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# Margarite pseudomorphs after chiastolite in the Rangeley area, Maine

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**Abstract**

In recent years margarite has been recognized as an important rock-forming mineral in several widely distributed localities. This paper reports an occurrence of margarite pseudomorphs after chiastolite in metamorphosed black shales of the Rangeley area, Maine. Analyses are presented for coexisting margarite, muscovite, and chlorite. As with most reported analysis of margarite, a considerable amount of the paragonite end-member is present in solid solution (~28.4 mole %).

## Introduction

Until fairly recently margarite has been considered as a mineral of special compositional environments. More recently it has been found as a rock-forming mineral in numerous localities: in Europe, Sagon (1967, 1970), Frey and Niggli (1972), Höck (1974), and Ackermand and Morteani (1973); in the Scottish Dalradian, Chinner (1974); in Vermont, Lanphere and Albee (1974) and A. B. Thompson (personal communication); and in British Columbia, Jones (1971). Moreover, experimental data is now becoming available on margarite and its phase relations; *e.g.*, Velde (1971), Chatterjee (1974), and Storre and Nitsch (1974). In addition, some theoretical treatments have also been made of margarite phase relations; *e.g.*, Frey and Orville (1974) and Thompson (1974).

This paper describes an occurrence of margarite in northwestern Maine where margarite occurs as pseudomorphs of chiastolitic andalusite with even the fine details of the graphitic crosses preserved.

## Geologic setting

The margarite-bearing rocks occur in the Small's Falls Formation in a road cut at a locality on Highway 4 known as Small's Falls (about 8 miles east-southeast of the town of Rangeley). The Small's Falls Formation contains lithologies ranging from granular calc-silicate to pelitic schist (Moench, 1971). It is an unusually distinctive unit inasmuch as it commonly contains up to 10 modal percent of pyrrhotite and several modal percent of graphite.

The stratified rocks of northwestern Maine have been metamorphosed to various grades during the Acadian event in Lower Devonian time, *e.g.*, Guidotti (1970), Boone (1973). In the vicinity of Small's Falls the metamorphic history involves polymetamorphism. In some specimens chiastolite is completely replaced by coarse margarite, and staurolite from adjacent stratigraphic units is commonly replaced by aggregates of coarse chlorite and muscovite. The most recent metamorphism took place under garnet-zone conditions.

## Petrography

The specimen in which margarite has been identified is fairly typical of the pelitic varieties of the Small's Falls Formation in the middle grades of metamorphism. It is a well-foliated phyllite or schist which is dark grey to black on fresh surfaces and has some minor crinkling. Lenticular blebs of pyrrhotite are readily seen in hand specimen, and in some cases tiny chlorite plates are also visible.

The most interesting mineralogical feature of the pelites in the vicinity of Small's Falls is the development of chiastolite megacrysts with dimensions up to

A. B.

FIG. 1. Photomicrograph of margarite pseudomorphous after chiastolite, all at 10X. (A) A portion of a large pseudomorph showing detailed distribution of graphite. (B) Same view in crossed nicols.

TABLE 1. Analyses* of coexisting margarite, muscovite, and chlorite from specimen Ra-a86′-66, Rangeley area, Maine.

| | Margarite | Muscovite | Chlorite |
|---|---|---|---|
| $SiO_2$ | 32.23 | 47.60 | 28.04 |
| $Al_2O_3$ | 50.35 | 35.57 | 23.50 |
| FeO | .13 | .32 | 9.07 |
| MgO | .29 | 1.08 | 25.49 |
| $TiO_2$ | .04 | .71 | .05 |
| MnO | .01 | .02 | .66 |
| $K_2O$ | 000 | 9.16 | 000 |
| $Na_2O$ | 2.23 | 1.16 | 000 |
| CaO | 10.00 | 000 | 000 |
| $H_2O$** | 4.86 | 4.45 | 13.10 |
| Formulas Based on 22 Oxygen (Micas) and 28 Oxygen (Chlorite) | | | |
| IV Si | 4.248 | 6.233 | 5.459 |
| Al | 3.752 | 1.767 | 2.541 |
| Total Al | 7.820 | 5.489 | 5.391 |
| VI Al | 4.068 | 3.722 | 2.850 |
| Fe | .014 | .035 | 1.477 |
| Mg | .056 | .212 | 7.396 |
| Ti | .003 | .070 | .007 |
| Mn | .001 | .002 | .109 |
| Σ | 4.142 | 4.041 | 11.839 |
| XII K | 000 | 1.530 | 000 |
| Na | .570 | .294 | 000 |
| Ca | 1.412 | 000 | 000 |
| Σ | 1.982 | 1.824 | 000 |
| Mg/Fe | | | 5.006 |
| Mn/Fe | | | .074 |
| Na/Na+Ca+K | .288 | .161 | |

*Analyses by electron microprobe; see Guidotti et al. (1975) for details of run conditions.
**Value for $H_2O$ by difference from 100%
Margarite cell parameters: $a$ = 5.126(2), $b$ = 8.855(3), $c$ = 19.168(5), β = 95.45(2)°, Vol. = 866.09(3) Å³
Estimated standard errors are in parentheses and refer to the last decimal place.

