Many of the original papers quoted above were not available to the writer, and the references were obtained in part from that excellent paper by Williams in the *American Journal of Science*, to which the reader is referred for additional information.

VOLTAITE FROM JEROME, ARIZONA

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The Department of Geological Sciences, University of California, has received some very good specimens of the rare mineral voltaite from Jerome, Arizona, sent by Mr. George L. McIntyre of Eureka, Utah. He reported that the specimens were formed in brecciated quartz immediately above burning sulphide ore on the upper levels of the United Verde Mine. It is his opinion that the voltaite has been formed by the ascending sulphur vapors. The ore of the mine has been burning for a number of years; it was first set on fire when the back of a stope collapsed and the friction ignited the sulphur present in the sulphides. Reber[1] reported the burning sulphide ore in his report on the region, but he made no mention of the voltaite. This article was prepared under the direction of Professor Arthur S. Eakle and the writer wishes to gratefully acknowledge his aid and helpful criticism.

The mineral when fresh occurs in small, black, opaque, resinous crystals varying in size from 1 mm. to 5 mm. Crystals of the 1 to 2 mm. size predominate; only in one specimen were the larger crystals obtained. The hardness is about 3 and the mineral gives a greenish gray streak. The specific gravity as determined with a Jolly balance is 2.75. The fracture is conchoidal with no apparent cleavage. It is difficultly soluble in water but goes into solution readily with dilute acid. A strong potassium flame is obtained before that blow-pipe and the assay turns to a brick-red powder.

Several of the crystals were measured on a Fuess reflecting goniometer and good reflections were obtained from the faces of the fresh crystals. The crystals are isometric with the majority showing simple cubes, but the combination of cube and octahedron was found on several crystals, and one crystal is a combination of the octahedron and dodecahedron.

Under the microscope, the voltaite is transparent, having a pale green color. The mineral is isotropic and the index of refraction

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[1] Reber: *Am. Inst. Min. Met. Eng.*, **66** (1922).

determined by the oil immersion method is 1.604 ± .003. This corresponds to the optical properties of voltaite determined by Larsen.[2]

A chemical analysis was made of hand picked material. The water content was determined by the Penfield closed tube method adding lead oxide to keep the sulphur trioxide from escaping. Very satisfactory results were obtained in this manner. The ferrous iron and the total iron were determined by titration with potassium permanganate, while the ferric iron plus alumina were determined by precipitation with ammonium hydroxide. The magnesia, sulphur tri-oxide, and potassium oxide were determined by standard gravimetric methods.

The chemical analysis is as follows:

SO_3	47.83
Al_2O_3	6.06
Fe_2O_3	14.34
FeO	8.82
MgO	1.55
K_2O	4.52
H_2O	16.13
Total	99.25

The voltaite alters rather quickly upon exposure to the air, forming a yellow powder. When studied under the microscope this was found to consist of an uniaxial and a biaxial mineral. The uniaxial mineral is yellow in color with a low birefringence; it is optically positive. The indices, determined are $\epsilon = 1.538$, $\omega = 1.532$. These values are low for coquimbite, the hydrous ferric sulphate, but Larsen[3] has found a similar mineral associated with voltaite from Sierra de Caporasee, Chile, and believes it to be related to coquimbite. The biaxial mineral occurs in minute plates, distinctly pleochroic, Z = yellow green, Y = colorless. X is perpendicular to the plates and was not determined. The birefringence is strong, $\gamma = 1.602 \pm .003$, $\beta = 1.563 \pm .003$, α was not determined. $2V = 45° \pm 5°$. The mineral is optically positive. This agrees satisfactorily with Larsen's determination of the optical properties of copiapite, the platy hydrous ferric sulphate. The copiapite is by far the more plentiful of the two minerals; a rough estimate from a study of the powder in oils gave, copiapite 80%, coquimbite 20%.

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[2] Larsen: *U. S. G. S. Bull.*, **679**, p. 155 (1921).

[3] *Op. cit.*, p. 155.

Thus we have two hydrous ferric sulphate minerals forming as alteration products from the voltaite.

