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Research Paper

Geochemistry of an Alaskan-type mafic-ultramafic complex in Eastern Desert, Egypt: New insights and constraints on the Neoproterozoic island arc magmatism

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ABSTRACT

Mikbi intrusion (MI) is a part of the Neoproterozoic Nubian Shield located along the NE–SW trending major fracture zones prevailing southern Eastern Desert of Egypt. In this study, we present for the first time detailed mineralogical and bulk-rock geochemical data to infer some constraints on the parental magma genesis and to understand the tectonic processes contributed to MI formation. Lithologically, it is composed of fresh peridotite, clinopyroxenite, hornblendite, anorthosite, gabbronorite, pyroxene amphibole gabbro, amphibole gabbro and diorite. All rocks have low Th/La ratios (mostly <0.2) and lack positive Zr and Th anomalies excluding significant crustal contamination. They show very low concentrations of Nb, Ta, Zr and Hf together with sub-chondritic ratios of Nb/Ta (2–15) and Zr/Hf (19–35), suggesting that their mantle source was depleted by earlier melting extraction event. The oxygen fugacity ($\log fO_2$) estimated from diorite biotite is around the nickel-nickel oxide buffer (NNO) indicating crystallization from a relatively oxidized magma. Amphiboles in the studied mafic-ultramafic rocks indicate relative oxygen fugacity (i.e. ΔNNO; nickel-nickel oxide) of 0.28–3 and were in equilibrium mostly with 3.77–8.24 wt.% H_2O_{melt} (i.e. water content in the melt), consistent with the typical values of subduction-related magmas. Moreover, pressure estimates (0.53–6.79 kbar) indicate polybaric crystallization and suggest that the magma chamber(s) was located at relatively shallow crustal levels. The enrichment in LILE (e.g., Cs, Ba, K and Sr) and the depletion in HFSE (e.g., Th and Nb) relative to primitive mantle are consistent with island arc signature. The olivine, pyroxene and amphibole compositions also reflect arc affinity. These inferences suggest that their primary magma was derived from partial melting of a mantle source that formerly metasomatized in a subduction zone setting. Clinopyroxene and bulk-rock data are consistent with orogenic tholeiitic affinity. Consequently, the mineral and bulk-rock chemistry strongly indicate crystallization from hydrous tholeiitic magma. Moreover, their trace element patterns are subparallel indicating that the various rock types possibly result from differentiation of the same primary magma. These petrological, mineralogical and geochemical characteristics show that the MI is a typical Alaskan-type complex.

1. Introduction

Mafic-ultramafic rocks as mantle-derived magmas produced in diverse tectonic settings can offer important information on Earth's evolution and tectonic processes. The geochemical characteristics of the magmas formed in each tectonic setting reflect the source chemical history. Mid-oceanic ridge (MOR) magmas which form ophiolites generally indicate that their mantle source underwent earlier partial melting events. Arc setting magmas which form concentrically zoned mafic-ultramafic intrusions indicate input of the subducted slab to the mantle source (e.g., Pearce and Stern, 2006; Helmy et al., 2015). Ophiolite sequences located along

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