CONTEMPORANEOUS CRYSTALLIZATION OF BERYL AND ALBITE VS. REPLACEMENT

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In many mineral deposits containing the platy variety of albite, one commonly finds beryl and albite in close genetic relationship which, during the past two decades, has been explained by some students of mineral genesis in pegmatites as due to replacement of the beryl by albite, or by the replacement of the albite by beryl.[1] The later mineral, in either case, being introduced in late hydrothermal or pneumatolytic solutions.

During the past five years I have collected specimens of these two intergrown minerals from the Golding-Keene mine, three miles north of Gilsum, New Hampshire, and the Strickland mine on Collins Hill, four miles northeast from Middletown, Connecticut. The beryl-albite intergrowths from these widely separated mineral deposits are excellent examples and are characteristic of this type of occurrence. These intergrowths also possess characters which, without doubt, show the associated minerals to be of essentially contemporaneous origin instead of either one replacing the other.

The beryl crystals containing the intergrown albite are invariably tapered, Fig. 1, and have angles between the opposite prism faces up to 30°. They vary in color from translucent yellow and white to an aquamarine bluish-green at the small end where the material is sometimes

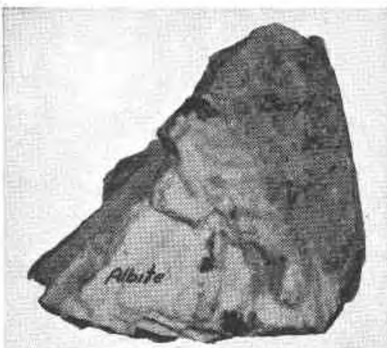

Fig. 1. Tapered crystal of the beryl-albite intergrowth; at the larger end cleavelandite is shown growing *away* from the intergrowth. $X=0.28$. Specimen from the Strickland mine.

[1] Hess, F. L., Pegmatites, *Econ. Geol.*, vol. **28**, pp. 447–462. 1923.
Hess, F. L., The pegmatites of the Western States in the Lindgren volume, Ore deposits of the Western States, *A.I.M.E.*, New York, **1934.**
Anderson, A. L., Genesis of the mica deposits of Latah County, Idaho: *Econ. Geol.*, vol. **28**, pp. 41–58, 1933.
Megathlin, G. R., The pegmatites of the Gilsum area, New Hampshire: *Econ. Geol.*, vol. **24**, pp. 163–181, 1929.

clear and transparent but badly fractured. The faces of these crystals, while not rough, lack the high polish frequently found on beryl and show the effects of interference from contemporaneous minerals then crystallizing from the same solution.

At the base or larger end of these tapered crystals where the beryl and albite are most intricately intergrown, the percentage of albite is always the higher. As the growth of the crystal proceeds outward at this end the amount of beryl rapidly diminishes and finally disappears leaving the albite to continue its growth. The large end of these crystals may at times consist of a hexagonal shell of beryl surrounding a "core" of fine-grained albite. Close, parallel sections show that the albite soon occurs as an intergrowth as illustrated in Fig. 2. The beryl at the large ends consists of plate or blade-like masses usually having their sides parallel to the first or second order prisms. In addition other forms as pyramids and pinacoid were noted. The luster of these is of the same quality as that of the external faces of the crystals.

FIG. 2. Section perpendicular to the c axis of a tapered beryl-albite crystal from the Golding-Keene mine. Albite (Ab), Beryl (Be). $X=1.4$. (Dotted line shows the outline of the section.)

The intergrowths break apart very readily and expose many contacts between the beryl and albite which show clearly that the latter was moulded around the beryl.

Within the crystal the albite is usually irregularly arranged and is often close to one side instead of being centrally located. It may continue in this position until the beryl occupies the entire area near the smaller end.

A number of pieces of this intergrowth found on the dumps were massive and without any indication of possessing an external outline. The beryl plates in these are often distorted but show clearly that they are often bounded by crystal forms, usually the prisms. Such intergrowths may represent the larger ends of large crystals, however, the top parts of crystals corresponding in size were not observed. It is believed, therefore, that these specimens may represent intergrowths of such a nature that the growth of the beryl was so completely disorganized by the simultaneous growth of the albite that it could not coalesce sufficiently to develop even the rough irregular skeleton crystals.

