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Finite-strain analysis of Metavolcano-sedimentary rocks at Gabel El Mayet area, Central Eastern Desert, Egypt

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ABSTRACT

Finite strain was estimated in the metavolcano-sedimentary rocks, which surround by serpentinites of Gabel El Mayet area. Finite strain shows a relationship to nappe contacts between the metavolcano-sedimentary rocks and serpentinite and sheds light on the nature of the subhorizontal foliation typical for the Gable Mayet shear zone. We used the R_f/ϕ and Fry methods on feldspar porphyroclasts and mafic grains from 10 metasedimentary and six metavolcanic samples in Gabel El Mayet region. Our finite-strain data show that the metavolcano-sedimentary rocks were moderately deformed and axial ratios in the *XZ* section range from 1.9 to 3.9. The long axes of the finite-strain ellipsoids trend W/WNW in the north and W/WSW in the south of the Gabel El Mayet shear zone. Furthermore, the short axes are subvertical to a subhorizontal foliation. The strain magnitudes increase towards the tectonic contacts between the metavolcano-sedimentary rocks and serpentinite. The data indicate oblate strain symmetry in the metavolcano-sedimentary rocks. Hence, our strain data also indicate flattening strain. We assume that the metasedimentary and metavolcanics rocks have similar deformation behaviour. The fact that finite strain accumulated during the metamorphism indicates that the nappe contacts formed during the accumulation of finite strain and thus during thrusting. We conclude that the nappe contacts formed during progressive thrusting under brittle to semi-brittle deformation conditions by simple shear and involved a component of vertical shortening, which caused the subhorizontal foliation in the Gabel El Mayet shear zone.

1. Introduction

The Central Eastern Desert of Egypt (Fig. 1) is characterized by a series of high-grade core complexes surrounded by low-grade volcano-sedimentary nappes of Neoproterozoic age (Fritz et al., 1996, 2002). The core complexes and the major tectonic trend on both sides of the Red Sea strike northwest–southeast and are related to a crustal-scale sinistral shear zone called the Najd Fault System (Stern, 1985). However, several belts in the Eastern Desert are discordant to the Najd Fault System. These belts include the Allaqi-Heaini and Abu Swayel belts in the southern Eastern Desert (Abdel Naby et al., 2000; Abdel Naby and Frisch, 2002), and the Wadi Mubarak belt in the Central Eastern Desert (Shalaby et al., 2005). The tectonic setting of most of these belts is explained as a part of the Pan-African nappe sequence (Berhe, 1990; Abdel Rahman, 1995; Abdel Naby et al., 2000; Blasband et al., 2000). Understanding the evolution of these belts is important for the interpretation of the Eastern Desert within the tectonic framework of the Neoproterozoic Pan-African orogeny. The Wadi Mubarak belt is located in the centr of the Najd Fault System between the Sibai dome and the Hafafit dome (Fig. 1). Structural correlation is facilitated by a series of intrusions into the Wadi Mubarak belt which resemble other intrusions in the Eastern Desert. The Wadi Mubarak belt contains two types of major structures: thrusts with intermediate dip and steep shear zones with a dominant strike slip component of motion (Fig. 2). Major thrusts bound the belt in the south and north, but local thrusts are also common within the belt and are related to the development of the regional fabric (Shalaby et al., 2003, 2005, 2006). Furthermore, the gneissic domes were referred to as "infrastructure" by El Gaby et al. (1990). They constitute of orthogneisses, psammitic schists and rare amphibolites that suffered amphibolite grade, polyphase metamorphic conditions (Neumayr et al., 1996, 1998). Volcano-sedimentary assemblage that constitute the Pan-African Nappes, are referred to as "suprastructure" by El Gaby et al. (1990), structurally overlie the gneisses. These volcano-sedimentary rocks are commonly referred to as ophiolitic mélange. They comprise ophiolites and calc-alkaline island-arc rocks and associated volcanoclastics metamorphosed at greenschist facies (Neumayr et al., 1998; Puhl, 1997). Based on the tectonic juxtaposition of low-grade metamorphosed cover units against high-grade metamorphosed basement, the gneissic domes

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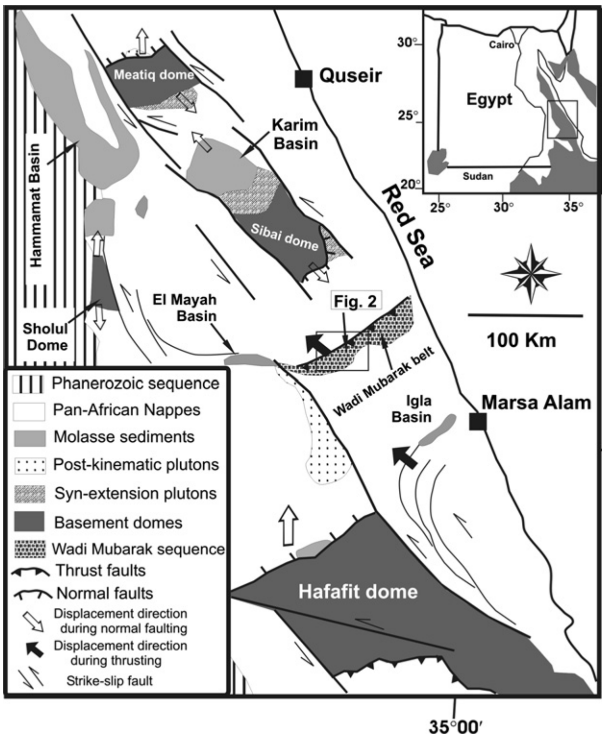

