Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PPS24-07 Room:106 Time:May 23 12:30-12:45

An ion microprobe study of FUN-like hibonite-bearing inclusions from the Murchison (CM2) meteorite

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There is a minor group of refractory inclusions, so called FUN (Fractionation and Unkown Nuclear effects) inclusions, which exibit distinct isotopic characteristics: (i) large mass-dependent fractionation in O, Mg and Si preferring heavy isotopes (F-signature), (ii) presence of unknown nuclear effects, esp., positive or negative anomalies in 48Ca and 50Ti (UN-signature), and (iii) little or no excess 26Mg (and excess 41K) from the decay of 26Al (41Ca). Absence of excess 26Mg suggests either their late formation after the complete decay of 26Al, or their early formation before injection of 26Al into the solar system from (a) stellar sorce(s). The presence of Ca and Ti isotopic anomalies may suggest their earlier formation. The origin of FUN inclusions is still not well understood, but they may have important information about evolution and isotopic homogenization process(es) in the early solar system.

We found three FUN-like hibonite-bearing inclusions (MC037, 040, 003) from the Murchison (CM2) meteorite, which exibit extremely large mass-dependent fractionation in Mg isotopes (up to ˜50permil/amu) but almost no excess in 26Mg. In order to better understand their isotopic characteristics, we further conducted ion microprobe analyses of Mg, Ca and Ti isotopes on these inclusions.

Results -Mg isotope-: Data for MC040 and MC003 show rather homogeneous composition with Phi-26Mg from ˜97 permil to ˜107 permil and ˜29 permil to ˜35 permil, respectively. However, MC037 data show highly heterogeneous composition with Phi-26Mg from ˜27 permil up to ˜95 permil. Hibonite and spinel in MC037 probably crystallized at various stages of the evaporation event, while those in MC040 and MC003 only at the last stage of the evaporation event, suggesting slightly different heating conditions for these inclusions. All the data for these inclusions show no excess 26Mg (Delta-26Mg ˜0) within uncertainties. Again MC037 data show large variations in the 27Al/ 24Mg ratio.

Results -Ca&Ti isotopes-: Both MC037 and MC040 do not show anomalies in 48Ca within analytical errors, but have small (<10 permil) but resolvable anomalies in 50Ti. MC003 show anomalies in 48Ca (<15 permil) and 50Ti (<6 permil).

Highly fractionated Mg isotopes, lack of resolvable excess in 26Mg and existence of 48Ca and 50Ti anomalies suggest that they are newly found FUN inclusions. The present results and previous works show that there are variations in F, UN, and 26Mg excess signatures among different types of FUN (F) inclusions. Further studies are required to better understand their relations and formation conditions.

Keywords: FUN inclusion, hibonite, ion microprobe, Mg isotope, Ca isotope, Ti isotope