Al–Mg systematics for partial melting of an Allende type B CAI, Golfball

*Noriyuki Kawasaki[1], Shoichi Itoh[2], Naoya Sakamoto[1], Steven B. Simon[3], Hisayoshi Yurimoto[1,4]

1. Hokkaido University, 2. Kyoto University, 3. University of New Mexico, 4. ISAS/JAXA

Ca-Al-rich inclusions (CAIs) are the oldest objects formed in our Solar System [1]. Recent high-precision Al–Mg mineral isochron studies using secondary ion mass spectrometry (SIMS) revealed detailed distributions of initial $^{26}Al/^{27}Al$ values, $(^{26}Al/^{27}Al)_0$, for individual CAIs in CV chondrites [e.g. 2–4]. Igneous and non-igneous CAIs show similar variations in $(^{26}Al/^{27}Al)_0$, which range from ~5.2 to ~3.4 $\times10^{-5}$ [4]. These variations in $(^{26}Al/^{27}Al)_0$ suggest that CV CAI formation processes continued for at least ~0.4 Myr at the very beginning of the Solar System. However, at the same time, they also raise a possibility of heterogeneous distribution of ^{26}Al in the CAI-forming region [e.g. 3, 5]. In this study, we present Al–Mg systematics of relict minerals and later-crystallized minerals from multiple partial melting events in an Allende type B CAI, Golfball [6–8]. Such an approach would enable to constrain age differences between multiple melting events, regardless of the possibility of heterogeneous distribution of ^{26}Al.
The Golfball CAI has a type B CAI bulk composition [6] and a unique structure [7]: a fassaite-rich mantle enclosing a melilite-rich core. Most of melilite crystals ($Åk_{30–70}$) occur as laths at the inclusion rim and in the core or as blocky shapes poikilitically enclosed in the fassaite grains in the core. In the core, gehlenitic melilite grains ($Åk_{5–12}$) are enclosed in strongly zoned ($Åk_{15–70}$) overgrowths with small compositional discontinuity at the boundary. These gehlenitic melilite grains ($Åk_{5–12}$) clearly could not have formed from a melt with bulk composition of Golfball or that of its core [6, 9], indicating they are relict grains that survived later melting event(s). High-precision *in situ* Al–Mg systematics with SIMS [3] was applied for the gehlenitic relict grains and the other melilite crystals as well as spinel, a liquidus phase. An Al–Mg isochron regression line for the data of gehlenitic relict grains and spinel gives $(^{26}Al/^{27}Al)_0 = (4.41 \pm0.22) \times10^{-5}$, while that for the other melilite crystals gives $(^{26}Al/^{27}Al)_0 = (4.41 \pm0.20) \times10^{-5}$. These results indicate that partial melting event(s) for the Golfball CAI occurred in very short order, probably shorter than a few tens of Kyr, after a precursor formation.

References: [1] Connelly et al. (2012) *Science* 338, 651–655. [2] MacPherson et al. (2012) *EPSL* 331–332, 43–54. [3] Kawasaki et al. (2019) *EPSL* 511, 25–35. [4] Kawasaki et al., under review. [5] Bollard et al. *GCA* 260, 62–83. [6] Simon and Grossman (2004) *GCA* 68, 4237–4248. [7] Simon et al. (2005) *MaPS* 40, 461–475. [8] Itoh et al. (2009) *MaPS* 40, Suppl., A116. [9] Beckett et al. (1999) *30th LPSC* #1920.

