American Mineralogist, Volume 66, pages 213–216, 1981

Margarite pseudomorphs after kyanite in Glen Esk, Scotland

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Abstract

This paper describes a new occurrence of margarite in a graphitic gneiss near Fettercairn village, Glen Esk, Scotland. Margarite occurs as pseudomorphs after kyanite and contains considerable paragonite component in solid solution (~25.5 mole %). The data presented enable establishment of another tie line on the white-mica plane of the system Al_2O_3–CaO–Na_2O–K_2O–SiO_2–H_2O.

Introduction

Recognition of margarite as a common rock-forming white mica resulted from the application of X-ray diffraction and electron probe analysis techniques to petrological problems. The number of reported margarite occurrences is continuously increasing and margarite is now considered as a widespread mineral, encountered in various types of low to medium grade metamorphic rocks (Hietanen, 1963, p. B24–B25; Sagon, 1967, 1970; Frey and Niggli, 1972; Ackermand and Morteani, 1973; Höck, 1974; Chinner, 1974; Fox, 1975; Guidotti and Cheney, 1976; Frey, 1978; Teale, 1979; Guidotti *et al.*, 1979).

Difficulties in interpretation of the various reported margarite-bearing assemblages led in turn to the application of experimental methods to these problems. Experimental data on margarite and its phase relations are becoming increasingly available (Velde, 1971; Wall and Essene, 1972; Storre and Nitsch, 1974; Chatterjee, 1974, 1976).

This paper describes a new occurrence of margarite in Glen Esk, Scotland, as pseudomorphs after kyanite, and presents data which establish another tie line on the white-mica plane of the system Al_2O_3–Na_2O–K_2O–CaO–SiO_2–H_2O.

Geologic setting

The margarite-bearing rock was collected 8 km NW of Fettercairn village (Fig. 1). The area studied lies within the region made classic by Barrow's work (1893,1912) on metamorphic zones and falls within parts of Barrow's original staurolite, kyanite, and sillimanite zones. A more recent account on the metamorphic history of Dalradian rocks in Glens Clova, Esk and Lethnot, Angus, Scotland has been presented by Harte and Johnson (1969).

Petrography

Margarite was found in a kyanite gneiss which contains the assemblage kyanite–muscovite–chlorite (retrograde) – plagioclase – quartz – graphite – tourmaline – apatite and opaques. The kyanite crystals are commonly twinned and have been partially replaced by margarite (Fig. 2). Fine-grained plagioclase is sometimes present as an additional mineral in the pseudomorphs. Porphyroblasts of plagioclase, muscovite, retrograde chlorite (after biotite), and quartz are developed at the border of the pseudomorphs and form the main groundmass of the rock. Graphite, tourmaline, apatite, and opaques are common accessories. Careful microscopic observation, X-ray dif-

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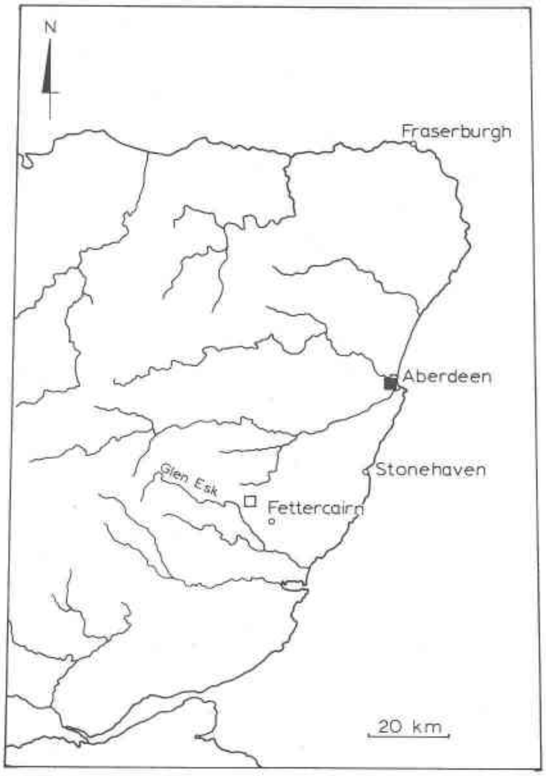

Fig. 1. Map showing the locality (□) of the collected sample.

fractograms, and microprobe analyses failed to reveal the presence of paragonite.

