

Phase equilibria of various types of silico-ferrite of calcium and aluminum in the FeO-Fe₂O₃-CaO-Al₂O₃ system in air.

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Introduction

The silico-ferrite of calcium and aluminium (SFCA) is a key bonding phase in iron ore sinters which improves the reducibility of sinters.

The SFCA group of phases has homologues with different reducibility¹⁾ and the existence of SFCA, SFCA-I and SFCA-II with the molecular formulas of M₁₄O₂₀²⁾, M₂₀O₂₈³⁾, and M₃₄O₄₈⁴⁾, respectively have been reported.

The present authors of the University of Queensland have tried to find out the relationship between the chemical compositions of CaO·3(Al,Fe)₂O₃ solid solution⁵⁾ (T-phase) in the same system and the types of SFCA with different crystalline structures based on the previous reports: Mumme et al. have reported the existence of SFCA, SFCA-I, and SFCA-II in the FeO-Fe₂O₃-CaO-Al₂O₃ system. However, the authors have not concluded the relationship yet.

The purpose of this study is to investigate the compositional region of various types of silico-ferrite of calcium and aluminium, and their phase equilibria in the FeO-Fe₂O₃-CaO-Al₂O₃ system at 1240 °C in air.

Experimental

(1) Preparation of the Samples

Table 1 lists the initial composition of the samples. Reagents grade of Fe₂O₃, CaCO₃ and Al₂O₃ were weighed and then mixed using an alumina mortar and pestle. Each mixture was compacted with pressure of 40 MPa to produce a small pellet weighing approx. 0.4 g.

(2) Equilibrium Experiment

(a) Sample B ~ F

A sample pellet placed on the sample holder⁶⁾ was suspended and was maintained at 1240°C for more than 48 hours in air and quenched.

(b) Sample A' ~ C'

A sample pellet was crushed into mixed powder. Approx. 0.3 g of sample powder was placed in a sample holder. A sample was preheated at 1300°C for two hours. Then the temperature was lowered to 1240°C at 0.1°C/ min, and then maintained at 1240°C for more than 48 hours in air and quenched

