Geophysical Research Abstracts, Vol. 9, 02259, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-02259

Along-strike Variations of the Slip Direction on Normal Faults: Insights from Three-Dimensional Finite-Element Models

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Normal faults in nature exhibit a systematic variation of fault-slip direction along their length (e.g. Cowie and Roberts 2001). Typically, the faults show pure dip-slip at their centers whereas near their tips a significant strike-slip component is observed, with the hanging wall moving toward the fault center. This symmetric spatial pattern of the slip-directions is commonly attributed to local strain patterns at the fault tips and internal deformation of the hanging wall. Here we present a series of three-dimensional finite-element models of normal faults to evaluate the along-strike variation in the ratio between the strike-slip and the dip-slip component. Our models include isolated faults of different lengths with pinned tips, i.e. no fault propagation was allowed. A comparison of the model results with field data shows that the displacement profiles and the slip vectors along the modeled faults mimic those of real normal faults reasonably well. The experimental results show that the magnitude of the strike-slip component along the faults is primarily depending on the fault length, the amount of dip slip at the center of the fault, and the distance from the center of the fault. The rake along the model faults is largest close to the fault tips, at the point where the ratio between the strike-slip and dip-slip component reaches a maximum. Our results imply that the strike-slip component and the slip direction along normal faults can be quantified and expressed by simple mathematical relations.