ALUNITE IN THE SAN CRISTOBAL QUADRANGLE, COLORADO.

By Esper S. Larsen.

INTRODUCTION.

In the course of the geologic mapping of the San Cristobal quadrangle, Colorado, under the direction of Mr. Whitman Cross, the writer examined a number of large areas of altered rock and found that alunite is a common and in places abundant mineral in the alteration product. The recent development of the potash industry whereby alunite has become recognized as a possible source of potash, has given additional importance to occurrences of this mineral, and it is the purpose of this paper to discuss briefly the known alunite deposits in the San Cristobal quadrangle.

GEOLOGY.

The greater part of the quadrangle is occupied by volcanic rocks of Tertiary age, and these rocks extend for many miles to the north, east, and west. They range in composition from rhyolite to basalt, but even the basaltic rocks commonly contain a considerable amount of potash feldspars. Lava flows form most of the material, but the area contains breccia beds and extensive intrusive bodies. In general the flows are flat and the structure is simple, but in places they are much faulted and tilted.

ALUNITE ROCKS.

Areas of altered rock a mile or more across are common in the volcanic region. Some are elongated or lenslike and are associated with fractures or vein fillings, and in places, as at Carson, these narrow altered zones are very abundant; others are more irregular in form. The altered rock is nearly always bleached white, and it is commonly softer than the unaltered rock. Many of these white outcrops are conspicuous and can be recognized at a considerable distance. In some parts of the quadrangle the alteration has given rise to kaolinite or to sericite, but from the writer's observations these types of alteration are not so extensive as alunitization, which has been observed in basaltic as well as in rhyolitic rocks.

The alunitized rock is usually white and commonly contains rather prominent cavities. As a rule the original texture of the rock is partly preserved. The alunitized rock can generally be distinguished from kaolinized or sericitized rock by its more compact, crystalline appearance and vitreous rather than earthy luster. Crystals and cleavage faces of alunite can be seen in the more coarsely crystalline rock, but most of the material is very fine grained and only pyrite can be recognized in the hand specimen. The thin sections show chiefly quartz and alunite, with a little pyrite, and some specimens, especially those derived from rather basic rocks, contain kaolinite or bauxite. The alunite is in some places scattered through the altered rock, but much of that derived from the more basic rocks partly replaces the plagioclase or occurs scattered through the groundmass. In a felsitic rhyolite at the head of South River small crystals of alunite are scattered throughout the altered rock, which retains some of its original felsitic texture.

OCCURRENCES OF ALUNITE.

Head of Middle Fork of Piedra River.—In the basin at the head of the west branch of the Middle Fork of Piedra River is a large area of altered breccia. The fresh rock contains abundant tabular crystals of labradorite and some augite and hypersthene in a groundmass of plagioclase and orthoclase. Quartz is generally present in the groundmass, which varies greatly in coarseness. The altered rock always contains abundant quartz and kaolinite or bauxite and usually a considerable amount of alunite. Pyrite is invariably present and gypsum is prominent locally. It is interesting to note that in the southeastern part of this area there are deposits of banded opal and sulphur rock and altered rock consisting of quartz, kaolinite, sulphur, and pyrite, but no alunite was observed associated with the sulphur type of alteration. This altered zone is in an area of intense faulting, and while no faulting was recognized in the immediate vicinity of the rocks showing alteration the two are probably related.

Head of South River.—At the head of South River, just east of Piedra Peak, the rhyolite which overlies the andesitic complex mentioned in the preceding paragraphs is intruded by a large body of diorite porphyry. About this intrusive the rhyolite is much altered and to the east of Piedra Peak the trail crosses a large body of this altered rock. Some prospecting for gold has been done in it, but the mineralized rock seems to be the only ore. The fresh rock is a fluidal felsitic rhyolite made up of quartz and orthoclase, with a little biotite. Three specimens of the altered rock were collected near the prospects and found to consist of a fine-grained aggregate of quartz, alunite, and pyrite.

A partial analysis of the typical altered rock was made by W. T. Schaller, with the results given on page 181 in column 1. The chemical composition of the fresh rock is not known, but the analysis of a similar rhyolite from California is given for comparison. A comparison of the two analyses shows a relative loss of some Al_2O_3, little change in the total iron and SiO_2, a loss of over half the K_2O, of more than half the Na_2O, and of nearly all the MgO and CaO. There has clearly been an addition of S and SO_3. The chemical analysis indicates that the rock contains about 69 per cent of quartz, 2 per cent of pyrite, and 29 per cent of alunite, and this agrees very well with the results obtained from a study of thin sections under the microscope.

Analyses of rhyolite.

	1	2
SiO_2	69.24	74.65
Al_2O_3	11.50	14.11
Fe_2O_3 } total iron	1.34	{ 1.08
FeO } total iron		.29
K_2O	1.99	4.59
Na_2O	.80	2.81
MgO	....	.20
CaO	....	.80

1. Alunitized rhyolite from head of South River. Analysis by W. T. Schaller.
2. Rhyolite from California. Analysis by W. F. Hillebrand.

Carson.—At the mining camp of Carson the quartz latite and other rocks carry numerous irregular or elongated areas of bleached and altered rock showing more or less mineralization. In general the alteration consists of kaolinization and sericitization, but near some of the veins quartz-alunite rock was found.[1]

Slumgullion Gulch.—The Slumgullion mud-flow is made up chiefly of andesitic rocks which were derived from the slopes above it. Much of the rock is greatly altered and somewhat mineralized, and to judge from the specimens collected much of the altered rock contains abundant alunite. The alunite occurs in rocks made up chiefly of opal, in which it lines cavities or is scattered through the opal. Alunite-quartz rocks were also collected. These rocks came from some of the large areas of altered rock that are so prominent about Slumgullion Gulch.

