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Depositional and erosional bedforms in Late Pleistocene-Holocene pro-delta deposits of the Gulf of Patti (southern Tyrrhenian margin, Italy)

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ABSTRACT

Multibeam bathymetry, high-resolution seismic profiles and seafloor samples have been analyzed to characterize depositional and erosional dynamics recorded pro-deltaic deposits and outer shelf sediments along of a sector of the NE Sicilian margin (southern Tyrrhenian Sea). The deltaic deposits cover an area of ca. 15 km^2 in front of the Mazzarrà River, and are morphologically characterized by waveforms trending overall along strike and incised cross-strike gullies of variable length. The gullies are shallow and characterized by small, coaxial erosive scours in the inner-middle shelf, whereas they become larger and deeper in the outer shelf-upper slope, in relation to the marked increase of slope gradients at the shelf break. Here, the wider gullies are characterized by a frame of crescent-shaped bedforms interpreted as cyclic steps, indicating the occurrence of sedimentary gravity flows in supercritical regime. Prodelta waveforms are widespread between −50 and −120 m, with wave lengths of 34–110 m and wave heights of 0.5–3 m. Morphometric characterization and spatial distribution of the waveforms suggests a main role in their genesis played by hyperpycnal flows, although we cannot discard the possible effect of internal waves or slow deformation processes (i.e., creep).

Depositional and erosional features similar to those observed on the seafloor are evident in the subsurface stratigraphy, revealing the onset and growth of the Mazzarrà Delta since the Last Glacial Maximum. The post-glacial sea level rise caused lateral shifts of the Mazzarrà River mouth controlling migration of depositional lobes and intensity of seafloor incision and sediment reworking, ultimately resulting in the observed wavy bedforms extending from the inner shelf to the upper slope.

1. Introduction

Geomorphic shaping of the seafloor at different spatial and temporal scales and in different marine environments generally reflects a strong interaction between oceanographic and sedimentary processes under long-term tectonic deformation. As a result, erosional features scaling from gullies to deeply incised channels (e.g., Burger et al., 2001; Ridente et al., 2007; Chiocci and Casalbore, 2011; Harris and Whiteway, 2011) and bedform fields including megaripples to large sediment waves (e.g. Lo Iacono et al., 2014; Lobo et al., 2015; Symons et al., 2016) have been frequently observed on modern continental margins.

The continental shelf and upper slope of the NE Sicilian margin, in the southern Tyrrhenian Sea (Fig. 1), provide an insightful example of multi-scale geomorphic features reflecting the interaction between recent and long-term sedimentary processes (Gamberi et al., 2014, 2015). This part of the Tyrrhenian margin is affected by differential regional uplift rates and deformation along regional tectonic lineaments (Ferranti et al., 2006; Sulli et al., 2013) causing massive input of sediment and frequent mass-wasting on the continental margin. Largely due to this active tectonic setting, the NE Sicilian continental shelf is narrow or absent and its edge typically cut back by canyon heads (Gamberi et al., 2015). Within this margin, we analyzed an area in the Gulf of Patti (Figs. 1 and 2) where the shelf is relatively wider and less carved by canyons compared to the nearby sectors. Here, the large input of terrestrial sediment funneled to a short and steep river stream led to the growth of a submarine delta characterized by different bedforms indicative of high-energy erosional and depositional events. Cross-strike shallow and sub-parallel incisions are superimposed on gentle depositional waveforms present in front of a mountainous river locally known as "Fiumara" (Sabato and Tropeano, 2004). Fiumara is a kind of gravel-bed rivers, very steep and short, having a great transport and erosion capacity because of their flow regime, dominated by long periods of inactivity alternated with short intervals of intense water supply and flash floods. During these events, large amount of sediment and debris are released at the river mouth and possibly evolves into hyperpycnal flows (e.g., Casalbore et al., 2011).

