Paleozoic stratigraphy of the Longi-Taormina Unit (Peloritanian Mountains, southern Italy)

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ABSTRACT: In this study, we report the results of litho- and biostratigraphic analyses made in the mildly metamorphosed Paleozoic succession of the Longi-Taormina Unit (Peloritanian Mountains, southern Italy), which up to now is poorly known. Three main formations based on their litho- and biostratigraphy have been defined and proposed for the first time (from base to top): Castelmola Formation, Lower Pizzo Leo Formation, and Upper Pizzo Leo Formation. The first two formations, composed mostly of marine fine-grained siliciclastic rocks, host Upper Ordovician calc-alkaline and Silurian alkaline volcanites, respectively. The upper formation is made up primarily of Silurian-Devonian pelagic metacarbonates which have released conodonts from Ludlow and Lochkovian (*delta* Zone) to Emsian (*kitabicus*, *excavatus*, and *nothoperbonus-inversus* zones) as well as Emsian dacryoconarids. These findings are relevant as they are the oldest ever found in this sector of the Alpine Chain, and they have enabled the best and most accurate dating made until now. The studied Paleozoic succession proved to be an important key-site to better understand facies evolution to neighboring domains like, in particular, the Calabrian Stilo Unit or other better-known Paleozoic sequences around the western Mediterranean, like those outcropping in the Alps or in the Betic and Rifian chains.

Key words: Lithostratigraphy, biostratigraphy, conodonts, upper Silurian (Ludlow), Lower Devonian (Lochkovian and Emsian), Calabria-Peloritani Arc, Sicily.

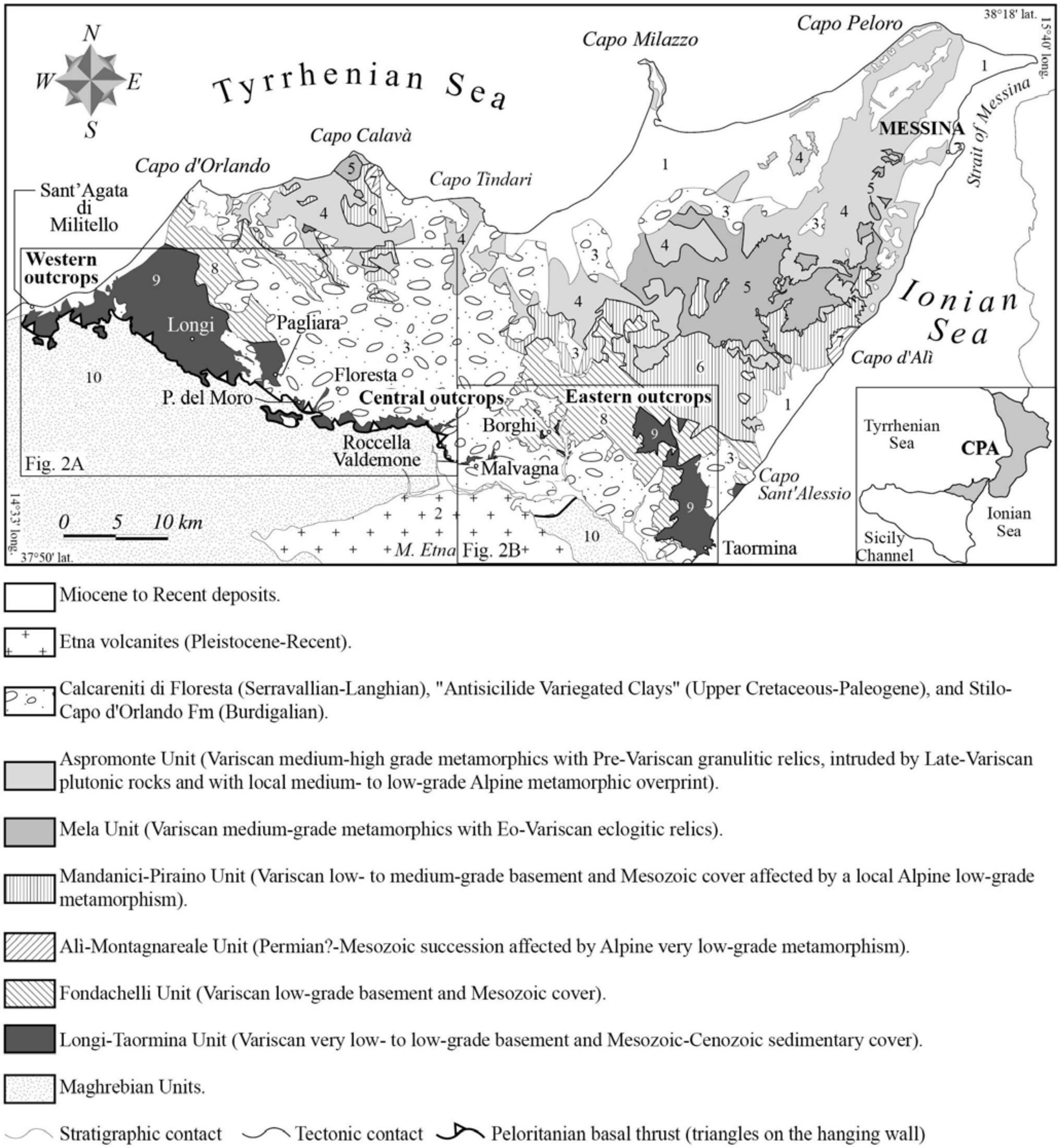
INTRODUCTION

The stratigraphy of Paleozoic successions outcropping around the western Mediterranean is well known just in those regions where the Variscan and/or Alpine deformation and metamorphism were moderate (e.g. Carnic Alps: Schönlaub and Histon 1999; Corradini and Corriga 2010; Sardinia: Storch and Serpagli 1993; Ferretti et al. 1998; Corradini and Serpagli 1999; Corriga et al. 2009; Pyrenees: Valenzuela-Ríos 1994; among many others). In more intensively deformed and metamorphosed successions, such as those of the Betic Cordillera (Malaguide Complex: Herbig 1984; Rodríguez-Cañero et al. 1990, 1997, 2010; Rodríguez-Cañero 1993, 1995; Rodríguez-Cañero and Guerra-Merchán 1996; Martín-Algarra et al. 2004, 2009a, 2009b; Navas-Parejo et al. 2008; Navas-Parejo 2012) or of the Calabria-Peloritani Arc (Lardeux and Truillet 1971; Bouillin et al. 1984, 1987; Majesté-Menjoulas et al. 1984, 1986; Spalletta and Vai 1989), reconstruction of Paleozoic stratigraphic successions is more difficult. Regarding the Calabria-Peloritani Arc, in which the most internal units of the Maghrebian Chain crop out, the Paleozoic stratigraphy has been recently updated on the Calabrian side of the arc (Stilo Unit: Navas-Parejo et al. 2009a, 2009b; Navas-Parejo 2012). Nevertheless, on the Peloritanian side of the arc (NE Sicily, text-figure 1), knowledge of its Paleozoic stratigraphy has been only partially bridged by synthetic and scattered biostratigraphic data related to the pre-Alpine basement of the Longi-Taormina Unit, the widest and least deformed unit (Navas-Parejo 2012; Somma et al. 2012; Rodríguez-Cañero et al. 2013) involved in the Peloritanian Alpine tectonic stack (Messina et al., 2004; Somma et al. 2005a, 2005b, 2013; De Capoa et al. 2013).

The aim of this study is to update and improve the accuracy of the Paleozoic stratigraphy of the pre-Alpine basement of the Longi-Taormina Unit. In this work, we summarize the lithostratigraphy, provide new conodont biostratigraphic data, propose new stratigraphic nomenclature, suggest the chronology of the volcanism according to the available geochronological data and the results of the lithostratigraphic and biostratigraphic analyses, and finally correlate the studied succession with the Paleozoic of the Calabrian Stilo Unit and with other better-known Paleozoic sequences around the western Mediterranean.

MATERIALS AND METHODS

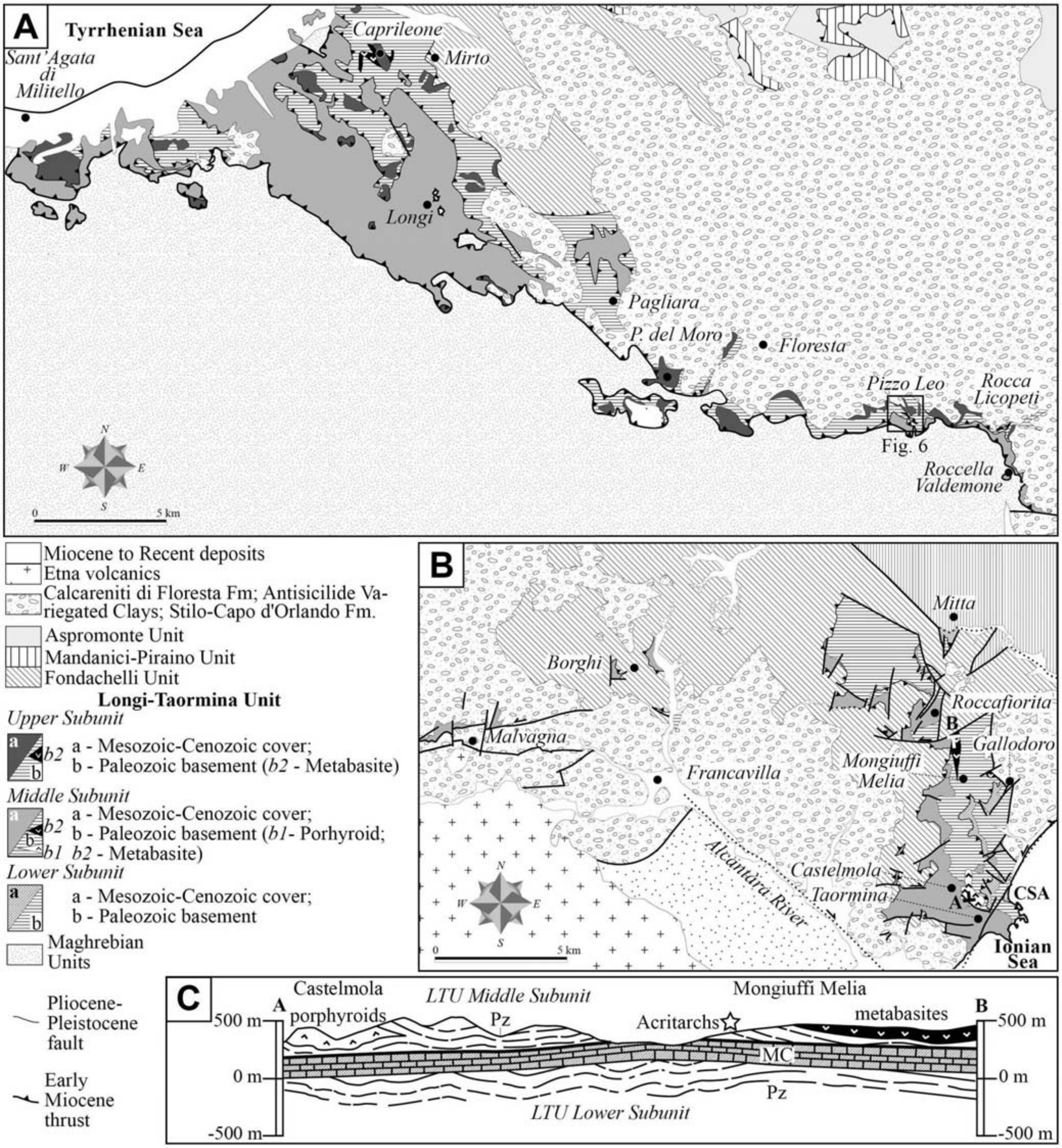
The Paleozoic rocks of the Longi-Taormina Unit (hereafter LTU, Bonardi et al. 1976, text-figure 1) still preserve, in a few of outcrops, their original stratigraphy, despite Paleozoic ductile deformation and metamorphism, responsible for two systems of Variscan foliation (S_{1v} and S_{2v}, Somma et al. 2005b), and Alpine



TEXT-FIGURE 1
Geological sketch map of the Peloritanian Mountains (modified after Messina et al. 2004; Somma et al. 2005a; Somma 2006; Aldega et al. 2011). In the insert at bottom right the Calabria-Peloritani Arc (CPA).

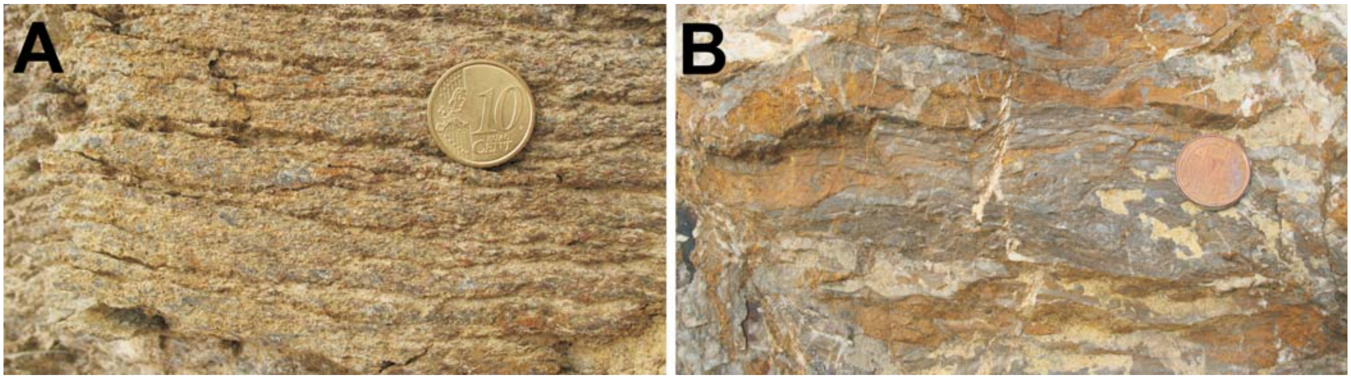
deformation, i.e. early Miocene overthrusting, and Plio-Pleistocene normal and strike-slip faulting. This study has been made in all the LTU better preserved outcrops, with particular regards to Paleozoic succession cropping out in the Pizzo Leo area (between Floresta and Roccella Valdemone villages, text-figure 2A), where several fossiliferous calcareous beds are well exposed and suitable for a careful conodont biostratigraphic analysis.

For conodont studies, 96 samples were collected and more than 480 kg of carbonate rocks were processed using standard dissolution (Jeppsson et al. 1999) and concentration (Anderson et al.



TEXT-FIGURE 2
Tectonic map of the Longi-Taormina Unit (modified after Somma 1999, 2006; Somma et al. 2005b; Lentini 2000). The LTU Paleozoic succession is not differentiated between the Lower, Middle, and Upper Subunit. Our samples from the Lower Unit were unproductive. A: Central-western sector. B: Central-eastern sector with location of the Castelmola-Mongiuffi section (A-B). Capo Sant'Andrea (CSA). C: Castelmola-Mongiuffi Melia section. Abbreviations are: Pz – Paleozoic basement, MC - Mesozoic-Cenozoic cover.

