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The Sciara del Fuoco debris stability (Stromboli volcano, Italy): a distinct element numerical modelling of possible triggering mechanisms.

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The work deals with the stability analysis of the volcanic debris materials of Stromboli (Italy), one of the most active volcanoes in Europe. The slope instability phenomena at Stromboli are represented not only by deep-seated gravitational slope deformations, but also by more frequent large landslides, such as those occurred in December 2002-January 2003, and shallow landslides, involving loose or weakly cemented deposits. The Sciara del Fuoco depression (SdF) is the result of the latest sector collapse affecting the NW flank of the volcano; it is covered by deposits related to the strombolian activity of the summit craters, as well as to paroxysmal events. The nature and the geotechnical properties of the debris materials filling up the SdF - grain angularity, high solid specific gravity but low unit weight for high porosity, cementation phenomena, high friction angle - allowed the formation of a steep slope, at limit equilibrium state. The volcanic activity, both explosive and effusive or the associated seismic one, supplies possible triggering factors. To evaluate their effect on the stability of the SdF debris a numerical modelling was performed by the particle code PFC2D (Itasca). It allows to analyse the movement and interaction of circular particles by the distinct element method. The conceptual model is build up as a close-packed assembly of bonded or unbonded particles which interact according to their specific particle contact properties. In codes like PFC2D the macro-scale material behaviour is given by the interactions of micro-scale components: interparticle friction coefficient, normal and shear stiffness at the particle contact, properties which are not directly known. Specific mathematical relations between mechanical parameters of the single particles and particles assembly were found as a function of the acting state of stress by the numeri-

cal simulation of a set of biaxial tests and the comparison of the stress-strain resulting curves with those obtained by the performed experimental triaxial compression tests. Their validity were considered with respect to the problem scale. The research reveals the necessity, for any specific problem, to carefully carry out a calibration phase in order to find mechanical microparameters which satisfy the natural material behaviour. The numerical conceptual model was created. A simplified geological section of the Sciara del Fuoco was built reproducing a volcanic succession of a decametres thick volcanic debris overlaying a lava bedrock, modelled as a rigid elastic solid. The model represents a portion of the Sciara del Fuoco having a mean constant dip angle of 37°. The fitted micromechanical parameters were assigned to the volcanic debris deposit. Because of a compacted initial state cannot be pre-specified, and the initial stress state cannot be introduced independently from the initial packing, a process analogous to physical compaction must be followed until the required porosity and geometry are obtained. When the model reaches the equilibrium, porosity, slope angle and single particles displacements are in good agreement with the actual situation of Sciara del Fuoco slope for stress state, geology and morphology. This model was then perturbed simulating some of the possible destabilizing actions: in particular the effect the impact of ejected boulders was analysed. During the eruption, occurred on April 2003, blocks of 15 t fell down on the SdF with impact velocity of 50-150 m/s. Simulations were performed with blocks weight=13 t impact velocity=60 m/s and 150 m/s. The impact of blocks along the slope, with different velocity, generates local perturbations; compaction upward and dilatation with small evidences of destabilisation downward. The global slope is not significantly disturbed by the impact. Additionally the effect of static load due to lava overburden and of the propagation of seismic waves on the slope stability is going to be performed. The obtained results are consistent with the SdF debris cover actual state. PFC2D results to be a useful tool in investigating debris flow triggering mechanisms.