The FUN inclusion which was formed at the timing similar to CAIs

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The refractory inclusion Kz1-In2 which was found in Kainsaz CO3 meteorite has O isotopic anomalies of delta 17O=-14 permil, delta 18O=6 permil. This is characteristic to FUN inclusions, which were rare type refractory inclusions and considered to be experienced distillation event. Although it is known that FUN inclusions have smaller excess-26Mg, which is caused by decay of 26Al (half life is 0.71 m.y.), than normal refractory inclusions, Kz1-In2 has large excess-26Mg comparable to those of normal refractory inclusions. Excess-41K which is caused by decay of 41Ca (half life is 0.10 m.y.) was also observed in Kz1-In2. This indicates that distillation events which formed FUN inclusions occurred at very close to the formation of normal CAIs.

Calcium-, Aluminum-rich Inclusions (CAIs), which rich in refractory elements (e.g. Al and Ca) are found in primitive chondrites. CAIs have not only characteristic chemical compositions but also isotopic anomalies in various species, so they are considered as to have important information about the early solar nebula. Here, we will report isotopic compositions of hibonite inclusion: Kz1-In2 in Kainsaz CO3 chondrite, which has characteristic O isotopes. Kz1-In2 is small CAI (100 micrometer in diameter) and it consists of euhedral hibonite (CaAl12O19) grain and spinel rim. This inclusion contains significant amount of FeO component but the other minor component were not observed with SEM-EDS.

Isotopic observations were carried out using an ion microprobe, CAMECA ims-6f of University of Tokyo. First, O isotopes were measured using Cs+ primary ion beam and then Mg and K isotopes were measured using O- primary ion beam. Each measurement was carried out under mass resolution enough to distinguish interferences but (40Ca42Ca)2+ can not distinguish from 41K+ so we corrected mathematically for the (40Ca42Ca)2+ contribution for 41K+ according to method by Srinivasan et al.(1996). Kz1-In2 has an O isotopic anomaly of delta 17O=-14 permil and delta 18O=6permil. Oxygen isotopes of CAIs are generally distributed on a single trend of delta 17O = delta 18O, which is named the Carbonaceous Chondrites Anhydrous Minerals line (CCAM line). O isotopic composition of Kz1-In2 is distinct from this trend. Similar O isotopic composition is observed in FUN inclusion, which is a rare type of CAIs and their O isotopic composition can be explained by mass fractionation effect. FUN inclusions have three isotopic characters, (1) Fractionated isotopes (F of FUN, e.g. O, Mg, Ca and Ti), (2) lower initial abundance of 26Al than normal CAIs, and (3) non mass-dependent isotopic anomaly of Unidentified Nuclear effects (UN of FUN, e.g. delta 48Ca and delta 50Ti). Excess-26Mg and excess-41K were observed in Kz1-In2. These isotopic anomalies were caused by decay of 26Al (half life is 0.71m.y.) and 41Ca (half life is 0.10m.y.) and calculated initial 26Al/27Al and 41Ca/40Ca ratios of Kz1-In2 were are about 5.3E-5 and 1.1E-8. These ratios are much higher than those of other FUN inclusions and rather comparable to normal CAIs.

Previously, FUN inclusions were considered as the evidence of isotopic heterogeneity in the early Solar System because it was known that non mass-dependent isotopic anomaly (e.g. delta 48Ca and delta 50Ti) and 26Al abundance were mutually exclusive and FUN inclusions have low initial abundance of extinct nuclides and non mass-dependent isotopic anomalies. Mg and K isotopic compositions of Kz1-In2 suggest that this FUN inclusion and normal CAIs have a common reservoir about 26Al and 41Ca. And if the fractionated isotopes of Kz1-In2 and those of other FUN inclusions reflect the same event, the timing of a distillation event that formed fractionated isotopes were very close to (or possibly at the same time with) normal CAIs' formation. Then, the question is the relation between fractionated isotopes and non mass-dependent isotopic anomalies, which often found together in the same FUN inclusions. In this respect, it is important to examine whether or not the hibonite inclusion Kz1-In2 has a non mass-dependent isotopic anomalies. We are now undertaking further ion microprobe analyses of Ca and Ti isotopes in this inclusion.