be prepared the product from the mechanical filter is dried in a rotary cylindrical type of oil-fired dryer which removes the last traces of moisture. It is then cooled and passes to the screening and packing plant.

The salt from grainers is conveyed directly to the drainage floors in the warehouse where it is allowed to stand until dry; or if it is to be mechanically dried it is allowed to drain until most of the moisture is removed, when it is conveyed to the rotary dryers for elimination of the remaining moisture.

### *Screening*

The salt produced by the vacuum process is very uniform in grain so that screening is resorted to for the purpose of removing any dust or fine material which may have been formed by abrasion, or any large lumps. The greater bulk of the product is of uniform size so that generally only one product is made. The best practice at present is to use some type of enclosed vibrating screen. Such screens are very efficient and rapid in operation and produce very uniform products. When grainer salt is being screened, the screen is generally equipped with several layers of wire cloth of different mesh, properly placed so that a number of products or grades are produced from the one screening operation.

### *Mixing and Packing*

Most of the modern salt plants are designed in such a way that the salt is not touched by human hands, all the operations being accomplished by machinery. This is especially true of all salt that is made for domestic consumption, or the salt used in curing foods.

The salt, after complete drying, is conveyed to the mixers where any ingredients which may be necessary to produce such products as "free flowing salt," "iodized salt," etc., are added. It is then conveyed to the automatic baggers or carton fillers where exact quantities are weighed for the barrels, bags, or cartons.

One form in which salt is marketed and which has found a ready sale is the "pressed block." The bulk salt is fed into machines which press it into blocks of 50 pounds each, the pressure exerted to make a solid block being over 1,000 pounds per square inch. Such blocks are finding a ready market for "cattle licks" in the same manner in which blocks of rock salt are employed. These blocks have an advantage over the blocks of rock salt since in certain cases they are made with small additions of sulphur, iodine, etc., and thus have the additional value of being a convenient method of administering doses of these medicines when needed by the stock.

The salt is marketed in many forms of containers such as barrels, bags of various sizes, and cardboard lots. Each company also produces a great variety of different grades to meet the requirements of the different industries and in most cases trade names have been adopted to designate the salt from the different companies under which their products have become widely known not only throughout the Dominion but in other countries as well.

### USES OF SALT

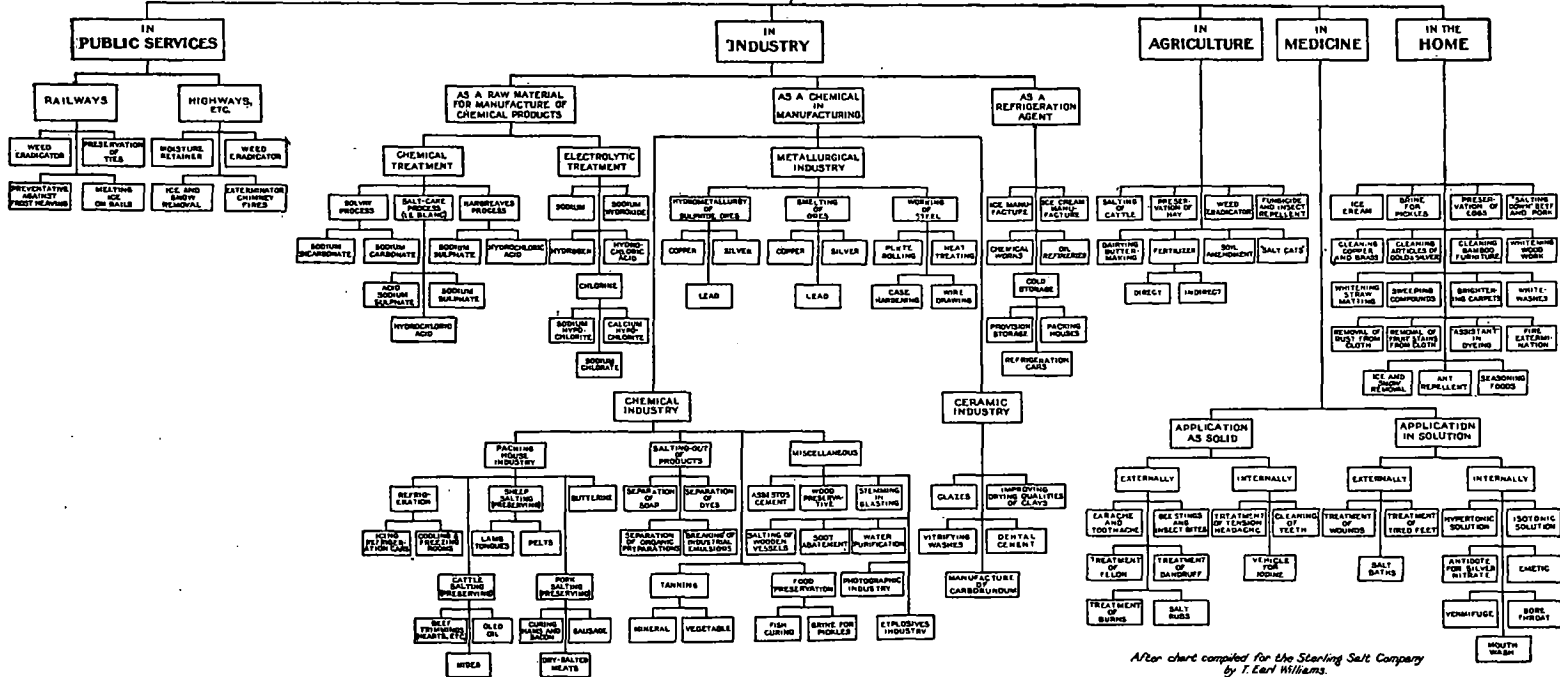
Salt is one of the basic minerals necessary for modern civilization and its application is so widespread that it is impossible to give more than the briefest outline of some of the more important uses. Figure 27, however, gives in chart form the uses of sodium chloride, in the home, in medicine, in agriculture, in industry, and in public utilities.

#### *Use in the Home*

Probably one of the earliest uses of salt was the domestic use of salt for seasoning food after cooking. In the early days before cooked foods were known food was eaten in its raw state and there was sufficient salts in the flesh to satisfy the requirements of the human system. With the advent, however, of cooked foods, over 70 per cent of the salt in flesh and in vegetables in their raw state was removed and the foods were found to be unpalatable and insipid to the taste so that artificial seasoning by salt came into use. For this purpose probably rock salt or salt produced from brines was employed.



**USES OF SALT  
(SODIUM CHLORIDE)**



*After chart compiled for the Sterling Salt Company by T. Earl Williams.*

Figure 27. Uses of salt.

The crude material of early days bears little resemblance to the refined products of the industry as marketed at the present time. Table salt of a degree of purity undreamed of by the earliest producers, is a common article of commerce. To some of these salts a small percentage of a moisture-absorbing material is added to make it flow readily from the shaker even in the dampest atmosphere.

Salt is also used in the home as a preservative for foods, for setting of dyes in new fabrics, for many of the routine cleaning operations, and a number of other special applications.

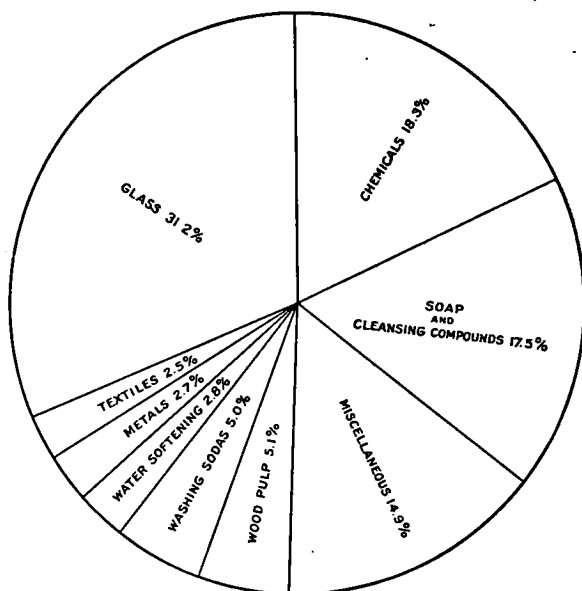


Figure 28. Estimated distribution of soda ash to various industries.

### *Medicine*

The earliest use of salt is unknown but probably its use as a treatment for wounds was one of the earliest. In the medical science it is employed both in its solid state and in solution and may be used externally or internally.

One of the more modern medicinal uses of salt is in the form of "iodized salt," used for the prevention or alleviation of goitre, an enlargement of the thyroid gland, caused by insufficient iodine in the blood. A minute proportion of iodine salts (0.01 per cent), sufficient to keep the thyroid gland properly supplied, is added to pure table salt and such salt is recommended for both table and cooking use. In this case the salt acts as the vehicle to carry the iodine.

*Agriculture*

Sodium chloride has been used for many years as a fertilizer for certain classes of crops, such as grains, peas, hops, potatoes, turnips, clover, grasses, etc., with highly beneficial results. The amount recommended to be used per acre will vary according to the type of soil and the class of crop, but will run from 700 pounds for light soil to as low as 300 pounds for heavy loam. It has also been found beneficial to fruit trees when placed in trenches around each tree.

Salt is also found to retain moisture in soils on which it has been spread, as well as acting as a weed eradicator.

For the curing of hay it has been found to give satisfactory results when used on a hay crop that has been cut just before the seeds have become fully ripe. Hay cured with salt is claimed to retain a larger percentage of proteins than hay cured in the ordinary manner by the sun after maturity.

Cattle need salt in their system and the custom of placing blocks of rock salt or pressed blocks of salt in the pastures and stables is a satisfactory way of supplying the needs of the stock.

For the manufacture of butter and cheese, salt is one of the necessary raw materials. With the increasing demand of the public for the highest quality in both these products the dairymen of the country are finding the necessity of employing only the best materials available for their manufacture and in consequence the salt manufacturers are preparing specially purified salt to cater to this trade.

*Industry*

The uses of salt in industry are many and only a few of the more important can be briefly mentioned.

As a raw material it forms the basis for the manufacture of a large number of chemical products such as sodium carbonate, sodium sulphate, hydrochloric acid, caustic soda, chlorine, and many others. The use of salt for this purpose will be briefly described in Chapter V, so will not be dealt with further at this time.

As a chemical it is employed in the metallurgical industry for the leaching out of copper, silver, and lead ores, and in some cases is used as a flux with the same ores in smelting. In the working of steel it is used in heat treating, case hardening, and plate rolling to loosen scale from the plates.

