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3D density model of the Central European Basin System

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The Central European Basin System (CEBS) includes the Southern and Northern Permian basins with main superimposed post-Permian basins, such as the Polish Basin, North German Basin, Norwegian-Danish Basin, Central Graben, Netherlands basins and others. Major evolutionary stages of this basin system are related to the regional latest Carboniferous-earliest Permian rifting, Late Triassic extension, Late Jurassic-Early Cretaceous transtension and Late Cretaceous–Early Tertiary compression. All these tectonic events are reflected in a complex present-day structure of the CEBS. Tectonically, the CEBS is situated between two deep reaching fault systems, the Tornquist Zone in the north-east and the Elbe Fault System in the south-west. The crust of the CEBS consists of an assemblage of crustal domains which have different consolidation ages. Large-scale crustal domains are represented by the Precambrian Baltic Shield and the East European Craton in the north and the north-east, Caledonian crust of Avalonia and Laurentia within the western and central parts of the CEBS, and Variscan crust in the south.

A 3D density model of the CEBS and adjacent areas has been obtained based on published data derived from refraction and reflection seismic lines, inversion of teleseismic receiver functions and deep wells. The 3D structural model includes ten layers from the base of the lithosphere to the sea level. These layers are (1) sea water; (2) Permian and Meso-Cenozoic sediments; (3) pre-Permian sediments; (4) Precambrian crust of the Baltic Shield and the East European Craton; Caledonian crust of Avalonia (5) and Laurentia (6); (7) Variscan crust; (8) high-density lower crust of the Precambrian crustal domain; (9) high-density lower crust of the Caledonian-Variscan crust; and an upper mantle layer (10).

Our results from 3D gravity modelling indicate a relatively light crust beneath the Caledonian-Variscan Europe, whereas the average crustal density is larger beneath the Baltic Shield and the East European Craton. The 3D density model further indicates that high-density lower crust of Precambrian Europe is locally more than 30 km thick. On the other hand, the Caledonian-Variscan crust is characterized by a relatively thin high-density lower crust. There, the thickness of the high-density lower crust varies between 0-2 km and 5-7 km, reaching up to 16 km beneath the central part of the Northeast German Basin and up to 13 km beneath the eastern part of the Norwegian-Danish Basin. This lateral variation of lower crustal densities beneath Caledonian Europe correlates spatially with some Permo-Mesozoic depocenters of the CEBS, indicating that lower crust could be locally reworked during Permian and Mesozoic tectonic events. In addition, the modelling results suggest that the lithosphere-asthenosphere boundary is located at more than 230 km depth within the Precambrian Baltic Shield and the East European Craton. In contrast, the depth of the lithosphere-asthenosphere boundary is around 110-130 km within the Caledonian and Variscan domains, rising up to 85-90 km depth beneath the northern part of the British Isles.