

The Chitinozoans in the upper Ordovician to lowermost Devonian succession of the Cellon-Section. – A preliminary report.

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Introduction.

The investigations of the chitinozoans from the Cellon section [Caradoc- Lochkovian] were part of a project with the goal of examining the geographic and stratigraphic distribution of the main palynomorph groups (acritarchs, chitinozoans, spores) within the different environments of the upper Ordovician to lower Devonian series in the Carnic Alps.

In the Silurian, the period mainly concerned by this research, these environments are: the "Plöcken Fazies", a shallow water environment with predominantly calcareous deposits; the "Bischofalm Fazies", a siliciclastic basinal environment, and the transitional "Findenig Fazies", mediating between the former two [the nearshore environment ("Wolayer Fazies") with strongly condensed sediments of very shallow water has not yet been studied].

In none of these facies *spores* could be observed. The *acritarchs* turned out to be highly influenced by the local environments. Their only remarkable occurrence is in the Lower Silurian of the Cellon section which belongs to the calcareous shallow water facies [PRIEWALDER, 1987].

The *chitinozoans* however, proved to be the geographically and stratigraphically widest distributed group of the palynomorphs.

From the siliciclastic and the transitional facies altogether 79 samples have been examined so far by spot checks to estimate the appearance of the chitinozoans: 60% of them were found to be fossiliferous.

From the Upper Ordovician to Lower Devonian sequence in the Cellon section 95 samples have been prepared. 48 of them [= 51%] yielded chitinozoans.

As the chitinozoans were opaque to transmitting light the investigations had to be carried out mainly under SEM. About 4.300 micropalaeontological objects [chitinozoans as well as chitinozoan-like and/or problematic particles] have been examined in this way.

It has to be pointed out that the names of the chitinozoans in this report are provisional because they are based on gross determinations only. Detailed morphological studies have yet to be done and will result in more diverse chitinozoan associations at many horizons of the Cellon section.

In the studied section, the chitinozoans appear in the following sequences [Fig. 1]:

- ⇨ in the Plöcken Formation [upper Ashgill];
- ⇨ in the lower part of the Kok Formation [upper Llandovery];
- ⇨ in the sequence from the uppermost Kok Formation to the top of the Cardiola Formation [upper Ludlow];
- ⇨ in the sequence from the upper part of the Alticola Limestone

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to the lower-most Rauchkofel Limestone [Ludlow/Pridoli boundary - lowermost Lochkovian].

The Chitinozoans of the upper Ordovician.

In the Uggwa Shale and Uggwa Limestone, respectively, chitinozoans are lacking. Instead, black and glossy particles with chitinozoan-like contours, probably consisting of graphite, are frequently present. In the light-microscope they may easily be confused with badly preserved chitinozoans.

Stratigraphically the chitinozoans make their debut in sample *126* at the base of the Plöcken Formation with a few insignificant specimens of the genera *Conochitina* EISENACK 1931 and *?Tanuchitina* JANSONIUS 1964. Further, numerous melanosklerits with a strong resemblance to chitinozoans can be observed, as well as chitinozoan-like graphitic particles.

At the top of this formation 3 assemblages [samples *128*, *129*, *45*] contain representatives of the genera *Conochitina*, *Desmochitina* EISENACK 1931 [e.g., *Desmochitina minor* EISENACK 1931], *?Rhabdochitina* EISENACK 1931, *Spinachitina* SCHALLREUTER 1963 and of the Ancyrochitininae, but most of all two taxa which are diagnostic for the Ashgill: *Armoricochitina nigerica* (BOUCHÉ 1965) and *Tanuchitina elongata* (BOUCHÉ 1965) thus indicating the Hirnantian *Tanuchitina elongata* - Biozone (PARIS 1990).

The Ashgillian samples yielded very few chitinozoans in a rather bad state of preservation: most specimens are three-dimensionally preserved, but broken.

The Chitinozoans of the upper Llandovery.

Between the Ordovician Plöcken Formation and the overlying Silurian Kok Formation there is a large stratigraphical gap comprising the entire Rhuddanian and also the Aeronian.

