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Petrogenesis of Neogene plutonic rocks from south Ardestan, Iran; mantle-derived arc magmatism

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The south Ardestan region in the Urumieh-Dokhtar arc covers an area of about 250 km2 that is characterized by plutonic rocks with a compositional spectrum ranging from gabbro, gabbro-norite, gabbroic diorite, diorite, tonalite to granodiorite. Gabbroic rocks are mainly tholeiitic in character, whereas the diorites, tonalites and granodiorites show increasingly stronger calc-alkaline affinity. Gradual compositional variation and limited variation in radiogenic isotopic ratios indicate that these different rock types are petrogenetically related and most probably are derived from a common primitive source. U-Pb LA-ICP-MS dating of zircon from four granitoids yielded ages that range from 25 to 24 Ma. For tonalitic rocks, internal Rb-Sr isochron ages (biotite, feldspars) indicate cooling ages that lie in the range 20.4 $\pm$ 0.1 to 22.1 $\pm$ 0.5 Ma, slightly younger than the zircons' ages. Their uniform initial Sr-Nd isotopic values imply that the major source component has probably been an asthenospheric mantle domain. This is further supported by the mantle-derived geochemical affinity of the plutonic rocks. A geodynamic model is presented in which the asthenospheric upwelling and partial melting in the south Ardestan has been triggered by Late Oligocene-Miocene rollback of the Neotethyan subducting slab. These melts were subsequently slightly modified through assimilation, fractional crystallization (AFC) en-route to the surface (A less than 6%). The trace element rich and high radiogenic Sr signature of some gabbros, this is the likely perturbation and then mobilization of Sr in the rock system during alteration. 43% fractional crystallization dominated by plagioclase and orthopyroxene is found responsible for magmatic evolution from gabbro to gabbroic diorite. Whereas, 44% fractional crystallization of a plagioclase-dominated mineral assemblage that also include clinopyroxene, titanomagnetite and orthopyroxene is found responsible for the evolutionary path from the gabbroic diorite to diorite. 22% fractional crystallization of amphibole and plagioclase is calculated as responsible for the differentiation path from diorite to tonalite. Assuming 6% crustal contamination effect inferred from isotopic trace elemental modelling by Cadomian crust, the major elemental crustal contamination effect on AFC product is found to be trivial. That is for K2O it is 10% and for other major elements less than 5%. M-REE abundances of the tonalites likely imply that a parental melts of these rocks have experienced significant amphibole differentiation due to a greater depth of magma chamber formation. We do not claim that our petrogenetic model for the south Ardestan plutonic rocks is representative for the whole UDMA. However, the new isotopic age and bulk rock data along with the mantle-dominated geochemical characteristics of the studied plutonic rocks open a new window for geodynamic interpretation and support a model suggesting that subduction still affected the UDMA in Miocene time.

Keywords: Urumieh-Dokhtar magmatic arc, plutonic rocks, U-Pb zircon ages, Rb-Sr biotite ages, Late Oligocene-Miocene, asthenopheric mantle, slab rollback