VISBLE NEAR-INFRARED REFLECTANCE SPECTROSCOPY OF SUB-µm SILICATE GRAINS. R. Sultana[1], P.Beck[1], O. Poch[1], S. Potin[1], E. Quirico[1], B. Schmitt[1], M. Roskosz[2] and M. Ciarnello[3], [1]Institut de Planétologie et d'Astrophysique de Grenoble (Université Grenoble Alpes, CNRS, Grenoble, France, robin.sultana@univ-grenoble-alpes.fr), [2]Muséum National d'Histoire Naturelle (Sorbonne Université, Paris, France), [3]INAF-IAPS (Istituto di Astrofisica e Planetologia Spaziali, Rome, Italy).

Introduction: Small bodies of the Solar System are covered with a regolith constituted by small grains which may be smaller than wavelengths at which they are observed. In addition, cometary dusts are expected to be constituted of sub-µm particles based on their thermal emission spectra [1-2] and *in situ* observations [3]. Sub-wavelength particles are expected to become highly forward scattering and non-reflective and cannot be described by radiative transfer models based on geometric optics that are commonly used to model Vis-NIR observations [4-5].

Here we will present a method to obtain hyperfine grains from millimeter sized particles and the first measurements of their optical properties.

Methods: In order to obtain very small grains, we defined a grinding-sieving protocol to crush crystals of olivine, synthetic quartz balls and chips of rhyolite. Each sample was ground using a 'planetary grinder'© Retsch PM100 and sieved mechanically or by hand, using whether dry or wet sieving (with ethanol). Starting material were initially millimeter-sized.

Dry grindings were first operated for 20 minutes using 15 mm balls of zirconium. The powder was then sieved and grains smaller than 50 µm were kept. Bigger grain powder was dry-grinded again for 20 minutes using 2 mm balls. This procedure was repeated until we got enough powder of small grains (< 50 µm). We then performed a 60 minutes long colloidal grinding of small grain powder (< 50 µm), with 0.5 mm balls in order to get the expected hyperfine grains (< 1 µm).

The powder was characterized by Scanning Electron Microscopy (SEM), providing particle size and particle size distribution. Images were analyzed with the ImageJ software, assuming elliptical grains (Fig. 1, 2). Note that some biases are likely present in this analysis. First, small grains are often stuck at the surface of larger grains, and therefore a non-negligible fraction of them is unseen in SEM images. Furthermore, grains are often overlapping each other, so the shape drawing and hence the grain size estimation cannot be fully trusted. Because of these biases - the large grains count might be overestimated.

Spectroscopy measurement in the visible and near infrared ranges was then operated with the spectro-gonio-radiometers SHINE [6] and SHADOWS [7], to collect spectra from 400 nm to 4200 nm, with an incidence angle of 0° and an observation angle of 30°. Sample surface were hand compressed with a spatula to minimize surface roughness.

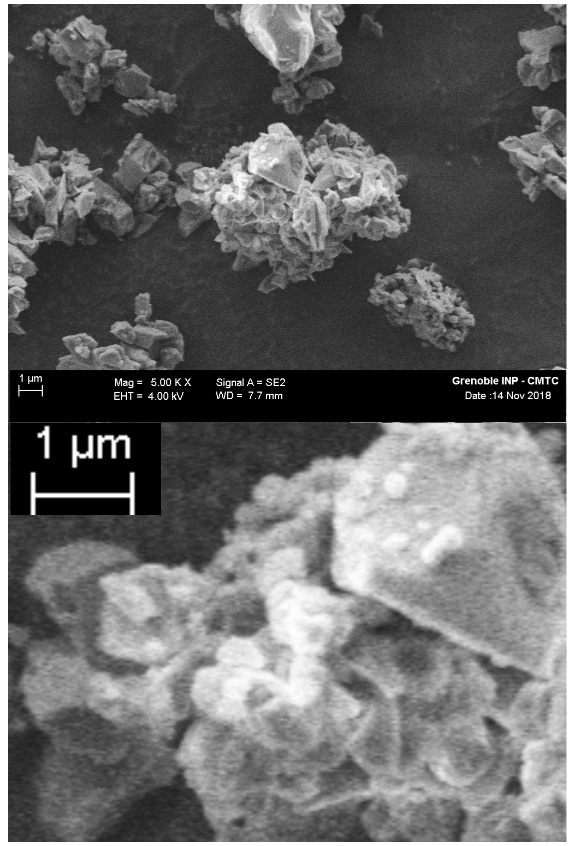

Figure 1. SEM images of olivine after 60 minutes in the planetary grinder. The size of the particles is decreasing down to 50 nm for the smallest grains. The lower picture is a crop of the upper one. Fine grains are visible on this image.

