On the Determination of Triggering Factors of Coastal Chalk Cliff Collapses in Upper Normandy

LETORTU Pauline [1], CADOR Jean-Michel [1], LE GENDRE Romain [2], QUENOL Hervé [3], COSTA Stéphane [1]

(1) GEOPHEN-UMR LETG 6554 CNRS, University of Caen Lower Normandy, Caen, France
(2) IFREMER, Laboratory Environment Resources of Normandy, Port-en-Bessin, France
(3) Laboratory Costel, Department of Geography, University of Rennes 2-Upper Brittany, Rennes, France

Session GM8.3
EGU 2011 - 1 - 206

Contact:
Pauline LETORTU
GEOPHEN-UMR LETG 6554 CNRS, , University of Caen Lower Normandy, France
Email: pauline.letortu@unicaen.fr

INTRODUCTION

The coastline of Upper Normandy (France) is made up of a 130 km long chalk cliff in the central and the oriental parts of the English Channel shoreline (**figure 1**). Spatial variability of cliff recession occurs due to layer variations in local lithology (**figures 2 and 3**) or the influence of natural and man-made obstacles to the longshore drift. Such cliff retreat is locally different and its rate can reach up to one meter per year.

Due to collapses (**figures 4 and 5**) threatening settlements close to the coastline, **better understanding of this rocky coast erosion is greatly needed.**

Fig. 1: Location of the Upper Normandy coastline

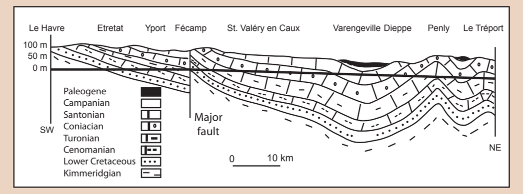

Fig. 2: Geology in Upper Normandy coastline [1]

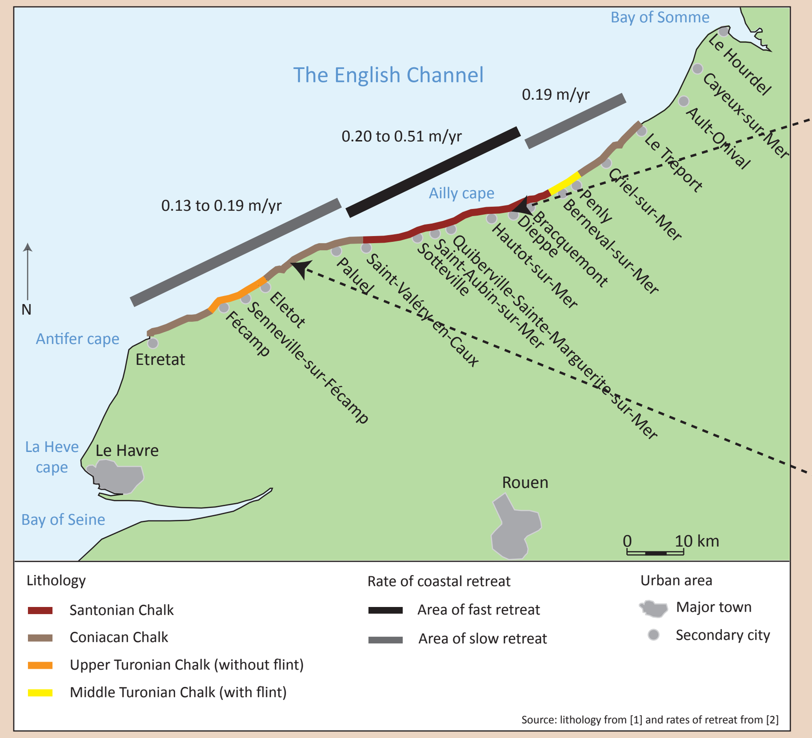

Fig. 3: Lithology and retreat rate in Upper Normandy coastline [2]

Fig. 4: A collapse in Dieppe observed (ESTRAN)

Fig. 5: A collapse in Saint-Martin-aux-Buneaux (Gendarmerie Nationale)

OBJECTIVES

The primary aim of this study is to determine the triggering factors of coastal cliff retreat.
We seek to contribute to scientific discussion about the predominance of marine processes and/or sub-aerial weathering processes in the trigger of cliff collapses. Human actions must be taken into account because they modify longshore drift (**figure 6**) and can increase swell action at the cliff foot with the implementation of artificial structures.