In the ceramic industry it is found that a small percentage of salt improves the drying qualities of certain clays. It is also an important constituent of certain glazes, known as "salt glazes", and is also used in the manufacture of carborundum along with coke, silica sand, and sawdust in the electric furnace.

The packing house industry employs salt for refrigeration purposes, for the curing of bacon, hams, meats of all kinds, and the preserving of pelts and hides.

It is used in the separation of soap, the setting of dyes, the separation of organic preparations, the deflocculating of industrial emulsions, and in tanning.

As a food preservative it finds one of its most extensive uses in the curing of fish.

In the preserving of fish for the markets, salt has long played an important part, but it is only within recent years that any systematic study of the effect of salt on the flesh of fish has been made. The results of these studies have been of the greatest interest and benefit to the fishery trade and have enabled the producers of salted fish to prepare better products both as to appearance and grade than were possible under the old hit-and-miss methods. It has been found that salt produced by solar evaporation from sea water contained a certain bacterial organism, which produced a red discoloration on the fish, especially cod fish, when cured with such salt. This organism is not present in salt produced from bedded salt deposits. The rate of penetration of salt into the tissues of the fish has also been extensively studied and the results have shown that the faster the penetration the better the quality of the product. The rate of penetration has been shown to depend to a great extent on the purity of the salt, the purer the salt the faster the penetration. The presence of calcium and magnesium compounds in the salt is found to be highly detrimental and tends to make the flesh white and opaque. Canada is fortunate in that all her salt is manufactured from bedded deposits and is of a high degree of purity.

As a refrigeration agent salt finds an extensive use in a large number of industries when cold storage is employed. Salt when mixed with ice gives a lower temperature than when ice is used alone, and for this purpose it is extensively employed in the manufacture of ice cream, in packing ice cream for shipment, in refrigerator cars, and also in refrigeration plants using brines made up of calcium chloride with sodium chloride.

### *Public Services*

Salt has been found to be beneficial to railways in the preservation of ties and fence posts. If salt is placed beneath a tie when it is placed in the roadbed, it is not so liable to be heaved by frost. Both steam and street railways employ large quantities of salt to thaw out switches and to remove ice from rails in order to allow the wheels to get a proper grip. On the right of way of railways salt is used to keep weeds under control.

On highways, if salt is added in small proportions with calcium chloride it is found to hold the moisture and keep down dust thus decreasing the wear of a road by loss of binding material.

In the putting out of chimney fires salt is frequently used and quickly smothers the blaze.

For the removal of ice and snow on street and sidewalks it is extensively used.

## CHAPTER V

## THE ALLIED INDUSTRIES USING SALT

Until recent years, the only use made of the extensive deposits of salt in Canada has been to produce commercial sodium chloride in the form of table, dairy, packing, and other grades of salt. The rapid growth and commercial progress made by the Dominion during the last few years, however, has greatly accelerated the demand for industrial products. This demand has, in some cases, caused an increase in the importation of the material required. Among the materials—the demand for which has been most noticeable—are those chemicals produced by the industries that use sodium chloride, either directly or indirectly, as one of the principal raw materials. The increasing demand of the Canadian trade for these chemicals—as evidenced by the increase in imports—has naturally evoked the question whether they can be manufactured in Canada. This question is partially answered by the fact that one company is already successfully producing caustic soda, liquid chlorine, hydrochloric acid, and bleaching powder, while another company is preparing soda ash from sodium chloride in the form of brine. But there are several other chemicals in the manufacture of which sodium chloride is utilized; and there is no reason why use should not be made of the extensive salt deposits of Canada in the establishment of these industries. In view of the rapidly increasing market there should be no difficulty in the disposal of the products of such undertakings.

In order that some idea may be obtained of their possibilities, a brief résumé is here given of several of the more important processes for the manufacture of those chemicals which use sodium chloride as a basic raw material.

## SODIUM CARBONATE

Although sodium carbonate is often found in extensive deposits in nature, it is generally very impure. Owing to the cost of dissolving, evaporating, and purifying, it rarely pays to operate a deposit of this nature except at actual points of consumption, as commercial sodium carbonate can more readily be prepared artificially from sodium chloride.

Sodium carbonate, or soda ash, is used for many different purposes, the principal ones being, in the manufacture of glass, in the making of certain kinds of soap, and in the purification of oils, etc.

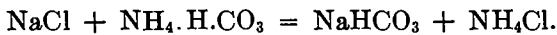
In the artificial preparation of sodium carbonate there are two processes of importance which use sodium chloride as a raw material.<sup>1</sup> These two processes are: (1) the Solvay, or ammonia soda process, and (2) the electrolytic process.

<sup>1</sup> The LeBlanc process for the manufacture of soda uses sodium chlorides indirectly, inasmuch as the sodium sulphate used in this process is produced from salt. As the process of producing sodium sulphate from salt is describe later, no further mention is made of the LeBlanc process.

## The Solvay Process

The reaction of ammonium bicarbonate on sodium chloride, with the separation of part of the sodium as sodium bicarbonate, was known to the chemists during the early part of the nineteenth century. A number of patents have been taken out in many countries, based on this reaction, and attempts were made to commercialize the different processes, with only indifferent success. About 1861, Ernest Solvay, a Belgian, commenced work along this line, and after a number of years of experimenting succeeded in overcoming the mechanical difficulties, and placed the process on a commercial basis. His inventions, although in a greatly modified form, are now employed in the process as carried on under his name in many of the large soda works, both in Europe and America.

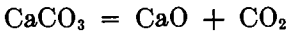
The reaction upon which his process is based may be stated in the following equation:—



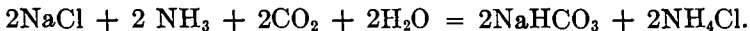
The raw materials required for this process are: limestone, sodium chloride (either as brine as it comes from the wells or rock salt dissolved), ammonia (either in the form of an ammonium hydrate solution or ammonium sulphate), and fuel.

In brief, the essential operations in this process are: to manufacture carbon dioxide from limestone; to pass this gas into the ammoniacal brine which has previously been prepared by saturating the brine with ammonia gas; the separation of sodium bicarbonate which forms as a precipitate from the solution; and the calcining of this precipitate to form sodium carbonate, or soda ash. The carbon dioxide formed from the calcining of the bicarbonate is employed again, as is also the ammonia, which is recovered from the solution—where it is in the form of ammonium chloride. The reactions which take place may be stated by the following equations:—

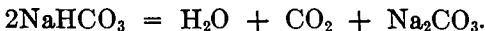
Limestone is burned with coke to form  $\text{CO}_2$ .



The  $\text{CO}_2$  is passed into the ammoniacal brine, where it reacts with the ammonia to form ammonium bicarbonate, which immediately reacts with the sodium chloride to form sodium bicarbonate:

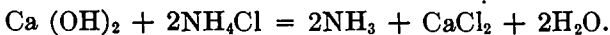


The sodium bicarbonate is calcined to produce soda ash:



The carbon dioxide thus recovered is again used in the process.

To recover the ammonia from the ammonium chloride, calcium hydroxide is added:



The calcium chloride thus produced is generally run to waste.

Figure 29, after Wilson,<sup>1</sup> shows diagrammatically the method of manufacture of soda ash by this process.

When considering the erection of an ammonia soda plant, it is well to locate where the salt is cheap and where sufficient quantities of pure limestone, ammonia, and coke can be obtained.

One large plant for the manufacture of soda ash by this process has already been erected in the salt district of Ontario. This plant obtains its salt (in the form of brine) and limestone locally and secures most of its ammonia from local gas works, or purchases it in the liquid form, the coke being imported.

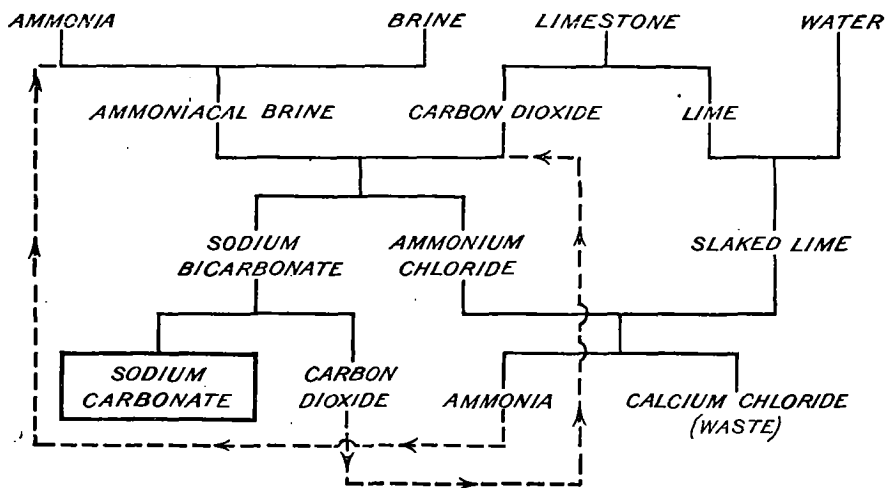


Figure 29. Manufacture of soda ash by ammonia soda process.

In Nova Scotia, limestone could be obtained locally, and coke obtained from the coals produced in nearby coal fields while supplies of ammonia are obtainable from by-product coke plants in that province. With the large deposits of sodium chloride at Malagash in Nova Scotia and at Gautreau, N.B., the possibilities of cheap manufacture of soda ash at some central point in the Maritimes are excellent, when the market for the product warrants such a step.

In Alberta, the salt areas are far from the present markets and far from available supplies of coke so that it is not probable that the manufacture of soda ash by this process will be undertaken for some time to come.

### Electrolytic Process for Preparation of Soda Ash

An electrolytic process for the manufacture of sodium carbonate crystals from the electrolysis of brine has been perfected and operated commercially, on a small scale, in England. This process known as the "Hargreaves and Bird process," consists of a diaphragm cell in which the walls of the cell are the diaphragm and the cathode. The diaphragm is impervious to the salt solution, but permits the sodium ions to pass. As the sodium ions are set free, they are converted into soda crystals by the blowing in of steam and carbon dioxide.

<sup>1</sup> Wilson, A. W. G.: "Chemical, Metallurgical, and Allied Industries in Canada"; Mines Branch, Dept. of Mines, Canada, Rept. 597, p. 50 (1924).

