Landslide events and river sediment transport: a case study of Tsaoling landslide along the Chingshui River, Taiwan

Rou-Fei Chen[1] , Jacques Angelier[2,3],Kuo-Jen Chang[1], Yu-Chang Chan[1], Jian-Cheng Lee[1]

[1.]Institute of Earth Sciences, Academia Sinica, P.O. Box 1-55, Nankang, Taipei, R.O.C., Taiwan
[2.]Observatoire Océnaologique de Villefranche, Géosciences Azur, B.P. 48, 06235, France
[3.]Institut Universitaire de France

ABSTRACT

On September 21. 1999, a catastrophic landslide occurred on the Tsaoling area, triggered by the destructive Chi-Chi earthquake (M_L=7.3) at an epicentral distance about 35 km. Detailed characterisation of the landslide topographic surface was carried out using a new LiDAR technique, 2.5 years after the 1999 landslide event. Because of high resolution, the digital elevation model (DEM) thus obtained allowed comprehensive visual and quantitative investigation of characteristic morphologic patterns along the sliding surface and deposition area (Chen et al., 2005). Combining the LiDAR analysis with field observation and earlier remote sensing data, we gathered consistent geological and morphological observations along the sliding surface and avalanche structures to analyse the landslide process at Tsaoling.

The Tsaoling area is mountainous and is of mature stage in topographic development in the Foothill Region of central Taiwan. The occurrence of successive landslides and related destruction in the Tsaoling area has been documented for the past 140 years. Historical catastrophic dip slope failures have repeatedly occurred, the first catastrophic failures occurrence on 1862 (triggered by an earthquake), 1941 (triggered by an earthquake), 1942 (triggered by heavy rainfall), 1979 (triggered by heavy rainfall), and 1999 (triggered by the Chi-Chi earthquake). The Tsaoling landslide region continued to be modified due to severe river erosion, especially during rainstorms. The most common digital terrain information in Taiwan is the DEM with 40 m grid accuracy. In this study, we analyzed the topographical change 5 years after the event, that is, for the period from September 1999 to July 2003.

Mountain erosion rates have been estimated form these measurements for the interval 1970-1999, river suspended-sediment discharge has been recorded at over 150 stations across Taiwan. The rates of uplift and erosion during the mountain building of Taiwan are variable and difficult to estimate. The study of the Tsaoling landslide reveals that the probability for repeated major landslide events is very high, which deserves careful consideration as far as natural hazard mitigation is concerned. We quantify the sediment transfer in the rivers running from high mountains to the sea, combining large numbers of water discharge data with smaller numbers of sediment content data for those measured records. This approach results in reduced albeit still large uncertainties while calculating the volume of sediment involved in transfer from mountain to sea, and hence the erosion rate. The impact of landslides caused by the destructive Chi-Chi earthquake on erosion budgets and denudation rates over the short, medium and long-term will be analyzed in further studies.