1995) methods. From the Gallodoro village outcrop (text-figure 2B), six samples were collected (text-figure 3B). These samples did not provide any conodont remains, but only abundant crinoid ossicles. Of the remaining 90 samples taken from Pizzo Leo area, only 36 samples proved productive. Due to the Variscan metamorphism and deformation, most of the conodont elements found are broken and deformed, and their original texture is altered. Their Color Alteration Index (CAI) is around 6-6.5 (*sensu* Rejebian et al. 1987).



TEXT-FIGURE 3
Paleozoic rocks of the LTU Lower Subunit. A: Metarenites and metamicroconglomerates (locality: 2 km SW of Gallodoro, text-figure 2B). B: Gray nodular metalimestones (locality: 1 km S of Gallodoro, text-figure 2B).

GEOLOGICAL SETTING AND STATE OF KNOWLEDGE

The LTU is the lowest unit of the Alpine tectonic stack of the Peloritanian Mountains, and is exposed along a WNW-ESE trending belt stretching from the Tyrrhenian to the Ionian coast of NE Sicily (text-figure 1). Since the LTU is unconformably overlain by Burdigalian deposits (Stilo-Capo d'Orlando Fm) in the central area of the belt, its outcrops are discontinuous and are divided in three sectors: western, central, and eastern (text-figures 1, 2). The LTU overthrusts onto lower Maghrebian Units along the basal thrust of the Peloritanian tectonic stack (Taormina Line, Bonardi and Giunta 1982) and is overthrust by the Fondachelli Unit (text-figures 1, 2A, 2B).

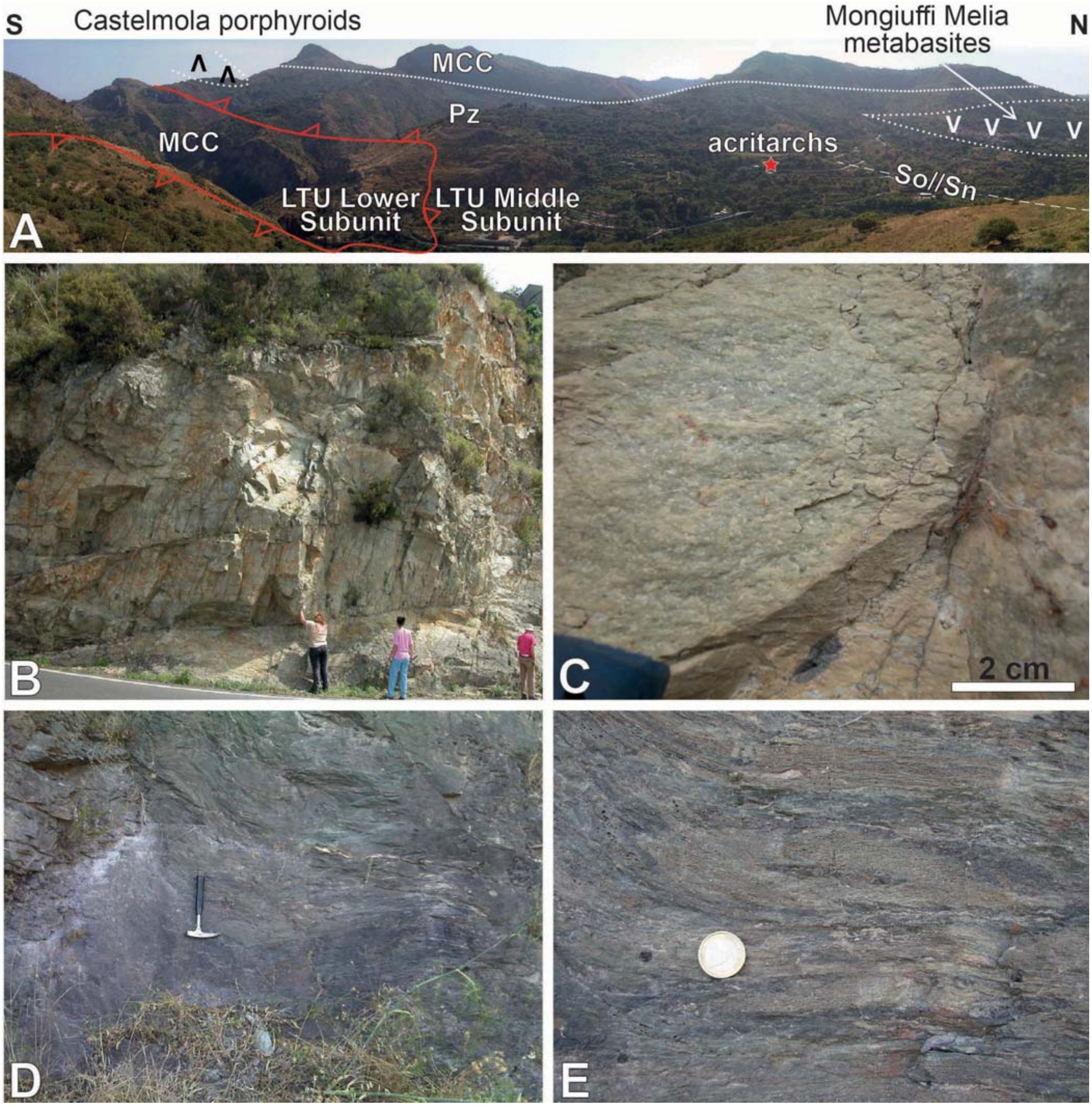
The LTU is tectonically subdivided in several subunits, designated, from base to top: Lower, Middle, and Upper Subunit (Somma et al. 2005b; Somma 2006). Each subunit is composed of a metamorphic basement overlain by a thick Mesozoic-Cenozoic sedimentary cover. The metamorphic basement is affected by Visean metamorphism (323-347 Ma K/Ar isotopic age, Guerrera et al. 1999), which occurred under subgreenschist to greenschist (chlorite zone) facies conditions ($T \simeq 350$ °C and $P \leq 0.2$ GPa, Atzori et al. 1984, and references therein). This basement is formed by a succession that is several hundred meters thick and composed of pre-Permian metamorphic rocks derived from sedimentary and volcanic protoliths (Somma et al. 2012).

The stratigraphic framework (Spalletta and Vai 1989; Acquafredda et al. 1994) has been poorly defined until now, being based on (usually poorly precise) biostratigraphic data related to a few scanty and scattered Paleozoic fossiliferous layers, with: acritarchs from Cambrian-Ordovician boundary metapelites (Majesté-Menjoulas et al. 1986; Bouillin et al. 1987); dacryoconarids found in Lower to Upper? Devonian metacarbonates (Lardeux and Truillet 1971; Acquafredda et al. 1991); and conodonts from upper Silurian-Lower Devonian (Somma et al. 2012; Rodríguez-Cañero et al. 2013) and Upper Devonian-lower Carboniferous (Majesté-Mejoulas et al. 1986; Bouillin et al. 1987) metacarbonates.

Metavolcanic rocks have been subdivided into three different groups. The first, present mainly in the Middle Subunit, consists of calc-alkaline volcanites, composed of andesites, dacites, rhyodacites, and rhyolites, widely cropping out in the eastern sector (Castelmola area, text-figure 2B). U-Pb geochronological data have demonstrated a Late Ordovician age for these volcanites (456-452 Ma, Trombetta et al. 2004). The second group of volcanites is represented by arc-tholeiites and dacites recognized exclusively in the Upper Subunit of the central and western outcrops (Ferla and Azzaro 1978; Bouillin et al. 1987; Acquafredda et al. 1991, 1992, 1994). These volcanites have been considered Carboniferous in age, but no isotopic or biostratigraphic data support this dating, which could rather correspond to the age of the metamorphism that affected these successions. The third group of volcanites is represented by alkaline basalts, dolerites, and volcanoclastic products (tuffs and hyaloclastites) originating from submarine eruptions (Atzori et al. 1984, 2001; Acquafredda et al. 1991, 1992; Cirrincione et al. 1999, 2005; Guerrera et al. 1999). These alkaline rocks appear in all subunits, but they are particularly widespread in the Middle Subunit (eastern sector: Mongiuffi Melia outcrop, text-figure 2B) and in the Upper Subunit (western and central sectors: Caprileone, Rocca Licopeti, and Pizzo Leo outcrops, text-figure 2A). The age of these volcanites is debated. A Lower Ordovician (Majesté-Menjoulas et al. 1986; Cirrincione et al. 1999) or Cambrian-Ordovician age (Cirrincione et al. 2005) for the alkaline volcanites of the eastern sector (Mongiuffi Melia area) is based on the location of one fossiliferous site with acritarchs (Majesté-Menjoulas et al. 1986; Bouillin et al. 1987) just below their main outcrop. A Devonian age for the volcanites exposed in the central sector (Banco di Formisia-Floresta-Monte Purritto-Roccella Valdemone, Ferla and Azzaro 1978) is based on dacryoconarids found in the overlying crystalline limestones. Finally, a Silurian-Devonian (?) age for the volcanites of the western sector (Caprileone area) is proposed by Duée (1961), as the metabasites are associated with metapelites and carbonate lenses with facies resembling those of the Silurian-Devonian.

Lower Subunit

The Paleozoic rocks of the Lower Subunit are exposed only in the eastern sector, in a less than 2km^2 outcrop (text-figure 2B). The Paleozoic succession is composed mainly of undated siliciclastic rocks, represented by greenish-grayish metapelites, very rich in metarenites and metamicroconglomerates lacking in the other subunits (text-figure 3A). In the upper part of the succession, S of Gallodoro village (text-figure 2B), the siliciclastic rocks host gray lens of metalimestones and slightly metamorphosed nodular limestones (text-figure 3B). In these



TEXT-FIGURE 4
A: General overview of the LTU Lower and Middle Subunits along the Castelmola-Mongiuffi Melia ridge (text-figure 2B-C). The site where Majesté-Menjoulas et al. (1986) found acritarchs of Cambrian-Ordovician boundary age can be observed. Abbreviations are: Pz - Paleozoic basement; MCC – Mesozoic-Cenozoic cover, dashed line – unconformity; So//Sn – Bedding subparallel to foliation. B to C: Upper Ordovician acidic volcanites of the Middle Subunit (locality: Taormina-Castelmola road). B: Porphyroids. C: Close-up of the acidic volcanites in the same site as B. D to E: Alkaline metabasites of the Middle Subunit (locality: Mongiuffi Melia village). D: Metabasites with flattened and sheared pillows. E: Close-up of sheared pillow metabasalts of the same outcrop as D.

metalimestones, Majesté-Menjoulas et al. (1986) found conodont fragments, among them *Polygnathus communis communis* (Late Devonian-Early Carboniferous).

Middle Subunit

The Paleozoic rocks of the Middle Subunit crop out primarily in the eastern sector (text-figure 2B). The best outcropping succes-

TEXT-FIGURE 5
Paleozoic succession of the Upper Subunit (locality: Roccella Valdemone-Floresta road, about 2 km NNE of Roccella Valdemone). A: Flattened, pillow alkaline metabasalts. B: Detail of a pillow. C: Lens of metacarbonates and calc-schists lying on alkaline metabasites. D: Close-up of the calc-schists of the outcrop shown in C.

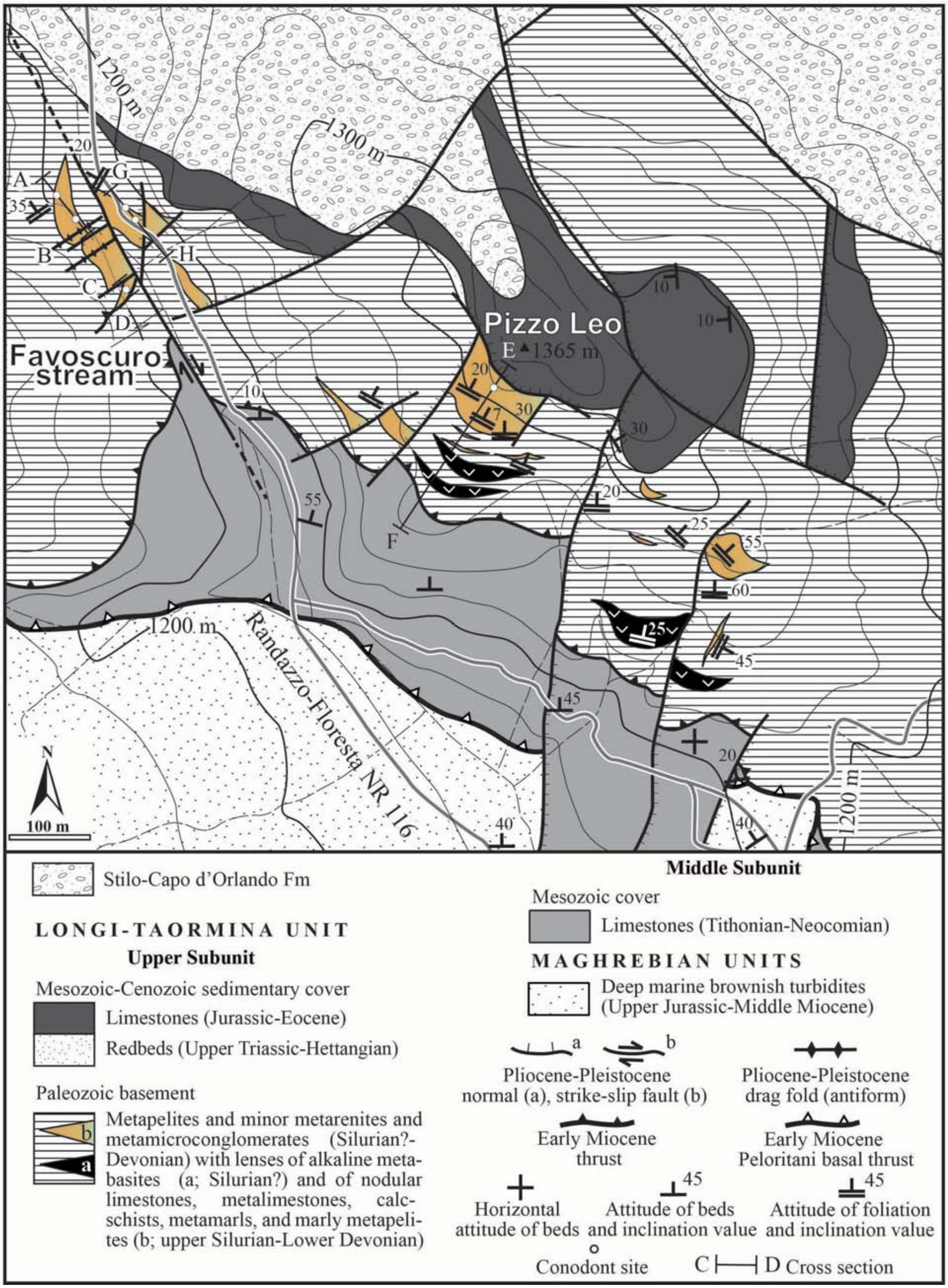
sion can be seen along the ridge extending from Taormina-Castelmola to the Mongiuffi Melia village (text-figures 2B, 4A). In the Castelmola area, beds are mildly folded, whereas in the Mongiuffi Melia area beds weakly dip N-NE-wards, and apparently in stratigraphic continuity (text-figures 2C, 4A).

