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The shape of metamorphic core complexes, an indicator for paleo-step faults? Insights from 3D numerical modelling.

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It has been known for long that metamorphic core complexes are typical structures formed in extensional settings where a strong decoupling occurs between the mantle lithosphere and the upper crust. Modelling of metamorphic core complexes generally involves a thermally or lithological weak lower crust set within extensional boundary conditions. Even with a 3D model, this typical setup ends up with metamorphic domes which are elongated in a direction normal to the stretching lineation.

However natural examples of metamorphic core complexes elongated in the direction of the stretching lineation have been described in the Alpin-Himalayan belt in the places such as Aegean and or Vietnam. The latter are associated with the red river strike slip fault while the former are until now associated with intense back arc retreat.

In order to model these structures, we have tested by the mean of 3D thermo-mechanical models several hypotheses like smooth lateral variation of the decoupling or extension rate, lateral shortening of the extensional structures. None of the listed above have allowed us to explain the shape of these domes. If, instead, we introduce a sharp lateral gradient of extension in the models by setting boundary conditions that could correspond to a pull apart (symmetric) or a lateral variation of slab retreat velocity across a step fault (one sided), we obtain domes elongated in the direction of extension at the edge of the sharp lateral gradient.

In the models, these domes form a lineament of rising lower crust within the middle crust. As they rise, they induce a local weakening which favours the propagation of a strike slip shear zone in the upper crust at the edge of the dome. It results that the deformation in the upper crust may be localised along large upper crustal strike slip shear zones while metamorphic core complexes are forming in the lower crust. The Moho beneath these dome appears to be flatter then in the regular stretching models and the exhumation rates obtained for the lower crust are of the same order or higher than in the classical metamorphic core complex models.

The models therefore predicts that in the context of a thickened crust decoupled from the mantle lithosphere, trans-tensional deformation causes the metamorphic domes to be elongated in the direction of extension rather than normal to this direction. This models directly applies to metamorphic core complexes that form within extensional fault step as on the Red River fault in Vietnam. In the Aegean, there are no field argument for the existence of a sinistral strike slip fault between the Menderes massif and the easternmost cycladic domes of Naxos and Mykonos. However, in the view of our modelling results, the characteristic elongation of these domes in their stretching direction is a field indicator for the existence and activity of sinistral shear zone between these two metamorphic core complexes at ca 15 Ma. At larger scale, the large gradient of extension rate necessary for these type of domes to form in the model could corresponds to the activity of a step fault within the retreating Aegean slab.