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Geomorphological and geotechnical constrains on large slope deformations

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Large slope instabilities are controlled by many different factors: recent geological history (e.g. glaciation and deglaciation cycles, periglacial conditions, erosion and valley deepening, tectonic stress, uplift, seismicity, and landsliding); structural features (joints, faults, foliations); slope materials (lithology, weathering, and metamorphism), topographic factors (slope length and gradient), and groundwater conditions. Slope geometry is also an important factor and the general morphology including the position of the unstable slope with respect to the main and tributary valleys may have important implications on stress distributions and localizations causing sacking development. Three dimensional (3D) geomechanical numerical models based on the finite difference method (FDM - Flac3D) based on elastoplastic rock-mass response have been prepared to evaluate the sensitivity in terms of stress and strain distributions to the main boundary conditions (e.g. glacial unloading, water table geometry, slope angle and length, etc.). Data used in the 3D models included the initial slope geometry, rock mass property, internal anisotropy (pervasive foliation planes), tectonic stress in terms of relationship between horizontal and vertical stresses. Models have been prepared representing a main and a tributary valley with different slope angles and with different orientation of pre existing internal rock mass discontinuities. We analyse the influence of erosion and valley deepening. Models have been set up assuming Mohr-Coulomb behaviour associated with ubiquitous joints to simulate the dipping of foliation in metamorphic rocks. Groundwater conditions were imposed simulating different piezometric levels and increasing them during deglaciation, when, it is assumed, water availability reaches a maximum. Models shows that the existence of a complex slope geometry in combination with highly persistent discontinuities is a condition

for producing large-scale slope failures. Of the various possible failure mechanisms toppling and dip slip sliding are the more important. The pattern of deformation is strongly related to the controlled factors introduced in the analyses. As a consequence we observed different shear zone geometries (shape, thickness, depth) and extension (below or beyond the slope crest) with different orientations of the anisotropy planes (dip slope, anti-dip slope, horizontal and vertical) with respect to the two valleys (parallel, perpendicular, transversal).