

*On Topaz and Beryl from the granite of
Lundy Island.*

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ALTHOUGH topaz and beryl have been previously recorded from Lundy Island, no account has hitherto been published of their characters and mode of occurrence. In the summer of last year a geological survey of the Island was commenced by one of us, and during the progress of the work good crystals of these minerals were obtained, the results of an examination of which it seems desirable to place before this Society.

Previous Literature.

Previous contributions to the mineralogy of Lundy Island consist only of lists of minerals, with few or no particulars as to their characters and mode of occurrence.

The earliest reference we have been able to trace is one by Townshend M. Hall,¹ who, in 1868, recorded the occurrence of felspar, magnetite, rock-crystal, schorl, and copper-pyrites. The second and last of these minerals, however, occur only in the slates and will not be further alluded to here.

In 1870, S. G. Perceval² communicated to the 'Geological Magazine' a letter noting the occurrence of topaz, his observations being based on specimens in the collection of Dr. Alfred Day of Clifton, and on one obtained by Robert Etheridge. He remarked upon the similarity of the crystals to those of the Mourne Mountains.

¹ T. M. Hall, 'The Mineralogist's Directory,' London, 1868, p. 58.

² S. G. Perceval, 'On the occurrence of topazes in Lundy Island.' Geol. Mag., 1870, vol. vii, p. 192.

In a paper on the geology and mineralogy of the Island, in 1871, Townshend M. Hall¹ gave a list, with brief particulars, of those minerals which had been observed by him in the granite. Among them he noted beryl, but made no mention of topaz.

Lastly, J. H. Collins, in his 'Handbook to the Mineralogy of Cornwall and Devon',² states that topaz is 'said to have been found on Lundy Island'.

Mode of occurrence.

The granite, in which the minerals occur, occupies by far the greater portion of Lundy Island. At its south-east end it is in contact with a small area of slates which it has metamorphosed. These slates are presumably Devonian, but, in the absence of fossils, their age is a matter of doubt. Elsewhere the granite is bounded by the sea, so that it is impossible to speak with certainty as to its exact relations to the surrounding rocks.

Intrusive alike into granite and slate are a large number of dykes varying greatly in size and ranging in composition from acid to basic types.

The granite was formerly extensively quarried and exported, and, although the industry is now quite abandoned, the excavations left by the quarrymen offer facilities for the examination of the rock in greater detail than otherwise would have been possible. The material described in this paper was obtained from the most northerly of these quarries, situated on the east side of the Island, one mile due north of the church.

The rock at this locality is a muscovite-biotite-granite with a strong tendency to idiomorphism on the part of the quartz. This mineral is somewhat dark in colour, and stands out in striking contrast to the opaque white felspar.

Under the microscope the bulk of the rock is seen to consist of quartz, orthoclase, and much-twinned plagioclase. The quartz contains numerous cavities enclosing bubbles of gas in liquid; many of these cavities are of the nature of negative crystals. Other inclusions in the quartz are small zircons and, more rarely, grains of pink garnet. The orthoclase occurs in large plates with a tendency to rough intergrowths with the quartz, and appears cloudy and decomposed; some of it is perthitic.

¹ T. M. Hall, 'Notes on the Geology and Mineralogy of the Island of Lundy,' *Trans. Devon. Assoc.*, 1871, vol. iv, p. 624.

² Truro, 1871, Part II, p. 101.

The plagioclase is sub-idiomorphic with respect to the quartz and orthoclase, and shows albite- and pericline-twinning. From a consideration of its refractive indices which, tested by the Becke method, are found to be less than those of quartz, and of the values of the symmetrical extinction-angles measured on the albite-lamellæ of Carlsbad-twins, this plagioclase appears to be albite or albite-oligoclase. Topaz, in irregular grains, is fairly abundant; and a biaxial, optically negative mineral, having a well-developed cleavage, straight extinction, and faintly coloured pleochroic halos around inclusions, appears to be cordierite.

Traversing the granite are numerous veins of aplite. These, when examined microscopically, show abundant topaz in irregular grains. The quartz and feldspar form an interlocking mosaic. The aplites often pass on the margins into coarse-grained pegmatites. In these pegmatites, but principally lining drusy cavities and fissures in the normal granite, occur well-shaped crystals of topaz and beryl, together with smoky-quartz, orthoclase, albite, mica, and, less frequently, tourmaline, fluor-spar, and apatite.

