Geophysical Research Abstracts, Vol. 8, 09326, 2006
SRef-ID: 1607-7962/gra/EGU06-A-09326

Quantification of fault-plane curvature and surface heterogeneity using terrestrial laser-scanning

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Variation in the three-dimensional geometry of fault planes has important implications for the kinematics and dynamics of faulting. Fault-plane heterogeneities, including local asperities, regions of high curvature, and disruption of the fault-plane surface by cross-faulting, all have the potential to increase frictional resistance, retarding further slip and changing the seismogenic response of the fault. Cross-faulting at high angles to the fault surface can also have a major impact on the sealing capability of the fault with respect to flow of hydrocarbons and other fluids.

New methods of digital geological survey allow high-precision spatial data to be acquired very rapidly. Terrestrial laser-scanning captures a dense point-cloud of data from the outcrop surface. A typical scan of a surface rupture will contain 10,000 to 10,000,000 individual points, take 10 minutes to 3 hours of scanning to acquire, and have a point spacing of 5-50 mm, depending on the desired level of detail in the scan and the type of equipment used. Multiple scans from different scan positions are used to give complete coverage of the exposed fault plane, and to integrate neighbouring scans along strike. In this way, a highly detailed topographic model can be acquired for long lengths of surface rupture. Real-Time Kinematic GPS allows each laser-scan dataset to be correctly georeferenced in a global reference frame with sub-centimetre spatial precision. This also allows individual geological observations to be precisely

tied to the laser-scan data.

These digital survey techniques form the basis for highly detailed quantitative characterisation of fault surfaces. A range of examples are presented, including the well-exposed segmented, oblique-normal fault at Arkitsa, in the Gulf of Evvia, Greece. Observations of fault curvature and heterogeneity derived from terrestrial laser-scanning are compared with larger-scale analysis from 3D seismic data.