The lowermost part of the Kok Formation [samples *46A*, *47*, *130*, *131*] yielded chitinozoan faunas with a great number of undeterminable specimens of the Lagenochitinidae and the Ancyrochitininae and taxa such as *Ancyrochitina* gr. *ancyrea* (EISENACK 1931), *Cyathochitina caputoi* DA COSTA 1971, many specimens of *Bursachitina* TAUGOURDEAU 1966 and *Conochitina* [e.g., *C.sp. cf. emmastensis* NESTOR 1982], as well as *Eisenackitina dolioliformis* UMNOVA 1976 which is a very characteristic Cellon-species and the index species of the upper Aeronian-lower Telychian *Eisenackitina dolioliformis* - Biozone [VERNIERS et al.1995].

Also the upper Telychian part of the Kok Formation [samples *49*, *50*, *132*, *133*] is rich in chitinozoans. Less important taxa are representatives of *Cyathochitina* EISENACK 1955, *Eisenackitina* JANSONIUS 1964, *Lagenochitina* EISENACK 1931 and *Sphaerochitina* EISENACK 1955. However, here also occurs one *Conochitina*-species [besides several others] which is similar to the important upper Telychian to lower Sheinwoodian *C.probosCIFera* EISENACK 1937, and an *Angochitina*-species which closely resembles *A.longicollis* EISENACK 1931, suggesting the *Angochitina longicollis* - Biozone [VERNIERS et al.1995] of upper Telychian age.

The chitinozoans from this part of the section are entirely or partly flattened and

frequently folded. In cases of intense folding or variable flattening of the vesicles [e.g. thinner-walled necks are more, thicker-walled body chambers less strongly deformed] their contours may be altered to an extent that the original taxon is difficult to recognize.

The Chitinozoans of the Wenlock - lower Ludlow.

Throughout the Wenlockian sequence of the Cellon section, the strata of which attain a thickness of only 5 meters thus indicating an extreme condensation [SCHÖNLAUB 1997], and also in the lower Ludlow, that means, in the middle and upper part of the Kok Formation, associations of determinable chitinozoans are missing. Only sporadic and badly preserved fossils are present [samples 135, 54, 136, 56].

The Chitinozoans of the upper Ludlow.

From the uppermost bed of the Kok Formation [sample 63] to the top of the Cardiola Formation [sample 145] a great variety of chitinozoans occurs.

The assemblages are dominated by *Angochitina*- [e.g., *A. echinata* EISENACK 1931], *Sphaerochitina*- [e.g., *S.sp. cf. impia* LAUFELD 1974], *Belonechitina*- and *Conochitina* - species [e.g., *B.sp. cf. latifrons* (EISENACK 1964), *B.sp. cf. lauensis* (LAUFELD 1974) and *C.sp. cf. tuba* EISENACK 1932].

Furthermore, some representatives of the genera *Ancyrochitina* EISENACK 1955, *Bursachitina* TAUGOURDEAU 1966, *Cingulochitina* PARIS 1981, *Eisenackitina* JANSONIUS 1964 and *Linochitina* EISENACK 1968 appear.

At the base of this sequence however, an *Angochitina*-fragment resembling *A.elongata* EISENACK 1931 was found, consequently referring the Cardiola Formation to the upper Gorstian-lower Ludfordian *Angochitina elongata* - Biozone [VERNIERS et al.1995].

Here an other - unusual - state of preservation of the chitinozoans can be observed: the vesicles of thin-walled taxa from limestones had collapsed three-dimensionally similar to a deflated rubber ball. This feature probably developed at an early stage of diagenesis when the internal cavities of the chitinozoans became dehydrated before mineral fillings precipitated. These fillings are common in chitinozoans from limestones and they are responsible for the three-dimensional preservation of the fossils.

From the base of the Alticola Limestone up to the end of the Ludlow, the examined samples did not yield chitinozoans.

The Chitinozoans of the uppermost Ludlow to the lower Lochkovian

From the Ludlow/Pridoli boundary beds within the Alticola Limestone up to the end of the examined section in the lower part of the Rauchkofel Limestone of lower Lochkovian age, numerous diverse chitinozoan assemblages occur.

