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Anatomy of a compound delta from the post-glacial transgressive record in the Adriatic Sea

Claudio Pellegrini [a,b,*], Vittorio Maselli [a], Antonio Cattaneo [c], Andrea Piva [d], Alessandro Ceregato [a], Fabio Trincardi [a]

[a] ISMAR (CNR), v. Gobetti 101, 40129 Bologna, Italy
[b] University of Bologna, Dipartimento di Scienze della Terra e Geologico-Ambientali, Piazza di Porta San Donato 1, 40126 Bologna, Italy
[c] IFREMER, Géosciences Marines Centre de Brest, BP70, 29280 Plouzané, France
[d] Eni, Exploration and Production Division, Sedimentology, Petrography & Stratigraphy Dpt., 20097 S. Donato Milanese, Italy

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ABSTRACT

On the Mediterranean continental shelves the post-glacial transgressive succession is a complex picture composed of seaward progradations, related to sea level stillstands and/or increased sediment supply to the coasts, and minor flooding surfaces, associated with phases of enhanced rates of sea level rise. Among Late Pleistocene examples, major mid-shelf progradations have been related to the short-term climatic reversal of the Younger Dryas event, a period during which the combination of increased sediment supply from rivers and reduced rates of sea level rise promoted the formation of progradations up to tens-meter thick. While the documentation of coastal and subaqueous progradations recording the Younger Dryas interval is widely reported in literature, the model of compound progradation within transgressive deposits has not yet been proposed. Here we present the documentation of a deltaic system where both delta front sands and related fine-grained subaqueous progradations (prodeltaic to shallow marine) have been preserved. The Paleo Gargano Compound Delta (PGCD) formed offshore the modern Gargano Promontory (southern Adriatic Sea), and is composed of a coastal coarse-grained delta of reduced thickness and a muddy subaqueous clinoform, up to 30 m thick. The PGCD, probably the first worldwide documentation of a compound delta within the transgressive record, provides the opportunity to investigate the processes controlling the formation of a compound delta system during an overall sea level rise and the factors that allowed its preservation. The finding of the PGCD provides the opportunity for a comparison with modern worldwide compound systems.

1. Introduction

Modern and ancient river deltas represent one of the most intriguing sedimentary archives in the geological record, as their internal geometry and evolution reflects the interplay between river dynamics, sediment availability, grain size distribution and the oceanographic regime of the receiving basin (Orton and Reading, 1993; Cross et al., 1993; Trincardi et al., 2004; Slingerland et al., 2008). After the first process-driven classification of Wrigth and Coleman (1972), and Galloway (1975), another important step in understanding delta dynamics was introduced with the concept of compound deltas (Swenson et al., 2005), i.e., deltas composed by shallow-water progradations that are genetically related to deeper subaqueous clinothemes. The transition in grain-size, mostly related to the oceanographic regime of the basin, is also reflected by the overall geometry, characterized by two main roll-over points (i.e., breaking in slope at the topset/foreset transition; Swenson et al., 2005; Cattaneo et al., 2007; Walsh and Nittrouer, 2009). The depth of the subaqueous rollover point is assumed to reflect the seaward limit beyond which wave-current shear stress decreases allowing sediment deposition (e.g., Nittrouer et al., 1986; Kuehl et al., 1986; Alexander et al., 1991; Pirmez et al., 1998; Walsh et al., 2004).

Along the western Adriatic basin, the modern highstand deposits are organized in shelf-wide progradations that locally show variations in the stratal geometry; from North to South on bidimensional profiles it is possible to identify: 1) a single rollover point, where the delta front and the prodelta are "attached" (Fig. 1 section A–A′); 2) two rollover points (coastal and subaqueous rollover point), where the delta front and the prodelta are separated, and their distance is governed by the oceanographic regime (Fig. 1 section B–B′, the 2D compound delta); 3) a single subaqueous rollover point where the subaqueous delta disconnected from the delta front (Fig. 1 section C–C′, purely subaqueous delta). In a section parallel to the modern shoreline from the modern Po River delta down to the Gargano Promontory, the Adriatic subaqueous clinoform has been interpreted as a "distorted" compound system (Fig. 1 section D–D′; Cattaneo et al., 2007).

The understanding of the physiographic parameters of the compound system is crucial to explaining the main processes and physical

* Corresponding author at: ISMAR (CNR), v. Gobetti 101, 40129 Bologna, Italy.
E-mail address: claudio.pellegrini@bo.ismar.cnr.it (C. Pellegrini).

