CORDIERITE GRANITE FROM TERIP TERIP, VICTORIA

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Introduction

The occurrence of cordierite granite at Terip Terip (Fig. 1), in the parish of Dropmore, County of Anglesey, is of interest in view of the rarity of this variety of granite (4, p. 241). Cordierite has previously

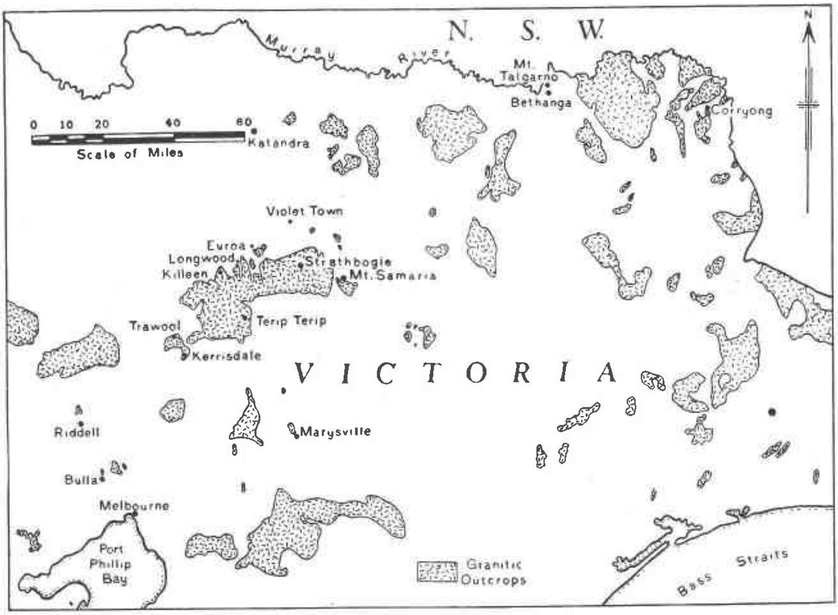

Fig. 1. Sketch map of portion of Victoria (eastern portion), showing granitic outcrops, and localities mentioned in connection with cordierite occurrences.

been recorded in Victorian granitic rocks from Bulla (6, p. 244), Trawool (6), Marysville (3, p. 149) and North-Eastern Victoria. In none of these occurrences is the cordierite developed in such abundance as at Terip Terip.

Description

The Terip Terip granite is light gray in colour and porphyritic. Phenocrysts of orthoclase, up to one and a half inches long, are set in a more or less medium, even-grained base of quartz, orthoclase, oligoclase, biotite and cordierite, as shown in Fig. 2.

The cordierite occurs as abundant bluish-gray patches, with the crystals often 10 mm. long. Most of the cordierite, especially the smaller crystals, has been altered to muscovite, chlorite, and greenish micaceous products regarded as pinite, but in occasional larger crystals, residuals of clear, unaltered cordierite occur within these alteration products. The clear, colourless portions of the cordierite are optically biaxial and negative. Low polarising fibrous aggregates, which occur along cracks in the outer parts of some of these larger crystals, probably consist of serpentine. Some of the pseudomorphs of secondary products developed

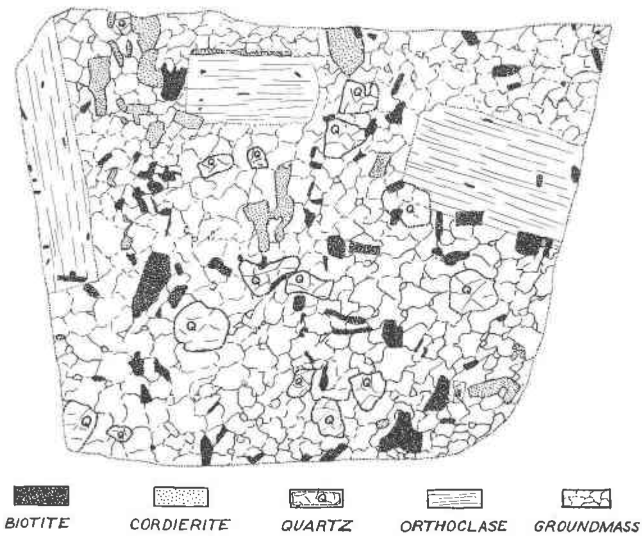

FIG. 2. Sketch of polished specimen of cordierite granite from Terip Terip. (Sketch enlarged one and one sixth times natural size.)

after the cordierite show fibrous, radiate and plumose structures. The alteration commenced around the edges of the crystals, and has penetrated along irregular cracks and poorly defined pinacoidal cleavages. Part of the pale greenish-yellow coloured products along some of the cracks and in the outer zones of larger crystals, is isotropic.

