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Occurrences of Common Salt in Alberta

by

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UNIVERSITY OF ALBERTA
EDMONTON, ALBERTA

November, 1949

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Introduction: In recent years the drilling of holes in the search for oil and gas accumulations has shown that deposits of rock salt have a wide extent in East Central Alberta. The discovery of these deposits has resulted in the construction of plants for the recovery of salt in Alberta and Saskatchewan. Since the immense quantities of salt available make possible the establishment of chemical industries making use of this commodity, the information contained herein may be of interest.

In assembling this report the publications by L. H. Cole, Bureau of Mines, Ottawa, and Dr. J. A. Allan, Department of Geology, University of Alberta have been freely consulted, and the writer expresses his indebtedness to these investigators. The writer also wishes to acknowledge the kindness of officials of the following organizations for supplying data which has added to the completeness of this report: Alberta Salt Co., Ltd.; Imperial Oil Co., Ltd.; Canadian Gulf Oil Co., Ltd.; Socony Vacuum Oil Co., Ltd.; British American Oil Co., Ltd.; Anglo-Canadian Oil Co., Ltd.; British Dominion Oil and Development Corp.; Bear Oil Co., Ltd.; and the Petroleum and Natural Gas Conservation Board.

Composition of Common Salt: The chemical name for salt is sodium chloride. By weight it is composed of 39.4 per cent sodium and 60.6 per cent chlorine. In massive bedded form it is known as rock salt, and as a mineral it is known as halite. A solution of common salt in water is known as brine.

Properties of Common Salt or Halite. This compound has many properties which serve to identify it. It is usually colorless, but may have pale pink, red, grey or blue shades due to the presence of various impurities. Its taste is characteristic. It is readily soluble in water to the extent of 35.6 parts by

weight of salt to 100 parts of cold water. It is transparent to translucent, and has a glassy lustre. The specific gravity of salt is 2.2 which makes it lighter than most rocks. Its hardness is such that it can be readily scratched by the thumb nail. Upon evaporation of brine it crystallizes into cubes of various sizes, which can be readily observed in household salt under magnification. Beds of rock salt become plastic when subjected to heavy earth pressures, and in places have accumulated by flowage to thicknesses of thousands of feet. Such accumulations are known as salt domes.

Modes of Occurrence of Salt. Common salt occurs at the earth's surface in four principal forms, viz.,: (1) dissolved in ocean water and in some inland seas; (2) in salt water (saline or brine) springs; (3) as a solid in beds (rock salt); (4) in crystals disseminated in the soil and rocks.

Ocean water contains 3.5 pounds of various kinds of salts in every 100 pounds of water. Of the 3.5 pounds of salts, 2.7 are common salt, the remainder being calcium sulphate, calcium carbonate, and potassium and magnesium salts. Ocean water is used in some places as a source of commercial salt. The water is run into pans or basins and evaporated by the heat of the sun. The residuum is known as solar salt, and its production is restricted to warm climates.

Saline or brine springs supply relatively small quantities of salt, which is either deposited about the mouth of the spring by evaporation, or is recovered through evaporation by artificial heat. Often the concentration of salt is too low for economical recovery except under special circumstances.

Beds of rock salt are the most important source of common salt, since they have a world-wide distribution, and since the salt is easily recovered. Salt beds vary in thickness from a fraction of an inch to over 3000 feet in

thickness. The beds may occur close enough to the surface to be mined in a manner similar to the underground extraction of coal, or they may be many thousands of feet below the surface. In the latter instance salt is recovered by solution in water, that is, fresh water is pumped to the salt bed, salt dissolves in the water, and the resulting brine is returned to the surface, where the salt is recovered by evaporation. Salt produced in this manner is called grainer salt, and about 2 3/4 pounds of water must be evaporated to yield one pound of salt.

In some places, as in dry lake bottoms and glacial deposits, minute salt crystals occur disseminated in porous soil or other unconsolidated sands and gravels.

