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Pre-congress field trip of the Paleo4Alps Congress,
Bolzano - July 19-23, 2026

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The Palaeozoic of the Carnic Alps (Italy-Austria)

Pre-congress field trip of the Paleo4Alps Congress, Bolzano - July 19-23, 2026

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Cover page figure: Panoramic view of the Cason di Lanza Pass area from the summit of Mount Pizzul. The rocks in the foreground belong to the Pre-Variscan sequence; the white cliffs of Mount Zuc della Guardia are Middle Devonian reef limestones. The mountains in the background consist of sediments from the Permo-Carboniferous sequence.

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ABSTRACT

The Carnic Alps are a segment of the Southern Alps located along the border between north-eastern Italy and Austria. One of the world's most studied Palaeozoic sequences is exposed here. It is divided into three parts: the Pre-Variscan sequence, which consists of rocks deposited between the latest Proterozoic and the Early Pennsylvanian, followed by the Permo-Carboniferous sequence (Upper Pennsylvanian to Cisuralian), and then by the lower part of the Alpine sequence (Guadalupian and younger rocks). Though affected by strong orogeneses, these sequences still preserve continuous and non-metamorphosed stratigraphy. The depositional settings range from shallow water to open marine environments.
The field trip is organised as a pre-congress excursion of the PALEO4ALPS – Joint Meeting of the Austrian, German, Italian, and Swiss Paleontological Societies (Bolzano, July 19-23, 2026) and includes three days of visits to various localities in the central sector of the Carnic Alps, focusing on different aspects of stratigraphy and palaeontology of the area. Stops at the visitor centres of the Transborder Carnic Alps Geopark are also scheduled.

Keywords: stratigraphy, tectonics, palaeontology, Palaeozoic, Perigondwana.

PROGRAM SUMMARY

The field trip spans three days, showcasing much of the geology and stratigraphy of the Pre-Variscan sequence of the Carnic Alps (Fig. 1). Most of the localities visited are accessible along roads, with a few requiring short hikes on well-traced paths. In addition to visiting sections and outcrops, geological overviews will also be provided.
The first day focuses on the Mt Zermula area, with several scheduled stops along the road and visits to sections that can be reached after short walks. Participants will explore rocks ranging from the Late Ordovician to the Pennsylvanian, including sections exposing Ordovician and Lower Devonian rocks, the Frasnian-Famennian and the Devonian-Carboniferous boundaries, a classic outcrop of the back reef "*Amphipora* limestone" (Spinotti Formation), and a renowned locality for Carboniferous plants.
The second day is dedicated to two areas: around Passo di Monte Croce Carnico/Plöckenpass and near Casera Pramosio. Starting from the parking at the Italian/Austrian border (1360 m) at Passo di Monte Croce Carnico, a short walk along path 427-3 will lead to the famous Cellon section (1550 m), reference for many Silurian studies worldwide. We will then move to the Italian side of the pass to observe the Upper Devonian and lowermost Carboniferous limestones of the Pal Grande Formation ("Clymeniae limestones"). At Malga Pramosio, we will visit a section featuring the "Annulata Event".
The third day will focus on localities in the Gail Valley: a classical section of the lower Silurian graptolitic shales, and a scenic outcrop where Permian plant trunks are preserved.
Before departing for Bolzano, a stop at the visitor centre of the Carnic Alps in Dellach is scheduled.

SAFETY

The field trip takes place mostly along roads, occasionally unpaved. Some localities are reached by hiking on well-defined paths through rugged mountain terrains. The maximum altitude is around 1650 m. Therefore, adequate technical personal equipment is required. Water can be found along the itinerary, but it is recommended to bring at least one litre of water. In some of the areas visited on the first day, there is no telephone coverage.
The best seasons for the visit are late spring to early fall. However, mountain huts in the Passo del Cason di Lanza area (day 1) and Malga Pramosio (day 2) are open only from June to September.

EMERGENCY PHONE NUMBERS

Mountain Rescue (Italy) - 112
Mountain Rescue (Austria) - 140

HOSPITALS

Italy - via Giobatta Morgagni 18-20, Tolmezzo. Ph. +39 0433 4881.
Austria - Laas 39, 9640 Kötschach-Mauthen. Ph. +43 4715 7701.

ACCOMMODATION

There are several hotels, B&Bs, etc. in the villages in the Carnic Alps. According to the field trip programme, it is suggested booking an accommodation in Sutrio, Paluzza, Timau (Italy) or Kötschach-Mauthen (Austria).

PLACES OF INTEREST

Geoparco delle Alpi Carniche/Karnische Alpen Geopark
Italy - https://www.geoparcoalpicarniche.org/it/
Tel: +39 0433 487726; e-mail: info@geoparcoalpicarniche.org
Visitor centre: Laghetti di Timau locality, 33026 Paluzza (UD)
Austria - Gail 65, A-9635 Dellach. http://www.geopark-karnische-alpen.at
Tel: +43 (0) 4718 / 301- 17, e-mail: office@geopark-karnische-alpen.at
Visitor centre: Gail 65, A-9635 Dellach

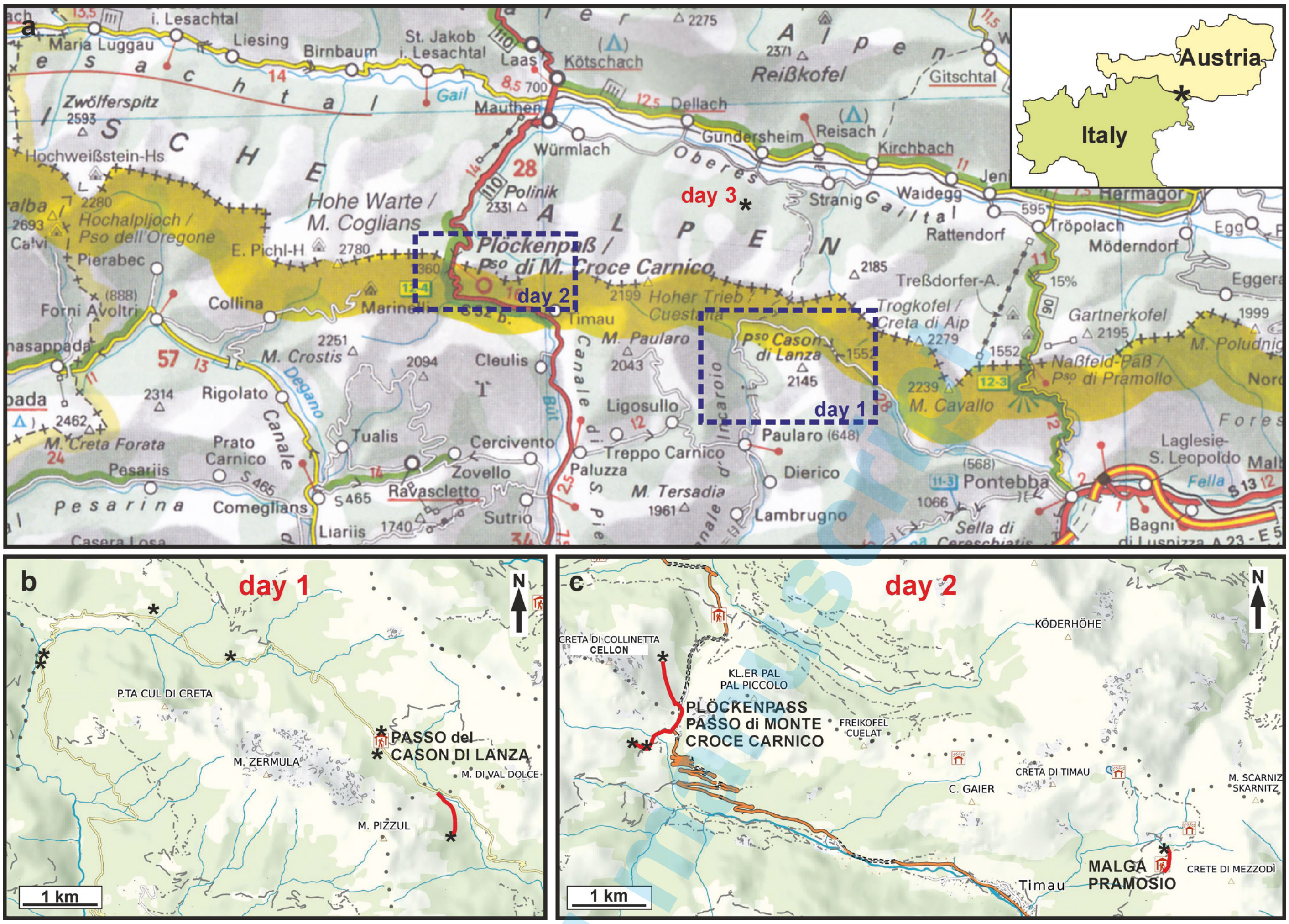

Fig. 1 - Itinerary of the field trip. a) Road map of the Carnic Alps with indication of the areas visited. b-c) Maps of the areas of Passo di Monte Croce Carnico (b) and Mt Zermula, with indication of the hiking itineraries (red lines) and stops (asterisks). For detailed maps of the three excursion days see figs. 9, 24 and 41, respectively.

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INTRODUCTION

Rocks deposited between the latest Proterozoic and the Late Triassic are exposed in the Carnic Alps, representing one of the most complete and studied Palaeozoic successions in the world. These rocks are subdivided into three sequences: the Pre-Variscan, the Permo-Carboniferous, and the Alpine sequences. The Pre-Variscan sequence includes rocks up to Early Pennsylvanian age, which were affected by the Variscan orogeny during the late Bashkirian and Moscovian (Schönlaub, 1980; Venturini, 1990; Schönlaub and Forke, 2007; Pasquarè Mariotto and Venturini, 2019). The Permo-Carboniferous sequence spans from the Middle Pennsylvanian to the Cisuralian. The youngest Palaeozoic rocks of the area represent the lower part of the so-called 'Alpine' sequence, referred to as the Permo-Triassic sequence by Venturini (1990), which began to be deposited in the Guadalupian.

The Pre-Variscan sequence is part of the Variscan ancient core of the Eastern Alps in the Southalpine domain and extends as a narrow strip for over 100 km in a W-E direction, with a N-S width that rarely exceeds 15 km (Fig. 2). To the north, it is bordered by the Gailtail Line, part of the Periadriatic Lineament, which separates the Southalpine domain from the Austroalpine domain. To the south, it is unconformably covered by upper Palaeozoic and Triassic successions (Venturini and Spalletta, 1998; Schönlaub and Forke, 2007). The entire area can be subdivided into two parts (Fig. 2), separated by the Val Bordaglia thrust (Brime et al., 2008), a prominent NE-SW trending fault: the eastern zone primarily consists of non- to low-metamorphic sedimentary successions, while the western zone is made of greenschist facies metamorphic rocks (Schönlaub, 1980, 1985, 1997; Venturini and Spalletta, 1998; Brime et al., 2008).

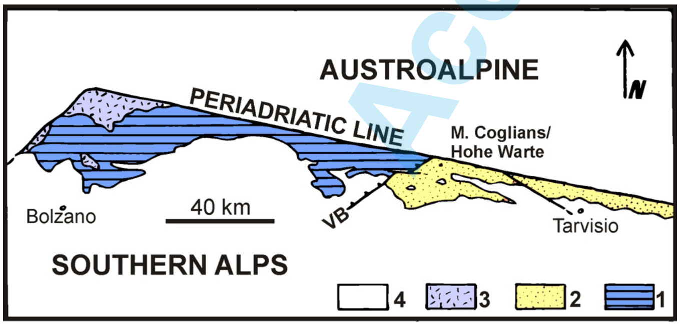

Fig. 2 - Simplified geological map of the Southern Alps showing the partition of the Palaeocarnic Chain into a West and an East Zone (after Venturini and Spalletta, 1998, modified). VB: Val Bordaglia thrust; 1: low to middle grade metamorphic basement; 2: non- to anchi-metamorphic units; 3: Variscan intrusive bodies; 4: post-Palaeozoic units.

PALAEOGEOGRAPHIC OVERVIEW

During the early Palaeozoic, the Carnic Alps were part of a group of terrains known as the Galatian terrane assemblage (Von Raumer and Stampfli, 2008). These terrains detached from the northern Gondwana margin during the Ordovician and moved northward at a faster rate than the main continent (Fig. 3). The relative positions of these terrains, which include - among others - the Prague Synform, Sardinia, and the Montagne Noire, remain unclear.

The drift from about 50°S in the Late Ordovician to 35°S in the Silurian, eventually reaching the tropical belt in the Devonian (Schönlaub, 1992), is reflected in distinct differences in litho- and biofacies along the Carnic Alps.

TECTONIC OVERVIEW

The Carnic Alps underwent either compressional or extensional deformational events during the Variscan and Alpine orogenies, resulting in a complex structural framework that includes low metamorphic terrains of Variscan age (Fig. 4) (Brime et al., 2008; Bartel et al., 2014). According to Venturini (1990), Variscan compression generated top-to-the-south thrusts and folds trending approximately N120°E. The first Alpine compressional phase, which occurred during the Chattian–Burdigalian age, was coaxial with the Variscan deformation, leading to the reactivation of pre-existing structures and an additional increase in their total shortening (Venturini, 1990). The two subsequent Alpine tectonic phases (Tortonian–Serravallian and Plio–Pleistocene) were characterised by a predominantly strike-slip stress regime, locally associated with compressional and extensional components (Venturini, 1990). These later phases played a major role in the development of kilometre-scale vertical folds along the Gailtal and Bordaglia lines, while in the rest of the Carnic Alps, they mainly disrupted the pre-existing structural assemblage through the formation of high-angle strike-slip faults.

THE PRE-VARISCAN SEQUENCE

The oldest rocks of the Carnic Alps that were affected by the Variscan orogeny during the late Bashkirian and Moscovian (Venturini, 1990; Schönlaub and Forke, 2007) constitute the so-called Pre-Variscan sequence. The revised lithostratigraphic scheme of this sequence includes 36 formations (Corradini and Suttner, 2015) and is here updated according to more recent results (Fig. 5).

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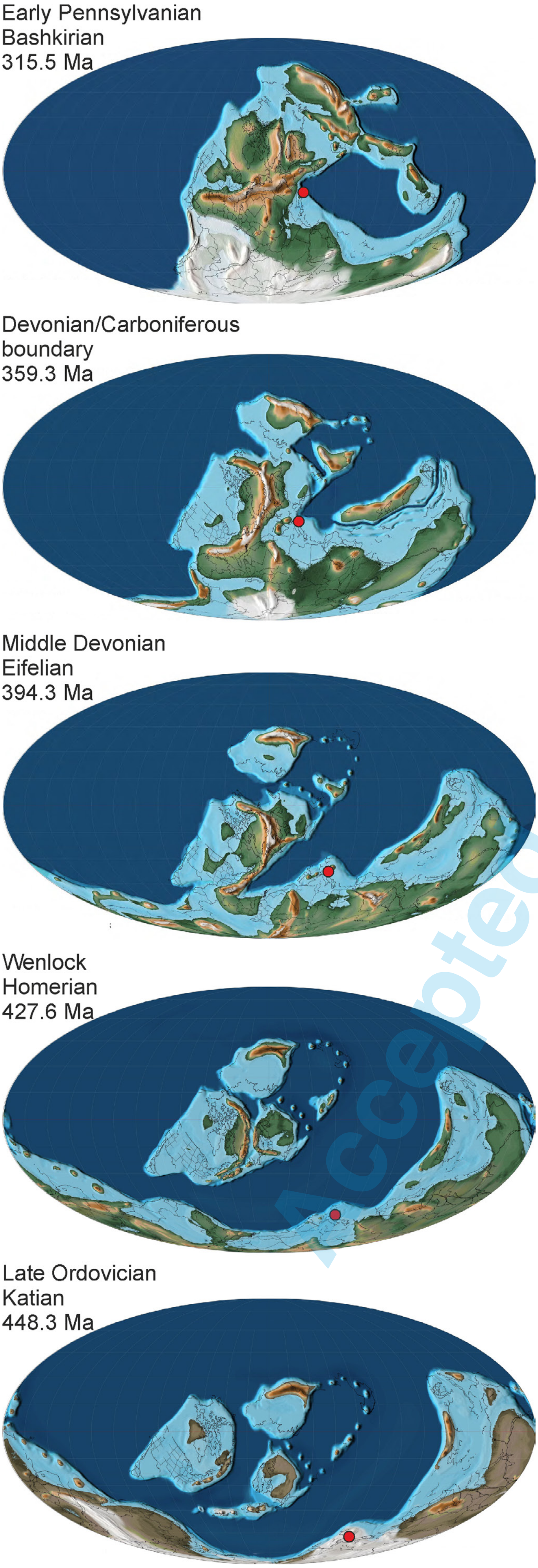

The oldest terms of the Pre Variscan sequence are exposed west of the Val Bordaglia Line. The oldest unit is represented by phyllitic schists and quartzites, along with subordinate conglomeratic layers of the lower unit of the Val Visdende Formation. The age of this unit was for a long time tentatively considered as Middle Ordovician, based on the overlying units, but recent studies attributed it to the Ediacaran on the basis of U/Pb radiometric age on zircons (Siegesmund et al., 2018; Ackerman et al., 2026). The Val Visdende Formation is followed, probably after an unconformable contact, by porphyroids (Comelico Formation) and volcanoclastic sediments (Fleons Formation) of Late Ordovician age.

Except for rare fossil occurrences in the Fleons Formation, the oldest fossiliferous rocks of the Carnic Alps belong to the Valbertad Formation (Katian). This unit consists of up to 100 m of shallow-water pelites, sandstones, and rare conglomerates deposited at medium-high southern latitudes. Fossils, mainly brachiopods, bryozoans, echinoderms, gastropods, and trilobites, are abundant. In the central part of the Carnic Alps, a coarser-grained sandstone unit (Himmelberg Formation) crops out. The basal clastic sequence is followed by an encrinitic limestone (Wolayer Formation) in the central part of the chain, and by the coeval slightly-deeper-water limestones of the Uqua Formation. Both these units are late Katian in age, although an extension to the basal Hirnantian cannot be excluded. The global glacially induced regression of the Hirnantian is documented by the calcareous sandstone of the Plöcken Formation, which provides evidence of the HICE $\delta^{13}C$ excursion (Schönlaub et al., 2011; Ferretti et al., 2023). This resulted in erosion and local non-deposition, as also indicated by Silurian strata resting disconformably above the Upper Ordovician sequence (Schönlaub and Histon, 1999; Brett et al., 2009; Hammarlund et al., 2012; Pondrelli et al., 2015; Corriga et al., 2021).

Silurian rocks vary from shallow water bioclastic limestones to nautiloid-bearing limestones, interbedded shales and limestones to outer-shelf or basinal black graptolitic shales and cherts ("lydites"). The overall thickness does not exceed 60 m. The Silurian transgression started at the base of the Llandovery, and, due to the disconformity separating Ordovician and Silurian strata, a hiatus extending at place up to the Ludlow is documented. For a summary, refer to Corriga et al. (2021).

Three calcareous units are distinguished vertically in the proximal parts of the basin: the Kok Formation (Telychian-lower Ludfordian), the Cardiola Formation (Ludfordian), and the Alticola Formation (upper Ludfordian-basal Lochkovian). These units correspond mostly to the

Fig. 3 - Palaeogeographic position of the Carnic Alps (red circle) from the Ordovician to the lower Carboniferous (maps after Scotese, 2014 a, b, c modified).

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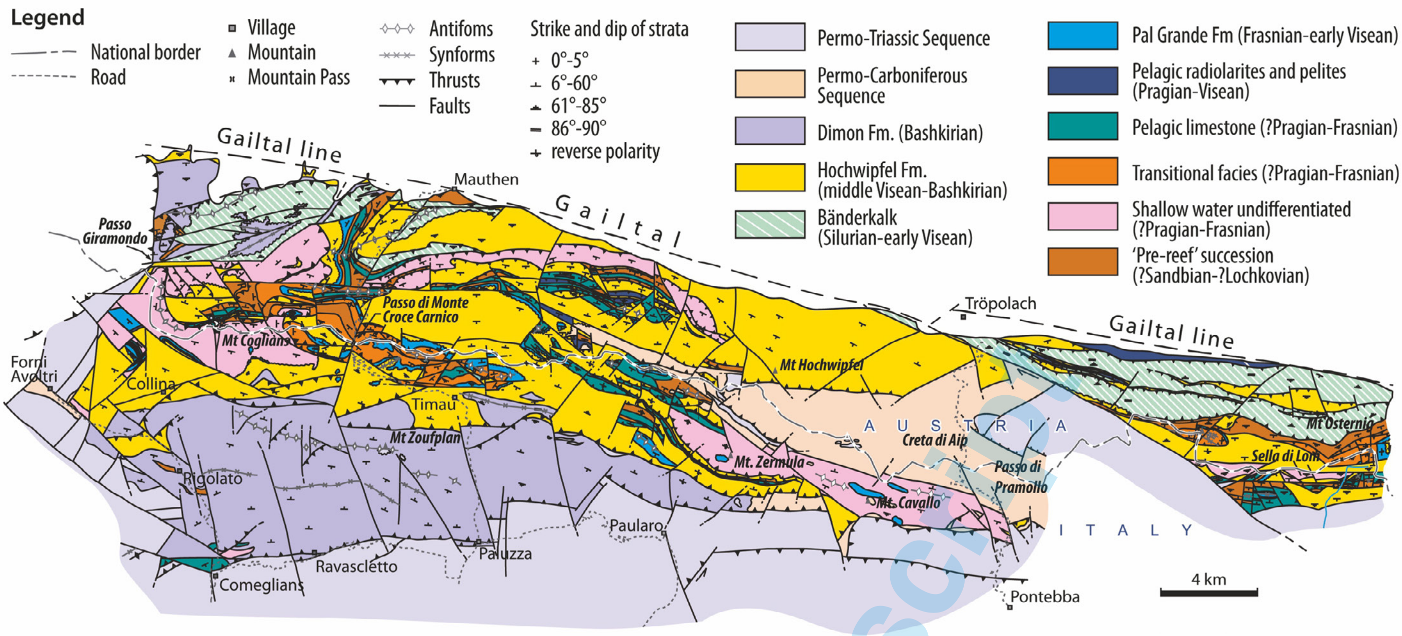

Fig. 4 - Sketch of the geology of the Carnic Alps (after Brime et al., 2008, simplified).

"*Orthoceras* limestones" described by earlier authors, and consist of bioclastic wackestones and packstones. Fossils, mainly orthoconic cephalopods, are abundant; numerous studies document the presence of conodonts, crinoids, trilobites, bivalves, gastropods, ostracods, brachiopods, chitinozoans, and acritarchs, among others (Brett et al., 2009; Corradini et al., 2010, 2015a; Histon, 2012; Ferretti et al., 2025; Corradini et al., 2026). Locally, the abundant ferruginous content in the Kok Formation generated exceptionally well-preserved coatings of fossils (Ferretti, 2005; Ferretti et al., 2025). In the deeper part of the basin, the Bischofalm Formation, consisting of black graptolitic shales with chert interbedded in places, was deposited. Graptolites are generally abundant (Jaeger, 1975; Jaeger and Schönlaub, 1977, 1994; Schönlaub, 1997). Intermediate sedimentary conditions between calcareous and shaley facies are represented by the Nölbling Formation, composed of alternating black graptolitic shales, marls, and limestone beds (Jaeger and Schönlaub, 1980; Schönlaub, 1997; Štorch and Schönlaub, 2012).

During the Lochkovian (Early Devonian) in the Carnic basin the calcareous part of the succession began to differentiate more distinctly (Kreutzer, 1990, 1992; Schönlaub, 1992; Kreutzer et al., 1997; Suttner, 2007; Corriga et al., 2012, Corradini et al., 2019). The Seekopf Formation was deposited in moderately shallow water, and the Rauchkofel and La Valute formations on the outer platform. In the deeper parts of the basin, the Nölbling and the Bischofalm formations continued their deposition up to the middle Lochkovian (*M. hercynicus* graptolite Zone). Eustatic variations at the Lochkovian/Pragian boundary generated an evident disconformity between the Rauchkofel and the Kellerwand formations, along with a hiatus estimated to last up to 2 Ma around the stage boundary (Pondrelli et al., 2020; Corradini et al., 2024).

Starting from the Pragian, the differences within the sedimentary basin increased and, over short distances, a strongly varying facies pattern developed, indicating highly diverse depths in the basin (Fig. 6). Between the Pragian and the early Frasnian, more than 1000 m of reef and near-reef limestones (Hohe Warte, Seewarte, Lambertenghi, Spinotti, and Kellergrat formations) and various intertidal lagoonal deposits (Polinik Formation) are time equivalent to less than 100 m of pelagic limestones (Findenig and Valentin formations). In the intermediate fore-reef areas, thick piles of mainly gravity-driven deposits accumulated (Kellerwand, Vinz, Cellon, and Freikofel formations); the thickness of these units decreases from west to east in the central sector of the Carnic Alps, according to the distance from the main source area (Pondrelli et al., 2020). In the deeper part of the basin, pelites and cherts of the Zollner Formation were deposited. Between the fore-reef and the deeper part of the basin, gravity-driven deposits alternated with pelagic limestone and black shales (Hoher Trieb Formation)

Reefs reached their maximum extension during the Givetian and early Frasnian, when the present Carnic Alps were at a latitude of about 30° S (Fig. 3; Schönlaub, 1992). Three major reef areas developed, now represented by the cliffs of Mt Coglians/Hohe Warte, Mt Zermula, and Mt Cavallo/Roßkofel, beside several minor buildups in the eastern sector of the Carnic Alps (Mt Sagran, Mt Gozman, Mt Capin di Ponente).