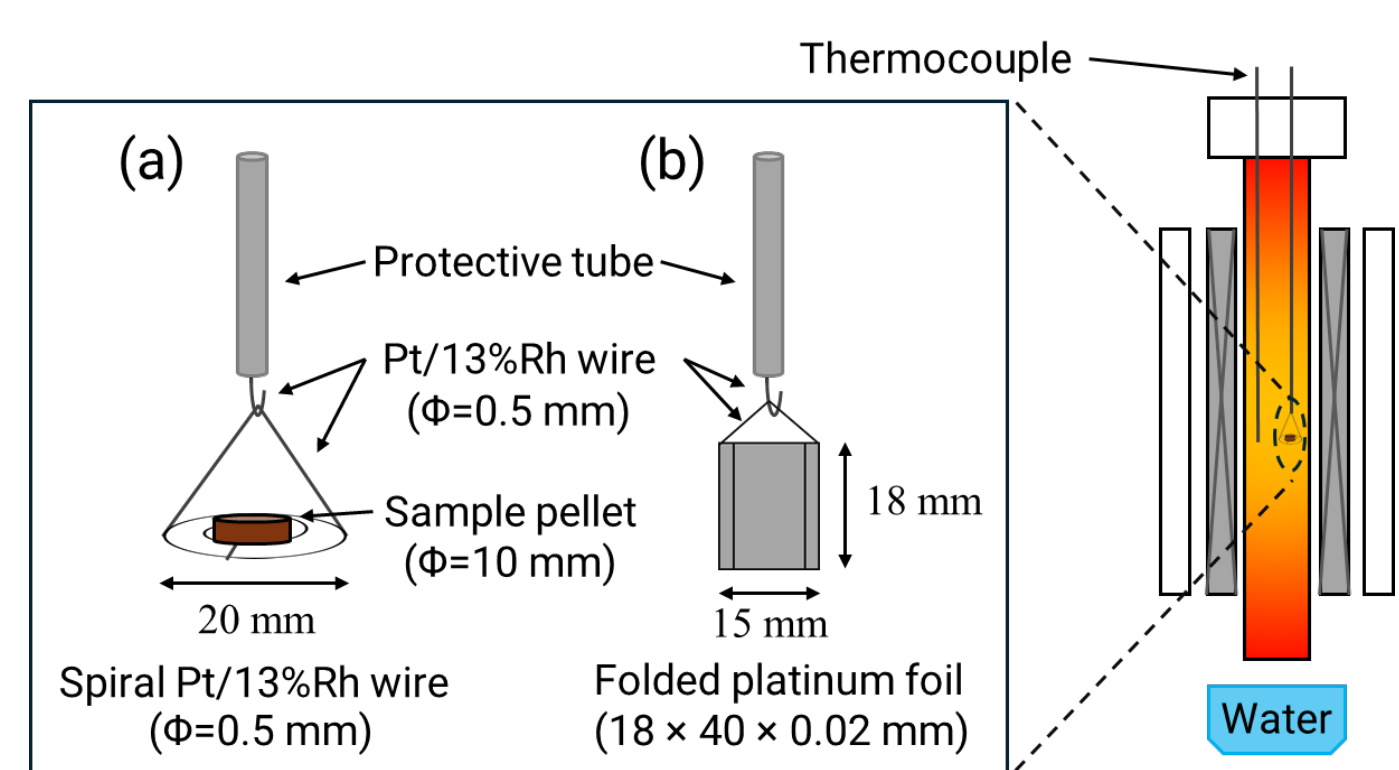


Fig. 1. Schematic of the experimental setup of (a) and (b).

