POTASH IN WESTERN SALINE DEPOSITS.

By James H. Hance.

FIELD WORK.

In 1912 the writer, under the general supervision of Hoyt S. Gale, visited various saline lakes, marshes, flats, and wells, chiefly in the western arid region, for the purpose of sampling and testing their waters and deposits for soluble potassium salts. A cursory examination was made at a number of widely scattered localities, but sufficient time for detailed study was afforded at none of the districts, and the results sought and obtained were chiefly the analyses of samples and a few observations incidental to their collection. Consequently the following is largely a review of the analytical results:

The places visited were Railroad Valley, Fourmile Flat, and Dixie Valley, in Nevada; the alkali lakes near Alliance, in northwestern Nebraska; Estancia Valley, Crater Salt Lake, Playas, and Carlsbad, in New Mexico; Adamana and Cochise Flat, in Arizona. The time devoted to any one locality varied from a day or two to a month, the latter period being given to the alkali lakes in western Nebraska.

NEVADA.

RAILROAD VALLEY.

Railroad Valley is the accumulation basin of one of the larger interior drainage systems of south-central Nevada. It lies about 100 miles east to northeast of Tonopah and a somewhat shorter distance southwest of Ely. Its name is probably derived from the fact that a proposed railroad route (Ely-Goldfield Railroad), which, however, was never carried beyond the making of preliminary surveys, traverses a considerable portion of it. It may be reached by road from either Tonopah or Ely, these being the nearest railroad points.

The valley proper is a typical Nevada desert basin, extending in a general north-south direction for about 85 miles and having a maximum width of 15 miles. Tributary to this valley are several small streams, some of which hold perennial waters in their upper courses, but all of which are generally dry before they reach the valley bottom. Duckwater and Currant creeks flow into its northern end; and the extensive desert valley of lower Hot Creek is tributary to it through the low Twin Springs Pass between the Pancake and Reveille ranges.

Railroad Valley is lowest in its north-central part, where a mud plain, known as Butterfield Marsh, covers an area of approximately 35 or 40 square miles in Tps. 8 and 9 N., R. 56 E. This is a typical mud playa deposit, usually dry though occasionally flooded by storm waters. The mud surface bears a thin crust of salts, especially after flooding and evaporation, but these salts are not prominent and are largely obscured by sediment and wind-swept dust. The margins of the mud flat show salt deposits in more conspicuous form. At the north end of the marsh lies a series of so-called salt pans, irregular areas more heavily crusted with salts and ranging in size from a fraction of an acre to several times that area. These pans are devoid of vegetation and are covered by saline efflorescences several inches in thickness. They stand somewhat above the elevation of the main playa and in time of extreme high waters are flooded and drained to the Butterfield Marsh.

Salt from the pans at the north end of Butterfield Marsh has for many years been collected for local use. In the early days these salts were scraped up into piles and taken to Tybo, a mining camp about 45 miles to the southwest on the west side of Hot Creek Valley, for chlorination of the lead-silver ores. It is reported that the high content of potash in this salt finally led to its disuse and to the substitution of salt from Great Salt Lake. The private investigation of potash prospects in Railroad Valley was suggested by an account of these circumstances found in the company records. Samples of the saline efflorescences tested by the Geological Survey were found to contain as high as 12 per cent K_2O in the soluble portion.

A series of samples, collected by E. E. Free of the Bureau of Soils and the writer, were analyzed by A. E. Merz in the cooperative laboratory at Reno, Nev. In the following tables the results of these analyses have been grouped as follows: Saline residues, including efflorescences and crusts; brines from shallow pits dug in the salt pans north of the marsh; spring and well waters, the average saline content of which is within the limits set for potable waters.

Potash analyses of saline residues from drainage basin of Railroad Valley.

No.	Source of sample.	Soluble portion expressed as per cent of sample.	K_2O content expressed as per cent of soluble portion.
1	Butterfield Marsh	33.86	9.06
2	.....do	44.08	9.87
3	.....do	55.20	12.19
4	.....do	49.10	10.02
5	.....do	58.32	7.18
6	.....do	48.82	11.03
7	.....do	42.62	8.46
26	Crust in center of Hot Creek valley	2.07	5.25

Potash analyses of saline residues from drainage basin of Railroad Valley—Continued.

