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Late Cretaceous extensional tectonics in Adria: Insights from soft-sediment deformation in the Sorrento Peninsula (southern Apennines)

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ABSTRACT

In this work we document a well-exposed example of Late Cretaceous syn-sedimentary extensional tectonics occurring in carbonates of the Apennine Platform of the southern Apennines. Soft-sediment deformation meso-structures and breccia bodies in the hanging wall of hundred metres long faults record a Late Cretaceous extensional stage along NE-SW striking faults. Such a trend becomes about E-W when Cenozoic vertical axis rotation is removed, being consistent with similar structures previously reported in other domains of the southern portion of Adria. This study contributes to identify a regional Albian to Late Cretaceous extensional pulse in the southern portion of Adria, which is proposed to be responsible for the drowning of several sectors of the continental bridge that connected Africa with Adria until Late Cretaceous times, and for the development of an E-W elongated basin that connected the Ligurian and Ionian seas from Late Cretaceous onwards.

1. Introduction

Differentiation of a formerly unique Triassic intracratonic carbonate platform into a suite of carbonate platforms and pelagic basins occurred from the Late Triassic to the Early Jurassic in a vast domain presently occupying the central Mediterranean area (Ogniben, 1969; D'Argenio et al., 1975; Sgrosso, 1988; Zappaterra, 1994; Mostardini and Merlini, 1986; Vlahović et al., 2005; Patacca and Scandone, 2007), as a result of the breakup of Pangea and initial development of the Neo-Tethys Ocean. Different paleogeographic domains, incorporated into the Adria continental paleomargins, lasted until the Late Cretacous, when the area was progressively involved into the Alps-Apennines-Dinarides orogenic system (e.g. Cello et al., 1982; Oldow et al., 1993; Dewey et al., 1989; Mazzoli and Helman, 1994). Large uncertainties exist about the pre-orogenic configuration of Adria and of the surrounding Ligurian and Ionian arms of the Neo-Tethys Ocean. An impressive number of paleogeographic reconstructions have been proposed for the area (e.g. Channell et al., 1979; Lowrie, 1986; Savostin et al., 1986; Ziegler, 1988; Platt et al., 1989; Catalano et al., 2001; Muttoni et al., 2001; Wortmann et al., 2001; Bosellini, 2002; Cavazza et al., 2004; Rosenbaum et al., 2004; Stampfli and Borel, 2004; Patacca and Scandone, 2007; Johnston and Mazzoli, 2009; Schettino and Turco, 2011; Roure et al., 2012; Carminati et al., 2012; Vitale and Ciarcia, 2013), which can be summarised in two competitive end-member models defining Adria as either a Mesozoic promontory of Africa (e.g. Argand, 1924; Channel, 1996; Muttoni et al., 2001; Zarcone et al., 2010) or as an independent microplate (e.g. Decourt et al., 1986; Anderson, 1987; Catalano et al., 2001; Finetti, 2005), which would have been divided from Africa by an active oceanic ridge that was possibly aborted during Late Cretaceous-Early Tertiary (Catalano et al., 2001). In essence, the debate focuses on whether – and in case when and by what type of crust – the Ligurian and Ionian seas were connected (Fig. 1). The cause of this ongoing debate lies in several reasons, including the fact that: (i) no direct information exists on the nature of the Ionian crust; (ii) the entire Ligurian oceanic crust has been subducted or incorporated into the Alps-Apennines-Dinarides orogenic system, almost synchronously with the tectonic dismemberment of the area that should have formed either the link between the two oceans or the bridge between Africa and Adria (Fig. 1) (e.g. Dewey et al., 1989; Cello and Mazzoli, 1999; Muttoni et al., 2001; Johnston and Mazzoli, 2009). This situation allows for a large degree of freedom in the restoration of the different paleogeographic domains of Adria, an uncertainty that can be partially reduced by integrating different datasets. In particular, various studies reporting dinosaur records, such as bones and tracks, in central and southern Italy (Zarcone et al., 2010 and references therein) suggest that a continental bridge between the Africa and Adria realms existed during the Jurassic-Cretaceous interval. On the other hand, stratigraphic evidence indicates that during the

