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Mesozoic(?) lithosphere-scale buckling of the East European Craton in southern Ukraine: DOBRE-4 deep seismic profile

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In order to study the lithospheric structure in southern Ukraine, a seismic wide-angle reflection/refraction project DOBRE-4 was conducted. The 500 km-long profile starts in the SW from the Alpine/Variscan North Dobrudja fold-thrust belt, being part of the Trans-European Suture Zone. It runs to the NE, mostly along the NW Black Sea coastal plain, towards the center of the Precambrian Ukrainian Shield. The field acquisition in October 2009 included 13 chemical shot points with charge sizes 600–1000 kg every 35-50 km and 230 recording stations, every $\sim$2.5 km. The high data quality allows modelling of the P- and S-wave velocity structure along the profile. Two methods were used for the modelling of the seismic data. At first, ray-tracing trial-and-error modelling was developed using arrivals of major refracted and reflected P- and S-wave phases. Next, the amplitudes of the recorded phases were analysed using finite-difference full waveform method. The resulting velocity model shows fairly homogeneous structure of the middle to lower crust both vertically and laterally. The situation is different in the upper crust, with Vp velocities decreasing upwards from c. 6.35 at 15-20 km to 5.9-5.8 km/s at the top of the crystalline basement and to c. 5.15 to 3.80 km/s in Neoproterozoic and Palaeozoic and to 2.70 to 2.30 km/s in Mesozoic strata. Below the upper crust the Vp smoothly increases downward, from c. 6.5 to 6.7-6.8 km/s near the crustal base, making it difficult to differentiate between the middle and lower crust. No Vp velocities exceeding 6.80 km/s have been recorded even in the lowermost part of the crust, unlike in similar profiles on the East European Craton. There is no clear change in the velocity field when moving laterally from the Precambrian platform into the younger tectonic units to the SW. Therefore, on purely seismic grounds it is not possible to distinguish major tectonic units known from the surface. The Moho is, however, clearly delineated by a velocity contrast of c. 1.3-1.7 km/s. A specific feature of the velocity model are waveform successive changes in Moho depth, corresponding to successive downward and upward bends, with wavelength of the order of 150 km and the amplitude attaining 8 to 17 km. Similar wavy aspect is shown by the upper mantle and upper crust, with shorter wavelength pattern in the latter. The origin of the undulations is explained by compressional lithospheric-scale buckling and ascribed to Late Jurassic-Early Cretaceous and/or end Cretaceous collision-related tectonic events associated with closing of the Palaeotethys and Neotethys oceans in this part of Europe. To our knowledge, no such spectacular folds deforming the Moho, have been as yet revealed elsewhere by either deep reflection of refraction seismics. The presence of several detachment horizons in the folded crust calculated in the velocity model, is compatible with the existence of fold systems with various dominant wavelengths at different crustal levels. Such a situation is considered as typical of lithospheric-scale folding and reflecting the rheological stratification of the lithosphere.