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# Morphologic and Geochronological constraints on the long (> Ma) and short (10-100 Kyr) term vertical rates on south Tibetan normal faults.

E. Kali (1), J. Van der Woerd (1), N. Arnaud (2), P.H. Leloup (3), G. Mahéo (3), J. Liu-Zeng (4), M.L. Chevalier (5), R. Lacassin (6), P. Tapponnier (6), and R. Thuizat (1)

(1) UMR 7516, EOST-IPGS, Université de Strasbourg, Strasbourg, France, France (elise.kali@eost.u-strasbg.fr), (2) Géosciences Montpellier, Université de Montpellier2, Montpellier France, (3) CNRS UMR 5570 Université Lyon1 - ENS Lyon, Villeurbanne, France, (4) Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing, China, (5) Stanford Tectonic Geomorphology Laboratory, Stanford University, Stranford, United States, (6) IPGP, Paris, France

Quantification of slip and exhumation rates along the long recognized north-south trending active normal faults of the Tibetan plateau are key data in order to constrain mechanical models of the geodynamic evolution of the India-Asia convergence zone. In this study, we combine morphologic, structural, petrological analysis and low to medium thermo-chronology of Quaternary and basement rocks in order to compare short-term and long-term fault rates along two of the main Tibetan rifts systems: Yadong-Gulu and Xainza-Dinggye.

At the southern end of the Xainza-Dingyye rift system the Ama Drime range (Everest region) is a horst flanked on each side by N-S trending ductile normal shear zones and active normal faults. Petrological studies combined with U/Pb and Ar/Ar geochronology reveal that the horst formation induced an exhumation on the order of 2 to 4 kbar (7 to 15 km), starting at ∼12 Ma. This corresponds to exhumation rates of 0.6 to 1.3 mm/year. Low temperature geochronology (apatite (U-Th)/He dating) indicate Pliocene apparent exhumation rates of about 1 mm/yr since ∼5 Ma for the whole massif (this study, Jessup et al., 2008).

Short term fault rates can be obtained using cosmogenic nuclide exposure ages of offset geomorphic features such as terraces or moraines. Such features are abundant along the western flank of the Ama Drime range, where the Kharta active fault separates the range from the Kharta basin where the Arun river has abandoned fluvial terraces. The river crosses the fault three times carving deep gorges into the footwall before finally crossing the Himalayas. In the southern part of the Kharta basin, river terraces ∼100 m above the present riverbed are offset between 10 and 15 m by one branch of the normal fault. 10Be cosmogenic nuclide exposure ages of these terraces range between 9 and 11 kyr, consistent with aggradation after the Last Glacial Maximum (LGM ∼20 ka), followed by rapid incision of the Arun. Together, offsets and ages imply a vertical throw-rate of about 0.9 to 1.7 mm/yr. A few kilometres south of Kharta, the normal fault offsets abandoned lateral moraines by about 30 m. The age of these moraines is yet unknown but 10Be ages of similar lateral moraines on the eastern flank of the Ama Drime range between 20 to 40 ka, in agreement with emplacement during the MIS stages 2-4 and a post-LGM glacier retreat. Taking these ages for the moraines near Kharta would yield a late Pleistocene slip-rate of 0.7 to 1.5 mm/yr on the western branch of the Kharta fault. 70 kilometres farther north-east, moraines across the Nabja west-dipping normal fault are offset by 15-20 m. All these data indicate similar short- and long-term vertical rates on the order of 0.6 to 1.7 mm/yr on the N-S active faults in the Ama Drime area.

Similar rates of deformation are found along two other rift systems. In the Kung Co half grabben, thermochronological data indicate apparent exhumation rates between 0.35 and 0.93 mm/yr since ∼4 Ma (Maheo et al., 2007). North of the Yarlung Zangbo, in the Nianqentanglha range exposure ages of lateral moraines have also shown to have ages ranging from 20 to 40 ka. Since these moraines are offset by 20 to 40 m this would correspond to 0.5 to 1.5 mm/yr of vertical offset but more precise estimates are underway.

Data from three different active south Tibetan grabens suggest vertical throw rates on the order of 0.5-1.7 mm/yr initiating in the Pliocene with the long-term, Pliocene apparent exhumation rate being similar than the Late Pleistocene-Holocene rates determined from offset moraines and river terraces. These results suggest that south Tibetan E-W extension rates did not significantly change since ∼4Ma. This has major implications for the structural evolution of the Tibetan plateau, particularly for models of E–W extension. More data on the timing of E–W extension throughout Tibet should help constrain further the age of extensional onset and whether it varies regionally.

References :
Jessup et al., Geology, 36, 2008.
Maheo et al., Earth Planet Sci. Lett., 256, 2007.