Two-stage exhumation of Greater Himalayan rocks: P-T-t-D results from mid-crustal rocks of central and eastern Bhutan

S.M. GORDON[1*], C. ZAMORA[1], R. KAUFFMAN[1], S. LONG[2], K. AGUSTSSON[1], B. GONZALES-CLAYTON[1], AND A.R.C. KYLANDER-CLARK[3]

[1]University of Nevada, Reno, NV, 89557, USA (*correspondence: staciag@unr.edu)

[2]Washington State University, Pullman, WA, 99164, USA

[3]University of California, Santa Barbara, CA, 93106, USA

Greater Himalayan (GH) rocks represent the metamorphic core of the Himalayan orogen. How these rocks were exhumed during active convergence continues to be debated. Within the eastern Himalaya, the Kakhtang thrust (KT) is interpreted to structurally thicken and divide the GH into upper and lower units. In order to investigate the timing of metamorphism and exhumation, metapelite, migmatite, and leucosome samples were collected along two N–S transects that cross the KT in central and eastern Bhutan. *P–T* estimates reveal consistent *T* (from ~720–620 ºC) and an upright *P* gradient, with *P* decreasing from ~10 to 5 kbar across the two transects. Within each transect, there are discrete increases in $P \pm T$ within the overall upright gradient. Split-stream LA-ICPMS monazite results from the GH in eastern Bhutan reveal a progressive younging of near-peak metamorphism within the GH, with dates of ca. 23–20 Ma for the structurally highest sample versus ca. 18–16 Ma for the structurally lowest sample. The central Bhutan transect reveals older near-peak metamorphic ages: ca. 48–46 Ma within the KT zone and ca. 25–22 Ma for the structrally highest sample. Trace elements suggest that the rocks underwent some decompression (garnet-breakdown) by ca. 16–14 Ma and ca. 26–17 Ma in eastern and central Bhutan, respectively. This is consistent with zircon from leucosomes that indicate initial melt crystallization began at ca. 27 Ma for upper-GH samples versus ca. 15 Ma for samples within the KT zone. LA-ICPMS U-Pb rutile and titanite ages and $^{40}Ar/^{39}Ar$ muscovite ages from both transects reveal cooling through ~400 ºC by ca. 11–8 Ma. The trend of older metamorphic and melt-crystallization ages with increasing structural level suggest that the rocks underwent initial exhumation driven by ductile underplating along intra-GH shear zones beginning at ca. 27 Ma; the underplating constructed a composite GH unit, and the shear zones are marked by jumps in *P* within the overall upright gradient. After underplating, the rocks remained at high temperatures until ca. 11 Ma, when the composite GH was exhumed as a whole to shallow crustal levels.