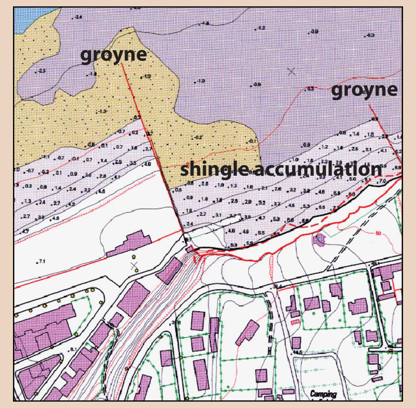

Fig. 6: Human interventions and their effects on the longshore drift [2]

METHODOLOGY

This study is carried out in collaboration with the non-profit corporation, ESTRAN. Thanks to this partnership, we have **a remarkable and unique database describing 332 cliff falls**. Some parts of coastline are highly sensitive to retreat (**figure 7**). Observed coastal cliff collapses mainly occurred during winter (**figure 8**).

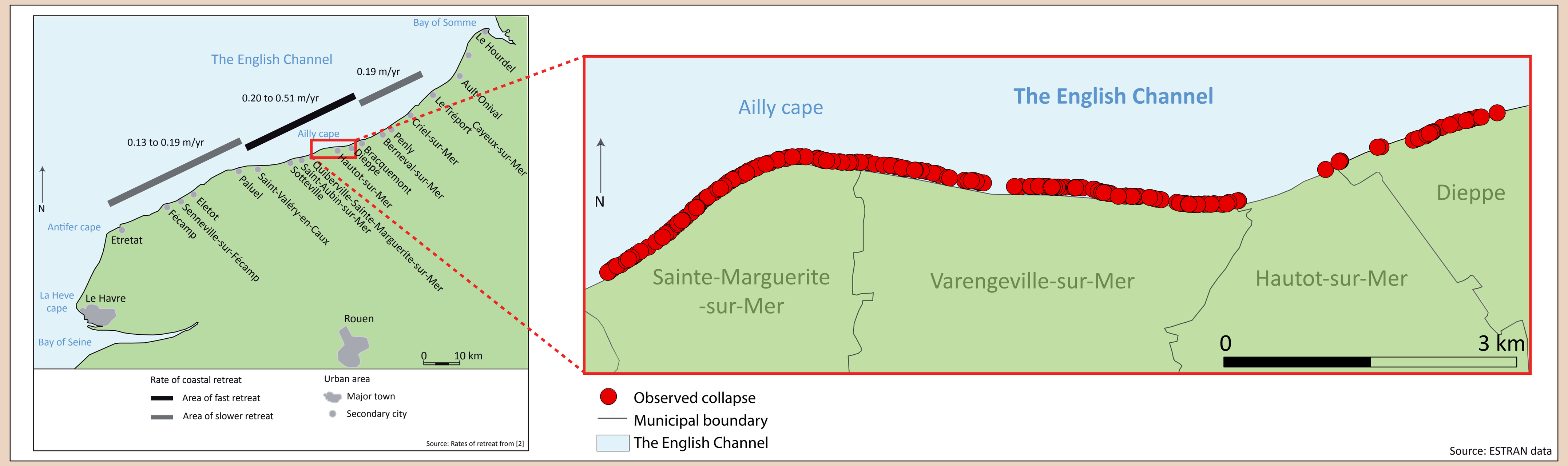

Fig. 7: Cliff collapses from Sainte-Marguerite-sur-Mer to Dieppe observed since 2002

