THE MINERALOGICAL MAGAZINE

AND

JOURNAL OF

THE MINERALOGICAL SOCIETY

No. 170 September, 1940 Vol. XXV

Note on an occurrence of bertrandite and beryl at the South Crofty mine, Cornwall.[1]

(With Plate XXV.)

By James Phemister, M.A., D.Sc.

Petrographer, Geological Survey and Museum, London.

[Read March 7, 1940.]

AMONG a series of specimens collected by Mr. H. G. Dines from the South Crofty mine, Illogan, one was found to contain bertrandite and beryl. The specimen was obtained from the back of the 290-fathom level, east of Robinson's shaft, in the no. 1 lode, which hades north and at this position is 3 feet 10 inches wide. The location of the specimen was about 9 inches from the granite footwall. In hand-specimen the rock is a normal stanniferous veinstone composed of massive quartz tinted grey-green by disseminated chlorite and tourmaline and traversed by stripes of blackish 'peach' and white vein quartz which run parallel to the lode walls. Microscopically it is composed essentially of quartz, chlorite, and tourmaline, with subordinate orthoclase, fluorspar, and cassiterite, accessory apatite, and local bertrandite and beryl. In its texture there is evidence of an early formation of stanniferous chlorite-tourmaline peach with quartz-fluorspar gangue, which was subsequently fractured and, later, more or less completely healed by an accession of quartz, some redistribution of the earlier minerals having taken place at the same time. The place of bertrandite and beryl in this general scheme is discussed below (p. 576).

Bertrandite.—This mineral is most abundant in a narrow vein-like aggregate of chlorite (daphnite) which with tourmaline forms one of the dark stripes in the veinstone. With chlorite, and sometimes quartz

[1] Communicated by permission of the Director, Geological Survey and Museum.

also, it occurs both as pseudomorphs after idiomorphic beryl (pl. xxv, figs. 2 and 3) and as shapeless clots more or less dispersed by late quartz of the veinstone. Its distribution, even in the dispersed mode of occurrence, is very restricted, since it has been found within a width of only 6 mm. of rock across the striping and seems also to disappear in a direction parallel to the stripe.

When embedded in chlorite, it habitually forms anhedral grains which often are grouped into composite grains up to 0·4 mm. across. Against quartz good crystal faces are developed and a few good prisms completely surrounded by quartz have been observed, the largest being 0·2 mm. in length. The bertrandite often encloses small flakes of chlorite and the two minerals clearly belong to one period of formation. It is recognized in thin section as an unusual mineral by its moderate refractive index combined with medium birefringence, biaxial negative character, and large optic axial angle. These characters, together with at least two good cleavages and trisector twinning with twinning axis parallel to the acute bisectrix, complete the qualitative diagnosis as bertrandite. The mineral was present in insufficient quantity for recognition in test crushed samples and the refractive indices were therefore determined on an uncovered thin section, the values being α 1·591, β 1·604 or 1·605, γ 1·614. By use of the Berek compensator the birefringence was determined as $\gamma-\alpha$ 0·025. Measurements of the optic axial angle by universal stage methods yielded values of 2V ranging from 71° to 76° for different grains. Three values of 2V, 71°, 72°, and 73½°, were obtained from a trisector twin which showed the emergence of an acute bisectrix from each sector (fig. 1). The measurements on this twinned crystal showed, as should be true for bertrandite, that the twinning axis coincides with the α-axis of optical symmetry and that the angle between corresponding β and γ axes in the twins is close to 60°. In the zone of the α-axis cleavages corresponding to (010) and (001) and faces corresponding to (011) and (031), on the assumption that α is the crystallographic *a*-axis, were observed in various grains.

Optical constants and such crystallographic relations as could be determined thus affirm the identity of the mineral as bertrandite. The values of the refractive indices are practically the same as those obtained by T. Vogt,[1] and somewhat higher than those given by H. L. Bowman,[2]

[1] T. Vogt, Bertrandit von Iveland im südlichen Norwegen. Zeits. Kryst. Min., 1911, vol. 50, pp. 6–13.

[2] H. L. Bowman, On the occurrence of bertrandite at the Cheesewring quarry, near Liskeard, Cornwall. Min. Mag., 1911, vol. 16, pp. 47–50.

for bertrandite from Iveland, Norway, and from the Cheesewring quarry, Cornwall, respectively.

