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On rashleighite, a new mineral from Cornwall, intermediate between turquoise and chalcosiderite.

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[Read March 11, 1937.]

THE mineral here described was at first considered to be an iron-rich variety of turquoise and was described by myself as such when this paper was read before the Society in 1937. At that time only a partial analysis had been made; since then Dr. J. A. Smythe of King's College, Newcastle-upon-Tyne, has most kindly undertaken at my instigation careful analyses of the mineral from both of its localities, Bunny mine, St. Austell, and Castle-an-Dinas wolfram mine, St. Columb Major. As a result of these two analyses, which are in close agreement, it is evident that the mineral is a new one, intermediate between turquoise and the two minerals chalcosiderite and andrewsite, and forming a middle member of what is probably an isomorphous group. The name rashleighite commemorates Philip Rashleigh, F.R.S., F.G.S., F.S.A., 1729–1811, of Menabilly, Cornwall, one of the earliest of Cornish mineralogists and famous for having amassed the finest collection of Cornish minerals ever made.

The table of analyses given below shows the relationships of the various members of the group and their respective specific gravities. The crystal system to which these minerals belong has only been established in the case of turquoise and chalcosiderite which are triclinic. Henwoodite (Sp. gr. 2·67) would seem to belong to this group, but an examination of a series of specimens shows that it is apparently a mineral of variable composition and the sole analysis by J. H. Collins, for which he did not claim a high degree of accuracy, cannot be considered very satisfactory, and for this reason it has not been included in the table and indeed it does not fit in well.

	1.	2.	3.	4.	5.	6.	7.	8.
P_2O_5	32·86	33·72	—	31·59	28·60	33·82	29·93	26·09
As_2O_5	—	—	—	0·48	2·11	—	0·61	—
Al_2O_3	40·19	32·75	—	21·63	20·84	10·45	4·45	0·92
Fe_2O_3	—	4·28	5	20·09	21·29	34·26	42·81	44·64
FeO	2·21	0·71	—	0·32	—	—	—	7·11
CuO	5·27	7·54	—	7·72	7·87	6·82	8·15	10·86
CaO	—	—	—	—	—	0·87	—	0·09
MgO	—	—	—	0·12	—	—	—	MnO 0·60
SiO_2	—	2·24	—	0·16	2·25	—	—	0·49
H_2O	19·34	18·96	—	17·40(+) 0·40(−)	16·45	13·70	15·00	8·79
	99·87	100·20	—	99·91	99·41	99·92	100·95	99·59
Sp. gr.	2·75	2·697–2·764	—	3·0	3·02	3·0	3·108	3·475

1. Turquoise, Persia. A. H. Church, Chem. News, 1864, vol. 10, p. 290.

2. Turquoise, Los Cerillos, New Mexico. H. Jung, Chemie der Erde, 1932, vol. 7, p. 81. [M.A. **5**–279.]

3. Ferri-turquoise, Lynch, Virginia, U.S.A., C. H. Robinson, The Mineralogist, Portland, Oregon, 1942, vol. 10, p. 44. [M.A. **8**–270.]

4. Rashleighite, Castle-an-Dinas mine, St. Columb Major, Cornwall. Analyst, J. A. Smythe.

5. Rashleighite, Bunny mine, St. Austell, Cornwall. Analyst, J. A. Smythe.

6. Alumo-chalcosiderite Schneckenstein, Saxony. A. Jahn and E. Gruner, Mitt. Vogtländ. Gesell, Naturfor., 1933, vol. 1, no. 8, p. 19. [M.A. **5**–391.]

7. Chalcosiderite, Phoenix mine, Linkinhorne, Cornwall. N. S. Maskelyne, Journ. Chem. Soc. London, 1875, vol. 28 (ser. 2, vol. 13), p. 591. Analyst, W. Flight. Also uranium oxide trace.

8. Andrewsite West Phoenix mine, St. Cleer, Cornwall. N. S. Maskelyne. Ibid., p. 486. Analyst, W. Flight.

Optical data for both turquoise and rashleighite are unfortunately lacking owing to the unsuitability of the material available. The results of an X-ray study of turquoise and chalcosiderite have been recently given by A. R. Graham and L. G. Berry,[1] but as Dr. F. A. Bannister points out, although powder photographs of turquoise, rashleighite, and chalcosiderite are all similar in pattern, only the complete investigation of the crystal structures will reveal how they differ. Analysis 5 of rashleighite gives a formula $CuO.3\frac{1}{2}(Al,Fe)_2O_3.2P_2O_5.9H_2O$, with molecular ratios $Al_2O_3 : Fe_2O_3 = 0{\cdot}2044 : 0{\cdot}1333$. [Cf. M.A. **10**–336.]

