

Missing carbonate and petit-spot silicate liquid immiscibility

*佐藤 勇輝¹、平野 直人¹

*Yuki Sato¹, Naoto Hirano¹

1. 東北大学東北アジア研究センター

1. Center for Northeast Asian Studies, Tohoku University

Alkaline monogenetic volcano known as petit-spot, which is distributed at the locality of the plate flexure, is characterised by extremely rich carbon dioxide in magma (~10 wt%; Okumura and Hirano, 2013). Sisson et al. (2009) argued that petit-spot magma forms where interstitial carbonate-silicate liquids are locally present in the shallow asthenosphere.

In most case, petit-spot magma of northwest Pacific experienced temporal stagnation at the mid-depth of the lithosphere during the melt-ascent (Valentine and Hirano, 2010). On the other hand, Sato et al. (2017) reported the strongly alkaline petit-spot basalts which directly ascent through extensional lithosphere with lower degree of fractionation and interaction with lithospheric mantle. This discovery allows us to discuss the magma processes at the lithosphere during the melt-ascent.

Numerous experimental studies show that partial melt of the carbonated peridotite is separated into silica-undersaturated alkaline magma and carbonatite magma as the result of the liquid immiscibility, which is often expressed by the pseudo-ternary multi-component diagram (e.g. Freestone and Hamilton, 1980). The chemical composition of alkaline magma which unmixed carbonatite resembles that of petit-spot magma.

Most of petit-spot basalts of northwest Pacific except for strongly alkaline ones are plotted along with the 1.5-3 GPa solvus of the pseudo-ternary diagram. This suggests that the parental magma of most petit-spots extracted from the carbonated mantle components of the asthenosphere divided by the miscibility gap into alkali silicate magma and carbonatite liquid. Therefore, geochemical variation of the alkali silicate magmas along the solvus isobar is corresponding to the depth of magma stagnates and fractionates at the mid-depth of lithosphere. The depth is consistent with the petit-spot melt last equilibrated with depleted peridotite at 1.8–2.1 GPa (1280–1290°C) as well (Machida et al., 2017). Although the carbonatite lava has not been found in the petit-spot volcanic field, they may dissolve in the seawater due to eruption depth to be deeper than the carbonate compensation depth.

The compositional trend of strongly alkaline petit-spot basalts, on the other hand, does not align along with the solvus at each pressure, and converged around the 0.5 GPa solvus, which is consistent with rapid magma ascending without any stagnation at the mid-depth of lithosphere. Therefore, strongly alkaline magmas have not arrived at the carbonatite-silicate melt miscibility gap plausibly due to more rapidly ascending melt. Although partition coefficients of the trace elements between immiscible carbonate and silicate liquids are complicated, some experimental studies show that La, Sr and Ba strongly partition into the carbonate liquid but Zr and Hf into the silicate liquid (e.g. Veksler et al., 1998). The trace element composition of strongly alkaline basalt suggests the melt without separation into immiscible liquids as well.

The lower to mid- lithosphere is metasomatized not only by alkali silicate petit-spot melt as mentioned by Pilet et al. (2016) but carbonatite melt unmixed from parental petit-spot magma. The carbon transportation to the deep mantle might be significant process through the subduction of carbonatite-metasomatized lithosphere

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