Oxygen isotope reservoirs in the outer asteroid belt inferred from oxygen isotope systematics of chondrule olivines, isolated forsterite and olivine grains in Tagish Lake-type carbonaceous chondrites

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博士論文

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(タギシュレイクタイプ隕石に含まれるコンドリュールの酸素同位体組成に基づく初期太陽系の小惑星帯外縁部の酸素同位体比)

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Abstract

Tagish Lake-type chondrites are grouplet of carbonaceous chondrites which consists of Tagish Lake meteorite and those similar to the Tagish Lake, and their delivery from D-type asteroids based on reflectance spectra. Since D-type asteroid located outer regions of the asteroids belt than other asteroids, Tagish Lake-type chondrites retain a record of outer solar system evolution.

Based on mineralogy, reflectance spectrum and bulk oxygen isotope compositions, Wisconsin Range (WIS) 91600, Meteorite Hills (MET) 00432, and Dhofar (Dho) 735 can be classified to Tagish Lake-type chondrites. To understand oxygen isotope signatures and redox conditions of the chondrule formation environments at the outer regions of the asteroid belt, I analyzed major element concentrations and oxygen isotope ratios of olivine grains in chondrules, isolated forsterites, and isolated olivines from the WIS 91600 and MET 00432 carbonaceous chondrites. The oxygen isotope ratios of individual chondrules and isolated grains show a wide variation in $\delta^{18}O$ from –9.9‰ to +9.1‰ along the carbonaceous chondrite anhydrous mineral (CCAM) and primitive chondrule mineral (PCM) lines. The $\Delta^{17}O$ (= $\delta^{17}O - 0.52 \times \delta^{18}O$) values of the measured objects increase with decreasing Mg#; i.e., FeO-poor objects (Mg# > 90; type I chondrules and isolated forsterites) mainly have $\Delta^{17}O$ values of ca. –6‰, and FeO-rich objects (Mg# < 90; type II chondrules and isolated olivines) have $\Delta^{17}O$ values ranging from –3‰ to +2‰. Similar trends are observed for ferromagnesian silicate grains from comet Wild2 and CR chondrite chondrules, particularly in terms of FeO-rich objects with $\Delta^{17}O$ values ranging from –3‰ to +2‰. It is suggested that FeO-rich objects like those found in Tagish Lake-type chondrites were transported to the outer solar nebular regions where comet Wild2 formed.

Based on Fe-Mn systematics, FeO-rich objects in Tagish Lake-type chondrites and Wild 2 particles are different and Wild 2 particles show lower Fe/Mn ratios. This difference might have been caused by reduction and metal loss before or during chondrules forming event. This imply that FeO-rich objects in Wild 2 particles might have crystalized under more reduce conditions than FeO-rich objects in CR and Tagish Lake-type chondrites.

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