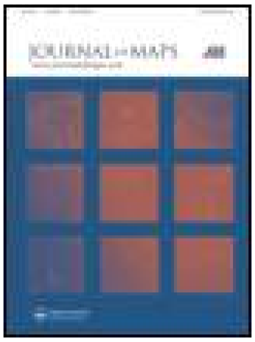

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SCIENCE

Geology of the Northern Simbruini Mts. (Abruzzo – Italy)

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ABSTRACT
This paper presents the results of a geological mapping project across the northern portion of the Simbruini Mts. (Latium-Abruzzi Domain – Central Apennines), where a thick Cretaceous and Miocene carbonate succession, followed by a thick upper Miocene terrigenous foredeep succession, is exposed. The terrigenous succession also includes a peculiar lithoclastic unit ('brecce della Renga fm.'), whose sedimentation is linked to pre-orogenic (Tortonian-Messinian) extensional tectonics. The study area experienced late Messinian-early Pliocene compression, which is the Apennine chain building phase, followed by Quaternary post-orogenic extension, related to the opening of the Tyrrhenian basin. A geological map, at 1:20,000 scale, illustrates the main stratigraphic and structural features of the area.

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Apennines; stratigraphy; Cretaceous; brecce della Renga; chain building; Miocene; pre-orogenic extension

1. Introduction

The present paper is companion to the geological map (Main Map) of the northern portion of the Simbruini Mountains (Central Apennines – Latium-Abruzzi geological domain – Figure 1), in the westernmost sector of the Abruzzo region (Province of L'Aquila, Central Italy). The map covers an about 80 km^2 wide area, roughly oriented NW–SE, mainly located above 1000 m a.s.l., the main peaks being Mt. Midia (1737 m), Mt. Cacume (1655 m), Mt. Fontecellese (1627 m) and Mt. Morbano (1626 m).

The Latium Abruzzi Domain is one of the pre-orogenic paleogeographic domains in which the central Apennines are subdivided (Figure 1). This Domain is generally characterized by shallow-water carbonate sedimentation since the Upper Triassic throughout the Mesozoic, and, although with large hiatuses (see chapter 3), the Cenozoic (Accordi & Carbone, 1988; Chiocchini, Chiocchini, Didaskalou, & Potetti, 2008; Civitelli & Brandano, 2005; Parotto & Praturlon, 1975). Conversely, in the adjacent Tuscan and Umbria-Marche-Sabina Domains the Early Jurassic rifting phase (Fabbi & Santantonio, 2012; Santantonio & Carminati, 2011) produced the drowning of the carbonate platform and the consequent onset of pelagic sedimentation since the Hettangian/Pliensbachian. The typical Latium-Abruzzi stratigraphy consists of a thick Meso-Cenozoic carbonate platform succession, generally overlain by upper Miocene/Pliocene terrigenous units representing the Apennine chain foredeep sedimentation (Bigi, Costa Pisani, Milli, & Moscatelli, 2003; Critelli et al., 2007; Milli & Moscatelli, 2000). The terrigenous succession in the study area (Figures 1(c) and 2) includes a peculiar, markedly lithoclastic unit, the 'brecce della Renga formation' (Compagnoni, Galluzzo, & Santantonio, 1990; Devoto, 1967; Fabbi & Rossi, 2014).

The mapping project was part of a research project aimed at the reconstruction of the Miocene paleogeography of the study area, and to the sedimentological study of the 'brecce della Renga fm.'. For this reason a new geological map was produced, although the study area has already been mapped (sheet #367 'Tagliacozzo' of the geological map of Italy at 1:50,000). There are, thus, along with many obvious similarities, some differences between the map presented here and the official geological map, mainly due to the more detailed field surveying scale (1:10,000 vs. 1:25,000), which allowed better outcrop representation (including those of limited extent) and to a new interpretation of some tectonic and stratigraphic features. The main difference is the separate representation of each sublithofacies of the 'brecce della Renga fm.' Making is easier to identify the present-day distribution of these deposits, which are controlled by the Miocene paleogeography (see below). In addition, some faults have been reinterpreted as paleofaults, buried by the 'brecce della Renga fm.' instead of cutting them, and the pattern of tectonic lineaments is now better constrained with new and more detailed field data.

2. Methods

The map is the result of a geological survey originally performed at 1:10,000 scale, using an enlarged 1:25,000 IGM topographic map (Series 25, year of publication 1994. Sections: 367 II 'Tagliacozzo'; 367 III 'Arsoli'; 367 IV 'Carsoli'). A lithostratigraphic criterion has been used for this study, accompanied by

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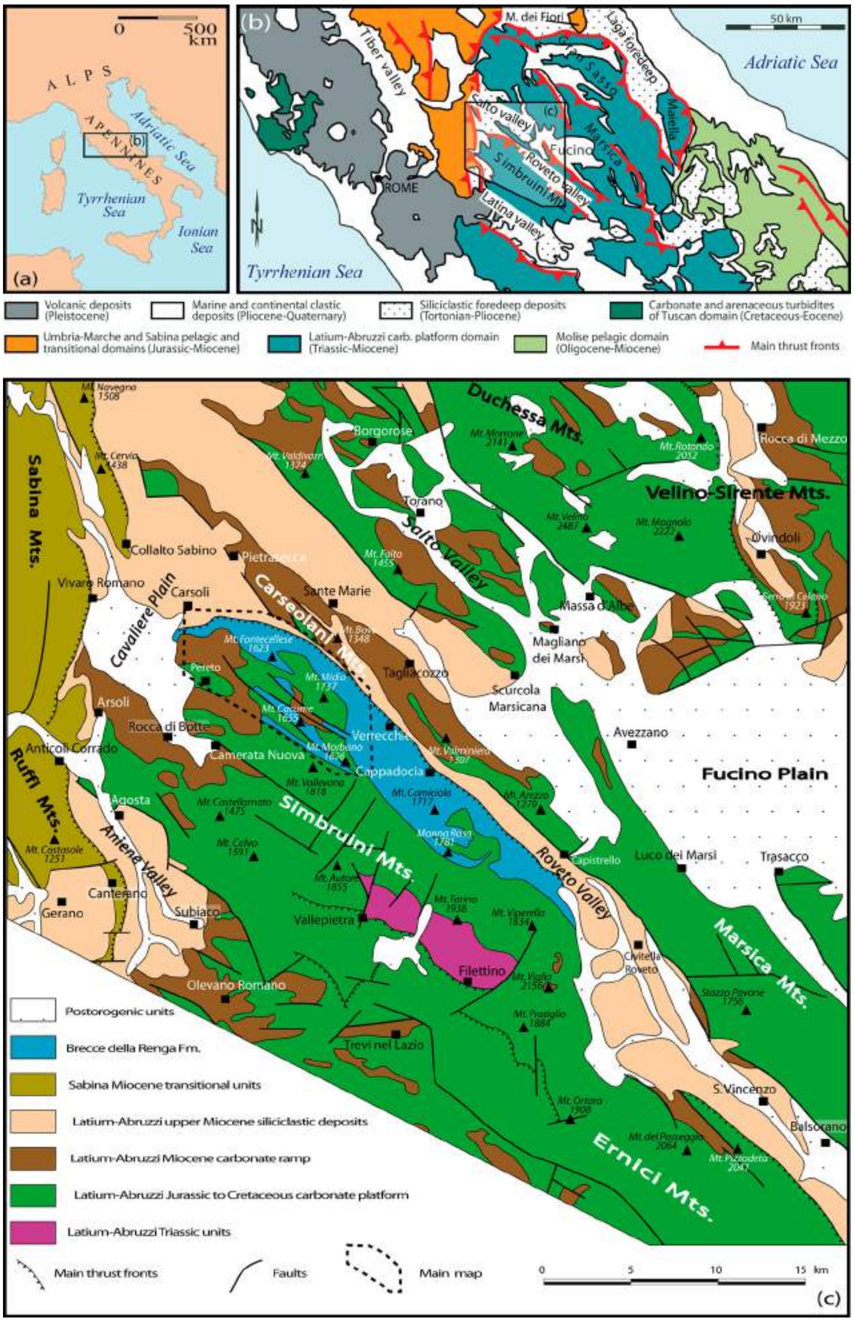

