OLIVINE PETROFABRIC ANALYSIS OF BRACHINITES: IMPLICATIONS FOR PETROGENETIC DIVERSITIES. T. Mikouchi[1], A. Takenouchi[2], M. Yasutake[3,4], H. Hasegawa[1], A. Yamaguchi[2], A. Miyake[5], A. Tsuchiyama[4,6] and A. J. Irving[7], [1]University of Tokyo, Tokyo 113-0033, Japan, [2]National Inst. Polar Res. (NIPR), Tokyo 190-8518, Japan, [3]Japan Synchro. Radiation Res. Inst. (JASRI), Hyogo 679-5198, Japan, [4]Ritsumeikan University, Shiga 525-8577, Japan, Guangzhou Inst. Geochem., GD 510640, China, [5]Kyoto University, Kyoto 606-8502, Japan, [6]University of Washington, Seattle, WA 98195, USA, E-mail: mikouchi@um.u-tokyo.ac.jp.

Introduction: Brachinites and related meteorites have been considered as a single "primitive achondrite" group, but recent studies of numerous newly-recovered specimens have suggested that they experienced diverse igneous processes [e.g., 1,2] and may originate from multiple parent bodies. Olivine is a key mineral in brachinites not only because it is the most abundant phase (typically >85 vol.%), but it commonly exhibits petrofabric textures related to the olivine crystallization processes or secondary episode. In our previous study [1] we demonstrated that some brachinite-related meteorites exhibited *b* and *c* axes concentrations of olivine crystals, implying either specific accumulation processes of crystallizing olivine or possible deformation record in the interior of the parent body. It is important to study olivine petrofabric textures of additional brachinite samples in order to constrain dominant formation mechanism of brachinite olivine and better understand thermal evolution of the parent body or bodies.

Samples and Methods: Thin sections of NWA 3151, NWA 4872, NWA 4874, NWA 4876, NWA 4882, NWA 5969, NWA 5971, NWA 6349, NWA 6474 and NWA 7388 were analyzed to obtain electron back-scattered diffraction (EBSD) patterns of olivine using EBSD detectors equipped with FEI Quanta 200 3DS FIB-SEM instrument at Kyoto University and JEOL JSM-7100M FE-SEM at NIPR. The obtained distributions of olivine crystallographic axes were analyzed with AZtec software. The employed cell parameters of olivine are a=4.8 Å, b=10.2 Å, c=6.0 Å, $\alpha=\beta=\gamma=90^{\circ}$ with the orthorhombic crystal system of the *Pbnm* space group. Cautions should be taken because some literatures employed the *Pnma* space group as we have previously pointed out [3].

Results and Discussions: There are several samples clearly showing preferred shape orientations of olivine (e.g., NWA 3151, NWA 4874 and NWA 5969) (Fig. 1). They also show preferred crystallographic orientations of olivine either or both for *b* and *c* axes. For example, NWA 3151 shows concentration of *c* axis, but both *a* and *b* axes are randomly oriented (Fig. 2). NWA 4874 is an interesting sample because concentrations of both *b* and *c* axes are observed (Fig. 2). Similar double axis concentration is found for NWA 5969 olivine. Among ten samples analyzed, only NWA 7388 displays *c* axis concentration (random orientations for *a* and *b* axes). The other six samples do not show clear preferred crystallographic axis concentration although the analyzed areas were small for NWA 5971, NWA 6349 and NWA 6474.

Crystallographic axis concentration of *b* and *c* axes of olivine could be formed by accumulation of crystallizing olivine in magma chambers of brachinite-related meteorites [1]. In the case of *b* axis concentration, the most plausible mechanism is that euhedral olivine crystals with large (010) plane surface were accumulated by their *b* axes normal to the bottom of the magma chamber [e.g., 4]. However, as observed for olivine in numerous terrestrial mantle rocks [e.g., 5], rheological deformation can also concentrate *b* axis by activation of the relevant olivine slip system. It is hard to distinguish which process was responsible for the studied samples only from this study. The concentration of *c* axis can be achieved under a similar, but slightly distinct accumulation process. When magmatic flow is dominant, it can concentrate *c* axis along the flow because igneous olivine usually has the longest dimension along *c* axis [1]. In the case of NWA 4874 and NWA 5969, showing both *b* and *c* axes concentration, probably the above two processes were both present. From these points of view, the samples showing random distribution of olivine crystallographic axes can be interpreted as residue. NWA 4872 is such an example without any concentration of olivine crystallographic axes, consistent with the formation as residue as suggested by its REE abundance pattern [6].

Conclusions: This study demonstrates that both preferred shape and crystallographic orientations of olivine can be found nearly half of brachinites and related meteorites studied, further strengthening that they were originated from one or more differentiated parent bodies where accumulation of crystallizing olivine in magma chambers was common and sometimes involved magmatic flow. Any role for deformation processes in the petrogenesis of brachinites will have to be assessed by analyses of additional samples.

References: [1] Hasegawa et al. (2019) *MAPS*, *54*, 752-767. [2] Crossley (2020) *MAPS*, *55*, 2021-2043. [3] Yasutake et al. (2019) *82nd MetSoc. Meeting*, id.6093. [4] Wen et al. (2018) *Amer. Mineral.*, *103*, 735-741. [5] Mercier & Nicolas (1975) *J. Petrol.*, *16*, 454-487. [6] Hyde et al. (2014) *MAPS*, *49*, 1141-1156.