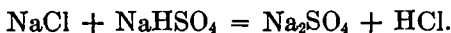
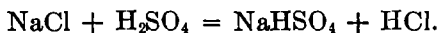
## SODIUM SULPHATE

Like sodium carbonate, sodium sulphate occurs naturally, in large deposits, in western Canada, the United States, and other countries. The artificially manufactured substance, however, is so cheap, and the deposits in western Canada handicapped by long freight hauls to the markets, that the demand for the manufactured product will continue for many years to come.

Artificial sodium sulphate is known as salt cake, and the commonest process for producing it is from the action of sulphuric acid on sodium chloride. The salt for this process is preferably rock salt or the coarsest salt produced from evaporation.

The process may be carried on in two ways: (1) sulphuric acid as such, may be added directly to the sodium chloride, or (2) sulphur dioxide, oxygen, and steam may be added to the sodium chloride.

By the first method, the acid sodium sulphate is formed, and this reacts again with salt to form sodium sulphate according to the following reactions:—

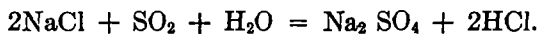


This process is the one which has been most employed in the manufacture of salt cake and is the first step in the LeBlanc process for the manufacture of soda ash.

The second method, known as the Hargreaves process, achieved considerable success a number of years ago especially in England and Europe. It is probable that this process would have in time become the general system for the manufacture of salt cake had not the discovery of the ammonia soda process, about the time that the Hargreaves process was just becoming well established, dealt a serious blow to the LeBlanc process. On account of the large sums of money invested in the LeBlanc process plants the manufacturers were compelled to lay the greatest stress on the recovery of salt cake by the first step of this process, and the Hargreaves process suffered in consequence.

While there were twelve plants in Europe employing the Hargreaves process in the year 1891, by the year 1918, the seven of these plants that were situated in Great Britain and Ireland were all closed down.

The process is of interest, however, since it dispenses with the manufacture of sulphuric acid. Hargreaves process depends on the reaction of sulphur dioxide gas on sodium chloride in the presence of air and steam. Pure sulphur dioxide gas, of itself, does not decompose sodium chloride, but when steam and air are mixed with it, the salt is gradually decomposed and in time completely converted into sodium sulphate. The final reaction may be represented by the following equation:—



The sodium chloride has to be specially prepared. Pan salt to which generally a little finely-ground rock salt has been added, is moistened and pressed into cakes or small bricks and dried. This gives the salt a sufficient degree of porosity when placed in the decomposition chamber, to make it completely permeable to the gases, as well as having sufficient strength to resist crushing under the weight of the charge.



The sulphur dioxide is obtained from pyrites burners, similar to those used in the manufacture of sulphuric acid. In this process, however, the burners are specially designed and built back to back in order that as little as possible of the heat generated in them be wasted.

The steam, which is superheated and completely dried, is added to the sulphur dioxide gas either in the gas-space above the burning pyrites or else in the large pipe which carries the gas from the burners to the cylinders.

The salt is placed in a series of vertical cast-iron cylinders each holding approximately 50 tons. These cylinders, which are brick encased, are each provided with a fireplace, so that the whole cylinder can be externally heated. There are generally ten in number, connected up in two rows of five each to form a "cylinder battery." The hot sulphur dioxide gases are led into the cylinders, which are kept at a temperature of 500°C, and passed over the salt from the top downwards.

The gases direct from the pyrites burners are never passed over the fresh salt, since the reaction would generate such a high heat that the salt would be fluxed. They are, therefore, first led into the cylinder in which most of the salt has been converted into the sulphate, afterwards passing through the other cylinders, so that by the time the gases reach the cylinder in which fresh salt has just been charged, most of the sulphur dioxide has been removed.

The complete conversion of the salt into sulphate in one of the cylinders takes approximately three weeks.

The hydrochloric acid produced by the process is drawn off from the last cylinder of the series together with other gases, and after being cooled is led directly into the condensing towers.

The yield of salt cake by this process will vary from 7,000 to 7,500 tons per year per battery.

Sodium sulphate finds its principal use in the pulp and paper industry for the manufacture of 'kraft paper' by the sulphate process, in the manufacture of glass, in the dye industry, and as one of the raw materials in the manufacture of sodium carbonate by the LeBlanc process.<sup>1</sup> When crystallized, it is used in a number of industries under the name of Glauber's salt.

## ELECTROLYSIS OF SALT

Probably that branch of the alkali industry, using sodium chloride as a basic raw material, which has developed most rapidly in recent years is the manufacture of liquid chlorine and caustic soda by means of the electrolysis of salt either in the form of a brine or fused state.

There are two methods employed in the electrolytic decomposition of salt. The first one is that in which a fused electrolyte is employed, while the second process makes use of a solution of salt in water as the electrolyte.

The first process presents great difficulty, as there is the question of keeping the electrolyte fused; but the caustic so produced requires very little further concentration. There are, however, several processes involving the use of the fused electrolyte, which have been operated successfully.

<sup>1</sup> For more extensive list of uses see Mines Branch Report 646, "Sodium Sulphate of Western Canada".

The wet method, or the one in which sodium chloride in solution is used as the electrolyte, is the most extensively employed on this continent.

When a brine, saturated with respect to sodium chloride, has an electric current passed through it, it is decomposed into its component parts, sodium and chlorine. There is an excess of water present so that the sodium reacts with it to form a weak solution of caustic soda and in turn, liberates hydrogen.

The reactions which take place are:—



The great difficulty at first encountered with this method, was that these materials tended to reunite and form objectionable compounds which interfered with the electrolytic action, unless they were at once passed into an inactive region. With the latest type of cells, however, these difficulties have been overcome, so that this process is now employed in most of the largest plants.

Several methods are employed to keep the products of the electrodes separate. The most important of these are: (1) by diaphragms, (2) by density difference, and (3) by mercury cathode.

*Diaphragm Cell.* In the cell of this type the liquor around the anode is completely separated from that around the cathode by means of a diaphragm. This diaphragm must be composed of some material that will resist the action of the solutions in the cell, and at the same time not offer any great resistance to the passage of the current. This is the type of cell employed by the Canadian Industries, Limited, at their chemical branch, Sandwich, Ont.

*Difference in Density of Original Solution and Products.* By this method advantage is taken of the difference in the specific gravity of the original solution and the product formed at the electrodes. The process, as applied to the production of caustic soda and chlorine, consists in placing the cathode in the bottom of the cell with the anode at the top. This arrangement allows the chlorine to be liberated without having much of the solution to traverse, and the caustic soda, being heavier than the salt solution, remains in the bottom of the cell, and is drawn off from time to time.

*Mercury Cathode.* In this method a mercury cathode is employed. The sodium is separated from the chlorine in the cell in the form of amalgam with the mercury, and can be removed and afterwards converted into the hydrate form. This method causes little wear and tear on the cells; but it requires a large quantity of mercury to be constantly in use for each ton of caustic produced.

### Products from the Electrolysis of Salt

There are three products resulting from the electrolytic decomposition of brine, namely chlorine gas, weak caustic soda solution, and hydrogen gas.

### Chlorine

The chlorine gas coming from the cells is cooled and dried to remove all the moisture and in consequence can be handled in iron equipment since dry chlorine does not attack iron. The gas may then be used in several ways.

It may be passed through slaked lime to produce bleaching powder, a compound which has the power to readily give up its chlorine when acted upon by an acid.

In brief, the process generally employed consists of passing the chlorine gas through a series of large lead-lined chambers, in which slaked lime is spread on the floor to a depth of about two inches. The floor is made of cement and asphalt, in which are buried the pipes for the cooling process. The prepared bleach is drawn from the chambers by means of openings in the floors. Generally, a number of these chambers are operated in series, thus doing away with the necessity of stirring the lime, and the consequent escape of chlorine gas during the turning operation.

Bleaching powder, or chloride of lime, was used extensively in the bleaching of vegetable fibres, for the bleaching of pulp and paper, and also as a disinfectant; but of recent years it has largely been replaced for these purposes by liquid chlorine.

#### LIQUID CHLORINE

One of the largest uses made of the chlorine gas from the electrolytic cells is for the preparation of liquid chlorine. By means of suitable cooling and compression machinery the pure dry gas is liquefied and shipped to the trade in 150-pound cylinders or specially built 15- and 30-ton tank cars. In these cylinders and tank cars the liquid chlorine is under a pressure of about 100 pounds per square inch at ordinary summer temperature (78°F).

#### USES OF LIQUID CHLORINE

*Bleaching in the Pulp and Paper Mills.* As already stated, where formerly bleaching powder was used entirely for the manufacture of bleaching liquor in the pulp and paper industry, in the larger mills liquid chlorine is now employed. The advantages of preparing bleach liquor from liquid chlorine and a suitable brine are:—

1. More efficient bleaching due to a more neutral solution.
2. A decided saving in bleach cost.
3. Production of a more stable bleach liquor.
4. Reduced amount of sludge to be handled.
5. Elimination of the disagreeable features from the bleach house.
6. Less labour required.
7. No loss of chlorine in transit.

When small quantities of bleach liquor are required or where a suitable lime is not readily available, it has been found advantageous to use liquid chlorine in conjunction with bleaching powder. On dissolving bleaching powder in water to produce bleach liquor there is always a considerable amount of sludge remaining after the available chlorine has been extracted. Since the greater part of this is lime, if liquid chlorine is added it will combine with it to form exactly the same bleaching agent as was extracted from the bleaching powder, thus greatly increasing the capacity of the bleach liquor plant as well as reducing the cost of the bleach liquor.

*Bleaching in the Textile Mill.* Liquid chlorine has made the manufacture of bleaching solution for the textile mill a simple matter. Sodium hypochlorite, the solution used, is made by dissolving a definite quantity of caustic soda and adding the required quantity of liquid chlorine to satisfy the equation. The advantages of using liquid chlorine in place of bleaching powder are that no settling is required, no lime to precipitate in the fibres so that a softer textured fibre is produced, and the tensile strength of the fibres is increased.

*Water Purification.* Many of the diseases, such as typhoid fever, cholera, dysentery, etc., which have in the past taken heavy toll of life throughout the world, have been traced directly to the use of contaminated drinking water. With the increasing tendency of human beings to flock to cities it has become more and more important to supply such centres with a pure water supply. It is rarely that a sufficient supply of pure water in its natural state can be obtained, so that some means of purifying existing supplies has to be resorted to. Mechanical filtration plants have met with good success in reducing the typhoid death rate, but in spite of the success of such methods some germs still remain and it is necessary to destroy them. For this purpose liquid chlorine has been found to be eminently satisfactory.

