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Structural constraints on the evolution of the Meatiq Gneiss Dome (Egypt), East-African Orogen

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ABSTRACT

Amphibolite-grade quartzofeldspathic gneiss domes surrounded by greenschist-grade island arc and ophiolitic assemblages is a characteristic feature of the Arabian–Nubian Shield in the Eastern Desert of Egypt. The mode of formation of these domes, including the Meatiq Gneiss Dome, is controversial, as is the protolith age of these gneisses. Reinvestigation of selected segments of the Eastern Desert Shear Zone (EDSZ), a high-strain zone separating the eugeoclinal units from the underlying quartzofeldspathic gneisses show it to be a top-to-the NW shear zone which was later folded about a NW–SE trending fold axis (long axis of the gneiss dome). Kinematic indicators (shear bands, duplex structures, etc.) along the north-eastern and south-western flanks of the dome therefore show apparent left-lateral and right-lateral strike-slip displacement across the EDSZ. These observations are in conflict with most previous tectonic models which link formation of the dome to extension in a NW–SE oriented corridor bordered by two sub-parallel left-lateral NW–SE oriented strike-slip faults. Emplacement of upper crustal, low-grade, eugeoclinal rocks tectonically on top of middle crustal amphibolite-grade quartzofeldspathic gneisses indicates that the EDSZ may represents an extensional fault with a possible break-away zone in the southern part of the Eastern Desert. Alternatively it can be explained as the result of two (or more) tectonometamorphic events with an intervening episode of erosion and exhumation of high grade rocks prior to emplacement of the eugeoclinal thrust complex. Recent U–Pb TIMS ages on syntectonic orthogneisses and post-tectonic granites in the area show that shearing and subsequent doming must be younger than 630 Ma, possibly as young as 600 Ma.

1. Introduction

A peculiar feature in the western part of the Arabian–Nubian Shield (ANS) is the presence of medium- to high-grade ortho- and para-gneisses surrounded by low-grade (greenschist grade) metasedimentary and metavolcanic assemblages of island arc affinity with variably well-preserved ophiolite fragments (Fig. 1) (Kröner, 1979; Sturchio et al., 1983; El Gaby et al., 1988, 1990; Fritz et al., 2002; Andresen et al., 2009). These high-grade metamorphic gneiss terrains are particularly well developed in the Eastern Desert of Egypt, but also occur in Sinai (Kröner et al., 1994; Blasband et al., 2000). The gneisses appear in most places as dome-like structures, and a high-strain zone, hereafter named the Eastern Desert Shear Zone (EDSZ) separates the high grade rocks from the structurally overlying low-grade eugeoclinal rocks. Both the high- and low-grade units are intruded by younger undeformed/post-orogenic circular granitic plutons.

Various tectonic models have been proposed to explain the formation of the gneiss domes and the abrupt change in metamorphic grade between the gneiss domes and the overlying eugeoclinal rocks. Sturchio et al. (1983a,b) compared the gneiss domes of the Eastern Desert to metamorphic core complexes associated with crustal scale extension, as in the North American Cordillera (e.g. Lister and Davis, 1989), but Sturchio et al. (1983a,b) concluded that the Meatiq dome was the result of contractional tectonics and thrusting. Others link formation and exhumation of the domes to NW–SE oriented crustal scale strike-slip faulting and formation of pull-apart basins separating the gneiss domes (e.g. Bregar et al., 2002). A third model has been advocated by Fritz et al. (1996, 2002) and Fritz and Messner (1999) who propose that the domes are the result of E–W shortening combined with transcurrent faulting. The postulated strike-slip faults associated with the gneiss domes in the Eastern Desert are often linked to the NW-striking Najd Fault System on the Arabian Peninsula (Fig. 1; Stern,