Origin of Common Salt. The original source of common salt is considered to be the rocks of the continents. In the weathering of these rocks new minerals are produced, among which are the soluble salts - sodium chloride, calcium sulphate, etc. Most of these soluble salts eventually reach the oceans, thereby increasing the salt contents of these waters, since only water is evaporated from the ocean surface. It is thought that the beds of rock salt have resulted from evaporation of sea water.

Several theories have been put forth to account for the occurrence of thick beds of common and other salts. These may be found hundreds or thousands of feet above sea level, and bedded with shale, limestone and dolomite, thereby indicating deposition by sedimentary processes. There is general agreement that salt beds were formed from sea water which evaporated in basins or arms of the sea that were wholly or in part separated from the oceans. Some of the basins must have extended for tens and even hundreds of miles, since some salt deposits have an extent as great as this. Experimental evaporation

of sea water has shown a more or less definite order in which the dissolved salts are deposited as concentration of the brine proceeds, provided evaporation continues without interruption. Iron hydroxide is precipitated first, followed in order by calcium carbonate (limestone), calcium sulphate (in the form of anhydrite or gypsum), sodium chloride (common salt), magnesium salts, and lastly potassium and other sodium salts, these last occurring at the top of the deposit. Beds of salts deposited in this manner are known as evaporites. In nature, the process of evaporation is subject to many influences and conditions, consequently the salt beds seldom occur in the above sequence. Often there are interbeds of gypsum, limestone, dolomite and shale in rock salt deposits; and moreover potassium and magnesium salts are seldom present in quantity, due either to non-deposition or removal by solution after deposition. The evaporite beds have been preserved by coverings of shale, limestone and other sediments, from solution by ground waters.

Some fresh water lakes, once of great size, have become salty by gradual evaporation, and may have reached the stage where salts are being deposited. Great Salt Lake in Utah is a relic of a much larger lake, which resulted from the melting of ice during the Glacial Age. Great Salt Lake is now depositing salts on its bed. The Dead Sea in Palestine is another enclosed body of water heavy with salts, concentrated by evaporation.

Brine springs probably arise from circulating ground waters coming into contact with beds of rock salt, and then reaching the surface, or they may consist of salt water issuing from limestone in which sea water was trapped when the rock was first formed.

Uses of Common Salt. Common salt is one of our most important minerals, for it is used not only in foodstuffs, but is an essential raw material in the

chemical industry. It is indispensible for seasoning food, since it is necessary to the normal metabolism of animals. However, only a small percentage of the world's production is used for that purpose. Large quantities are used in the curing of fish and meat, in the preparation of pickles, sauces and bread, in the salting of hides, and in the preservation of butter, cheese and oleomargarine. On the farm it is fed to livestock, and is used as a fertilizer and weed-killer, and in salting hay.

Its uses in industry are manifold, being utilized in the pure state and also as a source of many chemicals. As sodium chloride it is used as a refrigerant; to give a salt glaze to sewer pipe and other articles of pottery; to regenerate zeolites in water softening; to fix dyes; and as an ingredient in certain toilet preparations such as toothpaste. It is the raw material for a long list of chemicals which are derived either directly or indirectly from salt, over 50 per cent of the total consumption being used for this purpose. The manufacture of soda ash (sodium carbonate) utilizes from 30 to 40 per cent of the total salt output, for this substance is used in the production of glass, soap, washing soda, and other sodium compounds. Caustic soda (sodium hydroxide), another product of salt, finds extensive usage in the manufacture of soap and rayon, for the digestion of wood pulp in paper manufacture, in the refining of petroleum, and in the purification of bauxite, the principal ore of aluminum. Chlorine, also derived from common salt, is used in bleaching pulp, paper and textiles; in sterilizing water and in the manufacture of hydrochloric acid.

History of the Salt Industry in Alberta. The salt industry is probably one of the oldest industries in Alberta, since the salt springs along Salt River, which has its source in the extreme northern part of Alberta (Figure 1, page 13), were known to the earliest explorers, and are recorded in their journals as far

back as 1820. At that time salt from these springs was an important article of commerce, and supplied the greater part of the northwest. The trade in salt was carried on until recently. The salt was sacked during the summer, and transported after freeze up (Cole, 1930, page 58).

