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The Potash Industry of Nebraska

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THE POTASH INDUSTRY OF NEBRASKA

BY

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and Soil Survey Commission

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EXPLANATORY NOTE

The matter in this bulletin was prepared by Dr. George E. Condra, Director of Conservation and Soil Survey of Nebraska, for the Nebraska State Board of Agriculture. Dr. Condra has given many months of careful and painstaking investigation of this subject, and what he says may be taken as authoritative.

The Bureau of Publicity desires to give Dr. Condra full credit for the splendid report herein given, and to thank E. R. Danielson, Secretary of the State Board of Agriculture, for his kindly permission to publish this as one of the bulletins of the Bureau of Publicity. The Bureau is in daily receipt of letters asking for information about the potash industry of Nebraska, and the Director knows of no better way of imparting that information than by reproducing Dr. Condra's comprehensive article.

WILL M. MAUPIN, Director.

A PRELIMINARY REPORT ON THE POTASH INDUSTRY OF NEBRASKA

By G. E. Condra, Director, the Nebraska Conservation and Soil Survey

The potash industry of Nebraska has developed within a short time. Starting with small shipments of alkali crusts collected from the shores of McCarthy Lake and shipped to Omaha, the industry has grown to a value of several million dollars. The processes involved in the reduction and refining of the potash have not been perfected to a high degree of efficiency.

Four large reduction plants are operating, the fifth plant is building and three more are to start within a few weeks. One refining plant is operating at Omaha, and a reduction plant building at Antioch will do refining also.

Nebraska produces about two-fifths of the potash output of the United States, leading in the amount coming from lakes and lake beds.

The Potash Region of Nebraska

The production is now confined to Sheridan, Garden and Morrill counties. The lakes being worked lie north and south of the C. B. & Q. Railroad, beginning a few miles east of Alliance.

The area with producing lakes, extends about thirty miles north and south and between twenty and thirty miles east and west. (Fig. 1). It occupies nearly equal areas on each side of the railroad. Small intermittent lakes occur on the table lands of Box Butte county and some of them might be worked. Among these are Bonness, Putman and Morrison.

At first it was thought that only two or three of the lakes would become of importance as sources of potash. Now about seventy-five of them are known to contain potash in paying quantities.

Though it is thought that the potash region of Nebraska has been fairly well determined, and that few strong lakes remain untested and unleased, we are convinced that the exploratory work should be continued. Lakes with some potash occur in the Pawlet district of Garden County, in part of Grant County, in widely scattered areas of Cherry County, in McPherson County, in the southern part of Brown County, and in southwestern Holt County. Such tests as have been made of these lakes seem to show more magnesium and sodium than potash. All these lakes should be tested, however, and by wells. A considerable amount of potash is known to occur near Ellsworth.

There are many lakes in Cherry County, as near Cody, near Merriman, in the southwestern corner of the county and between Simion, Brownlee and Wood Lake. Among the best known of these are Big Alkali, Red Deer, Clear, Dad's, Pelican, Willow, Dewey, Marsh and Cody. Among the Brown County lakes are Enders, Moon, Rat, Long, Marsh, Willow and Chain Lakes.

Topography. The lakes occur in two physiographic regions, namely, the table lands and the sand hills, but mostly in the latter.

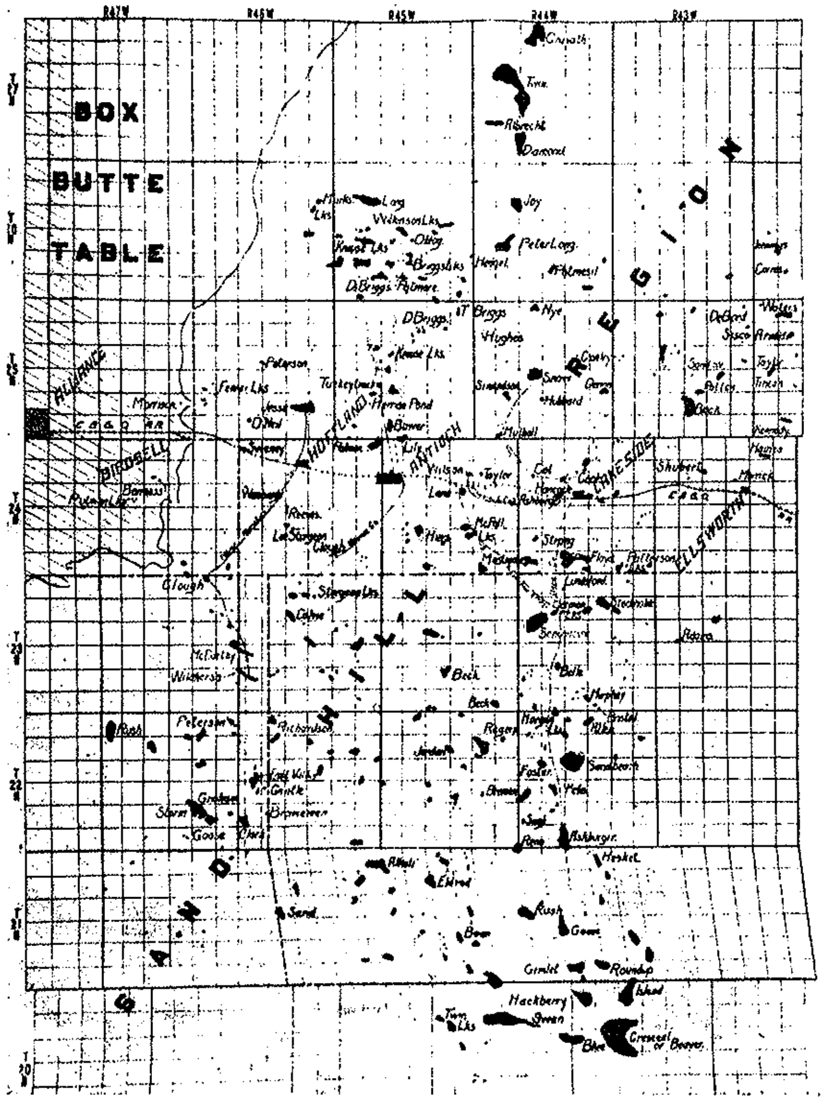

FIGURE 1—MAP SHOWING LOCATIONS OF LAKES

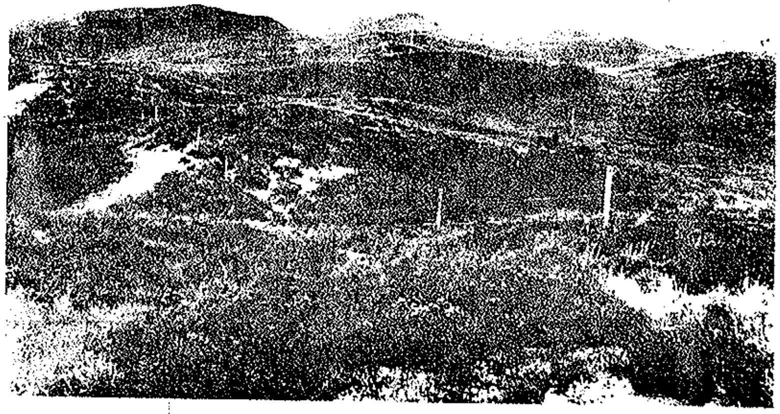

FIGURE 2—A TYPICAL VIEW OF THE SAND HILLS

The sand hills occupy about 20,000 square miles of Nebraska. The largest belt of such hills is in the north-central part of the state, extending from Holt County southwestward, and occupying much of the area between the Platte and the Niobrara. Box Butte table is west of this.

The surface of the sand hill country is comparatively rough (Fig. 2). It is modified by many hills, basins, valleys and lakes. The valleys are one-quarter to one mile or more wide. Their courses are very irregular. In places the grouping of the hills is such as to form ridges. Some hills are low and small; others rise 100 feet or more above the valleys. About two-thirds of the region is occupied by hills and one-third by basins, valleys and lakes (Fig. 3). Though there is an east-west grouping of hills, valleys and lakes in much of the region, this pattern does not prevail. In places the direction is northwest-southeast and in others southwest-northeast. In many parts of the region, there is no system in the arrangement of surface features. In the part along the C. B. & Q. Railroad, the direction of small valleys is east and west (Fig. 4). Most of the large valleys south of the railroad extend southeastward and southward. Those on the north, range eastward and northeastward, and in some parts nearly due north and south.

The hills were produced largely by wind action. The more or less mobile subsoil was eroded from a table-land formerly connected with Box Butte Table. Nearly all of the original surface drainage pattern has been effaced. The hill form is not changing much at this time because of the holding power of the vegetation.

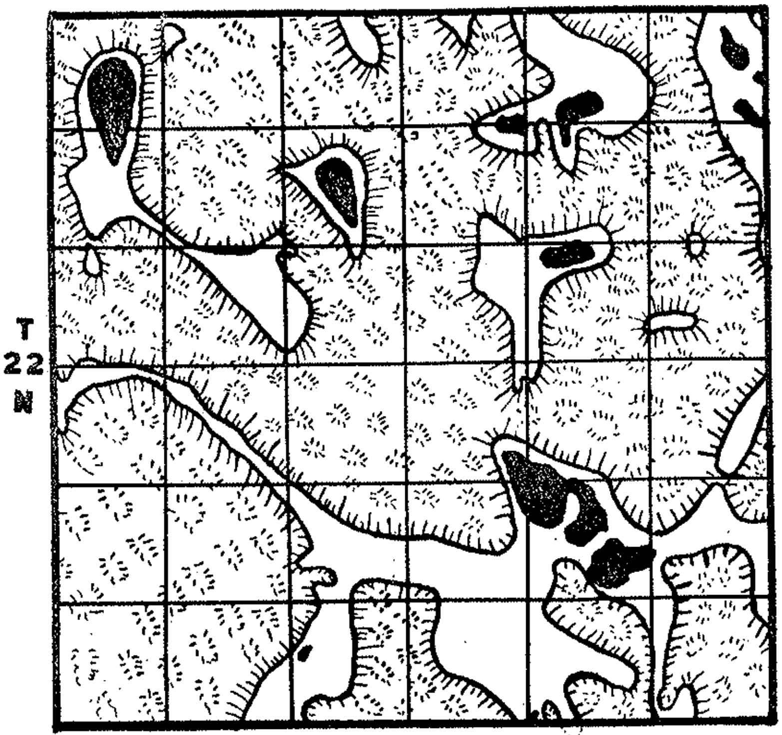

FIGURE 3—SKETCH MAP SHOWING HILLS, VALLEYS AND LAKES ABOUT TEN MILES SOUTHEAST OF HOFFLAND

Drainage. The table-land has surface drainage, and on the part where potash occurs, the streams flow into small intermittent lakes. These lakes lie above the water table.