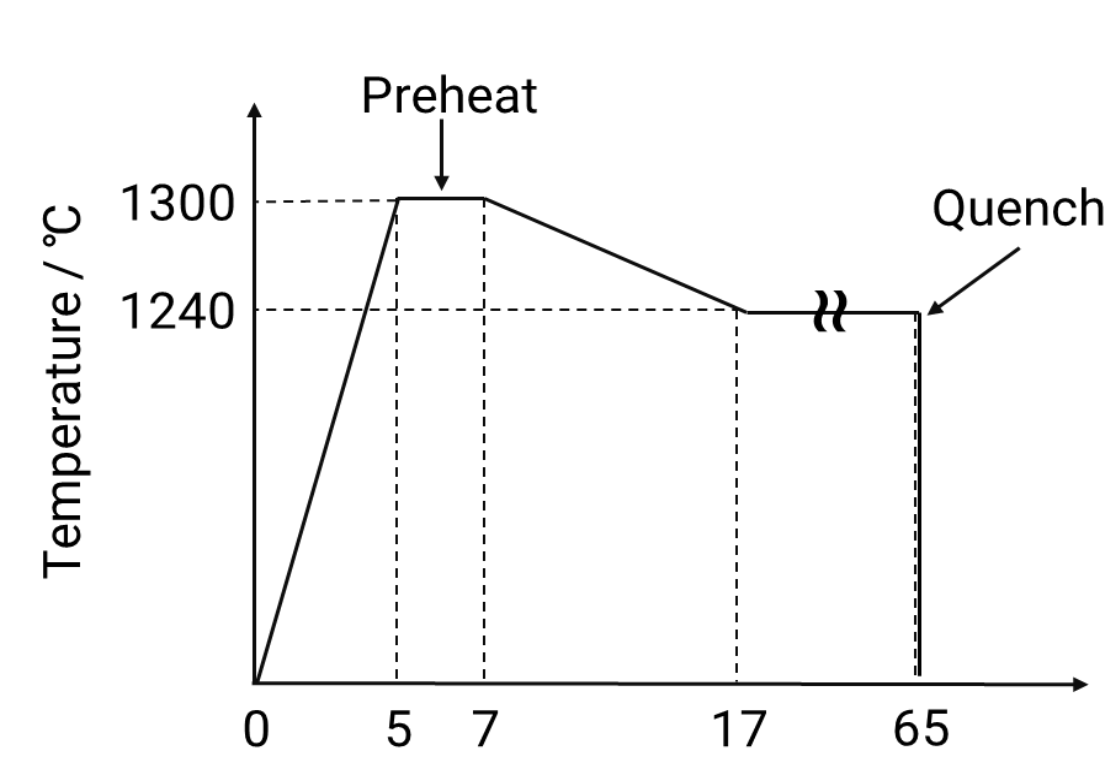


Fig. 2. Temperature history of (b).

(c) Sample G ~ J

A sample pellet placed on the sample holder was preheated at 1400°C for two hours. Then the temperature was lowered to 1240°C at 0.1°C/ min, and then maintained at 1240°C for more than 1 week in air and air cooled.

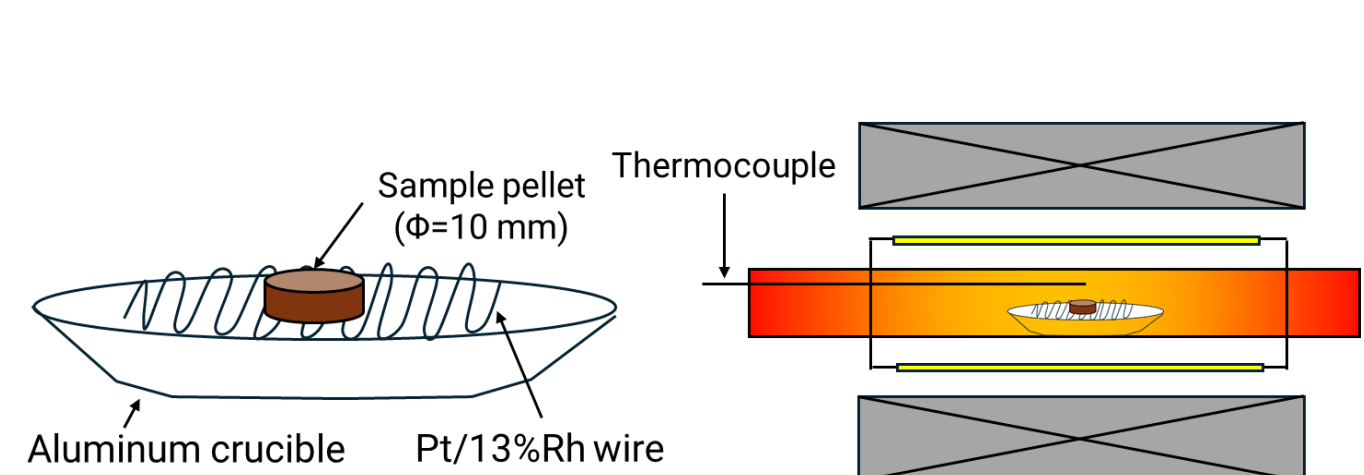


Fig. 3. Schematic of the experimental setup of (c).

