CHARACTERIZATION OF ORGANIC MATERIALS IN THE XENOLITHIC CLASTS IN SHARPS (H3.4) METEORITE USING MICRORAMAN SPECTROSCOPY.

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Introduction: Graphitization of carbon is an irreversible process which alters the structure of graphitic materials in response to the increase in metamorphic grade (temperature and/or pressure). Carbonaceous materials offer a reliable geothermometer as their Raman spectra change systematically with increasing metamorphic grade [1-3]. In this study, we identified carbonaceous materials in the xenolithic clasts in Sharps and interpreted their metamorphic history by revealing the structural organization (order) of the polyaromatic organic phases using μ-Raman spectroscopy.

Analytical methods: We analyzed the xenolithic clasts in Sharps (hereafter, Sharps) using a Jobin-Yvon Horiba LabRam HR (800 mm) μ-Raman spectrometer at the Department of Geosciences, Virginia Tech. The peaks were determined by simultaneous peak fitting to five Lorentzian profiles (one G and four D bands) and linear baseline correction accomplished using a custom software written in the Python programming language.

Results and Discussion:

Metamorphic grade. Our initial visual examination of the overall shape of the Raman spectra indicates that Sharps has been metamorphosed up to greenschist grade at around 330 °C. With increasing metamorphic grade, the intensity of the D1 band decreases relative to the G band, while the full width at half-maximum of the D and G bands ($D1_{FWHM}$ and G_{FWHM}) also decrease [4, 5]. The high relative D1 intensity and the broad G (G_{FWHM} ~62 cm^{-1}) and D1 ($D1_{FWHM}$ ~148 cm^{-1}) bands of Sharps indicate that the meteorite has only experienced low metamorphic temperature. The presence of the D3 band in the first-order region and the two broad S1 and S2 bands in the second-order region (2700 cm^{-1} and 2900 cm^{-1}) attest that Sharps was not heated above 400 °C.

We have also obtained the peak intensities I_D and I_G, integrated intensities (A_D, A_G), D1/G peak intensity ratio (I_{D1}/I_{DG}, i.e. peak height) (**R1 ratio**), and $A_{D1}/(A_G + A_{D1} + A_{D2})$ peak area ratio (**R2 ratio**). Generally, the R1 ratio of meteorites is ≥1 and increases with maturation grade [3, 6]. In this regard, CO3 Kainsaz offers a good dividing line because it exhibits an intermediate maturation, and its R1 ratio and D_{FWHM} are ~1.1 and ~120 cm^{-1}, respectively [3]. The R1 ratio and $D1_{FWHM}$ of Sharps are 1.23 and 124.08 cm^{-1}. In order to make comparison to the literature, we have also estimated the R1 ratio and $D1_{FWHM}$ using a 2 Lorentzian bands model, which gave 0.95 and 166.99 cm^{-1} for R1 ratio and D_{FWHM}, and indicates that Sharps exhibits a lower metamorphic grade than Kainsaz. The R1 ratio of Sharps is comparable to the values (1.3–2.1) obtained for low metamorphic grade metasediments in the chlorite zone [1]. The R2 ratio of Sharps is around 0.7. We used the equation from Beyssac et al. [1] which describes a linear correlation between R2 ratio and peak temperature, and obtained a peak metamorphic temperature of 330 °C for Sharps.

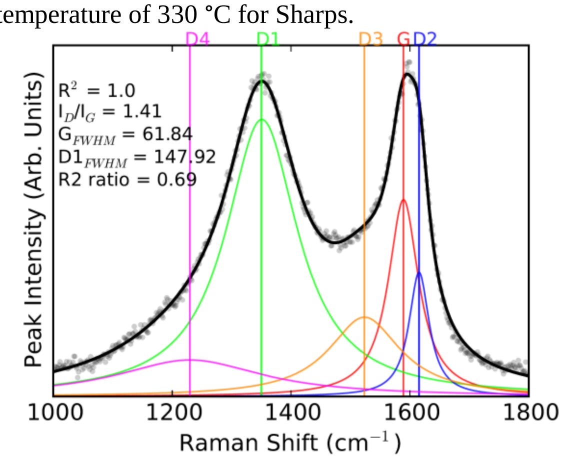

Figure 1. Peak decomposition of the first-order region of Sharps. (●): Background-corrected data. Black solid line: Peak-fitting result.

Organic composition. While the G band corresponds to stretching in both carbon rings and chains, the D band is caused by the breathing modes in rings and thus corresponds to aromatic structures [7, 8]. The μ-Raman spectra of the Sharps clast show a significant D band contribution, which indicates the presence of aromatic carbonaceous materials.

Conclusion: μ-Raman spectroscopy reveals that the xenolithic clasts in Sharps have been exposed to low metamorphic grade with peak temperature at 330 °C. The organic content of the clasts is composed of predominantly aromatic carbonaceous materials.

References: [1] Beyssac O. *et al.* (2002) *JMG, 20,* 859-871. [2] Kouketsu Y. *et al.* (2014) *Island Arc, 23,* 33-50. [3] Bonal L. *et al.* (2007) *GCA, 71,* 1605-1623. [4] Busemann H. *et al.* (2007) *MAPS, 42,* 1387-1416. [5] Buseck P.R. and Beyssac O. (2014) *Elements, 10,* 421-426. [6] Bonal L. *et al.* (2006) *GCA, 70,* 1849-1863. [7] Ferrari A.C. and Robertson J. (2004) *Phil Trans Math Phys Eng Sci, 362,* 2477-2512. [8] Castiglioni C. *et al.* (2004) *Phil Trans Math Phys Eng Sci, 362,* 2425-2459.