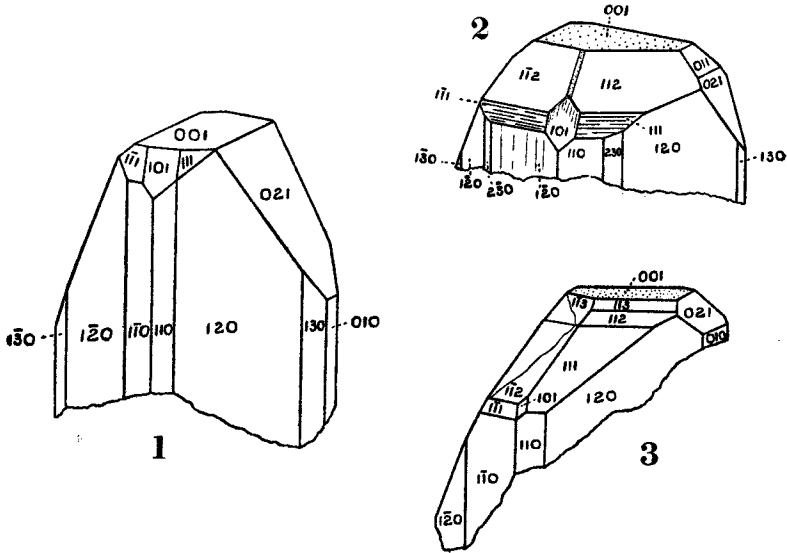
On one specimen a very small red grain occurs in feldspar, and this has been identified as garnet. We are informed by Mr. Walter Heaven, the heir to the property, that this mineral has been found abundantly in places, being known on the Island as ruby! Amethyst is also stated to have been found, but so far none has been detected by us, and it is just possible that fluor-spar has been mistaken for it.

When the cavities containing these minerals are first broken open they are found to contain a powdery clay-like substance resembling kaolin. In this many of the smaller crystals of topaz and beryl are loosely embedded, so much so, in fact, that they are easily washed out by a stream of water. Faces of the druses which have been exposed to the atmosphere have, of course, most of this clay removed, but a certain amount is invariably found adhering to and investing the crystals.

Description of the Minerals.

Topaz.—This mineral is quite plentiful in the druses, and occurs as well-formed crystals—usually pale-blue in colour, but often almost colourless—of various sizes and habits. The largest one noted measures 1 cm. along the *b*-axis and 0.5 cm. along the *a*-axis, but this is exceptional, and the crystals are usually much smaller. The basal plane (001) is always present and is invariably etched and dull; on no crystal was a reflection obtainable from this face. Sometimes the etching has not gone far and the plane is merely roughened, but in many cases it has

been eaten into a set of sharp pyramids. On several specimens the corrosion has followed a cleavage-crack, and the upper and lower parts of the crystal fit into each other by a series of tooth-like projections. It is evident that, subsequent to their formation, the crystals of topaz have been subjected to some powerful solvent which attacked and decomposed them. Further proof of this is afforded by the occurrence of dissected crystals with the spaces between the cracks and cleavages lined with a white, silvery mica. The topaz is in intimate association with quartz, felspar, and, in some cases, with beryl or tourmaline; often, too



Figs. 1-3.—Topaz crystals from Lundy Island.

the clay-like substance already mentioned is present. As will be shown later, this substance is not secondary mica, and is quite unlike the 'Steinmark'¹ associated with the topaz of some of the German localities.

The common forms are {001}, {010}, {110}, {120}, {130}, {101}, {021}, {111}, whilst {230}, {112}, {113}, {011} are of rarer occurrence. The crystals are usually prismatic parallel to the *c*-axis (fig. 1), and various unsymmetrical developments occur (figs. 2 and 3). Striation is common in the prism-zone, whilst etching is found on several planes in addition to (001) (fig. 2). On the crystal represented in fig. 3

¹ Cf. Hintze, 'Handbuch d. Mineralogie,' 1889, vol. ii, p. 112.

the faces (113) and (112) have been partly rounded. The following angles were measured on the crystals :

