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Wednesday December 16, 2020

Hellenic Committee for Geomorphology and Environment of the Geological Society of Greece

Under the auspices of the International Association of Geomorphologists

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Submarine Geomorphology of the Eastern Continental Platform of the Maltese Archipelago

S. Rossi [1], *C. Parenti* [1], *M. Prampolini* [2], *P. Coratza* [1], *M. Soldati* [1]

(1) Department of Chemical and Geological Sciences, University of Modena and Reggio Emilia, Via Campi 103, 41125 Modena, Italy, sofiarossi978@gmail.com (S.R.) carlotta.parenti@unimore.it(C.P.) paola.coratza@unimore.it (P.C.), mauro.soldati@unimore.it (M.S.)

(2) Natural Research Council, Institute of Marine Sciences (CNR-ISMAR), Via Gobetti 111, 40129 Bologna, Italy, mariacristina.prampolini@bo.ismar.cnr.it

Introduction

The goal of this study was to reconstruct the geomorphological evolution of the eastern continental shelf of the Maltese archipelago through the analysis of the main submarine landforms and the production of a synoptic geomorphological map of the area at a 1:50,000 scale.

The study area (Figure 1) is the continental shelf located NE of the Maltese archipelago (central Mediterranean Sea). It was entirely emerged during the Last Glacial Maximum (LGM) and successively submerged during the post-glacial sea-level rise (Figure 2) (Lambeck *et al.,* 2011). During the last glacial cycle, the sea-level reached its minimum, being approximately 130 m lower than today.

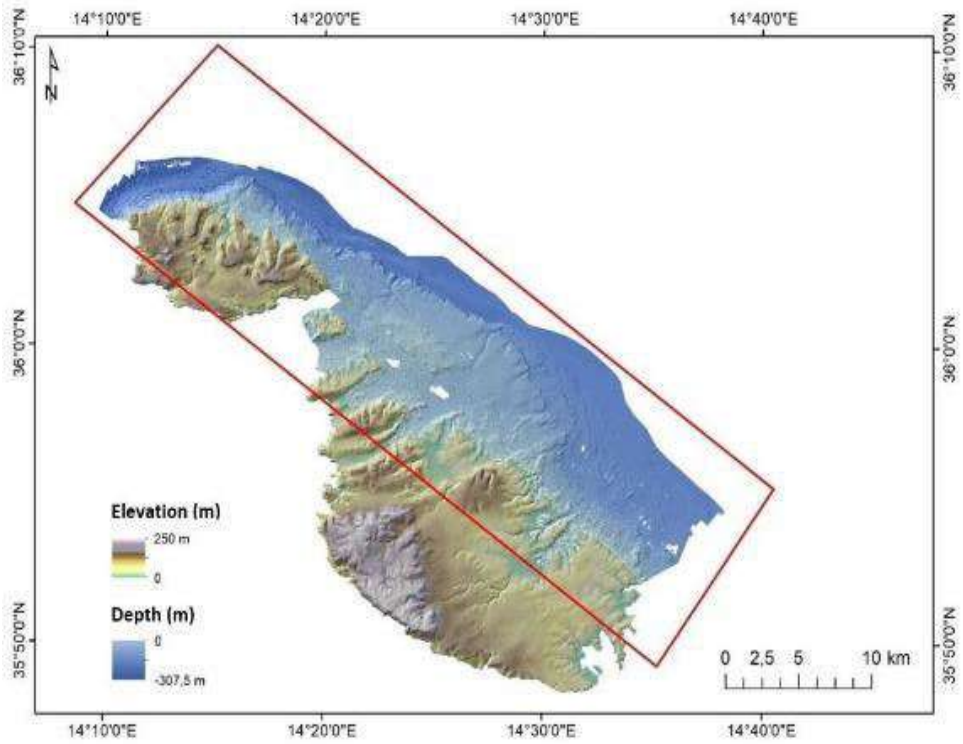

Figure 1. Location of the Maltese archipelago and its continental shelf.

