Hydrogen isotopic evolution of water and organic compounds on carbon-rich asteroids.

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Organic matter (OM) and hydrated minerals found in chondrites are the remnants of organic and water reservoirs present in the protoplanetary disk 4.6 billion years ago. These components show systematic but variable enrichments in D, the heavy isotope of hydrogen, comparing to the Sun. Although at least a part of these enrichments argues for low temperature ion-molecule reactions in the protoplanetary disk or in the molecular cloud, it is unclear how these isotopic signatures might have been modified by chemical reactions or isotope exchanges occurring on the asteroidal parent body [1].

In situ measurements of hydrogen isotope compositions at the micrometer-scale in a large pool of chondrites can help to trace the interactions between OM and water on asteroids. We thus measured the D/H and C/H ratios in the fine-grained matrices of different carbonaceous chondrites (CCs) at the scale of some micrometers by using SIMS IMS-1280HR at Hokkaido University. Depending on the position of the primary beam on the matrix, the D/H and C/H ratios vary as a function of the relative amount of OM to hydrated minerals. Positive correlations between theses ratios are found in the matrices of the CI Orgueil, of the CR Renazzo and of a set of CM chondrites (Murchison, Mighei, Murray and Cold-Bokkeveld). These correlations imply that the H budget in the matrices of these CCs results from the mixture of D-rich OM and D-poor hydrated silicates. Using the zero intercept of the correlations, we estimated the water D/H compositions in the different chondrites [2].

The D/H ratios obtained in these CCs are compared with isotopic measurements in the insoluble OM [3, 4 and this study] and bulk measurements in CC chondrites [1]. In CM chondrites, the initially D-poor water seems to be locally enriched in D by a reaction with a minute amount of a D-rich component initially associated with the refractory insoluble OM.

References: [1] Alexander et al. 2012, Science. 337, 721–3 [2] Piani et al. 2015, EPSL 415, 154–164 [3] Remusat et al. 2010, Astrophys. J. 713, 1048–1058 [4] Alexander et al. 2007, GCA 71, 4380–4403.