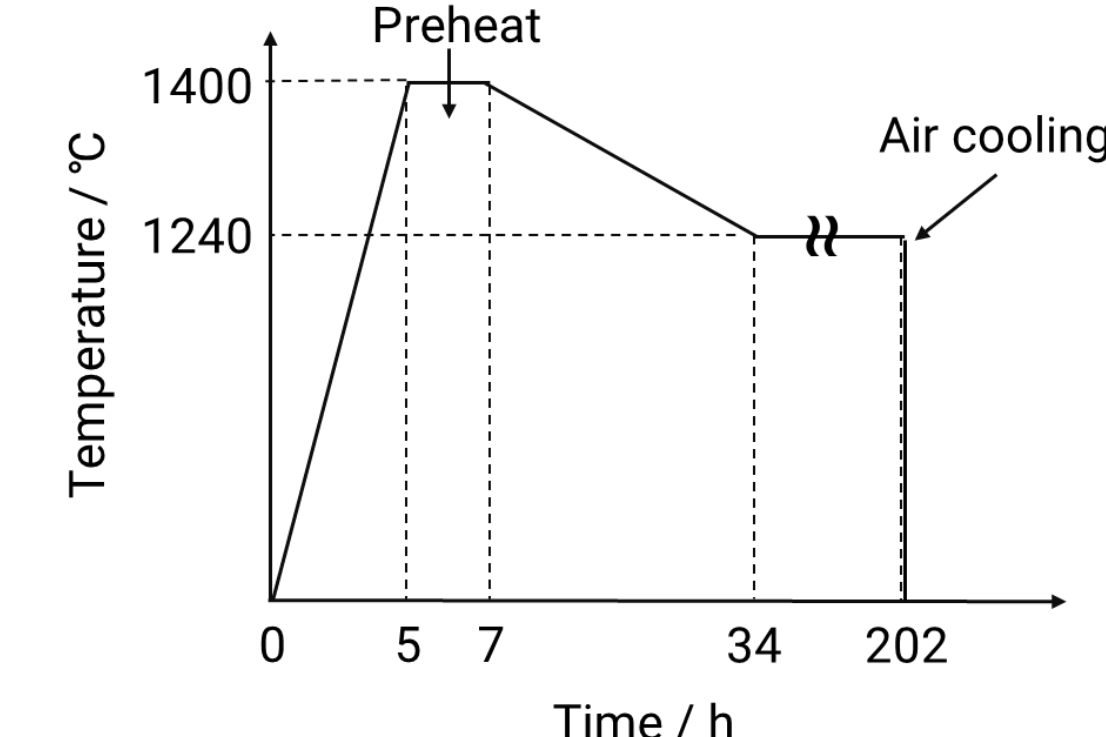


Fig. 4. Temperature history of (c).

(3) Sample Analysis

Each obtained sample was divided into two parts. One was pulverized into a powder and analyzed by X-ray diffraction (XRD) to identify the phase present. The other part was analyzed by electron probe microanalysis (EPMA) to observe the microstructure and measure chemical compositions.

For sample B and E, the types (crystalline structures) of SFCA were identified using single crystalline XRD analyses.

