

Geochemistry, geochronology, and Sr-Nd isotopes of the Late Neoproterozoic Wadi Kid volcano-sedimentary rocks, Southern Sinai, Egypt: Implications for tectonic setting and crustal evolution

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Abstract:

The Kid Group is one of the few exposures of Neoproterozoic metavolcano-sedimentary rocks in the basement of southern Sinai in the northernmost Arabian-Nubian Shield. It is divided into the mostly metamorphosed volcanoclastic Melhaq and siliciclastic Urn Zariq formations in the north and the mostly volcanic Heib and Tarr formations in the south. The Heib, Tarr, and Melhaq formations reflect an intense episode of igneous activity and immature clastic deposition associated with core-complex formation during Ediacaran time, but Urn Zariq metasediments are relicts of an older (Cryogenian) sedimentary sequence. The latter yielded detrital zircons with concordant ages as young as 647 +/- 12 Ma, which may indicate that the protolith of Urn Zariq schist was deposited after similar to 647 Ma but 19 concordant zircons gave a Pb-206/U-238 weighted mean age of 813 +/- 6 Ma, which may represent the maximum depositional age of this unit. In contrast, a cluster of 11 concordant detrital zircons from the Melhaq Formation yield a weighted mean Pb-206/U-238 age of 615 +/- 6 Ma. Zircons from Heib Formation rhyolite clast define a Pb-206/U-238 weighted mean age of 609 +/- 5 Ma, which is taken to approximate the age of Heib and Tarr formation volcanism. Intrusive syenogranite sample from Wadi Kid yields a Pb-206/U-238 weighted mean age of 604 +/- 5 Ma. These constraints indicate that shallow-dipping mylonites formed between 615 +/- 6 Ma and 604 +/- 5 Ma. Geochemical data for volcanic samples from the Melhaq and Heib formations and the granites show continuous major and trace element variations corresponding to those expected from fractional crystallization. The rocks are enriched in large ion lithophile and light rare earth elements, with negative Nb anomalies. These reflect magmas generated by melting of subduction-modified lithospheric mantle, an inference that is further supported by epsilon Nd(t) = +2.1 to +5.5. This mantle source obtained its trace element characteristics by interaction with fluids and melts from subducting oceanic crust during the Late Cryogenian time, prior to terminal collision between fragments of East and West Gondwana at similar to 630 Ma. Positive epsilon Nd(t) values and the absence of pre-Ediacaran zircons in all but Urn Zariq metasediments indicate minor interaction with Cryogenian and older crust. A model of extensional collapse following continental collision, controlled mainly by lithospheric delamination and slab break-off is suggested for the origin of the post-collision volcanics and granites at Wadi Kid. No evidence of pre-Neoproterozoic sources was found. Kid Group Ediacaran volcanic rocks are compositionally and chronologically similar to the Dokhan Volcanics of NE Egypt, which may be stratigraphic equivalents. (C) 2012 Elsevier B.V. All rights reserved.

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Author(s): NAVON, O; REYMER, APS

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Author(s): Stern, R. J.; Ali, K. A.; Liegeois, J. P.; et al.

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Geochemistry, provenance, and metamorphic evolution of Gabal Samra Neoproterozoic metapelites, Sinai, Egypt

Author(s): [Abu El-Enen, MM](#) (Abu El-Enen, Mahrous M.)

Source: JOURNAL OF AFRICAN EARTH SCIENCES Volume: 59 Issue: 2-3 Pages: 269-282 DOI: 10.1016/j.jafrearsci.2010.11.002 Published: FEB 2011

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Abstract:

Metapelites are exposed at Wadi Ba'ba, east of Abu Zenima city; represent the northwestern extension of the Fieran-Solaf Metamorphic Complex, Sinai Peninsula, Egypt. The metapelites are characterized by $qtz + pl (An(24-28)) + bt + grt \pm crd \pm sil$ mineral assemblage, indicating upper amphibolite facies with peak metamorphic conditions of 700 degrees C and pressures of 7 kbar, as determined by conventional geothermobarometric methods. This resulted in incipient migmatization, forms patches of leucosomes and melanosomes. Geochemical investigation indicates that the precursor sediments of the metapelites had been deposited as immature Fe-rich shales from source materials of dominantly intermediate composition. Source area exhibited weak to moderate chemical weathering in a tectonically active continental marginal basin within a continental-arc system. A strong shallow-dipping foliation, characterizing the metapelites, was folded around an open antiform with sub-horizontal south plunging hinge.