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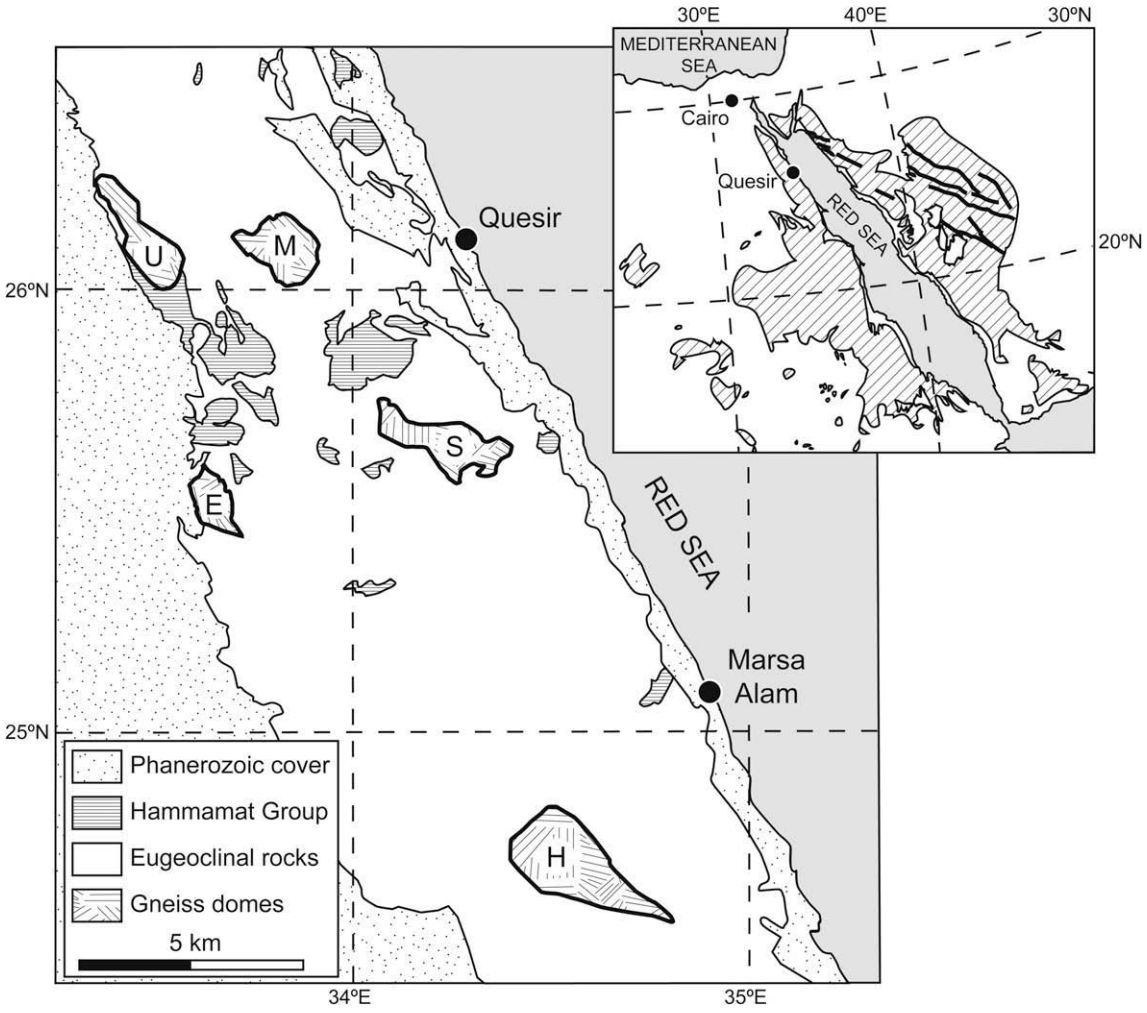

Fig. 1. (a) Overview of the Central Eastern Desert, Egypt, modified from Fowler et al. (2007). Gneiss complexes shown are the Meatiq (M), Um Had (U) El Shalui (E), Sibai (S) and Hafafit (H). Inset shows the extent of the Arabian Nubian Shield (striped), and elements of the left-lateral Najd fault system (thick lines) on the Arabian peninsula, simplified from Abdeen and Greiling (2005) and Sultan et al. (1988). (b) Simplified geological map of Central Eastern Desert showing the location of the three main gneiss domes. Also shown are some of the late-orogenic molasse basins (Hammamat Group).

1985; Fritz et al., 1996). Greiling and El Ramly (1985) and Greiling et al. (1988, 1994) interpret some of the domes as ramp anticlines related to crustal thickening and NW-ward thrusting. Loizenbauer et al. (2001) interpreted the Meatiq Gneiss Dome, the subject of this contribution, to be a metamorphic core complex formed by (NW–SE) crustal extension following thrusting. In recent years some authors have argued that formation of the domes is strongly controlled by diapiric emplacement of Late Neoproterozoic plutons located at depth below the domes (Bregar et al., 2002; Fritz et al., 2002; Neumayr et al., 1998).

To test these models and to constrain the formation of the gneiss domes in time and space, a combined geochronological and structural study of the Meatiq, Hafafit and Sibai gneiss domes in the Central Eastern Desert, Egypt has been undertaken. Zircon and titanite U–Pb TIMS data from granitoids and orthogneisses in the Meatiq Gneiss Dome provide the first temporal constraints (Andresen et al., 2009). These data indicate a magmatic emplacement age of 631 ± 2 Ma for the Um Ba'anib Orthogneiss, and emplacement of several large and small syn-tectonic granitoids in the time interval 609–605 Ma (Fig. 2b). Below we present new structural data from key areas along the contact between the high- and low-grade units. Our work focuses particularly on the postulated left-lateral strike-slip faults bordering the Meatiq Gneiss Dome to the NE and SW. Based on these new data it is concluded that there is little support for the strike-slip model originally proposed by Wallbrecher et al. (1993), and used as a tectonic framework for several subsequent publications (Neumayr et al., 1996; Fritz et al., 2002; Loizenbauer et al., 2001).

2. Regional geology

The deformed and variably metamorphosed pre-Cretaceous rocks making up the Eastern Desert of Egypt can be subdivided into three main lithotectonic units: (i) a lower tectonostratigraphic unit composed of medium and high-grade metamorphic ortho- and para-gneisses, (ii) a structurally overlying low grade unit of ophiolite and island arc assemblages with (iii) a sequence of non-metamorphosed to weakly metamorphosed and deformed volcanic (Dokhan Volcanics) and sedimentary rocks (Hammamat Group) unconformably on top (Fig. 1). All these units are intruded by numerous post-orogenic granitic plutons. The post-orogenic granitoids range in age from 610 Ma to 550 Ma (Stern and Hedge, 1985; Moghazi, 1999; Moghazi et al., 2004; Andresen et al., 2009). Variably deformed (syn-tectonic) calc-alkaline plutons ranging in age between c. 700–600 Ma are widespread in the units underlying the Dokhan Volcanics and the Hammamat Group (Kröner et al., 1994). The medium- and high-grade gneisses are often referred