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Landslides and erosion induced by the 2005 Fogo-Congro seismic crisis (S. Miguel, Azores)

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A seismic crisis started in Fogo-Congro seismogenic region (S. Miguel Island-Azores) on May 10th, 2005. Between May and December more than 46000 earthquakes were registered by the Azores Seismological Surveillance System (SIVISA). On the September 20th and 21st, 2005, occurred the two strongest earthquakes within this period, with magnitudes (Ml) 3.9 and 4.3 respectively. The epicentres were located in the central part of the island, reaching a maximum intensity of V/VI (EMS-98) in the closest villages. Despite the moderate magnitude of these earthquakes, they did not promote severe damages or casualties. The density of landslides within the epicentre area was significant. Some rural roads were temporarily closed and dams were formed due to landslides.

As result of several field incursions and a helicopter flight, provided by the Civil Protection (SRPCBA) in conjunction with Portuguese Air Force (FAP), the earthquake-induced landslides were mapped. These were subsequently digitized and plotted in a GIS-based format. The majority of these landslides were disrupted inside watersheds, characterized by hillslopes composed of weakly cemented explosive deposits, resulting from Fogo Volcano eruptions, with very low values for resistant parameters, oversteepened by fluvial incision. All of the identified landslides correspond to debris flows and shallow soil slips (1-5 m deep) usually evolving downslope into debris flows and travelled until they reach the stream lines. The exceptionally rapid movement (1-3 m/s) of the landslides was indicated by eyewitness accounts and the average volume of these landslides never exceeds 10000 m^3.

More than 100 landslides were identified, roughly, inside a circular area of about 5 km^2, centred in the seismic crisis epicentral zone. This landslide density is related to

the shallow focal depth of the earthquakes and consequent strong ground acceleration and the site geologic and topographic setting. Furthermore, most of the landslides in this area were located close to the inter-fluvial crest zones, emphasizing the importance of topography in the amplification of seismic waves. The highest density of landslides was found in slopes exposed to the opposite side of the earthquakes epicentres referred above. This fact could be related with the P-wave arrival, since the terrain characteristics are very homogeneous. Finally were used empirical functions from literature, relating magnitude with landslide distribution, the total area and volume of triggered landslides, as well as the area and volume of the maximum landslides.

Landslides added heavy sediment loads to the stream lines and caused some environmental damage in the watersheds and increased the probability of flash floods in villages located in the lower part of the watersheds, as it already occurred. Many additional landslides will undoubtedly be triggered and reactivated, during the winter of 2005-2006, due to the heavy rainfall periods that characterise this area in that time of the year.

This preliminary survey provides an overview of the: (1) earthquake-triggered landslide distribution; (2) typology of the triggered landslides and (3) damaging effects of the landslides. This case study represents an important lesson for landslide risk mitigation in Azores, which can be used, in the future, for land-use and emergency planning, reducing future damage in such earthquake prone region.