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Magmatic and hydrothermal processes in the Mesozoic alkaline intrusions, Central High Atlas (Morocco): Petrography, mineralogy, and geochemistry

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In the Moroccan Central High-Atlas, the major outcropping magmatism corresponds to Mesozoic Jurassic-Cretaceous alkaline intrusions, which are important targets for geological exploration, with both scientific and economic interests. Like several alkaline igneous complexes worldwide, these Moroccan complexes could be potentially associated with mineral deposits of great economic value, such as rare earths, igneous phosphates, and igneous potash. Only a few studies have provided information on the petrogenesis of some individual intrusions and there is still a need for systematic petrographic, mineralogical, and geochemical data on the magmatic evolution of the entire alkaline suite and associated hydrothermal process. To fill this gap, we present new petrological, and mineral/whole-rock major/trace geochemical data from magmatic/metamagmatic rocks of four major alkaline intrusions of the Central High Atlas (Tirrhist, Tassent, Tasraft, Anefgou). Our results emphasize the strong similarity between these intrusions, which host almost all terms of alkaline magma differentiation series ranging from mafic (gabbros/olivine-gabbros), intermediate (monzodiorites/monzonites), to felsic rocks (syenites/quartz monzonites). The main cause of variation in rock facies is fractional crystallization, from the most primitive mafic rocks to the more felsic rocks. This is notably evidenced by the parallelism of trace element patterns (with slight pronounced negative Eu anomaly in the felsic rocks), pointing to a common source. Otherwise, a hydrothermal alteration (mainly Na-metasomatism) is involved and recorded in the intermediate and felsic facies. It is indicated by the striking Na enrichment (up to 8 wt.%), and the ubiquitous hydrothermal veins observed in the most evolved rocks. This post-magmatic event is probably responsible for the deposition of the fine gem and mineral specimens found in the Moroccan Central High-Atlas, such as fluorapatite, albite, titanite, zircon, epidote, prehnite, magnetite, and garnet.