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Interactions between mountain piedmont deformation, fluvial terraces formation and alluvial fans evolution : Analogue modeling and comparison with north-east Tian-Shan (Xinjiang, China)

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Mountain belt topography results from complex coupling between crustal deformation, surface processes (erosion, sedimentation) and climate variability (Summerfield, 2000 ; Burbank and Anderson, 2001, Persson et al., 2004). In Graveleau et al. (2005, 2007a & 2007b), we presented a new approach based on quantitative analogue modeling to study tectonics/erosion/sedimentation couplings in mountain belt piedmonts. We have demonstrated that it is possible to study mountain range morphology by using analog experiments and realistic boundary conditions in terms of tectonics and surface processes. Surface topography and kinematics of structure can be regularly measured by using a laser interferometer and image correlation techniques. These devices provide high resolution DEMs and accurate horizontal shortening measurements (in the order of, respectively, 0.5 mm and 0.05mm) that allow precise quantification of deformation pattern and erosion/sedimentation fluxes. This work represents the next step of our methodology as it aims at going through our experiments by analyzing and comparing the results with natural field examples. We analyze qualitatively and quantitatively how morpho-structural markers (faults, folds, alluvial fans, drainage network, terraces) form, evolve through time and record active deformation. We first study separately how alluvial fans and fluvial terraces evolve during experiment performed with simple deformational conditions (shortening accommodated along a single active fault). Then we study their contemporaneous evolution and how do they interact.

We compare our results to northern Tian-Shan foreland data where active tectonics and surface processes have shaped the morphology with numerous morpho-tectonics markers. Our results show that alluvial fans geometry display statistical relationships between characteristic measurements (fan size, basin size, main stream length) that can be compared to natural phenomenological law (Hack law). For instance, fan area and drainage basin area are linearly correlated with time whereas main stream length is logarithmically correlated with time. Fan area versus drainage basin, one the one hand, and main stream length versus drainage basin area, on the second hand, are also linearly related. Terraces forming above a single thrust result from interactions between the evolution of deformation pattern (uplift) and the evolution of drainage network (hydraulic flow, piracy). Brutal changes in hydraulic discharge and rapid adaptation of drainage network to the new conditions seem to prevail the terrace pattern.

Key-words: Analog modeling, relief, foreland morphology, propagation fold, Tian-Shan.

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