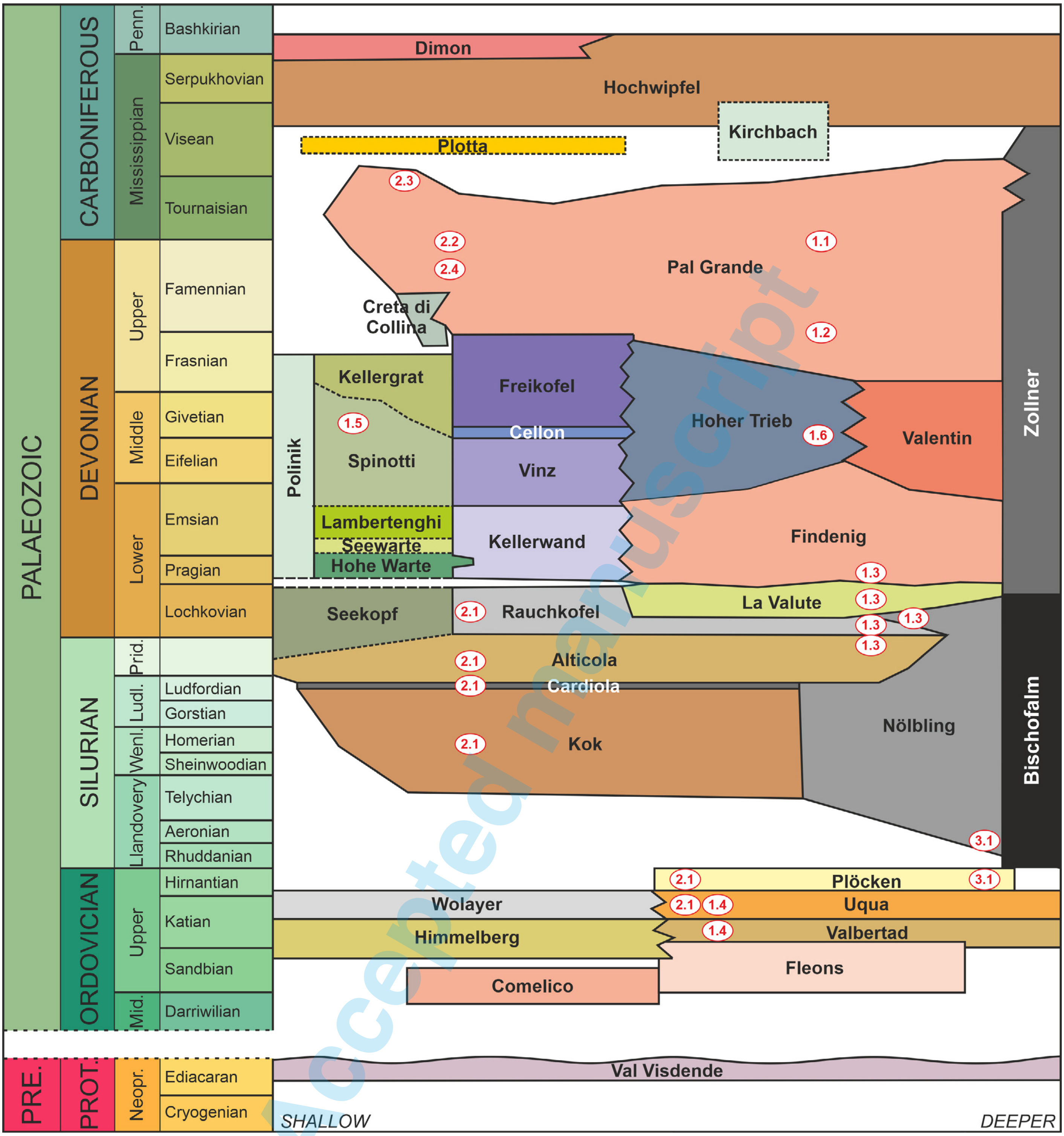

Fig. 5 - Lithostratigraphic scheme of the Pre-Variscan sequence of the Carnic Alps (after Corradini et al, 2015b, modified). Red numbers indicate the stops where the formations will be observed.

The fossil content (Fig. 7) is always very abundant: tabulate and rugose corals, stromatoporoids, crinoids, brachiopods, gastropods, bivalves, ostracods, cephalopods, trilobites, algae, calcispheres, and foraminifers (Kreutzer, 1990, 1992; Rantitsch, 1992; Schönlaub, 1992; Kreutzer et al., 1997; Corradini et al., 2019).

Beginning in the early Frasnian, a combination of local tectonic movements and global sea-level variations led to the disappearance of the reefs (Corradini and Pondrelli, 2021). In a small area southwest of Passo di Monte Croce Carnico, dark limestones rich in brachiopods were deposited above the reefal units during the late Frasnian and early Famennian

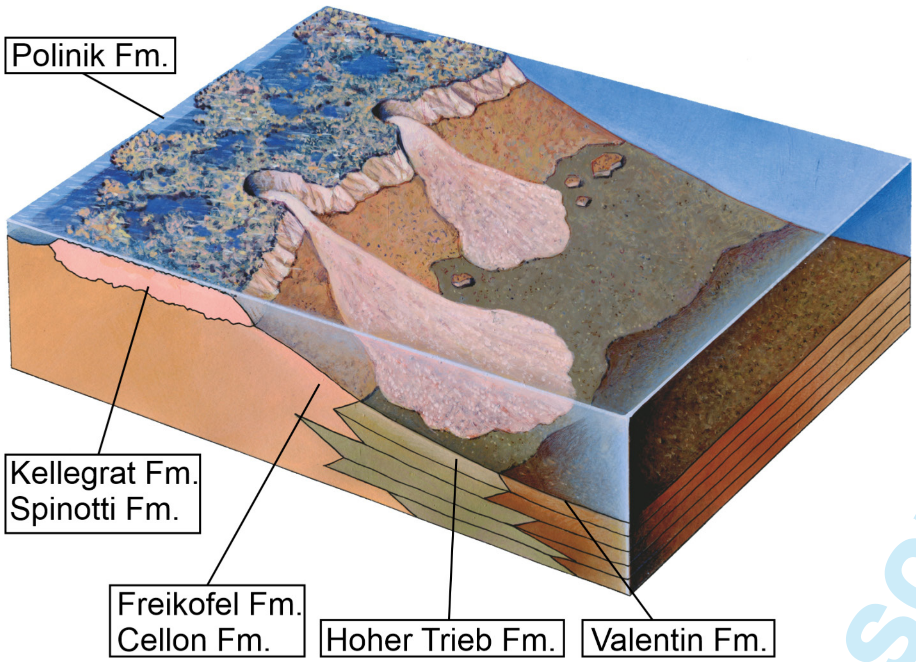

Fig. 6 - Block diagram of the depositional settings of the Givetian of the Carnic Alps.

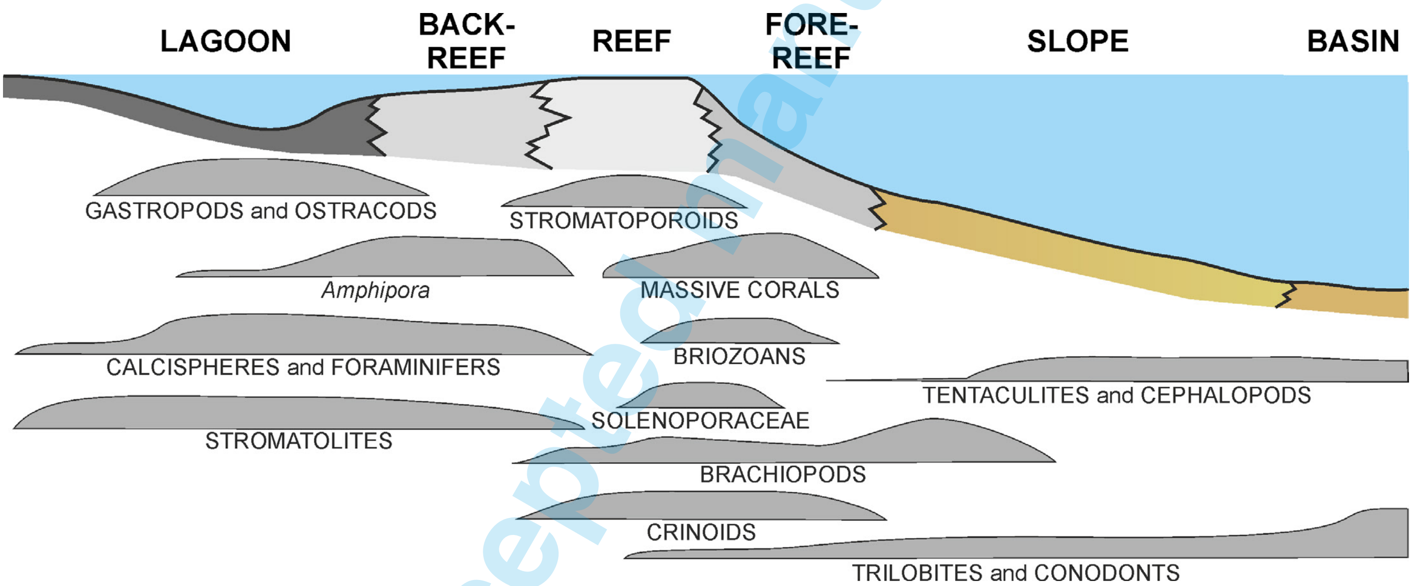

Fig. 7 - The distribution of main fossil groups in the Devonian of the Carnic Alps (after Vai, 1998, modified).

(Creta di Collina Formation). At the same time, in the other parts of the basin, a uniform pelagic environment developed, which continued up to the early Visean (Schönlaub, 1969; Schönlaub and Kreutzer, 1993; Perri and Spalletta, 1998a; Corradini et al., 2017, 2025): the Pal Grande Formation is represented by a greyish, pinkish, reddish wackestone with cephalopods. Sea level drops are documented up to the lower Visean, generating palaeokarstic events in the early Mississippian (Corradini et al., 2017, 2025). At places, cherty sediments (Plotta Formation) unconformably capped the Pal Grande Formation (Schönlaub et al., 1991; Pondrelli et al., 2015).

Starting in the late Visean, up to 1000 m of arenaceous-pelitic turbidites of the Hochwipfel Formation were deposited. This unit is interpreted as a Variscan flysch sequence (Vai, 1963; Amerom et al., 1984; Spalletta and Venturini, 1988, and references therein) and consists of quartz sandstones and greyish shales, with intercalations of mudstones, chaotic debris flow deposits, and chert and limestone breccias. Locally, plant remains are present and rare trace fossils can be found (Amerom et al., 1984; Amerom and Schönlaub, 1992). Short local episodes of carbonate deposition from the late Visean to the earliest Serpukhovian are represented by the Kirchbach Formation. In the upper part of the

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Mississippian, basic volcanites and volcanoclastic sediments (Dimon Formation) were deposited and are widely exposed on the Italian side of the central part of the chain. They are related to crustal thinning associated with a rifting episode (Vai, 1976; Rossi and Vai, 1986; Läufer et al., 1993, 2001). These conditions continued up to the late Bashkirian (Pennsylvanian), when the Variscan orogeny in the Carnic area marked the end of the deposition of the Pre-Variscan sequence (Venturini, 1991).

THE VARISCAN OROGENY AND THE POST VARISCAN ROCKS

The Variscan orogeny reached its climax during the Moscovian and affected the Pre-Variscan sequence, producing different systems of asymmetric folds, faults and thrusts distributed along a N 120°-140°E direction trend (Venturini, 1990).

The uplift of the Palaeocarnic chain generated an erosional-depositional sedimentary hiatus. In places (Tarvisio, Pramollo and Forni Avoltri sectors) this gap lasted until the latest Moscovian, when, due to the subsidence related to a strike-slip tectonic system, the Permo-Carboniferous Sequence was deposited disconformably on top of the Pre-Variscan Sequence. The Permo-Carboniferous sequence consists of alternating cycles of fluvio-deltaic and marine deposits, generated by frequent eustatic sea level changes due to the Permo-Carboniferous glaciation. Different lithostratigraphic schemes (Fig. 8), generally similar, have been established by Italian (Venturini, 1990) and Austrian authors (Forke et al., 2006; Schönlaub and Forke, 2007).

The sequence starts with basal breccias and conglomerates, resulting from the erosion of the Palaeocarnic Chain. These basal conglomerates were attributed by Venturini (1990) to the Bombaso Formation and are overlaid by sediments subjected to frequent transgressive-regressive cycles, with alternating fluvio-deltaic clastic sediments and calcareous shallow water deposits. Different authors discriminate five formations belonging to the Pramollo Group (Venturini, 1990), or several members within the Auernig Formation (Forke et al., 2006; Schönlaub and Forke, 2007).

Calcareous facies are dominant across the Carboniferous-Permian boundary and in the lower Cisuralian. The three formations (Schulterkofel, Val Dolce, and Zweikofel formations), grouped by Venturini (1990) in the Rattendorf Group, indicate a general transgression with more stable marine conditions. The transgressive trend continues up to the late Artinskian and ends with the Trogkofel Group (Venturini, 1990) (Trogkofel Formation - Forke et al., 2006), characterised by reefs up to 400 metres thick.

Within the middle Permian, a transpressional tectonic phase causes extensive emersion and karstification. In the late Permian, an extensional phase started, controlling the deposition of a sequence of continental ruditic deposits (Tarvisio Breccia), followed by marine to terrigenous deposits (Val Gardena Sandstones), and finally evaporitic, lagoonal, and shallow marine sediments (*Bellerophon* Formation). This Permo-Triassic sequence was deposited in an environment characterised by alluvial fans at the base (Tarvisio Breccia and Sesto Conglomerate), which evolved into alluvial plains with irregular braided rivers that deposited a thick sequence of pelites and sandstones (Val Gardena Sandstones). The *Bellerophon* Formation, marking the end of the Palaeozoic in the Carnic Alps, is characterised by gypsum, graywackes, and evaporitic dolostone in the lower part of the succession, and by dolostone and black limestone in the upper part.

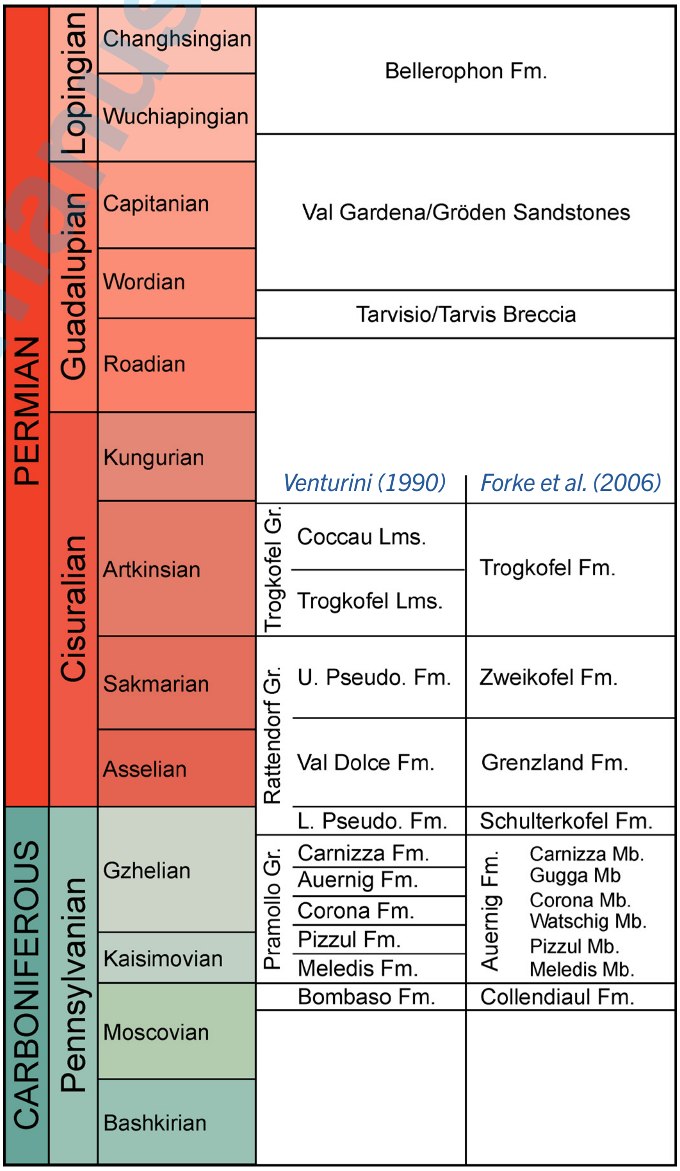

Fig. 8 - Lithostratigraphic scheme of the Permo-Carboniferous sequence of the Carnic Alps.

DAY 1

The first excursion day is devoted to the area of Mt Zermula. Seven stops are scheduled along the road connecting Paularo to Passo di Monte Croce Carnico and Pontebba, or are reached through short walks (Fig. 9). Rocks from the Katian to the latest Permian are exposed in the area (Fig. 10). Of the seven stops planned in the area, six are dedicated to different units of the Pre-Variscan sequence, and the last one to the basal part of the Permo-Carboniferous sequence.

Mount Zermula represents one of the three main Devonian shallow water platforms of the Carnic Alps. However, the whole area was overturned during the Variscan orogeny. The thrusts and folds present in this area show a constant top-to-the-south vergence (Venturini, 1990). The higher parts of Mt Zermula represent Devonian reefal rocks thrusted on top by an Upper Ordovician to lower Carboniferous succession showing mostly basin to slope depositional environments. The NW-SE trending structures were later reactivated during Alpine times as compressive structures during the Tortonian-Serravallian phase and as dextral strike slip during the Plio-Pleistocene phase (Venturini, 1990). At Cason di Lanza Pass, this phase is expressed by the N120°E trending dextral strike-slip "Cason di Lanza" line, inherited from a syn-sedimentary Permo-Carboniferous fault, which offset the Variscan multi-kilometric anticline, placing in contact the Variscan sequence to the south and the Permo-Carboniferous sequence to the north (Venturini, 1990).

For recent geological overviews on the area visited today, refer to Corradini et al. (2012, 2016, 2020b, 2023b), Pondrelli et al. (2015) and Corradini and Pondrelli (2021).

Stop 1.1 - The Devonian/Carboniferous boundary in the Plan di Zermula A (PZA) section

Coordinates: 46°34'22.8" N, 13°06'43.5" E. Altitude 1010 m

The Plan di Zermula A (PZA) section is located along the road connecting Paularo to Passo del Cason di Lanza, on the south side of the steep cliff above the Rio Chiarsò canyon. Parking spots are available just before the section. The Plan di Zermula A (PZA) section (Fig. 11) is one of the four sections in the Carnic Alps where the Devonian/Carboniferous boundary is exposed (Spalletta et al., 2021). It is a short, overturned section, located along the limb of one of the minor parasitic folds along the macro, pluri-kilometric, asymmetric fold constituting the Mt Zermula massif (Venturini, 1991).

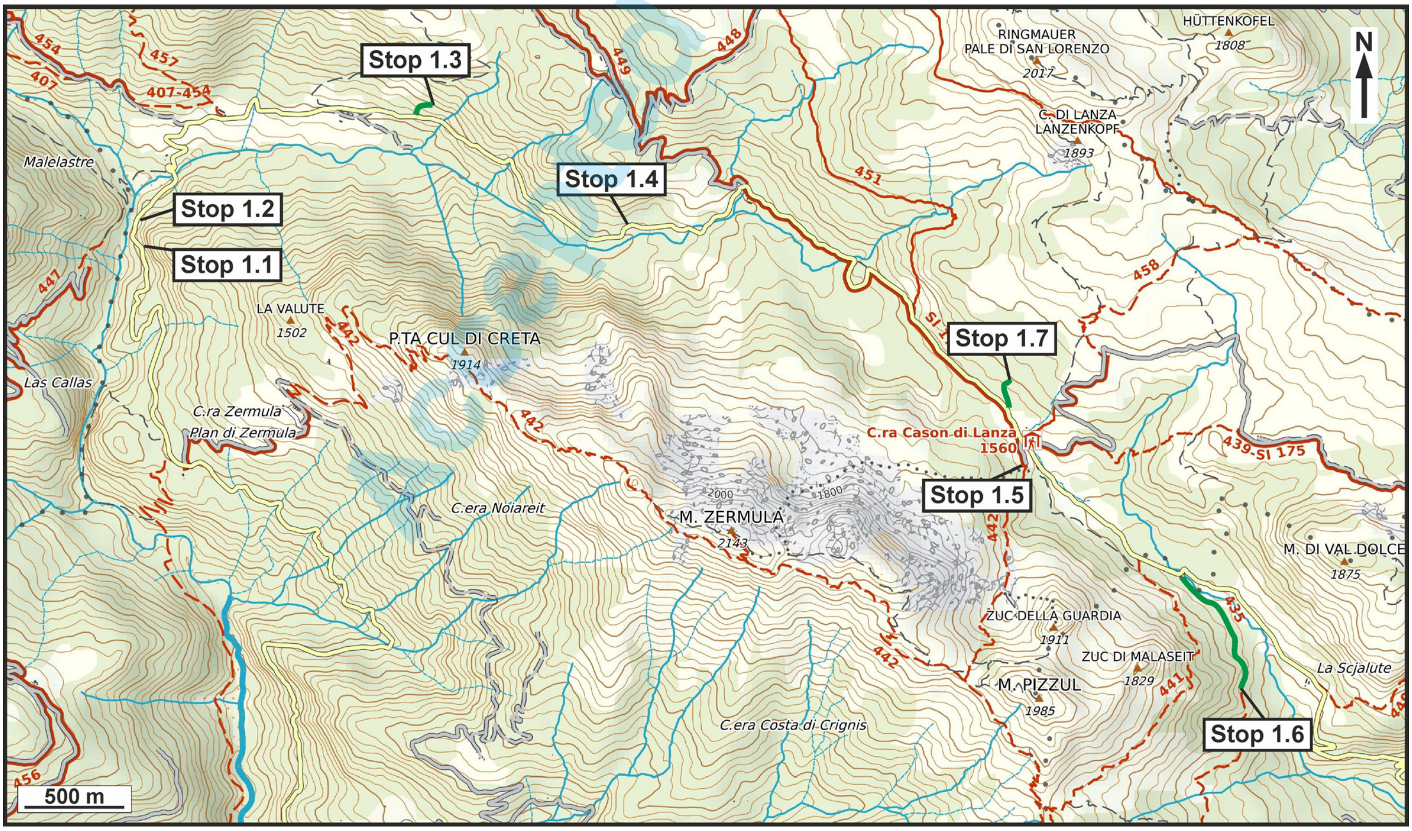

Fig. 9 - Topographic map of the itinerary of day 1.

Simplified Legend

Permo-Triassic Sequence
- Bellerophon Fm.
- Val Gardena Sandstones

Permo-Carboniferous Sequence
- Val Dolce Fm.
- Lower Pseudoschwagerina Fm.
- Carnizza Fm.
- Auernig Fm.
- Corona Fm.
- Pizzul Fm.
- Meledis Fm.
- Bombaso Fm.

Variscan Sequence
- Dimon Fm.
- Hochwipfel Fm.
- Pal Grande Fm.
- Middle Devonian shallow water, undifferentiated
- Alticola Fm., La Valute Fm., Findenig Fm., Hoher Trieb Fm. and Freikofel Fm.
- Bischofalm Fm. and Nölbling Fm.
- Valbertad Fm., Uqua Fm., Plöcken Fm.

Fig. 10 - Simplified geological map of the Mt Zermula-Passo del Cason di Lanza area (after Venturini et al., 2002, modified).

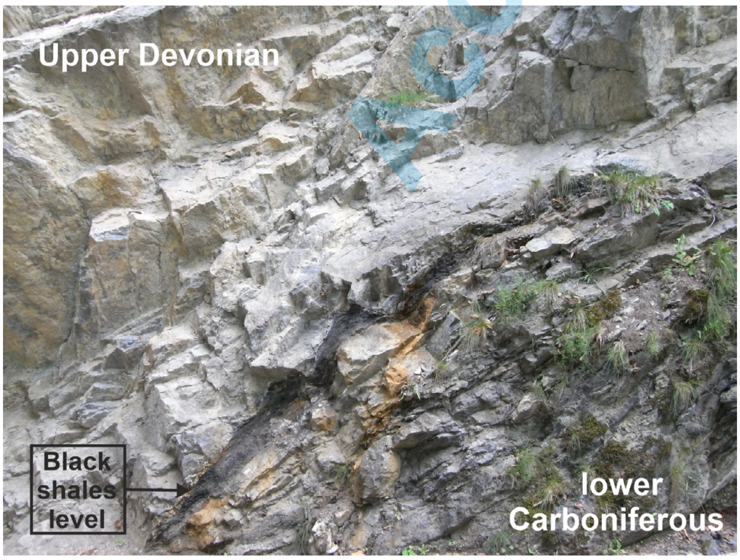

Fig. 11 - View of the Plan di Zermula A section. Note that the section is overturned.

The section was first described by Venturini and Spalletta (1991). Conodont biostratigraphy of the section was studied by Perri and Spalletta (2001), Kaiser et al. (2009), Spalletta et al. (2021), and summarised by Corradini et al. (2023b). Geochemical studies were carried out by Kaiser et al. (2008, 2009), who investigated the stable isotope stratigraphy, and by Pisarzowska et al. (2020) and Rakociński et al. (2020), who studied the whole-rock geochemistry and selected mineral components of the interval around the Devonian/Carboniferous boundary.

