

*On rhodonite and tephroite from Treburland manganese mine, Altarnun, Cornwall; and on rhodonite from other localities in Cornwall and Devonshire.*

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TREBURLAND MANGANESE MINE, ALTARNUN, CORNWALL.

(Six-inch Ordnance map, Cornwall, 22 NW., 1907.)

OF the many small manganese deposits which have in the past been worked in both Cornwall and Devonshire that of Treburland is from the mineralogical point of view by far the most remarkable, its especial interest being due to the variety of minerals which it has afforded and to the fact that it and one other are the only manganese deposits in the west of England which are known to lie on the contact of igneous and sedimentary rocks and which have consequently been vitally affected by contact metamorphism.

The following observations are based on frequent visits to the spot since the year 1906, when I first stumbled across the locality, which, strange to say, has only received very cursory mention by the Geological Survey and has altogether escaped mention in mineralogical literature.<sup>1</sup> The old workings, which are of very small extent and shallow, are situated on the south side of the river Lynher about midway between the ruined corn mill of Trevague and Treburland homestead in the parish of Altarnun, and  $1\frac{1}{2}$  miles by road from the village of Five Lanes. At what date the deposit was discovered I know not, but between the years 1887 and 1890 the mine produced 470 tons of manganese ore (pyrolusite) and was then worked in conjunction with the adjoining Treburland tin and wolfram mine and by the same adventurers. The name New Phoenix was given to the joint concern by the manager, Captain Vercoe, in consequence of the flippant and uncomplimentary name, Wheal Flop, by which the tin mine was known to the miners. Close to the manganese workings are the ruins of a tin-stamping mill and in the walls of this are built blocks of rhodonite. The appearance of this mill suggests that it is of some antiquity and the water-wheel which drove it was fed with water by a leat, an underground portion of which appears to have traversed the manganese deposit; hence this may very well have been discovered during the construction of this watercourse. Most if not all of the dump material, which I have systematically broken up and examined, appears to have been raised during the 1887-1890 working. Some 120 yards to the south there is situated the old Treburland tin and wolfram mine, alias Wheal Annie or Wheal Flop, which worked on true lodes traversing both granite and killas, and a part of which has recently (1942) been again set to work.

Unfortunately nothing can now be seen of the actual manganese deposit, which lies just within the killas or contact-altered sedimentary Upper Devonian slate

<sup>1</sup> The occurrence of rhodonite at Treburland was communicated by me to the late Mr. J. H. Collins and is mentioned in his *List of minerals found in Cornwall and Devon, with notes supplementary to the author's 'Handbook'*. Journ. Roy. Inst. Cornwall, 1911, vol. 18, p. 456.

(Woolgarden phyllite of the Geological Survey) close to its junction with the main Bodmin Moor granite mass: the distance to the nearest granite at the surface being about 120 yards and underground, allowing for the dip, probably very considerably less. The dump material, which is very fresh, makes it clear, however, that it is a bedded deposit conforming in some respects to the type usually met with in east Cornwall and Devonshire. The ore lies within or in contact with a band of highly calcareous calc-silicate rock, originally an impure limestone, which has been intensely metamorphosed by the granite, giving rise to a varied and extremely interesting assemblage of minerals. Aplite veins were also met with in the workings and evidently traverse the calc-silicate rock as at Meldon in Devonshire. The hard silicate manganese ore consisting of rhodonite, bustamite, and tephroite occurs in the form of loose more or less rounded blocks which when *in situ* had packed between them soft pyrolusite, the ore sought for. There were actually two pockets, probably part of the same bed, which were worked out. One of these was beneath the dumps on the north or right-hand side of the road where the calc-silicate rock is still visible in an overgrown pit, the other on the south or left-hand side of the road. Both pockets were reached by a short and very shallow level driven from the marshy ground by the river Lynher, the depth nowhere exceeding 25 feet.

Speculating on the origin of the deposit, it seems safe to assume that the manganese was originally deposited as the carbonate rhodochrosite and it is obvious that the present assemblage of silicated manganese minerals is the result of contact metamorphism, while a few are of secondary origin or alteration products. In some of the west of England deposits which have not been subjected to metamorphism the manganese still retains its carbonate form, in part at any rate, though much has been altered to oxide. Examples of this are well seen at three manganese mines in Devonshire: Chillaton and Hogstor mine, Milton Abbot; Scanniclift Copse mine, Doddiscombsleigh; and Stancombe mine, Bovey Tracey. At Haytor iron mine, Ilington, Devonshire, the well-known magnetite beds were likewise almost certainly originally carbonate and, as at Treburland, were intensely metamorphosed by the upheaval of the adjoining Dartmoor granite. Some stress has been laid by the Geological Survey on the fact that many of the west of England manganese deposits have intrusions of greenstone in their immediate vicinity, and in this respect Treburland is no exception, for greenstone outcrops at a very short distance from the workings; there is, however, no evidence that I can see to suggest that there is any connexion between the two.

The following minerals have so far been identified on material obtained from the small dumps, the manganese minerals in particular forming extremely fine specimens. Those marked with an asterisk are from the calc-silicate rock. Of the metallic minerals only magnetite and pyrrhotine are at all abundant. Psilomelane, common in many of the Cornwall and Devonshire manganese mines, appears to be absent.

