NORTHWEST AFRICA 1109 AND CAMEL DONGA: METAL-BEARING BRECCIATED EUCRITES.

J. Isa[1], A. Yamaguchi[2], K. Shinotsuka[1] and M. Ebihara[1], [1]Department of Chemistry, Tokyo Metropolitan University, Hachioji, Tokyo 192-0397, Japan (isa-junko@ed.tmu.ac.jp), [2]National Institute Polar Research, Tokyo 173-8515, Japan.

Introduction: HED (howardites, eucrites, diogenites) meteorites are the largest group of achondrites. HED meteorites are products of earliest magmatic activity in a large asteroid (4Vesta) 4.56 Ga ago. The textures and bulk compositions suggest that almost all HED meteorites experienced impact events shortly after the formation. Some polymict breccias of HED meteorites (e.g., polymict eucrites, howardites) contain foreign materials derived from impactors such as fragments of carbonaceous chondrites, FeNi metals, metal-sulfide-rich clasts. Mesosiderites are believed to have formed by large impact onto a large planetesimal (HED parent body?) by molten FeNi metals.

We studied two brecciated eucrites that contain certain amounts of Fe-metals. They are Camel Donga and NWA1109. Camel Donga is a monomict eucrite that contains about 2% of metallic Fe [1]. NWA1109 is a polymict breccia that contains a small amount of Fe-metal. NWA1109 has not been neither petrologically characterized nor chemically analyzed in detail. In order to better understand the origin of the Fe-metals, we performed a petrological and geochemical study of these meteorites, focusing on the occurrences of Fe-metals and platinum group elements (PGEs) in NWA1109.

Samples and analytical techniques: Surfaces of Camel Donga show a matrix with many clasts, fragments of pyroxene and plagioclase, and brown stains (Fe-FeS-rich portions) (< 2-3 mm in size). For chemical analyses, we made no attempt to separate brown stains from silicate portions. The broken surface of sample for chemical analyses is a relatively homogeneous matrix (or deformed clast?) with many brown stains. The samples include a (relatively) large fragment (1.759g; ,22) and a fraction of mixed fine grains (0.136g; ,132)

Cut surfaces of NWA1109 show a homogeneous gray matrix with embedded angular dark-clasts (<5 mm), basaltic clasts (< a few mm), and irregular brown stains (metal-rich portions) up to 3-4 mm in size. The metal-rich portions occur not evenly in the matrix. We separate a portion rich in brown stains (31) and four portions of gray matrix (32, 33, 34, and 35) for chemical analyses. The weight of these samples ranges from 0.332 to 0.622 gram.

Bulk chemical compositions were determined for Camel Donga and NWA1109 by using prompt gamma-ray analysis (PGA), instrumental neutron activation analysis (INAA), instrumental photon activation analysis (IPAA) and isotope dilution inductively coupled plasma mass spectrometry (ID-ICP-MS). All the samples of Camel Donga and NWA1109 were analyzed by PGA, INAA and IPAA for major, minor and trace elements. Only NWA1109,31 was analyzed by ID-ICP-MS for PGEs.

We made polished thin and thick sections (PTSs) of adjacent chips for the chemical analyses. The PTSs were examined optically, and with a SEM and EPMA.

Bulk chemical composition: All five samples of NWA1109 have identical chemical compositions within analytical uncertainties for major and minor elements. Abundances of trace lithophile elements including rare earth elements (REEs) are 10-20 times CI values and within the range for basaltic eucrites. The abundances of Ti and Sm show a good correlation for eucrites (Fig. 1). NWA1109 is plotted in the area for basaltic eucrites. This is also supported by the Mg number (=molar Mg/(Mg+Fe) x 100) (33 – 39), Al_2O_3/Na_2O ratios (22.2 - 26.4) and Al_2O_3/CaO ratios (1.17 - 1.22). These facts are consistent with the observation that most of the clast components in NWA1109 are basaltic eucrites. Only one sample (,31) yielded a positive Ir value (6.4 ppb) with large analytical uncertainties of 34% (1δ).

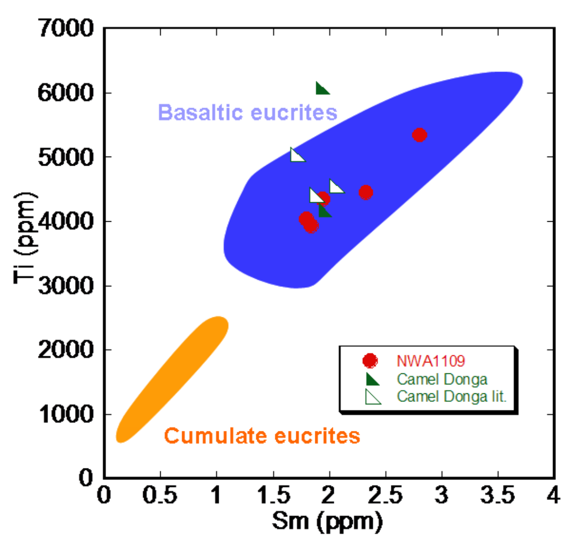

Fig. 1. Sm vs. Ti of Camel Donga and NWA1109. Ranges of basaltic eucrites and cumulate eucrites are shown for comparison.

