

NITRATE GROUP

Jordan Valley District

Malheur County

Owners: C. C. Anderson, 4 claims; and S. S. Scoggin, 4 claims, both of Jordan Valley, Oregon.

Location: Sec. 33, T. 28 S., R. 41 E., below the junction of Bogus Creek and the Owyhee River on both sides of the river.

Miscellaneous: This property is located 20 miles from the highway and about 14 miles N. W. of Arock, Oregon. It is about 30 miles by air S. E. of the railroad at Riverside. It is in sagebrush country with no timber. The river is fairly large, with a good all-year-round flow.

Geology: The river canyon exposes a section consisting of over 100 feet of a gray to whitish well-banded rhyolite with perlitic and lithophysae structures which give it a very open texture. The dense well-banded rhyolite looks coarse-banded sandstone. The perlitic material looks in places like a conglomerate in places like ~~conglomerate~~. The numerous open cavities are in places lined (glomerate) or filled with soluble nitrates or other salts and secondary concentrations of this material appear at the head of the talus slopes around the cliffs. These salts apparently occur in small amounts throughout the entire flow which forms the walls of the canyon for nearly a mile, and are secondarily concentrated in several pocket areas and cavities. Overlying the rhyolite there is a columnar basalt flow from 20 to 50 feet in thickness. Above this is several hundred feet of yellow tuff. An intercanion flow of lava at one time filled the gorge to a height of at least 50 feet, but now this has been nearly all eroded away leaving occasional beach remnants

Analysis by George W. Gleeson, of Oregon State College, was as follows:

	# 1	# 2
% soluble water 100° C.	7.07	59.37
% Insoluble	92.93	40.63
	100.00	100.00

Analysis of soluble portion:

NaSO ₄	7.09	0.58
NaCl	17.30	0.50
NaCO ₃	Trace	Trace
NaNO ₃ (by diff.)	75.61	98.92
	100.00	100.00

NITRATE GROUP (continued - p. 2)

Conclusions: Although the material is too hard to mill and leach for the extraction of the nitrate salts, another possibility is suggested. Drilling several drill holes from above into the deposit and pumping water into these holes the entire deposit might be leached in place, the liquor being carried off in tunnels from below. It is possible that the cost factors in this way might be so reduced as to compete with more favorably located deposits.

John Eliot Allen

5/14/39

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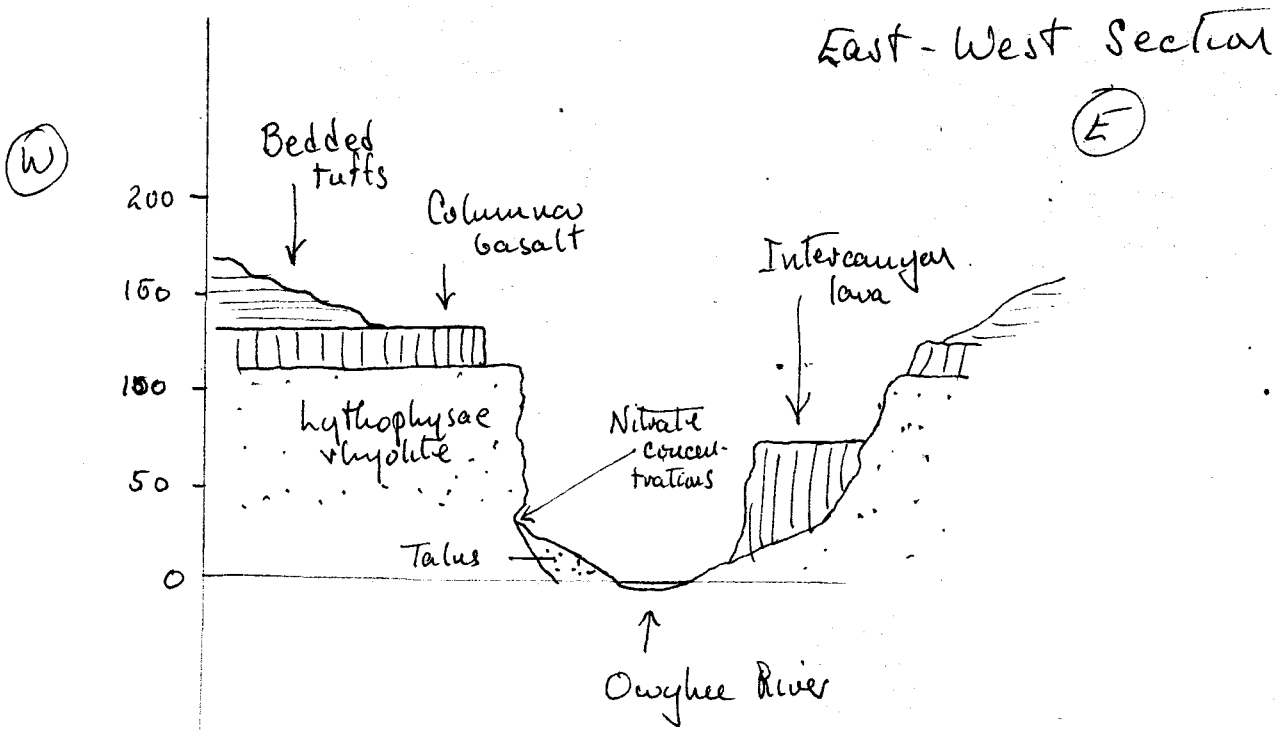
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Jordan Valley
5/14/39



Looking downstream (north) showing west cliff and overlying basalt flow and tuffs



Cliff above cavern from south



Cliff and cavern from north. Note caves at head of talus.

Looking upstream from north to south.



*Fill with
Nitrate report
Hex*

R E P O R T

on

THE NITRATE DEPOSITS OF SOUTHEASTERN OREGON

BY

IRA A. WILLIAMS

Oregon Bureau of Mines and Geology

May, 1918.

THE NITRATE DEPOSITS OF SOUTHEASTERN OREGON

by

Ira A. Williams

The first announced discovery of nitrates in southeastern Oregon was their occurrence at various points along Sucker creek in Malheur county, about 18 miles southwest from Homedale, which is on the Snake river a few miles across the line in Idaho. Nitrate salts were recognized here in 1914, also on Jump creek south of Homedale in Idaho.