At the base of this succession [sample 73 = uppermost Ludfordian; samples 74, 75 =

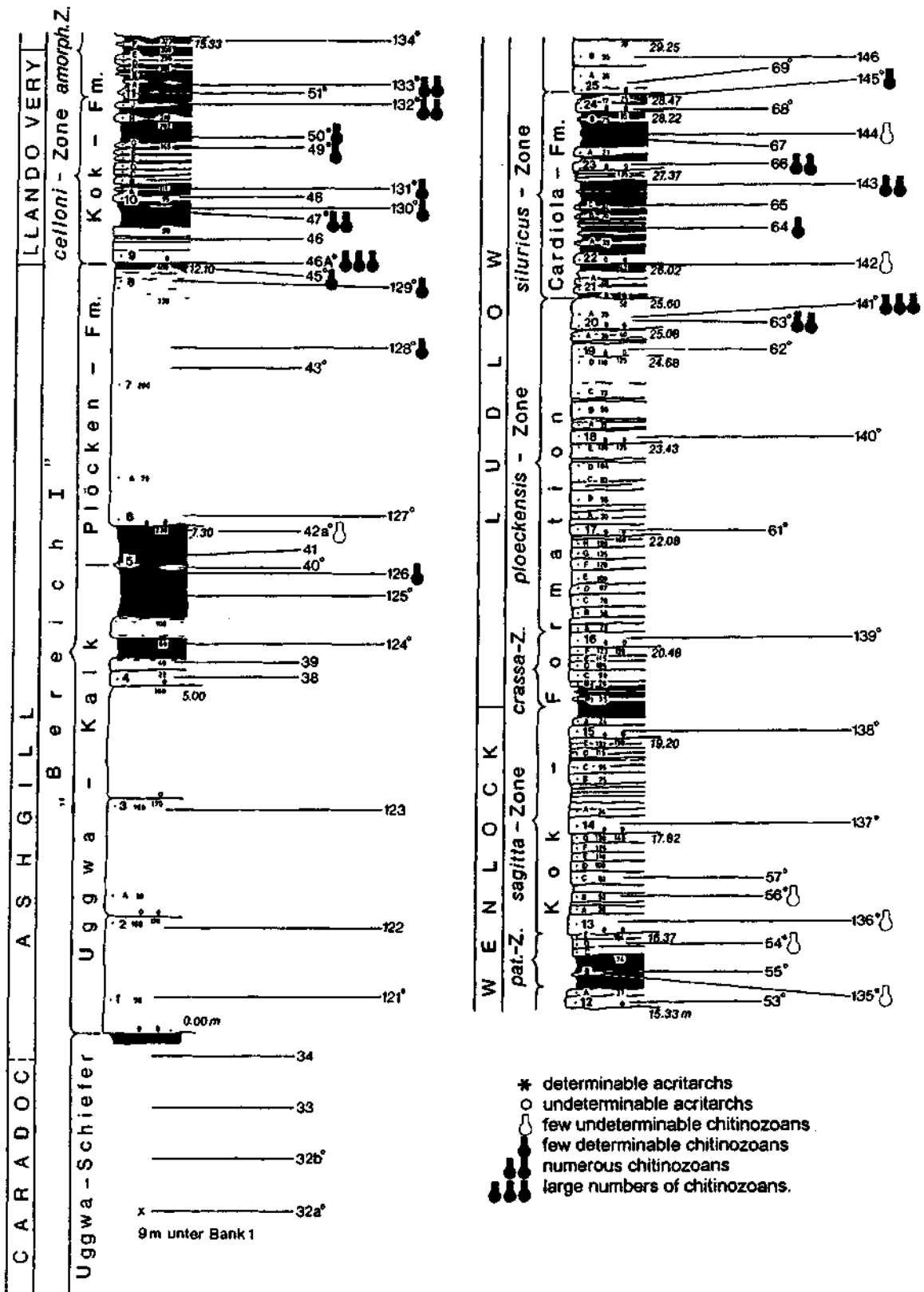
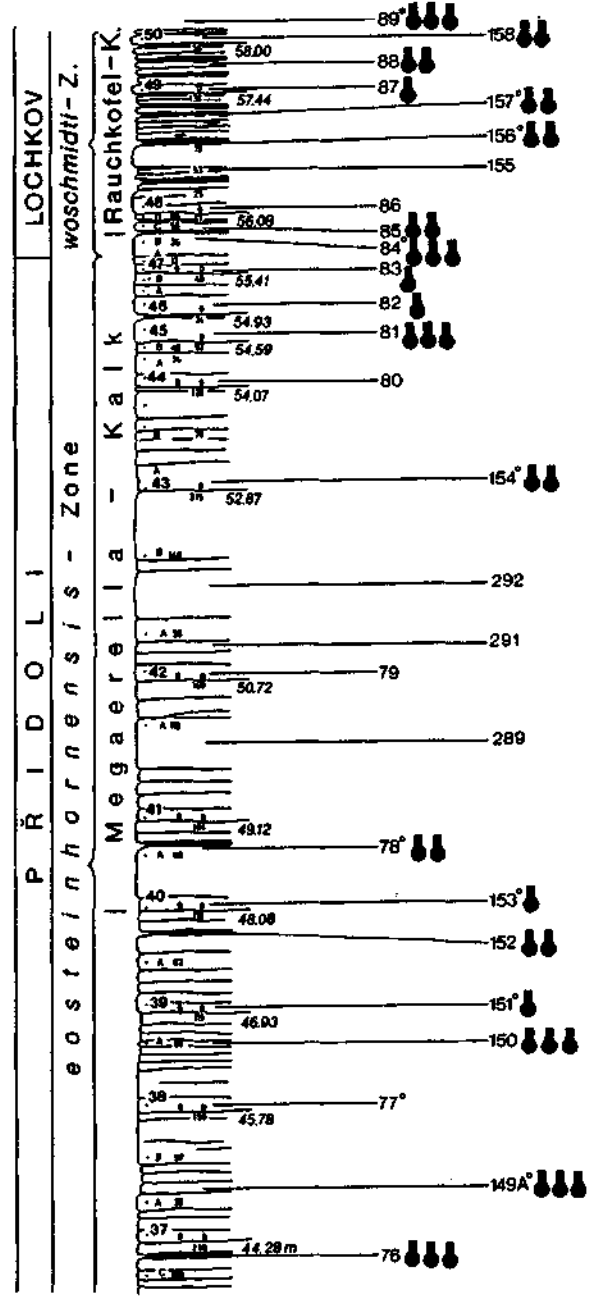
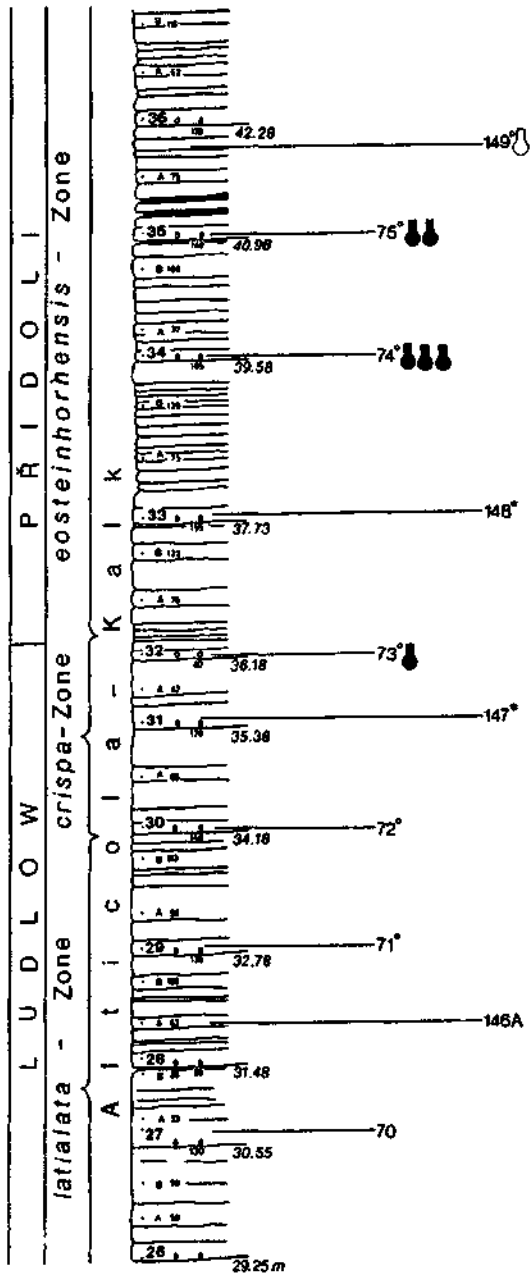


