Journal of Maps

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/tjom20

Geohazard features of the Gulf of Taranto

Silvia Ceramicola, Maria Rosaria Senatore, Andrea Cova, Agostino Meo, Edy Forlin, Salvatore Critelli, Nora Markezic, Massimo Zecchin, Dario Civile, Alessandro Bosman, Oliviero Candoni, Daniele Casalbore, Marianne Coste, Diego Cotterle, Michele Deponte, Rocco Dominici, Lorenzo Facchin, Emiliano Gordini, Eleonora Morelli, Francesco Muto, Daniel Praeg, Roberto Romeo & Francesco Latino Chiocci

To cite this article: Silvia Ceramicola, Maria Rosaria Senatore, Andrea Cova, Agostino Meo, Edy Forlin, Salvatore Critelli, Nora Markezic, Massimo Zecchin, Dario Civile, Alessandro Bosman, Oliviero Candoni, Daniele Casalbore, Marianne Coste, Diego Cotterle, Michele Deponte, Rocco Dominici, Lorenzo Facchin, Emiliano Gordini, Eleonora Morelli, Francesco Muto, Daniel Praeg, Roberto Romeo & Francesco Latino Chiocci (2024) Geohazard features of the Gulf of Taranto, Journal of Maps, 20:1, 2431073, DOI: 10.1080/17445647.2024.2431073

To link to this article: https://doi.org/10.1080/17445647.2024.2431073

JOURNAL OF MAPS
2024, VOL. 20, NO. 1, 2431073
https://doi.org/10.1080/17445647.2024.2431073

SCIENCE

OPEN ACCESS

Geohazard features of the Gulf of Taranto

Silvia Ceramicola[a], Maria Rosaria Senatore[b], Andrea Cova[a], Agostino Meo[b], Edy Forlin[a], Salvatore Critelli[c], Nora Markezic[a–d], Massimo Zecchin[a], Dario Civile[a], Alessandro Bosman[e], Oliviero Candoni[a], Daniele Casalbore[f], Marianne Coste[a–g], Diego Cotterle[a], Michele Deponte[a], Rocco Dominici[h], Lorenzo Facchin[a], Emiliano Gordini[a], Eleonora Morelli[e], Francesco Muto[h], Daniel Praeg[g], Roberto Romeo[a] and Francesco Latino Chiocci[f]

[a]National Institute of Oceanography and Applied Geophysics – OGS, Trieste, Italy; [b]Department of Science and Technology (DST), Università degli Studi del Sannio, Benevento, Italy; [c]Department of Environmental Engineering, Università della Calabria, Arcavacata, Italy; [d]Department of Mathematics, Informatics and Geosciences, Università degli Studi di Trieste, Trieste, Italy; [e]Istituto di Geologia Ambientale e Geoingegneria, Consiglio Nazionale delle Ricerche (IGAG-CNR), Rome, Italy; [f]Dipartimento di Scienze della Terra, Università Sapienza, Rome, Italy; [g]Geoazur Laboratory, French National Centre for Scientific Research, Valbonne, France; [h]Department of Biology, Ecology and Earth Science – (DiBEST), Università della Calabria, Arcavacata, Italy

ABSTRACT
Here, we explore the complex seabed morphologies of the Gulf of Taranto in southern Italy including their connection to the geodynamic evolution of the region that began during the Neogene period when the Adria plate started subducting beneath the retreating Calabrian arc. We compiled the first Maps of the Geohazard Features of the Gulf of Taranto through comprehensive and collaborative high-resolution seabed surveys, integrating regional high-resolution multibeam sonar and sub-bottom profiling. Our findings indicate that the most significant marine geohazards identified are (i) the headwall of the shelf-indenting retrogressive canyon near Cirò Marina, situated close to the harbour, (ii) multiple landslide scarps on the steep slopes of intra-slope basins, along with buried stacked debris flow deposits at their base, indicating repeated mass movements, (iii) large-scale landslide scarps eroding the Apulian slopes (some controlled by faults). We propose that seismicity and tectonic tremor associated with slow slip events, represent potential triggers for geohazards in the Gulf of Taranto. The distinctive physiography of the Gulf creates a natural laboratory for studying and monitoring coastal and marine geohazards. Our study offers a resource for improving the understanding of marine geohazards along the Ionian Calabrian and Apulian margins in the Gulf of Taranto crucial for safeguarding coastal communities and marine infrastructures.

ARTICLE HISTORY
Received 24 March 2024
Accepted 7 November 2024

KEYWORDS
Marine geohazards; seafloor mapping; Gulf of Taranto; Ionian Calabrian and Apulian margins

1. Introduction

The article presents the maps of geohazard features of the Gulf of Taranto, developed as part of the MaGIC Project (MArine Geohazard along the Italian Coasts), a significant coordinated effort involving Italy's entire marine geological research community from 2007 to 2013. These morphological features indicative of geohazards were identified through high-resolution multibeam echosounder surveys and sub-bottom profiling, focusing primarily on the seabed's morphology and shallow subsurface processes and events. The cartographic results are illustrated within a general map of the physiographic domains of the Ionian Sea (1:250,000 scale) and seven maps (1:100,000 scale) subdivided as follows: Cirò Marina (Sheet 40), Corigliano (Sheet 41), Metaponto (Sheet 42), Taranto (Sheet 43), Manduria (Sheet 44), Valle di Taranto (Sheet 45), Gallipoli (Sheet 46) (for location see Figure 1). The maps were produced using the same interpretative and cartographic standards, described by Ridente and Chiocci (this volume). This article describes the main morphological features indicative of geohazards of the Gulf of Taranto, and is subdivided into seven distinct subchapters (4.1- 4.7) addressing each Sheet. The study offers two levels of interpretation: a map of the Physiographic Domain at a 1:250,000 scale, and a more detailed map of the Morphological Units and Morpho-bathymetric Elements (areas and vectors) at a 1:100,000 scale (Chiocci et al. 2021).

2. Study area: the Gulf of Taranto

The seabed morphologies in the Gulf of Taranto were largely shaped by the formation of the Southern

CONTACT Silvia Ceramicola sceramicola@ogs.it National Institute of Oceanography and Applied Geophysics – OGS, Trieste 34010, Italy
Supplemental data for this article can be accessed online at https://doi.org/10.1080/17445647.2024.2431073.

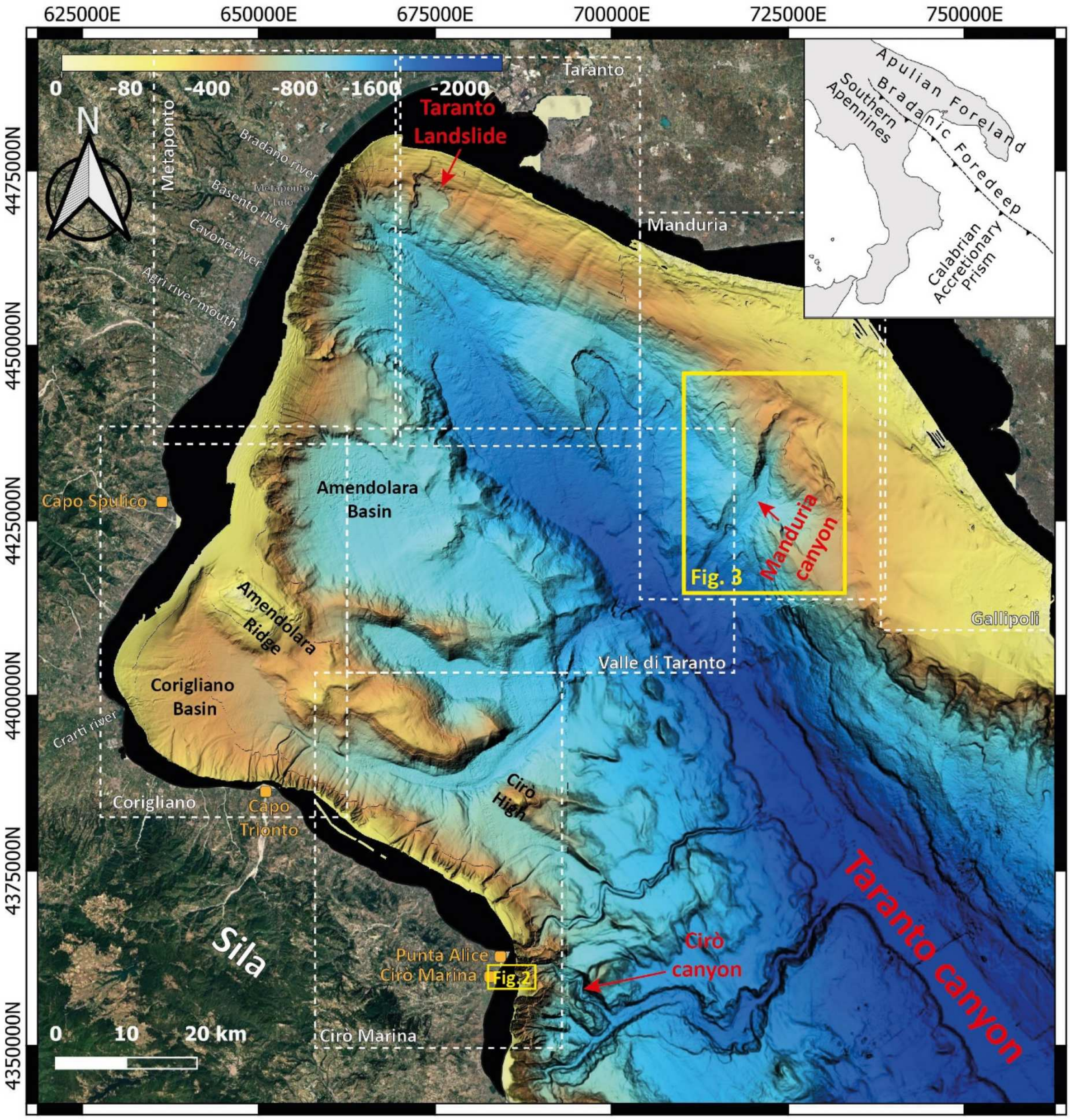

Figure 1. Shaded relief map of the Gulf of Taranto, highlighting the main morpho-structural and sedimentary features characterising the region. Offshore bathymetry is based on DTMs of variable resolution (5–20 m grids) acquired during the MaGIC Project. Dotted box marks Sheets 40–46, while black areas indicate gaps in data caused by limitations in multibeam acquisition from research vessels near the coast. These gaps highlight the need to improve high-resolution seabed coverage in coastal areas which is essential for assessing marine geohazards. Inset shows a schematic geological setting of Southern Italy.

