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Rapid recession of fault-scarp knickpoints: 10-year changes since the 921 Chi-Chi Earthquake, west central Taiwan

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Many waterfalls (knickpoints) were formed according with the emergence of surface ruptures along the Chelungpu thrust fault in west-central Taiwan at the 921 Chi-Chi Earthquake on September 21, 1999. Since then the fault-scarp knickpoints, except for those which have soon been fixed under artificial riverbed protection, have receded upstream at extremely rapid rates, causing bedrock incision for tens to hundreds of meters in length within a decade.
In the Ta-chia River, in which the most distinct waterfall was formed, the mean rate of the knickpoint recession was revealed by field topographic measurement to be 3.3 m/y in the earlier 6 years (1999-2005) and 220 m/y in the last 4 years (2005-2009). A model analysis using an empirical model of knickpoint recession, in which relevant physical parameters of erosive force and bedrock resistance are involved as a dimensionless index, suggests that this acceleration of the recession can be due to the increase in flood frequency and intensity, narrowing of the channel width, and/or anisotropy of rock strength (sandstones and mudstones) along the stream. The other knickpoints showed relatively similar mean recession rates in 1999-2005 and 2005-2009 on the order of 20-60 m/y, and these changes in their recession rates can be commonly affected by severe flood occurrence in the study area. Some of the knickpoints are also affected by artificial work of riverbed protection such as check-dam construction and installation of concrete blocks onto riverbed, but the dams or blocks are easily broken and removed after the passing of the receding knickpoints in the bedrock beneath them. Those artificial erosion controls have thus not successfully worked against the extremely rapid erosion of bedrock by the rivers. The extremely rapid erosion of the knickpoints are likely affected by the abundant sediment particles supplied from further upstream catchment. In fact, all the abundant gravels on the riverbed, having a mean b length of 41.5 cm with a maximum size exceeding 3 m, are quite harder than the bedrock therein.

Keywords: Waterfall, Knickpoint, Erosion, Bedrock, Gravel, Chelungpu Fault