Fluid-fluxed melting of the mantle as the cause of intraplate magmatism over a stagnant slab: implications from Fukue Volcano Group, SW Japan

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The Pacific Plate subducting from the Japan Trench has accumulated in the mantle transition zone beneath NE Asia, and intraplate magmatism has been active above the stagnant Pacific slab. Since the discovery of a remnant of the Pacific slab in the mantle transition zone (Fukao et al., 1992), slab stagnation and its relationship with intraplate magmatism has received growing attention. In particular, electric conductivity observations have suggested a remarkably hydrous mantle transition zone beneath NE China (e.g., Kelbert et al., 2009), and experimental, seismic, and numerical studies have indicated that dehydration of the stagnant slab plays a significant role in magma genesis (e.g., Ohtani and Zhao, 2009). In this study, a petrological and geochemical study was carried out on basalts from a monogenetic volcano (Akashima Volcano) in the Fukue Volcano Group, SW Japan, to clarify the role of deep dehydration of the stagnant Pacific slab in the magmatism.

Akashima is a small volcanic island (0.52 km^2), located southeast of Fukue Island, which is at the southwestern end of the Goto Islands. The eruption products (46.8–51.0 wt.% SiO_2) consist of a low-Si group (< 48.4 wt.%) and a high-Si group (> 48.8 wt.%), and the former predates the latter. The modal abundance of phenocrysts is typically ~5% olivine for the low-Si group. Some samples additionally contain small amounts (< 0.5%) of plagioclase phenocrysts. The products of the high-Si group typically contain ~5% olivine and ~10% plagioclase phenocrysts. The low-Si samples have higher TiO_2 and rare-earth element concentrations, and higher $^{87}Sr/^{86}Sr$ ratios and lower $^{143}Nd/^{144}Nd$ and $^{206}Pb/^{204}Pb$ ratios than the high-Si samples.

The low-Si samples have distinct incompatible element concentrations and Sr, Nd, and Pb isotopic compositions from those of the high-Si samples. This observation suggests that the low-Si and high-Si magmas were not produced by a series of magmatic processes. The most magnesian samples in each group are primitive (> 8 wt.% MgO), and therefore, both the low-Si and high-Si magmas originated from different source mantle materials. The H_2O contents of the primary magmas were estimated as ~2 wt.% for both the low-Si and high-Si groups. Analyses using multicomponent thermodynamics suggested that the low-Si and high-Si primary magmas were generated at ~2.5 GPa and 1345ºC and at ~1.8 GPa and 1285ºC, respectively. The melting pressure of ~2.5 GPa for the low-Si magma suggests its generation in the asthenospheric mantle. On the other hand, the melting pressure of ~1.8 GPa for the high-Si magma coincides well with the depth of the asthenosphere–lithosphere boundary at 60–65 km (~1.8 GPa) beneath Fukue Island (Zhu et al., 2006). Therefore, the high-Si magma is considered to have been generated by interaction of the low-Si magma with the SCLM.

The H_2O/Ce ratios of the primary low-Si magma of ~650 is higher than the range of 100–250 for normal MORB (Michael, 1995), and is closer to the range found in subduction zone magmas (800–10000; Ruscitto et al., 2012). This observation suggests that the source mantle of the Akashima magma is

significantly hydrous compared with the normal asthenospheric mantle. The mantle potential temperature for the low-Si Akashima magma, calculated as ~1300ºC, is within the range for subduction zone magmas (1150–1350ºC; Lee et al., 2009). Therefore, the Akashima magma may have been generated primarily by melting of the ambient asthenospheric mantle at ~2.5 GPa, triggered by an influx of fluids originating from dehydration of the stagnant Pacific slab, similar to the case of the Chugaryong Volcano in Korea (Sakuyama et al., 2014). The water storage capacity of the upper mantle is significantly lower than that of the underlying mantle transition zone. Therefore, the release of fluids from the mantle transition zone to the upper mantle may suggest that the transition zone beneath Akashima was locally saturated with water.

Keywords: Intraplate magmatism, Mantle transition zone, Water, Stagnant slab