	Measured.	Calculated. ¹
(110) : (110) ...	55° 44'	55° 43'
(230) : (230) ...	76 30	76 50
(120) : (010) ...	43 21	43 24
(130) : (010) ...	32 15½	32 14
(010) : (021) ...	27 42	27 39
(010) : (011) ...	46 28	46 21
(101) : (110) ...	39 22	39 21
(110) : (111) ...	26 10	26 6
(110) : (112) ...	44 24	44 25
(110) : (113) ...	55 47	55 46

Beryl.—Whilst not so common as topaz, this mineral is comparatively abundant in the druses of the granite. It occurs as pale-yellow or, more rarely, as pale-blue or colourless prisms, the largest of which measures 0.7 cm. in length and 0.3 cm. in breadth. They are commonly seated on feldspar and, like the topaz, are sometimes invested by the clay-like substance already mentioned. The forms observed are *c* {0001}, *m* {1010}, *p* {1011}, *s* {1121}; fig. 4 represents one of the best crystals obtained. The prismatic faces are almost invariably striated vertically, but the basal plane and the pyramids are often bright and lustrous and yield good reflections. In some cases,

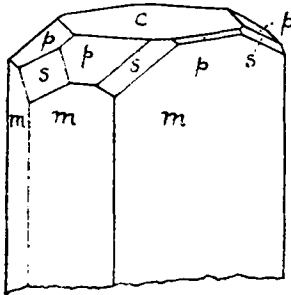


FIG. 4.—Beryl crystal from Lundy Island.

however, crystals show signs of corrosion, and it is interesting to note that the pyramidal faces seem to have been the most readily affected; crystals occur on which the basal plane and prismatic faces are quite bright, whilst the pyramids are replaced by a corroded band.

Quartz.—The quartz occurs in crystals of the usual habit up to an inch in length, and shows all variations in tint from black through pale-brown to almost colourless. Sometimes the faces are dull and corroded, but just as often they are bright and shining.

¹ Calculated from the elements given in Dana's 'System of Mineralogy,' 6th edition, 1892.

Felspar.—The felspars present some interesting features in hand-specimens. The crystals of orthoclase occur up to three-quarters of an inch in length, and are well formed. They have bright lustrous faces, but in many instances this appearance of freshness is deceptive, and, when scratched by a knife, the substance underneath is found to be quite soft and powdery. Sometimes the alteration has not proceeded far, but in other cases the whole crystal is friable and readily falls to powder. There is little doubt that the decomposition product is, in part at least, kaolin, and on some specimens little rectangular hollows filled with a clay-like substance are quite common. This question of the alteration of the orthoclase will be considered more fully in the sequel.

Crystals of albite are of frequent occurrence in the druses, but they are not so plentiful nor so large as those of the potash-felspar. They sometimes take the form of large plates showing the characteristic striation, or they may be found as small crystals perched on the smoky-quartz or on the orthoclase. In contrast to the latter mineral, the albite is always perfectly hard and fresh besides being much clearer; its identity was established by a determination of its refractive index (about 1.534) with suitable oils.

Mica.—White and brown micas occur as crystals and plates. They fuse readily in the blowpipe-flame and impart a strong red coloration to it, thus showing the presence of lithium.

Tourmaline.—This mineral is occasionally found as stout, black prisms, vertically striated and trigonal in section. It occurs in intimate association with felspar, and is sometimes partially invested by the clay-like substance.

Fluor-spar.—Small octahedra of purple fluor-spar have been observed on one or two specimens. They are usually seated on felspar, and sometimes form crusts on the larger crystals of orthoclase, which are powdery and decomposed. Sometimes the fluor-spar itself is coated with a thin film of clay, which gives it a strong resemblance to a pseudomorph.

Apatite.—Small, bluish prisms of this mineral have been detected, but they are by no means common, and the resemblance to the pale-blue beryl is so strong that the species is exceedingly apt to be overlooked. The pale-blue apatite can be distinguished, however, by its inferior hardness and by the fact that the prisms are soluble in acid, the solution so obtained reacting for phosphate. On one specimen a small terminated prism was observed, the basal plane and pyramidal faces being developed. Unfortunately, on an attempt being made to detach the crystal for measurement, it went to pieces, and, as no other terminated one has been noted, the forms have not been determined.

Kaolinization.