While the many parts and projections of the beryl contributing to the make-up of these irregular masses and tapered crystals are usually in parallel growth and probably connected, this is not always the case for small beryl crystals were observed that stood at an appreciable angle to the adjoining beryl. The small crystals were not tapered and had not reached the stage of development where the albite caused serious morphological interference with their growth.

The intergrowths are frequently associated with an adjoining graphic structure consisting of albite and a faint smoky variety of quartz. The surrounding albite may be of medium-grain or of the bladed variety, cleavelandite, which radiates from the beryl-albite intergrowths or other minerals preceding it from the same magma fraction. This radial habit of cleavelandite is often very important in establishing its relationship to the surrounding minerals—a feature that seems to have been overlooked or ignored by the advocates of the replacement hypothesis.

The minerals associated with the beryl-albite intergrowths are chiefly quartz, tourmaline, muscovite, apatite and garnet. These in every respect appear to be similar to those in the adjacent albite. There seems to be no particular reason why these minerals should not be the same within and outside of the beryl-albite whether they represent a replacement pair or are of contemporaneous origin. Hence they have no important diagnostic value.

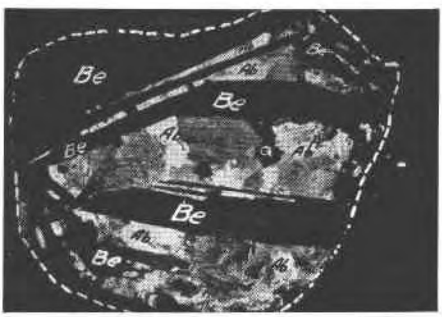

FIG. 3. Section parallel to and $\frac{1}{2}$ inch from that of Fig. 2 and shows the quick change in structure. Beryl (Be), Albite (Ab), Quartz (Q). $X=1.5$.

Microscopic examination shows that the albite within the beryl is comparatively fine to medium-grained and is not cross-cut by the narrow plates or blades of beryl as one would certainly find of frequent occurrence if the beryl replaced the albite, especially under the conditions illustrated in Figs. 2 and 3, where the blades of beryl are much narrower than the average width of the albite grains. At the extremities of these blades one occasionally finds grains of albite *growing around* the edge of the blade. This position of the beryl apparently "working into" the albite may lead one to conclude that the beryl replaces the latter, but such a conclusion based on this relationship must be erroneous for with *very few* exceptions the albite grains are not cross-cut by the beryl. The few exceptions that were noted undoubtedly represent sections cut close to an end or irregular edge of the beryl. A section along the line X−X′ in Fig. 4 would show a cross-cutting relationship, however, below this extreme end no other section would show this feature. Hence, the very infrequent occurrence of cross-cutting mitigates against a hypothesis postulating the replacement of the albite by the beryl. Instead, it shows that occasionally an albite grain *grew around* the edge of the beryl when the growth of the latter was arrested.

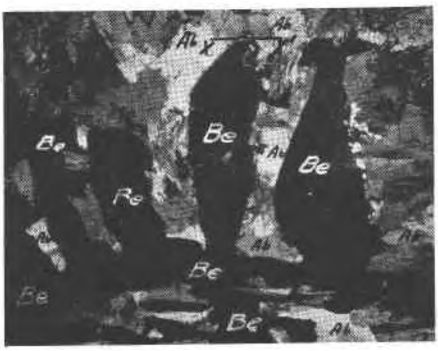

FIG. 4. Section parallel to the *c* axis and from the same crystal as Figs. 2 and 3. It shows the quick change in structure along the *c* axis. Beryl (Be), Albite (Ab). $X=2.64$.

The very long straight and sharp contacts between the beryl and albite as shown in Figs. 2 and 3 are especially noteworthy. Contacts of this kind are not favorable criteria of replacement. When they occur with other features adverse to replacement hypotheses they cannot be called exceptions to the rule of replacement. Sharp, linear contacts are very common between contemporaneous minerals when one of them possesses a strong tendency to form euhedral crystals. In these figures the blades are usually parallel to either the first or second order prisms.