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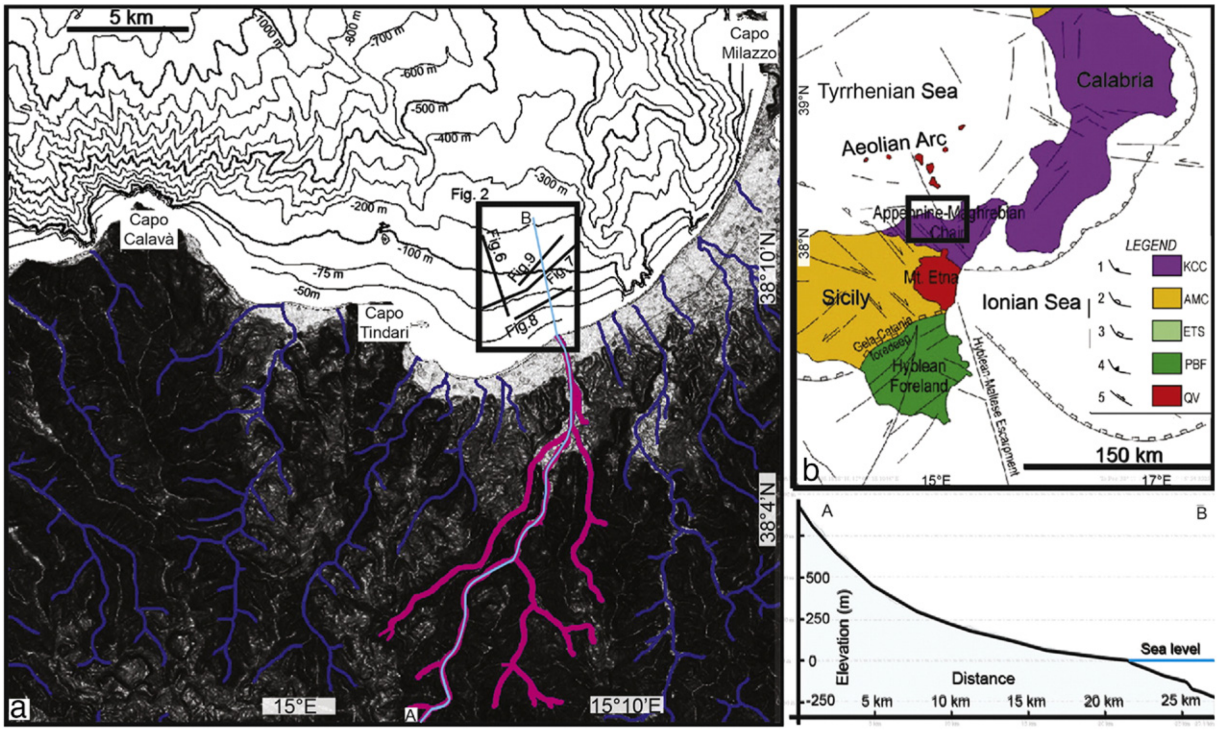

Fig. 1. a) Shaded relief map of the onland sector (azimuthal enlightening, data downloaded from Aster GDEM, https://lpdaac.usgs.gov/) and isobaths of the NE Sicily offshore (location in the Fig. 1b), where the fluvial drainage is indicated by the blue lines; the bold magenta line indicates the Mazzarrà Fiumara. The light-blue line across the continental shelf indicates the trace of the longitudinal profile (A–B) of Mazzarrà Fiumara and associated submarine delta shown on the lower right; b) Simplified structural map of Southern Italy; KCC: Kabilo-Calabride Chain Units; AMC: Appennine-Maghrebian Chain Units; ETF: External Thrust System Units; PBF: Pelagian Block Foreland Units; QV: Quaternary Volcanoes.
(Source: modified from Lentini et al., 2006).