Rhodonite	Galena	Magnetite	Amphibole
Bustamite	Blende	Quartz	*Garnet (Andradite and Spessartine)
Tephroite	*Pyrrhotine	Calcite	Idocrase
Bementite	Chalcopyrite	Fluorite	*Axinite
Pyrolusite	Malachite	Apatite	*Apophyllite
Rhodochrosite	Pyrite	Albite	Lepidolite
Manganocalcite	Marcasite	Pyroxene	*Chlorite
Molybdenite	*Arsenopyrite	*Wollastonite	

*Rhodonite.*

The mineral is extremely abundant, forming the greater proportion of two of the small dumps, and loose masses are also to be found everywhere scattered over the surface in the proximity of the workings. It forms large very hard crystalline somewhat rounded blocks externally altered to a thin black crust of pyrolusite, the blocks being in the exact condition in which they lay loosely in the bed. It varies in texture from fine-grained to very coarse in which the crystal cleavages  $m$  (110) and  $M$  ( $1\bar{1}0$ ) sometimes attain a length of  $6\frac{1}{2}$  cm. This very coarse rhodonite consists of interlocked cleavages with markedly curved surfaces, the colour varying from rose-pink to brownish-pink, while towards the exterior of the masses an interesting stage in alteration is shown—the pink colour has almost disappeared and the mineral, though retaining its translucency, has become nearly colourless with a fibro-lamellar structure, the successive surfaces of the cleavages and the minute transverse cracks being coated with brown and black films of pyrolusite. In another beautiful variety, which is rare, the component rose-pink cleavage crystals have assumed a definite radiating and somewhat fibrous form. The colour of the finer-grained mineral, which is by far the most abundant, varies from pale pink through various shades to deep vinaceous, some possessing a most unusual and beautiful purplish vinaceous tint which, as far as I am aware, is peculiar to this locality. Large slabs of all the varieties and particularly of the latter, measuring up to  $10 \times 7$  inches which have been sliced and polished, form extremely beautiful specimens; the purplish vinaceous groundmass showing here and there faint purplish-grey patches, while traversed in all directions by infiltration veinlets of black pyrolusite from which spread stains of light brown. Towards the margin of many of the masses the rhodonite passes into brown tephroite, the fine-grained rhodonite also including large cleavage crystals of tephroite; others consist of a brown to slightly pinkish coarsely crystalline intimate mixture of rhodonite, bustamite, and tephroite, while in others again the rhodonite is intergrown with fine-grained pale-green pyroxene. In some of the Treburland rhodonite, but not all, the beautiful pink colour of the freshly fractured surfaces tends to become slightly brownish on exposure to light, likewise the greenish colour of the fine-grained pyroxene intimately associated with the rhodonite becomes a nondescript greyish-brown.

Rarely joints in the crystalline mineral are covered with small, definite, though for the most part cleaved and interlocked crystals which attain a length of 7 mm.; this being the first locality in Great Britain which has afforded crystallized rhodonite. The crystals, which are pale pink and sometimes quite transparent, resemble in habit very acute rhombohedra. They are simple combinations of  $m$  (110),  $M$  ( $1\bar{1}0$ ), and  $k$  ( $\bar{2}21$ ) (fig. 1) and thus closely resemble one of the acute types of crystals from the Harstig mine, Pajsberg, Sweden, figured by G. Flink.<sup>1</sup> The faces  $m$  (110) with their perfect cleavage and pearly lustre are usually upper-

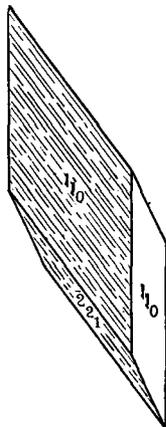


FIG. 1. Crystal of rhodonite from Treburland manganese mine, Cornwall.

<sup>1</sup> G. Flink, Zeits. Kryst. Min., 1886, vol. 11, pl. 9, fig. 29.

most; those of  $M$  ( $\bar{1}\bar{1}0$ ) and  $k$  ( $\bar{2}21$ ) are deeply striated parallel to their mutual intersections from repetition of the two forms. In consequence of the repetition striae a certain amount of rounding results and the  $m$  (110) cleavage face more often than not presents a canoe-shaped outline. On one specimen the faces of ( $\bar{1}\bar{1}0$ ) and ( $\bar{2}21$ ) are curiously plated with a thin film of brassy pyrite. The angles obtained from the measurement of two minute but uncleaved crystals are (110) : ( $\bar{1}\bar{1}0$ ) =  $92^{\circ} 28'$  and ( $\bar{1}\bar{1}0$ ) : ( $\bar{2}21$ ) =  $31^{\circ} 9'$ . The mineral is optically positive, as is to be expected with a lime content of only 7 %; when rich in lime, as in bustamite, it becomes negative. The specific gravity of the pale-pink coarsely crystalline rhodonite from the specimen yielding the measured crystals is 3.57. All of the Treburland rhodonite examined effervesces decidedly with acid. An analysis by Dr. J. A. Smythe on material from the best crystallized specimen is as follows and shows the mineral to be a normal iron-rich rhodonite in which zinc is absent.

SiO <sub>2</sub> .	MnO.	FeO.	MgO.	CaO.	CO <sub>2</sub> .	H <sub>2</sub> O(+).	H <sub>2</sub> O(-).	Total.
46.65	37.00	7.65	1.67	7.00	0.09	0.52	0.05	100.63

The Treburland rhodonite sometimes contains embedded specks of garnet (spessartine), galena, molybdenite, and on joint faces chalcopyrite and traces of malachite.

#### *Bustamite.*

The presence of this mineral was discovered by Professor C. E. Tilley as the result of a visit with me to the locality in 1944 and will be described by him in a separate paper dealing especially with its paragenesis (this vol., p. 236). It occurs intimately associated with both rhodonite and tephroite, and more rarely in nearly pure masses composed of coarse, somewhat fibrous cleavages of a pinkish-buff colour very near the vinaceous-buff of R. Ridgway. The purest and finest specimens were obtained from the ore pocket on the south side of the road, that is, from the workings nearest the granite.