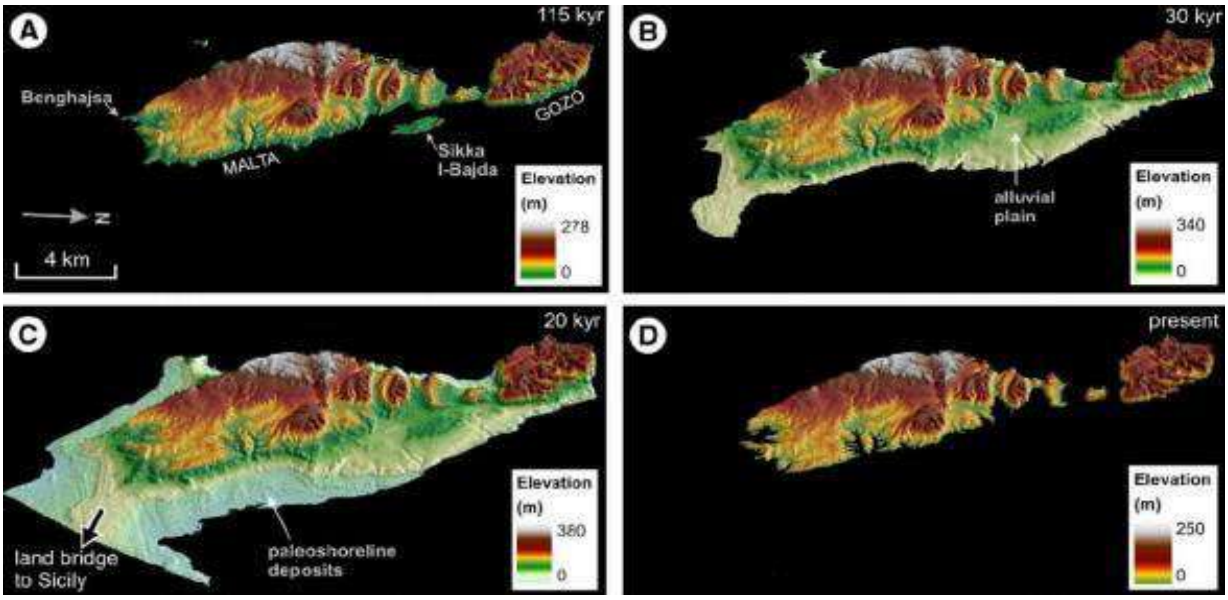

Figure 2. Maltese paleo-geography (115 kyr, 30 kyr, 20 kyr, present) (modified after Foglini et al., 2016).

Marine transgression has not significantly modified the currently submerged landforms, which are still easily recognizable.

The research was carried out as part of the European Marine Observation and Data Network (EMODnet), which aims to share information on the geology of the seabed of Europe. In particular, the data used for geomorphological mapping were elaborated to contribute to the EMODnet Geology portal, as part of Work Package 4 "Seafloor geology/geomorphology" and Work Package 8 "Submerged Landscapes".

Methods

The spatial and chronological data regarding investigated area were organized in a GIS environment; the map was produced by means of ESRI Arcgis 10.1 software, and the legend was based on landform genesis.

Results

The Maltese submerged landscape shows structural, marine and coastal, fluvial, karst, gravity-induced and man-made landforms.

The NE area of the Maltese archipelago includes a sub-planar continental shelf bounded by a continental slope whose base is about -130 m deep. This escarpment is NW-SE oriented, parallel to one of the fault systems characterizing the Maltese area and by which it seems to be controlled (Micallef *et al.,* 2013; 2019).

Other structural escarpments occur on the continental shelf and border the marine terraces; they are mainly oriented NW-SE or ENE-WSW and, being parallel to the fault systems of the Maltese islands, are interpreted as submarine evidence of these faults (Micallef *et al.,* 2013; 2019). Some

of them are in correspondence of ancient coastline deposits related to the sea-level oscillations. Other structural landforms include outcrops of limestone plateaus, similar to those occurring on land, that are bordered by structural scarps. A remarkable example is given by the Sikkail-Bajda plateau, which is characterized by the superimposition of Upper Coralline Limestone Formation on the Blue Clay Formation. Furthermore, this submerged plateau appears to have been affected by karst processes that have formed a karst pavement on its surface and favored the development of bedrock-collapse sinkholes (up to 250 m of diameter) and solution sinkholes.

The continental slope is characterized by different levels of marine terraces (Figure 3A), with NW-SE orientation, which are interpreted as coastal paleo-platforms formed during the lowstand phases of the sea-level (Micallef *et al.,* 2013; Prampolini *et al.,* 2017). Marine landforms include a contourite deposit of fine elongated sediments SE-NW-oriented, located at a depth greater than -130 m and modelled by bottom currents (Béranger *et al.,* 2004). On the continental shelf, ripple marks modelled by SE-NW oriented background currents occur offshore Mellieha and St. Paul's Bay.

