Journal of Maps

ISSN: (Print) 1744-5647 (Online) Journal homepage: http://www.tandfonline.com/loi/tjom20

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To cite this article: Simone Fabbi (2018) Geology of the eastern slopes of the Simbruini Mts. between Verrecchie and Capistrello (Central Apennines – Abruzzo, Italy), Journal of Maps, 14:2, 435-446

To link to this article: https://doi.org/10.1080/17445647.2018.1483843

Published online: 02 Jul 2018.

JOURNAL OF MAPS
2018, VOL. 14, NO. 2, 435–446
https://doi.org/10.1080/17445647.2018.1483843

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Geology of the eastern slopes of the Simbruini Mts. between Verrecchie and Capistrello (Central Apennines – Abruzzo, Italy)

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ABSTRACT

This paper presents the results of a geological mapping project across the eastern Simbruini Mts. and the higher Roveto Valley (Central Apennines). The study area belongs to the Latium-Abruzzi Domain, which is characterized by a Cretaceous and Miocene carbonate platform succession followed by a thick upper Miocene terrigenous succession. A unique feature of the study area is the existence of a thick clastic unit, the 'brecce della Renga fm.'; this unit was produced by the dismantling of the margins of a large pre-orogenic extensional structural high, which rose within the foredeep basin starting in the early Tortonian. Following the Messinian-Pliocene Apennine chain building phase, the area was subjected to post-orogenic Quaternary extension, related to the opening of the Tyrrhenian sea. A geological map on the 1:20,000 scale illustrates the main stratigraphic and structural features of the area.

ARTICLE HISTORY
Received 21 December 2016
Revised 26 May 2018
Accepted 30 May 2018

KEYWORDS
Apennines; Cretaceous; Miocene; geological mapping; Simbruini

1. Introduction

The present paper is supported by a geological map (Main Map) of a sector of the Simbruini Mountains and the higher Roveto Valley (Central Apennines), in the Latium-Abruzzi geological domain (Figure 1). This is the second of two companion geological maps of the Simbruini Mts., the first (northern Simbruini Mts.) having already been published (Fabbi, 2016). Due to this, obvious similarities occur in the text, concerning the stratigraphic description and the geological setting. The new map covers an area roughly oriented NW–SE and about 70 km² wide, located in the westernmost sector of the Abruzzo region (Province of L'Aquila, Central Italy). The western part of the study area falls within sheets #367 'Tagliacozzo' and #376 'Subiaco' of the official Geological map of Italy on the 1:50,000 scale (Servizio Geologico d'Italia, 1998, 2005), while the eastern part would fall in the sheet #377 'Trasacco' whose realization is still not planned.

The map was conceived originally as a byproduct of a research project whose main target was to investigate the sedimentology of the 'brecce della Renga fm.' (Fabbi & Rossi, 2014 – see below) and the paleostructural features of the late Miocene Simbruini structural high (Carminati, Fabbi, & Santantonio, 2014; Fabbi, Galluzzo, Pichezzi, & Santantonio, 2014 – see below). The main differences with the already published geological cartography (Devoto, 1970; Servizio Geologico d'Italia, 1998, 2005) of the area are due to the higher detail of surveying which allowed the accurate mapping of each different lithofacies of the 'brecce della Renga fm.', a more detailed representation of the Mesozoic substrate and a reinterpretation of structural features, that were misrepresented or erroneously interpreted in the previous maps.

1.1. Regional geological setting

The Central Apennines (Figure 1) is a mountain chain advancing from SW to NE, whose growth and migration is related, since the Miocene, to the W-directed subduction of the Adriatic continental crust under the Italian peninsula (Carminati & Doglioni, 2012; Cosentino, Cipollari, Marsili, & Scrocca, 2010 and references therein).

The Latium-Abruzzi Domain is one of the paleogeographic domains that characterize the Central Apennines since the Jurassic (Figure 1). In the earliest Jurassic, the present-day central and northern Apennines were occupied by a vast shallow-water sea, characterized by carbonate sedimentation (Bosellini, 2004). Since the Hettangian/Pliensbachian, such carbonate platform was fragmented and partly drowned as a consequence of a well-known Early Jurassic rifting phase (Santantonio & Carminati, 2011; Fabbi & Santantonio, 2012 and references therein). Subsequently to the rifting stage, thus, a distinction between geological domains can be done, based on the different tectono-sedimentary evolution of the

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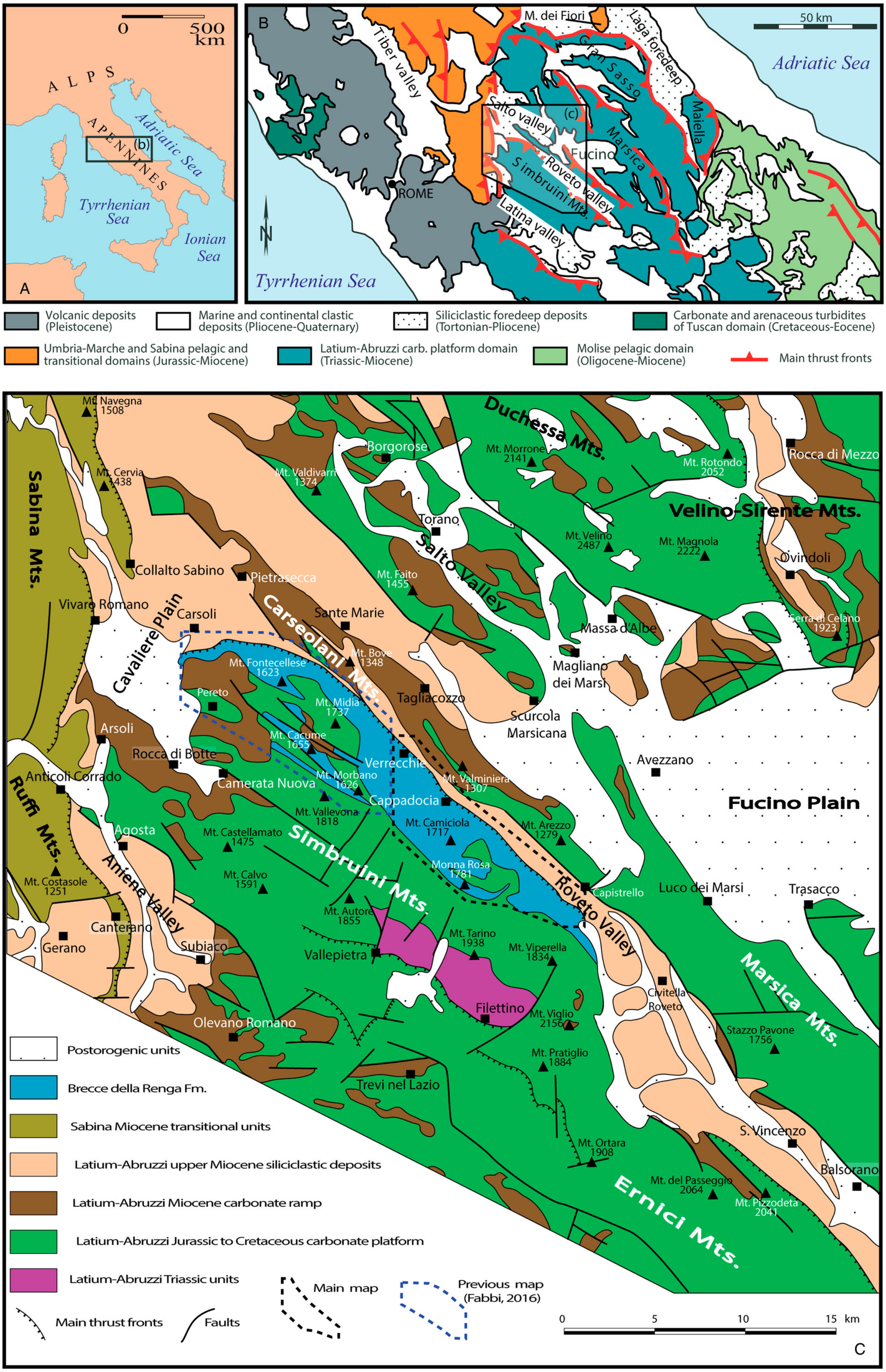

