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An outer ramp to basin plain transect: Interacting pelagic and calciturbidite deposition in the Eocene–Oligocene of the Tuscan Domain, Adria Microplate (Italy)

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ABSTRACT

The interaction of ramps, basin plains and turbidite systems on the scale of tens of km has been rarely observed in fossil examples. Deep marine Eocene–Oligocene beds are exposed in the axial zone of the Chianti Mountains, Italy, and compose a regionally continue stratigraphic succession known as the Scaglia Toscana Formation. The formation was deposited in the Tuscan Domain of the Adria Microplate. This research aims at depicting its depositional architecture and evolution in the type area. Stratigraphic and sedimentologic analyses were performed on a ca. 25 km-long transect that includes depositional systems sectioned both in the down- and along-dip directions. Shaly-carbonate deposits compose a complex of interacting ramps, basin plains and turbidite floor fan systems. Ramp deposits accumulated above the lysocline and in oxic conditions. Basin plain beds were deposited below the lysocline and were subject to episodes of oxygen depletion. Turbidity flows fed elongate fan lobes characterized by poor channelisation. The basin palaeogeography hampered the development of slope apron turbidite systems.

The Eocene–Oligocene geodynamic setting of the Tuscan Domain was characterized by the evolution of a peripheral bulge and by the early structuring of a foredeep basin. Syn-sedimentary tectonism acted a primary role in the basin-scale arrangement. However other mechanisms also contributed to the local facies distribution, including the disposition of sediment-source areas and intrabasinal confinement morphologies, as well as relative oscillations of the depositional surface with respect to the lysocline and oxycline.

1. Introduction

Deep marine settings characterized by interacting outer ramps and turbidite fans are inadequately documented (Markello and Read, 1981; Hurst and Sheehan, 1985), despite their remarkable potential as oil reservoirs (Mazzullo and Chilingarian, 1992; Al-Husseini, 1997; Van Geet et al., 2002). This gap stems from a lack of fossil examples and modern analogues. Documentation of modern carbonate submarine fans is for instance still lacking (Payros et al., 2007; Payros and Pujalte, 2008). The occurrence in the fossil record is also scattered, since calciclastic submarine fans are commonly substituted by aprons (Mullins and Cook, 1986). The depositional systems in outer ramp settings are also not fully understood (Burchette and Wright, 1992): as remarked by Pawellek and Aigner (2003), the abundance of studies examining shallow inner ramps (Wright and Burchette, 1998; Pomar, 2001) contrasts with the lack of focus on outer equivalents. Notable exceptions are given by Calvet and Tucker (1988), Pedley (1992), El gadi and Brookfield (1999) and Bádenas et al. (2003).

The Eocene–Oligocene of the Adria Microplate is suitable for the study of interacting ramps and deep marine settings (Royden et al., 1987). The fragmented plate margin was articulated in a series of carbonate platforms and basins. In present day, these are exposed in a suite of peri-Mediterranean orogenic belts that include the Southern Alps, the Northern Apennines and the Dinarides (Vlahović et al., 2005). This study sheds new light on the subject, by documenting the interaction of outer ramps, basin plains and turbidite systems within the Eocene–Oligocene shale and carbonate successions of the Scaglia Toscana Formation in the Chianti Mountains, Northern Apennines, Italy (Figs. 1, 2). Since the 1960s, pioneering studies documented the heterogeneous stratigraphy of the unit (Nocchi, 1960; Canuti et al., 1965), which is characterized by a southward and upward transition from ramp and basin plain to turbidite facies (Fig. 3). Nonetheless, a comprehensive basin-scale architectural depiction of the unit is still lacking, and represents the goal of the present study. This will be assessed by means of: (1) geometric characterization of architectural elements, (2) description and interpretation of sedimentary facies, (3) reconstruction of a physical stratigraphic and architectural framework. The above-mentioned points will be discussed in terms of depositional setting, geodynamic framework and palaeogeography. It will be

