Neotectonic modeling of Central Asia

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Two of the most prominent deformed areas on Earth, the Zagros and Himalaya-Tibet orogens, are located along the southern margin of Eurasian plate. They are the result of Arabia/Eurasia and India/Eurasia collisions occurred in Cenozoic times. In both cases, the collision occurred between the strong and resistant lithospheres of Arabia and India (with Archean-Proterozoic shields) and weaker material along the southern edge of the Eurasian plate. Major pre-existing sutures and/or large-scale fault zones between the different accreted Gondwana-derived continental blocks are responsible for the weakness of the Eurasia margin. The convergence resulted not only in the building of mountain ranges over the north-eastern edges of the Arabian and Indian plates, but also in widespread deformation several hundreds of km inwards with respect to the suture zones. Thus, the understanding of the deformation patterns in Zagros and Himalaya-Tibet orogens requires the study of the lithospheric structure and the analysis of the deformation of the whole Central Asia region.

This work aims to study the neotectonics of Central Asia (Fig. 1), and in particular the Himalaya-Tibetan orogen. To this end, we use the thin-shell finite element code SHELLS (Bird 1999), in which the horizontal components of the momentum equation are solved using a 2-D finite element grid, and the horizontal velocities do not change in depth. Some characteristics of three-dimensional methods are incorporated, since volume integrals of density and strength are performed numerically in a lithosphere of laterally varying crustal and lithospheric mantle thicknesses.

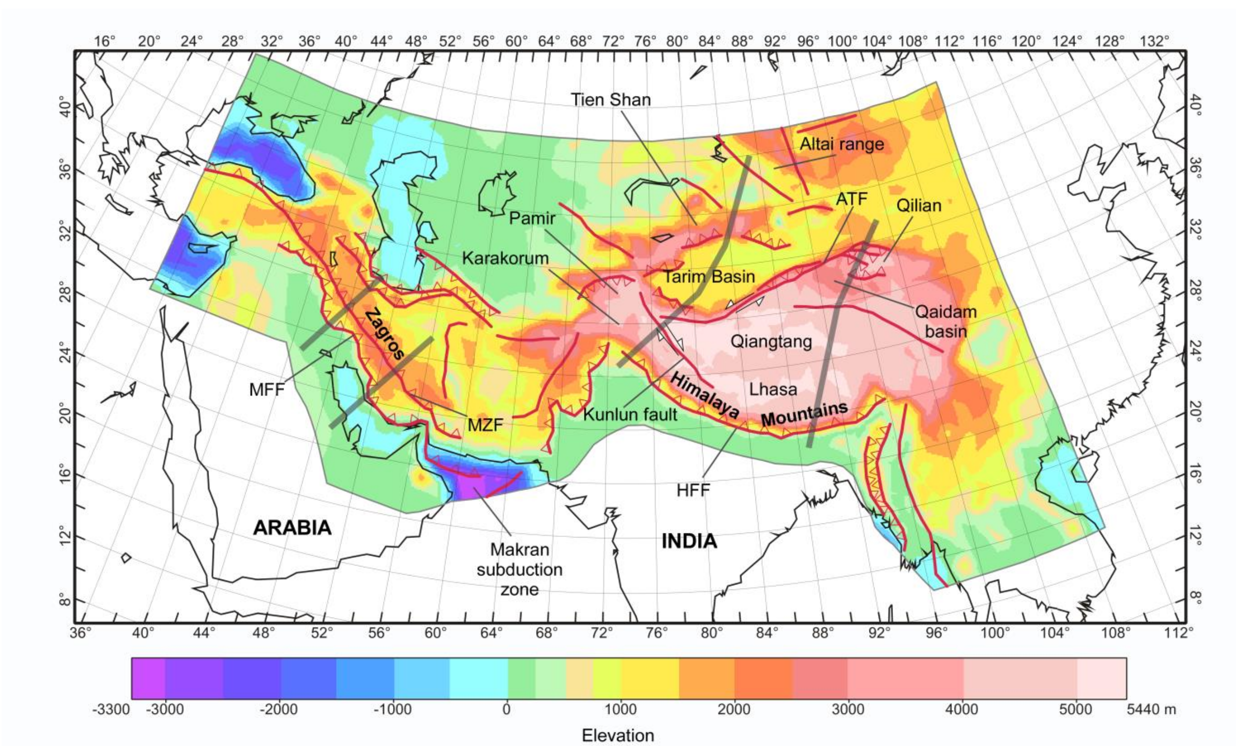

Figure 1. Topography map and main tectonic features in Central Asia. Thick light grey segments crossing Zagros and Himalaya-Tibetan orogens indicate the location of 2-D modelled cross-sections coming from the geophysical-petrological previous study. Their results on crustal and lithospheric structure are incorporated to the model.

