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Large-scale single incised valley from a small catchment basin on the western Adriatic margin (central Mediterranean Sea)

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ABSTRACT

The Manfredonia Incised Valley (MIV) is a huge erosional feature buried below the Apulian shelf, on the western side of the Adriatic margin. The incision extends more than 60 km eastward, from the Tavoliere Plain to the outer shelf, not reaching the shelf edge. High-resolution chirp sonar profiles allow reconstruction of the morphology of the incision and its correlation at regional scale. The MIV records a single episode of incision, induced by the last glacial–interglacial sea level fall that forced the rivers draining the Tavoliere Plain to advance basinward, reaching their maximum extent at the peak of the Last Glacial Maximum. The valley was filled during a relatively short interval of about 10,000 yr during the Late Pleistocene–Holocene sea level rise and almost leveled-off at the time of maximum marine ingression, possibly recording the short-term climatic fluctuations that occurred. The accommodation space generated by the lowstand incision was exploited during the following interval of sea level rise by very high rates of sediment supply that allowed the preservation of up to 45 m of valley fill. High-resolution chirp sonar profiles highlight stratal geometries that are consistent with a typical transgressive valley fill of an estuary environment, including bay-head deltas, central basin and distal barrier-island deposits, organized in a backstepping configuration. The highest complexity of the valley fill is reached in the shallowest and most proximal area, where a kilometric prograding wedge formed during a period dominated by riverine input, possibly connected to high precipitation rates. Based on the depth of the valley margins during this interval, the fill was likely isochronous with the formation of sapropel S1 in the Mediterranean region and may have recorded significant fluctuations within the hydrological cycle.

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1. Introduction

Incised valley systems are common features in the geological record and several examples of them have been discovered and studied from Precambrian to modern shelf settings (Allen and Posamentier, 1993; Dyson and Von der Borsch, 1994; Ardies et al., 2002; Flood et al., 2009; Simms et al., 2010). In the last few decades several authors have focused on the study of incised valley systems as key elements in the identification of sequence boundaries and for their relevance as hydrocarbon reservoirs (Harms, 1966; Posamentier et al., 1988; Van Wagoner et al., 1988; Shanley and McCabe, 1994). Moreover, especially when referring to the Late Quaternary, incised valleys and their fills are particularly important as they may provide the only sedimentary record of lowstand intervals (Thomas and Anderson, 1994; Payenberg et al., 2006), giving the possibility to extend the investigation of climatic changes that occurred to glacial times (Simms et al., 2010).

Incised valley systems can be defined as elongated fluvially-eroded topographic lows characterized by a basinward shift of the depositional environments across a basal sequence boundary of regional extent (Zaitlin et al., 1994). Two kinds of mechanisms may lead the shelf to become exposed through a base level fall: eustatic falls or regional tectonic uplifts (Jervey, 1988). In both cases, during base level falls and consequent shelf exposure, fluvial systems migrate basinward eroding the shelf and evolve reorganizing their channel pattern (Schumm, 1993; Ethridge and Schumm, 2007; Martin et al., 2011). Beside base level fluctuations, the formation of incised valleys can also reflect two other factors: climatic changes, controlling the hydrological cycle and i.e. water discharge, and stream capture, leading to increased discharge in the resulting combined system (Thorne, 1994).

The formation of incised valleys during fourth order cycles (sedimentary cycles of ~100 kyr duration; Mitchum and Van Wagoner, 1991) is mainly driven by the rate and amplitude of sea level oscillations (Van Heijst and Postma, 2001): fluvial incision related to Type 1 sequence boundaries, when sea level falls beyond the shelf edge (Vail et al., 1984; Posamentier et al., 1988), leads to the best developed incised valley systems, which can extend from a highstand shoreline to the head of a slope canyon (Leeder and Stewart, 1996; Thieler et al., 2007). When a sea level fall does not reach the shelf edge, the fluvial incision is restricted to a portion of the shelf (Talling, 1998), leading to the formation of piedmont incised valley systems (sensu Zaitlin et al., 1994) atop of Type 2 sequence boundaries. Most examples of Quaternary valley systems are “compound-fill” incised valleys that reflect a polycyclic evolution, with multiple cycles of incision and infill driven by repeated

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base level changes (Gensous and Tesson, 1996; Reynaud et al., 1999; Burger et al., 2001; Greene et al., 2007).

Here we present a preliminary study of an extensive incised valley (Fig. 1), formed in the Apulian shelf (Gulf of Manfredonia, southwestern Adriatic Sea) through only one cycle of base level change (i.e., the Late Pleistocene–Holocene sea level fluctuation), buried by the Late Holocene highstand mud wedge, and fed by a small catchment basin, with the aim of understanding the role of high-frequency climate-driven processes in the evolution of the valley fill (Dalrymple and Zaitlin, 1994; Roy, 1994; Nordfjord et al., 2006; Billeaud et al., 2009).

2. Study area

2.1. Geological setting

The Gulf of Manfredonia flanks the eastern side of the Apulian Tavoliere, which belongs to the Bradanic Trough domain (Royden et al., 1987). The Apulian Tavoliere is 4300 km^2 wide and is limited by three mountain chains: the Mountains of Daunia to the west, the Gargano Promontory to the north and the Murge highlands to the south (Fig. 1). The Gargano Promontory and the Murge are two domains of the Apulian platform, representing the uplifted flexural outer bulge of the foreland of the westward subducting Adria Plate (Channell et al., 1979; Anderson, 1987; Doglioni et al., 1994). The Meso-Cenozoic succession of the Apulian Platform is composed by Triassic anhydrite–dolomite deposits covered by an alternation of shallow water carbonates and pelagic sediment (Zappaterra, 1990; Butler et al., 2004).

