

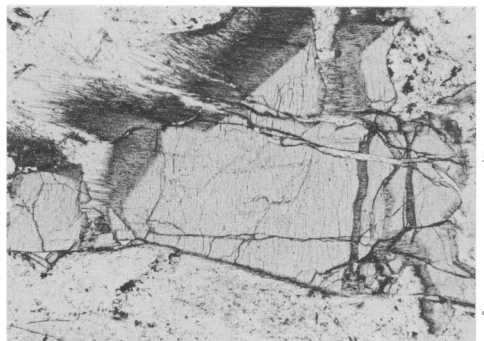
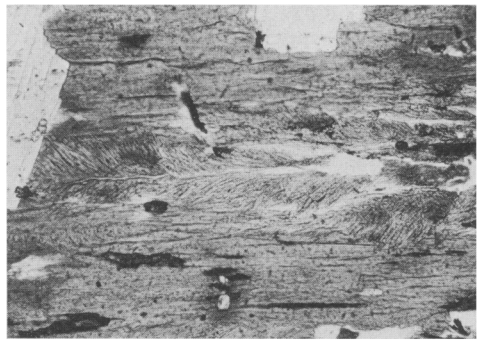
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Luxullianite *in situ* within the St. Austell granite, Cornwall

LUXULLIANITE has long been regarded as a petrological curiosity, unique to its type locality at Luxulyan, near St. Austell. Distinctive in appearance, it consists of pink alkali feldspar phenocrysts in a black groundmass of tourmaline and quartz, and is characterized texturally by radiate 'suns' of acicular tourmaline. Previous descriptions, however, relate exclusively to loose boulders of luxullianite found in fields (e.g. Bonney, 1877; Wells, 1946). Examples of superficially similar tourmalinized rocks have been described *in situ* in other localities (e.g. Blyth, 1949), but these lack the fine acicular tourmaline developed in luxullianite *sensu stricto*.

This note reports the discovery of several veins of luxullianite currently exposed *in situ* in a granite quarry near Luxulyan, both in the working face and in the quarry floor. The veins take the form of vertical sheets within the granite, and range from a few centimetres to about one metre in thickness. Their SW.-NE. orientation corresponds with local joint directions. One of the largest luxullianite veins is laterally discontinuous, dividing into three parallel veins with a total thickness of 2 m, before reuniting into a single vein that narrows and disappears altogether. The total length of this vein system, exposed as quarrying progressed, was about 25 m. The contacts between luxullianite and granite are gradational, and it is clear from field and microscopic evidence that the luxullianite results from metasomatic alteration of granite *in situ*, and not from the emplacement within the granite of a late stage magma.

For the first time it has been possible to examine petrographically the material that is transitional between luxullianite and its parent granite, and to observe the intermediate stages of progressive tourmalinization. The unaltered granite adjacent to the veins contains phenocrysts of white orthoclase microperthite up to 3 cm in length, with equigranular oligoclase, biotite, muscovite, brown tourmaline, and quartz as the other major constituents. The luxullianite consists of pink orthoclase, quartz, muscovite, chlorite, a little topaz and pyrite, and blue acicular tourmaline needles both in radiate (tourmaline sun) configuration and as overgrowths upon primary brown tourmaline.



FIGS. 1-3: FIG. 1 (top). Tourmaline needles forming upon biotite cleavage flake. FIG. 2 (centre). Feather-like development of tourmaline along cleavage plane of biotite. FIG. 3 (bottom). Oriented overgrowth of secondary tourmaline needles upon primary brown tourmaline. (c-axis horizontal.)

Particular interest lies in the mineralogical changes taking place across the transition zone. In passing from granite to luxullianite, over a zone about 0.25 m wide, the following processes were observed:

Transitional rock showed progressive reddening of the alkali feldspars, caused by minute specks of iron oxides within the feldspar crystals. At the same time, replacement of both alkali feldspar and plagioclase by tourmaline and quartz was taking place, with new tourmaline appearing around their margins and along their cleavage planes. As a result of this latter process, most of the K-feldspar phenocrysts were reduced to smaller, corroded fragments in optical continuity, while the plagioclase crystals, which originally were much smaller and fewer, seem to have been completely eliminated in favour of tourmaline and quartz. Along the cleavage planes of the biotite crystals, the growth of radiating acicular tourmaline (figs. 1 and 2) began with the appearance of minute blue tourmaline needles (less than 0.1 mm in length). Eventually the biotite became converted entirely to blue tourmaline of radiate and feather-like habit, associated in some specimens with chlorite, and surrounded by quartz. Existing brown tourmaline crystals became fringed with secondary blue tourmaline needles, growing in optical alignment with the primary phase (fig. 3). Muscovite, primary tourmaline, and accessories such as apatite, zircon, and opaque iron oxides remained stable throughout, while quartz appears to have recrystallized around the secondary tourmaline.

