IDPs' SILICATE 10 µm SIGNATURES VERSUS ALIPHATIC 3.4 µm FEATURES: A KEY TO THEIR ORIGIN? S. Merouane[1], Z. Djouadi[1], L. d'Hendecourt[1], J. Borg[1], [1] IAS, CNRS, UMR 8617, Université Paris Sud, bat 121, F-91405 Orsay Cedex, France (sihane.merouane@ias.u-psud.fr).

Introduction: Interplanetary Dust Particles (IDPs) are cosmic dust originating from asteroids and comets collected on Earth in the stratosphere, making them available for laboratory analyses [1,2]. The silicate component of a given IDP could give an important information on its origin (cometary or asteroidal) [3].

In this work, using the 10 µm band (i.e. 1000 cm^{-1}), the well-known and generic signature of silicates in the mid-infrared spectra, we aim to quantify the contribu-tion of each silicate (olivine vs pyroxene, crystalline as well as amorphous) of a few IDPs. Combining our quantification to the information deduced from the analysis of the 3.4 µm aliphatic organics bands, we try to obtain clues on the formation and evolution of our investigated IDPs. We present here promising preliminary results showing that the aliphatic chains in the organic components of pyroxene-rich IDPs are shorter than those of olivine-rich IDPs.

Experiments: The studied IDPs (L2036 AE3, L2036 AE4, L2021 Q3, L2036 AG1 and L2021 B11) were crushed in a diamond compression cell following the protocol of [4]. Infrared micro-spectroscopy from mid to far infrared (2.5-100 µm) was performed on the SMIS2 beamline of the french synchrotron SOLEIL (http://www.synchrotron-soleil.fr/Recherche/LignesLumiere/SMIS) using a NicPlan microscope attached to a Fourier Transform infrared spectrometer (FTIR). We also used Raman spectroscopy and SEM-EDX in order to get complementary information on our samples. Raman spectra were acquired at SOLEIL with a spectrometer DXR from Thermo Fisher with a 532 nm laser and SEM-EDX analyses were performed with a SEM Hitachi 3600N and an EDX spectrometer ThermoNoran System SIX at the French national facility MINERVE (http://www.ief.u-psud.fr/ief/ief.nsf/CTU/CTU_presentation.html) of "l'Institut d'Electronique Fondamentale" (IEF, Orsay, France).

Procedure: We acquire mid-infrared transmission spectra of standards of silicates commonly found in IDPs (olivine and pyroxene). We use crystalline and amorphous Mg and Fe end-members of each silicate family. The crystalline samples are prepared in the same way as the IDPs. Amorphous silicates are obtained by electron beam evaporation under vacuum of crystalline samples on KBr or CsI pellets [5].

For each sample (i.e. IDPs as well as the used standards), we first extract the silicate feature in the range 1250-750 cm^{-1}. We then perform a linear base-line-correction and normalize the spectra to the peak maximum for each spectrum in this frequency range. A numerical combination of the standards "10 µm feature" is then used to fit the 10 µm band of the IDPs. The fit procedure is completed when minimizing the χ^2 values. The choice of the standards to use for each IDP is made according to their characteristic features found in both IR and Raman spectra and to the presence of Fe in EDX spectra.

Results: In order to validate our numerical procedure we first applied it to mixtures of forsterite (Mg-end-member of olivine) and enstatite (Mg-end member of pyroxene) that we synthesized with known compositions. Our method gave the right composition within 5% error. The procedure is then applied to the studied IDPs. The obtained results are given in Figure 1, where the solid lines represent the IDPs' spectra and the dotted ones are the best fits found with our analytical technique.

L2036 AE3 is principally composed of crystalline silicates, mostly-Mg-rich pyroxene. The 10 µm band of the IDP is narrower than its corresponding fit. This is probably due to a difference in the thickness between the IDP and the used standards. However all the features obtained in the numerical spectrum (dotted line) are found in the IDP's spectrum (solid line).

L2036 AE4 is composed of olivine, mostly Fe-rich olivine. This is coherent with the EDX analyses indicating large quantities of Fe as well as the Raman spectra in which the Fe end-member of olivine was identified . However, the 10 µm band is not perfectly fitted as it lacks a contribution at ~ 9.5µm (~ 1050 cm^{-1}), which is not yet identified.

L2021 Q3 is a very crystalline Mg-rich olivine. It seems to have suffered significant thermal heating, as suggested by the aromatics ordering from the narrow D and G Raman bands (not shown here). All these data are in good agreement with what was obtained by Wopenka [6] on olivine-rich IDPs.

L2036 AG1 consists mostly of amorphous pyroxene, but we do not fit a contribution at ~ 9 µm (~1100 cm^{-1}) which is also not identified yet.

L2021 B11 is mostly composed of crystalline pyroxene.

On the other side of the spectrum, in the 3.4 µm regions, we have access to the length of the aliphatic chains of the organic component in the IDPs by determining the CH_2/CH_3 ratios (see Tab.1). This has been done for each studied IDP except for L2021 B1 for wich no aliphatics feature has been observed because of its bad quality baseline probably due to the sample's complex shape.

