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Stratigraphic architecture of the Montenegro/N. Albania Continental Margin (Adriatic Sea—Central Mediterranean)

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ABSTRACT

The Montenegro/Northern Albania Continental Margin (MACM), in the eastern Adriatic Sea, is a convergent margin at the Dinarides Chain front supplied by major fluvial systems, such as the Buna/Bojana and Drini Rivers. Analysis of high-resolution seismic reflection profiles and core samples, which included paleobiologic legacy of macrofossil assemblages and radiometric dating, shows that the post Last Glacial Maximum (LGM) deposits are confined into mid-shelf basins partially bounded toward the sea by tectonic highs, such as the Kotor and Bar ridges, while the outer shelf exposes lowstand deposits locally covered by a thin veneer of Holocene mud. Pre-LGM units consist of four depositional sequences bounded by erosional surfaces of regional extent related to sea level lowstands during Marine Isotopic Stages (MIS) 10, 8, 6 and 2. This pattern is observed close to the shelf-break, at water depths of 200–220 m, where a stack of sedimentary sequences records sea level changes at the scale of 100 kyr. Position and estimated ages of buried shorelines indicate that the outer shelf subsidence rate has been about 1.12 mm/yr during the last ~350 kyr, while a morphological analysis carried out along the LGM paleoshoreline suggests that the northern sector of the MACM has been uplifted of up to several tens of meters during the last ~20 kyr.

1. Introduction

The stacking of stratigraphic sequences along continental margins reflects the interaction between several natural processes, such as sea level changes, tectonic deformation (subsidence or uplift), sediment supply and reworking by bottom currents. This is also the case of the Adriatic Sea, a Mediterranean epicontinental basin located between three orogenic belts, the Apennines to the West, the Dinarides to the East and the Alps to the North (Fig. 1). The stratigraphy of the Adriatic margin is mainly controlled by high-frequency glacio-eustatic oscillations, which caused extended horizontal shifts of the coastal facies due to the low topographic gradients. During the Late Pleistocene, in particular, the combined effect of eustatic fluctuations and long-term subsidence allowed for preservation of relatively thick sequences (Ridente and Trincardi, 2002; Maselli et al., 2010).

The eastern and western Adriatic shelves are characterized by similar geodynamic settings and a common history of Late Quaternary paleogeographic changes, culminated ~21 kyr in the last episode of glacio-eustatic lowstand (−120 m below the present-day datum; Clark et al., 2009).

The western Adriatic shelf is characterized in its northern part by high accommodation due to the constant and high subsidence rate at the front of the Apennine Chain. In the southern Adriatic Sea (Fig. 1), compressive deformations reach the uppermost part of the stratigraphic sequence (Ridente and Trincardi, 2006). In such zones, accommodation is relatively limited, and highly variable along the margin, reflecting the growth of gentle synclines and anticlines.

Recently, Maselli et al. (2010) presented a compilation of subsidence-rates in different sectors of the western Adriatic margin, from estimates carried out by several authors. These rates range from 1.2 mm/yr in the north, to 0.3 mm/yr in the central sectors. Conversely, the southern Adriatic shelf surrounding the Apulia swell is uplifting at rates in the order of 0.2–0.3 mm/yr. Unlike the Italian side, the eastern Adriatic shelf is still poorly covered by marine geological and geophysical data. In particular, seismo-stratigraphic studies are lacking along the Montenegro–N. Albania Continental Margin (hereafter called MACM), with the exception of some seismic reflection datasets collected by oil companies and still mostly unpublished (Dragasevic, 1974; Oluic et al., 1982) and a preliminary study by Del Bianco et al. (2010); therefore, a thorough study of the Late Quaternary stratigraphy is missing.

The MACM is a convergent margin supplied by major fluvial systems, such as the Buna/Bojana and the Drini Rivers, which carry the sediment loads to the narrow shelf. Source areas for these sediments are

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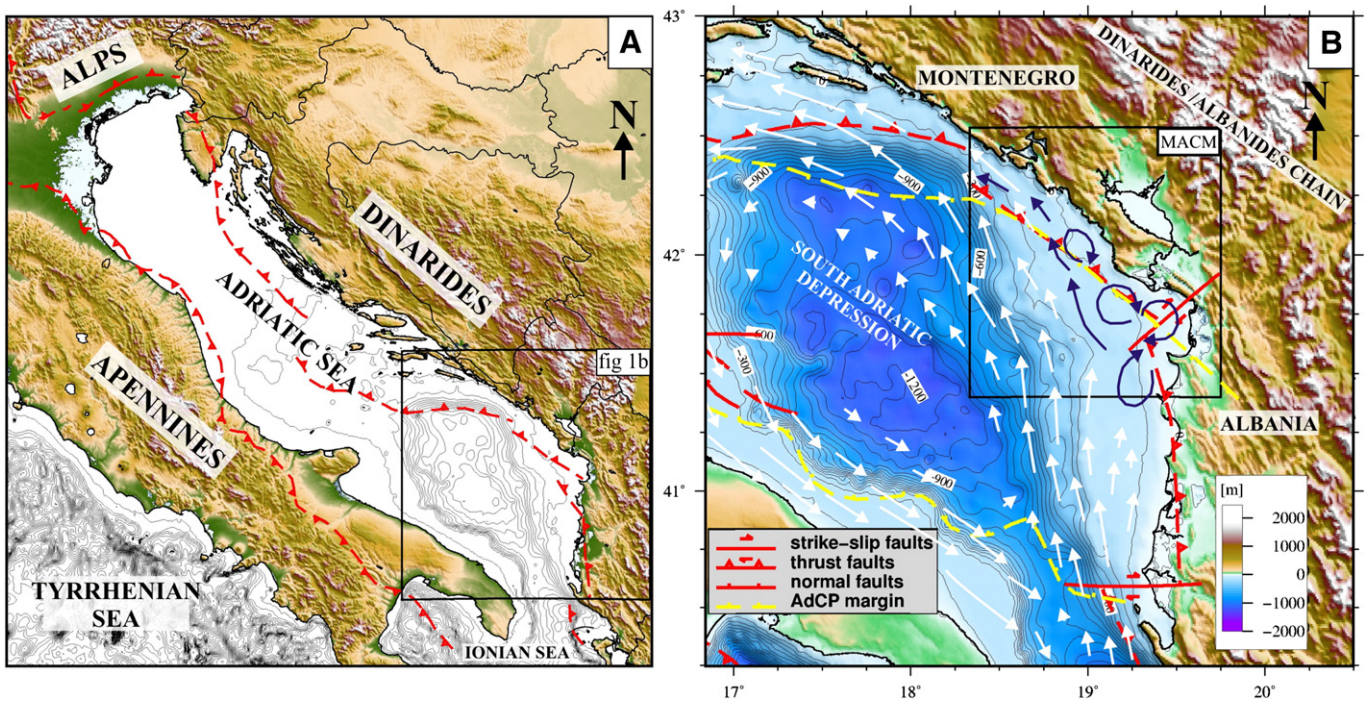

