ON THE TOPAZ QUARTZ PORPHYRY OR STANNIFEROUS ELVAN DYKES OF MOUNT BISCHOFF.

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(PLATE.)

This rock was first described by S. N. Wintle in 1875* as eurite porphyry, which it had been termed by Professor G. H. F. Ulrich, who, however, did not publish his description until 1877†. In 1875 also the late Chas. Gould wrote as follows:—

"Mount Bischoff is a conical eminence rising to about 2,500ft. above the level of the sea. . . . It consists of a small protrusion of a porphyritic rock having a felsitic base, with granules and crystals of quartz and felspar; it weathers white, and is honeycombed or vesicular on the surface, most probably from the decomposition and removal of pyrites, which is freely disseminated throughout in places‡."

Profeesor G. von Rath, of Bonn, first determined the existence of topaz in specimens sent to him by Professor Ulrich. His description was published in 1879§. The rock was further submitted to methodical investigation in 1884, when A. von Groddeck microscopically examined specimens at Clausthal, received from Tasmania. Von Groddeck's two papers on the subject disclose a thorough treatment of the material available*. He definitely negatived the idea of his sample being quartz-porphyry at all, and called it a porphyritic topaz rock. In 1892 Mr. H. W. Ferd. Kayser in his paper on Mount Bischoff, read before Section C, Australasian Association for the Advancement of Science at Hobart, 1892, refers to dykes of Eurite or Quartz-porphyry and Topaz-porphyry, and in a subsequent paper by Messrs. Kayser and Provis (1895-6)†, the dykes are called Topaz-porphyry and Quartz-porphyry. Mr. A. W. Clarke, in 1892, wrote a short note on the microscopical appearance of a specimen of this rock in the collection of Mr. R. L. Jack, Government Geologist for Queensland, but while

* "Stanniferous Deposits of Tasmania." Trans. Roy. Soc. N.S. Wales, vol. ix 1875, p 87.

† "New York Year Book of Mineralogy," 1877, p. 494.

‡ "Q. Journal Geolog. Soc.," vol. xxxi., 1875, p. 109.

§ "Berichter der Niederrheinischen Gesellschaft," Bonn, 1879.

* Proc. Roy. Soc. Tasmania, 1885 p. 388, and 1886, p. 189.

† Proc. Inst. Civil Engineers, vol. cxxiii., 1895-6, p. 4.

noticing "a radially arranged mineral highly colored between crossed nicols," failed to recognise it as Topaz‡. Finally, the topaz and quartz-porphyries of Mount Bischoff are recorded in the work mentioned at foot§. No systematic microscopical examination seems to have been published since von Groddeck's time. His material was plainly limited, and the essential nature and derivation of the rock were not dealt with in his painstaking inquiry.

After renewed examination in the field, and with the aid of an extensive series of microscopical slides, it may be permitted to us to re-state the problem, and, as we believe, advance a step in the process of its solution.

That dykes of an acidic porphyritic rock traverse the Palæozoic slates and sandstones at Mount Bischoff is well known. This rock carries topaz both crystalline and amorphous, and that mineral at Mount Bischoff appears always to be associated with Cassiterite. Professor Krausé, alluding to these dykes, says: "The white porphyry composing the summit of Mount Bischoff contains in a felsitic base crystals of quartz and an abundance of fine-grained amorphous topaz, with here and there a cavity lined with groups of radiating acicular crystals of topaz. Pseudomorphs of topaz after quartz are also not uncommon."* This, perhaps, is the latest description of the rock in question, but it applies to only one variety of a very variable rock. In prosecuting our investigations our aim has been to obtain samples as little altered as possible, in the hope of being able to detect the presence of minerals of the parent rock. We have succeeded in finding specimens showing constituents which have not succumbed to the obliterating processes of topazisation. When sliced they reveal quartz, felspar, and mica as porphyritic constituents. The felspar outlines are mostly filled in with talc and radiating crystals of topaz (pycnite). This explains the rarity of felspars in the altered rock. Topaz crystals settle in the interior of a crystal of felspar, replace its substance, and finally its outline is lost in the ground-mass of the rock. In this way many phenocrysts are now indeterminable.

