RIEBECKITE IN QUARTZ VEINS FROM THE MICHIPICOTEN DISTRICT, ONTARIO

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ABSTRACT

A fibrous variety of riebeckite is described as occurring in quartz veins and in both granitic and basic volcanic wall rocks in the Michipicoten area, Ontario. It represents one of the last stages of hydrothermal alteration, replacing all other minerals present, but particularly quartz, greenish muscovite, epidote and carbonates. As gold in nearby veins is also described as one of the last minerals to be deposited in the veins the question is raised as to a genetic relationship existing between it and the riebeckite.

The occurrence of fibrous riebeckite in quartz veins and in adjacent wall rocks in the Michipicoten area, Ontario, is sufficiently rare to merit a brief description. Its development in the quartz and replacement of biotite and epidote in adjoining rocks throw additional light on the nature of the hydrothermal solutions accompanying vein formation.

Specimens of riebeckite in quartz vein matter with granitic wall rock attached were collected by Mr. O. A. Evans of Sault Ste. Marie in 1933, from the vicinity of the Parkhill and Minto Gold Mines and were forwarded to the writer for identification. A. G. Darling studied the mineral for a bachelor's thesis. Dr. E. L. Bruce kindly made a spectrographic analysis of the mineral.

PREVIOUS WORK IN MICHIPICOTEN AREA

The general geology of the Michipicoten area is described by T. L. Gledhill.[1] M. H. Frohberg[2] has written in detail regarding the quartz-tourmaline, gold-bearing veins of the same district, and discusses the metamorphism attending their introduction, but no mention is made by either of the above authors of riebeckite as a constituent of the veins or containing rocks. Its occurrence even in this area would appear, therefore, to be rare.

Gledhill relates the quartz veins to an Algoman series grading from diorite to granodiorite and quartz porphyry, which intrude schistose, basic, Keewatin lavas. The veins are classified as fissure fillings varying somewhat in their mineral content. They follow the contacts between intrusives and lavas but also cut across both. Gledhill infers a two-stage mineralization, the first characterized by introduction of quartz, sulphides including chalcopyrite, pyrrhotite, pyrite, galena, sphalerite, and

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[1] Gledhill, T. L., Michipicoten gold area, District of Algoma: *Ann. Rept. Ont. Dept. Mines*, vol. **36**, Pt. II, 1927.

[2] Frohberg, M. H., Beiträge zur Kenntnis der turmalin führenden-gold-quarz gänge des Michipicoten-Distriktes, Ontario: *Min., petrogr. Mitt.*, **44**(5), pp. 349–409.

arsenopyrite, and probably some gold, solutions accompanying which are believed to have produced various wall rock alterations, the second consisting chiefly of the introduction of gold along fractures in the earlier sulphides.

PROPERTIES OF MICHIPICOTEN RIEBECKITE

Physical. It occurs in botryoidal, reniform and globular aggregates composed of columnar, radiating, or felt-like masses of fibers, .01 mm. in diameter or less. Lacks asbestiform habit.

Optical. $N_g = 1.699$
$N_m = \ ?$
$N_p = 1.693$
$2V =$ large
Sign: +, as obtained from parallel groups of fibers, angle of rotation of bisectrix figure over 30°.
Color: dark blue, pleochroic with absorption, X much stronger than Y and Z
$X =$ deep blue in thick aggregates, light greenish blue in thin fibers.
$Y =$ light yellowish green.
$Z =$ deep blue, thick; gray, thin.
Interference color: ultra or Berlin blue.
$X \wedge c = 0° - 5°$
Dispersion: strong.

Extinction angles measured with fibers in position of least absorption give the following:

$$\begin{aligned} X \wedge c &= (600\ \mu\mu)\ 5\tfrac{1}{2}° \\ &= (589\ \mu\mu)\ 7° \\ &= (550\ \mu\mu)\ 9° \end{aligned}$$

Chemical. A spectrographic analysis of the mineral shows the presence chiefly of iron, silicon and sodium. For comparative purposes plates were made of asbestiform South African crocidolite and the Michipicoten mineral; identical spectra were obtained. Two samples of the Michipicoten mineral were analyzed by A. G. Darling for sodium according to the method recommended in Fales "Inorganic Quantitative Analysis." The average sodium obtained in the two 0.1 gram samples was 4.80 per cent ($Na_2O = 6.47\%$). This compares well with the calculated 4.92% sodium, using Winchell's formula for riebeckite as $H_2Na_2Fe_5Si_8O_{24}$, and also with analyses of South African and other crocidolites given in Dana's "System of Mineralogy"[3] as ranging from 5.69 to 7.71 per cent Na_2O. It is somewhat lower in soda than analyses of riebeckite which vary from 8.33 to 8.79 per cent Na_2O.

Alteration. Where oxidized the mineral turns brown and the birefringence increases considerably.

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[3] Dana's *System of Mineralogy*, p. 400.

IDENTIFICATION

On the basis of extinction angles, sign, and chemical similarity to crocidolite, the Michipicoten mineral is classified as a variety of riebeckite. Unfortunately no analyses of ferrous and ferric iron are available at present to further distinguish it from arfvedsonite.

