

## **Title of the Research Project and keywords**

The Role of Inherited Geological Structures and Morphoevolution on the Gravitational Morpho-genesis along Rocky Coasts.

Keywords: coastal landslides; coastal cliffs; geomorphometry; remote sensing; field survey; tectonics; geo-mechanics; geomorphology.

## **Research Area**

Area 04 – Earth Sciences, sector ERC PE10

SSD: GEO/03 Structural Geology & GEO/04 Physical Geography and Geomorphology

## **General presentation of the project and state of the art**

The proposed research project will focus on the evaluation of the role exerted, at different space/time scales, by the structural setting and the long-term landscape evolution on the landslide proneness along hard and soft rocky coasts.

Rocky coasts represent about 80% of coasts worldwide and represent a great part of coasts around the Mediterranean area. Rocky coasts have been largely studied, representing landscape units with high economic, socio-cultural, and touristic values (Miccadei et al., 2019). Both hard and soft rocky coasts characterize the coastal sector of the Marche Apennines (Italy) and display both active and relict landforms where the gravitational morpho-genesis with its linked processes has a predominant role (Bigi et al., 1995; Savelli et al., 2017). Some studies have been recently conducted at the Conero promontory, based on geomorphological and structural analyses, finalized to understand the role of geological/structural setting, and long-term landscape evolution, on the landslide proneness. This study has provided interesting results for this particular area that is characterized by active coastal cliffs where the stratified calcareous, and marly-calcareous bedrock formations are typically affected by mass rock creep (MRC) process evolving in catastrophic slope failures (Troiani et al., 2020). Nonetheless, after the result from the Conero area, this argument displayed the needs of generalization and opened new research sceneries. In particular, it is not clear enough if the results obtained along the hard rocky coast of the Conero promontory are valid i) for the soft rocky coasts (or where alternations of hard/soft rock types crop out) (such as the San Bartolo costal area); ii) for the sectors characterized by relict coastal cliff (such as the Ardizio costal area); iii) for the sectors, such as those located in the southern Marche coastal zone, where a complex combination of marine, fluvial and gravity-induced processes typically characterize the long-term morphoevolution. This research project, basing on both traditional and the most recent structural/geomorphological investigation techniques, has the finality to enhance the present scientific knowledge to solve the above-mentioned challenging questions. In this context, the tasks proposed in this project represent the natural prolongation of the reserch conducted for my MSc Thesis, discussed at the Sapienza University of Rome, that focused on the structural/geomorphological characterization of the rocky coast at the Conero promontory with implications for the coastal slope instability.

## **Research Objectives**

The general scope of this project is the improvement of the knowledge on the slope instability along rocky cliffs at the external sectors of active mountainous chains.

Specific research aims are:

- Realization of detailed geomorphological and structural maps of the rocky coasts along the external sectors of the Marche Apennines;
- Decoding the style (and calculating the rates) of the long-term morphoevolution due to both endogenic (uplift and active tectonics) and exogenic (stream entrenchment, marine erosion, landslides) processes by means of detailed analysis of the planar geomorphic markers (marine and fluvial terraces, alluvial and coastal fans);

- Deciphering the role of the inherited geological structures and the long-term morphoevolution on the coastal slope instability combining detailed geomorphological and structural analyses.

## **Methodology and expected results**

The geomorphological and structural analyses proposed in the present research project will be conducted using both traditional and recently introduced advanced investigation methods. Field surveys will be conducted and, in particular, will be supported by land surface quantitative analyses through the application of geomorphometric techniques starting from high-resolution Lidar-derived DEM in both GIS and MATLAB environments. These methods have been widely demonstrated to be useful for the automatic detection of erosional and depositional landforms due to fluvial, gravity and marine processes. Remote sensing investigation based on radar imagery (for example the ones from Sentinel-1 and CosmoSkyMed Earth observation missions) will be also performed to support the survey and mapping of the gravity-induced instabilities along the coastal area.

The first fundamental expected result is the updating of the existing geomorphological and structural maps available for Marche coastal sectors, which will be the starting point for the further analyses of this project and that can be also fundamental for further studies along the Marche coasts for different scientific and technical scopes.

Other expected results are:

- A detailed mapping of the geomorphic markers such as fluvial and marine terraces, and alluvial/coastal fans and their geo-chronological collocation;
- A detailed geo-mechanical characterization of the outcropping rock masses;
- A detailed mapping of coastal landslides of different typology and state of activity;
- A well constrained estimate of the style and rates of the long-term morphoevolution;

## **Bibliography (essential)**

Miccadei, E.; Mascioli, F.; Ricci, F.; Piacentini, T. Geomorphology of soft clastic rock coasts in the mid-western Adriatic Sea (Abruzzo, Italy). *Geomorphology* 2019, 324, 72–94.

Bigi S., Cantalamessa G., Centamore E., Didaskalou P., Dramis F., Farabollini P., Gentili B., Invernizzi C., Micarelli A., Nisio S., Pambianchi G. e Potetti M. (1995) – La fascia periadriatica marchigiana – abruzzese dal Pliocene medio ai tempi attuali: evoluzione tettonico – sedimentaria e geomorfologica. *Studi Geologici Camerti, Volume Speciale 1: 37-49.*

Savelli D., Troiani F., Capitolo P. & Nesci O. (2017) – Rocky cliffs joining velvet beaches: the northern Marche coast. *Landscapes and Landforms of Italy, World Geomorphological Landscapes.*

Troiani F., Martino S., Marmoni G.M., Menichetti M., Torre D., Iacobucci G. & Piacentini D. (2020) – Integrated field surveying and land surface quantitative analysis to assess landslide proneness in the Conero promontory rocky coasts (Italy). *Applied Sciences*, 10, 4793.

## **Description of the research in the three-year period (feasibility)**

First year:

- Definition of the study areas (Area1: San Bartolo, Area 2: Ardizio and Area 3: Porto San Giorgio-San Benedetto del Tronto coastal reach);
- Bibliographic study;
- Preparation of the satellite imagery, Lidar-DEM and GIS-projects;
- Planning of the field activities through remote sensing surveys and preliminary fieldworks along the three study areas.
- Formative activities: participation to seminars and schools for improving the knowledge on geomorphometric techniques.

Second year:

- Detailed structural and geomorphological field surveys;

- Land surface quantitative analyses;
- Remote sensing investigation to support fieldworks.
- Divulcation activities: participation to national and international congresses and meetings and writing of scientific papers (at least one) on peer-review journals.

Third year:

- Application of UAV/SfM to obtain detailed DSM in specific zones;
- Interpretation of the results;
- Writing of the PhD Thesis.
- Divulcation activities: participation to national and international congresses and meetings and writing of scientific papers (at least one) on peer-review journals.