The publicity given to this discovery rapidly led to a widespread search for nitrates in all parts of the semi-arid sections of Oregon. Throughout the succeeding three and one half years, including the year just past, an unrecorded number of nitrate showings have been found in localities scattered from Deachutes county at the northwest, through all of the three largest counties of the state, viz., Lake, Harney and Malheur, to both the Nevada and Idaho borders on the south and east respectively.

In general, certain features are common to practically all occurrences of nitrates so far examined in southeastern Oregon. They are found universally associated with the more acid types of volcanic rocks, *Rhyolite, andolite tuffs, and particularly silicified andolite and tuffs are the predominant varieties in which occurrences of nitrates have been observed.* Not a single verified instance of the finding of nitrates in connection with the basalt, which covers enormous areas in this portion of Oregon, is on record.

Secondly, the prevailing nitrate compounds recognized in these deposits are both sodium (NaNO_3) or Chile saltpeter, and potassium nitrates (KNO_3), common saltpeter, and occasionally small amounts of calcium nitrate ($\text{Ca}(\text{NO}_3)_2$), or of the similar compound of magnesium. Rarely however, do these salts occur alone, or even constitute the main proportion of a deposit. They are everywhere accompanied by one or more of the following substances: sulphates of sodium (Na_2SO_4) or of magnesium (MgSO_4), and less frequently of aluminum and of lime; common alum is sometimes present; chloride of sodium (common salt) and of potash; carbonates of sodium and lesser amounts of magnesium and calcium carbonates. The salts are not uncommonly stained with iron compounds, chiefly ferric oxide, or the hydrate by alteration of iron sulphate.

A third point of resemblance among the various occurrences, is that of the position in which they are found. With but very rare exception, all occur in the walls, roof or floor of open caverns, in partially protected crevices or other recesses in the rocks with which they are associated. They appear as incrustations or coatings on surfaces, as disseminated crystals or crystalline masses in the dust, rock scales or talus and organic matter that compose the floor of caves, and in the pores,

cells, and vesicles of the rock adjacent to such openings. In the majority of instances there is evidence that animal, bird, or reptile life either has inhabited or at the present time make use of as a dwelling place the chambers in or near which the nitrate salts are found.

In the following paragraphs brief consideration is given to each of the localities visited by the writer in the past two field seasons where the occurrence of nitrates has been announced.

Sucker Creek

Following the discovery of nitrates here in 1914, Mr. G. R. Mansfield of the U. S. Geological Survey visited the locality and has described the deposits in Bulletin 620-B of that Survey. Sucker creek is a tributary of Snake river which it joins just below Homedale, the terminal station on a branch of the Oregon Short Line railroad. Much of the course of Sucker creek is cut in the Eocene lake beds which consist generally of sandy clays, volcanic tuffs, some conglomerates and sandstones. The lake beds are interbedded with and overlie rhyolitic lavas into which Sucker creek has trenched a deep rugged canyon in parts of its course. It is in and associated with the rhyolite that the nitrates occur.

For several miles along this stream and some of its main tributaries in T. 24 S., R. 46 E. nitrate claims have been staked and a variable amount of development work done on a few of them. Mr. Mansfield in the report referred to described some of the claims, with illustrations; also the mode of occurrence of the salts and their character. The reader is referred to that paper. The accompanying photographs show something of the character of the topography and the nature of the rocks in which nitrates are found in favorable places (See negs. 1, 3, 4, 6, 7). In texture, the rhyolite ranges from dense to vesicular, and the rhyolitic tuffs from compact to ashy and porous, nitrates and other soluble salts appearing more frequently in the more open-textured varieties. A notable feature of both tuff and lava is the more or less constant presence of secondary silica in the pores, cells, and the lining of crevices in the rock. Much of the silica is opal and agate and obviously marks a period of hydrothermal action.

In 1915 and 1916 an organization known as the American Nitrate Company undertook the prospecting and exploitation of a group of claims located on Sage creek and on Sucker creek above the union of these two streams. Experimental leaching vats and an evaporating plant were constructed, and an effort made to determine the quantity and breadth of distribution of the salts, and the feasibility of extracting and refining them for the market on a commercial scale.

Samples taken by the writer in 1916 from various openings made by this company were tested qualitatively in the field by Mr. G. E. Stowell of this Bureau. The tests demonstrated the existence of a mixture of soluble salts in every exposure, altho in some instances the quantity

diminished to scarcely a trace. Chlorides and sulphates were uniformly present, the bases being sodium, potassium, calcium, magnesium and aluminum. Some of the best showings were in the outcropping slopes of a bed of ashy shale clay to the north of Sage creek. It was here that the leaching plant was installed with the intention of working the outer one foot to eighteen inches of the sandy clays for the nitrate salts. Qualitative tests indicated the presence of an unusual percentage of nitrates. The results of the quantitative analysis of an average surface sample from this slope is as follows. Mr. G. E. Stowell made the determinations.

Sample of nitrate-bearing clay from "Shamrock Green"

SO ₃	0.40	percent
Chlorine	0.52	"
Calcium	0.41	"
Potash (K ₂ O)	0.30	"
Soda (Na ₂ O)	1.00	"
N ₂ O ₅	0.69	"

The above constituents represent a combined total of soluble salts of somewhat more than 3 percent.

Operations were continued by this company for some months, and this and other prospects abandoned finally, after a thorough trial had demonstrated the impossibility of producing the salts found in the Sucker creek district on a profitable commercial scale by the methods employed. In all instances where tunnels were driven into the tuff or rhyolite at points of surface exposures of nitrates, the values were found to rapidly diminish, and, if the work proceeded to some depth, dwindle to a trace or absolute disappearance.

Owyhee River

In northern Malheur county, deposits of nitrate salts have been found at a number of points in the canyon of the Owyhee river both upstream and down from Watson post office. Messrs. O. A. and J. H. Matthews of Twin Falls, Idaho, hold options on some 1600 acres largely in Twps. 25 and 26, R. 44. Development work is now being done on their claims in secs. 19 and 25, of Twp. 27 R. 43 and 42 respectively.

Where the prospecting work is under way the salts occur at the base of a northward facing vertical cliff of rhyolite and rhyolite tuff probably 100 feet in height, at the head of a talus slope, some 130 feet above water in the Owyhee river. The tuff is porous, pebbly, and in places open-textured, even soft and friable. For a distance of 100 to 150 feet along the face and for several feet above the upper border of the talus slope, every protected re-entrant, and particularly the walls of a series of undercut caverns are heavily coated with a whitish efflorescence of what analysis shows to be chiefly sodium nitrate (see photo A &

cut of B). Quantities of the salts are also mixed with the dirt and organic matter in the floors of the caverns and a series of open cuts in the talus slope prove, according to Mr. J. H. Matthews, that the nitrate is quite generally distributed throughout a large body of material. The extent of the salts into the rock of the cliff itself has not yet been ascertained. Mr. Matthews figures that approximately 25,000 yards of workable ground have to date been blocked out at this place.

