MICRO RAMAN SPECTROSCOPIC INVESTIGATIONS OF THE NATURE AND PROVENANCE OF MINERAL AND CARBONACEOUS MATERIAL IN THE 1.9 GUNFLINT FORMATION: REDEFINING D AND G CARBON PARAMETERS FOR THE DETECTION OF BIOSIGNATURES. D. M. Bower¹, A. Steele¹ and L. Kater², ¹Geophysical Laboratory, Carnegie Institution of Washington, 5251 Broad Branch Rd, NW, Washington, DC, 20015, dbower@ciw.edu, a Steele@ciw.edu, ²WiTech-ULM, Germany.

Introduction: The identification of biosignatures and detection of extra-planetary life is one of the primary goals in astrobiology. Intrinsic to this goal is the improvement of analytical techniques and protocols used to identify biosignatures. Micro Raman spectroscopy is a non-destructive method that allows for in situ analysis of samples and unambiguous identification of a wide range of minerals and compounds. Carbonaceous compounds specifically have been used as biosignatures in ancient rocks. Problems arise, however, because carbonaceous compounds from different sources often share the same spectroscopic characteristics [1,2,8]. To tease out a biogenic signal, young samples of known provenance are typically analyzed and used as a baseline for comparison to much older samples or samples that have experienced extreme temperatures and pressures. To this ends we used the high-resolution imaging and geochemical mapping capabilities of micro Raman spectroscopy on chert samples from the ~1.9 Ga Gunflint Formation as a preliminary investigation into the nature and provenance of the mineral and carbonaceous material. The wide array of morphological microstructures, carbonaceous components, and mineral assemblages in the Gunflint samples provide the perfect testing ground for these techniques [3,4]. To further constrain D and G band carbon characteristics, micro Raman analyses were also performed on a suite of chert samples and meteorite samples. The spectral features of each sample set were quantified and compared. The results give much needed information for biosignature identification in these and other biologically significant rocks.

Method: Raman spectra of the samples were collected using a WITEC Digital Pulse scanning near-field optical microscope (AlphaSNOM) with Scan Control Spectroscopy Plus. The Raman scans were conducted with a a frequency-doubled YAG laser with wavelength 532nm. The laser was focused through a 25µm diameter fiber and a 100x ocular lens. The scan speed was 3-5s dwell time per pixel at 78 kW cm⁻². Images and virtual maps of the spatial elemental and mineral composition of the microtextures were generated using Witec Project 1.99 software. The collected spectra were deconvoluted and quantified using ACD Labs 12 software.

Results: The Gunflint samples used in this study do not contain any obvious microfossils in the morphologic sense. There are however many areas that contain what appears to be dark, carbon-rich matter. The chemical maps show that the carbon in these samples mainly occurs within the grain boundaries of the chert, rather than having a specific association with a microfossil-like feature. The D and G band spectral characteristics are similar to those that are associated specifically with microfossils in other samples (Fig 1). Disordered carbon D bands are typically centered at 1334 cm⁻¹ and graphitic G bands are centered at 1600 cm⁻¹. There are also minor sulfides present in association with the carbon. These spatial relationships are shown in figure 2.

Conclusions: The unique mapping capabilities of micro Raman spectroscopy provide a greater view of the spatial relationships between carbonaceous materials and other features in ancient rocks. The D and G band spectral characteristics of the carbonaceous mate-
rial found in biologically associated structures are interestingly similar to those of either questionable or abiologic origin. Only by fully exploring the spatial relationships and spectral characteristics will the establishment of biosignatures for life detection in ancient rocks on Earth and those on other planets be made.

Figure 2: Sum color map showing the spatial relationship of G band carbon (red) within chert (blue) grain boundaries.

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