The sand hill drainage is largely underground. The ground water is shallow in the valleys and exposed at places as lakes. The underflow is eastward, veering a little to the southeast in much of the potash region. On the north the underflow moves to the tributaries of the Niobrara and here some of the valleys carry small streams. On the south the underflow is towards the Blue Water and other small branches of the North Platte.

The area where the best lakes occur is one of slow underflow and of little loss by outward drainage. This condition has been an important factor in the development of alkali lakes.

Structure. The sand hill belt is covered with dune sand in the hills, and by sandy loams on the valleys and basins. The mantle rock is quite thick. Bedrock is reported to have been reached by a drilling near Hoffland, at a depth of about 100 feet.

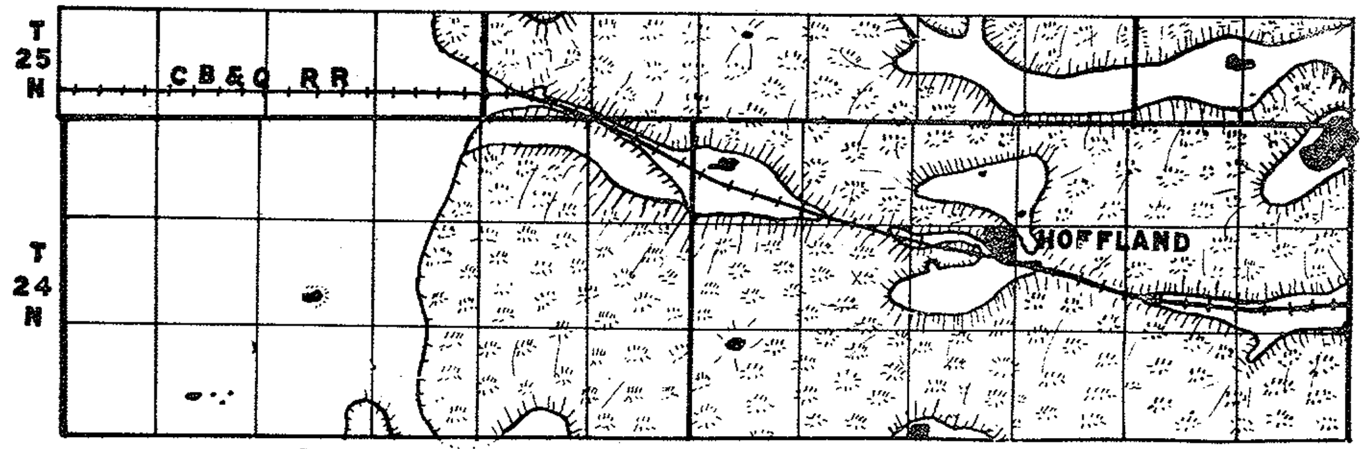

FIGURE 4-A—SKETCH MAP SHOWING THE LOCATION OF THE C. B. & Q. RAILROAD IN THE VICINITY OF HOFFLAND. THE RAILROAD FOLLOWS VALLEYS MOST OF THE DISTANCE IN THE SANDHILLS AND ACROSS THE TABLE LAND EAST OF ALLIANCE

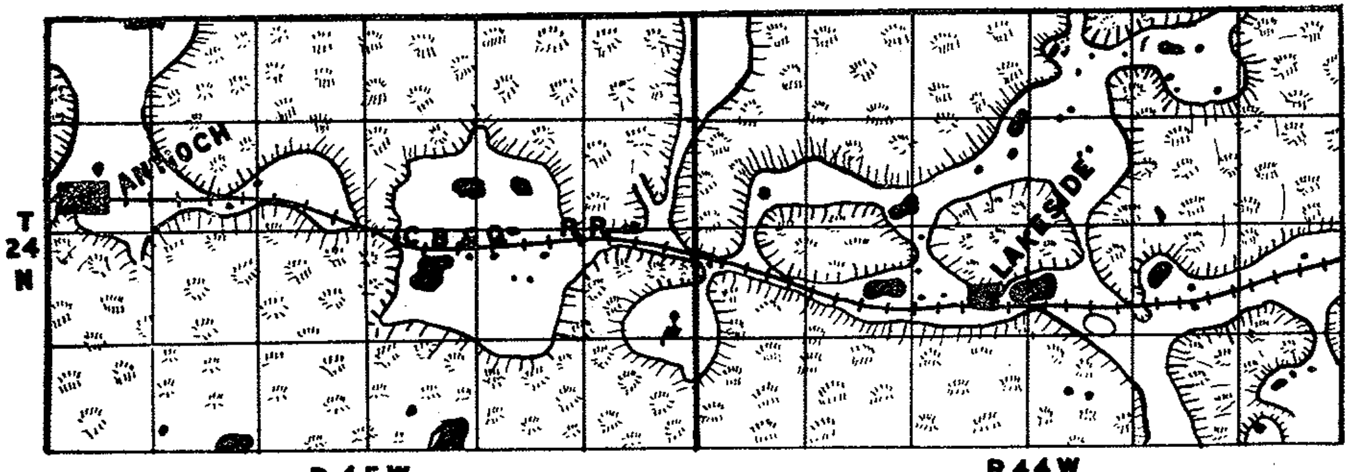

FIGURE 4-B—SKETCH MAP SHOWING THE LOCATION OF THE C. B. & Q. RAILROAD BETWEEN ANTIOCH AND LAKESIDE. EXCEPT FOR A SHORT DISTANCE THE RAILROAD FOLLOWS VALLEYS

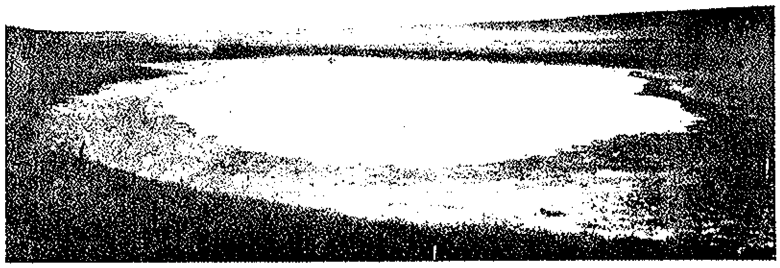

FIGURE 5—AN ALKALI POND NEAR LAKESIDE

The table-land is quite thickly mantled with sandy loam and fine sandy loam, beneath which, at comparatively shallow depths, are layers of silty clay and the so-called magnesia rock.

The bedrock immediately below the dune sand, and the surface of Box Butte Table is of Tertiary age. It is formed by what is known as the Arikaree Formation. This formation is separable into fairly distinct divisions which need not be considered in this connection. In general it is composed of rather poorly defined layers of sand, gravel, silty clay and light colored, friable calcareous sandrock.

Below the Arikaree is the well known Brule clay, which outcrops prominently at the foot of Pine Ridge and at a number of places in the North Platte Valley. The total thickness of the Brule, the Arikaree and other Tertiary formations in this part of the state is 1,000 feet or more. The Tertiary deposits rest unconformably on the Pierre shale of Cretaceous age.

Generally speaking, the mantle rock of the potash region is underlain by sedimentary Tertiary formations and definitely cut off from the older formations which outcrop in the foothills of the Rocky Mountains. The structure of the bedrock near the surface is of the kind that would prevent leakage or seepage from the deeper formations of Cretaceous and older age.

Transportation Facilities. The potash region is served by the C. B. & Q. Railroad (Fig. 4). The presence of a railroad near the lakes has been of great importance in many ways, as in moving freight and labor. Most passenger trains stop at the towns having potash plants.

The public roads are not good as a rule. Those in valleys are fair. The stretches on hills are poor to very bad. They have been a hindrance in the potash development.

The potash companies, assisted by the Alliance Commercial Club and County Commissioners, have improved a road from Alliance to Hoffland, Antioch and Lakeside. This road is south of the railroad. It is used principally by autos and auto trucks.

Description of Lakes. There are many lakes in the sand hills. Some are small, being mere ponds (Fig. 5), and a few lakes have areas of 600 acres or more. The depth varies from a few inches to several feet. The usual depth of the larger lakes is from 1 to 3 feet. The lakes are constantly changing in form, depth and size in sympathy with the rainfall, underflow and evaporation. Most ponds and some lakes dry up during late summer (Fig. 6).

There are all stages between fresh and alkali lakes. As a rule, the fresh ones are deep and with outward drainage. The alkali lakes are at dead ends of drainage. Many of the fresh lakes contain rushes, cattails, and other plants of similar habitat (Fig. 7). Those having salt grasses along their shore lines, and about which occur myriads of alkali flies in the summer time, are apt to be alkaline. The alkali lakes usually appear yellowish in color, yet this is not a sure sign of alkalinity. Their beds are covered with muck underlain with hardpan, called magnesia. The water has a characteristic odor and a bitter taste. Birds and live stock avoid strong alkali water.

Alkali and fresh lakes may occur practically side by side, but as a rule, those on a given valley or hay flat show similar characteristics, if they have about the same drainage conditions.

The alkali lakes contain more plant and animal life than is generally supposed. There are several species of low plants and a few species of animals, represented by many individuals. Among the plants are diatoms, desmids and chara. The plants first named are very simple and usually called the single celled microscopic organisms. The charas are known as stoneworts. They are small branching plants, rising from the lake beds. It is thought that the lower species of plants occur in all the alkali lakes.

The animals usually found in the alkali waters are bugs, small crustaceans and salamanders. Flies show up in the summer in great swarms which cover the vegetation along the lake shores. The salamanders do not pass through their normal development, but remain in the axolotl stage. This animal is wrongly thought by ranchmen to be half fish and half lizard.

