COMET 81P/WILD-2 CARBON – AN EXTRAORDINARILY DIVERSE SUITE OF MATERIALS. Marc Fries[1] and Andrew Steele[2], [1]NASA Jet Propulsion Laboratory, 4800 Oak Grove Dr., Pasadena, CA 91109 marc.d.fries@jpl.nasa.gov, [2]Geophysical Laboratory, Carnegie Institution of Washington, 5252 Broad Branch Rd. NW, Washington, DC 20015.

Introduction: Raman spectroscopic analysis of particles of comet 81P/Wild-2 retrieved by the Stardust spacecraft reveals an extraordinary range of formation and/or alteration conditions for their carbonaceous components. Among reduced aromatic carbon-rich materials, examples of Stardust carbon span a wide range of structure ranging from very poorly ordered, soot-like solids all the way to crystalline graphite. Multiple examples exist of carbonaceous materials rich in aliphatic compounds as well. Collectively, this sample suite describes a very broad range of source gas mixtures and thermal condensation and/or alteration environments. The diversity of Stardust carbon tells a story of material transported to the 81P/Wild-2 parent body through extensive radial transport early in the formation of the Solar System much as the same conclusion can be reached by examining the broad range of Stardust silicate materials [1].

Methods: Raman imaging was utilized to locate and interrogate Stardust carbonaceous materials in ultramicrotomed thin sections using a WITec alpha-SNOM instrument with Raman imaging capability. Rastered images were collected using very little laser power (less than 0.030 mW total over a 360 nm diameter spot) such that entire Stardust particle sections were imaged. This amount of laser power is insufficient to produce high-S/N Raman images, but suffices to produce low-quality maps useful for finding candidate carbonaceous materials. Spots within the scans were analyzed using low power, long integration time measurements to produce high quality spectra. Individual spectra were interpreted and peak parameters recorded using peak fit routines in the Igor software package. Particular attention is paid to carbon G band parameters as a measure of carbon structure. The G band contains information about the mean crystalline domain size (G band position) and crystalline domain size distribution (G band FWHM), both of which in turn are products of a given carbonaceous material's formation temperature and subsequent thermal metamorphism. A plot of G band center vs. FWHM produces a distinct thermal metamorphism trendline as well as specific plot domains for graphitic, amorphous, and "non-graphitizable" carbon. This provides a simple, direct means of ascertaining the structure of carbonaceous materials and estimating their thermal history (see Figure 1). Aliphatic compounds are identified by their strong C-H Raman modes and characterized in terms of their structure by analysis of the position and FWHM of that suite of modes.

Results and Conclusions: Stardust samples exhibit an extraordinary range of structure and chemistry in their carbonaceous materials. As an example of poorly ordered material, particle F13B "Don" exhibits G band parameters consistent with material that has witnessed very little or no thermal alteration since its initial formation, which likewise occurred at low temperature. At the opposite extreme, particle C2092,7,81,1,4 includes crystalline graphite, attesting to thermal conditions in the 1000º C range either during formation or subsequent to it. Another particle, C2044,2,41,11,0, spans an extreme range of values that defies simple explanation.

A minor constituent of aliphatic carbon-rich material has also been noted on the basis of the appearance of C-H Raman stretch modes in some samples. Such aliphatic compound-rich materials have been described elsewhere and have been found to include wide variation in chemical and isotopic composition. [2,3] Considered in concert with the aromatic-rich carbonaceous materials present in Stardust samples, there must have been a broad range of chemical environments present during deposition and alteration to explain the breadth of carbonaceous material chemistry found in Stardust samples.

Analogue experiments using well characterized coal samples captured in aerogel at 6 km/s [4] suggest that capture in aerogel drives exposed carbonaceous material towards a specific region of the G band graph (Figure 1). Particle C3054,0,35,25,0 exhibits G band values in the same range, suggesting that this particle shows signs of alteration during capture. Overall, however, the suite of Stardust samples shows remarkably little in the way of capture alteration.

The wide range of structure and chemistry in Stardust samples is difficult to explain through parent body processes alone. It is, however, consistent with observations of Stardust silicates which reveal a very diverse range of source materials. Together, these two lines of evidence seen in silicate and carbonaceous materials show that the 81P/Wild-2 parent body was assembled from materials that were formed and processed in distinctly different portions of the protoplanetary disk than what can be expected of materials formed at present-day cometary orbits.

References: [1] Simon S., Joswiak D.,Ishii H., Bradley J., Chi M., Grossman L., Aleon J., Brownlee D., Fallon S., Hutcheon I., Matrajt G., McKeegan K. (2008) *MAPS* 43,11, p. 1861-1877. [2] Cody G., Ade H., Alexander C.M.O.D., Araki T.,Butterworth A., Fleckenstein H., Flynn G., Giles M., Jacobsen C., Kilcoyne A.L.D., Messenger K., Sandford S., Tyliszczak T., Westphal A., Wirick S., Yabuta H. (2008) *MAPS* 43, p. 353.365. [3] Matrajt G., et al (2008) *MAPS* 43, p.315.334. [4] Fries M., Burchell M., Kearsley A., Steele A., *MAPS* in press.

Figure 1 (Below): Plot of peak position and FWHM of the G band of carbonaceous materials. Increasing thermal maturity drives peak parameter position in this graph along the “Increasing Crystalline Order” trendline, with crystalline graphite present in a distinct portion of the graph shown here with a circle. Four different carbonaceous materials from Stardust samples are shown here. “F13B” occurs at the poorly-ordered end of the trendline. C2044,2,41,11,0 spans most of the entire range of the trendline. C3054,0,35,25,0 falls in a range of values consistent with capture alteration, and C2092,7,81,1,4 is crystalline graphite.