Figure 1. (a) Location and (b) regional geology of Central Italy; (c) schematic geological map of the Simbruini Mts. and neighboring areas. Modified after Carminati et al. (2014).

biostratigraphic analyses (in thin section), and integrated with sedimentological analysis for the terrigenous deposits (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 as those described in Compagnoni et al. (2005); minor differences concern the stratigraphy of the terrigenous units, which have recently been reviewed for the scope of the CARG (Geological mapping of Italy) project.

3. Stratigraphy and geological setting

The stratigraphy of the study area (Figure 2) is regionally known as the Latium-Abruzzi succession, and reflects the evolution of the Latium-Abruzzi carbonate platform, which was the site of shallow-water deposition since the Late Triassic to the middle Miocene (Accordi & Carbone, 1988; Chiocchini et al., 2008; Damiani, 1990; Damiani, Catenacci, Molinari, Panseri, & Tilia, 1998; D'Argenio, 1974; Parotto & Praturlon, 1975, 2004).

In the late Miocene the study area became involved in the Apennine chain orogenic phase, which caused the definitive halt of shallow-water carbonate sedimentation and the development of a thick syn-orogenic (foredeep) terrigenous succession, essentially Tortonian-early Messinian in age (Bigi et al., 2003; Carminati, Fabbi, & Santantonio, 2014; Compagnoni et al., 2005 and references therein).

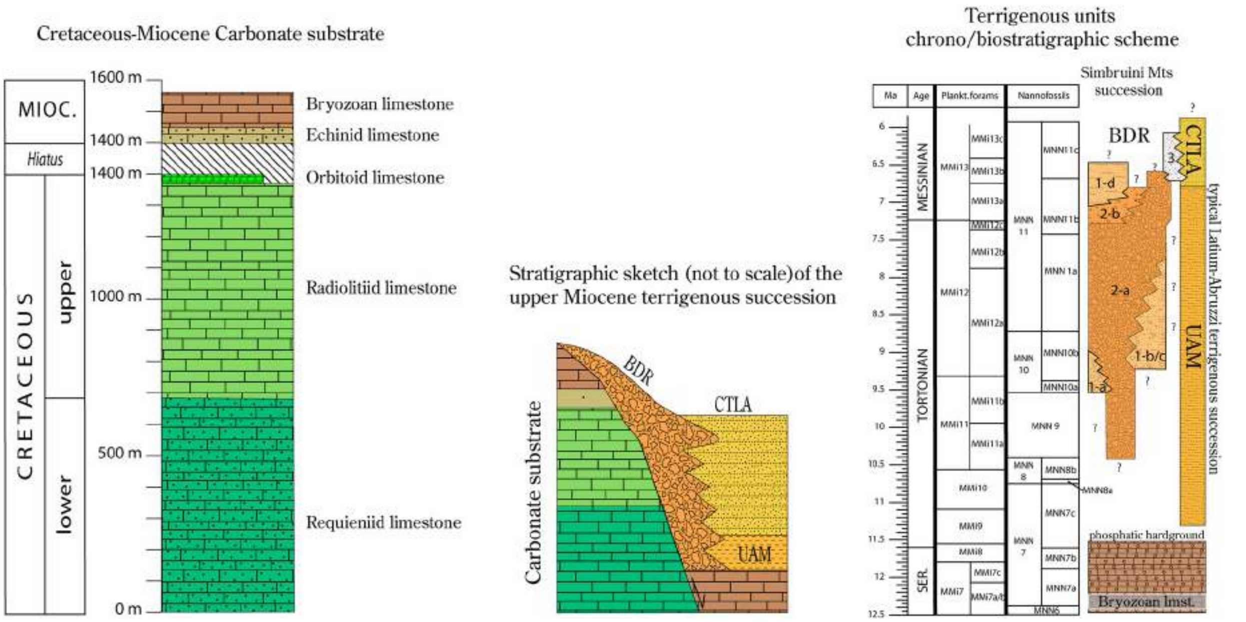

Figure 2. Stratigraphy of the study area: UAM = 'unità argilloso marnosa'; BDR = 'brecce della Renga fm.'; CTLA = 'complesso torbiditico altomiocenico Laziale-Abruzzese'. Modified after Fabbi (2013) and Fabbi and Rossi (2014).

Due to the orogenic uplift, the majority of the area emerged during the Pliocene, and the outcropping continental deposits are essentially Quaternary in age.

In this section the main features of the stratigraphic units cropping out in the study area, and their significance in the general geodynamic setting of the region, are briefly discussed.

3.1. Carbonate platform succession

Although carbonate sedimentation in the region starts in the late Triassic, the oldest unit cropping out in the study area is the Aptian-Cenomanian 'requieniid limestone' (Figure 3), a thick succession (ca. 600 m) of dm-thick beds of wackestone to coarse packstone, characterized by common intervals with abundant requieniids (rudistid bivalves). Dolomitized and green shaly leveles are common. The very rich fossil assemblages include *Archaeoalveolina reicheli*, *Belorussiella* sp., *Cretacicladus minervini*, *Cuneolina* gr. *Camposauri*, *C. laurenti*, *?C. scarsellai, Cribellopsis arnaudae, Glomospira urgoniana*, *Haplophragmoides* cf. *globosus, Moesiloculina histri, Nezazzata isabellae, Novalesia* sp., *Praechrysalidina infracretacea*, *Pseudonummoloculina* sp., *Sabaudia minuta, S. capitata, Thaumatoporella* sp., *Trochamminoides coronus, Valvulineria* sp., miliolacea, ostracods and fragments of bivalves (Fabbi, 2013).

