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From transtension to extension: Neogen kinematic evolution of the Lepontine Dome (Swiss Alps) revealed by dynamic fault analysis and morphotectonics

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The main updoming of the Lepontine Gneiss dome started some 32-30 Ma ago with the intrusion of the Bergell tonalites and granodiorites, concomitant with dextral strike-slip movements along the Tonale and Canavese Lines (Argand's Insubric phase). Subsequently, the center of the main updoming has migrated slowly to the west, reaching the Simplon region some 20 Ma ago. The architecture of this Oligocene-Miocene basement unit, resulting from ductile and semi-ductile deformations, is composed by two "sub-domes": the Simplon dome to the west and the Ticino dome to the east, separated by the "Maggia steep zone". Both of them are formed mainly by stacking of different nappes consisting of orthogneissic cores discontinuously mantled by a schistose paragneissic envelope and overlying Mesozoic metasediments which are tectonically interposed between the older sequences and interpreted as "nappe separators". These ductile structures begin to be well documented (Steck and Hunziker, 1994) contrary to the brittle post-nappe tectonics of the dome that still remains underexplored.

Thus, the network of faults and morphotectonic lineaments of the western parts of the Lepontine dome (Central Alps) is here examined to investigate the late alpine kinematics from Oligocene to Quaternary times. Calculations of the stress distributions (dihedra calculations, P-T-B axes method, numerical dynamical analysis, direct inversion) have yielded a stress field which may be attributed to an important phase of extension during Oligocene to Miocene, probably following the early "core complex" stage of extension leading to the development of the Lepontine gneissic dome. Indeed, all the methods indicate that this crustal-scale rigid block faulting is characterised by a normal paleostress tensor with a NE-SW trending axis $\sigma 3$ (similar to those calculated all along the Simplon line). Nevertheless, it appears different sets of faults, well expressed by morphological features visible on the satellite images. Different sets of fault can be observed with the following trend: NW-SE with normal offset (the most represented), N90˚ to N100˚ with normal/dextral offset, and N0˚ to N20˚ with normal/sinistral offset. This particular fault pattern seems concordant to transtensional models established previously (Schreurs and Colletta, 1998; Waldron, 2005), where incremental strain associated with simple-shear deformation in a strike slip zone could explain the reactivations and the small variations of fault trend.

The occurrences, characteristic for a specific fault set, of cohesive or non-cohesive cataclasites derived from gneisses associated with pseudotachylyte veins, fault planes with chlorite and quartz slickenslides, and/or gouge, suggest an important brittle history and, especially, probably a progressive evolution in the formation of these different sets of fault, sometimes involving reactivation of some of them. These field-based studies are complemented by on-going analytical work on pseudotachylytes in order to better constrain the timing of the deformation. Indeed, some occurrences of true glass, resulting from melting/quenching processes, would allow timing constraints to be obtained. Some morphological features suggest also a possible quaternary activity of some WSW-ENE trending fault.

These observations appear well in line with others studies on the entire arc from the Bergell intrusion (Ciancaleoni, 1999) to the western boundary (Sue et al, 2005) and can be explained by a model that involves foreland propagating structural systems facilitating arc-normal contraction in the foreland and arc-parallel extension in the hinterland that work together to maintain the arcuate shape of the Alps.

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