No.	Source of sample.	Soluble portion expressed as per cent of sample.	K_2O content expressed as per cent of soluble portion.
28	Flat at west end of Twin Springs Pass	13.16	4.25
30	....do	6.22	6.52
40	Crust from east end of Twin Springs Pass	1.74	8.81
43	Crust at Mormon Well	4.55	5.29
45	Crust below terrace at Sharp's ranch	27.36	5.05
48	Crust from flat near Sharp's ranch	33.98	3.10
54	Playa below Willow Springs	25.24	.89
55	Half mile north of sample 54	22.74	3.28
56	Edge of main flat below Bullwhacker Springs	53.80	1.22
57	Main flat one-quarter mile west of sample 56	7.58	1.64
58	Crust from outflow of Willow Springs	33.00	5.87
59	Crust from surface near Bacon Springs	27.56	4.10
62	Crust from surface near Cold Spring	24.48	4.68
64	Surface crust one-half mile east of Duckwater	27.56	1.05
66	Crust from ditch at Irwin ranch	12.10	1.65
71	Surface crust at Locke's ranch	59.92	4.35
75	Crust 6 miles south of Locke's ranch	1.59	....
76	Crust 100 yards southeast of sample 75	4.55	8.53
80	Crust from draw 3.8 miles northeast from Locke's ranch	68.22	6.85
81	....do	56.63	2.98
82	....do	55.72	3.67
84	Crust from dune 5.5 miles northeast from Locke's ranch	14.69	4.06
87	Crust from road 6 miles northeast from Locke's ranch	30.46	4.53
88	Crust from road 6.5 miles northeast from Locke's ranch	24.03	2.33
89	West of west edge of salt pan about 7 miles northeast from Locke's ranch	25.58	5.71
90	West edge of salt pan (89)	49.48	7.91
91	Center of same pan (89)	70.97	6.97
92	....do	74.72	8.46
93	East edge of same pan (89)	56.37	7.54
94	East of east edge of same pan (89)	16.68	3.98
95	Draw 7.1 miles northeast of Locke's ranch	53.00	7.39
96	....do	71.64	9.20
97	....do	69.12	7.72
98	....do	55.16	9.22
99	530 feet east of 95	64.96	8.52
100	....do	66.62	5.76
101	West edge of salt pan 1,100 feet east of 95	34.48	2.22
102	Center of salt pan 1,100 feet east of 95	55.18	8.96
103	....do	43.24	3.90
104	East edge of same pan 1,600 feet east of 95	53.96	3.78
105	Northwest edge of salt flat 0.6 mile east of 95	72.64	6.38
106	100 feet east of 105	46.38	6.73
107	80 feet east of 106	76.38	5.00
108	80 feet east of 107	60.02	3.41
109	110 feet east of 108	58.72	2.38
110	East edge of pan 125 feet east of 109	28.54	3.90
111	Drainage line west of drilling camp, about one-eighth mile east of 110.	59.62	6.11
112	125 feet east of 111	59.16	5.45
113	100 feet east of 112	56.48	6.20
114	420 feet east of 113	72.22	4.23
115	Northeast side of salt flat, 6 miles south of Locke's ranch	41.24	1.53
116	One-quarter mile southwest of 115	10.56	6.02
120	One-half mile north of 116	5.36	6.16
122	Below sample 120	79.56	12.10
124	97 feet west of north quarter corner of sec. 2, T. 8 N., R. 56 E	68.74	1.90
125	375 feet west of north quarter corner of sec. 2, T. 8 N., R. 56 E	45.42	2.94
126	725 feet west of north quarter corner of sec. 2, T. 8 N., R. 56 E	56.90	5.04
127	775 feet west of north quarter corner of sec. 2, T. 8 N., R. 56 E	76.40	3.68
128	850 feet west of north quarter corner of sec. 2, T. 8 N., R. 56 E	62.08	6.65
129	1,075 feet south of north quarter corner of sec. 2, T. 8 N., R. 56 E	55.22	2.73
131	1,350 feet south of north quarter corner of sec. 2, T. 8 N., R. 56 E	83.40	4.53
132	1,750 feet south of north quarter corner of sec. 2, T. 8 N., R. 56 E	40.42	2.06
135	1,200 feet south of north quarter corner of sec. 2, T. 8 N., R. 56 E	68.64	3.39
137	2,225 feet south of north quarter corner of sec. 2, T. 8 N., R. 56 E	14.18	1.81
139	900 feet northwest of center of sec. 2, T. 8 N., R. 56 E	47.18	1.30
144	1,680 feet northwest of center of sec. 2, T. 8 N., R. 56 E	82.46	2.66
145	Old salt mound about center of sec. 5, T. 8 N., R. 57 E	41.34	2.83
146	1,375 feet northwest of center of sec. 2, T. 8 N., R. 56 E	72.06	2.26
148	Probably west side of sec. 1, T. 8 N., R. 56 E	58.22	9.26
149	100 feet north of 148	44.22	6.58
152	150 feet north of northeast corner of sec. 2, T. 8 N., R. 56 E	29.80	4.83
155	350 feet northwest of northeast corner of sec. 2, T. 8 N., R. 56 E	69.00	10.17
159	1,650 feet southwest of McDonald Spring	67.92	3.79
162	750 feet southwest of McDonald Spring	48.92	1.48
165	1,600 feet southwest of McDonald Spring	64.62	3.26
166	1,200 feet southwest of McDonald Spring	76.58	3.42
168	About 4 miles northeast of Locke's ranch	41.10	1.83
	Average of 85 samples	45.57	5.23

