Characteristics of Oxygen isotope ratios of chondrules and isolated olivine grains from Tagish Lake C2 chondrite

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Recent studies on oxygen isotope systematics of chondrules show that chondrules in individual chondrite groups have characteristic distributions in their oxygen isotope ratios and Mg# (molar % of MgO/(MgO+FeO)) [1, 2]. The correlations between Mg# and $D^{17}O$ values (= $d^{17}O_{VSMOW}$ - 0.52 ×$d^{18}O_{VSMOW}$) of chondrules can be explained by mixing of ^{16}O-rich anhydrous dusts and an ^{16}O-poor oxidizing agent (most likely H_2O ice) in chondrule forming regions [3]. Based on similar Mg# - $D^{17}O$ correlations between CR chondrite chondrules and cometary silicate particles from comet Wild 2, it has been proposed that many of cometary silicate particles formed in the outer regions of the asteroid belt [e.g. 4, 5]. The Tagish Lake meteorite (ungrouped C2) is an appropriate sample to investigate the Mg# - $D^{17}O$ systematics of silicate particles formed in the outer regions of the asteroid belt because the Tagish Lake meteorite probably derived from a D-type asteroid [6]. Previous oxygen isotope studies on olivine grains from Tagish Lake and Tagish Lake-like meteorites [e.g. 7] show that their Mg# - $D^{17}O$ systematics are similar to that of CR chondrite chondrules. Here, we report new oxygen isotope data of olivine grains from the Tagish Lake meteorite for better understandings of the Mg# - $D^{17}O$ systematics of silicate particles in the outer regions of the asteroid belt.

Two polished epoxy mounts of the Tagish Lake meteorite, TL-KC-1 (8mm ×5mm) and TL-KC-2 (4mm × 3mm), were prepared for this study. Due to extensive aqueous alteration in the Tagish Lake parent body, phyllosilicates and other secondary phases such as magnetite and carbonates replace primary anhydrous phases. However, remaining olivine grains in chondrules and matrix tend to have sharp grain boundaries and no apparent evidence for the Mg-Fe exchange between olivine grains and matrix was observed. No alteration features were observed in these grains. Forty chondrules and isolated olivine grains (hereafter "ferromagnesian inclusions") were selected for oxygen isotope measurements (34 type I [Mg#>= 90] and 6 type II [Mg#<90]). Oxygen isotope ratios of olivine grains were measured with an ion microprobe, CAMECA IMS 1280-HR at Kochi Institute. A 20 kV accelerated Cs^+ primary beam (~30 pA, ~3 um in diameter) was used. The analytical conditions were similar to those in [1].

Oxygen three-isotope ratios of ferromagnesian inclusions from Tagish Lake are distributed along the PCM (primitive chondrule minerals) line [1]. Most type I ferromagnesian inclusions are relatively ^{16}O-rich ($D^{17}O$ = -7.4 to -3.9‰) and type II ferromagnesian inclusions are relatively ^{16}O-poor ($D^{17}O$ >= -3‰). Of six type II ferromagnesian inclusions, two inclusions have $D^{17}O$ ~ 0‰, which are recognized in in Tagish Lake-like meteorites, CR chondrites, and cometary silicate particles, but are almost absent in other carbonaceous chondrites [e.g., 2-5, 7]. The present results are further evidence for the link between ferromagnesian inclusions accumulated into asteroids in the outer regions of the asteroid belt (possibly D-type asteroids) and silicate particles accumulated into cometary nuclei in the Kuiper belt. As discussed in [4, 5, 8], type II silicates are common in cometary silicate particles, which is distinct from ferromagnesian inclusions in Tagish Lake(-like) meteorites and CR chondrites. Most cometary silicate particles formed in H_2O ice enriched oxidizing regions. Such regions were probably farther than where typical ^{16}O-rich type I chondrules of carbonaceous chondrites formed.

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