MINERALOGY AND PETROLOGY OF STARDUST PARTICLES EXTRACTED FROM THE WALLS OF TRACK 80 J. Stodolna, D. Jacob and H. Leroux, Laboratoire de Structure et Propriétés de l'Etat Solide UMR CNRS 8008, Université des Sciences et Technologies de Lille, 59655 Villeneuve d'Ascq, France, julien.stodolna@ed.univ-lille1.fr.

Introduction: Since the return to Earth of the Wild 2 comet samples by the Stardust mission, most of the studies have been performed on terminal particles located at the end of the deceleration tracks. However, the major fraction of the cometary material is unevenly distributed along the track walls [1,2]. Particles within samples extracted from the walls show strong collect-induced thermal alteration but their study remains important to understand the physical and chemical nature of the Wild 2 material.

The aim of this work is to investigate by transmission electron microscope (TEM) the mineralogy and petrology of a sample extracted from the wall of track 80.

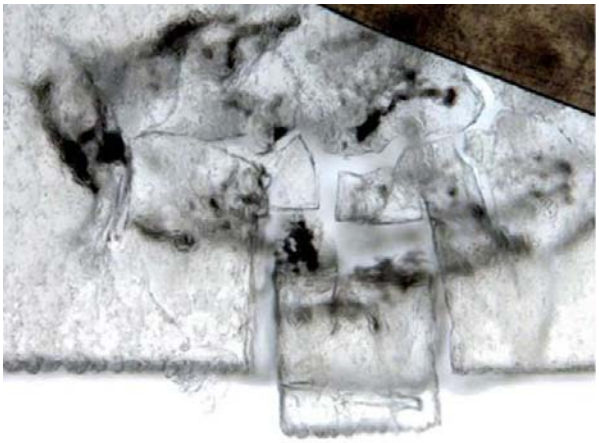

Fig.1: Sample C2092,3,0,0 dissected from track 80 (lower part of the micrograph). This track have a large bulbous shape (about 5 mm lenght and 2 mm wide).

Samples and experimental procedures: The specimen was extracted from the track 80. The samples have been prepared at the University of Washington by the acrylic embedding method [3]. The track is first keystoned and a piece of aerogel is extracted (Fig. 1). The aerogel block is then compressed between two glass slides. The compressed aerogel is embedded in an acrylic resin and ultramicrotomed. The sections deposited on a carbon coated TEM grid are washed with chloroform to dissolve acrylic. This method allows to avoid the optical selection of a priori features of interest and to preserve the aerogel medium in which Wild 2 particles are encassed. Thus, very small and weakly contrasted objects are included in the final TEM preparation.

TEM results have been obtained using a Philips CM30 and a FEI Tecnai G2-20 both equipped with Energy Dispersive X-ray Spectroscopy (EDX) (see [4] for a full description of the analytical procedure). The microscopes are also equipped with a precession module (Nanomegas Spinning Star). Applying precession, diffraction patterns are always symmetric in intensity [5] even if the sample is not perfectly oriented, which is very convenient in the case of small imbricate particles. Furthermore, intensities are more directly related to the factor structures, which makes phase indentification more reliable.

Results : The sample presents a large microstructure diversity. The thermally modified amorphous material is predominant but well-preserved crystalline grains are also found.

The thermally modified particles present the same microstructure as that described in [6] (Fig.2). It consists of a silica-rich glassy matrix embedding a large number of small Fe-Ni-S inclusions and vesicles. The compositions are SiO_2-rich due to mixing with molten aerogel. To explain this microstructure, Leroux et al. [6] proposed a model based on a redox reaction and sulfides breakdown processes that likely happened during the high temperature stage of the capture. The composition of the thermally modified patches is variable from place to place. Fe and S appear to be mostly present within the Fe-Ni-S nanophases. Typically the bulk concentration of this SiO_2-rich glassy material for the majors elements (Mg, Fe and S) is below 3 at%.

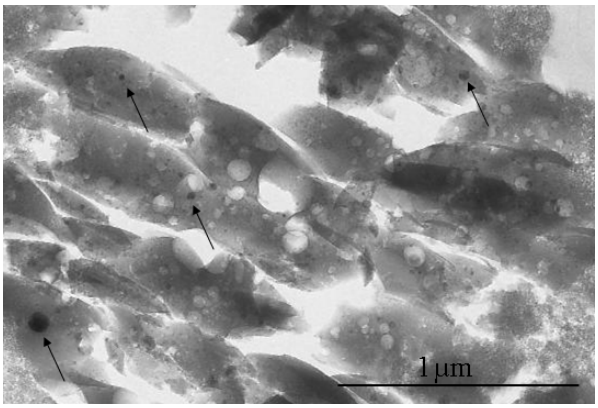

Fig.2: Bright field TEM image showing the microstructure of the thermally modified particles. Vesicles appear as bright disks. Some Fe-Ni-S nanophases are arrowed.

