



## **Understanding causes of mass movements focussing on rainfall. Two case studies of the Lower Garagoa River Basin (Boyaca, Colombia)**

**M. Portilla** (1, 2), M. Hürlimann (1), and J. Corominas (1)

(1) Technical University of Catalonia, Department of Geotechnical Engineering and Geosciences, Barcelona, Spain ([modesto.portilla@upc.es](mailto:modesto.portilla@upc.es) / Fax: +34 93-4017251 / Phone: +34 93-4016925), (2) National University of Colombia, Department of Geosciences, Bogota, Colombia ([mportillag@unal.edu.co](mailto:mportillag@unal.edu.co) / Fax: +57 1-3165390 / Phone: +57 1-3165388)

The establishing of appropriate relationships between mass movements and their causes is rather difficult. During the last decades different relationships of rainfall thresholds have been published, but there are still many uncertainties. In Colombia, there have been propounded several thresholds for rainfall intensity-duration that trigger mass movements. This work presents a study of two different mass movements that occurred at the La Peña Hill and at San Jose gorge, distant less than 10 Km each other and having very similar settings. Special attention is paid to the analysis of rainfall data recorded at Sutatenza Meteorological Station from 1962 to 2005.

On November 10, 2000, a thunderstorm occurred over the La Peña hill, 6-Km eastern of La Capilla town. It produced a 50 minutes-rainfall which had 10.8-mm at Sutatenza Meteorological Station (6.7-Km south of the La Peña hill), and 16.8 mm/day were recorded at Valle Grande Pluviographic Station (3.9-Km south-east of the Tambor Mountain). As a consequence of this rainfall came about a translational landslide at the foot of the La Peña hill (sandstones and claystones in a broad, shallow, large, and wide catchment), which temporally clogged the Honda ravine channel and after that a debris flow took place.

On the other hand, on August 14, 2004, in a broad region of Sutatenza municipality took place a persistent rainfall, which provoked an earth flow along the lower trajec-

tory of the Volcan rivulet from its San Jose gorge tributary (claystones with intercalations of limestones in a narrow, deep, small and elongated catchment). The rainfall recorded at Sutatenza Meteorological Station (4.7-Km south-eastern of San Jose gorge) was 4.6 mm and lasted 1 hour. This rainfall was preceded by another one that lasted about 3.5-hour and registered 9.6 mm at Sutatenza Meteorological Station on August 13. Moreover, rainfall was 20.6 mm at Valle Grande Pluviographic Station, from 10 p.m. (August 13) to 6 a.m. (August 14).

The results of the rainfall data analysis show that in the Lower Garagoa River Basin, in order to get an index of the amount of rainfall necessary to generate mass movements, we need to take in account two components; the leading factor which is accounted by long-period antecedent rainfall, and a triggering factor represented by a short-period rainfall at the moment by which the mass movement take place. It was found that an appropriate threshold for rainfall events that induced mass movements in the Lower Garagoa River Basin is the 5-Month Inter Annual Accumulated Rainfall (950 mm, long-period antecedent rainfall) in conjunction with the event rainfall intensity or short-period rainfall (higher than 10 mm/h in sandstone bedrock, and higher than 10mm/3h in clayey outcroppings).