Voltaite was first observed in 1792 by Breislack in the solfatara near Naples, Italy, but it was not named until 1841 by Scacchi.[4] In 1867, Tschermak[5] discovered voltaite in Kremnitz, Hungary, associated with melanterite. Blass[6] made the next discovery; in 1883, he found voltaite in an altered pyritiferous trachyte from the region of Madeni Zagh, Persia. Schmölnitz, Hungary, yielded the next find of voltaite crystals; Krenner[7] described these in 1887. Collins[8] was the next to describe a new locality of voltaite; he found octahedrons of voltaite associate with coquimbite and melanterite in a filled cavity close to the cap of an orebody in Concepcion Mine, Spain. Larsen[9] used voltaite from Sierra de Caporasse, Chile, for the determination of the optical properties; he obtained it from Colonel Roebling's collection but no mention is made of the date of its discovery. Thus, the voltaite from Arizona seems to be the seventh reported locality of this mineral. Ablich[10] made artificial voltaite crystals in 1842 by allowing the constituents to evaporate in a sulphuric acid solution at room temperature.

The outstanding difference between the voltaite from Jerome, Arizona, and voltaite from other localities is the low percentage of RO and comparatively high percentage of R_2O_3. However, $RO+R_2O_3$ is approximately equal in all cases. It is interesting to note however that the artificial voltaite made by Ablich has the same characteristics regarding the ratios of RO and R_2O_3.

The presence of the voltaite only in the upper levels of the United Verde Mine immediately above the burning sulphide ore indicates that it is connected genetically with this phenomenon. The high percentage of water is rather suggestive that the voltaite was deposited from aqueous solutions at comparatively low temperatures. Scacchi[11] believes that the voltaite at the solfatara near Naples was formed by the ascending sulphur gases uniting

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[4] Scacchi: *Zeit. d. Geol. Ges.*, **4**, 163 (1852).

[5] Tschermak: *Sitzungsber. d. Akad. Wien.*, **56**, (1) 831 (1867).

[6] Blaas: *Zeitsch. f. Kryst.*, **10**, p. 409.

[7] Krenner: *Földt. Közl.*, **17**, 556 (1887).

[8] Collins: *Mineral. Mag.*, **XX**, No. 100, p. 34 (1923).

[9] *Op. cit.*

[10] Scharizer: *Zeit. f. Kryst.*, **54**, 123 (1914).

[11] Scacchi: *Op. cit.*

with the decomposed rocks of the solfatara. At Jerome, the hanging wall of the mineralized area is diorite, but the voltaite is not formed by direct contact with the diorite as shown by its occurrence in brecciated quartz, but it might well have formed by a concentration of the sulphur vapors in the ground waters above, which would probably contain iron, magnesia, and potash as a result of decomposition of the diorite. This would be more or less comparable to the conditions in the solfatara where the voltaite was first found.

Some altered pyrite from Shasta County, California, was sent to the University of California and examined by the writer. A large amount of this is melanterite, but minute black octahedrons are scattered throughout the mass. Microscopic study with oils showed that these octahedrons were isotropic, $n = 1.596 \pm .003$. The color under the microscope is a pale oil green; the fracture is conchoidal. The crystals were too minute for goniometric or blowpipe study, but the association with melanterite, the same association found in Kremnitz, Hungary and Concepcion Mine, Spain, plus the optical properties which correspond with those of voltaite, suggest very strongly that we have the mineral voltaite in California, making two known occurrences in North America.

AN OCCURRENCE OF PITTICITE IN NEVADA

William F. Foshag, *U. S. National Museum*[1]

AND

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The iron arsenate-sulphate, pitticite, was first found by one of us (H. G. C.) in 1923 on the 400 foot level of the White Caps Mine at Manhattan, Nevada, as a secondary formation in the old workings.

The White Caps ore body represents a replacement and impregnation of limestone of Cambrian age, in this district called the "White Caps Limestone." The ore minerals are the sulphides of arsenic, realgar and orpiment, the sulphide of antimony, stibnite, and minor amounts of pyrite. The ore values are entirely its gold content. The gangue minerals are calcite, in part recrystallized into large rhombs, quartz and adularia feldspar

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[1] Published with the permission of the Secretary of the Smithsonian Institution.