CHEMICAL FRACTIONATION IN THE PRESENCE OF AMBIENT GAS.  H. Nagahara, Department of Earth and Planetary Sciences, Building #5, University of Tokyo, Hongo, Tokyo 113-0033, Japan (hiroko@eps.s.u-tokyo.ac.jp).

Introduction: Loss of volatile elements during chondrule formation has been long in debate. In order to model the chemical evolution of chondritic materials during heating and cooling in general, experimental data on evaporation rate in the presence of ambient gas are needed, because the evaporation rate has large dependence on ambient gas composition. Therefore, we have made evaporation experiments in the presence of ambient gas. The evaporation rate in the presence of ambient gas is shown in the Hertz-Knudsen equation, 
\[ j = \frac{\alpha_{\text{evap}} P_{\text{eq}} - \alpha_{\text{cond}} P}{(2\pi mkT)^{1/2}}, \]
where \( j \) is the evaporation rate, \( \alpha_{\text{evap}} \) is the evaporation coefficient, \( P_{\text{eq}} \) is the equilibrium vapor pressure of the species concerned, \( \alpha_{\text{cond}} \) is the condensation coefficient, \( P \) is the partial pressure of the species that can be obtained by chemical equilibrium calculation, \( m \) is the molecular weight of the species, \( k \) is the Boltzman constant, and \( T \) is temperature. \( \alpha_{\text{evap}} \) is obtained in vacuum experiments, and \( \alpha_{\text{cond}} \) is obtained in the present experiments. The equation tells that the ambient pressure (\( P \)) and condensation coefficient (\( \alpha_{\text{cond}} \)) strongly affect the evaporation rate, which further affects the timescale for fractionation.

Experimental: Experiments were conducted in the Knudsen cell with an orifice with various sizes, which controls the pressure built up within the capsule. The cell is of platinum with 3 mm diameter and about 1 cm length, and a hole varies from 0.25 mm to 2.8 mm diameter. The silicate portion of the powdered Jilin (H5) chondrite was used as a starting material. Experimental temperature was 1300°C and 1270 °C, and the duration ranged 40 min to 30 h. The weight loss and the composition of the interstitial melt between porphyritic crystals in the residues were analyzed.

Results and Discussion: The residue is porphyritic regardless of the experimental conditions with phenocrysts of olivine and low-Ca pyroxene. The degree of melting is about 25–30% at 1300°C and 15–20% at 1270°C. Interstitial melt is almost homogeneously distributed in the residues, and no melt/solid separation took place. Melt separation was significant at 1400°C, although the results are not discussed in the present study. The residues show systematic compositional changes depending on the experimental temperature and duration. The concentration of Na₂O, K₂O, and SiO₂ decreases and that of Al₂O₃ and CaO increases with increasing time and temperature. The MgO and FeO contents show complex changes with experimental conditions because of crystallization of olivine and pyroxenes and the usage of Pt capsules. The range of melt composition is in good agreement with that of mesostasis of type II chondrules [1]. The results differ from continuous evacuation experiments at higher temperatures [2] in that SiO₂ evaporates significantly at fairly low degree of evaporation where alkalis are the dominant evaporating species. This may be due partly to large kinetic barrier (small \( \alpha_{\text{cond}} \)) for recondensation of SiO, which resulted in larger evaporation rate, and partly to smaller evaporation barrier (large \( \alpha_{\text{evap}} \)) because of the residence of alkalis at lower temperatures, which generally lowers the polymerization of silicate melt. Another important result is fairly large fractionation of Na and K. The fractionation factors at the experimental conditions are 10–100 for Na and 2–20 for K, which suggests the relatively larger loss of Na than K during heating. By using the experimental results, the conditions to retain the initial chemical composition during heating and cooling are investigated assuming a constant volume of the system with the dust/gas ratio as a free parameter. The alkali loss by 10–20% is possible in short duration heating at dust enriched conditions, but K enrichment relative to Na and Sc [3] can not be achieved.