

NOTES AND NEWS

CORUNDUM IN A DIKE AT GLEN RIDDLE, PENNSYLVANIA

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GENESIS OF CORUNDUM

The genesis of corundum is such an interesting problem that it has intrigued mineralogists of all times. A lengthy literature concerning the mineral has accumulated but the conclusions reached as to its genesis have varied widely. With such diverse opinions expressed it is necessary to proceed slowly in accepting a viewpoint, as the mineral may be formed perhaps in several different ways.

Morocowicz showed that corundum can be crystallized from magmas containing an excess of alumina, according to a definite law, but the laboratory experiments are not similar to the conditions under which corundum is formed in nature. It has been shown that corundum may be formed as a secondary mineral in corrosion rims, but this type of genesis is applicable to only a very small number of unimportant deposits.

In dealing with the Canadian and Indian occurrences, the geologists state that all these deposits of workable size are primary crystallizations from high-alumina magmas, in accordance with Morocowicz's law, but in describing these deposits they state that all workable concentrations occur in pegmatites. Their description would seem to contradict their statement as to origin. Since corundum is known to be the first mineral to separate from high-alumina magmas on cooling, it could hardly be concentrated in the pegmatites derived from these magmas.

The writer has recently been impressed by the evidence that corundum is not a primary pyrogenic mineral, but that it has developed through volatile reactions at a high temperature, *i.e.*, at the highest temperature at which volatiles can be expelled from the magma. The pyrogenic mineral involved in these reactions, the writer believes to be anorthite, the calcic end member of the plagioclase series. This feldspar containing 36.7% alumina is generally abundant in corundum-bearing formations. Where the corundum develops in these formations, the anorthite (or plagioclase containing the anorthite molecule) usually shows the effects of an attack by volatile constituents.

Two reactions by which corundum is formed from anorthite have been described in the literature: one, the so-called "corrosion rim" reaction between anorthite and hypersthene by which actinolite and corundum are developed; the other, a reaction between anorthite and olivine with the formation of hornblende and corundum. Since both reactions start with pyrogenic (water-free) minerals and develop a mineral (actinolite

or hornblende) containing hydroxyl, both reactions must result from an attack by volatiles at sub-magma temperatures.

A third reaction involving anorthite, by which the writer believes corundum may be developed, is the reaction by which antiperthites are formed. This process appears to have operated extensively where corundum deposits occur in high plagioclase or alkaline rocks. In this reaction a feldspar of the potash-barium type, relatively low in alumina and high in silica, replaces a feldspar of the lime-soda series, relatively high in alumina and low in silica. The reaction requires potash in alkaline solution, and possibly also barium, and is therefore confined to alkaline rocks or to rocks invaded by alkaline solutions. As a result of the replacement, one half of the alumina in the anorthite will be set free. The writer believes that this alumina is available for the development of corundum under certain physical conditions, and with proper chemical environment. The solutions remaining after this reaction are still alkaline but carry soda and lime, instead of potash and barium. These alkaline solutions could transport this free alumina short distances before precipitation, hence the large corundum crystals in the alkaline pegmatites.

As a possible illustration of this principle we offer a description of the corundum occurring in a dike at Glen Riddle, Pa., which the writer has recently studied jointly with Mr. A. E. Meier.

DESCRIPTION OF CORUNDUM BEARING DIKE AT GLEN RIDDLE, PA.

The dike at Glen Riddle carrying corundum is a narrow plagioclase dike of gabbroid composition cutting serpentinized pyroxenite. Along the border zones of the dike the plagioclase carries from 30% to 50% anorthite. Toward the centre of the dike the plagioclase changes to a sodic oligoclase. This dike shows numerous crushed zones paralleling the walls. These have been invaded by volatiles which we believe had a granitic origin. We have found feldspars similar to the feldspars of these zones in another dike nearby which is unmistakably granitic. All formations in this district have been extensively invaded by volatiles of granitic origin. There is no other igneous body in the district from which these volatiles could have originated.

These volatiles have reacted with the plagioclases of the dike to form potash-barium feldspars, hyalophane, and antiperthites consisting of a plagioclase host invaded by a potash-barium feldspar. A fuller description of the dike and its field relations will be given in a paper by Mr. Meier.

The corundum is found in the crushed zones with hyalophane, and only in these zones where they cut the calcic feldspar along the border of the dike. Where the crushed zones cut the sodic plagioclase we find

hyalophane, but no corundum associated with it. We do not know how this feldspar replacement is accomplished, but consider it a substitution of potash and barium for the soda and lime of the original plagioclase, under alkaline conditions. What role the barium may play in the reaction chemically, we do not know. We note that Pratt and Lewis in describing a similar dike at Buck Creek, N. C., mention barium minerals with the corundum. The percentage of barium in antiperthites at corundum localities, as far as we know, has not been investigated.

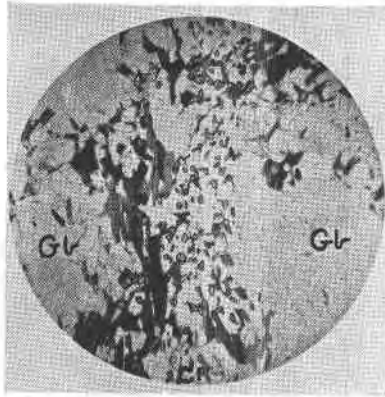


FIG. 1. Crushed zone containing corundum. "Cr," fine-grained hyalophane and corundum; "Gb," coarse-grained gabbroid minerals, chiefly plagioclases of dike. $\times 8.1$ nicol.