#### *Tephroite.*

Tephroite, though not nearly so abundant as rhodonite, with which it is intimately associated, occurs in considerable quantity. In its purest form it presents very dark-brown fine-grained crystalline masses often bordering rhodonite, there being, however, usually a sharp boundary between the two minerals. More rarely it forms large dark-brown cleavage crystals up to 3 cm. but with no definite outline shape, set in a groundmass of medium-grained pink rhodonite often admixed with pinkish-buff bustamite. In other specimens tephroite forms the groundmass with here and there large cleavage crystals of deep pink rhodonite. Again, there are many large masses of a coarse-grained intimate mixture of rhodonite, bustamite, and tephroite, which vary in colour through shades of pink and brown.

The lustre is greasy and the fracture conchoidal. Under the microscope, the fine-grained tephroite is seen to consist of about equal proportions of translucent pale smoky-brown to yellowish, and opaque almost black particles—this, however, is apparent rather than real, for, when crushed the grains are of a uniform smoky-brown to yellowish colour, the difference while in mass being due to the thickness of the particles on fracture. There are two cleavages at right angles, the prominent one which is often distinct is parallel to (010) and rudely striated,

that parallel to (001) is smooth and much less conspicuous. Tephroite is biaxial and negative, the refractive indices being all about 1.74.  $2V$  is high, about  $60^\circ$ . The specific gravity of the pure fine-grained mineral analysed is 4.07.

The following analysis by Dr. J. A. Smythe shows the mineral to be an iron-rich tephroite in which zinc is absent. In preparing the sample for analysis a very small quantity of rhodonite and pyrolusite was separated by bromoform, the final product being entirely magnetic. The only other element detected was a trace of boron. To Mr. F. A. Bannister I am indebted for a confirmatory X-ray photograph.

SiO <sub>2</sub> .	MnO.	FeO.	MgO.	CaO.	CO <sub>2</sub> .	H <sub>2</sub> O(+).	H <sub>2</sub> O(-).	Total.
29.90	53.26	13.01	1.77	1.57	0.20	0.65	0.07	100.43.

#### *Bementite.*

This mineral is rare at Treburland. It occurs in two ways. As sharply defined parallel veinlets up to 6 mm. across, traversing masses of fairly coarse crystalline rhodonite, the colour being brownish-yellow, the Dresden brown of R. Ridgway. Also hemispherical on joints in rhodonite covered with crystals of that mineral. The hemispheres up to 4 mm. in diameter are formed of radiating translucent brownish-yellow foliae with pearly lustre, thin cleavage flakes being light yellow and transparent. The hemispheres are interspersed between the crystals of rhodonite and little sheets of manganocalcite. One specimen of rhodonite was found which, when broken, shows, on the two halves of an open joint, botryoidal spheres of partially altered bementite. These spheres are chamois-coloured and have become soft, but still retain their foliated radiating structure. Upon them are minute globular crystals of rhodochrosite and some black shining botryoidal pyrolusite, while underlying them are well-defined crystals of rhodonite. Drusy crusts of a white to slightly pink undetermined mineral sometimes coat the spheres of bementite when lining cavities. Bementite is optically negative with a specific gravity of 2.83, which is a good deal lower than that of the Franklin Furnace mineral. It is hoped that it will eventually be possible to collect sufficient pure material for a complete analysis without destroying the few specimens which have so far been found.

#### *Pyrolusite.*

This mineral, which formed the ore worked, occurs as black, shining, rather scoriaceous masses, also earthy sooty-black and brown, and more rarely as glossy black botryoidal aggregates. Much of it appears to result from the alteration of rhodonite and nearly all the larger masses have a core of that mineral.

#### *Rhodochrosite and Manganocalcite.*

Rhodochrosite has been identified on two specimens only in the form of minute  $\frac{3}{4}$  mm. pale pink spheres built up of successive crystal layers forming rosettes, the pole of each being a smooth bright face (0001), and also with these as minute translucent dark brownish-red globules, on crystals of rhodonite with bementite. The specific gravity is 3.51. Manganocalcite is seen to be present, associated with the manganese silicates, in thin sections; more rarely it is visible to the eye in the form of small, practically colourless sheets on the joints showing crystals of rhodonite.

*Other minerals.*

Of the metallic minerals *Molybdenite* is the most interesting. It occurs rarely as minute very bright flakes embedded in the pale pink crystalline rhodonite and also as similar flakes between the basal partings of the coarse brownish-green to brown pyroxene (manganhedenbergite). Embedded flakes of molybdenite have also been noted in the rhodonite from two of the other localities described in this paper. *Galena* occurs rarely as small bright cleavages up to  $2\frac{1}{2}$  mm. embedded in both rhodonite and tephroite. *Blende* has been observed once only in minute quantity on a joint in rhodonite. *Pyrrhotine* is relatively abundant, associated with pyroxene and amphibole, and more particularly in the dark calc-silicate rock. *Chalcopyrite* occurs somewhat rarely in patches, intimately associated with rhodonite, bustamite, and tephroite, and I have one specimen of rhodonite on a joint face of which there are chalcopyrite and traces of malachite with pyrite, marcasite, galena, blende, spessartine, garnet, and idocrase. *Pyrite*, though not abundant, forms small masses composed of rude cubes with quartz; it is also disseminated as specks through the dark calc-silicate rock, &c. *Marcasite* has been identified, on one specimen only, as a thin crust on rhodonite with chalcopyrite, &c. *Arsenopyrite* is rare in the form of tin-white short prismatic crystals (110), (012) up to 3 mm. in length, embedded in dark calc-silicate rock. *Magnetite* occurs as large, very dense, and rather fine-grained crystalline masses streaked here and there with brownish-yellow garnet.