Rock salt was discovered in the province between the years 1907 and 1912 by the drilling of two wells to depths of over 1400 feet. These wells were drilled in search of oil near the town of McMurray. Brine from one of these wells was used in 1911 or 1912 to produce a small amount of salt, but the commercial possibilities of the salt deposits were not tested until 1919. In that year the Government of Alberta drilled a test hole to obtain details concerning the formations, and some salt beds were penetrated. A second well drilled in 1922 failed to contact salt beds. In 1924 the Alberta Salt Company operated a plant to recover salt at McMurray, and produced over 3000 tons in the next three years. The plant was then closed down. In 1928 the Alberta and Great Waterways Railway Company drilled a well at Waterways, and were successful in reaching a thick salt bed at a depth of 670 feet. In 1936 Industrial Minerals Limited drilled an exploratory salt well at Waterways, a few miles from McMurray, and at 694 feet found the top of a salt bed which proved to be 199 feet thick. During the ensuing year the same company drilled another well nearby, and placed it on production. This plant is still in operation.

Later the existence of thick beds of rock salt in East Central Alberta was shown in holes drilled for oil and gas. Bore hole #15, put down a few miles south of Vermilion by the Vermilion Consolidated Oil Company, passed through a salt bed in the interval of 3481 to 3903 feet. Some bore holes drilled in 1946 along the North Saskatchewan river near Elk Point encountered three thick salt beds, aggregating nearly 1000 feet. Since gas in large

quantities was also obtained in some of the Elk Point wells, all the essentials for the economic recovery of the salt were at hand, and a company was formed to recover salt. The companies associated in the drilling of the wells, - Anglo-Canadian Oils Limited, Calgary and Edmonton Corporation, and Home Oil Company - formed the Alberta Salt Company. A plant was constructed close to the town of Lindbergh, and was placed in operation early in 1949. Since 1946 salt beds have been drilled in many of the deep wells in East Central Alberta. Table I contains a list of these wells and the positions of the most significant wells are shown in Figure 1.

Salt Occurrences in Alberta. Common salt occurs in Alberta in brine springs, disseminated in the soil in certain places, and in beds of rock salt.

Brino Springs. The most important brine springs are those mentioned above that occur along Salt River. The springs are numerous, and fall into four groups. They issue at the base of a ridge in which are exposed patches of gypsum, and it has been suggested that the salt is derived from salt crystals disseminated in the gypsum. The spring water is almost saturated with salts, so that evaporation of the water causes salt to be deposited close to the orifices of the springs. Salt crystals have been deposited in places to a depth of two feet or more. It was this salt that served for over 100 years as an article of commerce, four tons or more being collected each year for use in the trading posts and missions of the Mackenzie River district.

Samples of spring water were taken for analysis by Dr. J. A. Allan, and a typical analysis of the salts therein was as follows:

Sodium chloride	97.71 per cent.
Calcium sulphate	1.60 " "
Magnesium chloride	0.31 " "
Potassium chloride	0.31 " "
Sodium sulphate	0.07 " "
	100.00 " "

The water contained over 262 parts per thousand of salts. In other words, the salts comprised 26.2 per cent of the weight of the spring water. The content of common salt was 25.6 per cent of the weight of the water. The temperature of the water was 35 to 40 degrees Fahrenheit, and the rate of flow varied from one to five gallons per minute.

Saline springs also occur at La Saline, about 26 miles north of McMurray. There are a number of springs in the group, and the water is rich in calcium carbonate, having built up a fairly large deposit of tufa in the vicinity. The water contains only 7.82 per cent of salts in solution, of which under 6 per cent is common salt. The water is thus far from being saturated.

Another group of saline springs is located along the Clearwater river about twelve miles east of the Alberta-Saskatchewan border, and still another group occurs along the Christina river, a tributary of the Clearwater. Other saline springs have been noted along the Peace and Athabaska rivers and the percentages of common salt in these springs are small.

Flows of salt water have been obtained in many wells drilled for oil and gas. Some of these wells are still flowing, yielding principally salt water and natural gas.