Bulk chemical compositions of two Camel Donga samples are similar to each other and are consistent with the literature values [1-4]. Although one sample (,22) showed larger contents of Fe and Co compared with those of another sample, no positive data were obtained for Ir by INAA.

Occurrence of metals in Camel Donga and NWA1109: Camel Donga is a breccia consisting of basaltic clasts and mineral fragments of pyroxene and plagioclase. Fe-metal (and FeS) is finely dispersed throughout the silicates. The size of the metal is typically 5-10 μm [1]. Considering the low contents of Ir and other siderophile elements, Palme et al. [1] concluded that the metals in Camel Donga were produced by in-site reduction of pyroxenes. We determined very low Co and Ir contents of our Camel Donga samples, supporting the conclusion of Palme et al. [1].

PTSs of NWA1109 display a brecciated matrix composed of lithic clasts and mineral fragments (several μm to ~1 mm in size). The silicate matrix is relatively porous. The metal-rich portions (~several mm) occur irregularly, outlined by weathering products (Fig. 2). The metal-rich portions contain thin, network-like Fe-metal along boundaries of mineral and lithic fragments. These metals contain relatively high Ni contents (0.63-0.91%) compared to those of Camel Donga.

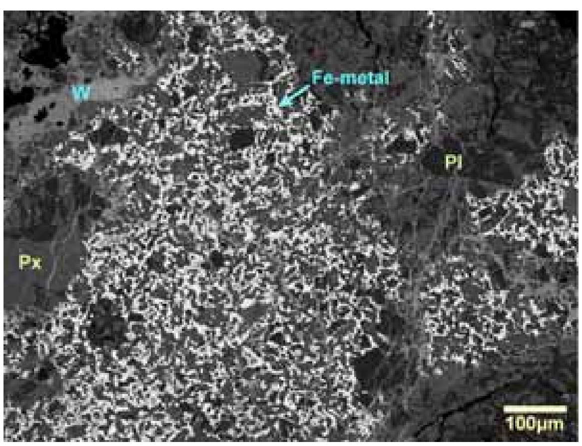

Fig. 2. Backscattered electron image of a metal-rich portion in NWA1109. Fe-metal (white) occurs along boundaries of silicate fragments. Px: pyroxene; Pl: plagioclase; W: weathering products.

The nature of foreign metal contributing to the Ni-containing metal portion in NWA1109: All PGEs were determined for NWA1109,31 by ID-ICP-MS except Rh which was determined by calibration method (Fig. 4). Considering that only subsample NWA1109,31 contains Fe-metal and has a positive Ir value in the powdered sample, Fe-metals are responsible for these PGEs. This interpretation is consistent with the relatively high abundances of Ni.

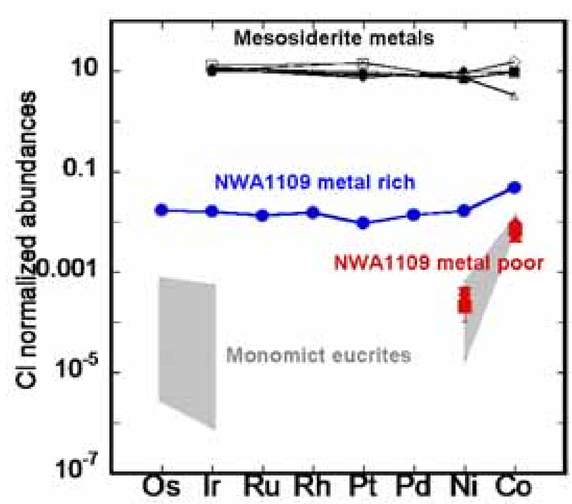

Fig. 3. CI-normalized abundances of PGEs for metal-rich and metal-poor portions of NWA1109. Ranges of mesosiderite metals and monomict eucrites are shown for comparison.

Warren [5] analyzed several monomict eucrites and found that refractory siderophile elements such as Re, Os and Ir were extremely depleted (10^{-3} to 10^{-6} x CI) in these meteorites. All PGEs in NWA1109,31 are present at 10^{-2} x CI, which is considerably higher than that for monomict eucrites (Fig. 3). Apparently, these PGEs in NAW1109,31 were contributed by foreign metals, which were contained in a projectile impacting onto the HED parent body(ies). Although all elements are not compared, comparable elements in these meteorites show similar relative abundances to those of NWA1109. If these meteorites are assumed to be projectiles, their contributions are calculated to be 0.1 to 1 wt% of NWA1109,31. As far as the bulk meteorite of NWA1109 is concerned, this estimate can be lowered, but its contribution cannot be negligible.

References: [1] Palme H. et al. (1988) Meteoritics 23, 49-57. [2] Cleverly W. et al. (1986) Meteoritics 21, 263-269. [3] Barrat J.A. et al. (2000) MAPS 35, 1087-1100. [4] Barrat J.A. et al. GCA 71, 4108-4124 (2007). [5] Warren P.H. (1999) Antarct. Meteorites XXIV, 185-186. [7] Hassanzadeh J. et al. (1990) GCA 54, 3197-3208.