Magma storage beneath Ardestan pluton, Iran; Insights from silicate minerals, zircon signatures and crystal size distribution

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Crystal cargo origins and bulk rock Zr-based thermometric parameters are fundamental to developing petrogenetic models of magmatism. The Ardestan quartz diorite to tonalite pluton, part of widespread Cenozoic magmatism within the Urumieh-Dokhtar magmatic arc, yielded LA-ICP-MS zircon age of 25.9 ± 0.3 Ma and 24.6 ± 0.1 Ma, respectively. The studied rocks are mainly composed of varying proportions of plagioclase feldspar (bytownite in the core to labradorite-andesine composition at the rim), magnesio-hornblende and magnesio-biotite. Zircons are depleted in LREE and enriched in HREE with restricted ranges in$(Gd/Yb)_N$ (0.03-0.07), positive Ce anomalies (Ce/Ce*= 0.4-113), negative Eu anomalies (Eu/Eu*=0.13-0.30) and high $(Sm/La)_N$ (>10) suggesting a magmatic origin. Enrichment in LREEs and moderate to negative Ce anomalies in some zircons is attributed to a change in the host magma composition and/or crystallization of zircon under high aqueous fluid activity near the end of magmatic crystallization. Ti-in-biotite geothermometery gives a mean crystallization temperature of 730± 56 °C, slightly higher than calculated $T_{Zr.Ti\ °C}$ (716± 50 °C) and similar to the average $T_{Zr.sat\ °C}$ (735± 26 °C). These results provide minimum estimates of temperature and indicate zircon crystallized from a fractionated magma. The resulting estimated fO_2 values show fairly high fO_2 (i.e., -13.6 to -16.9), indicating oxidizing crystallization conditions between the Ni-NiO (NNO) and Fe_2O_3-Fe_3O_4 (HM) buffers. Tight linear trends of halogen contents (F and Cl) versus X_{Mg} represent a narrow range of fH_2O, fHF and fHCl, clearly indicating that constant physico-chemical conditions throughout biotite growth. H The shape of crystal size distribution curves and the medium Al and Mg contents in amphibole and biotite, respectively, are consistent with a history of magma mixing involving injections of mafic magma into the evolving felsic chamber. Calculated residence time for Ardestan plagioclase crystals of ~630 years support field evidence that these plutons were emplaced at shallow depths.