

Ferrocapholite associated with low-grade blueschists, northern New Caledonia

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FERROCAPHOLITE has been discovered at two localities in low-grade blueschists in the Diahot region, northern New Caledonia. In one occurrence (specimen 23503), ferrocapholite was found in quartz veins associated with metamorphosed rhyolitic tuffs, and at the other locality (23514) it occurs as a gangue mineral at Ao Mine associated with quartz, a variety of carbonates, and sulphide ores.

Electron microprobe analyses show that 23503 contains a high total Fe (15.4 wt%) and correspondingly low Mg content (3.7), whereas 23514 contains a very much higher proportion of the Mg end-member (total Fe 10.7, MgO 6.4). Both contain only small proportions of Mn (< 0.10).

The Diahot region forms a small part of a regional blueschist belt in north-eastern New Caledonia that shows a continuous sequence of progressive metamorphism from lawsonite-albite facies through glaucophanitic greenschists to eclogitic glaucophanitic albite-epidote amphibolites (Brothers, 1974). Ferrocapholite has been found only in the lowest-grade rocks, above but close to the lawsonite isograd defined in pelitic country rocks, and where intercalated country metadolerites may carry pumpellyite. *T-P* conditions at the lawsonite isograd have been estimated as approximately 250 °C and 3 kb from oxygen isotope data (Black, 1974) and the experimental stability limits of lawsonite + quartz (Liou, 1971; Nitsch, 1972). While ferrocapholite appears to have crystallized in lower-grade schists, especially associated with acidic metatuffs, higher grades may favour the production of chloritoid, which has a similar

composition. Chloritoid is a common phase with Na-amphibole-almandine-epidote in the Diahot region at Balade and Murat mines in higher-grade iron-rich siliceous metasediments, possibly also of acidic tuffaceous parentage. If the reaction given by de Roever and Kieft (1971) and de Roever and Beunk (1971) is accepted (ferrocapholite → chloritoid + quartz + water) then the *T-P* conditions at Balade Mine (where chloritoid has crystallized), extrapolated as *c.* 400 °C and *c.* 6.5 kb, provide an upper limit for this reaction.

Fuller details of the geological setting, chemical, and optical properties of ferrocapholite in New Caledonia appear in the Miniprint section of this journal, p. M16.

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M16 R. M. Briggs: Ferrocarpholite from New Caledonia

FERROCARPHOLITE FROM NEW CALEDONIA

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FERROCARPHOLITE has been discovered at two localities in low grade blueschists in the Diabot region, northern New Caledonia. One occurrence (specimen 23514), where ferrocarpholite is a gangue mineral at Ao Mine (20°40' 05" S, 164°54' 55" E), has been described briefly in a paper on the Ca-Fe-Mn mineralization in the Diabot region by Briggs, *et al.*, (in prep.); it is associated with quartz, calcite, dolomite, magnesite and a variety of sulphide ores which are dominantly chalcopyrite with lesser amounts of sphalerite, pyrite, chalcocite, covellite and galena. The second ferrocarpholite (23503) was found in quartz veins associated with metamorphosed rhyolitic tuffs, 2 km west of Pilou Mine in the upper parts of the Tchiengane River (20°18'45"S, 164°04'36"E). In both localities the mineral is present as green radiating acicular crystals, up to 1 cm in length, which microscopically resemble actinolite.

Ferrocarpholite, FeAl₂(OH)₄Si₂O₆, was first described from the island of Celebes, Indonesia, by de Roover (1951). It is the ferrous iron analogue of carpholite *s.s.* which is the Mn-rich variety (Mn,Mg,Fe²⁺)Al₂(OH)₄Si₂O₆. More recently ferrocarpholite has been described from Calabria, southern Italy (de Roover, *et al.*, 1967; de Roover and Beunk, 1971), and from the Cottian Alps at Colle Clarbonet (Scaini, *et al.*, 1976). In all other recorded occurrences, ferrocarpholite has been found in lower grade high-pressure regional metamorphic rocks containing lawsonite, albite and lawsonite, albite, glaucophane assemblages.

Electron microprobe analyses, cell parameters and optical properties of both specimens of ferrocarpholite from the Diabot region are shown in Table 1. Specimen 23503 contains a high total Fe and correspondingly low Mg content, whereas 23514 contains a very much higher proportion of the Mg end member. Both contain small proportions of Mn.

This variation between Fe and Mg also affects the optical properties, with the more Fe-rich specimen (23503) having the lower optical axial angle and the higher refractive indices, as would be expected from the relationships shown by de Roover and Kieft (1971, Fig. 2). Specimen 23503 also shows the more distinct pleochroism; 23514 is almost colourless in thin section. Ferrocarpholite shows absorption for the common normal to the elongation, with the following pleochroic formulae: α = yellow-green, β = pale yellow-green, γ = very pale bluish-green.

Cell parameters for both Diabot samples are smaller than those of ferrocarpholite described from Celebes (de Roover, 1951), presumably due to the greater substitution of Fe²⁺ by the smaller Mg²⁺ ion.