Potash analyses of brines from shallow pits in salt pans north and northwest of Butterfield Marsh, in Railroad Valley.

No.	Source of sample.	Dissolved salts (dried at 105° C.) expressed in grams per 100 cubic centimeters of original sample.	K_2O content expressed as per cent of dissolved salts.
130	Shallow pit 1,250 feet south of north quarter corner of sec. 2, T. 8 N., R. 56 E	20.87	8.54
133	Upper brine, shallow pit 1,150 feet south of north quarter corner of sec. 2, T. 8 N., R. 56 E	12.63	6.14
134	Lower brine, shallow pit 1,150 feet south of north quarter corner of sec. 2, T. 8 N., R. 56 E	13.04	6.23
138	Shallow pit near center of sec. 2, T. 8 N., R. 56 E	.97	1.16
143	Shallow auger hole 1,375 feet northwest of center of sec. 2, T. 8 N., R. 56 E	15.74	5.94
153	Upper brine, shallow pit 675 feet north of the northeast corner of sec. 2, T. 8 N., R. 56 E	11.62	11.92
154	Lower brine, shallow pit 675 feet north of the northeast corner of sec. 2, T. 8 N., R. 56 E	12.09	11.78
156	Shallow hole, 300 feet northwest of the northeast corner of sec. 2, T. 8 N., R. 56 E	7.86	11.46
158	Shallow pit, 2,000 feet southwest of McDonald Spring	12.82	5.03
163	Lower brine, shallow pit 2,000 feet southwest of McDonald Spring	13.99	5.49
164	Shallow pit, 1,300 feet southwest of McDonald Spring	13.97	5.82
	Average of 11 samples	12.33	7.23

Analyses of natural spring and well waters from drainage basin of Railroad Valley.

No.	Source of sample.	Dissolved salts (dried at 105° C.) expressed in grams per 100 cubic centimeters of original sample.
17	Currant Creek at Currant post office	0.04
18	Ditch in Hot Creek Canyon at Wagner ranch	.06
21	Spring in Rattlesnake Canyon	.04
23	Stream in Tybo Canyon	.03
25	Draw in center of Hot Creek valley	.07
27	South ditch at west end of Twin Springs Pass	.04
29	North ditch at west end of Twin Springs Pass	.08
31	Spring at house in Twin Springs Pass	.03
42	Mormon Well	.03
47	The main spring, Sharp's ranch	.04
49	Well at Sharp's ranch	.04
50	Willow Springs	.05
51	Standing water on flat below Willow Springs	.18
52	Bullwhacker Springs	.04
53	Standing water on flat from Bullwhacker Springs	.34
61	Cold Spring, 1 mile north of Horton's ranch	.04
63	Draw, 2 miles out of Allred on Duckwater Road	.03
65	Ditch at Irwin ranch	.04
70	Main spring at Locke's ranch	.04
73	Spring 6 miles south of Locke's ranch	.07
157	McDonald Spring	.08
167	Well at drilling camp	.07
171	Black Rock Springs	.04
175	Hot Creek	.07
176	Hot Springs in Hot Creek Canyon	.08
177	Ditch above Hot Springs in Hot Creek Canyon	.05
178	Warm Springs, Hot Creek Valley	.08
186	Warm Springs, near Locke's ranch	.05
187	Well at Blue Eagle ranch	.05
188	Cold Spring at Blue Eagle ranch	.05
189	Warm Spring at Blue Eagle ranch	.04
	Average of 31 samples	.064

