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REE pattern and oxygen isotopes in a unique granular-olivine inclusion from the Murchison (CM2) meteorite

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A homogeneous granular-olivine (Fa38.5) inclusion (MI-GO) carrying minor merrillite and nepheline was collected from the Murchison (CM2) meteorite, and analyzed for rare earth (REE; La, Ce, Nd, Sm, Eu, Gd, Dy, Er, Yb, and Lu) and other trace elements (K, Rb, Sr, and Ba) by isotope dilution, together with petrographical observation. The inclusion shows no evidence for aqueous alteration petrologically and chemically but indicates conspicuous REE fractionations; light-REE (L-REE) enriched, smoothly heavy-REE depleted pattern (La, 6.1 $*$ CI; CI-norm. La/Lu ratio = 3.0) with a large negative Eu anomaly (~70% negative), high FeO content (30%) and fractionated alkali abundances (CI-norm. K/Rb = 2.2). The observed bulk REE pattern is substantially different from those of aqueously altered CM chondrules and also from any kind of chondrules and CAIs from carbonaceous and unequilibrated ordinary chondrites (UOCs), but relatively similar to those of some kind of achondrite and of lunar KREEP basalts. The unique REE features, being similar to so-called geochemical fractionation, can not be explained as being due to nebular fractionation nor aqueous alteration processes, but are well understood as having been resulted from equilibrium partitioning of solid/melt and/or solid/solid interaction in the planetesimal setting. The holocrystalline texture, the occurrence of crystalline nepheline and homogeneous FeO-rich olivine suggest that MI-GO experienced melting and slow cooling or metamorphism and was then incooperated into the Murchison parent body during the early regolith-forming processes. To clarify the origin and precursor materials of MI-GO, we measured oxygen isotopic compositions in olivine groundmass using the Cameca ims-1270 ion microprobes. Combining the result of oxygen isotopic compositions, we discuss the formation process of MI-GO and the early planetary differentiation in the parent planetesimal.