DEPOSITS OF MAGNESIA ALUM NEAR FALLON, NEVADA.

By D. F. Hewett.

LOCATION.

During the summer of 1921 deposits of magnesia alum were discovered in the low hills along the south shore of Lahontan Reservoir, about 16 miles southwest of Fallon, Churchill County, Nev. Particular interest is attached to these deposits because it has been recently recognized that the application of alum to certain hard soils in arid regions makes them more pervious to water and therefore susceptible to cultivation. As certain tracts near Fallon that once produced crops but have recently been abandoned because they became impervious can probably be reclaimed by the use of alum, a ready market exists for any alum that can be produced.

The deposits lie near the quarter corner between secs. 16 and 17, T. 18 N., R. 26 E. (See fig. 23.) In this region Carson River, rising in the snow fields of the Sierra Nevada, flows generally northeastward through a mountainous region to a broad, flat basin surrounded by high ranges and clusters of low hills. The river disappears in Carson Sink, which occupies the center of the basin. The alum deposits lie on the edge of some low hills south of the river at the point where it leaves the mountainous area and enters the broad plain. The construction of the Lahontan dam confined the waters of Carson River, so that a part of the valley west of Fallon is now occupied by a reservoir about 3 miles in diameter. The surface of the reservoir fluctuates throughout the year, but at the time of the writer's examination, May 26–27, 1922, it stood at the highest level recorded, and water flowed over the spillway of the dam. Although the original river channel lay a mile north of the alum deposits, the level of the reservoir has risen so much that water 10 feet or more deep now lies within 500 feet of most of the deposits that have been found. As the reservoir is navigable for boats of shallow draft and as the tracks of the Southern Pacific Railroad lie close to the north shore, only modest improvements would be needed to permit the alum-bearing material to be mined and shipped to the Fallon district at a low cost

The features of the region near the alum deposits are shown in Figure 23, which represents a part of the Wabuska quadrangle, and in Figure 24, which was prepared by the writer at the time of the examination. The outstanding local feature is a terrace about a mile wide, which is limited on the south by a group of low hills that rise 500 feet higher and on the north by Lahontan Reservoir. This terrace was once cut by a deep ravine which drained northwest but

