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A Late Ordovician conodont fauna from the Uqua Section, Carnic Alps, Italy

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ABSTRACT - The Uqua Section of the western Carnic Alps (Italy) represents the reference succession where conodont studies in the Ordovician of southern Europe were initated. The pioneer paper by Serpagli (1967) described the fauna there recovered as morphospecies, in use at that time, with the introduction of several new taxa that were carefully designated but illustrated only with drawings.

A biostratigraphically diagnostic conodont fauna of more than 1500 specimens, preliminarily reported by Vai & Spalletta (1980) but never described, is herein analyzed and figured for the first time. The Amorphognathus ordovicicus *Biozone is represented by a well-preserved conodont assemblage of 15 species belonging to 15 genera. Common taxa are representatives of* Hamarodus brevirameus, Scabbardella altipes *and* Amorphognathus ordovicicus. *They co-occur with less common species including* Dapsilodus mutatus, Eocarniodus gracilis *and* Plectodina alpina. *This fauna, documenting the* Hamarodus brevirameus-Dapsilodus mutatus-Scabbardella altipes *biofacies, is strikingly similar to other occurrences elsewhere in the Carnic Alps. The uppermost calcareous blocks, associated with an Hirnantian brachiopod fauna, do not vary significantly in conodont content from the lower levels. The Uqua Section does not reveal the typical Hirnantian conodont signature, indicated by the genera* Sagittodontina *and* Istorinus, *reported in the Carnic Alps only from the Cellon Section.*

INTRODUCTION

A series of early conodont studies in the mid last century was using single element (form) taxonomy. In spite of the successive multielement taxonomic revolution, several of those papers still represent masterpieces commonly referred to even nowadays. They report accurate descriptions of morphotypes, reinforced by illustrations of the specimens by hand-made camera lucida drawings displaying all diverse views of the elements (including transversal sections of the base or at different heights of the cusp) as electronic microscopes were still not the routine. In spite of their enormous significance, most of these old collections have been rarely restudied and re-assembled with a modern taxonomic approach, preferring descriptions of new sections and the study of additional samplings.

The Carnic Alps have been extensively studied for decades thanks to the magnificent Paleozoic sequences exposed. Stache (1874) was the first to record Ordovician rocks and faunas from the Uqua valley, located west of the city of Tarvisio in the easternmost part of the Carnic Alps (Fig. 1). Late Ordovician acritarchs, algae, bivalves, brachiopods, bryozoans, chitinozoans, conodonts, corals, echinoderms, foraminiferans, gastropods, graptolites, nautiloids, ostracods, radiolarians, sponge spicules, trilobites and trace fossils have been reported (Ferretti et al., 2023 and references therein), while no fossil record is so far reported from the Lower and Middle Ordovician, dominated by terrigenous sequences and volcanics. The Upper Ordovician Sandbian, Katian and Hirnantian stages are biostratigraphically well constrained by means of conodonts, brachiopods, graptolites, chitinozoans and trilobites (Schönlaub et al., 2017; Schönlaub & Forke, 2021 and references therein).

Conodont investigation in the Ordovician of the Carnic Alps started in the late 60s-early 70s of the last century (see below a brief summary). Particular importance were studies led by Serpagli in the Uqua valley, culminating in his monumental monograph of 1967, published in Italian, with samples collected from a 2 m calcareous level ("Tonflaserkalke") in the Rifugio Nordio area, later referred to as the Uqua Section (samples RN 1, RN 2, RN 3 and RN 4). A collection of over 3000 elements was there recovered from about 9 kg of material. An additional conodont assemblage was provided by twelve productive samples in the close-by area of Monte Zermula, where the "Tonflaserkalke" reached a thickness of 3.5 m, but conodont productivity was lower as over 38 kg of processed limestone produced about 3000 elements (Serpagli, 1967).

In the same Uqua valley, Vai conducted different sampling campaigns, summarized in his paper of 1971. In particular, in 1969 he resampled for conodonts exactly the four Rifugio Nordio/Uqua Section levels of Serpagli (301 = RN 4, 302 = RN 3, 303 = RN 2, 304 = RN 1) that, with additional sampling from some overlying limestone pebbles or tabular blocks floating into a quartz-rich sandstone bearing brachiopods of the *Hirnantia* fauna, were later reported in Vai & Spalletta (1980). The lower part of the section was assigned to the Upper Ordovician while the uppermost samples, where Ordovician elements appeared associated with Silurian ones, was provisionally attributed to the Llandovery. No description or illustration of the material was given, as the paper was planned as a field-excursion guide to an International Conodont meeting.

The aim of the present study is to provide a review of the original conodont collection of Vai & Spalletta (1980), by also integrating unpublished data, in an attempt to unravel a global signal for the Late Ordovician of the Carnic Alps.

GEOLOGICAL SETTINGS

The Carnic Alps, the easternmost part of the Southern Alps, are located across the Austria-Italy border. They crop out in a narrow strip from the Passo di Monte Croce Comelico to the Tarvisio area (Fig. 1) reaching about 110 km in length and a maximum width of 15 km. They underwent both Variscan and Alpine orogenies. The oldest part of the sequence, ranging from the ?Cambrian-Lower Ordovician to the basal part of the Pennsylvanian (upper Carboniferous), constitutes the so called "Paleocarnic Chain", the Variscan core of the Eastern Alps. This oldest Chain consists mainly of non- to anchimetamorphic units with some low-grade metamorphics cropping out as elongated tectonic slices along the Gailtal valley and can be split into two zones (western and eastern) marked by different deformative characters and history. The two zones are separated by the Val Bordaglia Thrust (Venturini & Spalletta, 1998; Hubich et al., 2000; Brime et al., 2008), an important Variscan tectonic lineament directed NE-SW. The western Zone, ranging from Passo di Monte Croce Comelico to Forni Avoltri, consists of epimetamorphic rocks mainly of Ordovician age (Hubich et al., 2000; Laüfer et al., 2001; Sassi et al., 2004; Corradini & Suttner, 2015). The eastern Zone from Forni Avoltri to Tarvisio is represented by non- to anchimetamorphic units with minor epizonal area successions. The non metamorphic units constitute one of the best preserved and complete Paleozoic sequences of the world, globally renowned for their rich fossil content. The Gailtal Line, eastern segment of the Periadriatic Lineament, borders the Paleocarnic Chain to the north; to the south, the Chain is unconfortably covered mainly by Triassic successions.

The study of the Paleozoic rocks of the Carnic Alps started in the late XIX century when Austrian geologists began to investigate the fossiliferous non metamorphic successions. These oldest studies on lithostratigraphy and paleontology include papers by Stache (1874) who was the first specifically focusing on rocks and fossils of the Uqua valley. Although the Paleozoic successions of the Carnic Alps have been intensively investigated for over 150 years, the lithostratigraphic pre-Variscan units were formalized only recently (Corradini & Suttner, 2015) as a result of an international project involving mainly Austrian and Italian scientists. The Ordovician successions were formally subdivided into eight formations (Schönlaub, 2015a, b; Schönlaub & Ferretti, 2015a, b, c; Schönlaub & Heinisch, 2015; Schönlaub & Simonetto, 2015; Schönlaub & Venturini, 2015). The Lower to Middle Ordovician formations, cropping out west of the Val Bordaglia Line, are represented by terrigenous and volcanic to volcanoclastic successions that underwent low grade metamorphism and lack any fossils.