Red Mountain.—Red Mountain, a few miles southwest of Lake City, is formed of great flows of quartz latite. The rock is characterized by large crystals of feldspar, some quartz, biotite, and augite in an aphanitic groundmass. The large feldspars are in part orthoclase, in part andesine or microperthite. The groundmass is made up of quartz and orthoclase. The rock is rather rich in alkalies. Locally it has been much altered, and the largest body of altered rock covers an area of over a square mile, occupying the crest and slopes of Red Mountain. This rock is commonly stained red from iron, but

[1] Larsen, E. S., The economic geology of Carson camp, Hinsdale County, Colo.: Bull. U. S. Geol. Survey No. 470, 1911, p. 33.

otherwise it is nearly white. Bodies of opal and quartz are abundant, but by far the greatest part of the mass is made up of quartz or opal and alunite, with some pyrite and a varying amount of kaolinite. The alunite and quartz are locally present in a very fine grained aggregate, but commonly the alunite crystals are collected in the original feldspar crystals and to a less extent scattered through the groundmass. No analyses are available, but the microscopic study indicated a considerable amount of alunite.

GENESIS.

All the alunite occurrences described are clearly the result of the alteration of igneous rocks. From a study of the thin sections and of the partial analyses of the South River rock it is believed that in the process of alunitization most of the silica of the rock remains as quartz and the iron as pyrite, and that most of the alumina goes into the alunite. The magnesia and lime are almost completely removed and the alkalies are much decreased, soda to a greater extent than potash. In the conversion of orthoclase to alunite and quartz without the removal of alumina two-thirds of the alkali is removed and there is an increase of about 14 per cent in weight and a somewhat smaller increase in volume. In the alunitization of a soda feldspar the increase in weight is nearly 20 per cent, and if some of the soda is replaced by potassium the change is even greater. Many of the alunitized rocks show porosity and other evidence that there was a decrease in volume on alunitization. This may be accounted for in part by the loss of the lime and magnesia but chiefly by the loss of alumina and possibly also of silica.

The character of the alunite rock, which consists of quartz, alunite, and pyrite, and the absence of any oxidation products point to some other origin for the rock than descending oxidizing solutions. The same suggestion is offered by the great extent of the alunite rock in the areas on South River and Red Mountain, each of which covers approximately a square mile, and the exposure for a vertical distance of nearly 2,000 feet on Red Mountain, the uniformity of the alteration, and the lack of large veins or other sulphide bodies associated with the alunitization. Sulphates are known to occur as original constituents in some of the sulphide veins of the region. Indeed, in the vein of the Golden Fleece mine, on the east slope of Red Mountain, the mineral hinsdalite, which has the composition $2PbO.3Al_2O_3.2SO_3.P_2O_5.6H_2O$ and is closely related to alunite, is an abundant original constituent in a quartz sulphide vein.[1]

[1] Larsen, E. S., jr., and Schaller, W. T., Hinsdalite, a new mineral: Am. Jour. Sci., 4th ser., vol. 32, 1911, p. 251. Irving, J. D., and Bancroft, Howland, Geology and ore deposits near Lake City, Colo.: Bull. U. S. Geol. Survey No. 478, 1911, p. 54.

The evidence suggests hot ascending solutions as the cause of the alunitization. The field relations point strongly to deep-seated hot sulphuric acid solutions without the aid of surface agents. However, in view of the fact that geologists do not generally admit the presence of such solutions, the evidence in the present case is not sufficient to justify the assumption of such a source for the alunitization in the San Cristobal quadrangle. The alternative source is the mingling of hot ascending solutions or gases carrying H_2S and of surface oxidizing waters.[1]

[1] For a discussion of the origin of alunite see Butler, B. S., and Gale, H. S., Alunite, a newly discovered deposit near Marysvale, Utah: Bull. U. S. Geol. Survey No. 511, 1912, p. 21.

SURVEY PUBLICATIONS ON ALUMINUM ORES—BAUXITE, CRYOLITE, ETC.

The following reports published by the Survey or by members of its staff contain data on the occurrence of aluminum ores and on the metallurgy and uses of aluminum. The Government publications, except those to which a price is affixed, can be obtained free by applying to the Director, U. S. Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C.; the folio from either that official or the Director of the Survey.

BURCHARD, E. F., Bauxite and aluminum: Mineral Resources U. S. for 1906, 1907, pp. 501–510. 50c.

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——— Bauxite [in Rome quadrangle, Georgia–Alabama]: Geol. Atlas U. S., folio 78, 1902, p. 6. 25c.

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HUNT, A. E., Mineral Resources U. S. for 1892, 1893, pp. 227–254. 50c.

PACKARD, R. L., Aluminum and bauxite: Mineral Resources U. S. for 1891, 1892, pp. 147–163. 50c.

——— Aluminum: Sixteenth Ann. Rept., pt. 3, 1895, pp. 539–546. $1.20.

PHALEN, W. C., Bauxite and aluminum: Mineral Resources U. S. for 1907, pt. 1, 1908, pp. 693–705, $1; idem for 1911, pt. 1, 1912, pp. 923–939.

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SPURR, J. E., Alum deposits near Silver Peak, Esmeralda County, Nev.: Bull. 225, 1904, pp. 501–502. 35c.

STRUTHERS, J., Aluminum and bauxite: Mineral Resources U. S. for 1903, 1904, pp. 265–280. 70c.