Figure 1. (A) Location and (B) regional geology of the Central Italy; (C) schematic geological map of the Simbruini Mts. and neighboring areas. Modified after Carminati et al. (2014) and Fabbi (2016).

basin. In the Tuscany and Umbria-Marche-Sabina Domains (Figure 1) tectonic subsidence caused the rapid drowning of the carbonate platform and the onset of pelagic sedimentation; differently the Latium-Abruzzi Domain saw continued shallow-water carbonate production throughout the rest of the Mesozoic, and, following a regional hiatus (see below), the Cenozoic (Accordi & Carbone, 1988; Chiocchini, Chiocchini, Didaskalou, & Potetti, 2008; Civitelli & Brandano, 2005; Parotto & Praturlon, 1975). The general stratigraphy of the area consists of a thick (>3 km) Meso-Cenozoic carbonate platform succession, overlain by upper Miocene-Pliocene terrigenous units representing sedimentation in the Apennine chain foredeep basin (Bigi, Costa Pisani, Milli, & Moscatelli, 2003; Critelli et al., 2007; Milli & Moscatelli, 2000). The terrigenous succession in the study area (Figure 1(C), Figure 2) includes a lithoclastic unit, the 'brecce della Renga formation' (Compagnoni, Galluzzo, & Santantonio, 1990; Devoto, 1967; Fabbi & Rossi, 2014 – see below), which was sedimented in response to the erosion of submarine escarpments produced by an extensional phase predating the Apenninic compression (Compagnoni et al., 1990; Fabbi et al., 2014; Fabbi & Rossi, 2014).

2. Methods

Field mapping was originally performed on the 1:10,000 scale, using an enlarged 1:25,000 IGM topographic map (Series 25, year of publication 1994. Sections: 367 II 'Tagliacozzo'; 376 I 'Castellafiume'; 377 IV 'Capistrello').

Stratigraphic units represented in the map have been determined using a lithostratigraphic criterion. The lithostratigraphic study was accompanied by biostratigraphic analysis performed both on microfossil assemblages (essentially benthic forams and calcareous algae in thin section) and nannofossils (on smear slides); the determination of macrofossils (e.g. rudist assemblages) resulted also useful for stratigraphic considerations. In addition, the biostratigraphic study has been integrated with sedimentological analysis for the terrigenous deposits (see Fabbi & Rossi, 2014). No formalized stratigraphic units exist for the carbonate platform succession of the central Apennines, so the stratigraphic units used in this paper are the same described in Compagnoni et al. (2005) and Damiani, Catenacci, Molinari, Panseri, and Tilia (1998), with minor differences discussed in the text.

3. Stratigraphy and geological setting of the mapped area

The stratigraphy of the study area (Figure 2) essentially reflects the evolution of the Latium-Abruzzi carbonate platform, which hosted shallow water sedimentation from the Late Triassic to the middle Miocene (Accordi & Carbone, 1988; |Chiocchini et al., 2008; Damiani, 1990; Damiani et al., 1998; D'argenio, 1974; Parotto & Praturlon, 1975, 2004). Since the late Miocene the area was involved in the Apennine Chain building (see below) and the sedimentation style changed from carbonatic to lithoclastic/siliciclastic, and finally, following the emersion from the sea and the uplift of the chain in the latest Messinian-Pliocene (Fabbi &

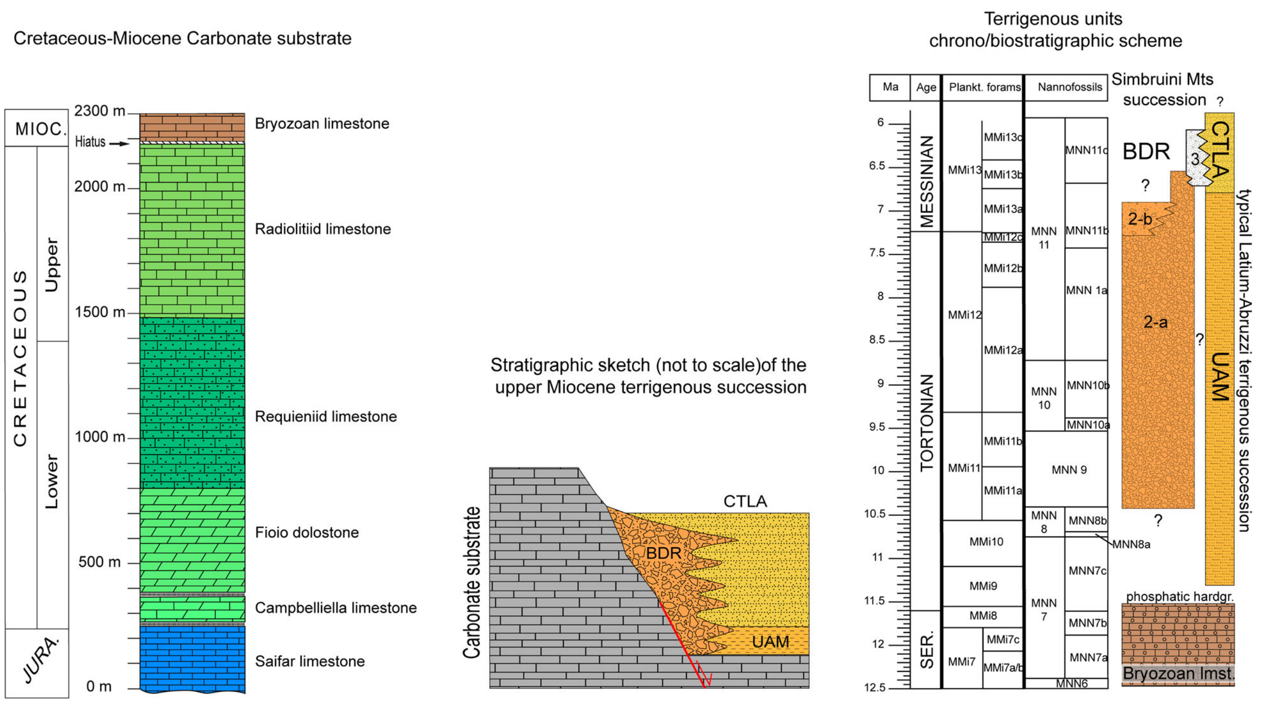

Figure 2. Stratigraphy of the study area: UAM = 'unità argilloso marnosa'; BDR = 'brecce della Renga fm.'; CTLA = 'complesso torbiditico altomiocenico Laziale-Abruzzese'. Modified after Fabbi and Rossi (2014) and Fabbi (2016).

Santantonio, 2018), a further shift occurred from marine to continental sedimentation.

In the following text the description of the stratigraphic units is therefore organized in three different sections, reflecting the main evolutionary steps of the study area:

i Carbonate platform succession: 'Saifar limestone', 'Campbelliella limestone', 'Fioio dolostone', 'requieniid limestone', 'radiolitiid limestone' and 'bryozoan limestone'
ii Terrigenous succession: 'brecce della Renga fm.' and 'complesso torbiditico altomiocenico laziale abruzzese'
iii Continental deposits: valley bottom deposits, landslide and slope debris.

3.1. Carbonate platform succession

While carbonate sedimentation in the region started in the late Triassic (Chiocchini et al., 2008 and references therein), the earliest part of this sedimentary history, up to the middle Jurassic, crops out outside the mapped area.