Bunny tin and wolfram mine, St. Austell, Cornwall

(Six-inch Ordnance map, Cornwall, 41 SE., 1908.)

This mine is situated in the heart of the china-clay district, on the south-east side of Hensbarrow Beacon, $3\frac{1}{2}$ miles north of St. Austell, on

[1] A. R. Graham and L. G. Berry, Amer. Min., 1947, vol. 32, p. 201 (abstract); A. R. Graham, Univ. Toronto Studies, Geol. Ser., 1948, no. 52 (for 1947), p. 39. [M.A. **10**–336.]

the west side of the road from that town to Roche. The mine was undoubtedly worked for tin at an early period.[1] In 1838 it was working under the name of St. Austell Hills mine, and after a period of abandonment was reopened from 1864 to 1875 as Old Bonney and Shelton (Bonney being merely a misspelling for Bunny). It was again reopened for tin and wolfram as Bunny mine in 1901 and continued working, not very successfully, until 1907, since when it has remained abandoned.

There are several more or less parallel lodes, similar in character, traversing the kaolinized granite in a north-east direction and underlying north-west. At the time of the last working three of the lodes were actually being worked, the most important being that known as the Main or no. 1 lode, and it was from this, particularly at the 80-fathom level, that the specimens of rashleighite here described were obtained. The Main lode consists of a series of parallel mineralized veinlets, each enclosed in greisen, the thickness of the greisen depending on the width of the veinlet. The greisen passes abruptly into either soft kaolinized granite or a fairly hard silicified granite. The veinlets vary in width from a mere string to 20 inches, their filling consisting of quartz with china-clay (kaolin), cassiterite, wolframite, and in places a good deal of rashleighite, tourmaline, gilbertite, and more rarely a little chalcosine, mispickel, and pyrite. A little purple fluorite occasionally coats joints on the adjoining kaolinized granite, while the greisen contains an abundance of topaz as a micro-constituent. While the mine was being worked between 1864 and 1875 the late Mr. J. H. Collins collected specimens of the rashleighite, but assumed the mineral to be chrysocolla, which in some specimens it certainly somewhat resembles, and in his pamphlet 'The Hensbarrow granite district' (Truro, 1878, p. 45) he says 'at Bunny some of the tin ores are coated with a beautiful green silicate of copper'. These specimens of rashleighite collected by Mr. Collins are now in my collection. Since that date a good deal of the mineral was collected by the late Mr. W. Boxhall of Treverbyn, Mr. F. H. Butler, and Mr. G. H.

[1] The name Bunny was used by the early Cornish miners to signify a kind of stockwork or ramification of veinlets of ore. W. Pryce, Mineralogia Cornubiensis, 1778, p. 317, defines it as 'A pipe of Ore. A great collection of Ore without any vein coming into or going from it'; either tin or copper ore. John Hawkins, On the stratified deposits of tin-stone, called tin-floors, &c. (Trans. Roy. Geol. Soc. Cornwall, 1822, vol. 2, p. 33), describes such a deposit at Botallack mine, St. Just, which was known as Grylls's bunny. At Bunny mine there are two large rudely circular pits adjoining one another, the site of ancient workings on a ramification of tin veinlets in the kaolinized granite and not to be confused with the numerous china-clay pits in their immediate neighbourhood. The comparatively modern underground mine workings are situated on the ground between these two pits.

Richards, the two latter being mineral dealers in London, and sold to collectors as chrysocolla. During 1905–1907 when the mine was last worked I went underground on several occasions and collected specimens from the 80-fathom level and from a qualitative examination assumed the mineral was turquoise. In 1931 Mr. Herbert J. Thomas of Truro made a partial quantitative analysis on material which he had collected that year on the old dumps and on the strength of this analysis in which the alumina and iron were not determined separately, he also assumed the mineral to be turquoise and a brief notice of the presentation by him of a specimen to the British Museum appeared in 'The Times' newspaper of November 30, 1931, the locality being given as St. Austell, Cornwall.