The occurrence and relationship of these intergrowths seem to possess many features incompatible with any reasonable replacement hypothesis and one may raise the following questions concerning the replacement of the albite by the beryl or vice versa:

1. If the beryl was introduced in later solutions—
   (*a*) Why should it develop these unusual ramifications in this comparatively uniform material (albite with minor accessories) when it possesses a very strong habit of forming well-shaped euhedral crystals?
   (*b*) Why should the resulting crystals be so different at the opposite ends when beryl is a holohedral mineral?
   (*c*) Why do not the slender beryl blades consistently cut across the larger albite grains?
2. If the albite replaces the beryl—
   (*a*) Why does it replace one end of the crystal externally and the other end internally in order to develop tapered crystals with a core or irregular intergrowth of beryl and albite at the one end and be usually free from albite at the other?
   (*b*) Why does not the cleavelandite grow *into* the beryl instead of *away* from it as shown in Fig. 1?
   (*c*) Why should the albite follow directions parallel to the prism faces when the mineral does not have a cleavage or other structure that would influence replacement in these directions?
   (*d*) If the blade-like parts of the beryl are residua of replacement they would show rough pitted solution surfaces instead of being comparatively smooth and having a luster of the same quality as the external prism faces.

There appears, therefore, too many inconsistencies for one to accept a replacement hypothesis to account for the origin of this intergrowth of beryl and albite, that is, for either a replacement of the albite by the beryl or the replacement of the beryl by albite.

A contemporaneous origin for these two minerals is one which will permit a logical explanation for the various occurrences and characters shown by the specimens developed in these mines, and no doubt will explain the origin of those from other localities. Intergrowths of this kind are common among other pairs of minerals and, prior to the wave of replacement hypotheses during the past few decades, have been considered as originating from the crystallization of a magma fraction consisting essentially of the constituents involved in the intergrowths. In this instance the intergrowths may readily develop from a magma fraction rich in albite and beryl and produced as a late fraction of the original pegmatite magma. A progressively contemporaneous crystallization of these two minerals may readily develop skeletonized beryl crystals which were simultaneously filled in by albite and the accessory minerals of this pegmatite magma fraction. The stronger crystal forming habit of beryl apparently gave this mineral the ability to control the structure and no doubt it slightly preceded the albite which offered an interference of such a nature that they together developed the tapered beryl-albite crystals and also the irregular intergrown masses of these minerals without any external form. In order for the massive intergrowths to develop both the beryl and albite must, of course, reach the point of crystallization at approximately the same time and the rate of crystallization of both must be sufficiently balanced in all directions until the beryl is exhausted or until its solution and solid phases are isolated by the vastly more abundant albite surrounding the latter. Under other, yet very similar, conditions and probably nearby, the intergrowth from its inception was irregular and unbalanced, thereby offering relatively greater advantages for one or the other of the crystallizing substances to predominate in its development in some particular direction depending upon the physico-chemical conditions present. The much larger quantity of albite always present in these solutions caused the direction favoring this mineral to expand while at the same time in the opposite direction, as the beryl is gradually excluding the albite and becoming lower in concentration, the intergrowth develops a reduced cross-sectional area. This reduction of area may be somewhat influenced by the external crowding of the albite. Since the tapered end of the beryl crystal is always clearer and often of gem variety, it indicates that this part must have developed more leisurely when the concentration and supersaturation of the beryl was very low.

Under nearly similar physico-chemical conditions the beryl may reach an advanced stage of crystallization before the albite became supersaturated sufficiently for it to crystallize, and consequently the beryl will develop euhedral crystals unless adjoining substances should interfere. The albite (cleavelandite) being the next to crystallize would attach itself to the exposed parts of the beryl and develop a crust. The cleavelandite may be followed by quartz which is frequently the last mineral to crystallize in quantity. It appears to the writer that the material represented in Hess' Fig. 6[2] belongs in this category and does not indicate a series of replacements as he described.

[2] Hess, F. L., The natural history of pegmatites: *Eng. & Min. Jour. Press*, vol. **120**, pp. 289–298, 1925.

Summary

The beryl-albite intergrowths occurring at the Golding-Keene and the Strickland feldspar mines are shown to be of such a nature that an origin through the processes of replacement is most unlikely, while on the other hand their relationship and other features clearly indicates a contemporaneous crystallization.