From the present study of *in situ* relationships, it has been possible to reconsider previous petrographic interpretations (Bonney, 1877; Wells, 1946). However, it should be noted that neither of these authors had seen the parent rock. Bonney suggested that the large *brown tourmaline* crystals

in luxullianite were derived by replacement of biotite, while Wells envisaged brown tourmaline instead of biotite as a primary constituent of the parent material. The parent granite here under consideration contains biotite in addition to primary brown tourmaline, and the former mineral may be seen in the process of conversion not to brown tourmaline, but directly to the acicular blue variety. According to Bonney, the *acicular blue tourmaline* was formed from feldspar, liberating free silica in the process. Wells, however, proposed that some of the secondary blue tourmaline was formed by replacement of primary tourmaline (evidenced by corrosion of primary tourmaline and parallel optical alignment of the two tourmaline phases). The parent and transitional material examined in the present study contains primary tourmaline as irregular in outline as that in the luxullianite. Therefore, no corrosion during tourmalinization need be invoked to explain its present embayed shape. The alignment of the secondary phase parallel to the *c*-axis of the primary (fig. 3) may be considered comparable with the type of overgrowth seen in sedimentary authigenic tourmalines (as described by Krynine, 1946). Hydrothermal overgrowth upon existing tourmalines appears to have caused the chemical differences between inner and outer zones of large tourmaline crystals, reported by Power, 1968.

Chemical changes, determined in the whole rocks by X-ray fluorescence and tabulated in Table I, differ from those inferred by previous authors. Both Wells and Bonney assumed an increase in silica with tourmalinization; Wells proposed removal of K and Na, and Exley and Stone (1964), referring in general terms to the Cornubian Province, stated that K was displaced during tourmalinization. In the present investigation, it was possible to analyse four samples, namely unaltered St. Austell granite (LX 001), outer

TABLE I. *Partial chemical analyses*

	LX 001	LX B1-3	LX B4-6	LX 008		LX 001	LX B1-3	LX B4-6	LX 008
SiO ₂	69.38	69.46	62.50	53.89	Sr	82	80	88	156
Al ₂ O ₃	14.05	14.73	18.69	19.21	Rb	469	807	971	672
TiO ₂	0.36	0.30	0.38	0.45	Zr	156	122	150	189
Fe ₂ O ₃ *	2.53	1.60	2.20	8.81	Nb	24	17	18	21
MnO	0.06	0.01	0.01	0.07	Y	29	16	35	30
MgO	0.61	0.27	0.40	1.47					
CaO	1.00	0.23	0.19	0.34					
Na ₂ O	3.37	0.42	0.57	1.11					
K ₂ O	4.57	11.15	13.43	9.81					
P ₂ O ₅	0.17	0.12	0.11	0.17					
	96.10	98.30	98.48	95.33					

LX 001 unaltered granite; LX B1-3 transition zone; LX B4-6 advanced transition zone; LX 008 luxullianite. Major oxides %; trace elements ppm.

* Total iron as Fe₂O₃.

transition zone (LX B1-3), inner transition zone (LX B4-6), and luxullianite (LX 008). From the results of the partial chemical analyses shown in Table I, it may be seen that about 15% silica by weight is lost in the transition from granite to luxullianite, and that aluminium and iron constitute the main additions to the system. Based on the behaviour of K and Na, an alkali exchange mechanism is proposed, that results in a net increase in K at the expense of Na.

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*Department of Mineralogy
British Museum (Natural History)
Cromwell Road, London SW7*

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CAROL J. LISTER

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Improved sample preparation for fluid inclusion studies

IN a previous paper (Brumby and Shepherd, 1976) details were given of a method for preparing mineral samples for fluid inclusion studies. Subsequent work indicated that certain improvements were desirable due to the need for thinner specimens, easier polishing, and faster throughput. The method described below is based on the earlier work, and whilst retaining the same principles, has been designed to satisfy the new requirements. It is also considered to be suitably cost effective, employing inexpensive materials, one operator, and a minimum of equipment.

Method. The mineral chips to be examined are placed in 32 mm diameter silicone rubber moulds and coated with Ceemar polyester embedding resin. After this has set at room temperature, the moulds are filled with Araldite epoxy resin (MY 750/HY 956 100:20), which is allowed to harden, again at room temperature. The resulting blocks are then removed from the moulds and cured at 50 °C for at least 1 hour to reduce brittleness. Parallel-sided slices 1.0-1.5 mm thick are cut from the cooled blocks, which are supported in a purpose-designed clamp (Brumby and Shepherd, 1976) fixed to the magnetic chuck of a diamond saw. The slices are then attached to 130 mm diameter duralumin discs with low melting-point Lakeside resin (Type 30C) and ground flat on a Speedfam 12 lapping

machine using 600-mesh carborundum in water. Grinding is continued until sub-surface damage (see discussion) has been removed from all slices. 1200-mesh carborundum is then substituted to provide a pre-polish finish. The required degree of polish is obtained using an optical quality felt lap, charged with zirconium oxide and water, fixed to the original steel lap. As in the grinding process, suitable weights are added to achieve optimum efficiency. The slices are then removed from the duralumin discs by heating to 50 °C on a hotplate, transferred polished side down to plate glass discs, and attached with Lakeside 30C, ground as described above to the correct thickness, polished, and again removed by warming. Finally, paper tissues are used to absorb excess Lakeside resin from the warmed slices.

Discussion. Blocking with epoxy resin is considered necessary as it offers easier handling and orientation of small specimens during sawing, and provides an ideal support for easily cleaved, soft, or friable materials.

Being readily soluble in chloroform, the polyester coating may be dissolved prior to thermometric analysis allowing stress-free removal of the polished mineral slice from its Araldite surround. The solvent also removes any traces of resin, which may later decompose at higher temperatures and