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Systematic stream piracy controlling the evolution of transverse rivers in the Ouarzazate foreland basin (Morocco)

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The Ouarzazate basin is a Cenozoic foreland basin located to the south of the High Atlas Mountains. Since it became externally drained in recent times, the fluvial dynamics of the basin has been dominated by erosive processes due to a base level fall. The aggradation of Quaternary sediments in the basin is related to the transverse rivers draining the High Atlas orogen. Previous studies documented that both the deposition and the abandonment of Quaternary terraces and alluvial fans were directly controlled by climatic change. Estimated incision rates are moderate to high during the Upper Pleistocene and Holocene (0,3-2 mm/a); by contrast, the current landscape of the basin is characterized by large and flat extensions of aggraded thick-gravel deposits, covering the fine-grained Tertiary basin infill.

The main rivers have watersheds between 100-300 km2 and their bed is covered by coarse gravel sediments. On the contrary, secondary streams with small drainage areas in the interfluves directly incise the basin bedrock, with scarce streambed deposits. In addition, these secondary streams run at a lower elevation than the level of the main rivers, attesting to a non-direct correlation between incision efficiency and size of the catchment. Satellite imagery, elevation data and field observations demonstrate how minor streams increase their catchment area by lateral erosion, thus creating large flat erosional areas (pediments) lying below the main rivers, where the basin bedrock is exposed. We show that these pediments progress headwards capturing the main rivers, which thus become unconfined and loose their concave-up profile. These relationships suggest that the discharge-to-sediment supply ratio plays an important role on the river behavior and broadly controls the erosion in the Ouarzazate synorogenic basin. Erosion is not directly proportional to the drainage area following a simple stream power law, but instead it appears controlled by the sedimentary flux. In the main rivers coming from the High Atlas, high sediment discharge blankets streambeds and inhibits incision. By contrast, such process does not operate in small catchments draining the interior of the Ouarzazate basin, giving a simple explanation for the deeper incision of the secondary streams. Knickpoints associated to captures of the main rivers by the secondary ones can reach a few tens of meters of difference in elevation; they are soon smoothed out, and river profiles recover a new concave-up shape in part due to downstream sedimentary aggradation, which creates fan shaped deposits over the previously formed pediment that provides new accommodation space.

The study demonstrates an unsteady state of the drainage network of the Ouarzazate basin and its recent reorganization, apparently uncoupled from tectonic or climatic processes. We envisage the systematic piracy processes occurring at Ouarzazate as a mechanism of channel dynamics, alternative to progressive vertical incision and lateral migration.