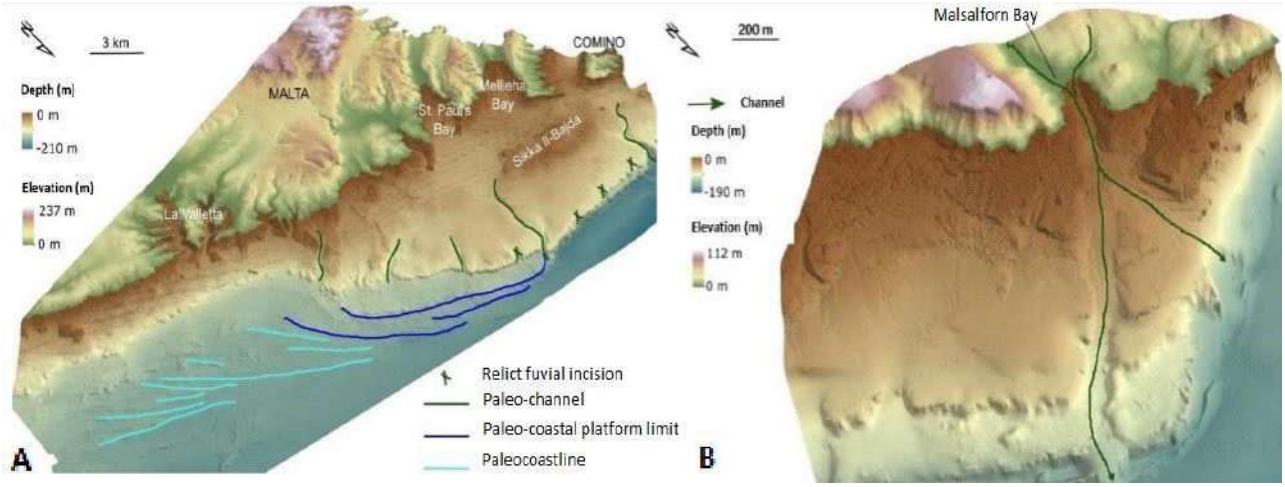

Figure 3. A) Marine terraces interpreted as coastal paleo-platforms; B) Channels of fluvial origin located at Marsalforn Bay (Gozo).

Near shore and below the main escarpment, there are isolated gravity-induced block deposits that can be referred to various types of landslides (lateral spread, block slide, rock fall). The Sikkail-Bajda plateau is surrounded by blocks of large dimensions, which are interpreted as evidence of lateral spreading. Other blocks located at the base of the continental slope have been interpreted as the result of collapses and rock falls associated with coastal erosion. Different types of gravity-induced landforms largely characterize the northeastern coast of Gozo, where limestones overlap clayey terrains favoring the development of lateral spreading, which tend to evolve into block slide that often continue below sea-level (Prampolini *et al.,* 2018). Landslides are mainly controlled by the presence of tectonic discontinuities and lithological structures and likely developed in a subaerial environment, and then submerged during the post-glacial sea-level rise (Soldati *et al.,* 2018).

Other relevant landforms are the ENE-WSW oriented channels, which affect the shelf and indent the continental escarpment. They are located in front of Marsalforn Bay (Gozo) (Figure 3B), facing

the island of Comino and in the area between St. Paul's Bay and St. Julian's Bay (Malta). Upstream of these channels, interpreted as paleo-riverbeds, there are flat areas interpreted as alluvial plains. There are also numerous gullies, channels engraved in clayey slopes and developed in climatic conditions wetter than the current ones.

Man-made landforms are concentrated offshore the capital Valletta. Near the port, dredging, anchoring and material unloading activities have created curvilinear streaks that cross the seabed, which is also characterized by the presence of wrecks sunk during the Second World War and now used as scuba diving sites. On the seabed of Ramla Bay there are remains of historic defense walls, built to protect the bay from possible enemy attacks from the sea.

Conclusions

The eastern Maltese continental shelf is characterized by landforms and deposits typically due to subaerial processes, such as fluvial, coastal, karst and gravitational processes. The landforms deriving from subaerial modeling are still easily recognizable thanks to the carbonate lithology that characterizes the Maltese archipelago and the scarce contribution of terrigenous sediments due to the semi-arid climate of the area. Thus, once submerged, the landscape was only partially modified by erosion and sedimentation processes. The processes that shaped the landscape during the lowstand phases of the sea-level are not currently active and the platform thus hosts predominantly relict landforms.

The marine processes currently taking place on the NE continental shelf of the Maltese islands are mainly attributable to SE-NW oriented bottom currents (Béranger *et al.,* 2004), which led to the formation of ripples and a drift current deposits.

The study made it possible to deepen the knowledge about the landforms of the Maltese submarine landscape from the Last Glacial Maximum until today and to outline its geomorphological evolution. This work also allowed representing data that previously had not been summarized in a synoptic geomorphological map.

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