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Structure and timing of exhumation of the highest Alpine range: the Mont-Blanc massif.

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The external crystalline massifs (ECM) of the Alps have the highest summits and the roughest topography of the belt. That topography results from the interaction of the rock uplift of the ECM and associated sedimentary cover, with erosion and subsequent deposition in the Molasse basin. The summit of the Mont-Blanc massif is the highest point in the Alps (4810m). However, the timing and mechanism of Tertiary deformation and exhumation of the massif was unclear. Therefore, we have re-examined the alpine structural evolution of the Mont-Blanc and the surrounding area.

The Mont-Blanc and the Aiguilles Rouges ECM are windows of Variscan basement within the Penninic and Helvetic nappes. New structural, $^{40}Ar/^{39}Ar$ and fission-track data combined with a compilation of earlier P-T estimates and geochronological data provide constraints on the amount and timing of the exhumation of these massifs. Alpine exhumation of the Aiguilles Rouges was limited to the thickness of the overlying napes ($\sim$10 km), while rocks now outcropping in the Mont-Blanc have been exhumed from 15 to 20 km depth. Uplift of the two massifs started $\sim$22 Ma ago, probably above an incipient thrust: the Alpine sole thrust. At $\sim$12 Ma, the NE-SW trending Mont-Blanc shear zone (MBsz) initiated. It is a major steep reverse fault with a dextral component, whose existence has been overlooked by most authors, that brings the Mont-Blanc above the Aiguilles Rouges. Total vertical throw on the MBsz

is estimated to be between 4 and 8 km. Fission-track data suggest that relative motion between the Aiguilles Rouges and the Mont-Blanc stopped ∼4Ma ago. Since then, uplift of the Mont-Blanc has mostly taken place along the Mont-Blanc back-thrust, a steep north-dipping fault bounding the southern flank of the range. The highest topography is located where the back-thrust intersects the MBsz.

Uplift of the Mont-Blanc and Aiguilles Rouges occurred towards the end of motion on the Helvetic basal décollement, located at the base of the Helvetic nappes, but is coeval with the Jura thin-skinned belt. North-westward thrusting and uplift of the ECM above the Alpine sole thrust deformed the overlying Helvetic nappes, and formed a backstop, inducing the formation of the Jura arc. In that part of the external Alps, ∼NW-SE shortening with minor dextral NE-SW motions appears to have been continuous from ∼22Ma until at least ∼4Ma ago but may still be active today. Based on these constraints, we propose a sequential history of the alpine structural evolution of the units now outcropping NW of the Pennine thrust. Such a reconstruction is a first step towards a real 4D budget taking into account uplift, erosion and depositional rates.