Recently, new geochronological data age (Siegesmund et al., 2018, 2021) lead to date back possibly to the Cambrian the oldest Ordovician Val Visdende Formation. The Ordovician non- to anchimetamorphic formations present to the east of the Val Bordaglia Line have been assigned to the Sandbian, Katian and Hirnantian (Schönlaub et al., 2017; Schönlaub & Forke, 2021; Ferretti et al., 2023). All the Ordovician rocks, including the volcanic and volcanoclastic metamorphosed units, represent predominantly shallow-water marine deposits of an open sea bordering the North Gondwana continental plate. The lower part of the Upper Ordovician (lower-mid Katian) is characterized by siliciclastic sediments of the Valbertad Formation (Schönlaub & Simonetto, 2015) likely deposited in shoreface to upper offshore environments. The following upper Katian fossiliferous limestone of the Wolayer and Uqua formations (Schönlaub & Ferretti, 2015a, b) have been interpreted as sedimented in agitated shallow water (Wolayer Formation) or in a deeper-calmer offshore (Uqua Formation) environment. The latter unit, exposed in the Uqua valley, varies in thickness and lithology from 1.5 to 9 m (being 7.3 m visible at the Cellon type locality). The main lithology displays a bedded flaser-type limestone, passing to a nodular limestone in other occurrences (Schönlaub & Ferretti, 2015b). The Wolayer Formation, outcropping in the area of Lake Wolayer, is made by a 10 to 17 m thick white to grayish and locally pinkish massive or indistinctly bedded coarse-grained pelmatozoan limestone (Schönlaub & Ferretti, 2015a). The youngest Ordovician Plöcken Formation (Schönlaub & Ferretti, 2015c) of Hirnantian age is composed by shallow water mixed siliciclastic and carbonate rocks, of which sedimentation was strongly influenced by the Late Ordovician glacial event.

HISTORICAL BACKGROUND ON THE CONODONT STUDIES

Conodont investigation in the Ordovician of the Carnic Alps started almost 60 years ago, as recently summarized by Ferretti et al. (2023). First papers compiled in the late 1960s-early 1970s were necessarily using single element (form) taxonomy, as common at that time. However, most of these reports were of limited global applicability as written in Italian or in German.

In his fundamental paper for Silurian biostratigraphy, Walliser (1964) reported from the Cellon Section an Ordovician conodont assemblage from the Bereich I. However, it was with the series of papers by Serpagli and co-Authors that a true comprehensive study on the Ordovician conodont faunas really started. Serpagli & Greco (1965a, b) and Serpagli (1967) described a rich and well-diversified conodont association from the Rifugio Nordio and Monte Zermula sites, on the Italian side of the Carnic Alps. Unluckily, no photographic images were provided and elements were figured by ink drawings.

Manara & Vai (1970) reported Late Ordovician-Early Devonian faunas from the southern flank of M. Rauchkofel. Schönlaub (1971) revisited the conodont Bereich I of Walliser (1964) and, by comparison with

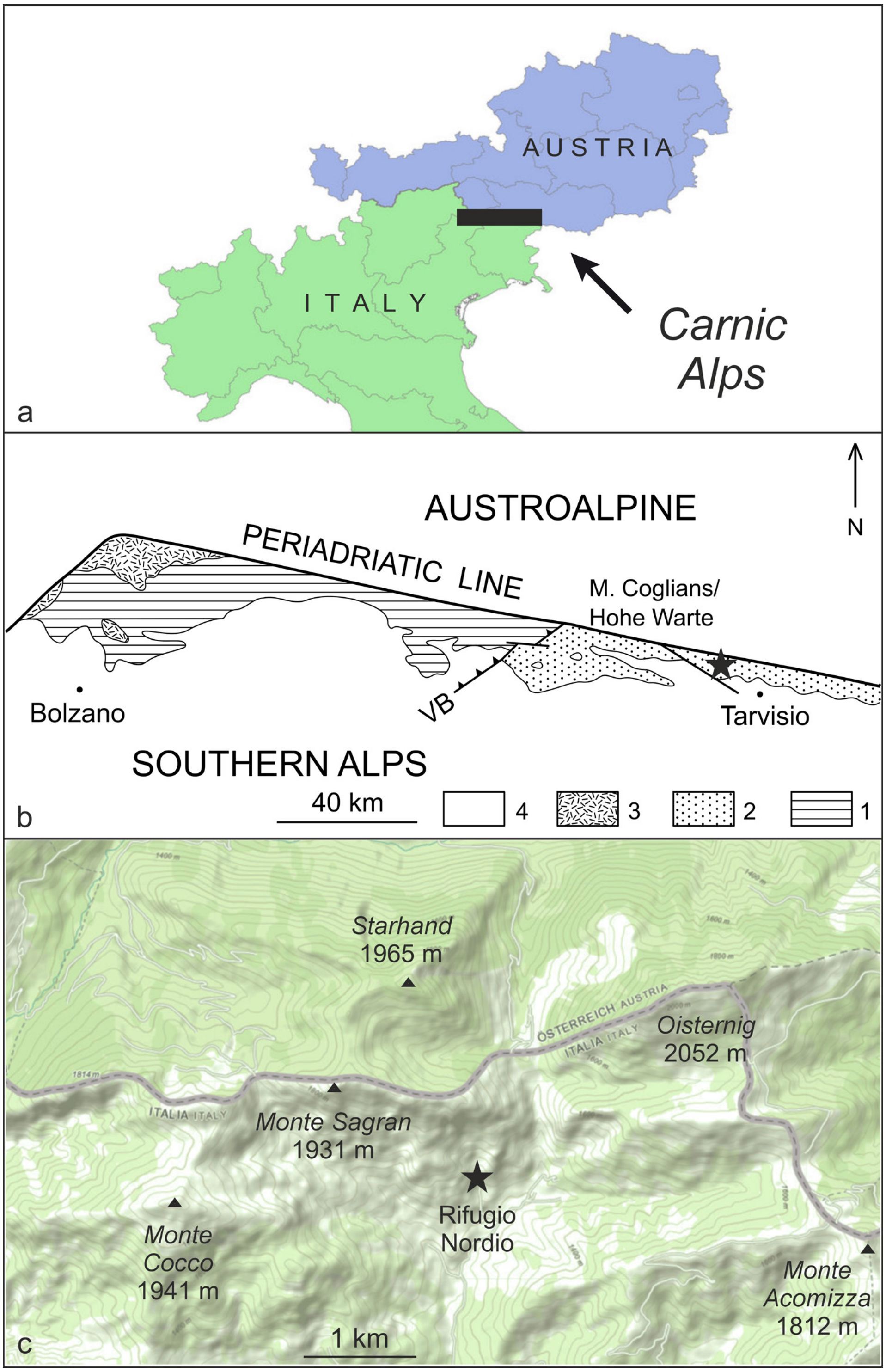


Fig. 1 - (color online) a) Location of the Carnic Alps. b) Simplified geological map with the Val Bordaglia Thrust separating the Paleocarnic Chain into a western and an eastern Zone (after Venturini & Spalletta, 1998, modified). VB: Val Bordaglia Thrust; 1: low to middle grade metamorphic basement; 2: non- to anchi-metamorphic units; 3: Variscan intrusive bodies; 4: post-Paleozoic units. c) Location of the Uqua Section (black star), also reported in (b).

coeval fauna from the Seewarte Section, the material was finally assigned to the "Ashgill". Flajs & Schönlaub (1976) provided further data from the Polster region.