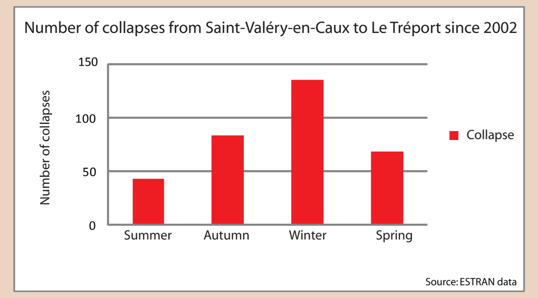

Fig. 8: Number of collapses from Saint-Valéry-en-Caux to Le Tréport since 2002

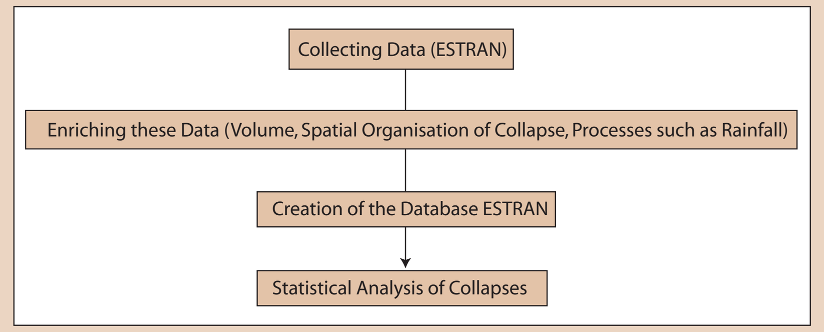

Fig. 9: Methodological framework

The analysis deals with **the statistical definition of the relationships between processes and the collapse** (**figure 9**).

RESULTS

To determine triggering factors, we applied a **principal component analysis (PCA) over a 10-day period**. Though **the role of rainfall, tidal range, and wind seem to be preponderant**, the factor analysis points to **the high complexity of the process of collapse triggering** (**figure 10**).

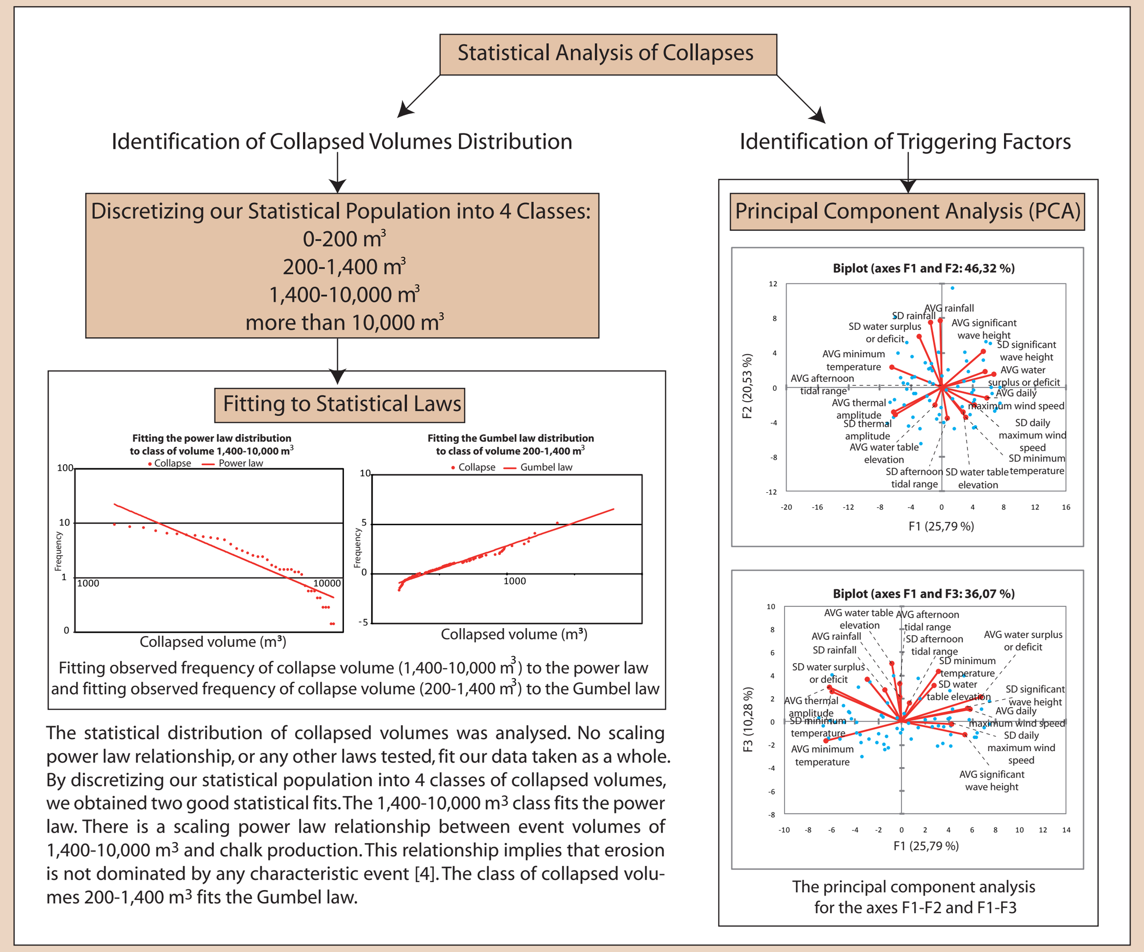

Fig. 10: Statistical analyses and results

Based on the PCA, excess of water and frost/thaw cycles prove to be the main continental factors triggering coastal cliff collapses. **A climate index [3] summing up these two main continental factors (figures 11 and 12) has been created.**

