**EFFECT OF METAMORPHISM ON OLIVINE DEHYDRATION IN CO CHONDRITES.** S. Azevedo-Vannson[1], L. Remusat[1], M. Verdier-Paoletti[1] and M. Roskosz[1], [1] Muséum National d'Histoire Naturelle, Institut de Minéralogie, de Physique des Matériaux, et de Cosmochimie (IMPMC), UMR CNRS 7590, Sorbonne Université.

**Introduction:** The chondrule formation process remains debated. They could have a planetary or more likely a nebular origin [1]. If so, chondrules have crystallized from droplets of silicate magma in the gas phase of the protoplanetary disk. The hydrogen-rich gas present in the disk therefore likely interacted with the chondrule precursors. The molecular gas of the protosolar nebula is one of the three main hydrogen reservoirs in the solar system along with water ice and organic matter. This gas could have been incorporated in solids as suggested by the large quantities of hydrogen detected in the olivine of CM chondrules[2] and in the Itokawa irradiated regolith [3].

CM and CO chondrites exhibit chemical similarities including oxygen isotopic composition. Their chondrules may derive from a common reservoir[4] hence CO chondrules could also have accreted significant amounts of hydrogen during their formation. However, CM and CO chondrites did not undergo the same secondary processes on their parent body. The CM underwent aqueous alteration while the CO were thermally metamorphosed at several hundreds of degrees. The aim of this study is to constrain the quantity of hydrogen contained in chondrule olivines found in CO chondrites and to assess the influence of secondary processes on hydrogen content and isotopic signature in these iconic constituents of carbonaceous chondrites.

**Samples and Methods:** Three CO carbonaceous chondrites showing different degrees of metamorphism were investigated: Kainsaz (CO3.2), Ornans (CO3.4) and Lancé (CO3.5). Three polished sections were prepared in epoxy and carbon coated (20 nm thick).

Hydrogen abundance and isotopic composition of olivines in chondrules were measured with a Cameca NanoSIMS 50 (IMPMC, Paris) equipped with a Hyperion O source. The vacuum never exceeded $3 \times 10^{-9}$ mbar in the analytical chamber. The isotopic composition (D/H ratio) and H concentration were measured separately. For measurement of the D/H ratio, a 400 pA primary beam was scanned over the $10 \times 10$ µm$^2$ surface area, after $12 \times 12$ µm$^2$ were presputtered at 2 nA. Secondary ions of $^1H^+$ and $D^+$ were then collected over $4.4 \times 4.4$ µm$^2$ area. Prior to the quantification of H, an area of 8 µm × 8 µm was presputterd with a 3 nA current. The samples were then analyzed with a 400 pA current rastered over the 5 µm × 5 µm area and the secondary ions $^{28}SiH^+$ and $^{30}Si^+$ were collected over the 2.2 µm × 2.2 µm area. The $^{28}SiH^+/^{30}Si^+$ ratio defines the H concentration of olivine. Pyroxenes and glasses were used as standards.

Microprobe analyses of major elements (e.g. Fe and Mg) were performed at the Camparis facility (OSU EcceTerra, Paris).

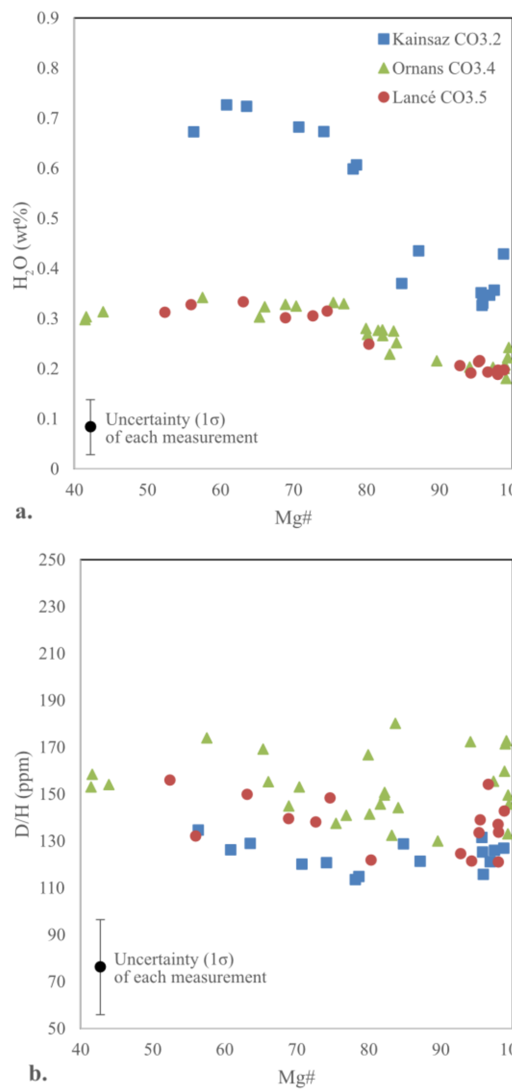


Figure 1: Hydrogen content expressed as water concentration (a) and D/H ratio (b) as function of Mg# (Mg/(Fe+Mg)) of olivine in CO chondrites (Kainsaz, Ornans and Lancé).