The 'Saifar limestone' (Bajocian-Tithonian) is the oldest unit exposed in the study area (Figure 3); it is a gray wackestone/mudstone organized in dm-thick beds. Although in the literature oolitic-bioclastic intercalations are described, along with abundant micropaleontological assemblages (Damiani et al., 1991, 1998), the outcropping portion of the unit only shows oligotypic assemblages, characterized by abundant Favreina *prusensis* and *Favreina* spp., and rare *Cladocoropsis mirabilis*. *F. prusensis* is found, in the successions described for the sheet #376 'Subiaco' of the Geological map of Italy (Servizio Geologico d'Italia, 1998), in Berriasian-Valanginian beds (see also Kuss & Senowbari-Daryan, 1992), but in literature it is commonly described in Kimmeridgian-Tithonian strata (Molinari-Paganelli, Pichezzi, & Tilia - Zuccari, 1980; Schweigert, Seegis, Fels, & Leinfelder, 1997). The occurrence of *Cladocoropsis mirabilis,* which is a marker of the lower Callovian – upper Kimmeridgian (Chiocchini et al., 2008), allows to tentatively ascribe the outcropping portion of this unit to the Kimmeridgian. The thickness is undeterminable, but Damiani et al. (1991) estimate this unit exceeds 800 m.

The '*Campbelliella* limestone' (Figure 3) overlies the 'Saifar limestone', and is a gray-hazel packstone/wackestone, often dolomitized, organized in dm- to m-thick beds, characterized by the abundance of the dasycladal alga *Campbelliella striata,* along with *Salpingoporella annulata, Clypeina solkani, C. radici, Favreina salevensis, Arenobulimina* sp., *Triploporella neocomiensis*, gastropods, ostracods and bioclastic debris. This unit has been separated from the following unit (where it had been placed by Damiani et al., 1998), due to the ubiquitous presence of the marker *Campbelliella striata*. The '*Campbelliella* limestone' crops out in a limited area, close to Colle la Fossa. The short stratigraphic range of *Campbelliella striata* (upper Tithonian – lower Berriasian), coupled with the absence of the Jurassic marker *Clypeina jurassica* in the analyzed samples, allow to ascribe this unit to the lower Berriasian. The thickness is about 100 m.

The 'Fioio dolostone' (Figure 3) overlies the '*Campbelliella* limestone' in the succession, although no continuous exposures can be observed; it is a thick stack of dolomitic and incipiently dolomitized beds, found essentially along the Fosso Fioio valley (Compagnoni et al., 2005; Damiani, Molinari, Pichezzi, Panseri, & Giovagnoli, 1990). The rare preserved (non-dolomitized) limestone levels contain abundant micropaleontological assemblages, including *Salpingoporella annulata* and other dasycladaceae (*Coptocampylodon* sp.?), ostracods, fragments of gastropods, miliolidae and other benthic forams (*Istriloculina* sp., *Valvulineria* sp.? *Belorussiella* sp., *Mayncina bulgarica* and *Campanellula capuensis* among others). The age of this unit is late Berriasian- Barremian/earliest Aptian, and the thickness is about 400 m.

Above the 'Fioio dolostone' the succession continues with the Aptian – lower Cenomanian 'requieniid limestone' (Figure 3). It is a wackestone to coarse packstone, organized in dm-thick beds with common requieniids (rudistid bivalves). In the lower portion of the unit dolomitized beds and green shaly levels are also common, along with rare oolithic horizons. Fossil assemblages are generally very rich and include *Archaeoalveolina reicheli*, *Arenobulimina* sp., *Belorussiella* sp., *Bolivinopsis* sp., *Cretacicladus minervini*, *Cribellopsis arnaudae*, *Cuneolina laurenti*, *C.* gr. *camposauri*, ?*C. scarsellai*, *Glomospira urgoniana*, *G.* cf. *Watersi, Haplophragmoides cf. globosus, Istriloculina sp., Moesiloculina histri*, *Nezazzata isabellae*, *Novalesia* sp., *Paleocornuloculina lepina*, *Paleosigmoilopsis appenninica*, *Praechrysalidina infracretacea*, *Pseudonummoloculina* sp., *Sabaudia auruncensis*, *S. capitata, S. minuta, Salpingoporella dinarica,* Sellialveolina *viallii*, *Spiroloculina cenomana*, *Thaumatoporella* sp., *Trochamminoide coronus*, *Valvulineria sp.*, miliolacea, ostracods and fragments of bivalves (Fabbi, 2013, 2016). The thickness of this unit is about 600 m.

The 'radiolitiid limestone' (upper Cenomanian – lower Maastrichtian), which typically follows in the region the 'requieniid limestone', is made of dm- to m-thick tabular beds of white packstones and wackestones, along with common lensoid bodies mainly composed of rudists and rudist debris (Hippuritidae and Radiolitidae – Figure 3). The microfossils assemblages include *Accordiella conica*, *Cuneolina* spp., *Decastronema barattoloi*, *Moncharmontia appenninica*, *Nezazzatinella* sp., *Nummoloculina* sp., *Pseudocyclammina*

