# METAMORPHISM AND GEODYNAMICS OF THE PROTEROZOIC KABUL BLOCK: PRESERVATION AND MODIFICATION OF CRUSTAL FRAGMENTS WITHIN AN OROGENIC ZONE

by

**STEPHEN PAUL COLLETT**

Supervised by

Prof. Ing. Shah Wali Faryad, CSc.

**Institute of Petrology and Structural Geology, Faculty of Science, Charles University in Prague**

## Thesis Summary

In this thesis we attempt to unravel the metamorphic history of basement rocks from the Kabul Block and its geodynamic evolution through the geological record. The Kabul Block is an exotic terrane within the framework of Afghanistan. It is situated within a tectonic zone known as the Afghan Central Blocks that form along the triple junction of major continental masses (the Eurasian, Indian, and Arabian plates). Unlike the the other Afghan Central Blocks with thick Phanerozoic cover sequences Precambrian basement rock crop-out extensively within the Kabul Block. This is usually attributed to an apparent dome like structure. The basement rocks are comprised of a large variety of different lithologies and are classified into multiple formations which exhibit varying degrees of metamorphism and deformation. The lowermost basement units which experienced a polymetamorphic history and up to granulite-facies conditions is usually classified as the Khair Khana or Sherdarwaza Formation. The Khair Khana Formation is distinguished from the Sherdarwaza by the preservation of granulite-facies assemblages and by possibly older Neoarchean age. The Sherdarwaza Formation is dominated by migmatite and orthogneiss with strong retrogression of granulite-facies phases. The Khair Khana and Sherdarwaza Formations are unconformably overlain by the Kharog and Welayati Formations, the relations of which are unclear. Both the Kharog and Welayati are described as containing several varieties of micaschist and amphibolite, with the Kharog additionally containing minor quartzite, marble, and a basal conglomerate and both record metamorphic conditions up to amphibolite-facies.

The lowermost basement rocks belonging to the Khair Khana Formation consist of orthogneiss and granulite-facies assemblages that have been confirmed to have a Neoarchean component (up to 2750 Ma). U/Pb SHRIMP analysis of zircon cores revealed a small number of Neoarchean ages, while the

majority of cores yielded early Paleoproterozoic ages of 2200 - 2500 Ma. Conventional geothermobarometry and phase equilibria modelling on well preserved granulite-facies assemblages indicates that the rocks reached conditions of approximately 850 °C at up to 7 kbar of pressure. Textural relations indicate that this was a strongly temperature dominated event. U/Pb SHRIMP dating of zircon rims and U-Th-Pb dating of monazite inclusions in granulite-facies garnet suggest that this event occurred in the late Paleoproterozoic (~ 1750 - 1900 Ma).

The granulite-facies assemblages are overprinted by a younger, amphibolite-facies metamorphism, and are unconformably overlain by amphibolite-facies rocks belonging to the younger Welayati (and Kharog?) Formation(s) that lack paragenetic evidence for a preceding high-grade metamorphism. The Welayati Formation crops-out extensively in the south of Kabul City and consists of kynaite- and staurolite-bearing micaschists and garnet-amphibolites, which contain textural relations suitable for the construction of a pressure-temperature (P-T) path. Inclusion assemblages in porphyroblastic garnet yield P-T conditions of around 525 °C and 6 kbar. Chemical zonation in garnet and phase equilibria modelling indicates that from this point garnet grew during a pressure increase of ~ 3.5 kbar over a temperature increase of ~ 125 °C. A subsequent period of near isothermal decompression of up to 2 kbar is recorded by plagioclase and biotite porphyroblasts which overgrow and cross-cut the main foliation. Ar/Ar dating of mica and U-Th-Pb dating of monazite has been used to constrain both the amphibolite-facies overprint in the Sherdarwaza and Khair Khana Formations, and the metamorphism in the Welayati Formation to the Early-Mid Neoproterozoic (~800 - 850 Ma).

Subsequent deformation and metamorphism is evidenced by the transformation of the amphibolite- and granulite-facies assemblages to lower-grade phases and by the partial resetting of geochronological systems. The lack of equilibrium assemblages precludes the constraining of P-T conditions for these transformations and the age relations are not clearly resolved. However, north from the Kabul Block, in the Western Hindu Kush, Paleozoic and Cenozoic metamorphic events are observed. Eocene pressure dominated amphibolite-facies metamorphism is recorded in Cretaceous meta-granitoids. This metamorphism occurred as a result of indentation tectonics resulting in the wedging of the Kabul Block between the Helmand and Nuristan Terranes.

