Geophysical Research Abstracts
Vol. 15, EGU2013-7236, 2013
EGU General Assembly 2013

Influence of the Lithosphere-Asthenosphere Boundary on the lithospheric stress field: inferences based on geomechanical modeling.

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A 3D lithospheric model is set up to study the crustal state of stress in the north-west of the Alps, a region where no internal deformation have been detected after more than 10 years of GPS measurements (Nocquet, 2012). The study area involves a 350km by 400km by 230 km parallelepiped incorporating the main structural elements of the lithosphere such as the ground topography, the Moho and the lithosphere-asthenosphere boundary (LAB). The model is gravity driven and two sets of boundary conditions are studied: no displacement or a normal stress proportional to the gravity in the lithosphere and no displacements within the asthenosphere. The results of the model are compared to the principal stress directions and to the principal stress ratio (R = (S2-S1)/(S3-S1)) derived from focal mechanisms inversions and from observations in the four deep (>4.5 km) boreholes available in the area.
The numerical model (FLAC3D) used for this investigation is based on an explicit finite difference scheme well adapted to take into account various rheological properties for the geomaterials. Results show that, whatever the boundary conditions are, the geometry of the LAB is the dominant feature that controls the stress field in the lithosphere when applying a hydrostatic pressure at the base of the lithosphere. Its main feature is its plunging under the Alps so that the principal stress directions in the lithosphere are found to rotate horizontally according to a scheme not compatible with observations. Yet the geometry of this boundary is well documented by various seismic data (surface waves and receiver functions). It is concluded that the lithospheric stress field is not compatible with a simple pressure applied at the Lithosphere-Asthenosphere Boundary. This may suggest that either the rheology of the asthenosphere cannot be assimilated to that of a fluid over long time-scale or there is an asthenospheric flux that controls the stress field in the lithosphere. Work is presently ongoing to investigate what asthenospheric flux would be required to fit the first order characteristics of the lithospheric stress field.

Nocquet J.-M., 2012. Present-day kinematics of the Mediterranean: a comprehensive overview of GPS results. Tectonophysics, 579, 220-242.