Petrogenesis of the Bir Madi gabbro-diorite and tonalite-granodiorite intrusions, South Eastern Desert, Egypt: Implications for tectono-magmatic processes at the Neoproterozoic Shield

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Abstract
The Neoproterozoic rocks of the Bir Madi area, south Eastern Desert, comprise a metagabbro-diorite complex (GDC) and a tonalite-granodiorite suite (TGrS). The GDC has a weak tholeiitic to strong calc-alkaline character and is made up of olivine gabbro, hornblende gabbro, diorite and monzodiorite. The olivine gabbro is characterized by abundance of augite and labradorite with pseudomorphic serpentine. The hornblende gabbro is mainly composed of hornblende, labradorite, andesine and minor amounts of quartz with or without augite. The diorite consists essentially of andesine, hornblende, biotite and quartz. The GDC is compositionally broad, with a wide range of SiO$_2$ (46-57 %) and pronounced enrichment in the LILE (Ba and Sr) relative to the HFSE (Nb, Y and Zr). The metagabbro-diorite rocks exhibit petrological and geochemical characteristics of arc-related mafic magmas, derived possibly from partial melting of a mantle wedge above an early Pan-African subduction zone of the Neoproterozoic Shield. The tonalite and granodiorite have a calc-alkaline affinity and show the geochemical signatures of I-type granitoids. The TGrS contains amphibolite enclaves and foliated gabbroic xenoliths. Based on the field evidence and geochemical data, the GDC and TGrS are not related to a single magma type through fractional crystallization. The presence of microgranular amphibolite enclaves in the tonalitic rocks argues against their generation by partial melting of a mantle-derived basaltic source. The tonalitic magma was originated from partial melting of an amphibolitic lower crust (i.e. anatexis process) at a volcanic arc regime during construction of the Arabian-Nubian Shield. Fractional crystallization of K-feldspar and biotite gave the more evolved granodiorite variety from the tonalitic magma. The gabbroic xenoliths are similar in their chemical composition to the investigated metagabbros. They are incompletely digested segments from the adjacent metagabbro rocks incorporated into the granitic magma through an assimilation process.