## Shrnutí Práce

Kábulský blok je čočkovitý fragment zemské kůry, který se spolu s Farah, Helmand, a Nuristan terány nachází v tektonické zóně známé jako ‚Afghan Central Blocks', které jsou situované v kolizní zóně mezi indickou, euroasijskou, a arabskou deskou. Kábulský blok je složen z vysoce deformovaného krystalinikého basementu překrytého slabě deformovanými svrchnopaleozoického-mezozoickými sedimenty. U / Pb SHRIMP analýza zirkonových jader z nejspodnější formace krystalinického basementu (Sherdarwaza a / nebo Khair Khana) indikuje Neoarcheanského stáří (~ 2700 Ma), zatímco většina zirkonvých jader spadá do spodněPaleoproterozoických věků (2200 - 2500 Ma). Sherdarwaza a Khair Khana formace jsou složeny především z migmatitů a ortorul, minoritně s mramory, křemenci, a amfibolity, které dosáhly podmínek granulitové-facie. Konvenční geotermobarometry a modelování fázových rovnováh v dobře zachovalých minerálních asociacích granulitové facie naznačuje, že horniny dosáhly podmínek přibližně 850 ° C při tlaku až 7 kbar. Texturní vztahy ukazují na dominantně teplotní event. U / Pb SHRIMP datování okrajů zirkonu a U-Th-Pb datování monazitových inkluzí v granátech granulitové facie naznačují, že tato událost nastala v pozdním Paleoproterozoiku (~ 1750-1900 Ma).

Asembláž granulitové facie je přetištěna mladší metamorfózou v amfibolitovéfacii a je diskordantně překryta horninami amfibolitové facie náležící mladší formaci (Kharog a Welayati), která postrádá par-

agenezi předchozího vysokého stupně metamorfózy. Welayati Formace je výrazně rozšířena na jihu Kábulu a je tvořena různými varietami svorů a granátických amfibolitů, které obsahují texturní vztahy vhodné pro určování teplotně tlakových podmínek. Inkluze v porphyroblastech granátu naznačují teplotně tlakové podmínky okolo 525 ° C a 6 kbar. Chemická zonálnost v granátu a modelování fázové rovnováhy indikuje, že od tohoto bodu granát rostl s nárůstem tlaku o ~ 3,5 kbar a teploty o 125 ° C. Následná téměř izotermální dekomprese až do 2 kbar je zaznamenána plagioklasem a biotitickými porfyroblasty které přerůstají a přetínají hlavní foliaci. Ar / Ar datování slíd a U-Th-Pb datování monazitů byla použita k určení stáří jak přetisku v amfibolitové facii ve Sherdarwaza a Khair Khana formaci, tak k určení stáří metamorfózy ve formaci Welayati, což odpovídá spodně až středně Neoproterozoickému stáří (~ 800 - 850 Ma).

Následnou deformaci a metamorfózu dokládá transformace asembláže amfibolitové a granulitové facie do nižších fází a částečný restart geochronologických systémů. Nedostatek rovnovážného složení vylučuje určení P-T podmínek této transformace a ani stáří není jasně vyřešeno. Nicméně severně od Kábulského bloku, v západním Hindúkuš jsou jasně pozorovány paleozoické a kenozoické metamorfní eventy. Eocení tlakově dominantní metamorfóza v podmínkách amfibolitové facie je zaznamenána v křídových meta-granitoidech. Tato metamorfóza je způsobena indentační tektonikou která dává vzniknout vklínění Kábulského bloku mezi Helmand a Nuristan terány.

# Curriculum Vitae


**Name:**

Stephen Paul Collett

**Date of Birth:**

21st August 1989

**Nationality:**

British

**Home Address:**

Sudoměřská1096/28

130 00 Praha 3 - Žižkov

Czech Republic

**Work Address:**

Institute of Petrology and Structural Geology

Faculty of Science, Charles University

Albertov 6

128 43 Praha 2

Czech Republic

**Telephone:**

+420 775485263 (CZE) / +44 7960611886 (GBR)

**Email:**

colletts@natur.cuni.cz / scollett311@gmail.com


**Education:**

- 2000 - 2007 Aylesbury Grammar School, Buckinghamshire, United Kingdom
  - 2005: 12 GCSE's (A*-C) including: Mathematics, English, Physics, Chemistry, Biology, French
  - 2006: 4 AS-Levels (A-C) in Mathematics, Physics, Chemistry, Ancient History
  - 2007: 3 A-Levels (A-C) in Mathematics, Physics, Ancient History
- 2007 - 2011 Department of Geology, University of Leicester, United Kingdom
  - Master of Geology (Upper second class honours degree)
  - Dissertation title: The Himalayan Syntaxes: A review and analysis of the literature on models for the formation of the Nanga Parbat and Namche Barwa syntaxes
  - Thesis: Crustal Evolution in the Palaeo Proterozoic of Afghanistan: Insights from the Sherdawaza Gneisses of the Kabul Block
- 2011 - Present Institute of Petrology and Structural Geology, Faculty of Science, Charles University in Prague, Czech Republic
  - PhD. study under the supervision of Prof. Ing. Shah Wali Faryad, CSc.
  - Thesis: Metamorphism and geodynamics of the Proterozoic Kabul Block: Preservation and modification of crustal fragments within an orogenic zone

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