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Magmatism at the lithosphere–asthenosphere boundary in developing transtensional zone: Spatial-temporal change of sources for Quaternary potassic volcanic rocks from Wudalianchi, China

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Study of the Pliocene-Quaternary potassic rock series from the northern circuit of the Songliao basin that was subsided from the Middle Jurassic to Paleogene showed overall change of K2O content along the Wudalianchi zone and revealed its specific variations in the Wudalianchi volcanic field – the limited range of background K2O concentrations between 4.8 and 6.0 wt.% and locally reduced values at the beginning and at the end of the Quaternary volcanic evolution. Initial lava flows with K2O as low as 4.0 wt.% erupted along the Laoshantou – Old Gelaqiushan north-south locus from 2.5 to 2.0 Ma. Then, between 1.3 and 0.8 Ma, background irregular activity occurred in the South Gelaqiushan volcano and along the west-east locus of the Lianhuashan, Wohushan, Yaoquanshan, West Jaodebushan, West Longmenshan volcanoes. In the last 0.6 Ma three groups of volcanoes erupted: Western (North Gelaqiushan, Lianhuashan, Dzhianshan-Dzhiamshanzi), Central (Wohushan, Bijiashan, Laoheishan, Huoshaoshan), and Eastern (Weishan, East Jaodebushan, Xiaogoshan, West and East Longmenshan, Molabushan). Background eruptions continued in the Western and Eastern groups, whereas the Central group displayed stepwisely shifted activity from the southwest to the northeast with decreasing K2O concentrations in eruption products up to 3.2 wt.%. From a comparative analysis of K2O, other major oxides, and trace elements in rocks of early and late eruption phases in the Central group of volcanoes, we infer that in the first volcano (Wohushan), the rocks were almost compositionally similar to the background ones, in the second and third volcanoes (Bijiashan, Laoheishan) were partially close to the background rocks and partly differed from them, and in the fourth volcano (Huoshaoshan) were significantly different from the background rocks. We suggest that magma generation under the Wudalianchi volcanic field was controlled by a layer at the base of the lithosphere that divided and shielded sources of underlying homogeneous sub-lithospheric convective mantle and the overlying enriched heterogeneous lithosphere. The sub-lithospheric magma source had 87Sr/86Sr = 0.7052, sources of the shielding layer the same and lower Sr-isotopic values, and the sources of the overlying region the same and higher values. The developing north-south transtensional zone resulted in (1) background melting enriched material above the shielding layer and (2) local introduction of convective mantle component from its base. Local sub-lithospheric melts of 2.5–2.0 Ma, derived from the axial part of the main transtensional zone, were followed with background melts from a wider segment of the enriched lithospheric region at 1.3–0.8 Ma. Afterwards, in the past 0.6 Ma, background melting of the enriched lithosphere was focused mostly at the boundaries of the transtensional segment, whereas simultaneous local sub-lithospheric melting propagated within the shielding layer along the crack originated due to concentrating transtensional forces at the deeper central portion of the segment.
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