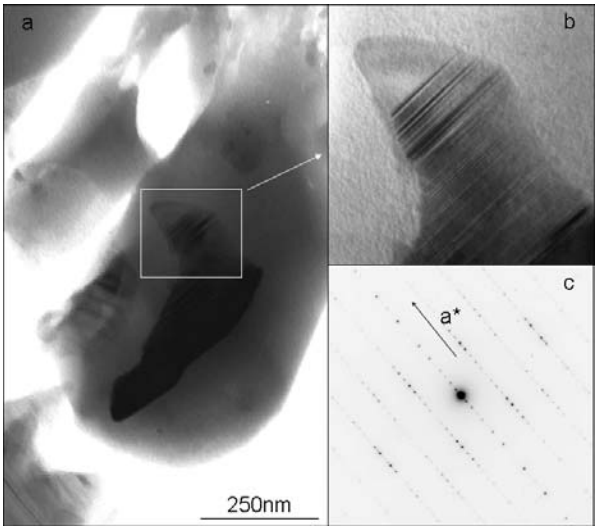

Fig.3: a) Bright field image of a crystalline enstatite grain surrounded by an amorphous rim. b) Ortho-clino inversion lamellae observed in the enstatite grain. c) Associated precession electron diffraction pattern along a [010] zone-axis.

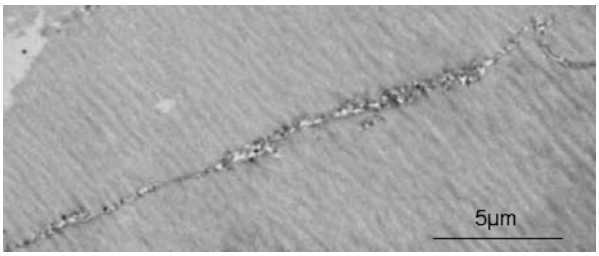

Fig.4 : One of the micro tracks observed in the sample

Concerning the crystalline particles, several olivine grains have been studied. They are typically 2 µm in size with a wide range of composition (see table 1 for representative compositions). The large composition range suggests that the initial Wild 2 particle was an aggregate of minerals having different origins. The internal microstructure is almost free of crystal defects suggesting that the olivine did not suffered from strong shock metamorphism. Ortho-enstatite grains are also found. A large majority of them are Mg-rich (Table 1). They contain clino-enstatite lamellae along (100) corresponding to ortho-clino inversion lamellae (Fig. 3). These ortho-clino inversion lamellae can give information about the thermal history of the particle, as in the case of the terminal particles [7,8]. Interestingly, those crystalline grains are frequently surrounded by an amorphous rim with a composition close to enstatite lightly enriched in SiO_2 due to mixing with molten aerogel. Compositions are given in table1. This microstructure likely represents a partial melting of the crystal during the collect. It is probably an intermediate stage between the well preserved terminal particles and the fully thermally modified grains frequently found along the track walls.

The sample contains also some "micro-tracks" in the compressed aerogel. They are made of very elongated channel, typically several µm in length. Very fine-grained cometary material is distributed along them. Those features are obviously coming from the fine scale breaking up and dispersion into the aerogel of the incident aggregate. More details are presented in [9].

Conclusion: The walls of track 80 contain abundant Wild 2 material which consists of a mixture of amorphous and crystalline phases. The amorphous components display clear evidence of thermal-induced modification due to the heating that occurred during the collect deceleration stage. The diversity of the microstructure suggests an initial aggregate of crystalline grains sticked together by fine-grained material. The latter strongly suffered thermal alteration and is found fully melted and mixed with molten aerogel. On the opposite, the bigger crystalline grains have been partially preserved.

O	Si	Fe	S	Mg	Al	Ca	Cr	Mn
olivine								
57.0	14.3	13.9	-	14.1	0.5	0.1	0.0	0.1
57.3	13.5	16.9	-	11.9	0.1	0.1	0.1	0.1
crystalline enstatite								
60.5	19.4	0.9	-	16.4	0.5	1.5	0.3	0.5
61.0	20.0	0.9	-	16.0	0.4	1.0	0.3	0.4
60.7	20.0	0.6	-	17.3	0.3	0.4	0.2	0.5
amorphous enstatite								
62.9	23.1	1.2	0.6	10.8	0.6	0.3	0.1	0.4
63.3	24.5	0.6	0.1	9.7	0.7	0.3	0.2	0.6

Table1: Representative EDS composition (at. %) for some particular areas.

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