An Antarctic chondrite story: from the field to the lab. V. Debaille[1], L. Pittarello[2], R. Armytage[1], S. Decrée[3], Ph. Claeys[2]. [1]Laboratoire G-Time, Université Libre de Bruxelles, Brussels, Belgium ; [2]Analytical-, Environmental-, and Geo- Chemistry, Vrije Universiteit Brussel, Brussels, Belgium ; [3]Royal Belgian Institute for Natural Sciences, Brussels, Belgium

Introduction:

Chondrites represent more than 90 % of all meteorites collected on Earth (see for example the meteorite database). Among them, ordinary chondrites constitute the largest population, and as such, have been regularly considered of lower importance compared to other rare types of meteorites. Since 2009, 3 joint Belgian-Japanese field campaigns have collected more than 1200 meteorites, including more than 95% of ordinary chondrites. Those samples are treated with the same care as provided for any type of meteorite. Chondrites are defrosted at NIPR under vacuum to prevent contamination by terrestrial water. A small piece is then cut to make both thin and thick sections dedicated to classification and further studies. Larger samples (>50 g) are cut in half by using a dry wire saw while the smaller samples are shared equally between Japan and Belgium. Despite being common, ordinary chondrites have proven to be valuable samples to understand the formation of the solar system, as demonstrated by several studies recently initiated by the Brussels meteorite group.

Preservation:

Chondrites are sensitive samples to curate because they contain Fe-Ni alloys that can rust easily. As such, it is of importance to provide the best conditions possible to preserve the samples. While it has been demonstrated that keeping the samples in a pure nitrogen atmosphere may be the most conservative method, this is also a very costly system. The Federal Belgian Science Policy recently funded a project that investigates the optimal temperature/humidity conditions for preserving those precious but fragile samples within curation centers. Sample analog will be used to examine the alteration rate (measured by the progressive transformation of Fe^{0} to Fe^{2+} and Fe^{3+}) according to different external conditions that occur in a climatic chamber.

Classification:

Back from the field, the classification of meteorites is an essential task. For ordinary chondrites, the main classification is made by measuring the Fe content in olivine and low-Ca pyroxene. The most accurate method is electron microprobe analyses (EMPA) and is traditionally used for achondrites or rare types of chondrites. However, considering the number of ordinary chondrites in collections, several other methods, faster but less accurate, have been developed for those samples, such as oil immersion [1] or magnetic susceptibility [2]. However, the first method is partially destructive and can lead to some inaccuracy [1] while the second is sensitive to the degree of alteration of meteorites [2]. We have thus developed a new classification method using Raman spectroscopy [3]. This method takes advantage of the relationship between the wavelength shift in spectra of olivine and low-Ca pyroxene and their respective Fe content (Fig. 1a). The different shifts observed for different peaks can then be related to the type of ordinary chondrites (Fig. 1b). This can provide a fast classification method, even though EMPA remains necessary in case of uncertain classification or if additional information is required.

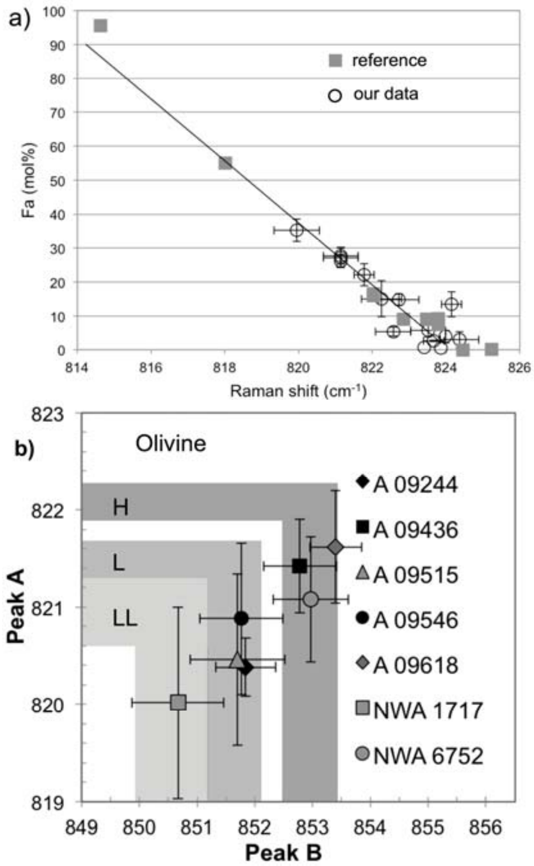

Figure 1: a) relationship between the wavelength shift and the Fe content (expressed as fayalite -Fa- component) in one of the two main peaks in olivine Raman spectrum; b) blind tests of classification of OC based on the wavelength shift for the two main peaks of olivine Raman spectrum. From [3].