Vai & Spalletta (1980) resampled the Rifugio Nordio Section of Serpagli (at that time Uggwa Section, later renamed as Uqua Section) and extended their sampling to younger levels. This association represents the core of the material analyzed in the present paper.

A further step in the study of the Ordovician of the Carnic Alps, and of conodonts in general, derived from the application of multi-element taxonomy. Sweet & Bergström (1984) revisited under this perspective

Serpagli's work. The Carnic association was attributed to the *Amorphognathus ordovicicus* Biozone and to the HDS –*Hamarodus europaeus* (now *brevirameus*)-*Dapsilodus mutatus*-*Scabbardella altipes*– biofacies, grading to the *Amorphognathus*-*Plectodina* biofacies. Sweet & Bergström (1984) remarked the absence of high-latitude markers such as *Sagittodontina robusta* Knüpfer, 1967 and *Istorinus erectus* Knüpfer, 1967.

New conodont material was collected and described in the late 1990s and early 2000s. Bagnoli et al. (1998) reported a moderately rich Ordovician conodont fauna from the Uqua Formation in the Valbertad Section. Ferretti & Schönlaub (2001) studied conodont contents from the Wolayer Formation, Uqua Formation and Plöcken Formation from several sections in the Austrian Carnic Alps, including an extensive resampling of the Ordovician part of the Cellon Section. Resulting data allowed a firm biostratigraphic assignment of the Carnic fauna and to stress the deep relationship with the Sardic coeval conodont association (Ferretti & Serpagli, 1991, 1998; Bergström & Ferretti, 2015; Loi et al., 2023) in contraposition to other high-latitude areas (e.g., Germany, Spain, France, Libya, etc.). Ferretti & Schönlaub (2001) and Ferretti et al. (2023) were also able to report and describe the first Hirnantian conodont fauna in Europe. Surprisingly, only in these younger levels, attributed to the *A. ordovicicus* Biozone, the cold-water genera *Sagittodontina* and *Istorinus* appear, documenting the immigration from colder areas and representing the first recorded conodont recovery fauna to the initial Late Ordovician extinction event (Ferretti et al., 2023).

Finally, sparse Ordovician faunas were recently described from the Rauchkofel Boden (Schönlaub et al., 2017) and Valentintörl sections (Corriga et al., 2021).

MATERIAL AND METHODS

Eleven samples have been collected for conodonts by Vai & Spalletta (1980) in the Uqua Section (Rifugio Nordio area) (Fig. 2). Only eight samples revealed to be productive (Tab. 1). Five are placed in the calcareous Uqua Formation, being samples 301-304 the corresponding ones described by Serpagli (1967). Three additional samples (381a, 381b, 381d) were collected a few meters above, within a sandstone unit bearing calcareous blocks that might represent the Plöcken Formation. However, this needs to be confirmed by a new detailed fieldwork and re-sampling of the section. The conodont elements were extracted by leaching in 10% acetic acid. The insoluble residues were washed and sieved using three standard sieves. The fraction 125 µm of each sample was then run through heavy liquid separation using tetrabromoethane. All complete and broken conodont elements found in the heavy part of the 125 µm fraction were picked under a binocular microscope.

The conodont collections are now deposited in the "Inventario Paleontologia Università di Modena e Reggio Emilia" at the Dipartimento di Scienze Chimiche e Geologiche, Modena, Italy, under repository numbers IPUM 35097-35150.

RESULTS

The conodont fauna investigated herein totals 1539 elements (Tab. 1). Preservation of specimens is moderately good with a few encrusted or broken specimens. The conodont specimens exhibit a CAI (Colour Alteration Index; cf. Epstein et al., 1977) of 4, indicating a heating of about 300 °C. No significant change in the composition of the conodont fauna through the study material was observed.

The identifiable elements were assigned to 15 different genera and to the following 15 species:

Amorphognathus ordovicicus Branson & Mehl, 1933
Ansella pseudorobusta (Serpagli, 1967)
Cornuodus longibasis (Lindström, 1954)
Dapsilodus mutatus (Branson & Mehl, 1933)
Dichodella exilis Serpagli, 1967
Eocarniodus gracilis (Rhodes, 1955)
Hamarodus brevirameus (Walliser, 1964)
Icriodella sp. A
Nordiodus italicus Serpagli, 1967
Panderodus gracilis (Branson & Mehl, 1933)
Plectodina alpina (Serpagli, 1967)
Protopanderodus liripipus Kennedy, Barnes & Uyeno, 1979
Pseudooneotodus mitratus (Moskalenko, 1973)
Scabbardella altipes (Henningsmoen, 1948)
Walliserodus amplissimus (Serpagli, 1967)
"*Acodus trigonius*" s.f.