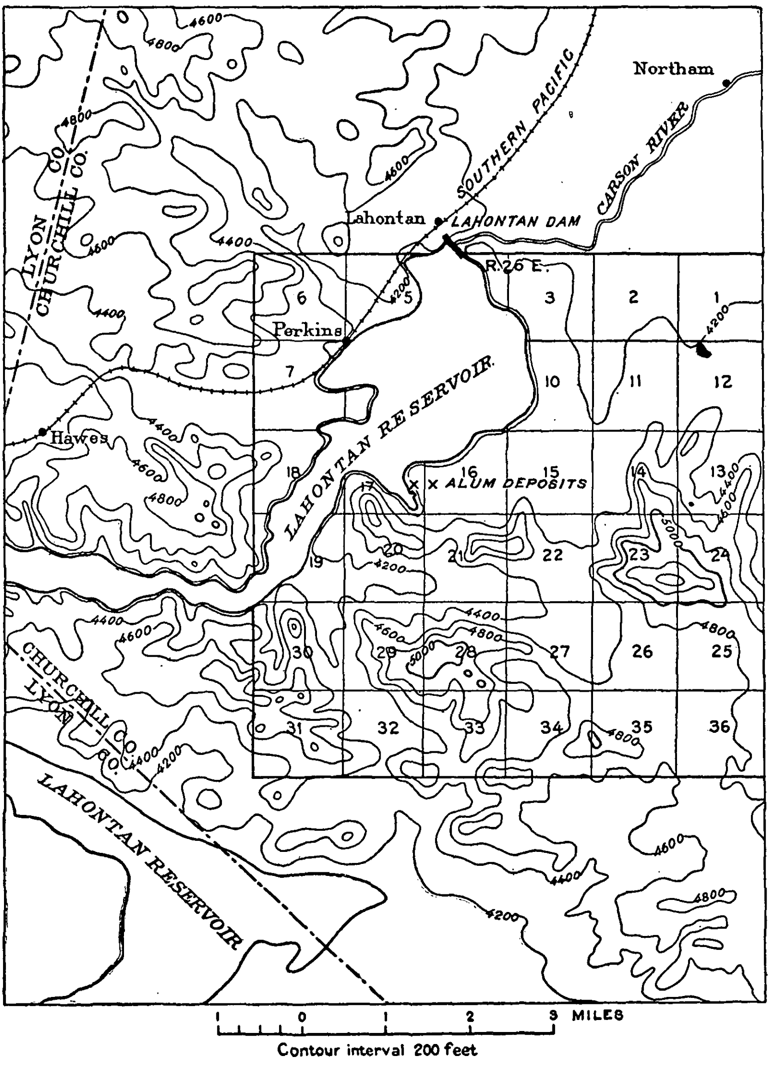

FIGURE 23.—Sketch map of western Churchill County, Nev., showing location of alum deposits near Fallon.

which, with the rise of the waters, is now occupied by an arm of the reservoir. The terrace is also dissected by other tributary ravines, and the deposits of alum crop out along their slopes. In May, 1922, the water stood about 125 feet below the average level of the terrace. A less conspicuous but well-defined terrace occurs along the hills south of the alum deposits, about 300 feet above the level of the lake. This terrace probably represents the position of Lake Lahontan, which once occupied a large area in western central Nevada.[1]

