

Timing of synconvergent extension in NW Himalaya: New geochronological constraints from the Gianbul dome (SE Zaskar)

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High-grade metamorphic rocks of the High Himalayan Crystalline Zone (HHCZ) of Zaskar are exposed as a 50 km large dome along the Miyar and Gianbul valleys in the NW Himalaya of India. This Gianbul dome is cored by migmatitic paragneiss formed at peak conditions of 800°C and 8 kbar. This migmatitic core is symmetrically surrounded by rocks of the sillimanite, kyanite ± staurolite, garnet, biotite, and chlorite mineral zones. The structural and metamorphic data from the Miyar-Gianbul Valley section reveal that the tectono-metamorphic evolution of the HHCZ in SE Zaskar is associated with a polyphase tectonic history involving converging nappe structures superimposed by opposite-directed extensional structures (Dèzes et al. 1999, Steck et al. 1999, Robyr et al. 2002). The first tectonic event corresponds to an early phase of crustal thickening related to NE-directed movements. This phase most likely took place during Early to Middle Eocene, and it led to the creation of Shikar Beh nappe, thrusting toward the NE along the Miyar Thrust and responsible for the prograde metamorphic field gradient in the southern limb of the dome (Steck et al. 1999, Robyr et al. 2002). Beneath the Miyar Thrust, partial melting, related to this initial phase, occurred at temperatures between 750 and 850°C. In the northern limb of the dome, the Barrovian prograde metamorphism is the consequence of a second tectonic phase, associated with the SW-directed thrusting of the Nyimaling-Tsarap nappe. During this phase, some of the paragneiss were migmatized as a consequence of temperature up to ca. 800°C at depth down to ca. 40 km (Dèzes et al. 1999, Robyr et al. 2002). Geochronological data reveal that this SW-directed phase occurred between Middle Eocene and Late Oligocene (Vance and Harris 1999, Schlup et al. 2003). Following these crustal thickening events, exhumation and doming of the HHCZ high-grade rocks were controlled by extension along the north-dipping Zaskar Shear Zone, in the frontal part of the Nyimaling-Tsarap nappe, as well as by extension along the south-dipping Khanjar Shear Zone, in the southern limb of the Gianbul dome. Rapid synconvergence extension along both of these detachments induced a nearly isothermal decompression, resulting in a high-temperature/low-pressure metamorphic overprint.

New geochronological dating of monazites from various migmatites in the footwall of the Khanjar Shear Zone indicates that these rocks cooled below $T=725^{\circ}\text{C}$ at 26.6 Ma. On the other hand, geochronological dating of monazites from an undeformed leucogranitic dyke cross-cutting the extensional structures of the Khanjar Shear Zone reveals ages between 19.9 and 23.6 Ma. These results consequently indicate that ductile shearing along the Khanjar Shear Zone ended by 23.6 Ma and that extension most likely initiated shortly before 26.6 Ma. In the Gianbul Valley, geochronological results from various leucogranitic plutons and dykes in the footwall of the Zaskar Shear Zone indicates that partial melting on the NE-half of the Gianbul dome occurred between 19.8 Ma and 22.2 Ma (Dèzes et al. 1999). Partial melting in this part of the Himalayan range is collectively interpreted as

the consequence of the rapid exhumation of the high grade metamorphic rocks along the Zaskar Shear Zone, in good agreement with the isothermal decompression revealed by the P-T data. On basis of these observations, it is commonly assumed that the onset of extension along the Zaskar Shear Zone was not significantly older than 22.2 Ma. However, structural analysis and geometric modelling indicate that the exhumation of the migmatitic Gianbul dome occurred contemporaneously along both the Khanjar Shear Zone and the Zaskar Shear Zone, mainly because of the lack of a major thrust between the two extensional shear zones. It consequently appears that the extension along the Zaskar Shear Zone has to begin shortly before 26.6 Ma. This age is in good agreement with the data from the northernmost part of the HHCZ of Zaskar where Vance and Harris (1999) indicate a rapid decompression in the HHCZ rocks of 4kbar at 25 Ma and where Inger (1998) demonstrates that ductile deformation along the Zaskar Shear Zone was ongoing at 26 Ma.

The petrographic and quantitative P-T results for the Miyar section and for the Gianbul section provide information about the depth of burial of the studied samples, as well as about the thermal structure during the tectonic evolution of a complete transect across the Gianbul dome. On the other hand, the mapping and structural analysis of this transect constrain its kinematic evolution. These various data, together with the geochronological constraints, can be combined to propose a semi-quantitative reconstruction of the tectono-metamorphic evolution across the Gianbul dome (**Figure 1**).

