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Deep basins, crustal architecture, Moho, and deep deformation under the North Marmara Trough, from the Seismarmara Leg 1 MCS and refraction seismic survey

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The Sea of Marmara is the continuation to the West of the North Anatolian Fault (NAF) that produced the two destructive earthquakes of Izmit and Duzce in 1999 just to its East. It is prone to future major earthquakes as it has experienced in the past and is a present seismic gap.

In 2001, the SEISMARMARA project was carried out in the whole North Marmara Trough with the aim to improve the knowledge of the regional tectonics and the evolution at crustal scale by imaging faults and the deep structure of basins and deep geological features. SEISMARMARA Leg 1 was a multi-method approach combining 2000 km of regional scale multichannel seismic profiles (MCS), with wide-angle reflection and refraction from the same source towards 37 OBS and as many land seismographs stations as well as earthquake recording by the same receivers.

MCS detects a reflective lower crust and the Moho boundary that appear upwarped on an E-W profile from the southern Central Basin towards more internal parts of the deformed region. In the North Marmara Trough (NMT) itself, the diverse azimuths and the crossings of the set of MCS profiles allow us to avoid the misinterpretation of late arrivals as the response of Moho, but do not distinguish it clearly. However, this Moho boundary under this North Marmara Trough itself can be identified reliably by the diagnostic velocity at the top of the upper mantle measured from Pn interface head-waves recorded at large offset thanks to the strength of the seismic source, by OBS and onshore seismometers. The depth and topography of the top of the mantle thus constrained reveal a significant and sharp reduction of Moho depth, on the order of 5 km occurring over few tens of kilometres from the East and West towards the North Marmara Trough (NMT).

On the MCS profiles, a dipping reflector through the upper crust is clearly imaged along the southwestern margin of the NMT where also tilted blocks of basement are found to bound the southwestern rim of the Central basin. This dipping reflector may be interpreted as the southern border fault of the North Marmara Trough. It can be mapped with a rather low angle 35° dip and interpreted as a detachment normal-fault in the upper crust. It prolongates towards a reflective lower crust, which is also revealed by some profiles beneath the whole southern margin. The observed thinning of the upper crust can occur thanks to this detachment that allows upper crustal material to be dragged from beneath it and above the lower crust, accounting for the extensional component but also southwest motion of the southern margin of the NMT.

Sections across the eastern half of the NMT, crossing the Cinarcik and Imrali basins, reveal several faults that are active and which reach into the basement. With their changing strike and proportions of normal and strike-slip displacement, they might be viewed as petals of a large scale negative flower-structure that spreads over a width of 30 km at surface and is rooted deeper in the lithosphere.

Under the Central Basin a very deep sediment infill is revealed and its extensional bounding faults are active and imaged as much as 8 km apart down to 6 km depth. We interpret them as two deep-rooted faults encompassing a foundering basement block, rather than being merely pulled-apart from a jog in a strike-slip above a décollement. The deep-basin lengthening would account for only a modest part of the proposed 60 km finite motion since 4 Myr along the same direction oblique to the NMT that sidesteps the shear motion from its two ends. Thus differential motion occurred much beyond the deep basins, like subsidence involving the NMT bounding-faults and the intracrustal detachments.

The complex partitioned motion localized on active faults with diverse natures and orientation is suggested to represent the overburden deformation induced from horizontal plane simple shear occurring in depth at lithospheric scale, and in front of the North Anatolian Fault when it propagated through the region.