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Late Cretaceous to Early Miocene evolution of the southern Prenestini Mountains (Central Apennines): from fault-block platforms to carbonate ramp

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ABSTRACT - The Latium-Abruzzi platform is a well-known large shallow water domain of Central Apennines, however the reconstruction of geometry and evolution of its western margin remains poorly known because it was involved into the out-of sequence Olevano-Antrodoco thrust system. The investigated area is located in the Prenestini Mountains, at the southernmost portion of the Sabina Domain, westward of the large Latium-Abruzzi Platform domain. Here isolated outcrops of Cretaceous to Neogene carbonate successions exhibit a complex history of shallow water carbonate production, drowning, erosive phases and condensed sedimentation within a tectonic-eustatic-controlled carbonate platform marginal domain. Stratigraphic and facies analyses allowed to recognize two main fault block platforms, respectively South Western Prenestini (SWP) and South-Eastern Prenestini (SEP) platforms which in turn have been disjointed into smaller blocks. The displacement of all these blocks can be referred to the widely recognized Upper Cretaceous extensional tectonic phase.

In these platforms, during the Paleocene-Eocene interval, the onset of pelagic environment, and the related condensed pelagites, coincides with main relative sea-level rise, whereas during the following falling stage the depositional surface, coming into the wave abrasion zone, was affected by high hydrodynamic energy and the produced pelagic carbonate sediment was swept away or trapped in local depressions and/or within the fractures forming the neptunian dykes. The coarse-grained material, produced by the erosion of the fractured and articulated Cretaceous substrate, was reworked together with fragments of pelagites to form lenses of polygenic conglomerates resting on top of the Cretaceous platform carbonates. In the Chattian to Aquitanian time interval, short phases of shallow water carbonate production were established during the sea-level fall, as testified by the larger benthic foraminiferal-rich carbonates, followed by erosion and reworking of the already produced sediments into the northern and more deep platform-to-basin zones.

Successively, during the Aquitanian to Serravallian time interval, a homoclinal ramp hosting the Guadagnolo fm, developed on the drowned fault block platforms, suggesting that during the Neogene the articulated substrate was roughly smoothed by the onlapping marly deposits of the Guadagnolo fm and could accommodate the subsequent bioclastic sedimentation allowing the development of a carbonate ramp depositional profile.

Keywords: Apennines; Latium-Abruzzi Platform; Prenestini Mt; platform drowning; condensed pelagites; neptunian dykes; facies analysis.

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1. INTRODUCTION

Carbonate platforms are dynamic systems able to produce their own sediment but very sensitive to a variety of processes such as tectonic subsidence, eustatic oscillation, seawater chemistry, climate, biota evolution and tectonic instability/seismicity (Hallock and Schlager, 1986; Testa and Bosence, 1999; Brandano and Corda, 2002; Pomar and Hallock, 2007; Hallock and Pomar, 2008; Corda and Palmiotto, 2015; Palmiotto et al., 2017). The ability of biogenic sediments to accumulate *in situ* or to be transported and settled elsewhere depends upon bottom topography, strengths of waves and currents, and capacity of the benthic community to decrease the sediment transport (Schlager, 2005; Hallock, 2015).

In this work, we focus on a western sector of the Latium-Abruzzi carbonate platform marginal domain outcropping in the Prenestini Mountains, at the southernmost end of the Sabina pelagic domain (Parotto and Praturlon, 1975) (Fig. 1). Here a Cretaceous to Neogene carbonate platform succession crops out exhibiting a complex history of shallow water carbonate production, drowning, erosive phases and condensed sedimentation in a marginal platform domain controlled by tectonics and eustatism. During Late Messinian-Early Pliocene, the pelagic Sabina Domain overlapped the Latium-Abruzzi carbonate platform domain along the out of-sequence Olevano-Antrodoco thrust system (Cosentino and Parotto, 1986; Corrado, 1995; Bollati et al., 2012). As a consequence, the reconstruction of the geometry and evolution of the margin of the Latium-Abruzzi platform remains poorly known.

In the Prenestini Mountains, isolated outcrops of platform carbonates offer the possibility to shed a light on the depositional history of the marginal area of Latium Abruzzi platform domain during the end of the Cretaceous and Cenozoic interval and to analyze the interplay of the different factors that controlled type of carbonate production, accumulation and erosion.

2. GEOLOGICAL SETTING

The Apennines are a Late Oligocene to Present fold-and-thrust belt due to the west-directed subduction of the Adriatic plate under the European plate (Doglioni, 1991).

The central segment of the Apennine chain consists of Triassic-to-Miocene carbonate and marly-carbonate successions deposited on the passive margin of the subducting Adriatic foreland. The study area is located between two main Mesozoic palaeogeographic domains: the persistent Latium-Abruzzi carbonate platform, to the east, and the Sabina pelagic domain, to the west, this last representing the southernmost part of the wider Umbria-Marche Basin (Fig. 1). These domains are the result of the Early Jurassic Tethyan rifting and fragmentation of a wide Triassic-Lower Jurassic carbonate platform which led to the development of a slow-subsiding pelagic domain (the Umbria-Sabina basin) and a faster subsiding persistent carbonate platform (the Latium-Abruzzi platform) (Carminati et al., 2013).

The Neogene to recent evolution of the central Apennines was characterized by the east-north-eastward propagation of the contractional deformation and by the evolution of eastward-younging foredeep basins (Patacca and Scandone, 1989). The progressive migration of deformation fronts was accompanied by extensional tectonics in the hinterland and the consequent opening of progressively younger backarc basins (Gueguen et al., 1998).

2.1. STRATIGRAPHY OF THE STUDY AREA

The studied area is located in the Prenestini Mountains at the southernmost end of the Sabina pelagic domain that overrode the Latium-Abruzzi platform domain by means of the Olevano-Antrodoco tectonic line (Parotto and Praturlon, 1975). This N-S oriented structure, Early Pliocene in age (Fig. 1), has been interpreted as an out-of-sequence thrust system (Cipollari and Cosentino, 1991) along which sectors of the platform margin were cut off

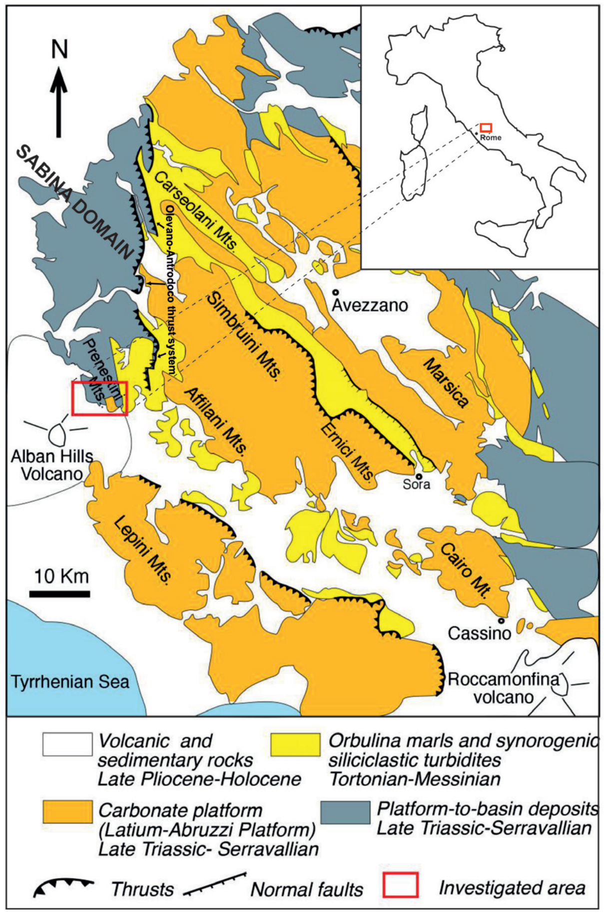

Fig. 1 - Schematic geological map and location of the investigated area (slightly modified from Milli et al., 2016).

making it difficult to reconstruct the original platform extension and palaeogeography.

