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Ductile crustal flow in Europe′s lithosphere

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Potential gravity theory demonstrates the presence of important gravity induced-horizontal stresses in the lithosphere associated with lateral variations in plate thickness and composition. New high resolution crustal thickness and density data provided by the EuCRUST-07 model (Tesauro et al. 2008) are used to compute lateral pressure gradients (LPG), which can drive horizontal ductile flow in the crust. We explore implications of channel flow concept for the possible range of crustal strength using end-member hard and soft crustal rheologies to estimate strain rates values 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. To investigate relationships between crustal and mantle lithospheric movement, we compare these results with the observed direction of mantle lithospheric anisotropy and GPS velocity vectors. The LPG estimated at the bottom of the upper and lower crust show similar patterns but different magnitudes. These results suggest that the direction of the horizontal stress affecting both crustal layers remains constant with depth. Our models predict large values of the LPG perpendicular to the European axis of mountain belts, such as the Alps, the Pyrenees-Cantabrian Mountains, the Dinarides-Hellenic arc and the Carpathians. In general, the crustal flow is directed away from orogens towards adjacent weaker areas (Alps, Appenines, Dinarides, and Carpathians). Gravitational forces directed from areas of high gravitational potential energy to subsiding basin areas can strongly reduce lithospheric extension of the latter, leading to a gradual late stage inversion of the entire system. Predicted pressure and strain rate gradients suggest that gravity driven flow may play an essential role in European intraplate tectonics. In particular, in a number of regions the predicted strain rates compete with tectonically induced strain rates. These results are also important to quantify the thickness of the low viscosity zones present in the lowermost part of the crustal layers.