MASSIVE LOW-FLUORINE TOPAZ FROM THE BREWER MINE, SOUTH CAROLINA*

J. T. Pardee, Jewell J. Glass and R. E. Stevens,[1]
U. S. Geological Survey, Washington. D.C.

Introduction

A mass of fine-grained topaz, unlike any deposit heretofore described, because of its large size and low-fluorine content, forms a part of the gold-bearing lode at the Brewer Mine near Jefferson, Chesterfield County, South Carolina.

The Brewer gold mine is one of the early discoveries of the Southern Appalachian region. In the course of intermittent mining operations during the last 100 years a superficial placer deposit has been largely stripped from an area of 20 or 30 acres and numerous pits have been excavated, one of them 300 feet across and 140 feet deep.

The country rock is a quartz-sericite schist that locally preserves the structure of a fine-grained waterlaid tuff, probably a rhyolite, from which it was derived. Certain layers of it carry much pyrophyllite. Exposures of a granite that intrudes the schist appear on the north and west at distances of a mile to a mile and a half.

The lode extends nearly half a mile along a broad ridge about 200 feet high between Little Fork Creek and Lynch's River. It is a large body composed chiefly of fine-grained quartz that shows the pattern of a breccia that it has replaced. As exposed in the largest excavation, the Brewer pit, the lode is generally weathered to depths ranging from 40 to 60 feet. At greater depths the rock is firm and flint-like. Generally it contains from 2 to 5 per cent of pyrite, unevenly distributed as aggregates and individual crystals. Small grains of enargite are sparingly scattered through parts of the rock and the following minerals not seen by the authors are reported: covellite,[2] cassiterite,[3] and bismuth ochre (bismite) and native bismuth.[4] Assays of samples from the Brewer pit show from .045 ounce to .13 ounce of gold per ton. Spectrographic tests of these samples by George Steiger showed no platinum or palladium.

In the weathered zone much of the flinty appearing quartz rock is disintegrated to a very fine white sand, some of it snow-white and some

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[1] Field work and geology by Pardee; microscopic work by Glass; and analytical chemical work by Stevens.

[2] Becker, G. F., Gold fields of the southern Appalachians: *U. S. Geol. Survey, 16th Ann. Rept.*, pt. 3, p. 279, 1895.

[3] Clark and Chatard, *Am. Jour. Sci.*, 3d ser., vol. **28**, p. 25, 1884.

[4] Tuomey, M., *Geology of South Carolina*, p. 97, **1848.**

more or less iron-stained. Alongside the sandy material are bodies with the structure of a breccia cemented with iron oxides. Both kinds carry fine particles of free gold. In several places the lode quartz is cut by veins of coarse white quartz ("bull quartz") that show no other minerals except rare groups of ilmenite plates.

As mentioned farther on, the quartz rock contains scattered grains of topaz. This fact was suspected by Graton,[5] who examined the deposit some 30 years ago. He mentions the quartz as "penetrated by numerous prismatic crystals, apparently of secondary origin, possibly topaz."

Massive Topaz

Physical and optical characteristics

A rock composed almost exclusively of very fine-grained topaz forms a considerable part of the lode northwest of the Brewer pit. Its exposures in place occupy an area about 25 feet wide and 50 feet or more long, but a greater extent of the body is indicated by the distribution of "float" on the slope above the outcrop. Loose fragments about the size of half a brick, some of them waterworn, are abundant in the waste heaps of placer pits along the slope below. In general appearance the topaz resembles the undecomposed quartz rock of the lode. In fact the two look so much alike that in a cursory examination they are not likely to be distinguished from one another unless the relatively high gravity (3.5) of the topaz aggregate should be noticed. Some specimens show the pattern of a breccia and others are marked with wavy lines or bands representing structures of a rock that the topaz has replaced. Contact relations of the two indicate that the topaz is later than the quartz rock.