CHEMICAL COMPOSITION OF LAKE BRINES

The strong water is called brine. Two things stand out prominently in determining value of brines, viz.—the percentage of soluble salts and the percentage of K_2O in the salts. The brines contain com-

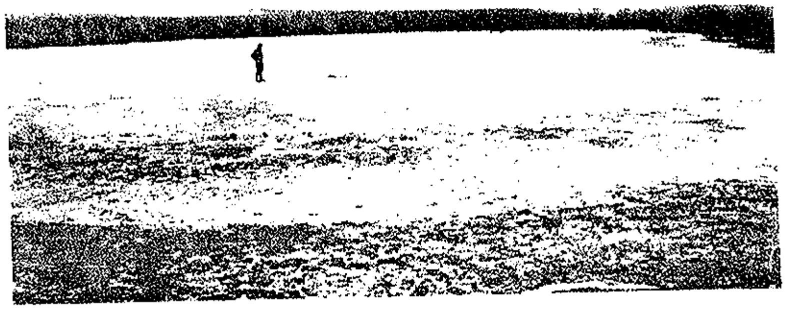

FIGURE 6—A DRY LAKE BED STREWN WITH ALKALI

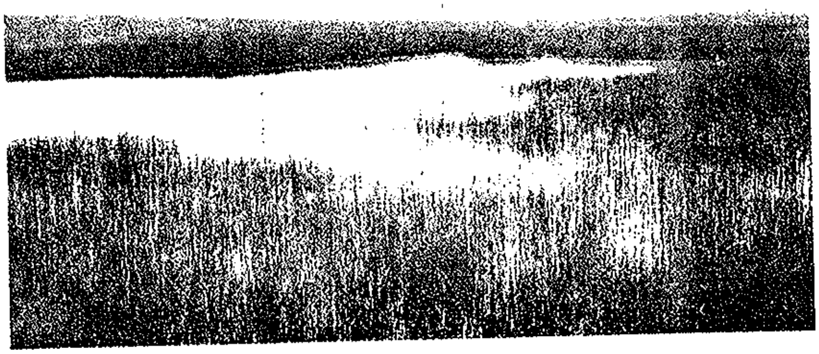

FIGURE 7—FRESH LAKE

pounds principally of potassium and sodium, and traces of magnesium, calcium, iron, etc. The compounds are principally sulphates, carbonates and chlorides. The relative amounts of sodium and potash vary considerably in the potash region, and there is a yet wider range if the lakes of the whole sand hill country are considered.

By the percentage of potash is meant the percent in the water or in the solids of the water. For example, a brine running 16 per cent solids and 28 per cent of that as potash (K_2O) would be reported: potash, 28 or as potash, 4.44. Both these are correct, but they refer in the one case to the solids and in the other to the water and salts combined.

The word "potash" has at least three meanings. In chemistry it is an element. Industrially it is K_2O, or some compound of potash or one or more compounds of potash together wtih salts of soda, magnesium, etc.

Potash salts are widely distributed in nature. This is shown by the following, compiled from Mr. H. S. Gale's report on Potash in 1916.*

"Sea water contains 3½ per cent of dissolved salts and .04 per cent K_2O. Great Salt Lake brine contains 20 per cent dissolved salts and .41 per cent K_2O. Searls Lake, California has in a saturated solution, 2.48 per cent K_2O. Jesse Lake, Nebraska, has shown as much as 19 per cent dissolved salt and 5.96 per cent K_2O in the water.

The following compounds occur in the alkali lakes of Nebraska, but in varying proportions:

Potassium carbonate, K_2CO_3—called pearl ash.
Potassium bi-carbonate, $KHCO_3$.
Sodium carbonate, Na_2CO_3—called soda ash.
Sodium bi-carbonite, $NaHCO_3$—Called cooking soda.
Calcium carbonate, $CaCO_3$—called lime.
Potassium sulphate, K_2SO_4.
Sodium sulphate, Na_2SO_4—called Glauber salts.
Magnesium sulphate $MgSO_4$—called Epsom salts.
Calcium sulphate $CaSO_4$—called gypsum.
Potassium chloride, KCl—called sylvite.
Sodium chloride, NaCl—called halite or common salt.

Usually the brines of producing lakes contain about equal percentages of potash and soda salts. The amount of dissolved matter, the "solids," run from about 2 per cent to 12 per cent or more. Nearly fresh lakes have only a fraction of 1 per cent solids.

A sample collected from a well in Jesse Lake and analyzed by Mr. John H. Show, contained the following:

* 1917, Gale, H. S. Potash in 1916, published by the U. S. Geological Survey. This paper has a bibliography on Potash. See pages 169 and 170.

Potassium oxide	(K_2O)	28.18%
Sodium oxide	(Na_2O)	27.79%
Sulphur trioxide	(SO_3)	11.97%
Carbon dioxide	(CO_2)	27.19%
Chlorine	(Cl)	3.38%
Total		98.51%

The above acids and bases when combined in the forms of neutral salt, show the following analysis:

Potassium sulphate	(K_2SO_4)	26.52%
Potassium carbonate	(K_2CO_3	21.48%
Sodium carbonate	(Na_2CO_3)	36.25%
Sodium bi-carbonate	($NaHCO_3$)	9.24%
Sodium chloride	(NaCl)	5.81%
Silica	(SiO_2)	.21%
Total		99.51%

Some free oxygen occurs in the water and the chemical reactions between the various compounds of the alkalis, iron and organic matter release gases such as hydrogen sulphide and carbonic acid gas.

The composition of the lake water is very similar to that obtained from the underlying sands. Samples of brines and muds collected by J. H. Hance were analyzed by A. R. Merz at the Co-operative Laboratory at Reno, Nev., with the following results:

Brines From Jesse Lake

No.	Location	Pct. of dissolved salts (dried at 105°C)	Pct. of K_2O in dissolved salts
24	Shallow pit at edge of lake	12.31	34.81
27	Pit 4 ft. deep, 40 ft. from lake shore	14.14	26.40
118	Middle of lake	13.55	29.97
	Muds From Jesse Lake		
26	1 ft. below surface, 40 ft. from shore	9.35	25.42
115	4 feet below surface	4.63	28.92
116	7 feet below surface	4.07	24.78
	Saline Residues From Jesse Lake		
25	Crust on southeast margin of lake	34.06	21.00
117	Surface incrustation	20.25	17.39

The evaporated salts are mostly sulphates, but include a large per centage of carbonates and some bicarbonates formed when the brine is dried at ordinary temperatures.

The weakest brines worked to date in the potash region of Nebraska ran 2 per cent solids, of which a little more than 20 per cent was potash. This strength is one extreme and Jesse Lake is the other. Most brines represent the mean between these.

FIGURE 8—VIEW SHOWING INCRUSTATIONS

ORIGIN OF POTASH BRINES

Much has been said and written concerning the origin of lake potash. Various theories have been proposed, and persons actively engaged in the potash industry have shown an interest in this subject. As we now see it, the origin of alkali lakes is best explained by physiography and chemistry. Hence the following discussion:

Development of Alkali Lakes. There are marked differences between table-land and sand hill lakes. The alkali of the former is easily explained, but the latter is more difficult.

The steps in the development of alkali in the small lakes on Box Butte table are about as follows: The wind erodes a small basin, or a drainage course is modified by drifting sand produced by erosion. In either case a basin or reservoir is formed which receives surface drainage when there is enough rainfall. Water entering this gathers more or less alkali from the soil and subsoil. The solutions are weak. Inwash brings fine sediment which silts the depression and checks the percolation. Water thus collected is lost by solar evaporation and the salts are concentrated and finally deposited on the lake bed. (Figure 8). This group of processes when continued long enough produces alkali such as occurs in Bonness and Putman lakes. These lakes do not have much potash in sands below the lake bed. Furthermore, much of the alkali and soda in the incrustations is blown away when the lake beds become dry.

Sand hill lakes are fed principally by underflow. The ground water percolates through the soil and subsoil and moves for considerable distances after reaching the water table. Many of the lakes are ground water exposed in depressions or low places in valleys. The depressions retain their positions with considerable permanence, yet the lake surfaces rise and fall with changes in the contour of the water table, due in part to the rainfalls, but caused principally by seasons or periods differing in the amount of evaporation.

The conditions which determine the accumulation of potash in sand hill lakes are about as follows: Comparatively fresh water enters the lakes from the highest point on the surrounding ground water, which

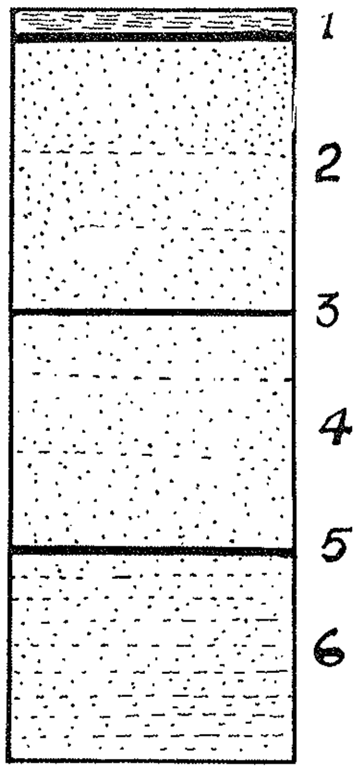

FIGURE 9—A SECTION SHOWING THE DISTRIBUTION OF MAGNESIA LAYERS AND POSITION OF SANDS. NO. 1 REPRESENTS THE LAKE UNDERLAIN WITH MUCK AND HARDPAN LAYER. NOS. 2 AND 4 REPRESENT POTASH SANDS. NOS. 3 AND 4 REPRESENT MAGNESIA LAYERS NO. 6 IS AN UNDERLYING FRESH WATER ZONE

usually is to the west. This seepage supply, though constant or nearly so, is most in evidence as a rule, in fall and spring. The water entering some lakes, passes out at once. In others it is held back by a sand dam, or by the natural form of the basin. In case the water is retained, the principal loss is through solar evaporation which becomes very heavy in the summer time. It is safe to state that about five feet of water would evaporate from one of these lake surfaces in a year.

The alkali solutions are concentrated by evaporation. The density attained varies with changes in the volume of water in the lakes and is affected by freezing. Lakes supplied by considerable water, and subject to evaporation for a long period become heavily mineralized.

Another feature of alkali lakes is hard to explain. It is the muck and the hardpan or magnesia layer on the lake beds (Figure 9). These impervious materials have importance in trapping the brines.

Formerly it was supposed that the impervious layers on lake beds were formed wholly by the inwash of very fine sediment from the hill sides. This view is now thought to be partly in error. An examination of the materials on the beds of several alkali lakes shows them to be principally fine sand, indurated or cemented by magnesia and alkali compounds. There are present also, compounds of iron, alumnia and organic material, most of which seem to have been formed in the lake itself and deposited on the lake floor. The conclusion is that the lakes, after becoming somewhat mineralized, began to precipitate certain compounds. Some of the materials were thrown down before the brine became very strong. Salts of magnesium, calcium and alumnia were dropped in a flocculent, colloidal form, making the muck and magnesia layers. Evidently the inwashed silt and sand had secondary importance in the development of the impervious beds. The magnesia layer is best developed, as a rule, in the east and southeast parts of a lake. It may extend beyond the border of a lake.

