Gas-melt reaction in the reduced nebula environment revealed by oxygen isotope of EH chondrules

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Unequilibrated enstatite chondrite provides an important constraint to understand the inner solar nebula environment and the formation process of inner protoplanetary disk. The remarkable feature of the enstatite chondrite is their highly reduced condition preserved in mineral assemblages. Oxygen isotope have given a key information to decipher the evolution process of nebula and chondrule formation. Reported oxygen isotopic data of bulk chondrules [1-3] and of in-situ pyroxene measurements [4] in enstatite chondrite, however, are distributed in a narrow range, which did not show valuable trend to explain the chondrule formation process clearly. The data variation can be influenced by the presence of ^{16}O-rich olivine relict and/or terrestrial weathering effect for bulk IRMS analysis and by large analytical uncertainty for SIMS analysis relative to natural variation. To remove these effects, pyroxene fragments in EH3 and EH4 chondrules were measured with high-precision IRMS method to detect the formation process of EH chondrules. The obtained data show systematic trend in the restricted range when they are compared with known bulk EC region [1-3, 5], forming a slope of >1 on the three-oxygen isotope diagram. Even in the single chondrite, pyroxenes from individual chondrules have distinct Δ^{17}O values. The obtained oxygen isotopic trend can be explained by the open-system isotopoic exchange between ^{16}O-rich precursor dust whose isotopic compositions is similar to olivines in carbonaceous chondrite and ^{16}O-poor SiO-rich nebular gas, a similar process proposed for the recently modeled chondrule formation process of carbonaceous chondrite [6]. This study revealed that the gas-melt reaction process at the elevated temperature was the major process for the formation of enstatie-rich chondrules in the inner solar system.

[1] Clayton et al. (1984), JGR, 89, C245-C249; [2] Clayton & Mayeda (1995) LPSC XVI, 142-143; [3] Clayton et al. (1991) GCA, 55, 2317-2337; [4] Weisberg et al. (2011) GCA, 75, 6556-6569; [5] Newton et al., MPS, 2000, 689-698; [6] Marricchi & Chaussidon (2015) EPSL, 430, 308-315.