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Transcrustal magmatic system in lamprophyre dike constructed by multiple magma reservoirs

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Abstract

The mineral assemblages, chemistry, and textures of igneous rocks can record crucial information on magmatic processes in transcrustal magmatic systems. To effectively identify such processes, we present systematic petrological, mineralogical, and geochronological data for a suite of lamprophyre dikes that intruded early flood basalts in the Tuoyun basin of Western Tianshan. The lamprophyre dikes show ocean island, basalt-like trace element patterns and depleted Sr-Nd isotope compositions, suggesting that they were derived from a depleted mantle source. Apatite U-Pb dating reveals that the lamprophyre dikes were emplaced at 66 Ma. These lamprophyre dikes consist of three groups of mineral assemblages: (1) Type-I Clinopyroxene (Cpx); (2) Amphibole (Amp) core and Apatite (Ap); and (3) Amp rim, Type-II Cpx, K-feldspar (Kfs), and Plagioclase (Pl). These mineral assemblages are in chemical disequilibrium and correspond to three magma reservoirs within the transcrustal magmatic system. Textural and geochemical features demonstrate that Type-I Cpx represents antecrysts captured from lower crustal crystal mushes. The Amp cores have the same rare earth element patterns as their enclosed Type-I Cpx inclusions, demonstrating that the cores were produced through peritectic reactions consuming Cpx. The third assemblages occur as microlites formed by shallow crystallization of evolved melts. Thermobarometric calculations suggest a lower crust magma reservoir at 20–30 km depth, a middle crust magma reservoir at ~15 km depth, and a shallow upper crust magma reservoir at <5 km depth, making up a magma plumbing system of the lamprophyre dikes. The transcrustal magmatic system involves multiple stages of open-system processes, including the recycling of early-formed crystals, multiple magma replenishment, peritectic reactions, and crystal fractionation, resulting in the formation of lamprophyre dikes.

Keywords: Lamprophyre dikes, transcrustal magmatic system, antecrysts, peritectic reactions, Western Tianshan