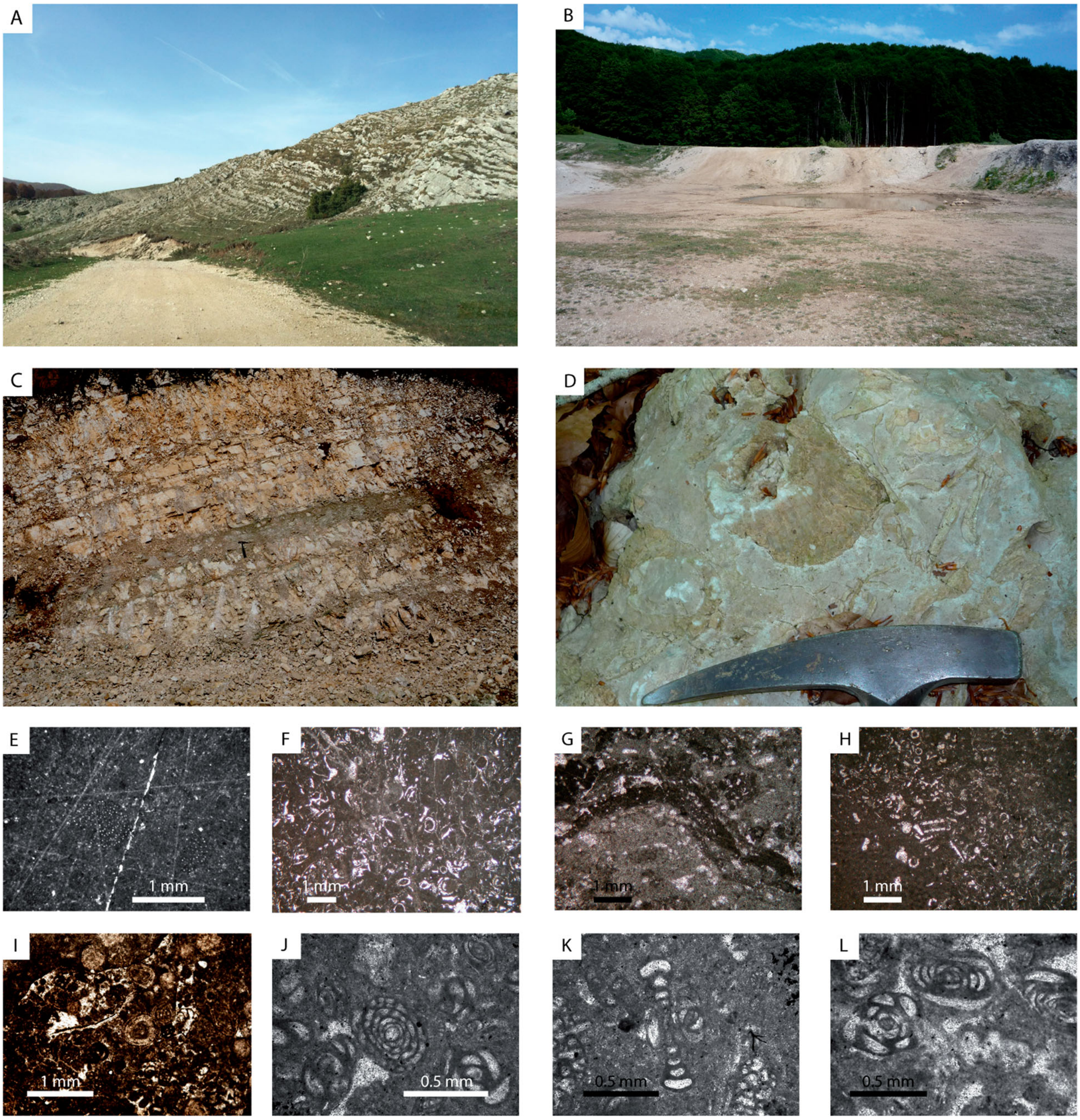

Figure 3. Cretaceous carbonate units (A) Field view of the Saifar limestone outcropping along the Fosso Fioio valley (out of the study area); (B) heavily weathered Fioio dolostone outcropping at Cesa Cotta; (C) requieniid limestone with green shaly levels at Camporotondo; (D) radiolitiid floatstone; (E) wackestone with *Favreina prusensis* and *Favreina* sp. (Saifar limestone); (F) packstone with abundant *Campbelliella striata* (*Campbelliella* limestone); (G) typical strongly dolomitized microfacies of the 'Fioio dolostone'; (H) wackestone/packstone with abundant *Salpingoporella annulata* (Fioio dolostone); (I) packstone with ooids and miliolacea (requieniid limestone); (J) packstone with *Ovalveolina maccagnoi* and miliolacea (requieniid limestone); (K) packstone with *Paleocornuloculina lepina* (requieniid limestone); (L) packstone with *Paleosigmoilopsis appenninica* and miliolacea (requieniid limestone).

cf. *sphareoidea*, *Pyrgo* sp., *Thaumatoporella* sp., ostracods, discorbacea, nubecularidae and rotaliidae (Fabbi, 2013, 2016). This unit only crops out in limited areas and no complete sections are exposed, so that the thickness (which should exceed 600 m – Damiani et al., 1998; Compagnoni et al., 2005; Fabbi, 2016) cannot be precisely determined.

A long phase of subaerial exposure of the region is believed to have taken place during the Paleogene, producing the so called 'Paleogene hiatus' (Cipollari & Cosentino, 1995; Cosentino et al., 2010; Damiani et al., 1990, 1991), although alternative models have recently been proposed (Brandano, 2017).

Carbonate production, characterized by heterozoan assemblages, was resumed starting in the early Miocene, producing a paraconformable contact with the Cretaceous substrate (Civitelli & Brandano, 2005).

The 'bryozoan limestone' (upper Burdigalian – lower Tortonian p.p. – Civitelli & Brandano, 2005) is the last carbonate platform unit in the region and is a thick to fairly bedded white packstone with abundant bryozoans and bivalves. The rich micropaleontologic assemblages include abundant benthic forams, serpulids, barnacles, echinoid fragments with syntaxial calcite cement, and rare planktonic forams. Some levels are dominated by rodoliths. The upper portion is characterized by a peculiar lozenge-shaped fracturing pattern. The unit in the study area directly rests above the Cretaceous substrate and exceeds 100 m in thickness.

3.2. Terrigenous succession

In the late Miocene, the Latium-Abruzzi platform was involved in the Apennine chain building (Bally, Burbi, Cooper, & Ghelardoni, 1986; Centamore, Rossi, & Tavarnelli, 2009; Doglioni et al., 1999; Mostardini & Merlini, 1986; Patacca, Scandone, Bellatalla, Perilli, & Santini, 1991, 1992; Royden, Patacca, & Scandone, 1987), which resulted in the shift from shallow-water carbonate to hemipelagic, to turbiditic foredeep sedimentation (Figure 2) (Bigi et al., 2003; Carminati, Corda, Mariotti, & Brandano, 2007; Centamore & Rossi, 2009; Cipollari & Cosentino, 1991; Critelli et al., 2007; Milli & Moscatelli, 2000; Patacca & Scandone, 1989). The hemipelagic interval (i.e. 'Orbulina marls' auctt. - Fabbi et al., 2014; Fabbi & Rossi, 2014; Pampaloni, Pichezzi, Raffi, & Rossi, 1994) does not crop out in the area, while the siliciclastic turbidites belonging to the 'complesso torbiditico altomiocenico laziale abruzzese' (*late Miocene Latium-Abruzzi turbiditic complex*) and the above mentioned 'brecce della Renga fm.' are extensively exposed.

The 'complesso torbiditico altomiocenico laziale-abruzzese' represents the foredeep sedimentation of the Latium-Abruzzi region. It is a very thick (several hundred meters) turbidite succession, dominated by sandstone intervals (Figure 4) organized in $T_{a\text{-}b}$ to $T_{a\text{-}e}$ Bouma sequences. The sandstones are composed almost exclusively of siliciclastic grains (quartz, micas, K-feldspar, plagioclase) along with rare lithoclasts and very rare bioclasts. Rare graded/ laminated calcarenites, mainly composed of undeterminable bioclastic debris, occur interbedded with the sandstones. The age of this unit is early Messinian *p.p.* (Compagnoni et al., 2005; Fabbi et al., 2014).

In the northeastern Simbruini Mts. a peculiar unit, the 'brecce della Renga fm.' (Devoto, 1967) represents the lateral equivalent of the 'unità argilloso-marnosa' and the 'complesso torbiditico altomiocenico laziale abruzzese' (Fabbi & Rossi, 2014 and references therein; Fabbi, 2016). This unit is markedly clastic and results from the dismantling of the margins of a prominent structural high existing in the area during the late Miocene (Figure 5) (Carminati et al., 2014; Critelli et al., 2007; Fabbi, 2013, 2016; Fabbi et al., 2014; Fabbi & Rossi, 2014).

The 'brecce della Renga fm.' was subdivided in three lithofacies and six sublithofacies by Compagnoni et al. (1990, 1991, 2005), based on field geometries, rudite/arenite/pelite ratio, and a diverse array of sedimentological features.

A detailed description of each lithofacies and sedimentology of the 'brecce della Renga fm.' can be found in Fabbi and Rossi (2014).

Only lithofacies 2 and 3 of the 'brecce della Renga fm.' are found in the study area.

The lithofacies 2 of the 'brecce della Renga fm.' crops out extensively and is subdivided into a massive sublithofacies (2-a) and a well bedded sublithofacies (2-b). The sublithofacies 2-a has a total thickness of more than 300 meters (Fabbi & Rossi, 2014) and is made of clast- supported carbonate breccias. The lithoclasts are markedly heterometric, ranging from sand to boulder (up to tens of meters across) size. Lithoclasts are Miocene and Cretaceous carbonates, with Miocene granules also comprising isolated coeval echinoids, bivalves, benthic forams and bryozoans. Yellow pelite intercalations (already described by Compagnoni et al., 1990, 2005; Devoto, 1967, 1970; Fabbi et al., 2014; Fabbi & Rossi, 2014; Parotto, 1969) are common (Figure 4), and provide the essential biostratigraphical elements to determine the age of the rudites (early Tortonian-early Messinian – Fabbi & Rossi, 2014). This massive lithofacies commonly lacks any stratal organization and rests unconformably on the Cretaceous bedrock (Fabbi, 2013; Fabbi & Rossi, 2014). At Cima Bertina the well bedded sublithofacies 2-b of the 'brecce della Renga fm.' displays a typical fining upwards trend coupled with an increase of siliciclastic components (Compagnoni et al., 1990). The matrix of the breccia is composed of skeletal grains (barnacles, bryozoans, bivalves, echinoids, red algae, rare benthic forams) and abundant siliciclastic grains (mainly quartz).

The lower Messinian lithofacies 3 of the 'brecce della Renga fm.' crops out along the NE slopes of the Simbruini Mts., and consists of stacks of dm- to m-thick breccia beds and associated arenites, interbedded with the siliciclastic turbidites; the breccias often form disorganized intervals, up to some tens of meters thick (Figure 4) also bearing large boulders of the carbonate substrate. Graded and laminated turbiditic calcarenites are commonly organized in stacks up to some meters thick. The fossil content of the calcarenites include fragments of echinoids, balanids, bryozoans, molluscs, and red algae, along with benthic forams (*Amphistegina* sp., *Elphidium* sp., *Planulina* sp., Anomalinidae, Cibicididae, Rotaliidae, Textulariidae). The abundant siliciclastic fraction is essentially composed of quartz and micas. The maximum estimated thickness is a few hundred meters.