*Fluorite* and *Apatite* are present as minute colourless grains in the aplite veins. Two forms of *pyroxene* have been identified. Diopside as minute pale green crystals in the calcite-garnet-filled vesicles in the calc-silicate rock described under garnet; and in fine-grained pale greenish form intergrown with fine-grained rhodonite, the green colour of this speedily turning to a nondescript brown after exposure to light. Manganhedenbergite as large translucent brownish-green to brown lamellar cleavages measuring up to  $3 \times 1\frac{1}{2}$  cm. It is externally altered to a rusty brown and coated with films of black manganese oxide, films of this permeating both partings and cleavages. The characteristic basal partings are very distinct as also the cleavages on prism and clinopinacoid. Under the microscope the mineral is seen to be full of dark inclusions, and here and there between the partings are numerous minute scales of molybdenite. This pyroxene was determined as being manganhedenbergite by Professor C. E. Tilley and an analysis of it appears in his paper dealing with bustamite and its paragenesis in the pages of this magazine (p. 237). *Wollastonite* forms thin layers in the highly calcareous portions of the calc-silicate rock and good specimens have been obtained showing the usual radiating aggregates of white silky fibres up to  $1\frac{1}{2}$  cm. across, and between which is intergrown yellow garnet. *Amphibole* occurs as blackish-green coarse cleavages associated with pyrite and pyrrhotine, also rarely as fibrous asbestiform bands. A yellow *garnet* definitely referable to spessartine occurs in the form of very small clear honey-yellow conchoidal fractured aggregates embedded in the pale pink crystalline rhodonite; and also as small sparkling honey-yellow to dark yellowish-brown crystals covering the surface of somewhat altered pyroxene (manganhedenbergite). These crystals, which attain a diameter of 1 mm., are simple but very unsymmetrical trapezohedra (211) the faces of which, though extremely bright, are mostly deeply striated

parallel to (110) from oscillation with that form. One of the dumps yields a banded dark grey contact-altered calc-silicate rock full of cinnamon-coloured garnet which has the characters of a calcium-iron-manganese-andradite. This garnet is present both as strings and in vesicles averaging 5 mm. in length, elongated in the direction of the foliation of the rock. The vesicles, in addition to garnet, usually contain calcite and more rarely diopside, apophyllite, and chlorite, and, when calcite-filled, both garnet and diopside have been able to form minute but definite crystals. There also occur considerable bands almost entirely composed of this brownish to cinnamon-coloured garnet, the joints of which are covered with small bright flattened trapezohedra associated with axinite. *Idocrase* is rare; it occurs with wollastonite and pyrrhotine as long columnar brownish-yellow prisms up to  $6\frac{1}{2} \times \frac{1}{2}$  cm. embedded in dark grey calc-silicate rock, also in one case as smaller prismatic aggregates with spessartine, &c., directly on rhodonite. *Axinite* is not very common, but one or two masses were obtained showing layers of large dark violet-brown shining lamellae up to 3 cm. in length, associated with lepidolite in rusty bands of the calc-silicate rock; also one specimen in which the axinite is associated with small trapezohedra of cinnamon-coloured garnet. An analysis of this axinite would be interesting, as it may well be sufficiently rich in manganese to be classed as a manganaxinite. The occurrence of *Apophyllite* has already been mentioned under garnet and is one of the minerals identified as occupying the vesicles in a peculiar form of calc-silicate rock. It forms colourless (001) cleavages with iridescent pearly lustre and is associated with calcite, &c. *Lepidolite* forms very fine-grained lavender-coloured patches, which under the microscope are seen to consist of very minute scales, and is associated with white felspar. It occurs both in the calc-silicate rock and in the aplite, or rather at the contact of the two, and exactly resembles the lepidolite which is found under similar conditions at Meldon, Okehampton, Devonshire, both in the aplite quarry and in the Southern Railway quarry.

#### PENCREBAR MANGANESE MINE, CALLINGTON, CORNWALL.

(Six-inch Ordnance map, Cornwall, 29 SW., 1907.)

It is rather remarkable that collections of British minerals have never contained really showy specimens of rhodonite, although the locality about to be described has been known for nearly 150 years and has yielded specimens equalling both in beauty and size any that have been found either in Russia or elsewhere. The locality is situated on the main Callington to Liskeard road,  $1\frac{1}{4}$  miles south of Callington, just in Pencrebar South Wood where it abuts on the road. Manganese (pyrolusite) was worked here prior to 1800 from pits a few feet deep in hard bands of chert containing much red jasper in Culm Measure slate. From the Philip Rashleigh collection I have a polished specimen of rhodonite obtained from here about the year 1800. John Mawe visited the locality about the year 1816, and James Sowerby in his *British Mineralogy* (1817) figures a specimen of rhodonite given to him by Mawe, who also supplied a description of the occurrence.<sup>1</sup> Mawe says he obtained many beautiful specimens, equalling the Siberian, from masses over a foot in size, at a depth of about six feet from the surface. The locality is

<sup>1</sup> J. Sowerby, *British mineralogy*. 1817, vol. 5, pp. 253-254, plate 536.

called Creva Wood by T. Hogg in his *Minerology of Cornwall* 1825,<sup>1</sup> and is referred to as a manganese quarry  $1\frac{1}{2}$  miles south-west of Callington by W. Phillips in his *Minerology* (1823);<sup>2</sup> and as a manganese quarry  $1\frac{1}{2}$  miles south-east of Callington by R. P. Greg and W. G. Lettsom (1858).<sup>3</sup> Connected with shallow workings in the wood, an adit level which is still open enters from the road-side and from the mouth of this in 1931 and subsequently I have removed very large masses of rhodonite, one measuring  $2 \times 2 \times 1$  feet and weighing over 2 hundredweights. These on being sliced and polished have yielded magnificent slabs of mottled light and dark rose-pink rhodonite with irregular patches of deep greyish-olive chert: some specimens also show small blotches of orange-cinnamon-coloured rhodonite in the pink mineral, the contrast of tints being extremely beautiful. For the most part the mineral has a uniform very fine-grain and appears exceedingly pure save for an external coating of pyrolusite and sometimes infiltration cracks filled with that mineral. Very rarely minute flakes of molybdenite and crystals of chalcopyrite occur embedded in the rhodonite. The freshly fractured surfaces of the Pencrebar rhodonite do not tend to become brownish on exposure to light. It seems quite probable that the mineral is present here in sufficient quantity and at such shallow depth as to be worth working for ornamental purposes.