Phase equilibria calculations in the KFMASH system indicate that the peak metamorphic conditions formed at 730-750 degrees C and 6.8-7.9 kbar. This was followed by a retrogression formed at 770-785 degrees C and 3.9-4.5 kbar. Hence, this implies an isothermal decompression and rapid exhumation of the metapelites from depth (25-29 km) in the lower crustal level at peak conditions, continuous to include shallow to middle crustal level (14-17 km), at overprint retrograde conditions. Subsequent isobaric cooling took place at 720-750 degrees C and 3.6-4.5 kbar. The resulting isothermal decompression followed by isobaric cooling clockwise P-T path of the metapelites is more likely, in which the high-temperatures attained maximum conditions during isothermal decompression were enhanced by heat flux, due to the presence of an active magmatic arc that formed on top of subducting young lithosphere. This is supported by a moderate geothermal gradient of 27-43 degrees C/km and dating compatibility of the Sinai granitoids and the metamorphic complexes. The P-T path segment records the tectonothermal histories of crustal thickening as a result of the East and West Gondwana collision at the metamorphic peak. This was subsequent by extensional and crustal thinning with syn-metamorphic magmatic intrusions, during P-T path retrogression, which resulted in the final assembly of the Arabian-Nubian Shield during Neoproterozoic. (C) 2010 Elsevier Ltd. All rights reserved.

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Author(s): Zeh, A.

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Geochemistry and metamorphism of the Pan-African back-arc Malhaq volcano-sedimentary Neoproterozoic association, W. Kid area, SE Sinai, Egypt

Author(s): [Abu El-Enen, MM](#) (Abu El-Enen, Mahrous M.)

Source: JOURNAL OF AFRICAN EARTH SCIENCES Volume: 51 Issue: 4 Pages: 189-206

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Times Cited: [6](#) (from Web of Science)

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Abstract:

The northern part of the Kid metamorphic complex, SE Sinai Peninsula, Egypt, comprises a thick sequence of volcano-sedimentary association, defined as Mahlaq Formation. It is composed predominantly of rhyodacitic to andesitic, less commonly of subalkaline basaltic metavolcanics and metatuffs interbedded and intercalated with metapelites and metagraywackes. Their bulk rock chemistry indicates that the magmatic rocks have calc-alkaline affinity, and derived from island arc - mid-oceanic ridge transitional regimes, presumably in a back-arc setting. Their peak mineral assemblages, mineral chemistry and calculated P-T metamorphic conditions indicate that the Malhaq association underwent metamorphism of lower amphibolite facies (480-570 degrees C/3-4 kbar), except the extreme northeastern part of upper amphibolite facies (645 degrees C/4.5-5.5 kbar). Geothermal gradients of the investigated metamorphic rocks range from 37 to 43 degrees C/km, may indicate that metamorphism took place in the upper plate of an active continental margin. Three deformation phases, D-1 to D-3, are recognized at the Malhaq nappe area, where peak metamorphic conditions occurred synchronous with the NW-directed thrusting during the D-2 phase. Possible heat sources during metamorphism is that resulted from heating contributing from the mantle derived magma in the documented arc environment in addition to the shear "stress" heating released during thrusting and stacking of the Malhaq nappe pile onto the older continental crust during the Pan-African orogeny. Metamorphic conditions increase northward coincident with NW-ward stacking propagation of the Neoproterozoic nappe that formed when the Mozambique Ocean had closed as a result of the assembly of East and West Gondwana during the Pan-African Orogeny. (C) 2008 Elsevier Ltd. All rights reserved.