Mineral data

Mineral compositions were determined with a Link Systems Model 290-2KX energy-dispersive spectrometer, attached to a Cambridge Geoscan. The spectra were processed using a commercial version of the program developed by P. J. Statham, Department of Mineralogy and Petrology, Cambridge.

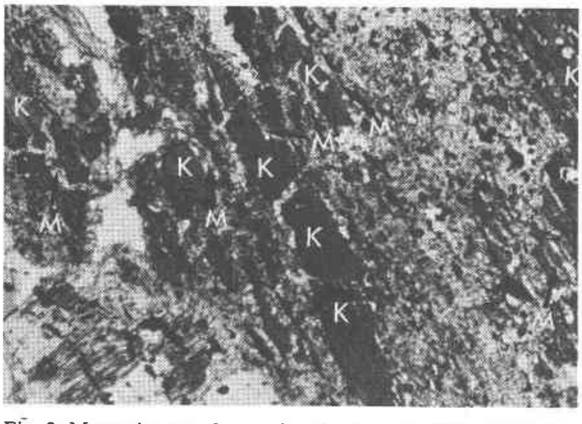

Fig. 2. Margarite pseudomorphs after kyanite (Glen Esk); K = kyanite, M = Margarite; (×4) (crossed polars).

Table 1. Microprobe analyses of coexisting margarite and muscovite from Glen Esk, Scotland

		Margarite	Muscovite
	SiO_2	32.59	45.73
	TiO_2	-	0.29
	Al_2O_3	50.33	34.20
	FeO	0.24	2.77
	MnO	-	-
	MgO	-	0.73
	CaO	9.79	-
	Na_2O	1.96	1.81
	K_2O	0.48	8.75
	Total	95.39	94.29
		Ions to 22(O).	
	Si	4.292	6.167
	Al^{iv}	3.708	1.833
	Z	8.000	8.000
	Al^{vi}	4.104	3.604
	Ti	-	0.030
	Fe^{+2}	0.026	0.312
	Mn	-	-
	Mg	-	0.147
	Y	4.130	4.093
	Ca	1.382	-
	Na	0.501	0.473
	K	0.081	1.507
	X	1.964	1.980
	Paragonite	25.50	23.88
Mol%	Margarite	70.36	-
	Muscovite	4.14	76.12

Representative analyses of coexisting margarite and muscovite are given in Table 1. Margarite contains negligible muscovite and muscovite does not contain any margarite component in solid solution. On the other hand, the margarite–muscovite pair contains substantial paragonite component in solid solution; nearly equal amounts (~25 mole %) of paragonite solid solution have been detected in each phase (Table 1). Similar observations have been also reported by other workers (Höck, 1974; Fox, 1975; Guidotti and Cheney, 1976; Teale, 1979; Guidotti *et al.,* 1979). Figure 3 is a Na–Ca–K plot of the margarite–muscovite pair from the sample analyzed, with SiO_2 in excess and a H_2O-rich fluid assumed present.

Discussion

The tie lines of the margarite–muscovite pairs reported by Höck (1974) and Teale (1979) (H-148/70 and 454/382) respectively, as plotted on the Na–Ca–K diagram, fall outside the three-phase field depicted by Guidotti *et al.* (1979). In contrast, the tie line derived from our study and one of Teale's (1979) tie lines (454/1301) fall within this field (Fig. 3). The