The topaz mass is not described as such in previous reports of the Brewer Mine. Apparently it has been classified heretofore along with the siliceous body as "flinty quartz." Its texture is very similar to that of flint or chert. It has a waxy luster, and its hardness is about 7, less than for normal topaz. It breaks with a conchoidal fracture and separates along joints into rather small smooth-faced blocks, some of which have forms suggesting pyramids and wedges. The color of these blocks of topaz is gray, mottled or streaked with white cloud-like bands in a dull gray sub-translucent mass. Some of the weathered fragments show the red staining of iron oxide. Some fragments which are gray on the surface are deep carnelian red on the interior, the iron stain being hidden by a gray-white leached zone a few millimeters thick. The iron stain appears to be due to the oxidation of small inclusions of pyrite. As shown by

[5] Graton, L. C., Reconnaissance of some gold and tin deposits of the southern Appalachians: *U. S. Geol. Survey, Bull.* **293**, pp. 90, 91, 1906.

the chemical analysis, the actual amount of iron present is small. A sample yielded .01 ounce of gold per ton by assay.

Thin sections show that the exceedingly fine grains of the massive topaz vary slightly in size among themselves. They are only a few microns in diameter and closely resemble the granules in a very fine-grained chert. The granules are arranged throughout the mass in irregular alternating bands of coarser and finer texture, thus giving a streaked appearance to the surface pattern of the groundmass. In transmitted light the thin section surface shows a stippled or shagreen effect, again in this way resembling chert.

On account of its fine-grained character only the mean index of refraction could be determined on the massive topaz, this is $n=1.631$, which corresponds to β in the crystals of the more coarsely granular variety associated with it, and thus indicates the same chemical composition.

Chemical Analysis

For the determination of silica and fluorine a sample weighing 0.2141 g. was fused with 5 g. sodium carbonate and the resulting cake thoroughly leached with water. The residue was ignited at a low heat, again fused with 5 g. sodium carbonate, the cake leached with water, and the second extract added to the first.

From the combined filtrates, which contained all of the fluorine, silica was removed by two precipitations with zinc oxide, as recommended by Hoffman and Lundell.[6] The residue, left after leaching the sodium carbonate cake with water, and the zinc precipitates were combined for the determination of silica by dehydration in the usual way.

The extracted fluorine was determined nephelometrically.[7] The solution, free from silica, was made just acid to methyl red and diluted to 200 ml. in a volumetric flask, giving a sodium chloride concentration of 55 grams per liter. From a 25 ml. aliquot calcium fluoride was precipitated as a colloid by reducing the solubility with alcohol and stabilizing the suspension with gelatin. At the same time 25 ml. of a standard sodium fluoride solution (0.2000 g. NaF and 55 g. NaCl per liter) was precipitated colloidally in the same way and the two opalescent solutions compared in a nephelometer to give a preliminary reading. In accordance with this estimate the unknown solution was diluted to within 5 per cent of equality with the standard in fluoride concentration, adding sodium

[6] Hoffman, J. I., and Lundell, G. E. F., Determination of fluorine and of silica in glasses and enamels containing fluorine: *Bur. Standards Jour. Research*, vol. 3, p. 581, 1930.

[7] Stevens, R. E., Nephelometric determination of fluorine: *Ind. and Eng. Chem., Anal. Ed.*, vol. 8, p. 248, 1936.

chloride to keep its concentration 55 g. per liter. Aliquots of the new unknown solution and of the standard were then precipitated colloidally and compared in the nephelometer to give a final reading.

Water was determined by the Penfield method on a sample ground to an impalpable powder, using sodium tungstate as a flux, and heating intensely with a full blast. Alumina was determined in the usual way on a separate sample.

The analysis of the massive topaz is as follows:

SiO_2	33.00
Al_2O_3	56.76
Fe_2O_3	trace
H_2O-	0.04
H_2O+	2.67
F	13.23
	105.70
Minus O=F	5.57
	100.13

The analysis is confirmed by the low specific gravity and by the optical properties.

From a review of the literature, it appears that the Brewer material shows the lowest F content and the highest H_2O content of any topaz yet described.

Three determinations of the specific gravity of a lump of the massive topaz were made by the water immersion method, correcting the results for temperature. The average of these gave a specific gravity of 3.509 ± 0.001 referred to water at 25°C., or a density of 3.499.

This specific gravity is the lowest recorded for topaz, as far as the writers know, and it accords with the low fluorine and a high hydroxyl content.

Other Types of Topaz in the Brewer Mine

White granular topaz aggregate

In addition to the massive fine-grained topaz described, the Brewer lode contains disseminated fine grains and, in one place at least, an aggregate of coarser grains. Specimens from a boulder found in an old placer working (Tanyard pit) about 1,000 feet south of the Brewer pit, are aggregates of white granular topaz from which some other more soluble mineral or minerals have been dissolved. The mass has a sponge-like structure, some of the cavities being rounded, others angular. The aggregate consists of clear, clean, colorless grains, about .01 mm. to .5

mm. in diameter (the prismatic grains being slightly longer than wide), loosely held together merely by interlocking. Apparently all cementing materials have disappeared and the mass is friable enough to be crushed with the hands. A few spots of iron oxide suggest that probably pyrite at one time occupied at least some of the spaces. If the ore minerals were removed from a specimen photographed and described by Singewald and Milton[8] in their paper on "Greisen and associated mineralization at Silver Mine, Missouri," the remaining vesicular topaz mass would resemble the granular topaz aggregate from the Brewer Mine.

Optical properties

Generally the grains of the white granular aggregate show, in thin section, a rounded outline; only few give a feeble suggestion of euhedral form. A considerable number of the larger grains show a rounded or elongated nucleus of topaz of different orientation from the surrounding material. Commonly a basal section of such a nucleus gives a small optical axial angle which indicates that it, like the surrounding topaz, has a low-fluorine, high-water content. A few minute inclusions of some birefracting mineral with low index, probably quartz, are observed, but the gas or liquid bubble inclusions often seen in topaz are absent in the specimens examined. A very few specks of a dark yellow-brown, high-index mineral are also present. The amount of impurities, however, is trifling and the loose granular aggregate is essentially pure topaz.

The individual topaz grains are colorless and transparent, most of them are rounded, but some are slightly prismatic. Grains showing basal cleavage are numerous. Their optical axial angle, $+2V=45°$ to 48°, is unusually small for topaz. The dispersion is distinct, $r>v$. Indices of refraction measured in white light are found to be: $\alpha=1.629$, $\beta=1.631$, $\gamma=1.638$. $B=0.009$. The optical properties were determined with index liquids standardized at the temperature of the room at the time the measurements were made and are correct to ± 0.0005.

The small optical axial angle and high indices of refraction indicate the material to be of the same low fluorine (13.23%) and high water (2.67%) content as the massive topaz. (Constant relation between fluorine-water content and optical properties are discussed further on.)

Disseminated Topaz

In thin section under the microscope a specimen of the unweathered lode rock from the Brewer pit is found to contain a few small scattered

[8] Singewald, J. T., Jr., and Milton, Charles, Greisen and associated mineralization at Silver Mine, Missouri: *Econ. Geol.*, vol. **24**, no. 6, p. 574, September, 1929. (Fig. 4, p. 574.)

grains of topaz, otherwise it consists of quartz and pyrite, with a very insignificant amount of sericite. Optically the disseminated topaz is the same as the others already described.

The groundmass of the lode rock is composed chiefly of very small anhedral grains, but it includes aggregates of coarser grains of quartz. A few of these larger quartz grains contain rounded islands or nuclei of quartz, apparently remnants of pre-existing grains enlarged by the later addition of quartz. Pyrite is abundant as euhedral crystals ranging from dust-like specks to individuals 1.5 mm. in diameter. Sericite forms tiny flakes interstitial in the quartz aggregate. It may replace the topaz or quartz.