The base of the Taormina-Castelmola-Mongiuffi Melia succession (along the Provincial Road SP 10, from Taormina to Castelmola village) is made up of greenish-grayish metapelites and metarenites with minor meter-thick beds of light quartzites. The succession hosts Upper Ordovician calc-alkaline volcanic rocks (Trombetta et al. 2004), up to about 230m-thick, in the Castelmola area (text-figures 2C, 4A). They are composed of whitish to light-yellowish-greenish andesites, dacites, rhyodacites, rhyolites (porphyroids, text-figure 4B-C), and sub-alkaline metatuffs (Cirrincione et al. 2005). In the Castelmola surroundings (text-figure 2B), Bouillin et al. (1987) found a carbonate lens yielding undeterminable conodont fragments. The authors assigned these conodonts to the Late Devonian-Carboniferous because of associated lydites, which are typical facies of lower Carboniferous beds in many Variscan areas. We were unable to find the conodont-bearing carbonate lens cited by Bouillin et al. (1987).

The Taormina-Castelmola succession continues upwards, in the Mongiuffi Melia area (text-figure 2B), with dark- and green-colored metapelites (presumably metamorphosed volcanoclastic pelites) evolving to metamorphosed alkaline volcanic rocks. These alkaline metavolcanites form an almost 100m-thick lens extending for about 1km (text-figures 2B, C, 4A). They are green, sometimes pillowed (text-figure 4D-E), and vacuolar, but usually they appear strongly flattened and sheared (text-figure 4E). These rocks are also associated with, and followed by, some layers of violet to light- and dark-greenish metatuffs (known as varicolored schists). The same metatuffs, associated with metapelites, are widespread both along the Taormina-Castelmola-Mongiuffi Melia ridge and from the Gallodoro cemetery up to the Mongiuffi area (text-figure 2B).

Upper Subunit

The Paleozoic succession of the Upper Subunit is exposed in mainly the western and central sectors (text-figure 2A). It is rather similar to that of the Middle Subunit but generally lacks basal beds with calc-alkaline rocks and is richer in carbonate beds. Actually, it consists mainly of greenish-grayish and dark metapelites and metarenites, bearing green alkaline



TEXT-FIGURE 6
Geological map of the Pizzo Leo area (modified after Rodríguez-Cañero et al. 2013; see location in text-figure 2A) with location of the Favoscuro west (A-B: northern part, C-D: southern part), Pizzo Leo (E-F), and Favoscuro east (G-H) section (see also text-figure 7).

TEXT-FIGURE 7
General overview of the LTU Middle and Upper Subunits and of the Peloritanian basal thrust on the Maghrebian Units in the Pizzo Leo area with studied sections (text-figure 6). Abbreviations are: FWS - Favoscuro west section, FES - Favoscuro east section, PLS - Pizzo Leo section, Pz – Paleozoic basement, MCC - Mesozoic-Cenozoic cover, MC - Mesozoic cover, MU - Maghrebian Units, dashed line - unconformity.

metavolcanites at the top, which evolve upwards to gray metacarbonates with metapelite intercalations.

The best outcrops of these metabasites are located in the LTU western (Caprileone village, text-figure 2A) and central (Rocca Licopeti, about 2 km NNE of Roccella Valdemone village, text-figure 2A) sector. These volcanites are composed of dark-green volcanic metabreccias evolving upwards to metabasalts and metatuffs (varicolored schists). The alkaline affinity of these volcanites has been demonstrated by Guerrera et al. (1999) in the Rocca Licopeti outcrop. These metabasalts, associated with metapelites, locally preserve pillow structures (text-figure 5A-B) with degassing vacuoles, mm to cm in diameter, which demonstrate their origin related to submarine eruptions. In the surrounding area (250m west of Rocca Licopeti), this volcano-clastic succession is overlain by undated light-gray and pinkish calc-schists (strongly folded) and pinkish metamarls, a few dozens of meters thick (text-figure 5C-D). The carbonates from this outcrop, previously studied by Boullin et al. (1987), did not provide any conodont remains (pers. com. of J. P. Bouillin).

A few kilometers to the west of Rocca Licopeti, in the Pizzo Leo area (text-figure 2A; along the Randazzo-Floresta National Road: NR 116) bounding the eastern side of the Favoscuro stream (text-figure 6), a Devonian dacryoconarid-rich bed was found by Lardeux and Truillet (1971). In the surrounding area, along the western side of the Favoscuro stream, Majesté-Menjoulas et al. (1986) recognized a dacryoconarid-rich bed overlain by metamarls with lenses of metalimestones yielding badly preserved Upper Devonian conodonts. No taxonomic description or photographic documentation of conodonts found in the LTU was provided by these authors to support the proposed ages. Part of the same carbonates cropping along the western side of the Favoscuro stream have recently provided upper Silurian to Lower Devonian conodonts (Somma et al. 2012; Rodríguez-Cañero et al. 2013), however.

THE PALEOZOIC SUCCESSION OF THE PIZZO LEO AREA

The LTU Paleozoic succession exposed in the Pizzo Leo area is about 300m thick and formed mainly by mildly metamorphosed siliciclastic rocks with volcanic lenses, overlain by metacarbonates (text-figure 6). Particularly, the siliciclastic beds are constituted by metapelites with minor metarenites and metaconglomerates, whereas the volcanites are represented by several-meter-thick lenses of alkaline metabasites. The overlying metacarbonates are composed of thick-bedded metalimestones, laterally evolving to metamarls with minor lenses of nodular metalimestones, evolving upwards to medium-bedded metalimestones, calc-schists, and metamarly limestones, with metapelite interbeds (text-figure 6).

In the Pizzo Leo area and the surrounding Favoscuro stream, three stratigraphic sections, called Favoscuro west, Pizzo Leo, and Favoscuro east, were measured and correlated (text-figures 6, 7).

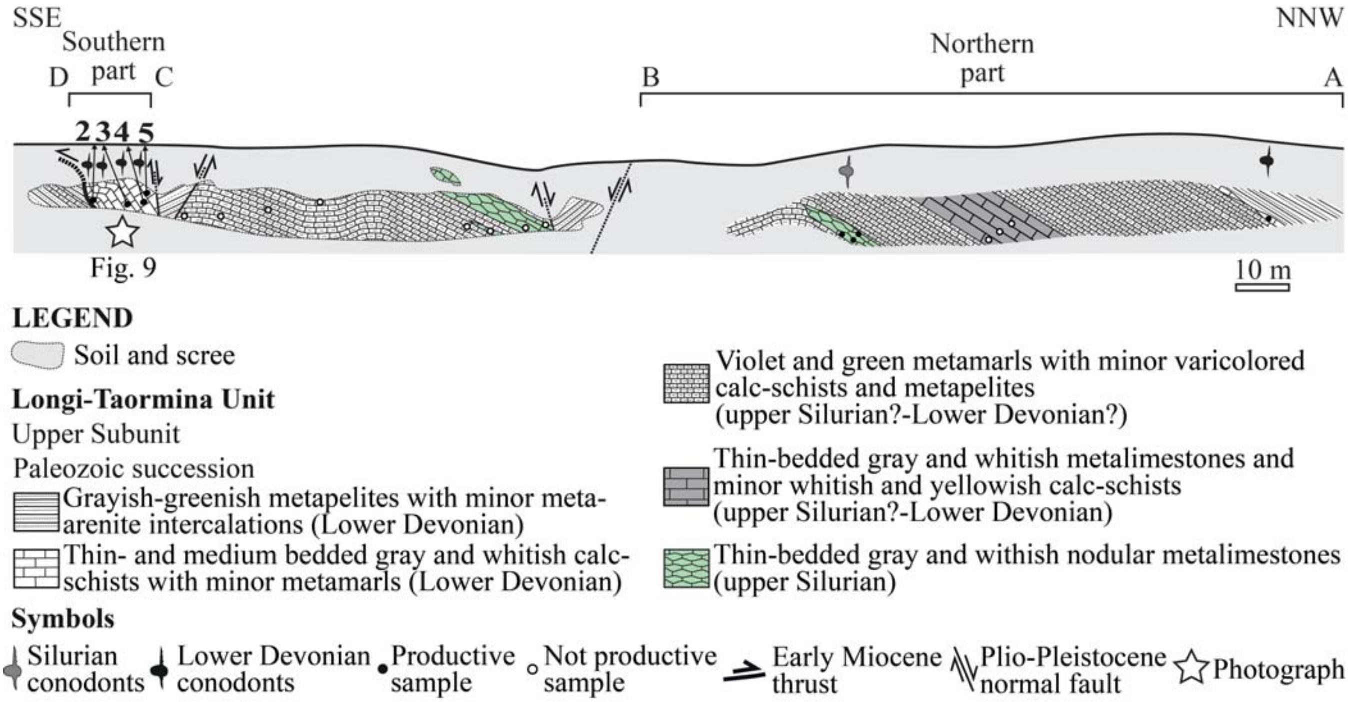
The Favoscuro west section

The Favoscuro west section (text-figure 8) is situated along a path at an elevation of about 1200m a.s.l. on the western slope of the Favoscuro stream, parallel to the Randazzo-Floresta NR 116. The section is located at coordinates: A - 37°57'23.37"N / 14°57'13.54"E, D – 37°57'19.24"N / 14° 57'16.86"E (text-figures 6, 7, 8, 9). This section seems to correspond roughly to where Upper Devonian beds were previously dated by Majesté-Menjoulas et al. (1986).

The Favoscuro west section (text-figure 8) shows a sequence dipping approximately NW-wards. The succession is tectonically disturbed by an early Miocene thrust and Plio-Pleistocene normal faults that caused open drag folds with decameter wavelengths (text-figure 8). Consequently, the section has been subdivided into a northern and a southern part, avoiding the intermediate deformed zones.

The Northern part

In the northern part of the section, recently studied by Rodríguez-Cañero et al. (2013), the following main lithostratigraphic units have been recognized, from base to top (text-figures 8, 10): A basal lens (1 up to 3-4m-thick) of whitish and grayish nodular metalimestones, Ludlow (late Silurian) in age on the basis of conodonts as *Ancoradella* cf. *ploeckensis* Walliser 1964, and *Kockelella* cf. *variabilis* Walliser 1957 (Rodríguez-Cañero et al. 2013); violet and greenish metamarls with minor varicolored metapelites and decimeter-thick calc-schists (around 45m-thick) with an intercalation of whitish and yellowish calc-schists (up to 10m-thick); and a topmost bed, a few of decimeters thick, of grayish calc-schists, earliest Emsian (*kitabicus* Zone) in age on the base of conodonts as *Polygnathus* cf. *kitabicus* Yolkin, Weddige, Izokh and Erina 1994 (Rodríguez-Cañero et al. 2013).



TEXT-FIGURE 8
Favoscuro west section: northern and southern part (see location of the section in text-figures 6, 7) (modified after Rodríguez-Cañero et al. 2013).

These conodont findings enabled for the first time the recognition of upper Silurian and Lower Devonian rocks in the Peloritanian Mountains. This result is important because these taxa are the oldest conodonts ever found in this sector of the chain and because this section encompasses the Silurian/Devonian boundary.

The Southern part

In the southern part of the section, an early Miocene thrust (text-figure 8) turned the stratigraphic succession upside down, causing the high inclination angle of bedding (text-figures 8, 10). In this tectonic slice, bounded to the north by a normal fault (text-figure 8), the metacarbonates are up to 9m thick and are represented mainly by light-gray medium-bedded metalimestones (text-figures 10, 11) with a dm-thick intercalation of dark-gray metamarls.

The samples collected in these metalimestones (geometrically from base to top: samples 2, 3, 4, and 5, text-figure 9) proved productive and have released several determinable conodont elements as well as others very badly preserved or too small.

Sample 2. This is the geometrically lowest sample of the section and it shows the youngest conodont association studied in the Pizzo Leo area. This level yielded *Polygnathus* cf. *nothoperbonus* Mawson 1987 - *inversus* Klapper and Johnson 1975. The element P_1 attributed to *Polygnathus* cf. *nothoperbonus-inversus* is deformed and broken, but it has a smaller basal cavity with a posterior inversion larger than the P_1 element of *Po. nothoperbonus*. These taxa belong to the *nothoperbonus* – *inversus* zones (text-figure 11, photo 1) (Emsian).

Sample 3. It yielded *Polygnathus excavatus excavatus* Carls and Gandl 1969 (text-figure 11, photo 3) and fragments of *Icriodus* sp. (text-figure 11, photo 2). The P_1 element of *Polygnathus excavatus excavatus* has an enlarged outer adcarinal trough, so that the carina is located near the inner platform margin, and a large and moderately deep basal cavity.

Sample 4. It yielded *Polygnathus* cf. *excavatus excavatus* (text-figure 11, photo 4), *Ozarkodina miae* (Bultynck 1971) (text-figure 11, photo 6-8), and *Pseudooneotodus beckmanni* (Bischoff and Sannemann 1958) (text-figure 11, photo 9). The P_1 element of *Ozarkodina miae* is characterized by an even denticulation blade and two lobes without any tubercle or shouldered rim.

