Evidence for volatile-rich mantle transition zone beneath NE China: implication from the geochemistry of melt inclusions from Wudalianchi basalts

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Water, carbon dioxide, sulfur, fluorine, and chlorine are the most popular volatiles in the Earth’s mantle (McDonough and Sun, 1995; Salters and Stracke, 2004). These volatile elements affect the mantle dynamics such as magma genesis, magma compositions, and mantle physics. It is, therefore, quite important to understand contents and behaviors of these volatile elements in the mantle. Because of difficulty to exactly estimate these volatile compositions of volcanic rocks using thermodynamics methods, these volatile compositions in MTZ are still controversial. Sporadic intraplate volcanism occurred around the Wudalianchi, northeastern China, in the Miocene (9.6 –7.0 Ma), middle Pleistocene (0.56 –0.13 Ma), and recent (1719 –1721 AD) periods, which is considered to be originated in hydrous MTZ affected by the stagnant Pacific slab lying beneath this area (e.g., Kuritani *et al.*, 2013). In this study, we obtained 47 basaltic samples from the Quaternary volcanoes in Wudalianchi area and analyzed whole-rock and mineral chemical compositions as well as volatile contents of olivine-hosted melt inclusions in order to clarify the origin of the volcanism and to estimate volatile compositions of MTZ, such as H_2O, CO_2, S, Cl, and F.

Major element compositions of whole-rock and olivine-hosted melt inclusions were analyzed by an X-Ray Fluorescence spectrometer (XRF), Electron Probe Micro Analyzer (EPMA), respectively. Volatile contents in melt inclusions were measured by Secondary Ion Mass Spectrometry (SIMS). Whole-rock compositions of these basalts are enriched in K_2O (4.4 –6.0 wt%) and depleted in FeO (7.1 –9.6 wt%) showing tight liner compositional trends from an SiO_2 content of 45.0 to 54.0 wt%. Olivine phenocrysts containing melt inclusions show Fo# (=100Mg/(Mg+Fe)$_{mol}$) from 81.3 to 85.4, but melt inclusions have lower Mg# (=100Mg/(Mg+Fe)$_{mol}$) from 65.2 to 78.3 than a melt in equilibrium with host olivine phenocryst, implying overgrowth of host olivine after entrapment of a melt inclusion. Therefore, we corrected compositions of melt inclusions to be in equilibrium with a host olivine by adding olivine (hosted-olivine overgrowth is 4 –9 wt%). Corrected compositions of melt inclusions possess limited range of SiO_2, MgO, and P_2O_5 contents from 51.8 to 53.9 wt%, 4.3 –5.4 wt%, and 0.9 –1.2 wt%, respectively, variation of which can be explained by fractionation of olivine, clinopyroxene, plagioclase, magnetite. The water and carbon dioxide contents in melt inclusions are 0.1 –1.2 wt%, 0 –2480 ppm, respectively. In particular, variable CO_2 contents (0 –2450 ppm) with limited variation of H_2O contents at more than 1.0 wt% correspond with a decompressive degassing trend of magma suggesting that H_2O contents (>1.0 wt%) of melt inclusions are original water contents in magma chamber. The highest H_2O content of 1.2 wt% shows good agreement with previous estimation (H_2O content 1.1 –1.4 wt%) by Kuritani *et al.* (2013). Overall variations of S, F, and Cl can be reasonably reproduced by Rayleigh fractional crystallization model suggesting that most samples have not degassed for S, F, and Cl. Fluorine contents (1230 –1510 ppm) of undegassed melt inclusions for given H_2O contents (1.1 –1.2 wt%) are still higher than the DMM –FOZO trend proposed by Shimizu *et al.* (2019). Degree of partial melting for Wudalianch basalts were estimated to be 7 –14 % using incompatible trace element compositions of primary melts that were estimated by the addition of 2 –10 wt% olivine crystals to the least fractionated magma. As a result, H_2O, F, and Cl contents of the source

mantle are ~500, ~50, and ~60 ppm, respectively, that are higher than DMM (H_2O : 190 ppm, F : 13 ppm, Cl : 5 ppm (Shimizu *et al.*, 2016)), implying the mantle transition zone above the stagnant Pacific slab is not only H_2O-rich, but also F-rich and Cl-rich compositions.

Keywords: alkaline basalt, melt inclusion, northeastern China, volatile