Apennines thrust belt-foredeep-foreland system during the Neogene-Quaternary as the result of the westward subduction of the Apulian lithosphere and the next collisional phase with the Adria continental block. This is part of a broader Mesozoic to Cenozoic tectonic framework in the central Mediterranean driven by the ongoing subduction between the Eurasian and African plates. With the exception of Calabria region, the landscape and seascape of southern Italy is an expression of the three structural domains that form the Southern Apennines system: the NW-SE oriented Southern Apennine chain, the Bradanic foredeep, and the Apulian foreland (e.g. Caputo et al., 2010; Chizzini et al., 2022; Doglioni et al., 1999a, 1999b; Finetti & Morelli, 1972; Merlini et al., 2000; Pescatore & Senatore, 1986; Senatore, 1988; Senatore et al., 1982; Teofilo et al., 2018).

To the South, the morphology of the Calabrian margin is associated with the southeastward migration of the Calabrian accretionary prism resulting from the northwestward subduction of the Ionian oceanic lithosphere. The rollback of the subducting slab drove the subduction process, which in turn facilitated the opening of the Tyrrhenian Sea as a back-arc basin since the mid-Miocene (Malinverno et al., 1986; Van Dijk & Scheepers, 1995; Zecchin et al., 2012, 2020, Mangano et al. 2022).

This complex tectonic setting has contributed to subdividing the Gulf of Taranto into three distinct morpho-structural sectors – Western, Central, and Eastern (Ceramicola et al., 2014, 2021; Senatore, 1987). Each sector reflects the unique geological characteristics and tectonic evolution of the corresponding structural domain, determining the diverse seabed morphologies we observe throughout the Gulf today (see Figure 1).

The Western sector includes the Calabrian margin, characterised by irregular shelves and steep slopes (up to 10°), up to 50 km wide (Figure 1). This area is marked by structural highs associated with Pleistocene transpressive fault zones (Del Ben et al., 2008; Ferranti et al., 2009, 2014; Ori & Friend, 1984; Senatore, 1988) and by intervening intra slope such as the Amendolara and Corigliano basins (Ceramicola et al., 2014, 2021, 2024; Pescatore & Senatore, 1986). South of the Corigliano Basin, the Rossano, Cirò and Crotone basins developed in the forearc sector linked to the southeastward migration of the Calabrian accretionary prism and they are cut by NW-trending strike-slip faults that have controlled their evolution (Civile et al., 2022; Mangano et al., 2023; Muto et al., 2014; Zecchin et al., 2020, Corradino et al., 2023).

The Central sector is characterised by the prominent NW-trending Taranto Canyon, which cuts into the continental shelf, reaching widths of up to 10 km (Figure 1). The main canyon body lies within the depression formed by the submarine extension of the onshore Bradanic Foredeep Basin. It extends over 350 km along the plate boundary to the open sea and reaching to abyssal depths of up to 4000 metres. The canyon's headwall is located approximately 2 km offshore from Metaponto village, on the incised shelf break (30 m b.s.l.), where recurrent gullies and linear incisions shape the steep slopes 10° (Ceramicola et al., 2021; Ceramicola et al., 2012; Meo et al., 2017; Senatore, 1987; Senatore et al., 2011). As the Taranto Canyon advances seaward, several smaller canyons from the Western and Eastern sectors converge with it.

The Eastern sector, corresponding to the foreland Apulian margin, features a continental slope (up to 5°) marking the edge of the Apulian platform (Senatore, 1988; Ceramicola et al., 2012; Ceramicola et al., 2021, Figure 1). This platform consists of a thick Mesozoic-Cenozoic carbonate succession (ca. 6 km) overlying a crystalline basement (Argnani et al., 2001; Channell et al., 1979; Mascle et al., 1984; Ricchetti et al., 1988; Scarascia et al., 1994) and crops out along the coast between Puglia and Basilicata. Offshore, the platform is covered by up to 1 km thick Plio-Pleistocene clastic deposits of the Bradanic foredeep basin (Artoni et al., 2019; Pescatore, 1985; Senatore, 1987). Normal faults, dipping towards both the chain and the foreland, characterise this area, forming small sub-basins in the foreland (Chizzini et al., 2022; Senatore, 1988). The absence of Oligo-Miocene deposits suggests that the Eastern sector of the Gulf was above sea level during that period. The lithosphere began inflecting below the Southern Apennines in the Pliocene, culminating in the Lower Pleistocene with the emplacement of the Metaponto Nappe (Finetti, 2003; Ogniben, 1969; Senatore, 1988).

Sedimentation in this sector of the Gulf is predominantly calcareous-clastic and organogenic on the continental shelf, transitioning to terrigenous along the continental slope (Senatore, 1988).

3. Methods and software

As the maps were produced using the same interpretative and cartographic standards, the procedure is described in detail in Ridente & Chiocci (this volume). The legend of the Physiographic Domain map is present on the map while the legend of the Morphological Units and Morpho-bathymetric Elements map is present as a separate table. The high-resolution multibeam bathymetry data were acquired by the research vessel R/V OGS Explora using echosounders Reson SeaBat 8111 (up to 500 m water-depth) and the Reson SeaBat 7150 (for deep water surveys) in the frame of the MaGIC, and the WGDT (Morphology and Architecture of the western portions of the Gulf of Taranto) projects using PDS2000 software. The data were processed in OGS and at the Department of the Earth Science (Sapienza and Unisannio) using Caris software and a DTM at variable resolution (5-20 m) was generated. The seafloor mapping was carried out using a dedicated version of the Global Mapper® software ('MaGIC Project' release). The sub-bottom profiles were carried out using a Benthos Chirp II hull mounted with 16 transducers. The data were output in XTF format and converted to SEGY format. The interpretation of the geomorphic features was obtained by integrating seabed morphologies with information from subsurface data, specifically the acoustic character of the reflections and their continuity in the subsurface.

4. Maps of morphological units and Morpho-bathymetric elements

4.1. Cirò area (MaGIC sheet 40)

The coastline north of Punta Alice in Calabria has an NW-SE orientation, shaped by the occurrence of the NW-trending Rossano-San Nicola and Pollino shear zones. The latter separates the Calabrian Arc to the south from the submarine extension of the southern Apennines to the north (Figure 1). In this area, where the continental shelf extends up to 8 km, single-headed and blind canyons, some up to 10 km long, develop subparallel to one another and flow into the adjacent Taranto Canyon (Figure 1). The main bodies of these canyons exhibit numerous cyclic step morphologies, indicating that they are actively and repeatedly influenced by high-energy turbidity currents, which shape the seabed through alternating patterns of erosion and deposition. The canyon walls (escarpments) display widespread scarps, suggesting a history of recurrent slope failures. The continental slope is delimited to the east by the Taranto Canyon, which consists of an NW-SE oriented canyon system up to 300-km-long, which separates the Calabrian and Apulian continental margins.

The peculiar geodynamic setting in this region has shaped a distinct morphology of the continental slope featuring large-scale structural highs that bound intra-slope piggy-back basins. These features, such as the Amendolara Ridge and Cirò High, exhibit reliefs exceeding 500 metres and slopes with steepness up to 10°. These structures correspond to fault-bounded features with a predominant NW-SE orientation, representing the offshore extension of the southern Apennine fold-and-thrust belt (Ceramicola et al., 2009, 2014, 2021a, 2024; Del Ben et al., 2008). The slopes of these structural highs are punctuated by widespread multiple mass transport complexes (MTCs) characterised by slide scarps, and scattered blocks measuring a few tens of metres. Stacked unstratified debris flow deposits are observed in sub-bottom data (Ceramicola et al., 2021a, 2014).