The general physiographic evidence in the valley shows that its lowest part has been at some time occupied by a lake. Terraces marking the more permanent of the higher water stages are quite prominent at certain places on the lower slopes, especially on the east side of the valley, above and south of the Blue Eagle ranch. The height of these terraces was estimated as 300 to 400 feet above the lower portion of the valley. A gravel bar, evidence of water action at a lower level, extends into the valley from the mouth of Currant Creek. None of these are of a permanent order but are built of loose and little consolidated material. Their character suggests comparative recency of formation and possibly limited duration of high-water conditions. It is supposed that the lake or lakes that occupied this basin may have been contemporaneous with the Quaternary Lakes Bonneville and Lahontan of this general region.

The hypothesis of the existence of buried saline deposits in this basin, on the basis of which a considerable amount of prospecting in Railroad Valley has already been done, has been reviewed in some detail in prospectuses issued at Tonopah by the Railroad Valley Co.,[1] by whom the work has been done.

In Free's paper the log of a well in Railroad Valley which reached a depth of 1,204 feet is quoted, and its interpretation with reference to possible former lake deposits is discussed. Free concludes that the well record indicates deposits formed in a shallow fluctuating lake, the clay beds corresponding to periods of lake expansion, and the sands and gravels to periods when a contracting shore line had exposed the site or had brought it within the zone of wave-moved sands along the shore. According to Free—

> Specimens of the lime-cemented sands at 1,140 to 1,175 feet have received very careful chemical and microscopical examination, and there seems no reasonable doubt that the cementing material of these strata was deposited on the bottom of an evaporating lake. The occurrence of gaylussite at 1,140 feet is especially significant, since this mineral is not known to be deposited except from waters which are brackish or saline.

It is stated in substance that materials resembling the calcareous tufas of the Lahontan basin and elsewhere have been obtained near the bottom of the well and are considered proof of the existence of an ancient lake whose shores or bottom stood at about this horizon. It is supposed by Free that the well is situated too near the margin of such a former lake to have penetrated any saline deposits that may have been deposited therein.

To Mr. Gale and the writer it appears that the record of lake history as observed in the terraces and gravel bar in Railroad Valley indicates

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[1] Railroad Valley Saline Co.: Potash, Sept. 7, 1911.
Free, E. E., Potash, Aug. 22, 1912; idem, rev. ed., Nov. 25, 1912.
Chandler, A. E., Railroad Valley water supply, Aug. 12, 1912.
Marean, H. W., Railroad Valley soils, Aug. 10, 1912.
Several minor circulars were also issued by the Railroad Valley Co.

a water stage of comparatively recent though prehistoric time. Lack of deformation by erosion of the unconsolidated materials along the existing shore terraces and their general relation to the configuration of the present valley bottom seem to indicate that they belong to a topography not greatly different from that of the present day. If so, the record of the desiccation of the lake or lakes of this period probably does not lie deep in the present deposits of the Butterfield Marsh, and might be recorded at a depth of 100 to 200 feet. It is possible that a stratum of tough white clay shown in the well record as extending from 135 to 187 feet may represent a deep-water stage of this lake. As to the existence of preceding and deeper lakes the present physiographic record seems very inconclusive. Deep well logs may throw the desired light on the subject. On the whole, drilling for potash in Railroad Valley is very much on the same footing as that conducted by the United States Geological Survey near Fallon, Nev. At neither place have present results produced conclusive evidence, and the correct interpretation of the logs at hand, as bearing on the former lake histories of the basins, is subject to considerable uncertainty.

FOURMILE FLAT.

Alkali Valley, now called Fourmile and Eightmile flats and sometimes referred to as Sand Springs Valley, lies from 15 to 30 miles southeast of Fallon, in Churchill County, Nev., along the stage road from Fallon to Fairview and Wonder. Fourmile Flat consists of a salt-incrusted expanse covering 12½ square miles, the greater part of which is generally dry, but which is occasionally partly flooded to a depth of several inches.

