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What caused the development of low angle detachment faults in western Anatolia?

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Extensional tectonics in the western Anatolia-Aegean region feature exhumation of the metamorphic core complexes that is accommodated by low angle normal (detachment) fault systems. Specifically, the central Menderes massif contains two symmetrically developed outward facing (Gediz and Büyük Menderes) detachment faults, which accommodated large scale displacements. Additionally, there are many younger high-angle normal faults in conjunction with the initiation of extension and synextensional magmatism since the Early Miocene. The standard fault mechanical theory does not allow such orientations, the occurrence of these faults at low angle and the seismicity on them are still not well-understood. Here, we investigate the evolution of the normal fault systems on lithospheric scale using thermomechanical forward models. We employ the numerical finite element code ASPECT to compute the visco-plastic deformation within a model domain that is 500 km wide and 165 km deep. The initial condition of our model is designed to reproduce the first-order lithospheric structure at the onset of Western Anatolia extension approximately 20 million years ago and consists of an upper crust (25 km thick) with wet quartzite rheology, a lower crust (25 km thick) with wet anorthite rheology, and a mantle lithosphere (30 km thick) with dry olivine rheology. We conduct two model suits where we investigate the impact of key parameters within a plausible range: (1) we vary the extension velocities imposed on the margins of the model boundary from Vext = 1- 4 cm/year full rate. (2) we vary the friction coefficient of the upper crust (fc = 0.05 to 0.8) corresponding to an internal friction angle of φ = 5 to 40. Our models show that these two parameters directly control the initial dip angle and development of the normal faults. We find that major faults are formed initially at 50-52° dip but evolve towards shallower dipping angles, 15-20°, because of the isostatic adjustment due to thinning/exhumation of the crust. The sequentially tilted faults on where slip can no longer be accommodated are abandoned and left behind as inactive low angle fault surfaces. Basin ward migration of newer fault is formed in the hanging wall to accommodate strain. The tectonic evolution of the central Menderes region is best reproduced in our reference model with a friction coefficient of 0.2 and an extension rate of Vext = 3 cm/yr. Namely, this model agrees well with the detachment faults shallowing dip angles, outward facing faults and symmetry with respect to the central Menderes massif. In addition, the exhumed massif has a dome shaped structure and the distance to one another (100 km) is comparable to those of Western Anatolia. Also, high angle normal faults are formed above the detachment faults, typical for Gediz and Büyük Menderes grabens. When the friction coefficient and extension rates are changed, differences in these structural elements are observed. We conclude that our reference model supports the two rolling-hinge detachment system separated by elongated metamorphic domes with fold axes perpendicular to the direction of extension.