Salt Impregnated Soil. Patches of salt impregnated soils are found in various parts of the Province and are usually associated with dried up springs and sloughs. They are often frequented by animals for their salt content, and consequently these small areas are known as "salt licks".

Rock Salt. No outcrops of rock salt are known to occur in Alberta, though several bore holes have penetrated salt beds at depths of less than 700 feet. Many more have encountered salt beds at greater depths. A list of the wells which were drilled in salt beds is given in Table I. The locations of the most significant wells are shown in figure 1.

TABLE I

NAME OF WELL	LOCATION					ELEVATION*	TOTAL DEPTH	SALT INTERVALS	TOTAL THICKNESS OF SALT (feet)
	L.S.	SEC.	TP.	R.	MER.				
Alberta Government #1		21	89	9	W. 4	795 G	685	631-	24
Bear Rodeo #1	8	20	89	9	W. 4	792 G	834	625-682 748-834	120
Northern Alberta Exploration #1		17	89	9	W. 4		1475	520-620 735-740	205
Northern Alberta Exploration #2		17	89	9	W. 4		1405	604-704 779-869	190
Industrial Minerals #1	1	10	89	9	W. 4	825 G	898	694-893	199
Industrial Minerals #2	2	10	89	9	W. 4		702	695-?	
Industrial Minerals #3	1	10	89	9	W. 4	853 G	952	723-934	211
Bear Maxgeorge #1	5	25	69	20	W. 4	1870	4108	3920-3930 3977-3981 4035-4040 4080-4085	
Anglo-Home-C. & E. Elk Point #3	15	35	57	5	W. 4	2111	5007	2894-3301 3659-3787 3860-4293	968
Anglo-Home-C. & E. Elk Point #2	3	14	57	6	W. 4	1858	4359	2806-3257 3554-3672 3770-4173	972
Anglo-Home-C. & E. Elk Point #1	7	26	56	5	W. 4	1840	3929	2775-3180 3480-3605 3702-3929	757

NAME OF WELL	LOCATION					ELEVATION*	TOTAL DEPTH	SALT INTERVALS	TOTAL THICKNESS OF SALT (feet)
	L.S.	SEC.	TP.	R.	MER.				
Anglo-Home-C. & E. Elk Point #4	3	26	56	5	W. 4	1724	3483	2617-3063 3364-3481	563
Imperial Ardrossan #1	8	17	53	21	W. 4	2380	5775	5785-5850 6440-6540	165
Imperial Looma #1	4	10	50	23	W. 4	2441	6500	6497-6500	3?
Anglo-Beaverhill Lake #2	11	11	50	17	W. 4	2252	5558	5100-5424	324
Vermilion Consolidated Oils #15	6	12	49	6	W. 4	1983	4632	3481-3903	422
Montreal Alberta #1	2	15	45	7	W. 4	2238?	4653?	4102-4514	412
Canadian Gulf Jerard #1	16	34	37	20	W. 4	2783	6050?	4951-5170	100?
Imperial Provost #2	1	33	37	3	W. 4	2422	6977	4605-4970 5231-5232	366
Socony Vacuum Craigmyle #1	12	32	32	16	W. 4	2717	6807	4724-4727 6567-6584 6588-6612	44
B. A. Hand Hills #1	7	14	30	17	W. 4	3373	6535	5482-5552	45?
Brook Stanmore #1	7	22	30	11	W. 4	2258 G	5210	4602-4642	25?
Princess C. P. R. #1	13	22	20	12	W. 4	2442	6155	5230-5232	2

*Measurements are made in feet from the kelly bushing or derrick floor excepting for those marked "G", which refer to the ground elevation.

The Alberta Government Salt Well #1 at McMurray definitely established the presence of beds of rock salt, for which there was strong evidence in the two holes drilled previously by the Northern Alberta Exploration Company. Beds aggregating 24 feet of salt were cored. Several other wells were drilled in the vicinity, and one of the most successful was Industrial Minerals #1 bore hole, which obtained a section of 199 feet of salt. The company, Industrial Minerals Limited, utilizes the salt in this bed in #2 drill hole, close by the first. Bear Rodeo #1 is another bore hole in the vicinity of McMurray. This hole passed through two salt beds at depths of 625' and 748'. The beds have a total thickness of 122'. The salt beds are at relatively shallow depths in these parts and, if present northeast of McMurray, should approach and perhaps if persistent, reach the surface because the strata rise in that direction. No outcrops of rock salt have been reported from that area, though the beds may be concealed by a cover of glacial debris.