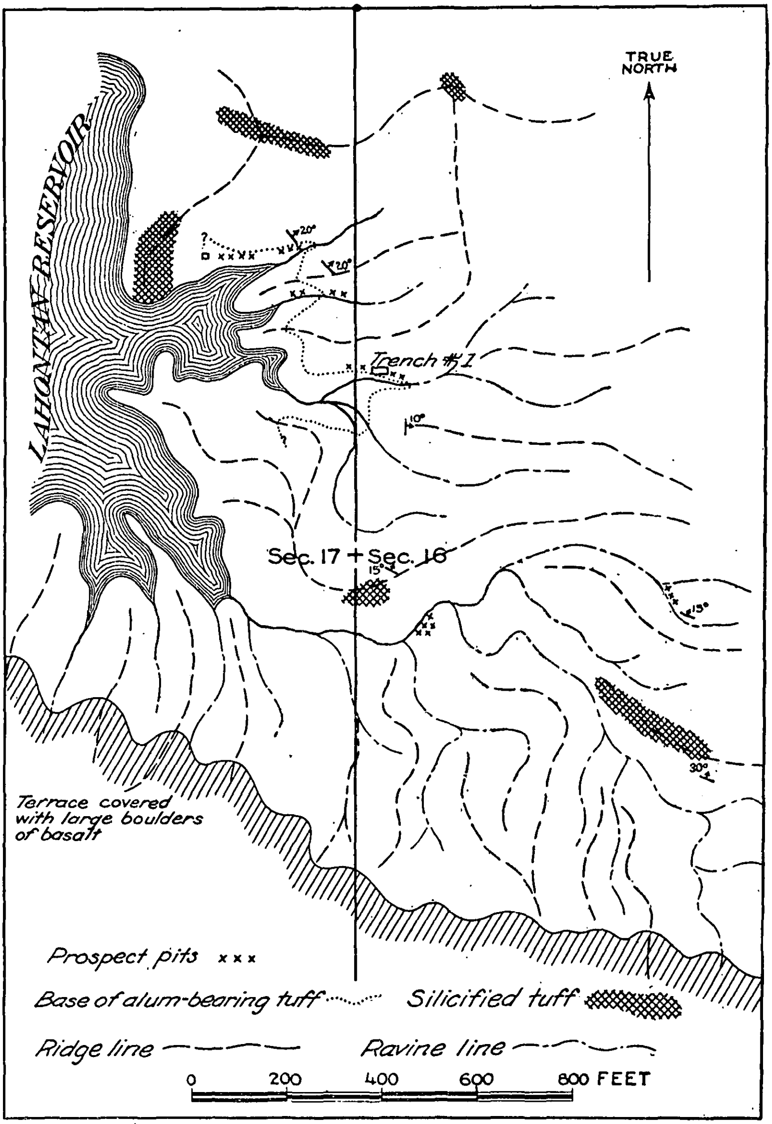

FIGURE 24.—Sketch map showing local relations of alum deposits near Fallon, Nev.

LOCAL GEOLOGY.

All the rocks near the alum deposits are igneous and fragmental. Although flows of basalt form the ridge half a mile south of the deposits, no other flows were found near by. The rocks range from

[1] Russell, I. C., Geological history of Lake Lahontan: U. S. Geol. Survey Mon. 11, 1885.

light-gray and brown laminated tuff resembling common clay shale to bedded breccia in which the coarsest fragments are about an inch in diameter. A line drawn northwest approximately following the principal ravine south of the alum deposits would roughly separate the fine bedded tuff on the northeast from the coarser material on the southwest. Only traces of alum have so far been found south of the ravine, and these were found in a local area of fine-grained material.

Knowledge concerning the unaltered tuff is largely obtained from several explorations for alum, as it is uniformly overlain by a layer of weathered material that ranges from 6 inches to a foot or more in thickness. In the prospect known as trench No. 1, where a vertical section 10 feet high is exposed, the lowest 4 feet is light chocolate-brown in color, is well stratified, and resembles a common variety of shale. The intermediate zone, 3 feet thick, is lighter, and the uppermost zone, also 3 feet thick, is light gray. Fragments from the upper zone, although outwardly gray, are distinctly light brown on the inside. Traces of carbonized plant material are rather common throughout the exposed zone. Some material showing plant remains collected from the same zone 150 feet farther north was submitted to F. H. Knowlton, of the United States Geological Survey, for identification. Although grasses could be recognized, they and the other remains were too fragmentary to serve to establish definitely the age of the rocks in which they were found. It was considered that the inclosing rocks are probably Tertiary. It seems highly probable that the brownish color of the unweathered tuff is due to finely divided organic matter. The even stratification shows that the tuff was laid down in water.

Close examination of the unweathered and unaltered tuff fails to show the presence of fragments of glass and other minerals characteristic of tuff. Abundant evidence that the material is tuff, however, is obtained here and there near the alum deposits where the tuff is silicified. Figure 24 shows five areas where the tuff is almost completely replaced by a chalcedonic silica and therefore weathers as conspicuous ledges. Although these areas are irregular in outline, the longest dimensions of most of them tend to follow the bedding. In these areas the texture and mineralogy of the original tuff may be discerned. Interbedded with the finer material are layers of coarser material that contain many angular grains of orthoclase in various stages of silicification. Although quartz was not identified, the coarser layers appear to be rhyolitic tuff. The silicified tuff uniformly contains a small proportion of minute grains of pyrite. As the rock weathers it becomes coated with thin films of limonite (hydrous ferric oxide) and jarosite (hydrous sulphate of iron and potash). Here and there, especially near the alum-bearing deposits, the unsilicified tuff also contains aggregates of small grains of pyrite.

The breccia that underlies the southern part of the area is also altered and decomposed by weathering. The southern limit of the breccia is a terrace strewn with large boulders of basalt that have probably weathered from the flows that crop out farther south.

A general idea of the local structure may be obtained from the few outcrops that show the bedding of the tuff. The beds strike northwest in the northwestern part of the area, north in the central part, and northeast in the southeastern part. They dip gently northeast and east. Small faults may be present, but they are not conspicuous. No intrusive rocks were observed near the alum deposits.