The Plan di Zermula section is the uppermost part of a strongly tectonised outcrop of Upper Devonian to Lower

Mississippian limestone of the Pal Grande Formation. The limestone sedimentation is interrupted by a 10 to 20 cm thick black shale interval interpreted as equivalent to the Hangenberg Black Shales (Perri and Spalletta, 2001). The irregular shape of the black shale level was attributed to weak tectonic displacement. Above the black shales, the calcareous sedimentation restarted with the deposition of about 80 cm of limestone, conformably followed by 20-50 cm of black radiolarian chert of the Zollner Formation and by grey pelites of the Hochwipfel Formation (Fig. 11).

The microfacies of the limestone is dominated by packstone-wackestone, rich in trilobites, ammonoids, ostracods, crinoids, and brachiopods (Spalletta et al., 2021). Macrofossils are not observable in the field. Conodonts are abundant and allow to discriminate several biozones from the *Palmatolepis gracilis expansa* to the *Siphonodella quadruplicata* zones. However, in the upper part of the section, some faults led to both elision and repetition of parts of the sequence (Fig. 12).

A continuous positive excursion in $\delta^{13}C_{carb}$ is documented (Kaiser, 2005; Kaiser et al., 2008). Rakociński et al. (2020) demonstrated a clear mercury enrichment associated with the Hangenberg event and suggested a volcanic-related methylmercury poisoning as a possible driver of the end-Devonian mass extinction.

Stop 1.2 - The Frasnian/Famennian boundary in the Plan di Zermula D (PZD) section

Coordinates: 46°34'27.9" N, 13°06'40.6" E. Altitude 1015 m

The Plan di Zermula D (PZD) section is located along the road connecting Paularo to Passo del Cason di Lanza, where an abandoned small quarry can be used as a parking place just north of the steep cliff above the Rio Chiarsò canyon. After a preliminary report (Corradini et al., 2023b), the conodont biostratigraphy and microfacies analysis were published by Jin et al. (2026).

This is the only section on the Carnic Alps with a black shale level at the Frasnian/Famennian boundary. This bed, equivalent to the Upper Kellwasser black shales, is documented everywhere in the world, testifying to the globally significant interval of widespread anoxia and extinction (Upper Kellwasser Event). However, in the other sections of the same age, located a few kilometres to the west, these shales are not present (Farabegoli et al., 2023). The presence of the black pelitic level only in this section could be explained by the physiographic characteristic of the Plan di Zermula area during the Late Devonian and early Carboniferous, when the area was probably a narrow and deeper trough that favoured

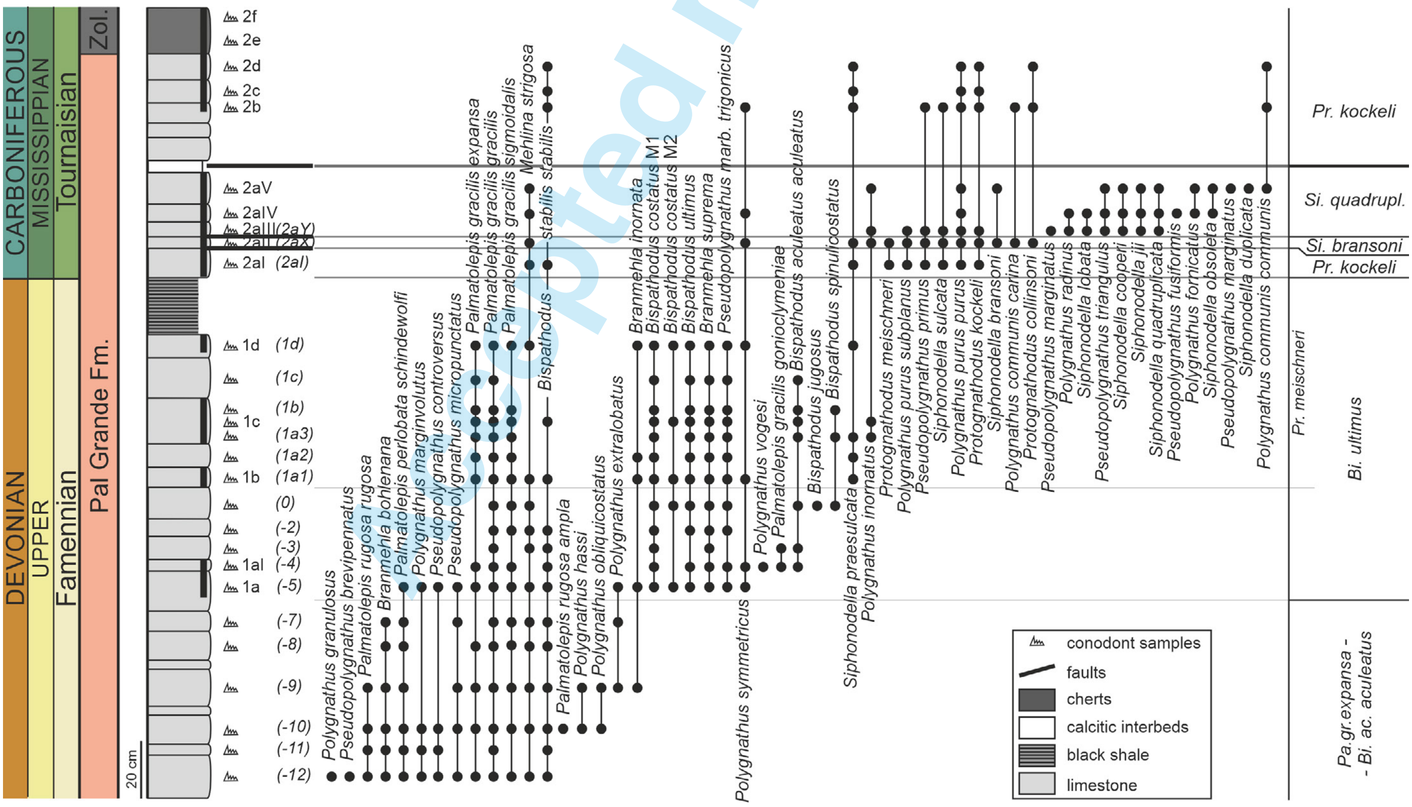

Fig. 12 - Stratigraphic column of the Plan di Zermula A section. From left to right: chronostratigraphy (System, Series, Stage), lithostratigraphy, stratigraphic column, conodont samples, distribution of conodonts, and biostratigraphy (after Corradini et al., 2023b, modified). Samples numbers in normal typeface are from Perri and Spalletta (2001), sample numbers in italics are from Kaiser (2005). Abbreviation: Zol. = Zollner Fm.

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restricted water circulation on the bottom (Spalletta et al., 2021; Jin et al., 2026).

The Plan di Zermula D section exposes a short, tectonically disturbed and overturned interval of the Pal Grande Formation, with a total thickness of approximately 5 m (Figs. 13-14). The lithology is dominated by grey to brownish-grey thin- to medium-bedded micritic limestone, with no significant lateral facies changes or lithologic transitions. A distinctive 25 cm-thick dark pelitic layer developed at approximately 1.4 m above the base of the section and is dated at the Frasnian/Famennian boundary (Jin et al., 2026).

Fig. 13 - View of the Plan di Zermula A section, with position of conodont samples.

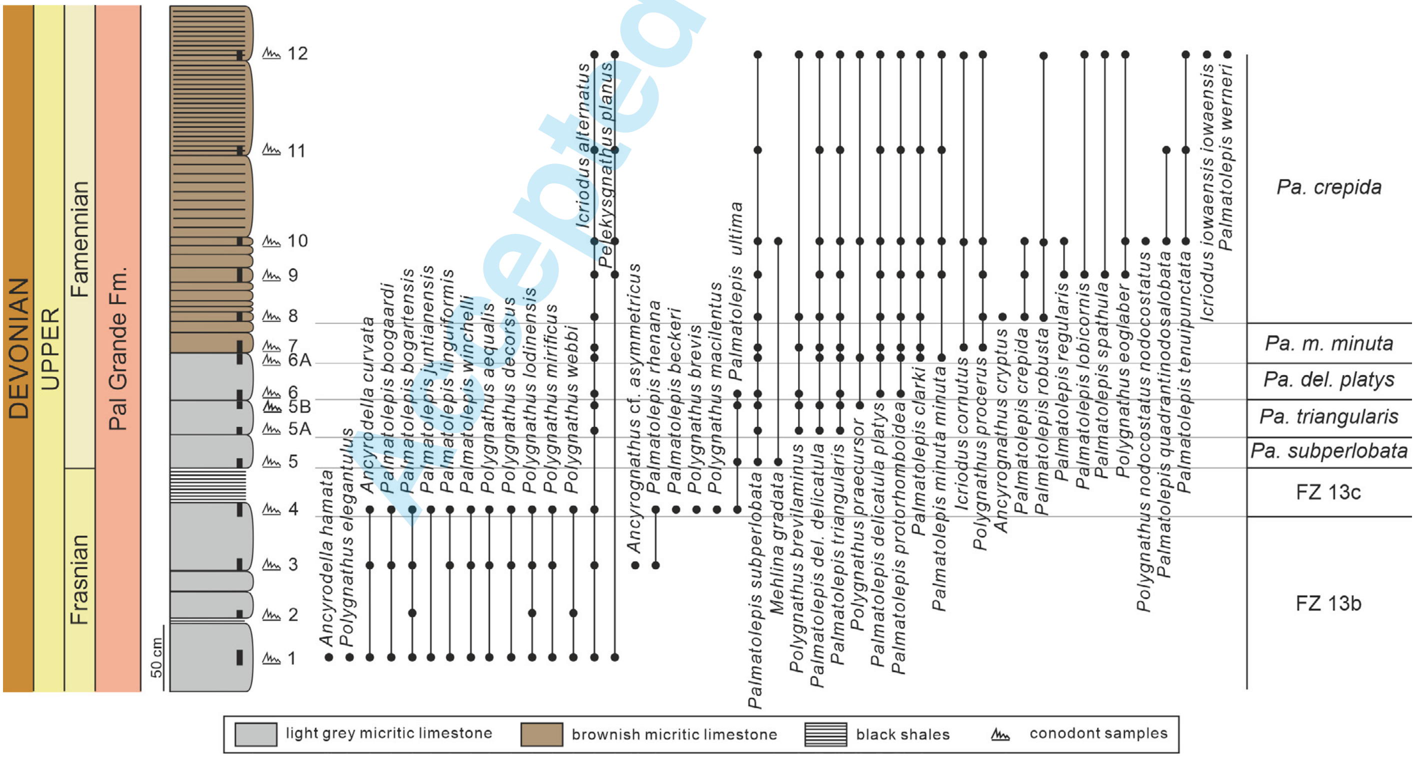

Fig. 14 - Stratigraphic column of the Plan di Zermula D section. From left to right: chronostratigraphy (System, Series, Stage), lithostratigraphy, stratigraphic column, conodont samples, distribution of conodonts, and biostratigraphy (after Jin et al., 2026, modified).

The conodont fauna is rich and diversified, and 44 *taxa* belonging to seven genera were documented (Jin et al., 2026), allowing to identify seven consecutive conodont zones spanning the late Frasnian to early Famennian, from the FZ 13b to the *Palmatolepis crepida* Zone (Fig. 14). However, abundance and diversity drop at the boundary, with a very scarce association occurring in the basal Famennian beds. The post-extinction recovery was relatively slower than in the other coeval sections in the Carnic Alps, probably due to the physiography of the area (Jin et al., 2026).

Stop 1.3 - Lochkovian cephalopods and crinoids in the Rio Malinfier West section

Coordinates: 46°34'50.8" N, 13°07'53.7" E. Altitude 1175 m

The Rio Malinfier West (RMW) section is exposed in the forest about 100 m west of the Rio Malinfier Creek, along a narrow and steep creek cleaned by a local flood in August 2008. It is suggested to park just after Casera Meledis Bassa, and walk on the road for 200 m, before entering in the forest above the road.

About 100 m of limestones and black shales attributed to the Alticola, Rauchkofel, La Valute, Nolbling and Findenig formations are exposed in the RMW section (Fig. 15). After preliminary works on the lithological sequence and conodont biostratigraphy (Corriga, 2011; Corradini et al., 2012; Corriga et al., 2017), the section was discussed in detail by Corradini et al. (2019), who described the complex tectonics and the palaeontological content.

The section is partly overturned and strongly tectonised. A distinct fault, roughly E-W trending, running at about 40 m above the base, cuts the section in two main exposures. Although the units exposed below and above the fault are mostly the same, the two parts of the section largely differ, suggesting that the fault adjoins two sequences of the same age possibly deposited in slightly different environments

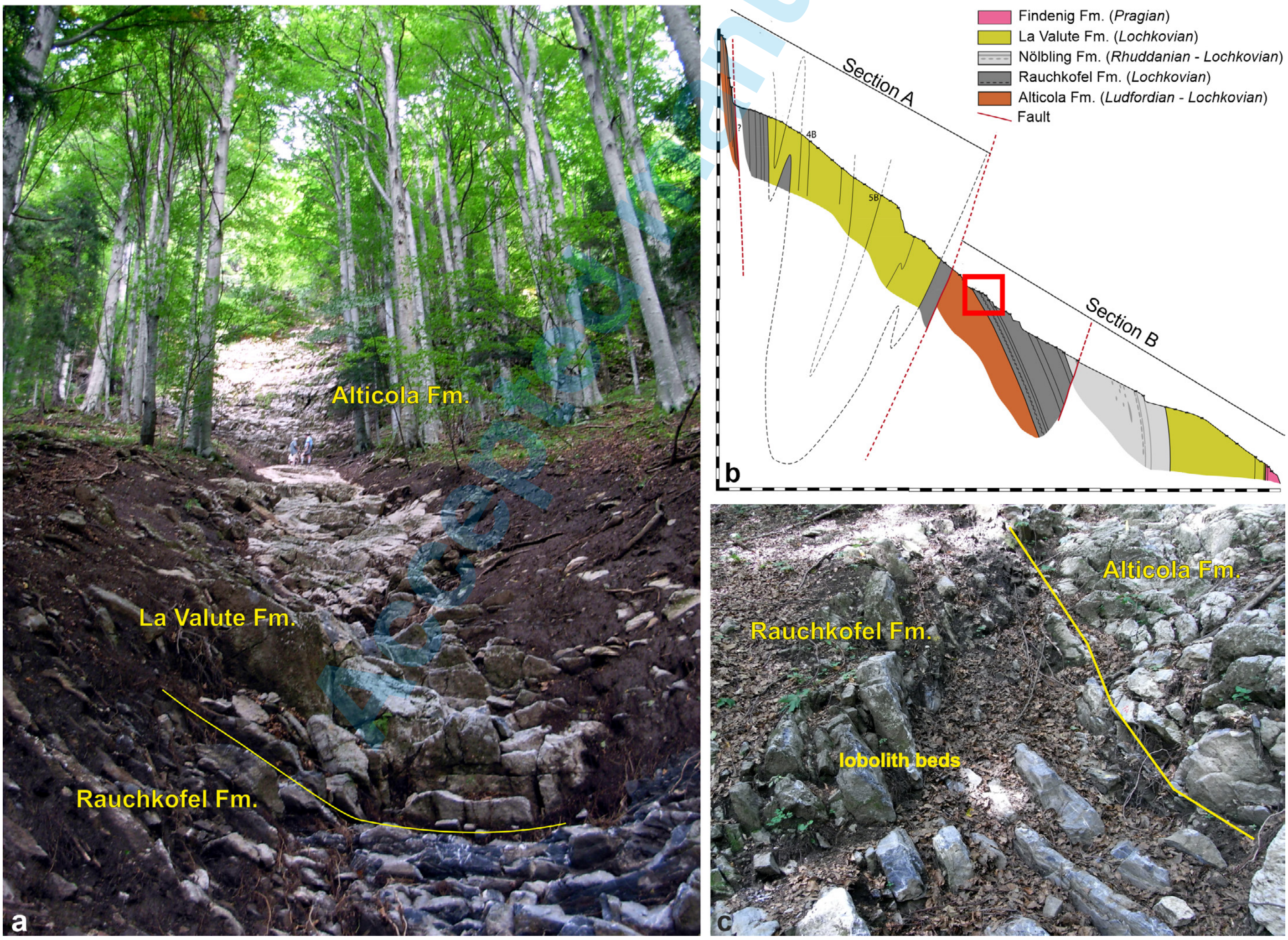

Fig. 15 - The Rio Malinfier West section. a) Panoramic view of the upper part (Sector A) of the section. b) Geological section through the RMW profile to show the complex structure of the section (after Corradini et al., 2019, modified). The box indicates the area figured in frame c. c) Close view of the transition between the Alticola and Rauchkofel formations in lower part of Sector B, with indication of the lobolith beds.

(Fig. 15b). The topographically upper part (Sector A) is characterised by a tight inclined decameter-scale syncline associated to smaller-scale asymmetric folds, in turn gently folded by a larger-scale structure; the lower part (Sector B) the succession is fairly undisturbed, with just very gentle folding and a minor fault.

The section starts with a steep wall constituted by about 2 m of cephalopod-rich limestones belonging to the Alticola Formation, and continues after 3 m of detrital cover accumulated at the base of the steep cliff with 3.2 m of dark limestones and intercalated black shales of the Rauchkofel Formation, that passes with a sharp contact into the La Valute Formation, that here is more than 30 m thick (i.e. much more than the usual thickness of the unit). In fact, this part of the section is affected by the afore-mentioned tight fold which causes the repetition. Close to the repeated transition to the Rauchkofel Formation, the bed thickness seems to decrease, probably because of the ductile shear associated to the fold propagation. Less than 2 m of Rauchkofel Formation are present before the fault. In the footwall of the fault, Section 2 starts with about 4 m of limestones of the Alticola Formation, slightly tectonised in the upper part, close to the sharp transition with the Rauchkofel Formation, here represented by about 16 m of dark limestone, with thin black shale intercalations. Limestone beds are thicker in the lower part of the units and become thinner in the upper part before the transition to the Nölbling Formation. This unit is here about 18 m thick and is represented mainly by black shales with a few carbonatic levels and lenses intercalated. The Nölbling Formation is overlain by the La Valute Formation with a sharp conformable contact. Compared to the same formation on the lower part of the section the unit is here slightly more marly and the beds are thinner, probably indicating a slightly deeper depositional environment. In the uppermost part the La Valute Formation becomes more nodular and marly, and grades into the reddish nodular mudstone of the Findenig Formation.

The biostratigraphy of the section was based on a relatively poorly preserved conodont fauna. The species *Zieglerodina schoenalubi* Corradini et al., 2019 (Fig. 16e) has its type locality in this section.

Orthoceratid cephalopods are present throughout the section, but the state of preservation is in general poor, being the specimens often weathered by dissolution and frequently recrystallised. They are better preserved in the lower part of the Rauchkofel Formation in section 2, were genera *Arionoceras* and *Michelinoceras* are reported. The association is often represented by small specimens, often oriented, and shell-in-shell specimens are frequent (Fig. 16a). Several juvenile specimens preserving their protochonch are present (Fig. 16b).

Crinoids are the most spectacular macrofossils of the RMW section, where stems fragments and several well preserved loboliths occur just above the base of the Rauchkofel Formation in Section 2 (Figs. 15c, 16g-i). The lobolith bearing beds are about 20 cm thick, and a few lobolith are present also on thinner beds between the thicker ones. Several loboliths, in general well preserved, are closely spaced on bedding plane. Some specimens show the typical wall structure of the plate loboliths (Fig. 16i).

A few gastropods (Fig. 16c-d), rare trilobites (Fig. 16f) and solitary corals have been collected from the Alticola and the Rauchkofel formations in the central part of the section, and poorly preserved monograptid graptolites from the lower Lochkovian black shales of the Rauchkofel Formation.

Stop 1.4 - The Upper Ordovician Valbertad section

Coordinates: 46°34’31.5” N, 13°08’39.3” E. Altitude 1346 m

The Valbertad section is measured in a roadcut and exposes about 36 m of Upper Ordovician siltstones, sandstones, and limestones assigned to the Valbertad and Uqua formations (Fig. 17). The section is the type section of the Valbertad Formation, which is here 34 m thick and consists of sandstones and siltstones. About 25 m above the base of the section, a few cm-thick nodular fine-grained calcareous lenses start to appear in concentrated intervals alternating with sandstones. These nodules become progressively more abundant in the upper part of the unit. The uppermost 2 m of the section are constituted by nodular micritic limestones of the Uqua Formation.

Fossils (Fig. 18) are present in the whole Valbertad Formation, being more abundant in the central part of the section within levels 6 and 7. They are concentrated in well-defined levels, where they are preserved by limonitisation, often as casts due to dissolution processes. Brachiopods, bryozoans, and cystoids, mainly Rhombifera, are common. Trilobite and corals (Tabulata) are also present, while gastropods and conulariids are rare. Bioturbations and a few trace fossils are also present.

Bagnoli et al. (1998, 2017) sampled the whole section for conodonts, but only the calcareous nodules and levels in the upper part (samples 11-19) were productive and yielded a rich association (19 species), in which *Nordiodus italicus* Serpagli, *Plectodina alpina* (Serpagli), *Scabbardella altipes* (Henningsmoen) and *Decoriconus costulatus* Serpagli are abundant (Bagnoli et al., 1998, 2017). The association is attributed to the Katian-Hirnantian *Amorphognathus ordovicicus* Zone; however, typical Hirnantian species are missing (Bagnoli et al., 2017).

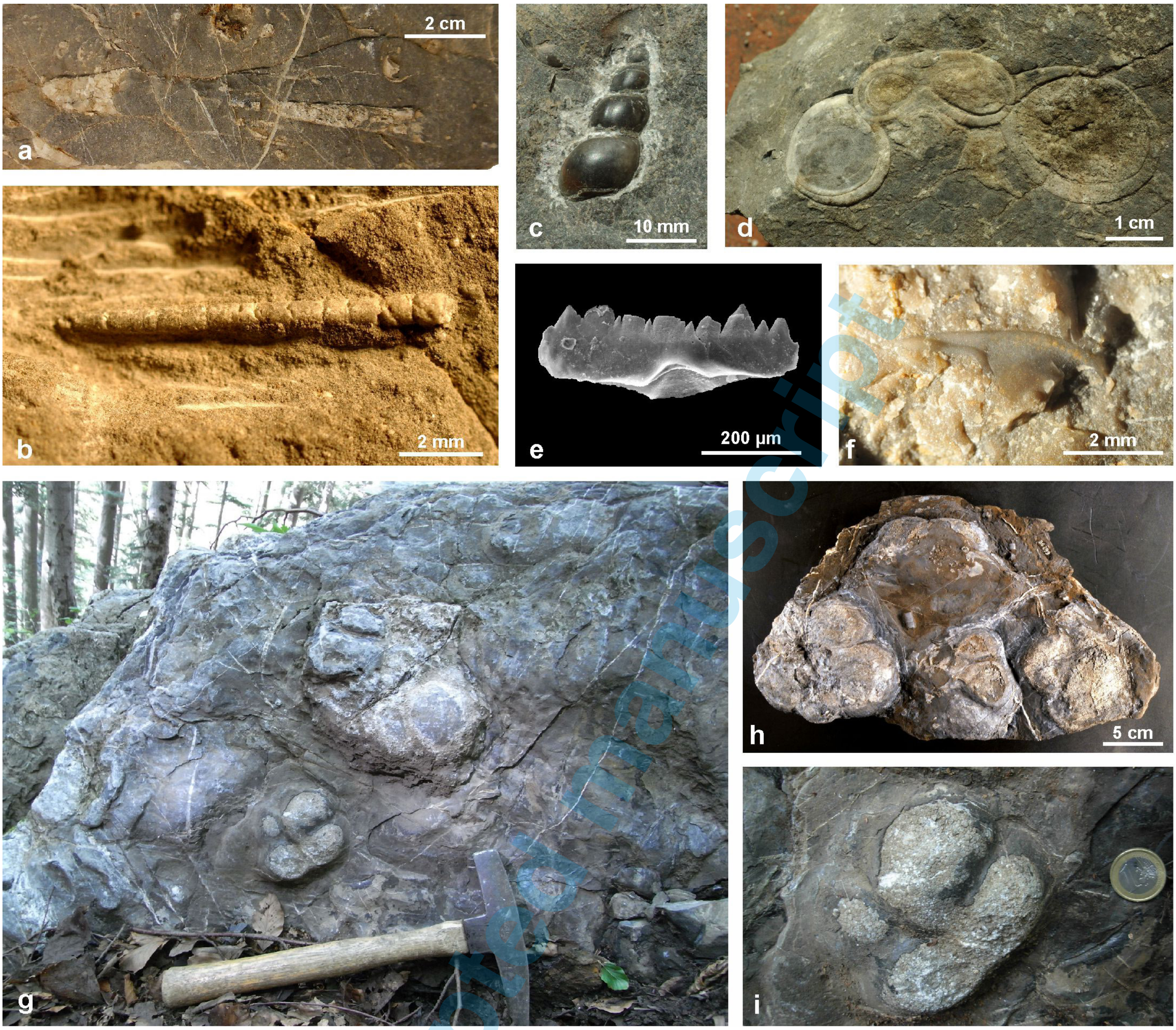

Fig. 16 - Fossils from the Rio Malinfier West section. a) Bed surface with recrystallised orthoconic nautiloids showing telescoping deposition. b) Protochonch of ?*Michelinoseras* c) Undetermined gastropod. d) Cross section of an Euomphalid gastropod. e) The holotype of the conodont *Zieglerodina schoenlaubi* Corradini et al., 2019. f) Fragment of a Proetid trilobite tentatively assigned to genus ?*Prionopeltis*. g) Detail of the lobolith beds in the field. h) Block with several lobolites and stem fragments. i) Detail of the surface of a plate lobolith, covered by closely spaced polygonal ossicles.

