MINERALOGICAL AND PETROFABRIC STUDY OF BRACHINITE REID 013.

H. Hasegawa[1] and T. Mikouchi[1], [1]Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, Bunkyo-ku, Tokyo 113-0033, Japan. (e-mail: hasegawah@eps.s.u-tokyo.ac.jp)

Introduction: Primitive achondrites have textures indicative of igneous rocks (achondrites), but have heterogeneity of oxygen isotopic and whole-rock chemical compositions that imply an affinity to chondrites [e.g., 1]. It is suggested that primitive achondrites exceeded their solidus temperature on their parent bodies, thus experiencing partial melting, but are derived from parent bodies in which planetary differentiation did not achieve isotopic equilibrium [e.g., 2]. Therefore, primitive achondrites are key to understand the earliest stages of planetary differentiation, as they are expected to record the information of incomplete melting and limited melt segregation in their parent bodies. Brachinite is one of the major groups of primitive achondrites, which is coarse-grained and dominantly composed of olivine. Lots of researchers suggest that brachinite is a partial melt residue [e.g., 3], while some indicate a cumulus origin [e.g., 4]. Thus, there has been no consensus on the origin of brachinites. Recently, a lot of ungrouped achondrites with generally similar petrologic, compositional and isotopic characteristics to brachinites have been found and are sometimes called "brachinite-like ultramafic achondrite meteorites" [3]. It is significant to know the relationship between brachinites and such "brachinite-like"s to better understand the formation process of brachinites and the geological environment on their parent body. The presence of a certain petrofabric texture has especially been reported in some brachinites and brachinite-like meteorites [4,5]. We consider that such textures are good traces to estimate igneous processes in their parent asteroids. From this point of view, we studied mineralogy of brachinite Reid 013 and compare its petrofabric texture with those in brachinites and brachinite-likes.

Samples and Methods: We prepared a thin section of Reid 013 and analyzed it by optical microscopy, FEG-SEM (JEOL, JSM-7100F) at the National Institute of Polar Research (NIPR) and EPMA (JEOL, JXA-8530F) at the University of Tokyo. In addition, in order to analyze the crystallographic preferred orientation (CPO) of olivine, we employed FEG-SEM (JEOL, JSM-7100F) at NIPR equipped with an EBSD (electron backscatter diffraction) detector and obtained crystal orientation stereographic nets using HKL's CHANNEL 5 software.

Results: Reid 013 is mostly composed of olivine (> 90 vol.%, $Fo_{\sim 67}$) and its grain size shows a bimodal distribution (~0.5 mm and <0.2 mm). Olivine grains commonly display triple junctions and hardly show wavy extinctions. Minor phases include clinopyroxene (~ 6 vol.%, $Wo_{\sim 46}En_{\sim 44}$), chromite (~ 1 vol.%) and the very fine assemblages (trace, <50 μm), which consist of orthopyroxene ($Wo_{\sim 2}En_{\sim 71}$), Fe, Ni-metal and sulfide. These assemblages are widely observed in brachinite-like meteorites. One Ca phosphate grain (~ 0.1 mm) is also present, but plagioclase is absent. The texture of the Reid 013 thin section studied is consistent with previous studies [e.g., 6], except for the absence of plagioclase. Each mineral grain is homogeneous in composition and does not show clear chemical zoning. We also measured the orientation of olivine crystals (one point per grain, 240 grains) by EBSD, but did not detect any clear CPO.

Implications: The petrography, modal abundances and the compositions of constituent minerals in our thin section of Reid 013 are within the range of brachinites [7]. Olivine, clinopyroxene and chromite grains do not show clear chemical zoning, which is also typical of brachinites. The existence of olivine CPO patterns that *c* axis of olivine is preferentially oriented was reported in brachinites (Elephant Moraine 99407 and Allan Hills 84025) [4], but we did not find obvious olivine CPO in Reid 013. In contrast, five brachinite-like meteorites (Divnoe, Northwest Africa 6112, Miller Range 090206/090340/090405) showed clear CPO patterns of olivine crystals [5,8]. These CPO patterns of olivine found in these brachinite-like meteorites are generally thought that they are cumulate rocks. We think that the lack of CPO patterns in Reid 013 indicates that this meteorite was formed as partial melt residue, not as cumulate. The oxygen isotopic compositions of brachinite-like meteorites are very similar to those of brachinites [e.g., 2,3,5], suggesting the origin from the same parent asteroid(s). However, in brachinite-like meteorites, the compositions of silicate minerals are slightly more magnesian than those in brachinites, and CPO patterns of olivine appear more common. This possibly indicates that brachinites including brachinite-like meteorites may be divided into two subgroups by their formation processes (partial melt residue and cumulate rock). To clarify the relationship between them, we plan to study and compare more brachinites and brachinite-like meteorites.

References: [1] Weisberg M. K. et al. 2006. *Meteorites and the Early Solar System II*, 19–52. [2] Greenwood R. C. et al. 2012. *Geochimica et Cosmochimica Acta* 94:146–163. [3] Day J. M. D. et al. 2012. *Geochimica et Cosmochimica Acta* 81:94–128. [4] Mittlefehldt D. W. et al. (2003) *Meteoritics & Planetary Science* 38:1601–1625. [5] Hasegawa H. et al. 2015. *Antarctic Meteorites* XXXVIII. [6] Goodrich C. A. et al. 2011. *Meteoritics & Planetary Science* 45:1906-1928. [7] Keil K. 2014. *Chemie der Erde - Geochemistry* 74:311-329. [8] Hasegawa H. et al. 2016. Abstract #2528. 47th Lunar & Planetary Science Conference.