Bertrandite, a hydrated silicate of beryllium, is a rare mineral, but is found at several localities[1] in Cornwall in addition to the Cheesewring quarry. At all of these, as at all other localities reported hitherto, it occurs in granite or pegmatite as small crystals on joint-planes or in cavities, and the occurrence under description is the first, so far as the writer has been able to discover, in which the containing rock is not granite, and in which the mineral has been recognized only under the microscope.

Beryl occurs in the same rock as the bertrandite described above, and while more abundant and more evenly distributed where it is present, it also is restricted to the neighbourhood of the dark stripe which contains the bertrandite. All the beryl occurs embedded in quartz and has a variety of habit. It may form single idiomorphic prisms, fresh except for a little chloritization along cracks and, more rarely, formation of bertrandite in cracks (pl. xxv, figs. 4 and 6). These prisms reach 0·5 mm. across. More frequently, it is present as slender prisms which are sometimes hollow, as swarms of needles (fig. 5), and as groups of beryl-material which is optically continuous and has arranged itself in a skeletal manner so that idiomorphic, but interrupted, crystal outlines become visible. The habit of the slender prisms greatly resembles that of tourmaline, which like the beryl frequently sends out acicular prolongations parallel to the *c*-axis. The swarms of needles are often strictly parallel and sometimes define a rectangular area suggestive of an earlier mineral. The swarms and the skeletal growths are enclosed in quartz but reach through the quartz grains without displacement at the grain boundaries. The beryl is identified by its shape, uniaxial negative character, birefringence estimated as 0·006 from the interference colour, and by its moderate refractive index which, from the slight relief of the mineral against quartz, must be about 1·57.

Another and earlier generation of beryl is represented by idiomorphic pseudomorphs filled with chlorite, chlorite and bertrandite, or chlorite and quartz with or without bertrandite; orthoclase is sometimes present as imperfect prisms enclosed in the quartz. The sections of the pseudomorphs show rectangular and hexagonal outlines, the hexagons corresponding in shape to regular basal and slightly elongated longitudinal sections. Rarely an almost circular outline suggestive of a twelve-sided

[1] A. Russell, Notes on the occurrence of bertrandite at some new localities in Cornwall. Min. Mag., 1913, vol. 17, pp. 15–21.

section has been observed. Where quartz forms part of the pseudomorph it is continuous with the surrounding quartz and appears to represent a late replacement of the pseudomorphous minerals. Needles of the new generation of beryl, orientated parallel to the earlier, sometimes appear in those pseudomorphs which are largely replaced by quartz. Under the dispersing action of late quartz-bearing solutions, the idiomorphic outline of the pseudomorphs degenerates and it is not possible to say whether some shapeless clots of chlorite and bertrandite represent the locus of earlier beryl crystals. It is, however, probable that some aggregations of chlorite and bertrandite have been deposited from solution, the beryllium presumably having been derived from beryl and transported over a very limited distance.

The appearance of chlorite in pseudomorphs after beryl is not common, the aluminous mineral arising in the transformation being usually muscovite. The chlorite present at South Crofty mine is the iron-rich species daphnite with uniaxial negative character and ω 1·660. Bertrandite is associated with chlorite in specimens from Wheal Metal, Breage. (A. Russell, loc. cit., p. 18.)

Paragenesis of the minerals and source of the beryllium.—Beryl is an extremely rare mineral in Cornwall, and hitherto Cornish bertrandite has appeared to be independent of beryl. In all other regions the derivation of bertrandite from beryl is evident and, though Machatschki[1] thinks the alteration is due to the action of descending alkaline solutions, it is generally[2] held that the transformation from the alumino-silicate, beryl, to the hydrated silicate, bertrandite, takes place during a late, hydrothermal phase of igneous activity. The South Crofty occurrence is consonant with this view. The stanniferous veinstones themselves represent a long-continued, interrupted hydrothermal stage of the igneous activity which earlier caused the irruption of the granites of Cornwall and Devon, and the transformation of beryl to chlorite and bertrandite occurred long before the close of the hydrothermal action. The exact date of the transformation is, however, difficult to ascertain. Chlorite forms an essential constituent of the cassiterite-bearing peach and there is no means of distinguishing it from the chlorite replacing

[1] F. Machatschki, Mineralogische Notizen. Der Beryll von Pisek und seine Zersetzungsprodukte. Zeits. Krist., 1926, vol. 63, p. 462. [M.A. 3–310.]

