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Olivine petrofabric and chemical study of Divnoe ungrouped primitive achondrite

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Brachinite is a small group of achondrites mostly composed of olivine. Currently ˜30 meteorites belong to brachinite, however, what are called “brachinite-like” but classified as “ungrouped” exist (e.g., Day et al. 2012; Keil 2014). Such “brachinite-like” meteorites have a similar rock texture, oxygen isotopic compositions or trace elements abundance to brachinite but do not perfectly match, and so they are classified as ungrouped. It is important to study these meteorites to understand the formation process of brachinite in general and their parental differentiated asteroid(s). Divnoe is one of such “brachinite-like” meteorite discovered in Russia in 1981 (Graham 1983; Petaev et al. 1994) and recently some meteorites similar to Divnoe have been found from hot and cold deserts (e.g., RBT 04239 and Tafassasset). These findings may establish a new achondrite group (“Divnoeite”) including some of above “brachinite-like” meteorites (Gardner et al. 2007). In this study we analyzed Divnoe from mineralogical and chemical points of view to better understand its petrogenesis.

Divnoe is a medium- to coarse-grained achondrite (˜0.5-2.0 mm in grain size) dominated by olivine (Fo_{72-80}) and apparent shape preferred orientation (SPO) of olivine grains is observed by optical microscopic observation. It is known that dislocation-creep controlled flow of upper mantle materials develops crystallographic preferred orientation (CPO) of olivine and seismic anisotropy in the Earth (Ohuchi 2013). Recently, Tkalcec et al. (2013) studied lattice preferred orientation (LPO) of olivine in diogenite and proposed solid-state plastic deformation in the dynamic interior of 4Vesta. Our EBSD (Electron Back Scatter Diffraction) analysis of Divnoe olivine grains shows that they are preferentially aligned along [001], which is parallel to elongation of olivine grains. The dimensions of [100] and [010] are randomly oriented. This observation indicates that CPO of Divnoe olivine was achieved when olivine grains accumulated in magma rather than plastic deformation after solidification in the interior of the parent body, which is consistent with previous study (Ando et al. 2003). Therefore, Divnoe is likely an olivine cumulate rock. However, we found that its bulk chemical composition has high abundance of siderophile elements (Ir, Pt: ˜0.5 x CI), which is unusual for an olivine cumulate. Such high abundance of siderophile elements may be derived from addition of an iron meteorite component by impact. It is required to analyze other Divnoe-like meteorites to see whether (1) olivine SPO is present or not and (2) such chemical signature (e.g., enrichment of siderophiles) is similarly seen.