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Metamorphic petrology unraveling secrets of the Arabian-Nubian Shield evolution

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The formation of orogens is a complex process often involving multiple stages of compression and extension. Arabian-Nubian Shield is a juvenile crust formed during the Pan-African orogen and the collision between East- and West-Gondwana. The formation mechanism was complicated and includes rifting of an old continent (Rodinia) and formation of oceanic crust followed by initiation of subduction, arc-arc collision, arcs-Sahara Metacraton collision and finally escape tectonic, formation of the largest pre-Mesozoic shear zone on the Earth – the Najd Fault System. In such complicated setting, the metamorphic petrology can be used as an effective tool to study the evolution of the shield and it can give valuable information about the thermal structural of the lithosphere during this stage of the evolution of the Earth. Baladiyah complex in the northern part of the Arabian-Nubian Shield will be used here as a case study to unraveling the tectonic evolution of the shield using metamorphic petrology. Field evidence from the Baladiyah complex shows several erosional unconformities separate different high grade metasedimentary rocks within the complex. This indicates that the tectonic evolution involved several cycles of exhumation and burial. Mineral equilibria approach and thermodynamic modeling are used to place constraints on the formation conditions of each of these cycles. It is shown that the complex is characterised by three regional metamorphic events followed by a fourth event of contact metamorphism due to the intrusion of post-tectonic granites. The first metamorphic event experienced peak metamorphism around 705 – 715 °C and 5.2 – 5.6 kbar and subsequent isothermal decompression to the Earth's surface. The second metamorphic events attained peak conditions of 635 – 670 oC and 4.2 – 5 kbar followed by exhumation, erosion and depositional of molasse sediments. The rocks were buried for a third time and metamorphosed to greenschist facies metamorphic condition (330 $\pm$ 30 oC and 3.6 – 4.6 kbar) under the load of molasse sediments. Post-tectonic granites were intruded at depth of 12 km during the final Pan-African exhumation causing the fourth metamorphic event (700 $\pm$ 25 oC). Correlation of this metamorphic evolution with the deformation history shows that the first and the second metamorphic events occurred in a compression regime (D1 and D2), interpreted to be related to the collision between East- and West-Gondwana. While the third deformation phase began as compression regime causing the third metamorphic event, and then turned into oblique transpressive regime which led to form escape tectonics and development of a large scale strike-slip shear zone "the Najd Fault System". This tectonic evolution accompanied several cycles of exhumation and burial indicates multistage crustal flexure during Gondwana Collision.