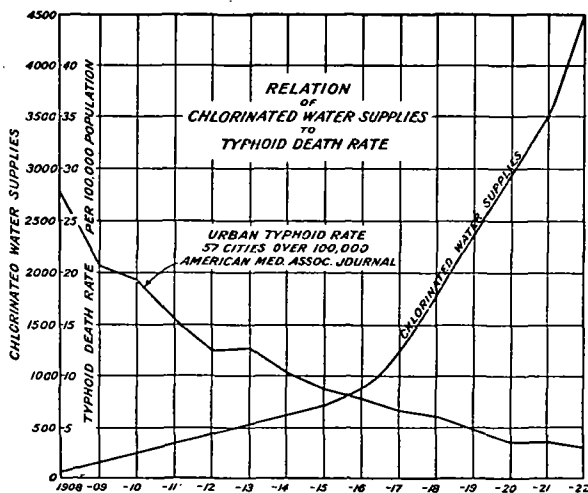


Figure 30.

Chloride of lime was first used for this purpose on the North American continent in 1908 and inside of two years over 200 cities in Canada and the United States were using water sterilized by this agent with a marked reduction in typhoid fever accompanied by a general reduction in the death rate due to this disease.

The placing of liquid chlorine on the market a few years later quickly led to its being substituted for chloride of lime as a water sterilizer with a consequent greater degree of control and more complete sterilization. The accompanying chart, Figure 30, shows the effect that chlorinated water supplies has had on the typhoid death rate in 57 cities of over 100,000 population in the years 1908 to 1922.

Liquid chlorine has also been employed to an increasing extent each year in the sterilizing of sewage effluents being discharged into rivers and lakes.

Use of liquid chlorine as a sterilizing agent has been made in creameries and other bottling works for the final sterilizing of the bottles, as well as in removing the noxious odours around pulp mills, incinerator plants, etc.

*Manufacture of Synthetic Hydrochloric Acid.* Synthetic hydrochloric acid is now made by burning hydrogen in an atmosphere of chlorine, and this method is now being employed at the Sandwich plant of the Canadian Industries, Ltd. The burners and absorption system is made entirely of fused silica and the acid produced is pure and water-white, 22° Baumé.

The distribution of chlorine manufactured in Canada and the United States is estimated to be in the following proportions to the different industries:—

Pulp and paper industry.....	50 per cent
Sanitation.....	15 “
Textile industry.....	15 “
All other industries.....	19 “

There are many other uses for liquid chlorine besides those here mentioned and its use is becoming more prevalent in the various branches of the industrial field. Thus it is used for sterilizing swimming pools, in refining oils, in ageing flour, in bleaching shellacs, in metallurgical processes, and as a medical disinfectant.

During the World War chlorine gas was the first poisonous gas employed but later a number of other gases were developed all of which had chlorine as a base or as an essential constituent.

Thus a material which in war was employed to produce agony and death, has in an era of peace been applied to industry with such success that at present it is really essential to modern present conditions of life.

### *Caustic Soda*

When brine is decomposed in the electrolytic cell a weak solution of caustic soda is produced. This solution, together with some undecomposed brine is carried to the evaporator department where the sodium chloride is removed and the solution is concentrated to 50 per cent strength. It can be shipped as liquid caustic in this form or further concentrated in evaporators and prepared for the market in the solid state, in which state it is shipped as solid, ground, or flaked, according to the demands of the different industries.

#### USES OF CAUSTIC SODA

Caustic soda finds an extensive use in many industries such as the manufacture of soap, in the refining of petroleum, manufacture of rayon, as household lye, in the pulp and paper industry, etc.

In 1927 the distribution of the total production of caustic soda in the United States was estimated by "Chemical and Metallurgical Engineering" to be approximately as follows:—

	Per cent
Soap industry.....	16.3
Petroleum refining.....	14.9
Miscellaneous chemicals.....	15.5
Rayon industry.....	11.8
Exports.....	8.7
Textile finishing.....	7.7
Household lye.....	6.3
Pulp and paper industry.....	6.0
Rubber reclaiming.....	5.6
Vegetable-oil refining.....	2.2
Miscellaneous.....	5.0

### *Hydrogen*

The third product of the decomposition of brine in the electrolytic cell is hydrogen gas. Use can be made of this for the manufacture of hydrochloric by burning it in an atmosphere of chlorine as already stated, or it may be made use of to make synthetic ammonia.

### *Hydrochloric Acid*

The production of hydrochloric acid from sodium chloride is also accomplished during the process previously described for the making of salt cake. The acid escaping from the pans or roasters of the salt cake manufacture is condensed in suitable condensing apparatus. Many types of condensing apparatus are employed, all more or less satisfactory.

## CHAPTER VI

## THE SALT INDUSTRY OF CANADA

The salt industry is one of Canada's oldest non-metallic industries, salt having been harvested both from the springs in Manitoba and in the Mackenzie River basin by officials of the Hudson's Bay Company in the early years of the last century. The production from these sources, however, was small and sufficient only to supply local demand.

The discovery of salt at Goderich, Ontario, in 1866 while drilling for oil, was the real beginning of the industry on an extensive scale, and less than six years after this discovery there were nearly a dozen plants in that part of Ontario manufacturing salt, the capacities running from 100 to 600 barrels per day.

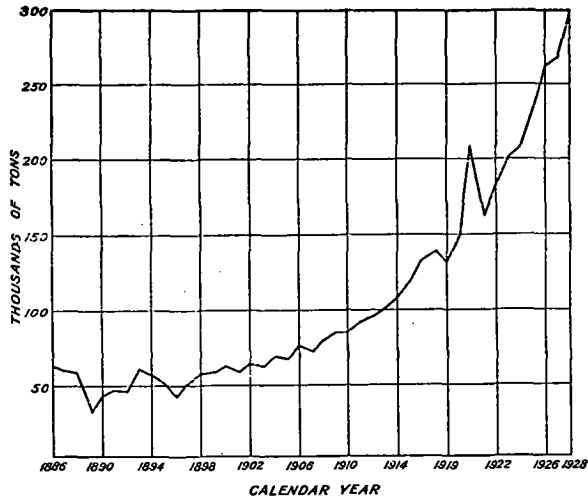


Figure 31. Chart showing production of salt in Canada, 1886-1928.

However, little real progress was made until the year 1911 when the Canadian Salt Company's plant for the manufacture of caustic soda and bleaching powder from salt brine was put into operation. The increase in production from that time has been very rapid as shown by Figure 31.

In 1917 the deposit at Malagash, N.S., was discovered, production starting the next year. The salt deposits in the McMurray field of Alberta, while known for a number of years previously, were not operated until 1925. Although they are not being worked at present, there is little doubt that the area will be extensively prospected in the near future, and, as the market for salt in the western provinces expands, salt from this locality will be an important factor.

The discovery of a thick deposit of salt at depth near Gautreau, N.B., some 18 miles southeast of Moncton, in 1921, has placed that province in a very favourable position for the production of salt. No attempts to operate this deposit have so far been made, although other drill holes recently put down prove the deposit to be of considerable magnitude, and one which adds greatly to the salt reserves of the country.

At present the two districts in which salt deposits are being exploited are the Ontario field and the Malagash field. The western half of Canada has no operating plants and its supply must come from either the Ontario field or imported from the United States or other countries. This in some measure accounts for the large proportion of the Canadian consumption being imported.

### CONSUMPTION

The production of salt in Canada has never equalled the consumption, the percentage produced in Canada of the total consumption for the last five years being:

	Per cent
1924.....	53.34
1925.....	54.99
1926.....	53.92
1927.....	60.48
1928.....	61.67

The reason for this has, in a large measure, been due to the situation of the working deposits with respect to the markets. For many years the only operating plants were in the Ontario field and this field is unfavourably situated with respect to the fisheries industry which is probably the largest individual consumer of salt in the whole country. Since the biggest centres of this industry are on the Atlantic and Pacific seaboard of the Dominion, far removed from the Ontario field, the supply of salt is naturally drawn from the cheapest source, which has generally been the imported material. With the opening up of the Malagash deposits in Nova Scotia the situation in the Maritime Provinces has been somewhat improved, but it takes time to place a new industry on an economical basis and to educate and prove to the consumers that the local material is in every way as good if not better than the imported article which they have used for years.

The fishing industry on the Pacific coast of Canada has still to depend on imported salt for use in curing fish so that until a deposit is found and a plant for the production of salt erected sufficiently near the western seaboard, importation of salt into British Columbia will continue.

It will, therefore, hardly be likely for some years to come that the Canadian production of salt will equal the consumption.

### MARKETING OF SALT

The marketing of salt is becoming each year increasingly more technical. Whereas in the early days of the industry in Canada, salt was sold in only a few different grades, generally as a side line by a salesman who depended on his main income from other lines, the demands of the several industries using salt have become stricter both as to quality and texture,



and so many new uses for salt have been found, that it has become necessary for a salesman not only to devote his whole time to the selling of salt, but he must of necessity be thoroughly conversant with the industries using his product as well as the nature of his goods, that he may intelligently advise his customers as to the advantages gained by using the increasingly purer grades that are now being produced. He must also have sufficient technical training so that he can authoritatively report on any difficulties encountered in the use of salt by any of his customers and to suggest remedies.

The day when one salt was as good as another has passed, and this is well illustrated in the part played by salt in curing meats. The curing of meat is in large part due to the withdrawal of water from the cellular structure of the meat. The presence of calcium and magnesium salts in even small quantities has a marked effect in decreasing the permeability of the membranes in the meat thus greatly retarding the time required for curing. By using a highly purified salt several Canadian meat-packing firms have greatly increased their output due to a more rapid cure, and have also distinctly improved the flavour of their products, since calcium and magnesium salts tend to impart to the meat a bitter taste. Similar illustrations might be given showing the benefits to be derived from using high-grade salt in a number of industries such as bread-making, butter-making, etc.

The education of the several industries and also the public to the advantages of using high-grade salt necessitates extensive advertising campaigns, and the sales staff and advertising department of a salt company has, from a small beginning, become one of the most important branches of the industry.

A salt company, in order to keep up with the rapid advances being made in all lines of industry, must of necessity have a well organized research staff, not only to keep a constant check on the quality of its products, but also to carry on research work to find new uses for salt, and to study the needs of the salt-using industries in an endeavour to assist them in getting the best possible results from their use of salt and incidentally increase the consumption. That such a policy is well worth while has been repeatedly demonstrated.

