Hurricane–triggered lahars at Volcán de Colima: evidences of flow dynamic from monitoring and field survey.

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Rain–triggered lahars represent a very common and dangerous phenomenon at Volcán de Colima, with between 15 and 20 events occurring per year including some that generate major damage to infrastructure. These flows initiate on the upper slope of the cone above 2500 m a.s.l. and usually erode and entrain material to transform into debris flows that deposit 1–2 m of sediment along ravines up distances of 12–15 km from source. The October 12th, 2011, Jova hurricane was an anomalously large rainfall event over Volcán de Colima area, with important effects on the morphology of the area and on the dynamic properties of lahars along the main ravines. This hurricane produced more than 200 mm of rainfall in 24 hours, triggering several lahars that lasted for more than 2 hours. Based on data recorded at the monitoring station located 4 km from the crater along the Montegrande ravine (equipped with a rain gauge station, a soil moisture sensor, a video–camera, a geophone, and a broadband seismometer of the COLIMA–RESCO network) we were able to record the event and to obtain physical parameters of some of these flows. Three main lahars were detected from the spectrograms, being the last one characterized by a train of seismic peaks that lasted for more than an hour. No images were available since the event occurred at night. However, comparing the topography before and after the event at the monitoring site, these flows were able to deeply erode older terraces. Field surveys performed three days after the Jova event, let us to better understand the downflow behaviours. Three main depositional units were recognized: the two lower units are massive, mostly composed of sand and gravel, with maximum thickness up to 50 cm. The upper unit is up to 1.5 m thick, massive or normally–graded with clasts up to 30 cm imbedded in a sandy matrix. The granulometric analyses show a very low percentage of the silt fraction (<5 wt%), with predominance of sand for the two lower units, and of gravel for the upper unit. Based on the extraordinary erosive power observed along the ravine and on the textural characteristic of the deposits we interpret that lahars were dilute, supercritical flows, within the hyperconcentrated flow regime. These flows are prone to entrain sediment through turbulence and tractive shear stress. The last lahar was probably the most erosive pulse, which subsequently transformed into a debris flow depositing a coarse, normally–graded unit farther downstream. Immediately after the event, a box–shaped canyon was formed, leading to tens of landslides occurring along the ravine, some of them damming the river and thus exacerbating the risk of highly sediment charged and damaging lahars in the near future.