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Blue amphibole from Precambrian metabasalts, Savage River, Tasmania

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Abstract

A blue sodic amphibole occurs in mafic greenschists associated with a Precambrian iron deposit at Savage River, Tasmania. Its composition falls between magnesioriebeckite and actinolite. Crystallization of the amphibole probably reflects *P, T* conditions intermediate between glaucophane–lawsonite schist and greenschist facies, and demonstrates partial closing of the miscibility gap between sodic and calcic amphiboles at these conditions.

A blue sodic amphibole occurs in Precambrian mafic schists and metabasalts in the Savage River area of northwest Tasmania. The rocks are interlayered with banded magnetite–pyrite–silicate deposits and are situated in a multiply-deformed metamorphic belt (Spiller 1974). The overall metamorphic grade is greenschist facies, but the presence of blue sodic amphibole suggests transition to the higher-pressure 'blueschist' facies (Brown 1974, Katagas, 1974). This note presents further data on the occurrence and composition of blue amphibole intermediate between actinolite and riebeckite.

The mineral assemblage found with the blue amphibole consists of:

(1) actinolite, albite, epidote, chlorite, titanite, magnetite, pyrite, and quartz in metabasalt 7281;
(2) actinolite, albite, epidote, green mica, chlorite, titanite, magnetite, pyrite, quartz, and tourmaline in metabasalt 7463;
(3) actinolite, albite, talc, green mica, calcite, quartz, magnetite, titanite, pyrite, and tourmaline in mafic schist 7475.

Textural relations are variable and the rocks range from actinolite-dominated, strongly-foliated mafic schists to more equigranular metabasalts. The minerals listed do not constitute equilibrium assemblages, and blue amphibole grains are rimmed by actinolite in all rocks. In one metabasalt (7281) the blue amphibole occurs as bladed crystals reaching 0.5 cm in size, rimmed by epidote, actinolite, and albite.

The optical properties for blue amphibole examined in this work are as follows: α = colorless to pale brown; β = blue; γ = lavender blue; $2V$ = 0–40°, optically negative, birefringence low to moderate. These properties are similar to those of glaucophane–crossite, and Spry (1964) in describing similar rocks from the Pieman River area, west Tasmania, identified the mineral as glaucophane.

Analyses of the blue amphibole indicate the most sodic compositions are magnesioriebeckite with a significant actinolite component (>18% molecular proportion) in solid solution (Table 1). Complete solid solution between the magnesioriebeckite and actinolite end-members is not demonstrated (Fig. 1) for the limited data presented here, but the analyses do indicate compositions plotting in the proposed compositional gap (*cf.* Katagas 1974). The separation of the compositions into two distinct fields in Fig. 1 points to a compositional gap smaller than that proposed by either Coleman and Papike (1968) or by Iwasaki (1963), and it is likely that the extent of this gap is sensitive to temperature (*T*) (Klein, 1969) or to *T* and pressure (*P*) (Brown, 1974).

The composition of the Savage River blue amphibole is similar to blue sodic amphibole with significant actinolite (>18% molecular proportions) in solid solution described by Katagas (1974) and Brown (1974) from metamorphic terrains containing greenschist facies assemblages. This composition contrasts with the typical blue sodic amphibole with low actinolite (<18% molecular proportions) in solid solution occurring in mafic rocks of the glaucophane-lawsonite schist facies (Black, 1973; Boucquet, 1974; Coleman and Papike, 1968; and Himmelberg and Papike, 1969).