This unit is followed by the upper Cenomanian – lower Maastrichtian 'radiolitiid limestone' (Figure 3), a thick (ca. 650 m) carbonate unit made of white packstones and wackestones in dm- to m-thick tabular beds, alternating with lensoid bodies mainly composed of rudists and rudist debris (Hippuritidae and Radiolitidae – *Biradiolites martellii*, *B. samniticus, Lapeirousella samnitica, Radiolites trigeri, Radiolites* sp., *Sauvagesia* sp., *Vaccinites* sp.). The abundant microfossil assemblages include *Accordiella conica*, *Cuneolina* spp., *Decastronema barattoloi*, *Moncharmontia appenninica*, *Nezazzatinella* sp., *Nummoloculina* sp., *Pseudocyclammina* cf. *sphareoidea*, *Pyrgo* sp., *Thaumatoporella* sp., ostracods, discorbacea, nubecularidae and rotaliidae (Fabbi, 2013). Rare corals have been found at Mt. Midia.

The youngest Cretaceous carbonate unit in the study area is the uppermost Campanian – lower Maastrichtian 'orbitoid limestone' (Figure 3), a thin (zero to few tens of meters) recrystallized packstone, organized in dm- to 1 m-thick beds and characterized by oligotypic faunas, with abundant *Orbitoides media* and *Orbitoides* spp.

No sedimentation is documented in the area during the Paleogene, probably due to a prolonged subaerial exposure of the region (Cipollari & Cosentino, 1995; Cosentino, Cipollari, Marsili, & Scrocca, 2010; Damiani et al., 1991; Damiani, Molinari, Pichezzi, Panseri, & Giovagnoli, 1990) which produced the regionally known 'Paleogene hiatus'. Carbonate production was resumed in the early Miocene, on a very gently dipping carbonate ramp characterized by heterozoan assemblages, and paraconformably developed above the Cretaceous substrate (Brandano, 2002; Civitelli & Brandano, 2005).

The Aquitanian – Burdigalian 'echinid limestone' ('calcareniti arancioni ad echinidi' in Bergomi & Damiani, 1976 and Compagnoni et al., 2005; UL1 in Civitelli & Brandano, 2005) directly rests on the Cretaceous units. It is an up to 50 m thick brown calcarenite, organized in cm- to dm-thick beds. Fossil assemblages are essentially made of echinid fragments,

