CAI formation: Processes and ages under scopes of O isotopes and Al-Mg systematics based on crystal growth

HISAYOSHI YURIMOTO[1,2]

[1]Natural History Sciences, Hokkaido University, Sapporo 001-0021, Japan
[2]ISAS/JAXA, Sagamihara, Kanagawa 252-5210, Japan

Ca-Al-rich inclusions (CAIs) are the oldest materials dated chronologically in the solar system and were formed by transient heating processes in the solar composition gas. The chemical compositions, mineral assemblages and textures of CAIs show that condensation, evaporation and melting occurred during the heating processes. The peak temperature was higher than 1700 K and the base temperature was around 1400 K. The pressure would be less than 10^{-3} bar, but not well constrained. The solar composition gas has two distinct O isotopic signatures of ^{16}O-rich and ^{16}O-poor. Probable reservoirs for ^{16}O-rich and ^{16}O-poor gases correspond to the Sun and the protoplanetary disk, respectively. However, it still under debate how the O isotopic signatures switched during CAI formation. It is the fact that a short-lived nuclide ^{26}Al existed at CAI formation and each CAI has various initial values of $(^{26}Al/^{27}Al)_0$ from 5.2 to 3.5×10^{-5}, and FUN-like CAIs have no detectable ^{26}Al existences. The chronological interpretation of Al-Mg systematics depends on how the ^{26}Al distribute homogeneously/heterogeneously in the early solar system.

Recently systematic isotope studies of O and Al-Mg based on crystal growth in individual CAIs and kinetic experimental studies in laboratory are in progress. The observations from natural CAIs are basically consistent with results and calculations from laboratory experimental studies for crystallization and time scales. These progresses infer that protoplanetary disk environments of CAI formation were dynamical. The environmental parameters should advance astrophysical models for CAI formation which have not been realized how distribute the two distinct O isotope reservoirs in the early solar system and how change O isotope supply rates from the two reservoirs to the CAI formation area.