During the first opposite-directed crustal thickening phases, the HHCZ high grade rocks were subducted down to ca. 30 km depth, where temperature up to 850°C triggered partial melting. As a consequence, the relatively high buoyancy of these low-dense and low-viscous migmatites counteracted the downward pulling forces exerted by the still subsiding lithosphere. From that moment, the migmatitic rocks of the HHCZ of Zaskar were squeezed by the compressive forces exerted by the ongoing collision and the backstop represented by the sedimentary series of the Tethyan Himalaya. The presence of two major thrust zones directly above this migmatitic zone induced a weakness in the upper crust facilitating the exhumation of these high-grade low-viscosity migmatites. As a consequence, high grade rocks of the HHCZ of Zaskar have been forced to extrude in this part of the range, and eventually “pierced” through the Tethyan sedimentary cover as a large-scale dome structure. Once the onset of extension along these detachments is triggered, decompression drives partial melting, leading to the development of positive feedback between melting and decompression, and thus enhancing the rapid exhumation of these migmatites. Following this initial doming phase, further extension along the Zaskar Shear Zone associated with combined thrusting along the Main Central Thrust led to tectonically-controlled ductile extrusion of the HHCZ toward SW.

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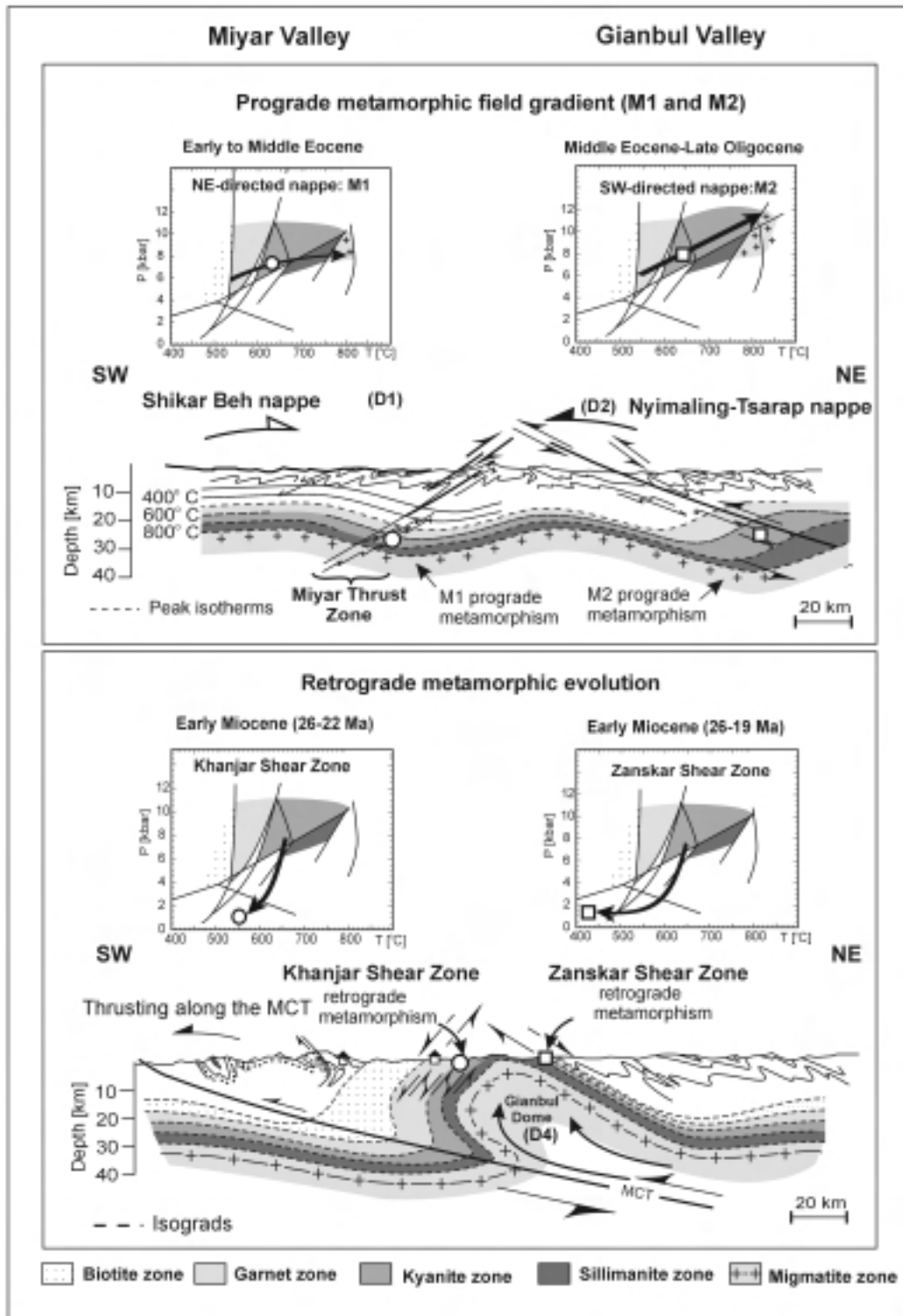


FIGURE 1. Semi-quantitative reconstruction of tectono-metamorphic evolution of the Gianbul dome