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The lithospheric strength along the Main Marmara Fault based on 3D density and thermal modelling

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In Northwest Anatolia, the dextral North Anatolian Fault Zone (NAFZ) goes through the Sea of Marmara and creates a section which is known as the Main Marmara Fault (MMF). Due to the NAFZ activity, the Marmara region is a major earthquake zone. This area hosts the Megacity of Istanbul in the vicinity of a seismic gap ($\sim$ 150 km long) in the MMF which has not ruptured since 1766. There is an ongoing controversial debate regarding the cause of the seismic gap and if either the fault is locked to a certain depth or is creeping. The main question is if the fault is geomechanically segmented or if the energy will be released over a big single rupture surface. To contribute to this discussion a detailed description and understanding of the lithosphere thermomechanical behaviour below the Sea of Marmara is key. In this study, we present 3D lithospheric-scale thermal and rheological models of the Sea of Marmara. These models are based on a 3D density model which is obtained from geological and geophysical data integration and constrained by gravity modelling. Accordingly, the lithosphere structure consists of six major layers. Two layers of syn- and pre-kinematic sediments with respect to the Sea of Marmara formation with an average density (ρ) of 2000 and 2490 kg.m^{-3}, respectively. These sediments rest on a heterogeneous crust including a felsic upper crystalline crust (ρ = 2720 kg.m^{-3}) and an intermediate to mafic lower crystalline crust (ρ = 2890 kg.m^{-3}). The crystalline crustal units are crosscut by two thick dome-shaped mafic high-density bodies (ρ = 3050 kg.m^{-3}), that spatially correlate with the bending segments of the MMF. Beneath these layers is a homogeneous lithospheric mantle (ρ = 3300 kg.m^{-3}) down to the thermal Lithosphere-Asthenosphere boundary (LAB). Along the MMF, the thermomechanical model generally indicates that the brittle-ductile transition zone occurs within the upper crystalline crust at a depth of around 18 km b.s.l, which is consistent with the 1999 Izmit earthquake. In contrast, the thermomechanical model indicates that the high-density bodies are colder and stronger than the surrounding crystalline units. Consequently, the brittle-ductile transition zone occurs, closer to the Moho discontinuity, at the depth around 23 km b.s.l. In conclusion, these results suggest that crustal heterogeneities significantly affect the rheological behaviour of the MMF, and support the hypothesis that the fault is geomechanically segmented.