3.3. Continental deposits

The studied sector of Central Apennines was finally uplifted and became emergent through the late Messinian – late Pliocene (Carminati & Doglioni, 2012;

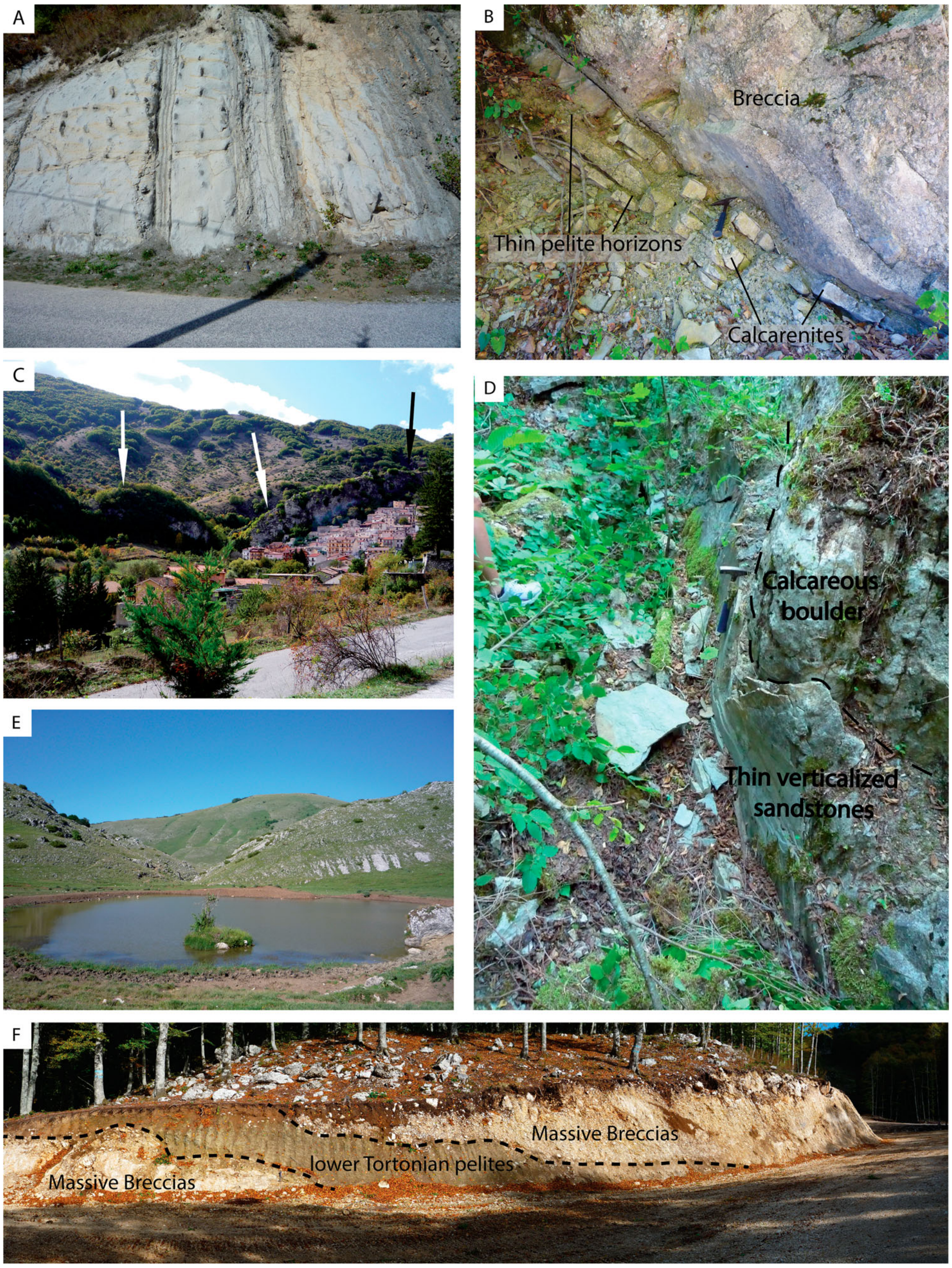

Figure 4. Upper Miocene terrigenous units (A) Vertical beds of turbiditic thick sandstone/thin pelite alternations ('complesso torbiditico altomiocenico laziale-abruzzese' at Verrecchie; (B) typical aspect of the lithofacies 3 of the 'brecce della Renga fm.' near Castellafiume (after Fabbi et al., 2014); (C) verticalized decametric breccia bed (arrows) outcropping at Verrecchie; (D) load deformations in sandstones at the base of the thick breccia bed shown in 'C' (lithofacies 3 of the 'brecce della Renga fm.' outcropping at Verrecchie – modified after Fabbi & Rossi, 2014); (E) S. Antonio lake, one of the sites where lower Messinian pelites outcrop intercalated to the sublithofacies 2-a of the 'brecce della Renga fm.'; (F) lower Tortonian pelites intercalated to the sublithofacies 2-a of the 'brecce della Renga fm.' along the Camporotondo ski slope (after Fabbi & Rossi, 2014).

Cosentino et al., 2010; Doglioni et al., 1999; Gueguen, Doglioni, & Fernandez, 1998).

Post-emersion continental deposits are essentially Quaternary in age. Being the mapping project focused on the substrate, continental deposits have been separated only on the basis of sedimentological and positional features, and they are subdivided into three separate categories:

i The deposits cropping out at valley bottoms (i.e. the Liri river alluvial sediments); the thickest soils (> 1 m) which commonly hide the bedrock in the inner valleys of the Simbruini Mts.; the volcaniclastic (essentially cineritic) deposits belonging to the Alban Hills or the Oricola volcanoes (Compagnoni et al., 2005; D'orefice et al., 2014) which occasionally are up to >5 meters thick (Figure 6) in the inner valleys of the Simbruini Mts.);
ii a wide landslide which affects the slope whose toe host the village of Petrella Liri, which is partly built on and around large fallen limestone boulders;

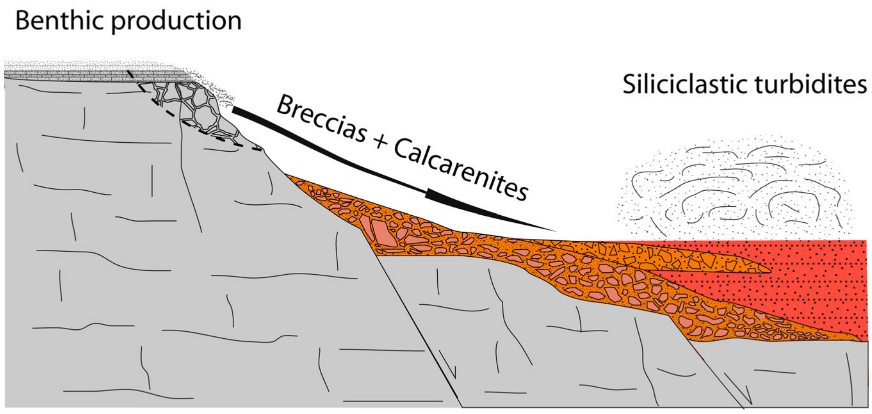

Figure 5. Sketch depicting the 'brecce della Renga fm.' depositional system. Modified after Fabbi and Rossi (2014).

iii slope debris, mainly composed of pebbles and boulders belonging to the carbonate succession and to the 'brecce della Renga fm.'.

4. Tectonics

At least three main tectonic phases in Miocene to recent times affected the study area: (i) A late Miocene extension, which originated the structural high whose dismantling produced the spectacular clastic deposits of the 'brecce della Renga fm.'; (ii) a latest Miocene-Pliocene compressional phase which gave origin to the Apennine chain; (iii) a Pleistocene post-orogenic extensional phase, which is still active in the Region, as confirmed by recent strong earthquakes.