The favorable position of the rock face at the base of which the nitrate occurs, accounts no doubt for its having been a rendezvous for stock for many years and doubtless for wild animal and bird life indefinitely. The droppings and other organic accumulations from such occupancy are strongly in evidence at various points. On the whole, the surface showings of soluble salts, which are prevailingly nitrate, are the most conspicuous and abundant of any prospect yet seen by the writer in southeastern Oregon. This property is known as the Hercules claim. Mr. Matthews reports other similar exposures at intervals farther up the river.

Five to six miles down the Owyhee from Watson is what is known as the Stickney group of claims along the west side of the river. Here, as up the river, the salts appear at the foot of cliffs at the upper limit of the talus slopes in both rhyolite and rhyolitic tuff. It is notable, however, that instead of nitrates being universally present, some exposures are practically free from this type of compound. For example, at the slightly undercut base of a south-facing cliff of hard, jointed rhyolite in Sec. 17 of Twp. 26 R. 44 E. the loose broken detritus that has scaled from the rock wall is in places literally bound together by inter-crystallization of a fibrous mass of mainly magnesium sulphate (epsom salts). Sulphates predominate to the practical exclusion of nitrates. Above the border of the talus for a few feet in the exposed and scaling rock ledge itself, only the less soluble calcium sulphate (selenite or gypsum) is present. At the height of one's reach, no salts could be detected. No organic matter whatever is in evidence in this exposure.

One half mile to the southward in this same section (17) and in contiguous section 8, the salts occur in the dirt and talus for a few hundred feet along the undercut base of a sharp cliff of inclined beds of buff, pebbly volcanic tuff. Here, again, sulphates predominate, the main compound being sodium sulphate (Glauber salts), and only a minor proportion of other non-nitrogenous salts. No systematic prospecting has been done on these claims. There is said to be other showings in this vicinity and at intervals for several miles farther down the river. But, as is true in all of the southeastern Oregon districts where nitrates are at all generally distributed, in successive occurrences, the salts present, or the combination of salts, is rarely found to be the same.

Thirteen miles west of Vale near the Vale-Burns road claims are held by Matthews Bros. of Twin Falls, Idaho. The lake beds are deeply dissected by side gulches and water courses leading into the valley of Malheur river in Sec. 16, Twp. 19, R. 43 E. Showings of soluble salts appear

at intervals along the outcropping edge of a 5-foot bed of pebbly tuff or fine-grained conglomerate. The stratum where best seen rests upon a well-cemented boulder conglomerate and is covered by indurated tuff and possibly interbedded lava in places. The salts occur in western exposures in undercut portions of the bed, which is relatively incoherent. A sample of the richest material, taken for the purpose of ascertaining the character of the salts present, gave distinct tests for sulphates, chlorides or nitrates. The bases recognized were sodium, calcium and magnesium, and less decisively, potassium. The salt content would thus appear to be a mixture of the same common varieties found in many other places in the region. No development work has been done to determine the extent or value of this deposit.

Duncan Bridge

Samples containing supposed nitrates from near Duncan bridge on the Owyhee in T. 31, R. 41 E. of Malheur county, were submitted to the Bureau in 1916 by Mr. W. P. Keady of Portland. Chemical analysis of four samples gave the following results:

Sample 1

Insoluble material (largely silica and alumina)	14.7	per cent
Sodium bicarbonate (NaHCO_3)	20.34	" "
Sodium sulphate (Na_2SO_4)	18.73	" "
Sodium carbonate (Na_2CO_3)	2.54	" "
Potassium nitrate (KNO_3)	.45	" "
Sodium chloride (Na Cl)	40.24	" "

Sample 2

Insoluble material	16.50	" "
Sodium bicarbonate	18.54	" "
Sodium sulphate	20.20	" "
Sodium carbonate	1.50	" "
Sodium chloride	40.80	" "
Potassium nitrate	1.34	" "

Sample 3

Insoluble material	25.60	" "
Sodium chloride	44.87	" "
Sodium sulphate	27.84	" "
Potassium nitrate	.97	" "

Sample 4

Insoluble material	18.97	" "
Sodium sulphate	34.76	" "
Sodium chloride	43.16	" "
Potassium nitrate	1.43	" "

In the vicinity of Duncan bridge about three hundred feet of the lake beds are overlain by 15 to 25 feet of more recent basalt, separated from the former by about 15 feet of gravel and sand (foto 12). Some two miles below the bridge, the uneven surface of the underlying silicified rhyolite appears in about Sec. 16 of T. 31, R. 41 E. and rises down-stream, so that the sedimentary lake beds are shortly apparently displaced entirely by the lava (foto 9).

The canyon of Crooked creek is a gash cut through the lake beds and into the rhyolite. Small showings of nitrates are found in a few protected places in the north wall of this canyon just above its embouchure into that of the Owyhee in Secs. 8 and 17. The salts occur here in the cells and vesicles of the lava, and in places as a coating in cracks, and in the rock detritus of the floors of undercut recesses at the base of cliffs that face the south along Crooked creek. The showings here are quite inconspicuous, and to the taste always contain a large proportion of common salt (NaCl) and of ordinary cooking soda (sodium bicarbonate).

Mr. Leonard Cole of Vale, Oregon reports that he is interested in some claims in which the occurrence of the salts is similar, some 50 miles farther up the Owyhee river. No development work is known to have been done on any of these claims.

Chemical tests by Mr. G. E. Stowell of a series of five samples of both salts and parent rock from what was considered most favorable positions in the canyon of Crooked creek, demonstrated the presence of both potash and soda nitrates in three out of the five. Epsom and glauber salts, soda, common salt, and some alum were found in the various samples.

McDermott

Mr. L. R. Hagler submitted some samples of soluble salts said to have come from a locality close to the Oregon-Nevada line 10 to 12 miles east of McDermott, southern Malheur county. Chemical tests showed that they contained both potassium and sodium nitrate.