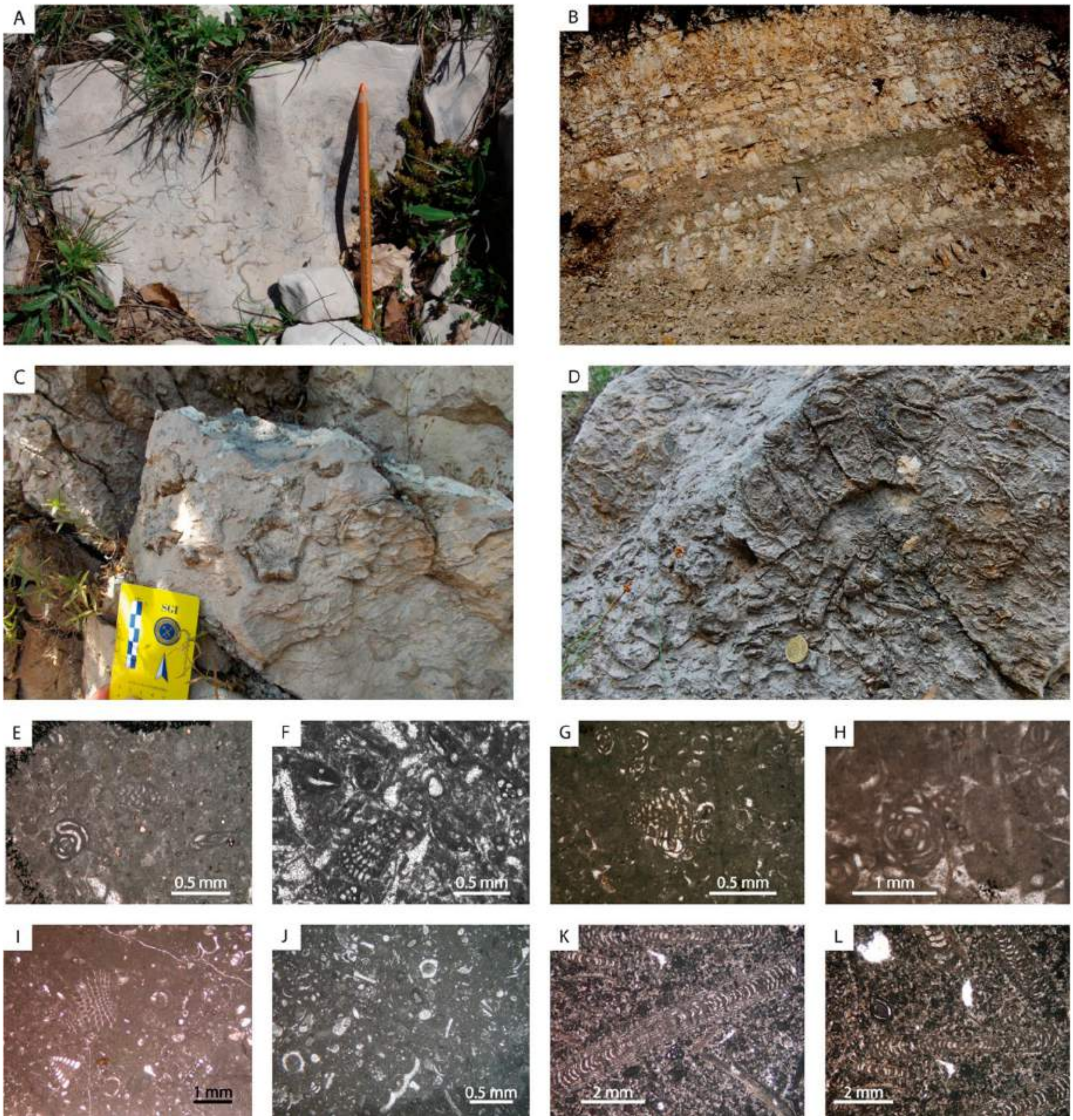

Figure 3. Cretaceous carbonate units. (a) requieniid floatstone at Mt. Fao Rotondo; (b) requeniid limestone with green shaly levels at Camporotondo (south of the study area); (c) radiolitiid floatstone at Marsia, the shells are in natural growth position, partly coalescent; (d) radiolitiid floatstone at Marsia, with a transversal section of a *Biradiolites martellii* right valve; (e) wackestone with *Cuneolina* sp., *Pseudonummoloculina* sp. and miliolidae (requieniid limestone); (f) packstone with *Cuneolina* sp. and *Moesiloculina danubiana* (requieniid limestone); (g) wackestone with *Cribellopsis arnaudae* and miliolidae (requieniid limestone); (h) packstone with *Glomospira urgoniana* and miliolidae (requieniid limestone); (i) wackestone with *Accordiella conica*, miliolacea, fragments of rudists and gastropods (radiolitiid limestone); (j) wackestone with discorbidae and miliolidae (radiolitiid limestone); (k and l) recrystallized floatstone with *Orbitoides* spp. and miliolidae (orbitoid limestone).

Ditrupa sp., benthic forams and rare bryozoans. The lowermost levels typically contain reddened and rounded clasts belonging to the Cretaceous substrate.

The youngest carbonate unit of the succession is the 'bryozoan limestone' (upper Burdigalian – lower Tortonian *p.p.* – Civitelli & Brandano, 2005), a massive white packstone with abundant bryozoans and bivalves (Figure 4), which occasionally form floatstones with ostreiids and pectiniids. The rich micropaleontologic assemblages include abundant benthic forams (buliminacea, rotaliidae, textularidae), balanids, echinoid fragments with syntaxial calcite cement and rare planktonic forams. Some levels are dominated by rodoliths and large whole echinoids (Figure 4(b)) (UL2 in Civitelli & Brandano, 2005). The upper portion is characterized by a peculiar lozenge-shaped fracturing pattern, and is mainly composed of bioclastic debris (UL4 in Civitelli & Brandano, 2005). The unit can either rest above the 'echinid limestone' or directly on the Cretaceous substrate. The 'bryozoan limestone' exceeds 100 m in thickness.

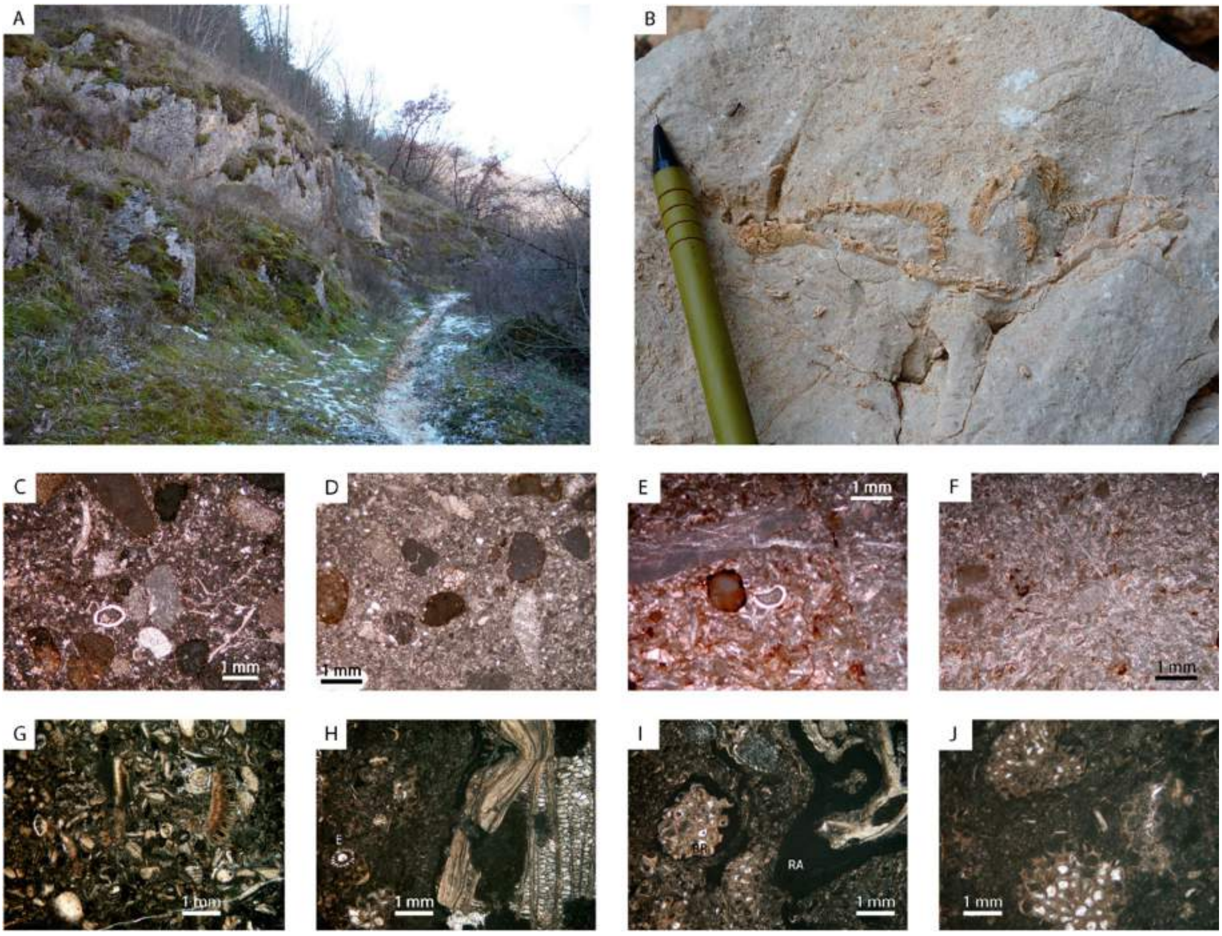

Figure 4. Miocene carbonate units. (a) Typical massive aspect of the bryozoan limestone outcrops; (b) large whole echinoid in the bryozoan limestone; (c–f) packstones with echinoid fragments, *Ditrupa* sp., undeterminable bioclastic debris and rounded lithoclasts of the Cretaceous carbonate platform (echinid limestone); (g) bioclastic packstone with fragments of echinids, balanids, bivalves and benthic forams; (h) packstone with a large bivalve (right half of the photomicrograph) an echinoid spine (E), and fragments of bryozoans; (i) packstone with bryozoans (BR) fragments covered by red algae (RA), balanids and benthic forams; (j) packstone with large bryozoans and abundant undeterminable bioclastic debris.