Referring again to the potash, it should be noted that the brine usually is most dense at the lower end of a lake, i. e. opposite the point where seepage water enters.

Alkali lakes deposit salts on their beds as the water lowers, especially so in late summer (Figure 5, 6 and 8). This gives a fringe or belt of incrustations. The color of this deposit varies from nearly white to yellowish. Often the deposit makes fantastic forms on the vegetation and lake beach.

Development of Lake Bed Potash. This relates to brines in sands below the lakes proper. Some have called these brines the sub-surface potash. Most of the producing lakes show the following section:

(1) Muck and magnesia.
(2) Sand, 2 to 40 feet.
(3) Magnesia or hardpan, six inches or more.

A second sand and a third hardpan occur in some lakes.

It is not easy to account for these potash bearing sands and the lower impervious layers. Apparently they represent ancient lakes. But, the question arises—how were they formed. No hardpan layers extend generally through the region. The typical hardpans are located mostly below the present lakes. This means that the same forces produced the surface lakes and the ancient or buried lakes. If this proves to be true, the land surface and the water table must have lifted during the development of the lake beds, and probably by stages or periods.

The table-land lakes have little or no sub-surface potash. The sand hill lakes may contain alkali in the lakes and in one or two sands below, but they are underlain at some depth by fresh water. In fact, good wells of fresh water can be obtained along the shores of these lakes or even under the lakes proper if the surface water is cased out.

It seems that the sand hill region, whose surface averages slightly lower than the table-lands has advanced westward. The water table came closer to the surface as the sand hills encroached upon the table-land. The deeper basins filled in to the water line, as the catchment areas of the lakes expanded. This change appears to have come by two or three stages. At each stand, sands were filled in and a magnesia or impervious bed was formed. The sands between the impervious layers are so named because they are the sources of brine. They are colored light green to dark green by iron compounds and are sometimes called green sands. The color of this sand is due to a film of greenish to dark iron covering the grains.

Some of the potash prospectors maintain that the brines in the lake beds have come from deep seated sources, from what they call a mother lode. Apparently there is no ground for this claim for the thick layers of Tertiary beds would cut off any connection with the formations of Cretaceous age. Then the Cretaceous deposits being thick and impervious, would prevent leakage from the older beds, which might or might not be a source of potash. It is evident that the view that brines come from a mother lode or deep source, is not well founded.

A few persons think that the brines come from shallow, artesian springs. It is true that practically all the lakes are fed by seepage water and in most cases the intake zone is along the west edges of the lakes. In some places, however, it has other points of entry, even from below a lake. A number of cases were found while sinking wells, in which the waters below the muck and magnesia broke through and lifted to and above the surface of the lakes, like artesian springs. The lifting of the sub-surface water seems to be caused by the dense or heavier water in the lake itself acting upon impervious layers which extend to higher ground. This condition of unequal densities develops a head, which really causes the water to lift through an opening, and above the lake surface. It should be noted that much of the water below the magnesia layer is fresh. This means that springs coming from this zone would have little value as a source of brine. The surface seepage does feed the lakes with weak brines.

Our conclusion is that the deeper hardpan layers were developed on the floors or beds of ancient lakes; that the water line has lifted two or three times, accompanied by basin filling, and that most of the ground water in the mantle rock below the alkali zones confined by impervious layers, is fresh or nearly so.

Where Strong Lakes Occur. These are found where the basins are most perfect for holding water; where the conditions favor, excessive evaporation and where there is a large supply of potash bearing water. The most typical lake of this kind is Jesse lake. Big Sturgeon, Snow, Ashburger and Cook lakes are examples of this type.

Ages of Lakes. The newest lake condition occurs on the table-land. Then come those of the sand hills in which muck and magnesia layers are absent or developing. The typical alkali lake with the hardpan bed follows, and the oldest are buried. They are represented by the alkali deposits lying between the impervious beds below the surface lakes.

Lakes may be classified according to the alkali compounds they contain. These are discussed at another place in this report.

The Probable Origin of Potash. The term potash as it is here used means potash salts, such as the sulphate, carbonate, nitrate or chloride or a combination of one or more of these with salts of soda, magnesia, lime, etc. The development of alkali salts beginning with the primary rocks as they occurred in the mountains, is outlined in the following paragraphs:

1. The Feldspathic and other potash bearing rocks of the Rocky Mountain areas were weathered and eroded. This released the materials now occurring in the Tertiary and later formations covering western Nebraska.

2. Debris from the primary potash bearing rocks was carried eastward by streams and built into the late Tertiary formations. This construction left a smooth, high plain or table-land where the potash region is now found.

3. The high plain was eroded by wind and streams. Valleys were carved out of the land and the water table deepened. Then the sand hills were formed as the destruction of the table-land advanced westward, and the water line lifted.

4. The rainfall and capillary water were instrumental in weathering and leaching alkali compounds from the mantle rock and bedrock.

5. These alkalies were gathered from large areas in the eroding region and from the table-land on the west and moved by the underflow in the direction of its drainage which for the most part was eastward.

6. Much potash was lost to tributaries of the Platte and Niobrara.

7. That part of the sand hills which intercepted the surface flow and the underflow, and in which the waters could not readily escape except by evaporation, became the potash region.

8. Water moving in from large catchment areas became trapped in basins and its alkali salts were evaporated to brine. The lakes through which the water drained and escaped remained fresh.

Discussion. Vegetation and prairie fires may have had some importance in the accumulation of the potash. But, the only work they did was to take compounds from the soil and release them. All the potash, as we see it, has come from the soil and bedrock, which were, in turn, derived from primary rocks. Water was the agency that brought the solutions to the lakes and solar heat caused the evaporation and concentration.

The precise chemical reactions whereby the potash compounds of the bedrock and sub-soil were released and taken up by the percolating waters and the underflow are not fully understood. Neither is it known just how the various potash, soda, magnesium, calcium and iron salts react under the conditions in which they occur in the bedrock, mantle rock and lake solutions. It is known, however, that mass chemical reactions do take place between these salts, that the reactions are affected to some extent by the organic matter in the lakes, and that the compounds thus produced are not equally soluble.

The chemistry involved in the development of potash lakes presents an attractive field for research. Probably the compounds enter the lakes mostly as sulphates. These in the presence of organic matter and iron of the sands are reduced to sulphides and finally changed to carbonates. The first compounds to be thrown out of solutions would be the salts of magnesium and calcium. The iron changes to sulphides and sulphates which cover the sand grains, giving the greenish colors. The organic matter decomposing, unites with the broken up compounds of potassium and sodium forming carbonates and bi-carbonates. This would, with enough vegetation and time, bring about the elimination of all sulphates and leave carbonates as the principal alkali compounds. Viewed in this light the oldest and most mature lakes would be found to contain principally the carbonates, as they do in some parts of the region.

It is possible that the alkali salts do not move through the sand dams and lake beds at the same rate. This, if true, will account in part for the varying kinds of salts occurring in the different lakes. The investigation of this subject belongs to what is called physical chemistry.

Broadly speaking, it may be said that the potash was released from the bedrock and its derivatives and concentrated in the lake beds primarily through the agencies of ground water and solar evaporation, and that organic matter and iron compounds have been important agencies in determining the nature of the potash compounds of the brines.

Life History of Potash Lakes. Our studies show that the potash lakes fall into four stages of development based on their physiographic history. The stages are as follows:

1. Intermittent table-land lakes.
2. Comparatively weak sand hill lakes.
3. The richest sand hill lakes.
4. Lakes losing strength.

Evidently the lakes in division one are destroyed by the advancing sand hills. Their alkali is moved onward to the incipient lakes in the second group and stage. The water from lakes in the second belt finally reaches the basins where conditions are most favorable for making the hardpan layers and the stronger solutions. This gives heavily mineralized lakes which finally, through mass chemical action, show more carbonates than sulphates. The three stages of lakes just named do not remain fixed. They change to a condition of decadence shown by decreasing mineralization. This is the fourth stage in which more alkali is lost than is received.

The cycle of development herein outlined, requires a long time, probably hundreds and thousands of years. The number of good lakes increases or decreases, depending primarily upon the potash supply and the development of outward drainage.

LEASING LAKES

The methods used in leasing potash lakes and oil lands are similar The work is done by private parties, or by the representatives of promoters who expect to turn the leases to some company, or by the operators themselves. In either case the person going to the field supplies himself with information concerning the ranch owners, and the names and locations of lakes. He visits the owners and urges the desirability of leasing according to his terms.

In the beginning of the potash development practically all of the ranchmen were anxious to lease or sell even at a low price. Later, they were leary and in some cases annoyed by the persistence with which they were worked.

The leases bind the lessor and lessee to a number of conditions relating to testing, erection of a plant, pumping, etc. Most leases have been just and fair to the lessors, but in a few cases there has been sharp practice. This has tied up lakes without production.

The royalties range from 5% gross to 20% gross of the production. Most royalties are 12½% gross.

The leases continue in effect during the period of profitable production of potash.

As a rule, the potash leases cover the other mineral rights, such as oil and gas.

School Land Leases. The press has run a great deal concerning the leasing of school land lakes. It reflects both criticism and commendation for the public officials having in charge the state lands on which potash occurs.

There are few laws on the statute books touching the state's mineral resources. Such as there are have been used as a basis for action by the Commission of Public Lands and Buildings. A plan for leasing was outlined and certain restrictions were named. The question was raised as to whether both agricultural and mineral leases could be made, and this was decided by the Commission in favor of double leasing.

Nearly all of the school land lakes have been leased by persons not in the potash business. The purpose in most cases evidently will be to sell the leases to promotion companies or to the potash plants.

A better plan in the management of the school land lakes would have been to determine the potash content of the lakes and the value of the same, and to lease to companies or persons ready and willing to develop the lakes. Probably this could not have been done under the law.

Nothing has given more publicity to the alkali resources of Nebraska than the discussion relating to the leasing of school lands. Evidently this has promoted the development of the region.

Some of the school lakes have little value and could be leased for a low royalty. Others are of more value and better located and should be leased to better advantage. The flat rate of one-eighth royalty will not cause weak lakes to be developed. The school lakes are scattered in sections 16 and 36, except those on lieu lands, and are therefore not compactly located so as to permit their working in a large way by a company operating a single plant.

