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Critical Review of Kinematic Analyses from the 2012 Preonzo Rock Slope Failure

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Structural and kinematic analysis of the fracture and joint patterns in the source area of rock slope instabilities has traditionally been considered an important component of pre-disposition and displacement studies prior to failure of such mass movements. These analyses are based on the assumption that fractures are fully persistent and that available surface outcrops represent the statistical conditions of fractures at depth, especially at the elevation of basal rupture planes. However, we have observed several cases where kinematic analyses from surface outcrops are ambiguous, or even misleading regarding kinematic feasibility. An impressive example of such a case is the Preonzo 2012 rock slope failure, where pre-failure kinematic analyses could not explain the observed slope movements and where we have the possibility to compare in detail the pre-failure kinematic analyses with the actual properties of the failed rock mass, the head scarps and basal rupture planes.
The Preonzo retrogressive rock slope instabilities are located at the western slope of the Riviera valley, within crystalline units of the Simano nappe (penninic domain), at an alpine meadow above the village Preonzo. During the last 25 years, progressively evolving tension cracks in the head scarp area and displacements of the rock face exposed below these tension cracks were systematically monitored, especially during a phase of increasing rockfall activity and displacement velocity occurring during the last 15 years. In May 2012 about 210'000 m3 of unstable rock failed in two catastrophic events and exposed a complex failure surface. A similar volume of unstable rock remained in situ.
Prior to this event, periodic fieldwork was performed over about 10 years to investigate the statistical properties of discontinuities in the area of the instability. Three main joint sets were recognized, accompanied by several randomly oriented discontinuities. Comprehensive kinematic analyses were conducted, which gave no explanations for the observed displacement rates, displacement fields and displacement vector orientations. After the event, several high-resolution photogrammetric models of the exposed failure surfaces were created from manned helicopter images. While the head scarps are controlled by the known pre-failure fracture patterns, the basal rupture plane is composed of newly ruptured rock bridges, breccia and steeply dipping fracture sets. At the large scale, the planar failure surface dips 42° out of the slope, which cannot be explained by discontinuities measured prior to the event. The mechanical evolution of this failure plane is the focus of an ongoing study.