COORDINATED FTIR AND TEM STUDY OF THE ORGANIC MATERIAL IN THE STARDUST PARTICLE FEBO AND THE IDP CHOCHA. G. Matrajt[1], G. J. Flynn[2], D. Brownlee[1] and D. Joswiak[1]. [1]Department of Astronomy, University of Washington, Box 351580, Seattle WA 98115 USA (matrajt@astro.washington.edu), [2]Dept. of Physics, SUNY-Plattsburgh, Plattsburgh NY 12901 USA (george.flynn@plattsburgh.edu).

Introduction: The Stardust (SD) spacecraft returned Wild 2 cometary samples that were captured in aerogel. The micron and larger fragments found along aerogel tracks often do not contain abundant carbonaceous material, in part because some thermally sensitive components were destroyed during capture [1]. A few tracks however, do contain organic material [1,2,3]. Track 57 (Febo) is one of them, where carbonaceous globules and other carbonaceous materials have been detected and shown to have ^{15}N and D isotopic anomalies [2]. In addition, XANES studies have shown that these materials have C bonded to O and N and the presence of C=O (carbonyl), confirming that these carbonaceous phases are organic. In the present study, we investigated organic materials with EELS and FTIR to further understand the nature of these phases and compare cometary organic material from Wild 2 to the very C-rich interplanetary dust particle (IDP) Chocha [4].

Techniques: In this study we worked with two different samples that are known to be C-rich: a SD particle, which is fragment #2 of track 57, called Febo and an IDP from the flight collector W7154, called Chocha. Previous studies of Febo showed that it contains carbonaceous material with ^{15}N anomalies. It was also shown that carbon is bonded to O and N in an organic material [2]. Recent studies of Chocha have shown that this is an extremely C-rich particle, where carbon accounts for about 95% (vol.) of the particle when observed in a microtomed slice [4]. To perform the analyses we cut the aerogel region containing the particle Febo and flattened and embedded it in acrylic [5]. IDP Chocha was extracted from the flag and the silicone oil was washed with distilled hexane and the particle was embedded in acrylic. Both samples were microtomed. The microtomed sections (50 nm thick) were placed on top of Transmission Electron Microscopy (TEM) grids coated with carbon films, washed with chloroform vapors to remove the acrylic and surveyed with a 200 kV Tecnai TEM coupled with a Gatan Imaging Filter (GIF) detector. Carbon was mapped with an Energy filter mode (EFTEM) and analyzed with Electron Energy Loss Spectroscopy (EELS). The C EELS spectra were processed with Gatan software and the background was subtracted using the conventional power law algorithm of the form AE^{-r} . The position of the 285 eV peak, corresponding to a C=C bonding was used for the comparison between the two samples. Infrared spectroscopy was performed on both samples using a Continuum Fourier Transformed Infra Red (FTIR) microscope located on beamline U2B of the National Synchrotron Light Source at Brookhaven National Laboratory. The infrared flux is ~1000 times that of a conventional globar instrument, delivering significantly higher sensitivity and/or spatial resolution. Spectra were obtained over a range of 4000 to 650 cm^{-1}.

Results: Fig. 1 shows the C-map images of both particles. The white areas are the C-rich materials. IDP Chocha is mostly made of carbon, whereas the C-areas in Febo are discrete and small regions heterogeneously distributed throughout the particle. The C-rich areas have distinctive textures and morphologies, similar to the ones previously found in other IDPs [4].

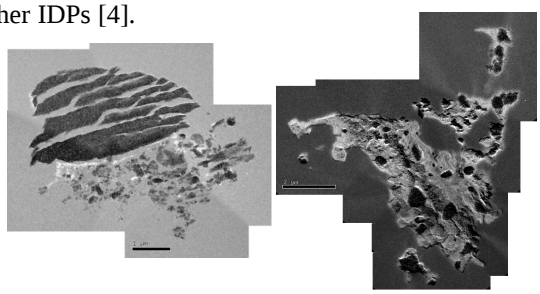

Fig 1. Carbon maps of SD particle Febo (left) and IDP Chocha (right).

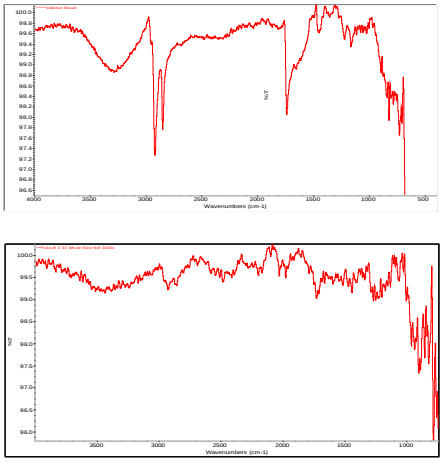

Fig. 2. IR spectra of IDP Chocha (top) and SD particle Febo (bottom).