South of Punta Alice, the continental margin is characterised by a narrow to absent (0 to 5 km) shelf and a wide (50 km) and highly articulated slope (Ceramicola et al., 2024, 2014, Figure 1). The continental slope is carved by numerous shelf-incising canyon systems and erosive channels that record the long-term transfer of sediments from the coastal areas into the Taranto Canyon. Here, the impressive canyon headwalls almost reaching the coastline are characterised by a dendritic morphology and by generally straight and ‘V’-shaped thalwegs (Figure 2). The headwalls include numerous tributaries, most of which incise the shelf-break and in many reach a few tens of metres away from the coastline. In this context, it is worthy of note the geohazard associated with the retrogressive activity of the headwall of the Cirò Canyon located at a depth of 10 m and reaching Cirò harbour (Figure 2) and to the railway line (Ridente et al., 2017). A retrogressive submarine landslide with an estimated volume of 1×10^6 m^3 was identified in 2005 at the head of the Madonna del Mare Canyon through repeated multibeam surveys by Casalbore et al. (2012), leading to significant damage to a nearby coastal chemical plant. Retrogressive landslides at canyon heads are recognised as one of the most critical marine geohazards along the Calabrian Ionian margin (Ceramicola et al., 2014, 2024), necessitating long-term repeat monitoring, particularly in areas where headwalls are known to be actively eroding and data are lacking (back area in Figure 1).

4.2. Corigliano area (MaGIC sheet 41)

The Calabrian margin of the Gulf of Taranto is characterised by imbricate crustal thrust structures that record compressive deformation during the Pleistocene (Senatore et al., 1988), expressed onshore and offshore as a series of NW-SE oriented thrust fronts. In the Gulf of Taranto, this has resulted in a continental slope of anomalous relief, comprising sub-parallel structural highs bounding intra-slope piggy-back basins. Examples of the latter include the Corigliano and the Amendolara basins, within which sedimentation has taken place contemporaneously with fault movements within the bounding highs (Del Ben et al., 2008).

From a physiographic perspective, the southwestern side of the Gulf of Taranto, spanning from Cape Spulico to Cape Trionto, features a narrow continental shelf, which is up to 5 km wide. This shelf transitions into a broad and gentle continental slope, extending over 50 km with a gradient of only about 2°. This slope is highly articulated and includes two significant perched basins: the Corigliano Basin, which is approximately 20 km wide and reaches 400 m water-deep, and the Amendolara Basin, which is around 30 km wide and reaches 800 m water-depth (Figure 1). The basins are separated by the structural high of the Amendolara Ridge up to 400 m high (Ceramicola et al., 2014). This complex topography reflects the intricate tectonic and sedimentary processes that have shaped this portion of the Gulf of Taranto.

The tectonic, physiographic and climatic configuration of the area leads to the production of a large amount of terrigenous sediment (Rago et al., 2017), which is transported to the Corigliano Basin by the Crati River, the largest watercourse of Calabria. The Crati River has shaped the Sibari plain and supplies a small cuspate delta that is actively prograding (Bellotti et al., 2003, Figure 1). The Crati Delta is notable as one of the first submarine turbidite depositional systems recognised in Italy, identified through studies conducted in the 1980s using high-resolution seismic profiles, side-scan sonar data and sediment cores from the upper part of the delta (Ricci-Lucchi et al., 1984). The delta occupies the Crati Graben, a structure that has been shown through onshore studies to have been tectonically active since the Pliocene and continues to be so in the present day (Monaco & Tortorici, 2000). The coastal plain associated

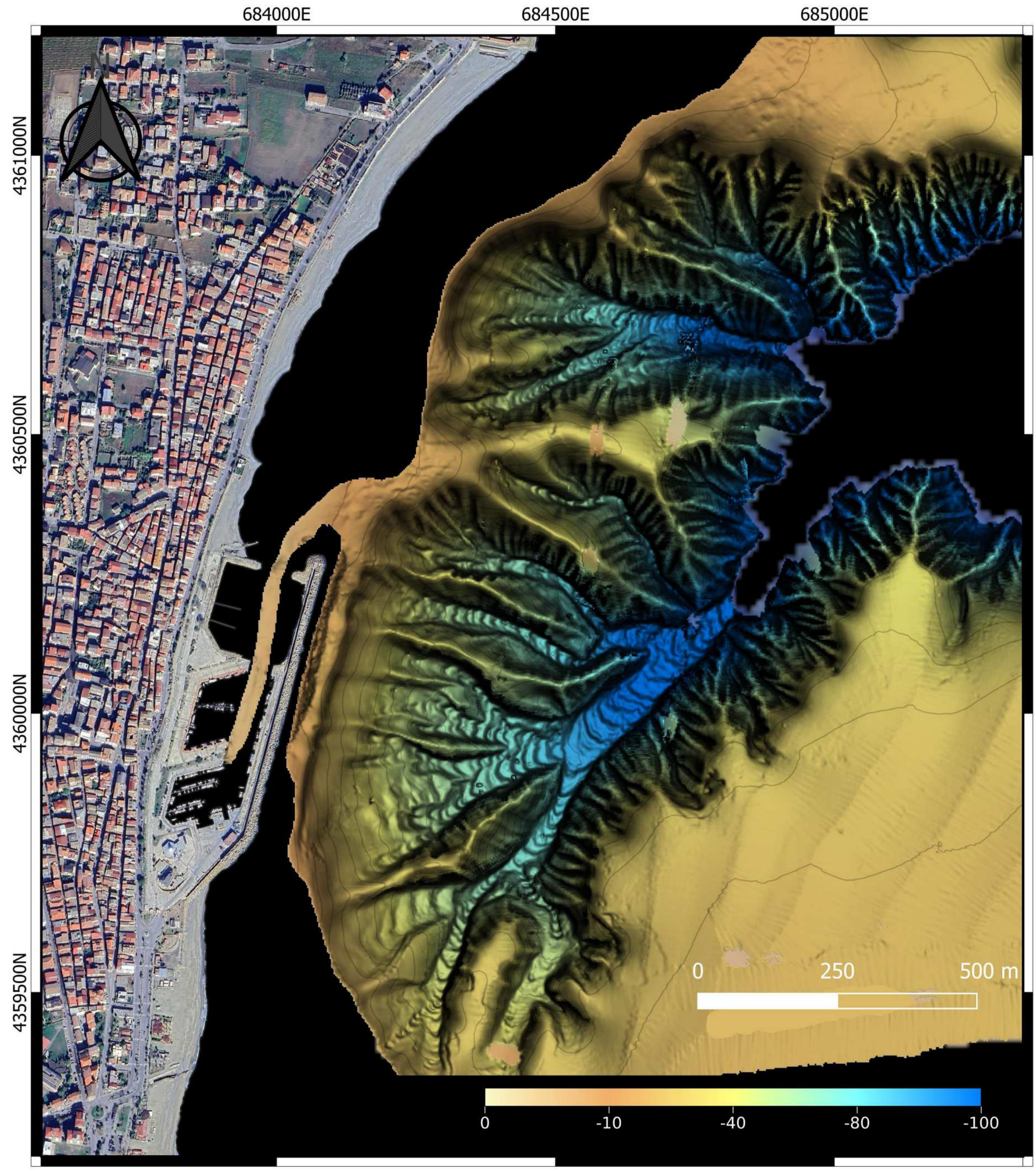

Figure 2. The headwall of the Cirò Marina canyon (1.5 km long and 50 m tall) incises the continental shelf up to a depth of 20 m, undermining the stability of the Cirò Marina harbour quay built in 2001. Storms, amplified by the steep morphologies of the canyon headwalls, are reported to recurrently damage the harbour infrastructure, which frequently requires repairs. To be noted the thalweg of the tributary channels of the Cirò canyon displays arcuate bedform morphologies, typically resulting from the activity of turbidity currents. These currents, which transport sediments downslope, can create distinctive bedforms on the seafloor, indicating cyclic episodes of sediment movement and deposition. The blended shaded relief map shows bathymetric data through a multilayered composition, including a color-coded depth map, multidirectional hill shading, and the application of the MSRM algorithm using the RVT software package (Novak et al., 2023).

with the Crati Graben has recorded significant subsidence throughout the Quaternary period, with rates exceeding 1 mm per year. This ongoing tectonic activity and sediment deposition have played a crucial role in shaping the delta and the surrounding region (Ceramicola et al., 2021b).

The Amendolara Ridge has an irregular slope profile, due to its dissection by NE-trending tectonic features that form a series of smaller morphological highs and lows. The ridge varies in water depth, from only 30 m below sea level in the northwest, to about 350 m below sea level in the southeast (Figure 1). Large portions of the Amendolara ridge were therefore emerged during the Last Glacial Maximum (~ 20.000 ka BP, MIS 2), when the Mediterranean Sea was up to 130 m below its present level (Lambeck & Purcell, 2005). Sub-aerial exposure is recorded by a buried erosional unconformity visible on sub-bottom seismic profiles that can be traced across the ridge and the adjacent continental shelf (Zecchin et al., 2011).

The slopes of the Amendolara Ridge are generally steep, ranging from 6° to 12°, and are widely affected by mass wasting phenomena, particularly on the northeastern flank of the ridge (Ceramicola et al., 2014). Sub-bottom profiles across the base of the slopes reveal that the basin fills are characterised by stratified fine-grained sediments interbedded with unstratified intervals. These unstratified intervals are interpreted as the result of recurrent mass failures originating from the slopes of the Amendolara Ridge (Ceramicola et al., 2014, 2021b; Ercilla et al., 2022). Additionally, sub-bottom profiles across the top of the ridge display highly reflective acoustic facies accompanied by frequent acoustic anomalies in the water column. These anomalies are interpreted as evidence of bioconstructions associated with benthic ecosystems, highlighting the biological activity on and around the ridge (Ceramicola et al., 2014; Coste, 2014; Geronimo et al., 1998).