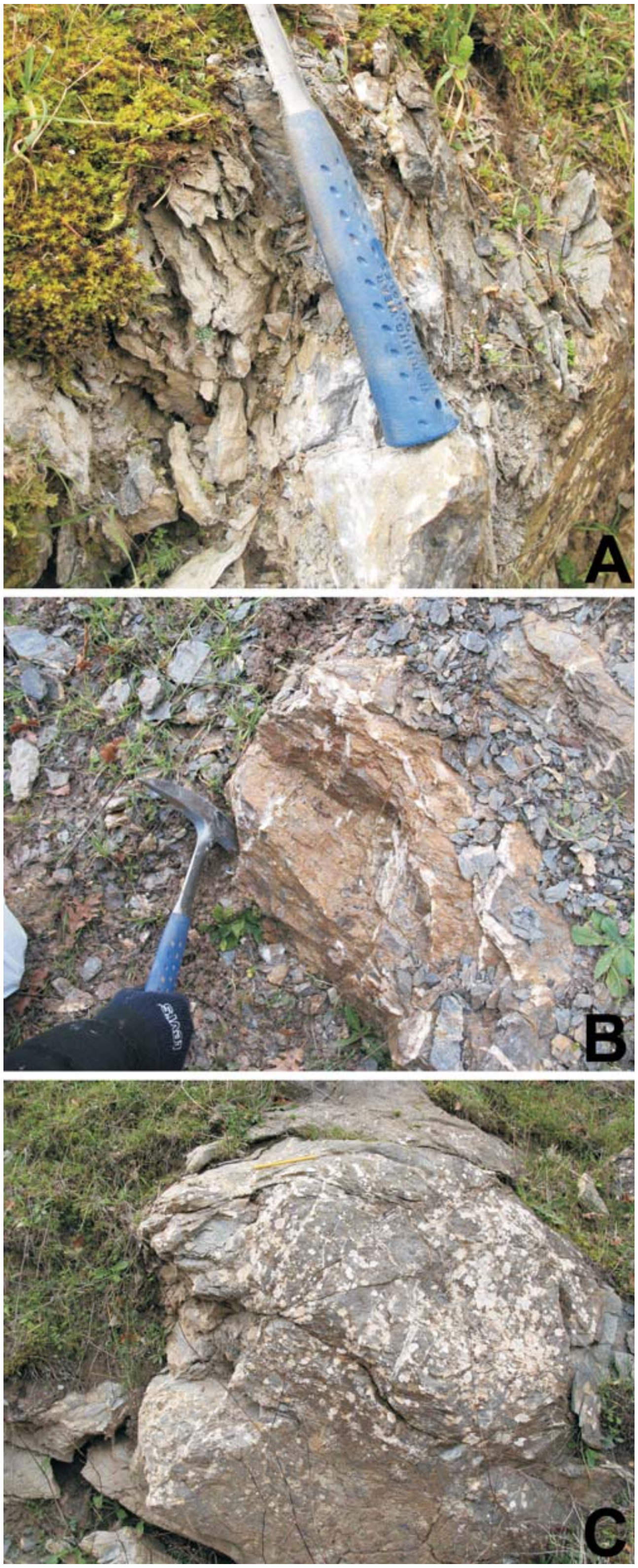
Sample 5. The geometrically highest sample yielded *Pseudooneotodus beckmanni* (text-figure 11, photo 10) and *Polygnathus* cf. *excavatus excavatus* (text-figure 11, photo 5). *Pseudooneotodus beckmanni* has an apparatus consisting of short and stout cones with deep basal cavities.

The presence of *Polygnathus excavatus excavatus* in samples 3 and 4 indicates that these beds belong to the *excavatus* Zone (Early Emsian).

The taxa analyzed confirm that the study succession is overturned, and that the age of these metacarbonates ranges, from base to top, from the *excavatus* Zone to the *nothoperbonus* – *inversus* zones (Emsian).

The Pizzo Leo section

The stratigraphic section (text-figure 12) is located along the slope southwestern of the Pizzo Leo, at coordinates: top (E) - 37°57'16.11"N / 14°57'39.34"E (1336m a.s.l); base (F) - 37°57'09.07"N / 14°57'35.53"E (1271m a.s.l., text-figures 6, 7). The lower-middle part of the succession shows a monoclinal setting toward NW, whereas the upper part (made up of carbon-



TEXT-FIGURE 9
Favoscuro west section: field views of light gray medium-bedded metalimestones which provided Emsian (Lower Devonian) conodonts (samples 2-3-4-5) along the southern part of the section (locality: western side of the Favoscuro stream, west of Pizzo Leo) (see location of photos in text-figure 8). A: Sample MAJ2. B: Sample MAJ3. C: Sample MAJ4 (at the base) and MAJ5 (at the top).

ates) is mildly affected by meter-wavelength open folds. The following lithostratigraphic units have been recognized, from base to top (text-figure 12).

Lower lithostratigraphic unit

This is made up of greenish to grayish (sometimes violet to pinkish) metapelites with minor gray to greenish metarenites and conglomerates (text-figure 13A). The latter clastic rocks locally preserve sedimentary structures (laminations, etc.) indicating the action of bottom currents. The siliciclastic rocks contain at least two lenses (up to 10m thick) of dark-green metabasalts and metadolerites in their lowermost part (text-figure 13B). Rare and meter- to decimeter-thick carbonate lenses of whitish to pinkish, locally nodular metalimestones (text-figure 13C) and calc-schists are intercalated in the metapelites and metarenites (text-figure 13D) overlying the metavolcanites. Gradually, the succession evolves upwards to gray metapelites with minor metarenite interbeds (text-figure 13E). The total thickness of metapelites is around 60m. Upwards, this interval gradually transforms into metacarbonates (text-figure 13E). Not all the samples studied for conodonts in this unit were productive.

Upper lithostratigraphic unit

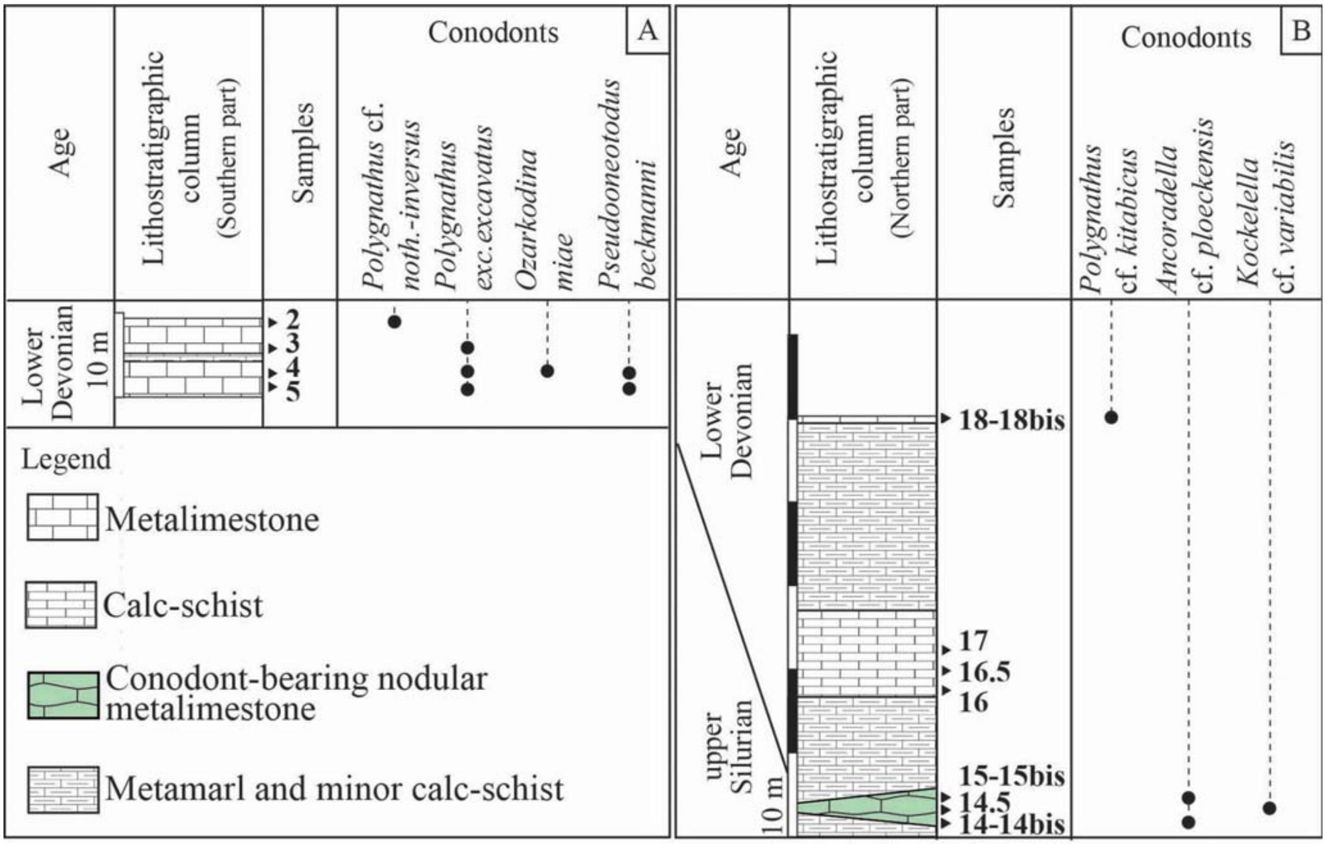
This unit is made up of grayish to beige (reddish when weathered), strongly deformed and recrystallized limestones, up to 47m thick. They are thick-bedded and nodular (up to 32m-thick) at the base (text-figure 13F), and change upwards into medium-bedded to platy limestones (up to 15m-thick) (text-figure 13G).

The Paleozoic succession ends with violet metamarls with minor varicolored calc-schists and metapelites c. 40m thick (text-figure 12), partly covered by soil. The succession here is covered by Triassic?-Hettangian continental redbeds with Pseudoverrucano lithofacies (Perrone et al. 2006).

Only three samples (174, 175, and 176), all collected in the platy limestones at the top of the section, yielded conodonts that can be classified (text-figures 14, 15).

Sample 174. The lowest fossiliferous sample held *Icriodus* cf. *woschmidti* Ziegler 1960 and *Ozarkodina remscheidensis* (Ziegler 1960). The P_1 element of *Icriodus* cf. *woschmidti* found in this sample is fragmented and very badly preserved but the main features of *I. woschmidti* are visible (text-figure 15, photos 2 and 3), such as the presence of transverse ridges instead of three rows of nodules, a weak thin median longitudinal ridge in the grooves between the transverse ridges, and a lateral process. The P_1 element of *Ozarkodina remscheidensis* (text-figure 15, photo 1) is broken and twisted, but the presence of a strongly expanded and slightly asymmetrical basal cavity, and the mostly irregular denticle height, particularly the one above the basal cavity, is typical of this species. The presence of *Icriodus woschmidti* indicates a Lochkovian age (Early Devonian) for these beds (text-figure 14).

Sample 175. It yielded *Ancryrodelloides omus* Murphy and Matti 1983 transitional to *Ancyrodelloides transitans* (Bischoff and Sannemann 1958; text-figure 15, photo 4) and *Pseudooneotodus beckmanni* (Bischoff and Sannemann 1958; text-figure 15, photo 7). The specimen of *Ancyrodelloides omus-transitans* recovered is badly preserved (text-figure 15, photo 4) but can be identified by the presence of nodules in one of the



TEXT-FIGURE 10
Stratigraphic columns of the Favoscuro west section. A: Southern part showing Emsian conodonts. B: Northern part showing upper Silurian and Lower Emsian conodonts (modified after Rodríguez-Cañero et al. 2013).

shouldered platform lobe, like *A. omus*, but the posterior processes do not bent laterally and the basal cavity is slightly constricted, like *A. transitans*. This species belongs to the *delta* Zone (Lochkovian).

Sample 176. The highest fossiliferous sample released *Ancryrodelloides omus* and several elements of *Oulodus* sp. The ramiform elements of *Oulodus* sp. are characterized by large basal cavities, extending all along under side of processes (text-figure 15, photos 8-11).

In conclusion, these three productive samples collected in the platy limestones allowed the upper beds of this lithostratigraphic top unit to be assigned to the Lochkovian (*delta* Zone).

The Favoscuro East Section

The stratigraphic section (text-figure 16) is located along the Randazzo-Floresta NR 116 (between km 12.7 and 12.8) at a mean altitude of about 1200m a.s.l. and at coordinates: top (G) - 37°57'23.94"N / 14°57'16.17"E; base (H) - 37°57'20.27"N / 14°57'19.22"E (text-figures 6, 7). The succession is characterized by a general dip NW-wards and is crossed by Pliocene-Pleistocene normal faults in the lower part. Thirty samples were collected in the metalimestones of this section, but only three samples yielded determinable conodont elements. The following lithostratigraphic units have been recognized, from base to top (text-figure 16).

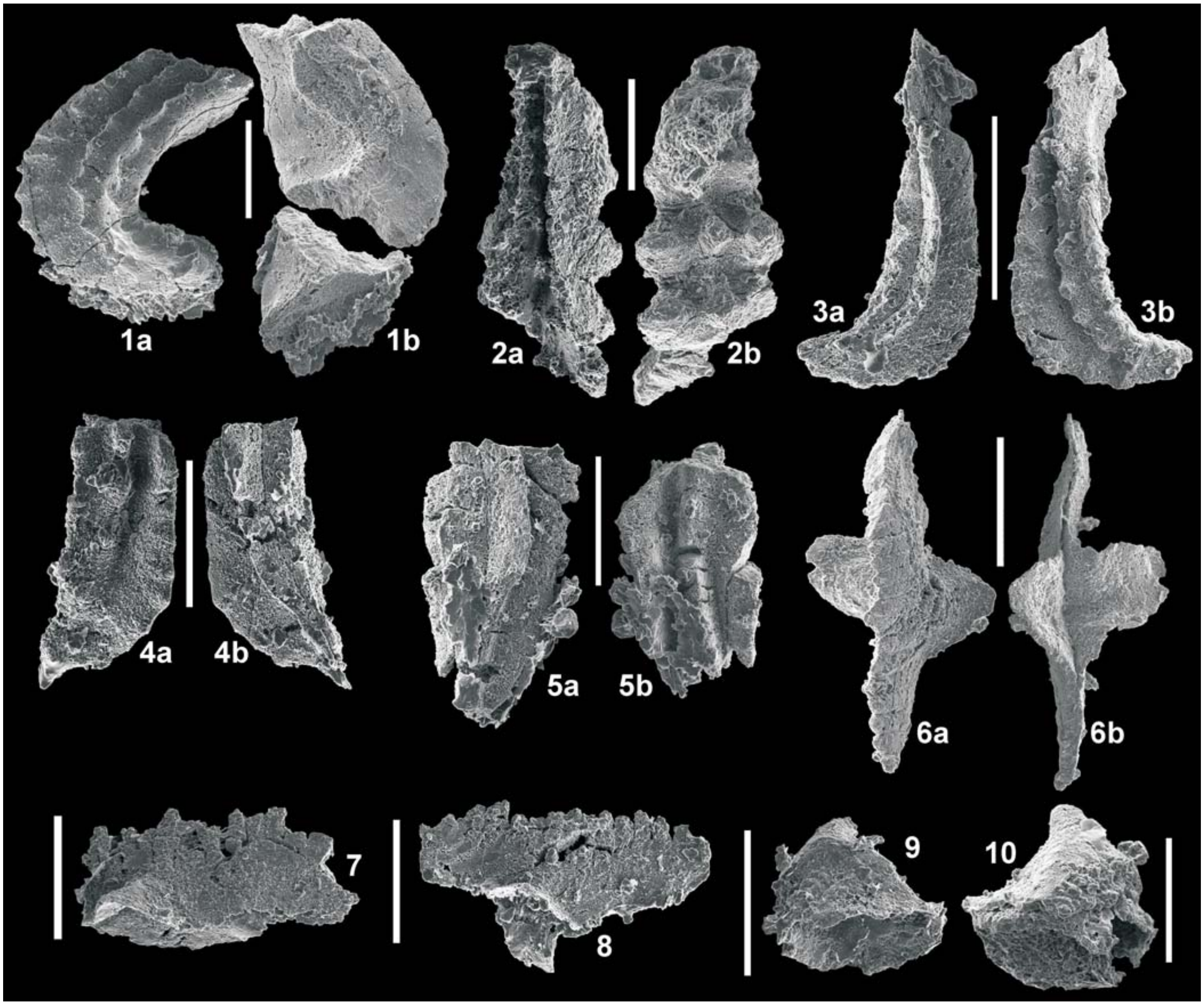
Lower lithostratigraphic unit

It is made up of gray metapelites covered mainly by soils.