The continuity of the salt beds southwards from McMurray has been demonstrated by the presence of salt in Bear Maxgeorge #1, northeast of the town of Athabasca. Salt was cored in this hole at intervals from depths of 3920' to 4085'. Total thickness of the salt bed or beds has not yet been determined at this locality.

Unusually thick beds of salt were discovered in 1946 in the vicinity of Lindbergh during the drilling of Elk Point #1 bore hole. Three beds of salt are present, and aggregate just under 1000 feet in thickness. Three other wells were drilled in the vicinity, and show that the beds extend for several miles. The beds are well situated for the establishment of a salt recovery plant since natural gas to supply heat for evaporation was found in large quantities in the wells, and since fresh water for dissolving the salt is obtained from the nearby

North Saskatchewan river. The plant of the Alberta Salt Company takes salt from the upper salt bed in #4 well. This bed is 446 feet thick. Recovery of the salt is by solution using river water. Analysis of the raw brine as it is pumped from the well is as follows:

Ions, etc.	Per cent.
Ca^{++}	0.109
Mg^{++}	0.285
Al^{+++}	Nil
Fe^{++}	Nil
$SO_4^{=}$	0.166
$CO_3^{=}$	0.060
Water	73.820
NaCl by difference	23.560
	100.00

No tests were made on the brine for potassium or phosphoric salts. The water as it comes out of the well is 98.8 per cent saturated, and contains by weight 23.56 per cent common salt. Since the river water used contains some dissolved salts, part of the impurities shown in the above analysis come from this source.

In Imperial Ardrossan #1, located just east of Edmonton, two salt beds were drilled and total 165 feet. The salt is impure, containing thin beds of silt and dolomite. To date this well marks one of the most westerly occurrences of an appreciable thickness of salt. The well was recently completed as a dry hole.

Anglo Beaverhill Lake #2 drilled through 324 feet of rock salt. The salt is reddish to greyish in color, and shows only occasional bands of clear, transparent salt. There are also streaks of shale and dolomite, which probably indicate proximity to the western margin of the basin of deposition. Another interesting