Occasional partially altered, small crystals are pseudo-hexagonal in cross section and show sector twinning, while simple twins are also present in sections parallel to the long axes of the crystals. Small crystals of zircon and apatite are included in the cordierite, and pleochroic haloes produced around the zircons are more pronounced where the cordierite has been altered to secondary products.

The cordierite apparently crystallised prior to quartz and orthoclase, as it is often embayed by these minerals, and where euhedral, it has these later formed minerals moulded around it. Many of the cordierite crystals, however, are anhedral, and their relationships to the other minerals are not clear.

The cordierite-bearing granite from Terip Terip shows other distinctive features in that the quartz is sometimes poikilitic, and sometimes occurs as pools in optical continuity. These pools are more common in the base of the rock, but are occasionally found within the larger cordierite crystals as vermicular growths. The orthoclase is microperthitic, poikilitic, and often cloudy from deuteric alteration, and the oligoclase is partially sericitised. Muscovite occurs as secondary aggregates, radially arranged plates and larger separated flakes. It is common throughout the rock, and often forms the outermost fringe of the altered cordierite crystals.

A Rosiwal micrometric analysis, using 2 mm. traverse intervals across sixteen thin sections of the Terip Terip cordierite granite, shows the main minerals to be present in the following proportions:

TABLE 1

Quartz	29.9%
Orthoclase	34.1
Oligoclase	19.1
Cordierite	6.8
Biotite	6.5
Muscovite	3.6

Except for muscovite, the alteration products of the cordierite were measured in with the cordierite. Biotite and cordierite are present in almost equivalent amounts, while the dominance of orthoclase over plagioclase feldspar indicates that this rock belongs to the granite family. It is a potash rich, two-mica cordierite granite.

The accessory minerals consist of zircon, apatite, ilmenite, rare colourless garnet, and rare purplish-blue fluorite which occurs along the cleavage directions in biotite. Two very rare accessory minerals observed in the heavy mineral suite, but not in thin sections, are tourmaline and anatase. The heavy mineral index number (i.e., the ratio of heavy to light minerals, using bromoform of specific gravity 2.88) is 6, and the specific gravity of the rock is 2.63. The heavy mineral assemblage is composed mainly of biotite.

Comparisons of the Terip Terip Cordierite Granite with Other Occurrences Containing Cordierite in Victoria

In addition to the occurrences of cordierite at Terip Terip, the author has discovered this mineral in the granitic rocks from Longwood, Kerrisdale, Killeen, Euroa, Mt. Samaria, Violet Town and Strathbogie, which are all part of the same mass as the Terip Terip and Trawool granites (Fig. 1). Cordierite also occurs in a tourmaliniferous granite dyke at Katandra, about forty miles north of Euroa.

The nature of the cordierite varies somewhat throughout this large intrusion of granite, which may be designated the Strathbogies Mass. Some of the Longwood occurrences show an apparent lamellar twinning which is absent from the Terip Terip examples. In the Kerrisdale rock, all of the cordierite has been completely altered to pseudomorphs of pinite. The occasional crystals of cordierite in the Trawool specimens are sometimes larger and fresher than the majority of the Terip Terip crystals. Pinacoidal cleavages are more pronounced in the cordierite of the Bulla and Trawool granitic rocks than in any of the others.

In all of these rocks, the cordierite crystals are almost free from inclusions of biotite and iron oxides. In the highly contaminated granitic rocks containing cordierite from Bethanga and Mt. Talgarno in North-Eastern Victoria (7), however, biotite plates are abundant throughout the cordierite crystals.

Origin of the Cordierite

The source of the constituents forming the cordierite in the Terip Terip granite probably lies in altered argillaceous sediments of Silurian age, since spotted cordierite hornfels forms the wall rock of the intrusion in this area. In view of existing analyses of Silurian shales in Victoria, these contact sediments are probably potassic.

In these thermally altered contact rocks, the cordierite contains numerous small, included plates of biotite. In highly contaminated granitic rocks such as those from North-Eastern Victoria, biotite inclusions in the cordierite are larger, but are not as numerous. It would therefore appear that the cordierite in these highly contaminated granitic rocks was xenocrystal in nature, like those in certain of the English Dartmoor granites (1, p. 189), and that clarification of impurities from the crystals was incomplete when crystallisation occurred.