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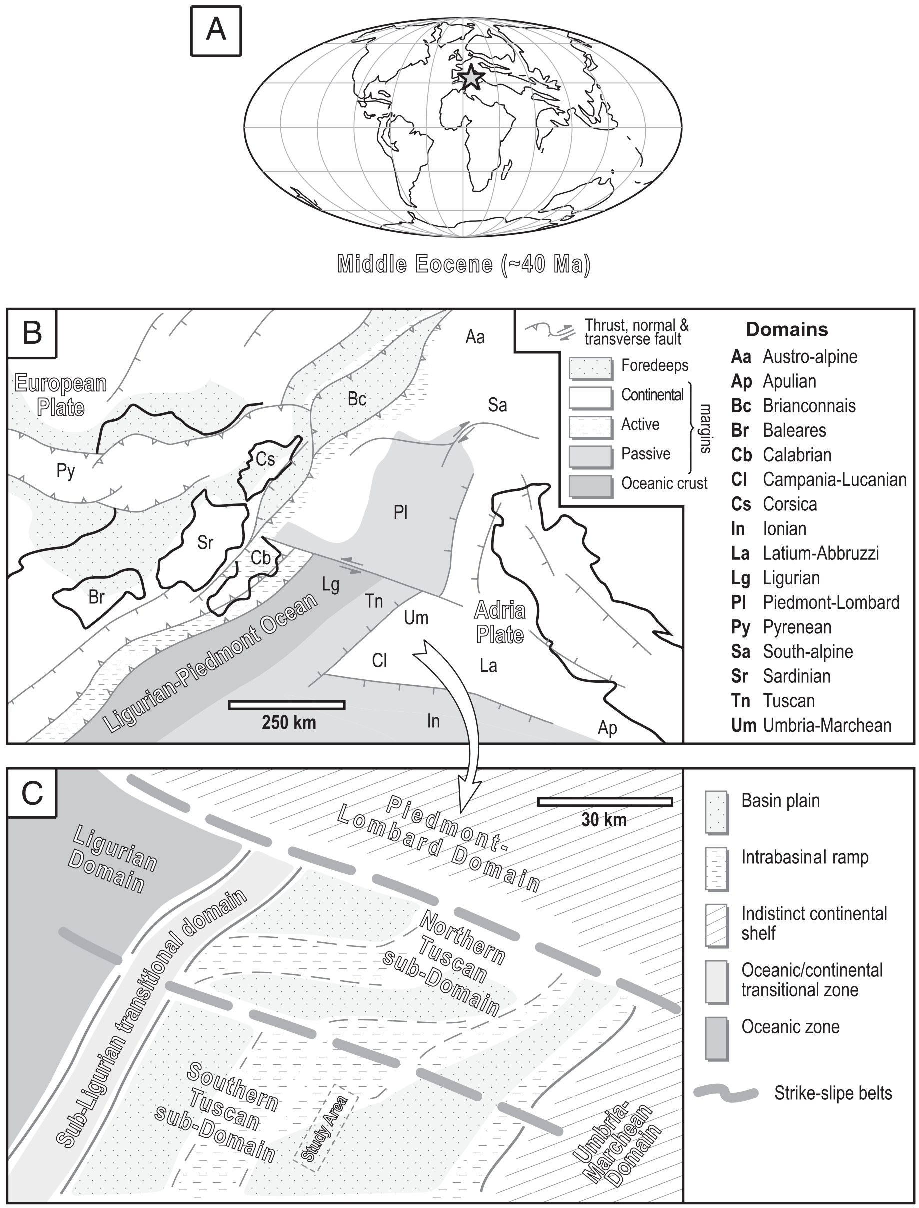

Fig. 1. Geological setting of the study area in the Eocene-Oligocene. **A**. Global palaeogeography during the middle Eocene time. The grey star indicates the location of the study area. **B**. Geodynamic framework of the Adria passive margin and surrounding areas (modified from Stampfli and Hochard, 2009). **C**. General palaeogeography of the Tuscan Domain and surroundings (modified after Fazzuoli and Sguazzoni, 1986). A more detailed palaeogeographic setting integrating the results of this research is reported in Fig. 17.

demonstrated how syn-sedimentary tectonism primarily governed the basin-scale structuring. In addition, it will be stressed how the local facies distribution responded to different forcing mechanisms that include the occurrence of inherited basinal morphologies, and fluctuations of the depositional surface with respect to the lysocline and oxycline.

2. Regional setting

The Eocene–Oligocene beds treated in this study are part of a thicker Triassic–Miocene succession that accumulated in the southern sector of the Tuscan Domain (Fazzuoli et al., 1994; Fig. 1). This palaeogeographic domain, part of the Adria Microplate passive margin (Channel et al., 1979; Bradley, 2008), underwent a diachronic uprooting and northeastward displacement during an early-middle Miocene orogenic phase (Carmignani et al., 2001, 2004; Stampfli and Hochard, 2009), and is now exposed in the Northern Apennines hinterland and axial range. The Scaglia Toscana Formation type-area is in the axial zone of the Chianti Mountains (Merla, 1968; Fig. 2A), where it constitutes the core of a dissected NE-verging anticline (Bonini, 1999; Cornamusini et al., 2011; Fig. 2). The formation is composed of up to 200 m of pelagic shales, marls and limestones. Its stratigraphic hierarchy remained controversial in the past decades, due to a marked internal heterogeneity (Fig. 3). Recently, Cornamusini et al. (2012; Fig. 3) individuate four members, namely (abbreviated forms in brackets): 1. Sugame Marlstones Member (Sugame Mb.); 2. Cintoia Shales Member (Cintoia Mb); 3. Montegrossi Calcarenites Member (Montegrossi Mb.); and 4. Dudda Shales and Limestones Member (Dudda Mb.). Regional biostratigraphic data indicate that the deposition of the Sugame, Cintoia and Montegrossi members was at least partly coeval (Nocchi, 1960; Canuti et al., 1965; Bambini et al., 2009; Ielpi, 2009), highlighting a diachroneity of the member boundaries.

The Scaglia Toscana Formation overlies a Mesozoic abyssal succession (Brolio Shales in Canuti et al., 1965; Canuti and Marcucci, 1967; Marcucci et al., 1994; Pignotti, 1994; Fazzuoli et al., 1996; Fig. 1C), and is topped by Chattian–Aquitanian foredeep siliciclastic turbidites (Macigno Formation; Ferrini and Pandeli, 1983; Cornamusini et al., 2002; Cornamusini, 2004a; Fig. 2B). A hiatus spanning from the late