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Combined photogrammetric techniques with classical structural surveys: a methodological workflow tested in fractured platform carbonates (Island of Pag, Croatia)

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In the last decades, digital field-mapping techniques on Digital Outcrop Models (DOMs) based on “close-range” photogrammetry have been successfully applied to integrate the “classical” structural analysis to obtain large and statistically-consistent datasets of structural elements, useful for modelling fracture distribution. Here we present the workflow we are applying for a multiscale characterization of fracturing in a folded Cretaceous carbonate platform in the Island of Pag, in the External Dinarides of Croatia, along with our preliminary results.

In the study area, the platform carbonates consist of rudist-bearing limestones, organized in 2-3 m thick beds of white floatstone with mudstone matrix, alternating with thinner (less than 1 m thick) beds of light brown packstone. A hierarchical organization of fractures is observed, including (1) hectometre-scale fracture corridors crosscutting the whole sequence, (2) through-going fractures cutting several mudstone beds, (3) strata-bound fractures and (4) a pervasive network of fractures completely included in the beds. To characterize the fracture network at multiple scales, we integrated satellite imagery and DOMs reconstructed from ground-based photogrammetry. Field surveys served to establish the relative chronology between fracture sets. DOMs were used to obtain 3D fracture networks and to create virtual bedding-parallel and bedding-perpendicular planar sections suitable to guarantee acquisition of statistically robust datasets for each fracture set. The DOMs are reconstructed with photogrammetric techniques and processed with the Visual Structure From Motion (VSFM) software. The VSFM algorithm links directly each pixel in the images (in 2D image coordinates) to the corresponding point (in 3D real space) on the DOM. This linkage allows to process the high-resolution images using image analysis techniques, and to project the extracted features on the DOMs without losing resolution. We developed a MATLAB® toolbox implementing: (1) three lineament detection algorithms, each of which optimized for different outcrop characteristics, (2) an interface to select and classify the relevant lineaments and (3) a tool to project the lineaments on the DOM surface and export them as 3D lines. Once projected on the DOM, faults and fractures are used for further 3D analysis. Our preliminary results suggest that the method can effectively increase the statistical strength of field-based fracture distribution studies.