In Canada the salt industry was, until 1911, of very limited extent, the per capita production in that year being 25 pounds. In 1928 the per capita production had risen to 62 pounds. That there is still room for expansion in this industry is shown when compared with the United States which had a per capita production in 1927 of 110 pounds.

The future possibilities of a forward movement in this industry are manifest when we glance at certain pertinent facts. The most obvious is the rapid increase in the population of our inland cities as well as the whole Dominion, with a corresponding demand for supplies of salt for domestic use; and to this may be added the increasing commercial supplies needed to keep pace with the rapid industrial growth of the country.

The extensive deposits being operated in Ontario and Nova Scotia have placed Ontario and the Maritimes in a very favourable position with respect to salt, and the increased requirements of the eastern part of Canada can reasonably be expected to be supplied by these deposits together with the recently proven beds of salt in New Brunswick.

On the other hand the western provinces, being at present minus any operating plants, are obviously at a great disadvantage since they have to pay high freight rates on the whole of their supply. But saline deposits are known to exist in northern Manitoba, and rock salt deposits in the McMurray district of Alberta, and with systematic drilling with a core drill, deposits of sufficient size to warrant working will probably be discovered. Such a discovery would furnish a cheap supply to meet the increasing demand of the Prairie Provinces.

The rapid growth of industry in Canada has naturally increased the demand of those chemicals derived from salt and plants are already in successful operation in Ontario using the large deposits of sodium chloride as a base from which to produce other chemicals. Past enterprise in this direction has only touched the fringe of the available resources, and the chance of profitable exploitation and investment along this line of industry is worthy of serious consideration.

### IMPORTS

The rates of duty on salt entering Canada are as follows:—

Tariff item		British Preferential tariff	Intermediate tariff	General tariff
40	Salt, for use of the sea or gulf fisheries.....	Free	Free	Free
41	Salt, n.o.p., in bags, barrels and other coverings, per one hundred pounds.....	Free	6½ cts.	7½ cts.
	Bags, barrels and other usual coverings, used in the importation of salt specified in this item	Free	25 p.c.	25 p.c.
42	Salt, in bulk, n.o.p., per one hundred pounds....	Free	4 cts.	5 cts.
42 A	Salt, table, made by an admixture of other ingredients, when containing not less than 90 per cent of pure salt.....	5 p.c.	10 p.c.	15 p.c.

The amount of salt being imported into Canada is still considerable, being nearly 40 per cent of the total requirements, but since 1923 there has been a steady decrease in importations. The greater proportion of the imports enters Canada for consumption on the Atlantic and Pacific seaboard for use in the fisheries and also as salt in bulk, so that until the Maritime deposits are further developed and deposits in western Canada are opened up, these importations will continue.

### EXPORTS

The export trade of Canada in salt has heretofore been small, but there is a steady and increasing market for some of the higher grades that Canada has to offer, so that there will probably be a small but steady increase in exports each year. In this connexion the export trade for chemicals made from salt is well worthy of serious study.

The following tables give the statistics of the salt industry up to the year 1928. The data for these tables were obtained from published figures of the Mining, Metallurgical and Chemical Branch of the Dominion Bureau of Statistics, Department of Trade and Commerce, Ottawa.

**TABLE VIII**  
**Production of Salt in Canada by Grades, 1924-28**

Grade	1924			1925			1926			1927			1928		
	Manu- factured	Sold	Value of salt sold (not including packages)	Manu- factured	Sold	Value of salt sold (not including packages)	Manu- factured	Sold	Value of salt sold (not including packages)	Manu- factured	Sold	Value of salt sold (not including packages)	Manu- factured	Sold	Value of salt sold (not including packages)
	Tons	Tons	\$	Tons	Tons	\$	Tons	Tons	\$	Tons	Tons	\$	Tons	Tons	\$
Table and dairy.....	41,198	41,134	663,296	47,452	46,790	713,571	50,642	50,905	762,491	53,649	53,477	802,922	56,252	56,214	708,927
Common fine.....	37,701	36,706	272,301	34,383	33,197	180,297	46,131	47,202	241,320	46,808	47,185	297,824	52,112	51,055	258,781
Common coarse.....	36,205	34,345	266,895	46,637	43,931	312,107	30,937	32,785	228,395	41,754	39,617	309,667	47,328	46,146	311,301
Land salt.....	4,920	4,862	23,889	5,133	5,125	21,826	4,170	3,965	16,865	5,955	5,829	37,072	3,662	3,685	17,798
Other grades.....	7,654	7,872	65,340	11,799	11,203	83,396	15,178	14,670	118,058	6,740	6,569	51,187	7,019	7,204	63,874
Brine for chemical works (salt equivalent sold or used).....	83,059	83,059	83,059	93,500	93,500	93,500	113,020	113,020	113,020	115,995	115,995	115,995	135,138	135,138	135,290
Total.....	210,737	207,979	1,374,780	238,904	233,746	1,410,697	260,078	262,547	1,480,149	270,901	268,672	1,614,667	301,511	299,445	1,495,971
Value of packages.....	.....	.....	548,631	.....	.....	548,528	.....	.....	569,396	.....	.....	524,437	.....	.....	580,822
Grand total.....	.....	.....	1,923,411	.....	.....	1,959,225	.....	.....	2,049,545	.....	.....	2,139,104	.....	.....	2,056,793

TABLE IX

## \*World Production of Salt, 1913 and 1923-27

(Long tons)

Country	1913	1923	1924	1925	1926	1927
<b>BRITISH EMPIRE</b>						
United Kingdom.....	2,203,732	1,886,882	2,045,762	1,933,590	1,727,443	1,983,486
Mauritius.....	(a)	1,500	1,500	1,500	1,500	1,500
Nigeria.....	394	400	400	400	400	400
Somaliland.....	(a)	1,707	1,446	2,336	2,077	2,367
South-West Africa Territory.....	(a)	(a)	335	425	400	400
Sudan.....	4,601	9,000	9,000	9,000	9,000	9,000
Tanganyika Territory.....	(a)	1,887	4,556	4,000	3,105	4,775
Union of South Africa.....	42,837	61,188	69,258	58,333	79,245	(a)
Canada.....	89,992	180,711	185,695	208,702	234,417	239,886
West Indies—						
Bahamas.....	26,000	2,680	1,570	1,291	7,358	1,893
Turks and Caicos Islands.....		58,060	52,327	62,432	53,958	27,923
Ceylon.....	13,190	28,279	9,263	20,263	15,962	(a)
Cyprus.....	(a)	766	22	3,000	3,000	3,000
India.....	1,472,784	1,900,829	1,623,475	1,295,144	1,638,749	1,611,945
Weihaiwei.....	(a)	2,000	2,000	2,000	2,000	2,000
Australia.....	64,981	98,286	110,687	126,251	139,101	123,212
<b>Total.....</b>	<b>3,918,491</b>	<b>4,234,175</b>	<b>4,117,296</b>	<b>3,728,667</b>	<b>3,917,715</b>	<b>4,011,787</b>
<b>FOREIGN COUNTRIES</b>						
Austria.....	358,887	81,953	109,382	128,705	142,849	145,741
Bulgaria.....	(a)	(a)	36,000	25,000	(a)	(a)
Czechoslovakia.....	See Austria	131,925	122,768	75,591	96,556	120,272
France.....	1,261,364	1,127,031	1,267,881	(b)1,327,049	(b)1,419,216	1,315,300
Germany.....	2,034,391	1,845,404	1,941,973	2,188,347	2,406,772	2,733,500
Greece.....	18,906	58,945	67,440	3,507	88,309	(a)
Italy.....	633,722	752,376	794,346	900,922	754,150	(a)
Jugoslavia.....	26,843	45,000	48,079	53,638	51,435	53,900
Netherlands.....	(a)	25,969	31,895	34,191	34,894	37,439
Poland.....	See Russia	357,468	365,217	423,197	450,277	530,792
Rumania.....	329,613	301,684	297,895	325,139	338,628	322,847
Russia.....	1,963,405	924,016	998,443	1,404,862	1,615,825	2,387,651
Spain.....	600,612	704,322	952,744	846,556	1,079,939	(a)
Switzerland.....	506,718	66,951	72,851	73,954	76,047	(a)
Algeria.....	26,566	24,676	23,163	26,579	42,534	36,353
Belgian Congo.....	79	80	80	80	80	80
Egypt (exports).....	154,640	154,758	206,584	207,795	177,617	219,020
Eritrea (estimated).....	19,678	20,000	20,000	20,000	20,000	20,000
Tripoli (estimated).....	(a)	(a)	(a)	19,000	19,000	19,000
Tunis.....	(a)	72,000	121,619	126,378	(a)	(a)
Dutch West Indies.....	13,201	11,605	8,751	19,087	(a)	(a)
Mexico (estimated).....	65,923	66,000	66,000	66,000	66,000	66,000
United States.....	4,298,638	6,366,708	6,074,210	6,604,909	6,581,786	6,757,759
Argentina.....	54,034	(a)	120,464	74,160	(a)	(a)
Chile.....	19,244	37,627	35,513	28,863	(a)	(a)
Colombia.....	28,534	29,000	29,000	29,000	29,000	29,000
Peru.....	24,040	26,096	28,513	23,002	28,661	(a)
Venezuela.....	(a)	30,000	30,000	30,000	30,000	30,000
China including Kwantung Peninsula (estimated).....	1,700,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
Dutch East Indies.....	100,449	122,066	129,741	434,364	375,173	(a)

TABLE IX—Concluded

## \*World Production of Salt, 1913 and 1923-27—Concluded

(Long tons)

Country	1913	1923	1924	1925	1926	1927
<b>FOREIGN COUNTRIES</b>						
Formosa.....	72,869	235,400	134,000	136,000	133,059	(a)
French Indo-China.....	(a)	11,215	4,184	5,861	20,152	27,263
Japan.....	629,721	472,195	626,929	657,935	710,528	1,067,944
Portuguese India.....	11,807	12,000	12,000	12,000	12,000	12,000
Siam.....	(a)	32,428	39,923	124,094	123,685	113,534
Turkey.....	(a)	100,000	100,000	100,000	100,000	100,000
Philippine Islands.....	19,186	30,803	28,454	30,120	23,695	(a)
Total.....	14,973,070	16,277,701	16,946,042	18,584,885	17,432,042	18,145,395
Grand total.....	18,891,561	20,511,876	21,063,338	22,313,552	21,349,757	22,157,182

\*Source prior to 1925.—Imperial Institute publications. Data for 1925 and 1926 obtained directly from the statistical bureaus of the different countries.