Intermediate lithostratigraphic unit

This is formed by grayish to whitish (reddish when weathered) thick-bedded and coarse-grained, strongly deformed metalimestones with isoclinal folds, up to 18m thick (text-figure 17A-D), which change upwards into a more platy succession (up to 6m-thick; text-figure 17B). This transition is marked by a bed rich in mm-sized dacryoconarids (text-figure 17C-E, firstly observed by Lardeux and Truillet 1971). Above this bed, after a badly exposed interval of metapelites and calc-schists, a massive, iron-rich reddish metalimestone bed changes upwards to bedded grayish metalimestones that gradually evolve to a more platy succession (up to 10m-thick). The succession is followed by 20m-thick pinkish to violet calc-schists and metamarls, with some gray platy metalimestone beds with metapelite intercalations at the top.

Three samples (143, 153, and 155) yielded determinable conodont elements; one sample was collected in the middle carbonate beds, and the other two in the uppermost beds (the upper calc-schists) of these levels.



TEXT-FIGURE 11
Devonian conodonts of the Favoscuro west section (Southern part). All scale bars are 200µm.

1 *Polygnathus* cf. *nothoperbonus* Mawson 1987-*inversus* Klapper and Johnson 1957, P_1 element MAJ2-1, 1a: Upper-lateral view; 1b: Lower view (broken).

2 *Icriodus* sp. (fragment), P_1 element MAJ3-1, 2a: Lower view; 2b: Upper view.

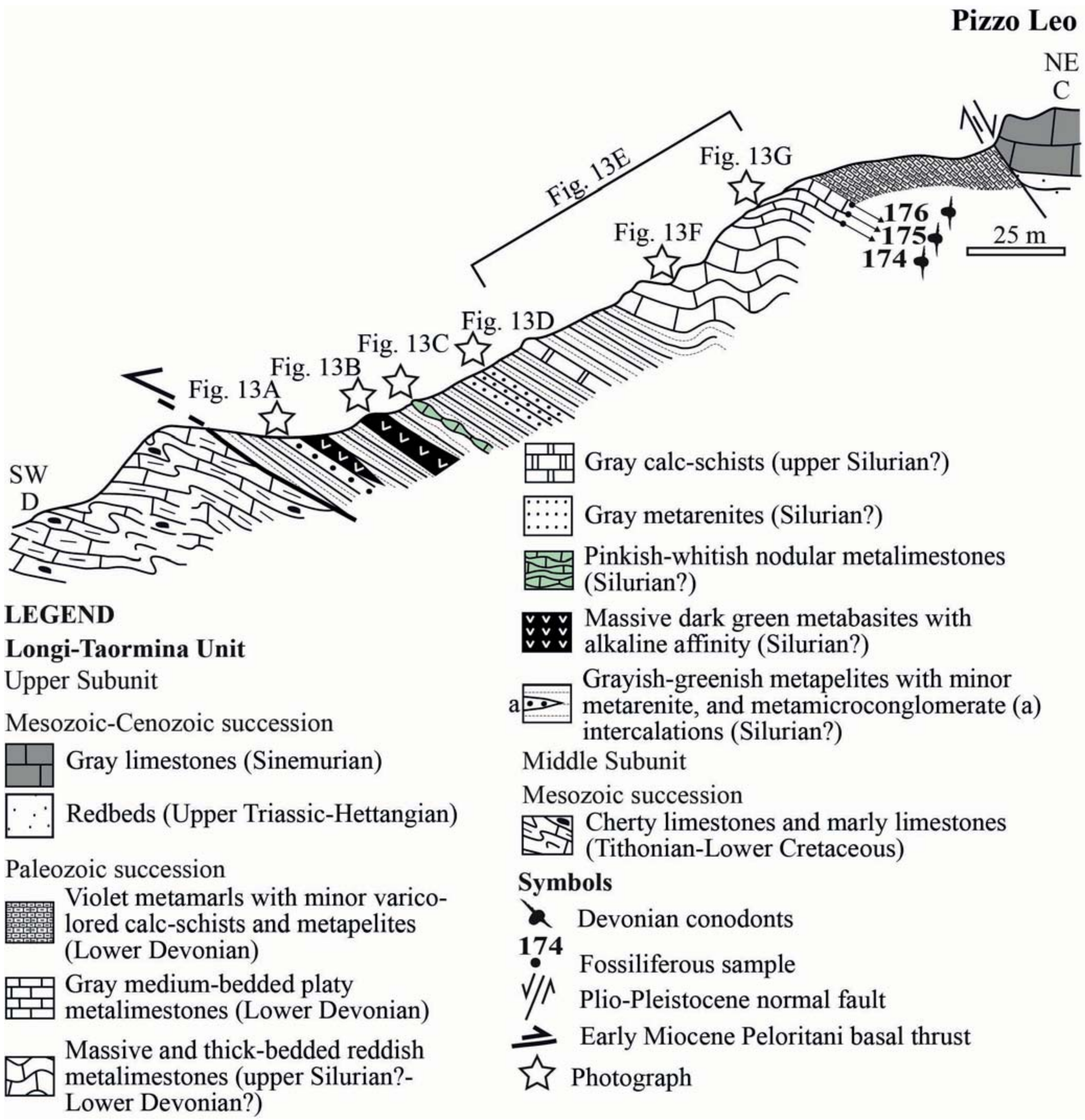
3 *Polygnathus excavatus excavatus* Carls and Gandl 1969, P_1 element MAJ3-4, 3a: Lower view; 3b: Upper view. 4-5. *Polygnathus* cf. *excavatus excavatus*.

4 P_1 element MAJ4-2, 4a: Upper view; 4b: Lower view.

5 P_1 element MAJ5-1, 5a: Lower view; 5b: Upper view.

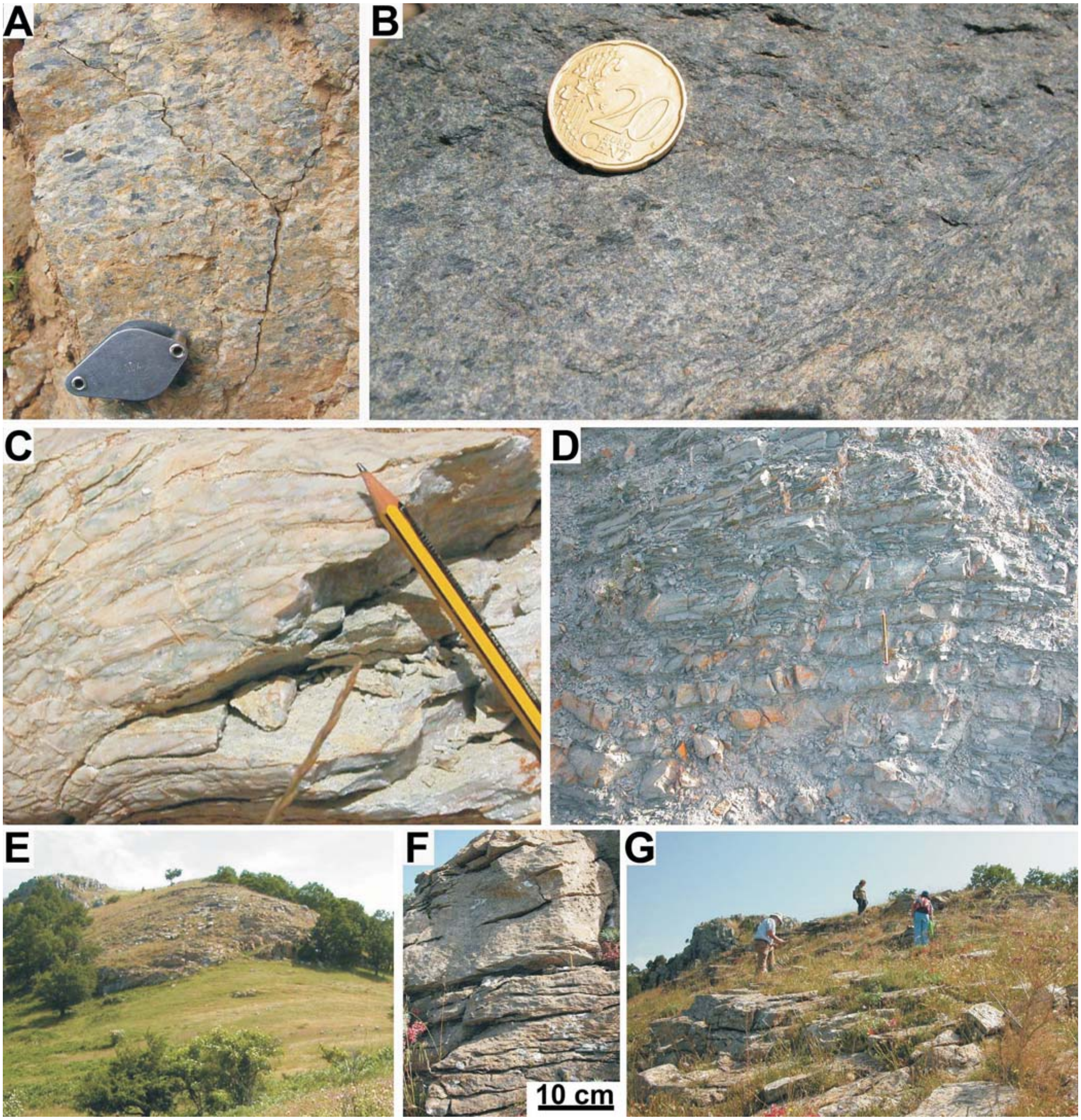
6-8 *Ozarkodina miae* (Bultynck 1971). 6: P_1 element MAJ4-9, 6a: Upper view; 6b: Lower view. 7: P_1 element MAJ4-10 lateral view. 8: P_1 element MAJ4-11, lateral view.

9-10 *Pseudooneotodus beckmanni* (Bischoff and Sannemann 1958). 9: Element MAJ4-7, lateral view. 10: Element MAJ5-3 lateral view.



TEXT-FIGURE 12
Pizzo Leo section (see location of the section in text-figures 6, 7).

Sample 143. The location of the lowest fossiliferous sample (143) coincides with the (geometrically) lowest basal beds of the platy limestone succession and was taken from the same bed bearing dacryoconarids mentioned above (text-figure 17E). The conodont association includes *Icriodus* gr. *bilatericescens* Ziegler 1956, *Icriodus* aff. *beckmanni* Ziegler 1956, and *Polygnathus luciae* Martínez-Pérez and Valenzuela-Ríos 2011 in Martínez-Pérez et al. (2011). A nearly complete I element of *Icriodus* is assigned to the *Icriodus bilatericrescens* group without specifying the subspecies (text-figure 19, photo 3). Despite having a lanceolate spindle and two well-developed processes forming a 180º angle, the developmental stage of these two processes differs slightly from that of the nominative species. Even though the element is partially broken, it shows a very well-developed posterior process, and an anterior process ornamented by a crest instead of by nodules. Another partially broken P_1 element was assigned to *Icriodus* aff. *beckmanni* (text-figure 19, photo 4), since it shows all the characteristic features of this species but the angle between the posterior outer process and the cuspid is slightly smaller, a fact that could be explained by tec-



TEXT-FIGURE 13
Pizzo Leo section: field views of the lower (A-D) and upper lithostratigraphic (E-G) units of the section (see location of photos in text-figure 12). A: Metamicroconglomerate intercalated in the metapelites. B: Dark-green metabasite in a lens hosted by the pelitic succession. C: Pinkish-whitish nodular metalimestones intercalated in the metapelites. D: Gray metarenites passing upwards to gray metapelites. E: Panorama of the metalimestones. F: Thick- to medium-bedded metalimestones. G: Well-bedded and platy metalimestones, which provided Lochkovian (Lower Devonian) conodonts (samples 174, 175, and 176).

tonic distortion, as the sampled rocks are strongly deformed. Two coniform elements belonging to apparatus of *Icriodus* are also present (text- figure 19, photos 10 and 11). The specimens of *Polygnathus luciae* studied are characterized by an elongated platform showing a characteristic "L"-shape, with a more developed outer platform in its posterior region, and by a slightly asymmetrical and inverted basal cavity (text-figure 19, photos 1 and 2). This taxon is closely related to *Polygnathus mashkovae* (text-figure 19, photo 9), but clearly distinguishable by the presence of a clear constriction in the anterior part of the element prior the expansion of the platform in the later species. The presence, in sample 143, of *Icriodus* gr. *bilatericrescens* and *Icriodus* aff. *beckmanni* allows this level to be assigned to the Emsian (Early Devonian). However, the record of *Polygnathus luciae* enables more precise dating, indicating an early Emsian age (text-figure 18), lower part of the *nothoperbonus* Zone (*sensu* Martínez-Pérez et al. 2011).

Sample 153. This sample released one P_1 element of *Polygnathus* cf. *nothoperbonus* Mawson 1987 (text-figure 19, photo 5). This element presents a long, narrow platform characteristic of *Polygnathus nothoperbonus;* however, its posterior end is broken, and the initial posterior inversion of the basal cavity is not clearly visible. In addition, the typical transversal ridges that ornament its tongue cannot be seen, although this could be because this specimen is probably a juvenile element, given its small size (around 0.5mm in length).

Sample 155. The highest fossiliferous sample of the section has yielded the characteristic Emsian conodonts *Critheriognathus steinhornensis* (Ziegler 1956), *Polygnathus mashkovae* Bardashev 1986, and *Polygnathus nothoperbonus* Mawson 1987. *Critheriognathus steinhornensis* (text-figure 19, photos 7 and 8) is clearly identified by the even denticulation of the blade and the rounded and clearly asymmetric lobes (the outer lobe being more developed than the inner one), which are located closer to the posterior half of the unit. *Polygnathus mashkovae* (text-figure 19, photo 9) has an asymmetric platform, with a narrow anterior third bearing a characteristic constriction and, at the posterior two-thirds, a broadly expanded platform developing a flange-like structure at the outer edge. In addition, the tongue, with continuous transverse ridges, is markedly deflected inwards and, in lower view, the basal cavity is clearly inverted. Finally, *Polygnathus nothoperbonus* (text-figure 19, photo 6), as mentioned above, has a characteristic long and narrow platform, where there is no high flange-like development of the outer edge, and a short tongue deflected inwards and bearing continuous ridges; these features allowed us to distinguish between this species and the above mentioned. This conodont association also belongs to the *nothoperbonus* Zone. According to Bultynck (1989), for the equivalent *gronbergi* Zone, and to Martínez-Pérez et al. (2011), the appearance of *Po. mashkovae* indicates an upper position within this zone. Consequently, the conodont association allowed the calc-schists also to be assigned to the upper part of the early Emsian (text-figure 18).