2.1.1. The Sabina pelagic domain

The Sabina succession consists of pelagic and hemipelagic deposits, Early Jurassic-Paleogene in age, characterized by the frequent occurrence of resedimented material deriving from the nearby Latium-Abruzzi carbonate platform. The Oligo-Miocene overlying deposits are represented by the informally named Guadagnolo fm (Civitelli et al., 1986; Mariotti et al., 2002; Brandano et al., 2005; Brandano and Corda, 2011; Bollati et al., 2011; Milli et al., 2016).

2.1.2. The Latium-Abruzzi carbonate platform

The Latium-Abruzzi platform succession is represented, throughout the Mesozoic, by a monotonous repetition of subtidal and peritidal cycles deposited on a persistent tropical-subtropical carbonate platform. Lithofacies vary from internal and open lagoonal to bioclastic to bioconstructed marginal facies developed on a large flat-topped platform; frequent hiatuses and exposures, generally of short duration, occur mostly during the Early-Late Cretaceous (Parotto and Praturlon, 1975; Damiani et al., 1991). From the Early Miocene onward, after the long Paleogene hiatus, shallow-water carbonates start again to deposit, generally paraconformably, over the Cretaceous limestones (Parotto and Praturlon, 1975; Brandano et al., 2010). The Miocene carbonates, known as the "Calcari a Briozoi e Litotamni" Fm., were deposited on a low-angle homoclinal ramp (Brandano and Corda, 2002). The age of the Miocene transgression ranges from early Burdigalian, in the western sector of the Latium-Abruzzi platform, to Langhian in the eastern sector (Corda and Brandano, 2003; Brandano et al., 2010). The shallow-water carbonate sedimentation was terminated by a plate flexure-related drowning and coeval input of terrigenous material. A well-developed phosphatized hardground (Brandano et al., 2009) marks the end of the carbonate sedimentation that was substituted by upper Tortonian-lower Messinian hemipelagic marls followed by siliciclastic turbidites (Cipollari and Cosentino, 1991).

2.1.3. The Prenestini Mountains succession

The Prenestini Mountains succession represents the transition zone from the Latium-Abruzzi platform domain and the Sabina Basin (Fig. 1). In northern Prenestini, Turonian-to-Eocene Scaglia fm consists of up to 450 m-thick interval of pelagites with chert alternating with larger benthic foraminiferal calcarenites and marls. The overlying Chattian to Aquitanian lower member of the informally named Guadagnolo fm (*sensu* Brandano and Corda, 2011) includes larger benthic foraminiferal calcarenites, marly-limestones and marls. The following intermediate (spongolitic) member of the Guadagnolo fm, Burdigalian-Langhian in age, is made up of alternating spongolitic marls and calcarenites, and its thickness ranges from about 100 to 400 m, followed by about 100 meters of calcarenites representing the upper member of the Guadagnolo fm (Civitelli et al., 1986; Brandano and Corda, 2011).

In the southern Prenestini (Fig. 1), around 300m-thick Aptian-to-Santonian shallow-water carbonates crop out ranging from inner to marginal shoals to biostromal facies. These carbonates are paraconformably overlain by few centimeters, up to a few meters, of laterally discontinuous condensed pelagites referable to the Scaglia Fm, locally represented by cavities fills and/or neptunian dykes (Carbone et al., 1971; Carbone and Sirna, 1981). The succession ends with few meters of spongolitc marls followed by the calcarenitic upper member of the Guadagnolo fm.

From a sedimentary-and-tectonic-evolutionary point of view, the southern Prenestini area during the Late Cretaceous, has been interpreted by Praturlon and Madonna (2004) as a persistent structural high affected by tensional tectonics. Shelf-edge carbonate facies, Aptian-Late Cretaceous in age, crop out in the Rocca di Cave sector followed by uplift and karst during the late Cenomanian-Turonian. Based on the deformation-style and stratigraphy, Bollati et al. (2011) subdivided the Prenestini Mountains into two main tectonic sub-units: the western and the eastern unit (sub-unit 4a and sub-unit 4b respectively of Bollati et al., 2011) (Fig. 2), here after South Western Prenestini (SWP) and South Eastern Prenestini (SEP). Successively Tavani et al. (2015) focused on the eastern sub-unit 4b (SEP). According to these authors in the Rocca di Cave fault system the condensed Scaglia Formation rests on top of progressively younger carbonate platform deposits, from Turonian-Santonian in the eastern sector, to Aptian-Albian in the western sector. This eastward rejuvenation of the Cretaceous platform substrate is interpreted to be related to the east-dipping normal faults whose activity predated the uplift and erosion of the Cretaceous carbonate platform. This N-S fault system displays a polyphasic activity documented by displacement of the entire Campanian-to-Miocene succession.

To the north of Rocca di Cave fault system, the Guadagnolo fm lies directly on the Cenozoic pelagic deposits of the Sabina succession, here this formation is hundreds of meters thick while towards the south, the Guadagnolo fm is only few tens of meters thick (Barbieri et al., 2003). Tavani et al. (2015) evidenced that the Rocca di Cave fault system represents the development of longitudinal and transverse extensional faults in a forebulge palaeodomain strictly related to the interplay between inherited structures and younger structures developed during the progressive arching of the forebulge-foredeep system.

3. METHODS

Field and sedimentological observations and geological mapping were performed on nine outcrops placed in the southern sectors of the Prenestini Mountains (Fig. 2). Considering the structural subdivision of Prenestini Mountains proposed by Bollati et al. (2011), four outcrops are in the south-western Prenestini (SWP) and five in the south-eastern Prenestini (SEP). The field observations were complemented with the petrographic examination of thin sections for textural characterization and identification of skeletal components. Biostratigraphy by planktonic foraminifera, and for some sections, by calcareous nannoplankton allow us to date the evolutional stages of the investigated area.

4. RESULTS

The analyzed outcrops encompass the Cretaceous-Miocene time interval. Outcrops, depositional facies, age and biota associations are summarized in table 1.

On the base of age and geometry of the pre-Miocene substrate and the subsequent Late Cretaceous-Paleogene stratigraphical evolution, the investigated area appears to be differentially articulated in two major sectors which of them, in turn, can be distinguished into smaller blocks.