A concentration of exceptionally pure salt covers more than a square mile in the southern portion of the area. During the sixties considerable salt was shipped on camels from Fourmile Flat to Virginia City for use in chlorinating the silver ores, and a smaller amount was obtained for domestic use. At present the production of salt from this deposit is exceedingly small, as rates for freighting by team are too high to make exploitation profitable.

Alkali Valley is an arm of the large basin formerly occupied by the Quaternary Lake Lahontan. The bottom of the valley has an elevation of 3,960 feet, and the Lahontan waters rose nearly to the 4,400-foot mark, as shown by terraces on the marginal slopes.

According to Russell[1] recent faulting has here developed a local drainage system, and the salt has been leached from the lacustrine sediments and concentrated in the lowest depression. Springs occur in the flat, and may have contributed in large measure to this saline

[1] Russell, I. C., Geological history of Lake Lahontan, a Quaternary lake of northwestern Nevada; Mon. U. S. Geol. Survey, vol. 11, 1885, pp. 235.

accumulation by leaching beds lower in the series, but as yet this hypothesis is unsupported by any proof.

Subsequent to the writer's visit a test well, sunk to a depth of 36 feet by C. E. Watson under the direction of Hoyt S. Gale, showed a surface stratum of 7 feet of hard crystalline salt underlain by a soft black mud. At a depth of 26 feet a flow of water was encountered. Samples were analyzed as follows by R. K. Bailey in the Geological Survey laboratory:

Potash analyses of waters of Fourmile Flat.

Source of sample.	Collector.	Dissolved salts (dried at 105° C.) expressed as per cent of original sample.	K_2O content expressed as per cent of dissolved salts.
Water from "Big Ben" hole, one-half mile west of Kinney's house.	R. K. Bailey	28.90	2.37
Water from hole 200 yards south of "Big Ben"	do	29.10	.73
Water from hole 450 yards south of "Big Ben"	do	29.02	.73
Water 6 inches below surface of salt crust	do	29.53	.70
Water from flow encountered at 26-foot depth	do	26.51	.43
Concentrated brine from hole in salt crust one-half mile northwest of old salt works. Brine filled hole to level with surface salt crust.	J. H. Hance	31.44	1.21
Old well at Salt Wells station, 16 miles southeast of Fallon, Nev., and 8 miles north of Fourmile Flat. Well is 41 feet deep.	do	.35	(a)
Well about 3½ miles northwest of Salt Wells and 11½ miles north of Fourmile Flat. Well is 9 feet deep.	do	.47	(a)
Three dug wells at the old camp site of Sand Springs station on east edge of Fourmile Flat; now abandoned. Wells range from 1½ to 15 feet deep.	do	.15 .08 .27	(a)
Shallow well at old borax plant on Eightmile Flat, about 2 miles southwest of Salt Wells station.	do	.32	(a)
Dug well on Eightmile Point, just north of Fourmile Flat. Well is 30 feet deep.	do	1.34	

a Not determined.

The richest brine sample shows a potash content of only 2.37 per cent and consequently none of the waters are believed to offer any promise as a commercial source of supply of this material.

DIXIE SALT MARSH.

Dixie Salt Marsh, termed Osobb Valley in older reports, is described in the Fortieth Parallel Survey report.[1] It is east of and about 500 feet lower than the Carson Desert, Nev., from which it is separated by the Stillwater Mountains. Physiographic evidence, including a terraced gravel bar northeast of the marsh, indicates previous occupancy of this valley by a shallow lake, which apparently was too short lived to entrench its shore line deeply. Dixie Salt Marsh, which represents the lowest portion of the present valley, covers about 40 square miles. Near the center of the marsh an area of about 9 square miles is covered with a salt crust ranging from 1 to 5 feet in thickness. This crust is

[1] Hague, A., and Emmons, S. F., Final Rept. U. S. Geol. Expl. 40th Par., vol. 2, 1877, pp. 707-708.

underlain by a saline mud, below which lies an alternating series of salt and mud.[1] When visited in July the surface salt was dry, but at other seasons of the year portions of the flat are flooded to a depth of 2 to 3 inches.

From 1861 to 1868 considerable salt was taken from this marsh and hauled by bull team to Virginia City for use in the treatment of the silver ores. Borax was obtained just north of the marsh and brought to Lovelocks for shipment by rail. Operations were discontinued some years ago, however, and at present no attempt is being made to develop the salt.