In colour the Bunny mine rashleighite is for the most part light blue-green, R. Ridgway's lichen-green, glaucous-green, and deep glaucous-green exactly matching the varying tints, while more rarely it is true turquoise-blue. The mineral, which occurs in some quantity, both fills the interstices and encrusts roughly crystallized prisms of greyish quartz, which projecting from a groundmass of quartz on the greisen walls form the central part of the veinlets. In the more open parts of the larger veins, the interstices besides being lined with a crust of rashleighite, are filled with soft white china-clay and also a yellowish clay-like substance, and on some specimens the mineral is thickly invested with scaly gilbertite. In other veinlets up to 2 cm. wide it completely encrusts small flat crystals of wolframite which thickly stud both walls and also fills the central portion of the veinlet. More rarely, it invests small lustrous black complex twinned crystals of cassiterite and little radiating aggregates of black tourmaline, or with pearly white rosettes of gilbertite lines cavities in rich crystalline cassiterite. In some cases the rashleighite occurs with no admixed minerals save a little included quartz, and in this massive or colloidal form fills the whole veinlet to a thickness of 2 cm., and it was on this material that Dr. Smythe's analysis was made. Under the microscope the crusts are seen to be minutely mamillary or sometimes stalactitic, the surface of the mamillations being indistinctly crystallized and occasionally showing very minute curved triangular faces.

In recent years I have obtained many good specimens of the mineral by digging into the small dumps close to the shaft upon which stands the ruined pumping-engine house. During the last war a small trial for wolframite was made in the form of a trench and short level on a vein outcrop a little south of the southernmost of the two old pits and in this

also a good deal of rashleighite of a true turquoise-blue colour was found under conditions exactly similar to those already described.

Castle-an-Dinas wolfram mine, St. Columb Major, Cornwall

(Six-inch Ordnance map, Cornwall, 33 SW., 1907.)

Soon after the commencement of mining operations at Castle-an-Dinas in 1918 my attention was attracted to a mineral which at that time occurred sparingly as very thin blue-green crusts on the banded sediment enclosing the lode.[1] As work proceeded the mineral became more abundant and by 1931 I had obtained sufficient material to more or less satisfy me that it was turquoise though the quantity of iron present seemed abnormal. In 1938 I gave a brief mention of the occurrence as an associate of the new mineral russellite.[2] On visiting the mine in February 1939, no. 4 level on the north side of the hill, the then deepest in the mine, had almost reached the granite core of the hill, and a stope above this level laid bare considerable quantities of the blue-green mineral now shown to be rashleighite. The lode at this point was full of loosely packed cavities and though still in the banded sediment, was traversed by parallel granite tongues. The filling consisted of much shattered quartz, often in thin sheets, considerable patches of wolframite, large friable masses of rashleighite, and a good deal of wavellite, brown lithia-mica, and rusty ochre. The colour of the Castle-an-Dinas rashleighite is usually light blue-green and brighter in tint than that of Bunny mine, very rarely it is true turquoise-blue, and occasionally pistachio-green. On many specimens it has an intimate association with wavellite. The commonest form is a light blue-green thin crust, sometimes rippled, and covering considerable areas of the banded sediment, the surface of the crust being composed of minute crystallized spheres, and usually sprinkled with silky-white needle crystals of wavellite; also in a similar form on the quartz-wolframite vein-stuff. Large and practically pure light friable and porous blue-green masses up to 23×20 cm. in size are often intersected by very thin sheets of quartz and associated with yellowish-brown ochre. These masses form very handsome specimens and it was upon this material that Dr. Smythe's analysis was made. Under the microscope they are seen to be composed of

[1] Mention of this as 'an as yet undetermined phosphate of alumina' is made in Min. Mag., 1925, vol. 20, p. 233.

[2] A. Russell, Min. Mag., 1938, vol. 25, p. 54. In an article on the Castle-an-Dinas mine by J. H. Trounson (Mining Mag. London, 1940, vol. 63, p. 20) the mineral is referred to as variscite.

countless minute translucent balls, lightly aggregated, their surface formed of curved triangular crystal faces. In the form of minute ½ mm. light blue-green translucent globules with small white spheres of wavellite on greisen adjoining wolframite-bearing quartz-topaz vein-stuff. The radiating needle crystals of wavellite often penetrate the globules of rashleighite which they support; and owing to the periphery of the wavellite spheres being impregnated with rashleighite they show in section an outer blue-green ring forming very beautiful objects under the microscope. In section the rashleighite spheres present a slightly radiating and concentric structure.

The occurrence of rashleighite in the tin-wolfram lodes traversing granite at Bunny mine and in the wolfram lode at Castle-an-Dinas mine would appear to resemble in some respects the occurrence of turquoise in the tin lodes traversing granite and aplite at Montebras, Creuse, France. Professor A. Lacroix in his description of the Montebras turquoise,[1] which apparently has never been analysed, states that it results from the alteration of amblygonite with which mineral it is intimately associated, its other associates being cassiterite, very rarely wolframite, and often wavellite, in a quartzose vein-stuff. The copper, Professor Lacroix suggests, has been furnished by small quantities of a sulphide in the cassiterite.

[1] A. Lacroix, Minéralogie de la France et de ses Colonies, 1901–1909, vol. 3, pp. 228–229, and 1910, vol. 4, p. 530.