THE ALUM DEPOSITS.

Minerals present.—The only alum that has been recognized in the deposits is pickeringite (hydrous magnesium-aluminum sulphate). It has been recognized by its optical properties under the microscope as well as by chemical tests. It forms small hard gray masses about the size and shape of half a small pea, and numbers of such masses form clusters rather firmly attached to the partings and open fractures of the tuff. In places where the tuff is much broken by fractures and joints the alum forms fibrous veins as much as 2 inches thick, which cement the fragments firmly. The color of such veins ranges from pure white to gray, locally tinted reddish. Many blocks of tuff that show neither of these forms of alum have a strong astringent taste and probably contain minute disseminated particles of alum.

Gypsum (hydrous sulphate of lime) is common near the deposits. It generally forms veinlets as much as half an inch thick in the surface zone of weathered tuff. Where these veinlets are laid bare by erosion they form transparent plates 2 to 6 inches long. Near the alum deposits, where the tuff is disintegrated to a light powder, there is commonly a hard surface crust as much as an inch thick. Such crusts do not have an astringent taste, and the cement that makes them coherent is probably gypsum.

Pyrite (or marcasite?) (sulphide of iron) is present in both the unaltered brown tuff and the gray silicified variety. In the brown tuff it forms sporadic aggregates of small round grains. These were noted only where alum has been found. The silicified tuff from each of the areas indicated on Figure 24 contains a small percentage of pyrite, which forms minute grains that are in general uniformly distributed through large masses of the rock. No alum was noted near by, however.

Sulphur forms clear yellow crystals on fractures in the tuff near trench No. 1. It is uniformly near the pyritic nodules in the tuff.

Jarosite (hydrous sulphate of iron and potash) is rather widespread on the surface near the alum deposits. It generally forms yellowish-brown masses resembling small cauliflowers, which appear to have developed freely in open spaces, possibly also in the loose surface layer of weathered tuff. Other hydrous sulphates of iron and the alkalies may be present, but none were identified. Many yellowish-brown stains and thin films on the weathered tuff and the silicified tuff undoubtedly are jarosite or related sulphates, although some are probably limonite (hydrous ferric oxide).

Sericite (a potassium mica) forms small chalky-white masses made up of minute lustrous plates that appear to replace the tuffs here and there in the area.

The deposits.—More or less alum has been found at five localities in this area, but it has been satisfactorily explored only at one locality, trench No. 1. The presence of alum is indicated by patches and streaks of darker material on the light-colored hard crust of weathered tuff that underlies a large part of the area. Such areas are indicated by crosses in Figure 24. The patches and streaks look much as if the tuff were wet in spots, but a test will show that it is not. Under the hard crust there is commonly a layer of loosely coherent weathered tuff a foot or less thick which appears to be barren of alum. This layer overlies the coherent nearly fresh tuff, which, if alum bearing, constitutes the largest source of supply.

Trench No. 1 is 40 feet long, 10 feet wide, and a maximum of 10 feet deep. Here the layer of loosely coherent weathered tuff is about 12 inches thick. This material overlies gray and brown tuff which contains more or less alum to a depth of 10 feet. About 100 short tons of rock has been removed from the trench, and analyses of five lots having a total weight of 50 tons show that the content of soluble magnesia alum ranges from 14.9 to 29.4 per cent. From the samples that have been taken it would appear that the alum content decreases steadily toward the bottom of the trench, where it probably does not exceed 10 per cent. On the other hand, the alum content of each of the different stratigraphic layers appears to be rather uniform throughout the trench. The zone can be traced to the next ravine, 150 feet to the north, where the hard surface crust contains a little alum. The next explorations lie 100 feet farther northwest, along a second ravine where several trenches have been dug. The unweathered tuff does not appear to contain alum here, however. In the deepest cut, a shaft 8 feet deep, the fine brown tuff is locally altered to white sericite.

