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Strength and Elastic thickness of the lithosphere and implication on ductile crustal flow in Europe

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The strength and effective elastic thickness (Te) of the lithosphere control its response to tectonic and surface processes. We present the first global strength and effective elastic thickness maps, which are determined using physical properties from recent crustal and lithospheric models. We estimated the lithospheric temperature from inversion of a tomography model and we extrapolated the results to the surface using crustal isotherms for different tectonic provinces based on characteristic values of radiogenic heat production. We assumed different rheologies of the upper and lower crust for continental areas, on the base of the geological features distribution. The results obtained allow us to compare for the first time the lithospheric characteristics of the different tectonic areas. The Te estimated from the strength is compared with the Te obtained by flexural loading and spectral studies. Lithospheric strength is primarily controlled by the crust in young (Phanerozoic) geological provinces characterized by low Te ($\sim$25 km), high topography (>1000 m) and active seismicity. In contrast, the old (Achaean and Proterozoic) cratons of the continental plates show strength primarily in the lithospheric mantle, high Te (over 100 km), low topography (<1000 m) and very low seismicity.

Using high resolution crustal thickness and density data provided by the EuCRUST-07 model we compute for the European continent the associated lateral pressure gradients (LPG), which can drive horizontal ductile flow in the crust. Incorporation of these data in channel flow models allows us to use potential gravity theory to assess horizontal mass transfer and stress transmission within the European crust. We explore implications of the channel flow concept for a possible range of crustal strength, using end-member ‘hard’ and ‘soft’ crustal rheologies to estimate strain rates at the bottom of the ductile crustal layers. The models show that the effects of channel flow superimposed on the direct effects of plate tectonic forces might result in additional significant horizontal and vertical movements associated with zones of compression or extension. Large values of the LPG are predicted perpendicular to the axes of European mountain belts, such as the Alps, Pyrenees–Cantabrian Mountains, Dinarides–Hellenic arc and Carpathians. In general, the crustal flow is directed away from orogens towards adjacent weaker areas. Predicted pressure and strain rate gradients suggest that gravity driven flow may play an essential role in European intraplate tectonics. These results are also important for quantifying the thickness of the low viscosity zones in the lowermost part of the crustal layers.