Fig.1: The location of the samples in the Cellon-section (drawing of the section after SCHÖNLAUB 1985).



lower Pridoli] *Ancyrochitina* gr. *ancyrea* (EISENACK 1931), *Eisenackitina granulata* (CRAMER 1964), *E. intermedia* (EISENACK 1955), *Sphaerochitina* cf. *sphaerocephala* (EISENACK 1932), some *Angochitina* EISENACK 1931, *Bursachitina* TAUGOURDEAU 1966, *Gotlandochitina* LAUFELD 1974 and the stratigraphically most important taxa *E. barrandei* PARIS & KRIZ 1984 and *Urnochitina urna* (EISENACK 1934), the latter in an atypical version, are present.

E. barrandei is the index species of the uppermost Ludfordian *Eisenackitina barrandei* - (total range) - Biozone of VERNIERS et al. 1995, while the total range of *U. urna* defines the entire Pridoli.

At the global stratotype section of the Ludlow/Pridoli-boundary at Pozáry Quarry (Prague Basin, Bohemia), the two species occur together within a very short interval in the Ludfordian/Pridoli – boundary-beds. Compared to the ranges of *E. barrandei* and the atypical *Urnochitina urna* in the Cellon section, some discrepancies are obvious which have to be settled by further studies.

The assemblages of the upper part of the Alticola Limestone and the lowermost Megaerella Limestone [samples 149, 76, 149A, 150, 151, 152, 153, 78, 154] are generally dominated by typical *U. urna*. Further important species are *E. granulata* and *Bursachitina krizi* (PARIS & LAUFELD 1980), the latter makes its debut in sample 149A with large quantities of individuals and then after a sudden and drastic reduction in the number of specimens disappears in the upper Megaerella Limestone. Some insignificant specimens of *Ancyrochitina*, *Angochitina*, *Linochitina* and *Sphaerochitina* are co-occurring.

The strata between the samples 78 and 154 in the lower part of the Megaerella Limestone proved to be barren of chitinozoans.

Above this level the chitinozoan fauna starts to rearrange: *U. urna* loses its numerical dominance, while representatives of other genera like *Angochitina* EISENACK 1931, *Cingulochitina* PARIS 1981, *Gotlandochitina* LAUFELD 1974, *Linochitina* EISENACK 1968, *Sphaerochitina* EISENACK 1955 and especially *Ancyrochitina* EISENACK 1955 become more and more frequent.

The uppermost Pridolian samples [81, 82, 83] of which the lower one yielded an enormous amount of chitinozoans are represented -among others - by *Linochitina klonkensis* PARIS & LAUFELD 1980, *Calpichitina corinnae* JAGLIN 1986, *Sphaerochitina* cf. *sphaerocephala* (EISENACK 1932), very few specimens of *U. urna* (EISENACK 1934) and a distinctiv *Ancyrochitina*-species provided with simple processes with very broad bases.

The Pridoli is defined by the total range of *Urnochitina urna*, which at the global stratotype section for the Silurian/Devonian-boundary at Klonk, Prague Basin, disappears exactly at the boundary, while in the Karlstejn section it ranges a few decimeters above the base of the Lochkovian [PARIS, LAUFELD & CHLUPÁČ 1981].

Due to the lack of the index-fossils, the chitinozoan biozones of the Pridoli which are the *Fungochitina kosovensis* -, the *Margachitina elegans* - and the *Anthochitina superba* - Biozones of VERNIERS et al. 1995, could not be identified at Cellon.

Sample 84 from the lowermost Lochkovian bed yielded comparatively numerous *U. urna*, which is the last documented occurrence in the section, as well as many well preserved and diverse representatives of *Angochitina*, *Gotlandochitina*, *Sphaerochitina* [e.g. *S. sphaerocephala*] and a few *Ancyrochitina* with unusual processes.

The chitinozoan assemblage of sample 85 contains a few *Angochitina* and *Cingulochitina* and also several well preserved *Eisenackitina bohémica* (EISENACK 1934), a species typical of the Lochkovian, which in the Prague Basin appears a few decimeters above the base of the Devonian, i.e. in bed 21 at the Klonek section [PARIS 1981].

The remaining samples in the Cellon section [156, 157, 87, 88, 158 and 89, the latter with a large number of chitinozoans] are dominated by numerous *Ancyrochitina* [at least 5 different species]. Moreover, there occur different taxa of *Angochitina*, *Sphaerochitina*, *Gotlandochitina*, *Linochitina* and *Cingulochitina* [e.g. *C. ervensis* (PARIS 1979)] .

The chitinozoans of the Pridoli/Lochkovian sequence are generally three-dimensionally preserved, especially thicker-walled specimens; thinner-walled individuals are often more or less strongly collapsed.

Conclusions.