The school land lakes might be pumped by companies having pipe lines near them provided that contracts fair to the state could be secured.

SURVEYS AND FIELD INVESTIGATIONS

The study of sand hill lakes has been under way for several years. The first work done by the Conservation and Soil Survey was for the purpose of determining what lakes are suited for fish culture. Then, little or nothing was thought of the potash resources. Many samples of water were collected and analyzed.

Another phase of the early field work related to the plant and animal life which have importance as a source of fish food. Dr. R. H. Wolcott and Dr. Elda Walker, of the University of Nebraska, were the leaders in the biological studies made of the lakes.

Dr. E. H. Barbour, of the State Geological Survey, has studied and described the sand hill lakes. Mr. Whitford, working under the direction of Dr. Barbour, visited many of the lakes a few years ago. A report was prepared, published, and distributed by the Geological Survey. This report did much to show the value of the state's alkali resources.

To Messrs. John H. Show and Carl Modesitt belong the credit for the first careful studies made of the alkali lakes. They began the field work about eight years ago and their efforts were chiefly instrumental in shaping the potash development. The past year has witnessed a great deal of activity in the way of lake investigations made by persons and companies hoping to secure leases and to start reduction plants. The Conservation and Soil Survey has access to the results of this work.

The State Conservation and Soil Survey, in line with its duties defined by the statutes, began a comprehensive survey of the potash lakes last spring. Three men were sent to Sheridan county and two men to Morrill county. One of the Sheridan county men enlisted, another worked until August, and the third, Mr. W. A. Norris, continued until

November. The results of the survey in Sheridan county were unsatisfactory. Messrs. F. A. Hayes and V. H. Seabury worked northeastern Morrill county. Their mapping was found to be accurate. The writer spent considerable time checking and extending the surveys.

Several difficulties were encountered on the survey, i. e., in securing lodging and board and on account of bad roads. Part of the time, roads were fair and some of the time they were too sandy at places for the use of autos.

Land Corners. Our greatest difficulty in parts of the region was due to the lack of agreement held in regard to land corners established by two or three surveys. Discrepancies of one-fourth mile were encountered. There is an overlap of three-fourths mile along the line between Garden and Morrill counties. The map shown by figure one of this report, is only approximately correct. It may be off three-fourths mile on the Morrill-Garden county boundary. The northeastern corner of Morrill county was plane tabled by our survey. The lakes there were tied to corners, observed by land owners, yet we do not agree with the original survey. Elsewhere, much of the region was covered with only a fair degree of accuracy. At places, where the corners are in dispute, the lakes were mapped from the locations given by ranchmen.

Land line suits are pending in the courts, and until these are decided one should not be too positive regarding the legal numbers of the land on which the lakes occur. For example, the location of the C. B. & Q. between Hoffland and Lakeside is not definitely known.

Testing Lakes. Our survey did some of this, but could not undertake to cover the whole field. Preliminary examinations of lakes were made by finding the Baume reading and noting the condition of the vegetation, lake bed and the presence or absence of incrustations.

The hydrometric test, if properly made, gives the percentage of solids. The water runs from zero to 5 or 6 Be. or more, depending upon the density. If sediment is in the water, as it may be on windy days, the reading is too high.

Hydrometric readings of lake waters are deceptive. It should be observed whether a lake or pond contains more water than usual or that it is low, probably nearly dry. A record made when a lake is very low shows a high density.

Density tests have less value than was formerly supposed. If a good reading is observed, it remains to be determined what salts are in the water. There may be more soda than potash. About all that can be said for this test is that it may show whether further prospecting should be done in the way of laboratory testing of water samples and by putting down wells.

Wells. Now that most potash is derived from the beds of lakes, i e., from the sub-surface, it has become the practice to thoroughly test out the waters below the lakes proper. This is done by putting down wells to depths of 15 to 40 feet by drilling with casing and sand bucket. Care should be exercised to prevent the mixing of lake water with that of the sands below. As a rule the casing is allowed to stand for a few minutes after the opening has been made through the hardpan layer in order to let the silt and mud settle around the pipe before water is withdrawn.

If brines are found in the first few wells, a number of wells are sunk in the lake bed to determine the producing area. The lake is surveyed into blocks, varying in size with the area of the lake. This gives well locations that serve to test out all the sands. In most cases the wells show only part of a lake bed to contain potash in paying quantities. This is the producing area.

Samples of water are taken from the well at frequent intervals and placed in jars or jugs labeled to show the lake, the well and sample number. An accurate log is kept of each well. This shows the thickness of beds or layers penetrated. Hydrometric readings are made at regular intervals for information concerning the strengths of solutions encountered.

Laboratory Tests. The brine samples secured from lakes and lake beds are usually shipped at once to the laboratory. Some operators do a part of the laboratory testing in the field. They take a certain quantity of the water, let it stand for about 24 hours, and then make a hydrometric test of the clear water. In order to facilitate shipment a given weight or volume of water is boiled down to determine the percentage of solids. A sample of the solids is sent to the central laboratory for analysis. The chemical analysis is made to show the percentage of potash salts or to show a complete analysis of all alkali compounds in the sample. The price paid for such analyses varies with the determinations made, ranging from about $2 to $20 per sample.

Evaluation of Lakes. The field examinations and the laboratory tests show the lake density and the potash content. These are used in determining the amount of potash in a lake or lake bed.

A report is made on the depth and thickness of sands, and the area of the lake bed in which paying quantities of brine occur. Having these data and the chemical data it is easy to determine and report the number of tons of potash both in the lake and in the lake bed. Such investigations and reports have been made on a large number of the lakes in the region.

The investigations of a lake should show the area in square feet the average depth, average density, amount of water in tons and the K_2O content, and for the underground zone, the area, depth or thickness, density, amount of water in tons, and the K_2O content. The amount of potash in the lake and underground should be determined and stated. Eventually, it will be possible to make a fairly accurate estimate of all of the potash resources of the state.

The value of a lake is also affected by its location with respect to a pipe line or its nearness to other lakes that may be reached by the same line. A lake several miles from a reduction plant is not nearly so valuable as one much nearer.

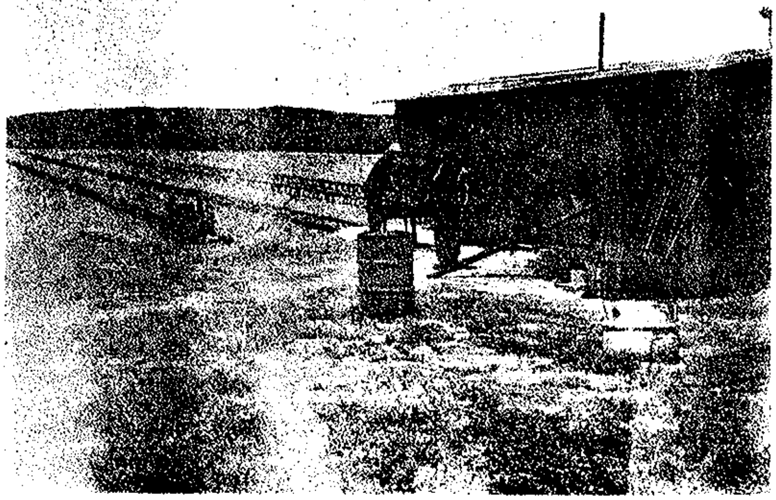

FIGURE 10—A PUMP HOUSE

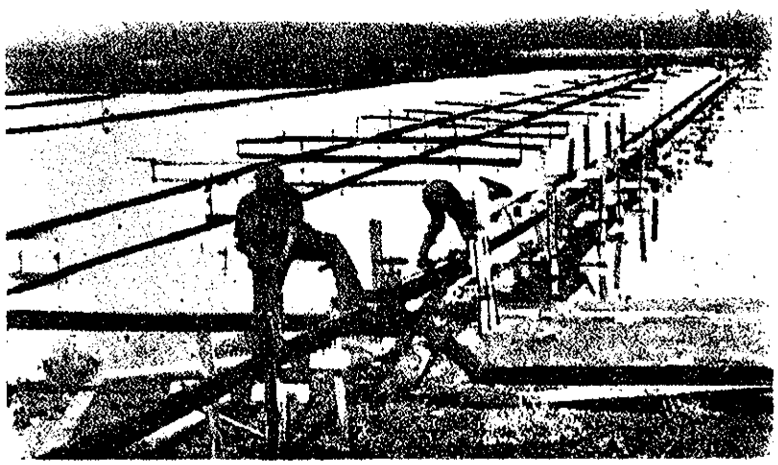

FIGURE 11—VIEW SHOWING HOW WELLS ARE DISTRIBUTED IN A LAKE

BRINE PRODUCTION

At first, the production was from lake waters, but now the principal source is the sub-surface sands. Production is by pumping. Brines are delivered to the reduction plants through pipe lines.

Pumping. Wells are put down in the lake beds where there are strong brines (Figure 10). The depth varies with the thickness of sands. Some wells are driven; others are made by lowering a large casing and then letting the sand point down and filling sand around it. The large casing is then removed. This method gives the stronger wells.

The sand points are attached to a gas pipe which is connected to a suction line (Figure 12). Wells are placed close in order to draw from all the sand. This may require about 50 wells for each five acres of lake bed. There are about 1,200 sand points in Jesse Lake covering a producing area of about 100 acres.

It requires high suction pumps to remove the brine. From 100 to 200 wells are connected to each pump. There are five pump stations at Jesse Lake with two pumps at each. Force pumps are used to drive the brine through pipe lines leading to reduction plants.

Pumping is done by motor drive or by gas engines. There are two twelve-hour shifts each day.

Brines are gauged by meters or by the use of stroke counters.

Most of the potash companies have pump stations at lakes and relay stations along the pipe lines.

Pipe Lines. There are several miles of pipe line in the potash region. They lead from the producing lakes to relay stations and finally to the reduction works. Some of these lines are made of iron casing, but most of those now installed are wood, wrapped with heavy wire. The diameters of the casings range from 2½ to 6 inches. Those made of wood are about 6 inches in diameter and are built to stand a head of 150 to 300 pounds. The lines are buried 30 inches below the surface as required by the state law. Some ditching is done by hand, but most of it is by mechanical diggers.

A plant operating from a number of lakes and with several pumps will collect water from laterals or branching lines at central points and then pump it to the central plant.

