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Parametric analysis of inherited low-angle fault reactivation, application to the Aegean detachment faults

E. LECOMTE, L. LE POURHIET, O. LACOMBE, and L. JOLIVET

Laboratoire de Tectonique, UMR CNRS 7072, Université Pierre et Marie Curie, 4 Place Jussieu, 75252 Paris Cedex 05, France. e-mail : emmanuel.lecomte@upmc.fr

Widespread occurrences of low angle normal faults have been described within the extending continental crust since their discovery in the Basin and Range province. Although a number of field observations suggest that sliding may occur at very shallow dip in the brittle field, the seismic activity related to such normal faults is nearly inexistent and agrees with the locking angle of 30° predicted from Andersonian fault mechanics associated with Byerlee's law.

To understand this apparent contradiction, we have introduced Mohr Coulomb plastic flow rule within the inherited low-angle faults where former studies were limited to a yield criterion. The fault is considered as a pre existing compacting or dilating plane with a shallow dip (0-45°) embedded in a brittle media. Following Anderson's theory, we assume that the maximal principal stress is vertical and equal to the lithostatic pressure. This approximation may not be true for small faults but it holds for large detachment faults where associated joints are generally vertical.

With this model, we can predict not only whether new brittle features forms in the surrounding of the low angle normal faults but also the complete stress-strain evolution both within the faults and in its surrounding. Moreover, the introduction of a flow rule within the fault allows brittle strain to occur on very badly oriented faults (dip < 30°) before yielding occurs in the surrounding medium.

After performing a full parametric study, we find that the reactivation of low angle normal faults depends primarily on the friction angle of the fault material and the ratio of the cohesion between the shear band and its surrounding. Our model is therefore in good agreement with previous simpler models, and the locking angles obtained differ in most cases by only 2 or 3° from previous yield criteria-based approaches which did explain most of the data especially the repartition of focal mechanisms worldwide.

However, we find that in some cases, significant amount of brittle strain may occur on badly oriented faults. In all those cases, the fault is in a strain hardening regime and therefore, this brittle strain may not be related to earthquakes. We classified the results of the parametric study into 4 modes of reactivation which include complete/partial reactivation with/without tension failure in the surrounding. The tabulation of those different modes of deformation allows recovering mechanical characteristics such as friction and cohesion ratio from field observations. We show how to apply it to field data from the detachment of Tinos (Greece).