Chemical diversity of chondrule melt and its origin

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Introduction

Common chondrules, Ca-Al-rich chondrules, and CAIs show compositional diversities, and their genetic relationships are not fully understood, although bulk chemical and isotopic compositions of type B1 CAIs are interpreted to be the results of condensation and subsequent evaporation (Righter et al., 2002). The diversity of chondrule melts was investigated in the present study with the special interest in evaporation in a simple system.

Experimental

Evaporation vector (direction and magnitude of compositional change) of liquid by evaporation was experimentally and theoretically investigated for wide ranges of melt compositions and temperatures in the system CaO-MgO-Al_2O_3-SiO_2. Equilibrium vapor pressure and the gas composition were calculated at temperatures ranging from 1000K to 2000K on the basis of thermodynamic model and parameters after Berman (1983) and Berman and Brown (1984). The compositions of type IA chondrules and Ca-Al-rich chondrules, equilibrium condensation path and evaporation path from the literature are compared with evaporation vectors.

Results and discussion

Bulk chemical compositions of type IA chondrules are located on the equilibrium condensation-evaporation path of the CI composition, which is saturated with forsterite at about 2100K. It can be formed from the precursor with the CI composition, heated to temperature about 2100K, began to crystallize forsterite at the temperature due to selective loss of SiO_2-rich component. The composition of the mesostasis suggests cooling down to about 1500-1600K. The pressure at the highest temperature is about several Pa. Ca-Al-rich chondrules, which are plotted at the locations rich in SiO_2, CaO, and Al_2O_3 were formed by mild heating at temperatures about 1300K to get much SiO_2- and (Al_2O_3+CaO)-rich composition. The present results show that the diversity of type IA and Ca and Al-rich chondrules were formed from precursor of CI composition through melting, partial evaporation, and crystallization due to evaporation.

References

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Noble gases of Antarctic lunar meteorite Yamato 981031

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Yamato(Y) 981031 lunar meteorite has been collected by the meteorite search party of the 39th Japanese Antarctic Research Expedition, and is suspected to be paired with Y793274 lunar meteorite based on the texture, mineralogy and bulk composition (Kaiden and Kojima, 2002). Mineralogical study on the Y981031 suggests source-crater paring of Y981031, Y793274 and QUE94281, which are brecciated mare basalts with some highland components (e.g., Arai et al., 2002). We measured noble gases of the Y981031 to confirm the predicted paring with Y793274 and to obtain noble gas signatures characteristic for materials derived from the lunar surface.

Noble gases were extracted from two chips weighing 0.1851g and 0.0579g by stepwise heating, and then measured on a modified-VG5400 (MS-II). The temperatures were 400, 600, 800, 900, 1000, 1100, 1200, 1300, 1400, 1600 and 1800°C, though the experiment was accidentally stopped at 1300°C on the sample 0.1851g due to leakage of vacuum of purification line.

Noble gas elemental and isotopic compositions are characterized by solar composition with small contributions of cosmogenic gases. Huge amounts of He ($1x10^{-3}cc^4He$) and Ne ($2x10^{-4}cc^{20}Ne$) were released in the temperature range of 800-1000°C, while heavier noble gases Ar, Kr and Xe released at higher temperatures of 1100-1300°C. The noble gas concentrations and those of cosmogenic ^{21}Ne and ^{38}Ar, 314 and 520 $x10^{-9}$cc/g respectively, agree well with the reported values for Y793274, indicating a long duration (ca. 500Ma) of irradiation by galactic cosmic-rays as well as solar wind particles on the lunar surface as described for Y793274 by Eugster et al. (1991) and Takaoka and Yoshida (1992). Trapped $^{40}Ar/^{36}Ar$=2.4, which is an antiquity indicator of regolith breccia, is also similar to 2.3 for Y793274 (Eugster et al., 1991). All the noble gas signatures determined for Y981031 support the paring with Y793274 lunar meteorite.

Noble gas release patterns show sharp increases at the extraction temperatures of 800°C for He and Ne and 1200°C for Ar, Kr and Xe. $^{20}Ne/^{22}Ne$ ratio was as high as 12.5 at the lower temperatures, and then decreased approaching to a mixing line between cosmogenic and SEP-like Ne components. These data indicate that most of low energy solar particles have been lost before arrival to the earth, probably due to gas loss by shock heating on the lunar surface.

References

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