4.3. Metaponto area (MaGIC sheet 42)

The area covered by Sheet 42 ‘Metaponto’ is characterised by physiographic domains that develop within a complex geological context, situated at the junction between the submerged and subaerial portions of the southern Apennines. This unique location results in a diverse landscape where the geological features of the Apennine chain interact with both marine and terrestrial environments (Finetti, 2003; Pescatore & Senatore, 1986; Senatore et al., 1988).

The Basilicata region is drained by five rivers that run parallel to each other and flow towards the sea: the Bradano, Basento, Cavone, and Agri rivers (Meo et al., 2017; Senatore et al., 2021a). Due to the lack of detailed high-resolution bathymetric data (indicated in black in Figure 1), it is challenging to establish the connection between these rivers and the distinctive morphologies observed offshore. These offshore features include canyons and gullies that erode and incise the outer continental shelf in varying patterns. Understanding the relationship between the rivers and these submarine landforms is crucial to assessing the geohazard risk that these and coastal infrastructures.

Where data are available, it is evident that the continental shelf exhibits a progressive reduction in width (Figure 1). For instance, of the mouth of the Agri River, the shelf is approximately 6 km wide. In contrast, off the coast of Metaponto Lido, the width of the continental shelf ranges between 1.7 and 2.5 km. This variation in shelf width reflects the influence of geological and hydrodynamic processes along the coast (Meo et al., 2017; Senatore et al., 2021a).

Here, the continental slope descends from 30 to 600 m water depth within just 4 km. The upper continental slope reaches an average depth of 450 m and is characterised by two arcuate portions of the margin, each extending about 50 km^2. Together, these features represent the head of the Taranto Canyon, which channels sediment into its main body (Figure 1). The canyon extends for more than 300 km down to the Ionian Sea (Figure 1). These two zones feature distinct sub-heads that exhibit differences in both morphology and sedimentary processes. Within each sub-head, multiple channel systems, known as branches, converge into the major depression represented by the Taranto Canyon. This give rise to two complex drainage basins that are only discreetly hierarchised (Meo et al., 2017). Although the two sub-heads exhibit distinct morphological features and sedimentary processes, the upper slope of the northern sub-head has an average gradient of 4°–5°, which decreases significantly to around 3° towards the base of the slope (Figure 1). At greater depths, from 500 m down to the eastern edge of the map, the Taranto Canyon broadens into a wide depressed area. At the base of the northern sub-head, the canyon is approximately 4 km wide, with slope values around 3°.

Further south, in the sector of the margin located between the mouths of the Agri and Basento river, there is a basin extending laterally up to about 8 kilometres from a depth of 550 m down to the base of the slope. This basin serves as a zone where sediment transported through the southern sub-head is delivered and temporarily deposited. It is connected to the Taranto Canyon, with slopes ranging from approximately 2° to 3° towards the southeast. Additionally, the activity of the southern sub-head of the Taranto Canyon has led to widespread slope instability. Recently, a large Mass Transport Deposit Complex (MTDC) has been identified in this area, reflecting significant sedimentary and geomorphological dynamics (Artoni et al., 2019). From a sedimentary perspective, the Taranto Canyon functions as both an accumulation and transit area for sediments originating from the continent. Recent sedimentation within the canyon is characterised by sandy-silty deposits intercalated with pelitic (clay-rich) deposits. This combination reflects a dynamic environment where coarse and fine sediments are deposited in alternating layers, influenced by various sedimentary processes and transport mechanisms (Pescatore, 1985; Senatore, 1987).

4.4. Taranto area (MaGIC sheet 43)

The Sheet 43 ‘Taranto’ covers the marine area between Taranto and Torre Zozzoli, located at the northeastern tip of the Gulf of Taranto. The substrate in this region is primarily composed of Mesozoic limestone which is extensively exposed on land. This limestone is overlain by Pliocene and Pleistocene deposits, with thicknesses that can locally reach approximately 500 metres in structurally lowered zones (Lieta 1 Well, AGIP, 1977).

The structural style in this area is characterised by tilted blocks separated by normal faults, which were active during the Pliocene and Pleistocene epochs. These faults predominantly dip towards the foreland (Belfiore et al., 1981; Pescatore & Senatore, 1986; Rossi et al., 1983; Senatore, 1987; Senatore et al., 1988; Tramutoli et al., 1984). The resulting morphology features a slope with a large-scale undulated surface, reflecting variations in sediment thickness resting on the downthrown blocks. The faults in this region generally follow a NW-SE trend and dip towards the Apennine chain. This orientation and dip reflect the tectonic forces that have shaped the area, contributing to the formation of the undulated surface and influencing the sedimentary and structural characteristics observed in the marine and adjacent land areas. In this area, slope instability, which was previously highlighted by Senatore et al. (1982), is widely distributed across the continental slope.

Among these slope instability phenomena, the Taranto Landslide is of particular interest as it represents the largest landslide in the entire northern Ionian Sea (Meo et al., 2018; Meo & Senatore, 2023; Senatore et al., 2021b; Senatore et al., 2022). Its scale and impact make it a significant feature in understanding regional geohazards and sedimentary dynamics. The Taranto Landslide, located approximately 11.7 km from the shoreline, exhibits a very complex morphology. It is situated at the edge of the shelf and extends down to the base of the slope, marking the eastern edge of the Taranto Canyon. The upper part of the landslide begins around 200 m water depth, forming an arch shape approximately 1 km wide. At 400 m water depth (3.5 km from the head scarp), the landslide's width expands to 2.3 km. At greater depths, a 6-km-long morphological step with a NW-SE trend and an average slope of 8° is observed. At its base, the landslide is 7 km wide, with a low gradient and a smooth surface extending for about 2.5 km, reaching a depth of 570 m and covering an area of about 13 km^2. Beyond this, the landslide narrows to 3 km and features a highly irregular surface with a hummocky morphology due to the presence of large collapsed blocks. These blocks, embedded in the sliding deposits, are found between 575 and 700 m depth and can reach heights of up to 35 m above the surrounding seabed. This portion of the landslide covers approximately 6 km^2 with a slope of about 3°. The landslide terminates at the base of the slope at about 1000 m water depth, where its toe is eroded by currents flowing through the Taranto Canyon. The volume of the landslide was estimated to be about 0.3 km^3 (Meo & Senatore, 2023). Comparing the volume of moved sediment with the volume currently within the landslide body suggests that strong and active currents were present in the canyon both in the past and present.

Morphometric parameters and empirical relations (Alberico et al., 2018; Watts et al., 2003) were used to estimate the tsunamigenic potential of the Taranto Landslide (Meo et al., 2018). The calculated values indicate a potential wave height of about 2.9 m, highlighting the significant impact the landslide could have had on generating tsunamis (Senatore et al., 2022).

4.5. Manduria area (MaGIC sheet 44)

The Manduria Sheet encompasses the outer portion of the Apulian continental shelf, which extends above the – 100 m contour. Below this depth, the continental slope widens up to 36 km and descends to depths of 1500 m. The margin in this area exhibits a similar organisation to that observed in Sheet 43, where a large-scale undulated sediment unit rests on downthrown carbonate blocks. Morphologically, the seafloor of the shelf located at water depths above 100 m features a step-like pattern. The shelf is characterised by an outcropping carbonate platform succession, with certain areas suggesting the presence of biogenic build-ups. These build-ups are inferred from 'deaf' echo-facies, which are comparable to those of the coral reefs identified south of S. Maria di Leuca (Savini & Corselli, 2010; Taviani et al., 2005). This indicates that the area may contain similar coral structures, contributing to its unique geological and ecological characteristics.

Below the shelf, the Apulia slope has gentle gradients of 0.6° in its upper part (100 - 400 m), steepens to 3.6° in the mid-slope (400-1000 m) with concave-downward longitudinal profiles, and reduces to 1.3-1.6° in the lower slope (1000-1500 m) with a concave-upward profile. Between 100 and 400 m water depths, the slope displays a wavy morphology oriented diagonally to the contours; sub-bottom profiles reveal sediments comprising continuous reflectors sub-parallel to the seabed that do not follow the underlying topography (Figure 1). These observations are consistent with sediment drifts deposited under the influence of bottom currents (Pepe et al., 2018). While this part of the slope contains no features indicative of mass failure, the steeper part of the slope (400 -1000 m water depth) has a very different character; it contains numerous arcuate escarpments corresponding to submarine landslide scars, both single and composite.

Comparable morphologies typical of mass failure are also observed downslope in the deeper slope sector, although lower gradients and a concave-upward slope profile suggest a transition to net deposition as a consequence of failure of the slope above (D'Acremont et al., 2022).

Further downslope, mass failure has contributed to create a long arcuate failure scarp (approximately 20 km long and 150 m high) that runs almost parallel to the eastern edge of the Taranto Canyon (Figure 1). This part of the Apulian slope is also incised by a distinctive morphology referred to as the Manduria Canyon (Ceramicola et al., 2014, 2021c), an elongate depression 20 km long, up to 1650 m wide that extends across water depths of 300–1800 m (Figures 1 and 3). The canyon is headless and lies more than 26 km from the coast, with no connection on land to the river network. This suggests that the canyon formed through retrogressive failure, as indicated by its increasing relief at greater depths and a step-wise axial profile featuring knickpoints (Figure 3). The Manduria canyon is partially controlled by underlying faults that offset the carbonate substrate of the Apulia Ridge (Figure 3), as revealed by sub-bottom and Videpi seismic data (Ceramicola et al., 2014, 2021c). Sediments evacuated from the Manduria Canyon over time are assumed to have been redistributed via the Taranto Canyon into the Ionian abyssal plain.

