

WAS THE DIVERSITY OF CHONDRULE COMPOSITIONS ACHIEVED BY EVAPORATION AND CONDENSATION PROCESSES? H. Nagahara¹ and K. Ozawa¹, ¹Dept. Earth Planet. Sci., Univ. Tokyo, Hongo, Tokyo 113-0033, Japan..

Introduction: Despite numerous trials to explain the origin of the diversity of chondrule compositions, there still is not a model that satisfactorily reproduces the whole range of diversity. The diversity has been attributed to variation of the precursor materials, but is inconsistent with recent finding of evidence for evaporation and/or condensation of various elements. Alkalies and Fe vaporize and condense at low temperatures, and their behavior differs from other major elements, Mg, Si, Ca, and Al. Mg/Si fractionation plays a key role for common ferromagnesian chondrules and (Mg+Si)/(Ca+Al) fractionation for Ca-Al-rich chondrules. It is, thus, important to specify process(es) responsible for such fractionation.

Experiments: Evaporation experiments in the system CaO(C)-MgO(M)-Al₂O₃(A)-SiO₂(S) were carried out to determine the evaporation rate of the each component. The composition of the starting material (57 wt% SiO₂, 9 Al₂O₃, 27MgO, and 7 CaO) is richer in the Ca, Al-components than the CI composition but poorer than the starting material used by [1], who aims to model the variation of CAI compositions. The starting materials were isothermally heated at 1600°C to 1300°C for 1 to 144 hrs. Fragments of the glass synthesized from oxide mixtures at 1 atm and 1600°C were kept in vacuum or in graphite capsules. The change of weight and composition were measured and compared with the thermodynamic calculation to determine evaporation coefficients.

Results: The starting material remains to be totally molten at 1500 and 1600°C within plausible degree of evaporation, which differs from previous evaporation experiments using composition close to CI. The evaporation degree reaches to ~50% in 144 hrs at 1500°C and in 30 hrs at 1600°C in vacuum, and larger when the samples were kept in graphite capsules due to enhancement of evaporation in more reducing conditions. The residue composition changed almost linearly with progress of evaporation, where CA/CMAS (initially 0.15) becomes ~0.3 and S/MS (0.58) becomes ~0.46 at ~50% evaporation. The evaporation coefficients, which are the ratios of actual evaporation rate against theoretically maximum rate, are ~0.05 at 1600°C and ~0.1 at 1500°C for Mg and ~0.07 at 1600°C and 0.09 at 1500°C for Si.

Discussion: The results are applied to estimate the change in composition of a silicate dust with the CI composition, which are instantaneously heated and subsequently cooled to cause recondensation of once vaporized gas. The silicate dusts (silicate melt) behaves as an open system, while the dusts and surrounding gas as a whole as closed system. The quantitative model is based on [2], which assumes constant and the same evaporation and condensation coefficients for all elements. The calculation results show that the variation of type IA chondrules are reproduced by evaporation of CI precursor materials, but the diversity of type II chondrules requires isolation of partially evaporated Si-rich gas to recondense separated from Mg-rich residue. Back reaction is important for Mg/Si fractionation because Si is more volatile than Mg and the earlier vaporized gas is more enriched in Si. Ca-Al-rich chondrule compositions are unable to be reproduced by this process. They need precursors that are fractionated in the forsterite component from the CI composition.

References: [1] Richter, F. M. et al. (2002) *GCA* 66, 521-540.
[2] Ozaawa, K. and Nagahara, H. (2001) *GCA* 65, 2171-2199