[2] F. H. Pough, Bertrandite and epistilbite from Bedford, New York. Amer. Min., 1936, vol. 21, p. 265 [M.A. 6–362]; P. Ramdohr, Bertrandit von Klein-Spitzkopje, Südwestafrika. Zentralbl. Min., Abt. A, 1936, p. 257 [M.A. 6–431]; W. Brandes, Das natürliche Vorkommen des Berylliums. Zeits. Prakt. Geol., 1933, vol. 41, p. 35.

beryl, except where the outline of the latter is preserved. Bertrandite is nevertheless most abundant in chlorite which has a vein-like relation to the peach, and it is only rarely that bertrandite-chlorite aggregates show any sign of mechanical fracture or distortion. Therefore it is probable that the transformation of beryl to bertrandite and chlorite took place after the brecciation of the tourmaline-peach. It seems most likely that the original beryl was present in the peach and one example of a pseudomorph possibly of beryl embedded in tourmaline aggregate has been observed. The pseudomorph has a hexagonal outline and is filled by quartz, chlorite, and tourmaline; it contains neither bertrandite nor secondary beryl.

The regeneration of beryl took place at the time of accession of quartz, which healed the fractured veinstone and redistributed some of the tourmaline. Recrystallized tourmaline is thus enclosed with acicular beryl in quartz (pl. xxv, fig. 5). The same type of beryl appears within pseudomorphs from which chlorite and bertrandite have been largely displaced by quartz. Development of secondary beryl has been reported from other regions, for example by Vogt (loc. cit., p. 7) from Iveland and by Penfield[1] from Mt. Antero, but from the latter locality the new beryl is described as residual by solution of the main beryl crystal.

The proximate source of the beryllium contained in the existing beryllium minerals is thus an early beryl, but the origin of this beryl is uncertain. There are two possibilities: (1) Since the lodes at South Crofty mine are in granite and probably originated along a line of fracture, it is possible that the beryl is relic from fractured granitic material. (2) The beryl may have been introduced by the early mineralizing solutions which deposited tourmaline, cassiterite, fluor, and quartz in the vein. In support of the first hypothesis is the apparently very local occurrence of the beryllium minerals. Moreover, though no structure definitely indicative of the presence of an early granitic breccia has been observed, the veinstone contains much orthoclase as small grains optically continuous over considerable areas, suggesting that orthoclase, presumably mechanically derived from granite, was an early component of the vein filling. The fixity of the beryllium minerals within or very close to the pseudomorphs of the original beryl suggests also that beryllium was not easily transportable by the later hydrothermal solutions. In support of the second alternative is the actual presence of the beryllium minerals as a constituent of veinstone in close

[1] S. L. Penfield, Some observations on the beryllium minerals from Mt. Antero Colorado. Amer. Journ. Sci., 1890, vol. 40, pp. 489–490.

association with tourmaline and cassiterite. The apparent rarity of this association may be due to the ease with which beryl is replaced by chlorite under the conditions prevailing in the Cornish lodes. The transformation having now been demonstrated, further work should prove whether it has operated extensively or whether beryl or its pseudomorphs must still be regarded as a rare and perhaps fortuitous component of the veinstone.

The writer wishes to acknowledge much helpful discussion with Dr. W. F. P. McLintock and the valued assistance of Miss E. M. Guppy in searching the literature.

EXPLANATION OF PLATE XXV.

Bertrandite and beryl from South Crofty mine, Illogan, Cornwall.

(The numbers refer to the Rock Slide Collection of the Geological Survey and Museum.)

FIG. 1. E. 18218. Trisector twin of bertrandite. Nicols crossed. ×360.