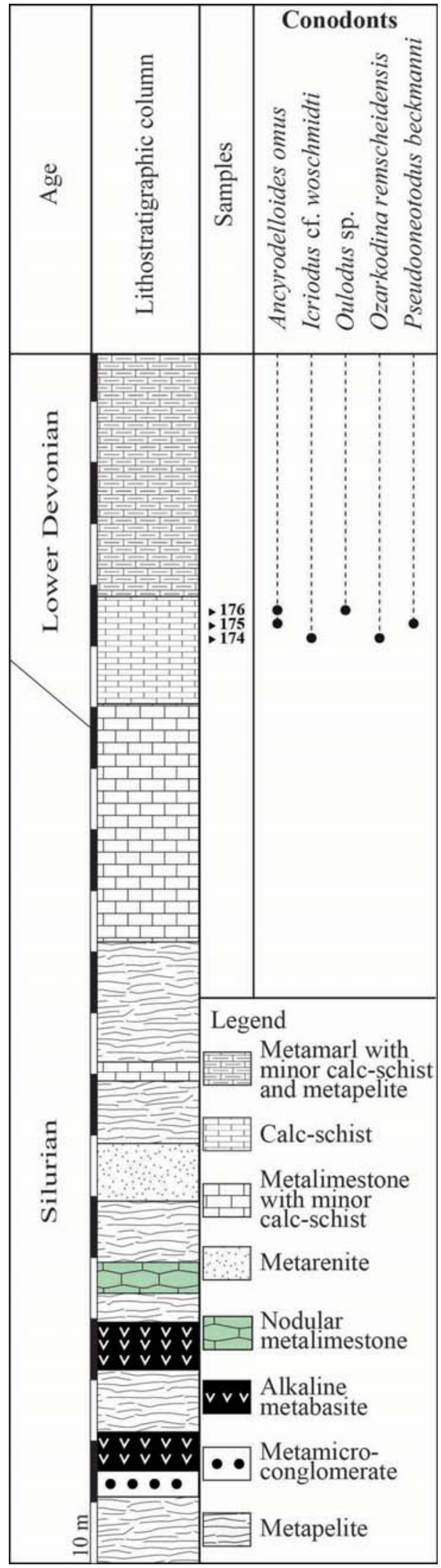
In conclusion, on the basis of the three productive samples, this lithostratigraphic intermediate unit can be assigned an early Emsian age (*nothoperbonus* Zone).

Upper lithostratigraphic unit

The succession ends with dark and brown metapelites, metarenites, and metamicroconglomerates (up to 30m-thick), partly covered by soil.

DISCUSSION

The composite stratigraphic column shown in Text-figure 20 (on the right) represents the general stratigraphy reconstructed for the LTU Paleozoic succession mainly exposed in the central and eastern outcrops (text-figure 2). Our stratigraphic analysis has enabled us to recognize three main lithostratigraphic formations that are named here, from base to top: Castelmola Formation, Lower Pizzo Leo Formation, and Upper Pizzo Leo



TEXT-FIGURE 14
Stratigraphic column of the Pizzo Leo section showing Lochkovian conodonts.

Formation (text-figure 20). Siliceous deposits overlain by siliciclastic rocks (Bouillin et al. 1987), both recognized only by previous authors, should be at the top of the succession.

A formal definition and description of the aforementioned three formations, and their correlation with other successions of the Mediterranean area, such as that of the Calabrian Stilo Unit or those of the Alps or Betic and Rifian chains, are presented below.

Castelmola Formation

The Castelmola Formation (text-figure 20), at least 500m thick, forms the lowermost part of the LTU basement. The formation appears in the Middle Subunit and is well exposed in the eastern sector of the LTU (type section along the Provincial Road SP 10, near Castelmola). The formation is cut at the base by the early Miocene basal thrust of the Middle Subunit. At the top it gradually evolves to the overlying Lower Pizzo Leo Fm. This transition is best preserved in the Castelmola-Mongiuffi Melia ridge along the Provincial Road SP 11 road, and represented mainly by greenish pelitic rocks with layers of litharenites and rare quartzites sedimented in marine terrigenous-clastic environments. The age of the Castelmola Fm is presumed to be Late Cambrian-Ordovician according to the acritarchs (Bouillin et al. 1987; Acquafredda et al. 1992) found in the area to the S of Mongiuffi Melia (text-figure 4A). The upper part of this formation contains a thick lens of calc-alkaline volcanic rocks (andesites, dacites, rhyodacites, rhyolites, metatuffs, text-figure 4A-C), Late Ordovician in age (456-452 Ma, Trombetta et al. 2004).

Undated porphyroids are also present in other Peloritanian (Mandanici-Piraino Unit, Messina et al. 2004) and Calabrian (Stilo Unit) tectonic units; moreover the LTU calc-alkaline rocks could be time equivalent to the calc-alkaline intrusive rocks (augen gneiss) that occur in the Peloritanian highest tectonic unit (Aspromonte Unit), although the age of the magmatism in this latter unit is slightly older (Fornelli et al. 2007). Regarding correlation, the Castelmola Fm should be equivalent to the roughly coeval pelitic-psammitic succession of the Val Visdende Group (Carnic Alps), and equivalent formations in the Austroalpine Mega-Unit (Piller et al. 2004) and in the Malaguide Complex (Betic Cordillera: Morales Fm.; Martín-Algarra et al. 2004, 2009b). In the Malaguide Complex, nevertheless, no traces of volcanic rocks have yet been found in the Morales Formation. On the contrary, the siliciclastic rocks of the Val Visdende Group, like in the LTU, are associated with intermediate to acidic porphyroids of Late Ordovician age (Comelico Porphyroid and Fleons Formation, Schönlaub and Histon 1999, and references therein). The calc-alkaline magmatism of the Castelmola Fm is also coeval with that of Sardinia, Iberian Massif, and Pyrenees (Montero and Floor 2004; Helbing and Tiepolo 2005; Valverde-Vaquero et al. 2005; Giacomini et al. 2006; Bea et al. 2007; Castiñeiras et al. 2008; Montero et al. 2009; Oggiano et al. 2010; Liesa et al. 2011, and references therein); however, as well as in some sectors of Sardinia (Oggiano et al. 2010), it ended a little bit later than in other European Variscan regions.

Lower Pizzo Leo Formation

The Lower Pizzo Leo Formation (text-figure 20) of the LTU, less than 150m thick, appears mainly in the Middle and Upper Subunits. It is well exposed in the eastern (Mongiuffi Melia area), central (Pizzo Leo area, type section), and western sectors (Rocca di Caprileone area) of the LTU. This formation changes upwards, with a sharp contact, to the carbonate succession of the Upper Pizzo Leo Formation. The passage is best preserved and well exposed at Pizzo Leo (Pizzo Leo section). The formation consists mainly of pelites with interbeds of quartzites, sandstones, and conglomerates sedimented in terrigenous-clastic marine environments. Several lenses of alkaline volcanites are present primarily in the lower-middle part of the formation, whereas thin lenses of pelagic whitish nodular limestones sometimes appear in the middle-upper part (text-figure 20).

The siliciclastic facies are greenish-grayish, some dark in color. Particularly, these dark pelites could be equivalent to the probably anoxic deposits (in origin) that appear in other Peloritanian tectonic units (Fondachelli and Mandanici-Piraino Units). In this latter unit, among other lithofacies, the black (graphite-rich) metapelites were interpreted by Bouillin et al. (1987) as corresponding to Silurian ampelites. Analogous rocks in the Stilo Unit of southern Calabria are represented by black-shale hori-

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TEXT-FIGURE 15
Devonian conodonts of the Pizzo Leo section. All scale bars are 200µm.

1 *Ozarkodina remscheidensis remscheidensis* (Ziegler 1960), P_1 element 07P-174-4, 1a: Upper view; 1b: Outer lateral view.

2–3 *Icriodus* cf. *woschmidti* Ziegler 1960, 2: P_1 element 07P-174-2, upper view; 3: P_1 element 07P-174-1, upper view.

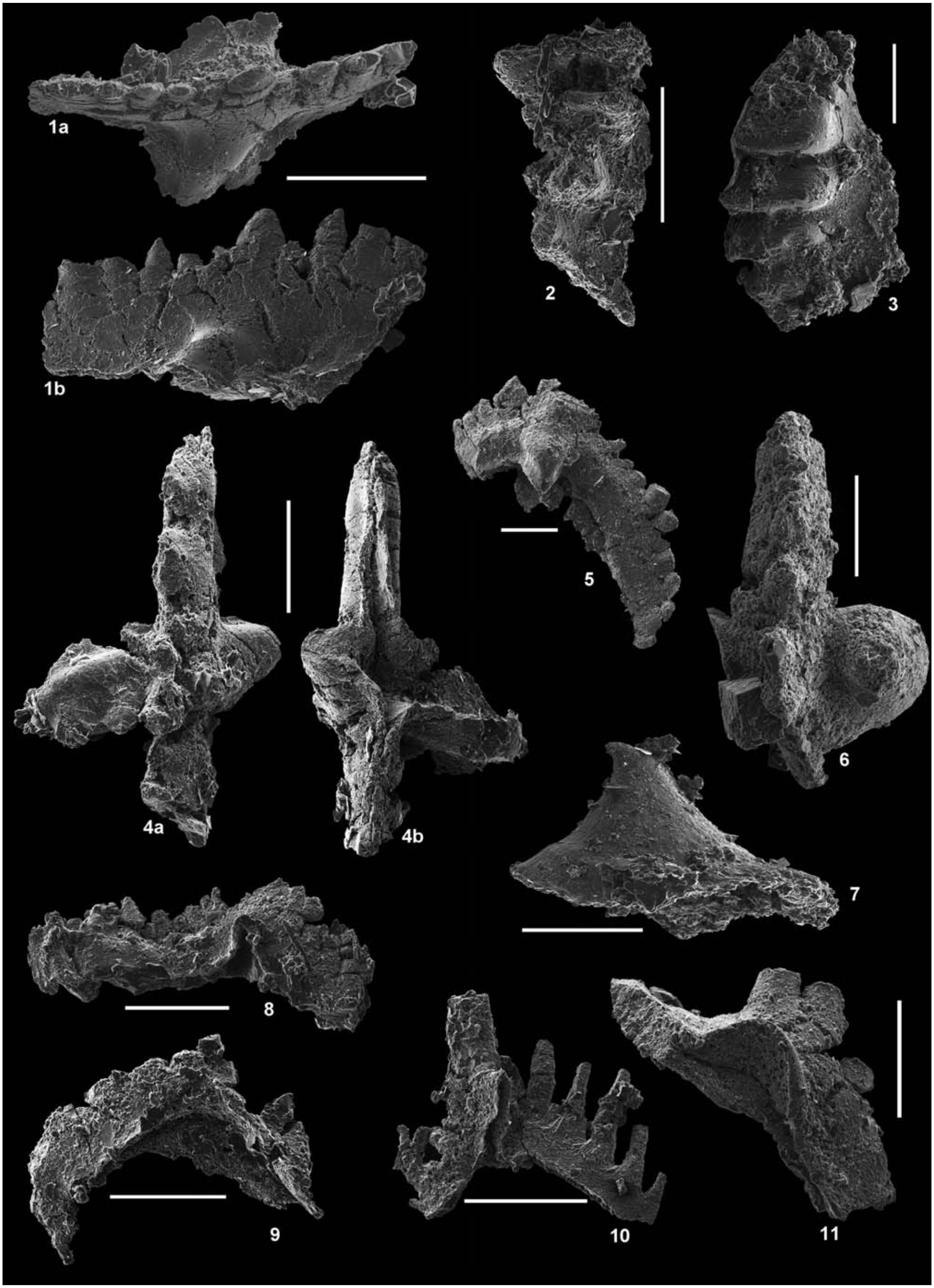
4 *Ancyrodelloides omus* Murphy and Matti 1983 - *Ancyrodelloides transitans* (Bischoff and Sannemann 1958), P_1 element 07P-175-1, 4a: Upper view; 4b: Lower view.

5 *Ancyrodelloides* sp. P_2 element 07P-176-6, lateral view.

6 *Ancyrodelloides omus* Murphy and Matti 1983. P_1 element 07P-176-1, upper view.

7 *Pseudooneotodus beckmanni* (Bischoff and Sannemann 1958), P_1 element 07P-175-3.

8–11 *Oulodus* sp. 8: Sb element 07P-176-4, posterior view; 9: P_1? element 07P-176-3, lower lateral view; 10: S_2 element 07P-176-9, posterior view; 11: P_2 element 07P-176-2, lower lateral view.