Summer Lakes. The brines in some lakes are too weak most of the year for production. They can be pumped to the beds of other lakes when evaporation is greatest and concentrated by solar evaporation. After this is done, other pumps draw the water off and force it to the potash plant. The water of such evaporating basins is allowed to collect in an artificial opening called a "sump" from which it is pumped. The American Potash company has made extensive use of this plan (Figure 13).

Winter Lakes. Ice forming on a lake causes the potash to concentrate in the water below. The brines are pumped when the density has increased sufficiently. This makes it possible to utilize the lakes which are comparatively weak during other times of the year.

POTASH REDUCTION

The brines are treated in reducing plants. A few small plants and four large ones have been erected. Three additional companies are either building or preparing to build.

The Potash Reduction Company plant is at Hoffland; the Nebraska Potash Works Company and the American Potash Company plants are at Antioch, and the Hord Alkali Products Company plant is at Lakeside.

The Alliance Potash Company is completing its works at Antioch. The Western Potash Company and the National Potash Company are starting to erect plants at this place. The Standard Potash Company proposes to build near Lakeside.

It appears that Antioch is destined to become the big potash center (Figure 13). This place has sprung up within a year. There are now more than 200 houses in the town. The two or three new plants should cause the growth to continue for some time.

Equipment of a Potash Plant. The reduction of potash is brought about by methods similar to those used in reducing juice at a beet sugar factory. Machinery is installed to pump and transport brine, to evaporate or boil down the brines, to dry the concentrated liquors, to crush the dried potash and to sack the same for shipment. The small plants are very simple and easily installed. A large plant costs $100,000 to $400,000. It requires several acres of land for a site and usually includes the following equipment and buildings.

1. A main building equipped for storing, evaporating, drying, grinding and sacking. This includes tanks, vacuum pans, furnaces or driers, grinding mills, etc.
2. Boiler and engine houses and equipment.
3. Bins for coal storage and tanks for oil storage.
4. Blacksmith shop, carpenter shop, and supply house.
5. Office buildings.
6. Bunk houses and eating houses.
7. Homes for employes.
8. Railroad siding.
9. Water supply, probably from wells.

The companies have had difficulty in securing machinery and building materials. This delayed the completion of plants.

Evaporation of Brine. This is the main process in potash production. It requires extensive equipment and about 75 per cent of the coal consumed in a plant.

In its simplest form, evaporation is done in open pans and by the use of direct heat. This method, used by small operators, is slow and wasteful of fuel.

The large plants use multiple evaporators—in double and triple effect. The evaporators are operated part under pressure and part under vacuum. Each evaporator consists of a steam chest, a liquid circulating space and a vapor space. Live steam enters the chest of the first

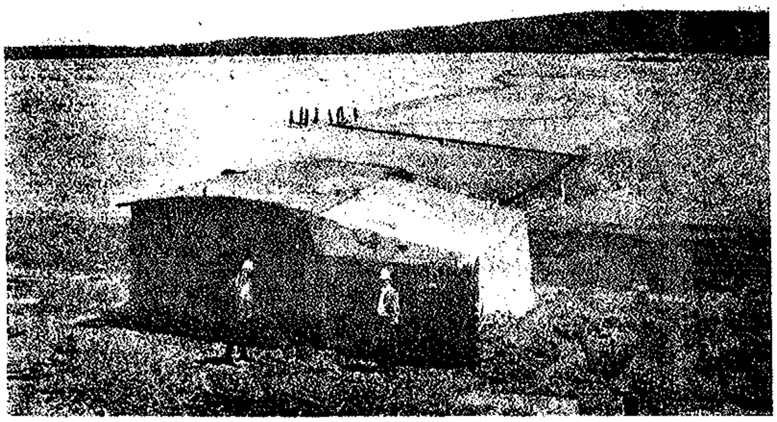

FIGURE 12—A SUMMER LAKE PUMPED BY THE AMERICAN POTASH CO.

FIGURE 13—GENERAL VIEW ACROSS PART OF ANTIOCH

body in the series and causes the brine to boil. The vapor given off in this evaporator is carried to the second body and so on through the series. The boiling point becomes lower in each succeeding evaporator. This is due to vacuum brought about by means of a pump and condenser.

> "In the operation of the triple effect, it is the custom to draw the weak liquor into the second body, then through a third and back to the first body, then from the first it is pumped to a finishing cooker, the object of all this procedure being that of preventing crystallization as far as possible by doing the concentration at the highest available temperatures."*

In most plants the brines are evaporated to some extent by the use of solar towers. The condensation of vapor in the last effect or effects is produced by pumping water through a condenser, from which it goes to the cooling tower or to a spray pond. The tower is essentially one of the effects.

The Potash Reduction Company uses two batteries of pans or evaporators—one a double effect, using steam two times, and the other a triple effect, using steam three times. In the triple effect, brines enter the first pan under 10 pounds or more pressure and at a temperature of about 240 degrees F. In the second the temperature is lower and there is a 5-inch vacuum. The third pan has an 18 to 20-inch vacuum and a temperature of about 160 degrees F. It is planned to unite these batteries of pans making a quintuple effect.

As has been shown by the foregoing, the brines pass through what might be called evaporators and vacuum pans arranged in a series. The liquor is reduced to 30 Baume or more. If the reduction is carried to the point of saturation the salts drop out as crystals and thus interfere with the operation of the pans. It would seem, however, that advantage might be taken of this crystallization and separation of salts. This could be done by keeping the liquor in motion and by drawing off the massecuite about as they do at sugar factories.

The product of the evaporators and vacuum pans goes directly to the driers or it is sent to a series of open tanks provided with steam coils and heated with live steam. A concentration of 40 to 45 Baume may be brought about in these tanks or in otherwise specially devised "cookers" or finishing tanks.

Drying the Liquor. The small plants continue the process of evaporation in open pans until the water is driven off and a crust is formed. This cannot be done in the vacuum pans of the large plants for evaporation must stop at or near the point of saturation.

The liquor from the pans or crystallizing vats is dried in rotating furnaces made of heavy boiler iron. The furnaces are cylindrical, 4 to 5 feet in diameter, 30 to 45 feet or more long, mounted on a low incline and rotated by a cog drive. The feed end is the higher. The inside of

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* W. C. Graham.

the drier has small projecting shelves which carry the potash upward during rotation and spill it through the heat draft. The liquor is fed to the driers by hand or from nozzles. The heat is produced by the direct action of oil flame blown into the furnace from the lower end making high temperatures. The clinker-like potash drops from the fire end of the drier.

It requires two men to run a furnace. Each large potash plant has four or more driers.

Grinding the Potash. The product of the driers is passed through grinding mills, of which there are several types in use. Each plant finds it an advantage to install two mills.

The potash is ground to the size represented by granulated sugar.

Sacking and Shipping. The ground potash is sacked in burlap coffee bags and sealed. The weight per sack is 200 pounds. New bags cost 20 cents each and second hand ones are cheaper.

The sacked potash is stored until shipped in car load lots.

Price and Market. The price is set for all producers on a basis of K_2O content. The price is now $4.50 or more per unit. This is about $90 per ton for 20-unit potash and about $126 per ton for a 28-unit product.

A small sample is taken of every sack of potash. A referee chemist is selected by agreement between the producer and buyer to determine the grade. All sampling is done at the plants.

The production finds a market in Baltimore, Atlanta, Richmond, Charleston, Jacksonville and other cities where there are large dealers in fertilizers. Freight on shipments is paid by the reduction companies.

THE POTASH REDUCTION COMPANY

This company was the first in the field. It built a small plant at Hoffland about eleven miles east of Alliance and has by a number of changes and improvements evolved a reduction works costing many thousands of dollars. (Figure 14). The company has pioneered potash production by experimenting on the methods and equipment used in reduction. It has built and torn down a number of buildings. Recently a large stack 210 feet high and a big boiler house were erected. Also, new equipment for reducing the brines and for grinding the potash were installed. The company owns many small houses which are rented to employes. Attention is given to the welfare of the laborers through public entertainments, public bath houses, etc.

The persons financially interested in the Potash Reduction company came mostly from Tekamah, Nebraska. Mr. John H. Show deserves most credit for starting this plant. Trained as an engineer and student of chemistry at the State University, he became interested in alkali salts used in the makings of soaps, and finally went to the sand hill region in search of brines. Associated with him was Mr. Carl Modesitt, a graduate of the State University, who had specialized in geography, geology and chemistry. These men spent a number of months making surface exami-

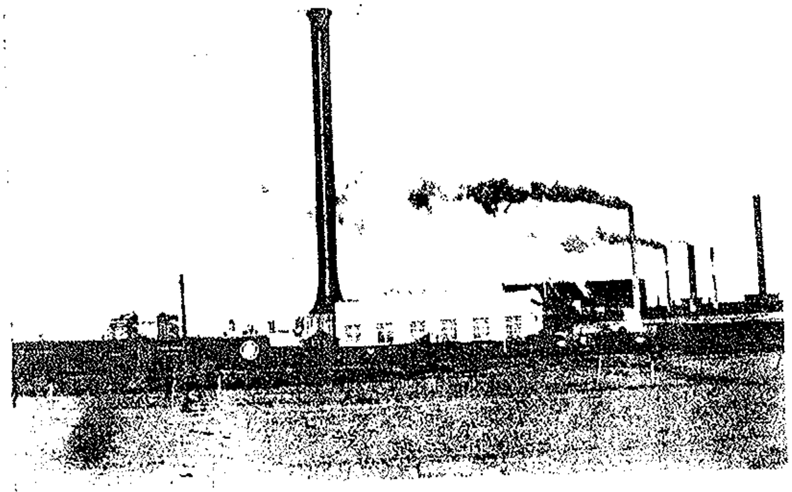

FIGURE 14—THE POTASH REDUCTION CO. PLANT, HOFFLAND

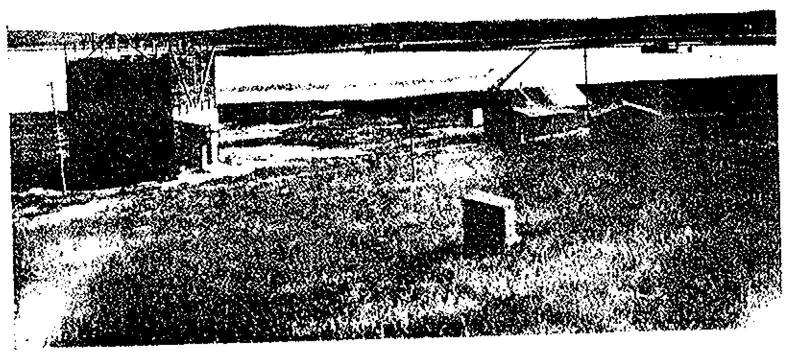

FIGURE 15—JESSE LAKE

nations of the lakes. Finally Jesse Lake was located and found to be much stronger than any of the large lakes that had been examined. This lake being close to the railroad was selected as the one from which an attempt would be made to produce potash. Messrs. T. E. Stevens, W. H. Austinberg, W. A. Redick and Dr. H. Reinbolt financed the field examination and the erection of the first plant. Messrs. V. I. Jeep and C. C. Denny former university students, were also associated with the organization of the company.