(a) Data not available.

(b) Exclusive of sea salt.

TABLE X

## Status of the Salt Industry in Canada

(For past 20 years in 5-year periods)

Period	Calendar years	Production		Consumption	
		Tons	Value	Tons	Value
			\$		\$
Pre war.....	1909-1913	455,555	2,218,709	1,121,554	4,584,411
War.....	1914-1918	630,477	4,144,358	1,396,161	8,222,943
Post war.....	1919-1923	907,005	7,958,178	1,705,238	14,018,068
Post war.....	1924-1928	1,272,389	7,376,264	2,194,492	12,713,559

TABLE XI

## Principal Statistics of the Salt Industry in Canada, 1924-28

Year	Number of firms	Capital employed	Number of employ-ees	Salaries and wages	Cost of fuel and electricity	Selling value of products
		\$		\$	\$	\$
1924.....	11	2,479,563	364	431,618	342,118	1,374,780
1925.....	12	2,563,508	402	467,487	315,368	1,410,697
1926.....	11	2,782,728	384	482,651	324,612	1,480,149
1927.....	10	3,194,802	376	499,967	287,260	1,614,667
1928.....	10	4,422,922	455	539,775	252,468	1,495,971

TABLE XII

## Production, Imports, Exports, and Consumption of Salt in Canada, 1924-28

	1924		1925		1926		1927		1928	
	Tons	Value	Tons	Value	Tons	Value	Tons	Value	Tons	Value
Production.....	207,979	1,374,780	233,746	1,410,697	262,547	1,480,149	268,672	1,614,667	299,445	1,495,971
Imports—		\$		\$		\$		\$		\$
Salt, for the use of the sea or gulf fisheries....	71,179	339,557	80,398	329,820	83,929	327,040	62,102	328,824	74,192	417,594
Salt, in bulk, n.o.p.....	68,199	332,649	73,166	327,364	75,965	393,747	72,933	321,538	68,765	254,218
Salt, n.o.p., in bags, parcels, etc.	43,508	462,184	40,061	420,137	28,053	284,118	40,882	376,648	45,589	416,149
Salt, table, made by an admixture of other ingredients, when containing not less than 90 per cent of pure salt.. (From April 1st, 1926) .....					454	31,689	844	55,070	479	35,007
Total imports.....	182,886	1,134,390	193,625	1,077,321	188,401	1,036,594	176,761	1,082,080	189,025	1,122,968
Exports.....	965	10,795	2,324	26,678	1,164	19,423	1,212	22,793	2,930	36,399
Apparent consumption of salt.....	389,900	2,498,375	425,047	2,461,340	449,784	2,497,320	444,221	2,673,954	485,540	2,582,570

TABLE XIII

## Production of Salt in Canada, 1886-1928

Year	Tons	Value	Year	Tons	Value	Year	Tons	Value
		\$			\$			\$
1886.....	62,359	227,195	1901.....	59,428	262,328	1916.....	132,903	717,653
1887.....	60,173	166,394	1902.....	64,456	292,581	1917.....	138,909	1,047,792
1888.....	59,070	185,460	1903.....	62,452	297,517	1918.....	131,727	1,285,039
1889.....	32,832	129,547	1904.....	69,477	321,778	1919.....	148,301	1,397,929
1890.....	43,754	198,857	1905.....	67,340	320,858	1920.....	209,855	1,544,724
1891.....	45,021	161,179	1906.....	76,720	329,130	1921.....	164,658	1,673,685
1892.....	45,486	162,041	1907.....	72,697	342,315	1922.....	181,794	1,628,323
1893.....	62,324	195,926	1908.....	79,975	378,798	1923.....	202,397	1,713,516
1894.....	57,199	170,687	1909.....	84,037	415,219	1924.....	207,979	1,374,780
1895.....	52,376	160,455	1910.....	84,092	409,624	1925.....	233,746	1,410,697
1896.....	43,960	169,693	1911.....	91,582	443,004	1926.....	262,547	1,480,149
1897.....	51,348	225,730	1912.....	95,053	459,582	1927.....	268,672	1,614,667
1898.....	57,142	248,639	1913.....	100,791	491,280	1928.....	299,445	1,495,971
1899.....	59,339	254,390	1914.....	107,038	493,648			
1900.....	62,055	270,458	1915.....	119,900	600,226	Total...	4,612,409	27,178,464

## INDEX

	PAGE		PAGE
Acknowledgments.....	1	Canadian Industries, Ltd. <i>See also</i>	
Addington Forks.....	5	Kincardine Salt Co.—	
Admiral island. <i>See</i> Saltspring island		Description of plants and products... 40-46	
Admiralty island. <i>See</i> Saltspring island		Photos.....42, 44, 46	
Ailsa Craig.....	30	Log of well at Windsor..... 30	
Alberger process for brine evaporation... 87	87	Canadian Salt Co. <i>See also</i> Canadian	
Alberta—		Industries, Ltd.—	
Brine springs..... 58-64	58-64	Early operations of.....30, 34	
Rock salt..... 65-70	65-70	Cape Breton island, brine springs.....2, 3-5	
Alberta and Great Waterways R. well—		Caustic soda—	
Analyses of salt from..... 69	69	Manufacture of, from salt at Canadian	
Log of..... 68	68	Industries Ltd. plant...34, 45, 46, 99, 102	
Alberta Government, wells drilled by... 66-68	66-68	Uses.....102, 103	
Alberta Salt Co., operations..... 68, 69	68, 69	Ceylon, production..... 109	
Photo..... 64	64	Chambers, A. R.—	
Algeria—		Rept. quoted..... 14	
Brines..... 75	75	Work at Malagash..... 12	
Production..... 109	109	Chilcotin r., brine springs..... 73	
Allan, J. A., rept. quoted..... 60, 62, 66, 67	60, 62, 66, 67	Chile—	
Antigonish, brine springs..... 3, 5, 6	3, 5, 6	Production..... 109	
Argentina, production..... 109	109	Salt occurrences..... 75	
Arkona..... 31	31	China, production..... 109	
Athabaska r., brine springs..... 63	63	Chlorine—	
Australia, production..... 109	109	Manufacture of, from salt at Canadian	
Austria, production..... 109	109	Industries Ltd. plant at Sandwich,	
		Ont.....99, 100	
		Uses.....100-102	
Baddeck, brine springs..... 5	5	Christina r., brine springs..... 58, 64	
Baddeck bay..... 5	5	Clinton—	
Bahamas, production..... 109	109	Log of well at.....28, 30	
Bailey, L. W., rept. quoted..... 19	19	Salt at..... 33	
Belgian Congo, production..... 109	109	Colchester county, brine springs..... 3, 7	
Bell, W. A., rept. cited..... 19	19	Colombia—	
Bell r., brine springs..... 51, 52	51, 52	Production..... 109	
Birch r..... 64	64	Salt occurrences..... 75	
Birchwood, brine springs..... 10	10	Congo. <i>See</i> Belgian Congo.	
Blyth..... 30	30	Conn bk., brine springs..... 7	
Bonaparte r..... 73	73	Cook brine spring..... 10	
Bosanquet..... 31	31	Courtright..... 31	
Brierly bk., brine springs..... 6	6	Cumberland county..... 3, 7, 10	
Brine springs—		Cypress, production..... 109	
Occurrences:		Czechoslovakia, production..... 109	
Alberta..... 58-64	58-64	D'Arcy Exploration Co., drilling by..... 21	
British Columbia..... 70-73	70-73	Dauphin l..... 49, 51	
Manitoba..... 47-55	47-55	Dawn tp..... 31	
Nova Scotia..... 2-10	2-10	Dawson, G. M., rept. cited..... 73	
Saskatchewan..... 55-57	55-57	Dawson bay, brine springs..... 49, 52, 53	
World..... 75	75	Deacon, Josiah..... 5	
Recovery of salt from.....77, 78, 81-88	77, 78, 81-88	Deep ck..... 66	
British Columbia, brine springs..... 70-73	70-73	Dominion well, capacity..... 33	
British Columbia Salt Works, Ltd.,		Dominion Salt Co.—	
deposit and plant with map..... 70-72	70-72	Description of plant.....37, 38	
British Empire, salt production..... 109	109	Log of well..... 29	
Brown, Wilfred, brine in well..... 11	11	Douglas seam..... 73	
Bruce county..... 30	30	Drilling for salt—	
Brunner Mond Co..... 34	34	Alberta..... 65-68	
Brussels..... 30	30	British Columbia..... 70, 72	
Bucklaw, brine springs..... 3, 4	3, 4	Manitoba..... 65	
Photo..... 4	4	New Brunswick..... 21-25	
Bulgaria, production..... 109	109	Nova Scotia..... 4, 6, 19	
		Ontario, early well records..... 27-31	
Caicos island, production..... 109	109	methods employed..... 78	
Callaghan, John..... 68, 69	68, 69	Duck r..... 48	
Calvert, A. F., rept. quoted..... 87	87	Dunmore..... 6	
Cameron, A. E., rept. cited..... 62	62	Dutch East Indies, production..... 109	
Camperville, brine springs..... 53	53	Dutch West Indies, production..... 109	
Camsell, Charles, rept. quoted..... 61	61	Duties. <i>See</i> Tariff.	

