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Structurally controlled failure initiation of deep seated mass movements

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Failure mechanisms and fracturing processes affecting the failure surface geometries were analysed at several deep seated rockslides in Northern Tyrol (Austria). Field observations show that in similar rock types slope instabilities often occur in less steeply inclined slopes, whereas the steeper slopes nearby remain at a stable condition over a time span of thousands of years. Especially in fractured rock masses characterised by deep seated mass movements, such behaviour is controlled by structural discontinuities i.e. tensile joints, shear fractures, bedding planes and brittle fault zones. The studied slopes presented herein are either situated within foliated crystalline or bedded carbonatic rocks units and reach differences in elevation from several hundred to more than thousand metres. The majority of these case studies show active, slowly creeping rockslides in crystalline rocks or sliding masses that reach after a displacement of several hundred metres a final stable stage. One site comprises the structurally predisposed wedge-failure of a fossil carbonatic “sturzstrom”. In general, all individual sites are characterised by different post-peak failure kinematics, i.e. slowly creeping or rapid catastrophic failure occurring after the formation of a coherent basal sliding zone. Apart from this discrepancy field observations clearly demonstrate the structural control on failure initiation as a common stability relevant factor. Well exposed scarp areas provide insights in processes of failure initiation through fracture propagation and coalescence of predisposed and favourably orientated brittle discontinuities. Both, foliation and bedding planes often do not act as a potential failure-plane due to their unfavourable intersection in relationship to the slope orientation. In contrast, there are preferable orientated meso-scale tensile joints and shear fractures that may control the slope deformation. Additionally, brittle fault zones and lithological weakness zones,

e.g. thin-bedded layers of marls, influence the geometry of the scarps and the failure zones. A general observation was that the sliding zones do not simply originate through in-plane shear failure (mode II) along sub-parallel non-persistent discontinuities with intact rock bridges. But brittle discontinuities form weak links through which the shear plane evolved in a multiple step-path failure mechanism. Consequently, the resulting failure zone is less inclined than the mean dip angle of the stability controlling fracture sets. In addition, the discontinuity pattern has a substantial effect on the geometry of the sliding mass and the sliding zone, forming a large-scale plane or wedge slide. Of course, beside structural features also material properties (e.g. intact rock strength, fracture toughness and strength) and system boundary conditions (e.g. slope inclination, water pressures, in-situ stresses) influence the slope failure initiation. Nevertheless, considerations of pre-existing structural features are important when applying hazard assessment techniques on a regional scale.