Characterization of tectonics, geomechanics and geomorphology as predisposition factors of slope instability by multicriteria analysis

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**Abstract.**

The French Basque coast cliffs are subject to landslides (slides and rock-falls) of different kinds and magnitudes. Such heterogeneous phenomena constitute a threat to people and properties. An appropriate risk management policy is required for this inhabited and touristy area. Such a policy should take into account the heterogeneity of instability phenomena and their consequences on erosion rates in order to optimize the realization of remediation measures both in time and in space. For this purpose, it is essential to quantify and qualify past and present erosion rates, to understand how the coast may evolve at short and long terms.

The French Basque coast is about 40 km long with an average N63°E azimuth orientation. It is mainly carved in flyschs, initially deposited in a distal sedimentary basin during the Pyrenean orogeny. This deposition was followed by northwestward structural nappes emplacement in a N150°E to N180°E convergence. This coast is remarkable for the high variability of its geomorphological and geological features combining seven types of coast with different type of landslides. Landslides, in the range of 100-100 000 m3 affect soft geological horizons and destructured bedrock; rockfalls in the range of 1-100 m3 affect solid flyschs beds. If most of phenomena have been mapped previously by the Aquitaine Coast Observatory, factors governing their dynamics are still poorly understood with regards to evolving climate change boundary conditions.

The main objective of this study, funded by The Ezponda project (FEDER project), aims to relate specific instability types to the geomorphological and geological variability of the coast using a trans-disciplinary analysis. For this purpose, two sites have been selected for their different types of slope instabilities and different geological settings: the Bidart coast and the Socoa cliff.

The site of Bidart has a length of 1 km. It is characterized by 70 m high cliffs and various instability types occurring in quaternary deposits (sands, gravels and colluviums), weathered bedrock (marls and limestone) and destructured bedrock. The site of Socoa is about 1.6 km long. It presents 40 m high cliffs, composed of alternating marls and limestones flysch beds, topped by a weathering fringe of variable thickness (from 0 m to about 10 m). Flysch layers with a coast-parallel strike, dip 45° in the Atlantic Ocean. This disposition provides an overall good resistance to marine erosion. Rock-falls in the range of a 10-3 (single block) to 102 m3 (single flysch bed) occur along the edges of penetrating sea caves, rooted on steep, cliff-cutting, faults.

Three main contextual parameters were measured on both sites:

* mechanical strength of the cliff, according to its lithology and its weathering degree using Hoek & Brown criterion. The geomechanical response of the material is characterized by different tests such as peeling it with a knife and breaking it with a hammer. We recorded 17 measures of this type at Bidart and 11 at Socoa, from 0.25 up to 100 MPa uniaxial compression strength according to the grade characteristics;
* fault planes and fractures: they are areas of mechanical weakness and of fluid circulation that contribute to the weathering of the cliff. Fault plane dip directions, dips, lengths, offsets and widths of influence were measured on site. 2-cm-spacing UAV photogrammetric point clouds were analyzed on Cloud Compare software to crosscheck the measurements at site scales, and allowed to identify out-of-reach faults. In the end, such data transferred to a GIS map report 61 geometric and kinematic measurements for Bidart and 49 for Socoa;
* geomorphological features: these features are potentially influenced by the above parameters, and may themselves influence instability types. They are field observations such as cave landforms, dihedral cut zones or topographic depressions.

First results, allow to identify six fault sets on Bidart and Socoa sites. At Socoa, some of them can be associated with specific geomorphological features. On Bidart site, geomorphological features have to be defined. For both of the sites, geomechanical units need to be characterized also considering the vertical influence of weathering. Geotechnical tests will complete these field analyses to constrain the geomechanical response of the materials.

Once the different parameters analyzed and fixed, a multi-criteria analysis will help understanding their relative influence and assess the susceptibility of the French Basque coast to several types of slope instabilities.

**Keywords:** Slope instabilities, Basque coast, susceptibility, geological setting, tectonics, geomechanics, weathering.