

KAERSUTITE (Ti-rich Amphibole) IN THE SNC METEORITES: CAN IT CRYSTALLIZE AT LOW PRESSURE? F. M. McCubbin¹, M. L. Whitaker¹, D. H. Lindsley¹, H. Nekvasil¹, ¹Department of Geosciences, State University of New York, Stony Brook NY 11794-2100, fmccubbi@ic.sunysb.edu.

Introduction: Kaersutite is a Ti-rich amphibole (5-10 wt% TiO₂ [1]) that occurs in SNC meteorites in melt inclusions. Both the basaltic shergottites and the Chassigny dunite, of the SNC meteorites, contain kaersutite in melt inclusions [2]. The shergottites contain ferro-kaersutite that is found within melt inclusions usually within cores of pyroxenes [2]. These kaersutites are generally low in OH⁻ content, and high in Fe [2]. The Chassigny meteorite contains kaersutites found within melt inclusions in olivine [2, 3]. Chassigny kaersutites are oxy-kaersutites with the O(3) site summing to about 0.4 anions per formula unit (apfu), requiring 1.6 O²⁻ [2]. Understanding the nature of the kaersutite within SNC meteorites may be essential for understanding the petrogenetic history of the SNC's.

Kaersutite on Earth is found in mantle-derived peridotites and as phenocrysts in alkalic rocks with obvious high-pressure history [4, 5]. Does this also require a high-pressure crystallization history on Mars? Before this can be answered, the lower pressure limits of its stability must be evaluated. Previous workers tried at low pressure to synthesize kaersutites similar to those in the Chassigny magmatic inclusions. The experiments were conducted over a range of temperature and pressure conditions as well as various fO₂ and fH₂O [6].

Using a basalt/natural kaersutite mixture, kaersutite was synthesized at 2 kbar and 960°C [6]. However, the kaersutite produced during the experiments formed rims around already existing kaersutite, and the new kaersutite produced had about 2 wt% less TiO₂ than kaersutites in Chassigny magmatic inclusions [6]. It was suggested that perhaps fluorine would increase the titanium content of the kaersutite and stabilize it under low pressure [6]. Ti-free fluor-amphiboles have been successfully crystallized at 0 kbar [7]; however, to date, no experiments have been conducted that attempted to synthesize purely fluorinated kaersutites at low pressure.

The focus of the present study is to attempt to synthesize kaersutite in order to experimentally investigate the stability of fluor-kaersutites under various P-T conditions ranging from 0-2 kbar and 700-900°C.

Experimental Technique: A powdered mix of oxides and CaF₂ was made based on the kaersutite compositions reported by [6, 3]. An Fe²⁺/Fe³⁺ ratio of 3.21 was used.

For all experiments at and below 2 kbar, the synthetic powder was dried at 800°C for 10 minutes in

order to drive off structural and absorbed H₂O. A zero kbar experiment was done using an evacuated silica glass tube in which Ag foil encapsulated powdered mix. The tube was then placed in a furnace, and a temperature of 900°C was maintained for a duration of 17 days (Table 1). Experiments conducted at conditions of 0.5-3 kbar and 700-800°C used welded gold tubes containing the powdered mix. The welded tubes were placed within hydrothermal cold-seal pressure vessels; pressure and temperature conditions were maintained for 10-14 days (Table 1).

Table 1. Experimental conditions of attempts to synthesize kaersutite. Phases were identified using optics, XRD, and electron microprobe.

Sample	T (°C)	P (kbars)	Duration (days)	New phases
1.001	900	0	17	ilm, amph, Ti-mag
1.002	700	1	14	ilm
1.003	800	1	13	ilm, amph, aug?, ol?, pl?
1.004	700	2	11	ilm
1.005	800	2	10	ilm, amph, Ti-mag, gl?
1.006	800	0.5	13	ilm, amph, aug?, ol?, pl?
1.007	700	0.5	13	Ilm, amph?, pl?, ol?

*aug- augite, amph- amphibole, gl- glass, ilm- ilmenite, ol- olivine, pl- plagioclase, Ti-mag- titanium magnetite, ?- possibly present.

Results: Although reaction was far from complete, amphibole was successfully synthesized in experiments at 800°C and 900°C (Table 2). Synthesized samples were extremely fine-grained and only the 2 kbar experiment could be analyzed by electron microprobe. None of the amphiboles analyzed by electron microprobe are kaersutite; in fact, Ti contents of these amphiboles are notably low (Table 2).

X-ray diffraction (XRD) patterns were analyzed for each of the experiments, and distinguishing peaks for kaersutite, (110) and (020), were compared with peaks for amphiboles produced in this study (Tables 3, 4).

Summary: None of the amphiboles produced in our synthesis experiments at 0-2 kbar have (110) and

(020) spacings that overlap with published kaersutites (Tables 3, 4). Coupled with the electron microprobe results, we conclude that kaersutite was not synthesized during these experiments. Given that the stoichiometric probability of forming kaersutite was high, and Ti-poor amphibole was successfully synthesized, it may be that fluor-kaersutite is not stable under these conditions. We realize that failure to synthesize does not prove instability. Therefore, we plan to continue our study, including synthesis of fluor-kaersutite at higher pressure followed by attempts to destabilize it at lower pressure.

Table 2. Amphibole compositions synthesized at 2 kbar and 800°C.

Oxide	Target Amph. [6]	Amph. 1	Amph. 2	Amph. 3
SiO ₂	39.49	46.87	45.74	39.65
TiO₂	7.00	0.34	0.30	0.57
Al ₂ O ₃	14.22	8.49	5.95	16.59
FeO	10.57	3.14	3.24	2.86
MnO	0.17	0.02	0.01	0.02
MgO	11.53	24.22	27.34	26.88
CaO	11.80	9.93	13.16	10.62
Na ₂ O	2.99	5.94	5.25	3.82
K ₂ O	0.33	1.05	0.74	0.32
Total	98.78	100.00	101.73	101.32

Table 3. D-spacings for kaersutite peaks resulting from (110) and (020) calculated from published cell parameters [8, 9, 1, 10].

Samples	(110) peak (Å)	(020) peak (Å)
K(3) [8]	8.440	9.010
K(2) [8]	8.439	9.008
Oxy-kaersutite [9]	8.434	9.032
K(4) [8]	8.433	8.998
DHZ kaersutite [1]	8.412	9.000
K(1) [8]	8.409	8.992
17-478 [10]	8.38*	8.995

* denotes non-calculated value

Table 4. peak positions from present study in the range 8.2-9.2Å.

Samples	(110) peak (Å)	(020) peak (Å)
1.003	8.547	9.066
1.005	8.515	9.103
1.006	8.499	9.121
1.001	8.499	9.121

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