Pre-orogenic paleofaults are largely sealed by the 'brecce della Renga fm.', and are mapped with a different symbol. The best exposure of pre-orogenic extensional faults is to be found at Colle la Fossa, where the Cretaceous substrate is cut by SW-dipping faults (with total throw of a few hundred meters) sealed by the sublithofacies 2-a of the 'brecce della Renga fm.' (Figure 7 – Carminati et al., 2014). A similar situation, with the breccias onlapping a SW – dipping normal fault paleoescarpment can be observed at Monna Rosa (Figure 8 – Carminati et al., 2014; Fabbi & Rossi, 2014). For a detailed description and analysis of pre-orogenic faults and of the paleogeographic setting of the area the reader is referred to the papers of Carminati et al. (2014) and Fabbi and Rossi (2014).

Figure 6. Volcaniclastic deposits outcropping at Camporotondo.

The Simbruini Mts. are essentially a wide NE-dipping monocline. This monocline is cut to the E and NE by the Simbruini thrust front, and is fragmented to the W by a large system of regional SW-dipping extensional faults (Figure 1), largely exposed outside the study area (Carminati et al., 2014 and references therein).

The main compressional fault in the study area is the Simbruini thrust front, one of the most important thrusts in the region, which trends NW–SE along the Roveto valley, and becomes a blind structure south of Cappadocia. In the field, it is possible to observe at least two main splays and several minor lineaments. Good exposures of the westernmost lineament are at Verrecchie and along the Verrecchie-Cappadocia road. The best exposure of the easternmost lineament occurs near the Cappadocia cemetery (Figure 9), where the most external outcrop of the lithofacies 3 of the 'brecce della Renga fm.' is severely deformed, and overthrusts the siliciclastic sandstones of the 'complesso torbiditico altomiocenico laziale abruzzese'. Kinematic indicators measured along the whole structure, including minor fault planes, show a general apenninic vergence (N 60° E – Fabbi, 2016). A minor reverse fault trends NW–SE and crops out along the Fioio valley, at the southwestern boundary of the study area, causing the overthrusting of the 'Saifar limestone' above the 'Fioio dolostone'. In addition, several low angle reverse planes cut the verticalized breccia beds at Verrecchie and along the Capistrello-Piani della Renga-Filettino road, evidencing that the breccias should be already lithified when the region experienced compressional tectonics (Fabbi, 2013; Fabbi & Rossi, 2014).

As was mentioned above, the main extensional faults of this sector of the Apennines are located outside the mapped area, where, however, a number of

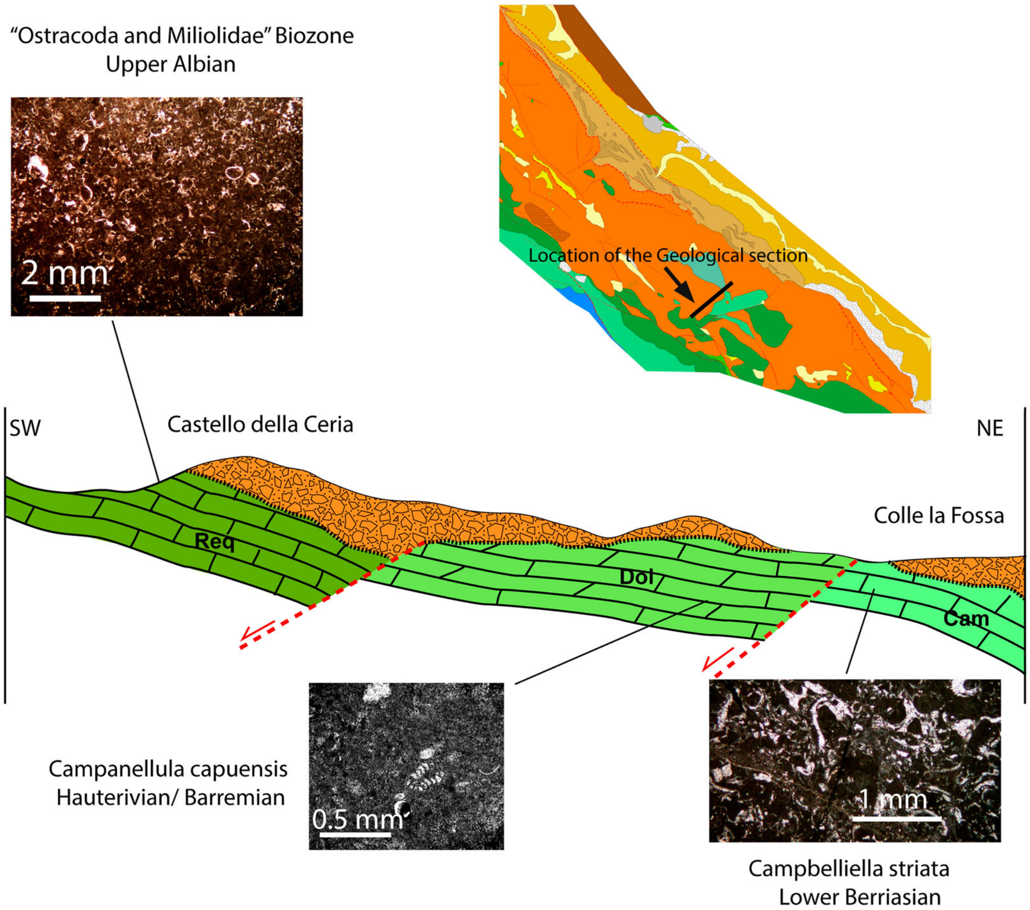

Figure 7. Geological section showing the paleofaults cutting the Cretaceous substrate near Colle la Fossa; the labels 'Req', 'Dol' and 'Cam' are referred, as in the Main Map to the 'requeniid limestone', 'Fioio dolostone' and '*Campbelliella* limestone' respectively (modified after Carminati et al., 2014).

minor faults can be observed. It is worth noting that the pattern of faults affecting the substrate is more dense than the pattern seen in the 'brecce della Renga fm.', which suggests that the substrate records subsequent superimposed tectonic phases, including the one which generated the breccias (Carminati et al., 2014; Fabbi, 2013), while the breccias record only orogenic compression and subsequent Quaternary extension.

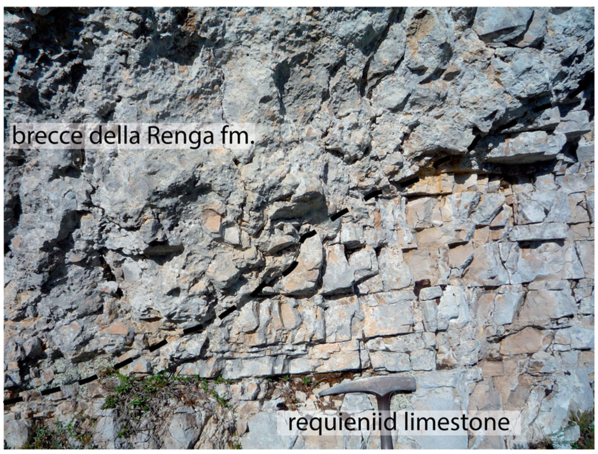

Figure 8. 'brecce della Renga fm.' laying above a paleoescarpment cutting the 'requieniid limestone' beds, exposed at Monna Rosa.

A major regional tectonic lineament observed in the study area is the left-lateral transpressive fault system which borders the left side of the Roveto valley (Compagnoni et al., 2005; Montone & Salvini, 1993; Smeraglia, Aldega, Billi, Carminati, & Doglioni, 2016). According to Galadini (1999) and Roberts and Michetti (2004), this fault is now reactivated as an extensional fault and it is still active and seismogenic. Subvertical fault planes are well exposed along the valley (Figure 9), generally striking N 140° E.

5. Conclusions

A geological map on the 1:20,000 scale displays the geology of the eastern sector of the Simbruini Mts., in Central Apennines. Following a common picture for the Central Apennines, this sector of the Chain is characterized by a thick (> 3000 m) succession of Mesozoic and Miocene shallow-water carbonates, belonging to the Latium-Abruzzi carbonate platform Domain.