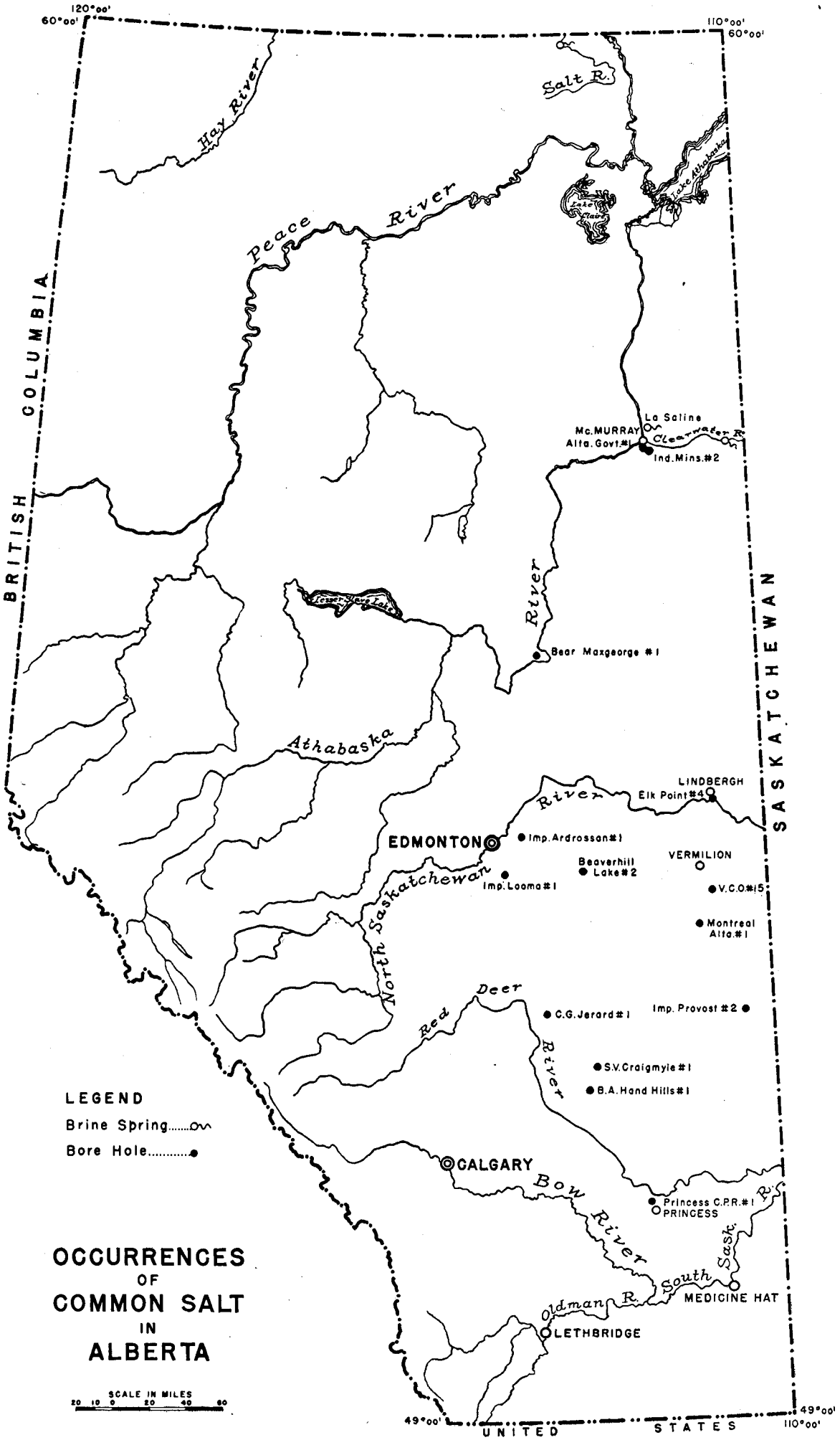
120°00'
60°00'
110°00'
60°00'
Hay River
Salt R.
Lake Athabaska
Lake Claire
Peace River
BRITISH COLUMBIA
SASKATCHEWAN
La Saline
Mc.MURRAY
Alta. Govt.#1
Clearwater R.
Ind. Mins.#2
Lower Peace Lake
River
Bear Maxgeorge #1
Athabaska
LINDBERGH
Elk Point#4
River
EDMONTON
Imp. Ardrossan#1
VERMILION
Beaverhill Lake#2
Imp. Looma#1
V.C.O.#5
Montreal Alta.#1
North Saskatchewan
Red Deer
C.G. Jerard#1
Imp. Provost#2
River
S.V. Craigmyle#1
B.A. Hand Hills#1
LEGEND
Brine Spring
Bore Hole
CALGARY
Bow River
Princess C.P.R.#1
PRINCESS
Sask. R.
South
MEDICINE HAT
Oldman R.
LETHBRIDGE
OCCURRENCES OF COMMON SALT IN ALBERTA
SCALE IN MILES
20 10 0 20 40 60
49°00'
49°00'
UNITED STATES
110°00'

FIGURE 1

feature of the drill core is a minor amount of potash inclusions at depths of 5123 and 5153 feet. No chemical analysis was made of the salt.

Imperial Looma #1, also near Edmonton, at a depth of 6500 feet apparently had barely reached salt deposits, having drilled only three feet of salt filled fractures when the well was completed at that depth.

Vermilion Consolidated Oil #15 well reached a salt bed at a depth of 3481 feet and drilled through 422 feet of salt, much of it crystal clear, before returning to shale and anhydrite. The core has numerous red streaks and blotches, and part is grey in color. There are a number of bands of shale and dolomite, inches thick, sporadically interspersed with the salt. Sixteen samples of the core were analysed by the Petroleum and Natural Gas Conservation Board, and show the percentages of sodium chloride (common salt) to range from 88.29 to 98.89, on an "as received" basis. Potassium chloride ranges from 0.07 to 0.92 per cent when calculated on the same basis. This well was drilled in 1944, and is the discovery well for the salt beds of East Central Alberta.

