

MODEL CALCULATIONS FOR EVAPORATION OF AOA AND CAI MELTS: IMPLICATIONS FOR THE BULK CAIs COMPOSITIONS OF CV3 AND CH-CB CHONDRITES. M. A. Ivanova^{1,2}, S. I. Shornikov¹, K. M. Ryazantsev¹, and O. I. Yakovlev. ¹Vernadsky Institute, Kosygin St. 19, Moscow 119991, e-mail: ivanovama@si.edu; ²Department of Mineral Sciences, National Museum of Natural History, Smithsonian Institution, Washington, DC. 20560, e-mail: MacPhers@si.edu.

Introduction: The most important formation processes of calcium-aluminum inclusions (CAIs) are condensation, melting and evaporation. The bulk compositions of most CAIs record the cumulative effects of these high-temperature and largely volatility-controlled processes during the first 1–2 million years of solar system history [1]. Our previous thermodynamic calculations of evaporation of several pristine CAIs enclosed in the *3N* host CAI [2] showed trends obtained for composition changes of their residual melts crystallized after evaporation. CAI *3N* from the Northwest Africa (NWA) 3118 CV3 carbonaceous chondrite is a unique ~2 cm-sized compound object, primarily a forsterite-bearing type B (FoB) CAI that encloses at least 26 smaller CAIs of different types, including compact type A (CTA), B, C, and an ultra-refractory inclusion [3, 4]. *3N* originated either as an aggregate of many smaller CAIs (mostly types A, B, C) plus accreted Fo-bearing material (resembling an amoeboid olivine aggregate (AOA)) which experienced partial melting of the whole; or else as an FoB melt droplet that collided with and trapped many smaller solid CAIs. Relative to typical type A and B CAIs found elsewhere, the bulk compositions of the A and B CAIs within *3N* more closely match the bulk compositions predicted by equilibrium condensation of a gas of solar composition. Being trapped within the FoB host-CAI may have protected them from the melt evaporation that affected most “standalone” CAIs. Therefore the unique *3N* CAI contains possibly the most pristine types of refractory material, and their bulk compositions were very important for the investigation of CAI evaporation processes, and our results showed that evaporation of several enclosed CAIs in *3N* could result in other known types of CAIs [2].

Here we present results on thermodynamic calculations of evaporation of refractory objects *5aN* from NWA 3118 and *52E* from Efremovka, CV3 chondrites and discuss the trends obtained for compositions of the residual melts crystallized after evaporation, and compare these trends with bulk compositions of CAIs from CV3 and CH-CB chondrites.

Results: For calculations of the residual melt changes obtained at a constant temperature of 2300 K from evaporation of refractory objects, we used the semi-empirical model of thermodynamic codes devel-

oped by [5,6]. This model is based on the theory of associated solutions and experimental data of component activities in molten oxide CaO-MgO-FeO-Al₂O₃-TiO₂-SiO₂ systems, found by the Knudsen mass spectrometric effusion method in the temperature range of 1600-2500 K. The original chemical compositions of CAI *5aN* and AOA *52E* are represented in Table 1 and on Fig. 1. These compositions have different contents of the main oxides (CaO, MgO, Al₂O₃, SiO₂ and TiO₂, FeO), and variable ratios between them. In texture and mineralogy the CAI *5aN* is a pristine fine-grained spinel-rich inclusion with no traces of melting and evaporation. AOA *52E* is a pristine amoeboid olivine aggregate consisting of forsterite, Al-diopside, anorthite and spinel. This AOA contains several enclosed CAIs.

