HEAVY NITROGEN IN HYDRATED CLASTS IN A CH CHONDRITE. C. Perron and S. Mostefaoui, Laboratoire d'Etude de la Matière Extraterrestre, Muséum National d'Histoire Naturelle and CNRS, 75005 Paris, France. perron@mnhn.fr

Introduction: CH and CB chondrites are rare, metal-rich meteorites with a number of pecularities [e.g. 1]. Among these is a strong enrichment in ^{15}N of their nitrogen [2, 3], which is still not explained. CHs and some CBs contain dark, hydrated inclusions made of phyllosilicates with minor carbonate, iron sulfide and magnetite [e.g. 1]. Hypotheses to explain the presence of these inclusions include accretion together with the other, high temperature, components of these meteorites, or incorporation into the regolith of their parent body, at a later time. CH and CB chondrites have widely been considered as highly primitive, but recent measurements of a rather young age for their various components [4, 5] are more in favor of another hypothesis: formation in the melt and vapor cloud produced by an impact between planetary bodies [6]. Such an origin would make accretion of hydrated clasts together with the other components rather difficult, though not impossible. If the hydrated clasts were incorporated later on in the regolith, their materials were likely initially totally unrelated to those of the host. However, the ^{15}N-enrichment, which is characteristic of CHs and CBs and uncommon in other meteorites, has been found in the hydrated inclusions of the CH chondrite PCA 91467 [7]. To explain this observation, these authors argued that the hydration occurred in-situ, in the parent-body [7]. To further explore this subject, we have embarked on the measurement of the isotopic composition of nitrogen in hydrated inclusions in another CH chondrite. Carbon isotopes were measured as well, hydrogen isotope measurements are underway.

Experimental: A polished mount of the CH chondrite Acfer 207 (paired with Acfer 182) was chosen for study. Abundant dark inclusions, with sharp outlines and sizes up to 600×400 µm² were found. The isotope measurements were performed with a NanoSIMS N50 ion microprobe, using a Cs^+ primary beam. Ionic images were obtained on areas in the range 3×3 to 40×40 µm². Compositions were normalized with respect to a terrestrial kerogen sample of known chemical and isotopic compositions. Twelve inclusions were surveyed, and 1 to 4 images per inclusion were obtained for 7 of these. For comparison purposes, a few analyses were also performed on the host, on randomly chosen areas.

Results: C and N appear to be concentrated in small areas about 1 µm in size, which will be referred to as "grains" in the following. Typical ion images are shown in Fig. 1. Isotopic compositions were determined for grains and for areas with less resolvable structure outside grains as well. While the $^{13}C/^{12}C$ ratio is close to normal everywhere, the $^{15}N/^{14}N$ ratio is highly variable, with $\delta^{15}N$ ranging from normal to more than 1000 ‰, both in the inclusions and in the host. The C/N ratio (determined from the C^- to CN^- ion count ratio and the composition of the standard) is also variable, from ~100 down to values as low as ~3.

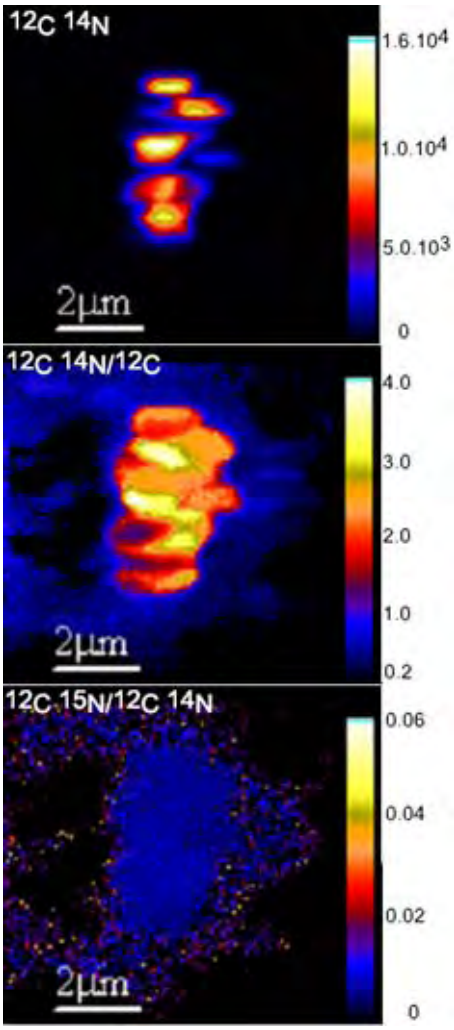

Fig. 1. Example of ion images obtained in a hydrated inclusion: $^{12}C^{14}N$ counts (top), $^{12}C^{14}N/^{12}C$ ratio (middle), $^{12}C^{15}N/^{12}C^{14}N$ ratio (bottom).

