Journal of

# African Earth Sciences

## Special Issue
## Arabian-Nubian Precambrian Basement Geology – Progress and Developments

*Guest Editors*

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Journal of African Earth Sciences
Volume 99, Part 1, 2014

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Journal of African Earth Sciences 99 (2014) 1–3

Contents lists available at ScienceDirect

Journal of African Earth Sciences

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

Editorial

# Arabian–Nubian Precambrian basement geology – Progress and developments: Introduction to the issue in honour of Samir El-Gaby

The Egyptian Eastern Desert and Sinai represent an intensively studied and critical portion of the Arabian–Nubian Shield (ANS) in Egypt. The Pan-African ANS (900–550 Ma) extends from Egypt through Sudan and Eritrea to Ethiopia on the western side of the Red Sea rift, and from Israel and Jordan through Saudi Arabia to Yemen on the eastern side of the Red Sea. The ANS was formed after intra-oceanic subduction of the Mozambique Ocean and accretion of island arc terranes, followed by collision of east and west Gondwana, and crustal extension that was accompanied by the intrusion of vast amounts of granitoid magmas. The ANS itself forms a part of the larger East African Orogen (EAO) that incorporated the juvenile materials composing the ANS and the older continental crustal materials occupying its margins. The EAO extends southwards from the shield into rejuvenated pre-ANS crust of the Mozambique Belt of Tanzania. The ANS formed during a critical stage of Earth's history spanning the sudden appearance of complex life forms in the Ediacaran, major changes in atmosphere and climate, and early evidence for tectonic styles that were to distinguish the Precambrian from the Phanerozoic Eon.

Throughout a long and academically productive career committed to deciphering the geological history of the Egyptian part of the ANS, the late Professor Samir El-Gaby was widely recognized for his influential tectonic models that were an inspiration for generations of Egyptian geoscientists from the 1960s to the present day, and helped to attract international interest and involvement in fundamental programmes of research in the Egyptian Proterozoic basement. In this role the present editors came into contact with him as a discussion partner at national and international conferences, or in their publications (e.g. Fowler and Osman, 2001; Abdeen and Abdelghaffar, 2011), and as co-editor to a volume on the Pan-African belt of NE Africa (El-Gaby and Greiling, 1988). Samir El-Gaby's international standing is manifested by numerous joint publications with co-authors from abroad and his frequent visits to central Europe, where, among others, the third editor was his host at several occasions.

This issue is dedicated to the esteemed Professor El-Gaby in recognition of his monumental contributions to the understanding of the Proterozoic evolution of the northern part of the ANS.

The issue assembles twelve research papers of more than twenty submitted or considered at an earlier stage. Whilst some of these have already been published, others are still at the review stage. In order not to delay the publication of those papers, which are already completed, we decided to go ahead with this issue. The reader is referred to later issues of the Journal, which will, eventually, contain further papers dedicated to Samir El-Gaby. The contributions to this volume cover a diversity of problems including geochemical, petrological, structural, tectonic, and resource geological aspects of the ANS in Egypt and northwestern Saudi Arabia. The issue divides these topics into three groups: geochemistry and petrology; structural evolution; and ore deposits and remote sensing.

## Geochemistry and petrology

Geochemistry and petrology were one of the major interests of Samir El Gaby, and we are glad about the three contributions dealing particularly with these subjects. *Abu-Alam* and *Hamdy* present detailed studies and thermodynamic modelling results on the Sol Hamed Ophiolite, which is, historically, one of the mafic–ultramafic complexes of the ANS that was first recognized as an ophiolite fragment. The ophiolite probably formed in a supra-subduction zone setting and was infiltrated by $CO_2$-rich fluids during subduction. A second stage of fluid activity occurred during prograde metamorphism. The paper sheds new light on the fluid activity during the Pan-African orogeny, an aspect of importance for both tectonic considerations and for the genesis of ore deposits. The Sol Hamed Ophiolite is part of a larger ophiolite complex in SE Egypt, which is cut in two by the Hamisana Shear Zone (HSZ). The HSZ is the topic of *Ali-Bik*, *Sadek*, and who provide new petrologic evidence on the genesis of the HSZ rocks and their metamorphic evolution. These rocks comprise ophiolites and sequences of volcanic arc igneous rocks together with related sediments, which experienced a polyphase structural and metamorphic evolution from amphibolite grade to retrogression. The paper also documents the interaction between petrogenesis and the Pan-African structural evolution.

