RAMAN CHARACTERIZATION OF THERMALLY ALTERED CARBON AND IMPLICATIONS FOR THE EVOLUTION OF UREILITE CARBON. A A. J. Wright[1] and J. Parnell[1], [1]Dept. of Geology, University of Aberdeen, Aberdeen AB24 3UE, U.K., (a.j.wright00@aberdeen.ac.uk).

Thermally altered carbon: Carbon is a fundamental component of many terrestrial rocks and meteorites. Its structural order can be used as a proxy for the degree of thermal alteration experienced by carbonaceous material; Raman micro-spectroscopy is routinely used for this analysis [1-3]. This study examined carbon in terrestrial samples and in 3 CCs and 12 ureilites to determine whether the range of compositions exhibited by terrestrial organic matter (OM) is comparable to that of meteoritic OM and if inferred trends of evolution with thermal alteration are comparable. The results were used to enhance understanding of the processes affecting extraterrestrial samples and specifically to determine if a relationship between the classes of meteorite studied is supported by feasible trends in the evolution of OM.

Samples: Terrestrial samples were chosen to reflect a range of thermal histories in which carbonaceous material had been severely heated either through progressive metamorphism due to regional P/T gradients (e.g. Proterozoic lithologies from Scotland and Canada) or by heating on a geologically instantaneous timescale, due to meteorite impact or igneous intrusion (e.g. impactites from the Sudbury Impact Structure, Canada; vesiculated vein material mobilized from Jurassic rocks in NW Scotland by Paleogene intrusions). In extreme examples, carbon underwent melting (e.g. sedimentary lithologies from Disko Island, West Greenland, assimilated into Paleogene lavas, and bitumen incorporated into Permo-Carboniferous dykes from central Scotland. The CCs analyzed in this study were 2 CV3 meteorites (ALH85006 and MET01080) and an ungrouped CR/CV chondrite (Sahara 00182).

Methodology: Measurements were performed on unpolished chips or on standard polished thin sections using a Renishaw inVia Reflex Raman spectrometer. A research-grade Leica reflected light microscope was used to focus an Ar^+ green laser with a wavelength of 514.5 nm. The spot size used was typically 1-2 µm in diameter and data were collected over a wavenumber shift of 1100–1700 cm^{-1}. WiRE curve-fit software was used to determine peak position and peak width at half maximum (FWHM) for the G-peak (generally occurring between 1582 cm^{-1}[4] and 1575 cm^{-1}[5]) and the additional spectral bands detected around 1355 cm^{-1} (D1) and 1620 cm^{-1} (D2), indicative of increased disorder in the carbonaceous structure [6]. Full width at half-maximum (FWHM) values also provide a useful correlation to the degree of structural order as the most organized material has the narrowest values [7].

Results: *Terrestrial samples:* carbon ranged from graphite to highly disordered carbon (Fig. 1); both phases were only found together in impactites from Sudbury, Canada (where the heterogeneity reflected the different components of the rock) or in igneous rocks (e.g. dolerite from Binny Craig, central Scotland; basalt from Disko Island, West Greenland). These data showed highly variable G-peak parameters and heterogeneity occurred at the µm scale. Heated material also showed a wide range of values, (e.g. Jurassic rocks from Torr Mor, NW Scotland). Less pronounced in-sample variation was observed in structurally disordered carbon but also occurred at the µm scale (e.g. altered bitumen from La Salvada, Argentina); metasedimentary units (Stoer and Durness Group rocks from NW Scotland); and in impactites from the Ries crater. Variation in bituminous carbon is also evident in plots of G-peak position against G-peak width; many of these samples plot along lines of negative slope, as discussed below.

Extraterrestrial samples: carbon in the meteorites showed a broadly similar distribution the terrestrial rocks (Fig. 1). Graphite was the dominant phase in all the ureilites studied but was intimately mixed with amorphous carbon on a µm scale. Diamond was identified in 9 of the ureilites; some spectra showed both graphite and diamond peaks indicating that these phases were in close proximity.