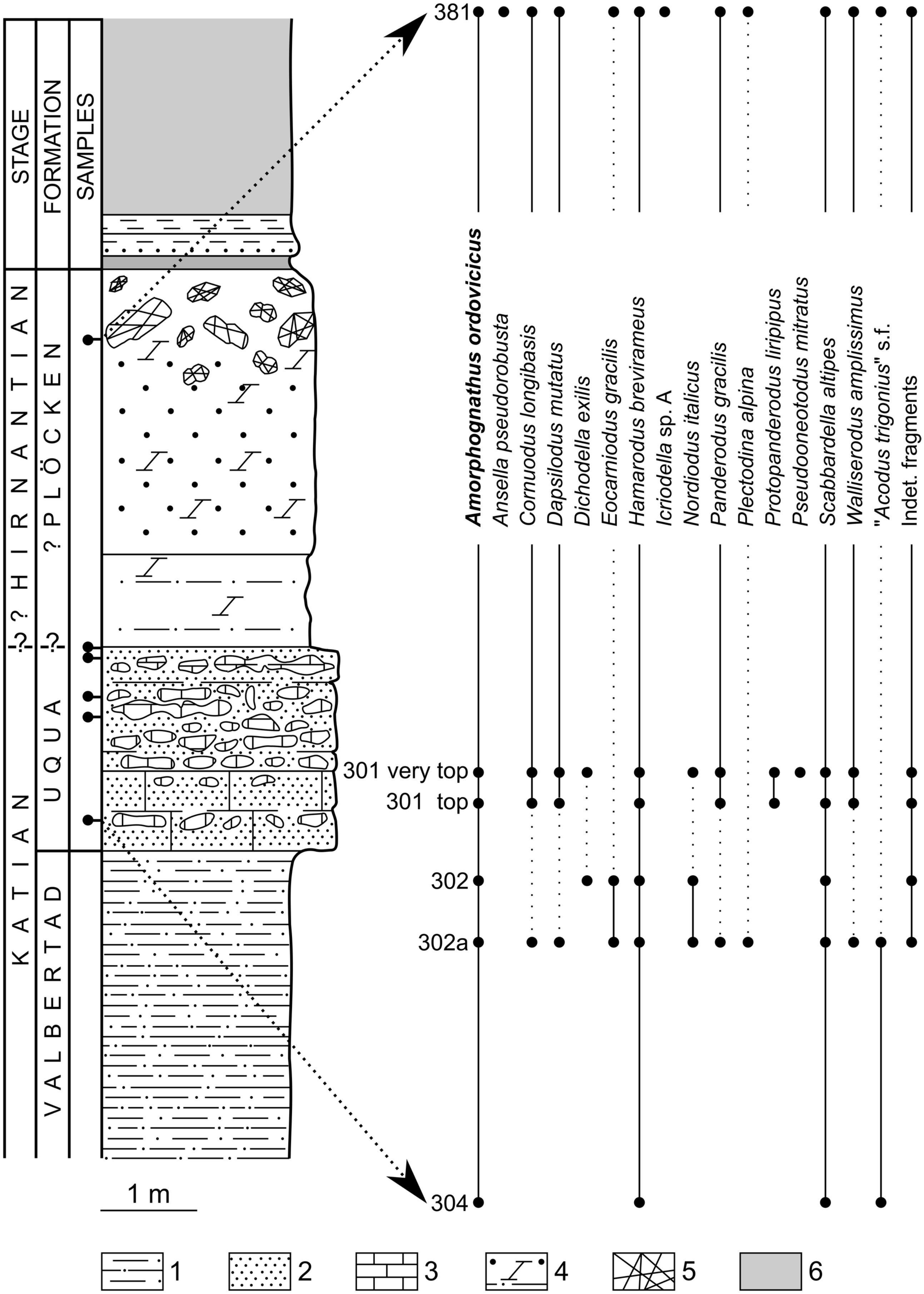
The conodont association is attributed to the Upper Ordovician *Amorphognathus ordovicicus* Biozone. The faunal content does not vary significantly in the uppermost calcareous blocks (samples 381a, 381b, 381d) that still bear typical Ordovician conodonts.

The conodont collection is numerically dominated by *Hamarodus brevirameus* (31%) and *Scabbardella altipes* (29%) that, together with *Amorphognathus ordovicicus* (19%), constitute over two-thirds of the assemblage. The three species are well recorded throughout the section in all the productive levels, being *H. brevirameus* and *A. ordovicicus* documented by the full apparatuses. The former species is numerically represented (in descending order) by Sc (Pl. 2, figs 5, 9), M (Pl. 2, figs 6-7) and Pa (Pl. 2, figs 1, 3) elements.

Amorphognathus ordovicicus counts mostly Pa (Pl. 1, figs 1-2, 4) and Pb (Pl. 1, figs 3, 5-7) elements, while ramiforms are extremely rare. A single M element was recovered (Pl. 1, fig. 8) and, in general, even if the total number of counted Pa specimens is possibly exaggerated due to their fragmentary status, in our calculations S elements (Pl. 1, figs 9-12) represent less than 1% of the species record in the Uqua collection.

A relatively common taxon is *Eocarniodus gracilis* (5%; Pl. 1, fig. 17), while all other species occur in frequencies close to or less than 1 per cent. In particular,

Fig. 2 - Chronostratigraphy and lithostratigraphy of the Uqua Section, Carnic Alps, Italy. Stratigraphic column of the Uqua Section (redrawn after Vai & Spalletta, 1980) and distribution of conodonts in the section. Sample 381 was further detailed with letters a-d in Vai & Spalletta (1980). 1: siltstone; 2: sandy calcarenite; 3: nodular limestone; 4: siltstone and sandstone; 5: limestone pebble or block; 6: black shale.


STAGE
FORMATION
SAMPLES
KATIAN
?HIRNANTIAN
VALBERTAD
UQUA
?PLÖCKEN
1 m
381
301 very top
301 top
302
302a
304
Amorphognathus ordovicicus
Ansella pseudorobusta
Cornuodus longibasis
Dapsilodus mutatus
Dichodella exilis
Eocarniodus gracilis
Hamarodus brevirameus
Icriodella sp. A
Nordiodus italicus
Panderodus gracilis
Plectodina alpina
Protopanderodus liripipus
Pseudooneotodus mitratus
Scabbardella altipes
Walliserodus amplissimus
"Acodus trigonius" s.f.
Indet. fragments
1
2
3
4
5
6

Formation	**U Q U A**					**? P L Ö C K E N**				
Conodont taxa	**304**	**302a**	**302**	**301 top**	**301 very top**	**381a**	**381b**	**381d**	**number of elements**	
Amorphognathus ordovicicus										*297*
Pa	8	78	16	9	43	1	28	12	**195**	
Pb	1	42	7	1	14	2	9	8	**84**	
M					1				**1**	
Sa		1	1						**2**	
Sb	1	4		1	1				**7**	
Sc		2						2	**4**	
Sd		1					1	2	**4**	
Ansella pseudorobusta										
M							1		**1**	
Cornuodus longibasis		4		4	1		2		**11**	
Dapsilodus mutatus		9		1	4			2	**16**	
Dichodella exilis										*5*
Pa			1						**1**	
M					1				**1**	
Sa					2				**2**	
Sb					1				**1**	
Sc										
Eocarniodus gracilis		59	3			2		7	**71**	
Hamarodus brevirameus										*480*
Pa	1	65	5	5	2	3	4	9	**94**	
Pb		25		1			1	1	**28**	
M	1	74	19	7	6	1	9	23	**140**	
Sa		16	1					2	**19**	
Sb	1	1							**2**	
Sc		157	16	5	1		1	16	**196**	
Sd		1							**1**	
Icriodella sp. A										
Pa								1	**1**	
Nordiodus italicus										*11*
Pa		3			1				**4**	
Pb		6	1						**7**	
Panderodus gracilis		3		2	1		6		**12**	
Plectodina alpina										*13*
Pa		1							**1**	
Pb		3							**3**	
M		3							**3**	
Sa		3							**3**	
Sb		1				1			**2**	
Sc		1							**1**	
Protopanderodus liripipus				4	11				**15**	
Pseudooneotodus mitratus					1				**1**	
Scabbardella altipes	4	155	38	93	101	2	23	31	**447**	
Walliserodus amplissimus		1		3	5		1		**10**	
"*Acodus trigonius*" s.f.	2	5						2	**9**	
Indet. fragments		60	7	14	15	8	20	15	**139**	
Total	**19**	**784**	**115**	**150**	**212**	**20**	**106**	**133**	**1539**	

Tab. 1 - Frequency of conodont elements in the material collected by Vai & Spalletta (1980) from the Uqua Section, Carnic Alps, Italy.