In the foregoing description reference has been made repeatedly to a clay-like substance which is present on every specimen of the pegmatites examined. It occurs in comparatively large masses, white to pale-yellow in colour, and intimately associated with felspar, topaz, beryl, fluor-spar, and tourmaline. It sometimes fills square-shaped hollows which obviously represent felspar crystals, and an almost perfect pseudomorph of felspar in it has been observed.

When some of the powder is crushed and examined in oil under the microscope it is seen to consist of aggregates of minute scales which are weakly doubly-refracting, and which have a refractive index (tested in oil) of 1.564. The water-content of the clay is about 18.1 per cent. (it lost about 2.5 per cent. in a desiccator), and its specific gravity is 2.32. These characters—especially the optical ones—agree fairly well with those of kaolinite, although the specific gravity is somewhat low.

It has already been noted that the large crystals of orthoclase are frequently powdery and decomposed, whilst those of albite are invariably fresh and clear. By boiling specimens in Canada-balsam it was possible to get sections made through some of the more completely decomposed portions of the rock, and an examination of these amply confirmed the evidence of selective kaolinization of the orthoclase afforded by the large crystals. In every case the orthoclase, or microperthite, shows signs of alteration, which takes the form of a development of kaolin with subordinate secondary mica. The albite, on the other hand, appears to have offered a stout resistance to the kaolinizing agent, with the result that clear and fresh plates of that mineral project into, or are completely enclosed by, large crystals of orthoclase more or less completely kaolinized. Dr. J. S. Flett mentions in the St. Austell memoir¹ the abundance of albite in the Cornish china-stones, and also the fact that it resists micaization better than orthoclase, although it is quite as susceptible to kaolinization. In the Lundy Island specimens there is no special abundance of secondary mica, whilst kaolin is exceedingly common and it has been derived chiefly from the orthoclase and microperthite. In the most thoroughly decomposed parts, however, the albite has also suffered change into kaolin and mica.

Mr. F. H. Butler in his papers² in this Magazine puts forward the

¹ 'The Geology of the Country around Bodmin and St. Austell.' Mem. Geol. Survey, 1909, p. 117.

² F. H. Butler, 'Kaolinization and other changes in West of England rocks.'

view that carbonic acid was the main agent in the kaolinization of the rocks of the West of England. He points out that minerals like topaz and tourmaline are unaffected by acids but are eroded by alkaline carbonates at a high temperature. He also remarks upon the presence of traces of china-clay in the tourmalinized rocks of the West of England, and ascribes the erosion of the tourmaline¹ to the alkaline carbonates set free during the kaolinization of the felspar. The specimens from Lundy Island would seem to support this view. Here there is a fair development of kaolin and topaz, the crystals of the latter mineral being invariably etched, eroded, and, in some cases, altered to a silvery white mica. It is quite conceivable that, with the development of kaolin from felspar by carbonic acid, the alkaline carbonates so formed may have attacked the topaz with formation of fluorides which, meeting with compounds of lime, would give rise to the crusts and crystals of fluor-spar.

The question of the age² of the granite of Lundy Island may well be left until the survey has been completed. The occurrence of drusy cavities containing such minerals as smoky-quartz, albite, topaz, beryl, octahedral fluor-spar, &c., recalls the granite of the Mourne Mountains in Ireland,³ although it is interesting to note that the feldspars of that rock are not kaolinized.

The specimens upon which the above observations were made have been deposited in the Museum of Practical Geology, Jermyn Street, London.

We take this opportunity of expressing our indebtedness to Dr. J. S. Flett and Mr. H. H. Thomas, of H.M. Geological Survey, for valuable suggestions, and to Mr. W. F. Saunt, the lessee of the Island, for ever-ready assistance in the field.

Mineralogical Magazine, 1908, vol. xv, pp. 128-146. 'The brecciation of mineral-veins,' *ibid.*, 1911, vol. xvi, pp. 124-135.

¹ F. H. Butler, *loc. cit.* (1908), p. 136.

² Cf. J. W. Judd, *Quart. Journ. Geol. Soc.*, 1874, vol. xxx, p. 275 (footnote); A. Harker, 'Tertiary Igneous Rocks of Skye.' *Mem. Geol. Survey*, 1904, p. 2 (footnote).

³ J. J. H. Teall, 'British Petrography,' 1888, p. 329.