THE INDEX CREATION

1) Identification of dry, wet, and transition periods by calculating the water balance over a 10-day period

2) Evaluation of the intensity of dry and wet periods by discretizing each period

3) Characterization and addition of duration factor using a multiplier

4) Possible addition of frost value, taking into account the duration and intensity of the phenomenon

Fig. 11: The index creation

The index in a wet context (**figure 12**) is **a good indicator of coastal collapses.** Higher index coefficients correspond with greater numbers of collapses. Some of these seem to be linked to runoff (**figure 13**).

This index allows us **to identify 10-day periods that are conducive to coastal collapse** in order to improve risk pre-

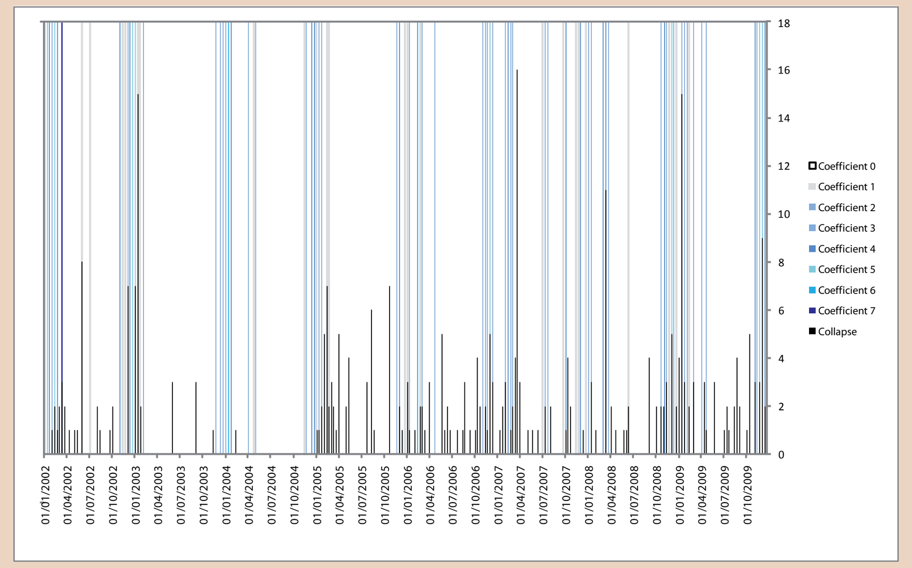

Fig. 12: Every 10 days from 2002 to 2009, the climate index was calculated in a wet context, and the number of collapses was observed.

Fig. 13: A collapse probably due to runoff

CONCLUSIONS

It is difficult to classify the processes that trigger coastal chalk cliff collapses. Indeed, numerous **combinations of factors**, and the phenomena of **process shifts**, or even **hysteresis effects**, draw a more **complex link between triggering agents and coastal cliff falls**. However, we have identified **periods of high probability of triggering** due to main continental factors. This index will prove to be **a useful tool in warning and protecting the human population.**

References:
[1] Costa S., 1997. *Dynamique littorale et risques naturels: L'impact des aménagements, des variations du niveau marin et des modifications climatiques entre la Baie de Seine et la Baie de Somme.* PhD thesis of l'University of Paris I, 376 p.
[2] Costa S., 2000. *Réactualisation des connaissances et mise en place d'une méthode de suivi de la dynamique du littoral haut-normand et picard*. Final report, Prefecture of Picardy, Contrat de Plan Interrégional du Bassin de Paris (CPIBP). 103 p.
[3] Savouret E., Amat J-P., Cantat O., Filippucci P., 2010. « Chronique du temps vécu à Verdun en 14-18 », *Actes de l'Association Internationale de Climatologie*, international symposium of Rennes, « Risques et changement climatique », vol. 3, pp. 571-576.
[4] Dewez T., Chamblas G., Lasseur E., and Vandromme R., 2009. Five seasons of chalk cliff face erosion monitored by terrestrial laser scanner: from quantitative description to rock fall probabilistic hazard assessment. *Geophysical Research Abstracts*, Vol. 11, EGU2009-8218, 2009, EGU General Assembly 2009