Pseudooneotodus mitratus (Pl. 1, fig. 13), *Ansella pseudorobusta* (Pl. 2, fig. 19) and *Icriodella* sp. A (Pl. 2, fig. 24) are represented by a single specimen.

Plectodina alpina is documented by the full apparatus (Pl. 1, figs 14, 18-19, 22-23) in only one sample (302a) and by an isolate Sb element in sample 381a (Pl. 1, fig. 24).

Nordiodus italicus is present with Pa (Pl. 1, figs 15-16) and Pb (Pl. 1, fig. 20) elements in three samples, and the possibility that "*Acodus trigonius*" might represent the ramiform elements of the apparatus needs to be supported by a larger faunal association.

Dichodella exilis is herein reported from only two samples, but with diverse elements of the apparatus, respectively the Pa (Pl. 2, fig. 12), M (Pl. 2, fig. 16), Sa (Pl. 2, fig. 11) and Sb elements. Bagnoli et al. (1998) suggested that *Birsksfeldia* must be regarded as a junior synonym of *Dichodella*. In addition, also *Gamachignathus* McCracken, Nowlan & Barnes, 1980, introduced contemporaneously with *Birksfeldia*, might represent a synonym of *Dichodella* (Ferretti & Schönlaub, 2001).

A peculiar Hirnantian conodont fauna was preliminarly described from the Cellon Section and attributed to the *A. ordovicicus* Biozone (Ferretti & Schönlaub, 2001; Ferretti et al., 2023). The distinctive genera *Sagittodontina* and *Istorinus* make their first appearance in the Carnic Alps and document the immigration of cold-water taxa reported before in rather low-diversity faunas typical of the Late Ordovician polar or subpolar region (Ferretti et al., 2014c). These two genera have not been recovered in the material here investigated, not even in the calcareous blocks associated with Hirnantian brachiopods. However, we cannot exclude that the blocks are simply displaced from the underlying calcareous horizon. The basal part of the Plöcken Formation is characterized by siltstone and shales that bear limestone clasts usually producing an Hirmantian fauna, but those clasts can as well be reworked from the underlying Uqua Formation, being the basal part of the Plöcken Formation often marked by channeling and erosion.

Based on the distinctive type of associations, Sweet & Bergström (1984) proposed the existence of three major conodont biofacies in much of the Upper Ordovician, specifically the *Sagittodontina robusta*-*Scabbardella altipes* biofacies in the Mediterranean Province, the *Hamarodus europaeus* (now *brevirameus*)-*Dapsilodus mutatus*-*Scabbardella altipes* (HDS) biofacies in the Baltic Province and the *Amorphognathus*-*Plectodina* biofacies in the British Province. This subdivision has been supported by successive investigations in Europe during the last 30 years (see Ferretti et al., 2014c and references therein). Whereas the Mediterranean Province faunas apparently occupied high latitudes and relatively cold waters near the pole, those of the British and Baltic provinces inhabited marine environments at lower latitudes (Ferretti et al., 2014a). The composition of the conodont fauna from the Uqua Section indicates that the assemblage represents the HDS biofacies.

Ferretti et al. (2014a, b) and Bergström & Ferretti (2015) displayed through pie diagrams the principal differences and similarities in taxa frequency among major Late Ordovician conodont assemblages. The pie diagram of the Uqua collection described in this study is reported in Fig. 3. Our data generally match those presented in Bergström & Ferretti (2015) for the same formation and calculated according to Serpagli (1967), with *Scabbardella altipes* (40%), *Hamarodus brevirameus* (24%) and *Amorphognathus* spp. (9%) again representing two-thirds of the entire fauna. Both associations (the one reported herein and that of Bergström & Ferretti, 2015) record a relative low presence of *Dapsilodus mutatus* (respectively 1% and 2%), the third marker of the HDS biofacies. Other *Hamarodus-Dapsilodus-Scabbardella* dominated faunas have been reported in Baltoscandia, with the Upper Slandrom Limestone from the Siljan Region (Sweden) that records *Hamarodus brevirameus* (42%), *Amorphognathus* spp. (15%) and *Scabbardella altipes* (9%) associated with a great abundance of *Dapsilodus mutatus* (25%) and the Mójcza Limestone (Poland) having *Scabbardella altipes* (48%), *Amorphognathus* spp. (16%), *Hamarodus brevirameus* (8%) associated to a relevant presence of *Dapsilodus mutatus* (16%) (Ferretti et al., 2014a; Bergström & Ferretti, 2015).

Finally, the rediscovery of Serpagli's original material allowed the study of a few thin sections of the Rifugio Nordio pioneer levels described by the Author in 1967. The limestone documents a bioclastic trilobite wackestone with fragmentary ostracodes, bryozoans and brachiopods scattered in the matrix, associated with abundant subangular quartz grains (Fig. 4).

SYSTEMATIC PALEONTOLOGY

Remarks - Most of the species present in the Uqua collection are well-known taxa that have been described adequately in the recent literature. A few remarks are given below on a single peculiar taxon that might reveal to be a distinctive species.

Genus *Icriodella* Rhodes, 1953
Type species *Icriodella superba* Rhodes, 1953.

Icriodella sp. A
(Pl. 2, fig. 24)

v. 1997 *Icriodella* sp.; Ferretti & Barnes, p. 33, Pl. 1, fig. 16.

Material - One specimen.

Description - A single fragmentary anterior process of a Pa element has been recovered in our material. It bears five distinct couples of node-like denticles, that increase in size towards the median part of the process. Denticles are never paired but slightly alternating on the two sides of the process. They are connected each other by a ridge that runs with a distinctive "zig-zag" pattern. The anterior process extends into a short denticulated sharp ridge. Deeply excavated lower surface extending along the entire length of the element.

