【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Mathematical and Physical Sciences)

Title of Project : Physicochemical analysis of early solar system based on formation kinetics of refractory inclusions of meteorites

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Research Project Number : 16H06349 Researcher Number : 80191485
Research Area : Geochemistry/Cosmochemistry
Keyword : Geochemistry, Cosmochemistry, Meteorites, Solar system, Protoplanetary Disk

【Purpose and Background of the Research】

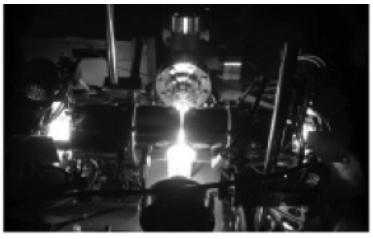
We have evidence of high temperature processes in the early solar system to condense solid materials from vapor and to melt solid precursors in the protoplanetary disk from studies of refractory inclusions (CAIs and AOAs) in primitive chondrites. The processes have not been observed by astronomical observations of protostars and protoplanetary disks. Therefore, the physicochemical conditions and the astrophysical setting have not well constrained.

In this study, we study physicochemical conditions of the high temperature processes generated in the early solar system by material synthesis experiments in laboratory according to analysis of isotopic mineralogy and petrology of refractory inclusions in primitive chondrites. This study is specially focused determination of total pressure, water vapor pressure, and gas/dust ratios in the inner edge of the protoplanetary disk.

【Research Methods】

Following is plans of laboratory experiments to determine physiochemical conditions (temperature, pressure and water vapor partial pressure) of CAI and AOA formation in the early solar system.

Synthetic laboratory experiments to reproduce petrographic texture and the isotopic spatial distribution of inter- and intra-minerals observed in natural CAIs are conducted. These experiments are crystallization experiments of CAI melt under low pressure and low water vapor pressure conditions to exchange oxygen isotopes. We used $H_2{}^{18}O$ vapor for these experiments. According to these experiments, we will determine partial pressure of water vapor of surrounding atmosphere. Then, we will calculate total pressure of CAI forming region using oxygen fugacity observed by natural CAI minerals.



We also conduct vaporization experiments of CAIs under low pressure H_2-H_2O condition. We realize elemental fractionation factor, isotopic fractionation factor and evaporation coefficient for CAI formation. Using these parameters, condensation timescale for natural CAIs is inferred as a function of temperature and pressure. Oxygen isotopic exchange rates and self-diffusivity of oxygen in crystals are determined by this experiment. Therefore, we can infer that CAI condensation time, condensation temperature, condensation pressure and dust/gas ratio in the early solar system using elemental and oxygen isotopic zoning observed in natural CAIs for condensation origin.

【Expected Research Achievements and Scientific Significance】

An expected research achievement is the first determination of physicochemical conditions of refractory materials formation at the beginning of solar system formation experimentally.

【Publications Relevant to the Project】

・Kawasaki, N., Kato, C., Itoh, S., Wakaki, S., Ito, M. and Yurimoto, H. (2015) ^{26}Al–^{26}Mg chronology and oxygen isotope distributions of multiple melting for a Type C CAI from Allende. *Geochim. Cosmochim. Acta* **169**, 99-114.
・Takigawa A., Tachibana S., Nagahara H. and Ozawa K. (2015) Evaporation and condensation kinetics of corundum:The origin of the 13-μm feature of oxygen-rich AGB Stars. *Astrophys. J. Suppl.*, **218**, doi:10.1088/0067-0049/218/1/2.

【Term of Project】 FY2016-2020
【Budget Allocation】 140,700 Thousand Yen
【Homepage Address and Other Contact Information】
http://vigarano.ep.sci.hokudai.ac.jp