Preliminary investigation results of organic matter in the Black Beauty (NWA 7034)

*Hiroki Suga[1], Masaaki Miyahara[1], Motoo Ito[2], Yasuo Takeichi[3], Hikaru Yabuta[1], Akira Yamaguchi[4], Yoshio Takahashi[5], Eiji Ohtani[6]

1. Hiroshima University, 2. Kochi Institute for Core Sample Research, JAMSTEC, 3. KEK-Photon Factory, 4. National Institute of Polar Research, 5. The University of Tokyo, 6. Tohoku University

Introduction: Martian basaltic breccia Northwest Africa 7034 (hereafter, NWA 7034) has the high contents of bulk carbon (2080 ±80 ppm) and water (6190 ±620 ppm) [Agee et al. (2013)]. The bulk-rock composition of NWA 7034 is similar to that of Martian surface collected by orbital satellites and rovers, thus the NWA 7034 becomes a direct linkage between Martian meteorites and Martian surface materials [Agee et al. (2013)]. Many alteration products (for example, organic carbon, carbonate and ferric hydroxides) occur between basaltic mineral fragments in the matrix of NWA 7034 [Agee et al. (2013)]. It is expected that the alteration products, which are akin to the near-surface materials of the Mars, formed by hydrothermal alteration induced by magmatic activities [Agee et al. (2013); Borg and Drake (2005)]. In this study, we work on characterizing the functional groups distribution/composition, textures, and isotpic signatures of the organic matter (OM) in NWA 7034 using our STXM-based multi-probe *in-situ* microscopic techniques to clarify the origin of OMs.

Sample and Experiments: A polished chip sample of NWA 7034 (7×10 mm) was prepared through dry polishing process for our STXM-based TEM/NanoSIMS microscopic *in-situ* analysis. Fine-textures of carbon-rich portions in the polished sample were observed using FE-SEM/EDS. The ultra-thin foils of selected carbon-rich portions were prepared by a FIB system for STXM, FE-TEM/STEM, and NanoSIMS analyses. FIB-assisted STXM analysis was conducted for C-, N-, O-, and Na-NEXAFS at PF BL13A (compact STXM). TEM/STEM observation using JEOL JEM-2100F was conducted for fine textural observations after the STXM measurements. Finally, C, O, and D isotope imaging using CAMECA NanoSIMS 50L was conducted to obtain their isotopic characteristics.

Results and Discussion: OMs distributed in the matrix of NWA 7034. From C-, N- and O-NEXAFS, OMs have C*=C (aromatic C), C=C-C*=O (vinyl-keto bond), C*≡N (nitrile), NHx (C*=O)C (amidyl), and OR(C*=O)C (carboxylic C). Although C-NEXAFS study for Matrian OMs is very limited, C-NEXAFS feature of OMs in matrix are similar to the C-NEXAFS features of opaque rim materials of carbonates in ALH 84001 [Flynn et al. (1998)] and OMs in Tissint meteorite fracture [this study]. In addition, C-NEXAFS features of OMs were different from terrestrial organic matters [Lehmann and Solomon. (2010)]. TEM/STEM observations revealed that OMs in NWA 7034 matrix is amorphous and partly be foamed. Fine-grained secondary minerals (*e.g.,* halite and smectite group clay minerals) were incorporated into OMs. This result suggested that OMs formed aquatic condition or experienced aqueous alteration (not high temperature). $\delta^{13}C$ value of OMs is 15 ±7 ‰, which is different from the $\delta^{13}C$ values of the OMs enclosed in minerals as inclusions in NWA 7034 (-23.4 ±0.73 ‰) and bulk-rock NWA 7034 (-3.0 ±0.16 ‰) within analytical error [Agee et al. (2013)]. The $\delta^{13}C$ values range is consistent not only with those for Martian atmosphere but also those for Martian carbonate which may reflect atmospheric value of their precipitation periods [Niles et al. (2005); Niles et al. (2010)]. As for bulk-rock NWA 7034 (-3.0 ±0.16 ‰), present result implies that the possibility of mixture contribution between magmatic components ($\delta^{13}C$ = -20 to -30 ‰) and Martian (sub)surface-related component (*e.g.,* 15 ±7 ‰). The δD value of the OM was 373 ±68 ‰(partly near 1000 ‰: clay minerals embedded region) which is slightly higher than that of

Martian mantle value (275 ‰), and approximately consistent with Martian subsurface ice/water [Usui et al. (2012)].

Conclusion: Through our STXM-based TEM/NanoSIMS microscopic in-situ analysis, OMs in NWA 7034 is Martian surface-related (high $\delta^{13}C$ and δD) and include Martian surface-related smectite group clay minerals (high δD).