One can see from Table 1 that pyroxene-rich IDPs (L2036 AE3 and L2036 AG1) are those displaying the shortest (or more ramified) chains, i.e. the lowest CH_2/CH_3 ratios. Having in mind that short chains are associated to hot environments [7] because thermal metamorphism tends to graphitize the material and thus to shorter the aliphatic chains, this seems to contradict the fact that pyroxene is mostly found in the coldest regions of the solar system [8]. This discrepancy could be due to mixing of inner and outer solar nebula matter and/or interstellar with protoplanetary matter. Moreover, our results are consistent with the fact that pyroxene is abundant in the general interstellar medium [9] where aliphatic chains tend to be rather short (CH_2/CH_3 of the ISM ~ 2.2 [10]).

Conclusion: Our method to quantify the 10 µm silicate feature is promising to infer the silicate composition of IDPs (or other anhydrous extraterrestrial particles). We propose a close link between the mineralogical composition and the aliphatics nature but the trend observed among 4 of our IDPs has to be confirmed by the analysis of a larger number of IDPs. If this trend is confirmed, we would have to find out why short (long) chains are "*systematically*" associated with pyroxene-rich (olivine-rich) particles, probably reflecting an evolutionary pathway This work is under progress.

References: [1] Warren J.L. et al. (1997) *Cosmic Dust Catalog*. [2] Rietmeijer F.J.M. (1998) *Planetary Materials*, 1-95. [3] Sandford S.A. et al. (1989) *Icarus* 82, 146-166. [4] Brunetto R. et al. (2011) *Icarus* 212, 896-910. [5] Djouadi Z. et al. (2005) *A&A* 440, 179-184. [6] Wopenka B. (1988) *EPSL* 88, 221-231. [7] Goto M. et al. (2003) *ApJ* 589, 419-429 [8] Gail H.P. (2010) *Lect. Notes Phys*. 815, 61-141. [9] Min M. et al. (2007) *A&A* 462, 667-676 [10] Matrajt G. et al. (2005), *A&A* 433, 979-995.

IDP	CH_2/CH_3
L2036 AE3	2.6 ± 1.6
L2036 AE4	5.2 ± 0.8
L2021 Q3	5.7 ± 0.7
L2036 AG1	3.3 ± 0.2

Tab. 1. asymmetric CH_2/CH_3 ratios obtained from the deconvolution of the 3.4 µm aliphatic feature for IDPs L2036 AE3, L2036 AE4, L2021 Q3 and L2036 AG1. We use 5 gaussian bands (two bands for CH_2 symmetric and asymmetric stretching modes (~ 2850 cm^{-1} and ~ 2920 cm^{-1} respectively), two bands for CH_3 symmetric and asymmetric stretching modes (~2870 cm^{-1} and 2950 cm^{-1} respectively), and a band at ~2900 cm^{-1} may be due to a Fermi Resonance (see [4]). There positions, Full Width at Half Maximum and areas are given by minimizing the χ^2 value.

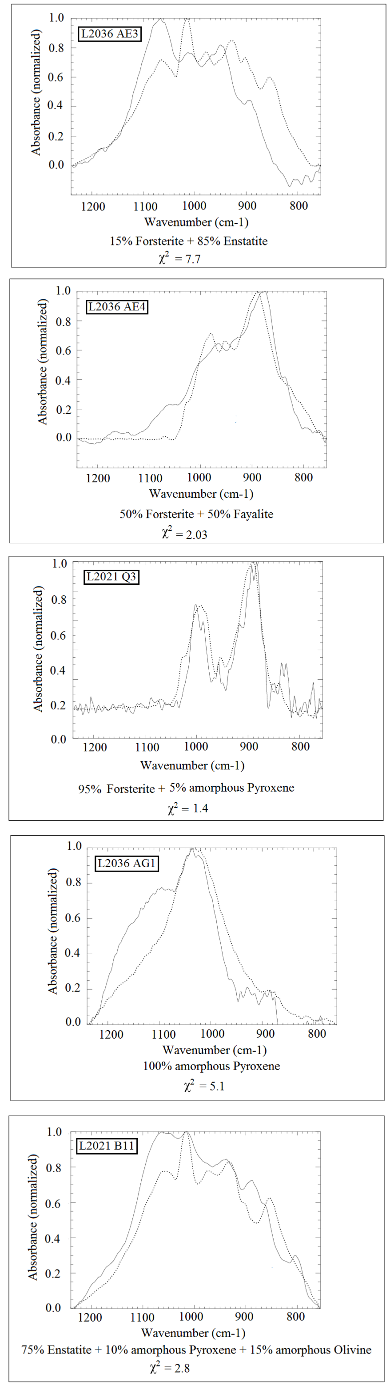

Fig. 1. The IR 10 µm band of silicates in IDPs L2036 AE3, L2036 AE4, L2021 Q3, L2036 AG1, L2021 B11 (solid lines) and their best fit (dotted lines). The compositions which minimize the χ^2 values are also given in the bottom of each panel.