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Development of ramp-flat structures during Aegean extension

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Low-angle extensional shear is frequently observed in the Aegean metamorphic rocks. This deformation is commonly interpreted as being related to detachment at crustal scale, yet it often corresponds to ramp-flat extensional systems that, at many places, control the deposition of Neogene sedimentary basins. From a mechanical point of view, the development of a ramp-flat structure requires the presence of weak layers that can be activated as décollement between stronger rocks units. In the Aegean, the décollement generally develops within the upper brittle crust (i.e. with temperatures lower than about 400°C) that consists in recently exhumed metamorphic rocks. The process by which, these layers become weak enough to form efficient décollements in extension is somewhat intriguing and not well understood. In this contribution we examine the particular case of ramp-flat structures of the Southern Rhodope Core Complex that controlled the deposition of late Miocene to Pleistocene sediments in continental and marine basins. Field evidence is used to argue that the décollement corresponds to marble layers that separate orthogneisses at 2-3 km depth within an upper brittle crust whose thickness is around 5 km. Field observation and stable isotope measurements suggest that the ramp-flat structure observed on the island of Thassos occurred in a marble unit rich in fluids at a temperature of around 200°C. Using laboratory experiments, we explore the geometry of extensional structures (fault systems, rollovers, piggy-back basins…) that can develop at crustal-scale as a function of: i) décollement depth and dip, ii) number of décollements, and iii) strength contrast, between the décollement and overlying strong units. The results are compared with the situation observed in the Southern Rhodope Core Complex. We are convinced that the principles of ramp-flat extension discussed here have a strong potential of application in many other orogenic domains affected by large-scale extension.