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Towards a generic methodology to assess instabilities and retreat rate in flysch seacliffs

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SUMMARY:

Flysch seacliffs are subject to various instability types and retreat rates. Characterizing the predisposing factors governing the erosion of these complex formations is a challenge to assess coastal landslide hazard. We propose a field observations-based generic methodology to assess the various instabilities and retreat rates of flysch seacliffs. For this purpose, we collected geomorphological and geological observations, including flysch facies, weathering, geological strength index and tectonics on two study sites of the French Basque coast. These data enabled us to build a decisional tree that we tested on other flysch seacliffs sites to assess the instability types.

Keywords: coastal erosion, seacliff, slope instabilities, flysch, generic methodology.

Abstract

Seacliffs represent 52% of the coast in the world (Young and Carilli, 2019). Seacliffs erosion by gravitational instabilities represents a risk for people and for economic activities. In order to predict these instabilities and to protect people, it is necessary to identify the types of instabilities contributing to erosion, the factors governing them and their contribution to retreat rates. In flysch seacliffs, the knowledge about variability of retreat rates (from 0.0034 to 1 m.yr⁻¹) and instability types is a challenge to assess coastal landslide hazard.

Cano and Tomás (2013) proposed a generic method for heterogeneous rocks such as flyschs, to identify their instability types and their geological and geomorphological contributing factors. This generic method gives a variety of predisposing factors combinations contributing to instability types. One theoretical advantage of the method is its applicability for different contexts, but the results are difficult to classify and to be transposed to other areas, moreover the rate erosion is not taken into account.

The aim of this work is to give a field observation-based transposable classification for flyschs seacliffs, to assess the geological and geomorphological factors conditioning their instability types and retreat rates. We believe the sedimentary facies classification of flyschs from Mutti and Ricci Lucchi (1972) could be a main predisposing factor to specific instability types. In addition, we believe that other factors such as weathering, tectonics, and strength indices may help to identify instability types and that the rate of erosion can be estimated from this information.

For this purpose we collected field observations in order to map instability types (Figure 1), geological units, geological strength index (Hoek and Brown, 1997; Marinis and Hoek, 2001), faults presence and the geometrical relationship between stratification and main slope (Cano and Tomás, 2013; Trenhaile, 1999). Geological field data are integrated into a 3D geological model based on GeoModeller (Calcagno et al., 2008)(Figure 2), in order to assess the influence of lithology and structures on landslide susceptibility in such heterogeneous contexts. This is synthesised within local conceptual sketches of instabilities (Figure 3) that enabled us to understand better the contributing factors to coastal cliffs evolution. In this way, this data enable us to: (i) test the method of Cano and Tomás (2013) on French Basque coast test sites, (ii) propose an improved instability types classification flow-chart based on a decisional tree integrating geological and geomorphological factors, including flysch facies, (iii) test this new method on other local and foreign flysch seacliffs. These various results will be confronted to retreat rates. The discussion will consider the variability of climatic and oceanic contexts and the possibility to adapt and to test the method on other flysch facies types.

The generic methodology developed here for flysch seacliffs aims to enable to characterize coastal instability types and retreat rates by field observations and simple indices. This method tested and validated for different flysch facies might be used in other geological contexts.



Figure 1: Itxas Gaïna compound landslide at Bidart, with rock block slide in marls and landslide in upper alluviums – Photography by CombyAVM 2018

