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Structural analysis of San Leo (RN, Italy) east and north cliffs using 3D point clouds

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The town of San Leo, like many others in the historical region of Montefeltro (Northern Apennines, Italy), was built in medieval period on a calcarenite and sandstone slab, bordered by subvertical and overhanging cliffs up to 100 m high, for defense purposes.
The slab and the underlying clayey substratum show widespread landslide phenomena: the first is tectonized and crossed by joints and faults, and it is affected by lateral spreading with associated rock falls, topples and tilting. Moreover, the underlying clayey substratum is involved in plastic movements, like earth flows and slides.
The main cause of instability in the area, which brings about these movements, is the high deformability contrast between the plate and the underlying clays.
The aim of our research is to set up a numerical model that can well describe the processes and take into account the different factors that influence the evolution of the movements. One of these factors is certainly the structural setting of the slab, characterized by several joints and faults; in order to better identify and detect the main joint sets affecting the study area a structural analysis was performed.
Up to date, a series of scans of San Leo cliff taken in 2008 and 2011, with a Riegl Z420i were analyzed.
Initially, we chose a test area, located in the east side of the cliff, in which analyses were performed using two different softwares: COLTOP 3D and Polyworks. We repeated the analysis using COLTOP for all the east wall and for a part of the north wall, including an area affected by a rock fall in 2006.
In the test area we identified five sets with different dips and dip directions.
The analysis of the east and north walls permitted to identify eight sets (seven plus the bedding) of discontinuities. We compared these results with previous ones from surveys taken by others authors in some areas and with some preliminary data from a traditional geological survey of the whole area.
With traditional methods only a limited number of measurements can be collected, and in small areas, that often are not representative of the entire rock mass. In this case, some of the discontinuities are located only in specific parts of the rock mass, thus resulting difficult to be detected with a classical survey. Moreover, certain sets are identifiable only in the uppermost or lowermost part of the cliff, and change their orientation along the surface.
For this reason, the integration of classical and innovative surveying techniques can be really useful. TLS survey and structural software analysis can help to understand which sets are really determinant for the structural description of the slab at the slope scale and therefore for the stability of the cliffs.
We are planning to complete the TLS survey all around the cliff, to obtain a full 3D model of the rock slab, to be used for numerical modelling. All the obtained results are validated with a site-survey, which is in progress at the moment.