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Cross-Bedding and Structural Mapping for Rockfall Assessment of a Tunnel using Hi-Resolution LiDAR (Fribourg, Switzerland)

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Lithology identification and discontinuity mapping are necessary for rockfall hazard assessment in tunnels. However, the restricted exposure and variability of rock face orientation in tunnels ought to be taken into account. Therefore, using Light Detection and Ranging (LiDAR) technique may significantly contribute to this task.

A historical carved tunnel in the Upper Marine Molasse (a poorly consolidated sandstone) of the City of Fribourg (Switzerland) was then investigated by fieldwork and LiDAR. Interestingly, it appears that in addition to joints and layering, some specific sedimentary structures, i.e. cross-bedding, have an important role in the tunnel roof stability. Cross-bedding is a sedimentary structure that can be identified clearly by the geometry of layer within one or more beds in a series of rock strata that does not run parallel to the plane of stratification.

In order to detect and analyse these sedimentary structures, the intensity of the backscattered LiDAR signal is analysed using the Oren-Nayar reflectance model, which considers range, incidence angle, scanned surface geometry (i.e. roughness). It provides corrected values of intensities that make possible to distinguish and identify geometry of cross-beddings in the tunnel.

An analysis of structural discontinuities was also performed using Coltop Software which identified joint sets developed inside the tunnel. Based on this approach, lithology characterizations, orientation of each discontinuity and bedding structures could be identified in point clouds confidently for understanding the mechanisms of potential rockfalls in the tunnel.