Late Quaternary mass-wasting records in the actively uplifting Pa-chang catchment, southwestern Taiwan

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Although dominated by erosion over long term, the active mountains of Taiwan commonly contain thick landslide/debris-flow gravels capping hillslopes or forming alluvial terraces. These deposits, and their associated landforms, serve to study ancient mass-wasting histories and their controls on fluvial processes. This study focuses on the Pa-chang River draining the <2000 m high Ali-shan area in southwestern Taiwan (current tectonic uplift: 5–8 mm/yr by leveling surveys). Although small (catchment area: 83 km^2), the Pa-chang exhibits one of the largest alluvial terraces in Taiwan (labeled CK), which stretches from the outlet of the catchment for 9 km along the river and comprises fluvial/debris-flow gravels up to 150 m thick. Totally 55 radiocarbon dates have been obtained, tracing the mass-wasting records back to 14.8 ka. The largest events, which created the CK and other alluvial terraces in the catchment, occurred in 10.0–11.3 ka and 8.7–9.4 ka. These events are synchronous with the formation of some regionally largest alluvial terraces in Taiwan, and may have been triggered by the frequent heavy rains associated with the maximum of the early Holocene East Asian summer monsoon. More mass-wasting events are dated at ~5.4 ka, ~1.9 ka, 1.2–1.7 ka, 0.7–0.9 ka, 0.5–0.6 ka, and ~0.2 ka. The vast supply of sediment from the recorded mass-wasting events not only caused aggradation of the river but also regulated the subsequent incision by forming boulder armors. This is shown by the negligible bedrock incision in the upper part of the catchment since the extensive early Holocene debris-flow deposition. The obtained incision rate increases to the downstream direction as the size/concentration of boulders reduce. Still, the 15 ka-averaged bedrock incision rate (<4.5 mm/yr) at the catchment outlet is lower than the uplift rate. In the same area, the bedrock incision rate in the past 0.5 ka is averaged ~25 mm/yr. Even higher rates of incision (>100 mm/yr) were detected further downstream after the recent gravel mining. The fact that the obtained bedrock incision rates/patterns are decoupled with the tectonic uplift advises caution in using short-term erosion data to interpret the long-term tectonics of the Taiwan's mountains.