Geophysical Research Abstracts
Vol. 15, EGU2013-11547, 2013
EGU General Assembly 2013

High resolution t-LiDAR scanning of an active bedrock fault scarp for palaeostress analysis

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Palaeostress analysis of an active bedrock normal fault scarp based on kinematic indicators is carried applying terrestrial laser scanning (t-LiDAR or TLS). For this purpose three key elements are necessary for a defined region on the fault plane: (i) the orientation of the fault plane, (ii) the orientation of the slickenside lineation or other kinematic indicators and (iii) the sense of motion of the hanging wall.

We present a workflow to obtain palaeostress data from point cloud data using terrestrial laser scanning. The entire case-study was performed on a continuous limestone bedrock normal fault scarp on the island of Crete, Greece, at four different locations along the WNW-ESE striking Spili fault. At each location we collected data with a mobile terrestrial light detection and ranging system and validated the calculated three-dimensional palaeostress results by comparison with the conventional palaeostress method with compass at three of the locations. Numerous kinematics indicators for normal faulting were discovered on the fault plane surface using t-LiDAR data and traditional methods, like Riedel shears, extensional break-outs, polished corrugations and many more. However, the kinematic indicators are more or less unidirectional and almost pure dip-slip. No oblique reactivations have been observed. But, towards the tips of the fault, inclination of the striation tends to point towards the centre of the fault.

When comparing all reconstructed palaeostress data obtained from t-LiDAR to that obtained through manual compass measurements, the degree of fault plane orientation divergence is around $\pm$005/03 for dip direction and dip. The degree of slickenside lineation variation is around $\pm$003/03 for dip direction and dip. Therefore, the percentage threshold error of the individual vector angle at the different investigation site is lower than 3 % for the dip direction and dip for planes, and lower than 6 % for strike. The maximum mean variation of the complete calculated palaeostress tensors is $\pm$005/03. So, technically t-LiDAR measurements are in the error range of conventional compass measurements. The advantages is that remote palaeostress analysis is possible. Further steps in our research will be studying reactivated faults planes with multiple kinematic indicators or striations with t-LiDAR.