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HISTORY OF CONODONT RESEARCHES IN THE CARNIC ALPS (AUSTRIA AND ITALY): AN OVERVIEW

SINTESI DELLA STORIA DELLE RICERCHE SUI CONODONTI NELLE ALPI CARNICHE (AUSTRIA E ITALIA)

Riassunto breve - L'importanza delle ricerche sui conodonti svolte negli ultimi sessant'anni in Alpi Carniche è legata soprattutto all'importanza dell'utilizzo di questi fossili come strumenti di datazione relativa e correlazione delle rocce paleozoiche e triassiche. Le imponenti successioni carbonatiche paleozoiche delle Alpi Carniche si sono dimostrate ricche di faune a conodonti che hanno consentito non solo di datare le rocce ma anche di riconoscere nuove specie, alcune delle quali hanno importanza stratigrafica anche al di fuori dell'area tipica (a livello globale). Viene brevemente delineata la storia delle ricerche a conodonti in Alpi Carniche che hanno prodotto, fino a oggi, 230 articoli, alcuni dei quali sono importanti a livello globale per la biostratigrafia. Vengono illustrati tutti gli olotipi delle specie istituite nelle Alpi Carniche. Viene inoltre indicato quanti lavori contengono descrizioni tassonomiche e quanti sono corredati da tavole e/o figure che illustrano il materiale studiato. Gli articoli sono stati infine raggruppati per intervalli stratigrafici.
Parole chiave: Conodonti, Alpi Carniche, Storia delle ricerche, Bibliografia.

Abstract - *A short history of more than sixty years of conodont researches in the Carnic Alps is outlined. It is noteworthy that the importance of these research is connected with the use of conodonts as biostratigraphic tools for relative dating of Palaeozoic to Triassic rocks, mostly limestone as the main Formations constituting the Palaeozoic sequence of the Carnic Alps. During the years of research 230 papers dealing with different aspect of conodonts were produced, some of these papers are indeed dealing with CAI, taxonomy, biofacies not only on biostratigraphy. Some of the biostratigraphic papers are important at global level, as well as some of the new species originally described from the Carnic Alps. The holotypes of the 38 species of conodonts established from the Carnic Alps are reillustrated. The number of papers dealing with taxonomy is indicated together with the number of papers containing plates or figures. The papers are also subdived according to stratigraphic interval.*
Key words: *Conodonts, Carnic Alps, History of researches, Bibliography.*

Introduction

The Carnic Alps constitutes the easternmost part of the Southern Alps and are located across the Italian/Austrian border (Fig. 1). The sequence there exposed spans the Middle Ordovician to the Upper Triassic, and it can be subdivided into two main parts: Pre-Variscan and Post-Variscan. The Pre-Variscan sequence is constituted by Middle Ordovician to mid Carboniferous rocks and was affected by the Variscan orogeny during the upper Carboniferous (Bashkirian and Moscovian). The Post-Variscan sequence can be subdivided in the so-called Permo-Carboniferous sequence ranging from the Pennsylvanian (upper Carboniferous) to the Middle Permian and the Alpine sequence starting within the Upper Permian. The Carnic Alps are the result of the superimposition of two orogenesis, the Variscan and the Alpine, nevertheless the whole sequence is made up by very low grade to non metamorphic rocks (Corradini et al. 2015e). The Palaeozoic rocks of the Pre-Variscan and Post-Variscan part of the sequence being mainly non metamorphic and rich in fossils were studied since the nineteen century. Most of these rocks are limestones, and yield conodonts.

Conodonts are phosphatic microfossils, the only hard constituent of a soft body animal which nature was a mistery for more than a century after their discovery. Today conodonts are considered being part of the phylum Chordata. The first description of conodonts was made in 1856 by Heinz Christian Pander that supposed they were fish teeth. The affinity of conodonts to fish was successively denied and the history of their taxonomic attribution is a series of controversies and mistakes due to the lack of a complete fossil. Despite their unknown nature, during the first half of the twentieth century conodonts aquired importance as biostratigraphic tools. Their importance is derived by their quite common presence in Palaeozoic and Triassic rocks, lacking other

microfossils, and it greatly increased during the second half of the last century after the diffusion of extraction techniques from carbonatic rocks by acid leaching using acetic or formic acid solution. The taxonomic attribution of conodonts to Vertebrata was firstly proposed only after the discovery in 1983 of fossil imprints of some almost complete animals, and it is currently accepted by the majority of researchers even if some debates are still underway.

History of conodont research in the Carnic Alps

The first conodont researches in the Carnic Alps started on the Austrian side in the mid 1950's with the first citation of Late Devonian palmatolepids by Müller (1956, 1959). In the same years Walliser started researches on Silurian conodonts of Germany and the Carnic Alps (Walliser 1957). His studies on the faunas from Cellon and the Wolayer Lake area culminated with the publication of the first conodont biozonation of the Silurian based on findings from the Cellon section that became the reference section for the Silurian conodont biostratigraphy (Walliser 1964).

On the Italian side of the Carnic Alps conodont studies started approximately ten years later with the first works of Serpagli on the Ordovician and Silurian (Serpagli & Greco 1965a, 1965b; Serpagli 1967). At that time the Carnic Alps were one of the area of study of the University of Bologna where the "Bologna School", leaded by Selli, followed the imprint of Michele Gortani. Gortani was Professor in Bologna for decades and, being born in Tolmezzo, focalised one his main field of research on the Palaeozoic of the Carnic Alps since the beginning of the twentieth century. Successively, the researches on the Carnic Alps were carried on by his students to whom he transmitted his interest and passion.

Serpagli was working for the University of Modena and the success of his results, together with the studies of Walliser on the Silurian, it ignited great scientific interest and the example of Serpagli was immediately followed by studies on conodonts by Manzoni and Manara at the University of Bologna.

During these pioneer years the technique to extract conodonts from limestones was leaching in a solution of acetic acid and the insoluble residues was then separated into light and heavy fractions using bromoform. Conodonts are found within the insoluble residue as their composition is similar to that of our bones (calcium fluoroapatite), and due to their high specific weight they remain in the heavy fraction. The use of heavy liquid separation help to reduce the amount of material that has to be observed under the light microscope for the separation of conodonts. Only in the late 1980, after the discovery of the connection between the use of bromoform and cancer, in the conodont laboratories