The corundum at Glen Riddle is interpreted as representing the excess alumina of the labradorite over the alumina content of hyalophane. The most anorthitic lime-soda feldspar found in the dike is a 50% labradorite containing 28.2% alumina, the most celsic potash-lime feldspar is a 16% hyalophane with 19.5 alumina. The difference in alumina, 7.7%, is approximately the percentage of corundum associated with the hyalophane in the crushed zones. It is not possible to give exact percentages as there is a continuous variation in composition both in the plagioclase and in the hyalophane. There is also a variation in the percentage of corundum at different points along the crushed zones, but this we believe can be explained by transportation of the alumina set free in the alkaline solutions before precipitation. We can say that the average percentage of corundum in these crushed zones is of the same order as the percentage of alumina that would be freed if the reaction took place as indicated, namely, approximately 7.7%. The formation of corundum at Glen Riddle, as here interpreted, is shown in the accompanying photomicrographs.

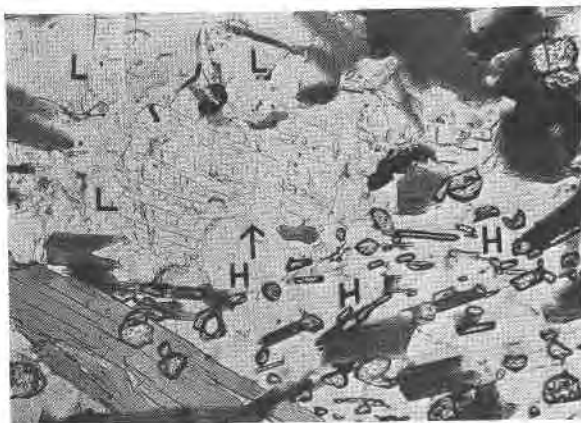


FIG. 2. Development of corundum from plagioclase. Section taken at border of crushed zone. "L," labradorite of dike with about 28.2% alumina; "H," hyalophane with approx. 19.5% alumina. Arrow points to antiperthite showing attack on plagioclase grain with embayment and penetration by hyalophane. $\times 75$. 1 nicol.

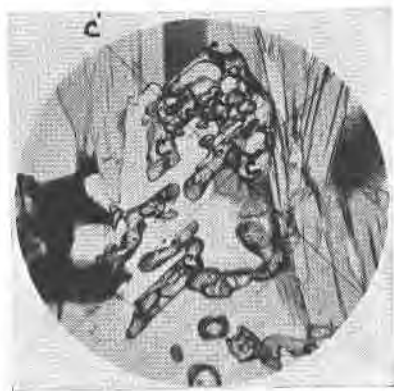


FIG. 3. Crystal grain of corundum assumed to have been formed from alumina freed by attack on plagioclase. All corundum grains, "C," behave as one crystallographic unit. White inclusions, hyalophane with various orientations. Cross-hair *C*' parallel to vertical axis of corundum. $\times 130$. 1 nicol.

SUMMARY OF DATA

This view is supported by the following:

1. The general association of corundum with alkaline rocks which could furnish the volatiles necessary for the liberation and transportation of hydrated alumina.

2. Types of formations in which corundum is concentrated—pegmatites and veins in high-alumina rocks, banded rocks, narrow plagioclase dikes, contacts, sediments near contacts. In all cases these formations are cut by channels through which volatiles may pass.

3. Abundant presence of anorthite molecule or a plagioclase at all corundum localities and evidence of volatile activity at these localities. The alumina content of anorthite is so high that any reaction involving the mineral would be likely to free some alumina. Anorthite is readily attacked by volatiles.

4. Presence of antiperthites in corundum-bearing plagioclase rocks. Corundum usually increases as these increase and disappears when these are absent.

5. Presence of zones or veins of lime or lime-soda minerals containing hydroxyl at many corundum localities.

6. The large size of corundum crystals in pegmatitic dikes.

7. Movement of alumina in nature suggests dissemination in magma and concentration by volatile activity.

8. Many natural crystals of corundum contain water inclusions.

9. Analyses of natural corundum show a variable ignition loss.

10. Parallel development of corundum and hematite in emery.

11. Frequent occurrence of corundum crystals partially replaced by muscovite, or similar secondary minerals. Corundum that has crystallized from a melt as a primary crystallization product is chemically inert and resists all attack by either acids or bases. It seems improbable that corundum so formed could be altered by any natural process. Alumina set free through volatile attack is chemically active and will combine with either acids or bases. Corundum crystals thus formed might retain some chemically active alumina (hydrated alumina) to respond to natural agencies yielding crystals partially replaced by muscovite or other similar minerals. No one has been able to prove as yet that corundum crystals can be developed from hydrated alumina, but laboratory experiments have shown that this alumina changes to corundum at 800°C., and the opinion has been expressed that this change might occur in nature at a lower temperature if given a longer period of time than is possible in laboratory experiments.

CONCLUSION

It has been the object of this paper to call attention to the possible formation of corundum deposits by high-temperature volatile reactions on calcic plagioclases.