The carbonate sedimentation ended in the late Miocene, because of the involvement of the region in the Apennine chain building phase. The ongoing foreland flexure caused the gradual shift from carbonate to

Figure 9. (A) and (B) Views of the strongly deformed most external outcrop of the 'brecce della Renga fm.' near the Cappadocia cemetery; (C) panoramic view of the Roveto Valley fault, taken from Mt. Padiglione.

siliciclastic sedimentation of the region, that became a complex foredeep basin, facing the Apennine orogenic system.

A result of the foreland flexure was a strong pre-orogenic extensional tectonic phase that affected the northern Simbruini Mts., producing a complex structural high within the basin. The dismantling of the flanks of such a high produced a thick lithoclastic unit (brecce della Renga fm.) which is widely exposed in the study area. This clastic unit is a *unicum* in the region and is partly lateral to the more typical foredeep succession of Central Apennines, represented here by turbiditic sandstones.

Since the Messinian the whole sedimentary succession was deformed and uplifted by the NE-verging Apennine building compressional phase. The final uplift of the chain caused the definitive halt of marine sedimentation in the region since the latest Messinian-Pliocene, and the sedimentation of continental deposits. The main orogenic structures in the map are the Simbruini thrust front, which becomes a blind structure south of the Cappadocia village, and the Roveto valley left transpressional system. The last tectonic event affecting the area is a SW-directed extensional phase, which is still active in the Central Apennines. Several normal faults cropping out in the area are interpreted as secondary lineaments related to such post-orogenic extension.

Software

The map has been drawn using the Adobe Illustrator CS2 software, on scanned hand-drawn maps. The topographic base map is the Abruzzo Region D.B.T.R. on the 1:25,000 scale (sheets 367E, 376 and 377W), available online.

Acknowledgments

I would like to thank Massimo Santantonio for fruitful discussions and for the critical revision of the manuscript. Maurizio Chiocchini, Rita Pichezzi and Mariagrazia Rossi are warmly acknowledged for their willingness and their essential help in determining microfossils. The base maps have been retrieved from the Regione Abruzzo Cartographic Service Opendata (http://opendata.regione.abruzzo.it/). Finally I would thank all those who helped me during the fieldwork: Giulia Colasanti, Damiano Mangiacapra, Gianluca Massetti, Gaia Mascaro, Natalia Prosciutti, Benedetto Petricca, Antonello Simonetti and Eugenio Carminati.

Disclosure statement

No potential conflict of interest was reported by the authors.

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References

Accordi, G., & Carbone, F. (1988). Carta delle litofacies del Lazio-Abruzzo ed aree limitrofe. *Quaderni della Ricerca Scientifica*, *114*, 1–223.

Bally, A. W., Burbi, L., Cooper, C., & Ghelardoni, R. (1986). Balanced sections and seismic reflection profiles across the central Italy. *Memorie della Società Geologica Italiana*, *35*, 257–310.

Bigi, S., Costa Pisani, P., Milli, S., & Moscatelli, M. (2003). The control exerted by pre-thrusting normal faults on the Early Messinian foredeep evolution, structural styles and shortening in the Central Apennines (Lazio-Abruzzo, area, Italy) [Special volume]. *Studi Geologici Camerti*, *2003*, 17–37.

Bosellini, A. (2004). The western passive margin of Adria and its carbonate platforms. *Special Volume of the Italian Geological Society for the 32 IGC*, 79–92.

Brandano, M. (2017). Unravelling the origin of a Paleogene unconformity in the Latium-Abruzzi carbonate succession: A shaved platform. *Palaeogeography, Palaeoclimatology, Palaeoecology*, *485*, 687–696.

Carminati, E., Corda, L., Mariotti, G., & Brandano, M. (2007). - Tectonic control on the architecture of a Miocene carbonate ramp in the Central Apennines (Italy): insights from facies and backstripping analyses. *Sedimentary Geology*, *198*, 233–253.

Carminati, E., & Doglioni, C. (2012). Alps vs Apennines: The paradigm of a tectonically asymmetric earth. *Earth-Science Reviews*, *112*, 67–96.

Carminati, E., Fabbi, S., & Santantonio, M. (2014). Slab bending, syn-subduction normal faulting and out-of-sequence thrusting in the Central Apennines. *Tectonics*, *33*, 530–551.

Centamore, E., & Rossi, D. (2009). Neogene-Quaternary tectonics and sedimentation in the Central Apennines. *Italian Journal of Geosciences*, *128*, 73–88.

Centamore, E., Rossi, D., & Tavarnelli, E. (2009). Geometry and kinematics of Triassic-to-Recent structures in the northern-central Apennines: A review and an original working hypothesis. *Italian Journal of Geosciences*, *128*, 419–432. doi:10.3301/IJG.2009.128.2.419.

Chiocchini, M., Chiocchini, R. A., Didaskalou, P., & Potetti, M. (2008). Microbiostratigrafia del Triassico superiore, Giurassico e Cretacico in facies di piattaforma carbonatica del Lazio centro-meridionale e Abruzzo. *Memorie descrittive della Carta Geologica d'Italia*, *84*, 5–170.

Cipollari, P., & Cosentino, D. (1991). La Linea Olevano-Antrodoco: contributo della biostratigrafia alla sua caratterizzazione cinematica [Special volume]. *Studi Geologici Camerti, spec.*, *1991/2*, 143–149.

Cipollari, P., & Cosentino, D. (1995). Miocene unconformities in the Central Apennines: Geodinamic significance and sedimentary basin evolution. *Tectonophysics*, *252*, 375–389.

Civitelli, G., & Brandano, M. (2005). Atlante delle litofacies e modello deposizionale dei Calcari a Briozoi e Litotamni nella Piattaforma carbonatica laziale-abruzzese. *Bollettino della Società Geologica Italiana*, *124*, 611–643.

Compagnoni, B., D'Andrea, M., Galluzzo, F., Giovagnoli, M. C., Lembo, P., Molinari, V., … Chiocchini, U. (2005). Note illustrative del F° 367 'Tagliacozzo'. *Servizio Geologico d'Italia*: Carta Geologica d'Italia alla scala 1:50000.

Compagnoni, B., Galluzzo, F., Pampaloni, M. L., Pichezzi, R. M., Raffi, I., Rossi, M., & Santantonio, M. (1991). Dati sulla lito-biostratigrafia delle successioni terrigene nell'area tra i Monti Simbruini e i Monti Carseolani (Appennino Centrale) [Special volume]. *Studi Geologici Camerti*, *1991/2*, 173–180.

Compagnoni, B., Galluzzo, F., & Santantonio, M. (1990). Le «Brecce della Renga» (M.ti Simbruini): Un esempio di sedimentazione controllata dalla tettonica. *Memorie descrittive della Carta Geologica d'Italia*, *38*, 59–76.

Cosentino, D., Cipollari, P., Marsili, P., & Scrocca, D. (2010). Geology of the central Apennines: A regional review. *Journal of the Virtual Explorer*, *36*. doi:10.3809/jvirtex.2010.00223

Critelli, S., Le Pera, E., Galluzzo, F., Milli, S., Moscatelli, M., Perrotta, S., & Santantonio, M. (2007). Interpreting siliciclastic-carbonate detrital modes in foreland basin systems: An example from Upper Miocene arenites of the central Apennines, Italy. *Geological Society of America Special Papers*, *420*, 107–133.

Damiani, A. V. (1990). Studi sulla Piattaforma lazialeabruzzese. Nota II. Contributo alla interpretazione della evoluzione tettonico sedimentaria dei Monti Affilani e «pre-ernici» e cenni sui rapporti con le adiacenti aree appenniniche. *Memorie descrittive della Carta Geologica d'Italia*, *38*, 177–206.

Damiani, A. V., Catenacci, V., Molinari, V., Panseri, C., & Tilia, A. (1998). Note illustrative del F° 376 'Subiaco'. *Servizio Geologico d'Italia*: Carta Geologica d'Italia alla scala 1:50000.

Damiani, A. V., Chiocchini, M., Colacicchi, R., Mariotti, G., Parotto, M., Passeri, L., & Praturlon, A. (1991). Elementi litostratigrafici per una sintesi delle facies carbonatiche Meso-Cenozoiche dell'Appennino centrale [Special volume]. *Studi Geologici Camerti*, *1991/2*, 187–214.

