

Petrogenetic significance of the triphylite + sarcopside intergrowths in granitic pegmatites: an experimental investigation of the $\text{Li(Fe,Mn)(PO}_4\text{)}\text{-(Fe,Mn)}_3\text{(PO}_4\text{)}_2$ system

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ABSTRACT

Lamellar textures involving triphylite and sarcopside are well known in rare-elements granitic pegmatites, and we describe herein new occurrences of these associations in the Cañada (Spain) and Tsaobismund (Namibia) pegmatites. These natural phosphates were analyzed by electron microprobe, and their relative proportions were measured. In order to constrain the temperatures at which these exsolutions were produced, we performed hydrothermal experiments between 400 and 700°C (1kbar), starting from the compositions $\text{LiFe(II)}_{2.5}\text{(PO}_4\text{)}_2$, $\text{LiMn}_{0.5}\text{Fe(II)}_2\text{(PO}_4\text{)}_2$ and $\text{LiMnFe(II)}_{1.5}\text{(PO}_4\text{)}_2$. Some samples synthesized at 500 and 700°C (1 kbar) show the presence of triphylite and sarcopside as dominant phases, thus confirming the primary origin of these phosphates.

Keywords: triphylite + sarcopside, hydrothermal synthesis, geothermometer, pegmatites.

INTRODUCTION

Lamellar triphylite + sarcopside associations are well known in numerous rare-element granitic pegmatites. These intergrowths are traditionally interpreted as exsolution textures, and Moore (1972) suggests the existence of a complete $\text{Li(Fe,Mn)(PO}_4\text{)}\text{-(Fe,Mn)}_3\text{(PO}_4\text{)}_2$ solid solution at high temperature. According to this hypothesis, exsolutions of sarcopside into triphylite, or of triphylite into sarcopside, would appear during cooling, depending on the composition of the parent high-temperature unique phase.

The aim of this study is to measure the chemical compositions of selected triphylite + sarcopside assemblages from granitic pegmatites, and to measure the proportions of lamellae. Then, hydrothermal experiments, which are still under progress, will help us to establish the temperatures at which the exsolutions were produced.

DESCRIPTION OF THE NATURAL ASSEMBLAGES

Triphylite + sarcopside intergrowths from the Cañada pegmatite, Spain (Roda *et al.*, 2004) and from the Tsaobismund pegmatite, Namibia (Fransolet *et al.*, 1986) were selected and preliminarily examined under the polarising microscope and with a scanning electron microscope (BSE mode). Figure 1 shows exsolutions of tiny triphylite lamellae into sarcopside, and Figure 2 shows exsolutions of large sarcopside lamellae into triphylite.

The relative proportions of these minerals, which are given in Table 1, depend on the chemical composition of the parent phase, which can be obtained by performing electron-microprobe analyses on associated triphylites and sarcopsides (Table 1). These starting compositions are necessary to constrain the Fe/Mn ratio of the starting material used in the hydrothermal experiments.

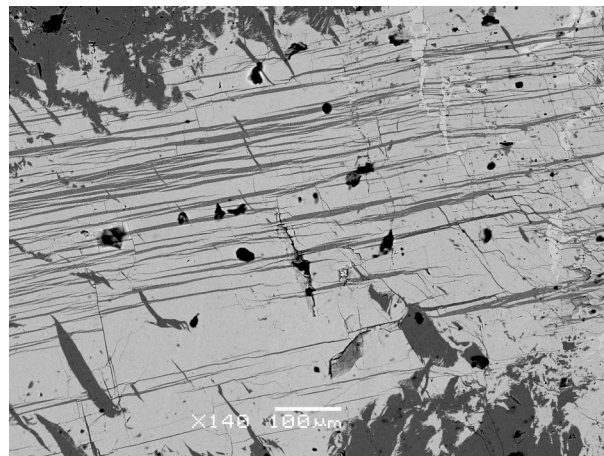


FIGURE 1. Sarcopside (light grey) including lamellae of triphylite (dark grey), Cañada pegmatite, Spain (sample SS-3, BSE image).

