Geophysical Research Abstracts,
Vol. 11, EGU2009-12195-3, 2009
EGU General Assembly 2009

How weak is Dead-Sea-Transform Fault?

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Among the key questions related to the Dead Sea Transform Fault (DSTF) are: (i) Why is the deformation localized between two plates at DST? (ii) What are rheological properties of the lithosphere beneath the DST? And in particular (iii) What should the rheological properties of the lithosphere beneath the DST be to allow it to work as a transform plate boundary with the slip rate of few millimeters per year?

This work is aimed at addressing the above questions using a thermo-mechanical model in an extended 2-D approximation (thin-shell approach) focused on the deformation processes in scale of several thousand of kilometers, although at the Middle East scale. Regional topography data and heat flow has been used to regulate the lithosphere structure and thermal regime under the assumptions of steady state and Airy isostasy.

We concentrate on the trade-off between fault friction coefficient and lithosphere thickness beneath the DST. Therefore, we compute a two-parameter suite of models with differing fault friction coefficient and differing mantle lithosphere thickness beneath the DST and evaluate their misfits relative to observed slip rates. Furthermore we examine the impact of fault's shape on the trade-off we mentioned above.

A variety of models were tested with different fault friction coefficient values (varying from 0.05 up to 0.40) and different upper mantle lithosphere thickness values (varying from 20 km to 40 km) beneath the Dead Sea Transform. We also analyze the effect of the shape of fault by considering (i) a large segment of DST extending from the Golf of Aquaba through Dead Sea and the Lebanon Mountain Belt until West Anatolian Fault and (ii) a short segment without considering the bending northern part, which comprises the region from the Lebanon Mountain Belt until the West Anatolian Fault.

Based on the plate velocity field, which is one of model's predictions, we conclude on possible rheology in terms of the trade-off between fault friction coefficient and lithosphere thickness.

The observed slip rate of 0.3-0.6 cm/year at the DST can be achieved only if the friction coefficient at DST is much lower than 0.10 and most likely less than 0.05. The friction at DST appears to be as low as for the world's weakest transform fault, the San Andreas Fault in California. The answer to this modeling surprise lies on the irregular shape of the DST, especially its bending in the northern part. Without its bending northern segment, DST would allow observed slip rates even being much stronger.