3.2. Terrigenous succession

In the late Miocene, the Latium-Abruzzi platform became involved with the Apennine chain building (Bally, Burbi, Cooper, & Ghelardoni, 1986; Centamore, Rossi, & Tavarnelli, 2009; Doglioni, Gueguen, Harabaglia, & Mongelli, 1999; Mostardini & Merlini, 1986; Patacca, Sartori, & Scandone, 1992; Patacca, Scandone, Bellatalla, Perilli, & Santini, 1991; Royden, Patacca, & Scandone, 1987), which resulted in the abrupt shift from neritic carbonate to hemipelagic and 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 drowning of the Miocene carbonate ramp is marked by a regional phosphatic hardground (Brandano et al., 2009 and references therein) followed by the early Tortonian-early Messinian ‘unità argilloso-marnosa’ (‘Marne a *Orbulina*’ auctt. – Compagnoni et al., 2005; Fabbi, Galluzzo, Pichezzi, & Santantonio, 2014; Pampaloni, Pichezzi, Raffi, & Rossi, 1994; Servizio Geologico d’Italia, 2010). This thin hemipelagic unit is made of grey marly limestones and marls, bearing glauconitic calcarenites and phosphatic granules in the lower portion (Figure 5). The marls are characterized by very abundant planktonic forams (*Orbulina* sp.) and ubiquitous burrowing (*Chondrites* sp., *Cylindrites* sp., *Planolites* sp., *Thalassinoides* sp., *Zoophycos* sp.). Resedimented calcarenite levels are common in the study area (Fabbi et al., 2014).

The change to the following ‘complesso torbiditico altomiocenico laziale-abruzzese’ (Servizio Geologico d’Italia, 2010) is transitional and marked by cm-thick siltite and arenite levels, which evolve upwards to a very thick (several hundred meters) turbidite succession (Figure 5), largely dominated by massive sandstone intervals organized in Ta-b/Ta-e Bouma sequences, with abundant flute and groove casts. The sandstones are composed of quartz, micas, K-feldspar, plagioclase, lithoclasts and very rare bioclasts. Lensoid breccias and graded/laminated calcarenites are interbedded with the sandstones, along with large (some tens of meters across) ‘bryozoan limestone’ olistoliths

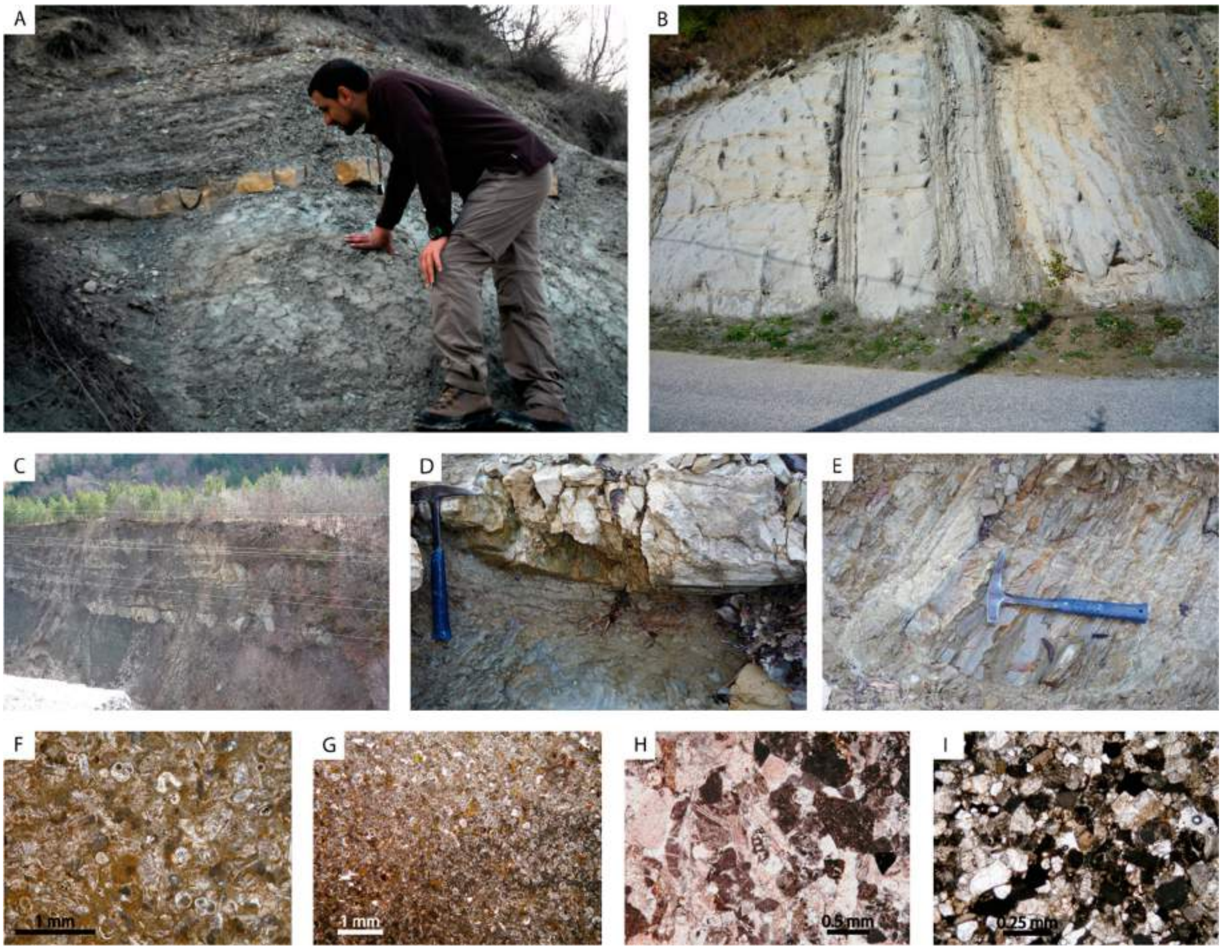

Figure 5. Upper Miocene terrigenous units. (a) Typical aspect of the 'unità argilloso marnosa'; (b) vertical beds of turbiditic sandstone/pelite alternance ('complesso torbiditico altomiocenico laziale-abruzzese'; Verrecchie village, south of the study area); (c) Massive sandstones outcropping along the road between Colli di Montebove and the Monte Bove Pass; (d and e) Calcarenitic intercalation within a pelitic interval of the 'complesso torbiditico altomiocenico laziale-abruzzese', and typical aspect of the pelites at Villaromana; (f and g) calcareous marls with abundant planktonic forams (*Orbulina universa*, *Orbulina* sp., globigeriniids), bioclastic debris and glauconite; (h and i) hybrid arenite with abundant siliciclastic material, along with bioclasts, including a specimen of *Nephrolepidina* sp.

