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Magnetic fabrics and Pan-African structural evolution in the Najd Fault corridor in the Eastern Desert of Egypt

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ABSTRACT

In order to assess the Pan-African structural evolution from early orogenic fabrics through Najd wrenching to the latest orogenic collapse/extension, the authors used field work, aided by aerial photographs and satellite images. This work is complemented by the study of the anisotropy of the magnetic susceptibility (AMS, or magnetic fabric). The Pan-African rock associations of the Um Gheig-Kadabora area can be divided into a lower tier composed mainly of amphibolite–migmatite and granitoid gneisses, and an upper tier of ophiolitic rocks, metavolcanics and their related volcaniclastics, and molasse-type Hammamat sediments. Both these units are intruded by late orogenic granitoid plutons and dykes. The lower tier is exposed in a domal structure in the El Sibai area, the upper tier forms a series of weakly to highly deformed thrust units, called Pan-African Nappes here, which are dissected by high strain shear zones. According to their age, these rock units are divided here into early and late-orogenic. The early orogenic rock association is characterized by medium–high metamorphic grades. The late orogenic rock association is characterized by low metamorphic grade. The rocks in the upper tier form a series of low angle thrust sheets, which are bounded by NW-striking high angle shear zones related to the Najd Fault System. The early orogenic rocks show a polyphase structural evolution with early folds, thrusts, and strike-slip shear zones. The late orogenic rocks show a relatively weaker deformation. The latest intrusives studied here are the dykes dissecting the late orogenic Kadabora granite. In the present work magnetic fabric data document the deformational features in detail and assess the role of the Najd Fault System in the deformational evolution. A strong variation in volume susceptibility of various rocks, due to their variations in mineral composition, is observed. Lower values are in the range of 10^{-6} SI units for late-orogenic alkaline granite and the dykes dissecting it, the highest susceptibilities exceed 7×10^{-2} SI units in magnetite-bearing serpentinite. Early orogenic rocks are characterized by relatively high anisotropies (P' up to 1.7) and are deformed in numerous shear zones. Most of these shear zones can be related to the Najd Fault System. In contrast, late orogenic sediments and intrusives show mostly low anisotropies. However, magnetic lineations are still distinctly oriented parallel with the Najd Fault trend. The very latest Pan-African intrusives, the broadly N–S trending dykes crosscutting the Kadabora pluton, imply c. E–W directed extension. Such an extension is consistent with the magnetic fabric in some of the dykes. Therefore, the Kadabora dykes mark the end of Najd wrenching and a late stage of extension in this part of the Eastern Desert of Egypt. The other dykes display mostly primary fabrics, related to magma flow during their intrusion and are thus post-deformational with regard to the Pan-African orogeny.

1. Introduction

The Pan-African orogeny in the Arabian–Nubian Shield (ANS) is characterized by a relatively short period of early collision and amalgamation of terranes, and a relatively long period of post-collisional structural and magmatic activity. According to Johnson et al. (2011) and Fritz et al. (2013) the northern part of the ANS amalgamated/sutured between c. 740 Ma and 700 Ma ago, whilst the structural and magmatic evolution lasted at least until the end of the Neoproterozoic. This latter period is characterized by both extensional, compressional, and wrench tectonics. A major regional structure is the Najd Fault System (Stern, 1985; Sultan et al., 1988; Johnson et al., 2011; Fritz et al., 2013), which

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cuts across the entire Arabian Shield for c. 1300 km (referred to as the Qazaz-Arika shear zone) and continues into the central Eastern Desert from SE to NW (Sultan et al., 1988; Fig. 1). Originally, it was regarded as a major strike-slip zone. However, subsequent work showed a more complex structure and evolution (Johnson et al., 2011; Fritz et al., 2013, and references therein). In particular, Fritz et al. (1996) envisaged separate, gneiss-cored structures aligned along the Najd Fault zone. Accordingly, the NW–SE trending strike-slip faults, which bound several gneiss domes (e.g. the Hajizah-Tin or Kirsh, An Nakhil, Wajiyah, and Ajjaj-Hamadat-Qazaz in the Arabian Shield, and the El Sibai and Meatiq domes in the Nubian Shield, Fig. 1), are discontinuous, and strain apparently decreases away from the gneiss domes. In the case of the El Sibai gneiss dome (Figs. 1 and 2), strike-slip displacements along the marginal faults should decrease both towards NW and SE. As a test of such a model and for further evidence on the structural evolution, the authors studied the Um Gheig-Kadabora area to the south and southeast of the El Sibai gneiss dome. Structural field work and sampling are complemented by studies of the magnetic fabric or anisotropy of magnetic susceptibility (AMS). AMS is applied in order to assess and quantify even weak deformation, which may not be easily detected by conventional methods. The AMS method has proved to be a powerful way of detecting bulk preferred orientation of minerals and/or crystal lattices (Borradaille, 1988). It can provide information on strain even in weakly deformed material (Kissel et al., 1986; Lowrie and Hirt, 1987; Lee et al., 1990; Aubourg et al., 1991). The AMS technique in combination with mesostructural studies has been widely used to complement structural work (e.g. Hrouda, 1982; Borradaille, 1988; Tarling and Hrouda, 1993; Borradaille and Henry, 1997; Hrouda and Jezeck, 1999; Borradaile and Jackson, 2004; Martin-Hernandez et al., 2004; Mallik et al., 2009; Mamtani et al., 2012), and is well-established as a fast and reliable method. Field mapping was complemented using traditional aerial photographs at a scale of 1:40,000 as well as geo-referenced false-color composite and band-ratio Landsat 7 Enhanced Thematic Mapper Plus (ETM+) images printed at a scale of 1:50,000. Attitudes of foliation, folds and faults were measured in the field and plotted on the geological map (Fig. 2). Oriented samples representing different rock units were collected for subsequent magnetic fabric studies (Tables 1 and 2).