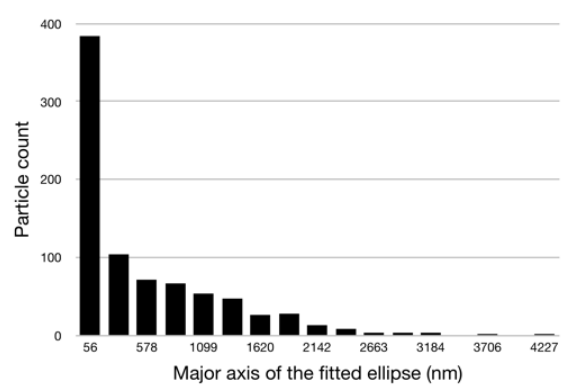

Figure 2. Size distribution of olivine grains after 60 minutes in the planetary grinder. The size of the particles is decreasing down to about 50 nm for the smallest grains. Because of bias inherent to the overlapping of grains, the number of small grains is probably underestimated.

Results: Spectra of olivine powders of different grain sizes are displayed in figures 3 and 4. We observe a small increase of the visible reflectance upon decreasing the grain size (Fig. 3), together with a decrease of the 1.05-µm olivine band-depth (Fig. 3-4). This effect was previously reported in the MIR for particles bigger than 5 µm [8].

Another interesting observation is the change of spectral slope over the whole wavelength range. The spectra become bluer for the fine-grained powders. This effect is theoretically expected [8]. For each spectra the water band at 2.9 µm increases when decreasing the particle size. This effect is likely due to an increase of the specific surface area with grinding time, leading to an increase of the amount of adsorbed water [9].

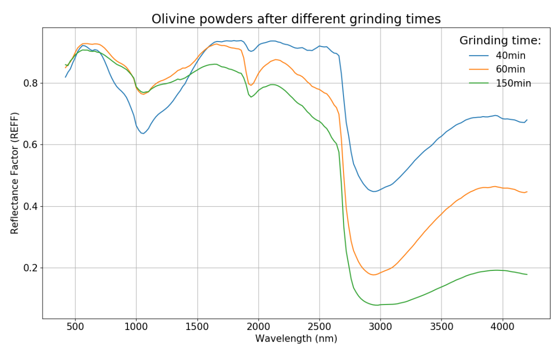

Figure 3. Reflectance spectra of olivine powders with different grinding time. The blue curve is the spectrum obtained after 40 min of colloidal grinding, the orange curve after 60 min, the green after 150 min. The global reflectance level is increasing when the particles become finer. We can also note that the spectra are bluer for finer grains.

Conclusion & Future work: These preliminary results on the optical properties of hyperfine particles (sub-wavelength) reveal a decrease of the depth of absorption features together with a "bluing" of the spectra. Future work will include the measurement of spectra under vacuum and 80°C to remove contribution from adsorbed water, spectral BRDF (Bidirectional Reflectance Distribution Function) measurements on the samples as well as the investigation of the spectral behavior of mixtures of hyperfine particles including opaque minerals (e.g. sulfides, oxides) [10].

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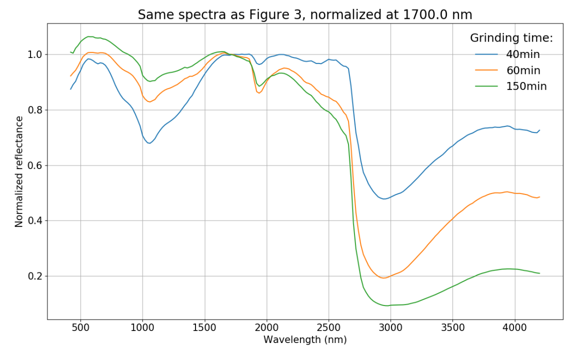

Figure 4. Same spectra normalized at 1700 nm.. The spectra become "bluer" when the particle size is decreasing. We can see that the 1050 nm band contrast is also decreasing with the particle size. On the other hand, the water absorbed band around 2900 nm is getting deeper because of the increasing amount of absorbed water.

References:

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