



Using non-steady state landscapes in active tectonic settings to quantify the effect of sediment flux in controlling bedrock incision rates

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A prime motivation for studying non-steady-state fluvial systems is that, potentially, they allow the underlying physics of fluvial incision processes to be elucidated. Several fluvial incision models have been proposed in the literature, which mainly differ in the treatment of sediment flux. However, at present, there is not a strong empirical basis for choosing among them largely because few well-constrained case studies of transient landscape response exist. A well-constrained system is one for which, at a minimum, the timing, magnitude and spatial distribution of the external forcing can be independently established and where the fluvial network is also well-characterised. We have been comparing two bedrock rivers draining across active normal faults in central Italy and mainland Greece for which these pre-conditions are met. The two catchments have similar drainage areas (65 km² vs. 98 km²), are actively incising into a similar bedrock lithology upstream of the fault (limestone), and are subject to similar climatic regimes. Both rivers have been perturbed by an increase in uplift rate along the active fault that was of similar magnitude (from ≤ 0.3 mm/yr to ~ 1 mm/yr) and occurred ~ 1 Ma in each case. In spite of these similarities, the two rivers have markedly different long profiles and calculated bed shear stresses differ by $> \times 3$ where the rivers cross the faults. The key difference between these two catchments is that the upper reaches of the Greek river, unlike the example from central Italy, are incising into Pliocene strata that contain fluvial conglomerates with abundant well-sorted

pebbles of a relatively resistant lithology. Field evidence shows that these pebbles are causing abrasion and plucking of the limestone bedrock, although there is significant (>80%) bedrock cover by pebble/gravel bars at low flow. In contrast 50-100% of the bedrock is exposed in the Italian example. Sediment supply to bedrock channels influences incision rate either through enhancing erosion of exposed bedrock or inhibiting erosion by limiting the amount of bed that is exposed (the “tools-versus-coverage” effect). This issue is relatively well understood from a theoretical standpoint (e.g., Sklar and Dietrich, *WRR*, v. 40, 2004) and simplified representations of the theory have been incorporated in numerical models to understand better long-term channel profile evolution (e.g., Gasparini et al., *GSA Spec. Pub. no. 398*, 2006). Our field observations from Greece and Italy indicate that the “tools-versus-coverage” effect does indeed lead to substantial differences in the nature and duration of the transient response of the landscape over timescales of 10^6 years. This is the first study to provide conclusive evidence of this effect over geologic timescales for a natural system. The field data collected from these two catchments is used to estimate the magnitude of the effect.