EFFECTS OF SHORT-TERM THERMAL ALTERATION ON ORGANIC MATTER IN EXPERIMENTALLY-HEATED TAGISH LAKE OBSERVED BY RAMAN SPECTROSCOPY

Q. H. S. Chan[1], A. Nakato[2], M. E. Zolensky[1], T. Nakamura[3], and Y. Kebukawa[4], [1]ARES, NASA Johnson Space Center, Houston, TX 77058, USA (hschan@nasa.gov), [2]JAXA, Kanagawa 252-5210, Japan, [3]Tohoku University, Miyagi 980-8578, Japan, [4]Faculty of Engineering, Yokohama National University, Yokohama, Japan.

Introduction: Carbonaceous chondrites exhibit a wide range of aqueous and thermal alteration characteristics. Examples of the thermally metamorphosed carbonaceous chondrites (TMCCs) include the C2-ung/CM2TIVs Belgica (B)-7904 and Yamato (Y) 86720. The alteration extent is the most complete in these meteorites and thus they are considered typical end-members of TMCCs exhibiting complete dehydration of matrix phyllosilicates [1, 2]. The estimated heating conditions are 10 to 10^3 days at 700℃ to 1 to 100 hours at 890℃, i.e. short-term heating induced by impact and/or solar radiation [3]. The chemical and bulk oxygen isotopic compositions of the matrix of the carbonate (CO_3)-poor lithology of the Tagish Lake (hereafter Tag) meteorite bears similarities to these TMCCs [4]. We investigated the experimentally-heated Tag with the use of Raman spectroscopy to understand how short-term heating affects the maturity of insoluble organic matter (IOM) in aqueously altered meteorites.

Analytical methods: The CO_3-poor lithology of Tag (#11) was located with X-ray computed tomography at the University of Texas. Subsamples (~100 mg) of the CO_3-poor lithology were subjected to heating experiments: (1) 600℃/1h, (2) 600℃/96h, (3) 900℃/1h, and (4) 900℃/96h. The samples were studied with Raman spectroscopy at NASA JSC using a Jobin-Yvon Horiba LabRam HR Raman microprobe. At least 12 spectra were collected on each raw matrix grain (flattened between two glass slides) with 514 mm excitation wavelength and a spot size of ~1 µm. The laser power at the sample surface was ≤450 µW and the total acquisition time was 450s. The peak parameters were determined by peak fitting to Lorentzian and Breit–Wigner–Fano profiles [5] and linear baseline correction.

Results and Discussion: The Raman parameters of the unheated Tag vary from previous studies [6, 7], probably due to different analytical methods, peak fitting algorithm, and/or sample heterogeneity due to the brecciated nature of Tag which contains two other major lithologies: CO_3-rich lithology and foreign clasts [8]. Nevertheless, the Raman parameters of the three adjacent unheated subsamples of the CO_3-poor lithology are comparable, indicating that the organic content is consistent within this lithology.

Heating experiment. A reduction in the intensity of the fluorescence background was observed after the samples were subjected to heating. A similar effect of heating on the fluorescence background has been observed for the thermally-altered CMs [e.g., 7]. The D band parameters show a clear correlation to the heating temperature, however heating duration does not appear to induce much change. Decreases in the fluorescence intensity and the D band full-width half-maximum (Γ) indicate that the IOM gains maturity through thermal annealing by losing hydrogen and heteroatoms to form polyaromatic structures such as hydrogenated amorphous carbons (α-C:H). The D peak center (ω_D) and Γ_D of the heated (≥700°C) Y-86720 are ~1349 and ~245 cm^{-1} respectively [6], which is placed between the 600℃ and 900℃ experiments on the ω_D *vs* Γ_D plot (Figure 1). Our experimental data also indicate that with increasing temperature (with short heating duration), the Γ_G first increases and then falls. However, the G band parameters show only negligible variation between the unheated Tag and the heated Y-86720 [6], which indicates that the G band is more sensitive to short-term heating. The IOM maturation grade strongly depends on the time/temperature history, although heating effects are rapid as the difference between the 1h and 96h experiments is insignificant.

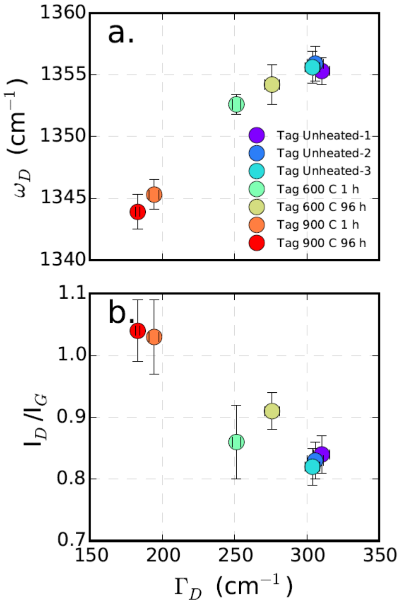

Figure 1. Raman spectral parameters.

Conclusions: We studied the experimentally-heated Tag with Raman spectroscopy. ω_D and Γ_D decrease with increasing temperature; Γ_G first increases and then falls. Despite the chemical similarities between Tag and the Belgica-like meteorites and the comparability of their D band parameters, a variation in G band parameters was only observed for the experimentally-heated (short-term) Tag but not the naturally metamorphosed Y-86720, which suggest that the IOM maturity and graphitization is time dependent.

References: [1] Nakamura T. 2005. *Journal of Mineralogical and Petrological Sciences* 100:260-272. [2] Tonui E. *et al.* 2014. *Geochimica et Cosmochimica Acta* 126:284-306. [3] Nakato A. *et al.* 2008. *Earth, Planets and Space* 60:855-864. [4] Nakato A. *et al.* 2016. *Lunar and Planetary Science Conference*. [5] Ferrari A.C. and Robertson J. 2000. *Physical Review B* 61:14095-14107. [6] Busemann H. *et al.* 2007. *Meteoritics & Planetary Science* 42:1387-1416. [7] Quirico E. *et al.* 2014. *Geochimica et Cosmochimica Acta* 136:80-99. [8] Zolensky M.E. *et al.* 2002. *Meteoritics & Planetary Science* 37:737-761.