The following analysis is by R. W. Woodward:[2]

Analysis of salts from Dixie Salt Marsh.

Chloride of sodium	96.49
Sulphate of soda	1.91
Carbonate of soda	.96
Water	.52
Insoluble residue (mainly iron and lime)	.12
	100.00

As shown in this analysis, the sample was nearly pure sodium chloride, and the deposit may be valuable in the future.

Samples collected by the writer and analyzed by R. K. Bailey in the Geological Survey laboratory were reported as follows:

Analyses of salts from Dixie Salt Marsh.

Source of sample.	Dissolved salts (dried at 105° C.) expressed as per cent of original sample.	K_2O content expressed as per cent of dissolved salts.
Concentrated brine from 2½ miles southeast of old Dixie station, near center of marsh. Brine filled hole to level with salt crust	29.13	0.22
Water from dug well at old Borax works just north of marsh. Well was 9 feet deep with 4 feet of water	.92	(a)
Hot springs on southwest margin of marsh. Temperature, about 71° C	.07	(a)
Hot springs at mound about 12 miles northeast of marsh. Temperature, about 67° C	.11	(a)

a Not determined.

Thirty-one samples[3] from drilled wells ranging in depth up to 98 feet taken and analyzed by the Railroad Valley Co. show a potash content of 0.19 to 0.75 per cent of the total solids in saturated solutions. Therefore, so far as shown by available tests, the potash content of the marsh is commercially negligible.

[1] Hague, A., and Emmons, S. F., loc. cit. Also written communication from E. E. Free concerning work done by the Railroad Valley Co. in Dixie Valley.

[2] Hague, A., and Emmons, S. F., op. cit., p. 708.

[3] Written communication of E. E. Free.

NEBRASKA.

The sand-hill region in northwestern Nebraska embraces more than 16,000 square miles of upland lying between Niobrara River on the north and North Platte River on the south. A number of alkali lakes and ponds are scattered over the west-central portion of this region, especially in Cherry, Sheridan, Box Butte, Morrill, and Garden counties. Alliance is situated just west of the hills on the Chicago, Burlington & Quincy Railroad, which bisects the hill area.

The ponds range in size from less than an acre to 2 square miles, although the water content is directly dependent on the rainfall. The deeper ponds are fresh or comparatively so, but the shallow ones are too brackish even for stock. It is reported that during the summer months many of the ponds dry up, leaving a saline mud incrusted with alkali.

Occasional attempts have been made to utilize this alkali as a fertilizer, but the deleterious effects of the carbonate salts might be expected to prohibit such use, and results up to the present time have not apparently justified the projects. It was reported to the writer that some years ago a carload of the dry material was shipped to Omaha, where it was mixed with slaughterhouse refuse for fertilizing material, but the value of the product did not seem to encourage further development.

A sample of water from one of the more saline ponds submitted by parties interested in the development of the salts showed on analysis 19.32 per cent of dissolved salts. Of this dissolved material over 30 per cent was K_2O, indicating a potash content in the original brine of nearly 6 per cent.

Recent activity, stimulated by the general search for potash, has directed attention to the content of these ponds, and an attempt is now being made to extract the soda and potash in marketable form. Samples collected by C. L. Modessitt, of Alliance, and analyzed by J. W. Show at Omaha, showed an excess of potash over soda in many of the soluble residues. The attention of the Geological Survey was called to this feature, and the writer spent some time in traversing the area for the purpose of securing representative samples and determining the extent of the deposits. The samples are grouped under muds, brines, and saline residues or crusts. In addition to the samples included in the tables, 94 others were collected, but, as these contained less than 3 per cent of dissolved material (87 of them contained less than 2 per cent), further analysis of their potassium content was not completed.

Potash analyses of muds from western Nebraska.

No.	Source of sample.	Soluble portion expressed as per cent of sample.	K_2O content expressed as per cent of soluble portion.
26	1 foot below surface of Jesse Lake, 40 feet from shore	9.35	25.42
77	1 foot below surface of flat, one-fourth mile north of railroad, 2 miles east of Reno post office	3.04	14.80
112	Lake at Lakeside	3.58	12.03
115	4 feet below surface of Jesse Lake	4.63	28.92
116	7 feet below surface of Jesse Lake	4.07	24.78
126	Lake in sec. 1, T. 21 N., R. 46 W	3.47	13.20
	Average of 6 samples	4.69	19.86

Potash analyses of brines from western Nebraska.