At first the output of the Potash Products company, the name then used, was small. By the middle of 1915 operation was undertaken on a large scale. Since that time the plant has operated nearly continuously. The product has been widely advertised and it now supplies a big demand in several states.

The company either owns or leases a number of lakes both north and south of the railroad. Jesse Lake, (Figure 15) from which much of the output of the Potash Production Company plant has been secured, is 2½ miles north of Hoffland. It has an area of about 235 acres. The surface water and the lake bed have been utilized. The percentage of solids runs between 10 and 20 Baume and the K_2O between 28 and 30. The lake has been reduced by heavy pumping. The water is carried through pipe lines to the central plant and reduced by the usual methods to a dried condition, then ground and sacked for market.

Recently the Potash Reduction Company built a pipe line southwestward to Clough Lake. Extensions will be made from this to McCarthy, Wildhorse, Richardson and to several other lakes in Rice Valley. A pipe line leading to the Nebraska Potash Works Company at Antioch which is to handle brines for the Potash Reduction Company, taps a number of lakes southeast of Antioch. Among these are Lane, McFall and Herman lakes.

The Potash Reduction Company is the largest operator in the field. The output of the plant has exceeded 100 tons per day. The company recently built a refining plant at Omaha to which a part of the potash from Hoffland will be diverted. Several potash and some soda compounds are to be made at Omaha.

THE HORD ALKALI PRODUCTS COMPANY

This company built the second plant in the potash region (Figure 16). It operates at Lakeside, just west of town. In fact it should be said that the town built just east of the potash plant.

The Hord company has large holdings of ranch land in the vicinity of Lakeside and on which are many ponds and lakes. Most of these show a low density, but several are quite rich in potash. Among the lakes used to date are Cook, Dougherty, Cat, Mulhall and Simindson. A pipe line is being extended to Snow Lake, a small part of which is on a school section. Another pipe line is to be laid southward from the plant to Ashburger Lake, a distance of about 15 miles. This may tap other lakes along the line.

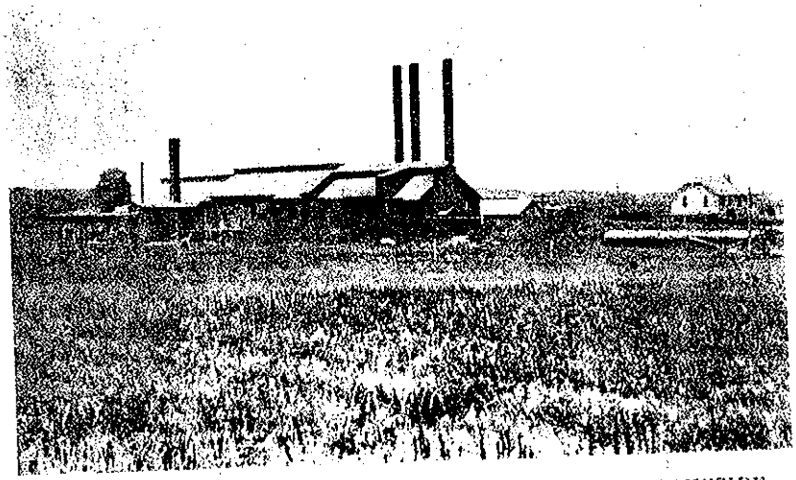

FIGURE 16—THE HORD ALKALI PRODUCTS CO. PLANT, LAKESIDE

As a rule the brines worked by the Hord company are a little lower in solids than are used by the plants farther west. The potash content compares quite favorably, though not as high as in Jesse Lake.

The Hord plant is well built and efficiently managed. It is in charge of persons who have had considerable experience in the chemical industries. The plant cost more than $200,000 not including a number of buildings which have been erected for housing and feeding employes. The plant is compactly built and has a capacity of about 80 tons a day. Not until the late summer of 1917 was the full capacity reached. The central offices are at Central City. Heber Hord is president, and W. E. Richardson is manager.

This plant has improvements over others in the region in the method used in feeding the liquor or concentrated brine to the driers. The liquor is sprayed in from nozzles. A part of the reduction of the brine is brought about by blowing air through the liquor.

The Hord Company ships the output principally to southern states for use in the manufacture of fertilizers.

AMERICAN POTASH COMPANY

The plant of this company is located north of the track at Antioch (Figure 17). It was built in 1916 and the first part of 1917, being the third in the field. The central office is at Omaha. Mr. Arthur English is president, and A. J. Dunbar is superintendent. The plant is compactly built and favorably located. The processes in reduction are about the same as those employed by other companies. The capacity is about 100 tons per day. The average daily output for August last was 77 tons. The total production for the year ending December 15th was sold to the American Agricultural Chemical Company.

The American Potash Company has several good lakes under lease. Most of them were secured from the Krause brothers. These lakes are reached by pipe lines ruunning northward about 15 miles and branching to the sources of brine supplies. A royalty of 20% is paid on these leases. A large lake basin is used for solar evaporation. Waters are supplied to this basin from weak lakes.

Brines controlled by the American company are quite high in solids and in potash content. Among the lakes used are Krause Nos. 1, 2, 3, 4 and 5, the Marks Lakes, Harrion Pond and Turkey Track Lake. Lily and Bower Lakes are used as winter lakes.

The original capitalization of the American Potash Company was $150,000. The capitalization was raised to $250,000. The company operates successfully and pays good dividends.

THE NEBRASKA POTASH WORKS COMPANY

The plant of this company is located north of the railroad at Antioch and immediately west of the American Potash plant (Figure 18). A considerable part of the water used for reduction has come from Ashburger, Palmer and Wilson lakes. One of the pipe lines extends eastward along the north side of the railroad and then branches to the Wilson and Ashburger Lakes. This line is now extending southeastward to Herman Lakes. Another line reaches northwestward from the plant to Palmer lake.

The Nebraska plant is quite well built, but it has not had sufficient brine at all times for capacity work. Some water used has run as low as 2% solids and comparatively low in potash content. The company has entered into a contract with the Potash Reduction Company to run some of their higher grade brines. This means that the plant should not be hampered in the future.

The Nebraska plant has certain novel features for drying. By this scheme some three or four grades of potash are obtained and comparatively little of the potash is lost.

THE ALLIANCE POTASH COMPANY

This company, recently organized, is constructing a plant at Antioch. The location is immediately east of the American Potash Company plant. The Krause brothers and Alliance people are chiefly interested in the company, though there are a number of other stockholders.

It is claimed that this plant will be the most modern in the region. It is being constructed with fire proof walls and in units, whereby the works can be extended if the developments warrant such.

The Alliance company has a number of good lakes under lease. The first one to be worked is the Big Sturgeon located about 5 miles south

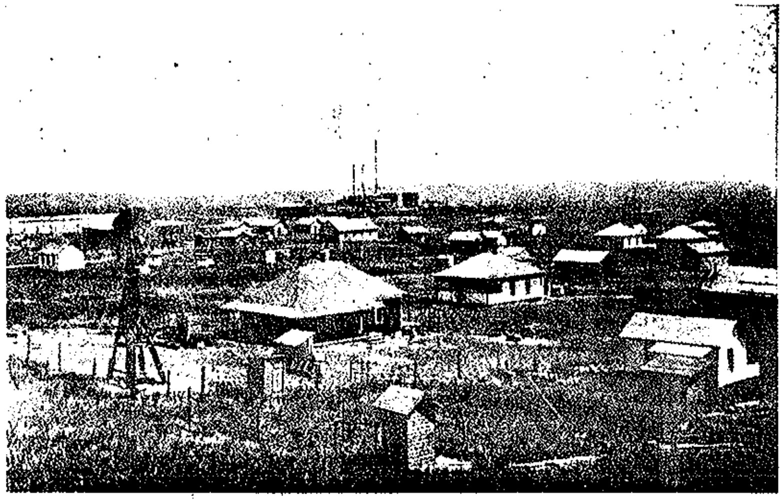

FIGURE 17--THE AMERICAN POTASH CO. PLANT, ANTIOCH

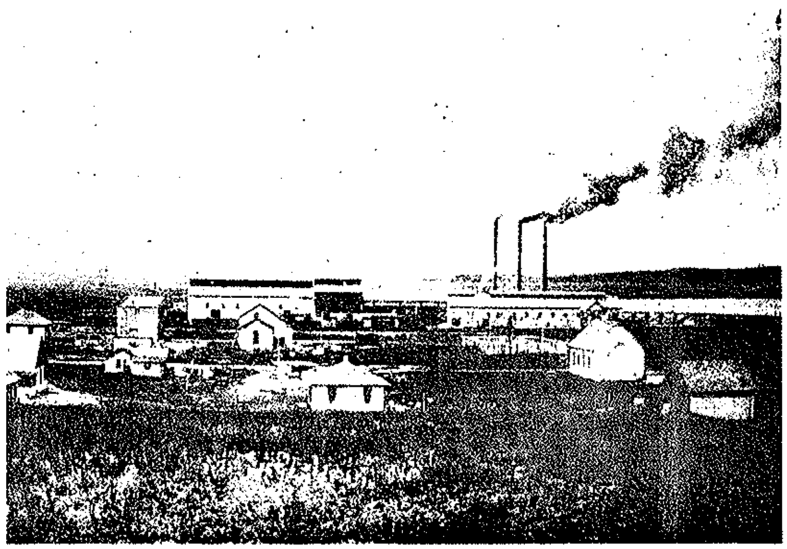

FIGURE 18--THE NEBRASKA POTASH WORKS CO.

west of Antioch. A pipe line has been completed to this lake and to small lakes along the route. The other source of brine supply will be lakes located 1 to 15 miles north of Antioch. These are some of the Wilkinson lakes and others in that vicinity. Six-inch pipe lines are being laid and efficient pumps are to be used in the production and transportation of brines. The plant is building for a capacity of 100 tons or more per day. The central office will be at Alliance.

