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Crustal thickening during amalgamation of East and West Gondwana: A case study from the Hafafit Complex, Egypt

Abu El-Enen, M.M.[1], Abu-Alam, T.S.[2], Whitehouse, M.J.[3], Ali, K.A.[4] and Okrusch, M.[5]

[1]Geology Department, Faculty of Sciences, Mansoura University, Egypt --- mahrousabuelenen@gmail.com
[2]Norwegian Polar Institute, Tromsø, Norway
[3]Dept. of Geosciences, Swedish Museum of Natural History, Stockholm, Sweden
[4]Department of Mineral Resources and Rocks, Faculty of Earth Sciences, King Abdulaziz University, Saudi Arabia
[5]Institut für Geographie und Geologie, Am Hubland, Würzburg, Germany

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The south-eastern sector of the Hafafit Metamorphic Complex, southern Eastern Desert of Egypt comprises infrastructural orthogneisses of tonalite and syenogranite parentage, amphibolites, and a volcano-sedimentary association. These are overthrust by an obducted suprastructural ophiolite nappe via the Nugrus thrust. The protolith of the biotite–hornblende gneisses was formed during island-arc accretion, while that of the garnet–biotite gneisses were formed in a within-plate regime, consistent with a transition to a post-collisional setting. The volcano-sedimentary association comprises interbedded and intercalated highly foliated metapelitic schists, metabasites, and leucocratic gneisses, deposited in a back-arc basin. The metapelites and the leucocratic gneisses originated from immature Fe-shales and arkoses derived from intermediate-mafic and acidic igneous rocks, respectively, via weak chemical weathering in a tectonically active island arc terrane. The intercalated amphibolites were derived from tholeiitic basalts generated in a back-arc setting.

The volcano-sedimentary association was metamorphosed under upper-amphibolite facies conditions, with pressures of 9–13 kbar and temperatures of 570–675 °C, as derived from conventional geothermobarometry and pseudosection calculation. A steep, tight clockwise *P*–*T* path is constrained and a geothermal gradient around 20 °C/km is estimated for the peak metamorphism. We assume that deformation and metamorphism are due to crustal thickening during the collision of East and West Gondwana, where peak metamorphism took place in the middle to lower crust at 33 km average crustal depth. This was followed by a subsequent quasi-isothermal decompression due to rapid exhumation during wrench tectonics. Sinistral transcurrent shearing with extensional denudation resulted in vertical ductile thinning that was accompanied by heat input from magmatism, as indicated by a higher geothermal gradient during retrograde metamorphism and exhumation of the complex.

U–Pb data from magmatic zircons yields protolith ages of 731 ± 3 Ma for the biotite–hornblende gneisses and 646 ± 12 Ma for the garnet–biotite gneisses. Conforming to field evidence, our geochronology data point to a depositional age of the volcano-sedimentary cover at around 650 Ma. The age of metamorphism is constrained by a low Th/U ratio of a zircon grain crystallized at an age of 597 ± 6 Ma.