Stop 1.5 - The back-reef "*Amphipora* limestone" (Spinotti Formation) at Cason di Lanza Pass

Coordinates: 46°33'52.5" N, 13°10'16.7" E. Altitude 1567 m

On the southern side of Cason di Lanza Pass, sediments from the calm lagoonal back-reef environment crop out and constitute most of Mt Zermula massif. They can be easily observed around the old military house, recently restored as "Rifugio 8th Alpine Regiment", at the beginning of path n. 442a to Mt Zermula. The geotrail "Luca Simonetto" to Mt Pizzul starts here (Corradini et al., 2023a)

These rocks, informally named "*Amphipora* limestones", belong to the Spinotti Formation, and are mainly constituted of "prairies" of *Amphipora ramosa*, trapping carbonatic mud (Fig. 19). The amphiporoid animal was a small calcified porifera belonging to class Stromatoporoidea. The stems are rods of a few millimeters in diameter and are composed of skeletal elements of fibrous calcite defining an irregular network of hard tissue; the labyrinthine canals between the elements open on the periphery in apertures of irregular shape or are covered there by a thin hard tissue membrane. A prominent axial canal crossed by dissepiments may or may not be present

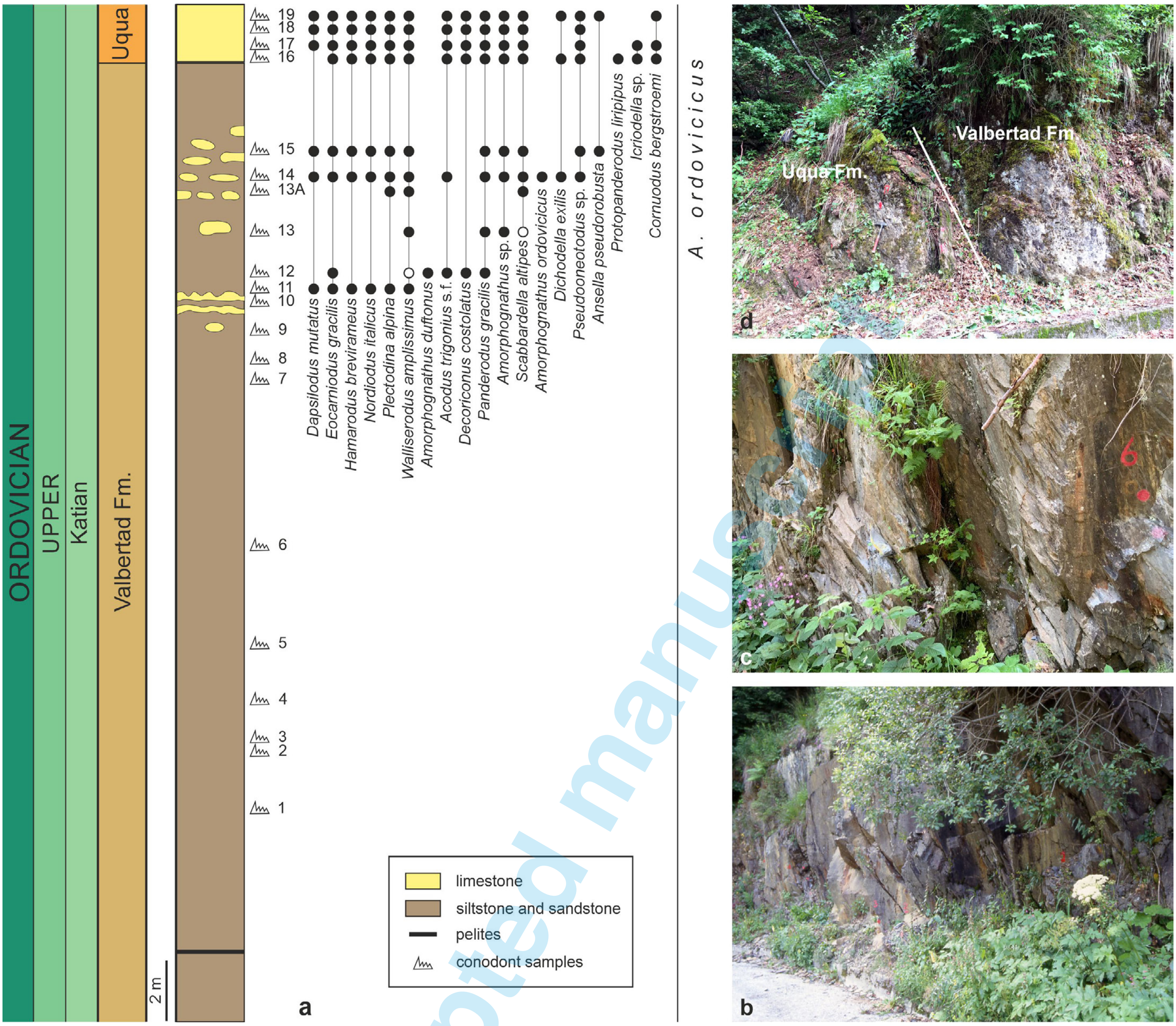

Fig. 17 - The Valbertad section. a) Stratigraphic column of the section. From left to right: chronostratigraphy (System, Series, Stage), lithostratigraphy, stratigraphic column, conodont samples, distribution of conodonts, and biostratigraphy (after Bagnoli et al., 2017, modified). b) View of the upper part of the section. c) View of the lower-central part of the section. d) View of the upper part of the section with the boundary between the Valbertad and the Uqua formations evidenced.

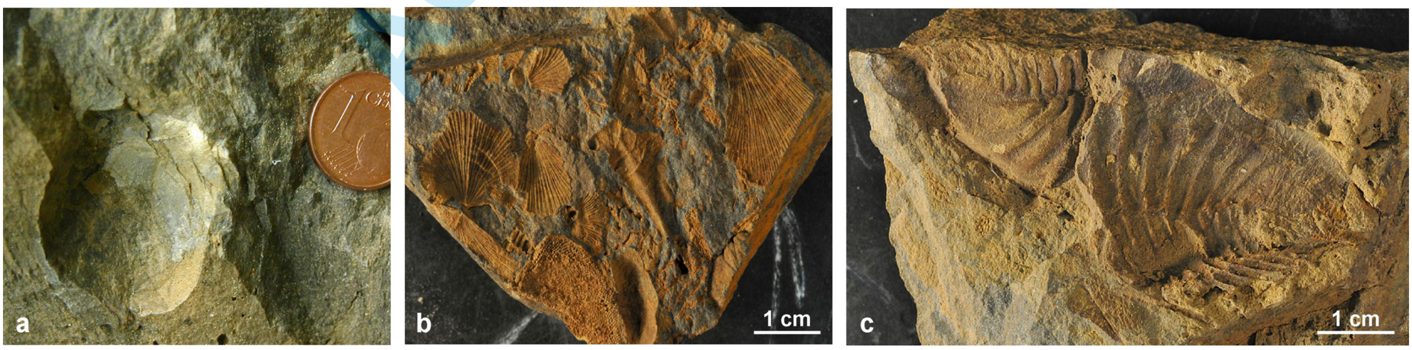

Fig. 18 - Fossils from the Valbertad section. a) Cystoid external cast showing the distinctive rhombic pattern of pores of Class Rhombifera. b) Slab with brachiopods and bryozoans. c) Stab with trilobite remnants and bryozoans.

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(Fig. 19c). Some specimens are branched, other remain as single tubes (Stearn, 1997).

The genus *Amphipora* is known from Emsian to early Famennian, with the most widespread distribution in Middle Devonian time. It lived in shallow, calm waters, and was anchored inefficiently by irregular outgrowths at the base or cemented into the substrate. Fossils are present in all the unit, and are very abundant in some beds, where big storms accumulated many specimens in well-observable beds.

Beside *Amphipora*, rugose corals, mainly of the genus *Dendrostella*, are present; additionally, in darker levels the brachiopod *Stringocephalus burtinii* occurs, allowing to attribute the outcrop to the Givetian (Middle Devonian). In other areas of the Carnic Chain this unit spans a wider time interval (Eifelian-Frasnian, Middle-Upper Devonian) and its thickness reaches 200-400 meters.

Stop 1.6 - The Kacak Event in the Zuc di Malaseit Bassa section

Coordinates: 46°33'19.6" N, 13°11'10.6" E. Altitude 1465 m

The Zuc di Malaseit Bassa section is located on the eastern flank of Zuc di Malaseit and will be reached after a short, easy walk along path n. 435, starting from the small parking near the bridge on Pontebbana Creek.

The section has a total thickness of about 15 m and exposes an overturned sequence of rocks belonging to the Hoher Trieb Formation of Middle Devonian age (Fig. 20). A detailed conodont stratigraphy was provided by Suttner et al. (2017a, b), who also studied the general fossil content; preliminary stable isotope and magnetic susceptibility data were presented by Kido et al. (2012), and oxygen isotopes by Suttner et al. (2021).

Two several meters-thick limestone breccia levels are present at the base and the top of the section, the central part of which consists mainly of limestone beds which are intercalated by chert layers; some siltstone layers, more abundant across the Eifelian/Givetian boundary, are also present. Chert nodules occur here and there within limestone beds.

Limestone beds mainly consist of peloidal grainstone with crinoids and sometimes foraminifera, ostracods, bryozoans, and calcispheres. Limestone breccias are composed of lithoclasts of peloidal grainstone, stromatoporoids, corals, brachiopods, and crinoid stem plates. Some chert-rich intervals consist of argillaceous,

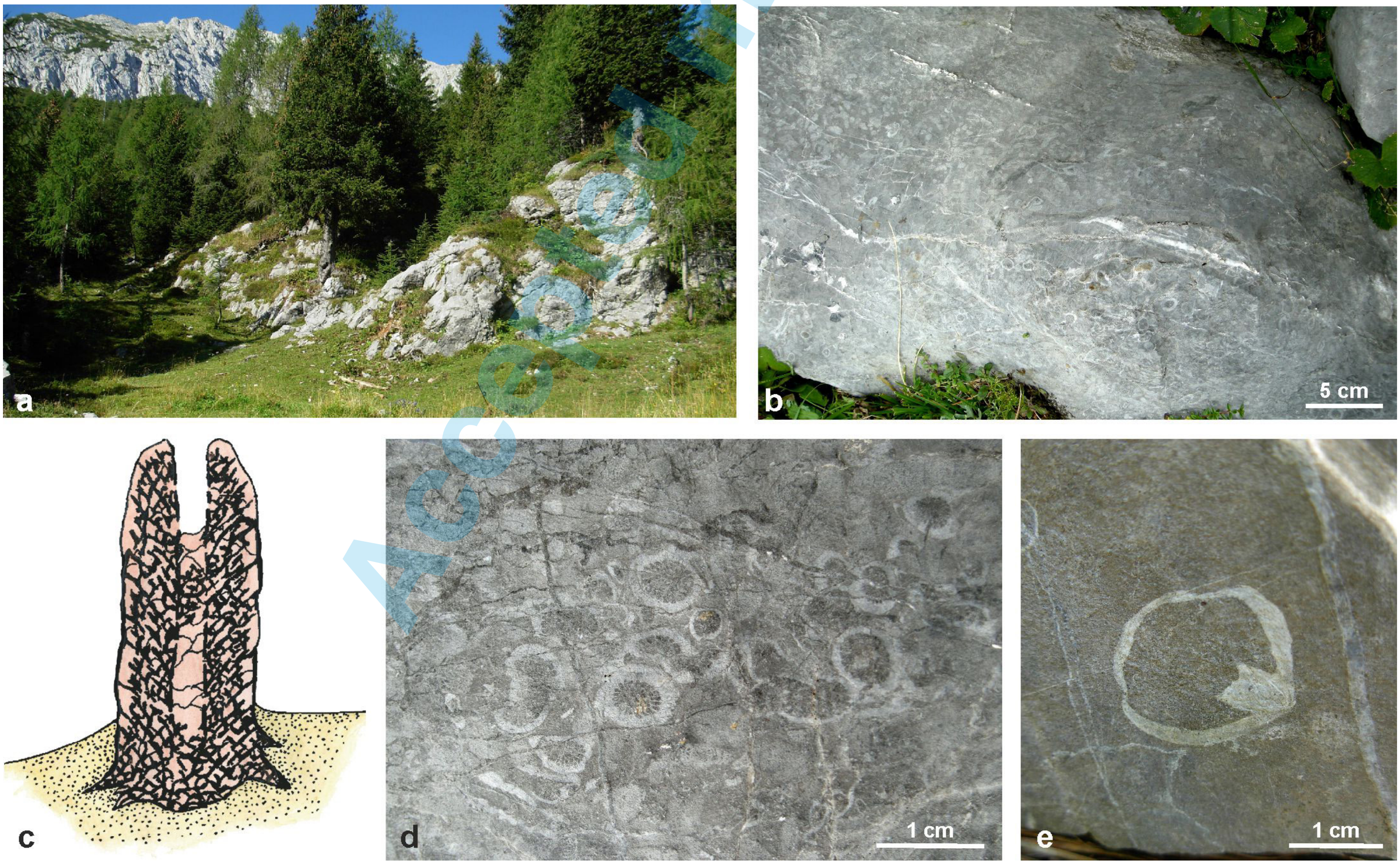

Fig. 19 - The "*Amphipora* limestones" at Passo del Cason di Lanza. a) view of one of the outcrops in the area. b) general view of a bed rich in *Amphipora* and corals. c) reconstruction of *Amphipora ramosa* (after Stearn, 1997, modified). d) close view of a rock surface with remnants of *Amphipora* and several rugose corals (*Dendrostella* sp.). The brachiopod *Stringocephalus burtinii* (Defrance).

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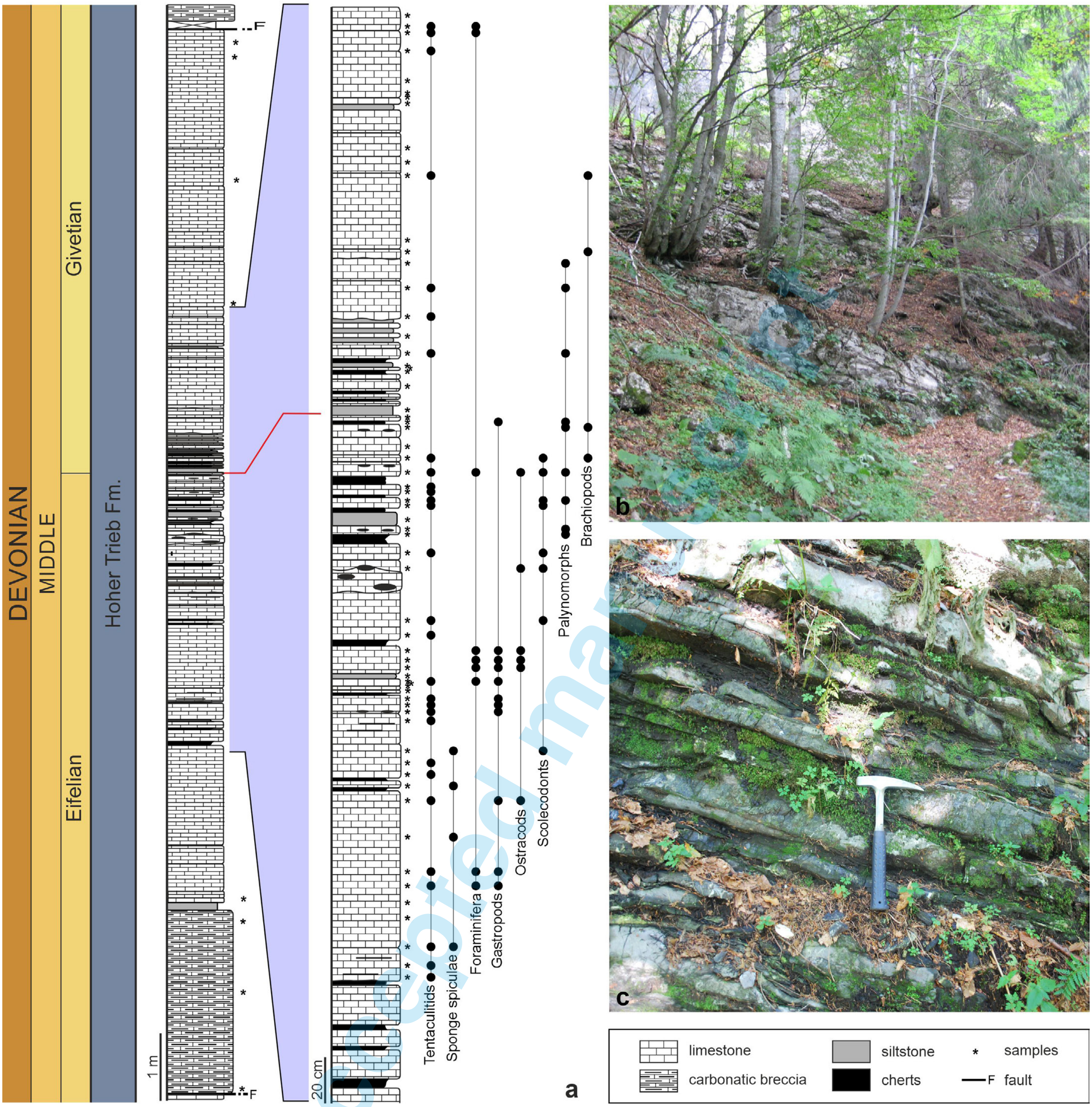

Fig. 20 - The Zuc di Malaseit Bassa section. a) Stratigraphic column of the section. From left to right: chronostratigraphy (System, Series, Stage), lithostratigraphy, stratigraphic column (after Suttner et al., 2017a, modified), samples, occurrence of main fossil groups in conodont residues. b) Panoramic view of the section. c) Detail of the part of the section across the Kačák Event (Eifelian/ Givetian boundary).

dark brown, organic-rich grainstone with layers of recrystallised skeletal grains and radiolarians. Some siltstones are organic-rich with a high clay content and yield crinoidal stem plates. Additionally, laminated carbonaceous siltstones occur and yield ostracod valves, broken tentaculitids, crinoids, and calcispheres. Rare sponge spiculae, brachiopods (*Opsiconidion* sp.), and gastropods are also present. Rugosa and tabulata corals, preserved by silicification, occur in the breccia levels.

The biostratigraphy of the section was provided by Suttner et al. (2017a, b), who documented thirty-eight *taxa* belonging to ten genera (*Belodella*, *Dvorakia*, *Icriodus*, *Neopanderodus*, *Oulodus*, “*Ozarkodina*”, *Panderodus*, *Polygnathus*, *Pseudooneotodus*, and *Tortodus*). The fauna

allows to recognize seven consecutive conodont zones, from the *T. australis* Zone (Eifelian) to the *P. ansatus* Zone (Givetian).
The central part of the section shows an excellent exposure of rocks across the Kačák Event (House, 1985). It is one of the main extinction events of the Devonian, caused by widespread dysoxic/anoxic conditions, and is represented by a black shale and chert interval documented globally in sedimentary sequences across the Eifelian/Givetian boundary. The event interval in general is characterised by distinctive faunal changes observed in pelagic and planktonic groups and significant extinctions among benthic invertebrates. The Kačák Event is known from one lacustrine (Marshall et al., 2007) and several marine areas within the Rheic, Palaeotethys and Panthalassic oceans.

Stop 1.7 - Pennsylvanian plants at Rio del Museo

Coordinates: 46°34'07.5" N, 13°10'12.1" E. Altitude 1585 m

Rio del Museo outcrop (Fig. 21) is one of the most classical localities for Pennsylvanian flora in the Carnic Alps. It is located in a narrow creek a few hundred meters north-west of Cason di Lanza hut and can be reached after a short, steep walk, leaving the asphalt road about 200 meters from the pass. The productive layers are represented by dark pelites deposited in a coastal lagoonal environment and belong to the Meledis Formation. This unit is mainly represented by fluvio-deltaic quartzitic conglomerates and transitional and shallow marine pelites and sandstones. Besides the rich fossil flora in the pelitic levels, ichnofossils (mainly *Zoophycus* and *Cosmoraphae*) occur in the sandstones.
The Pennsylvanian flora from the Carnic Alps was recently revised by Opluštil et al. (2021), based on the rich collections deposited in the Friulian Natural History Museum of Udine. From Rio del Museo the authors reported 21 species belonging to the lycophytes (*Syringodendron* sp.), horsetails (*Annularia carinata*, *Calamostachys tuberculata*, *Calamites* sp., *Stenophyllum oblongofolium*), fern-like plants of the family Zygopteridaceae (*Schizostachys* sp.), ferns of the order Marattiales (*Pecopteris candolleana*, *P.* cf. *lepidorachis*, *Lobatopteris* sp. 1, *Acitheca polymorpha*, *Acitheca* cf. *ambigua*, *Polymorphopteris* sp. 3, *Diplazites unitus*, *Scolecopteris densifolia*, *Scolecopteris* cf.

Fig. 21 - Panoramic view of the Rio del Museo outcrop.

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oreopteridia), ferns of the family Tedeleaceae (*Senftenbergia plumosa*, *Senftenbergia* cf. *saxonica*, *Oligocarpia* cf. *gutbieri*, *Sphenopteris* sp.), and seed ferns of the order Medullosales (*Alethopteris leonensis*, *A. zeilleri, Odontopteris brardii*, *Callipteridium gigas*, *C. zelleri*, *Cyclopteris* sp.). Selected specimens are illustrated in Figs. 22-23.

Fig. 22 - Large slab with several plant remnants from Rio del Museo: *Alethopteris sp., Annularia carinata* Gutbier, *Cyperites* sp., *Neuropteris* sp., and *Polymorphopteris* sp. 3 Opluštil et al., 2021. Scale bar = 3 cm.

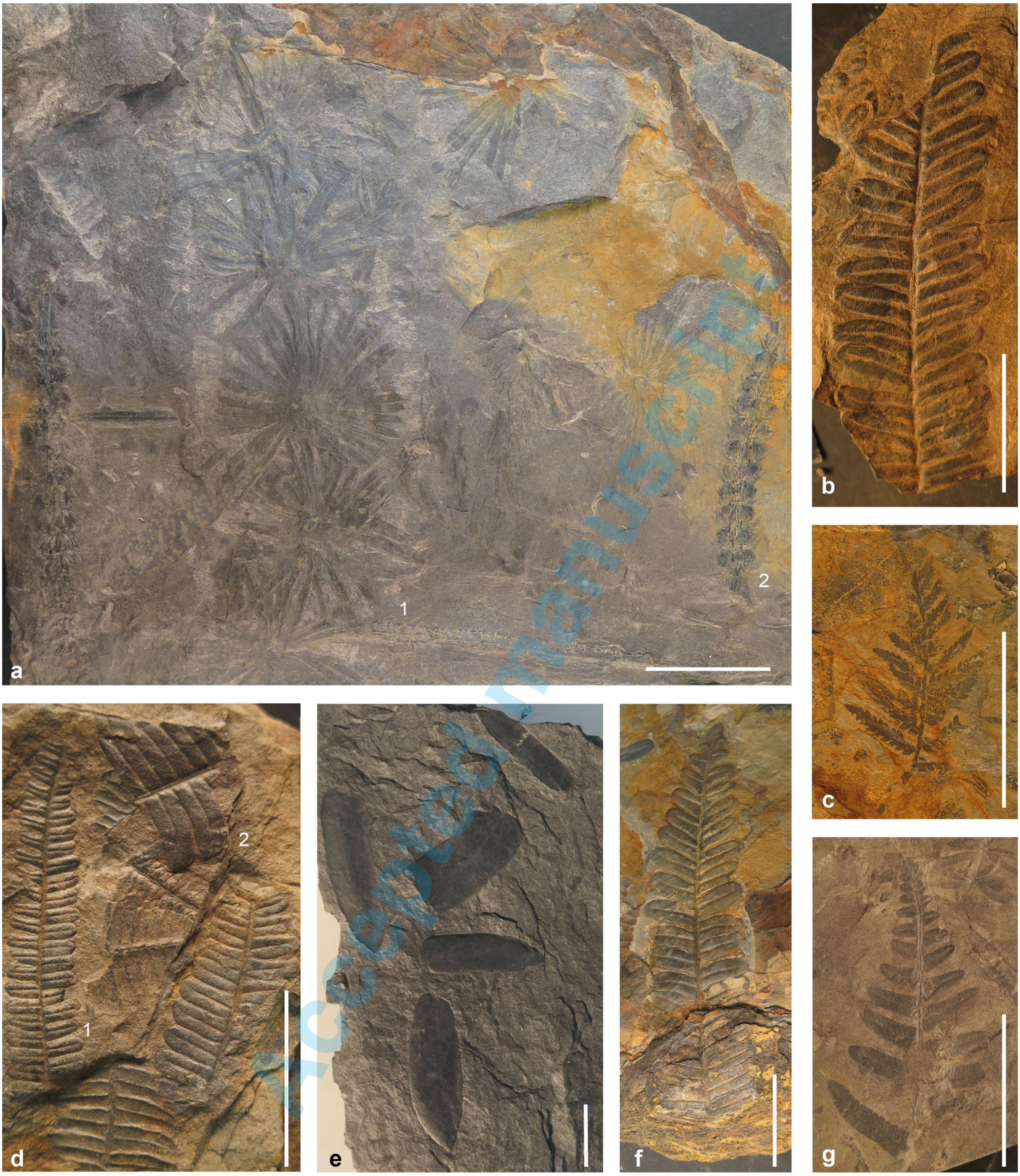

Fig. 23 - Selected plants from Rio del Museo. a) Slab with *Annularia carinata* Gutbier (1) and *Calamostachys tuberculata* Jongmans (2). b) *Alethopteris zeilleri* Wagner. c) *Senftenbergia* cf. *saxonica* Barthel. d) Slab with *Callipteridium gigas* Weiss (1) and *Pecopteris* cf. *lepidorachis* Brongniart (2). e) *Cyclopteris* sp. f) *Alethopteris zeilleri* Wagner. g) *Diplazites unitus* Cleal. Scale bars = 3 cm.

