Quantitatively deciphering paleostrain from digital outcrops model and its application in the eastern Tian Shan, China

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The knowledge of the strain/stress field evolution in time is important to seismic hazard assessment and risk mitigation, and is fundamental to the understanding of the earth dynamic system. Based on the principle that past tectonic stress should have left traces in the rocks, geologists have been trying to determine the paleostress history from evidence found in rocks for decades. Recent development of techniques for automatic extraction of fracture surfaces from digital outcrop models and estimation of historical shear deformation on rock fractures provide an efficient way of quantitatively acquiring large amount of high quality fracture/fault slip data (direction and sense of slip occurs on the fault plane) from outcrops. So unlike traditional paleostress inversion methods whose data is manually collected in the field, this high quality fracture/fault slip data provide an opportunity to develop fully automatic and quantitative methods for deciphering paleostrain. In this study, for slip on each fracture, the corresponding local strain tensor is calculated, then the local strain tensors are grouped into populations corresponding to far-field strain events and local strain events using a clustering analysis technique. The applications on outcrops in the eastern Tian Shan area give a clear picture of the paleostrain variation over space and time, and also throw light on the relationship between paleostrain, fracture development and the distribution of shear displacements in a thrusting environment.