#### LIDCOTT MANGANESE MINE, LANEAST, CORNWALL.

(Six-inch Ordnance map, Cornwall, 16 NW., 1907.)

This interesting old mine is situated on the north-east edge of Laneast Downs, 360 yards south-east of Lidcott farm in the parish of Laneast. It had been at work for many years prior to 1826, in which year it was taken over by the Lidcott Manganese Company.<sup>4</sup> In 1830 the mine was described by Henry S. Boase, who gives a brief but interesting account of it.<sup>5</sup> He states that it had been a profitable undertaking and the workings were then 20 fathoms deep, the ore being confined to a siliceous bed striking north-east and having a width of about 12 fathoms. This bed is enclosed in black shales and purple- and chocolate-coloured grits belonging to the Lower Culm Measures. The ore consists of pyrolusite with rhodonite and rhodochrosite and lies in pockets and strings in hard chert. The earliest working consisted of a large cavern-like excavation with many ramifications, open to the day, and which is still accessible and well exhibits the nature of the deposit. Later it was worked by shafts, of which there are several, communicating with an adit-level opening from the stream bottom to the north-east. The mine was last worked between the years 1875 and 1881 in conjunction with Westdownend farther to the north-east. From one of the overgrown dumps I obtained in 1936, and subsequently, several large blocks of rhodonite associated

<sup>1</sup> T. Hogg, *A manual of mineralogy*; in which is shown how much Cornwall contributes to the illustration of the science. First edition, Truro, 1825, p. 88.

<sup>2</sup> W. Phillips, *An elementary introduction to the knowledge of mineralogy*. Second edition, 1819, p. 184.

<sup>3</sup> R. P. Greg and W. G. Lettsom, *Manual of the mineralogy of Great Britain and Ireland*. 1858, p. 294.

<sup>4</sup> H. English, *A compendium of useful information relating to the companies formed for working British mines*. 1826, pp. 40, 41, 43, 105, 106.

<sup>5</sup> H. S. Boase, *Contributions towards a knowledge of the geology of Cornwall*. *Trans. Roy. Geol. Soc. Cornwall*, 1832, vol. 4, p. 233.

with rhodochrosite, grey chert, and chocolate-coloured grit, which on being sliced and polished have yielded handsome specimens. The rhodonite is rose-pink and fine-grained with rather coarser patches of an orange-cinnamon colour, and is intimately intergrown with areas of paler pink rhodochrosite showing distinct and much coarser cleavage, both minerals sometimes containing blebs of glassy quartz, while ramifying through the grit there are veinlets of nearly white manganocalcite. The specific gravity of the rhodochrosite is 3.6, and it is completely soluble in acid. It may here be mentioned that the depth of the pink colour shown by rhodochrosite and manganocalcite affords no criterion of the high or low manganese content, for it is found that the very slightly pinkish or pinkish-brown mineral is often true rhodochrosite, accepting 50 % of manganese carbonate as being the dividing line between the two minerals. As P. Krieger, however, has shown,<sup>1</sup> both the specific gravity and refractive index mount with the increase of manganese and thus afford evidence as to whether the mineral shall be classed as manganocalcite or rhodochrosite. The Lidcott rhodochrosite becomes somewhat yellowish-brown on exposure to light, and it is probably owing to admixture with this mineral that the rhodonite from Treburland and Week have the same tendency. The only other minerals observed on the dumps are quartz and a little pyrite.

HIGHER TRUSCOTT MANGANESE MINE (WHEAL TRUSCOTT), ST. STEPHENS  
BY LAUNCESTON, CORNWALL.

(Six-inch Ordnance map, Cornwall, 16 NE., 1907.)

Manganese, in the form of pyrolusite, was extensively worked close to the hamlet of Higher Truscott in the early part of the last century, and in more recent times returns of manganese ore from here are given under the heading of St. Stephens by Launceston. Thomas Spargo reports in 1865 that an adit was being driven to cut the lode, which looked well; in 1868 he mentions the adit being 20 fathoms deep, but the mine abandoned. The last working seems to have been in 1876-1877 when the official returns are given as 540 tons of brown haematite, of which 400 tons contained 15% of manganese. This so-called brown haematite was probably magnetite. Very little evidence now remains to indicate the site of the former operations and it is only within the last two years that I have been able definitely to locate the spot, which lies directly north-east of Higher Truscott hamlet and between it and the north end of Cannapark Wood. Here, as the result of the recent ploughing up of the pasture field nearest Higher Truscott, depressions in the ground, caused by subsidence, were exposed, surrounded by considerable quantities of pyrolusite with quartz, clearly the result of mining operations, while a little farther north-east in the north end of Cannapark Wood there are remains of old workings or rather dumps which contain magnetite with pyrite and some pyrolusite evidently from a bedded deposit. At 600 yards to the south and close to the railway there is a large quarry-like excavation which is marked on the six-inch map as Higher Truscott mine. No manganese is to be seen here and the working suggests that it was limestone which was quarried. Though no longer visible, there is some evidence of an adit-level having been driven from this excavation north, either to the manganese workings or to Cannapark limestone

<sup>1</sup> P. Krieger, Amer. Min., 1930, vol. 15, pp. 23-29. [M.A. 4-274.]

quarry. The manganese deposit at Higher Truscott is probably a bedded one and in part very quartzose; whether the magnetite occurs in the same bed or in another it is impossible to say. The enclosing rocks are Lower Culm chert, shales, and grits, with a sheet of lava and limestone in the immediate vicinity. It was here that the best British specimens of crystallized pyrolusite were found, of which I have a fine series from the old collection of Edmund Pearse (1788-1856), surgeon of Tavistock. Rhodonite also apparently occurred, for I have a more recent specimen showing the pale pink very fine-grained mineral in grey quartzose chert, labelled 'Manganese deposit, no. 2, quartz vein approaching the deposit, St. Stephens by Launceston'.