(Fabbi et al., 2014). These intercalations bear clay-chips and are characterized by rich fossil assemblages made of fragments of molluscs, bryozoans, coralline red algae, echinid and balanids, benthic forams (*Amphistegina* sp., *Elphidium* sp., *Nephrolepidina* sp., anomalinidae, cibicididae, planorbulinidae) and rare planktonic forams. The age of this unit is essentially early Messinian (Compagnoni et al., 2005; Fabbi et al., 2014).

Along with the above described 'normal' succession, in the northeastern Simbruini Mts. a peculiar unit, the 'brecce della Renga fm.' (Devoto, 1967) is a lateral equivalent of the terrigenous units (Fabbi & Rossi, 2014 and references therein). This unit is markedly clastic, lithologies ranging from pure breccias to rudite-arenite-pelite associations, and reflects the existence of a prominent structural high in the area (Figure 6), whose margins underwent dismantling (Carminati et al., 2014; Critelli et al., 2007; Fabbi, 2013; Fabbi et al., 2014; Fabbi & Rossi, 2014). These margins were submarine escarpments which could be sites of mineralization (i.e. phosphatization and silicification) as widely described in Compagnoni et al. (2005), Carminati et al. (2014), Fabbi et al. (2014) and Fabbi and Rossi (2014).

Compagnoni et al. (1990, 1991, 2005) first defined the chronostratigraphic boundaries of the 'brecce della Renga fm.' (early Tortonian-early Messinian), and proposed its subdivision into three lithofacies and six sublithofacies based on field geometries, rudite/arenite/pelite ratio and sedimentology (Figure 2). A detailed description of the lithofacies and sedimentology of the 'brecce della Renga fm.' can be found in Fabbi and Rossi (2014).

The lithofacies 1 is a pelite-arenite-rudite association (Figure 7(a–d)), with pelites often dominating, and is widely exposed in the northern sector of the study area. It is subdivided into four sublithofacies (1-a, 1-b, 1-c, 1-d) mainly based on varying pelite/rudite ratio (Fabbi & Rossi, 2014). On the map the sublithofacies 1-b and 1-c have been grouped based on the transitional nature of the boundary, which is poorly exposed in the field. The lithoclasts in this lithofacies are both Miocene and subordinately Cretaceous limestone, and also include large olistoliths of 'bryozoan

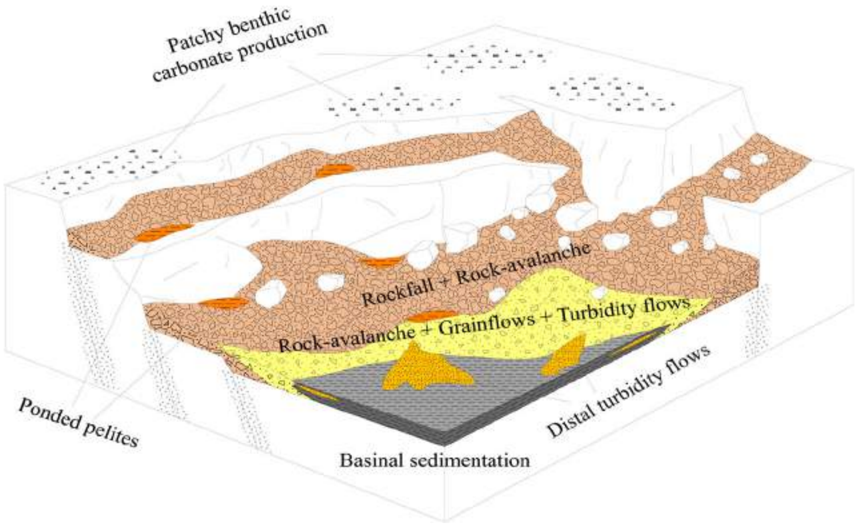

Figure 6. Schetch depicting the 'brecce della Renga fm.' depositional system. Modified after Fabbi & Rossi (2014).

limestone' (Figure 7(a)). The arenites and the breccia matrix are composed of fragments of bivalves, echinoids, balanids, bryozoans and red algae, along with *Ditrupa* sp., benthic forams and rare planktonic forams; the main siliciclastic components are quartz and micas (Fabbi et al., 2014).

The lithofacies 2 of the 'brecce della Renga fm.' (Figure 7(e–i)) is the most widely exposed and is subdivided into a massive sublithofacies (2-a) (Figure 7 (e–g)) and a well bedded sublithofacies (2-b) (Figure 7(h–i)). The sublithofacies 2-a outcrops extensively in the study area, with a total thickness of more than 300 meters (Fabbi & Rossi, 2014) and is made of clast-supported carbonate breccias. The clasts are markedly heterometric, ranging from sand grains to boulders (up to tens of meters across). This lithofacies rests unconformably on the Lower Cretaceous/Miocene substrate (Fabbi, 2013; Fabbi & Rossi, 2014). As the breccias were sedimented through low-efficiency processes (rockfall, rock-avalanche, grainflow) their composition is strongly influenced by the local substrate: Cretaceous clasts are dominant wherever the breccias are surrounded and overlie a Cretaceous substrate (i.e. along Miocene escarpments the Cretaceous rocks were exhumed), while Miocene clasts are almost exclusive wherever breccias lie on the Miocene substrate (i.e. Miocene faults/escarpments were shallower and the Cretaceous was not exhumed) (Fabbi & Rossi, 2014). Along with lithoclasts, Miocene granules include coeval intrabasinal isolated echinoids, bivalves, benthic forams and bryozoans (Figure 7). This unit commonly lacks any stratal organization, so even bed attitude is difficult to detect. A peculiar character of this sublithofacies is the presence of yellow pelite intercalations (Compagnoni et al., 1990, 2005; Devoto, 1967, 1970; Fabbi et al., 2014; Fabbi & Rossi, 2014; Parotto, 1969), which provide the essential biostratigraphical elements to determine the age of the rudites (early Tortonian-early Messinian – Fabbi & Rossi, 2014). In the inner (western) portions of the study area the sublithofacies 2-b of the 'brecce della Renga fm.' is typically well bedded, with a fining upwards trend, and with an upward increase of siliciclastic components (Compagnoni et al., 1990). Large ostreids, pectinids, balanids, echinoids and bryozoans are common intrabasinal components of the breccias and rounded chert clasts also occur. The matrix of the breccia is composed of skeletal grains such as fragmentary balanids, bryozoans, bivalves, echinoids, red algae, rare benthic forams and abundant siliciclastic grains (mainly quartz).

The third lithofacies of the 'brecce della Renga fm.' (Fabbi & Rossi, 2014) does not crop out in the study area.