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In order to determine the lateral variations of the lithospheric strength, elevation, heat-flow, crustal and lithospheric thickness are calculated assuming steady-state thermal regime and local isostasy. In the updated version of the code (Bird et al., 2008) two additional adjustable parameters are incorporated at each node in order to reduce locally large departures from isostasy: i) density anomaly of compositional origin in the lithosphere; ii) extra quadratic curvature of geotherm due to transient cooling/heating.

The input crust and lithospheric mantle structures are derived from elevation and geoid anomaly, assuming local isostasy and thermal analysis (Robert et al., in prep.). Previous results using a geophysical-petrological approach along four 2D lithospheric profiles down to 400 km depth (Fig. 1) are also incorporated to the model (Tunini et al., in rev; Tunini et al., in prep.). These profiles reveal a strong strain partitioning between the crust and the lithospheric mantle affecting the Zagros and Tibet orogens. A crustal thickening along the suture zone in the Zagros range corresponds to a thinning of the subyacent lithospheric mantle (LAB depth difference ~100 km). The lithospheric mantle below the north-eastern Tibetan Plateau (eastern Lhasa and Qiangtang regions), is thin (LAB depth ~120 km), weak and warm and characterized by a typical composition of supra-subduction mantle wedge as inferred by xenolith samples. A thick, fertile and strong lithosphere characterizes the Indian plate at the southern margin of Tibetan Plateau, plunging northwards with a progressive shallower angle from east to west.

The (potentially) active faults, defined with low friction coefficient, are taken from Taylor and Yin (2009) database, Berberian and Yeats (2001) and Holt et al. (2000). Boundary conditions are selected in a fixed-Eurasia reference frame, testing different Euler rotation poles from DeMets et al. (2010) and Liu and Bird (2008) for Arabia and India plates. Model predictions include velocities, fault slip rates, strain rates and stress tensors. Preliminary results will be compared with measured GPS, slip faults and stress data.

References

Berberian, M. and Yeats, R.S., 2001, Contribution of archaeological data to studies of earthquake history in the Iranian Plateau, Journal of Structural Geology, 23, 563-584.

Bird, P., 2003, An updated digital model of plate boundaries, Geochemistry Geophysics Geosystems, 4(3), doi:10.1029/2001GC000252.

Bird, P., Liu Z., and Rucker W.K., 2008, Stresses that drive the plates from below: Definitions, computational path, model optimization, and error analysis, Journal of Geophysical Research, 113, B11406, doi:10.1029/2007JB005460.

DeMets, C., Gordon, R.G., Argus, D.F., 2010, Geologically current plate motions, Geophysical Journal International, 181, 1-80.

Holt, W.E., 2000. Correlated crust and mantle strain fields in Tibet, Geology, 28(1), 67-70.

Liu, Z. and Bird, P., 2008, Kinematic modelling of neotectonics in the Persia-Tibet-Burma orogen, Geophysical Journal International, 172, 79-797.

Robert, A., Fernandez, M., Jiménez-Munt, I., Verges, J., Lithospheric structures in Central Eurasia derived from elevation, geoid anomaly and thermal analysis, in prep.

Taylor, M. and Yin A., 2009, Active structures of the Himalaya-Tibetan orogen and their relationships to earthquake distribution, contemporary strain field and Cenozoic volcanism, Geosphere, 5 (3), 199-214.

Tunini, L., Jiménez-Munt, I., Fernandez, M., Verges, J., Villaseñor, A., Lithospheric mantle heterogeneities below the Zagros Mountains and the Iranian Plateau: a petrological-geophysical study, in rev.

Tunini, L., Jiménez-Munt, I., Fernandez, M., Verges, J., Villaseñor, A., Looking at the roots of the highest mountains: the lithospheric structure of the Himalaya-Tibetan orogen form a geophysical-petrological study, in prep.