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H2O contents and hydrogen isotopic composition of apatite crystals in L, LL5-6 ordinary chondrites

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Introduction: Ordinary chondrites of petrologic types 4 to 6 exhibit a sequence of progressive chemical and textural equilibration. However, the conditions and environment of metamorphism are not well constrained. The role of fluids is poorly understood, although there is evidence that fluids were present (Li et al., 2000; Dunn et al., 2010; Jones et al., 2011). The secondary phosphate minerals apatite and merrillite can be used to interpret the conditions of the metamorphic environment, since they can potentially preserve a record of interactions with parent body fuids (Jones et al., 2011). In this study, we report the petrography, H2O contents and hydrogen isotopes in chlorapatite from L, LL5-6 ordinary chondrites using secondary ion mass spectrometry (SIMS).

Anaytical methods: 10 thin sections of Carnegie (L6) and thick section (Barwell (L5), Mocs (L5-6), Carnegie (L6), Ensisheim(LL6)) mounted one inch with San carlos Olivine were used in this study. Apatite grains were identified using elemental X-ray mapping. using scanning electron microscope (FE-SEM JEOL JSM 7000-F) and energy dispersive X-ray spectrometry (EDS Oxford INCA Energy) at Hokkaido University. Quantitative analyses were also performed using FE-SEM-EDS system.

The Hokudai isotope microscope system (Cameca ims-1270 SIMS instrument at Hokkaido University) was applied to determine D/H ratio and H2O contents of apatite. The meteorite and standard sample were kept pumping about two months in the ultra-high vacuum chamber in order to reduce the surface adsorbed water on the samples. The Dorang apatite (0.0478wt%) and Linopolis apatite (1.28wt%) were used to estimate the H2O content using the calibration curve with H/18O ratio. In the same analytical session, the H/18O ratio of San carlos olivine crystals were also measured to compare with those of chlorapatite from ordinary chondrites. The hydrogen isotopic compositions was calculated using Dorango apatite (dDSMOW =-121permil). The overall analytical errors were about 20permil (2sigma). The detail analytical conditions are shown in Greenwood et al. (2011).

Results and Discussion:

H2O content of apatite grain can only be estimated in Ensisheim (LL6) by SIMS because it is difficult to avoid cracks or metamorphic phases. H2O contents of apatite are estimated to be 18-35ppm. These results are much smaller than those based on a deficit. This difference is consists with that of Jones et al. (2011). In addition, the H/18O ratio of apatite grain from Ensisheim is about five times higher than those of San carlos olivine. In the future, H2O content of the apatite in chondrites will be estimated using a lower water content of standard.

The hydrogen isotopic compositions of apatite grains in the LL6 Ensisheim chondrite are likely to be D-rich. However, it is difficut to estimate these values quantitatively because of low water content. In the future, we will develop to measure the hydrogen isotopic compositions of such a low water content in apatatite grains.

Keywords: ordinary chondrite, apatite crystal, H2O, hydrogen isotopic composition, SIMS