No.	Source of sample.	Dissolved salts (dried at 105° C.) expressed as per cent of original sample.	K_2O content expressed as per cent of dissolved salts.
24	Shallow pit at edge of Jesse Lake	12.31	34.81
27	Pit 4 feet deep in Jesse Lake, 40 feet from shore	14.14	26.40
62	Pond 1 mile southwest of house on Star Ranch, sec. 17, T. 26 N., R. 43 W	3.21	35.85
73	Pond in sec. 19, T. 26 N., R. 44 W. (small)	8.15	15.50
74	Pond in sec. 19, T. 26 N., R. 44 W. (large)	4.70	31.40
79	Pond at F. C. Taylor's place, 3 miles east of Reno post office	7.20	23.14
85	Pond in northeast corner sec. 20, T. 26 N., R. 44 W	4.56	31.56
118	Middle of Jesse Lake	13.55	29.97
119	McCarty Lake, sec. 17, T. 23 N., R. 46 W	8.83	30.62
120	Pond one-half mile southeast of McCarty Lake	8.11	19.82
123	Richardson Lake, secs. 4 and 5, T. 22 N., R. 46 W	7.57	14.44
125	Lake in sec. 1, T. 21 N., R. 46 W	3.33	16.61
130	Thompson Lake, 15 miles southeast of Alliance	4.30	19.68
	Average of 13 samples	7.69	24.91

Potash analyses of saline residues from western Nebraska.

No.	Source of sample.	Soluble portion expressed as per cent of sample.	K_2O content expressed as per cent of soluble portion.
25	Crust on southeast margin of Jesse Lake	34.06	21.00
75	Alkali from road 8 miles west of north of Lakeside	4.62	6.16
78	Alkali sand south of railroad, 3½ miles east of Reno post office	8.51	11.27
94	Surface incrustation east end of Crevath Lake	34.05	17.17
113	Surface incrustation south edge of pond 1 mile west of north of Lakeside	30.85	2.40
117	Surface incrustation, Jesse Lake	20.25	17.39
132	East pond on Cluff place	8.97	29.70
134	Pond 1½ miles west of preceding	15.12	12.76
	Average of 8 samples	19.55	14.73

A complete analysis of these residues shows that they are markedly similar to the leachings of wood ashes and suggests one source of the alkali. These sand hills and adjoining meadows at one time supported a generous growth of brush and timber,[1] and the region has

[1] Bates, C. C., and Pierce, R. C., Forestation of the sand hills of Nebraska and Kansas: Bull. Forest Service No. 121, 1913, p. 17.

reached its present condition through repeated destructive fires. Prairie fires have also been of frequent occurrence and the natural leachings of these ashes may explain the concentrates in the depres, sions.

The alkali is disseminated in saline muds which underlie the ponds and the latter are rather isolated from each other. Thus, in order to utilize the deposits the saline content must be leached from muds and recovered from solution at different places, and this would entail a number of evaporating units, which, because of the severe winters, could be used for a portion of the year only. Refining is necessary to render either the soda or potash of value and would add considerably to the cost.

NEW MEXICO.

ESTANCIA VALLEY.

The study of the water resources of the Estancia Valley [1] and the discovery there of lake terraces and of saline accumulations suggested the possible presence of potash in commercial quantity.

In recent geologic time the basin was evidently occupied by a lake, which on evaporation left its saline content disseminated in the valley sediments. Ground-water movement is now concentrating the more soluble material in small depressions in the lowest portion of the area.

A number of samples of the muds and incrustations collected by the writer were found on analysis to contain little potash.

Potash analyses of samples from the Estancia Valley, N. Mex.

Source of sample.	Mud. Soluble portion expressed as per cent of sample.	Surface crust. Soluble portion (dried at 105° C.) expressed as per cent of sample.	K_2O content expressed as per cent of soluble portion.
Pond just north of Laguna Chico (average of 3 samples)	11.93		0.71
		58.82	.42
Pond 2½ miles east of Estancia station (average of 3 samples)		90.56	.06
Laguna Chico (average of 4 samples)	12.17		.88
		74.14	.15
Pond north of Silio station (average of 4 samples)	10.32		1.23
		40.35	.38
Laguna del Perro (average of 3 samples)	10.08		.98
		73.90	.22
Laguna Salina (average of 3 samples)	13.78		.93
		74.60	.14
Laguna Salina (brine)	27.30		1.35
Average of 9 samples		68.49	.21
Average of 17 samples	11.59		.96

[1] Meinzer, O. E., Geology and water resources of Estancia Valley, New Mexico, with notes on ground-water conditions in adjacent parts of central New Mexico: Water-Supply Paper U. S. Geol. Survey No. 275, 1911.