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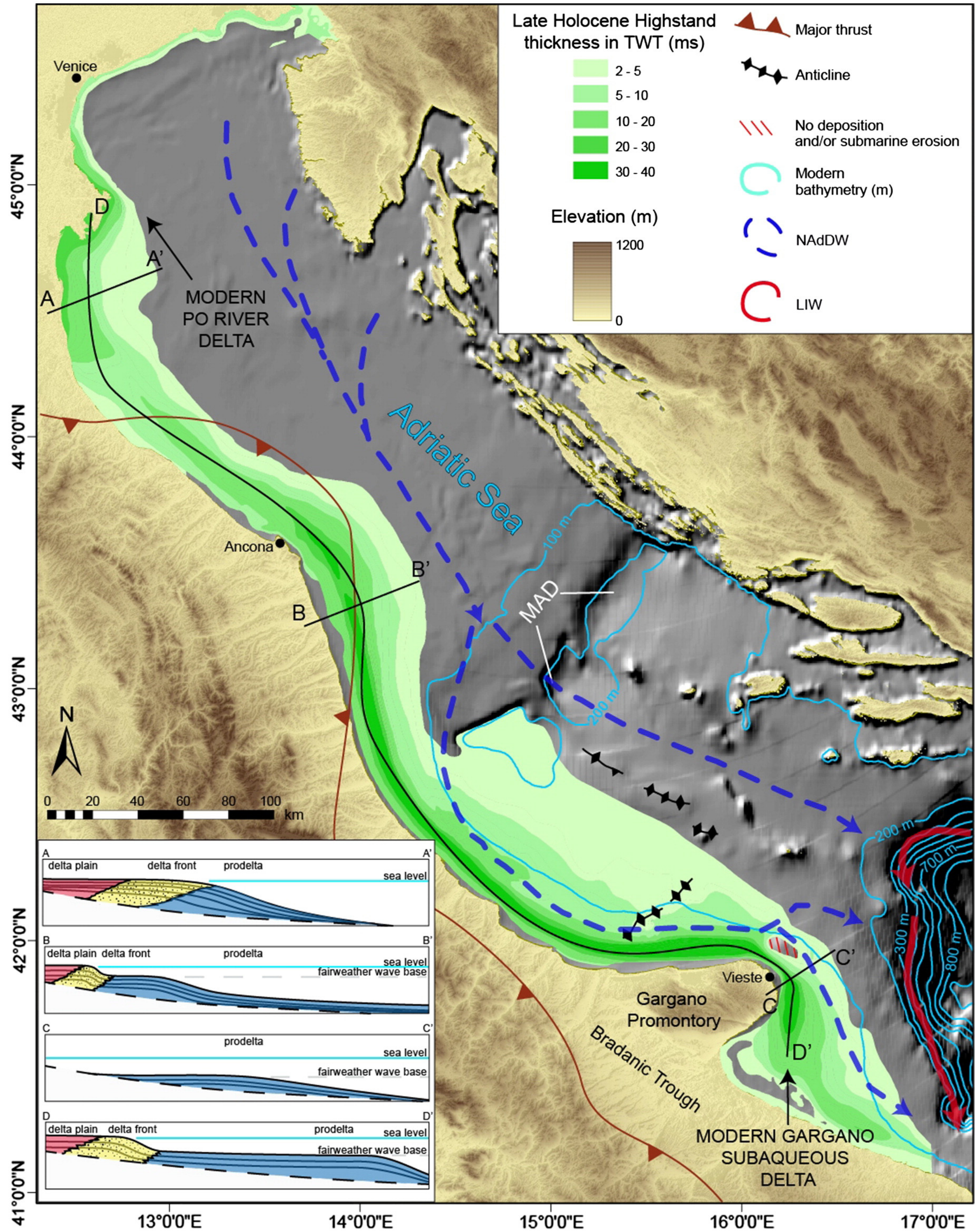

Fig. 1. Thickness distribution of the Late-Holocene HST wedge (from Correggiari et al., 2001; Cattaneo et al., 2007). Note the area of no deposition NE of Gargano Promontory. The bathymetry of the Adriatic is from Trincardi et al. (2013) and is shown with a 100 m contour on a DTM. The pathways of the NAdDW and LIW currents are highlighted by a blue dashed line and a dark red line, respectively. Bottom left: schematic stratigraphic sections illustrating the difference in delta configurations seaward of the Italian coast. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

laws that govern a couplet progradation (Patruno et al., 2015). Steckler et al. (1999) noticed that a subaqueous clinoform may prograde simultaneously with the costal delta system depending on the oceanographic regime of the receiving basin; Swenson et al. (2005) highlighted that such genetically-connected clinoforms (coastal and subaqueous) may be geometrically disconnected depending on fair-weather and storm wave bases (10/15 m to 30 m water depth, respectively; Cattaneo et al., 2003) exhibiting a dominantly along-shore thickness distribution and a typical convex seaward morphology (Cattaneo et al., 2003). Examples of compound delta systems may be found in both open ocean settings and enclosed basins: e.g., Amazon River, (Nittrouer et al., 1996); Ganges–Brahmaputra River (Goodbred and Kuehl, 2000); Yellow River — Shandong subaqueous clinoform (Liu et al., 2004); and Po River — Gargano subaqueous delta (Cattaneo et al., 2003). Furthermore,