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Bedload-Driven River Incision - Evidence from The 'Grand Canyon' of the Da'an River, Taiwan

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The role of sediment in bedrock river incision has received much attention in recent years, but the relative importance of bedload and suspended load in driving erosion remains an important question. We present a case study from the Da'an River gorge in western Taiwan where we are able to observe, on a single reach, incision behavior during both bedload-starved and bedload-rich conditions. The Da'an River provides a unique natural laboratory for the study of fluvial incision processes. In Sept. 1999, coseismic folding associated with the magnitude 7.6 Chi-Chi earthquake resulted in up to 10m of surface uplift in a 1 km long section of the river channel. In response to this uplift, the river has cut a dramatic gorge, with up to 20 m of incision into bedrock. The extremely rapid erosion rates enable us to directly observe the development of this bedrock gorge. We examine the evolution of the channel since 1999 using aerial photographs, RTK GPS, terrestrial LIDAR, and data from Taiwan's Water Resources Agency.

The Da'an River has experienced two distinct phases of post-earthquake evolution. Between 1999 and 2004, the channel experienced limited bedrock incision, and knickpoints remained stationary. From 2004 onward, the river incised extremely rapidly, cutting a deep bedrock gorge with local incision rates as high as 10 m/year, and knickpoint propagation rates of 100-200 m/year. Analysis of the hydrological records from gauging stations on the Da'an River indicates that the change in the behavior of the channel after 2004 cannot be explained by a change in discharge or flood frequency. The change in channel behavior does, however, coincide with a change in the flux of sediment into the uplift zone. Following the earthquake, the upstream boundary of the uplift zone consisted of an abrupt 6m high scarp. Between 1999 and 2004, this scarp acted as a barrier to the transport of bedload into the uplift zone. During the typhoon season of 2004, the area upstream of the scarp became completely filled in with sediment, and we see the first new deposition of coarse sediment in the uplift zone, indicating that the barrier to bedload transport has disappeared. The lack of incision and knickpoint propagation in the five years following the earthquake and the association between the introduction of coarse sediment into the channel and the onset of rapid incision indicate that incision in this system is primarily bedload-driven, and that erosion via suspended load is significantly less efficient.