The CV3s contained disordered carbon only whereas Sahara 00182 contained material similar to the ureilites, including diamond. The same relationship between G-peak parameters occurred in the CV3 chondrites; these data points correlated with statistical significance (R^2 = 0.90) with some of the terrestrial data sets above. Fries et al. [8] interpret this as an increasing metamorphic trend in carbonaceous meteorites, although other authors use different Raman parameters to predict metamorphic grade [9-11].

Implications for ureilite carbon: The results show that thermal alteration of OM produces similar inferred evolutionary trends in both data sets, such that graphitic material in ureilites can be derived from structurally disordered carbon in CV3s. The occurrence of heterogeneous carbon in terrestrial igneous rocks shows that igneous processes do not result in the homogenization of carbonaceous material during melting, even at high temperatures. This suggests that the precursor to the

UPB may have been an already thermally metamorphosed CC, similar to Sahara 00182, making it highly probable that the ureilites contain a primary carbonaceous phase. The similarity with terrestrial carbon remobilized by impact events or by heating suggests that a significant secondary carbonaceous phase is also present, consistent with at least 1 impact event [12-13]. This study confirmed that carbon is an important tracer in both terrestrial and extraterrestrial processes.

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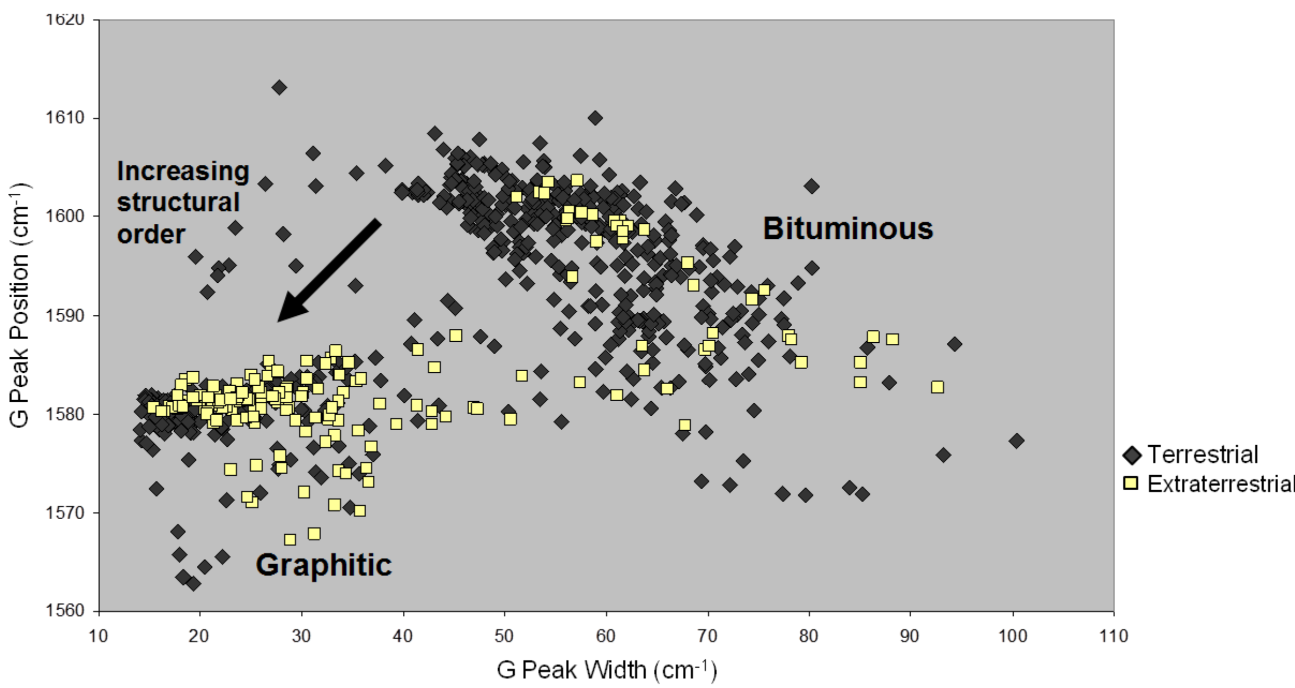

Fig. 1. Crossplot showing G-peak position against G-peak FWHM for a range of terrestrial samples and for 15 extraterrestrial samples (3 CCs and 12 ureilites). (terrestrial n = 639; extraterrestrial n = 189).