LREEs, Zr, and Th Enrichment of Autometasomatic Alkaline Dikes in Mamuju, West Sulawesi, Indonesia: Constraints from Petrology and Whole-Rock Geochemistry

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The alkaline intrusive complexes and their weathering products are one of the main sources of REEs. Therefore, a better understanding of the petrogenesis of the alkaline rocks related to the enrichment of REEs and other critical elements is an essential future scientific goal. In this study, we present optical microscopy, XRD, SEM-EDS, and whole-rock geochemistry (XRF; ICP-MS/OES) studies of alkaline dikes to elucidate the petrogenesis and characteristics of the enrichment in LREE-Zr-Th. The alkaline dike can be categorized into Fitzroyite lamproite rocks, which mainly consist of leucite, phlogopite, and pyroxene (ferrosilite; augite-aegirine), with accessory minerals such as zircon and apatite. The alkaline dike is a part of the Adang volcano complex, which is related to metasomatic undersaturated silica rock formed within plate continental extension. Whole-rock geochemistry of alkaline dikes varies from 50 to 52 wt % SiO_2. The ultra-potassic series contains very high K_2O (7–8 wt%) and K_2O/Na_2O (3–6), with moderate Mg# values (33–56). Therefore, they can be classified as alkaline series and belong to the metaluminous rocks, with A/CNK ratios between 0.67 and 1.04. Furthermore, the large-ion lithophile elements (LILEs) are enriched, followed by Ti, Sr, and P depletion, with insignificant Eu anomalies. The alkaline dikes are enriched in LREEs (901–1,558 ppm), Zr (968–3083 ppm), Th (152–408 ppm), U (30–37 ppm), Nd (164–282 ppm), and Pb (148–460 ppm). The REE-bearing minerals include zircon, barioperovskite, romanechite, rhabdophane, and Si-Fe-Al-Zr-Ti-Ca (Ce) mineral. The enrichment in LREE-Th-Zr of alkaline dikes is related to primary enrichment processes (fractional crystallization) and secondary upgrading by deuteric processes (autometasomatisme), indicated by the pseudomorphism of primary minerals. The parent magmas are likely derived from a metasomatized sub-continental lithospheric mantle (SCLM) origin.