4.1. SOUTH WESTERN PRENESTINI (SWP PLATFORM)

In the western part of this sector (Palestrina, section 2, Fig. 2), the Mesozoic substrate (not mapped in the

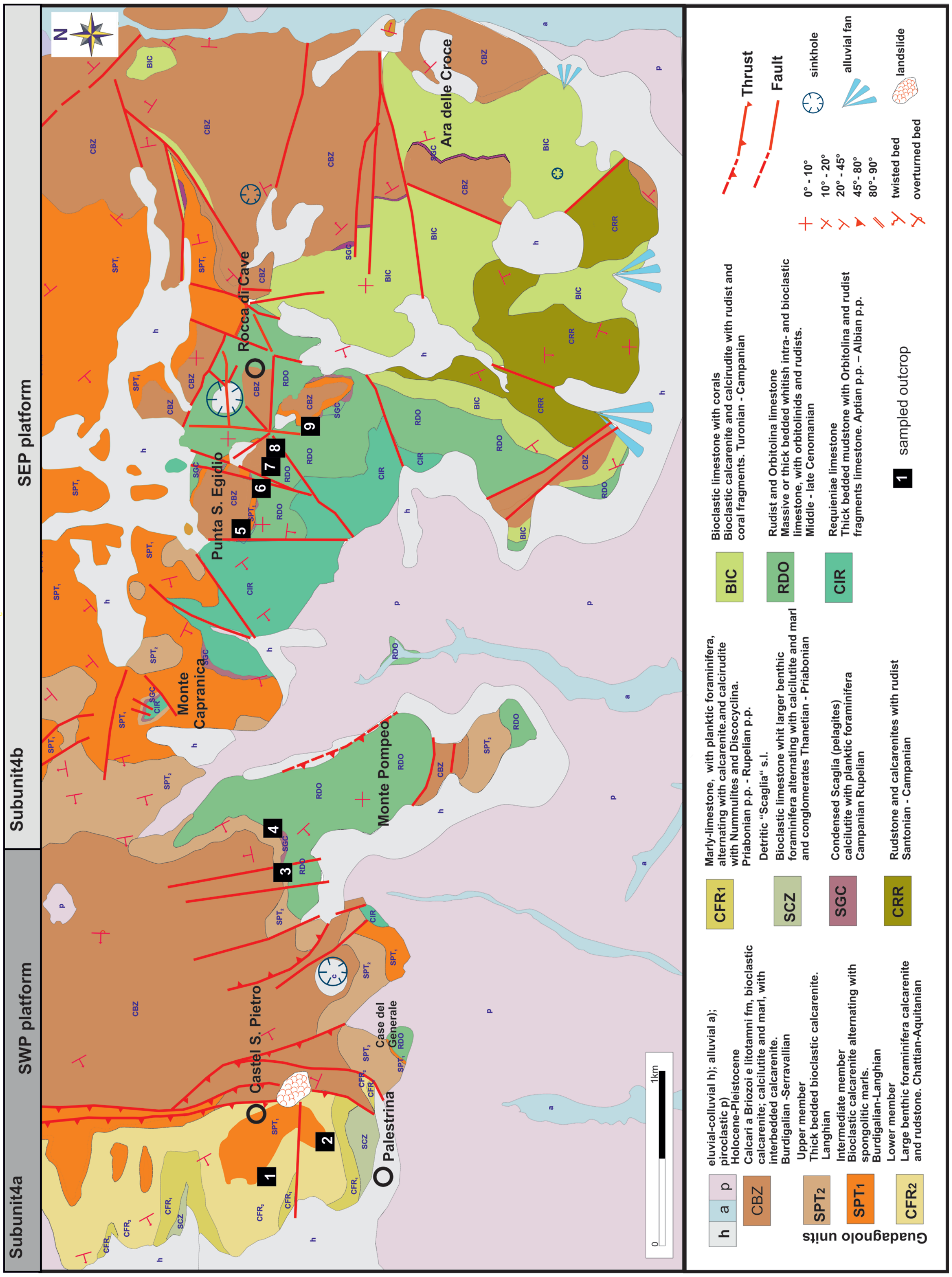

Fig. 2 - Simplified geological map of the southern Prenestini Mountains and location of the analyzed sections (modified from Servizio Geologico d'Italia, Foglio 375, and from Giordano et al., 2010). The pre-Miocene shallow-water limestones cropping out in the southern western Prenestini (SWP) are not mapped due to their limited size.

Tab. 1 - Age, environment, lithofacies associations and biota components of the analyzed stratigraphic sections.

Outcrop	Age	Environment/ processes	Lithofacies	Larger benthic foraminifera	Small benthic foraminifera, calcareous algae and skeletal components	Planktonic foraminifera	Calcareous nannofossils
1 Castel S. Pietro	Miocene	ramp	Marls and bioclastic calcarenites		Sponge spicules		
	Chattian to early Aquitanian	Gravity flows	Bioclastic rudstone, packstone, planktonic- and sponge-packstone-wackestone	*Heterostegina, Amphistegina, Nephrolepidina, Miogypsinoides, Miogypsina, Cicloclypeus*	Rotalids, miliolids, *Lobatula, Planorbulina*, Sponge spicules		
2 Palestrina	Miocene and reworked Oligocene	Ramp, gravity flows	Marls and bioclastic calcarenites containing a thick conglomeratic bed	*Lepidocyclina, Nephrolepidina tournoueri, Heterostegina* within the conglomeratic bed	Sponge spicules		
	middle Eocene	Reworked material within pelagic matrix	Polygenic conglomerates with lithoclast of platform limestones and pelagites	In the lithoclasts: Alveolinids *Orbitoides*, *Siderolites*	In the lithoclasts: rudist fragments	In the matrix: *Globigerinatheka*	
	Paleocene-early Eocene	Shallow-water mounds	Bioclastic packstone to floatstone		*Polystrata alba,* dasycladacean algae, miliolids, textularids, *Disticoplax*		
	Campanian-Maastrichtian	platform	Bioclastic packstone to rudstone	*Orbitoides, Siderolites calcitrapoides*	Rudist fragments		

Tab. 1 - ...Continued

3 Piano delle Cese ovest	Miocene	ramp	Marls and marly limestones, bioclastic wackestone packstone to grainstone Conglomeratic levels with clasts of platform limestones, pelagites and larger foraminifera-calcarenites	*Amphistegina*	*Elphidium, Cibicides, Nodosariacea,* Bryozoan Sponge spicules		
	middle Paleocene to middle Eocene	Condensed pelagites within ponds and neptunian dykes	Planktonic foraminiferal wackestone			*Planorotalites pusilla, Planorotalites pseudomenardi, Morozovella angulata Morozovella conicotruncata, Morozovella gr. velascoensis;* *Morozovella spinulosa, Morozovella lehneri, Planorotalites pseudoscitula, Planorotalites gr. palmerae, Acarinina gr. bullbrooki, Truncorotaloides topilensis, Subbotina, Globigerinatheka*	
	late Albian to early Cenomanian	platform	bioclastic packstone-grainstone to rudstone		*Orbitolina conica, Bacinella irregularis, Everticyclammina hedbergi,* miliolids, dasycladacean algae, rudist fragments		

Tab. 1 - ...Continued

4 Colle Pompeo	Miocene	ramp	Marls and marly limestones At the base a thin calcarenitic layer rich in glauconite grains		Sponge spicules		
	Aptian-Albian to Cenomanian	platform	Skeletal wackestone to packstone, grainstone		*Cuneolina pavonia parva, Nezzazata simplex, Bacinella irregularis,* miliolids, ostracods, Charophyta (*Atopopchara trivolvis*), *Orbitolina,* rudist fragments		
5 Rocca di Cave nord	Miocene	ramp	Marls and marly limestones		Sponge spicules		
	middle-late Paleocene (with reworked Maastrichtian planktonic foraminifera) to Rupelian	Condensed pelagites	Planktonic wackestone			*Parasubbotina pseudobulloides, Morozovella uncinata, Morozovella angulata, Planorotalites pusilla pusilla, Planorotalites pseudomenardi, Turborotalia cerroazulensis, Globigerinatheka, Acarinina bullbrooki, Catapsydrax, Morozovella spinulosa, Acarinina topilensis*	*Braarudosphaera bigelowi, Cruciplacolithus sp., Coccolithus pelagicus, Sphenolithus primus, Sphenolithus anarrhopus, Toweius pertusus, Chiasmolithus consuetus, Ericsonia robusta, Prinsius martinii, Sphenolithus radians, Dictyococcites bisectus, Ericsonia formosa, Cyclicargolithus sp. Dictyxiococcites sp., Cyclicargolithus abisectus, Reticulofenestra minuta, Ellipsolithus sp.*
	Cenomanian	platform	Bioclastic packstone to grainstone		*Orbitolina*, miliolids		

