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Can numerical fault-slip modeling help differentiate simple landscapes from composite landscapes that have been affected by changes in tectonic conditions? Insights from the south-central Alborz mountains, Iran

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The complex tectonic history of the south-central Alborz mountains, involving changes in the stress regime, has resulted in a composite tectonic landscape with inherited, tectonically overprinted topographic features. Fault kinematic analysis of major and minor faults in this area reveals early NW compression associated with dextrally oblique thrusting, superseded by NE-oriented compression, similar to the character of the present-day stress field. During the neotectonic regime the reactivation of previously generated structures has resulted in a nascent transpressional duplex adjacent to the city of Tehran. The variable fault kinematics through time have left important, long-lasting imprints in the landscape. Topographic residuals, calculated from DEM's, reveal topographically distinct zones inferred to indicate high-uplift zones in the duplex. Furthermore, our analysis also highlights areas which cannot explicitly be related to fault behavior expected under the present-day stress field. Differentiating between complex landscapes with inherited high topographic relief and a simple landscape related to protracted tectonic conditions is thus a major challenge. Indeed, the southern Alborz landscape underscores the need for a better understanding of the individual components that drive mountain-building processes, particularly if such landforms are

being used as proxies for past and ongoing tectonism.

Numerical modeling of vertical surface displacement due to slip along known faults can be used for comparison with present-day topography to constrain fault slip distribution. Furthermore, it can help identify inherited topography that cannot be explained by motion along regional faults and which is incompatible with the recent stress field. We used a numerical boundary-element model to calculate topographic relief related to motion along the observed major faults. Motion along individual structures was not predefined, but is a result of their orientation within the complex fault system and the regional stress field. In addition to the NNE compressional stresses, we introduced a component of left-lateral shearing by loading the faults with continuous slip from below or by imposing anti-symmetric displacement at a large distance from the investigated faults. The distribution of vertical strain can be compared with the DEM and the calculated topographic residuals.

Our preliminary modeling results reveal that the main topographic structures of the south-central Alborz mountains can be reproduced and are compatible with the experimental setup, whereas not all areas of presumed high uplift, ie. high topographic residuals, are mapped. We interpret these remaining structures as relict landscape elements resulting from inherited topography. Despite these findings, we identify one example of high modeled relief, where the real topography is rather subdued and erosion seems to dominate over fault activity and uplift. However, the model is limited by the extent of the introduced faults, and therefore by a possible lack of fault interaction with other nearby structures. Nevertheless, the modeling results allow a fast, synoptic overview of simple landscapes and show that the evolving landscape of the southern Alborz is indeed highly influenced by inherited structures. Therefore, future work will entail modeling the fault-slip distribution under past boundary conditions. Our analysis clearly helps to better understand the evolution of topography in the study area. Furthermore, the degree of conformity between the real and modeled topography varies with the ratio of compression and shearing, and may therefore furnish more insight into crustal processes governing the evolution of this complex sector of the Eurasia/Arabia collision zone.