This topazisation is what Rosenbusch calls a pneumatolytic phenomenon, viz., the development of topaz and tourmaline rocks in veins proceeding from granite. Fluoric and boracic acid vapours, given off at the time of intrusion and consolidation of the vein matter, are recognised as agents competent to effect the observed results. These solfataric vapours

‡ "Geology and Paleontology of Queensland." R. L. Jack and R. Etheridge, jr., 1892, vol. 1, p. 729.

§ Catalogue of the minerals sf Tasmania. W. F. Petterd, p. 90, 1896.

* An introduction to the study of mineralogy. F. M. Krausé, 1896, p. 220

under hydroplutonic conditions act upon a magma protruded from a deep-seated rock mass containing the elements of a granite. The protruded vein-rock thus becomes topazised and tourmalinised. It is hardly possible to separate physically the moments of topazisation and final consolidation, for we must conceive of this process being at work while the vein-mass as a whole was still viscous. The phenocrysts of felspar were probably attacked and digested during their passage from below. The Mount Bischoff rock is essentially a vein-rock, and we are disposed to refer it to the elvan group as a topazised elvan rock (now topaz quartz-porphyry). It has been called "eurite" in Grenville A. J. Cole's sense of compact granite=quartz-felsite, quartz-porphyry, etc. The original definition of eurite by D'Aubisson de Voisins described eurite as a compact granite with dominant felspar, but the name has been applied to quartz-felsites of varying origin, and has long since lost its significance as a rock title. Professor Cole has sought to revive it, but it apparently has not come into use in precise petrography. Eurite often occurred in a rock-mass as porphyritic granite or micro-granite, being the fine grained peripheral part of a body of granite, while elvan is always a vein-rock. The term elvan has been objected to as being somewhat indefinite, for the material of the veins has consolidated sometimes as granite-porphyry, at other times as felspar or quartz-porphyry. Again, the boundary line between granite-porphyry and quartz-porphyry is not sharply defined, for though the ground-mass of the former is typically microgranitic, it often passes over into the compact felsitic ground-mass of quartz-porphyry. Quartz-porphyry indeed is simply a modal term applied to acidic rocks. Sometimes it characterises effusive sheets, lava flows, otherwise it is applied to the material of compact intrusive veins (elvan). Some high authorities consider that the loose way in which "elvan" has been used ought to disqualify it as a scientific term; but this does not prevent us from attaching a definite meaning to the word, which we do when we employ it as signifying granitoid and quartz-porphyry veins extending from masses of granite into the surrounding rocks. Such veins consist typically of felspar and quartz-phenocrysts (accompanied by mica, hornblende, or augite) in an orthoclase and quartz ground-mass, which is micro-crystalline, crypto-crystalline, or felsitic. In the Mt. Bischoff rock the felspar of the ground-mass has been replaced by topaz. The analysis recorded by von Groddeck showed no alkali, and the rock consisted practically of quartz and topaz. But this would naturally be the case in parts of the rock where the topazisation process had proceeded to its ultimate stage.

In certain of our slides the substance, as well as the form of the felspar, has survived, and we are then able to diagnose the original rock as containing porphyritic crystals of quartz, felspar, and mica floating in a ground-mass, which is sometimes composed of granular allotriomorphic quartz, sometimes of crypto-crystalline or felsitic matter, but usually profusely besprinkled with scales of talc, derived from felspar and mica. Where the dykes contain less topaz, as on the North Valley side, we have detected a felsitic ground-mass. We may here mention that the survival of felspar is a rare occurrence; what petrological observers have seen hitherto have been crystal forms only; and what is pointed out to visitors at the Mount as kaolin is really a white decomposition product of pseudomorphous topaz and tourmaline. The quartz phenocrysts are idiomorphic, sometimes with perfect outlines, or with rounded corners and indentations. Fluid inclusions are present with fixed and moving bubbles.

In quartz-porphyry primary muscovite phenocrysts are not admitted by the best authorities as constituents, and it therefore becomes of some importance to establish the nature of the mica, especially as muscovite is a characteristic mineral of the elvan group. In our slices we have found numerous porphyritic forms indicating the presence of a mineral of the mica group, but in most instances the substance is so altered as to admit of a doubt whether it was a potash or magnesian mica. However, in one case we have detected a comparatively unaltered muscovite. Such an occurrence is excessively rare. This mineral has for the most part been converted into its alteration product pyrophyllite, aluminous talc, which has also spread through the substance of the felspar phenocrysts. It is likewise generally diffused through the ground mass in formless scales, affecting a larger size preferentially in the neighbourhood of phenocrysts, and showing vivid interference colours like those of muscovite. Whether the muscovite is a lithia-mica or not has not been determined. Dr. Sommerlad's analyses appear to have referred only to the dense topazised variety of the rock.