**Results and Discussion:** The hydrogen concentrations, expressed as water concentration, in olivine of the Ornans and Lancé chondrites varies between 0.18 and 0.33 wt% $H_2O$, whereas the water concentration of olivine in Kainsaz varies between 0.33 and 0.72 wt% $H_2O$ (Figure 1a). The D/H ratios in olivines of Kainsaz, Ornans and Lancé chondrules range between 114 ppm and 135 ppm, 130 ppm and 180 ppm and 121 ppm and 156 ppm respectively (Figure 1b).

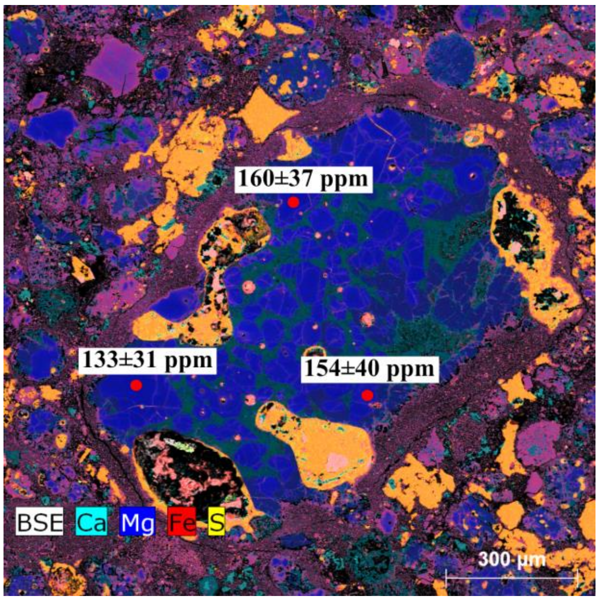


Figure 2: D/H ratios of three olivine from the same chondrule in Ornans.

Kainsaz, the least metamorphosed meteorite of our set, contains more hydrogen in its olivines than Lancé and Ornans. Moreover, ΔD (the difference between the minimum and maximum D/H ratios values within each chondrite, *i.e.* an index of heterogenity) of Kainsaz, Ornans and Lancé are 21 ppm, 50 ppm and 35 ppm respectively. Olivines in Kainsaz chondrules therefore show a more homogeneous isotope composition with an average value of 124 ppm. Ornans and Lancé have average of 153 ppm and 137 ppm respectively. However, these differences are within the uncertainty range. The isotopic composition of the olivines in these three meteorites can hence be considered relatively homogeneous.

Based on previous studies, the metamorphic temperature did not exceed 500°C for Lancé[5]. Ornans recorded an intermediate metamorphic grade and Kainsaz the lowest of the three samples analyzed here (~ 300°C)[6]. In the line with these temperature estimates, the most metamorphosed CO chondrites (Lancé and Ornans) have less water, higher D/H ratios and larger variability of isotopic composition in their olivines. This points to a partial dehydration of the parent bodies of these meteorites recorded in these olivines (the deuterium enrichment would be a result of distillation process). Some chondrules from Lancé and Ornans show heterogeneity of isotopic compositions in their olivines (Figure 2). This could point to a partial, diffusion driven loss of their hydrogen.

Conversely, the high hydrogen content and the homogeneous isotopic composition of Kainsaz' olivines point to a more limited hydrogen loss and/or to a process not limited by bulk diffusion. For these chondrules, hydrogen content may have been closer to what was acquired during the chondrule formation event in the protoplanetary disk. As previously presented, secondary processes, in particular aqueous alteration, may not have significantly disturbed H content of the chondrules of CM chondrites. Here we show that the hydrogen contents are similar in concentration but also in isotopic compositions between CM and moderately metamorphosed CO chondrites (e.g. Kainsaz). We therefore propose that the H accretion processes at work during the formations of chondrules found in CM and CO were similar. The hydrogen incorporation from the protoplanetary disk into the nominally anhydrous minerals (e.g. olivine) of carbonaceous chondrites would therefore have been particularly effective. Further work is needed to constrain these mechanisms.

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