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

Simone Fabbi

To cite this article: Simone Fabbi (2016): Geology of the Northern Simbruini Mts. (Abruzzo – Italy), Journal of Maps, DOI: 10.1080/17445647.2016.1237899

To link to this article: http://dx.doi.org/10.1080/17445647.2016.1237899
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 km² 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; Criteri 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...
biostratigraphic analyses (in thin section), and inte-
grated with sedimentological analysis for the terrige-
nous deposits (Fabbi & Rossi, 2014). No formalized
stratigraphic units exist for the carbonate platform suc-
cession 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 con-
cern 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 region-
ally known as the Latium-Abruzzi succession, and
reflects the evolution of the Latium-Abruzzi carbonate
platform, which was the site of shallow-water depo-
sition 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 sedimen-
tation and the development of a thick syn-orogenic
(foredep) terrigenous succession, essentially Torto-
nian-early Messinian in age (Bigi et al., 2003; Carmi-
nati, Fabbi, & Santantonio, 2014; Compagnoni et al.,
2005 and references therein).

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).
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 requienii (rudistid bivalves). Dolomitized and green shaly levels are common. The very rich fossil assemblages include **Archaeocalveolina reicheli**, **Belorussiella sp.**, **Creptiacidus minervini**, **Cuneolina gr. Camposauri**, **C. laurenti**, **C. scarsellai**, **Cribellopsis arnaudae**, **Glomospira urchionana**, **Haplophragmoides cf. globosus**, **Moesiloculina histri**, **Nezazzatinella sp.**, **Nezazzata isabellae**, **Novalesia sp.**, **Praechrysalidina infracretacea**, **Pseudonummoloculinia sp.**, **Sabaudia minuta**, **S. capitata**, **Thaumatoporella sp.**, **Trochamminoides coronus**, **Valvulineria 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** – **Bryozoa** **limestone**, **Echinid limestone**, **Orbitoid limestone**, **Radiolitiid limestone**, **Requieniid limestone**). The abundant fossil 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 Maaschtrichtian ‘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 oligotopic 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, Pichetti, Panzeri, & 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,
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 rodo-liths 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 3. Cretaceous carbonate units. (a) requeniid 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 martelli right valve; (e) wackestone with Cuneolina sp., Pseudonummoloculina sp. and miliolidae (requeniid limestone); (f) packstone with Cuneolina sp. and Moesiloculina danubiana (requeniid limestone); (g) wackestone with Cribellopsis amaudae and miliolidae (requeniid limestone); (h) packstone with Glomospira urgoniana and miliolidae (requeniid 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).
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, Harbaugh, & Mongelli, 1999; Mostardini & Merlini, 1986; Patacca, Sartori, & Scandone, 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 argillosomarnosa’ (‘Marne a Orbula’ 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.
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 (*Amphiste-gina* sp., *Elphidium* sp., *Nephrolepidina* sp., anomalini-da, cibicididae, planorbulinae) 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/arenite 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...
limestone’ (Figure 7(a)). The arenites and the breccia matrix are composed of fragments of bivalves, echi-noids, balanids, bryozoans and red algae, along with Ditrupa sp., benthic forams and rare planktonic for-ams; 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 sub-divided 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/Mio-cene 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 sub-strate (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 inter-calations (Compagnoni et al., 1990, 2005; Devoto, 1967, 1970; Fabbi et al., 2014; Fabbi & Rossi, 2014; Par-otto, 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 sub-lithofacies 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 intra-basinal components of the breccias and rounded chert clasts also occur. The matrix of the breccia is composed of skeletal grains such as fragmentary bala-nids, 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 Tyrrenhian basin (Carminati & Doglioni, 2012; Doglioni et al., 1999; Gueguen, Doglioni, & Fernan-dez, 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/lacus-trine deposits cropping out east of Roccaccerro; the thickest soils (>1 m) which commonly hide bed-rock in the inner valleys of the Simbruini Mts.; and finally the volcanlastic deposits, essentially cineritic sands belonging to the Alban Hills or the Oricola volcanoes – Compagnoni et al. (2005) and D’Orefice et al. (2014) – which
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 ‘breccia 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
of the ‘breccia 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 ‘breccia 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 abruptly 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 north-eastern 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.

