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Regional Magmatic Evolution and Metal Fertility of Igneous Rocks from the Kerman Porphyry Belt, SE Iran: Insights from Whole-Rock and Zircon Geochemistry and Geochronology

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The center of the Mesozoic-Cenozoic Neotethyan orogenic belt is located in Iran, where the porphyry-mineralized Urumieh Dokhtar Magmatic Arc (UDMA) extends from Urumieh in the NW to Dokhtar in the SE. The Kerman Porphyry Belt (KPB) is a well-explored and studied part of the Neotethyan orogeny and is located to the southwest of the UDMA. In the KPB, the main period of porphyry mineralization was early Middle Miocene, synchronous with the terminal collision of the Afro-Arabian and Eurasian plates. The KPB hosts several world-class porphyry Cu deposits, mostly associated with postcollisional calc-alkaline magmas including Sar Cheshmeh (13.6 ± 0.1 Ma; 1.7 Gt at 0.65% Cu, 0.03% Mo, 0.06 g/t Au) and Meiduk (12.5 ± 0.1 Ma; 500 Mt at 0.86% Cu, 0.01% Mo, 0.08 g/t Au), together with several smaller/less explored deposits such as Takht Gonbad (~26 Ma; ~60 Mt at 0.57% Cu).

In this study, we focused on the whole-rock and zircon geochemistry and geochronology of fertile and infertile igneous rocks that crop out in the region between Meiduk, Sar Cheshmeh, and Takht Gonabd in the KPB. Forty-six samples of fresh and altered volcanic and intrusive rocks were collected from surface outcrops and from diamond drill core at Takht Gonbad and Meiduk for whole-rock and zircon geochemistry analysis and geochronology. The samples were classified into nine different groups including Takht Gonabd porphyry (group 1), Takht Gonbad regional (group 2), Kuh-e-Panj (group 3), Sar Cheshmeh porphyry (group 4), Sar Cheshmeh regional (group 5), Meiduk porphyry (group 6), Meiduk regional (group 7), Rafsanjan 100k geologic map igneous rocks (group 8), and Neogene igneous suites (group 9).

The ages of zircons range from 42.6 ± 0.33 Ma (Dacite Lava) to 1.53 ± 0.17 Ma (andesite flow) from the Rafsanjan 100k geologic map area. Whole-rock assays have been combined with zircon chemistry to determine variations through time and differences between fertile and infertile magmatic suites by means of zircon and whole-rock REE trends, redox-sensitive Eu, and Ce enrichment/depletion. These data can be used to predict variations in magmatic water contents and magmatic oxygen fugacity as a proxy to porphyry fertility of the magmatic suites. The results showed maturation in arc magmatism from ~20 Ma in the KPB, which led to more evolved magmatism at later stages of arc history. The Pleistocene (1.6 ± 0.11 Ma) quartz-biotite-plagioclase-hornblende dacite porphyry flow dome near Sar Cheshmeh has the highest Sr/Y and La/Yb ratios, indicating early hornblende fractionation and higher water contents. These are the signatures of fertile magmas capable of producing porphyry mineralization.

Fig. 1. Total alkali silica classification diagram (Le Maitre, 1989) showing nine igneous suites from the Kerman Porphyry Belt.