This work shows that analysis of blue amphibole is essential to distinguish between optically similar am-

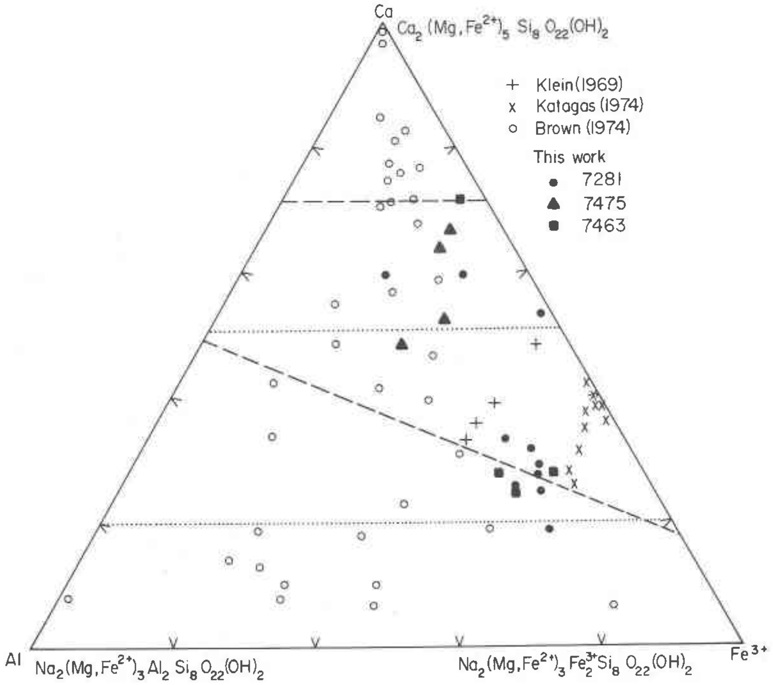

FIG. 1. Compositions of blue amphiboles from Savage River, Tasmania, compared with compositions of other amphiboles intermediate between tremolite/actinolite and magnesioriebeckite/riebeckite. Dashed lines denote miscibility gap between calcic and sodic amphiboles proposed by Coleman and Papike (1968) while dotted lines refer to the miscibility gap proposed by Iwasaki (1963). The lower group of solid symbols correspond to amphiboles with pleochroic schemes similar to that listed in the text, while the upper group have pleochroic schemes with a greenish-blue character.

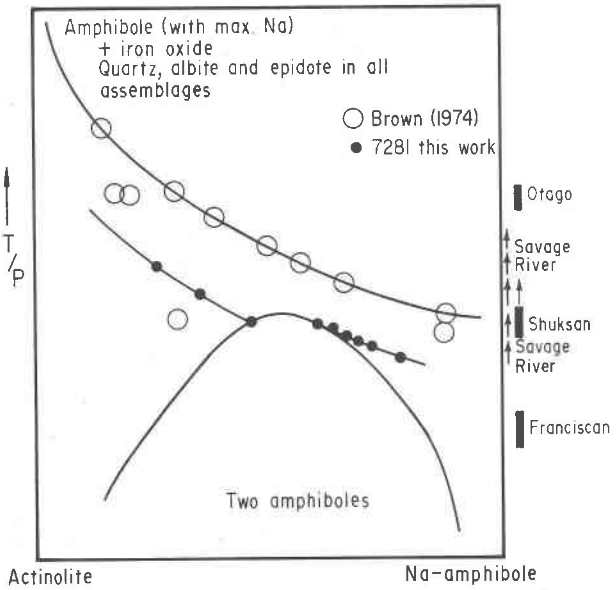

FIG. 2. Interpretation (modified from Brown, 1974) of miscibility between actinolite and Na-amphibole as indicated by data from the Savage River amphiboles, compared with Otago, Shuksan, and Franciscan examples.