Tab. 1 - ...Continued

6 Rocca di Cave sud	late Campanian to middle Eocene	Condensed pelagites	Planktonic wackestone			*Globotruncanita stuarti, Globotruncana linneiana, Globotruncana orientalis, Globotruncana lapparenti, Globotruncana falsostuarti, Globotruncana arca, Globotruncana rosetta, Globotruncana mariei, Contusotruncana patelliformis, Contusotruncana fornicata, Ventilabrella multicamerata, Contusotruncana contusa, Parasubbotina pseudobulloides, Praemurica inconstant, Morozovella gracilis, , Morozovella subbotinae, Morozovella aragonensis, Turborotalia cerroazulensis and Globigerinatheka*	*Quadrum trifidum , Quadrum gothicum, Thoracosphaera operculata, Braarudosphaera bigelowii, Chiasmolithus grandis*
7 S. Egidio	Miocene	ramp	Marls and marly limestones At the base a conglomeratic bed with clasts of Cretaceous platform and Paleogene pelagites and with glauconite grains		Sponge spicules		
	late Paleocene to middle Eocene	Condensed pelagites	Planktonic wackestone			*Morozovella, Globigerinatheka, Planorotalites, Acarinina bullbrooki*	
	Cenomanian	platform	Bioclastic grainstone to packstone, and wackestone		*Nezzazatinella*, miliolids, rudist fragments		

Tab. 1 - ...Continued

8 Rocca di Cave cemetery	Miocene	ramp	Marls and marly limestones At the base a thin calcarenitic layer rich in glauconite grains		Sponge spicules		
	Maastrichtian to middle Eocene	Condensed pelagites	Planktonic wackestone At the base about 2 meters of breccias and conglomerates with coarse-grained clasts of platform limestones			*Gansserina gansseri, Globotruncana cfr. falsostuarti, Globotruncanita stuarti, Globotruncana arca Globotruncana lapparenti, Parasubbotina pseudobulloides, Subbotina* cfr. *Triloculinoides, Acarinina bullbrooki, Globigerinatheka* cfr. *kugleri*	
9 Madonna della Neve	Aquitanian Burdigalian	ramp	Bioclastic packstone to wackestone	*Amphistegina, Heterostegina, Miogypsinoides,* Sponge spicules	Bryozoans, Sponge spicules		
	Campanian-Maastrichtian	Condensed pelagites	Planktonic wackestone			*Globotruncanita stuarti, Globotruncana ventricosa*	

figure) is represented by horizontally bedded skeletal packstone-grainstone to rudstone with rudist fragments and benthic foraminifera (*Orbitolina*), Cenomanian in age, overlaid by upper Campanian to Maastrichtian packstone to rudstone containing rudist fragments (Tab. 1). Scattered mound bodies overlie the Mesozoic substrate. These mounds are up to 5 m thick and up to 20 m wide, no internal structures may be recognized. The main components are coralline algae partially silicized, dasycladacee, miliolids, textularids, *Disticoplax*, indicating a Paleocene-early Eocene age. The mounds are onlapped by planktonic and spiculitc wackestone with interbedded calcarenites, referable to the Guadagnolo fm. Locally the contact between the substrate and the overlying Miocene deposits is marked by lenses of conglomerates, up to 4 m thick, with a planktonic foraminiferal wackestone matrix referable to middle Eocene, and containing clasts, not completely rounded, of upper Cretaceous platform limestones, clasts of marly limestones with planktonic foraminifera referable to the Scaglia Formation and clasts of limestones with larger foraminifera (Fig. 3A). The upper surface of the pre-Miocene substrate is irregular and affected by frequent neptunian dykes (20 cm deep) filled with spongolitic deposits of the Guadagnolo fm, lenses of conglomerate also occur (Fig. 3B). At about 50 meters above the unconformity, within the Guadagnolo marls, a 45 cm-thick *Lepidocyclina*-rich conglomeratic bed has been recovered.

In the northwestern part of this sector (Castel S. Pietro, section 1, Fig. 2), up to 50 meters of medium-to thick-bedded bioclastic calcarenites and calcirudites rich in larger foraminifera and frequent epiphytic foraminifera, are interbedded with planktonic foraminiferal mudstones to wackestones (Tab. 1). Beds show an internal lamination (Fig. 3C), with sets characterized by bedding-parallel lamination (bedding-plane concordant) and a general fining upward trend. Occasionally low-angle cross lamination may be observed. A characteristic horizon rich in black chert nodules is observable within the lower portion of this unit, dated at Oligocene-early Aquitanian. This portion is overlaid by spicolitic marls and bioclastic calcarenites referable to the Miocene Guadagnolo fm.

Moving towards southeast, Case del Generale (Fig. 2), a limited outcrop of platform limestones, Cenomanian in age, can be observable, consisting of skeletal packstone-grainstone to rudstone with rudist fragments and benthic foraminifera (*Orbitolina)*. A thin bed of Oligocene resedimented calcarenites, nearly exclusively made up of larger foraminifera, marks the contact with the overlying spongolitic marls and marly limestones of the Guadagnolo fm.

In the eastern part of this SWP Prenestini_sector, Piano delle Cese-Monte Pompeo (sections 3, 4, Fig. 2), the Mesozoic substrate is represented by horizontally bedded orbitolinids grainstones with cortoids and oncoids, late Albian to early Cenomanian in age (Fig. 4a). Above the Cretaceous unconformity, clasts of Cretaceous limestones have been recovered together with breccias and red soil infilling fractures. In the Piano delle Cese area the Cretaceous limestones are sharply truncated by a palaeosurface observable for about 100 meters of altitude difference (Fig. 3D). Silicized crusts and occasionally thin glauconitized hardgrounds locally affect this palaesurface which is also characterized by karst cavities and neptunian dykes, up to 80 cm deep, filled by condensed pelagites of different age, ranging between middle Paleocene (Selandian) to middle Eocene (Lutezian). The Miocene deposits lie in onlap on this unconformity at the base and paraconformably cover the top of the structure. They consist of spongolitic marls passing upward into marly limestones interbedded with laminated calcarenites, rich in echinoids and bryozoan fragments. Locally the occurrence of growth geometries in the Miocene strata suggest the presence of synsedimentary faults. Within the lower portion of the Miocene Guadagnolo fm, three conglomeratic levels (20, 80 and 30 cm in thickness) have been recovered, mostly lenticular in shape, containing lithoclasts of Cretaceous platform limestones, larger benthic foraminifera calcarenites and glauconitized pelagites. At the top of the structure, the Miocene carbonates, lying paraconformably on the Cretaceous substrate, consist of cross bedded skeletal grainstones referable to the upper portion of the Guadagnolo fm.