Half a mile north of Higher Truscott and directly adjoining Langore hamlet on the south there are some old completely overgrown manganese workings with an adit-level leading up to them from the stream to the west. There is also in this parish, in a meadow on Athill farm a mile south of Egloskerry (six-inch Ordnance map, Cornwall, 16 NW.), an old adit-level now completely blocked and with no dump, which was, however, evidently driven for manganese and where I have found traces of pyrolusite.

#### ST. MARY MAGDALENE, LAUNCESTON, CORNWALL.

(Six-inch Ordnance map, Cornwall, 16 SE. and 17 SW., 1907.)

The earliest published reference to the occurrence of rhodonite in the British Isles is that given by Dr. J. F. Berger in the Transactions of the Geological Society, London, 1811, ser. 1, vol. 1, p. 172, in which he states that the pink siliciferous oxide of manganese, the same variety that is found in the mines of Nagyag in Transylvania, is worked at St. Mary Magdalene, a mile south of Launceston. Berger states that he was informed of this and it is clear that he had not personally visited the locality, the location of which, despite many inquiries, I have so far failed to find. It seems very improbable that rhodonite has ever been used as a source of manganese in the British Isles.

#### GREYSTONE WOOD MANGANESE MINE, LEZANT, CORNWALL.

(Six-inch Ordnance map, Cornwall, 23 NW., 1907.)

This small mine is situated four miles south-east of Launceston in the parish of Lezant and was worked from 1877 to 1880, when it produced about 150 tons of manganese ore (pyrolusite) valued at £150. It was reopened for a short time in 1907 when a little exploratory work was done, but no ore raised. It appears to be a bedded deposit of the usual type, the enclosing rock being Culm Measure chert and slate with intrusions of greenstone in the proximity. The ore is principally pyrolusite with some rhodonite. The rhodonite is pale pink and very fine-grained, much admixed and veined throughout with quartz and chert, and occasionally includes specks of chalcopyrite. In acid it effervesces strongly, indicating a good deal of carbonate. Masses of this pale pink rhodonite may still be found, though not abundantly, on the most recent dump at the lower end of the wood. In the Geological Survey Memoir (1911), under the output of minerals, Greystone Wood manganese mine is credited as having produced, in addition to manganese ore, a few hundredweights of lead. This galena was, however, from

the neighbouring lead mine of North Wheal Tamar or Greystone silver-lead mine and not from the manganese mine, as reference to the official returns for 1879 will show.

#### SYDENHAM AND LEE WOOD MANGANESE MINE, MARYSTOW, DEVONSHIRE.

(Six-inch Ordnance map, Devonshire, 87 SW., 1907.)

This small mine was worked under the management of Thomas Small of Sydenham House in 1870–1871, when it produced 117 tons 11 cwt. of manganese ore in the form of pyrolusite, valued at £375. 13s. 6d. In 1914 the adit and shaft were cleared with a view to reworking, but nothing further was done. The deposit is of the usual bedded type, in Lower Culm chert, there being an intrusion of greenstone in the immediate vicinity. Rhodonite is abundant as pink very fine-grained masses in dove-grey chert much veined with quartz. Some of the masses when polished are beautiful, their colour a mottled pale pink to purplish vinaceous with small cinnamon-coloured patches and an outer ring and inroads of black pyrolusite. It shows decided effervescence with acid. Minute specks of molybdenite are occasionally embedded in it.

#### ALLERFORD MANGANESE MINE, MARYSTOW, DEVONSHIRE.

(Six-inch Ordnance map, Devonshire, 87 SW., 1907.)

This mine, which is not shown on the six-inch Ordnance map, is situated on the south bank of the stream 540 yards a little south of west of Allerford farm-house. It is evidently a bedded deposit in the Lower Culm chert and was worked from the year 1868 to 1873 by Charles, John, and Frederick Sims of Calstock.<sup>1</sup> The amount of ore (pyrolusite) produced is not known, as in every year, with the exception of 1872, when it produced 42 tons valued at £5 a ton, the returns were aggregated with the Sims brothers' other mines. The dumps are now completely grown over, but when visited by Mr. Arthur Kingsbury and myself in 1944 we obtained a single but interesting mass in which rhodonite is associated with rhodochrosite. The rhodonite is pale pink and exceedingly fine-grained and is more or less interlaminated with grey or dove-coloured banded chert. Intimately associated with it is pale pink rhodochrosite of comparatively coarse grain and showing well-defined rhombic cleavages, and in one part of the mass forming a distinct veinlet. This rhodochrosite is completely soluble in dilute acid. Both rhodonite and rhodochrosite include many minute blebs of glassy quartz, while the exterior of the mass as usual consists of pyrolusite and a white chalky substance.

#### WEEK MANGANESE MINE, MILTON ABBOT, DEVONSHIRE.

(Six-inch Ordnance map, Devonshire, 97 NE., 1889.)