	PAGE		PAGE
East Hansford, brine spring.....	10	Imports, Canada.....	107, 111
Edmonds, Prof. F. H., rept. quoted.....	57	Inniskillen well, capacity.....	33
Egypt, exports.....	109	International well—	
Electrolysis of salt.....	98	Capacity.....	33
Ells, S. C., rept. quoted.....	58	Depth.....	30
Ellsworth, H. V., work by, in Malagash area.....	14	Inverness county, brine springs.....	2, 3
Elmwood.....	55	Italy—	
Enniskillen tp.....	31	Analysis of salt from.....	15
Eritrea, production.....	109	Production.....	109
Essex county.....	31	Japan, production.....	110
Etheridge, Howard, brine springs on farm	6	Jugoslavia, production.....	109
Ettinger, Caleb, brine spring.....	10		
Ettinger bk., brine springs.....	10	Kelso, John, analyses by.....	69, 70
Evaporation of brines.....	81-88	Kempton, brine springs.....	3, 7
Exeter.....	30	Kennetcook Corner.....	10
Exports, Canada.....	107, 111	Kent county, depth of salt beds.....	31
Falmouth, rock salt.....	19	Kettles, use of, in brine evaporation.....	82
Filters, use of, in salt manufacture.....	86	Kincardine, depth of salt.....	30
Firebag r., brine springs.....	58, 64	Kincardine Salt Co.—	
Fletcher, Hugh, rept. quoted.....	5	Description of plant.....	34-36
Forbes, Donald G., rept. quoted.....	70	Log of well.....	28
Formosa, production.....	110	Kincardine well, log of.....	28
Fort Smith, brine springs near.....	62	Kindle, E. M., rept. cited.....	62
Photo.....	64	Kings county, N.B., brine springs.....	19-21
France, production.....	109	Kwinitsa, brine springs.....	70
Fraser, F. J., rept. quoted.....	21		
French Indo-China, production.....	110	Lambton county, depth of salt bed.....	31
		La Saline l., brine springs.....	58-60
Gautreau, N. B., rock salt deposit.....	21-25	Photos.....	58
Germany, production.....	109	Le Blanc process for making soda ash....	97
Gibbs, A. E., electrolytic cell, described and figured.....	44, 45	Leverin, H. A., analyses by.....	1
Gillespie, J.....	68	Liard r.....	64
Gladstone.....	51	Liverpool, analyses of salt from.....	15
Glencoe, depth of salt at.....	27, 30	Logan, J. F., analyses of salt by.....	15
Glendyer, brine springs.....	2, 5	London, Ont., depth of salt bed at.....	30
Goderich Petroleum Co.....	32		
Goderich Salt Co.—		McBride, J., brines on farm of.....	51
Description of plant.....	36	McConnell, R. G.....	60, 61, 63
Early operations and capacity of well..	33	McKay, D. M.....	7
Graduation method of salt recovery. <i>See</i> Wind evaporation.		McKay, George.....	12
Grainers, description and use.....	83	McMurray—	
Great Bear r.....	64	Brine springs near.....	58
Greece, production.....	109	Rock salt.....	65-68
		Mackenzie dist., brine springs.....	61-64
Halite. <i>See</i> Rock salt.		Maiden ck.....	73
Hants county, brine springs.....	10	Maitland r.....	31
Hargreaves and Bird process for soda ash	96	Mnitland well, capacity.....	33
Hargreaves process for making sodium sulphate.....	97	Malagash Salt Co. <i>See also</i> Malagash salt mine.—	
Harmon, D. W., rept. quoted.....	58	Description of plant with flowsheets... 16-18	
Hartford, brine springs.....	7	Photos.....	Frontispiece 14
Hawley's salt well, capacity.....	33	Malagash salt mine—	
Hayes, A. O., rept. quoted.....	12, 13	Analyses of salt from.....	15
Hendricks, Geo. N.....	19	Described.....	11-18
Hensall, depth of salt at.....	30	Photos.....	4, 12
Hind, Prof. H. Y., rept. quoted.....	47	Production.....	12
Hodge, A.....	33	Manitoba, salt occurrences.....	47-55
Hodgkinson process for evaporating brines	87, 88	Manufacture of salt from brines.....	76-78
Horse ck., salt brines.....	68	rock salt.....	78-88
How, Dr. Henry, analysis quoted.....	7	Maritime Provinces, salt deposits in....	2-25
Hubel, J. H. <i>See</i> Pritchard and Hubel.		Marketing of salt.....	105-107
Hudson Bay Co., salt springs worked by	47, 53, 63, 73	Preparation for market.....	88, 89
Hunt, T. Sterry, rept. quoted.....	32, 33	Mauritius, production.....	109
Huron county, depth of salt.....	30	Mayne, Hibbert, brine springs.....	10
Huron well, capacity.....	33	Mexico, production.....	109
Hydrochloric acid manufacture.....	102, 103	Middlesex county, depth of salt in.....	30
Hydrogen—		Mission salt spring, analyses.....	63
Manufacture of, from salt.....	99	Monkman, James.....	47
Uses.....	103	Monkman salt springs.....	51, 53
		Mossy r.....	51
		Muriatic acid.....	46
		Murray, Peter.....	11



	PAGE		PAGE
Nahanni Butte.....	64	Rock salt— <i>Concluded</i> —	
Nanaimo, brine springs.....	73	Occurrences—Canada—	
Neepawa, brines.....	51	Alberta.....	67-70
Netherlands, production.....	109	New Brunswick.....	21-25
New Brunswick—		Nova Scotia.....	11-19
Brine springs.....	19-21	Ontario.....	26-34
Rock salt.....	21-25	Saskatchewan.....	57
New Brunswick Gas & Oilfields, Ltd.,		Foreign.....	75
drilling by, with logs of wells.....	21-25	Recovery of salt from.....	78-88
New salt spring, analyses.....	63	Rondeau Park well, deptb of salt bed....	31
Nigeria, production.....	109	Roslin, brine springs.....	7
Nissouri West tp., depth of salt beds.....	31	Rumania, production.....	109
Norman, G.W.H.....	5	Rumball, Geo. & Co.....	32
Northern Alberta Exploration Co.....	65	Russia, production.....	109
North West Territory, brine springs.....	64	Russell bk.....	60
Nova Scotia—		St. Patrick channel.....	3
Brine springs.....	2-10	Salina, N.B., brine springs.....	20
Map showing location.....	2	Salina formation, Ont.....	26
Rock salt.....	11-19	Salt cake. <i>See</i> Sodium sulphate.	
production.....	12	Salt ck., brine springs.....	51
Nova Scotia Salt Works and Exploration		Salt pt., brine springs.....	51, 52, 54
Co.....	5	Salt Point pen.....	51
Oil springs.....	31	Salt r., Mackenzie dist.....	61, 62
Ontario—		Salt Springs, Antigonish county.....	6
Salt occurrences.....	26-46	Salt Springs, Cumberland county, brine	
Salt wells, capacity of.....	33	springs.....	10
Ontario salt well, capacity.....	33	Salt Springs, Pictou county, brine springs.	3, 7
Orangedale, brine springs.....	2, 3	Salt Springs bk, N.B.....	19
Orford.....	27	Sandwich, salt and chemical works at...	41
Otter brook, brine spring.....	10	Saskatchewan, salt occurrences.....	55-57
Oxford, brine springs.....	3, 7	Screening of salt.....	88
Pan process, use of, in brine evaporation..	82, 83	Sea water, recovery of salt from.....	77
Patterson station.....	10	Seafortb—	
Peace r.....	63	Depth of salt beds.....	30
Pelican bay, brine springs.....	51, 54	Early works at.....	33
Pelican ck.....	51	Seaforth Syndicate.....	33
Pembroke, brine springs.....	10	Senlac l., brine deposit.....	56
Peru, production.....	109	Senlac Salt Co., plant and operations....	57
Petrolia, depth of salt beds.....	31	Sboal r.....	51
Petrolia well, log of.....	29	Shutt, Dr. Frank T., analysis by.....	11
Philippine Islands, production.....	110	Siam, production.....	110
Pine ck., brine springs.....	51, 53	Skeena r.....	70
Plaster ck., brine springs.....	7	Slave r.....	61
Platt, Samuel.....	31	Smith, T., brines on farm.....	51
Platt well, capacity.....	33	Soda ash, manufacture of, from salt.....	94-96
Poland, production.....	109	Chart showing consumption of, in	
Pomquet, r.....	5, 6	industry.....	91
Ponton, A. W., rept. quoted.....	64	Sodium carbonate. <i>See</i> Soda ash.	
Port Franks, depth of salt beds.....	31	Sodium sulphate, manufacture of, from	
Portuguese India, production.....	110	salt.....	97
Potash salts.....	2, 14, 24	Solar evaporation of brines.....	79-81
Prince well, capacity.....	33	Solvay process for making soda ash.....	95-96
Pritchard, D. A. <i>See</i> Pritchard and Hubel.		Somaliland, production.....	109
Pritchard and Hubel, rept. quoted.....	44	Somers, Martin.....	6
Pumps—		South r.....	5
Use of, in salt manufacture.....	79, 87	Southwest Africa Territory, production..	109
Rainy Cove bk., brine springs.....	10	Spain—	
Red Clay. <i>See</i> Red Earth.		Analysis of salt from.....	15
Red Deer pen., brine springs.....	47, 49	Production.....	109
Red Deer r., brine springs.....	51, 53, 54	Spencer, T. W., rept. quoted.....	48
Red Earth ck.....	63	Springhill, brine springs.....	3, 10
Richardson, Sir J., rept. quoted.....	61, 64	Springs. <i>See</i> Brine springs.	
Rine, Willard, brine spring.....	10	Stapleton Salt Works.....	28
Robb, Charles, rept. quoted.....	3	Statistics—	
Rock salt—		Domestic consumption.....	105
Drilling.....	78, 79	Exports.....	111
Chemical composition.....	74	Imports.....	111
Minerals associated with.....	6	Production (1924-1928).....	104, 108, 111
Mining.....	78	World production.....	109, 110
<i>See also</i> Malagash salt mine.		Steam, brine evaporation by.....	83-87
		Steepprock r., brine springs.....	51, 52, 54
		Stinking ck.....	64

