

of the depositing solution, for all might be deposited at the same temperature, or at least within a few degrees of each other. The material studied apparently gives striking support to the experimental work of the authors cited above, provided, of course, that the interpretation of the black powder as being originally melnikovite is correct.

The writer inclines to the view that the solutions are of magmatic origin. The cobalt-nickel-copper deposits of Fredricktown and Mine La Motte are only a few miles away. The former, which are within a mile of this deposit, contain enormous quantities of marcasite along with the other sulphides, and this deposit may well be connected with them in origin. In fact, this deposit has a structural position in the dolomite adjacent to two outcrops of igneous rocks, which are pre-Cambrian, that resembles to a marked degree the mode of occurrence at Fredricktown. It may be added that pyrite is abundant in the granites and granite-porphyrines of the St. Francis mountains to the west.

As far as could be determined from the literature, this is the first instance where the amorphous iron disulphide may have been deposited by hot solutions along with the other polymorphous forms of the iron disulphide, and this gives added interest to the deposit.

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#### ADDITIONAL DATA ON THE PROPERTIES OF PUMPELLYITE, AND ITS OCCURRENCE IN THE REPUBLIC OF HAITI, WEST INDIES<sup>1</sup>

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In 1921 during a geological reconnaissance in the Republic of Haiti, undertaken by the Haitian government in cooperation with the United States Geological Survey,<sup>2</sup> Dr. J. S. Brown and the writer collected a cobble of a peculiar amygdaloidal basalt from the bed of the Limbé River at Limbé in northern Haiti; the basalt was not greatly unlike many of the older basaltic rocks of this region, but the amygdules were very noticeable and abundant, most of them being lined with white albite and the central part filled with greenish-yellow iron rich epidote and a deep bluish-green min-

<sup>1</sup> Published by permission of the Director of the U. S. Geological Survey.

<sup>2</sup> Woodring, W. P., Brown, J. S., Burbank, W. S.; *Geology of the Republic of Haiti*: Dept. of Public Works, Rep. of Haiti, Port-au-Prince, 1924.

eral which did not agree with any described species, but was considered from its crystal properties as probably belonging to the epidote group.<sup>3</sup>

It was the intention to separate this mineral and have a chemical analysis made but this work was delayed, and in 1924 when at Calumet, Michigan, the writer discovered while examining thin sections of the Keweenawan amygdaloids that the mineral from Haiti was apparently identical with the "green zoisite" of the copper deposits. This "green zoisite," subsequently given the name pumpellyite<sup>4</sup> by Palache and Vassar, was then under investigation in connection with studies carried on by the Calumet and Hecla Consolidated Copper Company.

Since that time the writer has had the opportunity to recheck his original determinations of the optical properties of the mineral from Haiti and compare them with those published for pumpellyite. The mineral was found to differ in optical orientation, and somewhat in indices and birefringence compared with the data given for pumpellyite. The mineral from Haiti while occurring in smaller quantity than pumpellyite in Michigan, is better crystallized and more satisfactory for optical study.

The bluish green mineral was determined to have the following optical properties:

Optically positive.  $2V$  large, estimated  $75^\circ$  to  $80^\circ$ . Dispersion strong,  $\rho < \nu$ .  $\alpha = 1.700$ ;  $\beta = 1.707+$ ;  $\gamma = 1.718 \pm^5$ . The  $\alpha$  and  $\gamma$  vibration directions are practically colorless; the  $\beta$  direction is bluish green. Crystal development is prismatic parallel to  $Y$  (= crystal axis  $b$ ?). Vibration direction  $\gamma$  makes an angle of about  $31^\circ$  with a cleavage presumably basal (001).

On the basis of the above optical properties, the mineral is probably monoclinic with prismatic development parallel to the  $b$  axis and an orientation practically identical with that of epidote. The basal cleavage is well developed and in sections parallel to the axial plane, which are colorless and non-pleochroic, measurements of the angle  $\gamma \wedge (001)$ , gave values around  $30^\circ$  to  $32^\circ$ . The birefringence of these sections was estimated to be about .020. Sec-

<sup>3</sup> Geology of the Republic of Haiti, Igneous Rocks, page 271.

<sup>4</sup> Palache, Charles, and Vassar, Helen E.; Some minerals of the Keweenawan copper deposits: Pumpellyite, a new mineral; sericite; saponite. *Am. Mineral.* vol. 10, No. 11, pp. 412-418, Nov., 1925.