Remarks - The denticulation of *Icriodella* sp. A is quite distinctive. *Icriodella superba* Rhodes, 1953 clearly displays couples of paired nodes that are symmetrical to the median axis of the anterior process. Denticles of the anterior process of *Icriodella rhodesi* Bergström &

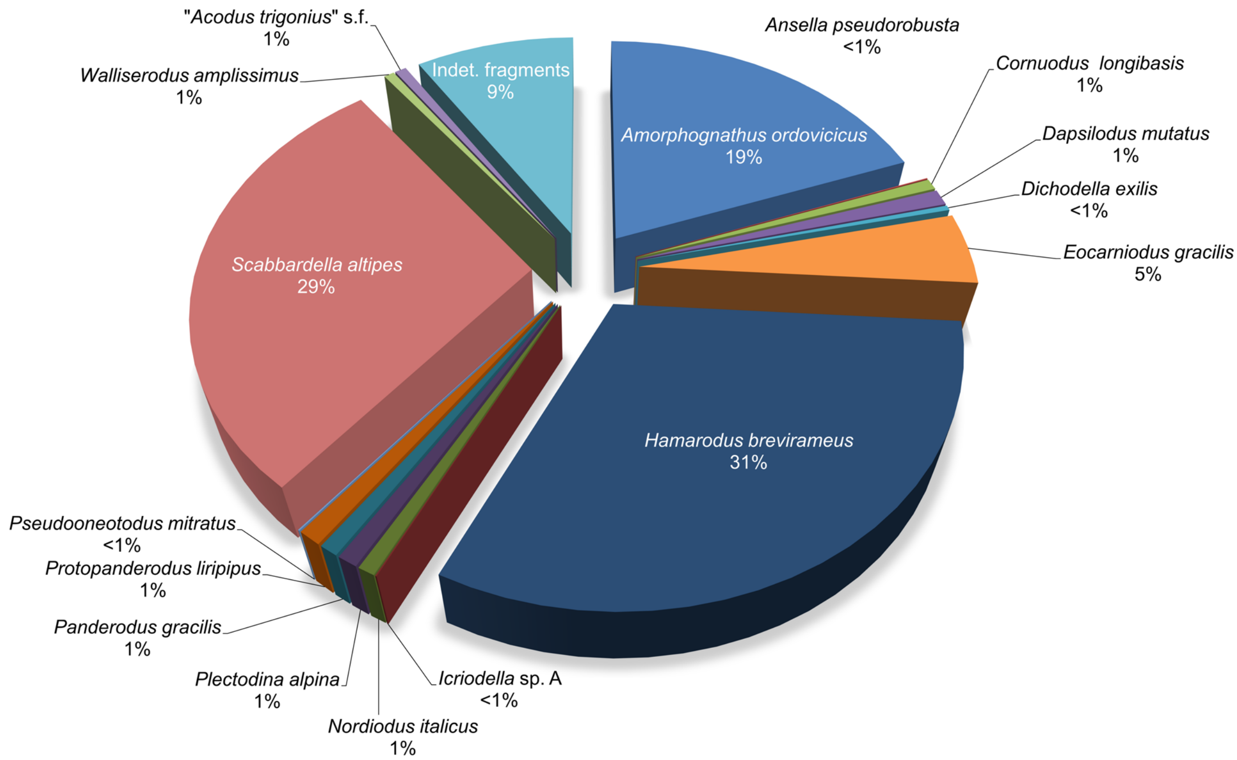
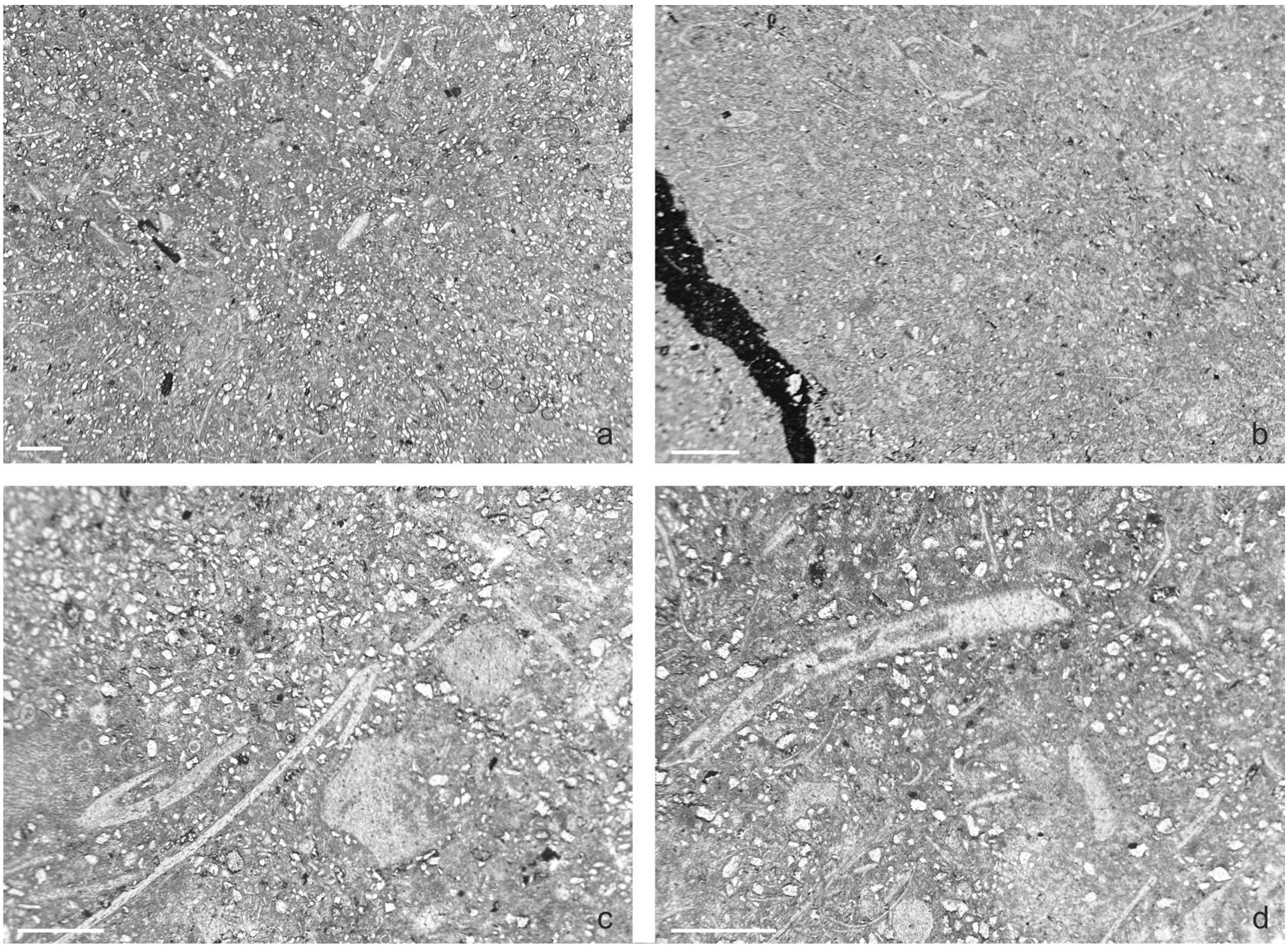


Fig. 3 - (color online) Pie diagram illustrating differences in relative abundance of conodont species in the material examined in the present study.



Ferretti, 2015 from the Keisley Limestone are connected by well-developed transversal bars, having a constant height also in the median part, that are parallel each other and perpendicular to the median axis of the process.

Ferretti & Barnes (1997) previously remarked on the presence in the Thuringian material of the "zig-zag" ridge connecting process denticles. Our material strongly matches the same pattern but is too sparse to allow further considerations.

CONCLUSION

The conodont collection of over 1500 conodont elements isolated from eight samples from the Uqua Section in the Carnic Alps, west of Tarvisio, Italy, provided a moderately diverse conodont fauna. Based on our study of this collection, a few general conclusions can be presented.

