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Western Tibet relief evolution, insight from sedimentary record and thermochronology

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The Tibetan plateau is defined as a low relief high elevation zone, resulting from India-Asia convergence. However, its morphology is relatively heterogeneous. Especially the western Tibetan plateau is characterized by a strong relief, numerous peaks higher than 6000 m.a.s.l. and large (up to 10 km), deep (1-2 km) valleys. We investigate the origin of this particular morphology, coupling geomorphologic studies with sedimentary records and (U-Th)/He thermochronometry.

The western Tibet Tertiary sedimentation is mostly characterized by conglomerates, red sandstone and siltstones related with alluvial fan deposits. Zircon U-Pb dating of interbedded trachyte flows implies that deposition started before 25 Ma and was still ongoing at 20 Ma. These continental, detrital deposits are filling wide open valleys during probable arid climatic conditions. Such valleys are thus interpreted as inherited basins, paleovalleys, formed before detrital sedimentation i.e. at ∼25 Ma. Moreover, rare marine sediments were observed below the detrital deposits. Foraminifera suggest an Oligocene age, which implies that the paleovalleys already existed during the Oligocene, and that the emersion of the Western Tibetan Plateau occurred between the Oligocene and 25 Ma. This emersion thus occurred much later than the India-Asia collision (∼50-45Ma) but is compatible with the onset of the main thickening phase of the Indian plate.

The orientation of the inherited valley axis appears to be that of active strike slip faults that induced eastward extrusion of Western Tibet. This suggests that such extrusion was already active at the time of sedimentation (both marine and continental). Thus extrusion was also active during the plateau emersion at Oligocene time.

The morphology of the valleys, and their sedimentary infilling, suggest that a significant relief, similar to present-day one (about 1000-2000m between valleys floor and surrounding peaks) already existed at the time of sedimentation. This implies that very little erosion and only uplift took place following plateau emersion. Assuming an Oligocene emersion and considering the present-day elevation of the valley floor (∼ 4300-4500 m.a.s.l.) it yields a mean uplift rate of about 120-170m/Ma.

In order to test the slow erosion hypothesis we performed apatite (U-Th)/He dating. Samples have been collected from a vertical profile in a Cretaceous granodiorite. Ages range from 13 to 22Ma. Based on the age variation with sampling elevation an apparent elevation rate of about 0.7 mm/yr is obtained. Modelling of age-elevation relationships indicates that the measured cooling ages are compatible with a slow, continuous exhumation/erosion rate from 25 Ma to the present time. This is similar to previous calculations obtained elsewhere on the Tibetan plateau.

Today, the western Tibet is an internally drained area and local erosion induces filling of the paleovalleys. This implies that earlier erosion products were evacuated out of the plateau through the river network. Displacement along the Karakorum fault might be responsible from isolating Western Tibet from the nearby Indus drainage.

In conclusion, this study suggests that western Tibet morphology is inherited from the ante-emersion relief (Oligocene?) that was preserved by combination of slow erosion and evacuation of the detrital sediments toward the Indus river network.