LL CHONDRITIC BRECCIAS AND THEIR SIGNIFICANCE TO THE EVOLUTION OF LL PARENT BODIES.

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Introduction: Various kinds of breccia are abundantly encountered in meteorites. They are significant materials to discuss impact processes and constituent materials of planetary bodies. In ordinary chondrites, many breccias have been reported (e.g., [1]). Here we present our results on LL chondritic breccias, Asuka (A) 12011 and A 12389. The joint expedition party between Japan and Belgium (JARE-54 and BELARE 2012-2013) recently collected these meteorites from the Nancen Ice Field, Antarctica. The original weights of A 12011 and A 12389 are 113 g and 18.07 kg, respectively. A 12389 is the heaviest meteorite collected by this expedition party. Both meteorites are classified as LL genomict breccias [2].

Results: These breccias consist of various kinds of clasts within matrix. Here we define matrix as constituent materials other than clasts. The clasts mostly fall into petrologic types 3, 4, 5/6. However, others clasts are present (e.g., melt and darkened clasts). The type 5/6 clasts and the matrix are the most abundant components, 46 and 48 vol.% in A12011, and 43 and 44 vol.% in A 12389, respectively.

The constituent phases are olivine, low- and high-Ca pyroxene, feldspar, phosphates (Cl-apatite and merrillite), chromite, Fe-Ni metal, and troilite. Rare ilmenite and pentlandite are encountered in both breccias. Glassy mesostasis occurs only in chondrules as type 3 clasts in A 12011. The abundances of Fe-Ni metal and troilite are 5.4 and 2.1 vol.% in A 12011, and 6.2 and 1.9 vol.% in A 12389, respectively.

Olivine is mostly homogeneous, with an average composition of Fo_{72} in both breccias, with a large range of Fo content (Fo_{47-89}) in type 3 clasts in A12011. Low-Ca pyroxene is En_{76} in A 12011 and En_{75} in A 12389 on average. In type 3 clasts of A 12011, it has a wide range of composition, En_{66-96}. Feldspars are mostly $Ab_{84}Or_5$ in A 12011, and $Ab_{87}Or_3$ in A 12389. K-rich feldspars, lower than Or_{92}, are also present. Kamacite contains 5.8 wt.% Ni and 3.2 wt.% Co on average in A12011, and 4.6 wt.% Ni and 2.7 wt.% Co in A 12389.

A12011 contains solar gases, suggesting that it is a regolith breccia. On the other hand, A 12389 hardly contains solar gases. The cosmic ray exposure ages for A 12011 and A 12389 are ~25 and ~10 Ma, respectively. The K-Ar ages of 3.9 Ga and 2.3 Ga are calculated for A 12011 and A 12389, respectively, assuming the mean K concentration (857 ppm) of LL chondrites [3].

Discussion: The chemical group of these Asuka breccias is LL, as determined by mineralogy. The abundance of Fe-Ni metal and troilite supports this classification. They are similar in textures. However, the noble gas data seem to suggest that they are not paired.

At any rate, both chondrites contain various kinds of clasts, which represent a wide range of petrologic types. However, type 5 and 6 clasts are much more common than the others. A large component of matrix material resembles type 5 and 6 clasts, in both mineral compositions and texture. This is consistent with the common occurrences of type 5 and 6 in LL chondrite group. Both Asuka breccias formed through extensive impact processes on LL parent body(ies), and the interior materials were excavated and reassembled into these breccias. It is probable that A12011 experienced the impact process 3.9 Ga ago, whereas the K-Ar age of A 12389 was probably reset by later impact event. However, the occurrences of type 3 and 4 clasts suggest that intensive thermal metamorphism did not take place after the reassembly into breccias.

Importantly, the Asuka breccias have similar mineralogy and clast materials to Itokawa dust particles returned by Hayabusa mission [4]. The materials on the surface of 25143 Itokawa are probably similar to the Asuka breccias.

References: [1] Bischoff A. et al. 2006. *Meteorites and the Early Solar System II* 679-712. [2] Yamaguchi A. et al. 2014. *Meteorite Newsletter* 23. [3] Kallemeyn G. W. et al. 1989. *Geochimica et Cosmochimica Acta* 53: 2747–2767.] [4] Nakamura T. et al. 2011. *Science* 333: 1113-1116.