Geophysical Research Abstracts
Vol. 17, EGU2015-238, 2015
EGU General Assembly 2015

Autogenic terraces and non-linear river incision rates under steady external forcing

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Fluvial terraces are among the most commonly cited records of hydraulic changes and tectonic events, and researchers often use the timing of their abandonment to constrain regional climatic and tectonic forcings. However, it can be challenging to identify the cause of terrace abandonment, as the same first order signature results from multiple drivers: external forcings of tectonics and climate, and internal autogenic feedbacks. Misinterpretation of the origin of fluvial terraces carries important consequences, as they often are key evidences for geomorphological and tectonic studies. Using a numerical model we identify an autogenic mechanism in transport-limited rivers that produces accelerated incision rates and the abandonment of significant terraces under steady forcing conditions. We show that a 'bank-feedback' process controls the cross-sectional geometry of channel entrenchment through the rising cost of eroding higher banks. During a phase of incision under the forcing of regular discharges (e.g. bankfull floods), an incising alluvial river migrates in a floodplain bound by progressively higher banks. Consequently, the volume of sediment produced by a unit of lateral migration grows larger and eventually forms a talus that may persist for multiple flood events. The talus shields the toe of the bank and prevents lateral erosion while vertical erosion can continue unhindered. This bank-shielding mechanism becomes more effective as vertical erosion creates even higher banks, initiating a feedback that promotes dramatic vertical entrenchment and abandonment of wide terraces. We propose that such a 'bank-feedback' process also plays a large role in determining the source of bedload material by forcing the river to tap into deeper and older sedimentary strata. We compare the 'bank-feedback' mechanism with a well-studied case of the northern piedmont of the East Tian Shan. There, terrace ages documenting >200 m of Holocene river incision, record a fourfold acceleration of incision marked by the abandonment of remarkably large terraces during the incisional episode. Circumstantial geologic evidences strongly support the relevance of the 'bank-feedback' mechanism over external forcing and disputes previous tectonic or climatic interpretations of these terraces.