EXPERIMENTAL STUDY OF IGNEOUS KAERSUTITE STABILITY WITH APPLICATION TO SNC PETROGENESIS; Marie C. Johnson, Malcolm J. Rutherford, and Paul C. Hess, Dept. of Geological Sciences, Brown University, Providence, RI, 02912

The SNC meteorites are grouped together based on common textures, mineralogies, oxygen isotopes, and crystallization ages (<1.3 b.y.). They are fine-grained cumulate-textured mafic rocks which may have crystallized on Mars (1). A high-TiO_2 amphibole, kaersutite, has been identified in melt inclusions trapped in Shergotty and Zagami pigeonites and Chassigny olivines (2,3). Ion probe analyses of these kaersutites reveal that they have low-halogen contents, and, therefore, they are inferred to be hydrous (2). This observation depicts a unique occurrence of a hydrous extra-terrestrial mineral, and promises clues about the volatile content of the SNC parent magma.

Textural evidence indicates that kaersutite in the SNC melt inclusions is a magmatic phase, and did not grow by subsolidus reequilibration. Little is known about the stability of igneous kaersutite. Many terrestrial kaersutites are in mantle nodules implying a high-pressure paragenesis. A high-pressure origin seems inappropriate for the SNC kaersutites given the evidence for rapid cooling (the fine-grained interstitial mesostasis) and the fact that meteorite impacts have excavated the samples. The results of one experimental study of kaersutite stability at high-pressure create doubt that kaersutite is ever a stable igneous phase (4). However, cumulus kaersutite crystals are reported in natural hawaiite lavas estimated to have equilibrated at 1.5 – 3 kb (5). An experimental attempt to stabilize kaersutite in equilibrium with melt at conditions relevant to an origin on the SNC parent body (i.e., low-pressure) is described here.

Experiments were conducted at 2 and 2.5 kb, 950–850°C, at fO_2's buffered by either QFM or graphite-methane under water-saturated conditions. Starting materials were a natural Fe-Ti basalt and a natural alkali basalt. In a few experiments, natural kaersutite (TiO_2 = 5.7, Mg* = 73.5) and Fe-Ti basalt were mixed together in a 50-50 weight ratio. The purpose of these experiments was to impose kaersutite saturation on the system, and to analyze the resulting melt chemistry.

EXPERIMENTAL RESULTS. Small, euhedral kaersutites (>5 wt. % TiO_2) crystallized in all three experiments in which kaersutite saturation was imposed. These kaersutites are in equilibrium with dacitic melt and clinopyroxene, olivine, 1 – 2 % Fe-Ti oxides, and small amounts of plagioclase. In experiments run on the basalts alone, amphiboles with intermediate (3 – 4 wt. %) TiO_2 content crystallized. Coexisting phases in these runs are clinopyroxene, olivine, and greater amounts of Fe-Ti oxides and plagioclase compared to the kaersutite-bearing runs.

Once amphibole is a liquidus phase and begins to crystallize (920°C, 2 kb), the silica content of a coexisting melt increases. All experimental melts coexisting with amphibole are more silica-enriched (60 – 70 wt. % SiO_2) than the starting basalts. The D coefficient for TiO_2 (hornblende/melt) is sensitive to melt SiO_2 content and temperature and increases from 3 to 13 as the melt evolves from 58 to 70 % SiO_2 (920° – 860°C) (Fig. 1). As the melt SiO_2 content increases, FeO in the melt simultaneously decreases from 8 to 2 wt. %. Kaersutite, while coexisting with melts with SiO_2 contents from 64 – 71%, appears only in low-FeO melts. Conditions for kaersutite stability are indicated by the FeO/TiO_2 ratio of the coexisting melt, and are favored by decreases in this ratio (Fig. 2). The kaersutite-bearing charges also had low Fe-Ti oxide abundances.

The SNC kaersutites are characterized by TiO_2, Al_2O_3, and FeO (Mg* = 35) enrichment, and low SiO_2 and K_2O contents. All of the kaersutites produced experimentally to date have much higher Mg*'s, and higher SiO_2 and K_2O contents than the SNC kaersutites (Table 1). The experiments run using the alkali basalt starting material produced amphiboles with TiO_2 contents intermediate to those in the kaersutite-saturated experiments and the Fe-Ti basalt experiments (e.g., 25A, Table 1). In

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addition, the amphiboles crystallized have relatively high FeO and low K_2O contents approaching the SNC kaersutite composition.