1. A biostratigraphic assessment indicates that the Uqua collection is referable to the *Amorphognathus ordovicicus* Biozone.
2. The composition of the conodont fauna, with dominance of representatives of *Hamarodus*, *Scabbardella* and *Amorphognathus*, is typical of equivalent faunas from the Baltic Province sensu Sweet & Bergström (1984). The Uqua material shows some similarity to that of coeval faunas from the British Province, and differs in significant ways from those of the Mediterranean Province.
3. The Uqua Section documents a conodont association that existed in the Carnic Alps before the first phase of the Hirnantian mass extinction.

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Fig. 4 - Transmitted-light micrographs of petrographic thin sections of the original "Tonflaserkalke" of Serpagli (1967). a) Trilobite wackestone with abundant quartz grains in the calcareous matrix. Original sample RN 2 (herein sample 303). b) Trilobite wackestone with a distinctive iron-oxide vein in the lower-left of the frame, responsible of the reticulated appearance of the limestone in the field. Original sample RN 4 (herein sample 301). c-d) Skeletal biodebris constituted by trilobite and echinoderm fragments in a quartz-rich matrix; thin-shelled ostracodes are visible in (d). Original sample RN 2 (herein sample 303). Scale bars correspond to 0.5 mm.

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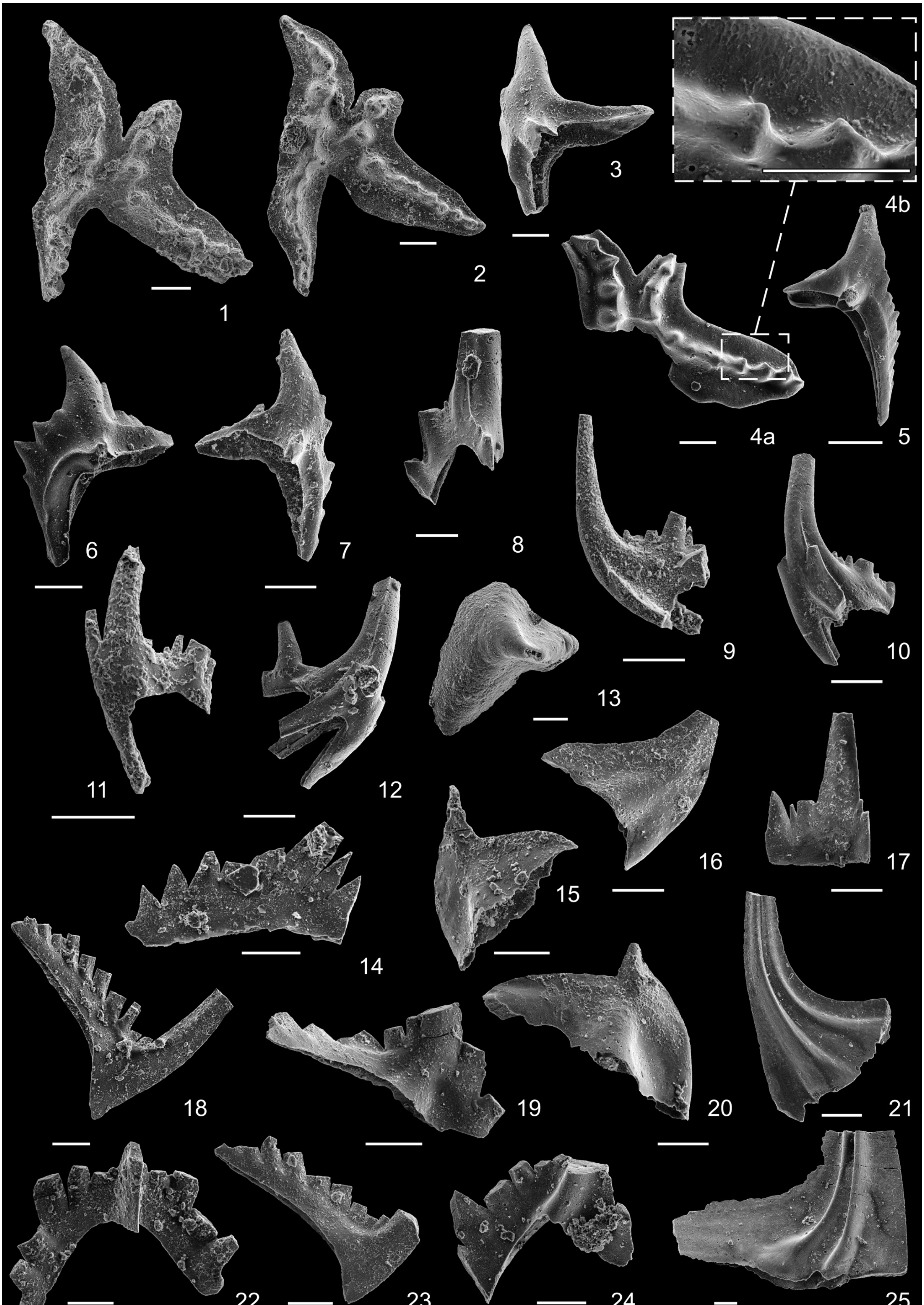
EXPLANATION OF PLATE 1

Late Ordovician conodonts from the Uqua Section, Carnic Alps, Italy. All scale bars correspond to 100 µm.

Figs 1-12	-	*Amorphognathus ordovicicus* Branson & Mehl, 1933.
	1-2, 4 -	Pa elements, upper views. 1, IPUM 35097, sample 302a. 2, IPUM 35098, sample 302a. 4, IPUM 35100, sample 381b, with details of cell? impressions (4b) along process border.
	3, 5-7 -	Pb elements, all lateral views. 3, IPUM 35099, sample 302a. 5, IPUM 35101, sample 301 very top. 6, IPUM 35102, sample 381b. 7, IPUM 35103, sample 302a.
	8 -	M element, posterior view of IPUM 35104, sample 301 very top.
	9 -	Sa element, lateral view of IPUM 35105, sample 302a.
	10 -	Sb element, lateral view of IPUM 35106, sample 301 very top.
	11 -	Sc element, lateral view of IPUM 35107, sample 302a.
	12 -	Sd element, lateral view of IPUM 35108, sample 381d.
Fig. 13	-	*Pseudooneotodus mitratus* (Moskalenko, 1973). Upper view of IPUM 35109, sample 301 very top.
Figs 14, 18-19, 22-24	-	*Plectodina alpina* (Serpagli, 1967).
	14 -	Pa element, lateral view of IPUM 35110, sample 302a.
	18 -	M element, lateral view of IPUM 35114, sample 302a.
	19 -	Pb element, lateral view of IPUM 35115, sample 302a.
	22 -	Sa element, posterior view of IPUM 35118, sample 302a.
	23 -	Sc element, lateral view of IPUM 35119, sample 302a.
	24 -	Sb element, postero-lateral view of IPUM 35120, sample 381a.
Figs 15-16, 20	-	*Nordiodus italicus* Serpagli, 1967.
	15, 16 -	Pa elements, lateral views of IPUM 35111 and IPUM 35112, both from sample 302a.
	20 -	Pb element, lateral view of IPUM 35116, sample 302.
Fig. 17	-	*Eocarniodus gracilis* (Rhodes, 1955). Lateral view of IPUM 35113, sample 302a.
Figs 21, 25	-	*Protopanderodus liripipus* Kennedy, Barnes & Uyeno, 1979. Lateral views of IPUM 35117 and IPUM 35121, both from sample 301 very top.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EXPLANATION OF PLATE 2

Late Ordovician conodonts from the Uqua Section, Carnic Alps, Italy. All scale bars correspond to 100 µm.