Fig. 2 shows the IR spectra of the C-rich regions of both samples.

Discussion: We identified five types of textures in the morphology of these materials that we have described previously in 6 IDPs [4]. These are called globular, vesicular, dirty, smooth and spongy. In particle Febo, we mainly observed the morphologies dirty, smooth and vesicular. Particle Chocha has all the morphologies [4] although in the section analyzed for this study the dirty texture was not found. The presence of similar morphologies for the carbonaceous materials in both samples could imply that the IDP Chocha has a cometary origin, however two other observations preclude this conclusion: First, most of these morphologies have also been observed in a variety of carbonaceous chondrites (CCs), including CRs, CMs and the unclassified Tagish Lake meteorite (see references and extensive discussion in [4]), indicating that these morphologies are not unique to either asteroid or cometary parent bodies but are rather widespread in the Solar System. Second, the ^{15}N and D anomalies measured in these carbonaceous materials [2,3,4 and references therein] are all found in the same range, indicating that these materials have a common origin, presumably cold molecular clouds or the outermost parts of the protoplanetary disk [4]. Therefore, based on the isotopic anomalies previously measured and the textural comparisons made in this study, it appears that the carbonaceous material found in Chocha and Febo is similar to the carbonaceous material observed in CCs, *i.e.* cometary, asteroidal and IDP carbonaceous material is correlated.

The IR data show that Febo has absorptions at 2926 and 2860 cm^{-1} corresponding to an aliphatic C-H_2 and weaker absorptions at ~2958 cm^{-1} corresponding to an aliphatic C-H_3 (which also overlaps C-H_2) and an absorption at 1730 cm^{-1} corresponding to a carbonyl (C=O). The IR data of Chocha shows a pair of absorptions at 2920 and 2847 cm^{-1} corresponding to aliphatic C-H; absorptions at 1226 cm^{-1} consistent with C-H_2 wagging mode, and 1176 cm^{-1} consistent with C-H_2 twisting mode; an absorption band at 1741 cm^{-1} corresponding to an ester carbonyl group; and an absorption at 1448 cm^{-1}, possibly carbonate. The comparison of the IR data of these two particles shows that IDP Chocha has a larger variety of organic compounds than Febo. This could be due to three possible reasons: one, given that the carbonaceous areas in Febo are smaller and less abundant than in Chocha, the detection limit and space resolution precluded resolving/identifing smaller peaks in Febo giving the impression that those peaks are absent. Alternatively, Chocha could very well be a sample with many more types of organic molecules present in its carbonaceous material than Febo, implying that the chemical processes that originated the organic compounds found in Chocha are different than the ones that manufactured the organics found in Febo. A third possibility could be that organic materials in the captured Wild 2 particles were partially destroyed/modified during collection.

We measured C, N and O with EELS and found O spatially related to C in most of the carbonaceous areas analyzed (data not shown), indicating that carbon is bonded to oxygen. This result confirms our previous findings of oxygen bonded to carbon obtained with XANES [2]. Both Chocha and Febo have peaks at ~285eV, indicating that some of the carbon in this carbonaceous materials is in the form C=C. We compared the 285 eV peak positions and noticed that in Febo it varies from 286.6 eV to 288 eV, whereas in Chocha the variations are wider and the values are smaller (from 285.2 eV to 287.5 eV). At present we don't understand the significance of these differences and what causes the variation in the position. Although it could be argued that the variation in positions is due to beam damage of the material, we performed EELS analyses with different acquisition times (data not shown) and we did not notice the peak position varying.

Conclusions. The comparison of the organic carbonaceous material in Febo and Chocha shows that: 1) texturally the material in both particles is identical, 2) oxygen is bonded to C in the carbonaceous material of both particles indicating that it is organic, 3) organic compounds show more variety in Chocha than Febo, and 4) the 285 eV peak positions are slightly different. Because the isotopic compositions previously measured in both particles are very similar and indicate a common origin, we suggest that the differences in the variety of the organic compounds is a parent body event. The parent bodies went through different processes that affected their organics or the chemical reactions that manufactured them.

References: [1] Sandford S. et al. (2006) *Science*, 314, 1720-1724. [2] Matrajt G. et al. (2008) *Meteoritics & Planet. Sci.*, 43, 315-334. [3] DeGregorio et al. (2010) *GCA*, 74, 4454-4470. [4] Matrajt G. et al. (2012) *Meteoritics & Planet. Sci* in press. [5] Matrajt G. and Brownlee D. (2006) *Meteoritics & Planet. Sci*, 41, 1715-1720.