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Sedimentology, faunal content and pollen record of Middle Pleistocene palustrine and lagoonal sediments from the Peri-Adriatic basin, Abruzzi, eastern central Italy

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ABSTRACT

A 25 m-thick outcrop section exposed at Torre Mucchia, on the sea-cliff north of Ortona, eastern central Italy, comprises a rare Middle Pleistocene succession of shallow-water and paralic sediments along the western Adriatic Sea. An integrated study of the section, including facies and microfacies analyses, and characterization of paleobiological associations (mollusks, fishes, ostracods, foraminifers and pollen), enable a detailed reconstruction of the paleoenvironmental and paleoclimatic conditions during deposition. The shallow-water deposits include a transgressive, deepening- and fining-upward shoreface to offshore-transition facies succession overlain by a regressive shoreface-foreshore sandstone body with an erosive base and a rooted and pedogenically altered horizon at the top that imply deposition during sea-level fall. This forced regressive unit is overlain by paralic strata forming a transgressive succession comprising palustrine carbonates and back-barrier lagoonal mudstones. The palustrine carbonates exhibit some of the typical features encountered in palustrine limestones deposited within seasonal freshwater wetlands (marl prairies). Following the sea-level rising trend, the freshwater marshes were abruptly replaced by a barrier-lagoon system that allowed deposition of the overlying mud-rich unit. Within these deposits, the faunal assemblages are consistent with a low-energy brackish environment characterized by a relatively high degree of confinement. The pollen record documents the development of open forest vegetation dominated by *Pinus* and accompanied by a number of mesophilous and thermophilous tree taxa, whose composition supports a tentative correlation with Marine Oxygen Isotope Stage 17. The new pollen record from Torre Mucchia improves our understanding of the vegetation development in the Italian Peninsula during the Middle Pleistocene and sheds new light on the role played by the most marked glacial periods in determining the history of tree taxa.

Introduction

Nearshore, palustrine, and lagoon systems are very sensitive to variations in sea level and/or sediment availability and their sediments represent ideal targets to assess past and present climate changes (e.g. Rossi et al., 2011; Amorosi et al., 2012, 2013; Sarti et al., 2015). The present contribution illustrates and interprets for the first time the paleontological content of nearshore and paralic strata exposed at the top of the middle Pleistocene Qm2 Unit in eastern central Italy. The studied section is the richest source of paralic mollusk, fish, and pollen assemblages documented so far in the Middle Pleistocene of the western Adriatic Sea and provides a rare opportunity to increase the modest knowledge available on these faunas and floras.

A 25 m-thick outcrop section of shallow-water and paralic sediments was studied through a multidisciplinary approach involving a detailed description of sedimentary facies and analysis of micropaleontological (planktonic and benthic foraminifers, ostracods and pollen) and macropaleontological (mollusks and

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fishes) fossil assemblages. Identification of this fauna and flora has significance for understanding the overall paleoecological settings and climatic conditions in which these sediments were deposited.

Geological setting

The central Apennines are part of an E-NE verging fold-and-thrust belt built up since the Late Oligocene in response to the westward subduction of the Adria micro-plate (i.e., a promontory of the Africa Plate) underneath the European Plate (Malinverno and Ryan, 1986; Ricci Lucchi, 1986; Doglioni, 1991). Progressive tectonic accretion and loading of subducting lithosphere in the Apennine subduction complex (Doglioni, 1991) resulted in the development of a highly articulated foreland basin system at the front of the chain, filled up by relatively thick, diachronous turbidite successions (Ricci Lucchi, 1986). Thrust fronts propagated toward the foreland, involving progressively younger and easternmost foredeep deposits into the orogenic wedge and, at the same time, gradually shifted the depocenters of both foredeep and wedge-top basins further to the east (i.e., Ricci Lucchi, 1986; Ori et al., 1991; Artoni, 2013). The Plio-Pleistocene Peri-Adriatic foredeep records the latest evolutionary stages of the Apennines chain and extends from the Po Plain to the north to the Gulf of Taranto to the south (Fig. 1A). During the latest Miocene to Pleistocene time interval the shape of the central portion of the Peri-Adriatic foredeep, also known as the Pescara depocenter (Ghielmi et al., 2013), was affected by a large variability in space through time, ranging from regular elongated shape to irregular shape, from simple foredeep to fragmented foredeep (Ori et al., 1991). The Quaternary depositional and structural history of this central portion is framed into a large-scale sequence-stratigraphic scheme (Cantalamessa et al., 1986). Specifically, within the traditional subdivision into Quaternary marine (Qm) and Quaternary continental (Qc) unconformity-bounded stratigraphic units, regionally correlatable unconformities divide the Quaternary portion of the basin fill into three major allogroups (Qm1, Qm2, and Qc from oldest to youngest). The unconformities separating these units are well recognizable along the basin margins and document the combined effects of global climate changes and phases of basin reorganization linked to the effects of long-term and regional-scale tectonics (e.g., Ori et al., 1991; Artoni, 2013; Bigi et al., 2013). Overall, these allogroups record a pronounced regressive trend recorded by an upward progression from slope and shelf mudstones of Qm1 (Cantalamessa et al., 2009; Di Celma et al., 2010, 2013, 2014, 2016a; Di Celma, 2011) through littoral sandstones and conglomerates of Qm2 (Cantalamessa and Di Celma, 2004; Di Celma et al., 2016b) to conglomerate-dominated fluvial deposits of Qc (Di Celma et al., 2015). Outcrop equivalents of the Qm and Qc units, displaying strong similarities in terms of both lithology and vertical stacking of facies, have been identified along the Adriatic side of Italy in the Emilia, Marche, and Molise Apennines (Cantalamessa and Di Celma, 2004; Amorosi et al., 2009; Bracone et al., 2012a, 2012b; Gunderson et al., 2014). By the early Calabrian onwards, the thrust-related structures ceased to be active and the central Peri-Adriatic foredeep was uplifted at an average rate of 0.8–1.0 m/ka (Centamore and Nisio, 2003; Pizzi, 2003).