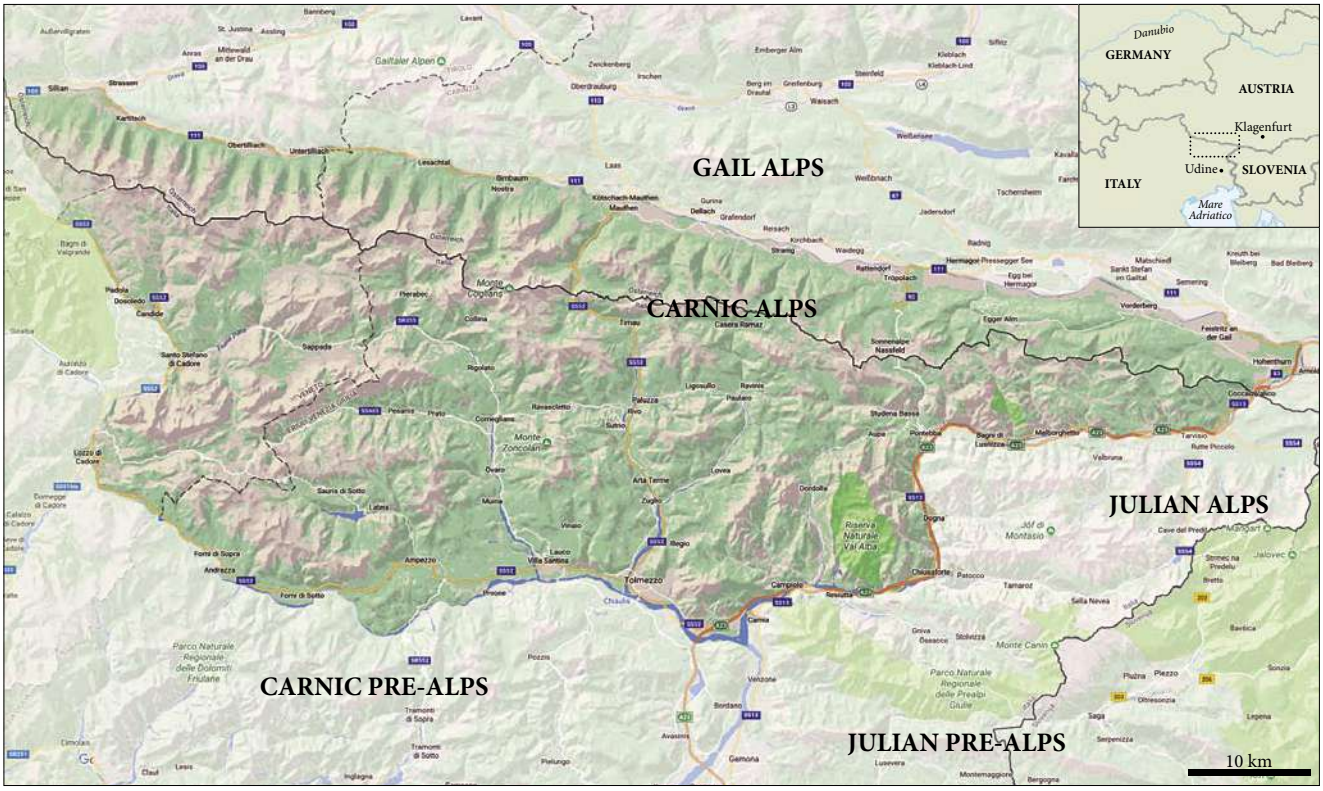


Fig. 1 - Location map of the Carnic Alps.
- *Ubicazione delle Alpi Carniche.*

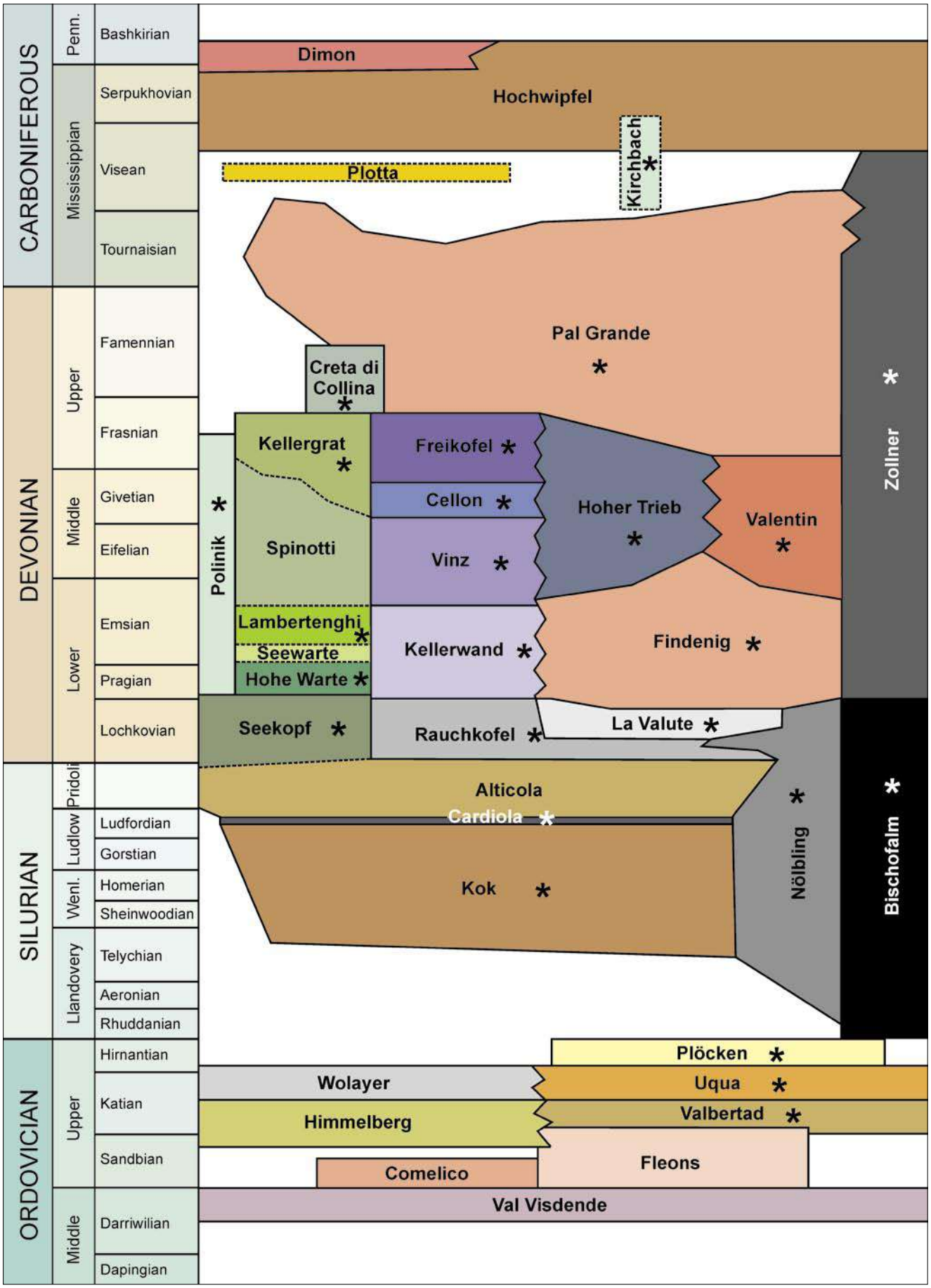


Fig. 2 - The stratigraphic scheme of the Pre-Variscan sequence of the Carnic Alps (after Corradini et al. 2015e, modified). Asterisks indicate the formations yielding conodonts.

- *Schema stratigrafico della sequenza Pre-Varisica delle Alpi Carniche (modificato da Corradini et al. 2015e). Gli asterischi indicano le formazioni in cui sono stati trovati conodonti.*

this dangerous substance was substitute with a solution of sodium polytungstate.

On the Austrian side of the Carnic Alps some researchers used different techniques for the search of conodonts extending their research to the cherts of the Palaeozoic Pre-Variscan sequence (Zollner Formation). They were successful using optical observation of the surface of black chert bedding planes (Flügel et al. 1959; Leditzky 1973), and years later dissolving chert in a solution of 30% of hydrofluoric acid (Herzog 1988).

The studies started by Manzoni in Bologna focused mainly on the Devonian and lower Carboniferous sequences, especially on the pelagic limestone that provided rich conodont associations. These limestone became the main field of research in Bologna.

In Austria the conodont studies proceeded with papers by Pölsler, Schönlaub and Ebner (Pölsler 1969a, 1969b; Schönlaub 1969a, 1969b and following years; Ebner 1973a, 1973b). Great increment was determined by work of Schönlaub and his collaborators and students.

Since the first researches carried by students from Bologna the conodont study has not been limited to the Italian side of the Carnic Alps, but sometimes across the border Italy/Austria, or in Austria (e.g.: Manara & Vai 1970). Despite these scattered "incursion" a real collaboration with the Austrian colleagues did not started until the late 1990's when Ferretti from the University of Modena started to study Silurian facies and Ordovician conodonts in collaboration with colleagues of the Geologische Bundesanstalt. This collaboration was limited to stratigraphic sections located in Austria.

Conodont research on the Italian side of the Carnic Alps experienced a big progress in the late 1990s when several students were involved in the organization of the Seventh International Conodont Symposium (ECOS VII). The Symposium represented a dividing line between past and future for Italian conodont researchers, and lead to new fruitful collaboration.

Another demarcation line, the invisible country border between Austria and Italy, so often crossed when walking on mountain paths, was at last overstepped during the last ten years thanks to a joint project leading to the formalization of all the Pre-Variscan lithostratigraphic units previously named with different informal names on both sides of the border. In that contest conodonts played an important role, being the best tool for providing the age of the various units (Fig. 2).

Hopefully the recent results will not be the only products of a flourishing partnership. In the end conodonts become the main "trait d'union" between cities and countries, at least in the small part of world constituting the beautiful Carnic Alps.

Conodont papers from the Carnic Alps

About sixty years of studies in the Carnic Alps produced up to now 230 published papers somehow dealing on conodonts from the Carnic Alps. A few papers submitted for publication, but not already accepted, were not considered in this summary. Beside papers, a huge number of abstracts have been published in con-

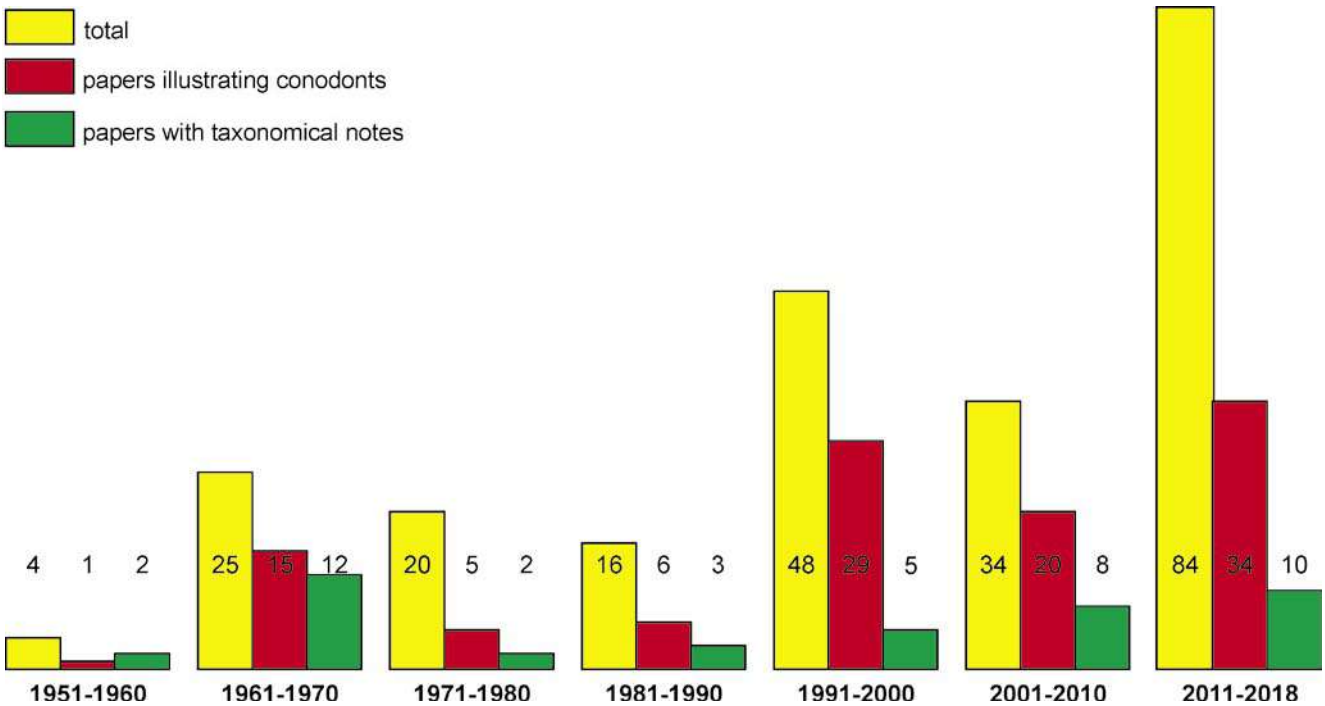


Fig. 3 – Distribution of conodont papers from the Carnic Alps by decade.
- *Numero di pubblicazioni sui conodonti delle Alpi Carniche per intervalli di dieci anni.*

nection with national and international congresses, but are not considered here because it is almost impossible providing a complete record of conference presentations. Also, most of the data anticipated in abstracts are later published in papers.