phiboles of the glaucophane–crossite and the magnesioriebeckite–actinolite series. The identification of blue amphibole alone is insufficient to infer the high-pressure, low-temperature conditions of the glaucophane-lawsonite-schist facies (Turner, 1968). However, the narrowing of the miscibility gap between sodic and calcic amphiboles may provide some indication of the *P, T* conditions of formation of blue amphiboles of this type, and Brown (1974) suggests that the coexistence of blue sodic amphibole with albite and iron oxide (magnetite) allows the maximum content of the sodic end-member in the sodic–calcic amphibole solid solution series for a given *T/P* ratio. Brown (1974) and Katagas (1974) predict that with increasing *T/P* the apparent miscibility gap between the sodic and calcic amphiboles is reduced or closed. The appropriate *T/P* condition proposed is intermediate to the glaucophane–lawsonite–schist facies and the greenschist facies, within the range of 5–10 kilobars and 300–400°C. The oxygen fugacity indicated by the blue amphibole-bearing assemblages is at least higher than the quartz–mag-

TABLE 1. Selected analyses of blue amphiboles and their host rocks from Savage River, Tasmania.

	Blue amphiboles			Metabasalt	Mafic schist
Specimen	7281	7281	7281	7463	7475
SiO_2	53.66	53.49	53.69	48.71	45.09
TiO_2	0.03	0.06	0.06	1.20	0.94
Al_2O_3	3.97	3.94	3.41	13.84	7.48
Fe_2O_3	14.06*	10.72*	6.89*	5.44	10.17
FeO	7.66*	9.64*	7.67*	6.93	11.24
MnO	0.19	0.28	0.28	0.15	0.13
MgO	9.67	10.30	14.40	7.67	11.87
CaO	2.92	4.99	9.37	9.03	4.74
Na_2O	5.82	4.48	2.17	2.98	2.18
K_2O	0.02	0.10	0.06	1.14	0.42
P_2O_5	ND	ND	ND	0.12	0.02
Loss	ND	ND	ND	2.02	4.59

ND = not determined
* calculated (see below)

Structural formulae (anhydrous 23 O's)			
Si	7.71	7.71	7.64
Al^{iv}	0.29	0.29	0.36
Σ tetrahedral	8.00	8.00	8.00
Al^{vi}	0.38	0.38	0.21
Ti	0.01	0.01	0.01
Fe^{3+}	1.52	1.16	0.74
Fe^{2+}	0.92	1.16	0.91
Mn	0.02	0.04	0.03
Mg	2.07	2.21	3.06
Σ octahedral	4.92	4.96	4.96
Ca	0.45	0.77	1.43
Na	1.62	1.25	0.60
K	0.01	0.02	0.01
Σ X	2.08	2.04	2.04

Amphibole analyses (see also fig. 1) determined by electron microprobe (specimens 7463, 7475 on a T.P.D. probe at A.N.U. using the method of Reed and Ware, 1973 and specimen 7281 on an ETEC probe at Macquarie University following the method of Bence and Albee, 1968). Fe^{3+} has been calculated adopting the method of Brown (1974) and analyses adjusted to an "anhydrous" total of 98.00%. Rock compositions determined by X.R.F. analysis except for Na_2O (flame photometry) and FeO (wet chemistry). Numbers refer to specimens housed in the School of Earth Sciences, Macquarie University.

netite–fayalite buffer, and is similar in the nearby greenschist facies assemblages. Thus there is no evidence to suggest that high fO_2 is critical in the development of the blue amphibole in an otherwise greenschist facies terrain (*cf.* Brown, 1974).

A diagrammatic representation of the *P, T* dependence of the closing of the miscibility gap between Ca- and Na-amphiboles, and a comparison with other areas may be made using an interpretative diagram of Brown (1974). This is given in Fig. 2 and illustrates the *P, T* conditions for crystallization of the Savage River amphiboles probably at slightly lower temperatures (or higher pressures) than the Shuksan rocks described by Brown (1974).

Thus it is inferred that the magnetite–albite–magnesioriebeckite-bearing rocks of the Savage River area reflect crystallization at *P, T* conditions intermediate between the greenschist and glaucophane–lawsonite–schist facies, with subsequent adjustment of the mineral assemblage, corresponding to an increase in *T* or fall in *P*, or both. The end result is a typical greenschist facies mineralogy with relict cores of blue amphibole.

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