Another of the most westerly occurrences of salt at depth is in the bore hole, Canadian Gulf Jerard #1. This hole was drilled to a depth of 6930'. At a de pth of 4951' a series of alternating salt and anhydrite beds 219' thick were encountered. Of this thickness approximately 100 feet was salt. The salt beds are over 20 in number and vary in thickness from one to 14 feet.

In the drilling of Imperial Provost #2, one bed of 365 feet thick was penetrated at 4605 feet and a thin one at 5231 feet. Small amounts of potash are present in the salt.

Socony Vacuum Craigmyle #1 found three salt beds, having a total thickness of 44 feet. The thinning in the southward direction connotes an approach to the southern edge of the salt basin. About 12 miles south of this well, British American Hand Hills #1 was drilled, and encountered alternating beds of salt and

gypsum in a zone 70 feet thick. Probably more than half of this thickness is rock salt, but the exact amount was not determined due to insufficient core recovery.

In a well, Brook Stanmore #1, drilled for oil near the town of Hanna, a section of about 25' of clean white salt was obtained. The whole of the salt beds was not cored, and the top of the salt bed not exactly determined, but it does occur between the depths of 4615' and 4634'. The thickness of the salt bed is reported to be approximately 125'.

The most southerly recorded occurrence of rock salt is in Princess C.P.R. #1. There two feet of rock salt occurred at the depth of 5230 feet, indicating that the salt beds have almost lensed out. Hence, this location probably marks the southern limit of the basin of salt deposition.

Extent and Age of the Rock Salt Beds. The wells drilled for oil and gas, given in Table I and shown in Figure 1, in general outline the basin in which salt was deposited in eastern Alberta. The southern limit is probably in the vicinity of Princess, the northern limit north of McMurray, and the western limit a few miles east of Edmonton. Thus, the area in which salt beds may be encountered in drilling is approximately 400 miles long by 125 miles wide. It is not at all certain that any one salt bed or even the salt zone is continuous throughout that area, since insufficient wells have been drilled deep enough to furnish correlative data. Furthermore, there is still some doubt as to whether the salt beds at McMurray are of the same age as those at Lindbergh and the other places in East Central Alberta. A Silurian age has been suggested for the McMurray salt beds, whereas the salt beds of East Central Alberta are assigned to the Devonian. If all the salt beds were of the same age, there would be a greater probability that the salt horizons would be continuous and, therefore, that they would have a greater extent. It would appear that the centre of the salt basin in Alberta is

in the vicinity of Lindbergh, since it is there that the greatest number and thicknesses of salt beds have been found.

The relatively small percentages of potash in the salt beds so far discovered require explanation. The potash could have been removed by solution after deposition, or the centre of the basin may have been shifted while the potash was still in a liquid state. The latter explanation has interesting possibilities for, if true, the main body of potash still awaits discovery.

Salt Production in Alberta and Canada. Canadian salt production comes from four provinces - Nova Scotia, Ontario, Manitoba and Alberta. Ontario supplies about 85 per cent of the total production, and the other three provinces produce approximately equal amounts. Over one-half of the Canadian production is used by the chemical industry in the manufacture of caustic soda, soda ash and other chemicals. Very little of Alberta's production has industrial application.

The following table shows the growth of salt production in Alberta in recent years.

Year	Alberta (tons)	Canada (tons)	Total Value $
1938	4,045	440,045	1,912,913
1939	3,319	424,500	2,486,632
1940	6,742	464,714	2,823,269
1941	16,617	560,845	3,196,165
1942	22,360	653,672	3,844,187
1943	17,499	687,686	4,379,378
1944	25,335	695,217	4,074,021
1945	29,421	673,076	4,054,720
1946	31,016	537,985	3,626,165
1947	28,890	728,545	4,436,930
1948	34,329	-----	-------

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