3 cm in width and 15 cm in length. These megacrysts tend to lie within the foliation planes. In the specimens studied thus far the aluminum silicate has been completely converted to margarite. The margarite occurs as coarse sheaves which make up virtually all of the pseudomorph. Only minor quartz and the graphite of the original chiastolite are present as additional minerals in the pseudomorphs (Fig. 1).

Visual modal estimates of the groundmass of the specimen provide the following data: quartz 50%, muscovite 33%, chlorite 5%, graphite 3%, pyrrhotite 8%, and rutile 1%. Muscovite and chlorite occur as fine-grained laths which define the foliation. No plagioclase or paragonite was detected either by thin-section investigation or by electron microprobe. Because graphite is abundant, fine-grained, and widely dispersed, it causes a darkening or blurring of the thin sections—a feature which makes petrography and modal estimates difficult. The rutile occurs as tiny amber-colored prisms, some of which display knee-shaped twins. Tourmaline is present as tiny yellow prisms.

## Mineral data

Table 1 provides chemical data for the margarite, muscovite, and chlorite. Figure 2 is a plot of the coexisting margarite and muscovite on the white mica plane of the system $Al_2O_3$–CaO–$Na_2O$–$K_2O$ with $SiO_2$ in excess and an $H_2O$-rich fluid assumed present. As has been found in most studies on margarite coexisting with other white micas, this margarite contains a considerable amount of the paragonite endmember in solid solution (*e.g.*, see the margarite–muscovite pairs from Höck (1974) and Fox (1974) as plotted on Fig. 2). Table 1 also presents cell dimensions of the margarite from the Small's Falls locality, obtained via the program of Appleman and Evans (1973).

## Discussion

This paper presents data which establish another tie line of the white mica plane. It thereby contributes further to understanding the miscibility relations among the white micas.

Of interest is the fact that this margarite, like those in a number of other occurrences [*e.g.*, Chinner (1974), Lanphere and Albee (1974)], seems to have formed in association with a pseudomorph-producing event. This suggests that in some cases the presence of margarite may be related to aspects of polymetamorphism rather than being direct primary formation.

Many (but not all) occurrences of margarite as a rock-forming mineral seem to involve the presence of graphite [*e.g.*, this report, Sagon (1967, 1970), Chinner (1974), Frey and Orville (1974), and Frey and Niggli (1972)]. Graphite may be present in other parageneses involving margarite but the published reports have not always listed the opaques present [*e.g.*, graphite is present in many of the specimens studied by Höck (1974), according to Frey (personal communication)]. This is regrettable, because it is possible that in some cases the presence or absence of margarite as a rock-forming mineral might be a function of fluid composition during metamorphism.[1] For example, at a given *PT*, fluid composition may control not only the stability field of pure margarite but also its reactions with other phases, and thus determine whether margarite can occur in rocks with common pelitic bulk compositions.

Obviously many more data are needed on margarite-bearing parageneses to fully understand their significance. As pointed out by Chatterjee (1974), the phase relations of margarite in the context of the tetrahedron defined by the components $Al_2O_3$–CaO–$Na_2O$–$K_2O$ (quartz-saturated) will be of prime interest for understanding the petrologic implications of margarite. However, to date, the available experimental data have provided little help on this point, because they have dealt with water-saturated systems that are free of $Na_2O$ and $K_2O$.

[1] As pointed out by Eugster and Skippen (1967), the opaque minerals in a rock commonly provide a means of assessing the composition of the fluid phase present during metamorphism.

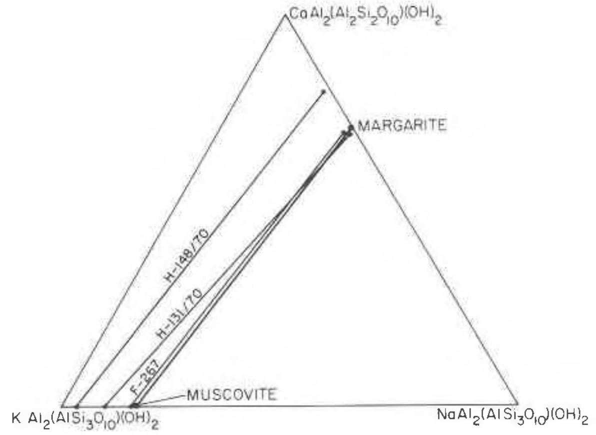


FIG. 2. Plot of margarite–muscovite pair from specimen Ra-a86'-66 on the margarite–muscovite–paragonite plane of the system $Al_2O_3$–$Na_2O$–$K_2O$–CaO (quartz and an $H_2O$-rich fluid assumed present); also shown are margarite–muscovite pairs from Höck (1974) (H–148/70 and H–131/70) and Fox (1974) (F–267).

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