Alum shows on the surface crust in two ravines southeast of trench No. 1, but the only explorations are shallow cuts that scarcely penetrate the weathered zone. No alum has yet been found in unweathered tuff.

Estimates of the average grade of alum-bearing rock are based upon the analyses of five samples weighing 105,290 pounds in all, collected in 1921 by agents of the Newlands Experimental Farm, Bureau of Plant Industry, United States Department of Agriculture. According to F. A. Headley, in charge of the farm, the alum content of the samples was as follows:

Alum content of samples from deposits near Fallon, Nev.

Sample No.	Weight (pounds).	Soluble magnesia alum (per cent)
Y1	20,875	19.86
Y2	34,350	14.90
Y3	18,310	23.93
Y4	16,850	29.40
Y6	14,905	21.00

The weighted average content of the five lots is 20.63 per cent.

Quantity of alum-bearing rock.—In order to estimate properly the quantity of alum-bearing rock in these deposits it is necessary that the essential processes in the genesis of the alum be understood. In general, alums are formed by the action of sulphuric acid upon aluminous material, such as clay, shale, and igneous rocks. The sulphuric acid may be formed in two ways, however—by the oxidation of metallic sulphides, such as pyrite, or by the oxidation of sulphurous gases, such as hydrogen sulphide, which is commonly found issuing from the earth near solfataras. In solfataric regions much sulphur is commonly set free and the rocks are generally deeply altered. It seems highly probable, therefore, that in the deposits near Fallon the alum has been formed by the action upon the fine tuff of sulphuric acid set free by the oxidation of the pyrite which it contains. Near the alum deposits the tuff is locally silicified, although elsewhere it is quite fresh below the crust of weathered material. The replacement of rocks by chalcedonic silica is commonly considered evidence of mineralization by waters of volcanic origin. Such altered igneous rocks are widely known in central Nevada, in such mining districts as Goldfield. The replacement by silica is commonly accompanied by deposition of pyrite. It is impossible to say with assurance whether the pyrite in the unaltered tuff was deposited by the same solutions that deposited silica and pyrite near by, or whether this pyrite was formed in association with carbonaceous material when the tuff was laid down. If the first explanation were true, the pyrite in the tuffs would be sporadically distributed; if the second were true, the pyrite might persist over larger areas and roughly coincide with the distribution of the layer of tuff in which it is found. As the tuff that contains pyrite shows little evidence of hydrothermal alteration, it is concluded that the second explanation is probably correct and that the alum will tend to follow a definite zone of tuff. The approximate base of the alum-bearing zone of the tuff is shown in Figure 24.

It is surprising to find a deposit of magnesia alum in rocks that appear to be deficient in magnesia. So far as the tuffs have been studied they appear to be rhyolitic and when fresh should have contained more soda and potash than magnesia. Under the circumstances one would expect to find soda and potash alums rather than magnesia alum. Possibly the tuff was uncommonly rich in magnesia, or perhaps under the local conditions magnesia alum is relatively less soluble than other alums.

In order to estimate the probable quantity of alum-bearing rock in this area, the following assumptions are made:

1. The alum has been formed by the action upon the tuff of sulphuric acid produced by oxidation of pyrite.

2. The oxidation has been effective to a depth of 25 feet below the surface.

3. The average thickness of alum-bearing tuff is 10 feet.

4. The central part of the area, which lies between the ravine adjacent to trench No. 1 and the next trench on the north, is probably underlain by alum-bearing tuff.

5. The tracts adjacent to the central part of the area on the north and south, which lie between the second ravine south of trench No. 1 and the second ravine north of it, may also contain some alum, but from the surface exposures it is estimated that the rock here would contain a lower percentage than that in the central area.

On these assumptions it is estimated that within the central area there is 17,000 tons of rock that probably contains 15 per cent of soluble magnesia alum. There is a fair possibility that the outlying areas contain an additional 13,000 tons of rock carrying 10 per cent of alum.