A visit to this locality proved that the sample came from altered silicified rhyolite, a great thickness of which appears to occupy a considerable area of country to the eastward from McDermott. This rock, as it is exposed along Rock creek, one of the headwaters of the north fork of Quinn river, weathers out in places into conspicuous domes or pillars, and jagged cavernous crags stand out from the canon walls (fotos 1a and 2a). It is in one of these, some 200 feet above the stream in the east wall of the gorge of Rock creek that the nitrates occur. The group of crags in which the salts are found is a contorted cavernous and scoriaceous rhyolite, obviously inhabited by both animal and bird life as attested by the presence of quantities of guano. The salts in small quantity coat the sides and top, here and there fill in seams, and permeate the soils in the floor of numerous small caverns. The location is approximately near the east edge of T. 41 S., R. 44 E.

Some nitrate claims are also reported as having been located on Little Cottonwood creek in Sec. 33 of T. 40 S., 41 E. or in adjoining sec. 4. of T. 41, R. 41 by N. P. R. Hatch and Thos. Defenbaugh of National, Nevada. No data as to the Occurrence of the nitrates in this locality are at hand.

Harney County

Samples containing potassium nitrate or natural saltpeter were sent in early in 1917 by Mr. Jake Gove of Burns, Oregon. The materials came from one of a large group of claims on a branch of Sagehen creek in T. 23, R. 29 E. some 15 miles southwest from the city of Burns. The country rock here is a hard, but cellular variety of acid volcanic lava known as rhyolite in the openings of which and in the walls and floors of caverns, the salts occur.

It is an observation worthy of record that of the two samples submitted by Mr. Gove, one from the surface showed a large amount of nitrate, while a second, taken from the breast of a tunnel 21 feet in, gave but a mere trace of nitrates. The admixed salts were sulphates and chlorides, some natural alum probably being present. A number of the claims on Sagehen creek were under option in 1917 to a company said to be organized in Baker, Oregon for the purpose of exploitation as nitrate prospects.

Samples coming from the vicinity of Mule spring, which is in T. 31 S., R. 27 E., north of the Warner lake region of Lake county, were sent in by Mr. W. A. Massengill of Lakeview. The salts present were predominantly nitrates of potassium and sodium, chiefly the former, and sodium chloride or common salt. In 1916 several quarter-section claims were said to be under option to a syndicate for prospecting. To date no development work has been carried on.

Mr. Albert Gibbons of Riley, Oregon which is T. 23, R. 27, of Harney County, submitted some samples of porous rhyolite containing both potash and nitrates, associated with common salt, epsom salt and common alum. Their exact source was not learned.

Rawhide Gulch

The American Nitrate Company, with holdings in both the Sucker creek section in Malheur county, and at Wagontire Mt. in Lake county, did prospecting work also in the gulch of Rawhide creek in Twp. 29 S., R. 26 E. Rawhide gulch is cut through rather flat-lying acid lavas and tuffs and is rarely more than 75 to 150 feet in depth. For several miles both up and down stream from the Ony Thompson homestead in sec. 24, there are indications of nitrates along a more or less continuous "rim" of fairly hard, pink rhyolitic tuff-breccia (photo 655). As elsewhere, the salts here are formed in crevices, and in the linings and floors of caves, undercut recesses, and other protected re-entrants in the face of ledges and cliffs. They are found also to an almost unexpected extent within the pores of the rock itself,

prevailingly in proximity to places where it occurs as coatings. The salts are potassium and sodium nitrates, accompanied always by sodium bicarbonate and common salt and occasionally alum. In the opening where nitrates are found there is evidence almost universally of present habitancy by animal and bird life.

The quantitative analysis of the salts from a sample of the rock in Rawhide gulch broken from a freshly blasted face where surface showings were favorable gave the following results:

Nitrogen pentoxide (N ₂ O ₅)	0.16 per cent
Potash (K ₂ O)	0.12 " "
Alumina (Al ₂ O ₃)	0.21 " "
Lime (CaO)	0.27 " "
Chlorine (Cl)	0.88 " "
Sulphur trioxide (SO ₃)	0.24 " "

Similar nitrate showings were prospected by this company in Buzzard gulch 15 to 18 miles northeast from Rawhide in the northeast corner of Twp. 28, R. 28 E. The salts occur here for a few miles both above and below where the Burns-Warner valley road enters the gulch, mostly in a rather soft rhyolitic tuff-breccia. On account of variations in its character, cavernous masses of the tuff protrude from the canyon wall in places, and these seem to have been favorable positions for the soluble salts to accumulate. They are not limited to these positions, however. Both here and in Rawhide gulch exposed faces of the tuff exhibit a sort of case-hardening, by which a relatively hard outer shell of often not more than an inch or less in thickness is present. Within this resistant and obviously less pervious shell, the clean crystalline soluble salts were frequently observed some distance from surface showings, as though their accumulation were not only favored but their residence protected after they were once formed. Hard, dense columnar basalt appears at intervals beneath the tuffs in the walls of the canon which in this locality is 150 to 200 feet in depth.

Qualitative tests of various samples of salts taken in Buzzard gulch indicate the presence of, predominantly, potassium nitrate, associated always with lesser amounts of chlorides and sulphates, and some carbonate. So far as can be learned, prospecting or exploitation has been abandoned in both of the last mentioned two localities.

Lake County

Warner Lake region. The front of the great fault scarp which borders Warner valley to the east rises, precipitously in part, to a height of from 1600 to 1800 feet above the level of the lakes of the valley floor. Along this front a series of relatively flat lying beds of volcanic lava are exposed, including a considerable thickness of interbedded tuffs and tuff-breccia (foto 6a). Near the top, or "rim" of this great wall the lavas are prevailingly basalt, while beneath there is much of the less basic varieties, probably andesitic, or even rhyolite.

Nitrate claims have been filed upon ground extending along the base of these cliffs at the east side of Warner Valley for a distance of some 12 miles. The showings so far found came from outcropping heavy beds of pink and gray, probably andesitic tuff, about five to seven hundred feet above water level in the lakes. In places these beds pass into the condition of reddish scoriaceous masses, and it is in these more open textured portions that the chief traces of nitrates are found.

Samples sent from this locality by O. B. Hardy of Lakeview contained nitrates in notable amounts.

A careful examination of these tuff beds was made by the writer for some distance along their outcrop within the limits of filings, and samples taken from several of the most likely points. Qualitative chemical tests made by G. E. Stowell revealed scarcely a trace of nitrates and but little more of common salt and soda.

A considerable area here was under option to a syndicate in 1916. A visit to this locality late in 1917 showed no signs whatever of development work, or of further prospecting; a fact interpreted by the claimants as indicating that the results of the preliminary investigations by this syndicate of the value of the ground were not encouraging.