Damiani, A. V., Molinari, V., Pichezzi, R. M., Panseri, C., & Giovagnoli, M. C. (1990). Il passaggio Cretaceo-Terziario nei sedimenti carbonatici di piattaforma dei Monti Affilani (Lazio). *Memorie descrittive della Carta Geologica d'Italia*, *38*, 21–37.

D'argenio, B. (1974). Le piattaforme carbonatiche periadriatiche. Una rassegna di problemi nel quadro geodinamico Mesozoico dell'area Mediterranea. *Memorie della Società Geologica Italiana*, *13*, 1–28.

Devoto, G. (1967). Le brecce calcaree mioceniche nell'alta Valle Roveto tra Castellafiume e Canistro (Frosinone, Lazio meridionale). *Geologica Romana*, *6*, 75–86.

Devoto, G. (1970). Sguardo geologico dei Monti Simbruini (Lazio nord-orientale). *Geologica Romana*, *9*, 127–136.

Doglioni, C., Gueguen, E., Harabaglia, P., Mongelli, F., Durand, B., Jolivet, L., … Seranne, M. (1999). On the origin of west-directed subduction zones and applications to the western Mediterranean. In *The Mediterranean basins: Tertiary extension within the Alpine orogen. Geological Society of London, Special Publication, Vol. 156* (pp. 541–561).

D'orefice, M., Graciotti, R., Chiessi, V., Censi Neri, P., Morri, A., Roma, M., & Falcetti, S. (2014). La conca intermontana di Oricola-Carsoli (AQ): caratteri geologici, geomorfologici e applicativi. *Memorie descrittive della Carta Geologica d'Italia*, *91*, 138 pp.

Fabbi, S. (2013). *La frammentazione della piattaforma carbonatica dei Monti Simbruini nel Miocene superiore* (PhD thesis), Università degli Studi di Roma 'La Sapienza'.

Fabbi, S. (2016). Geology of the northern Simbruini Mts. (Abruzzo–Italy). *Journal of Maps*. doi:10.1080/17445647.2016.1237899.

Fabbi, S., Galluzzo, F., Pichezzi, R. M., & Santantonio, M. (2014). Carbonate intercalations in a terrigenous foredeep: Late Miocene examples from the Simbruini Mts. and the Salto Valley (Central Apennines – Italy). *Italian Journal of Geosciences*, *133*, 85–100. doi:10.3301/IJG.2013.13.

Fabbi, S., & Rossi, M. (2014). The Brecce della Renga Formation: Age and sedimentology of a syn-tectonic clastic unit in the upper Miocene of Central Apennines. Insights from field geology. *Rivista Italiana di Paleontologia e Stratigrafia*, *120*, 225–242.

Fabbi, S., & Santantonio, M. (2012). Footwall progradation in syn-rift carbonate platform-slope systems (early Jurassic, northern Apennines, Italy). *Sedimentary Geology*, *281*, 21–34.

Fabbi, S., & Santantonio, M. (2018). First report of a Messinian coralgal facies in a terrigenous setting of Central Apennines (Italy) and its palaeogeographic significance. *Geological Journal*. Advance online publication. https://doi.org/10.1002/gj.3267

Galadini, F. (1999). Pleistocene changes in the central Apennine fault kinematics: A key to decipher active tectonics in central Italy. *Tectonics*, *18*(5), 877–894. doi:10.1029/1999TC900020

Gueguen, E., Doglioni, C., & Fernandez, M. (1998). On the post-25 Ma geodynamic evolution of the western Mediterranean. *Tectonophysics*, *298*, 259–269.

Kuss, J., & Senowbari-Daryan, B. (1992). Anomuran coprolites from Cretaceous shallow water limestones of NE Africa. *Cretaceous Research*, *13*, 147–156.

Milli, S., & Moscatelli, M. (2000). Facies analysis and physical stratigraphy of the Messinian turbiditic complex in the Valle del Salto and Val di Varri (Central Apennines). *Giornale di Geologia*, *62*, 57–77.

Molinari-Paganelli, V., Pichezzi, R., & Tilia - Zuccari, A. (1980). I coproliti di crostacei. Rassegna bibliografica e annotazioni tassonomiche. Parte 1: Genere *Favreina*. *Bollettino del Servizio geologico d'Italia*, *100*, 409–454.

Montone, P., & Salvini, F. (1993). Geologia strutturale dei rilievi tra Colli di Monte Bove (Carsoli) e Tagliacozzo, Abruzzo. *Geologica Romana*, *29*, 15–29.

Mostardini, F., & Merlini, S. (1986). Appennino centro meridionale. Sezioni Geologiche e proposta di modello strutturale. *Memorie della Società Geologica Italiana*, *35*, 177–202.

Pampaloni, M. L., Pichezzi, R. M., Raffi, I., & Rossi, M. (1994). Calcareous planktonic biostratigraphy of the marne a *Orbulina* unit (Miocene, central Italy). *Giornale di Geologia*, *56*, 139–153.

Parotto, M. (1969). Geologia. In: 'Idrogeologia dell'alto bacino del Liri (Appennino centrale)'. *Geologica Romana*, *8*, 177–559.

Parotto, M., & Praturlon, A. (1975). Geological summary of the Central Appennines. *Quaderni della Ricerca Scientifica*, *90*, 257–306.

Parotto, M., & Praturlon, A. (2004). The southern Apennine arc. In U. Crescenti, S. D'Offizi, S. Merlino, & L. Sacchi (Eds.), *Geology of Italy. Special Volume of the Italian Geological Society for the IGC 32 Florence-2004* (pp. 33–58).

Patacca, E., Sartori, R., & Scandone, P. (1992). Tyrrhenian basin and Apenninic arcs: Kinematic relations since late Tortonian times. *Memorie della Società Geologica Italiana*, *45*, 425–451.

Patacca, E., & Scandone, P. (1989). Post-Tortonian mountain building in the Apennines. The role of the passive sinking of a relic lithosphere slab. In A. Boriani, M. Bonafede, G. B. Piccando, & G. B. Vai (Eds.), *The lithosphere in Italy. Advances in earth science research. Accademia Nazionale dei Lincei* (pp. 157–176).

Patacca, E., Scandone, P., Bellatalla, M., Perilli, N., & Santini, U. (1991). La zona di giunzione tra l'arco appenninico settentrionale e l'arco appenninico meridionale nell'Abruzzo e nel Molise [Special volume]. *Studi Geologici Camerti*, *1991/2*, 417–441.

Roberts, G. P., & Michetti, A. M. (2004). Spatial and temporal variations in growth rates along active normal fault systems: An example from the Lazio-Abruzzo Apennines, Central Italy. *Journal of Structural Geology*, *26*, 339–376.

Royden, L., Patacca, E., & Scandone, P. (1987). Segmentation and configuration of subducted lithosphere in Italy: An important control on thrust belt and foredeep-basin evolution. *Geology*, *15*, 714–717.

Santantonio, M., & Carminati, E. (2011). Jurassic rifting evolution of the Apennines and Southern Alps (Italy): Parallels and differences. *Geological Society of America Bulletin*, *123*, 468–484. doi:10.1130/ b30104.1

Schweigert, G., Seegis, D. B., Fels, A., & Leinfelder, R. R. (1997). New internally structured decapod microcoprolites from Germany (late Triassic/early Miocene), southern Spain (early/Middle Jurassic) and Portugal (late Jurassic): Taxonomy, palaeoecology and evolutionary implications. *Paläontologische Zeitschrift*, *71*, 51–69.

Servizio Geologico d'Italia. (1998). Geological Map of Italy 1:50000, sheet #376 'Subiaco'.

Servizio Geologico d'Italia. (2005). Geological Map of Italy 1:50000, sheet #367 'Tagliacozzo'.

Smeraglia, L., Aldega, L., Billi, A., Carminati, E., & Doglioni, C. (2016). Phyllosilicate injection along extensional carbonate-hosted faults and implications for co-seismic slip propagation: Case studies from the central Apennines, Italy. *Journal of Structural Geology*, *93*, 29–50.