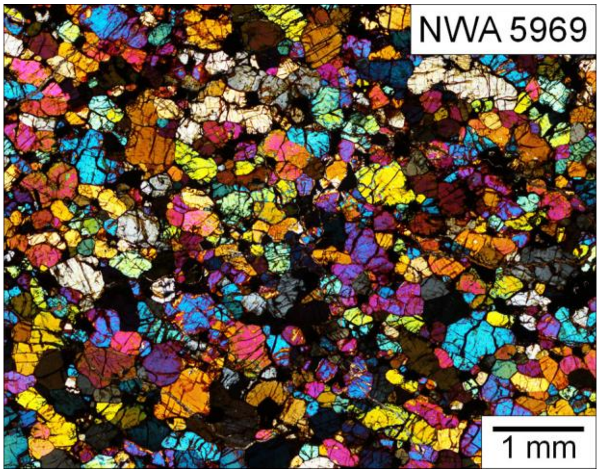

Fig. 1. Cross-polarized optical photomicrograph of NWA 5969, showing a shape preferred orientation of olivine (elongated parallel to NW/SE). The elongated direction is nearly parallel to *c* axis of olivine (Fig. 2).

Table 1. Summary table of the olivine properties for studied brachinite and related meteorite samples.

	Olivine Fa content	Olivine grain size	Shape preferred orientation	Crystal axis concentration	*M* index
NWA 3151	34-35	Medium	Yes	*b*	0.066
NWA 4872	32-34	Fine-Medium	No	None	0.057
NWA 4874	32-34	Medium	Yes	*b* and *c*	0.088
NWA 4876	32-34	Fine-Medium	No	None	0.055
NWA 4882	32-34	Fine-Medium	No	None	0.053
NWA 5969	29-31	Medium	Yes	*b* (and *c*)	0.105
NWA 5971	31-35	Medium	No	None?	0.086
NWA 6349	32-35	Fine-Medium	Yes?	None?	0.053
NWA 6474	33-36	Medium	No	None	0.066
NWA 7388	24-31	Medium	Yes	*c*	0.062

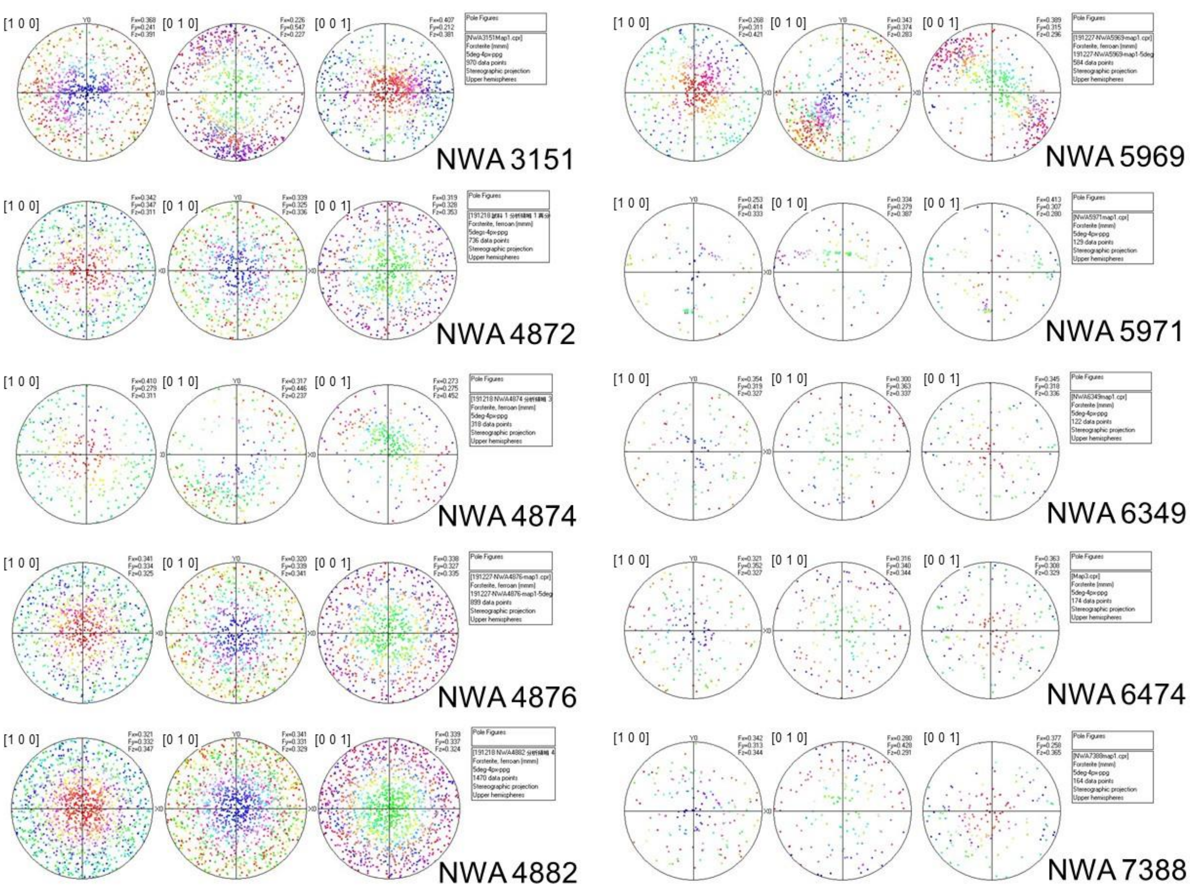

Fig. 2. Distributions of the crystallographic axis directions of analyzed brachinite olivine crystals using stereographic projections. Three circles for each sample show projections of *a*, *b* and *c* axes from left to right.