METAMORPHIC EVOLUTION OF TWO PANAFRICAN METAMORPHIC CORE COMPLEXES IN THE EASTERN DESERT OF EGYPT: TECTONIC IMPLICATIONS

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It is widely accepted that crustal consolidation of NE-Africa has largely been achieved by late Proterozoic accretion of island arcs without major crustal thickening. However, the existence and importance of metamorphic basement domes, exposed beneath Panafrican ophiolite and island arc volcanic rock sequences in the Central Eastern Desert (CED), has long been ignored. This study presents data on the P-T-t evolution of the Meatiq and the Hafafit basement domes, two metamorphic core complexes in the CED of Egypt, and the implications of the P-T data on the tectonic evolution of the area.

The Meatiq basement is composed of orthogneisses hosting amphibolite lenses in the structurally lowest parts, overlain by a metasedimentary sequence. Three regional metamorphic events have affected the Meatiq basement rocks, whereas only the last one affected both the basement and cover sequences. During the M1 event amphibolite lenses have been migmatized. Minimum temperatures for this event are estimated to be >750°C based on published experimental data. The migmatization of the mafic lenses probably belongs to an early tectonic cycle prior to the emplacement of the orthogneisses and the covering metasedimentary rocks.

Typical M2 metamorphic assemblages, best observed in the metasedimentary sequences, are Grt–Zn-rich Spl–Ms–Qtz–Bt and Grt–Ms–Sil–Plag–Qtz and locally Ky. M2 garnet hosts complexly folded ilmenite trails, but the core is chemically uniform, which indicates a high temperature (T > 640°C) diffusional garnet growth or equilibration. Only the garnet rim is characterized by lower FeO and higher CaO values indicating a retrograde growth or equilibration of the rim. Peak M2 temperatures are determined using Bt inclusions in Grt and range from 620° to 690°C. This is supported by a retrograde divariant reaction of Sil and Grt forming Fe–St in Grt rims implying T > 600°C and P > 4kbar. Peak M2 pressures, calculated using the GASP, GRIPS and GRAIL barometers, are 6–8 kbar. The retrograde phase of the M2 metamorphic event is constrained to T of 530°–590°C by Grt–Bt and Grt–St thermometry.

Microthermometric data of fluid inclusions in Qtz included in high metamorphic grade Grt indicate a low salinity H_2O-CO_2 fluid for the M2 event with peak metamorphic H_2O rich fluids and retrograde CO_2 rich fluids. The slopes of the isochores of the different fluid inclusion generations indicate a clockwise M2 P-T path. This is supported by the stability of Ky in the peak M2 and Sil in the retrograde M2 assemblage.

During the M3 metamorphic event M2 mineral assemblages have been retrograded to Chl and Bt mainly at the southern margin of the basement complex (PUHL et al., 1995). The assemblage Grt–Chl in the metasedimentary sequence of the basement limits T to 460°C to 550°C. In the structurally lower parts of the basement, M3 is evident by the growth of Chl in extension fractures in Grt. M3 assemblages in the basement cover comprise Atg–Trem–Tlc which constrain T to < 540 C.

In the Hafafit basement, amphibolites, serpentinites and migmatites of ortho- and para-gneisses are overlain by mylonitic gneisses. The migmatites have been intruded by trondhjemites and tonalites which range in age between 677 Ma and 700 ma (single zircon U/Pb evaporation technique, KRÖNER et al., 1994). The basement is covered by ophiolitic nappes. In contrast to the Meatiq metamorphic evolution, in the Hafafit basement only one high-grade metamorphic event could be observed until now and indications of a later low-metamorphic grade event are only locally developed.

Peak metamorphic mineral assemblages in the Hafafit basement comprise Grt–Plag-Hbl and Ky–Grt–Plag–Kfs–Bt in the migmatites. Kyanite is replaced by Sil, which forms the most abundant Al_2SiO_5-polymorph in the rock matrix, during slightly retrograde metamorphic conditions. Zn-rich spinel is present as accessory phase in the migmatites. Peak metamorphic temperatures, determined using TWEEQU thermobarometry on Grt and Plag cores and Hbl within migmatites, range from 700° to 780°C and pressures from 9 kbar to 11 kbar. Retrograde metamorphic conditions, calculated using the compositions of the rims of Grt, Plag and Hbl, range from 690° to 750°C and 7.4 kbarto 7.8 kbar. Conventional thermobarometry using Hbl-Grt thermometry and Grt-Hbl-Plag barometry confirm the TWEEQU results. The late-stage, low-grade metamorphic overprint is typically indicated in brittle deformation of plagioclase in strike-slip shear zones along the margin of the Hafafit basement and in late-stage chloritization of Bt.

The M1 metamorphic event in the Meatiq basement occurred probably in an extensional tectonic environment priorto the intrusion of the Um Ba´anib granitoid at approximately 780 Ma. The M2 metamorphic event is explained as having formed during ongoing extension between 780 Ma and 650 Ma. Peak metamorphic conditions indicate that the Hafafit basement may represent marginally deeper crustal sections than the Meatiq basement, although isotopic dating is necessary to determine whether the high-grade metamorphic event in the Hafafit basement was contemporaneous with, or occurred priorto the M2 metamorphic event in the Meatiq basement. The M3 metamorphic event in the Meatiq basement occurred during stacking of the Panafrican ophiolite and island arc volcanic nappes on the basement along subhorizontal thrust planes; and, the N–S directed extension along E–W striking low angle normal faults at the N and S margin of the basement dome during uplift.

$^{40}Ar/^{39}Ar$ mineral ages from newly formed muscovite within late strike-slip and extensional fault zones related to the uplift of the metamorphic dome are reported as 595 ± 0.5 and 588 ± 0.3Ma (FRITZ et al., in press) and document a late Panafrican age for the dome uplift. Metamorphic and structural evidence suggest a possible pre-Panafrican or early Panafrican high temperature metamorphic event (M1), a subsequent high temperature event (M2) and a late Panafrican low temperature event (M3), which was associated with uplift and exhumation of the basement dome.

FRITZ, H., WALLBRECHER, E., KHUDEIR, A.A., ABU EL ELA, F., DALLMEYER, D.R. (in press): Formation of Neoproterozoic metamorphic core complexes during oblique convergence - Eastern Desert (Egypt). - Journal of African Earth Sciences.

KRÖNER, A., KRÜGER, J., RASHWAN, A.A.A. (1994): Age and tectonic setting of granitoid gneisses in the Eastern Desert of Egypt and south-west Sinai. - Geologische Rundschau, 83, 502-513.

PUHL, J. NEUMAYR, P. HOINKES, G., MOGESSIE, A. (1995): Tectonic implications of different metamorphic evolution histories in the basement and the cover series in the Meatiq complex, Central Eastem Desert, Egypt. - Journal of the Czech Geological Society, 40/3, 37-38.