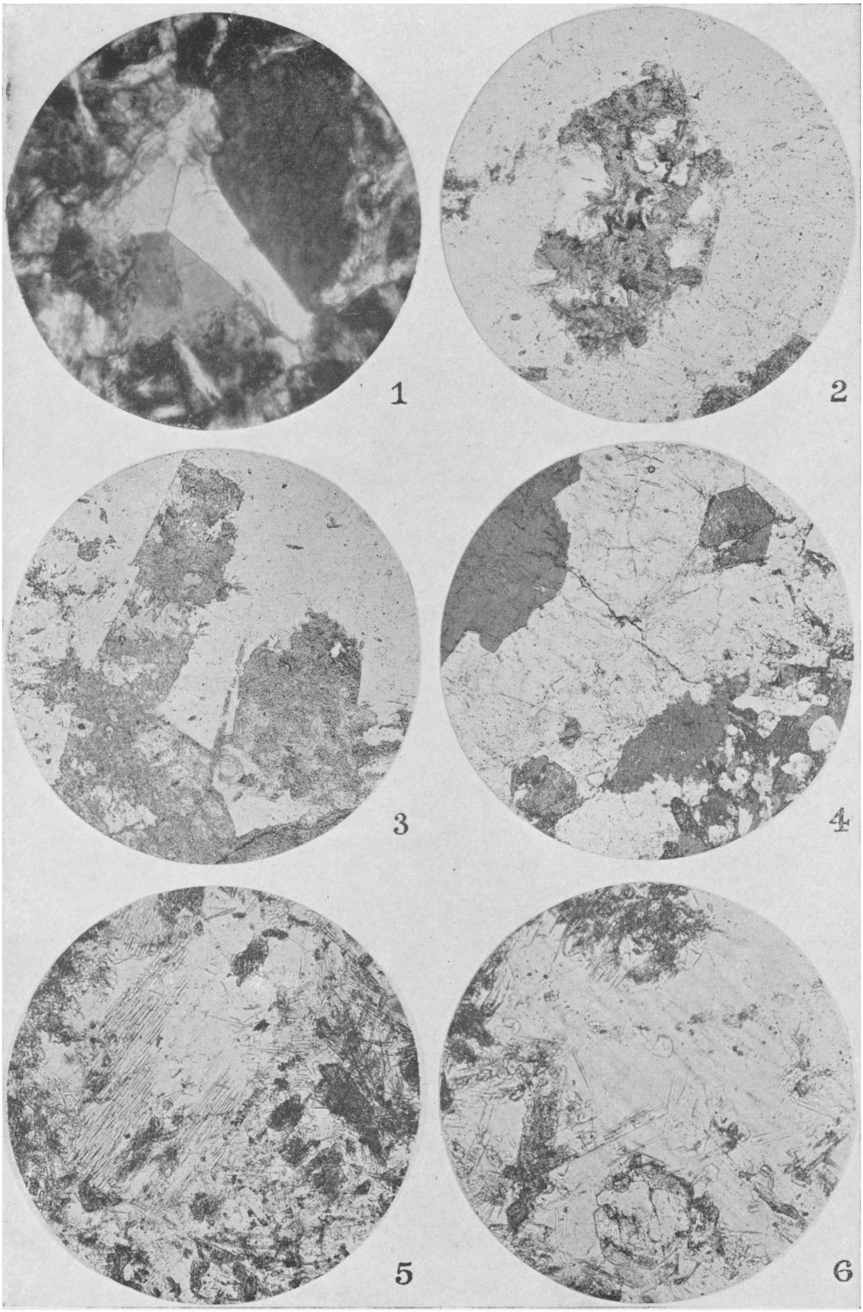
FIG. 2. E. 18218α. Pseudomorph of beryl in chlorite and bertrandite which are replaced, on left, by quartz continuous with the surrounding quartz. Ordinary light. ×47.

FIG. 3. E. 18218α. Pseudomorphs of beryl in chlorite and bertrandite, surrounded by quartz. Ordinary light. ×30.

FIG. 4. E. 18218g. Hexagonal crystals of beryl: at top right, fresh with chalybite in crack; bottom left, fresh with chlorite and bertrandite in cracks. Nicols crossed. ×24.

FIG. 5. E. 18218g. Needles of beryl associated with slender prisms and aggregates of tourmaline in quartz. Ordinary light, closely diaphragmed. ×53.

FIG. 6. E. 18218α. Hexagonal and prismatic, acicularly terminated, sections of beryl, showing variable replacement by chlorite. Ordinary light, diaphragmed. ×70.



J. PHEMISTER: BERTRANDITE AND BERYL FROM CORNWALL.