4.6. Valle di Taranto area (MaGIC sheet 45)

Sheet 45 'Valle di Taranto' encompasses portions of the three distinct physiographic domains that reflect the area's complex geological context, shaped by the Adriatic-Ionian subduction: (i) the Apulia margin to the east, (ii) the Taranto Canyon, and (iii) the Ionian Calabrian margin. The most prominent feature in this sheet is the main body of the Taranto Canyon.

The Taranto Canyon is one of the most peculiar systems of the Ionian area. It incises the Taranto Canyon which is the offshore continuation of the Bradanic trough, a Pliocene NW-trending depression that constitutes the current foredeep of the Southern Apennine chain (Senatore, 1987; Senatore, 1988). The canyon is set on the deepest part of this depression and is characterised by a straight headwall about 30 km long, composed of a series of coastal gullies that develop parallel to each other and are in turn organised in second-order heads in a linear shape ' (see Sheet 42). The main branch develops for more than 300 km along the entire subduction front, separating the Apulian side, to the East, from the Calabrian one, to the West (see Sheet 42 in this volume). The Taranto Canyon is active and it is inferred to accommodate a great deal of the mass wasting deposits that are generated along the Apulian continental slope. These deposits are carried down in the deep Ionian basin at water depth that exceeds 3000 m.

Along the Calabrian margin of Sheet 45, the canyon margin is up to 400-m high with steep slopes of 9° to the NW and up to 14° to the SE. Along the Apulia margin, the canyon flank is lower (tens of metres) and has gentler slopes (3°-4°). The canyon axis has an undulating relief and dips from 0.8° at 1400 m depth to 0.4° at 1900 m depth. East of the Taranto Canyon, the Apulia margin forms the foreland of the Calabrian subduction zone (Senatore, 1988; Senatore et al., 1988). The Apulia foreland is underlain by the Apulia Ridge unit (Argnani et al., 2001), which consists mainly of Mesozoic and Cenozoic carbonate deposits up to 6000 m thick, lying on a crystalline basement (Channell et al., 1979; Mascle et al., 1984; Ricchetti et al., 1988; Scarascia et al., 1994).

Sedimentation along the margin is mainly calcareous and biogenic on the shelf, and siliciclastic on the slope. The distal part of the Apulia margin in Sheet 45 has relatively low-gradient slopes (2°–2.5°) but is characterised by numerous seabed scarps corresponding to single and composite landslide scars, recording intense mass wasting activity.

At the foot of the slope, sedimentary bodies up to 15 km long are interpreted as intra-channel deposits. These formations result from the interaction of sediment flows within the canyon with landslides from the canyon walls, which occur due to the unbuttressing of the canyon walls (Ceramicola et al., 2021d).

4.7. Gallipoli area (MaGIC sheet 46)

The Sheet 46 'Gallipoli' is characterised by a narrow continental shelf, about 3 km wide and less than 100 m deep, alongside a broader and gentle continental slope that extends to a depth of 500 m within approximately 20 km (Figure 1).

The continental shelf lies above a break-in slope at −100 m and is characterised by a thin sedimentary cover punctuated by an outcropping carbonate platform and biogenic constructions. Several scattered bedrock outcrops are indicated by characteristically 'deaf' seabed echo-facies on sub-bottom profiles. 'Jagged' morphologies observed in this area are similar to associations of Posidonia and coral reefs, which are identified in the southern sector offshore S. Maria di Leuca and interpreted as 'coralligenous' (Savini & Corselli, 2010; Taviani et al., 2005).

The gently dipping continental slope shows a longitudinal profile that is rather flat in the proximal part (slope angle: 0.2°) and rounded (concave downwards) in the distal part (slope angle: 0.7°). The upper slope between the shelf break and the −120 m contour contains a series of mounds and depressions from which no samples are available. Based on morpho-bathymetry and echo-facies mapping, these structures are interpreted as bioconstructions, Posidonia meadows, pockmarks, and other depressions of uncertain origin. The slope between −120 m and −500 m depth is characterised by wavy morphologies that appear to be the result of interaction of sediment

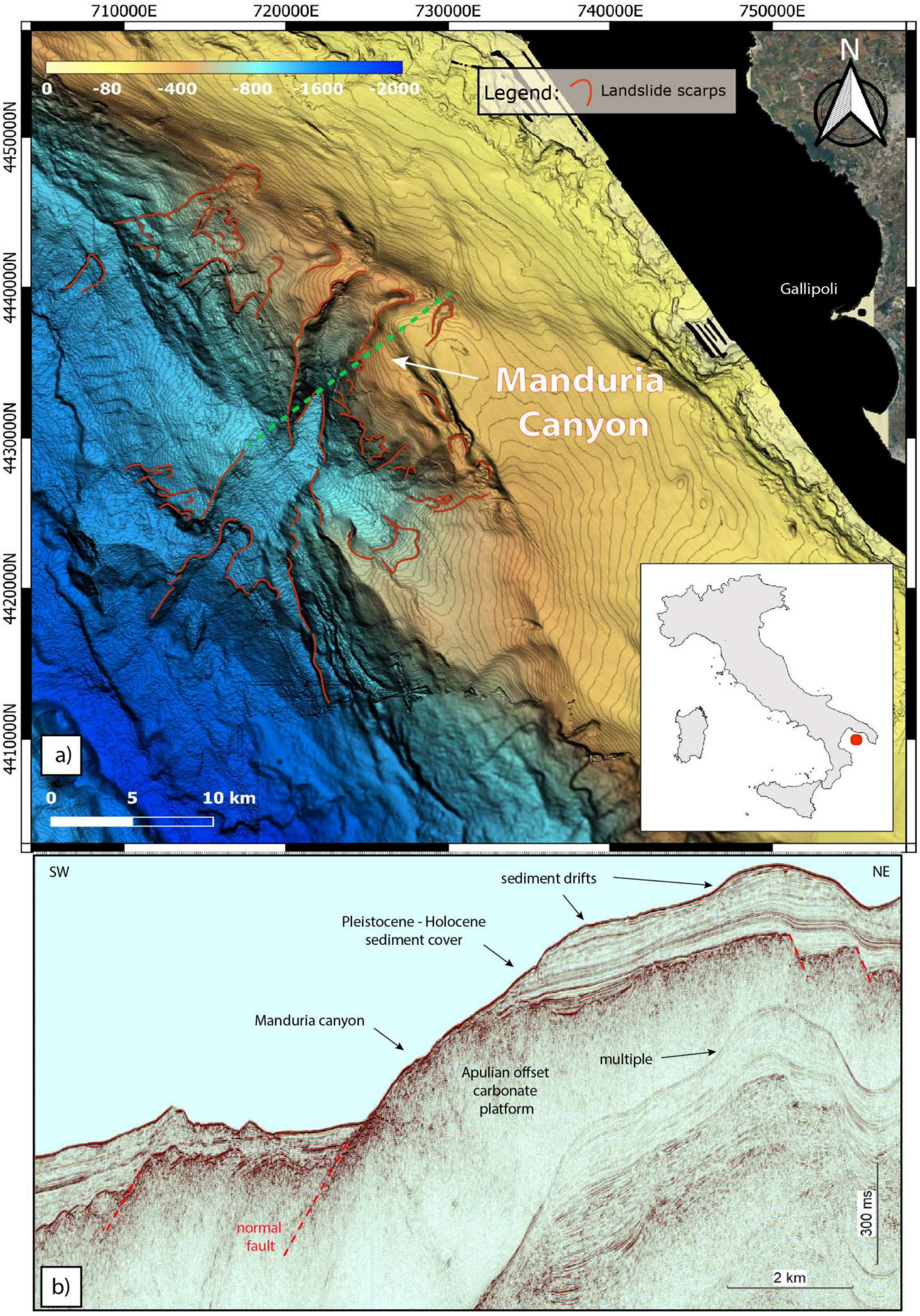

Figure 3. a) Shaded relief showing the Apulian margin incised by a distinctive morphology referred to as the Manduria canyon, an elongate depression 20 km long, up to 1650 m wide that extends across water depths of 300 -1800 m. The feature is located over 26 km from the coast, lacks a connection to the river network and exhibits a distinct retrogressive character, indicating it was formed by multiple successive failures The green line indicate the location of the 2D seismic profile shown in b). b) 2D seismic reflection profile along a SW-NE transect across the Manduria Canyon, showing the offset Apulian carbonate platform overlain by a 200 ms thick Pleistocene-Holocene sediment cover. Sigmoid-shaped deposits in near-bottom sediments on the upper slope indicate the activity of bottom currents. (Processing of seismic profile by Giuseppe Brancatelli).

transport by bottom currents and the blocky structure typical of the carbonate substrate of this area. Some features referred to as ‘depressions of uncertain origin’ appear to lie adjacent to tectonic lineaments that disrupt the carbonatic substrate of the Apulia Ridge. Morphological elements indicating instability (e.g. failure scars, blocks, deposits) have been observed and mapped near the shelf break in the central part of the Sheet such as the Gallipoli slide (Ceramicola et al., 2021e).

