



UNITED STATES
DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY
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STATE DEPT. OF GEOLOGY
& MINERAL INDS.

March 29, 1968

Mr. Ralph S. Mason
Through Hollis M. Dole
Department of Geology and Mineral Industries
State of Oregon
1069 State Office Building
Portland, Oregon 97201

Dear Ralph:

I sent your write-up on the soda ash deposits to G. I. Smith, Chief of the Survey's Branch of Light Metals and Industrial Minerals. I am returning, for your consideration, the text on which G.I. has made a number of editorial comments. These are relatively minor, and I think that you will agree that most of them improve or clarify the text. Smith, however, has some comments about the analyses that are more fundamental, and I can only refer them to you. He points out that very few sodium carbonate minerals contain 46 percent water of crystallization--^{still lower} or the plus 50 to plus 60 percent values shown in your two tables. A sample of pure natron would contain 63 percent H₂O, but natron seems unlikely to survive in the high temperatures prevalent in southern Oregon at the time the samples were taken. Smith therefore questions whether columns 2 and 4 show water of crystallization or something else. In fact, he states that it is not clear from footnotes 1 and 2 (or 3 and 4) of table 1 what the analyses represent, and I must confess after studying the problem I am lost, too. For instance, the phrase "composite of 3 samples averaging 54 percent soluble salt (in anhydrous state)" leaves me completely confused; I simply don't know what you mean.

The same questions apply to your table 2. For instance, why does the table show water of crystallization for analyses 2 through 4 but not for 1 and 5? Is it because these values are higher than the theoretical water of crystallization? If so, does it cast doubt on the validity of the other water of crystallization analyses, all but one of which are above 50 percent?

I am sorry to raise these questions at this late date, and I am hopeful that you have a simple explanation. Perhaps a clarification of what the analyses represent will solve the problem.

Sincerely,

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A. E. Weissenborn
Research Geologist
Branch of Resources Research

Enclosure

Analyses of Crystalline Salts from Alkali Lake
(in percentages by weight)

	1	2	3a	3b	3c	3d	3e	4	5
Na ₂ CO ₃	7.53	34.91	43.35	53.00	38.90	35.83	33.49	40.51	18.44
NaHCO ₃	4.64	3.92	nil	nil	2.01	1.00	.67	.74	1.44
NaCl	5.30	3.67	1.07	1.93	1.49	1.22	1.72	1.49	3.27
Na ₂ SO ₄	3.07	2.49	1.54	1.92	1.33	.91	.77	1.29	1.72
Na ₃ PO ₄	.43	n.d.	.11	.09	.12	.11	.10	.11	.18
Na ₂ B ₄ O ₇	.62	n.d.	.14	.10	.23	.14	.07	.14	.24
KCl	1.48	1.01 ^{a/}	.36	.33	.74	.45	.37	.45	.89
LiCl	nil	n.d.	nil	nil	nil	nil	nil	nil	nil
Br ₂	.0033	n.d.	.0018	.0010	.0016	.00078	.00052	.0011	.00052
I ₂	.0001	n.d.	.0002	.0004	.0001	.0001	.0001	.0002	.0001
SiO ₂	.21	n.d.	.08	.08	.21	.18	.16	.14	.20
Insoluble	n.d.	n.d.	.02	n.d.	n.d.	n.d.	n.d.	----	n.d.
Difference ^{b/}	----	54.00	53.33	42.55	54.97	60.16	62.65	54.73	----
Total	23.28	100.00	100.00	100.00	100.00	100.00	100.00	100.00	26.38

^{a/} K₂SO₄ instead of KCl

^{b/} Essentially water of crystallization and a little insoluble matter

Analyses 1, 3, 4, and 5 by W. P. Smith's Laboratory, Painesville, Ohio; No. 2 recalculated from an analysis by L. L. Hoagland, State Dept. Geology and Min. Ind.

1 Surface crusts, November 1945.

2 Composite of three samples representing the top two feet of solid salts in a "pothole", September 4, 1944.

3 Lens of salts in a "pothole", November 1945; (a) top 3 inches; (b) 3 to 6 inches; (c) 6 to 18 inches; (d) 18 to 22 inches; (e) 22 to 28 inches.