The reference list includes 137 authors from 24 countries, Italians, Austrians and Germans representing two thirds of the total.

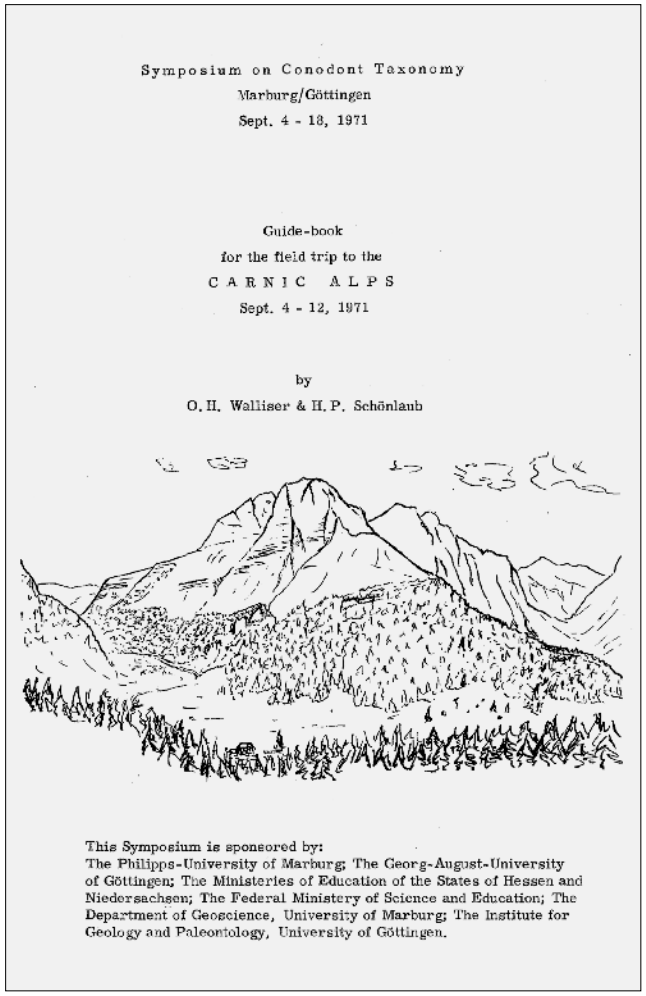
In Fig. 3 the papers are subdivided into decade of publication, showing a general increasing from the beginning to present. Most of the papers deal on local stratigraphy, where conodonts are the main tool for providing the age of the investigated rocks, whereas a few more deal on the general geology of the Carnic Alps reporting a few conodont data. About one half of the papers illustrates conodonts from the Carnic Alps, and only 43 include a taxonomical part (Fig. 3). A few studies deal with conodont biofacies and Color Alteration Index.

The importance of the conodont studies in the Carnic Alps is highlighted by the fact that this region is the only area of the world visited four times during field trips connected with international conodont simposia (ECOS I, Marburg, Germany, 1971; ECOS II, Vienna, Austria, 1980; ECOS VII, Bologna-Modena, Italy, 1998; ICOS 4, Valencia, Spain, 2017, Fig. 4), and only two of these meetings were held in Austria or in Italy. The guidebooks (Fig. 5) prepared in those occasions provide a summary of data available at the time of these meetings.

Contribution to global stratigraphy

It is well known that the first conodont zonation for the Silurian was proposed by Walliser (1964), who based his scheme primarily on the succession of conodonts in the Cellon section, but also including data from

Fig. 4 - Photograph of the participants to the ICOS 4 (4th International Conodont Symposium) field trip in the Carnic Alps, July 2017, at Cellon section.
- *Foto di gruppo dei partecipanti all'escursione nelle Alpi Carniche del congresso ICOS 4 (4th International Conodont Symposium). Sezione di Cellon, luglio 2017.*


Symposium on Conodont Taxonomy
Marburg/Göttingen
Sept. 4 - 18, 1971

Guide-book
for the field trip to the
CARNIC ALPS
Sept. 4 - 12, 1971

by
O. H. Walliser & H. P. Schönlaub

This Symposium is sponsored by:
The Philipps-University of Marburg; The Georg-August-University of Göttingen; The Ministeries of Education of the States of Hessen and Niedersachsen; The Federal Ministery of Science and Education; The Department of Geoscience, University of Marburg; The Institute for Geology and Paleontology, University of Göttingen.

Fig. 5 - Front page of the guidebook of the field trip in the Carnic Alps (Walliser & Schönlaub 1971) connected with the ECOS I (1st European Conodont Symposium, Marburg 1971).
- *Frontespizio della guida all'escursione nelle Alpi Carniche del congresso ECOS I (1st European Conodont Symposium, Marburg 1971) (Walliser & Schönlaub 1971).*

Bohemia and Spain. Walliser (1964) recognized 12 successive first appearance zones spanning the Silurian and the Lower Devonian.

This scheme was utilized for long time worldwide, and many of Walliser's zones are still present in the more recent Silurian condont zonations. The upper part (Ludlow and Pridoli) of the most recent zonation is based on the revision of the Walliser collection from Cellon and other data from the Carnic Alps (Corradini et al. 2015a).

Other global biozonation schemes built combining data on conodont distribution from the Carnic Alps and other areas are provided by Corradini & Corriga (2012) for the Pridoli and the Lochkovian (upper Silurian and lowermost Devonian), Spalletta et al. (2017) for the Famennian (Upper Devonian), and Kaiser et al. (2009) and Corradini et al. (2016b) across the Devonian/Carboniferous boundary.

Contribution to taxonomy

As reported above, only less than 20% of papers includes a taxonomical part where conodont taxa are discussed. This may be explained as in most of the contributions well known conodont taxa were mentioned by stratigraphic purposes only. Nevertheless, some papers represent milestones for conodont taxonomy, for the detailed taxonomical work and the proposal of new species (and even new genera): Walliser (1964) and Serpagli (1967) introduced several new taxa, and most of their species are still valid even if the taxonomical concept of conodonts changed from element taxonomy to multielement apparatus.

Thirty-eight species of conodonts are established from the Carnic Alps in ten papers. The holotypes are reproduced in Figs. 6-10. In stratigraphical order the papers introducing new species are:
- Serpagli (1967) described 7 new species from the Upper Ordovician of Mt. Zermula and Rifugio Nordio sections (Fig. 6): *Ansella pseudorobusta* (Serpagli), *Cornuodus bergstroemi* Serpagli, "*Decoriconus*" *minutus* (Serpagli), *Dichodella exilis* Serpagli, *Nordiodus italicus* Serpagli, *Plectodina alpina* (Serpagli), *Walliserodus amplissimus* (Serpagli).
- Walliser (1964) described 18 new species from the Silurian of Cellon section (Fig. 7): *Ancoradella ploeckensis* Walliser, *Aspidognathus tuberculatus* Walliser, *Hadrognathus staurognathoides* Walliser, *Kockelella crassa* (Walliser), *Kockelella patula* Walliser, *Kockelella ranuliformis* (Walliser), *Oulodus elegans detortus* (Walliser), *Ozarkodina eosteinhornensis* (Walliser), *Ozarkodina sagitta sagitta* (Walliser), *Pedavis latialata* (Walliser), *Pterospathodus amorphognathoides amorphognathoides* (Walliser), *Pterospathodus amorphognathoides angulatus* (Walliser), *Pterospathodus celloni* (Walliser), *Pterospathodus pennatus pennatus* (Walliser), *Pterospathodus pennatus procerus* (Walliser), *Walliserognathus posthamatus* (Walliser), ?*Wurmiella hamata* (Walliser), *Wurmiella inflata* (Walliser).
- Corradini & Corriga (2010) described *Wurmiella alternata* Corradini & Corriga from the Pridoli of Rifugio Lambertenghi Fontana section (Fig. 8).
- Suttner et al. (2017) described *Icriodus marieae* Suttner, Kido & Suttner from the Givetian of Wolayer Glacier section (Fig. 9.4).
- Pölsler (1969b) described *Polygnathus lodinensis* Pölsler from the Frasnian of Findenigkofel 5 section (Fig. 9.9).
- Perri & Spalletta (1981b) described *Ancyrodella pramosica* Perri & Spalletta from the Frasnian of Pramosio 327 section (Fig. 9.7).
- Perri & Spalletta (1990) described *Polygnathus padovani* Perri & Spalletta from the Famennian of Las Callas section (Fig. 9.6).

