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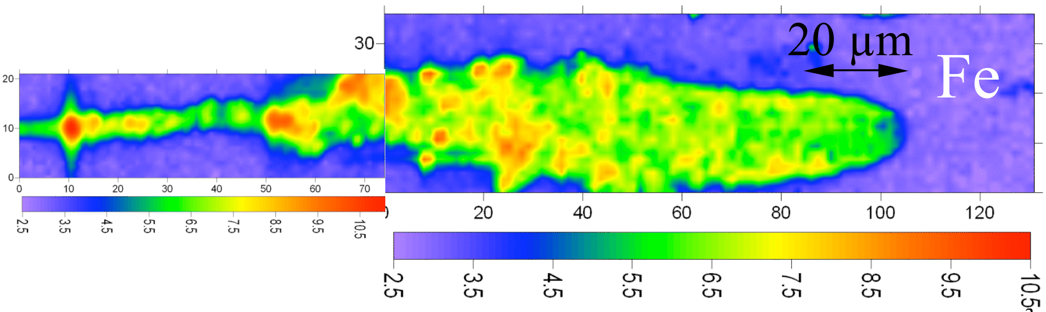
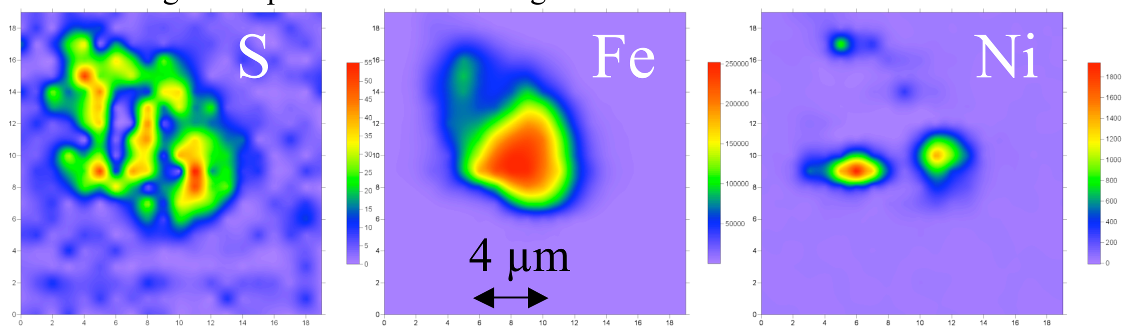
This work is part of the NASA Preliminary Examination Team (PET) on Bulk Chemistry investigation of Wild 2 cometary grains brought back to Earth by the Stardust mission [1]. X-rays are among the least destructive yet sensitive micro-probes, capable of analysing minute samples embedded in low density collectors, so methods based on Synchrotron Radiation had access to Stardust samples in priority. The main goal of the PET was to produce a preliminary characterization of the abundance and nature of the elements present in the returned samples [2]. In this phase it was paramount to analyze the grains in-situ, in the aerogel foam of the collectors to record the total mass fragments and avoid extraction risks, by combining high ($1\mu m$) and moderately high resolution ($2 \times 4\ \mu m^2$).

We have performed measurements on beamlines ID22/ID21 of the ESRF synchrotron in Grenoble, France, devoted to high/low energy microspectroscopy and recorded results on a collection of 6 keystones. Keystones are milimeter slices of Si aerogel containing the grains slowed down throughout their volume.Mapping out the terminal particles and the tracks was a mandatory task to obtain total mass of elements, subtracting the Si aerogel which is not pure.



Iron fragmentation between a track and terminal particle (TP), res=$2 \times 4\ \mu m^2$

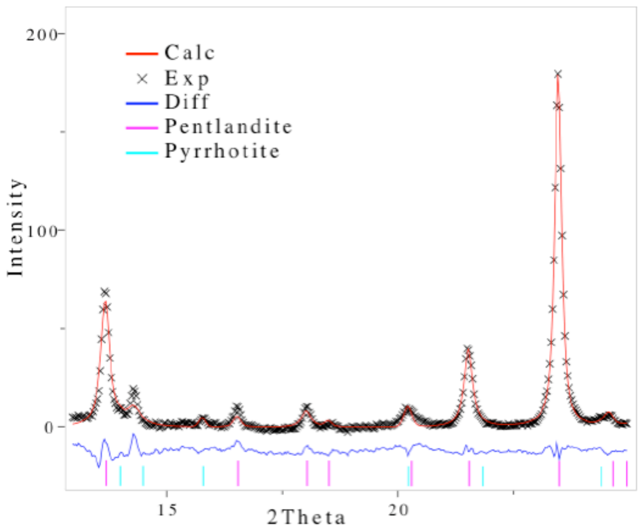
Results show that aerogel slowing down is a process which fragments the grains which are loosely bound such as aggregates or conglomerates. Mass ratios of the TP/track are about 10/90 confirming the importance of collecting *in-situ* all tracks.