1.) In the Cellon section, the chitinozoans are present in almost all series of the upper Ordovician to lower Devonian succession. This is in contrast to the acritarchs which are mainly restricted to the upper Llandovery to lower Wenlock sequence.

In several samples [46A, 141, 74, 76, 149A, 150, 81, 84, 89] the chitinozoans occur with large numbers of individuals and generally great diversity.

2.) The chitinozoan assemblages of the Ashgillian and the upper Llandoveryian strata of the Cellon section, which rest conformably one upon the other but are separated by a large stratigraphical gap are unequivocally different and in each case typical for their ages.

The Llandovery/Wenlock-boundary and the Wenlock/Ludlow-boundary, respectively, cannot be established by the aid of chitinozoans because these fossils are missing throughout the Wenlock and also in the lower Ludlow.

As for the chitinozoans, the position of the Ludlow/Pridoli- boundary in the Cellon section is not yet clear and needs further investigations.

Finally, the base of the Lochkovian is well documented by diagnostic chitinozoan assemblages.

Almost all of the chitinozoan bearing sequences of the Cellon section can be assigned to the existing global chitinozoan biozones. These are:

the Hirnantian *Tanuchitina elongata* - Biozone;

the upper Aeronian - lower Telychian *Eisenackitina dolioliformis* - Biozone;

the upper Telychian *Angochitina longicollis* - Biozone;

the upper Gorstian - lower Ludfordian *Angochitina elongata* - Biozone;

the uppermost Ludfordian *Eisenackitina barrandei* - Biozone;

the Pridolian *Urnochitina urna* - Biozone;

the lower Lochkovian *Eisenackitina bohémica* - Biozone.

3.) Obviously, environmental conditions were more favourable for the chitinozoans in the upper than in the lower part of the section: Starting with the topmost layer of the Kok Formation [upper Ludlow] up to the lower Lochkovian Rauchkofel Limestone, the assemblages show greater diversities, larger numbers of individuals and also better preservation than in the upper Llandoveryian to lower Ludlowian Kok Formation. This is in

good accordance with the results of recent studies concerning the environmental development of the Cellon section, suggesting more stable pelagic conditions from the Alticola Limestone onward [HISTON & SCHÖNLAUB, 1999 (in press)].

However, presently the reasons for the occurrence of at least some chitinozoans in the unfavourable high energy environment of the Plöcken Formation, and their absence in the off-shore low-energy facies of the Uggwa Limestone and the Uggwa Shale are difficult to explain.

4.) The Hirnantian-age chitinozoans of the Cellon section show a pronounced relationship with assemblages of the Northern Gondwana cold-water realm, while in the Silurian and lower Devonian their affinities to representatives of the warm-water environments of Baltica/ Avalonia are obvious.

Most probably because of the palaeogeographic vicinity of the two depositional areas, the Silurian and lower Devonian chitinozoans of the studied section are very similar to those from Bohemia (so far, only very few and insignificant chitinozoan associations have been observed in the Ashgillian of the Barrandean region) [DUFKA, 1992; DUFKA & FATKA, 1993; KRIZ, 1992; KRIZ et al. 1986; PARIS & KRIZ, 1984; PARIS et al., 1981].

On the other hand, in the Cellon section samples from the base of the Wenlock to the lower Ludlow succession did not yield determinable chitinozoans whereas in Bohemia diverse faunas can be obtained from coeval strata [KRIZ, 1992; KRIZ et al., 1993]. This phenomenon might be caused by unfavorable conditions for the chitinozoans' preservation in the sedimentary environment of the Cellon section, like a high hydrodynamic regime in a very shallow sea - at least temporary, non-deposition of protecting sediment, oxidation.

Acknowledgment.

The investigations were supported by the *Austrian Science Foundation* to whom I want to express my appreciation.

I would like to thank *Dr.Florentin Paris*, University of Rennes, France, for his engaged and valuable discussion of my large collection of chitinozoans from the Cellon section.

References.

ACHAB,A., BERTRAND,R. & VAN GROOTEL,G.: Chitinozoan Contribution to the Ordovician and Lower Silurian Paleobiogeography.- *J.Geol.*, 100, 621-629, 5 fig., Chicago, **1992**.

BOUCHÉ, P.M.: Chitinozoaires du Silurien s.l. du Djado (Sahara nigérien).- *Rev. Micropaléont.*, 8, 151-164, 3 tab., 3 pl., