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Factors controlling evolution of pull-apart basins - insight from numerical modeling

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Pull-apart basins are depressions that are formed as a result of crustal extension along strike-slip systems where the sense of fault overstepping or bending coincides with the fault motion sense. They are common feature of strike-slip systems. We have accomplished a series of thermo-mechanical models of a pull-apart basin growing at a stepping of a transform fault due to progressive strike-slip motion. All models incorporate non-linear temperature- and stress dependent visco-elasto-plastic rheology with the parameters consistent with laboratory measurements. In the modeling we consider three-parametric model space, where the initial temperature (in fact initial surface heat flow), lower-crustal viscosity (at same temperature and stress) and the material softening rate, vary from model to model. The modeling shows that basin subsidence results from competition of the extension of the brittle part of the lithosphere, leading to its subsidence, and of the compensational flow of the deeper ductile part of the lithosphere pushing extended brittle block upwards. Result of this competition, i.e. subsidence rate and crustal structure are controlled by (i) thickness of the brittle layer and basin width, (ii) magnitude of strike-slip displacement, (iii) rate of frictional softening of the crust and (iv) viscosity of the ductile part of the lithosphere. The thickness of the brittle layer and viscosity of the underlying ductile part of the lithosphere, in turn depend on temperature, composition and material softening. We interpret the modeling results, deducing simple analytical model, that we call brittle brick stretching (BBS) approach, which despite of its simplicity, describes reasonably well structure and evolution of pull-apart basins. According to this model the basin

subsidence is driven by uniform fault-parallel stretching of the brittle part of the lithosphere bordered by the overlapping segments of the transform fault (brittle brick) with the fixed lower bottom. According to the BBS approach, the thickness of the sedimentary basin is proportional to the initial thickness of the brittle layer and to the magnitude of the strike-slip displacement. We also demonstrate that the structure and evolution of the Dead Sea Basin, located at a left stepping of the Dead Sea Transform in the Middle East is consistent with the BBS type of deformation with only minor contribution of compensational flow in the ductile part of the lithosphere.