Some of the specimens from the zone of weathering consist only of quartz and sericite. Samples of sand taken from disintegrated rock in place on the south side of the Brewer pit showed a range in composition approximately as follows: No. 1, topaz 0, quartz 100 per cent; No. 2, topaz 5 per cent, quartz 95 per cent; No. 3, topaz 15 per cent, quartz 85 per cent. The boulder of white granular topaz already described is a friable mass of topaz grains almost entirely without quartz. The variation thus shown by the few samples that have been studied suggests that adequate sampling would reveal a complete gradation from pure quartz to pure topaz.

The uniformity in optical properties of topaz from different parts of the Brewer Mine signifies uniformity in chemical composition, which in turn suggests a common origin. The area seems to have been saturated by magmatic solutions which were rich in fluorine, silica, and sulphides, and deficient in alkalies.

Constant Relation Between the Fluorine-Water Content and the Optical and Physical Properties of Topaz

According to Penfield[9] the variation which topaz shows both in chemical composition and physical properties results from an isomorphous replacement of fluorine by hydroxyl. As the hydroxyl replaces fluorine the value for 2E(2V) decreases. This relation is so constant that the percentage of H_2O can be estimated from the value of 2E(2V). Likewise the indices of refraction show a progressive change along with the variation in 2E(2V). As the OH replaces F the indices of refraction increase and the strength of the double refraction decreases as shown by the following extremes recorded in the literature:

[9] Penfield, S. L., and Minor, J. C., Jr., On the chemical composition and related physical properties of topaz: *Am. Jour. Sci.*, 3d ser., vol. **47**, p. 387, 1894.

	Utah	Minas Geraes	Brewer
F	20.33	15.48	13.23
H_2O	0.19	2.45	2.67
2V	67°	49°	48°±
α	1.6070	1.6294	1.629
β	1.6100	1.6308	1.631
γ	1.6180	1.6375	1.638
B	.0110	.0081	.009 all ± .0005
G	3.565	3.532	3.509

Optical properties on a crystal of rose topaz from the Urals noted by Sabot[10] are: $+2V = 49°\ 22'$; $\alpha = 1.6293$, $\beta = 1.6308$, $\gamma = 1.6379$. No chemical analysis was made of this topaz crystal. The indices, when rounded off to three decimal places, agree exactly with the Brewer topaz.

Summary

Topaz of a fine-grained chert-like character forms a large part of the gold-bearing lode at the Brewer mine, Chesterfield County, South Carolina. The enormous amount of this massive topaz, together with its unusual fine-grained texture and its low-fluorine content, constitutes the most unique and the most noteworthy occurrence of such a deposit ever to be recorded.

The massive topaz has a fine-grained quartz-like appearance in hand specimen. Microscopically the texture closely resembles chert. The mean index of refraction is $n = 1.631$, which corresponds to the low fluorine and high water contents. The chemical analysis shows fluorine 13.23 per cent, the lowest fluorine content, and water 2.67 per cent, the highest water content on record.

Granular topaz aggregates found in the associated rocks furnish the best material for optical observations. The small, clean, euhedral grains give complete optical data that substantiates the chemical analysis. The $+2V$ angle $= 48°$; the indices of refraction are: $\alpha = 1.629$, $\beta = 1.631$, $\gamma = 1.638$. $B = 0.009$.

Uniformity of the optical data of the massive, granular, and disseminated topaz indicates uniformity of chemical composition and suggests a common origin. Previously existing rocks of the area apparently reacted with solutions rich in fluorine, silica, and sulphides, and deficient in alkalies, and became replaced by topaz and quartz, and small quantities of sulphides.

[10] Sabot, R. C., *Thèse* **519**, *U. Gèneve*, 1914; *Zeits. Krist.*, vol. **56**, p. 631, 1922.