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COEXISTING GLAUCOPHANE AND RIEBECKITE-ARFVEDSONITE FROM NEW CALEDONIA

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ABSTRACT

Electron microprobe analyses are given for coexisting glaucophane and riebeckite-arfvedsonite from a lawsonite-bearing metabasalt. Possible origins of the amphibole association are discussed.

Relationships between coexisting sodic and calcic amphiboles are now well documented (Klein, 1968b; Himmelberg and Papike, 1969), but there have been few records of coexisting sodic amphiboles, and phase relations within the complex alkali amphibole system are still not well understood.

During a study of amphiboles in the New Caledonian blueschists, an example of coexisting glaucophane and riebeckite-arfvedsonite was found in a metabasalt outcropping lawsonite-albite bearing pelitic schists of the Pilou Formation (Espirat and Millon, 1965) 1 km east of Col de Crève-coeur.

Thin sections of the metabasalt (10811) show relic phenocrysts of augite overgrown by glaucophane, lawsonite, chlorite, accessory albite, and quartz. Riebeckite-arfvedsonite constitutes less than 0.2 modal percent of the rock and occurs most commonly as small green blebs averaging 20 microns in diameter, enclosed within glaucophane crystals, or rarely as larger more regular anhedra incompletely surrounded by individual glaucophanes (Fig. 1). Chemically and optically the contact between the two amphiboles is sharp, but cleavages persist through both amphiboles (Fig. 1.) indicating that the two phases are in crystallographic continuity. The glaucophane shows the following pleochroic scheme and orientation: α = colourless; β = violet; γ = blue; $b=\beta$; $c\wedge\gamma=5°$; while the riebeckite-arfvedsonite has: α = deep bluish green; β = deep olive green; γ = pale yellowish green; $b=\gamma$; $c\wedge\alpha=6°$. No exsolution lamellae have been observed in either amphibole.

The two amphibole phases were analysed with an A.R.L.–E.M.X. electron microprobe using the standards and analysing procedures discussed by Klein (1968 a,b). The analyses are presented in Table 1. Estimated errors are 3 percent for major and 5 percent for min or constituents. No attempt has been made to estimate the Fe^{2+}: Fe^{3+} ratio; the analyses have been recalculated anhydrous on the basis of 23 oxygens per

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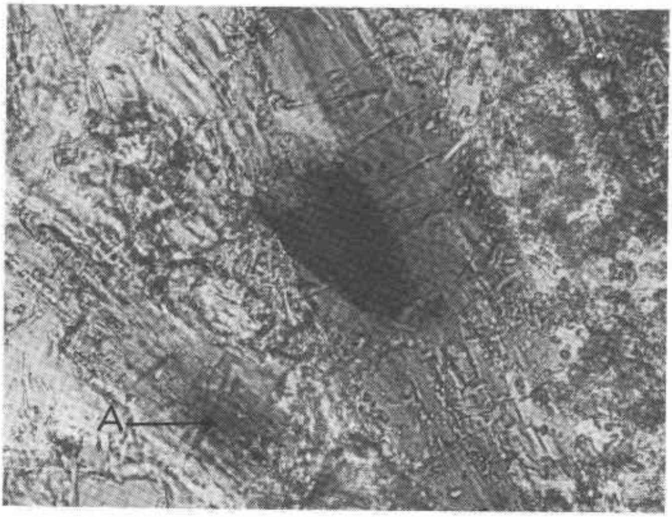

FIG. 1. Dark riebeckite-arfvedsonite anhedra partially surrounded by lighter glaucophane (center), and small riebeckite-arfvedsonite bleb (A) enclosed within glaucophane (lower left). (×500).

unit cell assuming total iron as FeO. A knowledge of the oxidation ratio of the amphiboles and subsequent calculation of part of the iron as Fe_2O_3 will have the effect of reducing Si^{iv} and hence Al^{vi} (coordination number 6) but will not radically change other values.