DAY 2

The second excursion day is subdivided into two parts: the morning is devoted to the area around Passo di Monte Croce Carnico/Plöckenpass (Fig. 24a), which is a deep pass in the central Carnic Alps between Pal Piccolo mountain to the east, and Creta di Collinetta/Cellon to the west; in the afternoon, we will move to the Pramosio area (Fig. 24b).

PASSO DI MONTE CROCE CARNICO AREA

Passo di Monte Croce Carnico is the main connection between Italy and Austria in the central Carnic Alps. During World War I, the area was the scene of heavy fighting, as evidenced by fortifications, trenches, and galleries still observable in the surrounding mountains. Rocks from the Katian (Late Ordovician) to the Carboniferous are exposed in the area.

The oldest units, of Late Ordovician age, are exposed in the Austrian side of the border in the nucleus of a huge anticlinal structure that involves the whole Creta di Collinetta/Cellon mountain (Fig. 25). The sequence continues with the various formations discriminated within the "Orthoceras Limestones" of Silurian and Early Devonian age, followed by a continuous sequence of the "transitional units", deposed between the reefs and the basin from the Pragian to the Frasnian. The upper part of the sequence is represented by pelagic, but not deep, rich in ammonoids limestone of the Pal Grande Formation ("Clymeniae limestones" *Auct.*) of late Frasnian to early Visean age. This carbonate sequence is unconformably capped by siliciclastic deposits of the Hochwipfel Formation (late Visean-Bashkirian).
On the Italian side of the pass, only the younger terms are exposed. Here, more to the south and to the west of the area mapped in Fig. 25, shallow-water brachiopod coquinas and dark limestones of the Creta di Collina Formation are exposed (upper Frasnian-middle Famennian). This unit uncorformably lies above the reefal rocks, and the upper part is interlayered with the Pal Grande Formation.

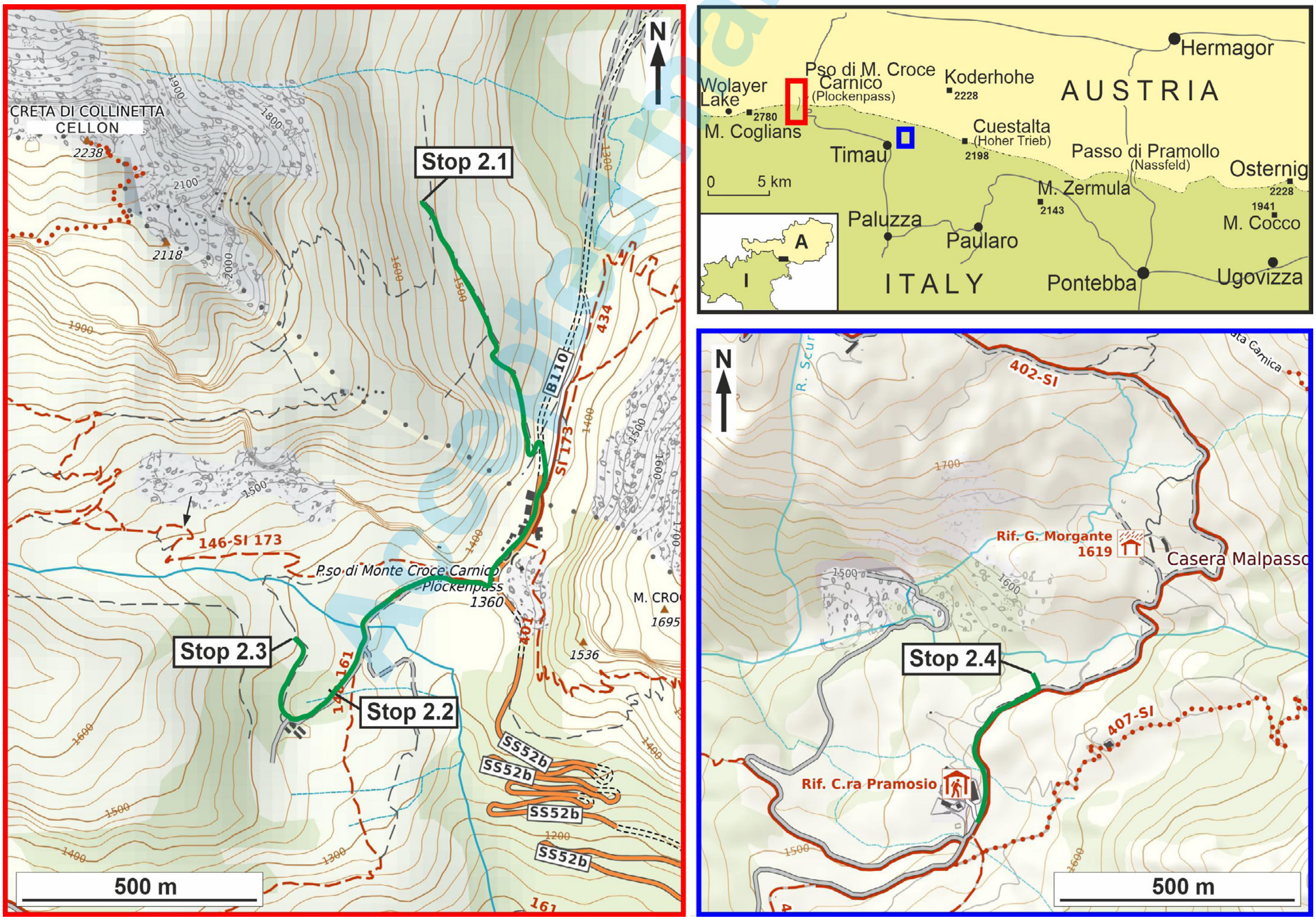

Fig. 24 - Topographic map of the itinerary of day 2. Red square: area of Passo di Monte Croce Carnico; Blue square: area of Casera Pramosio.

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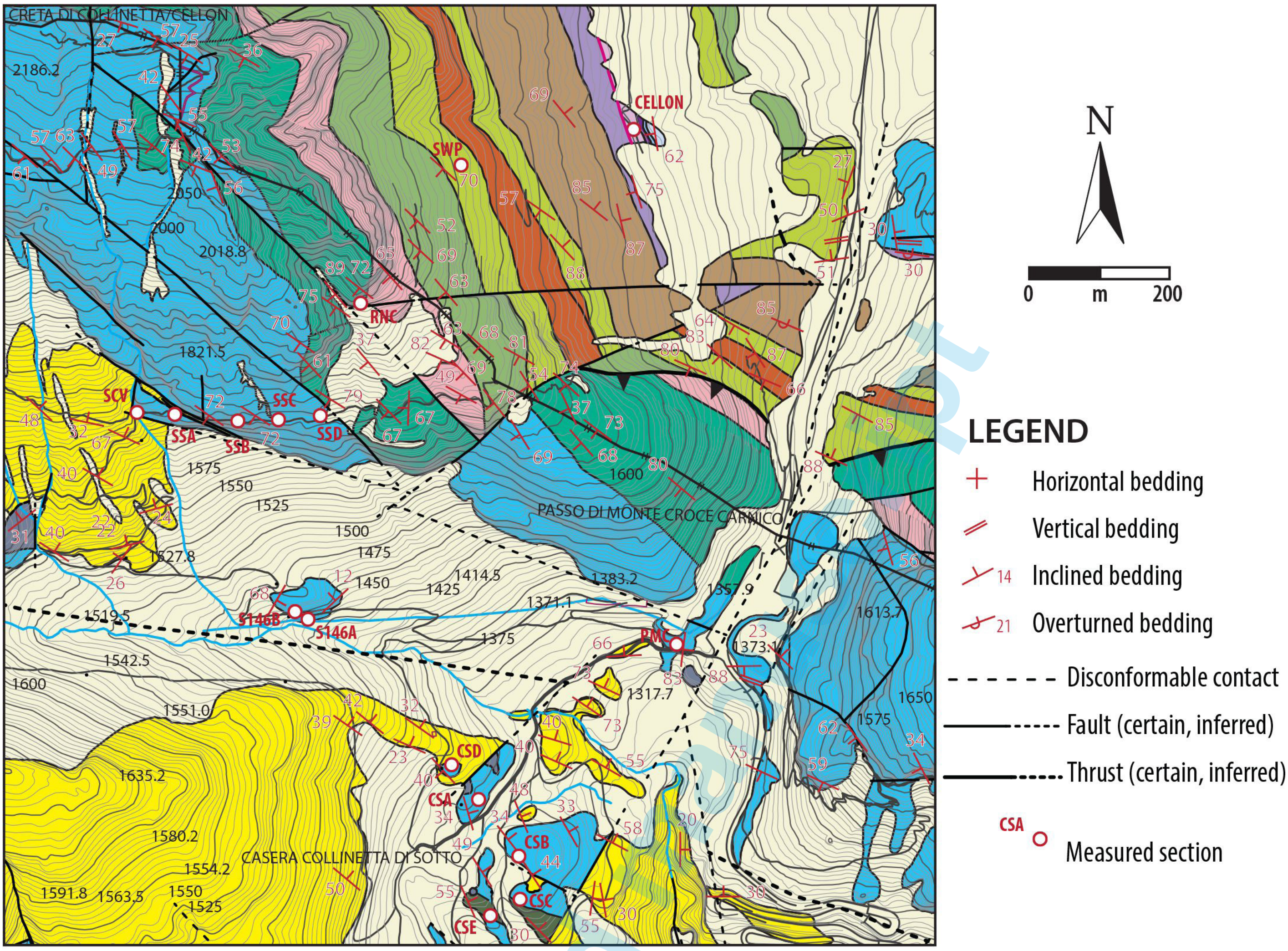

Quaternary (undifferentiated)

Hochwipfel Fm
Stratigraphic distribution: Middle Visean-Bashkirian

Plotta Fm
Stratigraphic distribution: (?) topmost Famennian to (?) Tournaisian

Pal Grande Fm
Stratigraphic distribution: Frasnian to Visean

Creta di Collina Fm
Stratigraphic distribution: Upper part of Frasnian to Famennian

Freikofel Fm
Stratigraphic distribution: Givetian to Frasnian

Cellon Fm
Stratigraphic distribution: Eifelian - Givetian

Vinz Fm
Stratigraphic distribution: Emsian to Eifelian

Kellerwand Fm
Stratigraphic distribution: Pragian to Emsian

Seekopf Fm
Stratigraphic distribution: Pragian

Rauchkofel Fm
Stratigraphic distribution: Lochkovian

Alticola Fm
Stratigraphic distribution: Ludfordian to lowermost Lochkovian

Cardiola Fm
Stratigraphic distribution: Ludfordian

Kok Fm
Stratigraphic distribution: Telychian to Ludfordian

Plöcken Fm
Stratigraphic distribution: Hirnantian.

Uqua Fm
Stratigraphic distribution: Late Katian to (?) basal Hirnantian

Valbertad Fm
Stratigraphic distribution: Katian

Fig. 25 - Geological map of the Passo di Monte Croce Carnico area (after Pondrelli et al., 2020, modified).

Stop 2.1 - The Cellon section

Coordinates: 46°36'32.2" N, 12°56'31.4" E. Altitude 1520 m

The Cellon section is located in a narrow avalanche gorge on the eastern flank of Mt Cellon/Creta di Collinetta, close to the Austrian/Italian border, and it can be reached with a short 20-minute hike on trail no. 427-3 from the Passo di Monte Croce Carnico/Plöckenpass. The section exposes rocks from the Late Ordovician to the Early Devonian (Fig. 26). However, although the conformable sequence suggests continuity of sedimentation, several small gaps have been recognised, reflecting eustatic sea level changes in an overall shelf water environment (Schönlaub et al., 1994; Corradini et al., 2015a; Arts et al., 2024).

The Cellon section is one of the most studied Silurian sections in the world and is the reference section for studies on Late Ordovician, Silurian, and Early Devonian. The section has been known since 1894, when Geyer (1894) described the rock succession exposed here. The

Fig. 26 - Views of the Cellon section. a) Panoramic view to the west of Mt Creta di Collinetta/Mt Cellon with indication of the lithostratigraphic units; the box indicates the area enlarged in b. b) Detail of the units in the Cellon Section. c) View of the Silurian and lowermost Devonian part of the section.

conodont fauna was studied and described first by Walliser (1957, 1964), whose pioneering work on the section included the first proposed Silurian conodont zonation for the world (Walliser, 1964). The Walliser conodont collection deposited in Göttingen University was later restudied and integrated by several new samples, which provided a precise updated biostratigraphy of the section (Figs. 27-30; Ferretti and Schönlaub, 2001; Corradini et al., 2015a; Corriga et al., 2016; Corradini et al., 2020a).
Lithological investigations and microfacies analyses were carried out by Flügel (1965), Schönlaub (1985), Kreutzer (1992), Dullo (1992), and Histon (2012). Geochemical data on Carbon isotopes were presented by Wenzel (1997) and Jeppsson et al. (2012), and geochemical proxies in the end-Ordovician mass extinction by Hammarlund et al. (2012); Histon et al. (2007) studied the occurrence of K-bentonites, and Brett et al. (2009) published a sequence stratigraphical study; finally, Arts et al. (2024) calibrated the section by means of astrochronology methods.
Beside conodonts, palaeontological studies on the Cellon section deal on several fossil groups: acritarchs (Martin, 1978; Priewalder, 1987), bivalves (Kříž, 1974, 1979, 1999), brachiopods (von Gaertner, 1930; Plodowski, 1971, 1973; Jaeger et al., 1975; Cocks, 1979), chitinozoans (Priewalder, 1997, 1999, 2000), cephalopods (Ristedt, 1968, 1969; Gnoli and Histon, 1998; Histon, 1999, 2002, 2012; Histon and Schönlaub, 1999; Histon et al., 1999), corals (Pickett, 2007), foraminifers (Langer, 1969; Kristan-Tollmann, 1971), graptolites (Jaeger, 1975; Jaeger et al., 1975; Štorch and Schönlaub, 2012), ostracods (Schallreuter, 1990), trilobites (von Gaertner, 1930; Haas, 1969; Santel, 2001), and "small shelly fossils" and machaeridians (Dzik, 1994).
Studies on Late Ordovician glaciation have been published in several papers (Schönlaub, 1971, 1988; Schönlaub and Sheehan, 2003; Schönlaub et al., 2011; Hammarlund et al., 2012; Štorch and Schönlaub, 2012), and the Lau Event interval by Jeppsson et al. (2012).
In addition, the Cellon section represents the type section of five lithostratigraphic units: Uqua Formation (Schönlaub and Ferretti, 2015a), Plöcken Formation (Schönlaub and Ferretti, 2015b), Kok Formation (Ferretti et al., 2015a), Cardiola Formation (Ferretti et al., 2015b), and Alticola Formation (Ferretti et al., 2015c).
The section is the type locality of several fossils (Figs. 31-33):

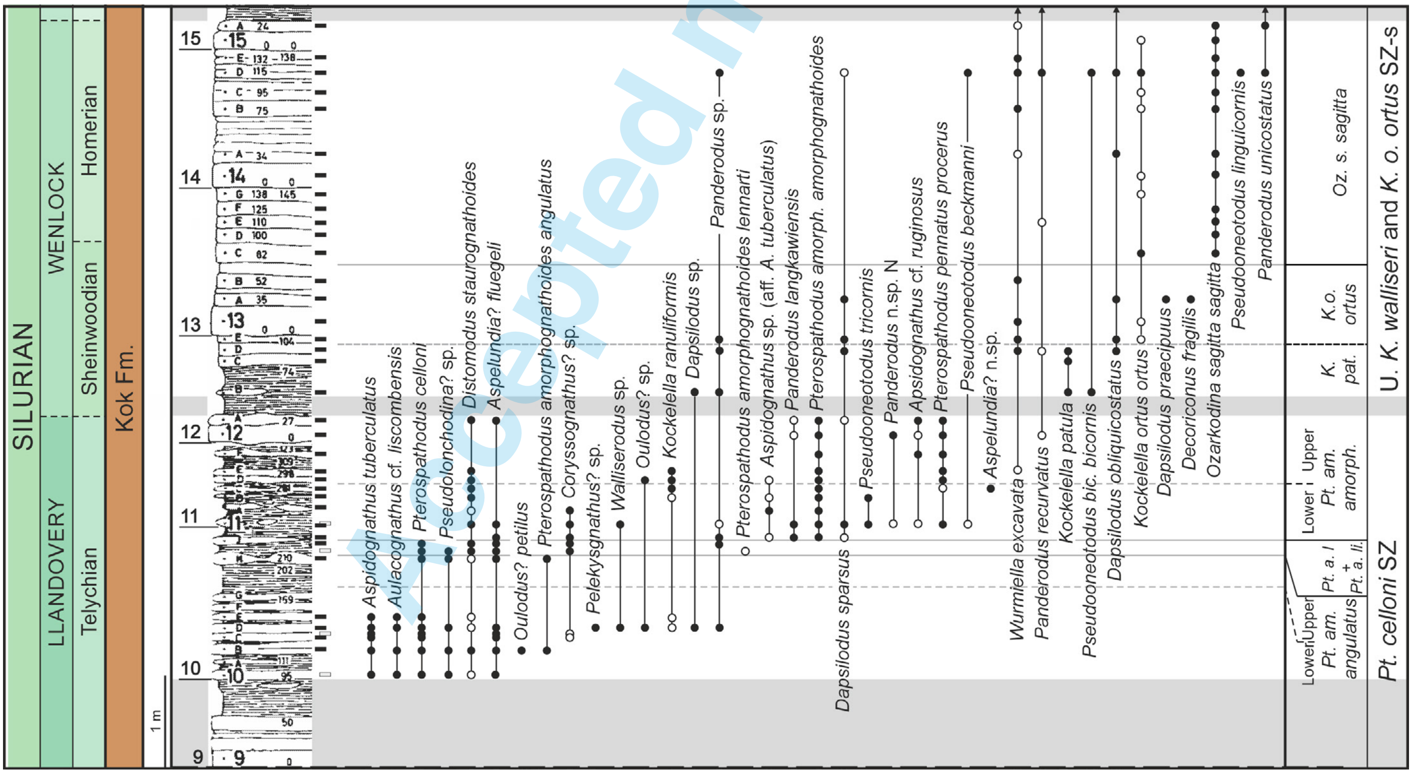

Fig. 27 - The Llandovery and Wenlock of the Cellon section (after Corradini et al. 2015a, modified). From left to right: chronostratigraphy (System, Series, Stage), lithostratigraphy, stratigraphic column (after the original drawing by Walliser, 1964), conodont samples (gray squares indicate samples for which the precise position in the section is not known), distribution of conodonts (white dots indicate problematic identifications), and biostratigraphy (subzones, zones, superzones). Arrows at the end of distribution lines indicate that the taxon also occurs above the illustrated interval. Horizontal grey belts: strata not dated, several biostratigraphic units have not been identified.

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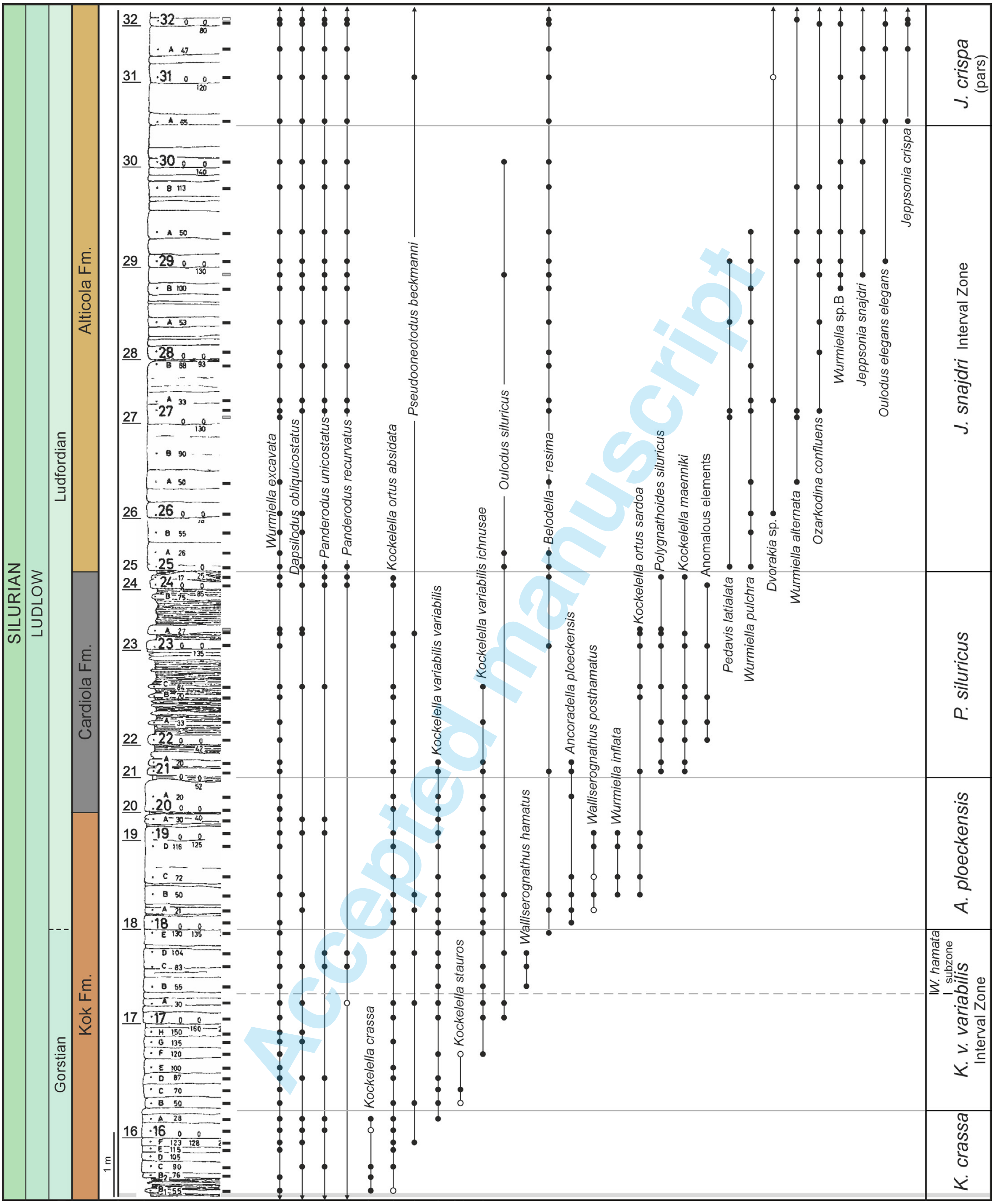

Fig. 28 - The Ludlow of the Cellon section (after Corradini et al. 2015a, modified). From left to right: chronostratigraphy (System, Series, Stage), lithostratigraphy, stratigraphic column (after the original drawing by Walliser, 1964), conodont samples, distribution of conodonts (white dots indicate problematic identifications), and biostratigraphy. Arrows at the end of distribution lines indicate that the taxon also occurs above/below the illustrated interval.