At the east side and back, as it were, of the crest of the high ridge which borders Warner valley, an occurrence of nitrates has been prospecting on the ranch of Frank Calderwood in Sec. 13, T. 37 S., R. 25 E. Here the salts are found as encrustations on the walls of crevices, in the litter and talus of the floors of caverns, upon their walls, and to a considerable extent permeating and filling the vesicles of the rock itself. Field examination of the rock shows it to be an acid lava, probably dacite or of about that degree of acidity. In places portions of the "rim" rock are a typical crater agglomerate which stands out in jagged red crags that are cavernous and open, and cut by irregular joints and crevices (fotos 3b & 5b). Such masses are notoriously inhabited by both animal and bird life.

Surface samples collected from the interior of recesses and from protected crevices show a high proportion of potassium nitrate, some sulphate and chlorides. Alum in small quantity is usually present.

Mr. Calderwood has prospected his holdings by tunneling at points where surface showings were most promising. Samples submitted for test from a drift run in on the level for a distance of 12 feet gave no response whatever to the test for nitrates.

The location of the Calderwood ranch and claims is some 2000 feet higher than Warner lakes and is reached by wagon road over a southward branch from the main highway between Plush and the Steens Mountain country.

Some nitrate prospects are reported by Mr. E. C. Ahlstrom of Lakeview as having been located 8 to 10 miles northwest of Alkali lake, which

is in Twp. 30 S., R. 23 E. at a place known as Wildcat Run. No development work has been done, although samples sent to the Bureau of Mines and Geology gave a decisive test for potassium nitrate associated with common salt and some sodium sulphate or glauber salt. The containing rock is an altered rhyolite.

Cougar Mountain. Cougar mountain is a conical elevation located in Sec. 14, Twp. 25, R. 15 E., Lake county, and is probably the site of former volcanic eruption. Its altitude is about 5200 feet. It appears to be made up of successive flows of porous to cellular rhyolite exhibiting extreme contortions in places, and intervening flow breccias. Along its south slope at an altitude of about 4400, a series of 10 or 12 claims have been taken on the basis of nitrate indications observed in protected undercuts and caverns at the base of a rather open-textured bed of the light gray rhyolite. The salts occur here just as described for many other localities and to the taste consist of saltpeter mostly, with common salt and sodium bicarbonate. Several pits have been sunk 4 to 10 feet into the rock at the base of the cliff. Samples taken from even these moderate depths below the surface indications, give no response whatever to chemical tests for nitrates or other soluble salts.

Wagontire Mountain Region. Wagontire mountain is really a series of dissected ridges radiating from a flattened conical elevation that has the appearance of having been uplifted since the later basaltic lavas spread over the region. The bulk of the Wagontire mass is of acid varieties of lava, undoubtedly largely rhyolite, and rhyolitic tuff and breccias. The Wagontire group of hills is in northeastern Lake county, in Twp. 25 S., R. 23 E. and extends to the eastward into contiguous portions of Harney county. The highest point rises to 6375 feet above the sea. Sheep Mt. to the north in Twp. 24, appears to be a spur connected with the main elevation, and is similarly composed of acid tuffs and cellular rhyolite in part impregnated with silica. The summit of Sheep Mt. is approximately 5650 feet.

Nitrates have been found in many places on Wagontire mountain and its environs. As a result, a considerable proportion of a township in area has been filed on, mainly about the east, south and west slopes of the mountain.

Streams have cut a series of radiating sharp, deep gorges into its slopes in these directions, and in the sides of these gorges are almost continuous exposures of the rocks of which the mountain mass is composed. More resistant lavas form "rim" rocks extending for miles in places (foto 10). Where protected along the face of these cliffs, in innumerable recesses at their base where they have undercut, or where they rest upon the tuffs or less resistant lavas, nitrates and certain associated salts occur on the walls of the rocks, lining caverns, in crevices, in the talus and organic and dirt accumulations of the floors or caves, and frequently to an unanticipated extent, permeating the pores and vesicles of the rock itself. Almost invariably there is evidence of the occupancy of these openings in the rocks by different forms of animal and bird life that inhabit the region

Geological Survey of the United States, Department of the Interior, Bureau of Mines, Washington, D. C. 20540. Report of Investigations No. 3027. Nitrate Deposits on Sheep Mountain, Colorado. By G. E. Stowell. 1928. 100 pages, 1 plate, 1 map. Price 1.00. (Revised edition, 1930.)

today. Along the gorge of Lost creek which flows to the northwest, and in others that lead down the west and southwest slopes of Wagontire mountain, the nitrate showings are present in a great many exposures, and most pronouncedly, it should be said, in the north walls of these gorges, and in exposures which face, thus, in a general southerly direction (foto 11).

The American Nitrate Company did a considerable amount of prospecting for nitrates on Wagontire mountain in 1916, and preliminary investigations were carried on in 1917 of the possibility of extracting the nitrate salts on a commercial basis. The operations of this company included prospect tunneling and quarrying at many points along Lost creek and successive radiating gulches about the southwest slope of the mountain; chemical tests of the rocks and determinations of the soluble salts to ascertain their nature and distribution; and finally the construction of an experimental plant for the extraction and recovery of these salts.

Samples taken from many places on the ground of the American Nitrate Company by the writer and G. E. Stowell, and tested by the latter, showed the prevailing presence of nitrates, associated usually with sodium bicarbonate, sodium chloride, and often times calcium and sodium sulphate and alum in lesser amounts. In some exposures the ordinary saltpeter variety of nitrates was the more plentiful, while in others chile saltpeter (NaNO_3) prevailed. In no average sample, however, which represented any considerable body of the rock, was the percentage of soluble salts more than a fraction of a percent. It was notable that the response to nitrate tests on materials from below the soil line at the top of the talus slopes was universally negative. Positive tests were obtained in the cliff as high as 25 feet above this line, and to a varying distance in from the face of the rock where drifts were cut, invariably decreasing, however, with added depth.

The above named company abandoned the Wagontire operations late in the summer of 1917 and dismantled their plant. Along the lower course of Lost creek, a series of horizontal drifts were cut into the rock at favorable positions to, in some instances, a distance of 40 to 50 feet. It is understood that the nitrates did not extend to any considerable depth and that the reason for indefinite suspension of the work here was the failure of the investigations to prove the presence of a sufficient body of workable nitrate-bearing rock on which to found commercial nitrate production.