Figs 1-10 - *Hamarodus brevirameus* (Walliser, 1964).
1, 3 - Pa elements, lateral views. 1, IPUM 35122, sample 302a. 3, IPUM 35124, sample 302a.
2 - Pb element, lateral view of IPUM 35123, sample 381d.
4 - Sa element, lateral view of IPUM 35125, sample 302a.
5, 9 - Sc elements, lateral views of IPUM 35126 and IPUM 35130, sample 302 and 302a respectively.
6-7 - M elements, all lateral views. 6, IPUM 35127, sample 381d. 7, IPUM 35128, sample 302a.
8 - Sb element, lateral view of IPUM 35129, sample 304.
10 - Sd element, lateral view of IPUM 35131, sample 302a.

Figs 11-12, 16 - *Dichodella exilis* Serpagli, 1967.
11 - Sa element, posterior view of IPUM 35132, sample 301 very top.
12 - Pa element, lateral view of IPUM 35133, sample 302.
16 - M element, lateral view of IPUM 35137, sample 301 very top.

Figs 13, 17-18, 21-22 - *Scabbardella altipes* (Henningsmoen, 1948). All lateral views. 13, IPUM 35134, sample 302. 17, IPUM 35138, sample 301 very top. 18, IPUM 35139, sample 302a. 21, IPUM 35142, sample 301 very top. 22, IPUM 35143, sample 302a.

Figs 14-15 - *Cornuodus longibasis* (Lindström, 1954). All lateral views. 14, IPUM 35135, sample 302a. 15, IPUM 35136, sample 302a.

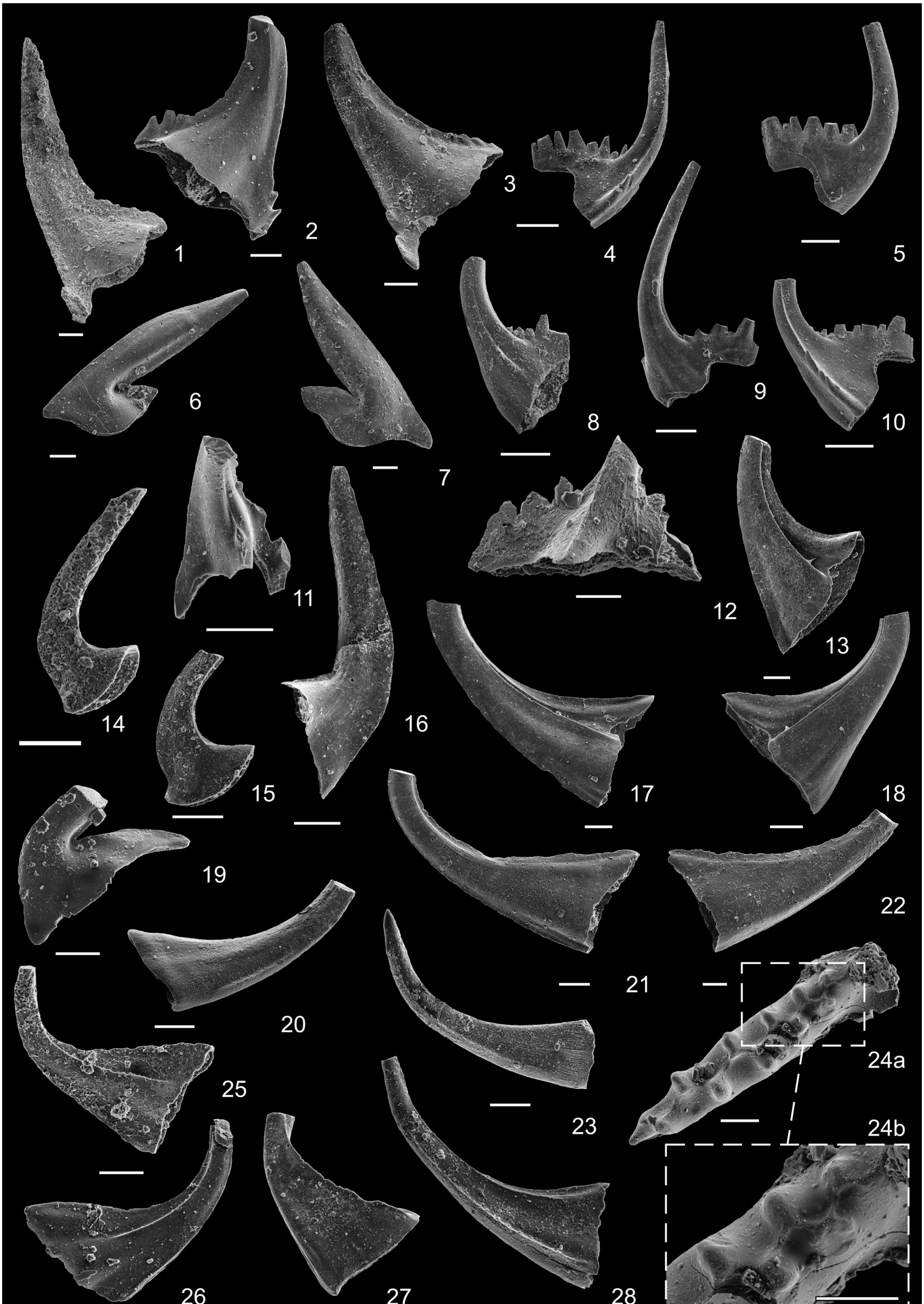
Fig. 19 - *Ansella pseudorobusta* (Serpagli, 1967). M element, lateral view of IPUM 35140, sample 381b.

Figs 20, 23 - *Panderodus gracilis* (Branson & Mehl, 1933). All lateral views. 20, IPUM 35141, sample 381b. 23, IPUM 35144, sample 302a.

Fig. 24 - *Icriodella* sp. A. Pa element, upper view of IPUM 35145, sample 381d, with details of the "zig-zag" pattern (24b) along the anterior process.

Figs 25-26 - *Dapsilodus mutatus* (Branson & Mehl, 1933). All lateral views. 25, IPUM 35146, sample 302a. 26, IPUM 35147, sample 381d.

Figs 27-28 - *Walliserodus amplissimus* (Serpagli, 1967). All lateral views. 27, IPUM 35148, sample 301 very top. 28, IPUM 35149, sample 302a.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