5. Conclusions

The Gulf of Taranto encloses a portion of the continental margin that includes over 200 km of coastline from Punta Alice (Calabria region) to Santa Maria di Leuca (Puglia region). The complex seabed morphology reflects the ongoing geodynamic setting characterised by the subduction of the Adria plate under the retreating Calabrian Arc. In detail, the result is a rather unusual geomorphic arrangement characterised by two adjacent continental margins separated by the deep front of the subduction occupied by the Taranto Canyon and the eponymous canyon, the longest of all the Mediterranean basins (350 km long and 50 km wide). West of the Taranto Canyon the Calabrian margin develops with narrow continental shelves and irregular continental slopes characterised by elongated morphological highs and intervening piggy-back basins. The steep slopes of the morphological highs host multiple landslide scars, and the adjacent basins are filled with repeated stacked debris flows indicating recurrent mass movements. The Calabrian shelves and slopes feature dramatic gullies and canyons, some exhibiting sharp retrogressive characteristics that extend to the coastline, posing significant hazards to vital infrastructures such as harbours and railways. A notable example is the 600 m long Cirò harbour, built on the retrogressive headwall of the Cirò Canyon, which has been identified as the most critical hazard along the Calabrian margin and necessitates regular monitoring by local authorities. East of the Taranto Canyon, the Apulian margin has broader continental shelves that are largely free from major hazards. However, the adjacent slopes are dissected over a stretch of more than 150 km by extensive stacked failure episodes, which impact the entire slope. Due to its unique nature and physiography, the Gulf of Taranto serves as a natural laboratory for studying a wide range of marine geohazards, particularly submarine landslides and their potential for generating tsunamis. Seismicity and tectonic tremor associated with slow slip events, represent significant potential triggers for geohazards along the Ionian Calabrian and Apulian margins in the Gulf of Taranto. Our regional case studies provide a reference for future detailed follow-up geohazard studies and monitoring. A long-term monitoring programme with repeat surveys would help tackle tsunamigenic hazards posed by landslides, which represent a significant hazard to coastal areas and offshore infrastructures in the Gulf of Taranto.

Acknowledgements

The research was carried out in the framework of the MaGIC Project, funded by the Italian Civil Protection Department; we thank the Captains, the Officers, crews, engineers and technicians of R/V Explora (OGS), R/V Urania and Maria Grazia (CNR), R/V Universitatis and Minerva Uno (Conisma) for their assistance during geophysical acquisitions. We would like to thank Riccardo Ramella for funding the shipping time of R/V Explora. The seismic profile shown in Figure 3b was processed by our colleague Giuseppe Brancatelli, to whom we extend our sincere gratitude. The authors would like to thank Francesco Falese for the great cartographic effort, the reviewers Nicola Scarselli and Michael Marani for having acted as reviewers and Francesca Budillon and Tommaso Piacentini for the valuable editorial support. The authors thank the IHS Markit® of S&P Global which provides the educational licence of the Kingdom^{TM} software for seismic interpretation. Part of this study was carried out within the RETURN Extended Partnership and received funding from the European Union Next-GenerationEU (National Recovery and Resilience Plan – NRRP, Mission 4, Component 2, Investment 1.3 – D.D. 1243 2/8/2022, PE0000005).

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

The authors agree to make data and materials supporting the results and/or analyses presented in this paper available upon reasonable requests.

References

AGIP. (1977). *Temperature sotterranee. Inventario dei dati raccolti dall'AGIP durante la ricerca e la produzione di idrocarburi in Italia*. AGIP. 1390pp.

Alberico, I., Budillon, F., Casalbore, D., Di Fiore, V., & Iavarone, R. (2018). A critical review of potential tsunamigenic source as first step towards the tsunami hazard assessment for the Napoli Gulf (southern Italy) highly populated area. *Natural Hazards*, *92*(1), 43–76. https://doi.org/10.1007s11069-018-3191-5

Argnani, A., Frugoni, F., Cosi, R., Ligi, M., & Favali, P. (2001). Tectonics and seismicity of the Apulian Ridge south of Salento peninsula Southern Italy. *Annals of Geophysics*, *44*(3), 527–540. https://doi.org/10.4401/ag-3573

Artoni, A., Polonia, A., Carlini, M., Torelli, L., Mussoni, P., & Gasperini, L. (2019). Mass transport deposits and geohazard assessment in the Bradano Foredeep (Southern Apennines, Ionian Sea). *Marine Geology*, *407*, 275–298. https://doi.org/10.1016/j.margeo.2018.11.008

Belfiore, A., Bonaduce, G., Garavelli, G., Mascellaro, P., Masoli, M., Mirabile, L., Moncharmont, M., Moretti, M., Nuovo, G., Pennetta, M., Pescatore, T., Placella, B., Pugliese, N., Russo, B., Senatore, M. R., Sgarrella, F., Sansone, E., Spezie, G., Thorez, J., … Vultaggio, M. (1981). La sedimentazione recente del golfo di taranto (Alto Ionio, Italia). *Ann. Ist. Univ. Navale, Napoli*, *49-50*(3), 1–196.

Bellotti, P., Caputo, C., Davoli, L. A., Evangelista, S., & Pugliese, F. (2003). Sedimentological and morphological evolution of the Crati River delta (Calabria, Italy). *Geografia Fisica e Dinamica Quaternaria*, *6*(6), 25–32.

Caputo, R., Bianca, M., & D'Onofrio, R. (2010). The Ionian marine terraces of southern Italy: Insights for the quaternary geodynamic evolution of the area. *Tectonics*, *29* (4), 12. https://doi.org/10.1029/2009TC002625

Casalbore, D., Bosman, A., & Chiocci, F. L. (2012). Study of recent small-scale landslides in geologically active marine areas through repeated multibeam surveys: Examples from the southern Italy. In *Submarine mass movements and their consequences. Advances in natural and technological hazards research* (vol. 31). Dordrecht: Springer. https://doi.org/10.1007/978-94-007-2162-3_51

Ceramicola, S., Civile, D., Caburlotto, A., Cova, A., Cotterle, D., Diviacco, P., Caffau, M., Pareg, D., Accettella, D., Colizza, E., & Critelli, S. (2009). Features of mass wasting along the submarine scope of the Ionian Calabrian margin. *Rendiconti Online della Società Geologica Italiana*, *7*(7), 87–89.

Ceramicola, S., Cova, A., Critelli, S., Forlin, E., Praeg, D., Zecchin, M., Caburlotto, A., Candoni, O., Civile, D., Coste, M., Cotterle, D., Deponte, M., Dominici, R., Gordini, E., Muto, F., Ramella, R., et al. (2021a). Foglio 40 cirò. In F. L. Chiocci (Ed.), *Atlante dei lineamenti di pericolosità geologica dei mari italiani Risultati del progetto MaGIC* (pp. 198–201). CNR edizioni.

Ceramicola, S., Cova, A., Critelli, S., Forlin, E., Praeg, D., Zecchin, M., Caburlotto, A., Candoni, O., Civile, D., Coste, M., Cotterle, D., Dominici, R., Facchin, L., Muto, F., Romeo, R., Ramella, R. (2021b). Foglio 41 corigliano. In F. L. Chiocci (Ed.), *Atlante dei lineamenti di pericolosità geologica dei mari italiani – Risultati del progetto MaGIC* (pp. 202–205). CNR edizioni.

Ceramicola, S., Cova, A., Forlin, E., Markezic, N., Mangano, G., Civile, D., Zecchin, M., Fanucci, F., Colizza, E., Corselli, C., Morelli, D., Savini, A., Caburlotto, A., Candoni, O., Coste, M., Cotterle, D., Critelli, S., Cuppari, A., Deponte, M., Dominici, R., Facchin, L., Gordini, E., Locatelli, M., Muto, F., Praeg, D., Romeo, R., Tessarolo, C. (2024). Geohazard features of the Ionian Calabrian margin. *Journal of Maps*, (20) 1. https://doi.org/10.1080/17445647.2024.2349785

Ceramicola, S., Cova, A., Forlin, E., Praeg, D., Zecchin, M., Candoni, O., Coste, M., Meo, A., Senatore, M. R., Ramella, R. (2021d). Foglio 45 valle di taranto. In F. L. Chiocci (Ed.), *Atlante dei lineamenti di pericolosità geologica dei mari italiani Risultati del progetto MaGIC* (pp. 218–221). CNR edizioni.

Ceramicola, S., Cova, A., Forlin, E., Praeg, D., Zecchin, M., Candoni, O., Coste, M., Ramella, R. (2021c). Foglio 44 Manduria. In F. L. Chiocci (Ed.), *Atlante dei lineamenti di pericolosità geologica dei mari italiani – Risultati del progetto MaGIC* (pp. 214–217). CNR edizioni.

Ceramicola, S., Cova, A., Forlin, E., Praeg, D., Zecchin, M., Candoni, O., Coste, M., Ramella, R. (2021e). Foglio 46 gallipoli. In F. L. Chiocci (Ed.), *Atlante dei lineamenti di pericolosità geologica dei mari italiani - risultati del progetto MaGIC* (pp. 222–225). CNR edizioni.

Ceramicola, S., Praeg, D., Coste, M., Forlin, E., Cova, A., Colizza, E., & Critelli, S. (2014). Submarine mass-movements along the slopes of the active ionian continental margins and their consequences for marine geohazards (Mediterranean Sea). In S. Krastel (Ed.), *Submarine mass movements and their consequences* (Vol. 37, pp. 295–306). Cham: Springer. https://doi.org/10.1007/978-3-319-00972-8_26.