3.3. Continental deposits

The final uplift and emersion of this sector of the Central Apennines occurred through the Messinian and late Pliocene, followed by a SW-directed extension of its inner portions, linked with the opening of the Tyrrhenian basin (Carminati & Doglioni, 2012; Doglioni et al., 1999; Gueguen, Doglioni, & Fernandez, 1998).

Pleistocene to Holocene continental deposits are distinguished in three separate units:

(i) all the Quaternary deposits cropping out at valley bottoms (i.e. the Turano river alluvial sands, silts and occasionally gravels, up to tens of meters thick – D'Orefice et al. (2014)); the fluvial/lacustrine deposits cropping out east of Roccacerro; the thickest soils (>1 m) which commonly hide bedrock in the inner valleys of the Simbruini Mts.; and finally the volcaniclastic deposits, essentially cineritic sands belonging to the Alban Hills or the Oricola volcanoes – Compagnoni et al. (2005) and D'Orefice et al. (2014) – which

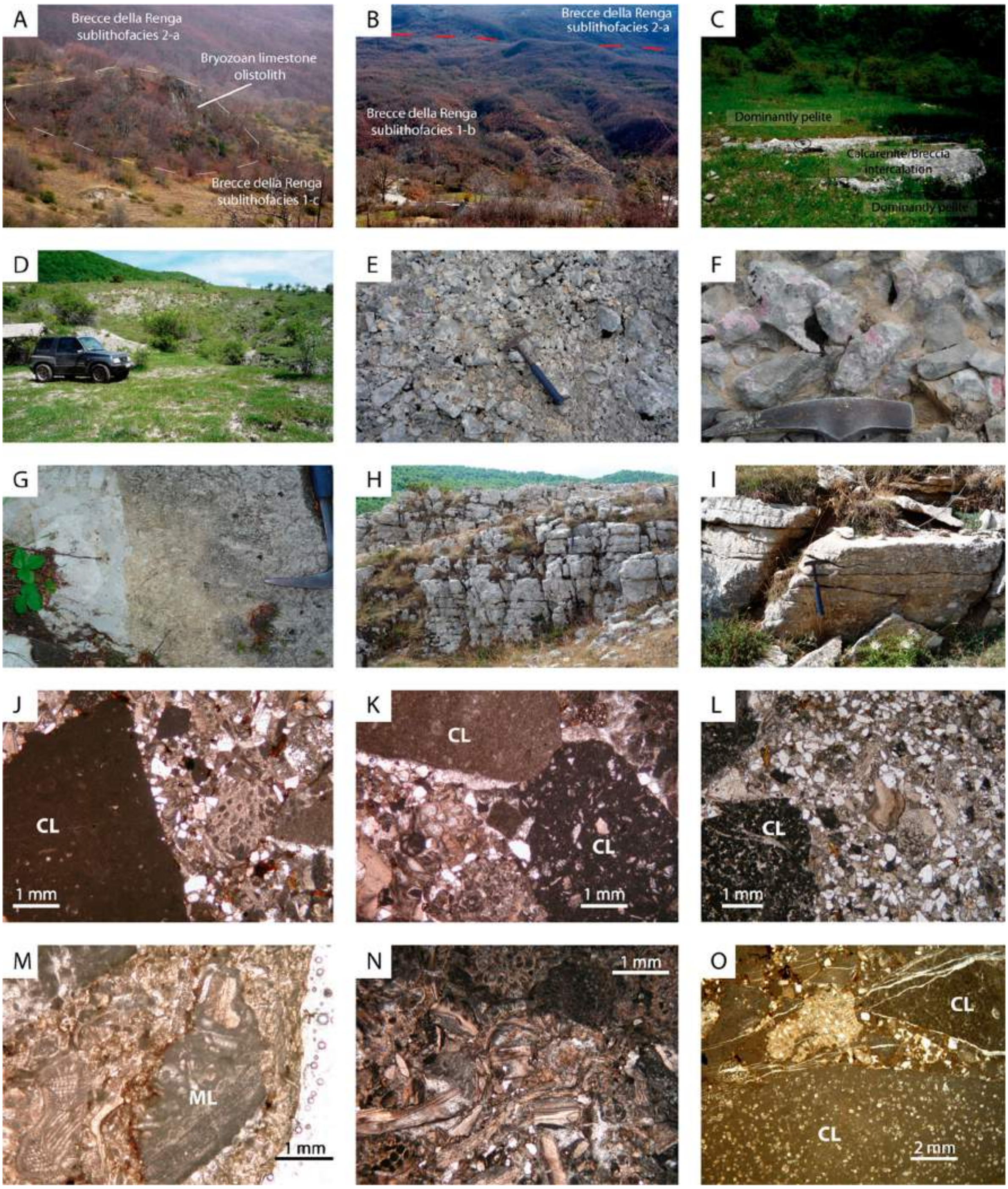

Figure 7. The 'brecce della Renga fm.'. (a) large olistolith of bryozoan limestone embedded within the sublithofacies 1-c near the Monte Bove Pass; (b) the NE slope of Mt. Fontecellese viewed from the village of Colli di Montebove, note the typical morphology of the pelitic sublithofacies 2-b; (c) a coarse intercalation within the sublithofacies 1-d near the village of Pereto; (d) The main outcrop of the dominantly pelitic sublithofacies 1-d (San Mauro); (e and f) typical aspect of the massive breccias (sublithofacies 2-a); (g) a large boulder of radiolitiid limestone within the breccia of the sublithofacies 2-a; (h and I) well bedded breccias of the sublithofacies 2-b at Campolungo and Mt. Morbano; (j–o) thin section views of the 'brecce della Renga fm.', Cretaceous (CL) and Miocene (ML) lithoclasts are admixed with coeval intrabasinal bioclastic material (bryozoans, balanids, benthic forams, echinoids and bivalve fragments) and abundant siliciclastic material, mainly composed of quartz.

occasionally can be some meters-thick in the inner valleys of the Simbruini Mts.);

(ii) a wide complex landslide which affects the northern slopes of Mt. Fontecellese, developed within shaly and marly lithologies;

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

4. Tectonics

This section contains a brief overview of the structural setting of the study area.