4.2. SOUTH EASTERN PRENESTINI (SEP PLATFORM)

In this sector the Mesozoic substratum is progressively younger moving toward the east: Aptian-to-Albian in the western sector (Monte Capranica), Cenomanian in the central area (Rocca di Cave-Punta S. Egidio, sections 5-9, Fig. 2) and Turonian-Campanian in the eastern sector (Ara della Croce) (Giordano et al., 2010; Servizio Geologico d'Italia, Foglio 375, in press). In the analysed sections (Tab. 1, sections 5, 7) the platform limestones are represented by orbitolinid packstone-grainstones and skeletal packstone-wackestones with rudist fragments, Cenomanian in age. Scattered condensed pelagites paraconformably overlie the Cretaceous substrate and/or fill cavities and fractures (Fig. 3 E,F, Fig. 5). The planktonic foraminifera and calcareous nannoplankton biostratigraphy indicate different time intervals (Fig. 4) ranging between Campanian-Maastrichtian (Tab. 1, sections 6, 8, 9), Paleocene-Eocene (Tab. 1, sections 5, 6, 7, 8) to Rupelian (Tab. 1, section 5). A thin level rich in glauconite grains marks the contact with the overlying spongolitic marls and calcarenites of the Guadagnolo fm. In the north-northeastern sector of this South Eastern Prenestini area (Tab. 1, section 8), spongolitic marls and marly limestones of the Miocene Guadagnolo fm overlie 2-3 meters of breccia with clasts of Cretaceous platform limestone directly or with the interposition of discontinuous lenses of pelagites.

5. DISCUSSION

The Latium-Abruzzi platform domain outcropping in the studied area appears to be differentially articulated in

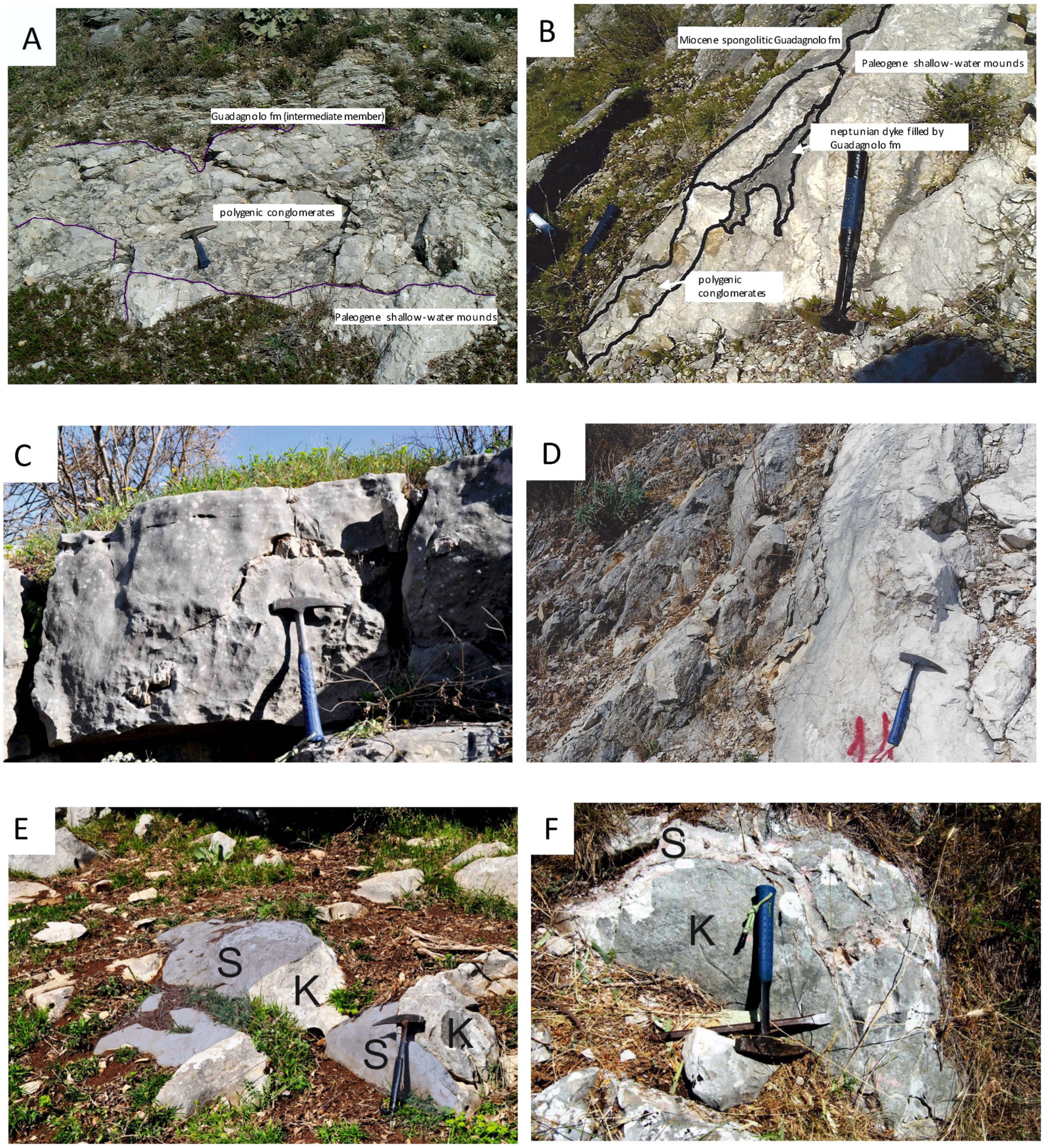

Fig. 3 - Lithofacies outcrops. A) Palestrina, section 2 (the pre-Miocene substrate is not mapped in Fig. 2): exposure of the Paleocene-lower Eocene shallow-water mounds unconformably covered by polygenic conglomerates with clasts of platform limestones and Scaglia Fm within middle Eocene pelagic matrix. At the top, Miocene spongolitic marls referable to the intermediate member of the Guadagnolo fm; B) Palestrina, section 2: detail of the unconformity between the Paleocene-Eocene limestones and the marly limestones of the Guadagnolo fm draping the mounds and infilling dykes. Lenses of polygenic conglomerates are also visible; C) Castel S. Pietro (section 1, Fig. 2): bioclastic calcarenites with larger foraminifera showing a bedding-plane concordant lamination; D) Piano delle Cese (section 3, Fig. 2): palaeoescarpment of the Cretaceous platform onlapped by marly limestones of the Miocene Guadagnolo fm.; E) Rocca di Cave-S. Egidio: scattered thin layers of condensed Scaglia Fm (S) paraconformably overlying the Cenomanian platform limestones (K); F) Rocca di Cave: detail of neptunian dykes within the Cretaceous platform limestones (K) filled by condensed pelagites of the Scaglia Fm (S).

two main sectors, respectively SWP and SEP, delimited by roughly N-S oriented faults already evidenced by Bollati et al. (2011). The two sectors are characterized by different age of pre-Miocene substrate and general stratigraphic architecture. Based on a number of evidences, the two sectors, which can be considered as two main fault block platforms developed basin westward of the large Latium-Abruzzi Platform domain, can be further differentiated into a number of smaller blocks.