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Geochemistry and metamorphism of the Pan-African back-arc Malhaq volcano-sedimentary Neoproterozoic association, W. Kid area, SE Sinai, Egypt

Author(s): [Abu El-Enen, MM](#) (Abu El-Enen, Mahrous M.)

Source: JOURNAL OF AFRICAN EARTH SCIENCES Volume: 51 Issue: 4 Pages: 189-206

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Abstract:

The northern part of the Kid metamorphic complex, SE Sinai Peninsula, Egypt, comprises a thick sequence of volcano-sedimentary association, defined as Mahlaq Formation. It is composed predominantly of rhyodacitic to andesitic, less commonly of subalkaline basaltic metavolcanics and metatuffs interbedded and intercalated with metapelites and metagraywackes. Their bulk rock chemistry indicates that the magmatic rocks have calc-alkaline affinity, and derived from island arc - mid-oceanic ridge transitional regimes, presumably in a back-arc setting. Their peak mineral assemblages, mineral chemistry and calculated P-T metamorphic conditions indicate that the Malhaq association underwent metamorphism of lower amphibolite facies (480-570 degrees C/3-4 kbar), except the extreme northeastern part of upper amphibolite facies (645 degrees C/4.5-5.5 kbar). Geothermal gradients of the investigated metamorphic rocks range from 37 to 43 degrees C/km, may indicate that metamorphism took place in the upper plate of an active continental margin. Three deformation phases, D-1 to D-3, are recognized at the Malhaq nappe area, where peak metamorphic conditions occurred synchronous with the NW-directed thrusting during the D-2 phase. Possible heat sources during metamorphism is that resulted from heating contributing from the mantle derived magma in the documented arc environment in addition to the shear "stress" heating released during thrusting and stacking of the Malhaq nappe pile onto the older continental crust during the Pan-African orogeny. Metamorphic conditions increase northward coincident with NW-ward stacking propagation of the Neoproterozoic nappe that formed when the Mozambique Ocean had closed as a result of the assembly of East and West Gondwana during the Pan-African Orogeny. (C) 2008 Elsevier Ltd. All rights reserved.

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Metamorphic evolution of Neoproterozoic metapelites and gneisses in the Sinai, Egypt: Insights from petrology, mineral chemistry and K-Ar age dating

Author(s): [Eliwa, HA](#) (Eliwa, H. A.)^[1]; [Abu El-Enen, MM](#) (Abu El-Enen, M. M.)^[2]; [Khalaf, IM](#) (Khalaf, I. M.)^[1]; [Itaya, T](#) (Itaya, T.)^[3]; [Murata, M](#) (Murata, M.)^[4]

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Abstract:

Petrology, mineral chemistry, and age dating of the metapelitic schists and gneisses in three metamorphic complexes of Sinai have been studied and reported with the aims of characterizing the nature, type, and age of metamorphism as well as the metamorphic evolution of the Sinai metamorphic complexes. Nine representative samples of metapelitic schists, migmatites, and gneisses from the Taba Metamorphic Complex (TMC), the Kid Metamorphic Complex (KMC) and the Feiran-Solaf Metamorphic Complex (FSC) in southern Sinai Peninsula have been analyzed by electron microprobe for their mineral assemblages and K-Ar geochronological methods for biotite separates. Garnet from the metapelites and migmatites are almandine-rich and usually show zoning with variable X-Fe values.

The estimated P-T metamorphic conditions of the TMC range from 560-578 degrees C/3-4.5 kbar for the metapelitic schists, to 685 degrees C/5.3 kbar for the migmatites, while those for the metapelitic schists in the KMC are 590 degrees C/4-5.9 kbar in the Umm Zariq Formation, and 636 degrees C/4.7 kbar in the northern part of the Malhaq Formation. The P-T metamorphic conditions of the hornblende-biotite gneisses from the SZ of the FSC are 634-641 degrees C/4-5 kbar. These P-T conditions and mineral assemblages indicate amphibolite facies conditions of the LP/HT-type of metamorphism.

The K-Ar biotite cooling ages range from 594 to 617 Ma for the TMC, from 593 to 609 Ma for the KMC, and from 589 to 602 Ma for the FSC. It could be suggested that the cooling metamorphic ages of all complexes lie at approximately 600 Ma, and thus point to a uniform and single metamorphic event for the whole complexes in the southern Sinai Peninsula.

The estimated geothermal gradient is in the range of 30-50 degrees C/km. Such a steep gradient and the LP/HT mineral assemblages suggest that they were formed in an extensional setting and a heat flow was transferred from nearby granite intrusions. (c) 2007 Elsevier Ltd. All rights reserved.

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Author(s): SHIMRON, AE; BROOKINS, DG

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Author(s): YARDLEY, BWD

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941-951 DOI: 10.1130/0016-7606(1978)89<941:GOTSGM>2.0.CO;2 Published: 1978

The texture and composition of tourmaline in metasediments of the Sinai, Egypt: Implications for the tectono-metamorphic evolution of the Pan-African basement

Author(s): [Abu El-Enen, MM](#) (Abu El-Enen, M. M.); [Okrusch, M](#) (Okrusch, M.)

Source: MINERALOGICAL MAGAZINE Volume: 71 Issue: 1 Pages: 17-40 DOI: 10.1180/minmag.2007.071.1.17 Published: FEB 2007

Times Cited: [3](#) (from Web of Science)

Cited References: [66](#)

Abstract:

Accessory tourmaline in metasediments from the Sinai crystalline basement exhibits textural and chemical signatures that relate to the evolution of regional metamorphism and deformation during the Pan-African orogeny and testifies to different P-T path segments. Tourmaline inclusions in various porphyroblasts were formed during the prograde phase of metamorphism; acicular to prismatic crystals in the matrix, oriented sub-parallel to, and enveloped by, the main foliation crystallized syntectonically under prograde and peak metamorphic conditions; tourmaline cross-cutting the main foliation may have formed just after the peak or during the retrograde phase of metamorphism. Some of the cores in tourmaline crystals, showing different colours, are interpreted as former detrital grains. The abundance of tourmaline decreases with increasing peak metamorphic conditions. The tourmaline investigated belongs to the schorl-dravite(ss) group, generally with X-Mg of 0.42-0.73 and $X\text{-Ca} = \text{Ca}/(\text{Ca}+\text{Na}+\text{K}+\text{square})$ of 0.02-0.24, typical of tourmalines in metapelites and metapsammities; whereas detrital cores have been derived from various sources, including former tourmaline-quartz and pre-existing high-metamorphic rocks. Tourmaline of the Sinai metasediments was formed during metamorphism of the sedimentary precursors, essentially in a closed system, where clay minerals and organic matter, together with detrital tourmaline, served as the source of boron. Although a metamorphic facies should be defined by characteristic mineral assemblages present in metamorphic rocks, tourmaline chemistry is a good monitor of P-T conditions in the metapelites and semi-metapelites investigated, showing an increase in X-Mg with increasing metamorphic grade, where $X\text{-Mg}(\text{tur}) = 0.60$ distinguishes between greenschist and lower-amphibolite facies, while $X\text{-Mg}(\text{tur}) = 0.65$ could distinguish lower- from middle- to upper-amphibolite facies. The results of tourmaline-biotite geothermometry compare well with our former temperature estimates using conventional geothermometry and phase-diagram modelling.

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ENGLAND

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IDS Number: 193ZG

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Author(s): Abu El-Enen, MM; Will, TM; Okrusch, M

Source: JOURNAL OF AFRICAN EARTH SCIENCES Volume: 38 Issue: 1 Pages: 59-78

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Author(s): Abu El-Enen, MM; Okrusch, M; Will, TM

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Author(s): Abu El-Enen, MM; Zalata, AA; El-Metwally, AA; et al.

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Issue: 1 Pages: 53-81 Published: JUL 1999

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Author(s): BHATTACHARYA, A; MAZUMDAR, AC; SEN, SK

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