The optical orientation, pleochroic scheme and formula which can be derived from the microprobe analysis of the iron-rich amphibole are al-

TABLE 1. COMPOSITION OF COEXISTING GLAUCOPHANE AND RIEBECKITE-ARFVEDSONITE

	Glauc.	Rb-Arfv.		Glauc.	Rb-Arfv
SiO_2	55.2	50.2	Si	7.72	8.03
TiO_2	0.1	0.5	Al^{iv}	0.28	—
Al_2O_3	9.7	1.7			
FeO^a	12.4	30.4	Al^{vi}	1.32	0.32
MnO	0.2	0.5	Ti	—	0.07
MgO	12.0	3.2	$Fe^{2+ a}$	1.45 } 5.29	4.07 } 5.29
CaO	1.7	2.4	Mn	0.02	0.07
Na_2O	7.0	5.4	Mg	2.50	0.76
K_2O	—	2.0			
Total	98.3	96.3	Ca	0.25	0.41
			Na	1.90 } 2.15	1.67 } 2.48
			K	—	0.40

[a] Total iron calculated as FeO.

most identical to the data given for arfvedsonite by Miyashiro (1957), but according to the later classification scheme of Borg (1967) the amphibole with its A site occupancy of >0.4 should be called riebeckite-arfvedsonite and Borg's terminology is followed here.

Recent oxygen isotope work (Taylor and Colemen, 1968) has shown that lawsonite bearing blueschists crystallized at temperatures of 200–400°C. The riebeckite-arfvedsonite bearing metabasalt occurs close to the lawsonite isograd in the lower grades of the New Caledonian blueschists and probably crystallized in the lower part of the temperature range given by Taylor and Coleman (1968).

The relations between members of the glaucophane-riebeckite series are well known and solid solution between end members has been demonstrated by a number of authors (Miyashiro, 1957; Borg, 1967; Coleman and Papike, 1968). A complete solid solution series between riebeckite and arfvedsonite has been synthesized by Ernst (1962) who observed no exsolution between synthetic end members at temperatures as low as 420°C.

The coexistence, at low temperatures, of two amphiboles which are known to form part of a solid solution series under a wider range of P-T conditions is interesting and a discussion of the possible origins of the association is warranted.

The riebeckite-arfvedsonite is unlikely to be a relic igneous mineral since (to this writer's knowledge) sodic amphiboles are unknown in basalts. Primary igneous amphiboles do occur in the lower Tertiary basalts of northern New Caledonia but in all cases they are kaersutitic hornblendes.

Chemical analysis of the metabasalt ($SiO_2=49.0$; $TiO_2=2.0$; $Al_2O_3=18.5$; $Fe_2O_3=4.2$; $FeO=4.7$; $MnO=0.14$; $MgO=7.4$; $CaO=10.3$; $Na_2O=3.0$; $K_2O=0.05$; $P_2O_5=0.08$; $H_2O+=0.5$) shows it to be a normal tholeiitic basalt, compositionally similar to other basalts in the district. Metasediments adjacent to the basalt are fine grained lawsonite-albite phyllites, completely lacking in sodic amphiboles. There is no evidence, either from the composition of the metabasalt or from the surrounding metasediments, to suggest that the rocks may have been subjected to percolating iron-rich waters capable of crystallizing a riebeckitic amphibole prior to the onset of blueschist metamorphism.

The metamorphic history of the New Caledonian blueschist belt is very simple, and there is no evidence for more than one metamorphic event. The association of riebeckite-arfvedsonite with glaucophane could be interpreted as due to a change in one or more of the physico-chemical variables during the metamorphism although if this were the case a gradual chemical transition between the two amphiboles would be ex-expected rather than the observed sharp chemical and optical contacts.

Ross, *et al.* (1969) have described an exsolution sequence leading to the production of homogeneous patches of an exsolved phase within the host clinoamphibole. Such a process could possibly explain the association and textural relations of the riebeckite-arfvedsonite and glaucophane. However, exsolution lamellae have not been observed in alkali amphiboles although Sahama (1956) has interpreted optical anomalies in natural arfvedsonites as exsolution features.

There seems to be no convincing explanation for the coexistence of the riebeckite-arfvedsonite with glaucophane and hence the question whether the two amphiboles are an equilibrium or a disequilibrium assemblage must remain unresolved. Nevertheless, it should be pointed out that in the event that the two amphiboles are an equilibrium assemblage, the data presented here would indicate that a solvus exist between the riebeckite-arfvedsonite solid solution series and at least the aluminous members of the glaucophane-riebeckite solid solution series under the P-T conditions of the low temperature lawsonite-bearing blueschist facies.

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