During CAI and AOA melt evaporation the most refractory Al₂O₃ and CaO content in the residual molten material increased. Unlike our previous results [2], we observed different rates of MgO and SiO₂ evaporation depending on initial concentrations of oxides and in different activities of the oxides in the melt [7]. We observed inversion of volatilities of the MgO/SiO₂ ratios resulting in preferential evaporation of MgO compared to SiO₂ from the *52E* AOA melt (like all CAIs enclosed in *3N*) due to an almost solar initial CaO/Al₂O₃ ratio of the melt (~1). If the Al₂O₃ content predominates in the initial melt composition compared to CaO with initial CaO/Al₂O₃ ratio ~ < 0.3, similar to CAI *5aN*, we observe the usual ratio of MgO/SiO₂ relative volatilities.

Discussion: Based on the model results, we calculated compositional trends for CAI *5aN* and AOA *52E* inclusions crystallized from residual melts after evaporation and plotted them on a Ca₂SiO₄-Al₂O₃-Mg₂SiO₄ diagram (Fig. 1). All trends finally lead to CAI compositions corresponding to a Ca-aluminate binary system after FeO, MgO, SiO₂ evaporated from the melts.

Evaporation of AOA *52E* could result in compositions of Fo-bearing Type B, Type B and hibonite-rich CAIs, and its compositional trend is similar to those of the CAIs enclosed in *3N* [2]. All these CAIs and AOA *52E* have approximately solar CaO/Al₂O₃ ratio (~1). The model evaporation of AOA *52E* is consistent in general with the experimental work on evaporation of the MgO-rich material of FoB FUN CAIs [8]. Evaporation of CAI *5aN* resulted in compositions which have never been observed in CAIs from CV3

chondrites but have known among CAIs compositions of CH-CB chondrites (Fig. 2). CaO/Al₂O₃ ratio of 5aN is ~0.2 and similar to ratios of the most dominant CAIs from CH-CB chondrites (<0.3, NWA 470, Isheyev [9]). Based on our observations we can conclude that the final CAI compositions mostly depend on primary bulk chemical compositions of their precursors (mostly from the CaO/Al₂O₃ ratio) and the degree of evaporation processes if evaporation has taken place.

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Table 1. Chemical compositions of CAI 5aN and AOA 52E.

Oxides, Wt.%	SiO ₂	TiO ₂	Al ₂ O ₃	Cr ₂ O ₃	FeO	MnO	MgO	CaO	Na ₂ O	K ₂ O
5aN	28.19	0.55	35.05	0.11	7.69	0.02	15.18	9.39	3.21	0.55
52E	41.34	0.31	6.27	0.21	5.08	0.12	42.56	4.11	n.d.	n.d.

Fig. 1. Trends of chemical compositions of the CAIs enclosed in 3N, CAI 5aN and AOA 52E after evaporation.

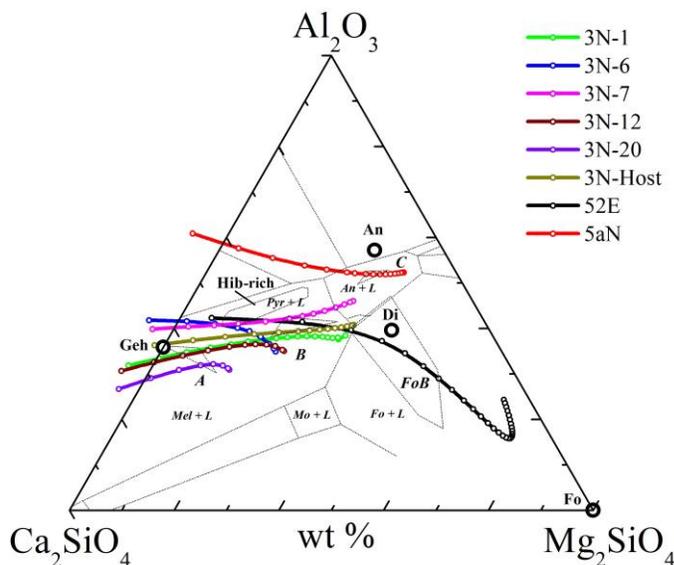


Fig. 2. Bulk compositions of CAIs from CV3 chondrites (left) and from CH-CB chondrites (right)