Results

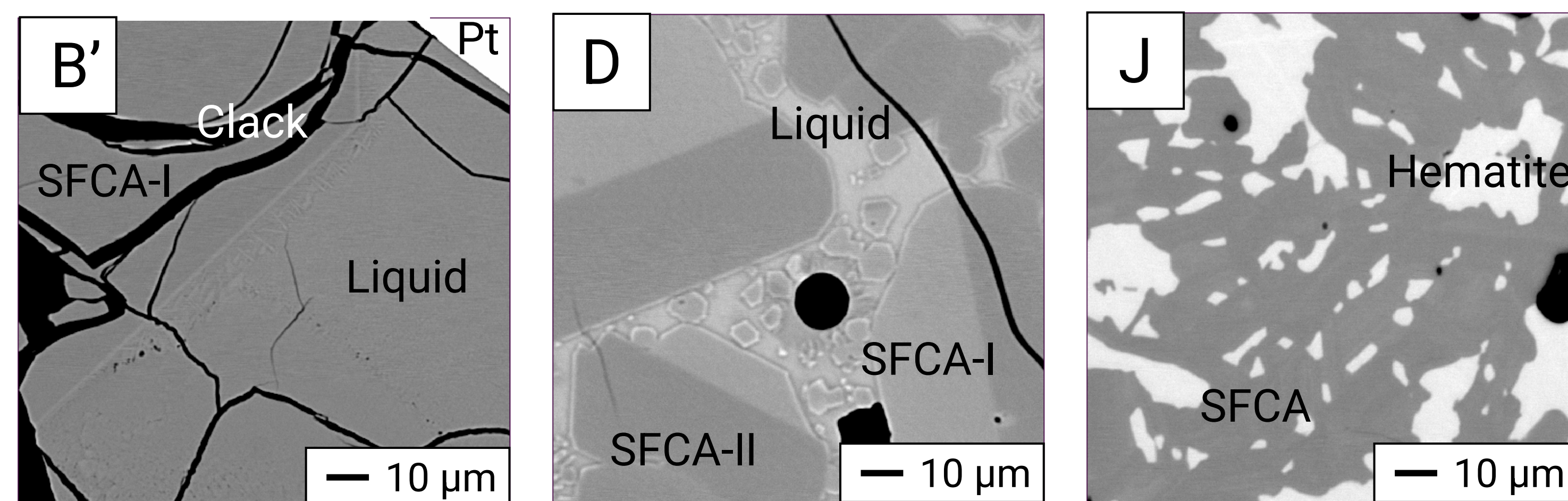


Fig. 5. Backscattered electron images (BEI) of Sample B', D and J.

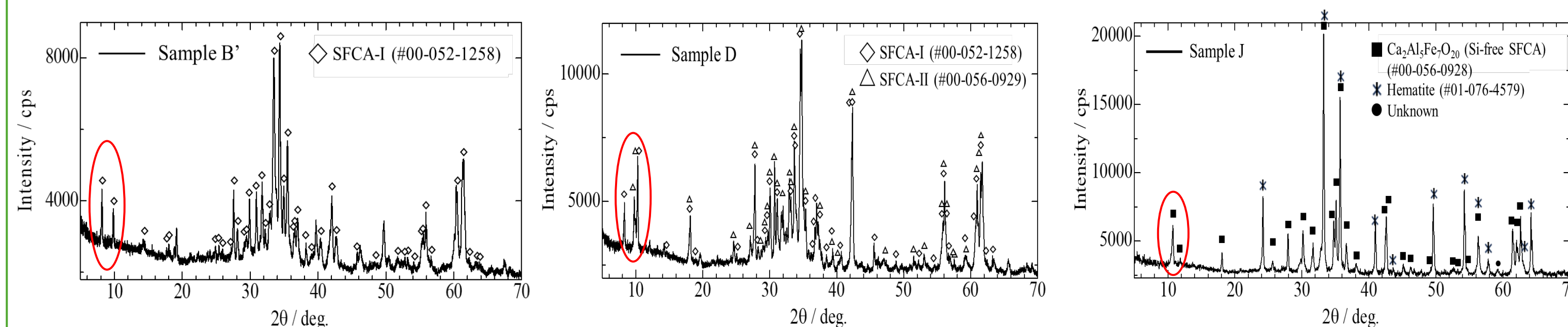


Fig. 6. XRD pattern of Sample B', D and J.