THE WESTERN POTASH COMPANY

During the summer extensive tests were made of lakes located principally to the north of Antioch and to the south of Hoffland. About thirty lakes, quite rich in potash are said to be under lease, as a result of this field and laboratory work. The leases are being taken over by the Western Potash company. The capitalization is to be about $500,000. This company plans to erect a large plant at Antioch to reduce and refine the potash. If the present plans are carried into effect this may become the largest potash plant in the state. Machinery, pumps and pipe line supplies have been purchased and the installation of the plant is to be started at once.

Among the lakes under lease to the Western Potash company are the Briggs lakes, of which there are four or more, the Wilkinson lakes, Nos. 1, 2, 3, and 4, Potmesill Lake, Patmore Lake, East Valley Lake and Clark Lake. Mr. W. E. Sharp is the president of this company and the central offices are at Lincoln.

THE NATIONAL POTASH COMPANY

Not much data are at hand showing the resources and plans of this company. According to reports received, the plans call for a plant at Antioch to be located just west of the Nebraska works.

The capitalization of the company is $500,000. Central offices are at Omaha. The plant will have a capacity of 100 tons a day.

The source of brines, at the start, will be the Beck lakes located between 10 and 12 miles southeast of Antioch. A pipe line will connect these and other lakes with the plant.

Messrs. O'Brien and Haines of Omaha were the organizers of this company.

THE STANDARD POTASH COMPANY

According to reports, a company with this name has leased the Lundsford lakes and will construct a plant at Lakeside, located southeast of town. The capitalization is said to be about $400,000 and the proposed capacity of the plant 100 tons.

Mr. F. J. Schnorr is president, and Frank E. Clark, is secretary. Offices are at Omaha.

THE NEBRASKA REFINING AND PIPE LINE COMPANY

This company, with offices at Valentine, has leased a number of lakes in different parts of the potash region. Several of the lakes are on school sections and some of them contain very good brines.

We do not have a report from this company, showing what plans have been made for building a plant. Mr. W. S. Ridgell is president.

SMALL REDUCTION PLANTS.

There has been more or less agitation favoring the building of cheap plants to produce potash from small lakes. The Rogers plant south of Antioch worked for a while and apparently successfully until it was shut down by litigation. The right of the operator to remove the brine was involved in the dispute. The cost of the Rogers plant was a little more than $1,000. The product was hauled to Antioch for shipment.

The King-Swenson Company is planning to erect a small plant, at Birdsell Station, costing about $10,000, and to pipe brines from small lakes located on the tableland. The lakes now under lease are the Bonness and the Putman lakes. More lakes, favorably located, may be leased if the plant is installed and it proves successful.

Messrs. Murray and Sarwine are associated in a small plant on Strong Lake southwest of Lakeside. We have no figures showing the cost and the output.

The Robbins plant, costing about $1,000, is reported. It is said to be about 10 miles south of Antioch.

SOME ECONOMIC ASPECTS OF THE POTASH INDUSTRY

It is now time that this industry should be studied with the purpose of conserving it for the state.

The following is a resume of some of the salient economic factors that may determine the permanence of the potash industry in Nebraska.

The Available Supply of Brine. Though a complete inventory of the brines has not been determined we conclude from data at hand that the volume of natural brine is less than some promoters claim. It is thought that if the plants now producing, building and contemplating building come to operation at their full capacity, the stores of high testing brines would be greatly reduced within four years. The brines are subject to depletion and economic exhaustion but not to complete physical exhaustion. Weaker brines are available for use after the richer ones are depleted. How long these may last cannot be detrmined at this time.

The Fuel Supplies. Two kinds of fuel are used in the plants—namely, coal and oil. A large amount of the coal is shipped from Wyoming. The oil is brought from Casper and Greybull, Wyoming. The coal costs from about $1.00 to more than $4.00 a ton at the mines, depending on the quality, whether slack, screenings, nut, or mine run. The freight rate is from $2.00 to $2.75 a ton. The government has given preference for the shipment of coal to the potash plants and this has been of importance to the companies. At a few times, however, the daily production of the plants has been reduced because of a lack of coal. It is to be hoped that the excessive demands made on the railroads because of the war, may not cause the fuel supplies to be cut off in the future.

The coal is used for generating heat for evaporating, and power to drive the machinery and generators of electricity used for light and power. Oil is used principally in the rotary driers and to some extent for pumping. The cost of the heavy fuel oil at the plants is now about 7 cents a gallon.

It requires a large amount of fuel to run a potash plant. The American Potash Company produced an average of 77 tons of potash per day in August with a consumption of 78 tons per day of coal and an average consumption of 46 gallons of oil per ton of potash. This was a tonnage of fuel greater than that of the potash shipped out. Fortunately, the potash plants are near adequate supplies of fuel. The price of fuel, however, is advancing.

The heat economy of the plants is quite low. Hot water from the evaporators might be used in the boilers. Greater use could be made of exhaust steam and of the hot vapors from the cookers.

Labor Supply. Most of the companies run a standing ad for labor. Each of the large plants has 125 or more persons on the payroll. These include, pipe line men, pump men, firemen, drier men, engineers, chemists, etc. The wage is high, yet the common labor is hard to hold. Laborers are shipped in principally from Omaha. Meals and lodging are furnished at about $1.00 a day to persons not living in homes.

The American Potash Company pays a bonus of 1 cent per ton of product per day to each employee. The effect of this has been to stimulate production. The plan may be put into effect at all of the plants.

It is more difficult to hire and hold labor in the potash region than it would be near a large city. Some trouble has been experienced with the I. W. W.'s. The officers of the plants are trying to prevent further disturbances from these floating trouble makers. The war is making the labor problem more difficult.

Cost of Production. The cost of production varies in the different plants. It is figured on a tonnage basis. There is a difference between the cost of operation and the cost of production. The first refers to the outlay in carrying on the processes in operating a plant. The latter must include all depreciation of plant, cost of leases, or price paid for lakes, royalties, expense in the installation of new equipment, etc.

Unfortunately, no very reliable data are at hand to serve in determining the cost of production. The cost, if properly figured, would be found to vary greatly in the different plants because of the advantages and disadvantages under which they operate. We refer to such as rich and weak brines, long pipe lines and their cost; low and high potash content; low and high royalties, and to conditions that have come as a result of good and bad management.

The cost of the production seems to have run between \$20 and \$44 per ton. The mean average is said to be \$30 or more. The cost of operation has run as low as \$10 per ton in some cases.

Use of Potash. According to a report recently published by the U. S. Geological Survey potash salts are used in fertilizers, in the manufacture of soap, glass, matches, explosives and for tanning, dyeing, electro plating, photography and in many chemical compounds. Contrary to the general belief, nearly all of Nebraska's output is used in the manufacture of fertilizers. Only a small part goes to refineries. The production is shipped to the south and southeast and to such centers as Baltimore, Indianapolis, Richmond, Savannah, Nashville, Jacksonville, New Orleans and Memphis.

Amount of Production. According to Mr. Gale, of the U. S. Geological Survey, the production of this year in the United States will come from the following sources: Natural salts and brines, in which Nebraska leads; alunite and dust from cement mills and blast furnaces; kelp; distillery slops, wood washings and miscellaneous industrial wastes; and wood ash. There probably will be a production in the United States equal to 25,000 tons of K_2O. Nebraska will account for about two-fifths of this. The 1918 output should be much larger in Nebraska.

Demand for Potash There is a strong demand for the output. It is made so because foreign potash has been cut off. Normally the United States consumes the equivalent of 200,000 tons of K_2O annually. This represents between four and five times this tonnage of crude potash. There still remains a large demand not supplied. This is a favorable condition viewed from the angle of the producer.

War Prices. Before the European war much of the fertilizer potash used in the United States was imported from Germany and at a cost farther below the present prices. At one time 16% potash came in at between \$7 and \$8 per ton, and 20% potash at about \$12 per ton. The highest price quoted on the first output in Nebraska was about \$20 per ton. As the foreign supply decreased the price of the domestic product advanced. Nebraska potash now sells at \$4.50 or more per unit, a unit meaning 1% of potash (K_2O) in a ton in the material marketed—that is, a product carrying 28% K_2O may be sold at \$4.50 a unit, which would be \$126 a ton for the material marketed. The reduction companies pay the freight.

The high price of potash has been a great incentive to the development of the industry in Nebraska. Without this the industry would not be in its present condition. Most of the producers are deeply concerned regarding future prices.

War Taxes. What is to be done in taxing the potash plants for war purposes? This matter is uppermost in the mind of everyone who owns potash stock. A special tax may be levied on production and excess profits. It is believed that the officers of the various companies will show the right spirit in this matter. Probably the better plan for the government to follow would be to stimulate production by not over-taxing the plants and to place the emphasis on taxing the incomes of the stockholders.

Permanence of the Industry. Is Nebraska to have a permanent potash industry? The answer to this question is in the future.

It is to be hoped that the future prospects may prove brighter than some think. In order to get at this matter let us observe the factors that should decide the case. They are prices and the supply of brine. If the first of these declines approaching the cost of production, the industry will be hampered. If the second, i. e. supply of brine, plays out, the industry will stop.

The plants are now receiving war prices for the production and there is no competition with foreign potash. The war will end some time and with it may come lower prices. Just how fast the decline should come cannot be determined at this time. Prejudice will keep out German potash for a while. The government may or may not enact a tariff to protect the potash industry. Ordinarily we should expect a decline in prices following the war, and probably a small margin will be left between cost of production and the market price.

Looking now at the available supply of brine, it should be understood that it is subject to economic exhaustion, that it is not easily replenished, and that unless much more brine is discovered, the heavy pumping will in time deplete the workable supply. The best brines are being pumped. Future production will be from decreasing densities and lower potash content. The effect of this should be apparent.

The plants are operating on a plan that calls for the largest production possible while prices are high. That there is enough brine to support most of the plants and probably all of them for a few years must be admitted. But this is a short period.

The lower prices after the war can be met, at least in part, by using the Nebraska product in refineries and turning out high priced chemicals. The recovery of soda along with the potash, if it can be done, will tend to enhance the value of the product of the reduction plants.

The depleting supplies of brines can be offset to some extent by the discovery of new supplies, by the natural increment or growth of salts in the lakes, by impovements made in methods of reduction whereby weak solutions can be run, and by a better system of management of the lakes and brines both weak and strong. This system should partake of the nature of farming or husbanding the alkali resources of all lakes.

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