Prolonged extension in the middle and upper continental crust: insights into the Simplon Shear Zone (Western Alps)

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The evolution of a shear zone in space and time is strongly influenced by PT conditions, differential stress, pore fluid pressure and time duration of activity (Fossen & Cavalcante, 2017). The understanding of mechanisms controlling the development of a shear zone is thus of paramount importance in constraining the rheology of the continental lithosphere. In particular, crustal scale low-angle normal faults are structures commonly active at mid to upper crustal levels within quartz- and feldspar-rich rocks promoting the exhumation of deep-seated rocks in orogenic post-collisional setting.

We studied the evolution of the Simplon Shear Zone (Switzerland) formed as an extensional detachment accommodating E-W directed lateral extrusion after the collision between Adria and Europe (Mancktelow, 1985). Several tens of kilometres of extension were accommodated by the Simplon Shear Zone, allowing the exhumation of the Lepontine Dome, the deepest part of the Central-Western Alps.

We investigated the evolution of the Simplon Shear Zone constraining the meso-, microstructures and vorticity distribution across the shear zone, its time of activity by $^{40}Ar/^{39}Ar$ dating of syn-shearing micas and its correlation with simple shear component distribution, the estimates of magnitude and variation of differential flow stress and strain rates during shear zone evolution obtained through EBSD-assisted quantitative microstructural analysis. All these data have been combined to reconstruct the structural and temporal evolution of the shear zone as the result of the response of involved rocks to changing PT and stress conditions.

The Simplon Shear Zone evolved from epidote-amphibolite to greenschist facies and then brittle conditions during shearing. A decrease of simple shear component from 88% to 37% towards the top of the shear zone is observed, with mylonites displaying ages within the 12-8 Ma time span. Calculated differential stress (59-78 MPa) and strain rate (10^{-11}-10^{-12} s^{-1}) are in agreement with values of several other crustal-scale low-angle normal faults developed at medium to shallow crustal levels (Montemagni & Zanchetta, 2022).

Our approach used at different scales revealed that the Simplon Shear Zone experienced a complex evolution, with shear strain that was heterogeneously distributed across the shear zone. Even though this heterogeneity, a general decrease of the simple shear component and increase of the differential flow stress toward the top of the shear zone is clearly defined.

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