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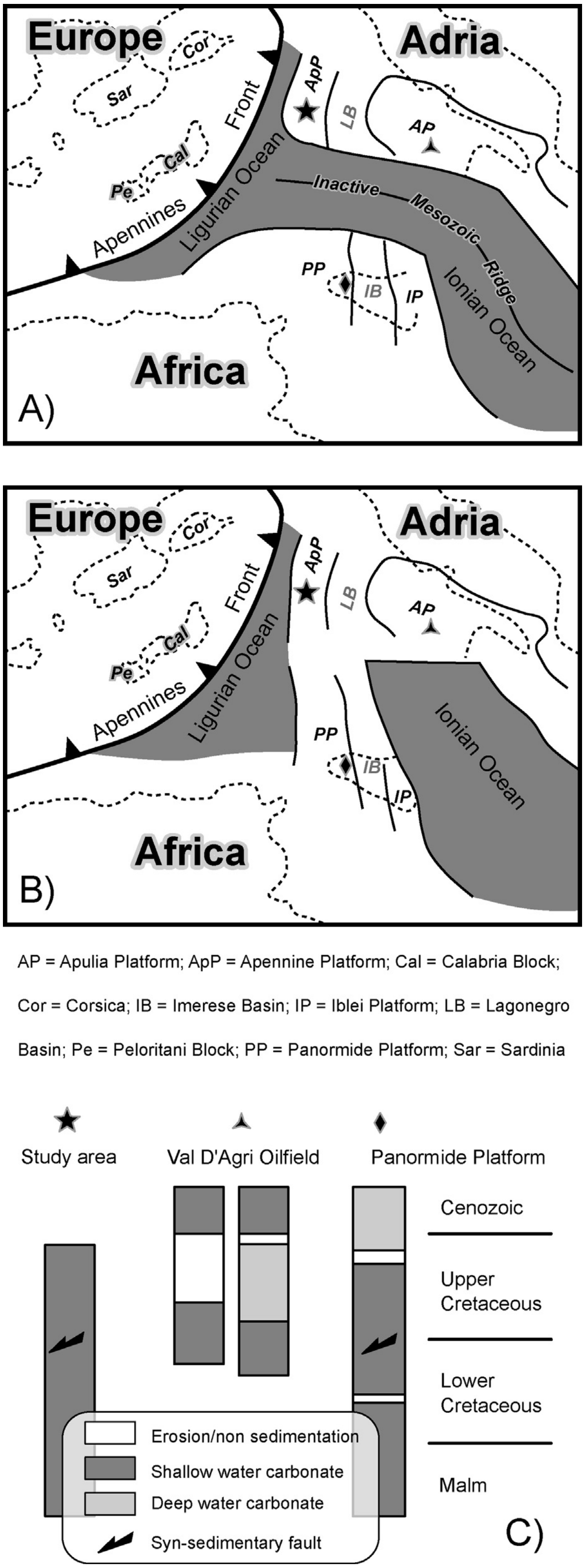

Fig. 1. End-member plate tectonic models for Adria in Paleogene times (modified from Muttoni et al., 2001). (A) The Ionian and Ligurian oceans are linked, thus Adria is an independent microplate (i.e., assuming Paleogene spreading in these oceanic domains). (B) The two oceans are unconnected, therefore Adria is a promontory of Africa. (C) Synthetic stratigraphic successions for areas discussed in the text (shallow- and deep-water sediments, and syn-sedimentary faults indicated).

Cenozoic, the Ligurian/Maghrebian Flysch Basin, located to the W of the supposed bridge, and the Lagonegro-Molise/Imerese Basin located to the E were connected by a deep channel (Vitale and Ciarcia, 2013; Vitale et al., 2013). Development of such a connection could partially relate to the drowning associated with the flexure of the Adria lithosphere ahead of the advancing Apennine belt (e.g. Roure et al., 2012). However, the persistence of shallow-water conditions in areas located at similar distances from the belt, indicate that flexuring alone cannot be responsible for the development of a roughly belt-perpendicular deep channel. These data witness for the existence of a Jurassic-Cretaceous continental bridge, which no longer existed during the Cenozoic (Vitale et al., 2013). A possible timing for the drowning of such a bridge is provided by stratigraphic data from the so-called Panormide Platform (which formed part of the inferred bridge). An Albian extensional pulse has been reported in this area (Bertok et al., 2012). This carbonate platform, starting from the uppermost Cretaceous, was affected by severe subsidence since the latest Cretaceous, as indicated by the deposition of a pelagic carbonate succession (Amerillo Formation; Grasso et al., 1978; Accaino et al., 2011) on top of shallow-water carbonates. This was roughly coeval with the emergence, and subsequent karstification, of further sectors of this carbonate platform (e.g. Dewever et al., 2010). However, the hypothesis of a Late Cretaceous drowning of the continental bridge is not yet corroborated by structural constraints. In particular, it is not yet defined whether the drowning of sectors of the Panormide Platform had a local or regional cause, the latter being a necessary condition for assuming a Late Cretaceous drowning of large portions of the continental bridge. Furthermore, while Late Triassic–Early Jurassic rifting and Cenozoic convergence have both left a clear imprint in the tectono-stratigraphic architecture of the southern portion of Adria, this region has been considered for a long time as almost tectonically stable in the time interval between these two main tectonic pulses.

The aim of this work is to contribute to a better understanding of the Cretaceous tectonics of Adria, by documenting an exceptionally well-exposed example of Albian syn-sedimentary extensional deformation in Apennine Platform carbonates (southern Apennines), an area that was forming part of the south-western portion of Adria (Fig. 1). Timing, trends and significance of extensional structures reported in this work are discussed and compared with other sparse evidence of Cretaceous tectonics reported from the Adria domain, in order to obtain a comprehensive picture of the extensional episode that took place during the Late Cretaceous in the southern portion of Adria and that eventually led to the drowning of the continental bridge previously linking Adria and Africa.

2. Geological setting

The outcrop investigated in this work is located in the Sorrento Peninsula (Fig. 2). It is located few tens of km to the SE of a major Albian breccia body, firstly described by Guzzetta (1963) and recently interpreted as being related with the occurrence of an Albian extensional fault (Iannace et al., in press). Similarly to most fold and thrust belts in the world, the study area has been characterised by a long and poly-phase deformation history. Until Middle Miocene times it formed part of the south-western portion of the undeformed Adria block, flanking to the east the growing Apennine fold and thrust belt (Vitale and Ciarcia, 2013). In the southern Apennine area, the continental paleomargin of Adria included the Lagonegro-Molise pelagic basin as well as the Apennine and Apulian carbonate platforms (Ogniben, 1969; Pescatore and Tramutoli, 1980; Mostardini and Merlini, 1986; Vitale and Ciarcia, 2013) originally located to the west and to the east of the basin, respectively (Fig. 1). These paleogeographic domains were incorporated, in Miocene times, into the E-directed southern