Topaz.—This is a constituent of stanniferous granites all over the world, but in the Mount Bischoff dykes it has taken possession of the rock substance to an extent which expels the original constituents. It occurs in three forms, columnar, prismatic, and amorphous.

The dense rock from the White Face, usually shown to visitors as the topaz rock, consists mainly of the columnar form with radiating crystals, known by the name pycnite. The radial aggregates give a dark cross in polarised light. Isolated crystals of quartz, sometimes with good hexagonal sections, are scattered in the interstices of the topaz. The rock of the Queen lode is a mass of radiating and prismatic topaz. The latter shows fine cleavage lines in sections not parallel to oP. We have found this basal cleavage of great value in distinguishing crystalline topaz from quartz. The paragenetic association of quartz and topaz with cassiterite is occasionally well displayed by prismatic crystals of the two first minerals being enclosed in crystals of cassiterite. The formation of all three was evidently synchronous.

In some specimens from the Mount we have the third form of topaz, in which it forms an amorphous or allotriomorphous granular mass, apparently taking the place of the ground-mass of the original rock.

A very interesting feature is the conversion of quartz to topaz, which is visible in hand specimens. A quartz-sintery looking rock, composed of quartz in hexagonal prisms, shows its individual crystals bordered with a white cloudy marginal zone of pseudomorphous topaz. Heated in the open tube, its vapour etched glass. This topaz effervesces slightly when treated with HCl, owing to the unexpected presence of lime, derived possibly from the alteration of sphene and apatite. We witness here a second conversion, that of topaz into prosopite, a double fluoride of calcium and aluminium. When this change is effected, topaz loses its transparency, becomes cloudy and opaque. Its hardness diminishes, and its specific gravity becomes less. Von Groddeck describes this pseudomorphosis fully in his paper "On the tin ore deposits of Mount Bischoff, Tasmania," 1886. Sandberger quotes this rather peculiar mineral from Altenberg, Geyer, and Hengsteverb in Saxony, and mentions that he has often remarked pseudomorphoses of prosopite—aggregates after pycnite and crystalline topaz†. Vauquelin had previously noticed the presence of calcium and water in pycnite from Altenberg, which is explicable upon the conversion theory. At Mount Bischoff this pseudomorphous alteration product has been mistaken for kaolin.

The pycnite variety of topaz is not often mentioned in mineralogical works. It is cited from Schneeberg in Saxony, Durango in Mexico (Bauerman), Altenberg (Collins), Schlackenwoald and Zinnwald in Bohemia (Bristow), Maulson in France in steatite, and Kongsberg in Norway in mica slate (Phillips). We have also found it associated with tourmaline and quartz in an argentiferous galena lode traversing syenite at the Lidjessy mines near Kara-Hissar-ï-Sharki, Asia Minor. On the other hand there is dyke rock at Mount Bischoff destitute of topaz. Thus a specimen from the West Bischoff Tin Mining Company's ground is a

† "Untersuchungen über Erzgänge." F. Sandberger, vol. ii., 1885, p. 171.

quartz rock, which consists of a granular quartz ground-mass enclosing large phenocrysts of quartz (often with striking marginal zonal inclusions), but containing no topaz.

Tourmaline is here a rock-forming mineral, making a dense green stone, which at one time was thought to be chlorite. It is arranged in microscopical, divergent, and felted prisms, and needles, bluish green in colour. Occasionally, rectangular crystal forms, which can be no other than those of orthoclase felspar, are discerned filled with or composed of small rods of tourmaline, demonstrating absolutely the secondary nature of this mineral. In the ground-mass of this tourmaline rock are nests of prismatic and granular topaz. Sphene is plentiful.

We have had slices cut showing the junction of the porphyry with the slate. The boundary between the two is perfectly sharp and well defined, and even where fragments of slate have been torn off and surrounded by porphyry the amount of contact alteration is inconsiderable.