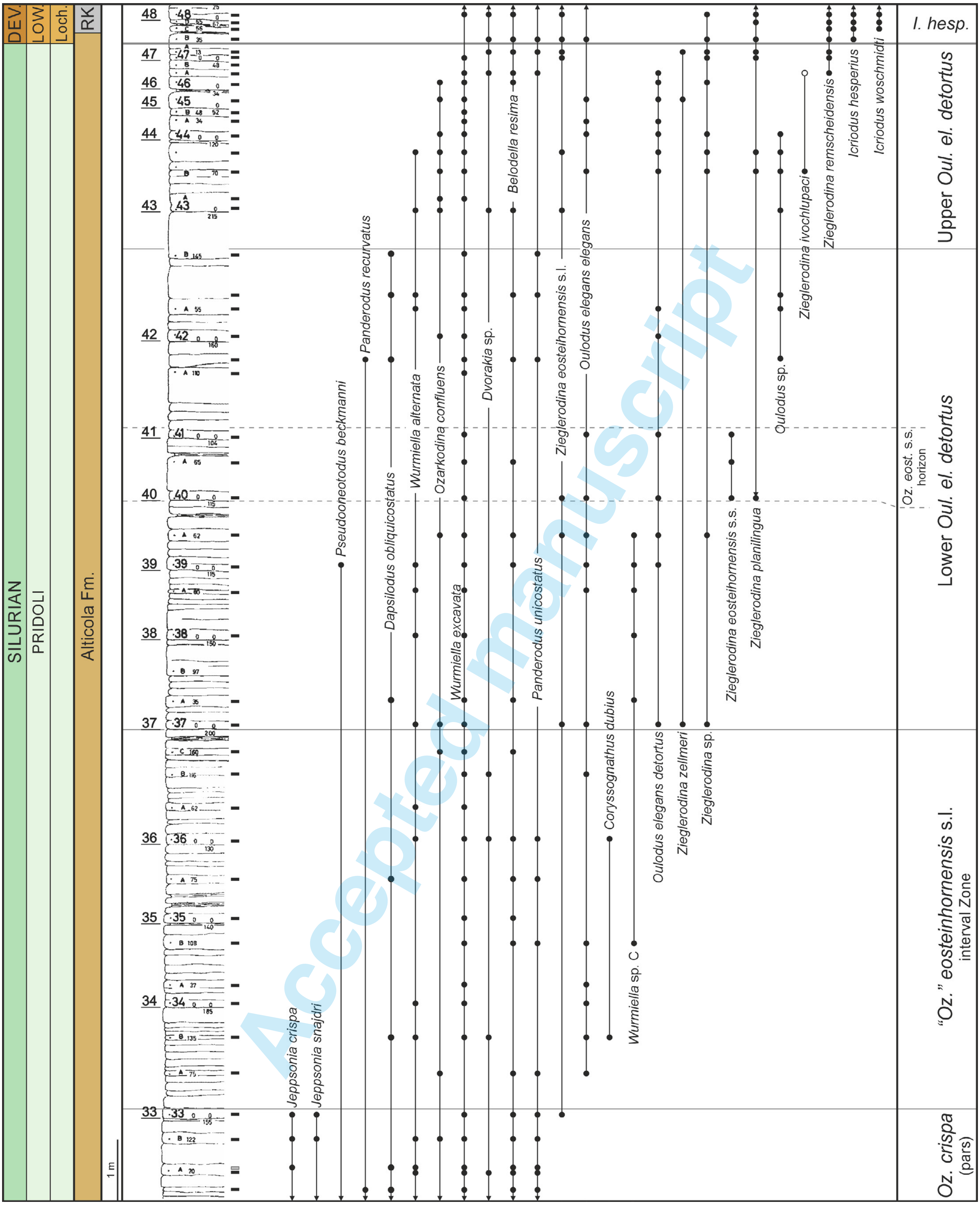

Fig. 29 - The Pridoli of the Cellon section (after Corradini et al. 2015a, modified). From left to right: chronostratigraphy (System, Series, Stage), lithostratigraphy, stratigraphic column (after the original drawing by Walliser, 1964), conodont samples, distribution of conodonts (white dots indicate problematic identifications), and biostratigraphy. Arrows at the end of distribution lines indicate that the taxon also occurs above/below the illustrated interval. Abbreviations: DEV=Devonian, LOW=Lower, Loch.=Lochkovian, RK=Rauchkofel Formation.

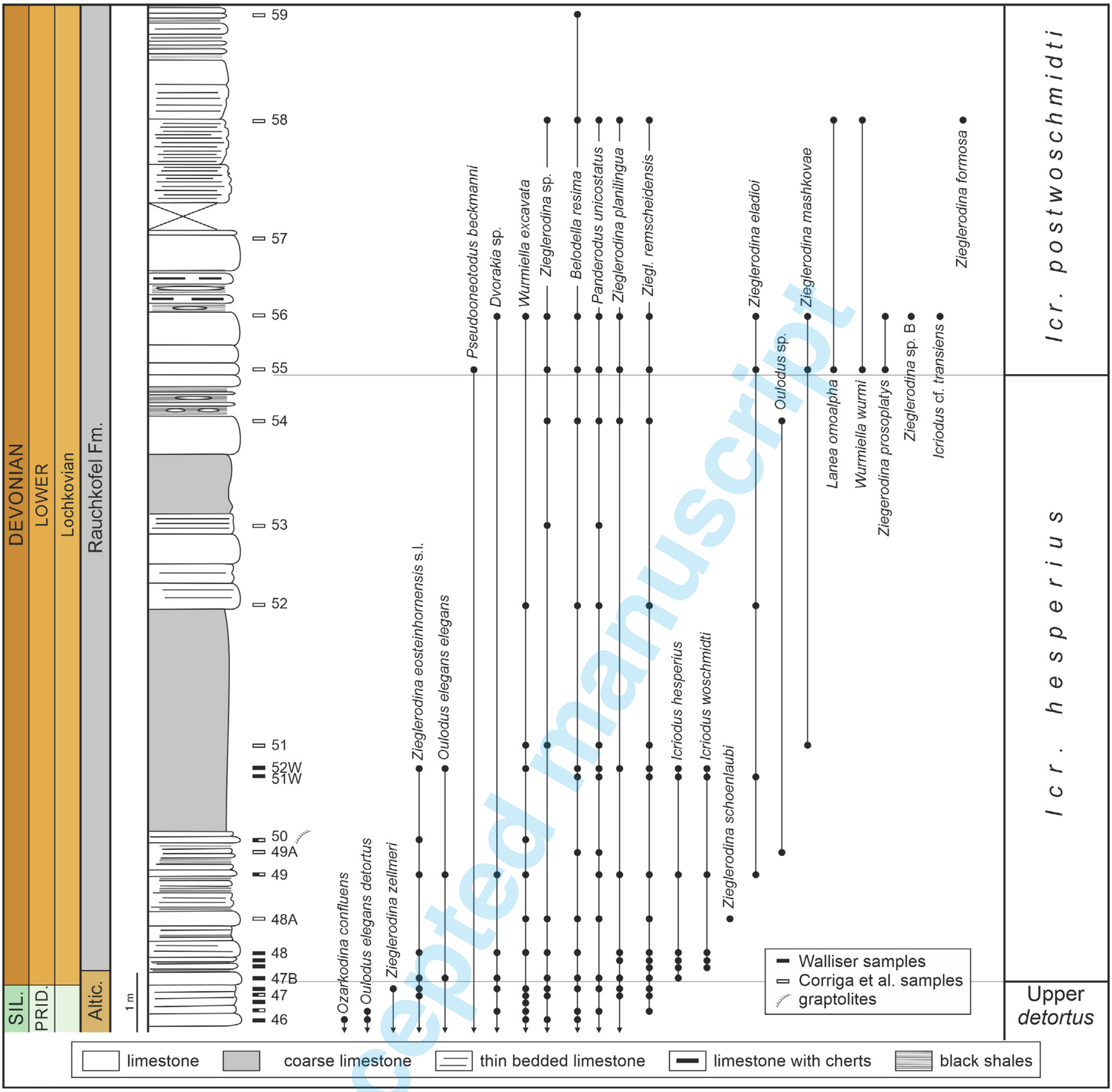

Fig. 30 - The Lochkovian of the Cellon section (after Corriga et al. 2016, modified). From left to right: chronostratigraphy (System, Series, Stage), lithostratigraphy, stratigraphic column, conodont samples, distribution of conodonts (white dots indicate problematic identifications), and biostratigraphy. Arrows at the base of distribution lines indicate that the taxon also occurs below the illustrated interval. Abbreviations: SIL=Silurian, PRID=Pridoli, Alt.=Alticola Formation.

- von Gaertner (1930) described the trilobite *Encrinurus celloni*.
- Walliser (1964) described 18 new taxa (species and subspecies) of conodonts: *Ancoradella ploeckensis*, *Aspidognathus tuberculatus*, *Hadrognathus staurognathoides*, *Kockelella crassa*, *Kockelella patula*, *Kockelella ranuliformis*, *Oulodus elegans detortus*, *Ozarkodina sagitta sagitta*, *Pedavis latialata*, *Pterospathodus amorphognathoides amorphognathoides*, *Pterospathodus amorphognathoides angulatus*, *Pterospathodus celloni*, *Pterospathodus pennatus pennatus*, *Pterospathodus pennatus procerus*, *Walliserognathus hamatus*, *Walliserognathus posthamatus*, *Wurmiella inflata* and *Zieglerodina eosteinhornensis*;
- Ristedt (1968) described 4 species of orthoconic cephalopods: *Hemicosmorthoceras laterculum*, *Hemicosmorthoceras celloni*, *Sphaerorthoceras carnicum* and *Parasphaerorthoceras accuratum*;

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– Plodowski (1971, 1973) described the brachiopods *Dubaria megaerella*, *Hebetoechia woschmidti*, *Lanceomyonia tardiplicata tardiplicata*, *Lanceomyonia tardiplicata alta* and *Oxypleurorhynchia acutiplicata*
– Cocks (1979) described the lingulate brachiopod *Caenotreta celloni* (now *Opsiconidion celloni*).
– Priewalder (1987) erected 7 new species of acritarchs: *Alveosphaera? densiporata, Diexallophasis parvifurcata, Helosphaeridium echiniformis, Lophosphaeridium hauskae, Multiplicisphaeridium carnicum, Multiplicisphaeridium martiniae* and *Tylotopalla cellonensis*;
– Kříž (1999) described 4 species of bivalves: *Cardicarnia barrandei*, *Cardiola stachei*, *Cardiola tinda*, *Mila janina* and *Patrocardia celloni*;
– Pickett (2007) erected the rugose coral *Spongophyllum coeni*.

The formations exposed (Figs. 26-30) and their fossiliferous content are briefly described below (from base to top):
Valbertad Formation. Poorly exposed below the base of the measured section; minimum thickness 15 m. It consists of greenish to greyish siltstones and shales. The age has been defined as Katian, based on the occurrence of the deep-water *Foliomena* brachiopod fauna (Harper et al., 2009).
Uqua Formation. Exposed in beds 1–5; ca. 5 m thick. The unit is represented by grey to brown flaser limestone dated to the Katian, *Amorphognathus ordovicicus* conodont Zone (Ferretti and Schönlaub, 2001).
Plöcken Formation. Exposed in beds 6–8; 6.2 m thick. It consists of greyish siltstone interbedded with impure bioclastic limestone at the base, grading upward into calcareous pyritic limestone and sandstone. The lowermost beds may indicate a diamictite origin, whereas the upper part shows soft-sediment deformation and gravity-driven features, including contorted structures, slumps, channel fills, and interbeds rich in fossil debris. It has been dated to the Hirnantian (*Metabolograptus persculptus* graptolite Zone), based on graptolites and brachiopods reported at the base of the unit (Jaeger et al., 1975; Štorch and Schönlaub, 2012). A carbonate $\delta^{13}C$ excursion corresponding to the prominent HICE peak at the Katian–Hirnantian boundary has been documented (Schönlaub et al., 2011).
Kok Formation. Exposed in beds 9–19; 13.5 m thick. It is represented by well-bedded, highly fossiliferous, brownish ferruginous cephalopod limestone, alternating at the base with black shale and marly interbeds. The formation is highly fossiliferous: cephalopods, trilobites, bivalves, brachiopods, gastropods and graptolites are observable in the field; among microfossils, conodonts, chitinozoans, achritarchs, scolecodonts and others have been documented. Trace fossils are also observable. The formation has been dated to Telychian to Ludfordian (from the *Pterospathodus celloni* to *Ancoradella ploeckensis* conodont zones), although several biozones are absent, either corresponding to thin black-shale intervals or to intervals of non-deposition (Corradini et al., 2015a).
Cardiola Formation. Exposed in beds 20-24A; it is a characteristic 3.5 m thick horizon of dark gray to black limestone with marly and shaly interbeds, deposited in a short interval of the Ludfordian (upper part of the *A. ploeckensis* to *Polygnathoides siluricus*) conodont zones. A hard ground is present at the top of the unit, indicating a *hiatus* between the Cardiola and the overlying Alticola formations, that has been estimated to last about 340,000 years (Arts et al., 2024).
Alticola Formation. Exposed in beds 25–47B; ca. 28 m thick. It consists mainly of grey to pinkish cephalopod limestone, with thin marly layers and occasional coarse bioclastic interbeds. The age range extends from the Ludfordian to the lowermost Lochkovian (from the *Ozarkodina snajdri* Interval Zone to the *Icriodus hesperius* conodont Zone). The Silurian/Devonian boundary is placed in the uppermost part of the formation, at the base of the bed corresponding to sample 47B, where the first occurrence of *Icriodus hesperius*—the index conodont for the base of the Devonian—has been documented (Corradini et al., 2015a). Cephalopods are abundant throughout the unit.
Rauchkofel Formation. Exposed from bed 47C to bed 59 and upward. The formation is composed of blackish, platy to laminated limestone with black marly and shaly interbeds; calcarenitic beds are present and become more common upward. At Mt Cellon, the unit is about 150 m thick, but only the lowermost 16.5 m were investigated in the Cellon section, as a steep wall prevented further sampling. Conodont and graptolite data (Walliser, 1964; Jaeger, 1975; Corriga et al., 2016) indicate a early Lochkovian age, corresponding to the *Icriodus hesperius*–*Icriodus postwoschmidti* conodont zones.
Higher in the mountain, the Kellerwand, Vinz and Cellon formations are exposed (Fig. 26a; Pondrelli et al., 2020).

Stop 2.2 - Casera Collinetta di Sotto A section

Coordinates: 46°36’00.4” N, 12°56’21.3” E. Altitude 1375 m

Casera Collinetta di Sotto A section is located about 500 m southwest of Monte Croce Carnico Pass and 100 m NE of the eponymous hut and can be reached in a few minutes with a short and easy walk on a dirt road. About 15 m of the grey to pinkish micritic limestones of the Pal Grande Formation are here exposed, unconformably capped

Fig. 31 - Holotypes of conodonts from Cellon section. All refigured after Walliser (1964). a) *Ozarkodina eosteinhornensis* (Walliser, 1964), P1 element, sample C 40, Alticola Formation, upper Pridoli. b) *Wurmiella inflata* (Walliser, 1964), P1 element, sample C 19, Kok Formation, Ludfordian. c) *Pterospathodus amorphognathoides angulatus* (Walliser, 1964), P1 element, sample C 10D, Kok Formation, Telychian. d) *Pterospathodus pennatus pennatus* (Walliser, 1964), P1 element, sample C 10J, Kok Formation, Telychian. e) *Ozarkodina sagitta sagitta* (Walliser, 1964), P1 element, sample C 14, Kok Formation, Homerian. f) *Pterospathodus celloni* (Walliser, 1964), P1 element, sample C 10J, Kok Formation, Telychian. g) *Oulodus elegans detortus* (Walliser, 1964), P2 element, sample C 45, Alticola Formation, upper Pridoli. h) *Walliserognathus posthamatus* (Walliser, 1964), sample C 19, Kok Formation, Ludfordian. i) *Pterospathodus pennatus procerus* (Walliser, 1964), P1 element, sample C 11D, Kok Formation, Telychian. j) *Walliserognathus hamatus* (Walliser, 1964), P1 element, sample C 17B, Kok Formation, Ludfordian. k) *Kockelella crassa* (Walliser, 1964), P2 element, sample C 16A, Kok Formation, Gorstian. l) *Kockelella ranuliformis* (Walliser, 1964), P1 element, sample C 11C, Kok Formation, Telychian. m) *Pedavis latialata* (Walliser, 1964), P1 element sample C 27, Alticola Formation, Ludfordian. n) *Pterospathodus amorphognathoides amorphognathoides* Walliser, 1964, P1 element, sample C 11D. o) *Aspidognathus tuberculatus* Walliser, 1964, P1 element, sample C 10D, Kok Formation, Telychian. p) *Kockelella patula* Walliser, 1964, P1 element, sample C 12D, Kok Formation, Sheinwoodian. q) *Hadrognathus staurognathoides* Walliser, 1964, P1 element, sample C 11C, Kok Formation, Telychian. r) *Ancoradella ploeckensis* Walliser, 1964, P1 element, sample C 19, Kok Formation, Ludfordian.

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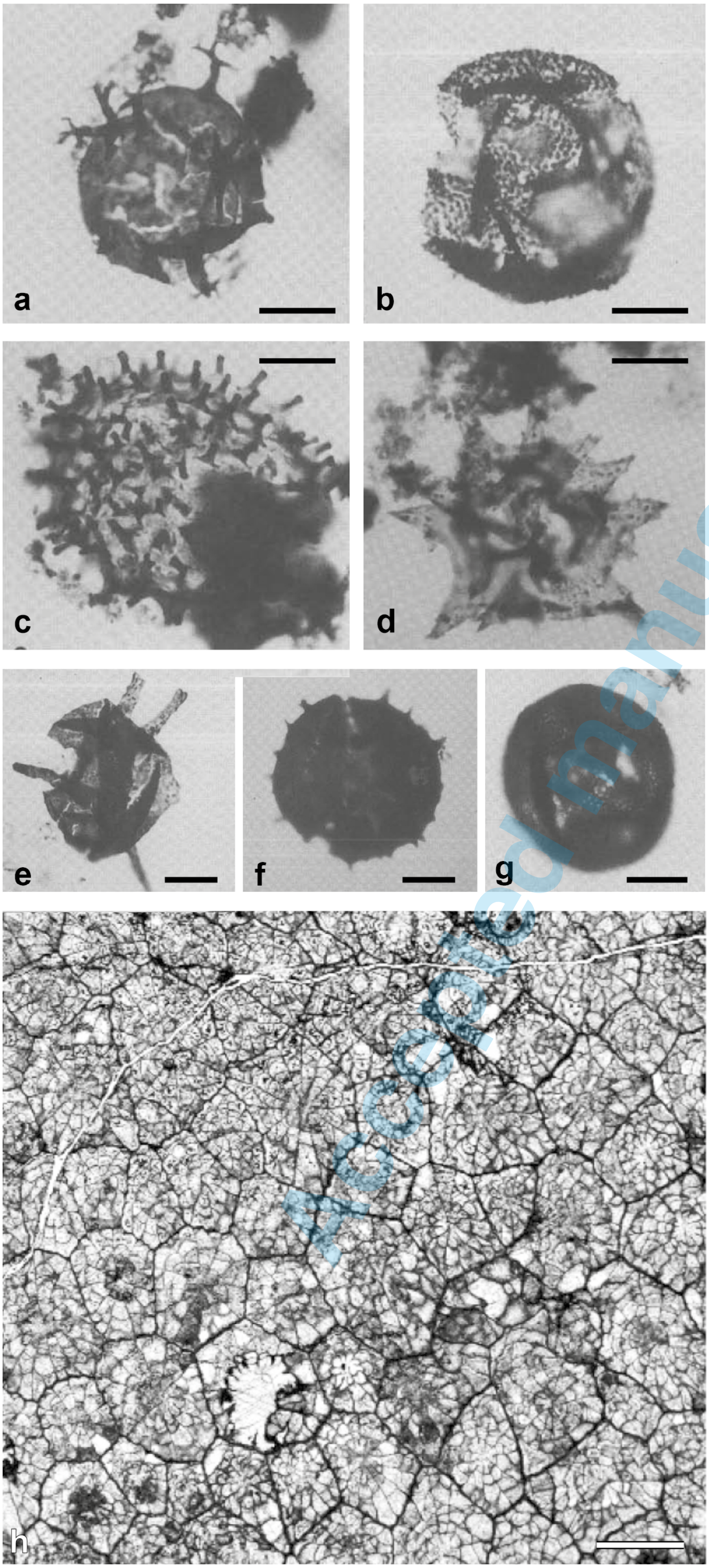

by a silcrete level attributed to the Plotta Formation (Fig. 34a-b). The rich conodont fauna of the section was studied by Perri and Spalletta (1998b) and is here integrated with a few more samples.

The limestone sedimentation is interrupted after 12.3 m by a 30 cm thick mineralised horizon (Fig. 34c) and is then resumed with another 2.7 m of micritic limestones. This mineralised level separates the Devonian and the Carboniferous parts of the section. The Devonian part is represented by well-bedded wackestone with fossil remains of ammonoids, brachiopods, trilobites, and ostracods. A level with stromatactis is present between samples 3 and 4. The Carboniferous part consists of a wackestone/packstone rich in goniatites, brachiopods, trilobites, ostracods, and rare crinoids.

The lower part of the section is referred to the middle to uppermost Famennian thanks to the rich conodont fauna that allows the recognition of several consecutive biozones from the *Ps. granulosus* Zone to *Pr. kockeli* Zone; the upper part is attributed to the upper Tournaisian and lower Visean *Sc. anchoralis* Zone to *Gn. homopunctatus* Zone. It thus appears that the top of the Famennian and most of the Tournaisian are missing in the carbonate succession, with a hiatus of at least 10 Ma associated with the mineralised horizon. Mineralogical and geochemical studies with the goal of obtaining information on the origin of this sedimentary gap are in progress.

Fig. 32 - Holotypes of fossil species from the Cellon section. Acritarchs (a-g) refigured after Priewalder (1987), rugose coral (h) after Pickett (2007) a) *Multiplicisphaeridium carnicum* Priewalder, 1987, below bed C12, Kok Formation, Telychian. b) *Lophosphaeridium hauskae* Priewalder, 1987, bed C11, Kok Formation, Telychian. c) *Tylotopalla cellonensis* Priewalder, 1987, base of bed C9, Kok Formation, Telychian?. d) *Alveosphaera densiporata* Priewalder, 1987, base of bed C9, Kok Formation, Telychian?. e) *Diexallophasis parvifurcata* Priewalder, 1987, bed C11, Kok Formation, Telychian. f) *Multiplicisphaeridium martiniae* Priewalder, 1987, base of bed C9, Kok Formation, Telychian?. g) *Helosphaeridium echiniformis* Priewalder, 1987, base of bed C9, Kok Formation, Telychian?. h) *Leucophyllum coeni* Pickett, 2007, bed C21, Cardiola Formation, Ludfordian. Scale bars: a-g: 10 µm; h-m = 2 mm.

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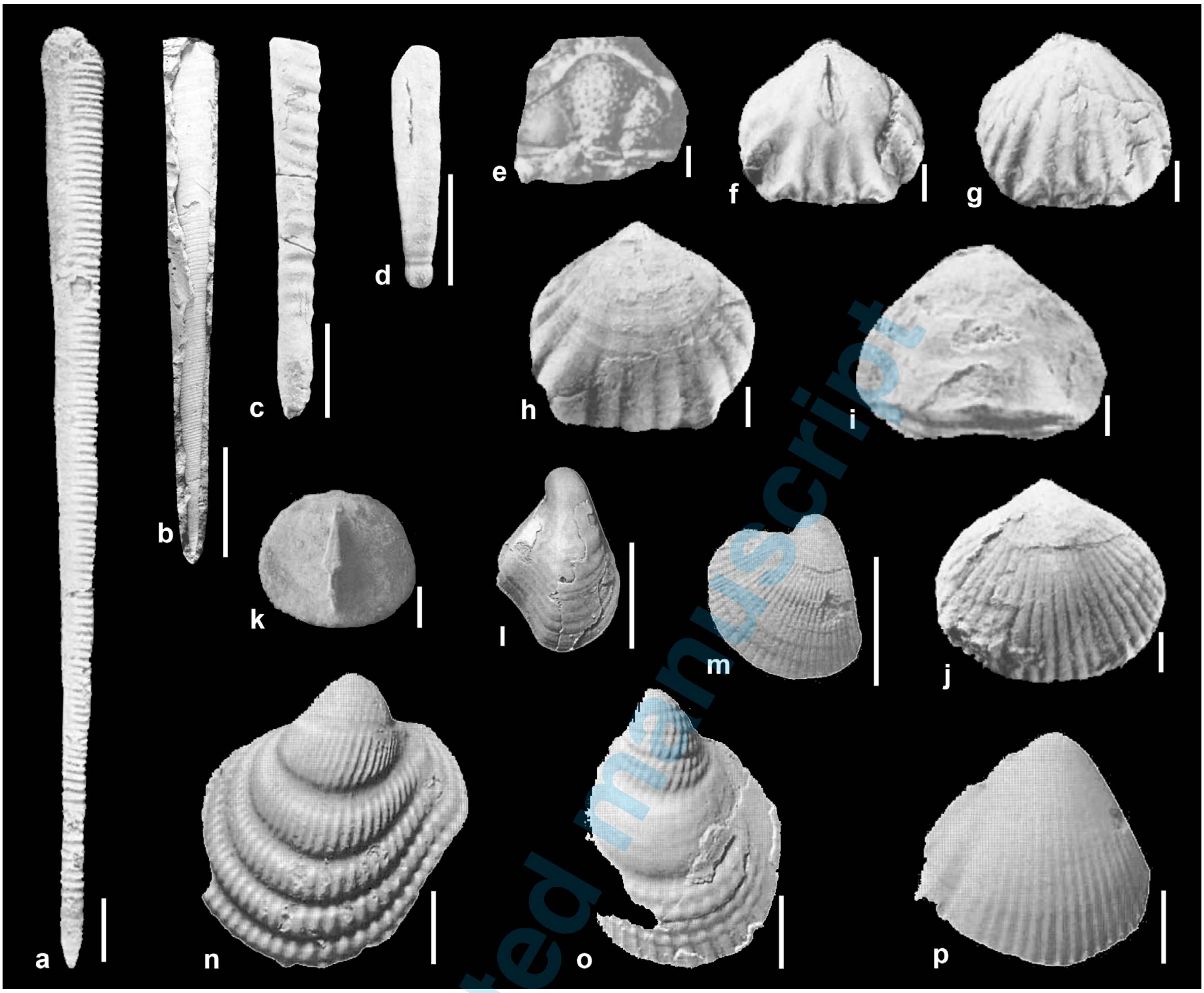

Fig. 33 - Holotypes of fossils from the Cellon section. Cephalopods (a-d) refigured after Ristedt (1968), trilobite (e) after von Gaertner (1930), brachiopods (f-k) after Plodowski (1971, 1973) and Cocks (1979), and bivalves (l-p) after Kříž (1999). a) Hemicosmorthoceras laterculum Ristedt, 1968, bed C40, Alticola Formation, upper Pridoli. b) Parasphaerorthoceras accuratum Ristedt, 1968, bed C40, Alticola Formation, upper Pridoli. c) Hemicosmorthoceras celloni Ristedt, 1968, bed C21, Cardiola Formation, Ludfordian. d) Sphaerorthoceras carnicum Ristedt, 1968, bed C40, Alticola Formation, upper Pridoli. e) Encrinurus ploeckensis von Gaertner, 1930, bed C15, Kok Formation, Homerian. f) Oxypleurorhynchia acutiplicata Plodowski, 1973, bed C35, Alticola Formation, lower Pridoli. g) Lanceomyonia tardiplicata alta Plodowski, 1973, bed C43, Alticola Formation, upper Pridoli. h) Lanceomyonia tardiplicata tardiplicata, Plodowski, 1973, bed C40, Alticola Formation, upper Pridoli. i) Hebetoechia woschmidti, Plodowski, 1973, bed C40, Alticola Formation, upper Pridoli. j) Dubaria megaerella Plodowski, 1971, bed C43, Alticola Formation, upper Pridoli. k) Opsiconidion celloni (Cocks, 1979), bed C10J, Kok Formation, Telychian. l) Cardicarnia barrandei Kříž, 1999, bed C12b, Kok Formation, Sheinwoodian. m) Patrocardia celloni Kříž, 1999, bed C12B, Kok Formation, Sheinwoodian. n) Cardiola tinda Kříž, 1999, bed C12B, Kok Formation, Sheinwoodian. o) Cardiola stachei Kříž, 1999, bed C12B, Kok Formation, Sheinwoodian. p) Mila janina Kříž, 1999, bed C23A, Cardiola Formation, Ludfordian. Scale bars: a-f, h-o = 2 mm; g = 200 µm.