Fig. 1. Geological sketch map of Central Eastern Desert of Egypt (after Shalaby et al., 2006).

have been described as metamorphic core complexes (Sturchio et al., 1983). Gabel El Mayet area is part of the basement complex of Egypt exposed in the Central Eastern Desert of Egypt. It comprises a succession of low-grade volcano-sedimentary rocks of island-arc and back-arc affinity (El Aref et al., 1993a; Akaad et al., 1995).

A number of finite-strain studies from natural shear zones show oblate geometries (Coward, 1976; ÓHara, 1990; Bailey et al., 1994; Ring, 1999; Kassem and Ring, 2004; Abdeen and Greiling, 2005). These oblate fabrics may result from volume loss in simple shear zones or from a component of pure shear accompanying shearing with or without volume loss (Ramsay and Wood, 1973; Simpson and De Poar, 1993; Mukul and Mitra, 1998; Kassem and Ring, 2004). A quantification of finite strain and the degree of non-coaxiality are needed to evaluate the significance of such oblate strain geometries and their relation to the flat-lying foliation which is characteristic of nappes in the internides of many orogens. In the Arabian–Nubian shield, nappe contacts are, at least in part, major lithological boundaries and the occurrence of metavolcano-sedimentary rocks between gneiss units are often used to map nappe boundaries (El Gaby et al., 1990; Fritz et al., 1996; Neumayr et al., 1996, 1998; personal communication with Dr. Samir El Gaby). The Gabel El Mayet region is a complicated structure. In addition, the contact between the serpentinite, which is surrounded by metavolcano-sedimentary rocks, is also a major lithological boundary marking the trace of a low-angle thrust fault, effected by northwest-southeast sinistral shear zones of the Najd Fault System (Stern, 1985).

Our main objective in this paper is to examine the finite strain and strain variation patterns in the metavolcano-sedimentary rocks and infer the possible direction of tectonic transport within the realm of Gabel El Mayet shear zone. Other major problems include the relationship between finite strain and tectonic contacts between the metavolcano-sedimentary rocks and serpentinite to explain the stage of orogeny during nappes form.

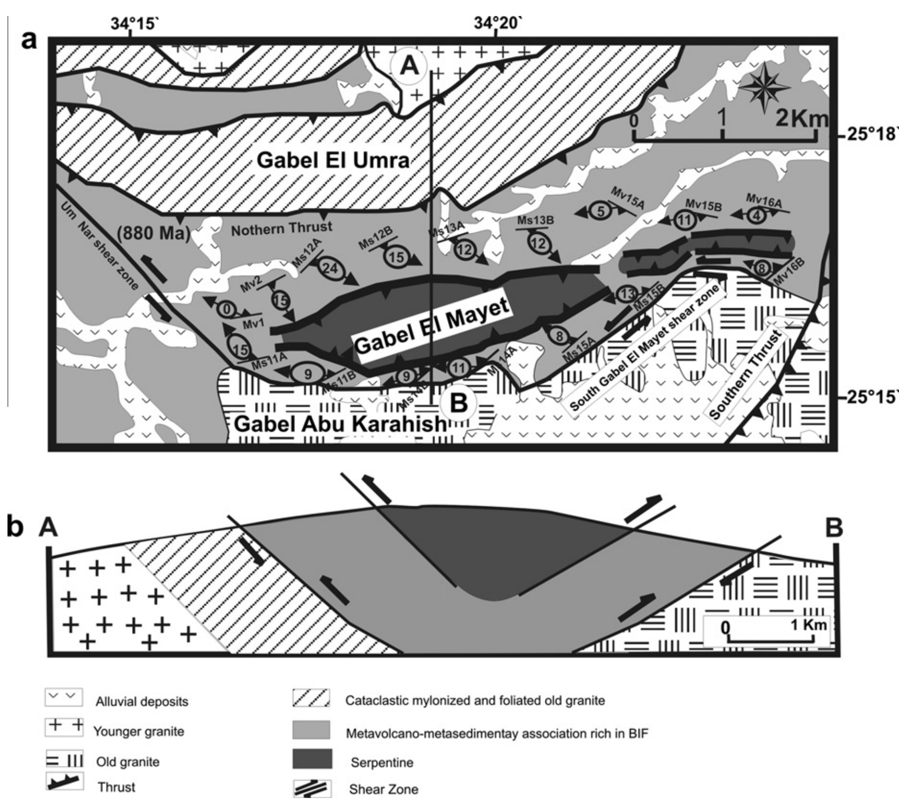

Fig. 2. (a) Tectonic map of Gabel Mayet and adjacent area (after Shalaby et al., 2005), and map showing samples locations show strike and plunging directions, arrow heads indicate orientation of lineation for long axes. The shape of the strain ellipsoids ($Z = 1$) are shown as grey color, plunge values inside the ellipses. (b) Cross-section *N–S* showing spatial distribution of lithological units and regional structures.