Ceramicola, S., Senatore, M. R., Coste, M., Meo, A., Boscaino, M., & Cova, A. (2012). Seabed mapping for geohazard in the Gulf of Taranto, Ionian Sea (southern Italy). *Rendiconti Online della Società Geologica Italiana*, *21*(21), 951–952.

Ceramicola, S., Senatore, M. R., Cova, A., Meo, A., Zecchin, M., Praeg, D., Cotterle, D., Critelli, S., Caburlotto, A., Civile, D., Coste, M., Dominici, R., Forlin, E., Muto, F., Bosman, A., Chiocci, F. L., Lai, E., Casalbore, D., Morelli, E., … Romeo, R. (2021). Tavola 9. Golfo di taranto. In F. L. Chiocci (Ed.), *Atlante dei lineamenti di pericolosità geologica dei mari italiani - risultati del progetto MaGIC* (pp. 196–225). CNR edizioni.

Channell, J. E. T., D’Argenio, B., & Horvath, F. (1979). Adria, the African promontory, in mesozoic Mediterranean palaeogeography. *Earth-Science Reviews*, *15*(3), 213–292. doi:10.1016/0012-8252(79)90083-7

Chiocci, F. L., Budillon, F., Ceramicola, S., Gamberi, F., & Orrù, P. (2021). *Atlante dei lineamenti di pericolosità geologica dei mari italiani-Risultati del progetto MaGIC* (vol. 351). CNR edizioni.

Chizzini, N., Artoni, A., Torelli, L., Basso, J., Polonia, A., & Gasperini, L. (2022). Tectono-stratigraphic evolution of the offshore apulian swell, a continental sliver between two converging orogens (northern ionian Sea. Central Mediterranean). *Tectonophysics*, *839*, 229544. https://doi.org/10.1016/j.tecto.2022.229544

Civile, D., Zecchin, M., Tosi, L., Da Lio, C., Muto, F., Sandron, D., Affatato, A., Accettella, D., & Mangano, G. (2022). The Petilia Sosti shear zone (Calabrian Arc, southern Italy): An onshore-offshore regional active structure. *Marine and Petroleum Geology*, *141*, 105693. https://doi.org/10.1016/j.marpetgeo.2022.105693

Corradino, M., Morelli, D., Ceramicola, S., Scarfì, L., Barberi, G., Monaco, C., & Pepe, F. (2023). Active tectonics in the calabrian Arc: Insights from the Late Miocene to recent structural evolution of the Squillace Basin (offshore eastern calabria). *Tectonophysics*, *851*, 229772. https://doi.org/10.1016/j.tecto.2023.229772

Coste, M. (2014). Les processus sedimentaires, depuis la pente continentale jusqu’au bassin, en contexte de tectonique active: analyse comparee’ entre la Marge Calabro’Ionienne et la Marge Ligure durant les derniers 5 Ma. [Doctoral dissertation, University of Nice Sophia Antipolis]. HAL archive, https://te.archives-ouvertes.fr/tel-01062293

D’Acremont, E., Lafuerza, S., Rabaute, A., Lafosse, M., Castelot, M. J., Gorini, C., Alonso, B., Ercilla, G., Vázquez, J. T., Vandorpe, T., Migeon, C. J. S., Ceramicola, C., López-González, N., Rodriguez, M., El Moumni, B., Benmarha, O., & Ammar, A. (2022). Distribution and origin of submarine landslides in the active margin of the southern alboran Sea (western Mediterranean Sea). *Marine Geology*, *445*, 106739. https://doi.org/10.1016/j.margeo.2022.106739

Del Ben, A., Barnaba, C., & Taboga, A. (2008). Strike-slip systems as the main tectonic features in the plio-quaternary kinematics of the Calabrian Arc. *Marine Geophysical Researches*, *29*(1), 1–12. https://doi.org/10.1007/s11001-007-9041-6

Doglioni, C., Gueguen, E., Harabaglia, P., & Mongelli, F. (1999b). *On the origin of west-directed subduction zones and applications to the western Mediterranean* (vol. 156, pp. 541–561). London: Geological Society, Special Publications. https://doi.org/10.1144/GSL.SP.1999.156.01.24

Doglioni, C., Harabaglia, P., Merlini, S., Mongelli, F., Peccerillo, A. T., & Piromallo, C. (1999a). Orogens and slabs vs. Their direction of subduction. *Earth-Science Reviews*, *45*(3/4), 167–208. https://doi.org/10.1016/S0012-8252(98)00045-2

Ercilla, G., Galindo-Zaldívar, J., Estrada, F., Valencia, J., Juan, C., Casas, D., Alonso, B., Comas, C., Tendero-Salmerón, V., Casalbore, D., Azpiroz-Zabala, M., Bárcenas, P., Ceramicola, S., Chiocci, F. L., Idárraga-García, L., López-González, N., Mata, P., Palomino, D., Rodríguez-García, J. A., … Yenes, M. (2022). Understanding the complex geomorphology of a deep sea area affected by continental tectonic indentation: The case of the Gulf of Vera (Western Mediterranean). *Marine Geology*, *448*, 106810. https://doi.org/10.1016/j.margeo.2022.106810

Ferranti, L., Burrato, P., Pepe, F., Santoro, E., Mazzella, M. E., Morelli, D., Passaro, S., & Vannucci, G. (2014). An active oblique-contractional belt at the transition between the southern Apennines and Calabrian Arc: The amendolara Ridge, Ionian Sea, Italy. *Tectonics*, *33*(11), 2169–2194. https://doi.org/10.1002/2014TC003624

Ferranti, L., Mazzella, M. E., Santoro, E., Monaco, C., & Morelli, D. (2009). Active transpression in the northern Calabria Apennines, southern Italy. *Tectonophysics*, *476* (1-2), 226–251. https://doi.org/10.1016/j.tecto.2008.11.010

Finetti, I. (2003). The CROP profiles across the Mediterranean Sea (CROP mare I and II) (2003. *Mem. Descr. Carta Geol. D'It. LXII*, 171–184.

Finetti, I., & Morelli, C. (1972). Wide scale digital seismic exploration of the Mediterranean Sea. *Bollettino di Geofisica Teorica ed Applicata*, *14*(56), 291–342.

Geronimo, I., La Perna, R., Rosso, A., & Sanfilippo, R. (1998). Notes on two upper circalittoral assemblages from the amendolara bank (northern ionian Sea). *Bollettino Dell'Accademia Gioenia di Scienze Naturali di Catania*, *30*(353), 243–262.

Lambeck, K., & Purcell, A. (2005). Sea-level change in the Mediterranean Sea since the LGM: Model predictions for tectonically stable areas. *Quaternary Science Reviews*, *24*(18-19), 1969–1988. https://doi.org/10.1016/j.quascirev.2004.06.025

Malinverno, A., & Ryan, W. B. F. (1986). Extension in the tyrrhenian Sea and shortening in the Apennines as result of arc migration driven by sinking of the lithosphere. *Tectonics*, *5*(2), 227–245. https://doi.org/10.1029/TC005i002p00227

Mangano, G., Alves, T. M., Zecchin, M., Civile, D., & Critelli, S. (2023). The rossano-San nicola fault zone evolution impacts the burial and maturation histories of the Crotone Basin, Calabrian Arc, Italy. *Petroleum Geoscience*, *29*(2). doi: 10.1144/petgeo2022-085

Mangano, G., Zecchin, M., Civile, D., Ceramicola, S., Donato, A., Muto, F., Tripodi, V., Critelli, S. (2022). Mid-miocene to recent tectonic evolution of the punta stilo swell (calabrian arc, southern Italy): an effect of calabrian arc migration. *Marine Geology*, *448*, 106810. https://doi.org/10.1016/j.margeo.2022.106810

Mascle, J., Auroux, C., & Rossi, S. (1984). Structure géologique superficielle et évolution récente de la dorsale apulienne (Mer ionienne). *Revue de l'Institut français du pétrole* (2), 10. https://doi.org/10.2516/ogst:1984009

Meo, A., Chiocci, F. L., & Senatore, M. R. (2017). *Morphometric measures to assess the maturity of the submerged drainage basins. The case of the Taranto Canyon upper reach.* IMEKO International Conference on Metrology for the Sea, Naples, 133–137.

Meo, A., Falco, M., Chiocci, F. L., & Senatore, M. R. (2018). Kinematics and the tsunamigenic potential of Taranto Landslide (northeastern Ionian Sea): morphological analysis and modeling. In *Landslides and engineered slopes. Experience, theory and practice* (pp. 1409–1416). CRC Press.

Meo, A., & Senatore, M. R. (2023). Morphological and seismostratigraphic evidence of quaternary mass transport deposits in the North Ionian Sea: the Taranto landslide complex (TLC). *Frontiers in Earth Science*, *11*, 10. https://doi.org/10.3389/feart.2023.1168373

Merlini, S., Cantarella, G., & Doglioni, C. (2000). On the seismic profile crop MS in the ionian Sea. *Boll. Soc. Geol. It*, *119*, 227–236.

Monaco, C., & Tortorici, L. (2000). Active faulting in the calabrian arc and eastern sicily. *Journal of Geodynamics*, *29*(3–5), 407–424. https://doi.org/10.1016/S0264-3707(99)00052-6

Muto, F., Spina, V., Tripodi, V., Critelli, S., & Roda, C. (2014). Neogene tectonostratigraphic evolution of allochthonous terranes in the eastern calabrian foreland (southern Italy). *Italian Journal of Geosciences*, *133*(3), 455–473. doi: 10.3301/IJG.2014.23

Novak, A., Poglajen, S., & Vrabec, M. (2023). Not another hillshade: Alternatives which improve visualizations of bathymetric data. *Frontiers in Marine Science*, *10*, 1266364. doi: 10.3389/fmars.2023.1266364

Ogniben, L. (1969). Schema introduttivo alla geologia del confine calabro-lucano. *Memorie Della Società Geologica. Italiana*, *8*, 453–763.