One of the last major Pan-African igneous activities produced the post-collisional granites in the Central Eastern Desert, which are tackled by *Osman and El Kalioubi*. In particular, the Um Had and Um Effein plutons of monzogranite, syenogranite and alkali feldspar granite show LREE enriched patterns and negative Eu anomalies, typical for post-collisional granites. The authors present geochemical discrimination diagrams implying fractional crystallization and crustal contamination of the granitoids, and their transitional character between calc-alkaline magmatic arc and within-plate settings. This transition accompanies the evolution from orogenic compression to subsequent extension, probably controlled by lithospheric delamination.

## Structural and tectonic evolution

Another major interest of the late Prof. Samir El-Gaby was the tectonic history of the Arabian–Nubian Shield. The following six

http://dx.doi.org/10.1016/j.jafrearsci.2014.06.004

papers on structure and tectonic evolution cover important aspects of this theme. An important terrane boundary between the Jeddah and Asir terranes in the southern Arabian shield is represented by the Ad Damm Shear Zone investigated by *Hamimi, El-Sawy, El-Fakharani, Matsah, Shujoon, and El-Shafei*. The authors have discovered that there is more to the history of this NE-trending dextral shear zone than just the role of conjugate to the NW-trending sinistral Najd system that it has been previously reported. They have discovered several distinct deformation events contributing to the activity of the Ad Damm Shear Zone since 620 Ma. Arabian shield post-amalgamation depositional basins and their structural history are compared by *Hamimi, El-Fakharani, and Abdeen* with Hammamat basins in the Nubian Shield. The Fatima and Ablah basins of the Jeddah and Asir tectonic terranes, respectively, are found to be transcurrent fault related structures that formed during or just after the Nabitah Orogeny (680–640 Ma), and were later multiply deformed by thrusting and folding. The Hammamat basins studied were developed in the Central and Southern Eastern Deserts. These basins also showed thrust and transcurrent fault related deformations.

Najd fault activity in the Central Eastern Desert of Egypt has been traced in time via the magnetic signatures it has left in early and late orogenic rocks of the Um Gheig – Kadabora area reported by *Abdeen, Greiling, Sadek and Hamad*. The authors show that the effects of Najd tectonics on magnetic anisotropies are strong in the early orogenic units, and weak but detectable in the later orogenic units. Najd activity had evidently ceased by the time of intrusion of the dykes in the Kadabora granite which marks a post-Najd stage of extension. Magnetic fabrics have also been employed in the study of the Um Had – Wadi Atalla – Wadi Hammamat area on the western side of the Central Eastern Desert by *Greiling, de Wall, Sadek, and Dietl*. Comparison of the magnetic fabrics of the Um Had and Um Sheqila plutons with the polyphase-deformed wallrocks reveals that these intrusions are not post-deformation but late syn-deformation and are associated with a regional NW-SE trending transcurrent shear zone. They point to a possibly more internal orogenic position for this area.

The detailed history of exhumation of the Meatiq gneissic dome in the Central Eastern Desert is illustrated by *Fritz, Loizenbauer, and Wallbrecher*. The authors have investigated the mechanism and timing of exhumation using detailed strain studies of a syn-extension pluton, and fluid inclusion data to constrain a model that explains the physical relations between the gneissic core and overlying nappes during the exhumation event between 600–580 Ma. The deformation history of mylonitized gneisses in the Migif area at the boundary between the Central and South Eastern Deserts was characterized by *Kassem*, using vorticity measurements on rotated porphyroclasts. He concludes that the stacking of nappes during their transport provided a vertical shortening that resulted in a horizontal foliation and a deviation of the strain in the mylonites from simple shear.