Although $\delta^{15}N$ and the C/N ratio are not stricly correlated, there is a clear tendancy for areas with high C/N ratio to have a low $\delta^{15}N$, and conversely for areas with high $\delta^{15}N$ to have a low C/N ratio. This is shown

in Fig. 2. Note that the actual phases analyzed are not known, and that our kerogen standard may not be the most appropriate one. However, given the large variations observed, we do not expect that the use of the real values would significantly alter the figure.

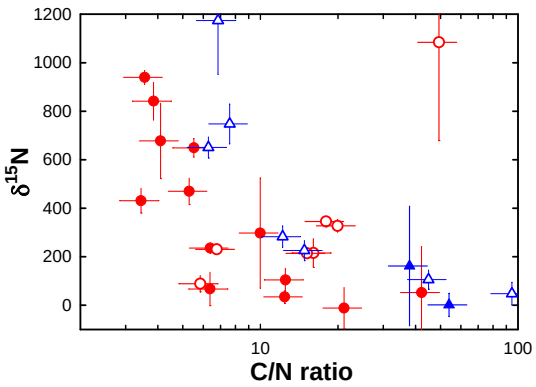

Fig. 2. $\delta^{15}N$ vs C/N ratio. Red circles are for hydrated inclusions, blue triangles for the host; full symbols are for grains, open symbols for areas outside grains. Error bars are 2 σs.

Discussion: Hydrated clasts in Acfer 207 contain heavy nitrogen, like the host. Moreover, the carriers of the nitrogen behave similarly in the two settings (Fig. 2). Thus, either the host and the clasts are genetically related, or both acquired their heavy nitrogen in the parent body, after acretion of the clasts. The absence of aqueous alteration of chondrules and metal in Acfer 207 means that hydration of the clasts did not take place in situ but rather before these were incorporated into the CH parent body. This would seem to favor nitrogen acquisition in the parent body, but it is difficult to find a process which could do this, especially as all CHs (and CBs) are enriched in ^{15}N, to comparable levels. On the other hand, it is also difficult to find processes in which hydrated materials and high temperature materials could have been closely related to each other before their common accretion.

One solution could be that, if CHs indeed formed in an impact plume, the hydrated clasts are remains of one of the impactors. As they could not have survived the impact event, they would have to have been part of something like the tail of a comet, following the impactor at some distance, and mixing with the CH material after its cooling. In this hypothesis, the heavy nitrogen would have been brought by one of the impactors, the initial parent body of the hydrated clasts. Heavy nitrogen would have been part of the plume and would have been incorporated in CH (and CB) materials as they formed This hypothesis is however not supported by the finding that in PCA 91467 the hydrated clasts carry only a minor fraction of the total heavy nitrogen, and that the highest values of $\delta^{15}N$ are found in other phases [7].

The trend shown in Fig. 2 implies that the heavy nitrogen carriers that we have analyzed have a surprisingly high N abundance compared to that of carbon, hardly consistent with organic matter. It makes one rather think of nitrides or of adsorbtion of N_2, or other N-rich molecules like HCN or NH_3, not very common in meteorites. This trend is at variance with that observed in samples of the Wild 2 comet returned by the Stardust mission. In these samples, high $\delta^{15}N$ values are associated with high C/N ratios, while spots with low C/N ratios present low, negative, $\delta^{15}N$ [8].

We must admit that the ^{15}N puzzle is not yet assembled, and that our measurements, although they yield new insights on the small scale characteristics of the heavy nitrogen carriers in CH chondrites, raise more questions than they bring answers.

References:

[1] Krot A.N. et al. (2002) *MAPS*, 37**,** 1451-1490.
[2] Prombo C.A. and Clayton R.N. (1985) *Science*, 230**,** 935-937.
[3] Franchi I.A. et al. (1986) *Nature*, 323**,** 138-140.
[4] Krot A.N. et al. (2005) *Nature*, 436**,** 989-992.
[5] Kleine T. et al. (2005) *GCA*, 69**,** 5805-5818.
[6] Wasson J.T. and Kallemeyn G.W. (1990) *EPSL*, 101**,** 148-161.
[7] Sugiura N. and Zashu S. (2001) *MAPS*, 36**,** 515-524.
[8] McKeegan K.D. et al. (2006) *Science*, 314**,** 1724-1728.