DISCUSSION AND CONCLUSIONS. The experimental results indicate that kaersutite can be a stable igneous phase capable of coexisting with dacitic melts at low pressures. The results support the observation that amphibole cannot coexist with basaltic melts at these pressures (2 – 3 kb); once on the liquidus, amphibole crystallization drives up the silica-content of the coexisting melt. Perhaps, kaersutite has not been observed outside the melt inclusions because only basaltic SNC's have been examined to date.

The experimental data suggest that a major control on kaersutite stability is the FeO/TiO_2 ratio of the coexisting melt. Experiments on a Fe–Ti basalt produced a low–TiO_2 amphibole in equilibrium with a relatively FeO–rich melt at a given SiO_2 content, while experiments on a more primitive composition ($SiO_2 = 44.5$, $MgO = 9.5$) produced a kaersutitic amphibole in a FeO depleted melt at a given melt SiO_2. Kaersutite appears to be stabilized at the expense of Fe–Ti oxides in the more primitive bulk composition. Extrapolating the experimental data shown in Fig. 2 suggests that the Fe/TiO_2 ratio of the parental SNC magma was about 3.

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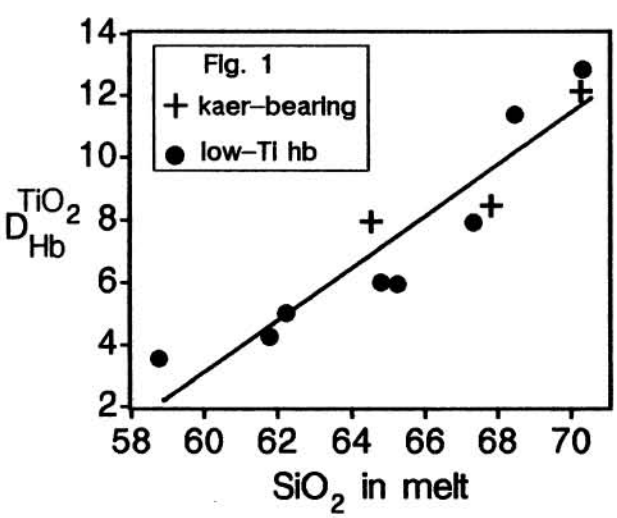
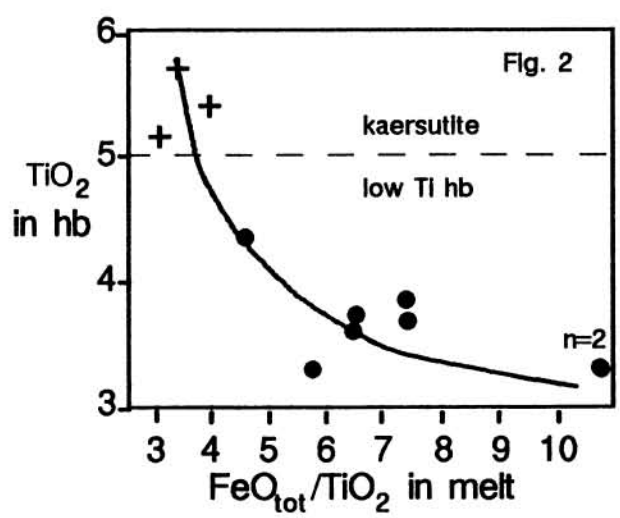
Table 1. Amphibole compositions.

exp	SiO_2	TiO_2	Al_2O_3	FeO	MgO	CaO	Na_2O	K_2O	MnO	Tot
SNC†	36.11	8.92	15.08	18.25	5.42	11.09	2.00	0.11	0.35	97.33
23	40.32	5.40	14.03	10.52	12.90	12.00	2.12	1.53	0.17	98.99
24	39.36	5.70	14.38	9.85	12.66	11.17	2.24	1.71	0.04	97.11
25B	40.71	5.15	13.40	14.87	13.00	11.14	2.19	1.42	0.14	98.83
25A	40.29	4.34	12.46	16.08	10.43	11.10	2.30	0.57	0.32	97.89

† Analysis from (2).





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