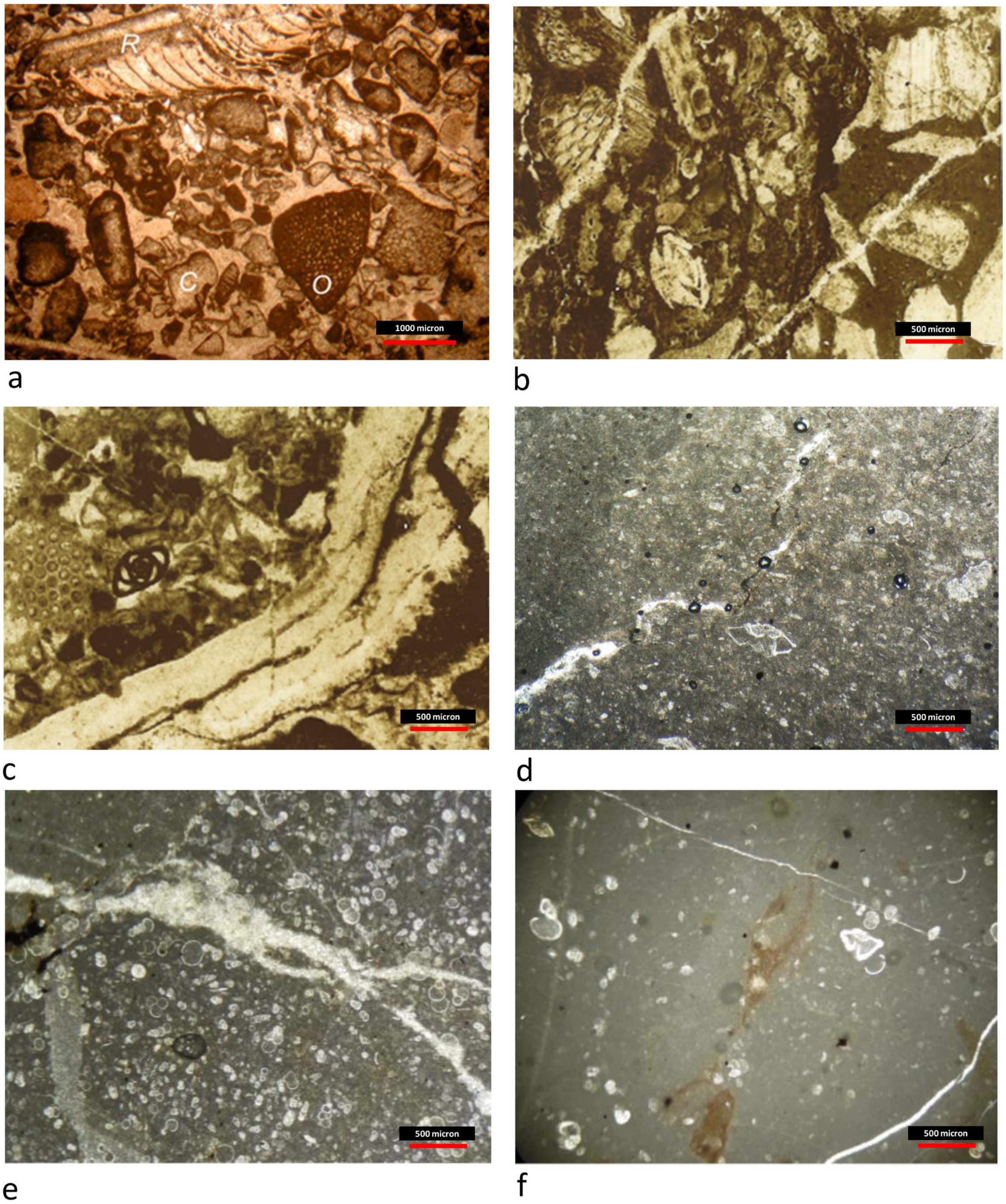

Fig. 4 - Microfacies. a) Grainstone with benthic foraminifera (*Orbitolina*), rudist fragments and cortoids (Cenomanian); b) stylolitic phosphatized contact between the Miocene Guadagnolo fm (here represented by packstone with bryozoans, echinoids and larger foraminifera, *Amphistegina*) and the Cretaceous platform limestones (here represented by bioclastic grainstone-packstone); c) floatstone with coralline algae (*Polystrata alba*) and benthic foraminifera (Paleocene-Eocene); d) planktonic foraminifera mudstone-wackestone with *Globotruncana ventricosa*, Campanian-Maastrichtian; e) planktonic foraminifera wackestone with *Parasubbotina pseudobulloides* and globigerinids, Paleocene; f) planktonic foraminifera mudstone with *Morozovella aragonensis* and globigerinids, Eocene.

5.1. THE SOUTH-WESTERN PRENESTINI (SWP PLATFORM)

In this sector (Fig. 2, sections 2, 3, 4) the age of the pre-Miocene substrate is different in age moving from west to east. In particular, the western sector (Palestrina) persisted as a shallow-water environment throughout the Cenomanian-Maastrichtian and up to Paleocene-early Eocene (as testified by the mound-shaped units described above) whereas the central (Case del Generale) and eastern zone (Piano delle Cese-Colle Pompeo) persisted as carbonate platform no later than Cenomanian. In addition, the occurrence of the already described palaeosurface dipping towards W-NW-SW exhibiting all the features characterizing a palaeoescarpment, let

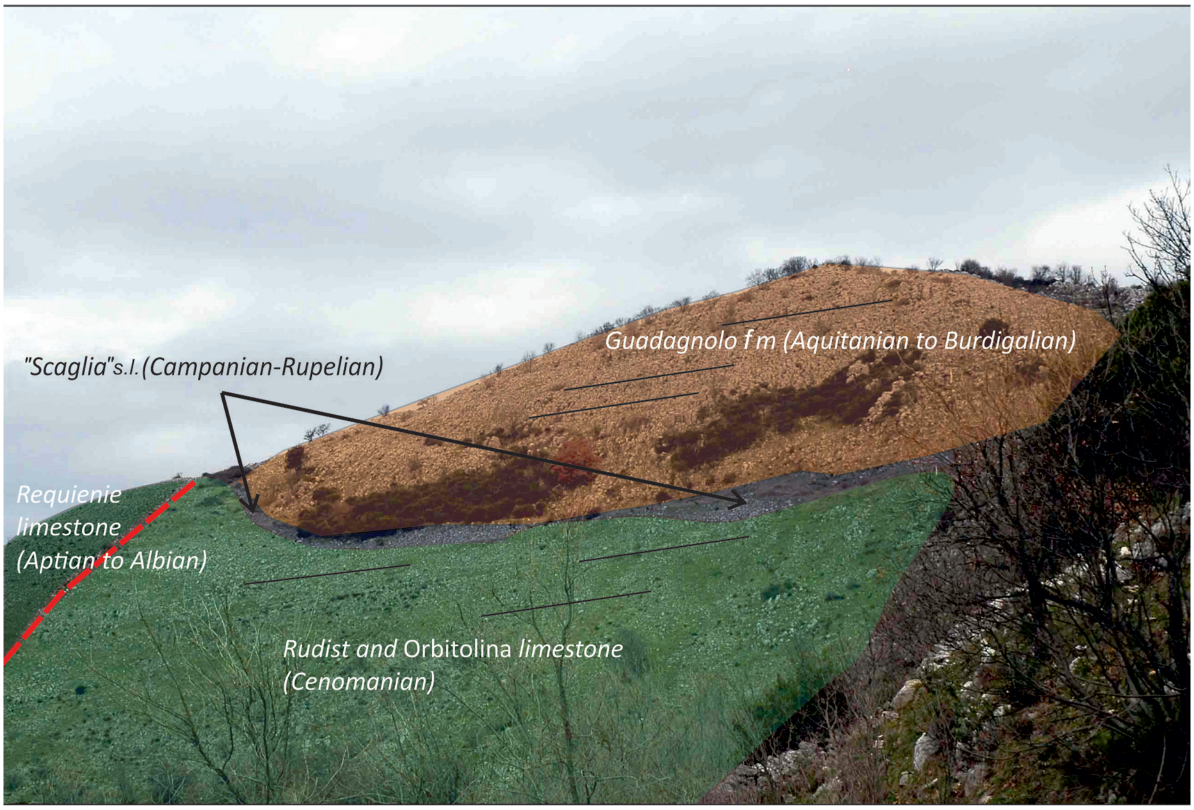

Fig. 5 - Photomosaic showing the stratigraphic relationships between the Cretaceous platform limestones and the overlying Miocene Guadagnolo fm by the interposition of discontinuous lenses of condensed pelagites of the “Scaglia” s.l.

us to rule out the possibility to justify the different age of the pre-Miocene substratum simply as a tilting block. As a consequence, we interpret this eastern sector of the SWP platform (Piano delle Cese-Colle Pompeo) as having been a tectonically-controlled palaeohigh until the Cenomanian which suffered drowning events during the Paleocene-Eocene (as testified by the condensed pelagites filling dykes and cavities) while at the same time the western block (Palestrina) continued to host shallow-water carbonates.

