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Contrasting slope channel styles on a prograding mud-prone margin

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ABSTRACT

The Pleistocene slope clinoform succession of the Pescara Basin foredeep (Central Adriatic Basin, Italy) has been investigated combining the analysis of the rollover point trajectories with 2D seismic facies analysis and 3D seismic geomorphology approach and visualization techniques. The study documents two different types of slope clinoforms, each of which is characterized by a specific slope turbidite system with distinctive morphologies, internal geometries and architectural elements.

Type 1 clinoforms are characterized by rectilinear, slope-confined gullies which develop during a phase of margin growth. Type 1 clinoforms are characterized by a rise of the trajectories of the rollover points, which can be indicative of intervals of relative sea level rise. In type 1 clinoforms most of the coarse-grained sediments are stored in the shelf. The slope-confined gullies barely indent the shelf break, are not connected to rivers, and develop thin (<30 m) frontal splays at the base of the slope. All these evidences indicate that the gullies are inefficient pathways to transfer sandy sediment basinward. The gully depressions are net-erosional and also the inter-gully sectors are sites of dominant sediment bypass. The infill deposit of the gullies consists of channel-wide high-amplitude reflectors (HARs) wedging-out downslope. The origin of the slope-confined gullies is interpreted to be linked to mass wasting processes affecting the upper slope and the shelf-edge during conditions of relative sea level rise. Longshore drifts and storm-driven turbidity currents rework the outer shelf, promoting the maintenance of gully systems, which become filled during the ensuing high-stand of the sea level.

Type 2 clinoforms are characterized by a negative trajectory of the rollover points, and develop during a lowering of the sea level and during lowstand periods. Type 2 clinoforms develop sinuous, aggradational slope channels which are river-connected, with incised valleys that supply sediment directly to the head of the slope channel. The slope channels are fed through sustained turbidity currents possibly associated with hyperpycnal flows. Type 2 slope channels develop in a net-aggradational setting, forming erosive based channel-fill deposits about 150 m thick which are characterized by high-amplitude reflectors (HARs). Type 2 slope channels are able to transfer larger amount of sediment to the basin, comparing with type 1 gullies, as the presence of thick (~150 m) channelized frontal–splay complexes seems to confirm. The combination of 2D and 3D data analysis has lead to the reconstruction of a sedimentological model which has the potential to be applied as analogue for seismic or outcrop-based studies of slope channels in supply-dominated, mud-prone margins.

1. Introduction

Understanding of the sedimentary processes responsible for clastic sediment transfer across continental shelves to the continental slope and beyond, represents the key for the development of exploration-oriented sedimentary models of continental margin evolution (Badalini et al., 2000; Posamentier and Kolla, 2003; Gee et al., 2007; Hubbard et al., 2010; Romans et al., 2011; Arnott et al., in this issue). The processes that govern the transport of sediment along modern continental slopes have been studied for decades using 2D seismic reflection data, showing that distinct slope clinoform geometries and seismic facies reflect the prevalence of specific sedimentary processes operating during different phases of the sea level cycle (Fulthorpe and Austin, 1998; Bullimore and Helland-Hansen, 2009; Plink-Björklund and Steel, 2002; Covault et al., 2007; Carvajal and Steel, 2009; Georgiopoulou and Cartwright, in this issue).

Early studies based on 2D seismic data are concentrated either on the growth of progradational margins, with emphasis on their internal stratal geometries, or on the evolution of major incised

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valleys and deep-sea channels as main pathways of sediment to the deep-sea. Since the late 90's the opportunity for the academia to access high-quality 3D seismic data across several subsurface study areas led to greatly improve the understanding of deep water turbidite systems, revealing significant differences in their external morphology and in their internal architecture (Kertznus and Kneller, 2009; Mayall et al., 2006; Clark and Cartwright, 2011; Etienne et al., 2013; Janocko et al., 2013; Thomas and Bodin, 2013).

Quantitative seismic geomorphology analysis coupled with seismic attribute maps, has led to the development of conceptual models for continental slope deposits and the development of tools for the prediction of their spatial facies associations and their temporal evolution (*e.g.* Weimer and Davies, 1996; Helland-Hansen and Hampson, 2009; Kertznus and Kneller, 2009; Henriksen et al., 2010).

In this article we present the study of a Pleistocene slope clinoforms succession located in the Pescara Basin (PB) foredeep (Central Adriatic Sea – Italy, Fig. 1a, b). By combining analysis of the rollover point trajectories, 2D seismic facies and 3D seismic geomorphology, two markedly different types of slope depositional systems have been recognized and seen to alternate each other cyclically. These two types of slope depositional systems, in the lack of dating of the studied succession, reflect distinctive sediment supply and climatic regimes, although the observed geometries are interpreted to be mainly related with relative sea level variations. The external geometries and the internal architectural elements of the distinctive turbidite systems in each of the clinoforms types of the PB have been investigated to obtain a general sedimentological model for submarine channel developed in high-supply, mud-prone, continental margins.