The geologic evolution of the southern Apennines started in the Lower Pliocene with the formation of the Bradanic Trough and evolved in two sedimentary cycles that reflect two geodynamic phases. The Bradanic Trough transgressive sedimentary cycle developed during the first phase, characterized by high subsidence rate (ca. 2 mm/yr) as a consequence of the westward subduction of the Adria Plate beneath the Apennine Chain (Doglioni et al., 1994). This sedimentary succession includes shallow marine carbonates (*Calcarenite di Gravina Unit*) and hemipelagic deposits (*Argille Subappennine Unit*). This cycle was

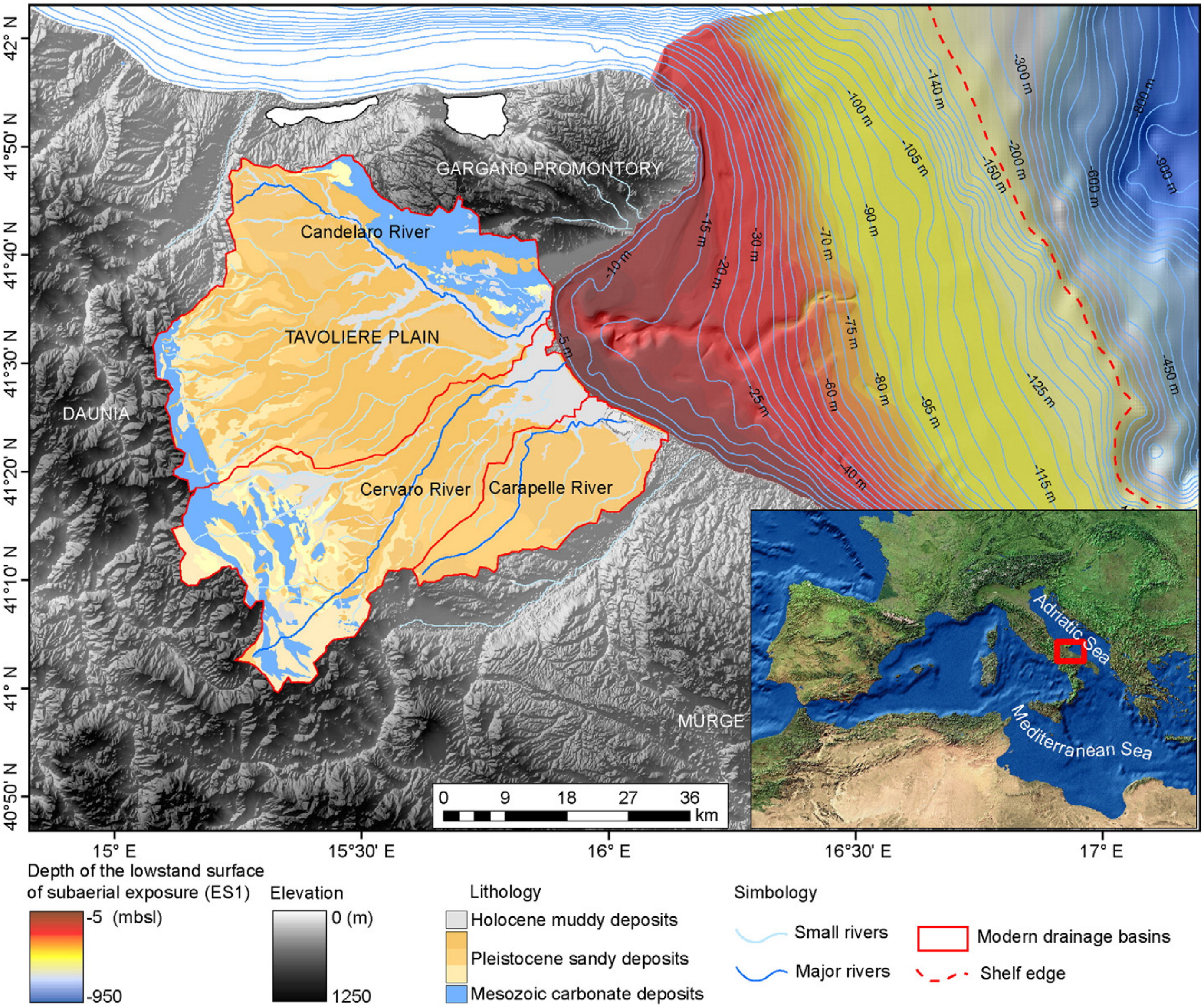

Fig. 1. Digital Elevation Model (DEM) of the study area. DEM derived from SRTM 90 m Digital Elevation Data (http://srtm.csi.cgiar.org), with dominant lithologies of the catchment area of the three main rivers draining the Tavoliere Plain and the Gargano Promontory (derived from http://www.sit.puglia.it/portal/sit_cittadino/Dati+Topografici/DTM). The depth of the reconstructed lowstand surface of subaerial exposure (ES1) is shown offshore. The bathymetric contours are spaced every 5 m from the shoreline to the shelf edge (red dashed line) and every 50 m toward the basin. Note the significant westward convexity of the -15 m bathymetric contour line.

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