EVIDENCE FOR SHOCK INDUCED DIAMONDS IN UREILITE METEORITE MILLER RANGE 090980

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Introduction: Ureilites are primitive achondrites that contain a high concentration of carbon (up to 8.5 wt% [1]). The carbon contained within ureilites is in the form of graphite and diamond [1-3]. The origin of the diamonds is debated with a shock origin [2], high pressure static growth similar to Earth's mantle [3], and chemical vapour deposition (CVD) from the Solar Nebula [4] all being proposed. The shock origin theory suggests that graphite is the original form of carbon, which then gets transformed into diamond through a high pressure phase transformation driven by an impact, and catalysed by the presence of (Fe,Ni,Co)-C liquids, now present as spherule inclusions in ureilite silicate minerals [1-2]. Static high pressure growth involes diamond formation within a large parent body to maintain high pressures for a long enough period of time to allow for large diamonds to grow [3]. CVD is a theory where diamonds directly crystallise out of the Solar Nebula through chemical reactions involving H_2CH_4 [1, 4]. Diamonds formed in different environments produce distinct peak shapes in Raman spectra. Here we investigated the diamond structure within ureilite meteorite Miller Range 090980 (MIL 090980) using Raman Spectroscopy, to determine their origin.

Methods: Scanning electron microscopy-energy dispersive X-ray spectroscopy (SEM-EDS) was used to map MIL 090980 and identify carbon-rich regions. Raman Spectroscopy was conducted on a C-rich region in MIL 090980 using a Renishaw InVia Raman microscope attached to a 45W (max power), 512 nm laser source and a 2400 mm grating. Analysis carried out using a laser power of 5% with 3 second exposure time. All analysis were conducted at the University of Glasgow ISAAC facility.

Results: Figure 1 shows a plot of the measured diamonds Raman shift vs the Full Width Half Maximum (FWHM) values. Raman shift is the difference between the ground state of a molecule and the final state post excitation from the laser beam defined by the peak centre [5]. FWHM refers to the width of the Raman peak at half of the maximum intensity. The FWHM and Raman shift of diamonds in MIL 090980 shows wide spread of values (Fig. 1). FWHM range from 1.3 to 53.4 centrered at 6.9 (Fig. 1). The raman shift values range from 1319.9-1335.3 cm^{-1} centered at 1332.0 cm^{-1} (Fig. 1).

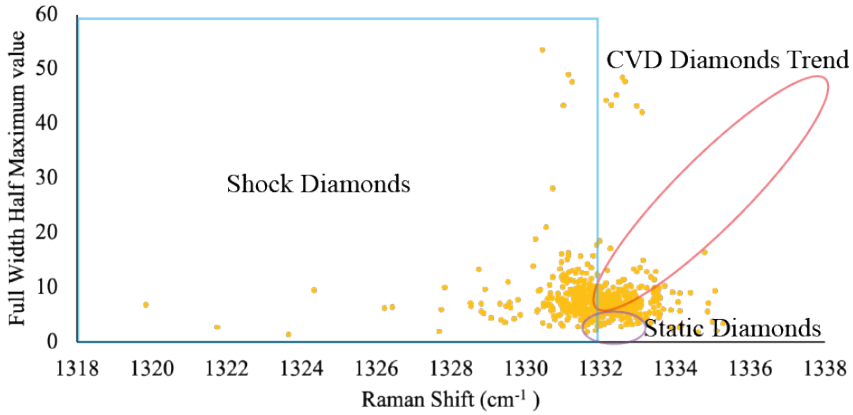

Figure 1: Plot showing the Full Width Half Maximum value vs the Raman shift for diamonds within ureilite MIL 090980 (orange points). Ranges of data from experiments including shock diamonds (blue line), CVD diamonds (red line) and static diamonds (purple line) are overlain. Experimental data is from [6].

Discussion: The Raman FWHM and Raman shift for diamonds in MIL 090980 were compared with experimental data for laboratory produced shock diamonds, CVD diamonds, high static pressure diamonds and ureilite diamonds previously published [6]. Raman spectra for experimentally shocked diamonds show a trend towards lower Raman shifts (Min: 1315 cm^{-1} [6]). Experimental CVD diamonds trend towards higher Raman shifts (1340 cm^{-1} [6]), with a correlation between higher Raman shift and higher FWHM values [6] (Fig. 1) . Raman data from high static pressure diamonds plot in a small area of 1332 to 1333 cm^{-1} with a FWHM value below 5 [6](Fig 1). This new data from MIL 090980 shows a cluster of measurements centered around a Raman shift of 1332 cm^{-1} with some scattering down towards 1320 cm^{-1} but no data points plot above 1335.3 cm^{-1}. This indicates that the diamonds within MIL 090980 are more consistent with shock diamonds than CVD diamonds. While some MIL 090980 data do plot in the region consistent with high static pressure growth the large spread of data points around this region indicates that a shock origin for these diamonds is the dominant mechanism for diamond formation in this ureilite.

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Acknowledgements: We thank the Smithsonian Institution for loaning the sample used in this study.