2. Geological setting

The Pescara Basin (PB) represents the Lower Pliocene to Upper Pleistocene foredeep of the Central Apennines (Fig. 1a, b, c). Overall, since the Lower Pliocene, the PB foredeep has been filled with about 5 km of turbidites derived from the erosional dissection of the Apennine chain (Ori et al., 1991). The infill of the PB has been divided into four stages marking different basin settings, due to variations in tectonic activity and sediment supply regime (Fig. 1c). The first three stages are characterized by high-subsidence rates and intense thrust activity, that led to basin fragmentation through the formation of several structural highs (Ricci Lucchi, 1986; Ori et al., 1991). Beginning in the Lower/Middle Pleistocene, the PB foredeep fill has recorded the cessation of the tectonic activity with a decrease in the rate of subsidence, favouring a more progradational setting which resulted in the deposition of a slope clinoform wedge, which is the focus of this study (Early phase 4 *sensu* Ori et al., 1991) (Figs. 1c and 2a). The increased rate of progradation of the margin reflects both a decreased subsidence rate and the increase in sediment input through a number of rivers that dissect the Apennines reaching the Adriatic Sea, analogous to the modern Adriatic coast (Maselli et al., 2010). The excess in sediment supply generated the prograding complex that progressively healed-out the foredeep structures. The late stage of Phase 4 (Fig. 1c) is associated with a shallow-water sedimentation resulting in the Pleistocene to

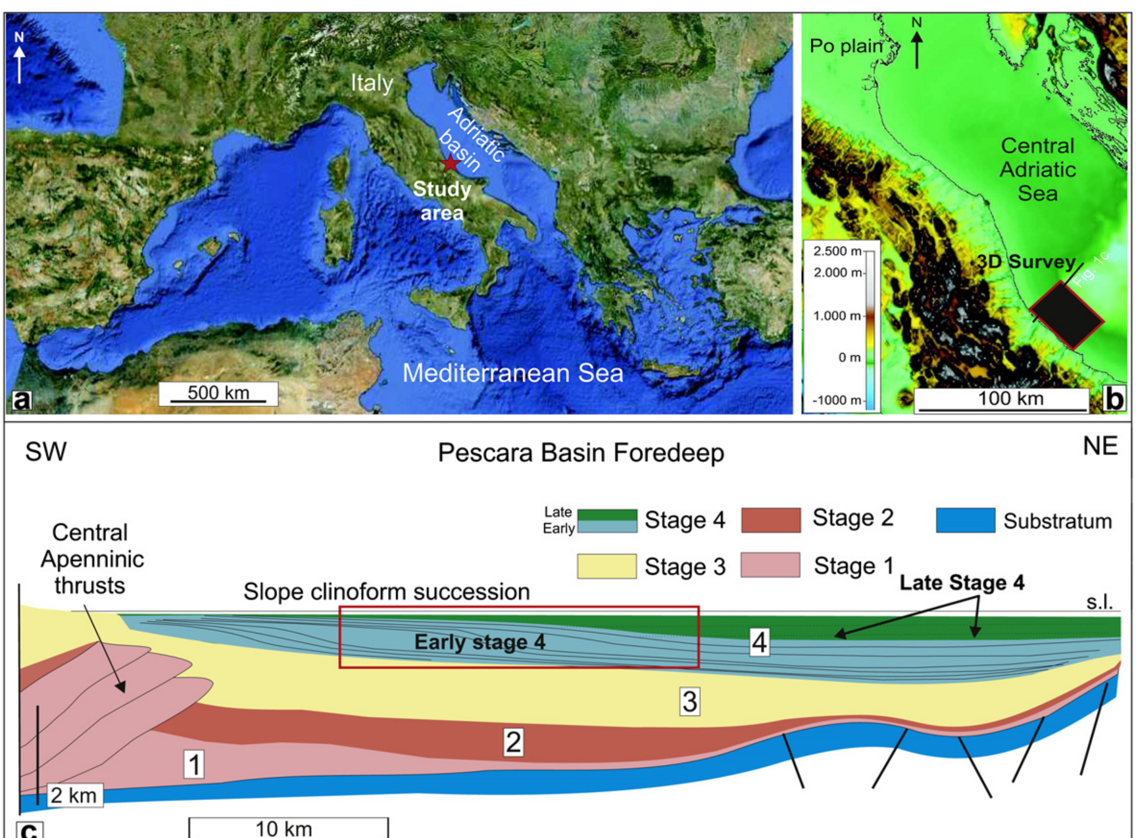

Figure 1. (a) Line drawing, from seismic profile, showing the schematic stratigraphy of the PB foredeep (modified from Ori et al., 1991). The substratum corresponds to pre-Messinian deposits. The red box indicates the slope clinoforms investigated in this work; (b) Digital Terrain Model of the Central Adriatic sea showing the location of the 3D seismic survey of Eni in the Pescara Basin foredeep (boxed area). The black line locates the line drawing of fig. 1a. (Combined Topography and Bathymery from: http://www.ngdc.noaa.gov/). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)