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Lithosphere structure in Europe from thermal isostasy

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ABSTRACT

A new method for modeling the thermal structure of the lithosphere, termed thermal isostasy, is presented and used to calculate the lithosphere thickness and to predict geothermal heat flux in Europe and the adjacent offshore regions. The method is based on analysis of topography deviations from the expected correlation between the Moho depth and topography. Anomalous topography is interpreted as caused by thermal anomalies in the lithosphere and by variations in the lithosphere thermal thickness. The new method allows for recovering the lithosphere thermal structure with a high lateral resolution and for testing the results by comparing the predicted and measured heat flux.

The results for Europe, constrained by the regional seismic crustal model EUNAseis, demonstrate that the lithosphere thermal structure is controlled by both the geodynamic setting and the lithosphere age. The lithosphere of the East European craton ranges in thickness from ca. 140-180 km in the paleorifts to 200-220 km on average with local lithosphere roots down to ca. 300 km depth, such as in the south-central Proterozoic Finland, and local thinning to < 100 km in the Peri-Caspian Basin and the Mezen rift system. Lithosphere thinning to 70-100 km beneath southern Norway may have caused its recent uplift. The craton to noncraton transition at depth roughly follows the geological boundary but with up to 200 km lateral deviations, which indicate reworking of the cratonic lithosphere along the craton edge. Paleoproterozoic – early Paleozoic Gondwana massifs of western Europe are distinct in having cold and thick lithosphere, typically 120-180 km thick, up to 200 km thick in the London-Brabant Massif, and only ca. 100 km in the Iberian Massif. The European Cenozoic Rift System is marked by a thin (< 80 km) and hot lithosphere that forms a linear belt from southern France to the North Sea. Lithosphere thinning to 50-60 km thickness beneath the Pannonian and Po basins may indicate the onset of oceanization. Cenozoic orogens of western Europe have lithospheric roots down to ca. 200-250 km associated with subducting lithospheric slabs, while a 80 km thick lithosphere beneath the Vrancea zone is in agreement with slab delamination. The Arctic shelf of the Barents Sea has a thick cratonic lithosphere with a sharp transition from a 120-150 km thick lithosphere of the western Barents Sea to a 175-230 km thick lithosphere of the eastern Barents Sea. The block with a ca. 150 km thick lithosphere in the North Atlantic region between the Aegir paleo-spreading and Norway may represent a continental terrane within the oceanic domain. The upper mantle temperature beneath the Bay of Biscay and the Black Sea is similar to the cratonic and is anomalously cold down to a 200 km depth.