Though possessing a fibrous habit and probable positive sign the mineral is not here classified as the variety crocidolite because of lack of asbestiform habit.

OCCURRENCE

In the Michipicotin area, deep blue riebeckite is found in a few quartz veins and in both granitic intrusives and basic Keewatin volcanics near the veins.

Occurrence in Veins

Within the veins it is confined to areas near the walls, filling or partly filling vugs and following fractures in greasy, gray quartz in irregular seams up to $\frac{1}{4}$ inch in width. In one specimen fine pyrite is associated with the riebeckite.

In thin section the riebeckite occurs chiefly as small globular bodies .05 to .5 mm. in diameter, irregularly replacing the quartz, and from the globules fine fibers project outward. One section shows the riebeckite filling fractures in broken pyrite grains, so it is definitely later in age than both quartz and pyrite.

The globular forms assumed by the riebeckite suggest a gel origin with subsequent crystallization.

Occurrence in Wall Rocks

Wall rocks containing the riebeckite which have been examined microscopically consist only of a granitic type and of a carbonate-brown biotite alteration zone.

In the former, medium grained feldspars consist now of albite, probably secondary after oligoclase. Quartz, biotite, and apatite are the other primary minerals. Secondary flakes of a greenish muscovite, clinozoisite and epidote replace the feldspars, quartz, and biotite, as also does riebeckite. The latter is developed particularly in aggregates of the light green mica and epidote, and definitely cuts both biotite and epidote. Replacement of the green muscovite is clear, and probably also of epidote. This appears in both cases to be gradual, the minerals becoming more strongly pleochroic in yellow and greenish blue but retaining a relatively high birefringence. Where the replacement is more complete the pleochroism becomes that of riebeckite and interference colors are gradually lowered to an ultra blue.

In the carbonate-biotite alteration product riebeckite is again found replacing greenish muscovite, transecting flakes of brown biotite, and replacing the carbonates, particularly along cleavages. It would appear, therefore, that the riebeckite is one of the latest minerals to develop in both the veins and wall rocks.

Hydrothermal Alterations Associated with Michipicoten Veins

The hydrothermal metamorphism of the wall rocks of the gold-bearing quartz veins of the Michipicoten area according to Gledhill[4] consists of two types. The more basic rocks (lavas) show the development near the veins and lamprophyre dykes of biotite and a "bluish green chlorite" (*riebeckite?*). The granodiorite intrusive at the Minto mine is altered near the veins to biotite, carbonates, sericite and quartz. Tourmaline is developed both in vugs in the quartz and in sheared walls. Analyses presented show a relative introduction of silica, alumina, potash and carbon dioxide, and a loss particularly of soda and lime.

Frohberg[5] on the other hand classifies the metamorphism as progressive and denoted by three important stages. The earliest alteration is the development of albite and biotite, the former particularly in plagioclase rich rocks. Tourmaline is a common associate, also clinozoisite, and arsenopyrite is noted as the chief early sulphide. Chemically this stage involves an addition of soda, alumina, and magnesia, and a loss of potash, lime, and silica. Second is the alteration of biotite to chlorite, the serpentinization of epidote, and the introduction of minor carbonates. The last stage is marked by the formation of sericite and carbonates in albite, chorite, biotite, and serpentine. Chemically as shown previously by Gledhill, soda is lost together with lime in this stage and potash is gained relatively. A still later development of carbonates locally replaces sericite, tourmaline and many sulphides.

While the present study has been limited by the few specimens available, it has been sufficient to indicate essential agreement with the successive stages of hydrothermal alteration outlined by Frohberg, but to his list there remains to be added the final development of riebeckite which is distinctly later than pyrite, biotite, epidote, muscovite and carbonates. Chemically its formation has involved essentially a second introduction of soda. In the pseudomorphous replacement of muscovite, which is most common, soda would presumably displace the potash, and iron, the alumina. A somewhat similar conversion of epidote to riebeckite is suggested in thin sections but because of the fine size of the

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[4] *Op. cit.*, p. 23.

[5] *Op. cit.*

former its identity is not certain. Such a change might involve the substitution of soda for lime, though no sodium bearing epidotes appear to have been described.

Since Gledhill[6] has called attention to the fact that some of the gold of the veins has been introduced "by alkaline solutions . . . after the sulphides were fractured," that is, as one of the last minerals, the question may logically be raised as to whether or not these final auriferous solutions were rich in soda, and as well as precipitating gold gave rise to the formation of riebeckite. In this connection attention may be called to Freeman's[7] suggestions that sulphides of many of the metals may be transported in part as double sodium sulphides which break down to colloidal sulphides (or free gold where it is present) in contact with water. While the sodium in solutions resulting from such decomposition might be completely removed in many cases because of its great solubility, the formation of sodium-rich minerals such as riebeckite might be a logical result in others. The globular form of the riebeckite would be in keeping with such an hypothesis, suggesting as it does an original colloidal origin.

[6] *Op. cit.*, p. 29.

[7] Freeman, Horace, *Eng. Min. Journ. Press*, Dec. 19, 1925.