4 Average of 3a to 3e inclusive.

5 Sample from depth of 42 inches in same "pothole" as No. 3.

Soda Ash

Natural ^{ANHYDROUS} sodium carbonate, Na_2CO_3 , or soda ash as it is commonly called, and Texas is an important industrial chemical. California ~~and~~ Wyoming/account for all of the ^{production of} naturally occurring soda ash in the United States. More than half of the total soda ash produced annually in the United States is a co-product of chemical processes. A total of 6.4 million tons/was produced in ash this country in 1965. ~~Slightly over three-fourths of the soda ash consumed was produced synthetically.~~

Soda ash ~~is~~ finds its biggest market in the manufacture of glass, followed by various chemicals derived from it. The pulp and paper industry requires about 10 percent of the output, and alumina and water treatment combined use the same amount. Soda ash serves as a raw material for the manufacture of several other ~~chemical products and~~ sodium compounds because it is comparatively cheap and reacts readily with most other chemicals. Caustic soda, NaOH , is finding increased use in the manufacture of glass, since it ~~permits~~ produces more rapid melting at lower temperatures than soda ash.

Soda ash, along with numerous other closely related evaporites, is formed by the evaporation of waters containing various dissolved salts. Concentrations of the evaporites in sufficient quantities to make them economically attractive has occurred in ^{A FEW} closed basins in areas where the trapped surface waters draining ~~from the~~ to dryness into the land-locked lakes or playas are evaporated/by solar energy. ~~and~~ The increasing salinity of the evaporating waters eventually reaches the saturation point for the least soluble sodium or calcium compound which is then crystallized out and is deposited on the lake bed. The deposition of other minerals having successively greater solubilities continues as the brine becomes more heavily concentrated. Variations in the annual rainfall, mean temperature, possible sunshine, wind and other factors determine the rate of ~~evaporation~~ inflow of

surface waters charged with dissolved salts and also the amount of evaporation of the ^{WATERS OF THE} lake or playa surface. Incomplete desiccation of the ^{PONDED} standing waters during "wet" years, or periods of years would result in the deposition of perhaps those that were more only the least soluble minerals, while ~~the more~~ soluble remained in solution. A "dry" year or series of ^{years having} lower than normal precipitation would see the complete evaporation of the basin waters. The net effect, over a period of years, is to build up layers of the various precipitated salts. Due to the vagaries of weather the layers are not uniform in thickness, ^{AND COMPOSITION} and unless the basin is very large, they ~~layers~~ tend to be quite thin. Recovery of such deposits of salts then requires in most cases a ~~xx~~ plant where they ^{salt} can be dissolved and separated by fractional crystallization.

Natural soda ash is produced from two types of deposits. Saline lakes which contain high concentrations of dissolved salts have been worked for many years. More recently a great deal of attention has been given to buried, in some cases deeply buried, beds of solid salts. In the latter case the deposits must be of considerable thickness and purity to make them competitive with surface brines. ^{Producers of} Both types of natural soda ash face stiff competition from the synthetic ~~manufactured~~ ash which is often manufactured much ^{to} nearer the point of consumption.

Deposits of soda ash in Oregon have been known for nearly 100 years. The saline lakes in the basin-and-range country of south-central Oregon have been investigated repeatedly and several abortive mining ventures have been undertaken. Total production of solid salts has amounted to a few hundreds of tons. ~~Currently there is little interest in the deposits.~~ Principal deposits include the following lakes or playas: Summer Lake, and Abert Lake, ^(SEE MAP) Alkali Lake (actually a playa), all in Lake County. Summer Lake ~~is~~ has a considerable playa surrounding it by the end of a normal dry summer season. Abert Lake develops a fairly extensive playa at its north end, and Alkali Lake has thin skims of water only during the winter months.

The lakes are located in a region of low rainfall, ~~but~~ hot, dry summers and cold dry winters. Elevation of the lakes is over 4000 feet above sea level.

Published references to the three saline lake basins and their included deposits of soda ash include the following: Russell (1884), Chatard (1890),

Van Winkle (1914), Waring (1908), Phalen (1917) and (1919), Gale (1914), and Stanley (1960)

Stafford (1937) ~~and~~ Allison and Mason (1947). In addition to the above reports there are numerous unpublished reports and studies in the files of the State of Oregon Department of Geology and Mineral Industries.

An investigation of Summer, Abert and Alkali lakes was conducted by the State of Oregon Department of Geology and Mineral Industries to determine the reserves available. Results of the study ~~were published~~ (Allison and Mason, 1947) revealed that both Summer and Abert lakes probably could not be recovered economically. At Alkali Lake it was estimated that there were between 75,000 and 200,000 tons of recoverable saline solids. The three lakes are located at considerable distances from population centers and any possible markets. ~~Any~~ Mining operations would have to ~~be~~ contend with rather severe climatic conditions, with periods of freezing and sub-zero temperatures are common during several winter months. Although the area is semi-arid, sufficient process water to operate ~~the~~ ~~an~~ ~~operation~~ with could probably be developed by drilling.