A number of nitrate claims have been located on Sheep mountain which lies contiguous to Wagontire at the north. Only a few shallow cuts have been made on Sheep mountain and its slopes are less deeply terraced by stream erosion. A sample offairly hard cellular lava from a recent prospect opening in the hillside, one-fourth mile from the wagon road at the east base of the mountain, gave no response to tests for nitrates or other soluble salts. One half mile over a ridge southwest from this point, and to the south of the summit of the mountain, a sample from a fresh cut in similar rhyolitic lava gave likewise no sign whatever of a nitrate con-

tent. It is said that nitrate showings have been found along the west slopes of this mountain, and that some prospecting has also been done here.

Meager showings of nitrates are found about the slopes of Glass Buttes near the northeast corner of Lake county in Twp. 23, Ranges 22 and 23. These buttes are apparently built up of earlier flows of acid lavas, many of which chilled quickly to a glass, hence their name. Some signs of nitrates occur here in a bed of cellular rhyolite exhibiting flow structure. Only two shallow surface cuts were found, neither of which penetrated to solid rock, and no nitrates or other soluble salts were detected.

Deschutes County

Early in the summer of 1917, Mr. Geo. S. Young of Bend, Oregon, had sent to the Bureau of Mines and Geology a series of nitrate-bearing samples taken by him from a heavy bed of dark gray to black volcanic tuff or tuff-breccia near the post office of Rivers, Oregon, which is in Twp. 20 S., R. 19 E. in Deschutes county. In this particular locality the tuff appears to be a low mesa-like erosion form, along the cliffs at the edge of which the nitrates and other soluble salts occur in etched-out pockets, undercut gaps, crevices and small caves. No very strong showings of the salts were found at any one place. All samples responded freely to the qualitative nitrate test and the flame showed the presence of potassium chiefly. Some chlorides and sulphates accompanied the nitrate in all samples. When the writer visited this place in October, 1917, a narrow drift was being cut into the tuff by Mr. Hallmeyer of Rivers. A sample taken from the face of this drift after it was in 25 to 30 feet, and forwarded to the Bureau through W. G. Peters & Co. of Tacoma, Washington, gave but the barest detectible trace of nitrate and a very slight amount of soluble salts of any kind.

Origin and Commercial Value of Southeastern Oregon Nitrates

In considering the economic importance of the nitrate deposits so far discovered in southeastern Oregon, there are several facts that should be called to mind in connection with the occurrence, association and possible origin of these salts. Both potash and soda nitre occur, the latter perhaps somewhat more commonly than the former. It is practically never the case that they are found alone, but they are usually accompanied by one or more of various other soluble compounds, notably carbonates of sodium and lime, chlorides of potassium and sodium, sulphates of potassium, sodium, magnesium, calcium, and aluminum as an alum. On the other hand, one or more of the series of soluble salts enumerated may and do occur in many places where nitrates are entirely absent, in positions apparently identical in every way with those that furnish strong nitrate showings nearby or elsewhere. It is also true that many obviously favorable points in a given region will be examined for nitrates in which neither they nor any other soluble salts are to be found.

We are thus confronted with a set of observed conditions that are

in general uniform wherever the nitrates have been found in Oregon; the correct explanation to which should afford a fairly definite clue to the origin of this class of compounds, as well as of the group of associated salts, and therefore of their probable commercial value. In nature, so far as known, bodies of nitrate salts are formed through organic agencies, the action of certain species of bacteria upon animal refuse, dead bodies, excrements, etc., and are normally produced in soil in the process of disorganization of dead plant life or humus matter. Breaking down of the mineral constituents of the soil or of an alkali-bearing rock provides the needed alkalis for the formation of the inorganic salts of nitrogen. The other associated salts enumerated, result likewise from the alteration and decay of rocks, but do not require the intervention of organic processes for their production.

The nitrates are very soluble in water, as are the chlorides, and most of equivalent sulphate and carbonate salts of the alkalis and alkaline earths. As a result, all of these substances are very susceptible to solution wherever water can reach them, and they accumulate only in positions where water evaporates and leaves them, and where they are entirely protected from re-solution and removal by moving water. Natural deposits of size are therefore rare, and, as would be anticipated, are found only in arid or semi-arid regions.

Chemical examination of the circulating waters of the earth, particularly water from deep wells and from both salt and thermal springs, proves the universal presence of dissolved mineral salts in them. The sulphates, chlorides, and carbonates are most common, but it is especially notable that, in all waters coming from any depth within the earth, the nitrates are conspicuously absent. Usually though not always, those of higher temperature carry a larger percentage of these salts. The latter are dissolved from the rocks through which the waters have moved, and are produced either directly by the action of the water upon these rocks due to dissolved gases, or taken from positions where they have previously been deposited by waters temporarily not able to longer contain them. In any case, the dissolved salts come originally from decomposition of the rocks with which the waters come in contact.

The movement of underground waters through rock strata is determined by gravity, hydrostatic conditions causing it to flow in the direction of least resistance. When a drill-hole punctures the roof of the water-bearing stratum in an artesian area, the water promptly rises to a certain level, or overflows, because a new "line of least resistance" has been provided. A change in the direction of its flow is thus brought about.

In a similar, though natural instead of artificial way, is the movement of underground waters influenced and determined, to a greater or less depth, by the normal processes of erosion. Streams of all sizes gnaw their courses into the surface of the land, and excavate to depths and widths varying from the merest of furrow or trench to that of the most profound canyon. In so doing, not only are ways produced for the flow of

origin of these masses of carbonate? As well as of the amount of associated
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in general principle presented the nitrate have been found in Oregon? The

surface waters by the down-cutting of the streams, but the water movement in each successive underlying water-bearing bed that is severed, is intercepted, the water content tapped or its flow otherwise interfered with.

So today, in all regions and in all countries, here and there springs issue from the ground. In a great many instances, it can be seen that these springs represent but intercepted portions of the underground flow that has been forced to the surface by the processes of erosion, and this fact is most conspicuous in rugged regions where the streams have cut deeply into the earth. Different rock strata carry varying amounts of water, depending upon their character and attitude, and the rainfall of the region where their supply is obtained. So that the amount that issues from dissected strata varies from springs of great volume to but the tiniest seep or trickle, a mere moist place upon the rocks, or so slight that it all passes into the atmosphere by evaporation as rapidly as it comes without giving visible evidence to the passerby of what is taking place.

