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3D Vp heterogeneity beneath the Marmara Sea: Shot tomography on a 2D OBS array

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After the 1999 Izmit and Duzce earthquakes, the multi-method SEISMARMARA seismic survey has been carried out with the aim to constrain the seismogenic part of the North Anatolian Fault (NAF) immersed into the Marmara Sea. During this survey, a network of 35 3-components Japanese Ocean Bottom Seismometers (OBS) placed on a 2D grid and land stations have recorded the current seismic activity for a period of 6 weeks and 2000 km of MCS profiles shot in the North Marmara Trough (NMT).

In the present study the first arrival times of artificial sources are inverted with the well known local earthquake tomography (LET) code Simulps in order to approach the 3D upper-crustal heterogeneity which then could be implemented as initial model easily and without any loss of information into a joint inversion of the local earthquake data and shots.

The 3D upper-crustal P-wave velocity heterogeneity of the North Marmara Trough (NMT) is derived by inverting a set of 16000 first arrival times of artificial sources. We have checked the sensitivity of the results to the grid geometry, the control parameters and the 1D initial velocity model. Due to a huge basement depth variation between the NMT rims and the trough itself, we have then designed a 3D a priori model by taking into account the sea-floor depth and the topographic trend of the basement. This 3D initial model allowed to include the shots recorded by 5 land stations into the inverted data set and to improve the image resolution at the borders of NMT. It allowed also to have a denser inversion grid which is needed for constraining the small wave-length heterogeneity of the Marmara Sea. The artefacts which may be due to the very large perturbations with respect to the 1D initial model were avoided with the use of this 3D initial model.

The reliability of the results are validated by synthetic tests and by the comparison with the seismic reflection and refraction profiles which principal characteristics such as the sedimentary infill and basement geometry are remarkably recovered by the inversion in the well resolved regions.

This study provides an unprecedented 3D view of the sedimentary thicknesses and of the basement topography which shows large vertical throws which may reach up to 7 km. It reveals also the variations of more than 2 km of the basement topography in a distance of 5 km along the sea-bottom trace of the North Anatolian Fault and its basins. The consideration of the 3D sedimentary thickness and of such basement topography is crucial for accurate relocation of the earthquakes by taking into account the 3D heterogeneity of both, upper-crustal P and S wave velocities. This 3D structure may find also further applications like in modeling studies for the evolution and the present activity of the Marmara Sea's features.