Ori, G. G., & Friend, P. F. (1984). Sedimentary basins formed and carried piggyback on active thrust sheets. *Geology*, *12*(*8*), 475–478. https://doi.org/10.1130/0091-7613(1984)12<475:SBFACP>2.0.CO;2

Pepe, F., Di Donato, V., Insinga, D., Molisso, F., Faraci, C., Sacchi, M., Dera, R., Ferranti, L., & Passaro, S. (2018). Seismic stratigraphy of upper quaternary shallow-water contourite drifts in the Gulf of Taranto (Ionian Sea, southern Italy). *Maine Geology*, *397*, 79–92. https://doi.org/10.1016/j.margeo.2017.12.004

Pescatore, T. (1985). Geologia e oceanografia del golfo di taranto. *CNR, Prog. Fin. Oceanografia e Fondi Marini, Rapporto Tecnico Finale*, 210pp.

Pescatore, T., & Senatore, M. R. (1986). A comparison between a present- day (Taranto Gulf) and a Miocene (Irpinian basin) foredeep of the Southern Apennines (Italy). *Special Publications International Association of Sedimentologists*, *8*, 169–182. https://doi.org/10.1002/9781444303810.ch8

Rago, V., Chiaravalloti, F., Chiodo, G., Gabriele, S., Lupiano, V., Nicastro, R., Pellegrino, A. D., Procopio, A., Siviglia, S., Terranova, O. G., & Iovine, G. G. (2017). Geomorphic effects caused by heavy rainfall in southern calabria (Italy) on 30 October–1 November 2015. *Journal of Maps*, *13*(2), 836–843. https://doi.org/10.1080/17445647.2017.1390499

Ricchetti, G., Ciaranfi, N., Luperto Siani, E., Mongelli, F., & Pieri, P. (1988). Geodinamica ed evoluzione sedimentaria e tettonica dell'avampaese apulo. *Memorie della Societa' Geologica Italiana*, *41*, 57–82.

Ricci-Lucchi, F., Colella, A., Gabbianelli, G., Rossi, S., & Normark, W. R. (1983). The crati submarine fan, ionian Sea. *Geo-Marine Letters*, *3*(2–4), 71–77. https://doi.org/10.1007/BF02462450

Ridente, D., Bosman, A., Casalbore, D., & Chiocci, F. L. (2017). Bedforms feeding and bedforms Fed by canyon activity around punta alice promontory (calabria ionian margin, Italy). In J. Guillén, J. Acosta, F. Chiocci, & A. Palanques (Eds.), *Atlas of Bedforms in the Western Mediterranean* (pp. 12). Springer. https://doi.org/10.1007/978-3-319-33940-5_37

Rossi, S., Auroux, C., & Mascle, J. (1983). The Gulf of Taranto (Southern Italy): seismic stratigraphy and shallow structure. *Marine Geology*, *51*(3/4), 327–346. https://doi.org/10.1016/0025-3227(83)90110-X

Savini, A., & Corselli, C. (2010). High-resolution bathymetry and acoustic geophysical data from Santa Maria di Leuca cold water coral province (northern ionian Sea—Apulian continental slope). *Deep Sea Research Part II: Topical Studies in Oceanography*, *57*(5-6), 326–344. https://doi.org/10.1016/j.dsr2.2009.08.014

Scarascia, S., Lozej, A., & Cassinis, R. (1994). Crustal structures of the ligurian, tyrrhenian and ionian seas and adjacent onshore areas interpreted from wide-angle seismic profiles. *Bollettino di Geofisica Teorica e Applicata*, *36*, 5–19.

Senatore, M. R. (1987). Caratteri sedimentari e tettonici di un bacino di avanfossa. Il golfo di taranto. *Memorie Della Società Geologica D'Italia*, *38*, 177–204.

Senatore, M. R. (1988). *Comparazione tra i depositi plio-pleistocenici del bacino di Gallipoli (Golfo di Taranto) e la successione miocenica del flysch di Faeto (unità irpine, Monti della Daunia): confronto tra l'avanfossa attuale e quella miocenica dell'Appennino meridionale* (Italia) [Doctoral Dissertetion], Consorzio Univ. Napoli e Palermo, Sede consorziata Napoli, Dottorato in Geologia del Sedimentario, 317pp.

Senatore, M. R., Diplomatico, G., Mirabile, L., Pescatore, T., & Tramutoli, M. (1982). Frammenti sulla scarpata continentale pugliese del Golfo di Taranto (Alto Ionio). *Geologica Romana*, *21*, 497–510.

Senatore, M. R., Meo, A., Boscaino, M., & Chiocci, F. L. (2011). Erosion and sedimentary processes in the Metaponto offshore (North Ionian Sea). IL QUATERNARIO. In *Il Quaternario - Italian Journal of Quaternary Science Congresso AIQUA 2011. Il Quaternario italiano: Conoscenze e prospettive, Roma, 24/25-02-11* (pp. 63–65, 24).

Senatore, M. R., Meo, A., Bosman, A., Casalbore, D., Chiocci, F. L., Lai, E., Morelli, E. (2021b). Foglio 43 taranto. In F. L. Chiocci (Ed.), *Atlante dei lineamenti di pericolosità geologica dei mari italiani - risultati del progetto MaGIC* (pp. 211–213). CNR edizioni.

Senatore, M. R., Meo, A., Bosman, A., Chiocci, F. L., Lai, E. (2021a). Foglio 42 metaponto. In F. L. Chiocci (Ed.), *Atlante dei lineamenti di pericolosità geologica dei mari italiani – Risultati del progetto MaGIC* (pp. 206–209). CNR edizioni.

Senatore, M. R., Meo, A., & Budillon, F. (2022). Measurements in marine geology: An example in the gulf of taranto (Northern Ionian Sea). In P. Daponte, G. B. Rossi, & V. Piscopo (Eds.), *Measurement for the Sea. Springer series in measurement science and technology*. Springer. https://doi.org/10.1007/978-3-030-82024-4_11

Senatore, M. R., Normark, W. R., Pescatore, T., & Rossi, S. (1988). Structural framework of the gulf of taranto (Ionian Sea). *Memorie della Società Geologica d'Italia*, *41*(4), 533–539.

Taviani, M., Remia, A., Corselli, C., Freiwald, A., Malinverno, E., Mastrototaro, F., Savini, A., & Tursi, A. (2005). First geo-marine survey of living cold-water Lophelia reefs in the Ionian Sea (Mediterranean basin). *Facies*, *50*(3/4), 409–417. https://doi.org/10.1007/s10347-004-0039-0

Teofilo, G., Antoncecchi, I., & Caputo, R. (2018). Neogene-Quaternary evolution of the offshore sector of the southern Apennines accretionary wedge, Gulf of Taranto, Italy. *Tectonophysics*, *738-739*, 16–32. https://doi.org/10.1016/j.tecto.2018.05.006

Tramutoli, M., Pescatore, T., Senatore, M.R., & Mirabile, L. (1984). Interpretation of reflection high resolution seismic profiles through the Gulf of Taranto (Ionian sea, Eastern Mediterranean), The structure of Apennine and Apulia deposits. The structure of apennine and Apulia deposits. Bollettino di Oceanografia Teorica ed Applicata, 2-1.

Van Dijk, J. P., & Scheepers, P. J. J. (1995). Neotectonic rotations in the Calabrian Arc; implications for a Pliocene-Recent geodynamic scenario for the Central Mediterranean. *Earth-Science Reviews*, *39*(3/4), 207–246. https://doi.org/10.1016/0012-8252(95)00009-7

Watts, P., Grilli, S. T., Kirby, J. T., Fryber, G. J., & Tappin, D. R. (2003). Landslide tsunami case studies using a Boussinesq model and a fully nonlinear tsunami generation model. *Natural Hazards and Earth System Sciences*, *3*(5), 391–402. https://doi.org/10.5194/nhess-3-391-2003

Zecchin, M., Caffau, M., Civile, D., Critelli, S., Di Stefano, A., Maniscalco, R., Muto, F., Sturiale, G. (2012). The plio-pleistocene evolution of the Crotone Basin (southern Italy): interplay between sedimentation, tectonics and eustasy in the frame of Calabrian Arc migration. *Earth-Science Reviews*, *115*(4), 273–303. https://doi.org/10.1016/j.earscirev.2012.10.005

Zecchin, M., Ceramicola, S., Gordini, E., Deponte, M., & Critelli, S. (2011). Post-LGM features along the Ionian Calabrian margin (Southern Italy). *Alpine and Mediterranean Quaternary*, *24 (Extended Abstract)*, 71–72.

Zecchin, M., Civile, D., Caffau, M., Critelli, S., Muto, F., Mangano, G., & Ceramicola, S. (2020). Sedimentary evolution of the Neogene-Quaternary Crotone Basin (southern Italy) and relationships with large-scale tectonics: A sequence stratigraphic approach. *Marine and Petroleum Geology*, *117*, 104381. https://doi.org/10.1016/j.marpetgeo.2020.104381