Apatite Lu-Hf geochronology of ultramafic cumulates: An example from Fanshan alkaline complex, North China Craton

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The radiogenic isotopic dating method of Lu-Hf system utilizes variations in $^{176}Hf/^{177}Hf$ resulting from the radioactive decay of ^{176}Lu to ^{176}Hf and variations in $^{176}Lu/^{177}Hf$ between rocks and different minerals. However, whole rock Lu/Hf isochrone often has too limited Lu/Hf variation to provide precise ages. Apatite, which is a common accessory mineral occurring in igneous, metamorphic and clastic sedimentary rocks, shows promises in Lu-Hf isochron dating for its preferential incorporation of rare-earth elements and its poor affinity for Hafnium, resulting in high $^{176}Lu/^{177}Hf$ ratios. Besides, apatite is a major host mineral for trace elements that provide massive information of provenance and petrogenesis process. Nevertheless, the low Hf yield of apatite poses obstacles on acquiring accurate and precise $^{176}Lu/^{177}Hf$ and $^{176}Hf/^{177}Hf$ values, thus severely impairing constructing high-precision Lu-Hf isochrones.

The Fanshan complex is an ultrapotassic alkaline-peralkaline pluton, located on the northern margin of North China Craton. It is a concentrically zoned complex, with syenite in the core, surrounded by ultramafic rocks and garnet-clinopyroxene syenite, respectively, towards the rim. The complex is known for its abundant phosphate reserves in apatite-magnetite deposit layer. Different isotopic systems have been utilized to constrain the emplacement age of the complex but give different results. In this work we analyze Lu-Hf isotopic system of magmatic apatite from Fanshan complex, together with clinopyroxene, biotite and whole rock in different zones, constructing Lu-Hf isochrones whose ages are parallel with U-Pb ages of baddeleyite and other accessory minerals in the same location. Combined with mineralogical characteristics, geochemistry and isotopic data, we propose that the three distinct zones of Fanshan complex are derived from a common parent magma, and they are products of crystallization from several batches of the same magma instead of only one batch of magma; the complex should originate from an enriched lithosphere mantle source.