In moist regions springs are more abundant on account of the greater rainfall and because of the correspondingly less amount of evaporation. On the other hand, in the arid regions, evaporation is at its maximum, while rainfall is least. We have in southeastern Oregon a region of low precipitation, where loss by evaporation is correspondingly great. Further, it is a region which in general shows evidence of having been more thoroughly watered and therefore more actively eroded in the not distant geologic past than it is today. Of late, however, evaporation has so much exceeded precipitation that there are numerous dry and encrusted lake beds, whose waters have gone into the air, leaving behind as a consequence whatever of dissolved substances they may have contained. Today the high rate of evaporation as compared with run-off is in evidence on every hand. Everywhere that water is exposed to the atmosphere, in lakes, along streams, and where it issues as springs or seeps, more or less of the soluble salts are in evidence.

In reviewing the various localities where the nitrates have been found, it will be recalled that they occur typically at the base of ledges or cliffs where they cannot be seen to have apparent connection of any kind with moving water. The fact that they, as soluble salts, are crystallized upon the rock walls and to an extent within the pores of the rock itself, proves that enough moisture has been or is present to bring about such distribution, but that it has been lost entirely by evaporation, in order that the salts are left where we find them. In general, other salts are associated with the nitrates, and these are the very salts that we have seen, are ever present in circulating underground waters, and come from the rocks through which these waters pass. They are deposited wherever these waters reach the surface and evaporate, the greater the quantity of water evaporating, the more salts deposited, by which we are led to the inference that where we find these two diverse types of soluble salts associated in position today, the moisture which was instrumental in depositing the one, doubtless also deposited and disseminated the other; but that since, so far as we know, the method of origin of the two is widely different, the sources from which

they were picked up by the water must likewise be equally widely separated.

The association of the nitrates in most of the deposits of south-eastern Oregon with one or more of the already named groups of other soluble salts is thus fortuitous, not genetic. This conclusion is strengthened by repeatedly observed occurrences of the sulphates, chlorides, carbonates, one or more of them, to the exclusion of the nitrates, in positions similar in every conceivable way to others where nitrates occur either almost alone, or accompanied by the other salts. It should be said, too, that many favorable places show no salts of any kind.

Our question then is first, as to why salts of any variety occur at one place and not at another; and, second, why the nitrates are found at one point and not at another, whether alone or in association with other mineral salts. The answer to the first refers us at once to the question of movement of underground waters. The base or foot or face of cliffs is a favorable place for the escape of water into the air. If the particular stratum or body of rock happens to be dry, there will be no water to escape, hence no deposition of salts. If the water that does escape carries no matter in solution, no salts will be deposited. Finally, if the position of escape by evaporation is so exposed that salts once left are again dissolved or washed away by the dash of rain, or other moving water, to the observer there will not be the visible evidence of the presence of encrusted salts to make clear what has taken place. Hence one exposure may be barren, and another apparently similarly environed, charged with soluble salts. It is the presence of representatives of the group of soluble salts that characterize circulating underground waters everywhere, and particularly in regions of volcanic and related rocks, which is the key to the origin of the Oregon deposits and to the agent that has effected their accumulation.

Why are the nitrates present at one place and not in another? For the ultimate origin of the nitrates we must look to one or both of the two sources already referred to. The soils of the region under consideration, and particularly most of the localities where nitrates have been found, are in general thin or practically entirely absent over considerable areas. The chief form of vegetation is a sparse growth of sagebrush, while a low annual precipitation makes conditions much less favorable to nitrification than in regions of moist climate. It is likely therefore that nitrates from these soils can be counted on as of very minor quantity if of any importance whatever. The other source of organic matter in a region such as this, between the nitrates and which by any obvious line of reasoning a connection can be assumed or traced, is the accumulated refuse of animal and plant life that exists in many of the caves and protected recesses where the nitrates are found. Many of these places show evidence of having been inhabited indefinitely by bird, and animal or reptile life, and the cave-soil of their floors is an earthy mixture of soil, excreta, hair, bones, flesh, etc., and often leaves of plants and twigs. It is by the artificial nitrification of masses of animal refuse that some commercial nitrates are produced, and it is recognized that in other parts of the world cave nitrates have been formed by this process. In the presence of an adequate amount of

moisture, there is every reason to believe that nitrification and the production of nitrates, has taken place in many of the cave-earths of south-eastern Oregon; and that it is by this method that most if not all of those yet discovered have been produced.

It is of interest to record that of the various exposures showing nitrates in ten separate localities in southeastern Oregon, the majority in every district are closely related in position to such cave accumulations. Caverns containing an abundance of organic refuse in which no nitrates appear are not uncommon, as do also occasional showings of nitrates occur in places where organic matter is now not in evidence. In dry caverns nitrification does not proceed, in extremely wet ones, the salts are washed away; while in other places caves may be abandoned by their inhabitants, or the salts travel by capillarity some distance in a porous rock and appear where there is now no obvious relationship between them and their organic source.

Where the nitrates are found in association with the other soluble salts, it has simply so happened that their position coincides with the place where the underground waters with their dissolved contents have reached the surface in some abundance and have deposited those contents by evaporation. It is entirely probable that the disintegrating influences of freezing and the force of crystallization of the salts within the pores of the rocks have been largely instrumental in producing many of the crevices, rock niches and caves, where nitrates now appear. The same water has probably nitrification and, on its way out, distributed the resulting nitrates, as we find them at present. Where these outward moving waters met no nitrates, or nitrifiable organic accumulations, only their own load of other salts was deposited; and thus, as already pointed out, we now find in many otherwise favorable positions only the chlorides, sulphates, carbonate salts, etc., such as circulating waters carry.

With the above facts of origin in mind, it should now be possible to draw some serviceable inferences as to the probable extent and therefore value of individual nitrate prospects. It has been shown that the origin of the nitrate compounds is without question at the surface. They have been put where we now find them by the evaporation of water in which they were dissolved, just as have the other salts that often accompany them; but they have been picked up incidentally, as it were, and bear no relation in point of genesis to those other salts. Water evaporates when it reaches the atmosphere, and for that reason leaves the salts it carries chiefly in the open-textured, air-filled outside portions of the rock through which it is moving but most largely upon its surface, and there only. Reasoning upon this basis alone, one would not expect to find the salts permeating more than a superficial surface portion of the rock on which it shows, and would anticipate that the amount of salts would grow rapidly less with depth until, within a relatively short distance, they would disappear completely. In at least three of the districts, on Sucker creek, Wagontire mountain and at Warner lake, this exact set of conditions has been proven to exist by a systematic series of prospect tunnels. In all instances the surface showings were the main portion, if not all, of the entire deposit.