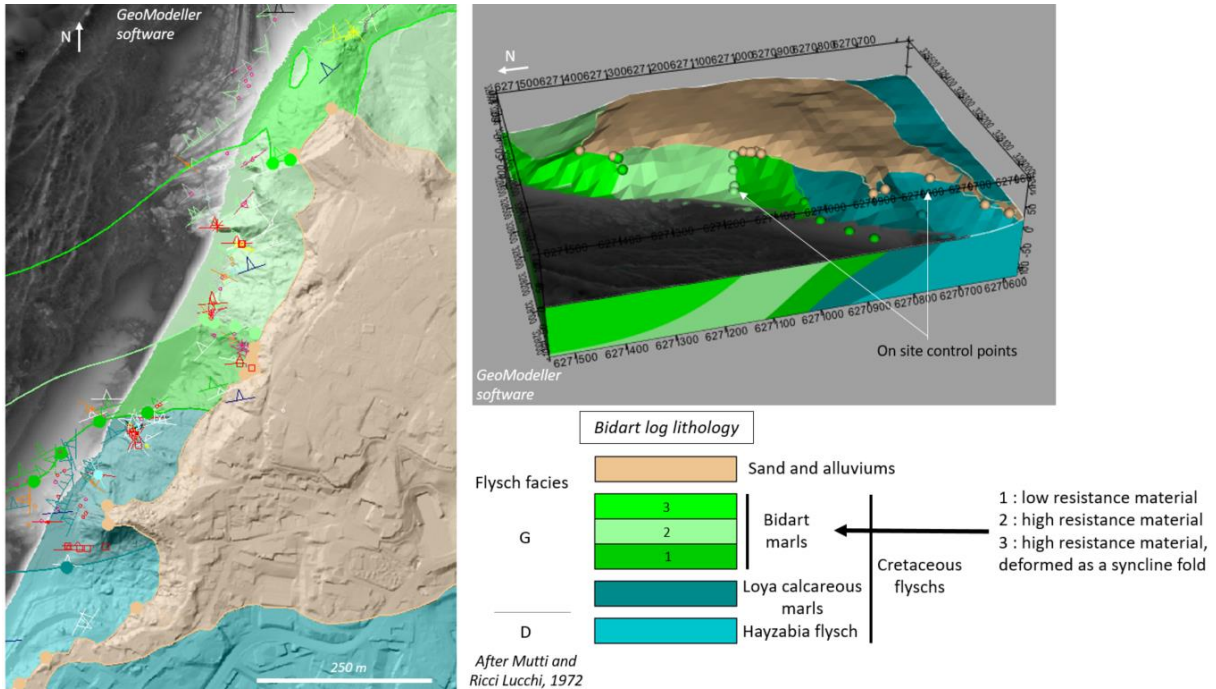


Figure 2: 3D geological model of Bidart flyschs and alluvium cover – GeoModeller (BRGM)

Conceptual sketch of "la Corniche" Bidart cliff erosion

In facies G flysch composed of weakly resistant marls

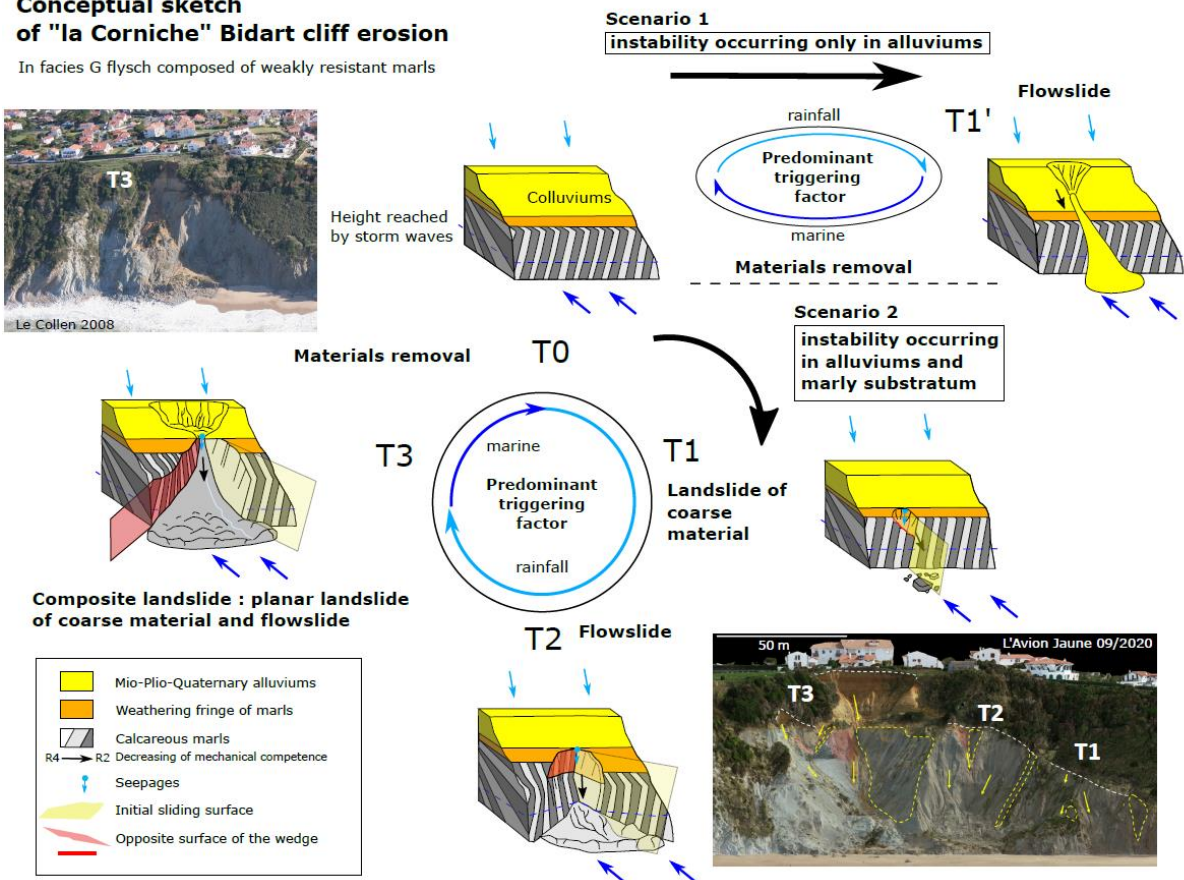


Figure 3: Conceptual sketch of “La Corniche” cliff erosion, in flyschs and alluviums, according to two different scenarii

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