The area was affected by at least three main tectonic phases in Miocene to recent times: (i) a late Miocene extension, which originated the structural high whose dismantling produced the spectacular clastic deposits

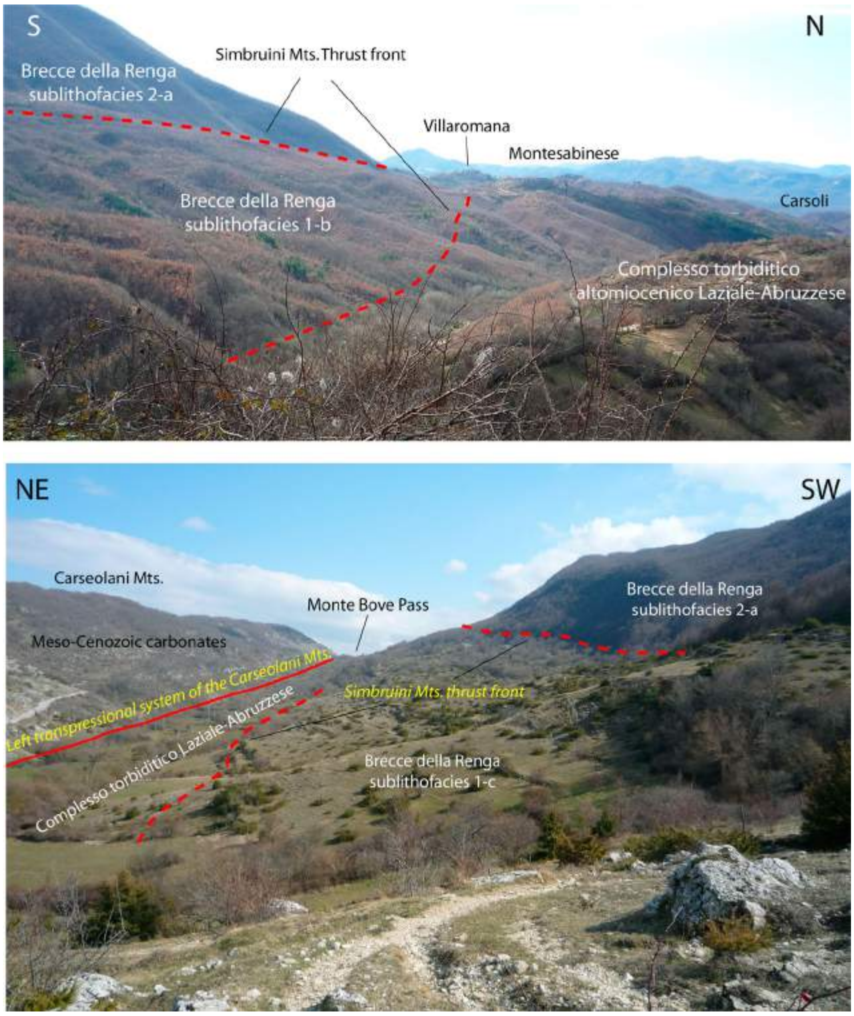

Figure 8. Panoramic views of the Simbruini Mts. thrust front, taken along the Turano river valley.

of the 'brecce della Renga fm.'; (ii) a latest Miocene-Pliocene compressional phase which is the origin of the Apennine chain and (iii) a Pleistocene post- orogenic extensional phase, which is still active in the western sectors of the Apennines. Strike-slip tectonics is commonly documented in the area (Compagnoni et al., 2005; Montone & Salvini, 1993); faults showing an important oblique slip are related both to the orogenic and the post-orogenic tectonic phases (Compagnoni et al., 2005; Montone & Salvini, 1993; Roberts & Michetti, 2004). Paleofaults interpreted as pre-orogenic are essentially sealed by the 'brecce della Renga fm.', and are mapped with a different symbol.

For a description and analysis of pre-orogenic faults and paleogeographic setting of the area see Carminati et al. (2014) and Fabbi and Rossi (2014).

The Simbruini Mts. can be described as a wide monocline, with beds roughly dipping toward the NE; bed attitude abrubtly steepens, up to vertical, close to the thrust front of the structure. The monocline is cut to the E and NE by the Simbruini thrust front and dismembered to the west by a large system of major (regional) SW-dipping extensional faults (Figure 1), whose plains crop out outside the study area (Carminati et al., 2014 and references therein). Only secondary extensional faults ascribable to the latter tectonic phase have been identified in the study area.

The main structural element in the study area is the Simbruini thrust front, one of the most important thrusts in the region, which trends roughly W–E in its northern portion and NW–SE along the Turano river valley, continuing southwards outside the map. In the field, it exists as a wide tectonized belt where it is possible to observe at least two main thrusts (Figure 8) and several minor lineaments (the latter having average throws of some tens of meters). The thrusts are often not clearly observable in the field, but they can be identified using alignments of cataclasites; in other cases their existence has been inferred in spite of poor exposure based on a 'geological necessity' (i.e. covered formation boundaries which are arguably not of stratigraphic nature). Kinematic indicators measured along the whole structure, including minor fault planes, show a general apenninic vergence (N 60° E – Fabbi, 2013).

Although the main extensional faults of the Simbruini ridge are located outside the mapped area, several minor faults are present in the mapped zone, most of them characterized by an important oblique component (transtensional faults – Fabbi, 2013). The main valleys in the study area are bordered by normal faults with throws generally ranging from some tens to few hundreds meters. Remarkably, in the westernmost portion of the map the succession is dissected by several small faults, making it difficult to determine the kinematics and the deformation history of this sector. The intense tectonization and fragmentation is possibly due to the superimposition of subsequent tectonic phases (Carminati et al., 2014; Fabbi, 2013).

A major regional tectonic lineament which crops out in the study area is the left-lateral transpressive fault system bordering the Carseolani Mts. (Figure 8) which, according to Roberts and Michetti (2004), is still active, although reactivated as an extensional fault. This lineament has been described by Montone and Salvini (1993) and Compagnoni et al. (2005).

5. Conclusions

A geological map on the 1:20,000 scale is presented here, displaying the geology of a complex sector of the Apennine chain, where a thick Cretaceous and Miocene shallow-water carbonate succession crops out extensively, along with upper Miocene terrigenous units deposited in the foredeep basin produced by the advancing Apennine orogenic system.

A pre-orogenic extensional phase caused the formation of a prominent structural high in a region, which roughly corresponds to the present-day northeastern Simbruini Mts. The syn-sedimentary normal faults have been exhumed and can be mapped in the field. The syn-tectonic dismantling of the margins of the structural high produced a thick lithoclastic succession which represents a *unicum* in the central Apennines and is made of calcareous breccias and associated pelite/arenite intervals. This clastic unit is partly lateral to the typical foredeep succession of the Central Apennines, represented by hemipelagites and turbiditic sandstones. The whole sedimentary succession was deformed and eventually exposed subaerially by the NE-verging Apennine building compressional phase, and subsequently dissected by SW-directed extension. The main structures ascribable to the latter phase crop out outside the study area. The main orogenic structure on the map is the Simbruini thrust front, while several normal and transtensional faults are interpreted as secondary lineaments related to the post-orogenic extension.

Software

The map was produced using Adobe Illustrator CS2 from scanned hand-drawn maps. The topographic basemap is the Abruzzo Region CTR at 1:25,000 scale, available online.

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No potential conflict of interest was reported by the author.

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