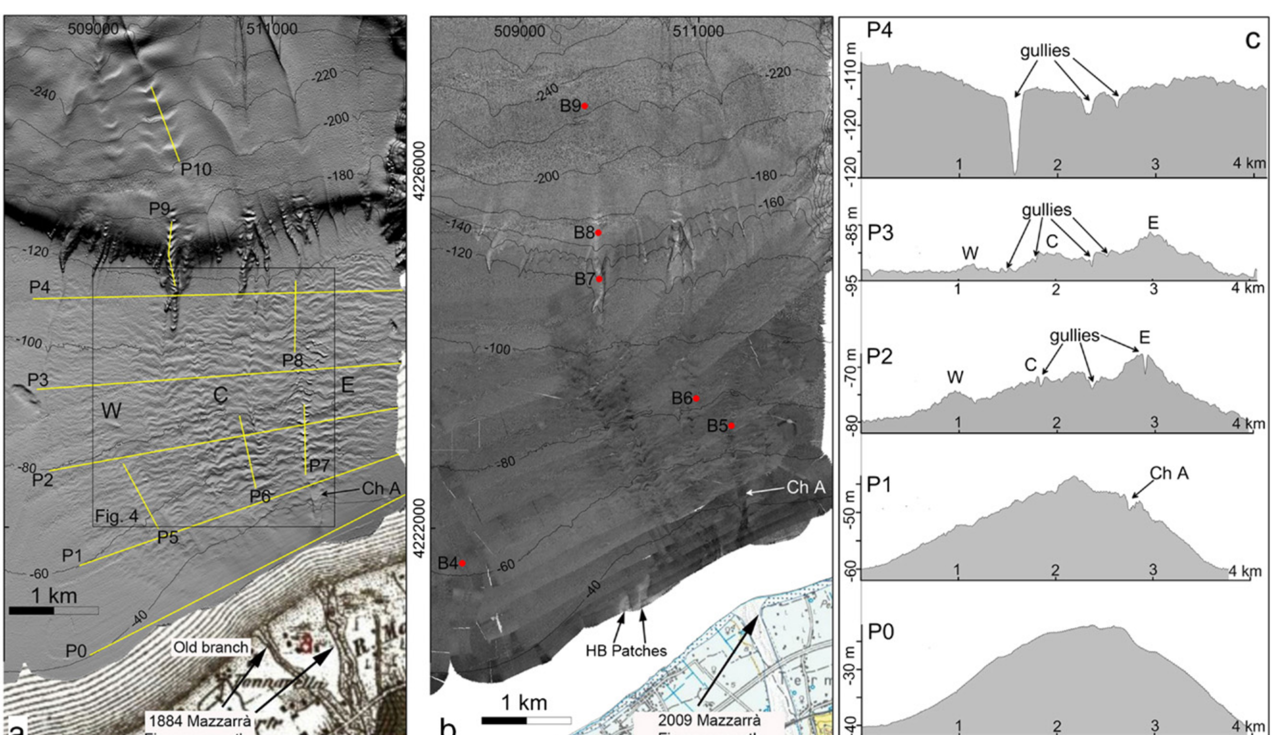

Fig. 2. Shaded relief map (a) and backscatter mosaic (b, high backscatter values are in lighter tones) of the submarine deltaic system facing the Mazzarrà Fiumara mouth. Note the difference of the Fiumara mouth geometry between the 1884 (a) and 2009 (b) geological map (data from http://193.206.192.231/carta_geologica_italia/tavoletta.php?foglio=253; http://www.isprambiente.gov.it/Media/carg/587_600_MILAZZO_BARCELLONA/Foglio.html, respectively). W, C, and E indicate the western, central and eastern part, in which the Mazzarrà submarine delta can be recognized based on the different geomorphology; yellow lines indicate the location of the bathymetric profiles shown in Figs. 2 (P0–P4, vertical exaggeration 30×) and 5 (P5–P10); red dots in Fig. 2b indicate the location of seafloor samples.