PAGE		PAGE
	Sudan, production.....	109
	Sulphuric acid for making sodium sulphate.....	97
	Sussex, N.B., brine springs.....	19, 20
	Swan r., brine springs.....	48, 51, 54
	Switzerland, production.....	109
	Sylvite.....	14
	Tanganyika Territory, production.....	109
	Tar island.....	63
	Tariff.....	107
	Tecumseh well, capacity.....	33
	Thamesville.....	31
	Thompson, E. A., analysis by.....	69
	Thompson, Laurin.....	7
	Tobique r.....	21
	Town Point.....	5
	Tripoli, production.....	109
	Tunis, production.....	109
	Turkey, production.....	110
	Turks island—	
	Analysis of salt from.....	15
	Production.....	109
	Tyrrell, J. B., rept. quoted.....	49, 51
	Union of South Africa, production.....	109
	United Kingdom, production.....	109
	United States, production.....	109
	Unity, Sask., rock salt.....	57
	Unity Valley No. 2 well.....	57
	Uses of salt.....	89-93
	Vacuum pans for evaporation of brines described and figured.....	84-87
	Venezuela, production.....	109
	Victoria county, N.B., brine springs.....	21
	Victoria county, N.S., brine springs.....	5
	Victoria well, capacity.....	33
	Wabiskaw r.....	58
	Walton, brine springs.....	10
	Waterways, wells drilled at.....	66-68
	Watson, James.....	3
	Weihaiwei, production.....	109
	West Indies, production.....	109
	West r., Antigonish county.....	6
	West r., Pictou county.....	7
	Westbourne, brine springs.....	51
	Western Canada Flour Mills, Ltd., description of salt plant.....	37
	Western Salt Co., description of plant.....	39
	Westmorland county, N.B., rock salt.....	21
	Whiteford, D.....	70
	Whitemud r.....	63
	Whycocomagh, brine spring.....	3
	Wind, evaporation of brines by.....	79
	Windsor, N.S.—	
	Brine springs.....	3, 10
	Rock salt.....	19
	Windsor, Ont., depth of salt bed.....	31
	Windsor Salt Co. See Canadian Industries, Ltd.	
	Windsor well, log of.....	30
	Wingham, depth of salt bed.....	30
	Winnipeg, brine springs near.....	55
	Winnipegosis l., brine springs near.....	49-54
	Photos.....	50, 54
	Wright, W. J., brine samples collected by.....	10
	Zone tp., depth of salt bed in.....	31



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- Salt Areas
- Saline Springs

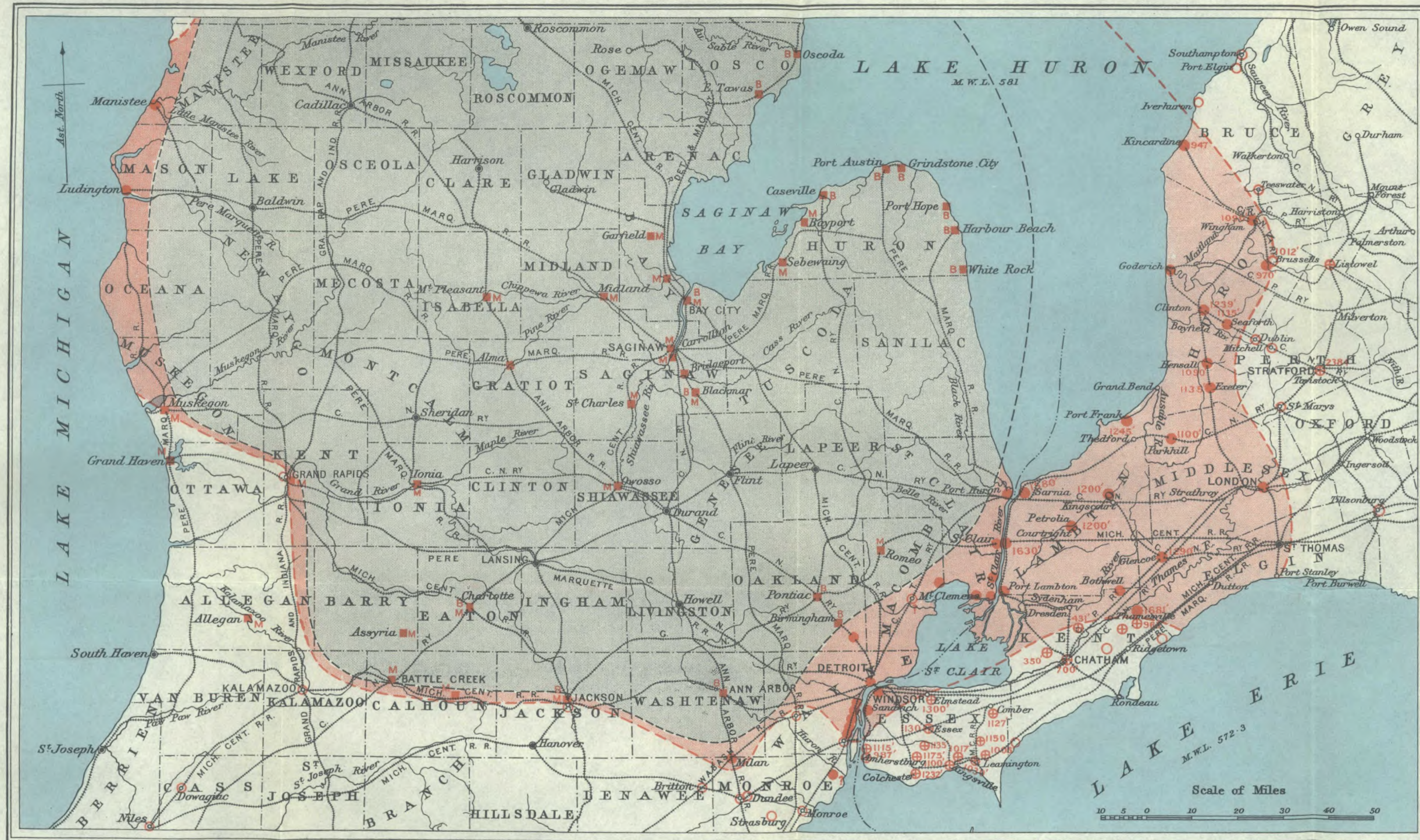
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**LEGEND**

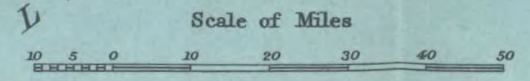
- Probable boundary of known productive area of Salina
- Salina unexplored in area. Probable depth to Salina in centre of this basin is 4200± feet.
- Drill-holes penetrating Salina which encounter Rock Salt.
- Drill-holes penetrating Salina which do not encounter Rock Salt.
- Drill-holes encountering only brines. The horizon of the brines from these wells is not known. The character of the rock encountered in wells seems to indicate the absence of Salina in this area.
- Drill-holes penetrating the Berea Sandstone
- Drill-holes penetrating the Marshall Sandstone.

**NOTES:-**

The brines from the Berea are very highly saturated; but of late years have not been used as a source of salt. Where these brines are encountered at depth, there is a marked increase in the percentage of bromides and the bittern was formerly used for the manufacture of bromine.

The Marshall Sandstone near the centre of the basin yields a strong brine which is the source of most of the salt in the Saginaw valley.

Figures in red after drill-holes show depth at which rock salt or brine was first encountered.



**ONTARIO-MICHIGAN SALT BASIN**  
SHOWING PROBABLE LIMIT OF PRODUCTIVE AREA

Information compiled from reports of Geological Survey of Canada, Ontario Bureau of Mines and Michigan Geological Survey. Accompanying Mines Branch Report No 716. 718

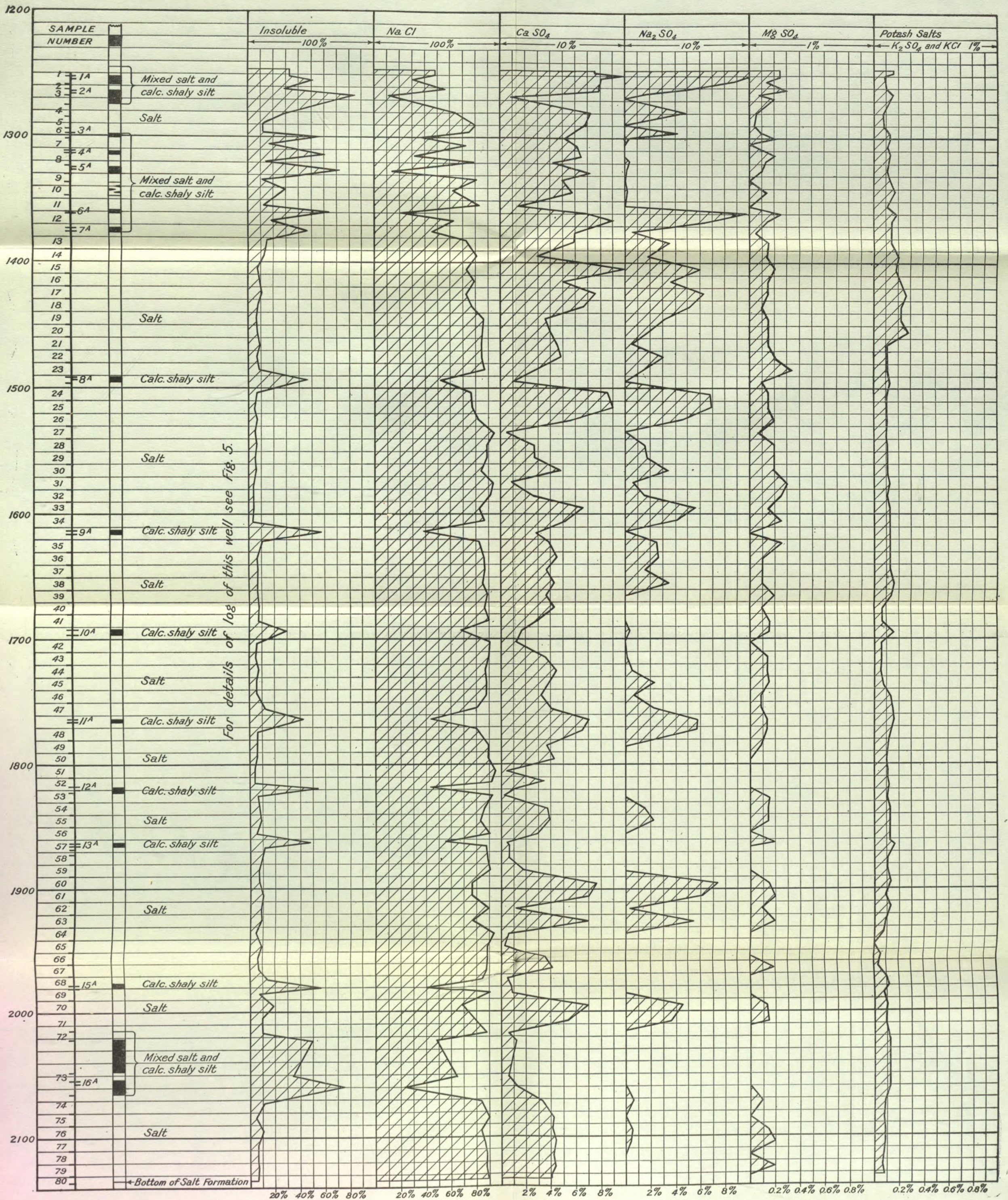


Figure 6. Graph showing percentage of constituents in salt core from Hole No. 88, Gautreau, N.B.