Stop 2.3 - Casera Collinetta di Sotto D section

Coordinates: 46°36’02.6” N, 12°56’07.7” E. Altitude 1415 m

The Casera Collinetta di Sotto D section is exposed a few tens of metres west of the Casera Collinetta di Sotto A section and exposes about 7 m of massive grey limestones of the Pal Grande Formation (Fig. 35). The section was recently described by Corradini et al. (2025).

The section consists of gray mudstone and wackestone organised in thick beds dipping roughly 70° to the south and is bounded by pelites and sandstones of the Hochwipfel Formation. In fact, the limestones represent an olistolith of the Pal Grande Formation, which slipped into the Hochwipfel Formation. Macrofossils are rare, and only a few ammonoids are observable in the field, mainly in the bed of sample CDS 3.

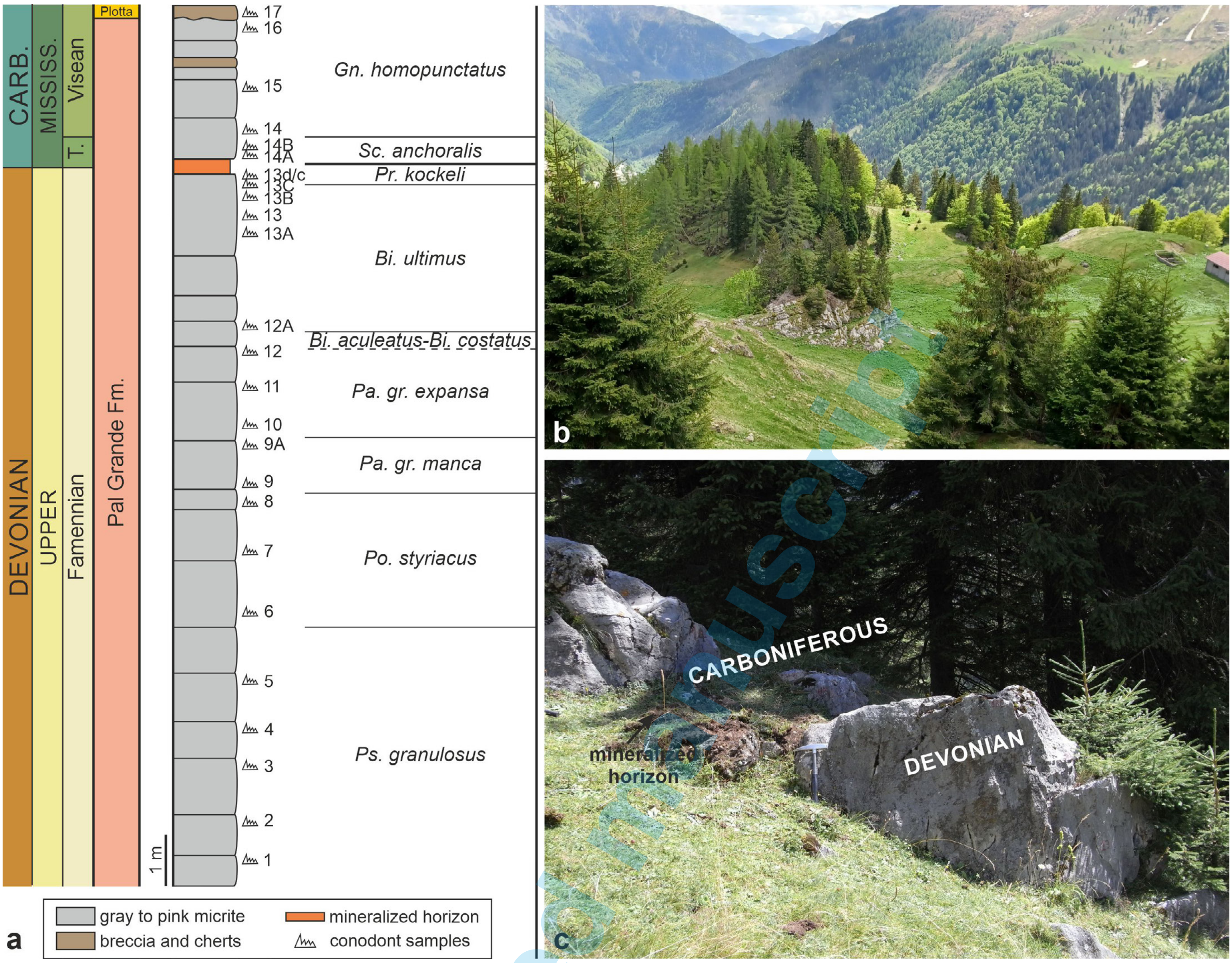

Fig. 34 - The Casera Collinetta di Sotto A section (CSA). a) Stratigraphic column of the section (after Corradini and Pondrelli, 2021, updated). From left to right: chronostratigraphy (System, Series, Stage), lithostratigraphy, stratigraphic column, conodont samples, and biostratigraphy. b) Panoramic view of the section from the west. c) Close view around the Devonian/Carboniferous boundary, where a 30 cm mineralised horizon interrupts the calcareous sequence.

The section has been attributed to the late Tournaisian and early Visean based on a rich and well-preserved conodont fauna (*Scaliognathus anchoralis* Zone and *Gnathodus* interregnum; Corradini et al., 2025). The Visean age of the uppermost part of the section is detected thanks to the occurrence of a single element of *Lochreia saharae*.

In the central part of the section, two bedding surfaces about 20 cm apart are characterised by decimetre-scale polygonal structures affecting the limestone parallel to bedding. The genesis of these structures might reflect desiccation processes likely related to exposure phases, biogenic activity (bioturbation), associated with microbial fauna (microbially induced sedimentary structures), synaeresis cracks, or seismites following mud shrinkage and sediment injection related to earthquakes.

Desiccation cracks would indicate subaerial exposure, while the two levels of bioturbation may suggest the formation of a hardground settling associated with a decline in carbonate factory production, leading to condensed sedimentation. Alternatively, a transgressive phase with more oxygenated conditions may have promoted bioturbation. However, this transgressive scenario is not supported by the rock record, which shows neither a revival of the carbonate factory nor a landward or deepening facies migration at the basin scale. Also, in Europe, high-frequency 4th-order eustatic variations are documented in the Tournaisian and in the Visean in Northern Europe (Poty, 2016; Herbig, 2016), within a 3rd-order sequence boundary more or less coincident with the stage boundary, or just below (Bábek et al., 2010). Based on these notes, Corradini et al. (2025) concluded that these levels are suggestive of sea level drop conditions, specifically indicating at least two episodes of high-frequency eustatic fluctuations near the Tournaisian/Visean boundary.

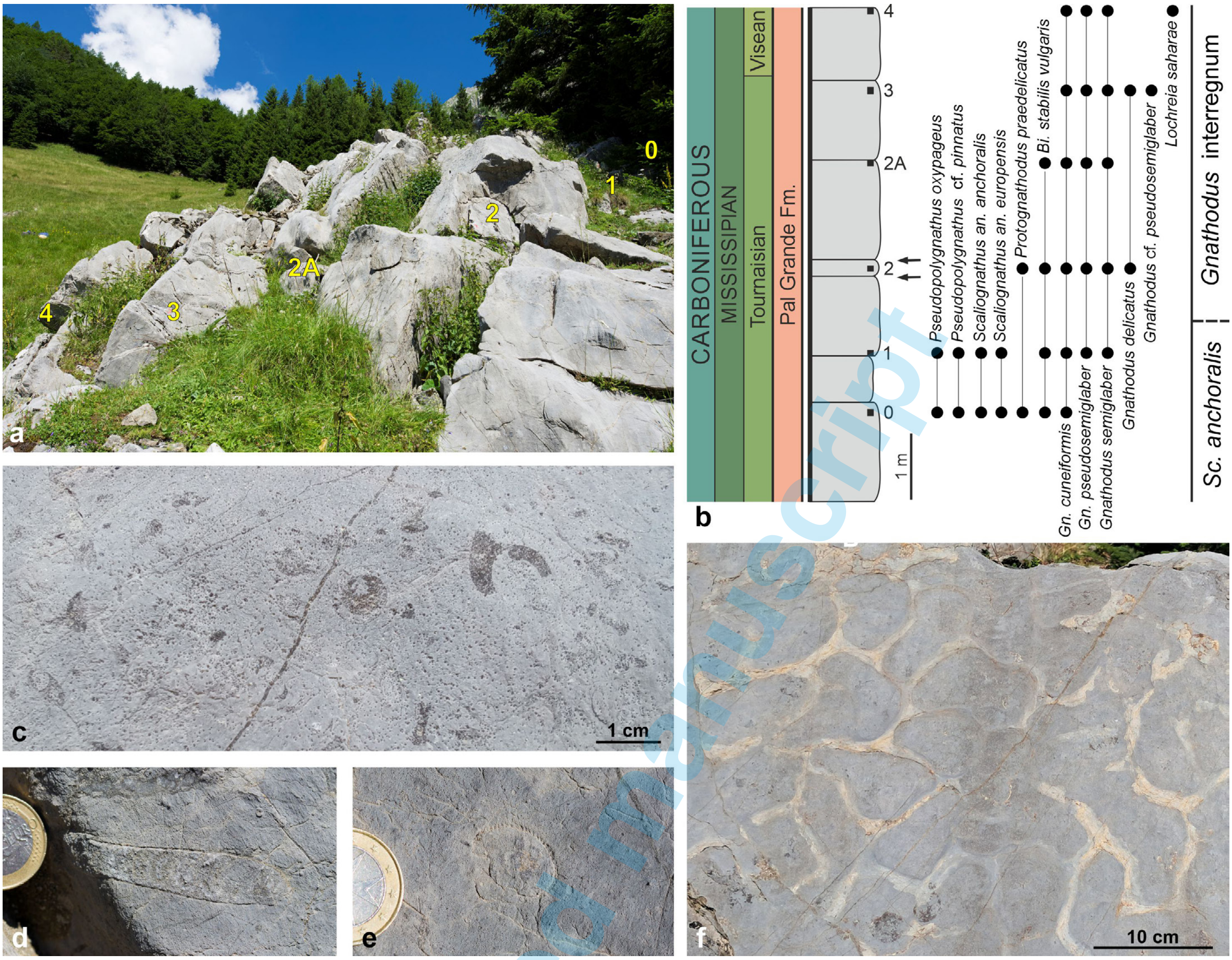

Fig. 35 - The Casera Collinetta di Sotto D section. a) View of the section with the position of the samples highlighted in yellow. b) Stratigraphic column of the section (after Corradini et al., 2025, modified). From left to right: chronostratigraphy (System, Series, Stage), lithostratigraphy, stratigraphic column, conodont samples, distribution of conodonts, and biostratigraphy. The arrows indicate the levels with polygonal structures. Abbreviations: *Bi.* = *Bispathodus; Gn.* = *Gnathodus*. c) Close-up view of a bed rich in ammonoid remnants. d) Longitudinal section of an ammonoid. e) Transversal view of an ammonoid. f) Detail of the surface with polygonal structures.

CASERA PRAMOSIO AREA

Pramosio is located north-east of Timau village (Fig. 24b) and represents a classical area for studies on the Late Devonian of the Carnic Alps. The succession consists of Lower to Upper Devonian limestones, disconformably overlain locally by the silcrete and chert layers of the Plotta Formation and/or by the radiolarian chert of the Zollner Formation, and by the siliciclastic deposits of the Hochwipfel Formation. Upper Devonian limestones of the Freikofel and Pal Grande formations make up most of the exposed section in the Pramosio area and have been extensively investigated by means of conodonts (Figs. 36-37). The Pal Grande Formation in this area is represented by almost all conodont biozones from Frasnian Zone 13a to the Famennian *Bispathodus ultimus* Zone, and its rich ammonoid (goniatites and clymenids) content has been the object of studies since the end of the 19th century (Gortani, 1907).

The area is dominated by a kilometre-scale Variscan anticlinal structures (Venturini, 1990), later amplified by a coaxial phase of Alpine compression in Chattian–Burdigalian time. This structure is subsequently dissected by younger Alpine fault systems active during the Serravallian-Tortonian and again in the Pliocene-Pleistocene. The cores of these folds preserve the oldest strata of the succession, which in the Pramosio area range from the Eifelian Vinz Formation up to the Hochwipfel Formation (Fig. 37). Here, the Devonian syn-reefal succession is represented by slope fore-reef deposits, supplied from the adjacent shallow-water environments. The uppermost part of the Freikofel Formation and the Pal Grande Formation record the post-reef sedimentation in this sector of the basin.

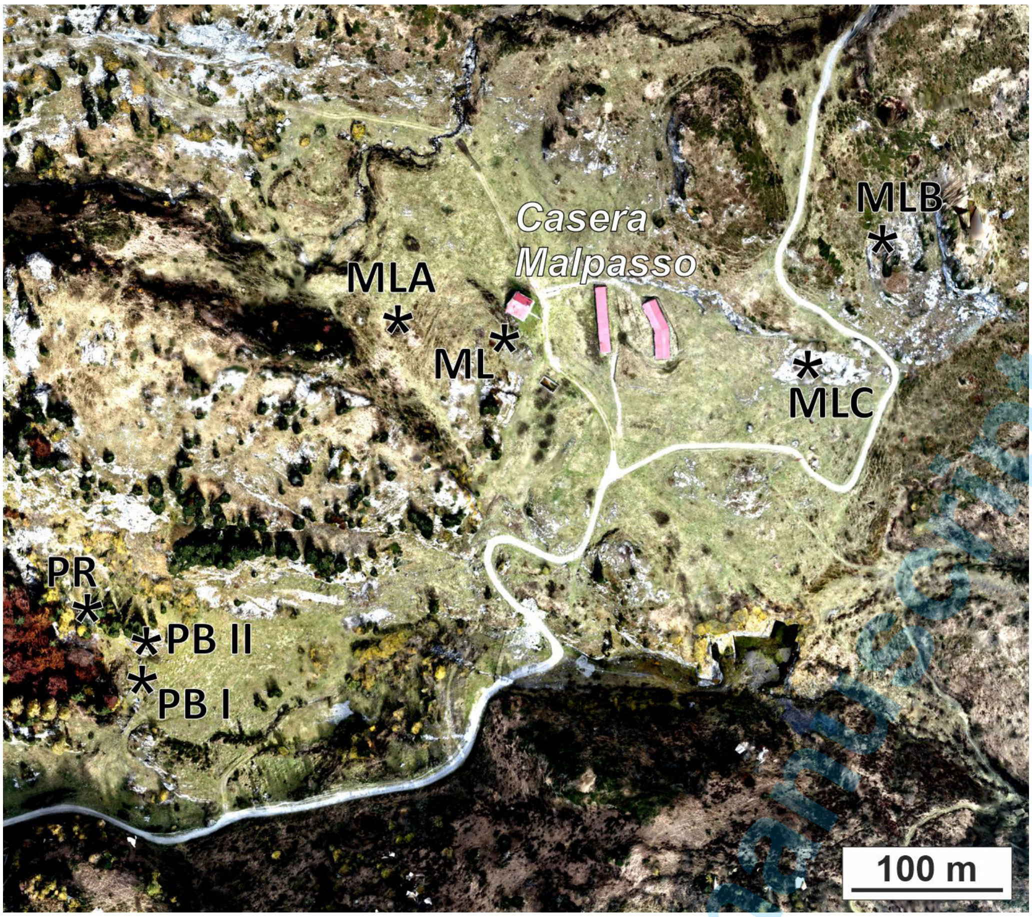

Fig. 36 - Orthorectified nadir view of the area north of Casera Pramosio with location of the measured stratigraphic sections. Abbreviations: ML = Malpasso; MLA = Malpasso A; MLB = Malpasso B; MLC = Malpasso C; PB I = Pramosio Bassa I; PB II = Pramosio Bassa II; PR = Pramosio.

Stop 2.4 - The Annulata event in the Pramosio Bassa section

Coordinates: 46°35'23.1" N, 13°01'58.5" E. Altitude 1565 m

The Pramosio Bassa section (Figs. 38-39) is located about 300 m north of Casera Pramosio, on the left side of path number 402, and is reachable after a short walk from the parking place. It exposes pelagic Upper Devonian limestones of the Pal Grande Formation and is especially interesting for documenting the Annulata Event.
Conodont data from part of the section (Pramosio Bassa I) were published by Perri et al. (1998), Mossoni (2014), and Spalletta et al. (2017). Mossoni (2014) also studied magnetic susceptibility, magnetic hysteresis, and major element content. Hartenfels and Becker (2016) mentioned the section in their global overview of the Annulata Event. The whole conodont collection has been revised for this work.
The Pramosio Bassa section has a total thickness of about 15 m and is separated into two parts (here named Pramosio Bassa I and Pramosio Bassa II, respectively) by a tectonic disturbance due to minor vertical faults belonging to a fault system whose main element is the Rio Seleit Line running along a small creek a short distance to the north (Spalletta et al., 1980). The Rio Seleit Line is a Variscan structure reactivated during the Alpine orogeny, acting as a dextral strike-slip fault during the Late Miocene-Pliocene. One of its major effects is the increased verticalisation of the Lower-Middle Devonian strata constituting the Mt Gamspitz. Minor faults of the same system of the Rio Seleit Line are responsible for the vertical displacement of the Devonian limestone sequence from Timau village to the Creta di Timau area.
The age of the Pramosio Bassa I section (Figs. 39-40) spans from the *Palmatolepis rugosa trachytera* to the *Palmatolepis gracilis expansa* Zone; the Pramosio Bassa II section (Fig. 40) spans from the *Polygnathus styriacus* Zone to the upper part of the *Bispathodus ultimus* Zone (*Pr. meischneri* Subzone). Apparently, a correlation between the two parts of the Pramosio Bassa section seems easy, especially considering the nearly horizontal bedding, but the vertical displacement between section PB I and PB II can be detected only by conodont biostratigraphic study, demonstrating that PB II is vertically displaced with respect to PB I. The original bedding planes are mm-cm thick, but the stratification now appears in beds 10 to ca 100 cm thick, often separated by mm levels of ochraceous pelite, with laterally irregular thickness along the exposure

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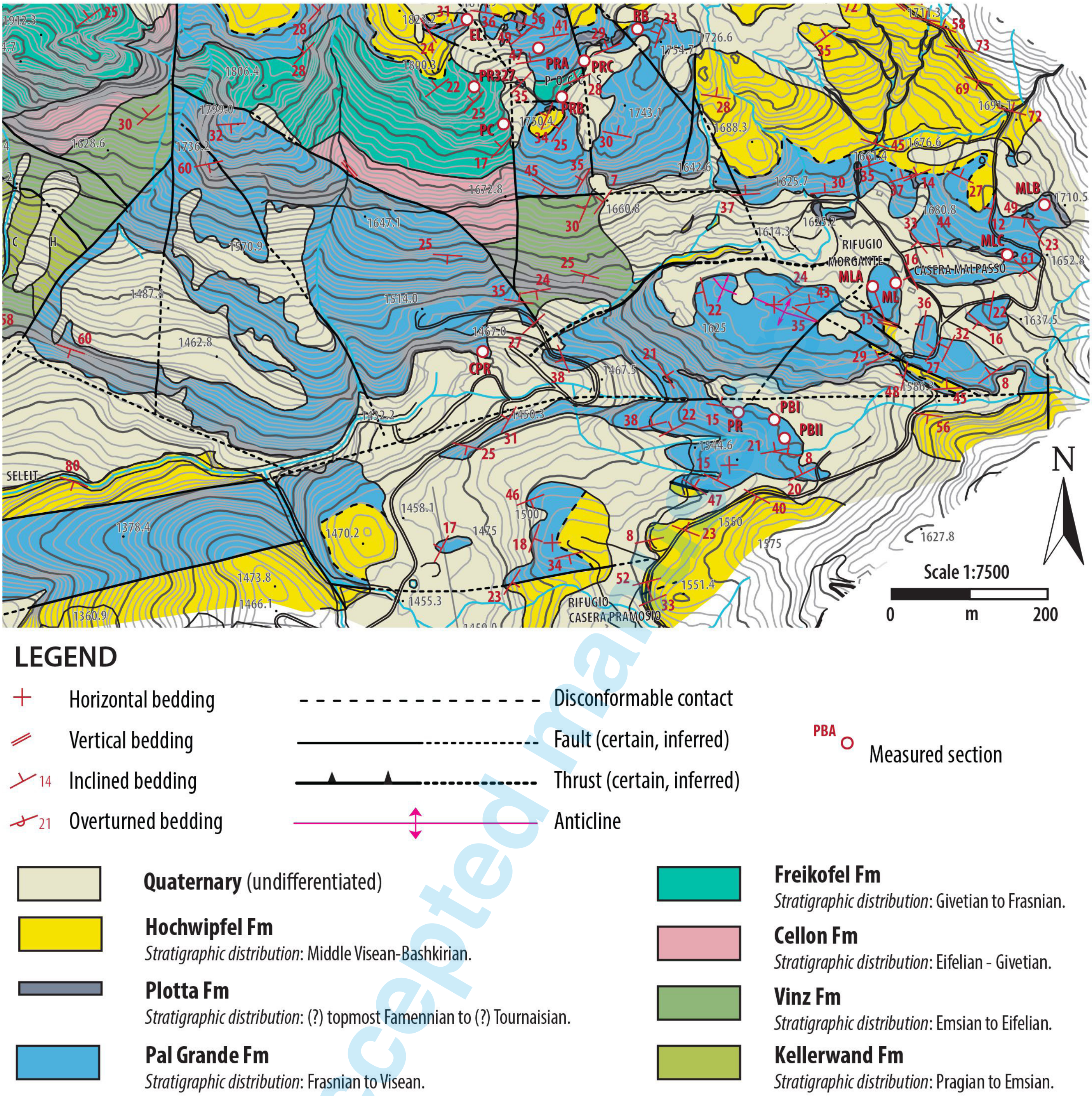

Fig. 37 - Geological map of the area north of Casera Pramosio (after Pondrelli et al., 2020, modified).

(Spalletta et al., 2017). The limestone sequence is also interested by levels with stromatactis structures. In the PB I section, the level of sample PB5a (Fig. 39b) is very rich in fossils of *Prionoceras* and other ammonoids. Hartenfels and Becker (2016) considered this level as an equivalent of the “Wagnerbank” of Thuringia, which represents a regressive phase in the highest part of the *annulata* Zone (UD IV-A). Black shale levels equivalent to the *Annulata* Black Shales are not present in this area. In the Carnic basin, a general transgressive tendency from the *Palmatolepis marginifera marginifera–Polygnathus styriacus* zones was inferred by Perri and Spalletta (2000) based on conodont biofacies analysis.

A few tens of metres to the west, the Pramosio (PR) section was measured (Spalletta and Perri, 1998). There, about 7 m of limestone of the Pal Grande Formation are exposed. A restudy of the rich conodont fauna enabled identification of the *Pa. gr. manca* and the *Pa. gr. expansa* zones. Abundant ammonoids are present in the upper part of the PB II and in the PR sections.

