Lithos 263 (2016) 52–65

Contents lists available at ScienceDirect

Lithos

journal homepage: www.elsevier.com/locate/lithos

A fore-arc setting of the Gerf ophiolite, Eastern Desert, Egypt: Evidence from mineral chemistry and geochemistry of ultramafites

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ARTICLE INFO

Article history:
Received 6 February 2016
Accepted 30 May 2016
Available online 10 June 2016

Keywords:
Neoproterozoic
Mantle rocks
Gerf ophiolite
Boninitic magma
Fore-arc

ABSTRACT

The Gerf ophiolite is the largest mantle-derived complex in the Arabian–Nubian Shield (ANS). This ophiolitic complex extends for tens of kilometers in the south Eastern Desert (SED) of Egypt as part of the Allaqi–Heiani and Oneib-Sol Hamed suture zones. The ultramafic section of the Gerf ophiolite comprises serpentinites, serpentinized peridotites and minor pyroxenites. All rocks contain relics of original magmatic phases. The elevated Cr# (>0.84) of Cr-spinels indicates that these rocks represent highly-depleted mantle residues after high degrees of melt extraction.

Mineral and bulk-rock chemistry show that the Gerf ophiolite suite represents fragments of oceanic lithosphere that developed in fore-arc setting in a supra-subduction zone (SSZ) environment. The pyroxenites have a LREE-enriched pattern relative to the serpentinites while the serpentinized peridotites display depleted patterns [average $(La/Yb)n = 0.56$)]. Modeling of LREE suggests that the LREE-enriched pyroxenites and serpentinites could have been produced via contamination of their mantle source by crustal material and/or subduction-related slab fluids during the mantle evolution in a SSZ setting or soon after ophiolite assemblage obduction onto the continental crust. In contrast, the LREE-depleted serpentinized peridotites could have been generated through MORB melt/mantle rock reaction.

1. Introduction

The Arabian–Nubian Shield (ANS) represents a juvenile crust that was formed during the Neoproterozoic by accretion of major fragments of East Gondwana (Australia, Antarctica, southern India) and West Gondwana (Africa, South America) (Abu-Alam et al., 2013; Johnson and Woldehaimanot, 2003; Stern, 2002). Ophiolites are important components of the ANS because they outline the sutures and the fossil subduction zones and help clarifying tectonic setting (e.g. Dilek and Ahmed, 2003; Stern et al., 2003). The ANS ophiolites date from 690 to 890 Ma (Stern et al., 2004). The Neoproterozoic ophiolites are common in the Eastern Desert (ED) of Egypt and belong to ANS. Ophiolite formation and emplacement is a significant evidence of Gondwana supercontinent assembly during the Neoproterozoic.

Ultramafic rocks are limited in the ED of Egypt. They are either parts of the zoned Alaskan-type complexes (Abd El-Rahman et al., 2012; Helmy et al., 2014, 2015), post-collisional extension-related layered intrusions (Abdel Halim et al., 2016) or dismembered fragment of ophiolitic successions. The Alaskan-type complexes are fresh dunite-clinopyroxenite-gabbro assemblages that commonly host Cu–Ni–PGE mineralizations (Helmy, 2004, 2005; Helmy et al., 1995). Layered intrusions comprise fresh lherzolite, orthopyroxenites, troctolites and gabbros (Abdel Halim et al., 2016). Ophiolitic ultramafics are represented by strongly deformed serpentinites enclosing rare peridotite and commonly host chromitites. The ED ophiolites experienced metamorphism ranging from low-grade green-schist to medium-grade amphibolite facies (e.g. El-Sayed et al., 1999; Farahat, 2008; Khedr and Arai, 2013). Their ultramafic section is mainly altered to serpentinite or to a combination of serpentine, talc, carbonate, magnesite, chlorite, tremolite, and magnetite.

A supra-subduction zone (SSZ) setting of the ED ophiolites is widely accepted (e.g. Ahmed et al., 2012a; Azer and Khalil, 2005; Azer and Stern, 2007; El Bahariya and Arai, 2003 and many others). Moreover, a back-arc basin setting is commonly inferred (Abdel-Karim et al., 2008; Ahmed et al., 2001; El Bahariya and Arai, 2003; El Gaby, 2005; El-Sayed et al., 1999; Farahat et al., 2004). This interpretation is based on the geochemical studies of the volcanic units of the ophiolite sequence. Only recently a fore-arc setting was suggested based on mineral and bulk-rock chemistry of serpentinites (Azer and Stern, 2007; Azer et al., 2013; Stern, 2004).

