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The reshaping of the South West Adriatic Margin by cascading of dense shelf waters

Federica Foglini *, Elisabetta Campiani, Fabio Trincardi

ISMAR-CNR, via Gobetti 101, 40129 Bologna, Italy

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ABSTRACT

The South West Adriatic Margin (SAM) includes a steep and morphologically complex continental slope stretching about 600 km from the Pelagosa sill to the Otranto strait. The margin is clearly dissected by submarine slides, active fault systems (e.g.: the Gondola deformation belt), numerous shallowly incised and relatively straight canyons located south of Bari Canyon, and a variety of large-scale erosional and depositional features. This area is seasonally impacted by dense shelf water forming in the North Adriatic through wind-forced winter cooling, moving south along the western side of the basin, and cascading across the South Adriatic slope.

The area has been investigated through multibeam surveys integrated by high-resolution seismic stratigraphic data resolving glacial and post-glacial deposits. This paper gives a detailed and comprehensive description of the SAM seafloor morphology to document how the process of dense shelf water cascading concurs to a thorough "restyling" of the submarine landscape by interacting with the pre-existing and markedly differentiated morphologies and sediment distribution. We focus on depositional and erosional features such as: giant sediment drifts down to 1200 m water depth, muddy and sandy sediment waves, comet marks against pre-existing slide blocks, furrow fields against steep slopes, large scours at the shelf edge and large erosional moats adjacent to major morphological barriers. The analysis of the bedform orientation and spatial distribution indicates that the downslope-cascading bottom-currents (dominantly directed to the SE) encounter a straight upper slope, oriented north south in the north and progressively more east west proceeding to the south; as the slope orientation becomes more E–W it also appears more dissected by small-scale canyons, active during glacial times. In the latter area, therefore, the dense shelf waters follow a slope-parallel direction almost perpendicular to the pre-existing slope canyons. As a consequence, erosional furrows develop perpendicular to the canyon flanks and some of the canyon heads become disconnected from the main canyon downslope.

1. Introduction

Dense shelf water (DSW) formation is known to occur in all the largest shelf areas of the northern Mediterranean, through winter cooling forced by cold winds blowing on relatively shallow shelves, and to impact the adjacent slopes through a density-driven cascading process likely reaching the deep sea (Canals et al., 2009). While in the Gulf of Lions and in the Aegean Sea the process of DSW cascading appears to respond quickly to wind forcing (Puig et al., 2013), in the Adriatic Sea the effect appears more delayed because the basin is elongated some 800 km in a NW direction and the DSW forming in the north reaches the SW Adriatic slope and eventually triggers the cascading process with a delay of few months (Vilibič, 2003; Verdicchio et al., 2007; Fig. 1).

Several authors have recently documented the effects of the DSW cascading on the slope of the Gulf of Lions, an area dissected by pre-existing canyons that are able to capture most of the DSW, particularly towards the west of the Gulf (Canals et al., 2006; Palanques et al., 2006; Puig et al., 2008; Canals et al., 2009). In this area the direction of the DSW cascades follows the same path of the sediment-laden turbidity currents active during glacial times and, therefore, have morphological signatures that may be difficult to disentangle. In the Adriatic, the Bari Canyon system (BCS) acts as the main active sediment conduit, where the intense cascading currents accelerate becoming confined while the occurrence of an open slope with a documented marked morphological variability allows an improved definition of how the process of DSW cascading can re-shape the morphology of a continental margin beyond canyon pathways. Verdicchio and Trincardi (2006), focusing on a portion of the open-slope (ca. 35 × 25 km) of the South Adriatic Margin (SAM) in a water depth range between 300 and 600 m, documented the presence of a multitude juxtaposed erosional and depositional features suggesting the constructive interaction between two distinct southerly bottom water masses: the LIW and the NAdDW. Trincardi et al. (2007b), described the extreme seafloor complexity in a key portion of the SAM that reflects long-term tectonic deformation and repeated mass wasting of regressive Pleistocene sequences. This area is characterised by a variety of sediment waves, erosional scours, longitudinal furrows, and giant comet marks not randomly distributed but

* Corresponding author.
E-mail address: federica.foglini@bo.ismar.cnr.it (F. Foglini).