- Gedik (1969) described 5 new species from the Famennian and the Tournaisian of Plöckenpass and Grüne Schneid sections (Figs. 9.1-9.3, 9.5, 9.10): *Branmehla laterigranosa* (Gedik), *Pinacognathus valdecavatus* Gedik, *Polygnathus biconstrictus* Gedik, *Polygnathus marginvolutus* Gedik, *Pseudopolygnathus granulocostatus* Gedik.
- Schönlaub (1969b) described *Siphonodella carinthiaca* Schönlaub from the Tournaisian of Kronhofgraben section (Fig. 9.8).
- Kozur et al. (1994) described *Neogondolella aequidentata* Kozur, Krainer & Lutz and *Paragondolella alpina postalpina* Kozur, Krainer & Lutz from the Middle Triassic of the Gartnerkofel-Zilkofel area (Fig. 10).

Stratigraphical subdivision of papers

The following lists provides in order of publication the conodont-related papers from the Carnic Alps

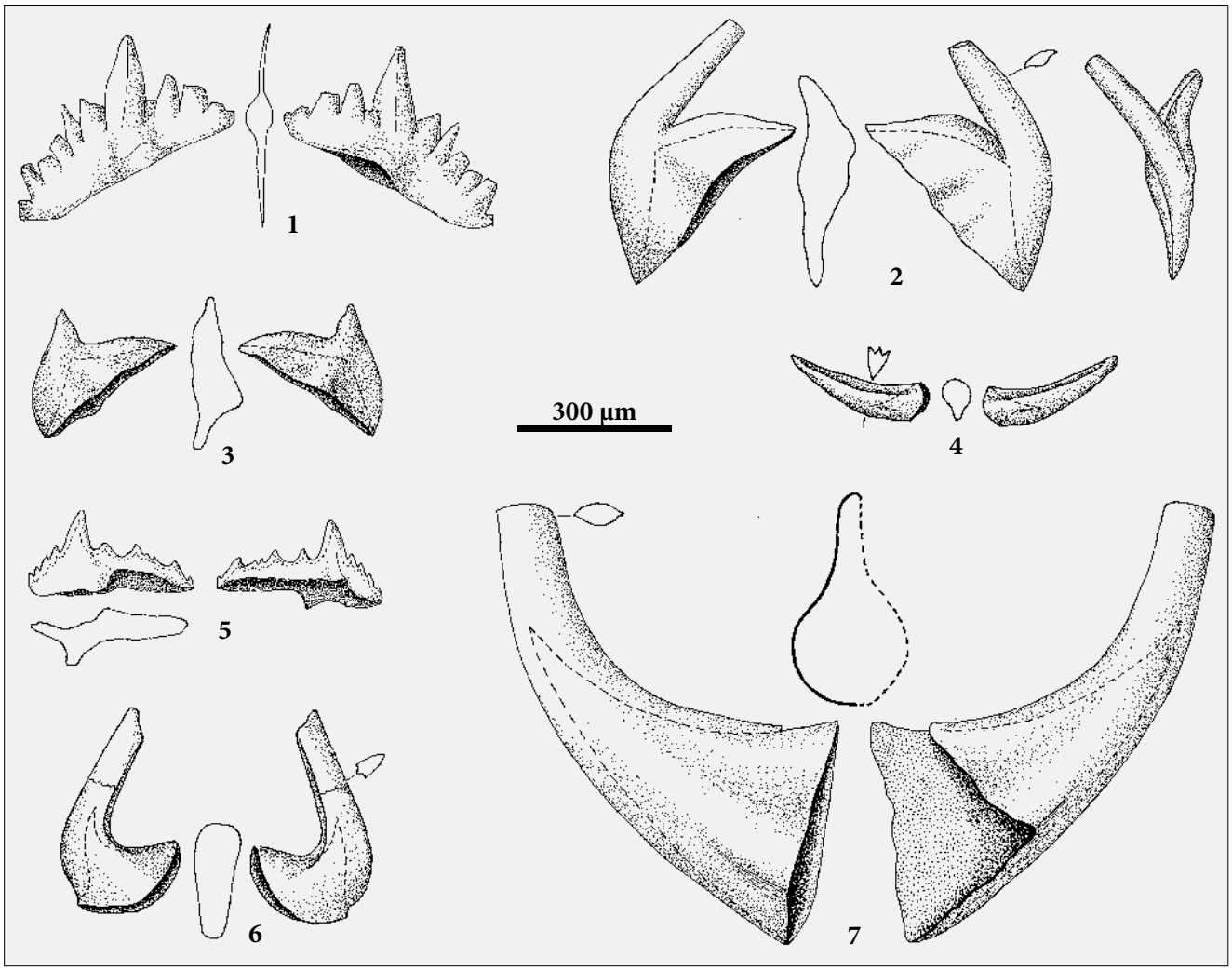


Fig. 6 - Holotypes of Late Ordovician conodonts described by Serpagli (1967) from the Carnic Alps.
1) *Plectodina alpina* (Serpagli, 1967); Mt. Zermula section; refigured after Serpagli (1967, pl. 22, fig. 8); 2) *Ansella pseudorobusta* (Serpagli, 1967); Rifugio Nordio section, refigured after Serpagli (1967, pl. 21, fig. 4); 3) *Nordiodus italicus* Serpagli, 1967; Mt. Zermula section, refigured after Serpagli (1967, pl. 19, fig 10); 4) "*Decoriconus*" *minutus* (Serpagli); Rifugio Nordio section, refigured after Serpagli (1967, pl. 9, fig.3); 5) *Dichodella exilis* Serpagli, 1967; Rifugio Nordio section, refigured after Serpagli (1967, pl. 29, fig. 10); 6) *Cornuodus bergstroemi* Serpagli, 1967; Rifugio Nordio section, refigured after Serpagli (1967, pl. 12, fig. 1); 7) *Walliserodus amplissimus* (Serpagli, 1967); Mt. Zermula section, refigured after Serpagli (1967, pl. 15 fig. 3).
- *Olotipi delle specie di conodonti dell'Ordoviciano superiore descritte da Serpagli (1967) dalle Alpi Carniche.*
1) Plectodina alpina *(Serpagli, 1967); sezione di Mt. Zermula; rifigurato da Serpagli (1967, tav. 22, fig. 8); 2)* Ansella pseudorobusta *(Serpagli, 1967); sezione di Rifugio Nordio, rifigurato da Serpagli (1967, tav. 21, fig. 4); 3)* Nordiodus italicus *Serpagli, 1967; sezione di Mt. Zermula, rifigurato da Serpagli (1967, tav. 19, fig. 10); 4)* "Decoriconus" minutus *(Serpagli); sezione di Rifugio Nordio, rifigurato da Serpagli (1967, tav. 9, fig.3); 5)* Dichodella exilis *Serpagli, 1967; sezione di Rifugio Nordio, rifigurato da Serpagli (1967, tav. 29, fig. 10); 6)* Cornuodus bergstroemi *Serpagli, 1967; sezione di Rifugio Nordio, rifigurato da Serpagli (1967, tav. 12, fig.1); 7)* Walliserodus amplissimus *(Serpagli, 1967); sezione di Mt. Zermula, rifigurato da Serpagli (1967, tav. 15, fig. 3).*