Rhodonite was recorded as occurring at this locality by the Lysons in their *Magna Britannia*, vol. 6, Devonshire, 1822, p. 269, and I have a specimen from

<sup>1</sup> The Sims brothers, with headquarters at Slimeford, Calstock, Cornwall, were for many years (1860 to 1880) actively engaged in manganese mining in east Cornwall and Devonshire. Besides actually working many of the mines they bought ore from those belonging to others and had a manganese grading and distributing yard at Slimeford, the remains of which still exist. The ore was brought here by carts after having been hand-picked, and, if water permitted, washed, at the mines.

there which was in the old collection of Edmund Pearse, surgeon of Tavistock. On a visit to Week in 1944, in company with Mr. Arthur Kingsbury, we succeeded in locating the old workings, which are not shown by name on the 1907 six-inch Ordnance map, although the old shafts are shown on the 1889 edition. They are situated in three fields some 730 yards south-east of Week farm-house, while in the valley bottom to the south there is an adit-level probably communicating with them. Here large blocks of rhodonite coated with pyrolusite weighing 80 or more pounds may still be found lying loose in the field or built into the field walls, and from these intensely hard masses magnificent specimens may be obtained. The line of old shafts which were sunk in chert belonging to the Lower Culm extend in a north-easterly direction, but it is only at the southern end that rhodonite is to be found. At a short distance to the east the chert is overlain by the Brent Tor lava. The rhodonite has a beautiful uniform rose-pink colour and is for the most part fine-grained crystalline usually breaking with a somewhat slaty or bedded structure. When polished it has a decidedly wavy appearance with alternating bands of pale and dark pink. It is often traversed by bands of blue-grey chert or prettily veined with dendritic pyrolusite which enhances its appearance, while here and there it has small included patches of colourless glassy quartz in which and bounding which the rhodonite has formed definite crystals up to 4 mm. in length. These, though not isolated, show canoe-shaped cleavage faces of  $m$  (110) and striated faces of  $M$  ( $1\bar{1}0$ ). The rhodonite from this locality, like that of Treburland, has a tendency to become slightly brown on the surface after exposure to light; polished surfaces are, however, not affected. The only associated minerals so far observed are minute embedded specks of galena, chalcocopyrite, and pyrite.

#### DOUBTFUL AND UNSUBSTANTIATED LOCALITIES FOR RHODONITE IN CORNWALL AND DEVONSHIRE.

Rhodonite, or minerals assumed to be rhodonite, have been recorded from the following additional localities in Cornwall and Devonshire; in each case, however, the reported occurrence is either very doubtful or manifestly wrong.

Thomas Hogg writing in 1825 gives, in addition to Creva Wood (Pencrebar), three other localities for 'red oxide of manganese' as distinct from his 'silicate of manganese'; these are Indian Queens, Veryan, and Trebartha.<sup>1</sup> The red oxide of manganese of these early writers is an ochre-red oxide of iron (haematite) coating botryoidal pyrolusite or psilomelane, specimens of which occur in several of the manganese mines near Brent Tor, Devonshire, especially at the Monkstone mine. J. H. Collins in his *Handbook to the mineralogy of Cornwall and Devon* (1871), evidently using Hogg as a source of information, repeats the three last localities as doubtful sources of rhodonite.<sup>2</sup>

*Indian Queens or Ruthvoes iron and manganese mine, St. Columb Major, Cornwall* (six-inch Ordnance map, Cornwall, 40 NE., 1907).—This old mine is on a true lode in slate (killas) within the metamorphic aureole of the neighbouring granite. There is no evidence, however, that any of the few minerals contained

<sup>1</sup> T. Hogg, *A manual of mineralogy*; in which is shown how much Cornwall contributes to the illustration of the science. First edition, Truro, 1825, p. 88.

<sup>2</sup> J. H. Collins, *Handbook to the mineralogy of Cornwall and Devon*. 1871, p. 88.

in it are the result of metamorphism. It was probably the first manganese mine to be worked in Cornwall, for the Rev. William Borlase, writing in 1758, says that it had then been recently discovered.<sup>1</sup> Part of this mine is now (1944) still at work as a source of red ochre for iron-oxide paint, and a good deal of manganese in the form of pyrolusite, with a little psilomelane, is still met with in pockets. I have, however, never seen a trace of rhodonite nor does its occurrence seem likely here.

*Pendower, Veryan, Cornwall* (six-inch Ordnance map, Cornwall, 65 SE., 1907).—At several spots on Pendower beach the cliff section shows curious but not very continuous beds of earthy black pyrolusite resting on a pebble bed (raised beach) with slaty chert above and below and in the immediate vicinity bands of impure limestone. We learn from the Rev. S. J. Trist, the vicar of Veryan, who wrote in 1818, that about the year 1816 this manganese was actually worked for a year or so.<sup>2</sup> I have examined this beach section carefully, but could find no other manganese mineral save pyrolusite.

*Tremollett manganese mine, North Hill, Cornwall* (six-inch Ordnance map, Cornwall, 22 SE., 1907).—Trebatha evidently refers to the old manganese mine which belonged to Colonel Francis Rodd of Trebatha Hall, a series of specimens of pyrolusite and psilomelane from which were contributed by him and his son the Rev. Edward Rodd to the Philip Rashleigh collection about the year 1800 and are described in the MS. catalogue of that collection. This mine I have definitely identified as being that of Tremollett, situated on the road-side between Middle and West Tremollett, North Hill. The dump is shown on the six-inch map but no name given. In 1874 the mine was again at work under the name of Coads Green manganese mine. The adit dump and also a shaft in the field on the opposite side of the road are still visible but almost completely grown over. I have found both pyrolusite and psilomelane here in abundance, but no rhodonite. In the old collection of minerals formed by Thomas Stewart Traill, M.D. (1781–1862), now preserved in the Geology department of Liverpool University, there is a good specimen of rhodonite, no. 2291, the Traill catalogue entry of which reads 'Silicated oxide of manganese, pink-coloured compact. Rodd's mine, near Launceston, Cornwall'. It may be added that Treburland is in the same neighbourhood, but as far as I can ascertain it never belonged to the Rodd family.