The displacement of these blocks can be referred to the Cenomanian tectonic phase, widely recognized throughout the central Apennine. The existence indeed of a middle-to-late Cretaceous extensional stage in the Apennines has been proposed long time ago (e.g., Carbone et al., 1971; Praturlon and Sirna, 1976; Mariotti, 1982) and now definitely recognized (Shiner et al., 2004; Praturlon and Madonna, 2004; Carminati et al., 2013; Tavani et al., 2013, 2015). In addition, the abundance of neptunian dykes developed within the Cretaceous substrate also testifies repeated extensional brittle fracturing of lithified platform carbonates (c.f. Lehner, 1991).

During the Oligocene, towards W-NW of the South Western Prenestini (SWP, Castel S. Pietro), an additional accommodation space should be created able to hosting the accumulation of the Chattian to Aquitanian larger benthic foraminiferal calcarenites due to gravity-flow processes. In the eastern sector of the SWP, few episodes of conglomerates and calcarenites with reworked material consisting of platform and pelagic limestones together with reworked Oligocene larger benthic foraminiferal deposits are observable within the Miocene onlapping deposits, in that testifying a palaeogeography suitable for gravity-flow processes.

5.2. THE SOUTH-EASTERN PRENESTINI (SEP PLATFORM)

In this sector (Fig. 2, sections 5, 6, 7, 8, 9) the age of the Cretaceous substrate is progressively younger moving towards east ranging from Albian to Cenomanian and to Campanian. It is paraconformably overlain by discontinuous lenses of condensed pelagites encompassing different ages, from late Campanian-early Maastrichtian to Paleogene. Within the condensed pelagites local reworking phenomena also occurred (i.e. reworked Maastrichtian planktonic assemblages within Paleocene pelagites, section 5, Rocca di Cave). Also in this SEP platform, the different drowning phases of the Cretaceous substratum, respectively Aptian-Albian (Monte Capranica, Giordano et al., 2010), Cenomanian (Rocca di Cave) and Turonian-Campanian (Ara della Croce, Giordano et al., 2010; Servizio Geologico d’Italia, Foglio 375, in press), suggest the influence of an extensional regime that produced the further disjointing of this sector. The occurrence at the base of the Maastrichtian pelagites (Rocca di Cave cemetery, section 8) of breccias and conglomerates containing large clasts of platform limestones, validate the hypothesis of the presence of a more eastern platform block where the shallow-water sedimentation remained active until the Turonian-Campanian. The syn-kinematic erosion of the fractured platform high could provide coarse-grained materials to be reworked into the already drowned zones. No records of Oligocene shallow-water sedimentation phases have been recovered throughout the SEP but only a thin level of condensed Rupelian pelagites (section 5).

5.3. INTERPRETATION

What discussed above allow us to propose a complex stratigraphic history of the studied area consisting of fault-block platforms affected by different phases of shallow-water sedimentation, exposure, drowning and erosion in response to the Cretaceous extensional regime. As a consequence of this tectonic activity, related to the regional E-W oriented stretching, the analysed area should have been detached from the Latium-Abruzzi platform marginal domain and further disjointed into different fault block platforms.

The platform blocks underwent a general fate of drowning, differentiated and not coeval, as testified by the different age of the condensed pelagites. The abundance of calcarenites and conglomerates rich in Oligocene larger foraminifera, throughout the entire SWP, testifies shallow-water sedimentation somewhere, successively eroded and resedimented as a consequence of an Oligocene-to-early Miocene erosional phase. This phase was responsible also of the limited preservation of scattered few meters of condensed pelagites visible only in small, topographically depressed areas or in karst cavities or infilling dykes. Finally, during the early Miocene, sedimentation resumes over all the platform blocks with the Guadagnolo fm locally resting directly on top of the carbonate platform sediments.

In this palaeogeographic contest the Guadagnolo fm represents the recovery of carbonate sedimentation on the drowned fault block platforms roughly smoothing the previous articulated palaeogegraphy. The former physiography hosting the marly- and skeletal-carbonate production and accumulation allowed the development of a ramp profile probably detached from the large Latium-Abruzzi platform domain where the coeval Miocene carbonate sedimentation is represented by the "Calcari a Briozoi e Litotamni" Fm. (Brandano and Corda, 2002; Brandano et al., 2010).

A schematic reconstruction of the environmental conditions of the Prenestini fault-block platforms before the instauration of the Guadagnolo fm is reported in figure 6. Following a generalized stage of shallow-water sedimentation throughout the Prenestini platform up to Cenomanian (Fig. 6a) not coeval phases of exposures and drownings should be invoked which caused karst dissolution and pelagic sedimentation respectively. The drowning-related pelagites infilling ponds, cavities, fractures and more in general forming the neptunian dykes, obviously accumulated during main relative sea level rise/ faster tectonic subsidence that produced general pelagic conditions. During the Paleocene-Rupelian time interval, as a consequence of repeated phases of lowstand, the summit of the carbonate blocks could be found within the zone of wave abrasion (Fig. 6b). In such conditions the produced pelagic sediments were swept away and/or moved seaward, reworked or captured in local depressions and/or within the fractures forming the neptunian dykes (i.e. reworking processes, probably related to the Ypresian sea-level fall, are documented in the SWP block, section 3, by the assemblage of reworked lower Eocene planktonic foraminifera together with the middle Eocene faunas). Evidence of erosional processes within the wave abrasion depth during the lowstand phases, can be provided by the conglomerates encompassing clasts of pelagites and clasts of the Cretaceous platform substrate such as, for example, the conglomerates with a middle Eocene muddy matrix recovered in the SWP-Palestrina zone (section 2). Phases of shallow water carbonate production during the lowstand stage are also documented by the basal portion of the Chattian to Aquitanian bioclastic deposits, rich in larger benthic foraminifera and with epiphytic foraminifera, outcropping in the western part of the SWP. These bioclastic sediments previously produced and accumulated were successively reworked into the deeper platform-to-basin zones.

Lastly the Burdigalian transgression (Fig. 6c), which roughly smoothed the antecedent articulated palaetopography, is almost always marked by detrital glauconite grains deriving from hardgrounds probably developed during the low-sedimentation rates related to the Chattian-Aquitanian sea level rise.