Acknowledgments

I would thank Massimo Santantonio for fruitful discussions and for the critical revision of an early version of the manuscript. Maurizio Chiocchini, Rita Pichezzi and Maria Grazia Rossi are warmly acknowledged for their willingness and their essential help on determining microfossils. Finally I would thank all who helped me during the fieldwork: Giulia Colasanti, Damiano Mangiacapra, Gaia Mascaro, Antonello Simonetti and Eugenio Carminati. The reviewers Pietro di Stefano, Pietro Paolo Pierantoni, Tommaso Piacentini and Makram Murad-al-Shaikh are acknowledged for their essential comments and suggestions which helped in improving the original version of the manuscript.

Disclosure statement

No potential conflict of interest was reported by the author.

ORCID

Simone Fabbi http://orcid.org/0000-0001-8469-4449

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.

Bergomi, G., & Damiani, A. V. (1976). Diagenesi precoce nei depositi Serravalliano–Tortoniano del Lazio e considerazioni sulla evoluzione strutturale del Bacino di sedimentazione miocenico. Bollettino del Servizio Geologico d’Italia, 97, 35–66.

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). Studi Geologici Camerti, 2003, 17–37.

Brandano, M. (2002). La Formazione dei ‘Calcari a Brioizi e Litotamni’ nell’area di Tagliacozzo (Appennino Centrale): e considerazioni paleoambientali sulle facies rodalgal. Bollettino della Società Geologica Italiana, 121, 179–186.

Brandano, M., Mateu-Vicens, G., Gianfagna, A., Corda, L., Billi, A., Quaresima, S., & Simonetti, A. (2009). Hardground development and drowning of a Miocene carbonate ramp (Latium-Abruzzi): From tectonic to paleoclimate. Journal of Mediterranean Earth Sciences, 1, 47–56.

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/IGJ.2009.128.2.419

Chiocchini, M., Chiocchini, R. A., Didaskalou, P., & Potetti, M. (2008). Microbiostратigrafia del Triassico superiore, Giurassico e Cretaceo 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-Antrrodoco: Contributo della biostratigrafia alla sua caratterizzazione cinematica. *Studi Geologici Camerti*, 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 litostratigrafici per una sintesi delle facies carbonatiche nei sedimenti carbonatici di piattaforma dei Monti Afiillani (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 breccia calcaree mioceniche nell’alta Valle Rovereto 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.

Dolgoni, C., Gueguen, E., Harabaglia, P., & Mongelli, F. (1999). On the origin of west-directed subduction zones and applications to the western Mediterranean. In B. Durand, L. Jolivet, F. Horvath, & M. Seranne (Eds.), *The Mediterranean Basins: Tertiary Extension within the Alpine Orogen*. (pp. 541–561). Geological Society: London.

D’Orefice, M., Graciotti, R., Chiessi, V., Censi Neri, P., Morri, A., Roma, M., & Falcetti, S. (2014). La conca intermontana di Oricolà-Carsoli (AQ): Caratteri geologici, geomorfologici e applicativi. In *Memorie Descrittive della Carta Geologica d’Italia* (Vol. 91, pp. 138). Rome: Ispra-Servizio Geologico d’Italia.

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

Fabbri, S., Gauzzo, 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/IGJ.2013.13

Fabbri, 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.

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

Gueguen, E., Dogliani, C., & Fernandez, M. (1998). On the origin of west-directed subduction zones and kinematics of Triassic-to-Recent structures in the western Mediterranean. *Tectonophysics*, 298, 259–269.

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.

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). Carcareuse planktonic biostratigraphy of the marne a Orbalune 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 Apennines. *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). Rome: Societá Geologica Italiana.

Patacca, E., Sartori, R., & Scandone, P. (1992). Tyrrhenian basin and Apenninic arcs: Kinematic relations since late Tortonian times. Memorie della Societá 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). Rome: Accademia Nazionale dei Lincei.

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. 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

Servizio Geologico d’Italia. (2010). Geological Map of Italy 1:50000, sheet #358 ‘Pescorocchiano’.