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Gravitational transfer zones influence DSGSD mechanisms and activity

Federico Agliardi, Margherita Cecilia Spreafico, Stefano Zanchetta, Riccardo Castellanza, Riccardo Asnaghi, Jacopo Paternoster, Chiara Crippa, and Giovanni Crosta
Università degli Studi di Milano - Bicocca, Earth and Environmental Sciences, Milano, Italy (federico.agliardi@unimib.it)

The influence of inherited tectonic structures like steep and low-angle faults, major shear zones and tectonic boundaries on Deep-Seated Gravitational Slope Deformations (DSGSD) has been widely documented. However, the controls exerted by non-persistent, partially overlapping master fractures on the topographic stress distribution, damage patterns, failure mechanisms and style of activity of large rock slope instabilities is still unexplored.
We investigate the mechanisms and activity of the Corna Rossa DSGSD (Valfurva, Italian Central Alps). This extends over 10 km2 affecting a 1500 m high formerly glaciated slope in quartz-phyllites and mica-schists of the Austroalpine Pejo unit, and is the most active DSGSD in the Lombardy region. Brittle tectonic deformation stages affected the area since Late Oligocene, resulting in the development of different fracture systems, from outcrop to regional scale. Notably, a swarm of WNW-ESE trending en echelon steep master fractures cuts the N valley flank, terminating and partially overlapping in the Corna Rossa ridge (3000m asl).
Geomorphological and morpho-structural analysis of field, aerial and HRDEM data, quantitative analysis of available satellite D-InSAR products, and 3D geometrical, geological and FEM numerical modelling allowed reconstructing a DSGSD characterized by a complex style of gravitational strain accommodation. This occurs through a complex series of gravitational shear and extensional zones up to 450 m deep. The entire slope is actively deforming in distinct sectors: 1) NW sector, characterized by pure sliding mechanisms testified by scarps, reaching up to the crest and showing highest radar LOS displacement rates; 2) SE upper slope sector, showing lower displacement rates and dominant extension along a wide graben at slope crest and multiple system of steep scarps and counterscarps downslope; 3) SE lower slope sector, showing mechanisms similar to sector 1 on smaller scale and displacement rates. We investigated the mechanisms underlying these observations by setting up a 3D FEM elasto-plastic model of multistage deglaciation and shear strength reduction, considering the rock mass as a Mohr-Coulomb material and including inherited, non-persistent fractures as thin layers of pre-damaged rock. Rock properties were derived by field and laboratory data. Our results outline the occurrence of a "gravitational transfer zone" within a DSGSD, accommodating gravitational strain by dominant extension in the interaction zone between partially overlapping gravitational "faults" (dominant slip). This strongly affects the mechanism, amount and rate of gravitational deformation in different DSGSD sectors, with significant geohazard implications.