## Ore deposits and remote sensing

This issue contains three papers dealing with gold mineralization in the Arabian–Nubian Shield. The first two deal with auriferous quartz ± carbonate veins in the Haimur and Dungash areas in the south and central Eastern Deserts of Egypt, respectively, while the third deals with the placer gold in the stream sediments between Duba and Al Wajh, Red Sea coast, northwestern Saudi Arabia.

In the Haimur area, *Zoheir and Emam* used the capability of the Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER) image data in mapping structures and hydrothermally altered zones for identification of possible mineralized alteration zones. Remote sensing is crucial for mineral exploration in two ways: (1) map geology and faults and fractures that localize ore deposits; (2) recognize hydrothermally altered rocks by their spectral signatures. The authors applied automated lineament extraction by LINE module process on high resolution ASTER data, which located dilation loci. They also applied mineral indices (band ratios) on ASTER data, which identified zones of possible mineralized alteration. These zones were found to be associated with the dextral NE-trending brittle-ductile shear zones that deform the early accretion-related structures.

In the Dungash area, *Zoheir and Weihed* discuss the geochemistry of the host metavolcanic/metavolcaniclastic rocks and suggest derivation from a low *K*, calc-alkaline magma in a subduction-related, back-arc basin setting and low-grade metamorphism, typical of gold-hosting greenstone belts elsewhere. The shear zone-related setting, mineralogy and isotopic characteristics of gold mineralization in the Dungash area are comparable with other orogenic gold deposits in the region (e.g., Barramiya deposit), which may suggest a regional setting controlling gold metallogeny of the region. The auriferous ore bodies in the Haimur and Dungash areas are associated with NE- and E-trending hydrothermally altered brittle-ductile shear zones, respectively. These shear zones are genetically related to the late Neoproterozoic dextral transpression that deforms earlier accretion-related folds and thrusts. Authors pointed out that this setting should guide future exploration programs in the central Eastern Desert province.

In the Duba–Al Wajh area in NW Saudi Arabia detailed ore microscopic studies supported by fire assay data of the heavy fraction of the stream sediments by *Moufti* show economic concentrations of gold in their silt fraction (40–63 μm) and also in the extremely fine fraction (⩽40 μm) as "dusty gold". Generally, fire assay data of gold proved that samples from the wadis in the southern sectors are more promising for future gold exploration and exploitation.

Altogether, the contributions in this issue reflect the breadth of the scientific interests of the late Professor Samir El-Gaby. The assembled papers also provide insights into the scientific progress and new developments of the studies in the basement of the ANS, which may serve as case examples for similar basement studies elsewhere. We hope, this issue will be stimulating further research into the fascinating subject of basement geology, which Samir El-Gaby has done so much to promote.

The issue was first planned in April 2012 and benefitted from the encouragement of Tim Horscroft of Elsevier, Sospeter Muhongo and Pat Eriksson, Chief Editors of the Journal of African Earth Sciences and Associate Editor Jean-Paul Liègeois. The present guest editors thank all the authors for their contributions and for their cooperation during the preparation of this issue. The firm support, advice and help of Journal Manager Monthi Fernandez are much appreciated. Thanks also go to Tracy Chen, Senior Publishing Content Coordinator for her kind assistance, as well as Yinghong Qiao, who took over from her. The success of this issue is also due to the professional efforts of the many reviewers for these contributions including:

*Hamdy Abd El-Naby, Mohamed Abdelsalam, Ahmed Akawy, Arild Andresen, Mokhles Azer, William Church, Helga de Wall, Mohammed El-Bialy, Hassan Eliwa, Rasmy Elgharbawy, Baher El Kalioubi, Esam Farahat, Harald Fritz, Zakaria Hamimi, Hassan Harraz, David Iacopini, Ghaleb Jarrar, Peter Johnson, Tim Kusky, Bernd Lehmann, David Lentz, Manish Mamtani, Martin Oczlon, Ali Osman, Talaat Ramadan, Ahmed Shalaby, Robert Stern, Kurt Stüwe, Cliff Taylor and Basem Zoheir.*

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Available online 19 June 2014

Journal of African Earth Sciences
Volume 99, Part 1, 2014

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