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Rock face stability analysis and potential rockfall source detection in Yosemite Valley

B. Matasci (1), G.M. Stock (2), M. Jaboyedoff (1), T. Oppikofer (3), A. Pedrazzini (1), and D. Carrea (1)

(1) University of Lausanne, IGAR-FGSE, Lausanne, Switzerland (battista.matasci@unil.ch), (2) National Park Service, Yosemite National Park, El Portal, California 95318, USA, (3) Geological Survey of Norway, NO-7491 Trondheim, Norway

Rockfall hazard in Yosemite Valley is especially high owing to the great cliff heights (~1 km), the fracturing of the steep granitic cliffs, and the widespread occurrence of surface parallel sheeting or exfoliation joints. Between 1857 and 2011, 890 documented rockfalls and other slope movements caused 15 fatalities and at least 82 injuries. The first part of this study focused on realizing a structural study for Yosemite Valley at both regional (valley-wide) and local (rockfall source area) scales. The dominant joint sets were completely characterized by their orientation, persistence, spacing, roughness and opening. Spacing and trace length for each joint set were accurately measured on terrestrial laser scanning (TLS) point clouds with the software PolyWorks (InnovMetric).

Based on this fundamental information the second part of the study aimed to detect the most important failure mechanisms leading to rockfalls. With the software Matterocking and the 1m cell size DEM, we calculated the number of possible failure mechanisms (wedge sliding, planar sliding, toppling) per cell, for several cliffs of the valley. Orientation, spacing and persistence measurements directly issued from field and TLS data were inserted in the Matterocking calculations.

TLS point clouds are much more accurate than the 1m DEM and show the overhangs of the cliffs. Accordingly, with the software Coltop 3D we developed a methodology similar to the one used with Matterocking to identify on the TLS point clouds the areas of a cliff with the highest number of failure mechanisms. Exfoliation joints are included in this stability analysis in the same way as the other joint sets, with the only difference that their orientation is parallel to the local cliff orientation and thus variable. This means that, in two separate areas of a cliff, the exfoliation joint set is taken into account with different dip direction and dip, but its effect on the stability assessment is the same.

Areas with a high density of possible failure mechanisms are shown to be more susceptible to rockfalls, demonstrating a link between high fracture density and rockfall susceptibility. This approach enables locating the most probable future rockfall sources and provides key elements needed to evaluate the potential volume and run-out distance of rockfall blocks. This information is used to improve rockfall hazard assessment in Yosemite Valley and elsewhere.