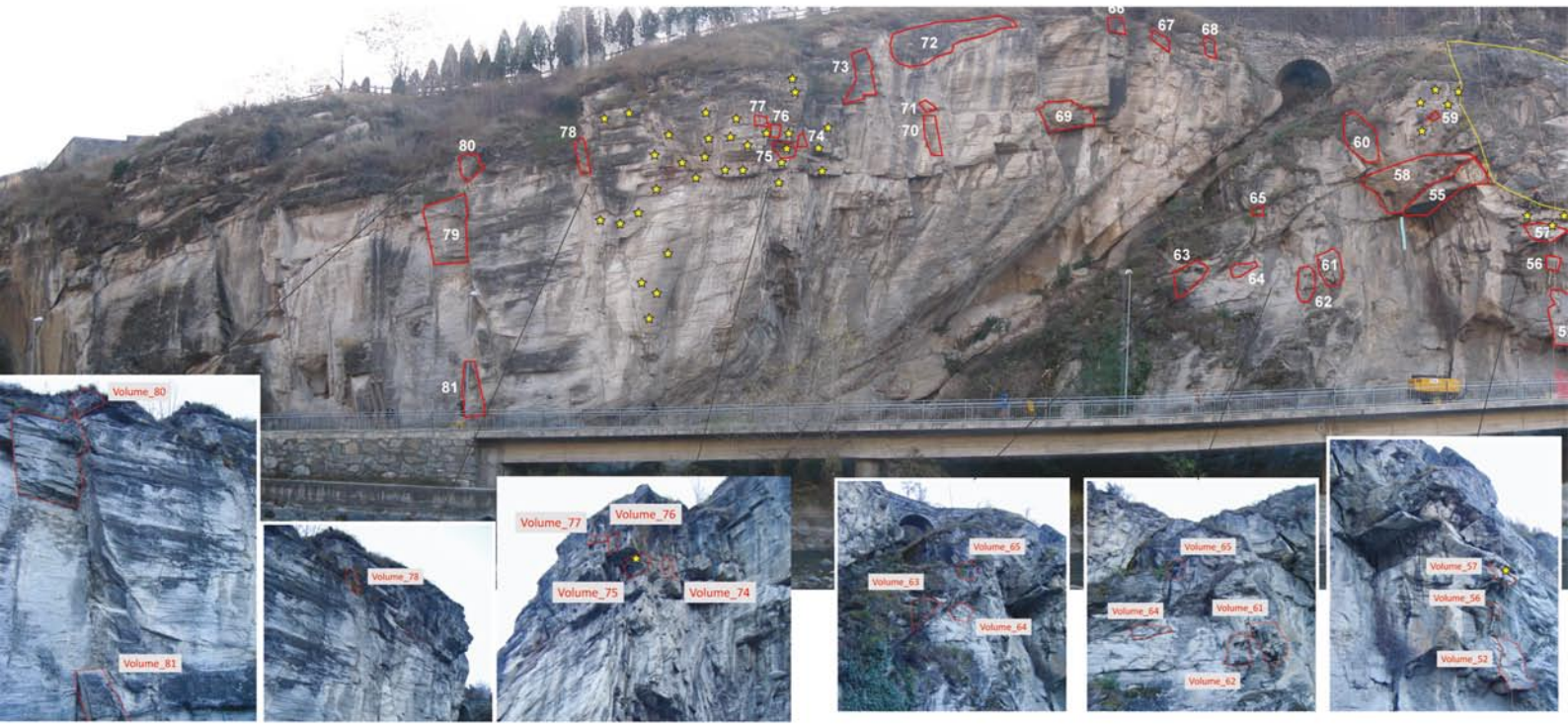

GEO4ROCK

Advanced rock mass characterization and reinforcement design of Rock Masses

Civil engineers have been building structures on or in rock for long time. ETS is specialized in Rock Engineering involving problems of discontinuous rock masses with a focus on the challenging situations for slopes and tunnels. ETS has developed advanced analysis methodology to investigate, model and design in a clear, repeatable and objective orientated-way. ETS has a large experience in the design of reinforcement works, both active and passive, early warning system and monitoring system. The methodology for slopes complies with the following steps:

-High productivity surveying techniques with the ETS multi-dimensional mobile mapping ARCHITA, in order to minimize time, cost and field work. The survey includes Terrestrial Laser Scanner (TLS) and thermo cameras;

-High detailed large-scale survey thanks to our qualified rock-climbers and the support of Unmanned Aerial Vehicles (UAV) for inaccessible rock cliffs;

- The integration of the different surveys is carried out in a unique 3D environment with a precision of few centimeters. The point cloud is processed to extract the rock mass discontinuities orientation and geometry;
- In-situ and lab testing to complete the geological and geomechanical characterization of the rock mass and the discontinuities;
- The data are analyzed to identify the probable failure mechanism and quantify the extent of unstable rock volumes;
- Stability and deformability assessment with the support of advanced numerical analysis (Plaxis, Flac, Rocscience) and choose of the eventual protection strategy (active, passive, combo);
- Design of the interventions, the monitoring system, the early warning system to the desired safety level taking into account the challenges of the specific site and the geological-engineering problems.

Raster maps can be created with the distribution of the significant parameters influencing the behavior of the rock mass (e.g. frequency, spacing, P21-cumulative trace length per unit are, Vb-elementary rock volume, Jv-volumetric joint count, etc.). The above parameters can be combined in order to obtain thematic maps draped over the 3D model of the rock mass indexes.

ETS is also specialized in the rock application for tunnels, both in deep and swallow contexts. Thanks to the practical experience and the design-numerical skills, ETS can deal with rockburst, faults, groundwater problems, rock swelling, creep, cavities and unstable wedges. ETS can effectively design proper solutions for both the temporary and the final lining in each condition.

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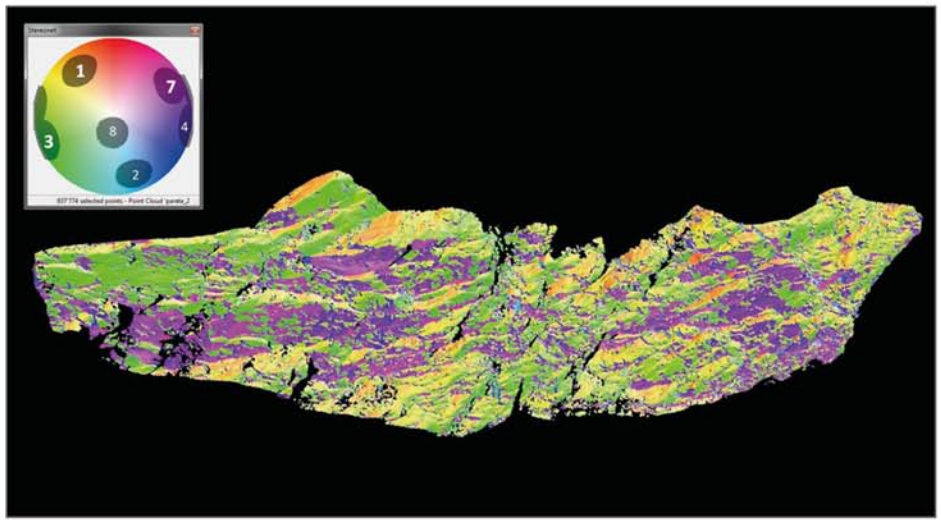
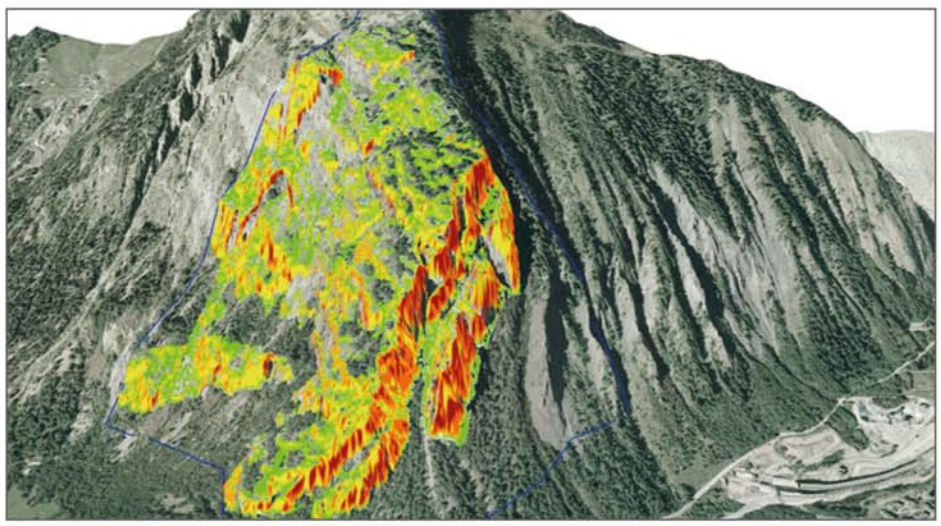
ETS

Geomatics, Geology, Geotechnics and Geomechanics for Rock Engineering



Dip and Dip Direction

A false colour 3D model of the slope is shown. The colours are defined by the local Dip and Dip Direction for each point of the dense 3D point cloud by applying a computer graphics classical Hue Saturation Value (HSV) wheel to a standard stereonet.



Rock Mass Index value map

The SMR value map for a rock cliff is shown. The input for a SMR value map are: the DEM of the slope, raaster map of the RMRb (Rock Mass Rating), raster map of the method of the excavation and the orientation (Dip, Dip Direction) of the selected sets of discontinuities. The analysis is carried for each pixel of the DEM and each set of discontinuity to calculate the minimum values of adjustment factor. The raster map can be draped over a base layout, topographic map, orthoimage and online basemap. The same map can be obtained for all the rock mass indexes (e.g. SMR, GSI, RMR).

Reinforcement works Design

The active reinforcement of a large weak rock slope is shown. The continuous distribution of significant parameters through maps can help in planning more detailed investigations, preliminary design and monitoring. The technologies of survey and investigation, the 3D distribution of the parameters and the accurate characterization allows a detailed assessment of the stability and deformability of the rock mass.

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