Two modes of origin can be postulated for the cordierite crystals in the Strathbogies Mass, which are nearly free of such inclusions. (1) They may be xenocrysts derived from the mechanical disruption of cordierite-bearing xenoliths. Owing to the slow cooling of the granite, the cordierite crystals may have been able to almost clear themselves of the biotite inclusions. Against this supposition, the arguments may be advanced that as far as the various specimens from the Strathbogies granitic mass are concerned, no intermediate stage in this "clearing" process, and no xenoliths in a state of partial disintegration have been observed in the cordierite-rich granite. (2) The other possibility is that the cordierite crystals are of pyrogenetic origin (1, p. 189), and have resulted from the enrichment of the granite magma in alumina by the assimilation of aluminous, argillaceous country rock. In favour of this possibility, is the tendency towards euhedral outline of many of the crystals.

It is not possible to arrive at any proof as to which of these modes of origin is the correct one, but the author is inclined to favour a pyrogenetic origin, in view of the arguments noted above.

The various degrees of alteration of the cordierite have resulted from the subsequent introduction of variable amounts of alkaline material from the magma. The pseudomorphs of secondary pinite, represent incomplete stages in the alteration of the cordierite to muscovite, of which mineral, pinite is a massive variety, stained pale yellowish-green in colour by the liberation of small amounts of iron from the cordierite. As chlorite is a secondary alteration product of biotite as well as of cordierite, it cannot be ascertained with any degree of certainty, how much of the chlorite in the rock is produced from biotite, and how much from cordierite. The only indication of the original mineral it was developed from, is provided by such crystals as retain the basal cleavage directions of biotite.

From the mode of alteration of cordierite in these granitic rocks, it would appear that Harker's formula: sericite+chlorite+iron=cordierite+biotite, as applied to the thermal alteration of argillaceous rocks (2, p. 50), is reversed when cordierite breaks down in the magma under the influence of alkaline solutions. Much of the secondary mica so formed has in large part been dispersed in the magma, and by mingling with the primary micas, has lost its identity of origin.

Conclusions

That cordierite is generally a rare constituent of granitic rocks, is borne out in Victoria by the fact that the examination of over 300 sections of granite and granodiorite, from over 100 localities in different parts of the State, has revealed this mineral in only four outcrops, namely (*a*) Bulla (6), (*b*) Marysville (3), (*c*) Bethanga and Mt. Talgarno in North-Eastern Victoria (7), and (*d*) the Strathbogies Mass (Terip Terip, Trawool, etc.).

Tattam considers that cordierite is probably never primary in granitic rocks, and that the cordierite in the Bulla and Trawool rocks is unique in occurrence (6, p. 247), but he adds that traces of its existence could be found in many other masses where the contact rocks contain this mineral. The only Victorian granitic rocks to indicate the probable presence of pinite pseudomorphs after cordierite, besides those already shown to possess cordierite as fresh or altered crystals, are from Riddell and from Corryong (Fig. 1). In these two rocks, there are no definite crystals of cordierite like those at the localities mentioned above.

The widespread and abundant occurrence of cordierite in the Strathbogies Mass is indicated by its presence in practically every section examined from this outcrop. Most of the localities referred to in this mass are along the contact with Silurian sediments that have been subjected to marked thermal metamorphism, especially along the southern boundary of the granitic massif (5, p. 297). One or two of the localities examined, however, are situated well within the granite mass, and there is little doubt that many other localities within the Strathbogies Mass, would reveal the presence of cordierite.

This widespread occurrence of cordierite throughout the large and texturally variable granitic outcrop of the Strathbogies, and the close association of argillaceous wall rock around the boundaries of the intrusion, suggest that there has been a wide and fairly constant process of assimilation of lithologically similar country rock by this batholith, resulting in relatively even contamination of the granitic rock over a wide area.

Tattam regards the cordierite in the granitic rocks from Bulla and Trawool as indicating contamination (6, p. 245), and this view is considered to be correct for all of the Victorian cordierite-bearing granitic rocks so far discovered, where the cordierite occurs either as xenocrysts or as products of crystallisation from a contaminated magma.

An effect of the assimilation of the argillaceous contact rock (potash rich), from which the cordierite was developed, has been to enrich the granite in alumina and potash (combined in muscovite), as exemplified by marginal occurrences in the Strathbogies Mass.

Acknowledgments

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