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Staurolite in amphibolite and hornblendite sheets from the Upper Seaforth River, central Fiordland, New Zealand

ALTHOUGH staurolite is most commonly regarded as an index mineral in metapelites (Chinner, 1965; Hounslow and Moore, 1967; Carmichael, 1970; Guidotti, 1970, 1974; etc.), it is not unknown from other bulk compositions; indeed, it has been reported from metamorphosed emery deposits (Jansen and Schuiling, 1976), grits and impure carbonate rocks (Kreige, 1918; report in Deer *et al.*, 1962), and amphibolite (Jan *et al.*, 1971). In so far as most recorded occurrences have clearly been in metasediment, the presence of staurolite has occasionally been used (e.g. Jan *et al.*, 1971) as an indication that the host rock, regardless of bulk composition, is of sedimentary origin. Recently, however, staurolite has been described (Kuroda *et al.*, 1976) in epidote amphibolite from the Oeyama ultramafic mass. Unfortunately, while the authors consider that the rock may represent amphibolitized pyroxenite, some uncertainty still exists as to its exact origin. Nevertheless, this latter occurrence is of particular interest since it is probably the first report of staurolite from such a basic composition. While such occurrences are undoubtedly rare, this is not the case in central Fiordland. Here kyanite and staurolite assemblages are common within sheets of amphibolite and hornblendite. These sheets are interlayered with metamorphosed gabbroic anorthosite. Horizons of troctolite and hornblende peridotite are also occasionally associated with the latter. Despite a lateral continuity of several hundred metres, individual sheets maintain a constant thickness of about 1.0–1.5 m, and remain remarkably homogeneous in composition throughout their length. These field relationships clearly demonstrate that the sheets comprise an integral part of a metamorphosed layered intrusion. As this appears to be the first documentation of staurolite from a rock of undoubted igneous origin, it is appropriate to present data on both its chemistry and mode of occurrence.

The most commonly observed assemblage comprises hornblende, plagioclase, kyanite, staurolite, and rutile, although corundum may appear instead of kyanite. Margarite is an important constituent of many assemblages, while biotite and pyrite are

common accessories. Clinozoisite and chlorite frequently appear as late stage retrograde products. The staurolite typically occurs as small granules disseminated throughout each specimen, in amounts rarely exceeding 5%. Occasionally it also appears as small (0.1–0.5 mm) euhedral prisms embedded along the periphery of hornblende crystals, especially where the latter adjoins

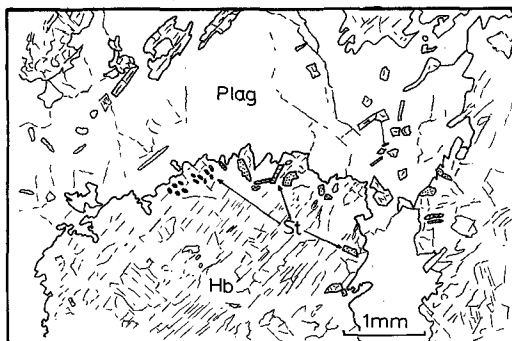


FIG. 1. Staurolite (St) embedded along periphery of hornblende (Hb) where latter is adjacent to plagioclase (Plag). Note that staurolite is strictly confined to this region and does not occur in core of amphibole. Small prisms disseminated throughout plagioclase are hornblende crystals.

plagioclase. A majority of these staurolite prisms are orientated so that they are perpendicular to the hornblende-plagioclase interface (fig. 1). Table I presents chemical data on staurolite from these interesting assemblages. For the purposes of comparison, analyses taken from two metapelites have also been included. In contrast to the latter and most analyses quoted from metapelites, the staurolite from the amphibolites shows unusually low FeO, which is compensated through higher MgO, ZnO, and Al₂O₃. Furthermore, these staurolites contain significantly lower amounts of SiO₂ than those of metapelites, indicating appreciable substitution of Si by Al. In fact, the Si contents lie well below the range (7.64–7.91 atoms of Si per unit cell) quoted by Griffen

TABLE I. Microprobe analyses of staurolite from the Upper Seaforth River, central Fiordland

| | Amphibolite | | Metapelite | | |
|--------------------------------|-------------|-------|------------|--------|----------------------------------------------------|
| | 41001 | 41041 | 41075 | 41108 | |
| SiO ₂ | 27.28 | 27.12 | 27.42 | 27.50 | Cations per unit cell, normalized to 44(O) + 4(OH) |
| Al ₂ O ₃ | 54.45 | 55.97 | 53.63 | 52.86 | Si |
| TiO ₂ | 0.58 | 0.15 | 0.74 | 0.78 | Al |
| FeO* | 10.66 | 10.50 | 11.52 | 12.52 | Ti |
| MnO | 0.20 | 0.20 | 0.00 | 0.29 | Fe |
| MgO | 2.78 | 3.13 | 1.98 | 1.95 | Mn |
| CaO | 0.02 | 0.05 | 0.00 | 0.00 | Mg |
| Na ₂ O | 0.08 | 0.05 | 0.04 | 0.04 | Ca |
| K ₂ O | 0.02 | 0.02 | 0.02 | 0.01 | Na |
| Cr ₂ O ₃ | 0.00 | n.d. | 0.08 | n.d. | K |
| ZnO | 1.00 | 0.49 | 2.00 | 2.20 | Cr |
| H ₂ O ^c | 2.16 | 2.18 | 2.15 | 2.15 | Zn |
| | 99.23 | 99.86 | 99.58 | 100.30 | |
| | | | | | 29.432 |
| | | | | | 29.479 |
| | | | | | 29.394 |
| | | | | | 29.488 |

* All Fe as FeO. n.d. = not determined.
c = calculated on the basis of 4(OH) per unit cell.

Numbers refer to thin sections recorded in the collection of the Department of Geology, University of Otago.

and Ribbe (1973) from a compilation of twenty analyses. Recent investigations, notably those of Smith (1968) and Griffen and Ribbe (1973) into the structure of staurolite indicate that all major cations are present in both octahedral and tetrahedral coordination, although Mg is considered to be concentrated in the former. Griffen and Ribbe (1973) also conclude that the principal substitutions are Zn and Al for dominant Fe in the tetrahedral site, and not Mg as commonly assumed. The primary substitutions in the octahedral sites involve Mg and Fe for Al. Therefore, while the analyses themselves do not permit evaluation as to which sites are involved, they are compatible with these interpretations. In particular the analyses indicate substantial substitution of Fe by Mg in the octahedral sites.

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