

Unraveling the Metamorphic History of the Besham Complex (NW Pakistani Himalaya) through Garnet and Accessory Mineral petrochronology

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The core of the Indian Syntaxis (Besham Complex) of the NW Pakistani Himalaya, primarily composed of granitic gneiss and amphibolite, has long been considered to have been unaffected by Himalayan metamorphism, despite its structural proximity to the Kohistan Island Arc (KIA) along the Main Mantle Thrust (MMT). This contrasts with the Nanga Parbat syntaxis further to the east, which shows a strong Himalayan metamorphic overprint. Recently, a controversy arose about a possible Himalayan metamorphic overprint also of the rocks of the Indus syntaxis (Treloar et al. 2019; DiPietro et al. 2021). To assess these contrasting views, we applied in situ accessory-phase and garnet petrochronology to a variety of samples recovered during our field campaign.

Quartz-bearing metaluminous rock samples and one carbonate-rich metasediment were investigated in detail. Three distinct U-Pb age groups were obtained, revealing a poly-metamorphic history. The two older groups showed evidence for Paleozoic metamorphism (345 ± 19 Ma garnet; 280 Ma zircon and titanite) and Jurassic metamorphism (188 ± 13 Ma garnet). Importantly, the youngest group yielded clear evidence for Himalayan metamorphism with 89 ± 12 Ma and 40 ± 4 Ma garnet, as well as apatite, zircon and rutile U-Pb ages in the range of approximately 50–22 Ma.

Zirconium-in-Rutile thermometry in a garnet-bearing metapelite was applied to estimate metamorphic conditions, yielding temperatures of 630 °C at pressures of approximately 1 GPa. This includes rutile inclusions in garnet that yielded an Oligocene U-Pb age.

The findings of this study provide evidence that the Besham complex represents a poly-metamorphic terrane, affected by Paleo- and Mesozoic pre-Himalayan as well as Cenozoic Himalayan metamorphism. Future petrochronologic research will aim to refine the timing and conditions of these metamorphic events.

[1] DiPietro, J.A., Pullen, A. and Krol, M.A., 2021. Geologic history and thermal evolution in the hinterland region, western Himalaya, Pakistan. *Earth- Science Reviews*, 223, p.103817.