1a
1b
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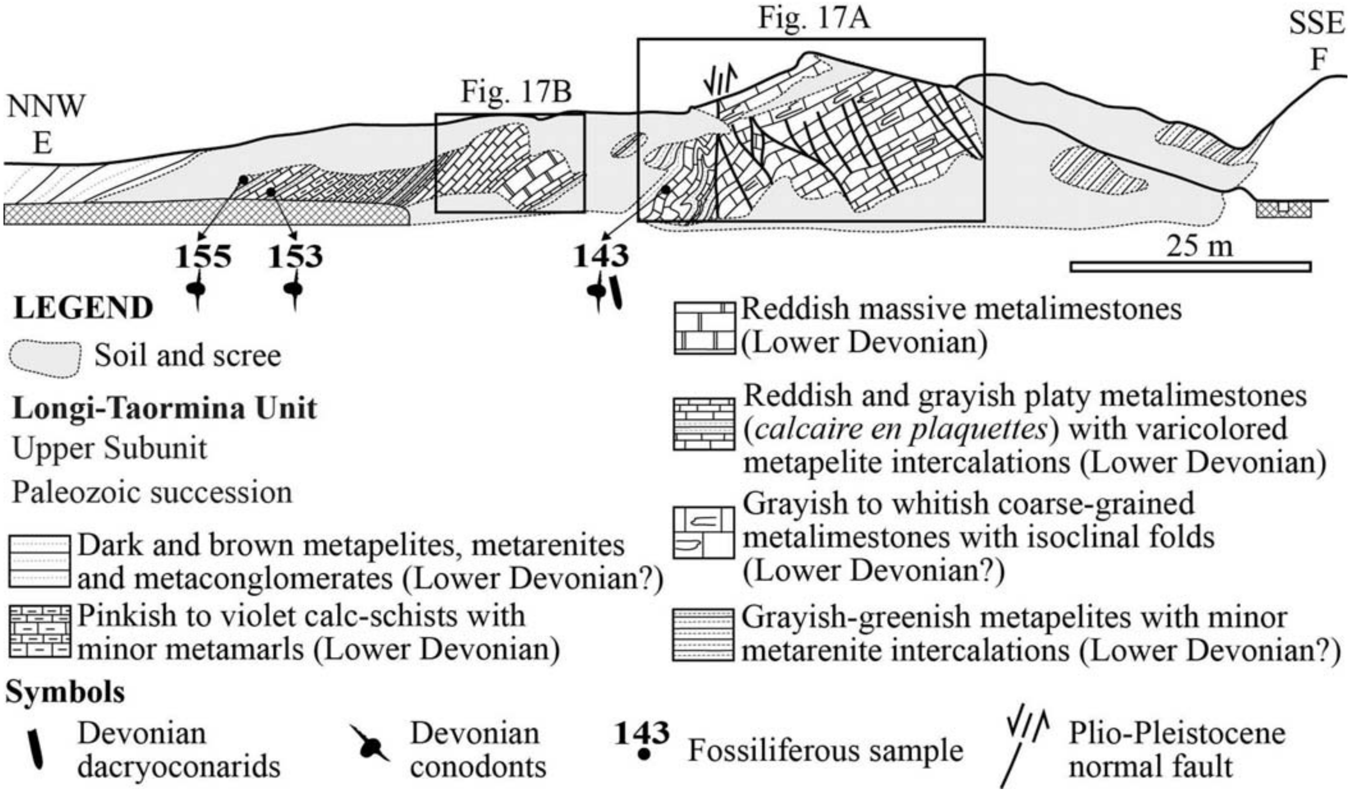


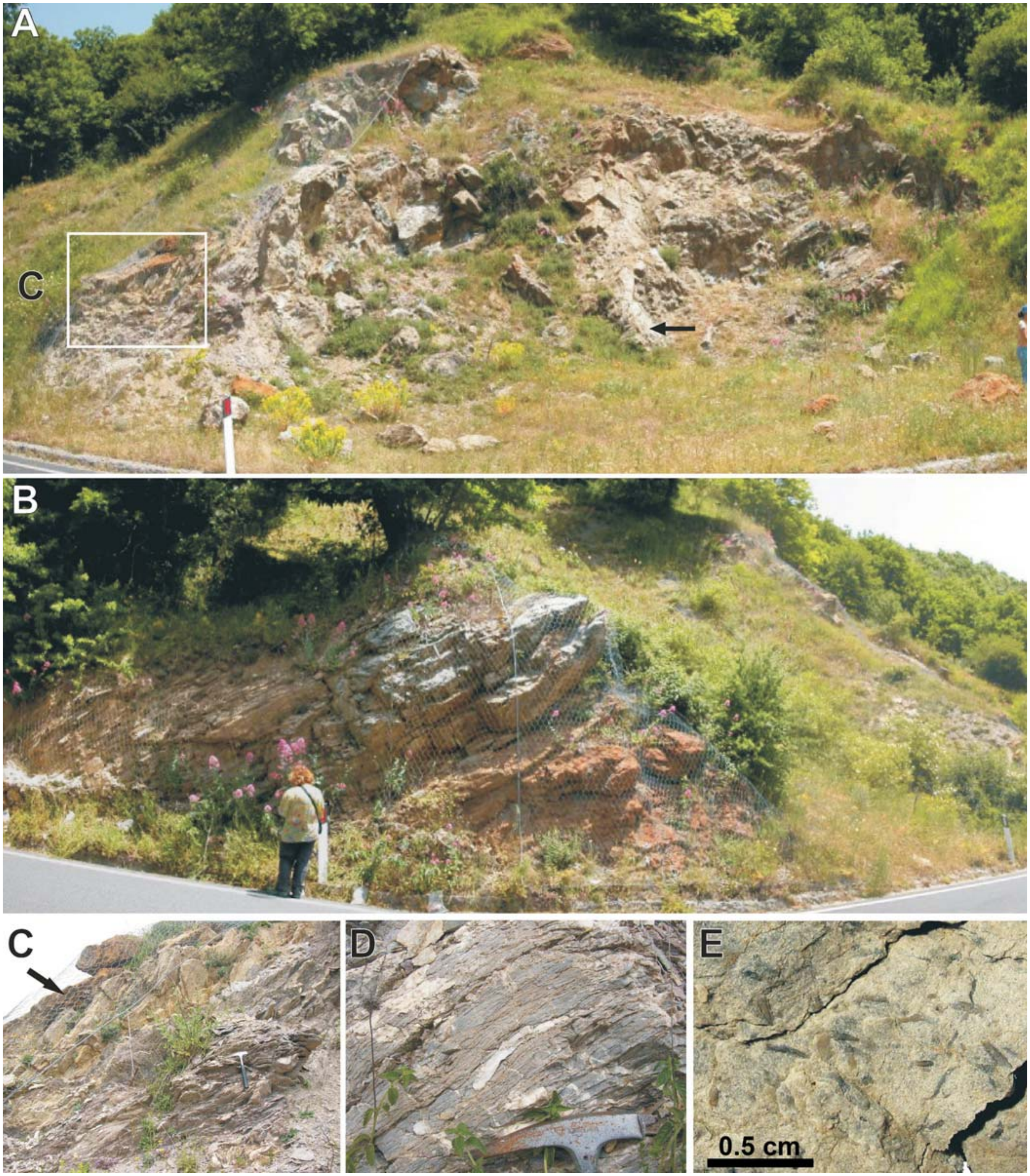
TEXT-FIGURE 16
Favoscuro east section (see location of the section in text-figures 6, 7).

zons, likely Silurian in age, near the top of the metabasite-bearing metapelites and immediately below Lower Devonian beds well dated by conodonts (Navas-Parejo et al. 2009a, 2009b). The dark pelites of the Lower Pizzo Leo Fm could also represent the deepest marine terrigenous counterparts of the Silurian graptolite-bearing black shales of the Carnic Alps (Schönlaub 1998; Schönlaub and Histon 1999; Piller et al. 2004; Ferretti 2005; Brett et al. 2009).

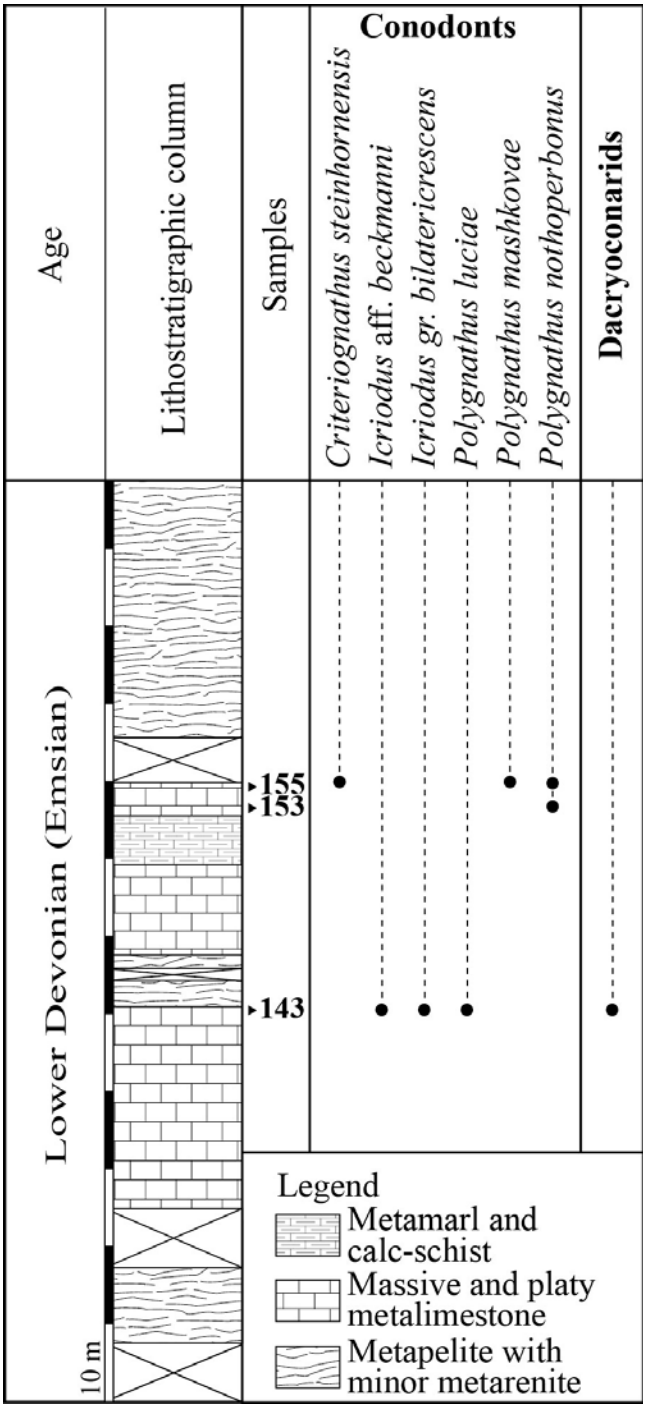
The basic metavolcanites hosted by pelites of the Lower Pizzo Leo Fm consist of submarine alkaline lava flows with pillow structures and volcano-clastic products. The alkaline metabasalts predominate over the pelitic rocks in wide areas of the LTU, especially in its westernmost outcrops (Caprileone village outcrop, text-figure 2A). Analogous metabasites or equivalent rocks (amphibolites) are also present in Peloritanian Fondachelli and Mandanici-Piraino Units and in the Calabrian Stilo Unit. Particularly, in the latter, the Paleozoic succession contains metabasites (green amphibolites of Pardalà), which, as in the LTU, invariably underlie well-dated Lower Devonian beds (de Capoa-Bonardi 1970; Bouillin et al. 1987; Navas-Parejo et al. 2009a and 2009b). Equivalent metabasites are also present in the Betic and Rifian chains, but their volume is much lesser than in the LTU (Chalouan 1986; Chalouan et al. 2008). Although the age of the main episode of alkaline volcanism in the LTU is not dated, we hypothesize that the age of the Upper Subunit metabasites is not younger than Ludlow-Lochkovian, given that: the alkaline volcanic rocks are overlain by limestones with Lochkovian conodonts (Upper Subunit, Pizzo Leo section; text-figure 20) of the Upper Pizzo Leo Formation (see below); the lenses of whitish nodular limestones directly overlying the volcanic rocks (Upper Subunit, Pizzo Leo section; text-figure 20) are probably equivalent to those that yielded Ludlow conodonts in the neighboring Favoscuro western section (text-figure 20); and the metabasites are associated with possible Silurian dark pelites. The hypothesis of a Silurian (Lower Devonian?) age for alkaline volcanism fits well also for the Mongiuffi Melia metabasites of the Middle Subunit, as these volcanites appear stratigraphically higher than the Upper Ordovician calc-alkaline rocks (text-figures 2C and 4A). However, new isotopic data from all the LTU metabasites themselves are needed to confirm this relative age dating.

Upper Pizzo Leo Formation

The Upper Pizzo Leo Formation (text-figure 20) represents the stratigraphically highest lithological unit recognized in this study. Up to 200m thick, it appears in the Upper Subunit, and is well exposed in the central sector of the LTU (Pizzo Leo area, type section). The base of the formation is represented mainly by grayish to beige thick-bedded metalimestones (Pizzo Leo section) that appear to evolve laterally to greenish and then to violet metamarls with lenses of whitish nodular metalimestones



TEXT-FIGURE 17
Favoscuro east section: field views of the limestones (locality: Randazzo-Floresta NR 116) (see location of photos in text-figure 16). A: Massive (right) to platy (left) metalimestones. B: Massive and iron-rich metalimestones, passing upwards to bedded metalimestones. C: Close-up of the area squared in A, corresponding to pinkish calc-schists in the transition zone from massive to well-bedded metalimestones. D: Deformed grayish metalimestones arrowed in A. E: Weathered surface of the marly metalimestone arrowed in C, rich in Emsian (Lower Devonian) dacryoconarids and conodonts (sample 143).



TEXT-FIGURE 18
Stratigraphic column of the Favoscuro east section showing Emsian conodonts and dacryoconarids.

(Favoscuro west section). The succession changes upwards to gray medium-bedded and platy limestones, pinkish to violet calc-schists, and varicolored metamarls, with greenish to violet pelite interbeds. The whitish nodular metalimestones at the base of the formation yielded Ludlow conodonts, whereas the overlying carbonates yielded Lochkovian to Emsian conodonts. This formation was deposited in pelagic marine environments.