The natural question will at once occur; if these are but surface concentrations, brought out and deposited by moving waters, will they not be constantly replenished, and, if removed, be replaced by a never-failing supply? The answer is that in places there is some evidence that salts, other than nitrates, are now being deposited, but at probably a much slower rate than formerly. In any case, the rate of accumulation could not be expected to furnish anything like a recurrent supply for commercial operations. The nitrates, too, are doubtless being produced and redistributed in small amount, but, more emphatically still than with the other salts, the re-supply of nitrates would be insignificant as compared with the needs of any kind of exploitation.

Each individual occurrence thus becomes a separate problem. Whether it is worth the expenditure of the time and money necessary to determine its extent and tenor must rest with the judgment of the person who is interested in it, and his interpretation of the surface indications. Just as in the exploitation of any other mining property each property must be considered, and prospected by itself. But it must be remembered, that, on account of the method and place of origin of this type of the nitrate ores, a rapid diminution of values with depth is an almost absolute certainty. The rich ore, if there is any, is at the surface, and a property showing lean surface indications may be abandoned at once as valueless from the commercial standpoint. Properties may be found where a sufficient quantity of the nitrates and other commercial salts have accumulated in the outer portions of protected porous rock masses, in the earth and on the walls of caves, and in adjacent bodies of talus to make their extraction feasible. But such deposits have thus far proven to be very scarce, nor is there likelihood of their discovery in any considerable number in the region.

The proper procedure in the case of prospects whose surface showings are suspiciously favorable, is to do an ample amount of excavating, test-pitting and sampling, that the pay ore can be blocked out, and not only ore tonnage but salt content calculated. The installing and operation of appropriate leaching equipment, and remoteness from transportation or market facilities, are factors to be carefully considered. In practically all instances, too, there will arise the extremely important problem of separating the various salts after they have been leached from the insoluble rock materials. It is thus highly essential to ascertain at the outset, whether the combination of the salts that will be produced is such as can be disposed of to advantage, and whether their separation into marketable groups or individual salts is to be a difficult and expensive or simple procedure.

Although nitrates are widely distributed in southeastern Oregon, experience and observation in the various districts have proved the extreme scarcity of deposits of any considerable size, or of surface or other showings that would indicate or even favor the likelihood of their existence. It is not the intention to affirm that profitably workable nitrate deposits will not be discovered, but it is not at all unlikely that such may prove to be the case.

Astrak Group

Sodium Nitrate

4/46

NAME

OLD NAMES

PRINCIPAL ORE

MINOR MINERALS

285

41E

33

T

R

S

PUBLISHED REFERENCES

..... *Malheur* COUNTY

..... *Malheur* AREA

..... ELEVATION

..... ROAD OR HIGHWAY

..... DISTANCE TO SHIPPING POINT

MISCELLANEOUS RECORDS

PRESENT LEGAL OWNER (S) *C.C. Anderson*

Address *Jordan Valley*

OPERATOR

Name of claims Area Pat. Unpat.

Name of claims Area Pat. Unpat.

EQUIPMENT ON PROPERTY

State Department of Geology and Mineral Industries

702 Woodlark Building
Portland, Oregon

NITRATE GROUP

MALHEUR COUNTY

JOHN HERMAN LABORATORY
771 San Julian Street
Los Angeles, California

Certificate of SPECTROGRAPHIC QUALITATIVE ANALYSIS

Made for Adelmann Brothers Date February 19th, 1943.

	ELEMENT	ESTIMATED QUANTITY
"S.K. Atkinson #1"	Silicon-----	10.0%
	Iron-----	10.0%
	Aluminum-----	10.0%
	Sodium-----	1.0 to 10.0%
	Potassium-----	1.0 to 10.0%
	Calcium-----	1.0%
	Magnesium-----	0.1 to 1.0%
	Manganese-----	0.1%
	Zirconium-----	0.1%
	Copper-----	0.01 to 0.1%
	Chromium-----	0.01 to 0.1%
	Titanium-----	0.01%
	Lead-----	0.001 to 0.01%
	Vanadium-----	0.001 to 0.01%
	Nickel-----	0.001 to 0.01%
	Strontium-----	0.001 to 0.01%
	Tin-----	0.001%
	Gallium-----	0.001%
Molybdenum-----	0.001%	
Cobalt-----	0.001%	
Barium-----	0.001%	
Silver-----	0.0001 to 0.001%	

CONFIDENTIAL

John Herman
Chemist

Certificate of Assay CHEMICAL ANALYSIS

Made for Adelmann Bros. Date April 12, 1943

S.K. Atkinson	Sodium Nitrate-----	None
	Potassium Nitrate-----	None
	Calcium Chloride-----	None
	Calcium Compounds (Total CaO)----	0.5%
	Barium Compounds-----	0.01%
	Magnesium-----	0.10%
	Vanadium-----	0.001%
	Iodine-----	None

\$ Paid _____

John Herman

State Department of Geology and Mineral Industries

702 Woodlark Building
Portland, Oregon

United States
DEPARTMENT OF THE INTERIOR
Bureau of Mines

Western Region

Salt Lake City, Utah
April 6, 1943

Mr. S. K. Atkinson,
Boise, Idaho.

Dear Mr. Atkinson:

Examination of your sample indicates that it is a partially disintegrated rhyolite. Qualitative tests made on this sample confirm the presence of nitrates but the amount present appears to be relatively small. It is quite possible that the nitrate content of this type of rock may vary considerably as is the case with similar deposits that have been observed in Utah.

The possibilities of this material as a source of nitrates depend on many factors and it would be a difficult matter to advise you definitely on the commercial possibilities of such a deposit. As suggested by Mr. Zimmerly in his letter of March 30, it would be advisable to arrange with Mr. A. B. Iverson for investigation of the deposit to determine its possible extent and nitrogen content.

Very truly yours,

R. E. Head,
Microscopist,
Western Region.

Extracts from a letter from Wallace D. Lowry, Assistant Geologist,
State Department of Geology and Mineral Industries, April 15, 1943.

"----Insol is largely feldspar, partly kaolinized---the solute gives a good SO_4 and Cl test. No Nitrate reaction what so ever could be present in small amount. Also no carbonate reaction to speak of. The spectroscope shows both Na and Ca. Evaporation of the solute shows thenardite (Na_2SO_4) is the predominate salt."