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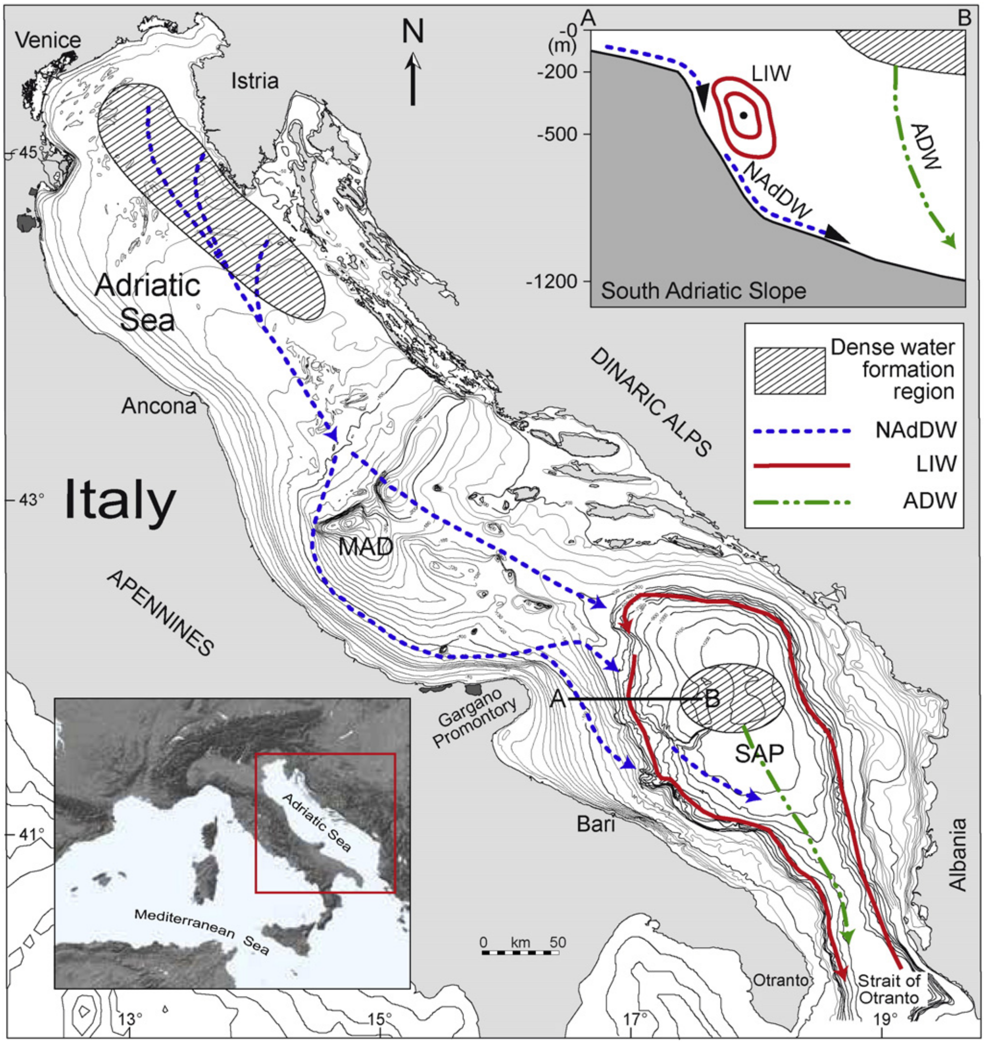

Fig. 1. Location of the Adriatic in the Mediterranean Sea, with schematic circulation path of the Levantine Intermediate Waters (LIW), the North Adriatic Deep Waters (NAdDW) and the Adriatic Deep Waters (ADW); deep water formation occurs through shelf water cooling, in the north, and open ocean convection in the South Adriatic Pit (SAP). Section A–B schematically shows the intermediate-deep water circulation on the Southwestern Adriatic Margin slope.
Modified from Verdicchio et al. (2007).

apparently genetically linked and with a consistent down-current arrangement.

In this paper with the availability of new higher resolution bathymetric and seismic data, covering most of the SAM, we are able to give a more comprehensive description of the morphology of the margin, and to analyse the distribution and orientation of the main fields of active bedforms and areas of dominant seafloor erosion. In this perspective, we attempt to determine the extent to which bottom-hugging currents link with the cascading process are effective in reshaping the entire margin landscape.

2. Study area

2.1. Geological and geomorphologic setting

The morphology of the South West Adriatic is dominated in the north by the presence of widespread mass-failure features, the largest of which is Gondola slide (Minisini et al., 2006), and in the south by multiple slope incisions, the major of which is the Bari Canyon System, which includes a channel-levee complex active until the early stages of the post-glacial sea level rise (Trincardi et al., 2007a). The northern domain is also dissected by the cross-slope Gondola deformation belt, which connects downslope to the Dauno Seamount (Fig. 2).

The Bari Canyon System (BCS) represents the main sediment conduit active during the last glacial interval characterised by two main conduits emanating from a broad crescent-shaped upper slope region (Ridene et al., 2007; Trincardi et al., 2007a). BCS appears markedly asymmetric with a right hand flank that is higher and steeper (about 800 m in relief and more than 30° steep) and a smoother left-hand side (Fig. 2).

The upper slope of the South Adriatic Margin (SAM) slope is steep and erosional down to ca. 350 m water depth and the lower slope is morphologically more articulated.(Verdicchio et al., 2007; Trincardi et al., 2007b). Where the slope is not erosional, a large variety of bedforms and sediment drift deposits record the prolonged activity of bottom currents, which are particularly effective where the slope morphology causes either flow splitting or flow convergence (Verdicchio and Trincardi, 2006). Core data indicate that these bottom-current deposits have grown particularly during the modern and previous interglacial intervals (Verdicchio et al., 2007).

Tectonic deformation affected the SAM during the last 500 kyr, causing the progressive seaward tilt of the margin (Ridente and Trincardi, 2002), while active tectonic deformation on the margin generated faults and gentle anticlines affecting shallow deposits along the E–W-trending Gondola deformation belt (GDB) (Tramontana et al., 1995; Ridente and Trincardi, 2005). The Gondola deformation belt includes several E–W and NW–SE fault segments dissecting the Southern Adriatic continental