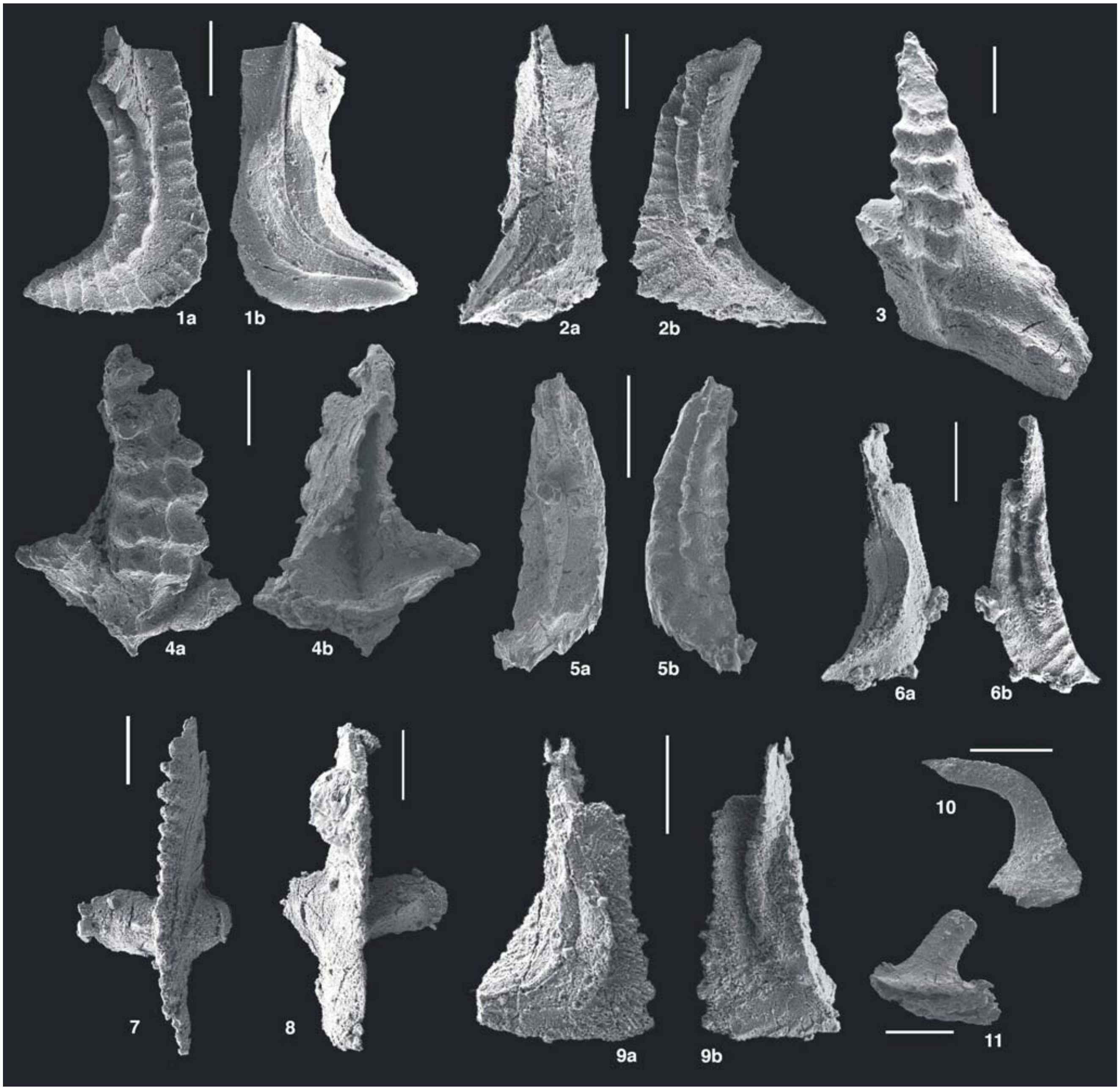
According to their stratigraphic position and lithofacies, the Ludlow nodular metalimestones present at the base of the Upper Pizzo Leo Fm are here considered to be possible equivalents to the uppermost Silurian carbonate lithofacies of the Carnic Alps (Schönlaub 1998; Schönlaub and Histon 1999) and of the Malaguide Complex (Martín-Algarra et al. 2004, 2009a, 2009b). In the Carnic Alps, the Silurian nautiloid-bearing, condensed, and nodular pelagic limestones are indicative of deep pelagic swells within the basin with reduced sedimentary rate. These Silurian condensed facies change laterally either to shallow marine bioclastic limestones interbedded with shales, or basinwards to graptolite-bearing black shales and cherts or to fine-grained siliciclastic turbidite successions (Schönlaub 1998; Schönlaub and Histon 1999; Piller et al. 2004; Ferretti 2005; Brett et al. 2009). This lateral transition from condensed, preferentially pelagic carbonate successions, to pelitic successions, has been interpreted as being due to the Pridoli transgression (Schönlaub and Histon 1999).

As concerns the Lochkovian to Emsian dacryoconarid- and conodont-bearing pelagic carbonates of the Upper Pizzo Leo Fm, they are certainly the corresponding facies to the Lower Devonian orthoceratid-, dacryoconarid-, and conodont-bearing pelagic carbonates found in the Stilo Unit (Navas-Parejo et al. 2009a). Nevertheless, with respect to the coeval facies of the Stilo Unit, the studied Lower Devonian limestones of the LTU are thinner and show facies associations poorer in fossils (a minor content in dacryoconarids and conodonts) and richer in terrigenous intercalations. In addition, the Devonian limestones of the Stilo Unit are frequently reddish, nodular, and condensed, and bear orthoceratids and isolated corals (Navas-Parejo et al. 2009b) not found in the LTU. The above-mentioned features indicate for the Stilo Unit a deep pelagic swell within a Devonian rift-related basin (Navas-Parejo et al. 2009b). Similar Devonian successions can also be found in the Carnic Alps (Schönlaub and Histon 1999; Piller et al. 2004) and in the Ghomaride and Malaguide Complexes around the Gibraltar Arc. Particularly, in this latter complex, local evidence of Devonian-Carboniferous carbonate platforms are also present as resedimented clasts (Martín-Algarra et al. 2004, 2009a, 2009b; Navas-Parejo 2012; Rodríguez-Cañero and Martín-Algarra 2013). Nevertheless, evidence of Devonian shallow marine limestones has not yet been recognized in any unit of the Calabria- Peloritani Arc.

Top unit

The LTU succession should continue upwards with radiolaria-bearing black siliceous facies (lydites) associated with pelites. These rocks were found only in scattered outcrops by previous authors (Bouillin et al. 1987). The deposition of these lydites, presumably lower Carboniferous in age, should fit well with the evolution found in many equivalent successions of other Alpine Mediterranean areas, such as in that of the Stilo Unit (Navas-Parejo et al. 2009a) or that of the Malaguide Complex (O'Dogherty et al. 2000; Martín-Algarra et al. 2004, 2009a, 2009b). The evolution from carbonate to siliceous facies points to deposition in a deep basin below the calcite compensation depth, and could indicate the maximum deepening of the Calabrian-Peloritanian and equivalent successions (Navas-Parejo 2012).

The LTU succession ends with immature siliciclastic facies like those found in the uppermost part of the successions studied in the Pizzo Leo area, which have been found only in scattered outcrops in other areas by previous Authors (Bouillin et al.



TEXT-FIGURE 19
Devonian conodonts of the Favoscuro east section. All scale bars are 200µm.

1–2 *Polygnathus luciae* Martínez-Pérez and Valenzuela-Ríos 2010, 1: P_1 element 07P-143-1, 1a: Upper view; 1b: Lower view. 2: P_1 element 07P-143-7, 2a: Lower view; 2b: Upper view.

3 *Icriodus* gr. *bilatericrescens* Ziegler 1956, P_1 element 07P-143-2 upper view.

4 *Icriodus* aff. *beckmanni* Ziegler 1956, P_1 element 07P-143-9, 4a: Upper view; 4b: Lower view.

5 *Polygnathus* cf. *nothoperbonus* Mawson 1987, P_1 element 07P- 153-1, 5a: Lower view; 5b: Upper view.

6 *Polygnathus nothoperbonus* Mawson 1987, P_1 element 07P-155-1, 6a: Lower view; 6b: Upper view.

7–8 *Critheriognathus steinhornensis* (Ziegler 1956), 7: P_1 element 07P-155-7; 8: P_1 element 07P-155-6.

9 *Polygnathus mashkovae* Bardashev 1986, P_1 element 07P-155-4, 9a: Lower view; 9b: Upper view.

10-11 *Icriodus* sp. 10: S_1 element 07P-143-12; 11: S_1 element 07P-143-17.

1987). These topmost sediments have been interpreted as equivalent to lower Carboniferous Culm-like deposits, analogous to those of the Malaguide Complex, but finer-grained (Martín-Algarra et al. 2004, 2009a, 2009b).

CONCLUDING REMARKS

The biostratigraphic and lithostratigraphic analyses performed in the Paleozoic succession of the Longi-Taormina Unit indicate the following (text-figure 20):

The Paleozoic succession can be subdivided, from base to top, into three formations: Castelmola Formation, Lower Pizzo Leo Formation, and Upper Pizzo Leo Formation. This lithostratigraphic nomenclature provides a new framework for future stratigraphic and paleogeographic research, both locally and regionally;

The age of the Castelmola Formation is currently ascribed to the Late Cambrian-Ordovician on the basis of acritarchs. The 456-452 Ma isotopic age (Trombetta et al. 2004) of the calc-alkaline volcanites present in the uppermost part of the formation allows the uppermost part of this formation to be ascribed to the Late Ordovician;

The age of the Lower Pizzo Leo Formation is presumably Silurian, the formation lying between Upper Ordovician volcanites at the base, and uppermost Silurian carbonates at the top;

The age of the Upper Pizzo Leo Formation ranges from the late Silurian to the Early Devonian on the basis of the conodonts studied. Particularly, the basal beds of the formation are attributed to the Ludlow on the basis of conodonts such as *Ancoradella* cf. *ploeckensis* and *Kockelella* cf. *variabilis*; the overlying beds are assigned to the Lochkovian (*delta* Zone) on the basis of *Icriodus woschmidti* and *Ancyrodelloides omustransitans*; and finally the middle-upper part of the formation is ascribed to the Emsian (from base to top: *kitabicus*, *excavatus*, and *nothoperbonus-inversus* zones) on the basis of *Icriodus* gr. *bilatericrescens*, *Icriodus* aff. *beckmanni*, *Polygnathus luciae*, *Critheriognathus steinhornensis*, *Polygnathus mashkovae*, *Polygnathus nothoperbonus, Pseudooneotodus beckmanni, Polygnathus excavatus excavatus*, *Polygnathus* cf. *nothoperbonus-inversus, Ozarkodina miae,* and *Polygnathus* cf. *kitabicus*;

The three aforementioned formations should be overlain by siliceous rocks (lydites), in turn topped by Culm-like siliciclastic rocks (both recognized only by previous authors), both probably Carboniferous in age;

Most of the Paleozoic succession of the Upper Subunit outcropping in the western sector (text-figure 2A) should presumably belong to the Lower Pizzo Leo Formation because of the abundance of alkaline volcanites;

The Paleozoic basin studied was the site of marine fine-grained siliciclastic sedimentation (Castelmola Fm and lower part of the Lower Pizzo Leo Fm) evolving upwards to pelagic siliciclastic-carbonate mixed facies (middle-upper part of the Lower Pizzo Leo Fm), followed by pelagic carbonates (Upper Pizzo Leo Fm). Particularly, the Lower Devonian beds of the Upper Pizzo Leo Fm with respect to the nearest coeval facies (Stilo Unit in southern Calabria) definitely point to more distal and deeper pelagic environments than those of the Stilo Unit;

As outlined above, the LTU reconstructed Paleozoic environmental evolution is similar to that of other better-known Paleozoic sequences around the western Mediterranean, as those of the Alps or Betic and Rifian chains.

ACKNOWLEDGMENTS

Financial support was provided by the Projects CGL2012-32169 (MCI-DGICYT) and P11-RNM-7067 (JA), by the RNM-208 and RNM-3715 research groups (Junta de Andalucia) and by the Messina University research project (2008-2009). P. Navas-Parejo is grateful for the grant BES-2006-13304 (MEC) for a research stage in Messina University (2009). C. Martínez-Pérez benefits from a postdoctoral Marie Curie contract. We wish to thank two anonymous reviewers and the Editor-in-Chief John A. Van Couvering for their suggestions, which contributed to improve the paper. The critical reading by Hans-Juergen Gursky, Graciela Sarmiento, and Hans-Georg Herbig of a preliminary version of this manuscript is also appreciated.

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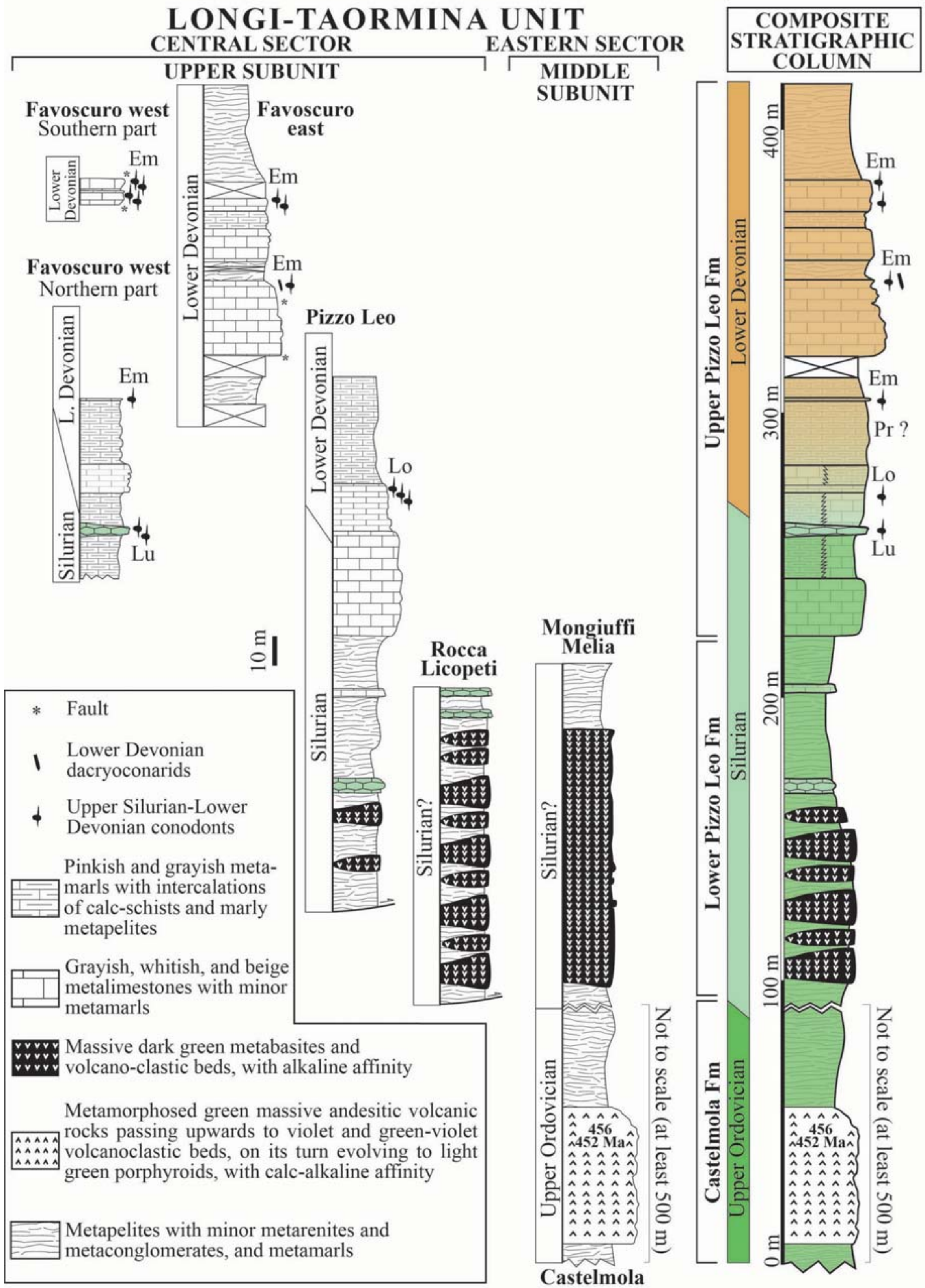

TEXT-FIGURE 20
Stratigraphic correlation panel of the LTU Paleozoic succession. On the right, the synthetic composite stratigraphic column. It is based both on bibliographic data related to the Castelmola, Rocca Licopeti, and Mongiuffi Melia outcrops (Majesté-Menjoulas et al. 1986; Cirrincione et al. 1999; Guerrera et al. 1999; Trombetta et al. 2004) and on present research. Abbreviations are: Lu: Ludlow; Lo: Lochkovian; Pr: Pragian; Em: Emsian.

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Received April 11, 2013
Accepted July 29, 2013
Published October 25, 2013