Fig. 1. A) The Adriatic Sea between the Alps/Apennines and the Dinaric chains; B) geodynamic, morphology and oceanographic setting of the South Adriatic Sea, with location of external thrust as limits of the Adria microplate (from Dragičević and Velić, 2002; G.M.O.T.M., 2004; Vlahović et al., 2005; Billi et al., 2007). Blue and white vectors indicate directions and intensity of local and regional currents, from Marini et al. (2010) and Poulain (2001), respectively. Black box delimits our working area.

the watershed of fluvial systems that drain the Dinarides, consisting of Lower to Middle Triassic and Jurassic/Cretaceous carbonate rocks.

In the framework of the ADRICOSM-STAR project, we carried out six oceanographic cruises along the MACM, onboard of vessels of the Italian National Research Council (CNR). Although the main-focus of the project was to study the present-day oceanographic regime and the environmental status of the coastal areas, during these expeditions, a variety of ancillary geophysical data including high-resolution seismic reflection profiles and multibeam swath bathymetry were acquired, as well as several samplings of the seafloor sediments through gravity and box corers.

Here, we present an analysis of such data, that enabled us to investigate the depositional patterns of Late Quaternary sedimentary sequences, i.e., the uppermost tens to hundreds of meters of the sedimentary record, and attempt to unravel relationships between tectonic and sea level changes. Our work includes the stratigraphic analysis of the post-LGM deposits, as well as the reconstruction of the MIS2 sediment dispersal system. We also attempted an estimate of the subsidence rate along the MACM during the last ~350 kyr, based on identification of paleoshorelines associated to three buried forced-regression sediment wedges, in analogy with similar most recent and better age-constrained deposits.

2. Geologic setting

The MACM is a convergent margin located in the southeastern sector of the Adriatic Sea, bounded to the northeast by the Dinarides/Albanides chain. The associated sedimentary basin constitutes the foredeep of the Dinarides/Albanides fold-and-thrust belt (De Alteriis, 1995; Argnani et al., 1996; Bertotti et al., 2001), that started forming in the Eocene along the southeastern branch of the Alpine chain (Rosenbaum and Lister, 2005). According to Argnani et al. (1996) the MACM morphology is partly inherited from the Mesozoic paleogeography, because the southern Adriatic developed over a Mesozoic epicontinental basin between the Dalmatian and Apulian shallow-water carbonate platforms.

The outer domain of the Dinarides/Albanides chain, which includes the coastal area and the continental shelf, constitutes the present-day collisional front, and is marked by compressive deformation along deep-seated thrust faults, which affects the entire sedimentary sequence (Aliaj, 1997). In the MACM offshore, the fold-and-thrust belt was imaged at crustal depths by closely spaced grids of multichannel seismic lines collected during the '80s and the '90s for exploration purposes. However, these data are still largely unpublished, if we exclude a few lines or line-drawing interpretations in Oluic et al. (1982), Aliaj (1998) and Aliaj et al. (2004). Such seismic reflection profiles show evidence of post-Messinian, or even Upper Pliocene to Quaternary deformation (Dragasevic, 1983). Focal mechanisms of recent earthquakes, as well as geodetic observations, suggest compressive deformations along the eastern Adria lithospheric block (Anderson and Jackson, 1987; Pondrelli et al., 2002; Hunstad et al., 2003), which appears displaced by a series of N–S oriented strike-slip faults. This fault pattern resulted in a NE–SW shortening along the Dinarides and Albanian chains, at estimated rates of 4–4.5 mm/yr (Grenerczy et al., 2005).

2.1. The Adriatic Sea

The Adriatic Sea (Fig. 1) is a semi-enclosed basin elongated in the NW–SE direction, with a length of about 800 km and a width of 200 km, which shows a remarkable latitudinal variability in the morphology of shelves and slopes (Trincardi et al., 2013). While the northern Adriatic is flat and shallow (average depth 70 m), the southern Adriatic between the Apulian platform to the W, and the MACM to the E, is relatively deep, up to 1200 m in the South Adriatic Depression (Fig. 1).

The MACM displays a double system of morphological scarps which bound the continental shelf (Del Bianco et al., 2014). The first scarp, between 100 and 130 m water depth, delimits the inner shelf, which reaches its minimum width (12–17 km) in the northern sector (Fig. 2). It widens toward south, reaching up to 45 km of width, where it is formed by the remnants of an abandoned lowstand delta (Del