R Raman Spectroscopy and Petrology of Antarctic CR chondrites: Comparison with other carbonaceous chondrites.

M. Komatsu[1,2*], T. J. Fagan[2], A. Yamaguchi[3], T. Mikouchi[4], M. E. Zolensky[4], and M. Yasutake[3]. [1]Graduate University for Advanced Studies, SOKENDAI, [2]Dept. Earth Sci., Waseda University, [3]National Institute of Polar Research, [3]Dept. Earth Planet. Sci., University of Tokyo, [4]NASA Johnson Space Center, USA. (*komatsu_mutsumi@soken.ac.jp)

Introduction:

In Renazzo-like carbonaceous (CR) chondrites, abundant original Fe,Ni-metal is preserved in chondrules, but the matrix is characterized by fine-grained magnetite with phyllosilicate [1,2,3]. This combination of reduced Fe in chondrules with oxidized Fe and phyllosilicate in the matrix has been attributed to aqueous alteration of matrix at relatively low temperatures [1,3].

In this study, we use Raman spectroscopy of matrix and petrology of amoeboid olivine aggregates to evaluate secondary alteration processes in a set of CR chondrites. Raman spectra from organic matter in chondrites can be used as indicators of metamorphic temperature [4,5], and AOAs are sensitive to fluid-assisted metamorphism [6,7]. Our results indicate minimal thermal metamorphic effects, particularly in comparison to metamorphism of the CV3 Allende.

Methods:

Polished thin sections of CR chondrites A-881828, Y-791498, and Y-982495, and ungrouped C3 chondrite A-881595 are studied in this project. A-811595 was originally classified as a CR chondrite [8], but reclassification as an ungrouped C3 has been suggested [9,10]. Nonetheless, we include A-881595 in this study. In addition to the CRs, some CO and CV chondrites were studied for comparison.

Imaging, mineral identification and EDS analyses were performed using a JEOL JSM-7100F FE-SEM at National Institute of Polar Research (NIPR), and Hitachi S-4500 SEM at University of Tokyo. Raman spectra were collected using a JASCO Raman Spectrometer at NIPR. Analytical parameters are similar to those in [5].

Results and Discussion:

Raman spectra of polished thin sections

The main traces of thermal maturity of organic matter in chondrites are: (1) width of the D-band (band associated with defects; full-width at half peak maximum = FWHM-D) and (2) ratio of peak intensities of the D-band vs. G-band (associated with graphite) = I_d/I_g. With increasing thermal maturity, FWHM-D decreases and Id/Ig increases [4]. [5] use these parameters to show variations in metamorphic grade in the CV3 chondrites, with Efremovka near 3.1-3.4 and Allende ≥ 3.6. Their study is based on raw samples, whereas our work is based on spectra from PTS. In our previous work [11], we showed that our spectra from Efremovka and Allende PTS yielded parameters similar to the results of [5], indicating that reliable OM maturity can be also obtained from PTS.

Raman spectra were collected on randomly selected matrix areas. Raman spectra from CR chondrites in this study exhibit first-order carbon D- and G-bands, at ~1350cm^{-1} and ~1600 cm^{-1} respectively (Fig. 1). They appear similar to those of Y-81020 (CO3.05) and Y-980145(CV, unclassified petrologic subtype). They are distinct from Allende CV3, which experienced aqueous and thermal alteration (CV>3.6).

[5] showed that I_d/I_g increases in petrologic types 3.0 to 3.7, consistent with our results from CO and CV chondrites (Fig. 1). The spectra collected for this study from CR chondrites, all show relatively low I_d/I_g, suggesting low thermal maturity, particularly in comparison with Allende (Fig. 1).

Petrology of AOAs in Antarctic CR chondrites

AOAs in CR chondrites in this study are less abundant than CV and CO chondrites; a few AOAs are found in each thin section. AOAs in the CR chondrites are composed of forsterite, Al-diopside, anorthite, spinel, Fe,Ni-metal and FeS (Fig. 2a-d). As described in previous studies [3, 12, 13], they do not contain secondary nepheline or fayalitic olivine. In A-881595, some anorthite is replaced by Mg,Al-silicates (Fig.2h), that are similar to phyllosilicates in AOAs in aqueously altered chondrites such as Kaba [7].

Matrix mineralogy

Matrices of CR chondrites are composed of fine-grained minerals such as framboidal and platelet magnetite, sulfides, calcite and phyllosilicates [1]. The abundance of magnetite varies among the CR chondrites, and lath-shaped phyllosilicates (<3 µm) are present in A-881595.

The matrix olivine grains of the CO and CV chondrites examined in this study show a general correlation between grain size and porosity vs. metamorphic subtype (Fig. 3;[7]).Also, the formation of fayalitic olivine appears to be a result of aqueous alteration. For the CR chondrites, matrix textures show little porosity, similar to weakly metamorphosed CVs and CO (Fig. 3). The presence lath-shaped phyllosilicates A-881595 may indicate heavy aqueous alteration.