Ophiolites are common in the South Eastern Desert (SED) of Egypt (Fig. 1). The SED ophiolitic sequences form parts of major suture

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http://dx.doi.org/10.1016/j.lithos.2016.05.023
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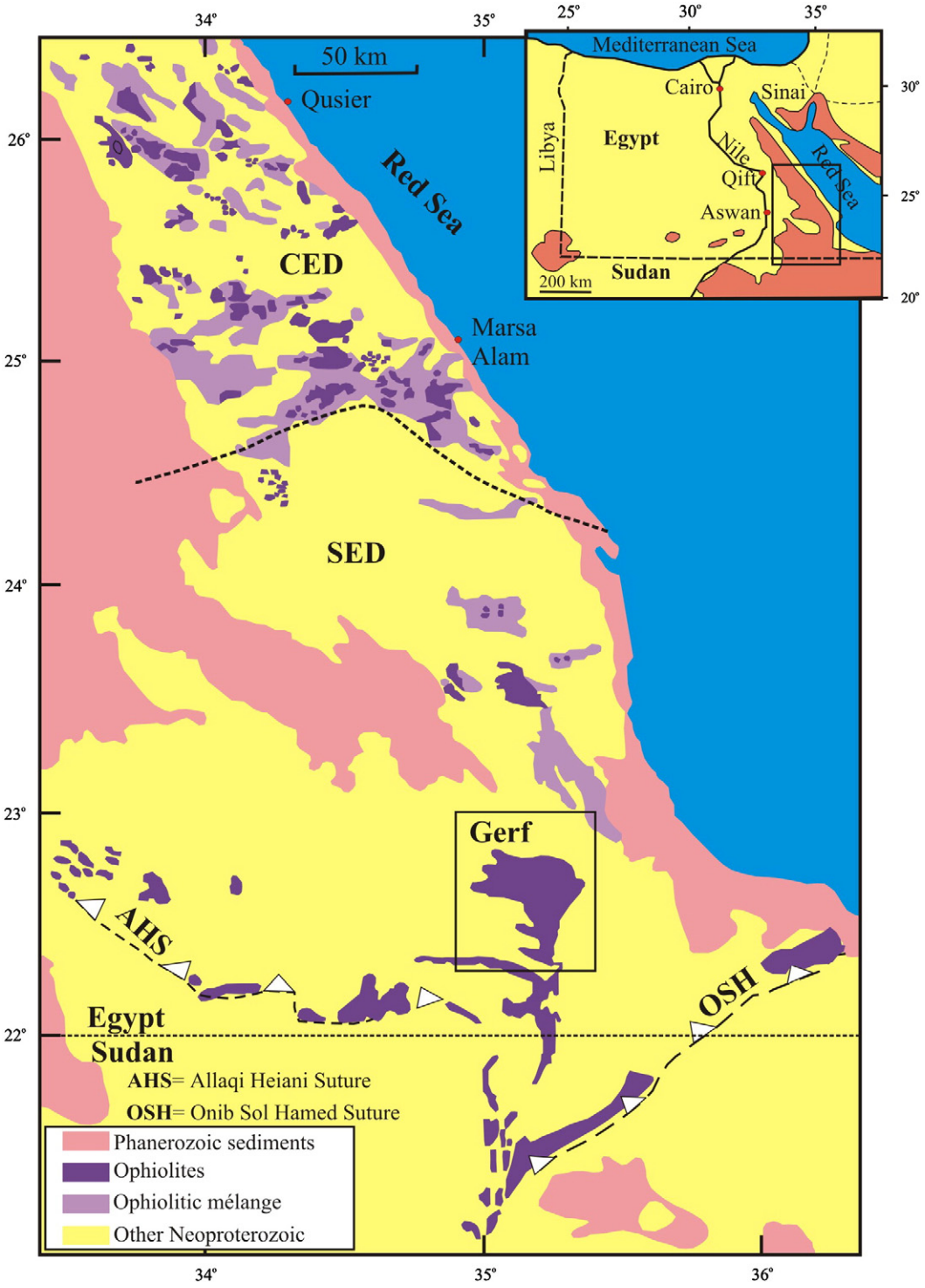

Fig. 1. Distribution of ophiolites in the Eastern Desert of Egypt and the location of the Gerf ophiolite (modified after Shackleton, 1994). Inset shows the general map of Egypt and the location of Fig. 1 is indicated.

zones: the Allaqi–Heiani and Onib-Sol Hamed suture zone (Fig. 1). Gabal Gerf ultramafites represent the largest ophiolitic body in the SED. Zimmer et al. (1995) studied the geochemistry of the isotropic gabbro and basalts and suggested a N-MORB setting. No data were presented for the ultramafic units. In this contribution we present bulk-rock, spinel, pyroxene, and olivine compositional data for the Gerf serpentinized ultramafics and describe for the first time pyroxenite layers from the Gerf ophiolites. The aim is to see if the geochemical evidence obtained from the ultramafic rocks support a N-MORB setting evident from the volcanic rocks (Zimmer et al., 1995) or a fore-arc setting like other ophiolitic sequences from the ED.

2. Field characteristics

The Gerf district is located 350 km southeast of Aswan City in the southern part of the SED of Egypt (Fig. 1). The Gerf nappe is the largest, apparently intact, ophiolite occurrence in the ANS (Abdel-Karim and Ahmed, 2010; Abdel-Karim et al., 2001; Zimmer et al., 1995). It is a