Laguna Salina, a salt-incrusted pond about 600 acres in extent, contains a large deposit of nearly pure sodium chloride, which has long been used as a domestic supply by a number of ranchers. Under the present climatic conditions this pond is capable of supplying a large amount of high-grade salt, although no effort has been made to put out a refined product. Thin layers of bloedite crystals occur intercalated with the salt and mud strata.

CRATER SALT LAKE.

Crater Salt Lake, in western New Mexico, 50 miles south of Zuni and 80 miles west of Magdalena, has been briefly described by Darton.[1] Samples of the brine and the mud, collected by the writer from the bottom of the lake, were analyzed in the Geological Survey laboratory, the brine by R. K. Bailey, who reported 16.50 per cent dissolved salts, of which 0.29 per cent was potash, and the mud by W. B. Hicks, who found 13.12 per cent of soluble material, 0.61 per cent of which was potash. The dissolved material is nearly pure sodium chloride.

PLAYAS.

A lake at Playas, N. Mex., reported as alkaline, was visited by the writer, but was found to be comparatively fresh. At some seasons of the year the lake bed is entirely dry, but even then very little alkali is present. The basin has evidently contained a large lake in the past, but the valley sediments are notably free from alkaline salts.

CARLSBAD.

A small lake about 15 miles southeast of Carlsbad, N. Mex., reported as saline, was visited by the writer. The lake occupies a depression of about a square mile in extent, and is a concentration of local drainage. The water sample was analyzed by W. B. Hicks at the Geological Survey laboratory and found to contain 11.15 per cent of dissolved salts, 0.85 per cent of which was potash. The dissolved material is evidently leached from the adjacent rocks, which belong to the "Red Beds," and is concentrated in this shallow depression. An alkali flat extends south from the lake, but was covered with snow at the time of the writer's visit.

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[1] Darton, N. H., Zuni salt deposits, New Mexico: Bull. U. S. Geol. Survey No. 260, 1904, p. 565.

ARIZONA.

ADAMANA.

A well 305 feet deep, drilled in Permian beds at Adamana by the Santa Fe Railway, flows approximately 25 gallons a minute.[1]

Record of artesian well at Adamana, Ariz.

	Feet.
Sand and sandy clay	0– 55
Sandstone	55– 58
Cement gravel	58– 59
Sandstone (water slightly salty at 88)	59–108
Brown shale	108–151
Red shale	151–200
Hard brown and blue shale	200–205
Red shale	205–275
Sandstone	275–285
Hard brown shale	285–305

A sample of this water analyzed by W. B. Hicks at the Geological Survey laboratory was found to contain 4.89 per cent of dissolved salts, of which 0.35 per cent was potash.

The saline content of this well water, as also that of the lake near Carlsbad and Crater Salt Lake, in New Mexico, is derived from the "Red Beds" and is relatively smaller than that in ordinary American river and lake water, which, according to Clarke,[2] contains on the average 1.77 per cent of potassium (or 2.13 per cent potash) in the dissolved solids.

COCHISE FLAT.

Cochise Flat covers about 50 square miles and borders the Southern Pacific Railroad in southeastern Arizona. Gravel terraces near the town of Cochise indicate a former occupancy of this basin by a prehistoric lake. No deeply entrenched shore lines were seen, however, and the lake period or periods may have been of short duration. No notable concentration of salts seems to have taken place at the surface, and what little saline matter is present is mostly black alkali, with some sodium chloride. A sample of efflorescences gathered near a small pool was examined by W. B. Hicks, of the Geological Survey laboratory, and found to contain 11.74 per cent of soluble material, 1.29 per cent of which was potash.

[1] Darton, N. H., Reconnaissance in northwestern New Mexico and northern Arizona: Bull. U. S. Geol. Survey No. 435, 1910, p. 79.

[2] Clarke, F. W., The data of geochemistry: Bull. U. S. Geol. Survey No. 491, 1911, p. 106.