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A method to estimate the pre-eruptive water content of basalts: Application to the Wudalianchi–Erkeshan–Keluo volcanic field, Northeastern China

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Abstract

Water plays an important role in the generation and evolution of volcanic systems. However, the direct measurement of the pre-eruption water content of subaerial volcanic rocks is difficult, because of the degassing during magma ascent. In this study, we developed a method to calculate the pre-eruption water content of the basalts from the Cenozoic Wudalianchi–Erkeshan–Keluo (WEK) potassic volcanic field, Northeastern China, and investigated their mantle source. A water-insensitive clinopyroxene–melt thermobarometer and a water-sensitive silica activity thermobarometer were applied to these basalts. Two pressure-temperature (*P*-*T*) paths of the ascending magma were calculated using these two independent thermobarometers, with a similar *P*-*T* slope but clear offset. By adjusting the water content used in the calculation, the difference between the two *P*-*T* paths was minimized, and the water content of the WEK melts was estimated to be 4.5 ± 1.2 wt% at a pressure range of 10.1–13.5 kbar, corresponding to depths of 37–47 km. Degassing modeling shows that during the magma ascent from below the Moho to near the surface, CO_2 was predominantly degassed, while the melt H_2O content kept stable. Significant H_2O degassing occurred until the magma ascended to 5–2 kbar. The silica activity *P*–*T* estimates of the most primary WEK samples suggest that the magmas were generated by the melting of convective mantle, which was probably facilitated by a wet upwelling plume from the mantle transition zone. The high water content found in the WEK basalts is similar to the recent reports on Phanerozoic intraplate large igneous provinces (LIPs) and supports the presence of hydrated deep mantle reservoirs as one possible source of the LIPs.

Keywords: Water content, potassic basalt, degas, thermobarometer, Northeastern China, Wudalianchi–Erkeshan–Keluo; Volatile Elements in Differentiated Planetary Interiors