The composition of the salts in the three basins is shown in the accompanying tables:

and Abert
Analysis of Salts from Summer/Lake Playas
(in percentages by weight)

		1	2	3	4
Na ₂ CO ₃	soda ash	70.80	35.54	78.95	31.55
NaHCO ₃	baking soda	9.45	5.01	.60	.24
NaCl	common salt	12.12	6.43	15.55	6.21
Na ₂ SO ₄	sodium sulphate	7.83	4.15	1.11	.44
K ₂ SO ₄	potassium sulphate	1.64	.87	1.40	.56
Water of crystallization		----	46.00 a	n.d.	61.00 a
	(more next page)	101.84	100.00	97.61	100.00
					a by difference

(add to bottom of table)

from Summer Lake

1. Composite of 3 samples/averaging 54 percent soluble salts (in anhydrous state), taken Sept. 1944. Analysis by L.L. Hoagland, State Dept. of Geology and Mineral Industries.

2. Same, recalculated to percentages of original composite sample.

3. Platy surface efflorescence, 1/16 inch thick, taken from the flat
~~Analysis of Abert Lake Brines Salts~~
~~(in percentages by weight)~~

beyond the north end of Abert Lake, Sept. 4, 1944; total soluble salts (dehydrated) 39 percent. Analysis by L.L. Hoagland etc.

4. Same, recalculated to percentage of original sample

Analyses of crystalline salts from Alkali Lake

(make xerox of table 6, p 9 sp 17)

add footnotes from following page

The concentration of dissolved salts in the three lakes varies seasonally. Total dissolved solids in Summer Lake range from a low of about 18 grams per kilogram in February to a high of more than 36 grams in October when the lake level is at or near its lowest point. The dissolved solids in Abert Lake water vary from a low of about 32 grams to a high of more than 66 grams per kilogram. Brines collected from a "pothole" at Alkali Lake in the month of September contained 347.7 grams of dissolved solids per kilogram of liquid. The brine in the "pothole" was saturated and crystal growths extending out from the margin and floor of the depression indicated that salts were being crystallized out of the brines.

The volume of brines available in Summer and Abert Lakes varies both seasonally and from year to year, depending upon climatic conditions. Summer Lake has a surface

The saline deposits at Summer and Abert lakes are similar ~~inxz~~ to numerous others located in semi-arid regions. At Alkali Lake, however, there is an unusual feature which has attracted some scientific investigation. Scattered over considerable stretches of the playa there are numerous "potholes" or shallow depressions containing lenticular masses of solid salts. The State of Oregon Department of Geology and Mineral Industries ~~performed~~ conducted a series of experiments to determine if possible the origin of the "potholes" ~~and~~ whether or not an artificially excavated depression would collect salts similar to the nearby naturally formed depressions, and (3) whether or not/a naturally formed "pothole" would regenerate once they had been excavated. The experimental work, carried out over a period of several years, indicated that natural "potholes" tended to refill with solid salts within a year or two after they had been excavated, and that artificially ~~excavated~~ depressions sloughed in and failed to accumulate any salts. The studies did not succeed in establishing the ^{method of} origin of the natural "potholes". Results of the ^{work} experimental/have not been published but are available for study in the department's files.

area of about 70 square miles and a maximum depth of about 10 feet. Abert Lake has an area of about 60 square miles, and like Summer Lake is very shallow. The brines in the "potholes" at Alkali Lake hardly constitute a measurable quantity. Most of the depressions are completely dry for the greater part of the year.

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The possibility that beds of salts might lie buried below the lake and playa surfaces of the three basins was considered by Allison and Mason (1947). It was found that the concentration of salts declined rapidly with depth below the playa surfaces at all three sites. The holes penetrated about 40 feet of plastic mud. Subsequent drilling of two holes which reached depths of 145 and 270 feet below the Alkali Lake ^{playa} surface failed to develop any concentration of solid salts. Both holes were terminated upon intercepting ^{fresh} artesian water. ^{successful}

The ^{successful} development of the Lake County soda ash deposits would very likely require some market outlet much nearer the deposits than those located west of the Cascades. Also a market which could use the ~~xxx~~ salts in their natural state without the necessity of elaborate and costly beneficiation might make the deposits economically attractive. ^{x a} Minor tonnages of the surface crusts have been used from time to time as ^{x a} weed killers ~~xxx~~ along local roads and highways. The development ^{severely} of the relatively small amount of soda ash available ^{severely} limits the capital investment required for plant construction.

of similar uses for both the solid salts and liquid brines could conceivably ~~xxxxxxx~~ result in a profitable operation.

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