References:

[1] Weisberg M. K. et al. (1993) *Geochim. Cosmochim. Acta, 57*, 1567-1586. [2] Kallemeyn G. W. et al. (1996) *Geochim. Cosmochim. Acta, 60*, 2243–2256. [3]Krot A.N. et al. (2002) *Meteorit. Planet. Sci., 37*, 1451–1490. [4] Quirico et al. (2003)

Meteorit. Planet. Sci., *38*, 795–881. [5] Bonal L. et al. (2006) *Geochim. Cosmochim. Acta*, *70*, 1849-1863. [6] Chizmadia L. et al. (2002) *Meteorit. Planet. Sci.*, *37*, 1781-1796. [7] Komatsu M. et al. (2015) *Meteorit. Planet. Sci.*, *50*, 1271–1294. [8] Kojima H. and Yamaguchi A. (2005) *Meteorite Newsletter, NIPR*. [9] Schrader D. et al. (2011) *Geochim. Cosmochim. Acta*, *75*, 308-325. [10] Davidson J. et al. (2014) *Meteorit. Planet. Sci.*, *49*, 1456–1474. [11] Komatsu M. et al., *Proc. 37th Antarc. Meteorites*, 45-46. [12] Weisberg M. K. et al. (2004) *Meteorit. Planet. Sci.*, *39*, 1741–1753. [13] Aléon J. et al. (2002) *Meteorit. Planet. Sci.*, *37*, 1729-1755.

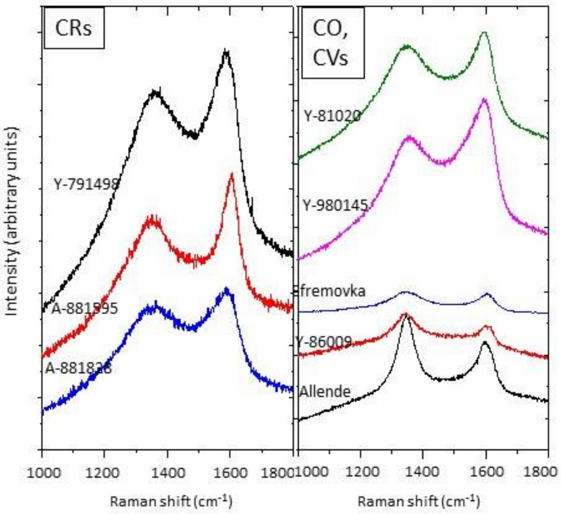

Fig.1. Representative Raman spectra of matrices of carbonaceous chondrites in this study. Spectra are vertically shifted for clarity. In each chondrites the first order carbon D- and G-bands are present.

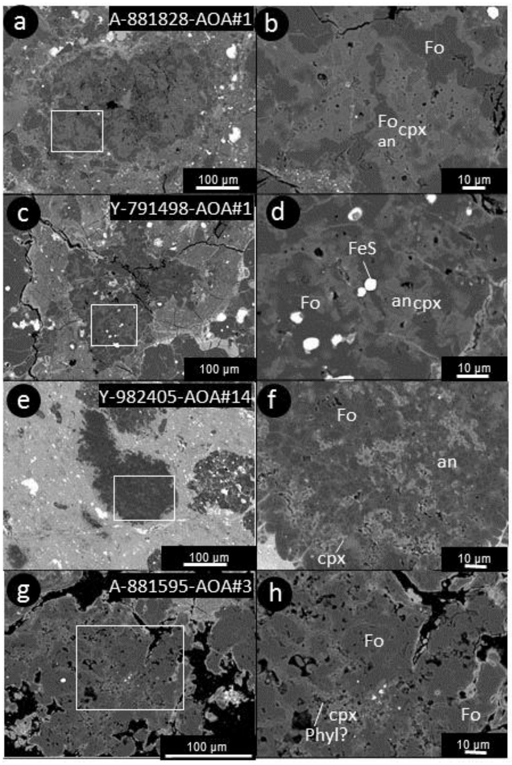

Fig.2. BSE images of AOAs from CR chondrites and A-881595. (a,b) A-881828 (c,d) Y-791498 (e,f) Y-982405 (g,h) ungrouped C3 chondrite A-881595.

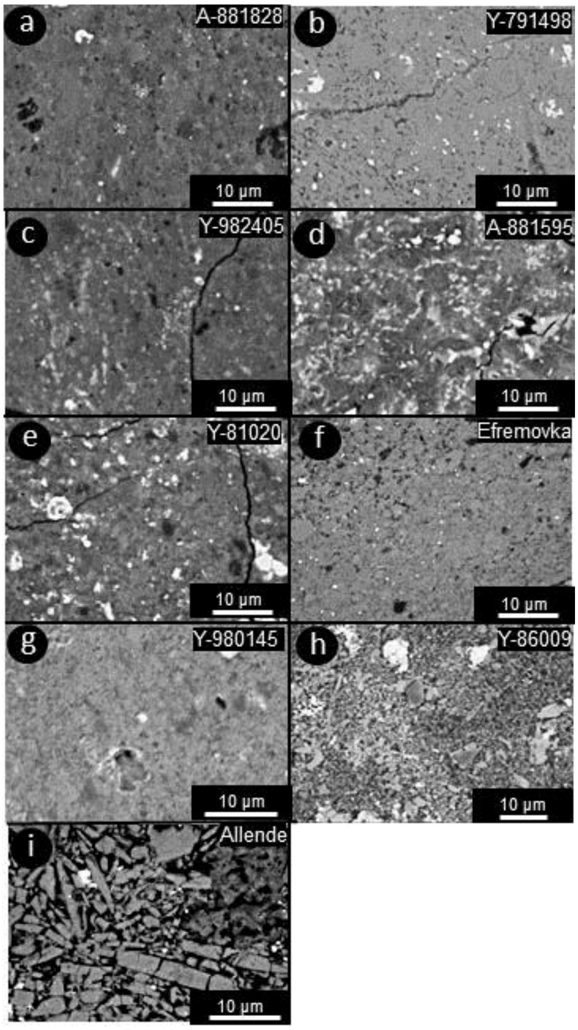

Fig.3. BSE images of matrix of CR (a-c), A-881595 (d), Y-81020 primitive CO (e), and CV chondrites (f-h).