Geophysical Research Abstracts
Vol. 20, EGU2018-8331, 2018
EGU General Assembly 2018

Lateral variations of crustal rheology and surface heat flow in the Northern Apennines: Correlations with tectonic inversion

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In this work the role of the lateral variations of crustal rheology and surface heat flow in the Northern Apennines is explored in order to investigate the geodynamic conditions correlated with the formation of a new E-dipping normal faults in the belt.

In the Northern Apennines the sharp variation of the heat flow at the surface along SW-NE profiles marks the transition from a western or Tyrrhenian domain, where extensional deformation has destroyed the pre-existing compressional belt, and an eastern or Adriatic domain, where the compressional structures are preserved. The present extension-compression boundary approximately coincides with the youngest and easternmost expression of extension of the Northern Apennines: the Alto Tiberina E-dipping normal fault (ATF).

To reconstruct the thermal state of the subsurface, we review and analyze the available geothermal measurements from deep boreholes present in this sector of the Northern Apennines, available by the Istituto di Geoscienze e Georisorse (IGG) of the Italian National Research council (CNR) which, with the technical and financial support of ENI, has updated the Italian National Geothermal Database. Many of the deep boreholes drilled in this sector were for hydrocarbon explorations and for that reason the temperatures reported in the wells reflect values disturbed by drilling and mud circulation, and needed to be carefully corrected.

The revised and corrected temperature data, including corrections for sedimentation, erosion and paleoclimate, are used to construct representative geotherms and to obtain a new surface heat flow map for the area. The temperature distribution thus obtained was used to estimate the rheological characteristics of the subsurface.

Two-dimensional rheological profiles across the ATF show that lateral rheological crustal variations have played an important role in the formation of the ATF and similar previously active extensional faults to the west. Lithospheric delamination and mantle degassing in the Tyrrhenian domain resulted in an easterly-migrating extension-compression boundary, characterized by the following properties: (i) the thickness of the upper crust brittle layer reaches a maximum; (ii) the critical stress difference required to initiate faulting at the base of the brittle layer is at a minimum; and (iii) the total strengths of both the brittle layer and the whole lithosphere are at a minimum.

Our conclusions are independent of any specific geodynamic models, and their reliability is a function only of the estimated crustal temperature distribution and rheological parameters. With respect to the latter, we have explored a range of values in the brittle and ductile fields, and the results are not critically parameter-dependent.