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Crustal shortening in the External French Alps: thermo-mechanical modelling

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We seek to understand the geometry of the inverted passive margins at small shortening rates. At crustal scale, passive margins are constituted of faulted basement rocks which have been in filled by syn rift sediments. Hence, we find two types of mechanical heterogeneities: the basins and the pre-existing faults.
The pre-existing faults are old and although they did cumulate large amount of shear strain during the rifting, it is not clear if they are indeed weaker of stronger than the basement. Therefore, the friction of the faults is explored as a parameter of the models. Similarly, the syn-rift basin are constituted of indurate sediments which mechanical properties may be quite similar to the basement after lithification or they may have kept a relatively lower effective viscosity because of their capacity to accommodate strain by small scale folding or more intense pressure dissolution.
The results of the parametric modeling study show that the presence of weak basins on its own is sufficient to localize the strain by increasing the rate of growth of the crustal scale folds. Even for relatively small friction, i.e. 10 degrees, within the pre-existing normal faults, those are only partially reactivated in presence of weak basin and due to the predominance of the folding mode, they become nearly vertical and locked after only few percent shortening. Also, the presence of weak basins favor the localization of strain at the base of the syn-rift sequence, inducing high shear stress at the very top of the basement which is sufficiently high to produce very small reverse faults.
Comparing the results of the models to the external Alps from the Valence basin to the penninic frontal thrust (at the latitude of Bourg d Oisans), we find that the geometry of the inverted margin cannot be explained by inversion of normal faults alone and the friction of the inherited normal faults must have been higher than 20 degrees during the inversion in order to explain the kinematics deduced from field observations.