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Mineral chemistry and geochemistry of the Late Neoproterozoic Gabal Abu Diab granitoids, Central Eastern Dessert, Egypt: Implications for the origin of rare metal post-orogenic A-type granites

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The Neoproterozoic Gabal Abu Diab pluton is a part of the Arabian Nubian shield (ANS) continental crust and located in the Central Eastern Desert (CED) of Egypt. It constitutes multiphase granitic pluton intruded into granodiorite and metagabbro-diorite rocks with sharp and nonreactive contacts. Based on field observations, colors, structural variations and petrographic investigations, this granitic outcrop consists of an inner core of two-mica granite (TMG) followed outward by garnet bearing muscovite granite (GBMG) and albite granite (AG). Petrographical study indicated that medium to coarse-grained TMG is dominated by K-feldspar (Or_{88-98}), quartz, plagioclase (albite, An_{0-7}), muscovite and biotite with hypidiomorphic texture. With exception the appearance of garnet and the disappearance of biotite the GBMG resembles the TGM, while AG is leucocratic without any mafic mineral. The main accessories are zircon, Nb and Ta-bearing rutile, columbite, ilmenorutile, ilmenite, magnetite and apatite. This mineralogical similarity and the existence of columbite group minerals (CGM) in all granitoids, indicates a cogenetic relationship. Microprobe analyses reveal that, besides the CGM, rutile and ilmenite are the main repository phases for Nb-Ta-Ti. Columbite-(Mn) exists as individual subhedral crystals (up to 100μm in size) or intimate intergrowth with Nb-bearing rutile and/or ilmenite. The CGM are represented mostly by columbite-(Mn) with Ta/(Ta+Nb) and Mn/(Mn+Fe) ratio ranging from 0.02-0.08 and 0.4-0.9, respectively suggesting extreme degree of magmatic fractionation. Rutile contains significant amounts of Ta (up to 4 wt.% Ta_2O_5) and Nb (up to 22 wt.% Nb_2O_5). Biotites are phlogopite-annite in composition ($Ann_{47-60}Phlog_{40-53,}$on average) and are enriched with Al^{IV} that characterize peraluminous granites. Garnets contain 60-69 mol.% spessartine and 28–36 mol.% almandine where, the ratio of spessartine and almandine together exceeds 95 mole percent, similar to garnet occur within A-type granite worldwide. According to Zhang et al., 2012, the garnet crystallized at the expense of biotite from the MnO-rich evolved melt after fractionation of biotite, plagioclase, K-feldspar, zircon, apatite, and ilmenite. The granitoids are alkali feldspar granites showing distinct geochemical features and most likely, belong to the post-orogenic younger Egyptian granitoids. They are peraluminous A-type alkaline rocks but they have lower Fe_2O_3, MgO, MnO, CaO, TiO_2, P_2O_5, Sr, Ba, V, and higher SiO_2, Na2O, K_2O, Nb, Ta, U, Zr, Th, Ga/Al and Rb than the typical rocks of this type. The positive correlation between Ba and Sr, and the negative correlation between Rb and K/Rb reveal fractional crystallization of alkali feldspar. The similarity in most geochemical characteristics suggests that Abu Diab granitoids are genetically related to each other and extremely enrichment in incompatible elements such as Nb and Ta, indicating that they crystallized from extremely differentiated magmas.

References:

Zhang, J., Ma, C. and She, Z., 2012. An Early Cretaceous garnet-bearing metaluminous A-type granite intrusion in the East Qinling Orogen, central China: Petrological, mineralogical and geochemical constraints. Geoscience Frontiers 3 (5), 635-646.