<sup>5</sup> Values for indices of refraction are  $\pm .003$ .

tions parallel to Y ( $=b?$ ) are distinctly fibrous in appearance and the interference colors show evidence of the strong dispersion.

The amygdaloidal basalt in which the mineral occurs is of a purplish brown color with abundant amygdules ranging from less than a millimeter to 4 or 5 mm. in diameter. The texture as revealed in thin section is intergranular and typical of basaltic rocks, with the plagioclase laths .05 to .10 mm. in length, and the interstitial areas occupied by granules of augite of about .05 mm. in size. The plagioclase of the original unaltered basalt has been recrystallized without destroying the texture or orientation and is now largely albite. The augite remains practically colorless and unaltered. Magnetite appears to have been partly recrystallized, and platy hematite, probably secondary, is common.

Many of the amygdules are lined with albite crystals, or the crystals may project into the amygdule, while the central part is occupied by a network of fibers and small prisms of pumpellyite. The largest prisms of pumpellyite seen are about 0.2 mm. in length and .05 mm. in cross-section. The pleochroic yellow epidote when present in the amygdule occurs at the very central part in radiating prismatic groups, and is clearly later than pumpellyite.

Veining the rock are a few veinlets a millimeter or less in width, consisting of albite and a little quartz.

The order of formation of the secondary minerals is albite, chlorite, pumpellyite, and finally epidote.

The basalt is presumably of the same age as many similar basaltic rocks of the northern range of Haiti. The exact age of these rocks is unknown but they are definitely pre-Upper Cretaceous and for certain reasons are considered most likely of middle Mesozoic age.<sup>6</sup>

The type of alteration described above is typical of certain stages of a widespread metamorphism in the volcanic rocks of the northern range,<sup>7</sup> and has probably been produced by a batholithic intrusion of quartz diorite of late Cretaceous age. In an intense development of the metamorphism the conversion of the basic plagioclase to an albite is invariably accompanied by the separation of epidote or clinozoisite, and often with the development of some sericite, while the pyroxene is converted partially or completely to uraltic hornblende. Where the intensity of the metamor-

<sup>6</sup> Geology of the Republic of Haiti, Igneous Rocks, pp. 267, 268.

<sup>7</sup> *Op. cit.* p. 272.

phism is less the augite is often uneffected as in the specimen described above. Still weaker phases are represented by the formation of prehnite and zeolites from the alteration of the feldspars, either as replacement of the feldspars or filling cracks and cavities in altered rocks.

The specimen containing the pumpellyite is possibly a unique variety of the intermediate phase of alteration in that no other occurrence of this mineral was found; nor was the particular amygdaloidal basalt containing this mineral found as a bedrock outcrop. It is possible however that a search in the vicinity of the upper part of the Limbé River would reveal outcrops of this rock, as the region was not explored during the reconnaissance.

### AMMONIOJAROSITE, A NEW MINERAL OF THE JAROSITE GROUP FROM UTAH

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One of the most illustrative cases of isomorphism in systematic mineralogy is furnished by the jarosite division of the alunite-beudantite group. The original jarosite, known since 1838, is a hydrous sulphate of ferric iron and potassium. Sixty-four years later Hillebrand and Penfield described two new jarosites in one of which the potassium was replaced by sodium while the other contained, in place of the alkali metal, lead. The latter mineral has been found in a number of places since and in some localities is an important constituent of ores. Still more recently Schaller has called attention to a very interesting member of the group in which silver enters as an essential constituent. The purpose of the present short paper is to describe briefly a fifth jarosite in which the essential alkali is ammonium oxide. The present members of the jarosite group are as follows:

Jarosite	$K_2O \cdot 3Fe_2O_3 \cdot 4SO_3 \cdot 6H_2O.$
Natrojarosite	$Na_2O \cdot 3Fe_2O_3 \cdot 4SO_3 \cdot 6H_2O.$
Plumbojarosite	$PbO \cdot 3Fe_2O_3 \cdot 4SO_3 \cdot 6H_2O.$
Argentojarosite	$Ag_2O \cdot 3Fe_2O_3 \cdot 4SO_3 \cdot 6H_2O.$
Ammoniojarosite	$(NH_4)_2O \cdot 3Fe_2O_3 \cdot 4SO_3 \cdot 6H_2O.$

The ammoniojarosite is from southern Utah. This is interesting, geographically, since all known members of the group have been

<sup>1</sup> Published by permission of the Acting Secretary of the Smithsonian Institution.