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The Rock Engineering System (RES) applied to landslide susceptibility zonation of the northeastern flank of Etna: methodological approach and results

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Ground deformations in the northeastern flank of Etna are well known. Despite only a few landslide events have been documented, these have significantly involved and damaged lifelines and buildings. These events are mainly related to the activity of the volcano-tectonic structures and associated seismicity, as in the case of the 2002 reactivation of the Presa landslide during an increased activity of the Pernicana fault system.

In order to highlight the areal distribution of potentially unstable slopes based on a detailed, site-specific study of the factors responsible for landslide, and to ultimately contribute to risk management, a landslide susceptibility analysis of the northeastern flank of Etna in the Pernicana area was carried out, and a susceptibility map at 1:10.000 scale was produced, extending over an area of 168 km2.

Different methods are proposed in the literature to obtain the regional distribution of potentially unstable slopes, depending on the problem scale, the slope dynamic evolution in the geological context, and the availability of data. Among semi-quantitative approaches, the present research combines the Rock Engineering System (RES) methodology with parameter zonation mapping in a GIS environment.

The RES method represents a structured approach to manage a high number of interacting factors involved in the instability problem. A numerically coded, site-specific interaction matrix (IM) analyzes the cause-effect relationship in these factors, and calculates the degree of interactivity of each parameter, normalized by the overall interactivity of the system (weight factor). In the specific Etna case, the considered parameters are: slope attitude, lithotechnical properties (lithology, structural complexity, soil and rock mass quality), land use, tectonic structures, seismic activity (horizontal acceleration) and hydrogeological conditions (groundwater and drainage). Thematic maps are prepared at 1:10.000 scale for each of these parameters, and instability-related numerical ratings are assigned to classes.

An instability index map is then produced by assigning, to each areal elementary cell (in our case a 10 m pixel), the sum of the products of each weight factor to the normalized parameter rating coming from each input zonation map. This map is then opportunely classified in landslide susceptibility classes (expressed as a percentage), enabling to discriminate areas prone to instability.

Overall, the study area is characterized by a low propensity to slope instability. Few areas have an instability index of more than 45% of the theoretical maximum imposed by the matrix. These are located in the few steep slopes associated with active faults, and strongly depending on the seismic activity. Some other areas correspond to limited outcrops characterized by significantly reduced lithotechnical properties (low shear strength).

The produced susceptibility map combines the application of the RES with the parameter zonation, following methodology which had never been applied up to now in in active volcanic environments. The comparison of the results with the ground deformation evidence coming from monitoring networks suggests the validity of the approach.