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Modeling Initiation, Localization and Development of the Dead Sea Transform

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Dead Sea Transform (DST) fault system is a part of the Syrian-African rift system and it extends from the divergent plate boundary of Red Sea rift at the south to the convergent plate boundary in the Taurus Mountains at the north. DST is a left-lateral transform fault, accommodating differential motion between African and Arabian plates. The morphology of the DST fault system is expressed by several linear stretches separated by a number of pull-apart basins, where the Dead Sea is a largest. Our previous models (Sobolev et al. EPSL 2005, Petrunin and Sobolev, Geology 2006, PEPI 2008) have been focused at two main topics: (1) major controls of the fault localization in strike slip settings and (2) major controls of the structure and evolution of pull-apart basins located at strike-slip faults. To do so, we use realistic elasto-visco-plastic temperature and stress dependent rheology to model lithospheric deformations. The largest limitation of our previous models is their relatively small size, which does not allow including the source of the strike-slip motion in the region, which is likely opening of the Red Sea Rift, and major obstacle for the propagating fault resulting in its bending in Lebanon. In present work we extend the model to the larger region. The new model domain includes north-western part of the Red Sea and extends to the Lebanon Mountains in the north where deformation becomes more complicated and large part of the strike-slip motion becomes distributed. Because of the significant size of the domain, we consider sphericity of the Earth surface.

Here we present three particular models. The first model is aimed at revealing controls of localization of the DST. In this model we use simplified lithospheric structure corresponding to continental margin conditions. As a model result we get fault system similar to the DST including the Lebanon thrust belt but without the chain of the pull-apart basins in the southern segment. The second model uses modified lithospheric structure considering thinning of the lithosphere due to Red Sea Rift opening. Its results confirms that the Red Sea Rift opening could be a possible reason for origination of the pull-apart basin series (Gulf of Elat, Dead Sea, and Sea of Galilee). The third model is aimed mainly at early history of the DST region. In contrast to previous two model, where kinematic boundary conditions were used (constant velocities at the side boundaries), in this model the constant force has been applied as a dynamic boundary condition. A magnitude of the force was estimated from the first two models. The model shows evolution of strain distribution during the Red Sea opening. At the first stage of the Red Sea opening (during Oligocene) the distributed strain is accumulated in broad zone along the DST area. Later, (early Miocene) it localizes and form structures similar to the Dead Sea fault system.