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Two styles of faulting associated with metamorphic core complexes: Importance of initial crustal configuration and mid-crustal flow

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Two styles of faulting, sequential- and domino-style, have been identified in metamorphic core complexes (MCCs) and discussed by various workers, however, a consensus has not been reached on the exact mechanisms and relationships between the two styles of faulting. We used a three-layered model of the crust, i.e., upper, middle and lower crust and used numerical method to study the formation of different types of MCCs. We found that the initial crustal structure and crustal strength of each layer, viscosity contrast between upper and middle crust particularly, are of great importance. An initially symmetric crustal structure, i.e., uniform thickness of each layer throughout the crust, generally favors sequential normal faulting, and leads to MCCs beneath sequentially initiated and then deactivated normal faults. However, an initially asymmetric crustal structure, i.e., variable thickness of each layer of the crust, favors sequential-style migratory low angle master faults to the first order, and domino-style high angle normal faults above their associated low angle master faults to the second order. High angle normal faults in each sequence are active simultaneously with their correlated master low angle normal fault. This correlation implies that the sequential normal faulting is more important in areas where the crust has a relatively uniform thickness, while sequential- and domino-style faulting are both important in provinces where the initial crustal structure is of variable thickness with changing topography and Moho relief, such as central Basin and Range in the Cenozoic for instance. Mid-crustal flow has been proved important in the formation of orogeny. Instead of local compensation in the crust with initially symmetric crustal structure, we found a long wavelength compensation between the upper and middle crust in the crust with initially asymmetric structure, which is a strong evidence that mid-crustal flow plays an important role in extension of crusts with non-uniform structure, such as orogens and continental margins. The relative strength of upper and middle crust is of great importance in controlling the size and geometry of MCCs. A relatively weak middle crust promotes relatively symmetric small MCCs with high relief and small width in both initially symmetric and asymmetric crust. However, a strong middle crust limits mid-crustal flow and promotes highly asymmetric MCCs with small relief and large width, especially in initially asymmetric crust. In addition, a weak transition zone between the upper and middle crust helps localize shear strain, which plays an important role in the formation of crustal scale shear zone.

Keywords: low angle normal fault, detachment fault, metamorphic core complex, crustal configuration, crustal flow