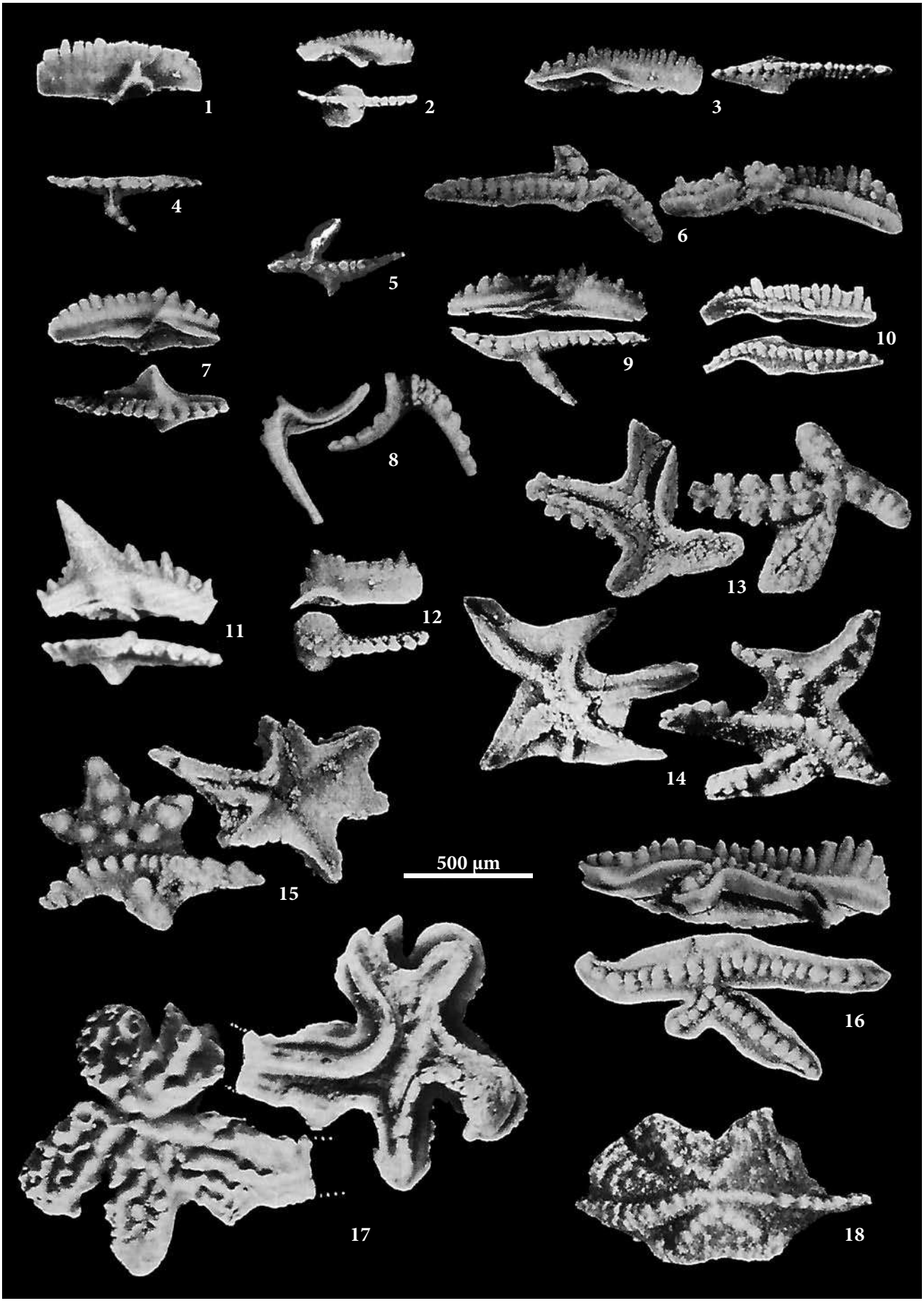

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Fig. 7 - Holotypes of Silurian conodonts described by Walliser (1964) from the Cellon section.
1) *Ozarkodina eosteinhornensis* (Walliser, 1964), P1 element, refigured after Walliser (1964, pl. 20, fig. 21); 2) *Wurmiella inflata* (Walliser, 1964), P1 element, refigured after Walliser (1964, pl. 20, fig. 2); 3) *Ozarkodina sagitta sagitta* (Walliser, 1964), P1 element, refigured after Walliser (1964, pl. 18, fig. 9); 4) *Pterospathodus amorphognathoides angulatus* (Walliser, 1964), P1 element, refigured after Walliser (1964, pl. 15, fig. 9); 5) *Pterospathodus pennatus pennatus* (Walliser, 1964), P1 element, refigured after Walliser (1964, pl. 14, fig. 26); 6) ?*Wurmiella hamata* (Walliser, 1964), P1 element, refigured after Walliser (1964, pl. 18, fig. 26); 7) *Pterospath*odus celloni (Walliser, 1964), P1 element, refigured after Walliser (1964, pl. 14, fig. 5); 8) *Oulodus elegans detortus* (Walliser, 1964), P2 element, refigured after Walliser (1964, pl. 30, fig. 34); 9) *Pterospathodus pennatus procerus* (Walliser, 1964), P1 element, refigured after Walliser (1964, pl. 15, fig. 5); 10) *Walliserognathus posthamatus* (Walliser, 1964), P1 element, refigured after Walliser (1964, pl. 19, fig. 2); 11) *Kockelella crassa* (Walliser, 1964), P2 element, refigured after Walliser (1964, pl. 24, fig. 16); 12) *Kockelella ranuliformis* (Walliser, 1964), P1 element, refigured after Walliser (1964, pl. 22, fig. 5); 13) *Pedavis latialata* (Walliser, 1964), P1 element, refigured after Walliser (1964, pl. 11, fig. 13); 14) *Ancoradella ploeckensis* Walliser, 1964, P1 element, refigured after Walliser (1964, pl. 16, fig. 16); 15) *Kockelella patula* Walliser, 1964, P1 element, refigured after Walliser (1964, pl. 15, fig. 16); 16) *Pterospathodus amorphognathoides amorphognathoides* Walliser, 1964, P1 element, refigured after Walliser (1964, pl. 15, fig. 9); 17) *Hadrognathus staurognathoides* Walliser, 1964, P1 element, refigured after Walliser (1964, pl. 13, fig. 7); 18) *Aspidognathus tuberculatus* Walliser, 1964, P1 element, refigured after Walliser (1964, pl. 22, fig. 18).
- *Olotipi delle specie di conodonti siluriane descritte da Walliser (1964) dalle sezione di Cellon.*
1) Ozarkodina eosteinhornensis *(Walliser, 1964), elemento P1, rifigurato da Walliser (1964, tav. 20, fig. 21); 2)* Wurmiella inflata *(Walliser, 1964), elemento P1, rifigurato da Walliser (1964, tav. 20, fig. 2); 3)* Ozarkodina sagitta sagitta *(Walliser, 1964), elemento P1, rifigurato da Walliser (1964, tav. 18, fig. 9); 4)* Pterospathodus amorphognathoides angulatus *(Walliser, 1964), elemento P1, rifigurato da Walliser (1964, tav. 15, fig. 9); 5)* Pterospathodus pennatus pennatus *(Walliser, 1964), elemento P1, rifigurato da Walliser (1964, tav. 14, fig. 26); 6) ?*Wurmiella hamata *(Walliser, 1964), elemento P1, rifigurato da Walliser (1964, tav. 18, fig. 26); 7)* Pterospathodus celloni *(Walliser, 1964), elemento P1, rifigurato da Walliser (1964, tav. 14, fig. 5); 8)* Oulodus elegans detortus *(Walliser, 1964), elemento P2, rifigurato da Walliser (1964, tav. 30, fig. 34); 9)* Pterospathodus pennatus procerus *(Walliser, 1964), elemento P1, rifigurato da Walliser (1964, tav. 15, fig. 5); 10)* Walliserognathus posthamatus *(Walliser, 1964), elemento P1, rifigurato da Walliser (1964, tav. 19, fig. 2); 11)* Kockelella crassa *(Walliser, 1964), elemento P1, rifigurato da Walliser (1964, tav. 24, fig. 16); 12)* Kockelella ranuliformis *(Walliser, 1964), elemento P1, rifigurato da Walliser (1964, tav. 22, fig. 5); 13)* Pedavis latialata *(Walliser, 1964), elemento P1, rifigurato da Walliser (1964, tav. 11, fig. 13); 14)* Ancoradella ploeckensis *Walliser, 1964, elemento P1, rifigurato da Walliser (1964, tav. 16, fig. 16); 15)* Kockelella patula *Walliser, 1964, elemento P1, rifigurato da Walliser (1964, tav. 15, fig. 16);16)* Pterospathodus amorphognathoides amorphognathoides *Walliser, 1964, elemento P1, rifigurato da Walliser (1964, tav. 15, fig. 9); 17)* Hadrognathus staurognathoides *Walliser, 1964, elemento P1, rifigurato da Walliser (1964, tav. 13, fig. 7); 18)* Aspidognathus tuberculatus *Walliser, 1964, elemento P1, rifigurato da Walliser (1964, tav. 22, fig. 18).*

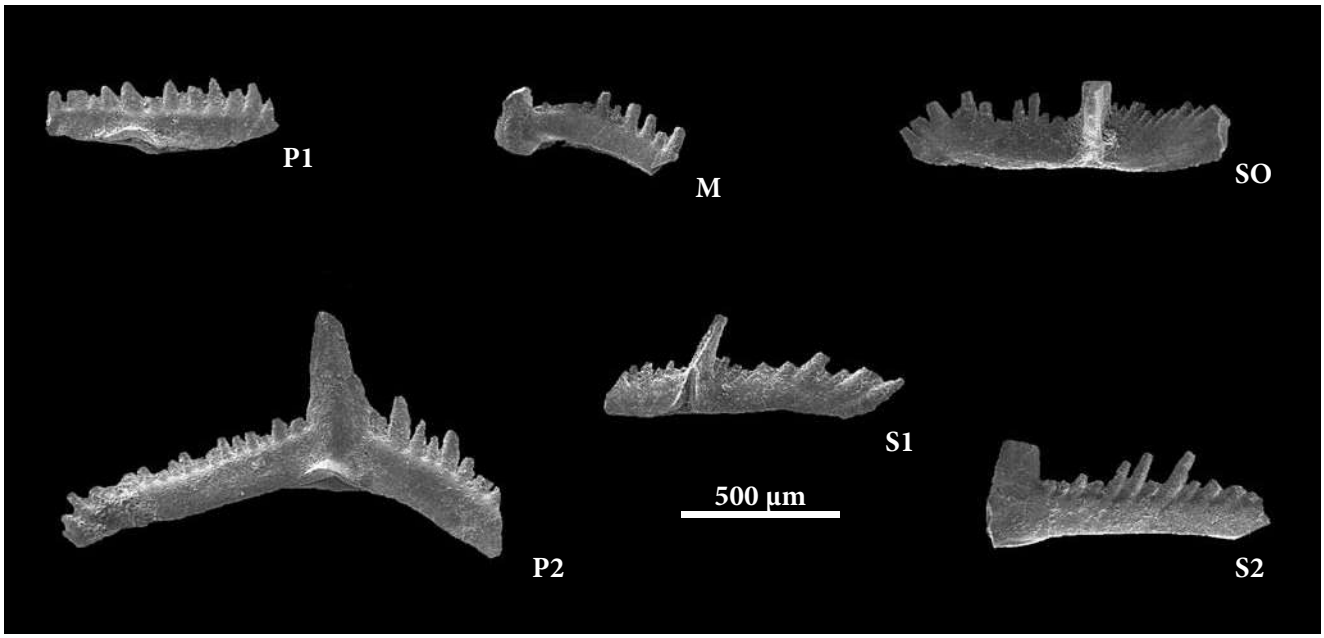

Fig. 8 - Holotype of *Wurmiella alternata* Corradini & Corriga, 2010, described from the Pridoli (upper Silurian) of Wolayer area (Rifugio Lambertenghi Fontana section). Letters indicate the different elements of the apparatus. Refigured after Corradini & Corriga (2010, pl. 2, figs 1-6).
- *Olotipo di* Wurmiella alternata *Corradini & Corriga, 2010, descritto dal Pridoli (Siluriano superiore) dell'area di Passo Volaia (sezione del Rifugio Lambertenghi Fontana). Le lettere indicano i diversi elementi dell'apparato. Rifigurato da Corradini & Corriga (2010, tav. 2, figs. 1-6).*

