Geophysical Research Abstracts
Vol. 15, EGU2013-3429, 2013
EGU General Assembly 2013

LIDAR-based outcrop characterisation — joint classification, surface and block size distribution

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Outcrops, in the first instance, only offer at best a 2–2.5D view of the available geological information, such as joints and fractures. In order to study geodynamic processes, it is necessary to calculate true values of, for example, fracture densities and block dimensions. We show how LIDAR-generated point-cloud data of outcrops can be used to delineate such geological surfaces. Our methods do not require the point-set to be meshed; instead we work with the original point cloud, thus avoiding meshing errors.

In a first step we decompose the point-cloud into tiny volumes; in each volume we calculate the best fitting plane. An expert can then decide which of the planes are important (in an interactive density pole diagram) and classify them. Actual block surfaces are identified by applying a clustering algorithm to the mini-planes. Subsequently, we calculate the size of these surfaces. Finally we estimate the block size distribution within the outcrop by projecting the block surfaces into the rock volume. To assess the reproducibility of our results we show to which extent they depend on various parameters, such as the resolution of the LIDAR scan and algorithm parameters. In theory the results can be calculated at the site of measurement to ensure the LIDAR scan resolution is sufficient and if necessary rerun the scan with different parameters.

We demonstrate our methods with LIDAR data that we produced in a sandstone quarry in Germany. The part of the outcrop which we measured with the LIDAR was out-of-reach for measurements with a geological compass, but our results correlate well with compass measurements from a different outcrop in the same quarry. Three main surfaces could be delineated from the point cloud: the bedding, and two major joint types. The three fabrics are almost orthogonal. Our statistical results suggest that blocks with a volume of several hundred liters can be expected regularly within the quarry.

The results can be directly used to characterise the fractures in an outcrop, for instance, to determine possible fluid transport for geothermal use, or to calculate block dimensions after quarrying.