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Geochemistry and petrogenesis of Mashhad granitoids: An insight into the geodynamic history of the Paleo-Tethys in northeast of Iran

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ABSTRACT

Mashhad granitoids in northeast Iran are part of the so-called Silk Road arc that extended for 8300 km along the entire southern margin of Eurasia from North China to Europe and formed as the result of a north-dipping subduction of the Paleo-Tethys. The exact timing of the final coalescence of the Iran and Turan plates in the Silk Road arc is poorly constrained and thus the study of the Mashhad granitoids provides valuable information on the geodynamic history of the Paleo-Tethys. Three distinct granitoid suites are developed in space and time (ca. 217–200 Ma) during evolution of the Paleo-Tethys in the Mashhad area. They are: 1) the quartz diorite–tonalite–granodiorite, 2) the granodiorite, and 3) the monzogranite. Quartz diorite–tonalite–granodiorite stock from Dehnow–Vakilabad (217 ± 4–215 ± 4 Ma) intruded the pre-Late Triassic metamorphosed rocks. Large granodiorite and monzogranite intrusions, comprising the Mashhad batholith, were emplaced at 212 ± 5.2 Ma and 199.8 ± 3.7 Ma, respectively. The high initial $^{87}Sr/^{86}Sr$ ratios (0.708042–0.708368), low initial $^{143}Nd/^{144}Nd$ ratios (0.512044–0.51078) and low $\varepsilon_{Nd(t)}$ values (−5.5 to −6.1) of quartz diorite–tonalite–granodiorite stock along with its metaluminous to mildly peraluminous character ($Al_2O_3/(CaO + Na_2O + K_2O)$ Mol. = 0.94–1.15) is consistent with geochemical features of I-type granitoid magma. This magma was derived from a mafic mantle source that was enriched by subducted slab materials. The granodiorite suite has low contents of Y (≤18 ppm) and heavy REE (HREE) (Yb < 1.53 ppm) and high contents of Sr (>594 ppm) and high ratio of Sr/Y (>35) that resemble geochemical characteristics of adakite intrusions. The metaluminous to mildly peraluminous nature of granodiorite from Mashhad batholiths as well as its initial $^{87}Sr/^{86}Sr$ ratios (0.705469–0.706356), initial $^{143}Nd/^{144}Nd$ ratios (0.512204–0.512225) and $\varepsilon_{Nd(t)}$ values (−2.7 to −3.2) are typical of adakitic magmas generated by partial melting of a subducted slab. These magmas were then hybridized in the mantle wedge with peridotite melt. The quartz diorite–tonalite–granodiorite stock and granodiorite batholith could be considered as arc-related granitoid intrusions, which were emplaced during the northward subduction of Paleo-Tethys Ocean crust beneath the Turan micro-continent. The monzogranite is strongly peraluminous ($Al_2O_3/(CaO + Na_2O + K_2O)$ Mol. = 1.07–1.17), alkali-rich with normative corundum ranging between 1.19% and 2.37%, has high initial $^{87}Sr/^{86}Sr$ ratios (0.707457–0.709710) and low initial $^{143}Nd/^{144}Nd$ ratios (0.512042–0.512111) and $\varepsilon_{Nd(t)}$ values (−5.3 to −6.6) that substantiate with geochemical attributes of S-type granites formed by dehydration-melting of heterogeneous metasedimentary assemblages in thickened lower continental crust. The monzogranite was emplaced as a consequence of high-temperature metamorphism during the final integration of Turan and Iran plates. The ages found in the Mashhad granites show that the subduction of Paleo-Tethys under the Turan plate that led to the generation of arc-related Mashhad granites in late-Triassic, finally ceased due to the collision of Iran and Turan micro-plates in early Jurassic.

1. Introduction

The basement of Iran, which was consolidated in late Precambrian as the result of Pan-African orogeny, is composed principally of metamorphic rocks and in part granites. This basement was, however, fragmented and rifted from Gondwana as the Paleo-Tethys and Neo-Tethys oceans opened and later re-combined (Berberian and King, 1981; Şengör, 1987). These important tectonic events affected the Iranian and adjacent plates, including the African, Indian, Arabian, and Eurasian plates, during Cambrian to Tertiary times (Alsharhan et al., 2001). The Tethyan region, which comprises the Iranian plate and adjacent areas, was subjected to three major evolutionary stages. The

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