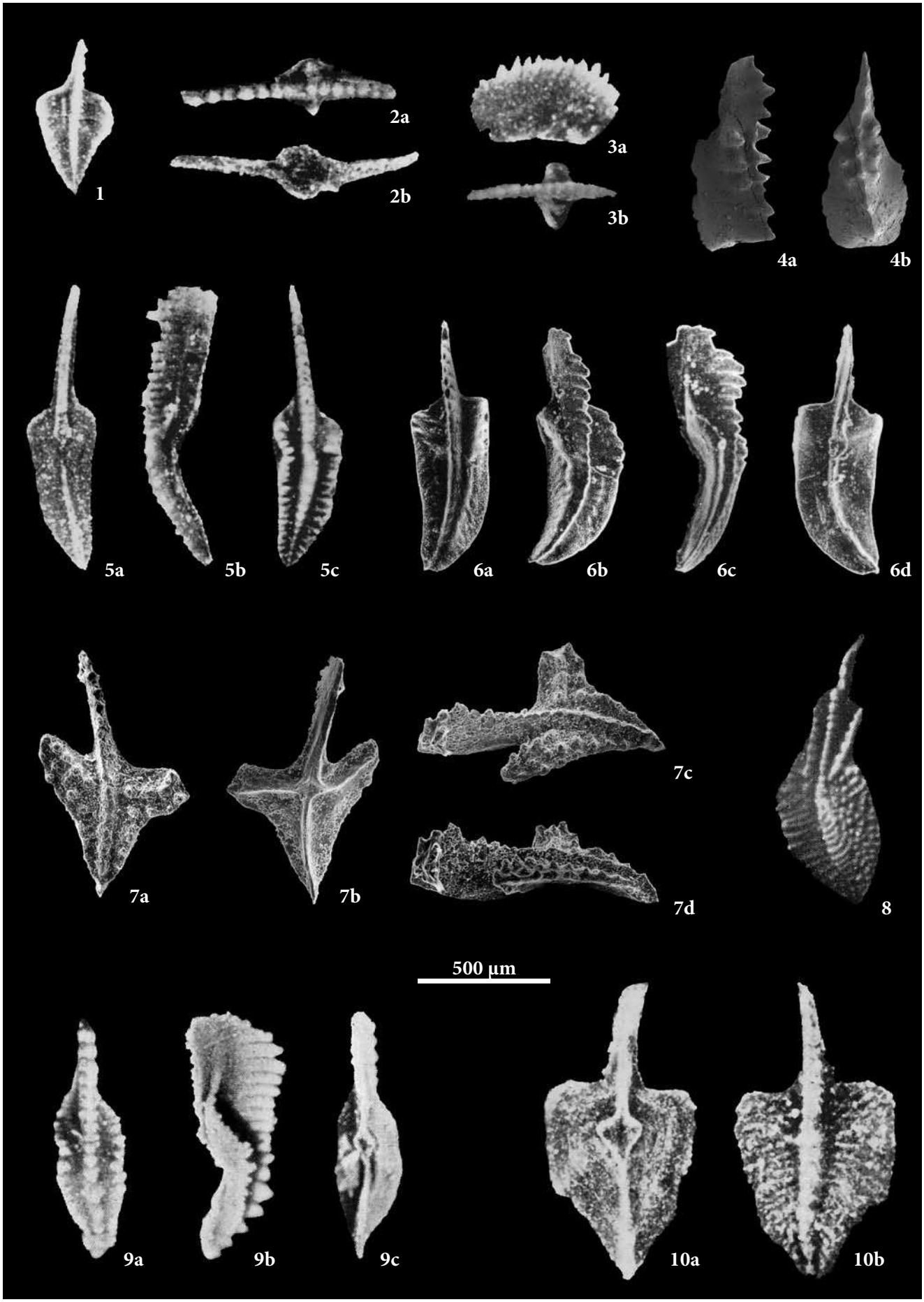
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Fig. 9 - Holotypes of Devonian and Lower Carboniferous conodonts from the Carnic Alps.
1) *Polygnathus marginvolutus* Gedik, 1969, upper view, Grüne Schneid 2 section; refigured after Gedik (1974, pl. 5, fig. 7); 2) *Branmehla laterigranosa* (Gedik, 1969), upper (2a) and lower (2b) views, section above the barracks at Plöckenpass; refigured after Gedik (1974, pl. 3, fig. 11); 3) *Pinacognathus valdecavatus* (Gedik, 1969), lateral (3a) and upper (3b) views, section above the barracks at Plöckenpass; refigured after Gedik (1974, pl. 1, fig. 9); 4) *Icriodus marieae* Suttner, Kido & Suttner, 2017, upper lateral (4a) and upper (4b) views, Wolayer "Glacier" section; refigured after Suttner et al. (2017, pl. 1 fig. 3); 5) *Polygnathus biconstrictus* Gedik, 1969, upper (5a), lateral (5b) and lower (5c) views, section above the barracks at Plöckenpass; refigured after Gedik (1974, pl. 4, fig. 7); 6) *Polygnathus padovanii* Perri & Spalletta, 1990, upper (6a), upper-lateral (6b), lateral (6c) and lower (6d) views, Las Callas section; refigured after Perri & Spalletta (1990, pl. 6, fig. 3); 7) *Ancyrodella pramosica* Perri & Spalletta, 1981b, upper (7a), lower (7b), upper-lateral (7c) and lateral (7d) views, Pramosio 327 section; refigured after Perri & Spalletta (1981b, pl. 1, fig. 3); 8) *Siphonodella carinthiaca* Schönlaub, 1969b, upper view, Kronhofgraben section, refigured after Schönlaub (1969b, pl. 2, fig. 1); 9) *Polygnathus lodinensis* Pölsler, 1969b, upper (9a), lateral (9b) and lower (9c) views, Findenigkofel 5 section; refigured after Pölsler (1969b, pl. 6, fig. 1-3); 10) *Pseudopolygnathus granulocostatus* Gedik, 1969, upper (10a) and lower (10b) views, section above the barracks at Plöckenpass; refigured after Gedik (1974, pl. 6, fig. 20).
- *Olotipi delle specie di conodonti del Devoniano e Carbonifero inferiore descritte dalle Alpi Carniche.*
1) Polygnathus marginvolutus *Gedik, 1969, veduta superiore, sezione Grüne Schneid 2; rifigurato da Gedik (1974, tav. 5, fig. 7); 2)* Branmehla laterigranosa *(Gedik, 1969), vedute superiore (2a) e inferiore (2b), sezione sopra le caserme di Passo di Monte Croce Carnico; rifigurato da Gedik (1974, tav. 3, fig. 11); 3)* Pinacognathus valdecavatus *(Gedik, 1969), vedute laterale (3a) e superiore (3b), sezione sopra le caserme di Passo di Monte Croce Carnico; rifigurato da Gedik (1974, tav. 1, fig. 9); 4)* Icriodus marieae *Suttner, Kido & Suttner, 2017, vedute obliqua (4a) e superiore (4b) views, sezione Wolayer "Glacier"; rifigurato da Suttner et al. (2017, tav. 1 fig. 3); 5)* Polygnathus biconstrictus *Gedik, 1969, vedute superiore (5a), laterale (5b) e inferiore (5c) views, sezione sopra le caserme di Passo di Monte Croce Carnico; rifigurato da Gedik (1974, tav. 4, fig. 7); 6)* Polygnathus padovanii *Perri & Spalletta, 1990, vedute superiore (6a), obliqua (6b), laterale (6c) e inferiore (6d), sezione di Las Callas; rifigurato da Perri & Spalletta (1990, tav. 6, fig. 3); 7)* Ancyrodella pramosica *Perri & Spalletta, 1981b, vedute superiore (7a), inferiore (7b), obliqua (7c) e laterale (7d), sezione di Pramosio 327; rifigurato da Perri & Spalletta (1981b, tav. 1, fig. 3); 8)* Siphonodella carinthiaca *Schönlaub, 1969b, veduta superiore, sezione del Kronhofgraben; rifigurato da Schönlaub (1969b, tav. 2, fig. 1); 9)* Polygnathus lodinensis *Pölsler, 1969b, vedute superiore (9a), laterale (9b) e inferiore (9c), sezione Findenigkofel 5; rifigurato da Pölsler (1969b, tav. 6, fig. 1-3); 10)* Pseudopolygnathus granulocostatus *Gedik, 1969, vedute superiore (10a) e inferiore (10b), sezione sopra le caserme di Passo di Monte Croce Carnico; rifigurato da Gedik (1974, tav. 6, fig. 20).*