The Mt. Bischoff stanniferous ground has always been looked upon as unique. It has been compared with the occurrence of the topaz quartz-porphyry of the Saxon Schneckenstein; but the latter, though presenting microscopical structural resemblances, differs widely in its geological relations, being a brecciated dyke in the contact zone of the tourmaline granite. The rock of the Saubachschlucht dykes in that locality shows a startling resemblance to the Mt. Bischoff porphyry, both in hand specimens and under the microscope. It is a quartz-porphyry dyke rock, with porphyritic quartz and felspar in an allotriomorphic quartz ground-mass. Secondary muscovite or talc is diffused through the rock, and topaz has crystallised as rods in the porphyritic felspars. There is considerable difficulty in determining the exact nature of the ground which is being worked at Mt. Bischoff. Some think it is a stockwerk; others a thermal spring deposit. Another theory is that it is the silicious plug of a vent in which stanniferous vapours ascended and condensed. Further work and study on the spot, especially underground, are requisite before a wholly satisfactory hypothesis can be framed. The results of microscopical investigation and our examination in the field lead us to look upon the mass of the great Brown Face as disintegrated, silicious, ferruginous, partly detrital rock surrounded by dykes on three sides, and fissured and affected by the agencies which formed the dykes. The concentrated material shed by the overhanging dykes has probably enriched the ground, while the mere disintegration of the enclosed area itself and consequent lowering of its surface would work in the same direction. The appearance of a basin-like vent at the summit of the Mount is deceptive and suggests false conclusions, for it is due merely to the directions of the several dykes which enclose the ground. The only channels from below are the fissures of the dykes and veins. As the underlay of the dykes is towards the central area, they most likely intersect in depth, and hence the inference suggests itself that, sooner or later, the Brown Face mass will pass down into dyke or lode rock. Geologically these porphyry dykes have been looked upon as protrusions or apophyses of the underlying granite, thrust through the slates, but such microscopical evidence as we have been able to collect tends to show that their mineralogical constitution differs from that of the nearest granite exposures. White mica is not known in the granites of that part of the island, its place being taken by biotite. It is likely that, though these dykes have a granite source, they represent fissures traversing alike the slates and the granite which probably immediately underlie them.

The nearest exposures of granite rocks occur at four and five miles from Waratah, viz., porphyritic granitite on the Corinna-road, four miles distant, and granitite at Wombat Hill, five miles. The porphyritic ingredients of the former are orthoclase and plagioclase felspars, dark brown and light magnesian micas and quartz in an allotriomorphic groundmass of quartz, orthoclase and mica; consequently there is a repetition of all three minerals. The most frequent minerals are the mica and felspar, while quartz is the least abundant porphyritic constituent. The mica is rich in inclusions of apatite; grains of zircon in ground-mass.

The Wombat Hill granitite consists of orthoclase + plagioclase + biotite + a little green hornblende. There is a disposition to pegmatitic intergrowth of quartz and felspar. The biotite encloses quartz, apatite, and zircon, and in colour is dark brown, sometimes bleached out. Near the 7-mile peg, on the Waratah-Corinna-road, a limited quantity of alluvial tin has been worked. The drift consists of quartz and black tourmaline of the more abundant type, which is unknown in the Mt. Bischoff elvans.

To sum up, the petrographical conclusions to which our inquiries have led us are:—

1. That the quartz-porphyry is not a marginal portion of the main granite mass, but belongs to dykes running through the granite, and having a slightly different composition from the latter.

2. That it partakes of the nature of elvanite, with occasionally a quartz felsite facies.

3. That both in its micro-crystalline condition and its felsitic modification it has been subjected to topazising and

tourmalinising agencies of hydro-plutonic nature, which have, when unchecked, transmuted the rock into a topaz quartz-porphyry.

4. That the crystallisation of the cassiterite was contemporaneous with that of the topaz and quartz. As to whether the tin ore ascended as a fluoride, or stannous acid was derived from the individual components of adjoining rocks, the microscopical appearances convey the impression that the condensation or precipitation took place in the presence of water.

5. That the great Brown Face workings are not in the basin of a vent issuing from the bowels of the earth, but are in the iron gossan of a fissured and disintegrated area enclosed by the quartz-porphyry dykes.

Our study lays no claim to be exhaustive. We have approached the subject simply with the desire to record such contributions to our knowledge as may be gleaned from the evidences furnished by microscopical petrography, and we lay before the Society this essay to expound the nature and genesis of the much debated Mount Bischoff rock, hoping that extended work by others will effect a further advance towards the solution of the problems which are involved in the inquiry.

List of 34 Minerals known to occur in the Elvan Dykes of Mount Bischoff.

Apatite—Occasionally obtained in small crystals, which can be recognised with unaided vision.

Arsenopyrite—In considerable abundance in the lower levels, associated with other forms of pyrites, through the mass of which are scattered small crystals of cassiterite.

Arsenic, native—As narrow blades and patches between the laminæ of siderite, fluorite, and pyrites in lower level North Valley workings.

Azurite—Occasionally met with in bunches of minute crystals in the Brown Face with malachite.

Cassiterite—The pyramidal crystals are often beautifully formed, with complex terminations and macles. The colour is invariably intensely black.

Chalcopyrite—The massive form only known in limited quantity.

Copiapite—As an efflorescence in the older adits.

Copper, native—Occurs as extremely thin foil interbedded in fissures in the slate adjacent to the elvans.

Cyanosite—On the roof and sides of adit, North Valley.

Diaspore—In the Stanhope Mine, but not abundant, as shining, flattened, and brittle prisms of a yellowish brown colour.

Fluorite—Variety chlorophane. Somewhat plentiful, occasionally in irregular masses without distinct crystallisation.

Hematite—Variety Reddle. The common matrix of the stanniferous portion of the surface workings of the mine.

Limonite—Equally as abundant as the last. The Brown Face is mainly composed of this substance, the black tin being usually irregularly disseminated throughout the mass.

Lithomarge—Commonly soft and unctuous, more or less coloured by ferric-oxide.

Malachite—Occurs in thin coatings and patches in the gossan, at the Brown Face.

Melanterite—Found incrustating in the old adits.

Monazite—Occurs in aggregation of small crystals of a light brown colour, with wolframite in the West Bischoff.

Muscovite—The unaltered mineral is extremely rare. As detailed in the context, it has almost invariably undergone considerable alteration.

Orthoclase—Can rarely be distinguished, as it has in most instances undergone topazisation, and can only then be detected by optical characters.

Pholerite—In the Stanhope mine this substance is sometimes met with in considerable masses. It is an extremely soft aggregate of mineral scales with a glimmering lustre.

Pyrolusite—The earthy variety is commonly intermixed with limonite.

Pycnite—As detailed, this is one of the most characteristic minerals of the Bischoff elvans.

Pyrites—Abundant both in the amorphous and crystalline forms.

Pyrophyllite—Very plentiful in aggregated, fibrous, radiating masses.

Prosopite—On the western side of the surface workings this substance is in great profusion. It usually forms a kaolin-like friable mass, throughout which are commonly scattered minute crystals of cassiterite.

Quartz—Of common occurrence in extensive masses and irregular bunches of interlaced crystals.

Siderite—In opaque, interbedded, obtuse rhombohedra of large size, of a yellow-brown colour.

Sphalerite—Of rare occurrence, in small patches with pyrites and the last.

Stilphnosiderite—This is occasionally met with in the form of thin varnish-like incrustations of extreme thinness of an intense black colour.

Sulphur—A somewhat large pocket was met with in the Brown Face, intermixed with bunches of minute quartz crystals and prosopite.

Topaz—This has only been detected of microscopic size as described.

Tourmaline—This is invariably of the peculiar dark green colour, characteristic of Bischoff. It is usually in felted masses of minute crystals, which rarely exceed 18 millimetres in length.

Vivianite—Has been obtained in groups of crystals in small fissures in the rock in one of the adits, and also in amorphous, clay-like masses.

Wolframite—In the West Bischoff this frequently occurs, intermixed with apatite and quartz.

EXPLANATION OF PLATE.

Fig. 1. Topaz rock of Queen Lode, Mount Bischoff × 18. The columnar form of topaz (pycnite) in radiating groups is shown with insterstitial quartz, differentiated under crossed nicols.

Fig. 2. Topaz quartz-porphyry, Mount Bischoff × 18, crossed nicols. The rectangular section of a large felspar crystal occupies the middle of the field. The substance of the felspar has been replaced by columnar and prismatic topaz.

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TOPAZISED ROCKS OF MT. BISCHOFF.