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3D strength and gravity anomalies of the European lithosphere

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Tectonic studies made in intraplate Europe have shown that this area is more active than would be expected from its location far away from plate boundaries. Intraplate Europe is characterized by horizontal and vertical motions with deformation rates of the order of 1-2 mm/yr and by diffuse seismicity, with earthquake magnitudes rarely exceeding 4.0, that can be attributed to the existence of old zones of weakness, which are reactivated under the current stress field. The construction of the first 3D strength cube of the European lithosphere has lead to a significant understanding of the dynamics of intra-lithospheric deformation processes. The identification of intraplate areas that are mechanically weaker or stronger than neighbouring areas helps to understand the observed spatial variation in the response of the European lithosphere to large scale plate tectonic and thermal loading.

The 3D strength model is constructed using a first order 3D geometrical model of Europe's lithosphere and consists of several regions, representing areas of different composition, tectonic and/or thermal history. For continental realms, a 3D multi-layer compositional model is constructed, consisting of one mantle layer, two crustal layers and an overlying sedimentary cover layer, whereas for oceanic areas a one-layer model is adopted. The depths of the different interfaces of the layers are distinguished on the base of deep seismic reflection and refraction or surface wave dispersion studies. The base of the crust is detected using a recently compiled European Moho map. Further constraints on the thermal lithospheric structure are obtained from heat flow studies and upper mantle seismic tomography.

The first results show that the European lithosphere is characterized by major spatial mechanical strength variations, with a pronounced contrast between the strong lithosphere of the East-European Platform east of the Tesseyre-Tornquist line and the relatively weak lithosphere of Western Europe. Within the Alpine foreland, pronounced north-west-southeast trending weak zones are recognized that coincide with major structures, such as the Rhine Rift System and the North Danish-Polish Trough, that are separated by the high strength North German Basin. Moreover, a broad zone of weak lithosphere characterizes the Massif Central and surrounding areas. A pronounced contrast in strength can also be noticed between the strong Adriatic indenter and the weak Pannonian Basin area and between the Fennoscandia, characterized by a relatively high strength, and the North Sea rift system corresponding to a zone of weakened lithosphere.

These results are compared with isostatic gravity anomalies and residual mantle anomalies calculated throughout the territory studied. The gravity effect is calculated constructing a numerical density model, which includes variations in the thickness and density of the sedimentary cover and solid crust, derived from generalization of seismic and geological data and specified on a $1^\circ \times 1^\circ$ grid. Residual mantle anomalies are calculating by removing the anomalous model field from the observed gravity field. The mantle anomalies are reliably separated into two components accounting for the effects of different factors: (1) The regional component does not correlate, in a first approximation, with crustal structures and reflects large-scale structural heterogeneities of the Eurasia lithosphere, supposedly related to its thermal regime. The regional component is consistent with the shear wave velocity distribution obtained from seismic tomography data. (2) The local component of the gravity field has wavelengths shorter than 2000-2500 km and evidently correlates with specific tectonic structures. A chain of negative mantle anomalies is located west of the Tesseyre-Tornquist line (Pannonian basin-Rhine grabe-Massif Central). In the context of isostatic anomalies, the use of the real data on crustal structures, instead of the traditional Airy scheme has led in many cases to a revision of the isostatic state of the crustal structures.