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Effects of lateral variations of crustal rheology on the occurrence of post-orogenic normal faults: the Alto Tiberina Fault (Northern Apennines, Central Italy)

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The Northern Apennines are characterized by formerly compressive structures partly overprinted by subsequent extensional structures. The area of extensional tectonics migrated eastward from Eastern Corsica to the Tuscany mainland sice the Miocene. The youngest and easternmost major expression of extension is the Alto Tiberina Fault (ATF), exposed in the Umbria region.
We estimate 2D rheological profiles across the Nerthern Apennines, and conclude that lateral rheological crustal variations have played an important role in the formation of the ATF and similar previously active faults to the west. Lithospheric delamination and mantle degassing resulted in an easterly-migrating extension-compression boundary, coinciding at present with the ATF, where (i) the thickness of the upper crust brittle layer reaches a maximun; (ii) the critical stress difference required to initiate faulting at the base of the brittle layer is at a minimum; and (iii) the total strenghts of both the brittle layer and the whole lithosphere are at a minimum.
The correlation between the bulk rheology of the crust and the location of the ATF is clear. However, the rheology by itself does not account for the low dip ($\sim 20^\circ$) of the fault. Two hypotheses are considered: (a) the low dip of the Alto Tiberina Fault is related to a rotation of the stress tensor at the time of initiation of the fault, caused by a basal shear stress of the order of 100 MPa possibly related to corner flow associated with delamination; or (b) the low dip is associated to low values of the friction coefficient (≤ 0.50) coupled with high pore pressures (about twice the hydrostatic value) related to mantle degassing.
Our results establishing the correlation between crustal rheology and the location of the ATF are relatively robust, as we have examined various possible compositions and rheological parameters. The hypotheses to account for the low dip of the ATF, on the other hand, are intended simply to suggest possible solutions worthy of further study.