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Mineralogy, geochemistry, and geotectonic significance of the Neoproterozoic ophiolite of Wadi Arais area, south Eastern Desert, Egypt

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ABSTRACT

The dismembered ophiolites in Wadi Arais area of the south Eastern Desert of Egypt are one of a series of Neoproterozoic ophiolites found within the Arabian–Nubian Shield (ANS). We present new major, trace, and rare earth element analyses and mineral composition data from samples of the Wadi Arais ophiolitic rocks with the goal of constraining their geotectonic setting. The suite includes serpentinized ultramafics (mantle section) and greenschist facies metagabbros (crustal section). The major and trace element characteristics of the metagabbro unit show a tholeiitic to calc-alkaline affinity. The serpentinized ultramafics display a bastite, or less commonly mesh, texture of serpentine minerals reflecting harzburgite and dunite protoliths, and unaltered relics of olivine, orthopyroxene, clinopyroxene, and chrome spinel can be found. Bulk-rock chemistry confirms harzburgite as the main protolith. The high Mg# (91.93–93.15) and low Al_2O_3/SiO_2 ratios (0.01–0.02) of the serpentinized peridotite, together with the high Cr# (>0.6) of their Cr-spinels and the high NiO contents (0.39–0.49 wt.%) of their olivines, are consistent with residual mantle rocks that experienced high degrees of partial melt extraction. The high Cr# and low TiO_2 contents (0.02–0.34 wt.%) of the Cr-spinels are most consistent with modern highly refractory fore-arc peridtotites and suggest that these rocks probably developed in a supra-subduction zone environment.

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Introduction

Abundant Neoproterozoic (ca. 750 Ma) ophiolites and ophiolitic mélanges are distinctive features of the Pan-African orogenic belt of the Arabian–Nubian Shield (ANS). Ophiolites are key components of the ANS, providing important clues about its origin and mineralization. The ANS ophiolites represent thrust sheets of ancient oceanic lithosphere, obducted over older continental basement (Shackleton *et al*. 1980) in the course of orogeny. They occur both as nappes (intact thrust sheet) and as mélanges (mixtures of tectonic fragments). The best-preserved ophiolites in the northern ANS contain all or most of the common stratigraphic sequence including pelagic sediments, pillowed basalts, sheeted dyke complexes, cumulate gabbros and peridotites, and tectonized peridotites. Several ANS ophiolites, including the Ghadir, Onib, and Ess localities (Hussein *et al*. 2004; Basta *et al*. 2011), have well-developed sheeted dike complexes, whereas a dike complex has not been reported in other localities.

Ophiolitic rocks of Neoproterozoic age are common in the central and southern sectors of the Eastern Desert of Egypt (Figure 1(a)), where they occur as highly altered serpentinites and talc-carbonate rocks enclosing rare relics of unaltered peridotite. These ophiolites were first described by Rittmann (1958), but later the complete ophiolitic sequence was well recorded in Wadi Ghadir (El Sharkawy and El Bayoumi 1979). Since then, the ophiolitic rocks of Egypt have generally been interpreted as parts of tectonically emplaced oceanic lithosphere (Shackleton *et al*. 1980; Ries *et al*. 1983; El Gaby *et al*. 1984, 1988; Abu El Ela 1996). Geochronologic results, summarized here, show that ophiolites of mid-Neoproterozoic age (690–890 Ma; mean = 781 ± 47 Ma) are abundant in NE Africa and Arabia (Stern *et al*. 2004). The Egyptian ophiolites have been reliably dated using Pb–Pb zircon evaporation techniques (Kröner *et al*. 1992; Loizenbauer *et al*. 2001) on zircons separated from gabbros and plagiogranites. Other ages have been obtained using Sm–Nd mineral and whole-rock techniques (Zimmer *et al*. 1995). According to Zimmer *et al*. (1995), Egyptian ophiolites formed over an interval of ~105 million years. The ages of the Egyptian ophiolites

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