Study area and methodology

Di Celma et al. (2016a) subdivided the sediments of the Middle Pleistocene Qm2 Unit exposed within the Ortona area, eastern central Italy (Fig. 1), into a stack of three unconformity-bounded sequences, namely $Qm2_3$, $Qm2_2$, and $Qm2_1$ from older to younger. Given that this study examines the distal outcrops of the Qm2 Unit, the top-down nomenclature allows potentially older sequences to be identified and consecutively numbered in the extensive

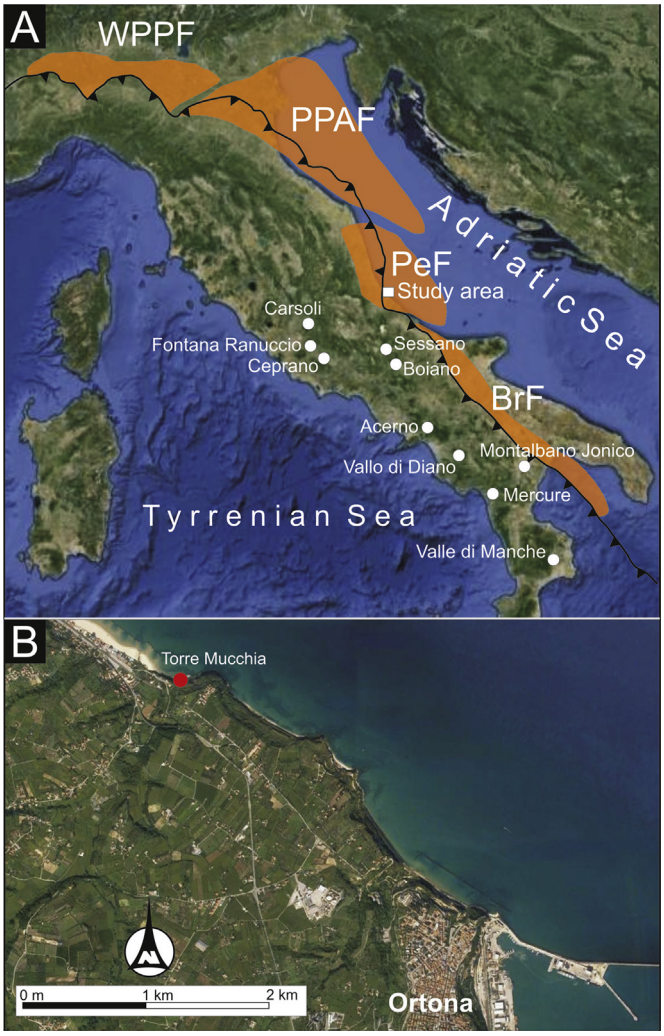

Figure 1. (A) Location map of Ortona and the main Middle Pleistocene Italian sites (between ca. 39° and 42° N) cited in the text for their palynological data. (B) Enlarged satellite image showing location of the study area. Distribution of the Modern Apennine Foredeep depocenters (brown area) with the location of the Western Po Plain Foredeep (WPPF), Po Plain-Adriatic Foredeep (PPAF), Pescara Foredeep (PeF), and Bradanic Foredeep (BrF) during the Gelasian-Late Pleistocene (modified from Ghielmi et al., 2013). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

exposures of the Qm2 Unit that continues to the west. The present study documents the stratigraphic context, paleontological content and related paleoenvironmental signal of shallow-water and paralic sediments exposed along coastal cliffs to the north of Ortona, where the upper portion of $Qm2_2$ and the lower portion of the overlying $Qm2_1$ crop out. The studied sedimentary section is difficult to access because the vertical cliffs are more than 20 m high. Only one locality, called Torre Mucchia (42° 22.677′N – 14° 22.595′E) was safely accessible (Fig. 2A). The section was measured on a decimeter resolution and the sedimentological characterization of the individual facies associations was focused on the registration of lithology, grain size, primary sedimentary structures, degree and type of bioturbation, paleosols, and the presence of fossils and accessory materials, including roots and plant fragments.

Field observations and measurements of the cemented chalky limestones have been integrated with sampling of oriented sediment blocks for micromorphological and microfacies analysis. Eight large hand samples were collected and thin sections were prepared from each of them. Thin sections were examined and described following