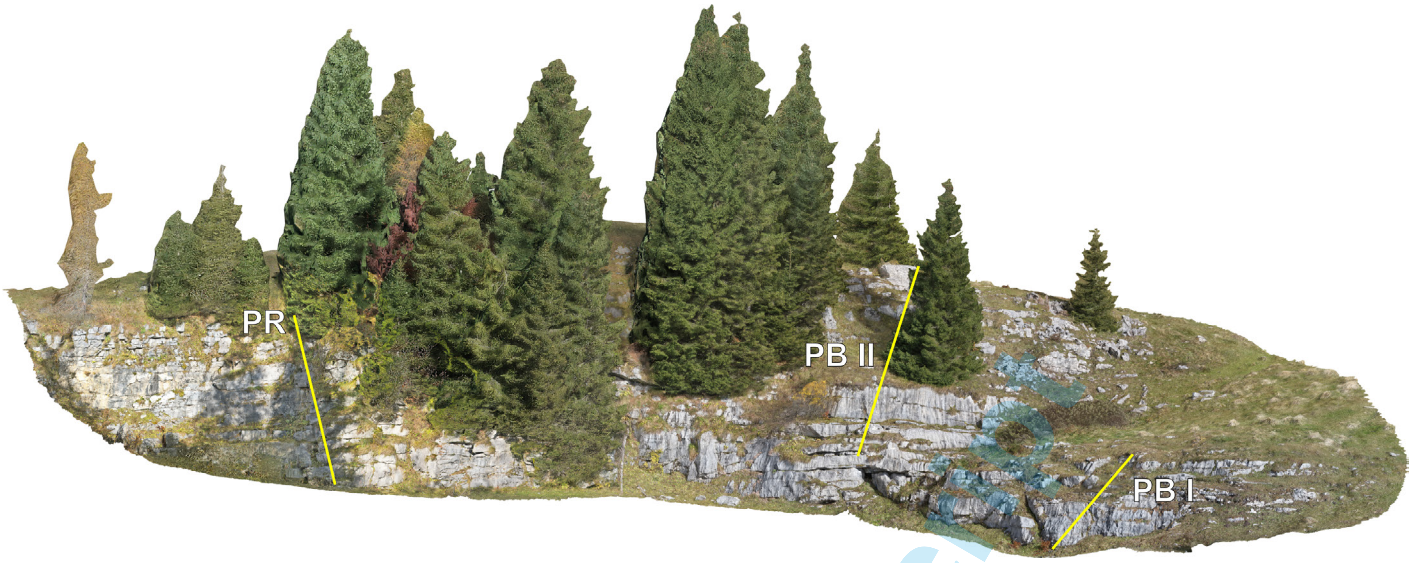

Fig. 38 - Panoramic orthorectified view heading north (4°) of the Pramosio and Pramosio Bassa I and II sections. Abbreviations: PB I = Pramosio Bassa I section; PB II = Pramosio Bassa II section; PR = Pramosio section.

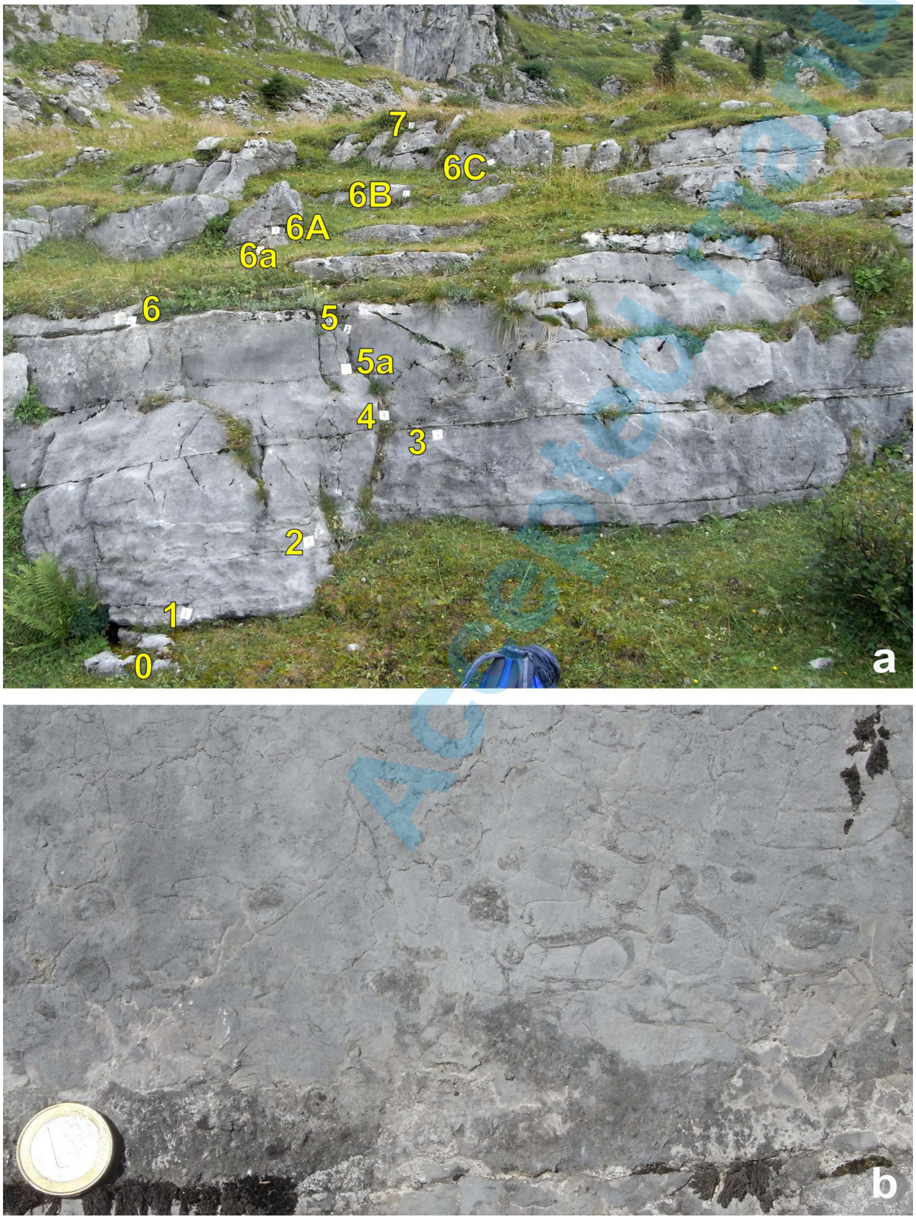

Fig. 39 - Views of the Pramosio Bassa I (PB I) section. a) Panoramic view with indication of the position of samples. b) detail of bed 5a, rich in ammonoids.

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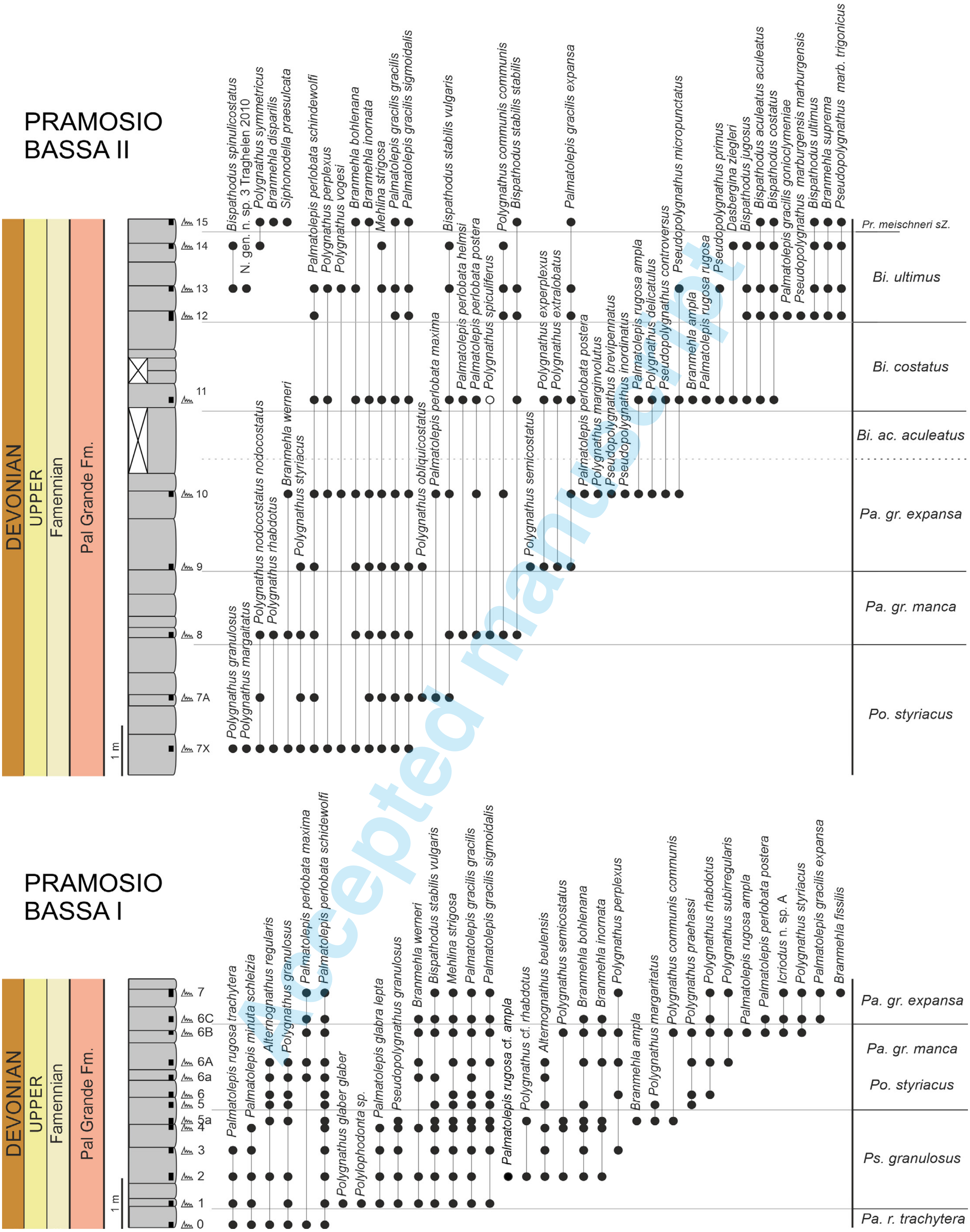

Fig. 40 - Stratigraphic column of the Pramosio Bassa I and Pramosio Bassa II sections. From left to right: chronostratigraphy (System, Series, Stage), lithostratigraphy, stratigraphic column, conodont samples, distribution of conodonts (white dots indicate problematic identifications), and biostratigraphy.

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DAY 3

On the third excursion day, two localities along the Gail Valley will be visited, as well as the Visitor Centre of the Carnic Alps Geopark in Dellach. It should be noted that the last stop is located north of the Gailtal Line, and therefore the rocks exposed there belong to the Austroalpine domain, and not to the Southern Alps. In the afternoon, we will move to Bolzano/Bozen.

Stop 3.1 - Silurian Graptolites in the Oberbuchach I section

Coordinates: 46°37´38" N, 13°06´32" E. Altitude 1120 m

The Oberbuchach I section is located in the roadcut of a small unpaved road running from the Gail Valley near Gundersheim to Gundersheim Alm (Fig. 41). The section exposes rocks for about 50 m of sandstones, black shales, and limestones of Katian to Gorstian age, and is a reference section for the Nölbling Formation (Schönlaub et al., 2015). It was studied by Jaeger and Schönlaub (1980), who provided data on Silurian and Lochkovian graptolites and conodonts. More recently, graptolites from the lower part of the section were studied by Štorch and Schönlaub (2012), and Schönlaub and Corradini (2017) revised the conodont fauna.
The section starts along a small side road with limestones of the Uqua Formation, not already studied in detail, followed by about 10 m of poorly bedded silty shales and muddy sandstones, belonging to the Plöcken Formation, which terminates with pyrite-bearing sandstones exposed where the road bends. Štorch and Schönlaub (2012) collected graptolites attributed to *Normalograptus* cf. *transgrediens* from a shaly horizon 50 cm below the top of the Plöcken Formation.
The section continues with a 0.5 to 1 m thick bed of quartzite, which subsequently passes upwards to the Nölbling Formation, represented by laminated dark-grey silty micaceous shale and black graptolitic shale, with intercalated limestone beds and lenses. Graptolites and rarer conodonts have been collected from various levels throughout the unit by Jaeger and Schönlaub (1980), indicating an age comprised between the Aeronian and the basal Gorstian for the Silurian part of the section (see Fig. 42 for the precise yielding). Štorch and Schönlaub (2012) confirmed the presence of a rich assemblage of the lowermost Aeronian *Demirastrites triangulatus* Biozone in the lowermost part of the black shale succession, about 30 cm above the basal quartzite. It results that at the Ordovician/Silurian boundary a hiatus spanning the whole Rhuddanian is present.

Stop 3.2 - Permian plants at Laas

Coordinates: 46°41´58" N, 12°59´05" E. Altitude 865 m

The locality is located north of Kötschach and is characterised by several large plant trunks (Fig. 43). One of those, 9 m long, is the largest plant fossil known from Austria. The locality was discovered around 1930 and was declared a natural monument in 1960. Since then, several more trunks have been found in the vicinity and are nowadays part of the "Geotrail Laas" by the Geopark of the Carnic Alps. Due to a storm event in 2018, the Geotrail is partly closed, and direct access to the petrified

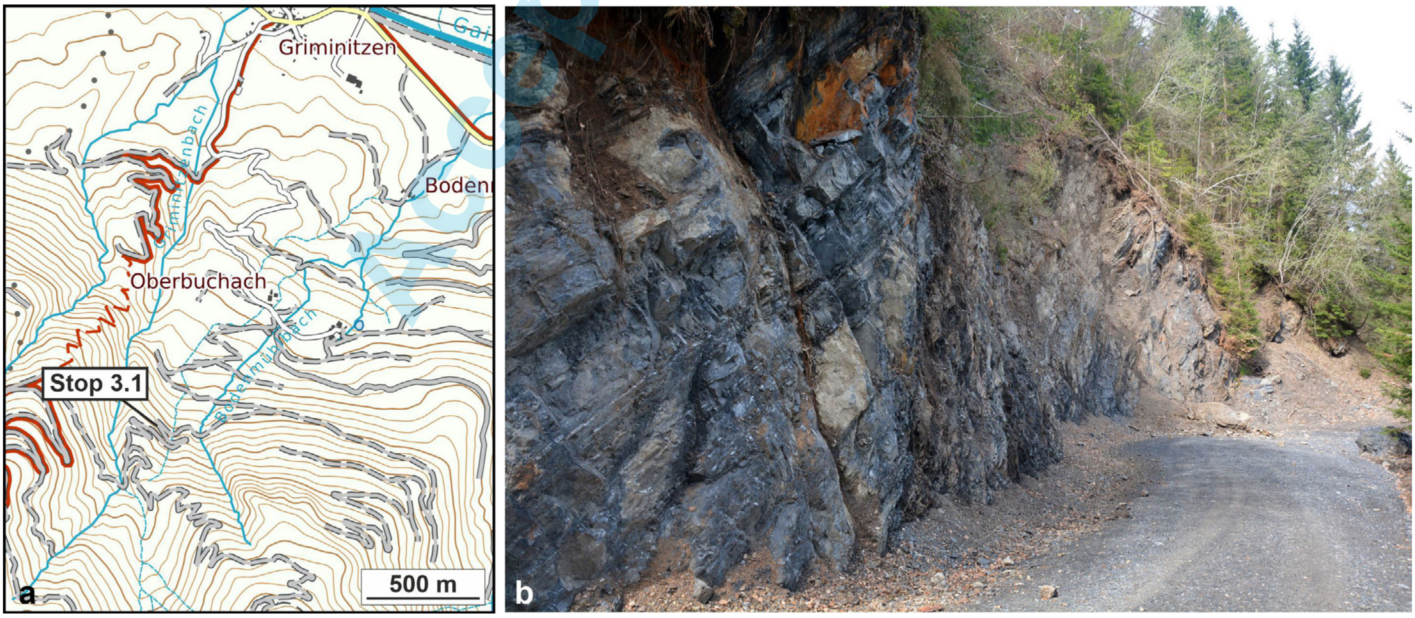

Fig. 41 - Location map (a) and panoramic view (b) of the Oberbuchach I section.

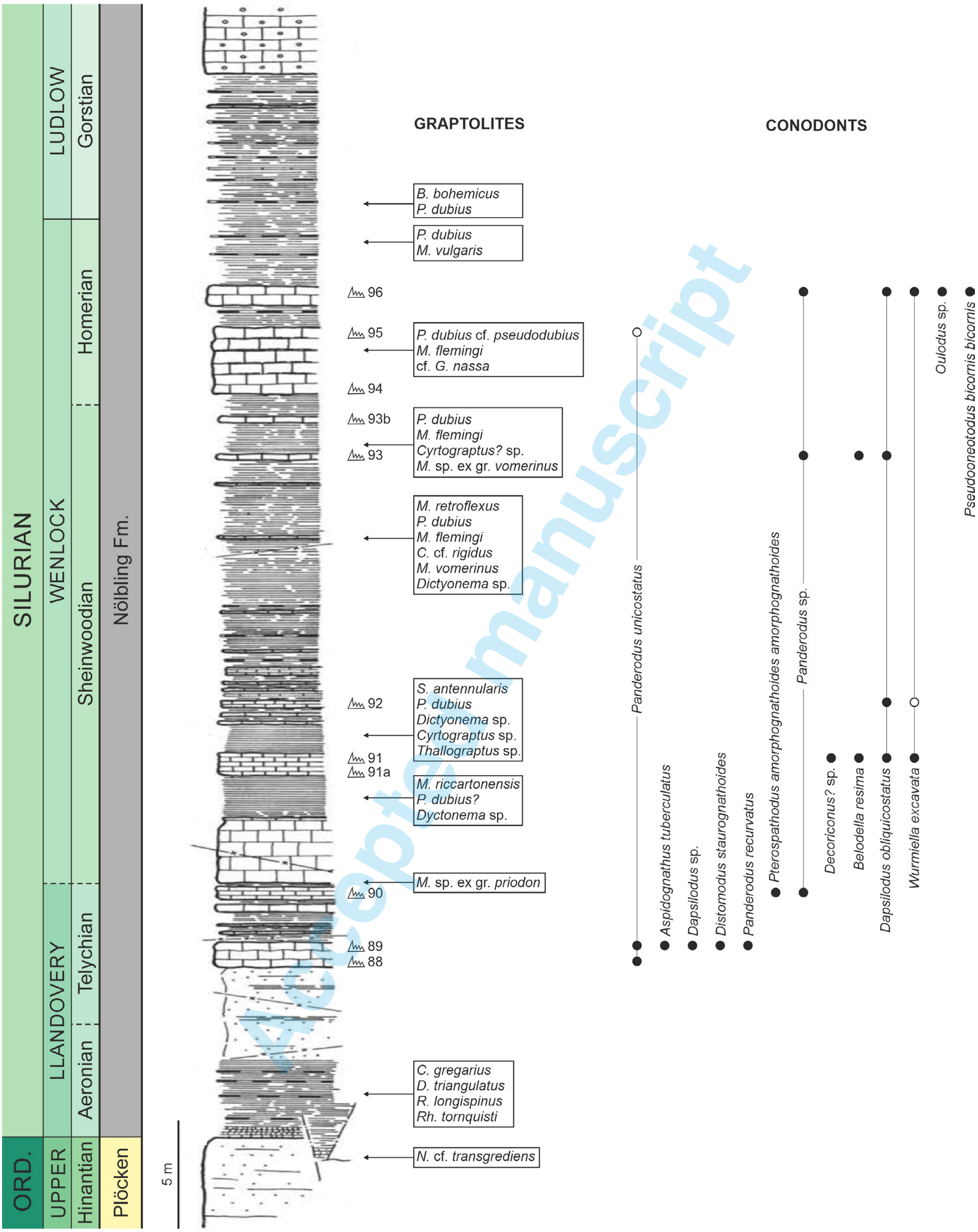

Fig. 42 - The Oberbuchach I section. From left to right: chronostratigraphy (System, Series, Stage), lithostratigraphy, stratigraphic column (modified after the original drawing by Jaeger and Schönlaub, 1980*), conodont samples, occurrence of graptolites and conodonts. Abbreviation: ORD.=Ordovician.

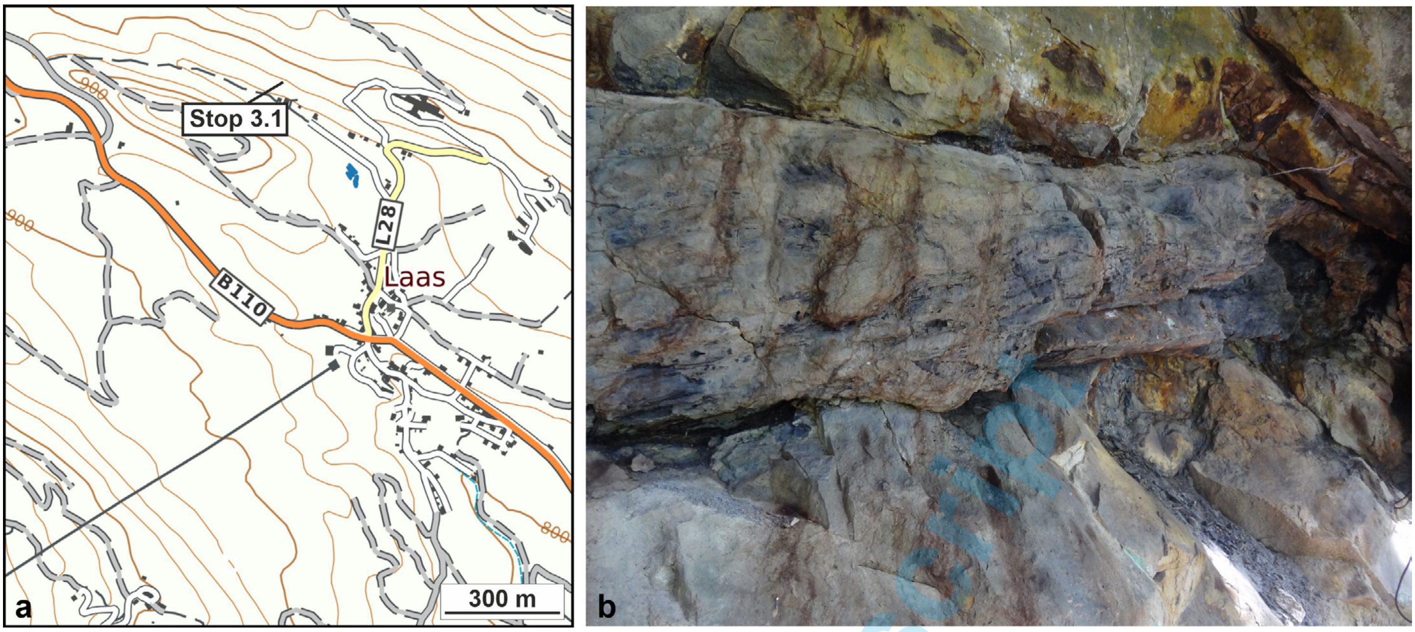

Fig. 43 - a) Location map of the stop at the lower Permian trunks locality near Laas. b) One of the trunks.

trees is presently not possible. Visitors are encouraged to check accessibility before reaching the site.

The tree trunks show no branching and no bark is present; the diameter ranges from 7 to 55 cm. The largest trunk has been identified by Anger (1964) as *Dadoxylon schrollianum* (Goepp.) Frentzen, a common conifer of the lower Permian. Kothe (2012) sampled from several trunks (including the largest) and showed that the original organic matter has not been replaced, but the original pores within the wood structure have been filled with pure quartz. A determination at a specific level was not possible, but the trunks likely belong to conifers.

The trunks are embedded in a sequence of grey to greenish, sandy, and fine-grained fluvial sediments and show no preferred orientation, thus pointing to a deposition as driftwood, which is in accordance with the clastic proximal to distal alluvial fan deposits with debris flows intercalated with *playa* sediments of the Laas Formation. However, for a long time these rocks were attributed to the lowermost part of the overlying Gröden/Val Gardena Sandstones, until Kothe (2012) and Kothe and Krainer (2014) demonstrated that they belong to the Laas Formation on the basis of the petrographic composition of the unit. Findings of other fossil plant remnants, including fragments of *Callipteris* cf. *conferta* and *Ernestiodendron filiciformis* within the lower part of the Laas Formation from the nearby locality "Kötschach 2" (van Amerom et al., 1976; Fritz and Boersma, 1987) support this hypothesis. The Laas Formation in the Drau Range is dated to the early Permian, with the absolute age of the trees commonly given at 280-290 Ma.

Kothe and Krainer (2014) also observed a thin tuffite layer, which indicates volcanic activity already in the early Permian; this might have been the source of silica used for the quartz infilling of the wood tissue.

The mainly grey-coloured sediments with the tree remnants indicate warm but still moist climates in the early Permian with a sparse vegetation and rare trees growing up to 30 m in height. The overlying red-coloured sediments of the upper part of the Laas Formation and of the overlying Gröden/Val Gardena Sandstones prove increasing temperatures with dry and desert-like environments.

Within the red sediments of the Laas Formation, several hundred tetrapod footprints have been discovered after a systematic excavation in 2017 (Lindenbauer et al., 2019). The vegetated floodplain provided living conditions for amphibians (*Batrachichnus*), reptiliomorph amphibians (*Amphisauropus*, cf. *Ichniotherium*), as well as reptiles (*Dromopus, Tambachichnium, Varanopus*). Ecological marks are given by microfossils as well as root marks, desiccation cracks, ripple marks, and algae mats. The exhibition "Saurians of the Gailtal Valley" in the visitor centre of the Geopark Carnic Alps gives an excellent insight into the world of 290 million years ago.

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