

In Situ Hf isotopic composition of VMS-bearing volcanics from the Neoproterozoic Shadli Metallogenic Belt, South Eastern Desert, Egypt: Implications for Magma Evolution

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The Shadli Metavolcanics Belt, located in the South Eastern Desert of Egypt and part of the Arabian-Nubian Shield, is a key region for studying the formation of volcanogenic massive sulfide (VMS) deposits. The Younger Hamamid Metavolcanics (YHM) group, which hosts VMS mineralizations, consists of a succession of mafic and felsic lavas interbedded with variable volcanoclastics. These metavolcanics have undergone significant deformation, metamorphism, and erosion during polyphase orogeny, which complicates the understanding of their genesis and evolution. This study focuses on in situ Lu-Hf isotope analysis of zircons from basaltic to rhyolitic rocks within the YHM group to gain insights into their magmatic evolution and source characteristics. Magmatic zircons from the basaltic lavas exhibit variable $^{176}\text{Hf}/^{177}\text{Hf}(t)$ ratios ranging from 0.2820643 to 0.2823014, corresponding to ϵHf values from -0.5 to -10.3. These values indicate significant contributions from older crustal components. The TDM1 ages for these zircons range from 1340 Ma to 1797 Ma, while the TDMC ages span from 1706 Ma to 2322 Ma, further supporting the involvement of ancient crustal material in their genesis. In contrast, zircons from the intermediate rocks of the YHM group, specifically andesite and dacite, show positive ϵHf values (+5.4 to +13.3 and +5.2 to +12.7, respectively) and plot entirely above the Chondritic Uniform Reservoir (CHUR) line on the ϵHf versus U-Pb age diagram. This suggests that these rocks were derived from a juvenile source, likely associated with island arc magmatism. The initial Hf isotope compositions from a rhyolitic sample, dated at approximately 695 ± 6.1 Ma, display $^{176}\text{Hf}/^{177}\text{Hf}(t)$ ratios between 0.2825219 and 0.282852. The predominantly positive $\epsilon\text{Hf}(t)$ values ranged from +4.7 to +14.9, with TDM1 model ages between 705 Ma and 1200 Ma, and TDMC ages from 710 Ma to 1330 Ma, indicating a mantle-derived source with minimal crustal contamination. The data collectively suggest a temporal evolution in the magmatic sources of the YHM group, with a shift towards more juvenile, mantle-derived sources during the later stages of volcanism. This is evidenced by the decrease in $\epsilon\text{Hf}(t)$ values and the reduced presence of pre-Neoproterozoic crustal components over time, which is likely due to decreasing crust-mantle interaction.