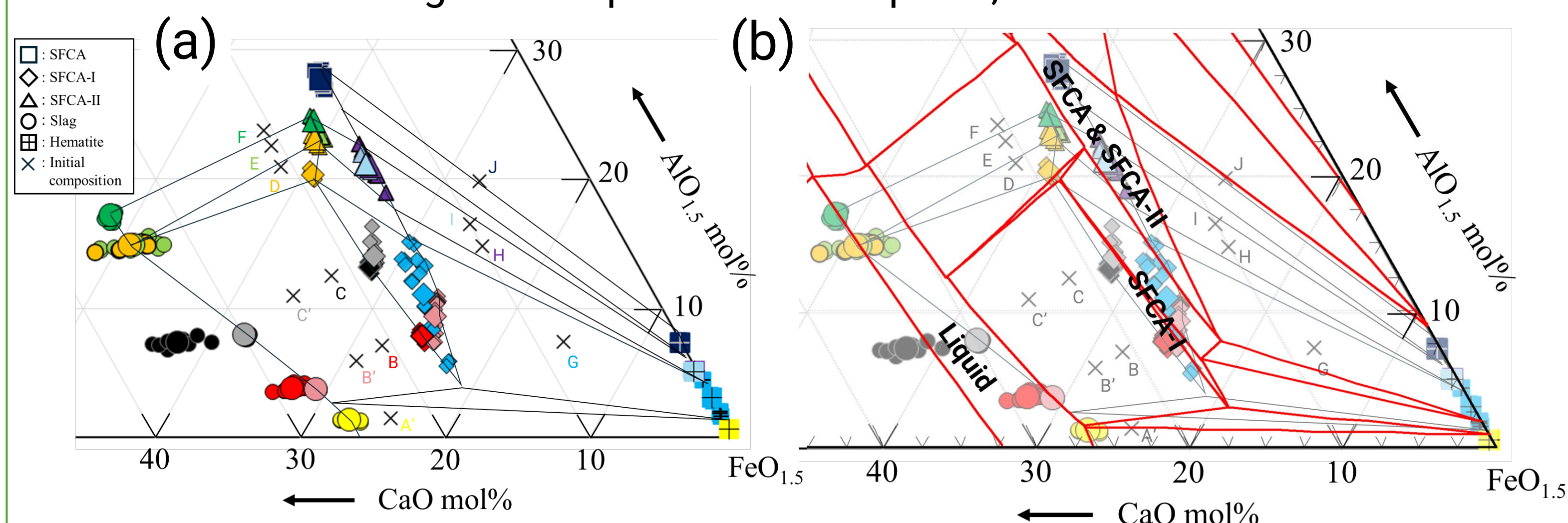


Fig. 7. (a) Isothermal section of the CaO-FeO_{1.5}-AlO_{1.5} system in air at 1240°C. (b) Comparison with the University of Queensland research.

SFCA-I in B and SFCA-II in E were also identified by single-crystal structural analysis. It has been found that the T-phase group consists of SFCA, SFCA-I and SFCA-II solid solution series. The lowest Al₂O₃ compositional area of the T-phase group corresponds to SFCA-I, the middle Al₂O₃ compositional area SFCA-II, and the highest Al₂O₃ compositional area SFCA.

Discussion

• Chemical compositions of SFCA-I and SFCA-II

Since EPMA cannot distinguish between Fe²⁺ and Fe³⁺, the measured chemical composition of SFCA-I and SFCA-II deviated from the structural formula. Estimating the amount of Fe²⁺ as satisfying the ideal structural formula is shown in Table 2.

• Chemical compositions of liquid phase.

Since the liquid phase composition is affected by the crystallization phase within the range of 10-20 μm from the solid phase⁷⁾, a starting composition should be selected in which the liquid phase is as large as possible.

Table 2. Ratios of Fe²⁺ to the total iron ions in SFCA-I and SFCA-II.

Sample	Phase	Percentages of cations (mol%)				Fe ²⁺ /Fe (mol%)
		Ca ²⁺	Al ³⁺	Fe ²⁺	Fe ³⁺	
B	SFCA-I	17.65	7.89	2.35	72.11	3.16
B'	SFCA-I	15.96	9.40	4.04	70.60	5.42
C	SFCA-I	18.66	13.16	1.34	66.84	1.97
C'	SFCA-I	17.88	14.03	2.12	65.97	3.11
D	SFCA-I	18.97	20.33	1.03	59.67	1.70
G	SFCA-I	15.96	11.11	4.05	68.89	5.55
D	SFCA-II	17.43	23.13	0.22	59.22	0.37
E	SFCA-II	16.87	23.35	0.78	59.00	1.30
F	SFCA-II	16.77	24.55	0.88	57.81	1.49
H	SFCA-II	14.61	21.02	3.03	61.34	4.71
I	SFCA-II	14.87	21.15	2.77	61.20	4.33

Conclusions

In the CaO-Fe₂O₃-Al₂O₃ system at 1240°C in air, SFCA-I was confirmed in the low Al concentration region, SFCA-II in the medium Al concentration region, and SFCA in the high Al concentration region.

In addition, it was suggested that SFCA-I and SFCA-II may contain 0.4~5.6% (to total iron ions) of Fe²⁺.

Reference

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