**Introduction:** Hydrothermal ore deposits are formed by the precipitation of sulfide minerals from hot aqueous solutions in void spaces, or by the migration through and replacement of rock. The occurrence of $sp^2$ hybridized carbonaceous material of various degrees of structural organization in hydrothermal ore deposits is widespread. However little work has been done to understand the association of $sp^2$ hybridized carbonaceous material with sulfide minerals in hydrothermal ore deposits. In this study, we explore the potential of Raman spectroscopy of $sp^2$ hybridized carbonaceous materials as a geothermometer to shed light on the temperature of ore-forming fluids for the formation of the McArthur River Pb-Zn-Ag orebody.

**McArthur River Pb-Zn-Ag mine:** The 1640 Ma giant Hyc (a contraction of the expression, “Here’s your chance”) ore deposit at McArthur River, Northern Territory, Australia, is one of the largest stratiform Pb-Zn-Ag deposits in the world. For several decades, a key source of information on the physical and chemical conditions of hydrothermal ore formation has been the analysis of fluid inclusions trapped during mineralization through and replacement of rock. The occurrence of sulfide minerals in hydrothermal ore deposits is widespread. However little work has been done to understand the association of $sp^2$ hybridized carbonaceous material with sulfide minerals in hydrothermal ore deposits. In this study, we explore the potential of Raman spectroscopy of $sp^2$ hybridized carbonaceous materials as a geothermometer to shed light on the temperature of ore-forming fluids for the formation of the McArthur River Pb-Zn-Ag orebody.

**Results and Discussion:** A representative carbon first-order spectrum in the range 1000-1800 cm$^{-1}$ is presented in Figure 1. In order to improve accuracy in the determination of spectroscopic parameters such as band position, bandwidth, line-shape (that is, Gaussian, Lorentzian or a mixture of both) and band intensity, curve fitting was performed for each spectrum. Figure 1 shows that five bands can be resolved into Gaussian-Lorentzian bands, D2 (disordered lattice $E_2g$ mode ca. 1615 cm$^{-1}$, G (assigned to a doubly degenerate in-plane C-C stretching mode with $E_{2g}$ symmetry) ca. 1598 cm$^{-1}$, D3 (amorphous $sp^2$ carbon) ca. 1545 cm$^{-1}$, D1 (a totally symmetric mode that becomes Raman-allowed when defects are introduced to the lattice or decreasing dimension of crystallites occurs with $A_{1g}$ symmetry) ca. 1345 cm$^{-1}$, and D4 ($sp^3$ bonds or C-C and C=C stretching vibrations of polyene-like structures) ca. 1215 cm$^{-1}$.

There is an overall trend throughout the orebody, which is demonstrated by a diminution in $G_{\text{ul}/2}$ from 64.3 to 46.9 cm$^{-1}$ from spectra acquired from the hot zone to the cooler zone. The reduction of the $G_{\text{ul}/2}$ results from increasing structural order in the solid carbon $sp^2$ hybridized network as a consequence of increasing thermal alteration. Previous studies of $G_{\text{ul}/2}$ reduction of Raman spectra of coals and kerogens [6] have observed that the $G_{\text{ul}/2}$ can be correlated to vitrinite reflectance measurements ($\%R_m$). According to previous studies, these $G_{\text{ul}/2}$ values can be interpreted to correspond to a range of $R_m$ from 1.3-2.0 % which correlates to a paleotemperature range [6] of 120-180°C.

More recently, a proxy to determine thermal alteration of diagenetic to low grade metamorphic (100-300°C) materials derived from R1 and R2 parameters from carbon first-order spectra has been proposed [5]. Where R1 is ratio of the D1/G bands, and R2 is the ratio of the D1/(G+D1+D2) bands. The following equation was derived and is used here:

$$T(°C) = 737.3 + 320.9 \ R1 – 1067 \ R2 - 80.638 \ R1^2$$

Applying this low metamorphic grade proxy to the three isolated carbonaceous material samples from the hot through to the cool zone of the 2 orebody a temperature estimate can be calculated in the range of 274 – 170°C. Both methods of temperature estimates are in agreement with those temperature delineated from [2,3].
which suggest that the mineralizing brines were moderately hot (150-250°C), oxidizing (sulfate>sulfide), and rich in metals.

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