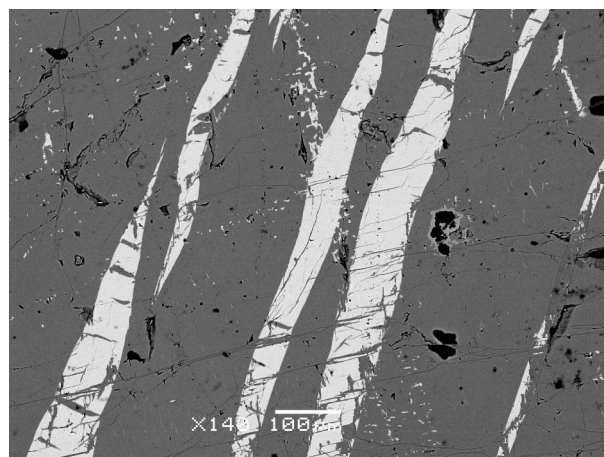


FIGURE 2. Triphylite (dark grey) including lamellae of sarcopside (white), Cañada pegmatite, Spain (sample SS-3, BSE image).

TABLE 1. Electron-microprobe analyses and relative proportions of triphylite and sarcopside, in two assemblages from the Cañada (Spain) and Tsaobismund (Namibia) pegmatites.

	Cañada, Spain (SS-3)		Tsaobismund, Namibia (8501-39)	
	Sarc.	Tri.	Sarc.	Tri.
P ₂ O ₅	39.71	45.19	38.69	43.65
MgO	0.77	1.10	1.42	1.03
MnO	12.11	8.86	11.48	16.01
FeO	45.47	35.15	46.67	28.69
Li ₂ O*	0.00	9.51	0.00	9.19
TOTAL	98.06	99.81	98.26	98.57
Cation numbers				
P	2.000	1.000	2.000	1.000
Mg	0.068	0.043	0.127	0.041
Mn	0.611	0.196	0.595	0.367
Fe ²⁺	2.262	0.768	2.386	0.649
Li	0.000	1.000	0.000	1.000
%	35.3	64.7	15.2	84.8

* : Calculated values.

HYDROTHERMAL EXPERIMENTS

The hydrothermal experiments were performed from the LiFe(II)_{2.5}(PO₄)₂, LiMn_{0.5}Fe(II)₂(PO₄)₂ and LiMnFe(II)_{1.5}(PO₄)₂ starting compositions, which correspond to mixtures of triphylite + sarcopside in a 1:1 ratio. Only Fe(II)-rich compositions were considered, since it appears that the natural compositions investigated herein do not reach a very high Mn-content (Table 1).

The samples, together with a small amount of water, were sealed in 2 mm diameter gold capsules, which were then introduced in conventional Tuttle-type cold-seal bombs (Tuttle, 1949). The final temperatures were 400, 500, 600 and 700°C, under a pressure of 1 kbar. The duration of the experiments was 7 days.

Two samples, synthesized at 500 and 700°C (1 kbar) from the starting composition LiFe(II)_{2.5}(PO₄)₂, were already examined by X-ray powder diffraction. The powder patterns show the presence of triphylite and sarcopside as dominant phases, thus confirming the primary origin of these phosphates. These promising results will be followed soon by electron-microprobe analyses, which should permit to better understand the phase relations in the Li(Fe,Mn)(PO₄)-(Fe,Mn)₃(PO₄)₂ system, between 400 and 700°C (1 kbar).

CONCLUSIONS

The preliminary results given here show that the triphylite + sarcopside assemblage is a primary assemblage in granitic pegmatites, since it has been reproduced hydrothermally at 500 and 700°C (1 kbar). The electron-microprobe analyses of these synthetic phosphates will certainly permit to establish the phase relations in the triphylite-sarcopside system, between 400 and 700°C (1 kbar). By comparison with the analytical data collected on natural assemblages, these experimental results should provide a relatively accurate

determination of the temperature at which the exsolutions crystallized.

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