2. Geological setting

The geology of the central Eastern Desert including the Um Gheig-Kadabora area has been described by many authors (e.g. Sabet, 1961; Akaad and El-Ramly, 1960; El-Ramly, 1972; El-Gaby, 1983; El-Gaby et al., 1984, 1994; EGSMA, 1989, 1992; Kamal El Din et al., 1992; Khudeir et al., 1992, 1995; Ashmawy, 1993; Kamal El Din, 1993; Greiling et al., 1994; Akaad et al., 1996; El-Sayed et al., 1999, 2002; Ibrahim and Cosgrove, 2001; Fritz et al., 1996, 2002, 2013; Fowler and Osman, 2001; Bregar et al., 2002; Abdeen, 2003; Abdeen and Greiling, 2005; Fowler et al., 2007; Abd El-Wahed, 2008; Youssef et al., 2009; Amer et al., 2010; Johnson et al., 2011). Accordingly, the Pan-African rock associations

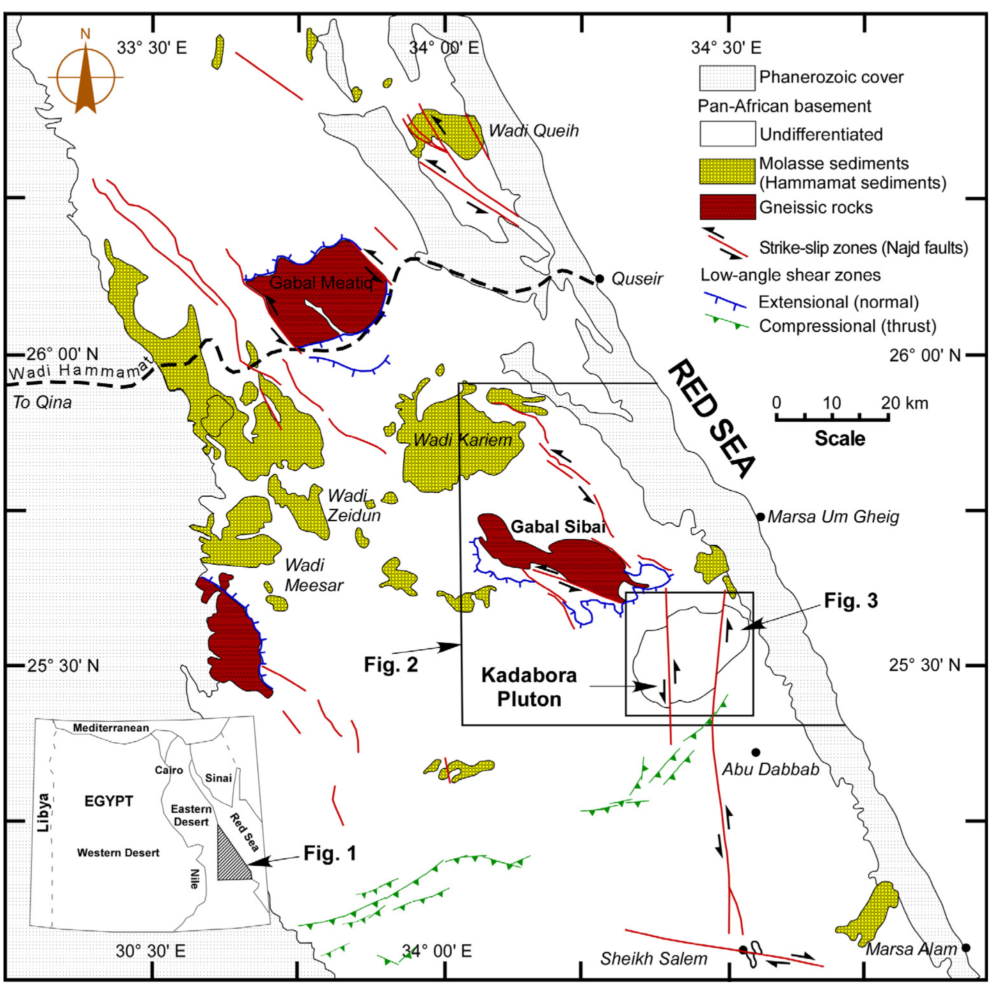

Fig. 1. Tectonic sketch map of the Central Eastern Desert of Egypt.