*West Down End manganese mine, Egloskerry, Cornwall* (six-inch Ordnance map, Cornwall, 16 NW., 1907).—According to the Geological Survey rhodonite occurred with wad in the neighbourhood of this mine in veins and lenses in Culm Measure radiolarian chert.<sup>3</sup> A very careful search on the dumps of this mine has failed to substantiate the occurrence.

*Lewannick Hill, Lewannick, Cornwall* (six-inch Ordnance map, Cornwall, 16 SW., 1907).—This also is given as a locality for rhodonite by the Geological Survey, the mineral being said to have been found in trial holes on a vein in Upper Devonian slate overlain by lava.<sup>4</sup> Every local endeavour to find the spot has failed, neither has reference to the original MS. six-inch geological map

<sup>1</sup> Rev. W. Borlase, *The natural history of Cornwall*. 1758, p. 130.

<sup>2</sup> Rev. S. J. Trist, *Notes on the limestone rocks in the parish of Veryan*. *Trans. Roy. Geol. Soc. Cornwall*, 1818, vol. 1, p. 112.

<sup>3</sup> *Mem. Geol. Survey, Special Reports on the Mineral Resources of Great Britain*, vol. 1. *Tungsten and manganese ores*, 1915, p. 45.

<sup>4</sup> *Ibid.*, p. 45.

afforded any confirmation. Records of this kind, unsupported by specimens of the mineral, are, to say the least of it, most unsatisfactory.

*St. Cleer, Cornwall* (six-inch Ordnance map, Cornwall, 28 SW., 1907).—In the Memoirs of the Geological Survey, *The Geology of the country around Tavistock and Launceston*, 1911, p. 77, in the description of the calc-silicate rocks in the metamorphic aureole near St. Cleer, mention is made of 'a pink mineral in the calcareous layers which has the cleavage of pyroxene and is apparently rhodonite', and it goes on to say that the same mineral had been met with at other localities near the outer margin of the aureole of metamorphism. Dr. J. Phemister, at my request, has most kindly examined the rock specimen and section on which the statement was based and reports that the rock contains no manganese, neither does the mineral conform with rhodonite in its optical properties.

*Chillaton and Hogstor manganese mine, Milton Abbot, Devonshire* (six-inch Ordnance map, Devonshire, 97 NW., 1907).—This mine has been worked somewhat extensively at intervals between 1858 and 1907, and the aggregate of its production is greater than that of any other manganese mine either in Cornwall or Devonshire. The ore is pyrolusite with some psilomelane and rhodochrosite passing into manganocalcite, and occurs in beds and pockets in Lower Culm chert with intrusions of greenstone in the vicinity. The Geological Survey have stated that 'the larger masses of ore (pyrolusite) contain little kernels of pink rhodonite'.<sup>1</sup> This I have been unable to substantiate, despite careful search, and it seems probable that the rhodochrosite was mistaken for rhodonite. The rhodochrosite does form a nucleus to masses of pyrolusite and has a dull brownish-pink colour with quite coarse cleavage faces.

*Black Down, Mary Tavy, Devonshire* (six-inch Ordnance map, Devonshire, 97 NE., 1907).—William Phillips, in 1819, recorded rhodonite as occurring here of a pale rose-red and brownish-black colour with crystals of quartz in its cavities and associated with pyrolusite,<sup>2</sup> and there are two old specimens answering to this description, labelled Black Down, in the Museum of Practical Geology. The locality is vague, there being no manganese workings actually on Black Down as far as I can ascertain, and it seems quite probable that Week mine, not far distant, was the source.

*Upton Pyne manganese mine, Exeter, Devonshire* (six-inch Ordnance map, Devonshire, 68 SW., 1907).—R. P. Greg and W. G. Lettsom (1858) give this mine as a locality for rhodonite.<sup>3</sup> No specimens of the mineral from here are known to me, neither have I been able to find any at the old workings.

In conclusion, it may be mentioned that there are four other localities in the British Isles at which rhodonite has been found, including one which will be described in a future paper. These are: Nant manganese mine, Llanfaelrhys, Rhiw, Carnarvonshire, where it was found by myself associated with ganophyllite, &c., in 1911; and at the neighbouring Benallt manganese mine, where it was lately found by Dr. W. Campbell Smith; at Balvraid, Gleann Beag, Glenelg, Inverness-shire, where it was found by Professor C. E. Tilley in 1937 with

<sup>1</sup> Mem. Geol. Survey, Special Reports on the Mineral Resources of Great Britain, vol. 1. Tungsten and manganese ores, 1915, p. 46.

<sup>2</sup> William Phillips, *An Elementary Introduction to the knowledge of mineralogy*. Second edition, 1819, p. 184.

<sup>3</sup> R. P. Greg and W. G. Lettsom, *Manual of the mineralogy of Great Britain and Ireland*. 1858, p. 294.

pyroxmangite<sup>1</sup> in a garnet-grunerite-schist; and lastly a mineral, possibly rhodonite, which Sir Charles Lewis Giesecke describes as 'red manganese-ore of a rose-red colour', which he found loose in 1826, near Gartan and Glenties, Co. Donegal.<sup>2</sup>

My thanks are especially due to Dr. J. A. Smythe for his ready and most valuable help in performing the chemical analyses, and also to Mr. Arthur Kingsbury for accompanying me to certain of the localities, and to Professor C. E. Tilley for the interest he has shown in the minerals concerned.

<sup>1</sup> C. E. Tilley, Pyroxmangite from Inverness-shire, Scotland. *Amer. Min.*, 1937, vol. 22, pp. 720-727. [M.A. 6-528.]

<sup>2</sup> Sir C. L. Giesecke, A descriptive catalogue of a new collection of minerals in the Museum of the Royal Dublin Society, to which is added an Irish mineralogy. 1832, p. 251.

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