The Diabot region forms a small part of an extensive regional blueschist belt which covers at least 4000 square kilometres in northeastern New Caledonia (Brothers, 1974). Rocks in the area consist dominantly of a Cretaceous sedimentary-igneous sequence of carbonaceous pelites with intercalated doleritic sills and rhyolitic tuffs and flows which were metamorphosed during the Oligocene to Lowermost Miocene. The Cretaceous sequence is overlain conformably by Eocene rocks to the southwest, comprising mainly siliceous argillites, phanites (massive chert) and limestones. Metamorphism has affected both the Cretaceous and Eocene rocks and increases progressively in grade towards the east coast of New Caledonia in a remarkably continuous sequence from lawsonite-albite facies through glaucophanitic greenschists to eclogitic glaucophanitic albite epidote amphibolites (Brothers, 1974). Lowest grade rocks occur in the southwest near the Cretaceous-Tertiary boundary. Both occurrences of ferrocarpholite were found in the lowest grade rocks (zone I as defined by Black, 1973a; Briggs, *et al.*, in prep.) in which the sericitic phyllites and schists contain neither lawsonite nor epidote, but metadolomites may carry pumpellyite. In terms of metamorphic facies, the lowest grade zone corresponds with the pumpellyite prehnite quartz facies of Winkler (1967) although prehnite is not known within the high-pressure schists of northern New Caledonia (Brothers, 1974).

Specimen 23503 lies on the pumpellyite isograd for metamorphic assemblages which is situated at a depth of 1.5 km in the metamorphic-tectonic sequence on the lower grade side from the lawsonite isograd for pelitic assemblages, or at a depth of about 10 km within the whole metamorphic-tectonic pile. Country rocks in the vicinity of 23503 are dark grey to black sericitic pelites and psammites, usually carbonaceous in the fine-grained phyllitic layers, with thin rhyolitic meta-tuff intercalations and metadolomite sills. Typically assemblages in pelites are quartz phengitic muscovite chlorite carbonaceous matter sphene with and without albite; acidic meta-tuffs carry quartz chlorite with and without albite, phengitic muscovite, sphene, pyrophyllite and opaque (usually pyrite); and those in metadolomites are chlorite-sphene with and without pumpellyite, phengitic muscovite and albite. Relict igneous textures are usually excellently preserved in the metadolomites as igneous plagioclase subophitically or optically intergrown with igneous augite.

Ao Mine occurs in a large lens-shaped segment of Cretaceous rocks which lies within phanitic Tertiary strata (Espirat and Milton, 1967). Structurally, this segment probably represents a detached slice of an overlapping schuppen-type or imbricate structure and rare tiny prisms of lawsonite in pelitic schists at Ao Mine probably crystallized under the sole of an over-riding small thrust sheet (c.f. Brothers and Blake, 1973; Brothers, 1974). However, lawsonite is absent north of Ao Mine (in the direction of increasing metamorphism) and does not occur again until on a regional scale immediately north of Pilou Mine. Thus the Cretaceous rocks at Ao Mine would best be regarded as a segment of lowest grade rocks (zone I) at about the same metamorphic level as, but on the lower grade side of, the lawsonite isograd since lawsonite has crystallized only sporadically. Country rocks at Ao Mine are black to dark grey carbonaceous sericitic phyllites intercalated with thin rhyolitic meta-tuff units and metadolomite sills. Typical assemblages in phyllites are quartz phengitic muscovite chlorite sphene carbonaceous matter with and without lawsonite; those in acidic tuffaceous rocks are quartz chlorite opaque (limonite, pyrite carbonaceous matter) with and without albite, sphene and phengitic muscovite; and metadolomites carry chlorite pumpellyite sphene.

de Roover and Kieft (1971) and de Roover and Beunk (1971) have suggested that while ferrocarpholite appears to crystallize in lower grade high-pressure regional metamorphic rocks, slightly higher grades of metamorphism possibly favour the production of chloritoid which has a similar composition. This suggestion is supported in the Diabot region where ferrocarpholite is clearly restricted to lower grade rocks, and especially associated with acidic meta-tuffs, whereas chloritoid is a common phase with Na-amphibole almandine epidote assemblages at Balade and Murat mines in higher grade iron-rich siliceous metasediments, possibly also of acidic tuffaceous parentage. Ferrocarpholite in the Diabot region has been found only in the lowest grade

Table 1 Electron microprobe analyses, cell parameters and physical properties of ferrocarpholite in the Diabot region, northern New Caledonia.

	Electron microprobe analyses		Atomic ratios to 8 oxygens (anhydrous)		Optical data		
	23503	23514	23503	23514	23503	23514	
SiO ₂	36.2	36.6	1.98	1.98	α	13.61 (6) Å	13.61 (2) Å
TiO ₂	0.16	0.15	0.007	0.006	b	20.06 (4) Å	20.07 (4) Å
Al ₂ O ₃	31.3	31.5	2.02	2.01	c	5.16 (3) Å	5.19 (1) Å
FeO*	15.4	10.7	0.70	0.48	v	1413.8 (2.2) Å ³	1417.7 (6) Å ³
MnO	0.03	0.10	0.001	0.005	w	1.618	1.607
MgO	3.7	6.4	0.30	0.52	β	1.631	1.620
Total	86.79	85.45	γ	γ	γ	1.639	1.627
FeO* = Total iron as FeO			z	z	z	0.021	0.020
			2Va	2Va		56° ± 2°	64° ± 2°

All refractive indices are ± 0.002

rocks above the lawsonite isograd, the T,P conditions of which have been estimated as approximately 250°C and 3 kb, determined from oxygen isotope geothermometry (Black, 1974) and the experimental stability limits of lawsonite + quartz (Liou, 1971; Mitsch, 1972). Since lawsonite is rare at Ao Mine and not developed on a regional scale, it is unlikely that T,P conditions at Ao Mine would be significantly higher than those of the lawsonite isograd. However, the very sporadic occurrence of ferrocarpholite in the Diabot region makes any estimation of the stability limits rather speculative. If the reaction given by de Roover and Kieft (1971) and de Roover and Beunk (1971) is accepted (ferrocarpholite → chloritoid + quartz + water) then the T,P conditions at Balade mine (where chloritoid has crystallized), extrapolated as 400°C and about 6.5 kb (Briggs, *et al.*, in prep.), provide an upper limit for this reaction.

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