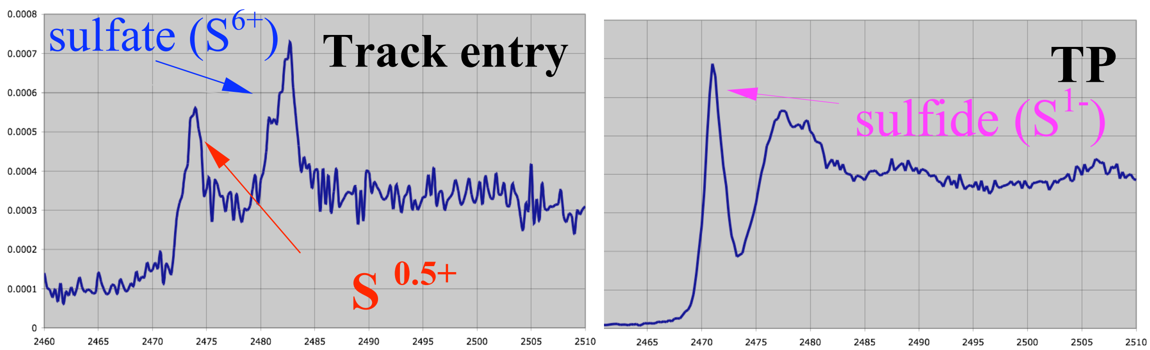
Strong heterogeneity (≈ 5 µm) of S, Fe, Ni in a TP, resolution 1 µm.

We estimated heterogeneity of a TP at 5 µm, which is much larger than the average heterogeneity observed on asteroid grains ($\ll 1\mu m$). In order to do an absolute quantification of mass we used a NIST thin glass standard (SRM 1833) which contains trace amounts of several elements. Errors using this standard range from a few percents to 20-30% for low Z (Si, S) strongly absorbed in the aerogel and grain.

Our 6 keystones were among the 25 which produced the PET preliminary results [4] and concluded in an enrichement of the moderately volatiles K, Cu, Zn, Ga while Cr, Fe, Ni are within 25% of the CI chondritic composition. Fe mass varies by more than 2 orders of magnitude in all keystones, exhibiting a strong heterogeneity. The ratio track/TP confirms the strong fragmentation in the aerogel and the need to collect signal form all the track. On selected zones of the track and on all TP we simultaneously collected diffraction data. This allowed the direct identification of the mineralogy of some of the grains which showed powder diffraction spectra. In the TP of all analyzed keystones we identified a few micron-sized crystals. These crystals were difficult to align using a simple sample holder but their presence constrains the thermodynamics of grain cooling. In a few cases, we identified and quantified using Rietveld refinement a powder diffraction phase which contains Fe and Ni sulfides (see adjacent graph). These sulfides are compatible with grain condensation at moderately high temperatures (<600°C).



Finally, we recorded the evolution of the charge states of S and Fe as a function of the position in the track by means of micro-Xanes measurements.



Grain redox by interaction with the SiO_2 aerogel.

The results are similar to our findings on previously analyzed aerogel tracks [3] and show an oxidation at the entrance of the track followed by fragmentation. TP is thus exposed and shows relatively smaller redox state than the entrance which is possibly indicative of the initial grain valence. All these analyses were combined to produce a description of the Wild 2 cometary grains [4, 5], as well as a history of their formation and of the thermal interactions during their slowing down in the aerogel collectors. Our results are compatible with the new scenario of cometary formation closer to the early Sun, by interaction with the strong bipolar plasma jets which later transported them to their contemporary dwelling in the Kuyper Belt. More detailed results are needed, particularly on the assemblages low/high temperature recorded by diffraction as well as on the aerogel alteration from Xanes. In order to identify these assemblages high resolution mapping is required to obtain composition maps and estimate grain morphology and fragmentation ratios between track and terminal particle.

References

[1] Brownlee, D. E. et al. *LPSC* XXXVII, abstract nr. 2286. (2006)

[2] G. J. Flynn, Team 1, Team 2, P. Bleuet, *LPSC* XXXVII, abstract nr. 1217, 2006[3]

[3] F. Grossemy, J. Borg, Z. Djouadi, A. Simionovici, L. Lemelle, D. Eichert, D. Deboffle, Planet. & Sp. Sci., (soumis), 2006.

[4] G. J. Flynn, Team 1, Team 2, Team 3 *et al.*, Science, (submitted), 2006.

[5] M. Zolensky *et al.*, Science, (submitted), 2006