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# Intracontinental tectonic stress field of the Tien Shan in Central Asia

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According to the plate tectonic paradigm, mountains are uplifted isostatically in response to crustal shortening and thickening where two continental plates collide. However, intracontinental deformations contradict the primary assumption of rigid plates in plate tectonics. A typical example is found in the Tien Shan which is located in Central Asia 1200 – 2000 km away from the Indian-Eurasian collision zone. The convergence between the India and Eurasia plates leads to a major compression in the direction of N 10° E in Central Asia. However, deformations observed in the Tien Shan are not consistent with the direction of convergence between India and Eurasia. Earthquake focal solutions, geodetic GPS measurements, geological evidence and viscous thin-shell modelling all show that the direction of principal stress in the Tien Shan is roughly normal to the strike of the mountain belt. It is high likely that there is a causal relationship between the Indian-Eurasian collision and the formation of this intraplate mountain belt. In this paper, the hypothesis that the Tien Shan was uplifted in response to the local stress field created by the underlying mantle circulation induced by the distant collision is tested. The calculated stress field derived from (1) the regional horizontal compression caused by interaction between the Indian and Eurasian plates, (2) the elevated gravitational potential energy, and (3) the plate flexural stress in response to the elastic lithospheric deflection as a result of topographic loading is presented. This superposed stress field is well constrained by the observed stress derived from seismic focal solutions, GPS measurements and surface geology.

The results suggest that almost the entire Tien Shan region is dominated by a large local compressional stress field. The largest compressional zone is in the central and western potions of the Tien Shan. Earthquake focal mechanisms, geodetic GPS measurement and geological evidence also suggest that the Tien Shan is still under compression and thrust faulting is prevalent. The thrusting of the old and strong Tarim Basin and Kazakh Platform towards the Tien Shan occur at large depths beneath the mountain belt, which cause crustal thickening, and lead to compression in the Tien Shan. The direction of the extension is roughly consistent with the background stress field caused by the Indian-Eurasian collision. The old and strong Tarim and Zungar basins and the Kazakh Platform must have resisted deformation and thickening, and the strong Tarim plate must have transferred the stress into the Tien Shan causing reactivation and significant crustal thickening of this mountain range. The analysis demonstrates that the flexural stress field resulting from the bending of the lithosphere beneath the Tien Shan is the major contributor to the total stress field. This implies that the local stress due to high topography and surface loading rather than regional stress resulting from the collision between India and Eurasia plays the dominant role in the Tien Shan lithospheric deformations. The stress fields derived from topography and flexure are negligible until significant uplift of the Tien Shan occurs. As this uplift becomes larger, the roles of flexural and topographic stresses in the total stress field become more important. The magnitude of the flexural stress due to lithospheric bending and the stress resulting from gravity potential can be significantly larger than the background stress (i.e., the stress field due to the collision between India and Eurasia) because they accumulate in response to loads at long geological time scales.

We conclude that the flexural stress field resulting from bending of the lithosphere beneath the Tien Shan is the major component of the total stress field. Our local stress field is consistent with the direction and style of major deformations in the Tien Shan area and it is also in good agreement with the World Stress Field derived using various methods.