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The roles of heritage vs thermal state of the lithosphere in the localization of detachment zones : insights from Mediterranean Core Complexes and numerical experiments.

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The most enigmatic features of metamorphic core complexes (MCC) refer to localized shallow dipping normal detachment shear zones, and preservation of almost flat Moho below the extended crust. Since the seminal work of R. Buck (1991), it is accepted that MCC form during extension of thermally relaxed hot, hence rheologically weak continental lithosphere. Initial Moho temperatures higher than 800°C are indeed predicted by many numerical models, and migmatites found in MCC cores also imply high temperature for the exhumed lower crust. A systematic review of tectonostratigraphies of the described-so-far Mediterranean MCCs shows that the detachment zones did not all develop on top of high-temperature metamorphic domes but some of them formed under much colder thermal conditions. This diversity can be described within a multi-parameter (P,T, strength) domain bound by 3 end-member cases: (1) high temperature core end-member (HT-MCC), representing most studied MCCs, and two cold end-member cases, one defined by (2) localization of crustal detachment in or on top of a preserved metasedimentary high-pressure metamorphic unit (HP-MCC), and (3) another one where the detachment is localized at the base of a high-strength upper unit, such as an obducted mafic sequence (HSU-MCC). Natural cases scatter within this triangular system, with pure HT-MCC cases (such as the Kabylian detachment, Algeria), pure HP-MCC cases (such as the Filabres detachment in the Betics, Spain), while HSU tectonostratigraphy is always coeval with a high-temperature core (eg Nigde, Anatolia) or a high-pressure nappe (in Corsica for instance). The largest core-complex systems, such as Menderes (Turkey), Rhodope (Greece and Bulgaria), and Cyclades (Greece), relate to the three end-member cases.
We run thermo-mechanically coupled numerical models of extension of multi-layered lithosphere. In these models we primarily varied the rheological strength of crustal layers and initial thermal conditions to explore the domain defined by the three end-members mentionned above. The models show that high initial Moho temperatures are neither necessary nor sufficient for the development of a MCC. The critical factor seems to be the value and "sharpness" of the competence contrast between the crustal layers: for MCC formation, this contrast should be exagerated by at least 1 order of magnitude, In the opposite case, transitional geometries toward narrow rifts are achieved, such as spreading domes or wide rifts. Such sharp competence contrasts even if considered as unlikely within "normal" lithostratigraphic sequences, can be inherited from the complex thickening stages of the lithosphere. In nature, the evolution of boundary and thermal conditions during extension may cause superposition of different structures within the same context, like the symmetric Alasehir-Buyuk detachment system at the top of the spreading dome-like Central Menderes succeeding to the asymmetric Simav detachment at the top of the Northern Menderes and at the base of the Ismir-Ankara Ophiolite in the high-pressure units underlying it.
MCCs would therefore be the reaction to extension of rheologically stratified continental lithosphere, with strong and sharp competence contrasts between the upper and lower crustal units that could result from tectonic heritage, such as orogenic crustal thickening and nappe stacking.