RAMAN SPECTROSCOPY APPLIED TO METEORITE PYROLYSATES: A STUDY OF THE MURCHISON CARBONACEOUS CHONDRITE. D. K. Muirhead[1], J. Parnell[1] and M. A. Sephton[2], [1]Dept. of Geology and Petroleum Geology, University of Aberdeen, Aberdeen AB24 3UE, U.K., (d.muirhead@abdn.ac.uk). [2]Dept. of Earth Science and Engineering, Imperial College London, London SW7 2AZ, U.K.

Introduction: The Murchison meteorite is a CM2 carbonaceous chondrite which fell in Australia in 1969 and has subsequently provided much of the current understanding of meteoritic organic matter (OM). The high molecular weight macromolecular insoluble organic matter (IOM) that comprises the majority of Murchison's organic material, has been characterised using various pyrolysis methods [1, 2 and refs therein]. These analyses have provided a greater understanding of the aromatic compounds present within the Murchison IOM. Consequently, the synthesis of organic compounds through abiotic processes in extra-terrestrial environments is now better understood.

Raman spectroscopy is an important analytical technique in meteoritic studies and has been used to characterise carbonaceous matter with respect to distinct populations [3] and for mapping out the location of OM within any given sample [4]. The technique has also been applied to the characterisation of the organic material captured as part of the Stardust project [5], which indicated clear differences between the Stardust samples, meteorites and interplanetary dust particles (IDPs).

Analytical procedure: Samples were subjected to differing types of pyrolysis: HF/HCl (hydrofluoric/hydrochloric acid) treated anhydrous pyrolysis at 150ºC, HF/HCl treated anhydrous pyrolysis at 310ºC, HF/HCl treated hydrous pyrolysis at 320ºC, and whole rock hydropyrolysis at 520ºC. Detailed descriptions of these analyses are reported at [1, 2].The purpose of this current work is to characterise any structural changes that may have occurred in the carbonaceous matter through the different pyrolysis regimes. Each pyrolysate was analysed using a Renishaw in-Via Raman microscope, using a green argon laser with wavelength ~514.5nm. Spectra were analysed using the Renishaw WiRE software with deconvolution carried out ~5 times per spectrum to ensure reproducibility of results. Plotting the G band position with respect to the G band full width at half maximum (FWHM) can be used to indicate the degree of structural order within a sample, where the G band approaches ~1580 cm^{-1} and the FWHM becomes narrower.

Results and Discussion: Raman spectra are presented in Fig. 1, indicating subtle changes between each sample. The cross-plot of the G band position and FWHM (Fig. 2) shows a clear trend from the anhydrous pyrolysis to the hydrous and hydropyrolysis samples indicating an increase in the structural order of the carbonaceous matter. This trend matches the expected changes from kerogenous carbonaceous matter towards graphitic carbonaceous matter as outlined in [6]. The spread in the data is less extensive towards the higher temperature pyrolysis, which is shown more clearly in Fig. 3. This suggests that the heterogeneity of the kerogenous material is decreasing at higher temperatures, leaving the refractory component dominated by at least five- or six-ring PAH units cross-linked together [2]. This would give a stronger Raman signature with increased structural order. The added pressures in the hydropyrolysis may also have contributed to the increase in order of the carbonaceous material.

These are preliminary findings and further work is needed to characterize the changes observed. The application of Raman spectroscopy to meteoritic samples is a valuable analytical technique that should help us understand the subtle yet significant changes that occur within the aromatic structures of carbonaceous material. This may also have implications for the study of OM in Stardust particles, meteorites and IDPs and allow a greater understanding of the occurrence and formation of organic matter in extra-terrestrial samples.

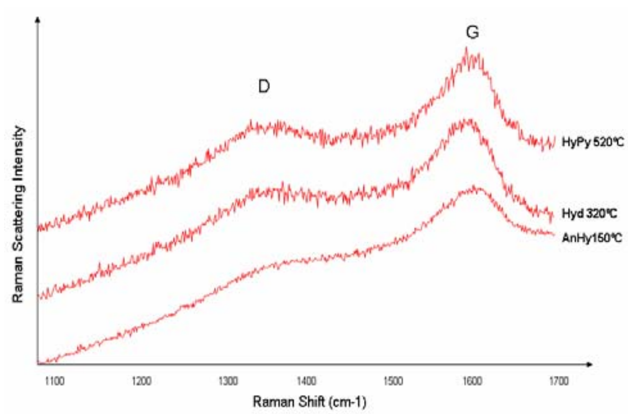

Figure 1. Raman spectra of three of the four pyrolysis samples studied (HF/HCl anhydrous pyrolysis at 310ºC not shown) showing the changes in structural order due to increasing temperature. The subtle narrowing of the G peak FWHM can be seen more clearly in Figs. 2 & 3.

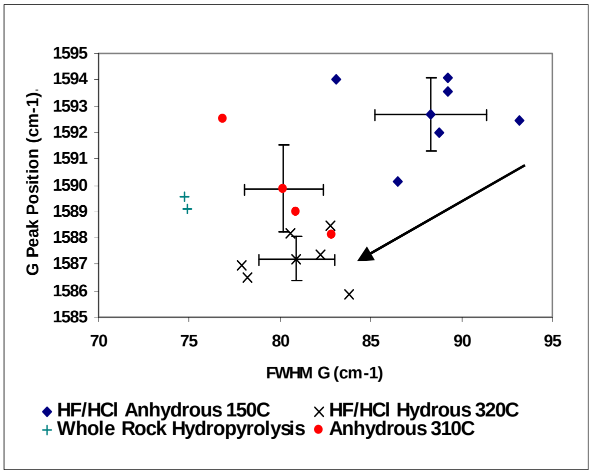

Figure 2. Plot of G peak position against G FWHM, showing the clear trend (indicated by arrow) of increasing structural order with respect to the increasing pyrolysis temperatures. Error bars for 1σ shown for mean value of each population, except hydropyrolysis as error bar smaller than symbol shown.

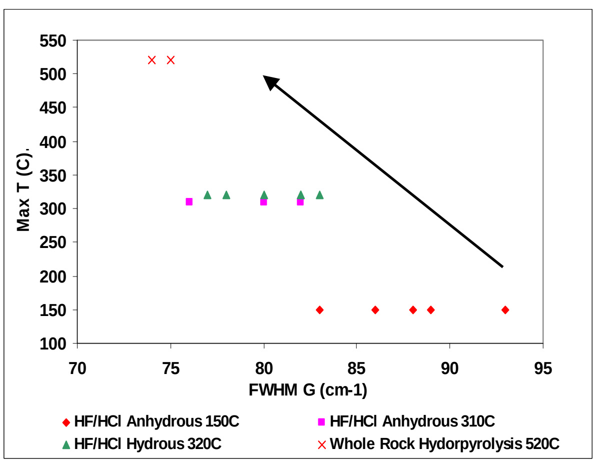

Figure 3. The linear change (indicated by arrow) of the G band FWHM with respect to the maximum temperatures of the pyrolysis regimes. Note also the narrowing spread of data.

Acknowledgement: DKM is in receipt of an EPSRC studentship. Use of the Raman Spectrometer kindly provided by the Dept. of Chemistry, University of Aberdeen and funded by the BBSRC.

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