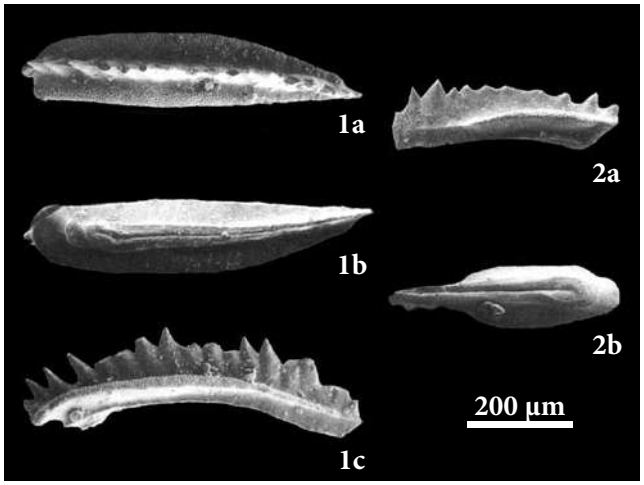

Fig. 10 - Holotypes of Triassic conodonts described by Kozur et al. (1994) from the Gartnerkofel East locality.
1) *Neogondolella aequidentata* Kozur, Krainer & Lutz, 1994: upper (1a), lower (1b) and lateral (1c) views; refigured after Kozur et al. (1994, pl. 2, fig 6); 2) *Paragondolella alpina postalpina* Kozur, Krainer & Lutz, 1994: upper (2a) and lower (2b) views; refigured after Kozur et al. (1994, pl.1, fig.7).
- *Olotipi di specie di conodonti triassici descritti da Kozur et al. (1994) dall'affioramento Gartnerkofel East.*
1) Neogondolella aequidentata *Kozur, Krainer & Lutz, 1994, vedute superiore (1a), inferiore (1b) e laterale (1c); rifigurato da Kozur et al. (1994, pl. 2, fig. 6); 2)* Paragondolella alpina postalpina *Kozur, Krainer & Lutz, 1994, vedute superiore (2a) e inferiore (2b); rifigurato da Kozur et al. (1994, pl.1, fig. 7).*

subdivided according to stratigraphic intervals (Fig. 11). Considering the huge amount of studies dealing on Devonian, reflecting the abundance and variety of Devonian rocks in the Carnic Alps, separate lists are provided for Early, Middle and Late Devonian respectively. Note that some papers are reported in more than one list, because they deal with various time frames.

Ordovician

Walliser 1964; Serpagli & Greco 1965a; Serpagli & Greco 1965b; Pölsler 1967; Serpagli 1967; Cantelli et al. 1968; Schönlaub 1969a; Manara & Vai 1970; Schönlaub 1971a; Schönlaub 1971b; Schönlaub 1971c; Walliser & Schönlaub 1971; Ebner 1973a; Jaeger & Schönlaub 1977; Schönlaub 1980; Vai & Spalletta 1980; Schönlaub 1985a; Schönlaub & Bogolepova 1994; Schönlaub et al. 1994; Schönlaub 1997a; Schönlaub et al. 1997a; Schönlaub et al. 1997c; Bagnoli et al. 1998; Pondrelli 1998 Ferretti et al. 1999; Ferretti & Schönlaub 2001; Pondrelli 2002; Brime et al. 2003; Brime et al. 2008; Dalla Vecchia 2008; Schönlaub et al. 2011; Hubmann et al. 2014; Schönlaub & Ferretti 2015a; Schönlaub & Ferretti 2015b; Schönlaub & Ferretti 2015c; Bagnoli et al. 2017; Corradini et al. 2017a; Schönlaub et al. 2017b.

Silurian

Walliser 1957; Walliser 1962; Forti & Nocchi 1963; Walliser 1964; Cantelli et al. 1965; Flajs & Pölsler 1965; Manzoni 1965; Serpagli & Greco 1965a; Pölsler

1967; Cantelli et al. 1968; Pölsler 1969a; Schönlaub 1969a; Skala 1969; Jaeger & Schönlaub 1970; Manara & Vai 1970; Schönlaub 1970; Schönlaub 1971a; Schönlaub 1971b; Schönlaub 1971c; Walliser & Schönlaub 1971; Auferbauer 1972; Ebner 1973a; Jaeger et al. 1975; Flügel et al. 1977; Jaeger & Schönlaub 1977; Jaeger & Schönlaub 1980; Schönlaub 1980; Schönlaub 1985a; Herzog 1988; Schönlaub & Flajs 1993; Schönlaub & Bogolepova 1994; Schönlaub 1994a; Schönlaub 1994b; Schönlaub 1994c; Schönlaub et al. 1994; Schönlaub 1997b; Schönlaub & Kreutzer 1997; Schönlaub et al. 1997a; Schönlaub et al. 1997c; Pondrelli 1998; Ferretti et al. 1999; Histon et al. 1999; Pondrelli 2002; Brime et al. 2003; Corradini et al. 2003; Križ et al. 2003; Ferretti 2005; Suttner 2006; Suttner 2007; Corradini 2008; Brime et al. 2008; Dalla Vecchia 2008; Verniers et al. 2008; Brett et al. 2009; Corriga & Corradini 2009; Corriga et al. 2009; Corradini & Corriga 2010; Corradini et al. 2010; Corriga 2011; Corradini et al. 2012; Corradini & Corriga 2012; Ferretti et al. 2012; Histon 2012; Jeppsson et al. 2012; Piras et al. 2012; Piras et al. 2013; Hubmann et al. 2014; Corradini et al. 2015a; Ferretti et al. 2015a; Ferretti et al. 2015b; Ferretti et al. 2015c; Pondrelli et al. 2015d; Schönlaub et al. 2015a; Suttner et al. 2015; Corradini et al. 2016a; Corriga et al. 2016; Ferretti et al. 2016; Corradini et al. 2017a; Corriga et al. 2017a; Schönlaub & Corradini 2017; Schönlaub et al. 2017a; Schönlaub et al. 2017b; Corradini & Corriga 2018; ; Corradini et al. 2019; Corradini et al. in press.

Early Devonian

Walliser 1962; Forti & Nocchi 1963; Walliser 1964; Cantelli et al. 1965; Flajs & Pölsler 1965; Manzoni 1965; Pölsler 1967; Cantelli et al. 1968; Bandel 1969; Pölsler 1969a; Pölsler 1969b; Schönlaub 1969a; Skala 1969; Manara & Vai 1970; Schönlaub 1970; Walliser & Schönlaub 1971; Auferbauer 1972; Ebner 1973a; Jaeger et al. 1975; Schönlaub & Flajs 1975; Fenninger et al. 1976; Flügel et al. 1977; Jaeger & Schönlaub 1980; Schönlaub 1980; Schönlaub 1985a; Schönlaub 1985b; Herzog 1988; Kreutzer 1989; Flügel & Schönlaub 1990; Kreutzer 1990; Schönlaub & Bogolepova 1994; Schönlaub et al. 1994; Schönlaub & Kreutzer 1997; Schönlaub et al. 1997a; Schönlaub et al. 1997b; Schönlaub et al. 1997c; Perri & Spalletta 1998b; Pondrelli 1998; Ferretti et al. 1999; Schönlaub 1999; Pondrelli 2002; Brime et al. 2003; Corradini et al. 2005; Suttner 2006; Suttner 2007; Brime et al. 2008; Corradini 2008; Dalla Vecchia 2008; Corriga & Corradini 2009; Corriga et al. 2009; Corradini & Corriga 2010; Corriga 2011; Corriga et al. 2011; Corradini & Corriga 2012; Corradini et al. 2012; Corriga et al. 2012; Hubmann et al. 2014; Bandel et al. 2015; Corradini et al. 2015a; Corradini et al. 2015b; Corradini et al. 2015c; Pondrelli et al. 2015a; Pondrelli et al. 2015b; Pondrelli et al. 2015d; Pondrelli et al. 2015f; Schönlaub et al. 2015a; Spalletta et al. 2015d; Spalletta et al. 2015f; Suttner et al. 2015; Suttner & Kido 2015; Corradini et al. 2016a; Corriga et al. 2016; Corradini et al. 2017a; Corriga et al. 2017a; Corriga et al. 2017; Schönlaub & Corradini

