



A multi-technique approach for characterizing the geomorphological evolution of a Villerville-Cricqueboeuf coastal landslide (Normandy, France).

Candide Lissak Borges (1), Olivier Maquaire (1), Jean-Philippe Malet (2), Christopher Gomez (3), and Franck Lavigne (4)

(1) Caen Basse Normandie, Geophen UMR 6554 CNRS, Geography, caen, France (candide.lissak-borges@unicaen.fr), (2) School and Observatory of Earth Sciences, Institute of Earth Physics, CNRS UMR 7516, University of Strasbourg, Strasbourg, France, (3) UMR 5600 CNRS, Ecole Normale Supérieure, Département Lettres et Sciences Humaines, Lyon, France, (4) UMR 8591 CNRS, Laboratoire de Géographie Physique, Meudon, France

The Villerville and Cricqueboeuf coastal landslides (Calvados, Normandy, North-West France) have occurred in marly, sandy and chalky formations. The slope instability probably started during the last Quaternary period and is still active over the recent historic period. Since 1982, the slope is affected by a permanent activity (following the Varnes classification) with an annual average displacement of 5-10 cm.y⁻¹ depending on the season. Three major events occurred in 1988, 1995 and 2001 and are controlled by the hydro-climatic conditions. These events induced pluri-decimetres to pluri-meters displacements (e.g. 5m horizontal displacements have been observed in 2001 at Cricqueboeuf) and generated economical and physical damage to buildings and roads. The landslide morphology is characterized by multi-metres scarps, reverse slopes caused by the tilting of landslide blocks and evolving cracks.

The objective of this paper is to present the methodology used to characterize the recent historical (since 1808) geomorphological evolution of the landslides, and to discuss the spatio-temporal pattern of observed displacements. A multi-technique research approach has been applied and consisted in historical research, geomorphological mapping, geodetic monitoring and engineering geotechnical investigation. Information gained from different documents and techniques has been combined to propose a conceptual model of landslide evolution:

- a retrospective study on landslide events inventoried in the historic period (archive investigation, newspapers);
- a multi-temporal (1955-2006) analysis of aerial photographs (image processing, traditional stereoscopic techniques and image orthorectification), ancient maps and cadastres;
- the creation of a detailed geomorphological map in 2009;
- an analysis of recent displacements monitored since 1985 with traditional geodetic techniques (tacheometry, dGPS, micro-levelling)
- geophysical investigation by ground-penetrating radar along the main road in order to assess the subsidence of the road according to the thickness of the filling material.

Integration of the knowledge allows to characterize the landscape changes over the historical time. Displacement values obtained over nearly 200 years reflect annual slow movement and crisis acceleration. Values are dispersed in space and time. An average of displacements of 12.30 m year⁻¹ (= 8.50) between 1829 and 2006 is observed for the Villerville landslide. This average allows calculating an annual displacement of 0.07 m which can be compared to data recorded since 1985 and by annual DGPS measurement data between 2008 and 2009.