The wedge-shaped geometry of the Guadagnolo fm, ranging in thickness from 10 m to 600-700 m proceeding from SSE to NNW, is to be related to the Early Miocene extensional phase cited by Tavani et al. (2015) which, by promoting the formation of E-W trending faults, caused a sinking area, to the north of the Prenestini platform, able to host the Guadagnolo fm sediments. This Early Miocene extensional stage is also testified by the occurrence of liquefaction structures related to palaeoearthquakes during the deposition of the Guadagnolo fm (Mariotti et al., 2002) and by the recognized growth geometries within the marly deposits of the Guadagnolo fm onlapping the palaeoescarpment at Piano delle Cese in that testifying the probable reactivation of inherited Cretaceous faults. Nevertheless, the generation of the accommodation space for the whole Guadagnolo fm, as suggested by Milli et al. (2016) on the base of its cyclic nature, its growth geometry and the stacking pattern was controlled, besides by tectonics, also by sea-level changes.

6. CONCLUSION

The stratigraphic evolution of the Latium-Abruzzi Platform cropping out in the Southern Prenestini Mountains was strongly controlled by the Cretaceous extensional regime well known throughout the Apennines chain. As a consequence of this tectonic

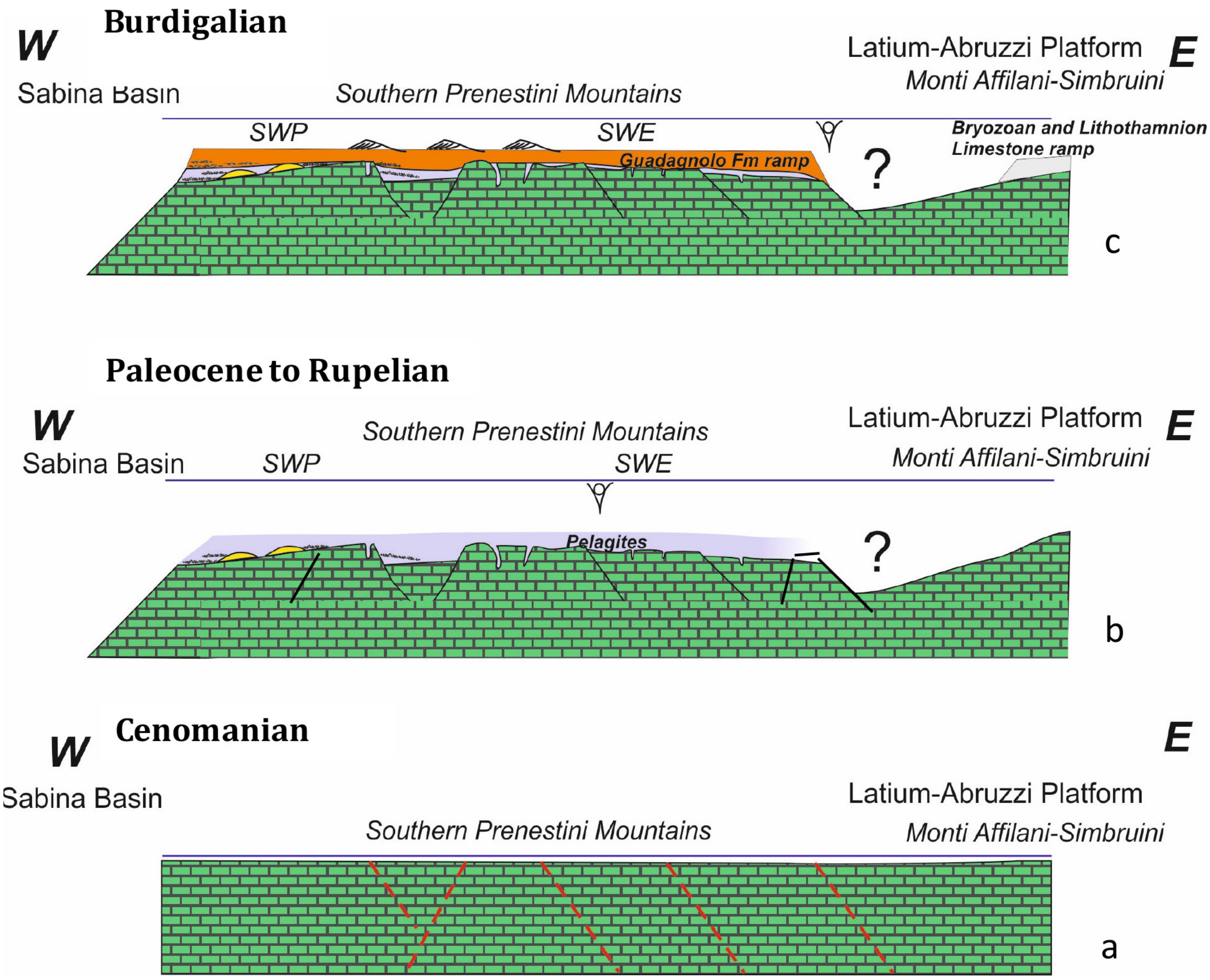

Fig. 6 - Sketch of the evolution of the southern Prenestini area from the Late Cretaceous onward. a) generalized conditions of shallow-water carbonate sedimentation during Cenomanian throughout the Latium-Abruzzi platform accompanied by extensional tectonic phase; b) during the Paleocene-Rupelian time interval repeated phases of sea-level fall caused erosion and reworking of pelagic sediments and their capturing almost exclusively in cavities and fractures; c) from the Burdigalian onward the marls and marly limestones of the Guadagnolo fm, onlapping and smoothing the previous articulated palaeotopography, begin to deposit allowing the development of a ramp profile. The cartoons are not to scale.

activity the analysed platform sector has been detached from the wider Latium-Abruzzi platform and further pull apart into two major fault block platforms, respectively SWP and SEP, developed westward of the large Latium-Abruzzi Platform domain. Both these two blocks were further disjointed into a number of smaller blocks.

In the SWP platform the western sector is characterized by Upper Cretaceous platform carbonates and scattered mounds bodies, Paleocene-early Eocene in age, which in turn are unconformably overlain by lenses of Paleogene conglomerates and onlapped by the Guadagnolo marls. The eastern sector of the SWP exhibits a well-preserved palaeoescarpment of a Cenomanian carbonate platform, affected by cavities and dykes filled by Paleogene condensed pelagites, and successively onlapped and paraconformably covered by the spongolitic marls of the Guadagnolo fm.

In the SEP platform, the Cretaceous platform substrate, different in age moving from west to east (from Aptian-Albian, to Cenomanian to Turonian-Campanian) is unconformably overlain by lenses of Maastrichtian to upper Eocene condensed pelagites filling ponds and neptunian dykes and successively capped by the Guadagnolo fm marls.

After the Cretaceous extensional tectonics, mostly between Paleocene and Eocene, the fault block platforms experienced pelagic deposition during the main relative sea level rises, whereas during the lowstand phases, the summit of the platform blocks could be found within the wave abrasion zone. As a consequence, the produced pelagic sediments were partially swept away and/or captured in local depressions or in the fractures while the coarse sediments produced by the erosion of the fractured platform substrate, together with the already deposited pelagites, could accumulate as polygenic conglomerates. Lastly the Chattian to Aquitanian larger benthic foraminiferal-rich calcarenites, recorded throughout the SWP, can indicate short phases of shallow water carbonate production during the sea-level drop followed by erosion and reworking of the produced sediments into the deeper platform-to-basin zones.

During the early Miocene a homoclinal ramp, represented by the Guadagnolo fm, developed on the drowned fault block platforms, suggesting that the indented substrate was roughly smoothed by the onlapping spongolitic-marly deposits and could accomodate the skeletal carbonate production and accumulation to allow the development of a ramp profile.

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