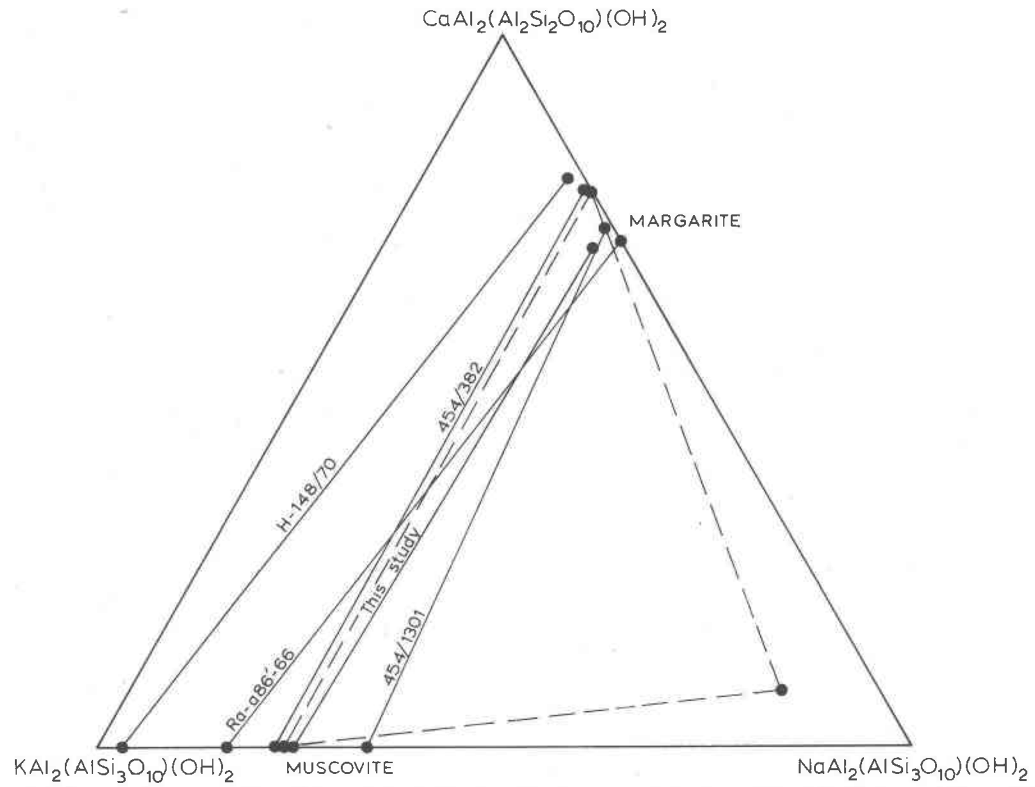

Fig. 3. Coexisting margarite–muscovite pair from this study plotted on the Na–Ca–K (end-member white micas) diagram; also shown are margarite–muscovite pairs from Höck (1974) (H-148/70), Teale (1979) (454/382, 454/1301) and Guidotti and Cheney (1976) (Ra-a86′-66). Dashed lines show average end-member values for margarite, paragonite, and muscovite pairs reported by Guidotti *et al.* (1979).

margarite–muscovite tie line (H-148/70) given by Höck (1974) is of nearly the same orientation as that (Ra-a86′-66) given by Guidotti and Cheney (1976). The latter, however, crosses the Guidotti *et al.* (1979) muscovite–margarite tie line (Fig. 3) for coexisting muscovite–paragonite–margarite, implying that the amount of paragonite solid solution in margarite of the three-mica assemblage is lower than that in the muscovite–margarite assemblage.

The data are conflicting and no firm conclusion can be reached on the amount of paragonite solid solution in margarite and muscovite from paragonite-bearing and paragonite-free rocks. These amounts probably depend on specific conditions of metamorphism. Our results, however, suggest a more extensive paragonite solid solution in coexisting margarite–muscovite pairs than that found in the three-mica specimens reported by Guidotti *et al.* (1979).

The fact that in most of the margarite occurrences reported so far, margarite appears as a pseudomorphic replacement of aluminosilicate polymorphs (Chinner, 1974; Lanphere and Albee, 1974; Guidotti and Cheney, 1974; Teale, 1979; Guidotti *et al.*, 1979) is of great interest. The replacement of the aluminosilicate by margarite is by no means puzzling, inasmuch as both minerals have the same Al:Si ratio and only CaO and H_2O need to be added, as suggested by Burt in Guidotti *et al.* (1979). The CaO may well be contributed by the plagioclase (Ab_{78} An_{22}) in the groundmass (Guidotti *et al.*, 1979). Nevertheless, difficulties arise in the interpretation of the replacement textures. The common occurrence of margarite associated with a pseudomorph-producing event suggests that, in some cases, margarite may not be a primary phase of the prograde sequence and is instead related to polymetamorphism.

Further data are needed on the phase relations of margarite in the system Al_2O_3–CaO–Na_2O–K_2O–SiO_2–H_2O. Precise data on the metamorphic histories and the metamorphic conditions of areas where margarite is developed will likewise be needed before an understanding of the petrologic implications of margarite appearance can be reached.

Acknowledgments

This work was carried out at the Geology Department, University of Manchester. E. B. would like to thank Dr. B. J. Wood for his advice and Professor J. Zussman for allowing the use of analytical facilities.

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Manuscript received, April 15, 1980;
accepted for publication, July 16, 1980.