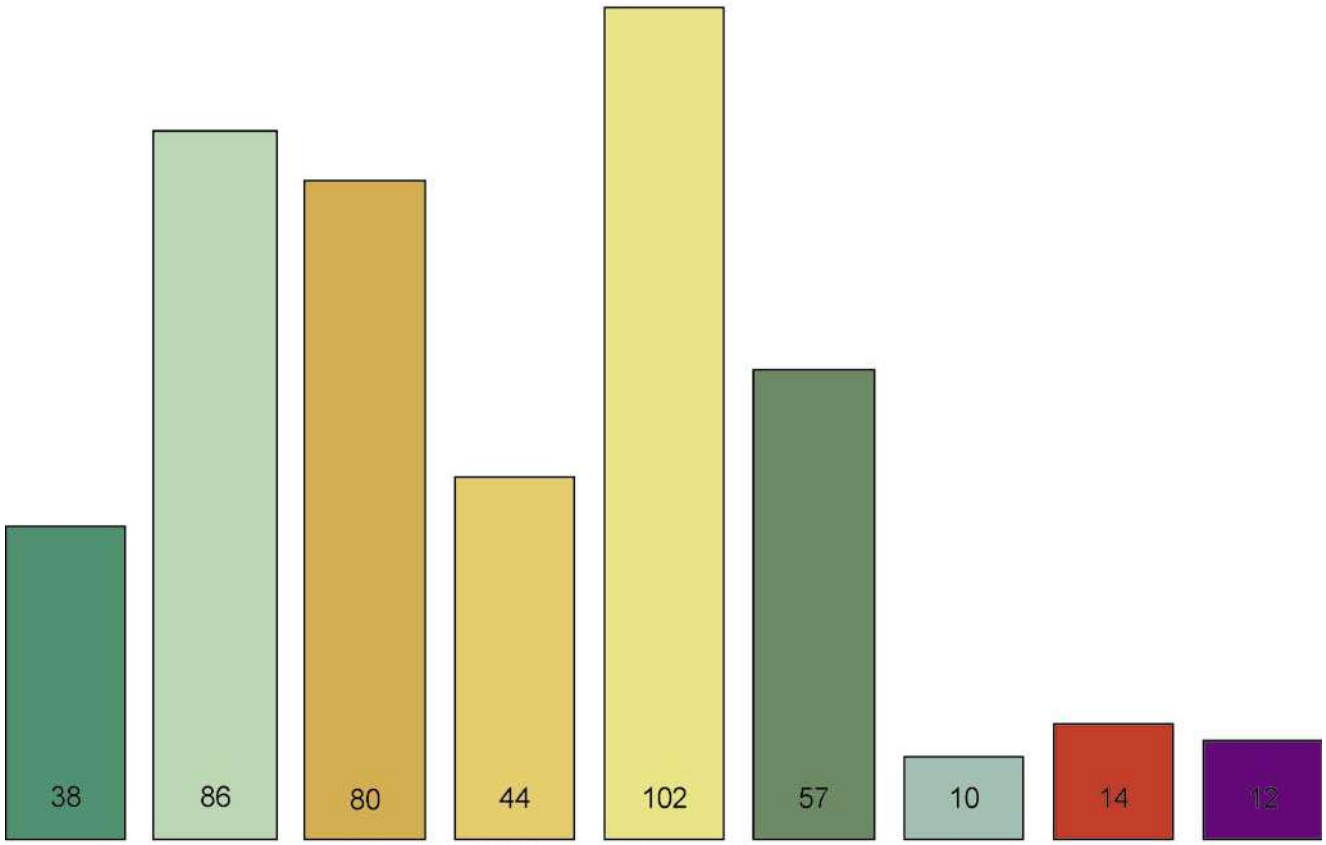

Fig. 11 - Distribution of conodont papers from the Carnic Alps by Period. Data from Early, Middle and Late Devonian units are provided separately due to the variety and abundance of Devonian rocks.
- *Numero di pubblicazioni sui conodonti delle Alpi Carniche per periodo geologico. Considerando l'abbondanza e la varietà delle rocce devoniane, vengono forniti separatamente i dati per il Devoniano Inferiore, Medio e Superiore.*

2017; Schönlaub et al. 2017a; Schönlaub et al. 2017b; Corradini et al. 2019; Corradini et al. in press.

Middle Devonian

Flajs & Pölsler 1965; Pölsler 1967; Cantelli et al. 1968; Pölsler 1969a; Pölsler 1969b; Schönlaub 1969a; Skala 1969; Walliser & Schönlaub 1971; Ebner 1973a; Schönlaub 1980; Schönlaub 1985a; Schönlaub 1985a; Herzog 1988; Kreutzer 1989; Kreutzer 1990; Schönlaub et al. 1994; Schönlaub et al. 1997b; Perri & Spalletta 1998b; Pondrelli 1998; Spalletta & Perri 1998a; Spalletta & Perri 1998b; Schönlaub 1999; Pondrelli 2002; Brime et al. 2003; Brime et al. 2008; Dalla Vecchia 2008; Corradini et al. 2012; Hubmann et al. 2014; Pas et al. 2014; Kido et al. 2015; Pas 2015; Pondrelli et al. 2015b; Pondrelli et al. 2015c; Pondrelli et al. 2015d; Pondrelli et al. 2015e; Pondrelli et al. 2015f; Spalletta et al. 2015d; Spalletta et al. 2015f; Corradini et al. 2016a; Schönlaub et al. 2017a; Suttner et al. 2017a; Suttner et al. 2017b; Suttner et al. 2017c.

Late Devonian

Müller 1956; Flügel et al. 1959; Forti & Nocchi 1963; Flajs & Pölsler 1965; Manzoni 1965; Ferrari & Vai 1966; Manzoni 1966; Pölsler 1967; Cantelli et al. 1968; Manzoni 1968; Gedik 1969; Müller 1969; Pölsler 1969a; Pölsler 1969b; Schönlaub 1969a; Schönlaub 1969b; Skala 1969; Walliser & Schönlaub 1971; Auferbauer 1972; Ebner 1973a; Ebner 1973b; Ferrari & Vai 1973; Leditzky 1973; Gedik 1974; Schönlaub 1980; Perri & Spalletta 1981a; Perri & Spalletta 1981b; Herzog 1983; Spalletta et al. 1983; Schönlaub 1985a; Schönlaub 1985b; Herzog 1988; Schönlaub et al. 1988; Kreutzer 1989; Kreutzer 1990; Perri & Spalletta 1990; Perri & Spalletta 1991; Schönlaub et al. 1991; Dreesen 1992; Schönlaub et al. 1992; Schönlaub 1993; Joachimski et al. 1994; Schönlaub et al. 1994; Spalletta & Perri 1994; Schönlaub et al. 1997b; Perri & Spalletta 1998b; Perri & Spalletta 1998c; Perri & Spalletta 1998d; Perri & Spalletta 1998e; Perri & Spalletta 1998f; Perri et al. 1998; Pondrelli 1998; Spalletta & Perri 1998b; Spalletta & Perri 1998c; Spalletta & Perri 1998d; Spalletta et al. 1998a; Spalletta et al. 1998b; Schönlaub 1999; Perri & Spalletta 2000; Perri & Spalletta 2001; Spalletta & Perri 2001; Pondrelli 2002; Brime et al. 2003; Kaiser 2005; Kaiser et al. 2006; Kaiser 2007; Randon et al. 2007; Brime et al. 2008; Dalla Vecchia 2008; Kaiser et al. 2008; Hartenfels & Becker 2009; Kaiser et al. 2009; Corradini et al. 2011; Kaiser & Corradini 2011; Hartenfels 2011; Corradini et al. 2012; Corradini et al. 2013; Mossoni et al. 2013; Hubmann et al. 2014; Kumpan et al. 2014; Mossoni 2014; Pas et al. 2014; Kido et al. 2015; Pas 2015; Pohler et al. 2015; Pondrelli et al. 2015d; Pondrelli et al. 2015e; Pondrelli et al. 2015f; Spalletta et al. 2015a; Spalletta et al. 2015a; Spalletta et al. 2015b; Spalletta et al. 2015f; Corradini et al. 2016b; Hartenfels & Becker 2016; Corradini et al. 2017b; Corradini et al. 2017d; Schönlaub et al. 2017a; Spalletta et al. 2017a; Spalletta et al. 2017b; Spalletta et al. 2017c; Schönlaub in press.

lower Carboniferous (Mississippian)

Flügel et al. 1959; Müller 1959; Flajs & Pölsler 1965; Ferrari & Vai 1966; Manzoni 1966; Pölsler 1967; Cantelli et al. 1968; Manzoni 1968; Gedik 1969; Schönlaub 1969b; Gedik 1974; Ebner 1973a; Ebner 1973b; Schönlaub 1980; Spalletta 1981; Herzog 1983; Herzog 1988; Schönlaub et al. 1988; Flügel & Schönlaub 1990; Schönlaub et al. 1991; Dreesen et al. 1992; Schönlaub et al. 1992; Schönlaub & Kreutzer 1993; Schönlaub 1993; Schönlaub et al. 1994; Spalletta & Perri 1994; Schönlaub & Kreutzer 1997; Perri & Spalletta 1998a; Perri & Spalletta 1998b; Perri & Spalletta 1998e; Spalletta & Perri 1998e; Pondrelli 1998; Perri & Spalletta 2000; Perri & Spalletta 2001; Pondrelli 2002; Brime et al. 2003; Brime et al. 2003; Hubmann et al. 2004; Kaiser 2005; Kaiser et al. 2006; Kaiser 2007; Randon et al. 2007; Kaiser et al. 2008; Kaiser et al. 2009; Corradini et al. 2011; Kaiser & Corradini 2011; Corradini et al. 2012; Corradini et al. 2013; Kumpan et al. 2014; Schönlaub et al. 2015b; Spalletta et al. 2015b; Spalletta et al. 2015c; Spalletta et al. 2015e; Corradini et al. 2016b; Corradini et al. 2017c; Corradini et al. 2017e; Spalletta et al. 2017b; Schönlaub in press.

upper Carboniferous (Pennsylvanian)

Luppold 1994; Pondrelli 1998; Forke & Samankassou 2000; Forke 2001; Forke 2002; Pondrelli 2002; Brime et al. 2003; Forke et al. 2006; Brime et al. 2008; Hubmann et al. 2014.

Permian

Holser et al. 1991; Schönlaub 1991; Schönlaub et al. 1994; Forke 1995; Pondrelli 1998; Forke 2001; Forke 2002; Pondrelli 2002; Brime et al. 2003; Forke et al. 2006; Schönlaub & Forke 2007; Brime et al. 2008; Davydov et al. 2013; Hubmann et al. 2014.

Triassic

Pfeiffer 1988; Holser et al. 1991; Schönlaub 1991; Kozur et al. 1994; Schönlaub et al. 1994; Krainer & Lutz 1995; Nicora & Rizzi 1998; Pondrelli 1998; Pondrelli 2002; Brime et al. 2003; Schönlaub & Forke 2007; Brime et al. 2008.

Papers on conodonts from the Carnic Pre-Alps and Julian Alps

Beside the huge amount of papers dealing on conodonts from the Carnic Alps, a few more publications report data from the Triassic of the Carnic Prealps or of the Julian Alps. These papers were not considered in the text above, but are here mentioned in order to provide a complete documentation of conodont papers from the area: Lieberman (1978); Farabegoli et al. (1984); Roghi et al. (1995); Jadoul et al. (2002); Scotti et al. (2002); Preto et al. (2005); Dalla Vecchia (2012).

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1) Before going to press, the article have been updated by inserting the most recent publications.

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