The average composition of the solar system?:

Because of their primitive characteristics, many studies have used chondrites for evaluating the average composition of the solar system and of the bulk silicate Earth, especially for lithophile and refractory elements such as REE and Hf (e.g. [4, 5]). However, several studies have indicated isotopic discrepancy between the average of the chondrites and the Earth, not only for Lu-Hf (e.g. [5]), but also for Sm-Nd and more particularly ^{142}Nd [6].

The Lu-Hf spread in chondrites has been addressed by [7] who suggested that only type 3 chondrites should be used for assessing the average composition of the solar system. Martin et al. [8] thus investigated the re-distribution of REE and Hf between minerals during metamorphism. They found out that REE are mainly borne by phosphates while Hf is mainly distributed within silicates. During thermal metamorphism, Lu and Hf are thus decoupled, hence potentially explaining the lack of robust average for this system in chondrites. Debaille et al. [9] also modeled the preferential diffusion of REE from phosphates compared to Hf that could lead to spurious ages for both chondrites and achondrites.

The discrepancy in ^{142}Nd between chondrites and the Earth is more complicated to understand. It could be related to a reservoir hidden within the earth [6], the Earth not being chondritic [10] or to nucleosynthetic anomalies [11]. Because Antarctic meteorites should be the less prone to terrestrial alteration, a set of Antarctic ordinary chondrites are investigated for their ^{142}Nd systematics [12]. One to 1.5 g of ordinary chondrites has been carefully processed, using the purification and analytical procedures described in [13]. This is the first time that Antarctic meteorites have been used for this purpose. Compared to previous results, our data set shows a narrower variation range at μ^{142}Nd= -10 ± 3, slightly shifted towards the terrestrial average (Fig. 2). The consistency of our data set leads to a robust average of ^{142}Nd value in ordinary chondrites still shifted compared to the Earth. No nucleosynthetic anomaly has been observed, in agreement with the small μ^{142}Nd range. No systematic variation has been observed between H, L and LL, or between metamorphic type, indicating that the Sm-Nd is well preserved during thermal metamorphism, as expected from [8]. On the other hand, a larger than expected Sm/Nd was observed within ordinary chondrites, hence questioning the homogeneity of elemental distribution within ordinary chondrites.

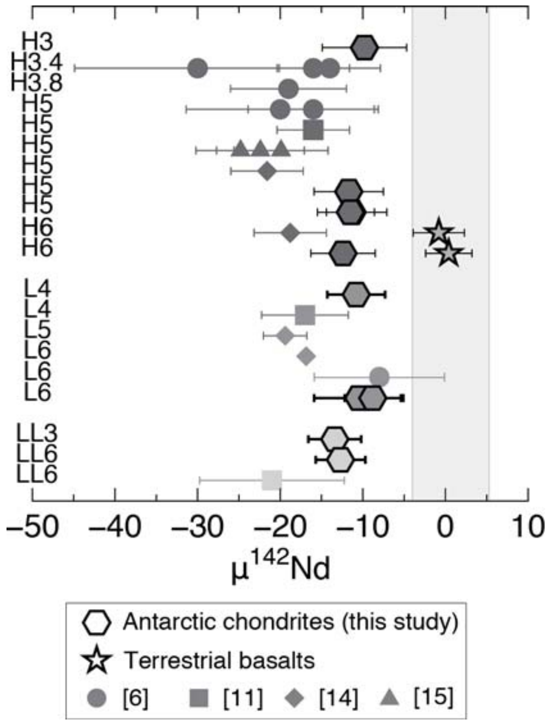

Figure 2: μ^{142}Nd of ordinary chondrites where μ^{142}Nd is the deviation of ^{142}Nd/^{144}Nd in the sample relative to a terrestrial standard in ppm. Literature data from [6, 11, 14, 15].

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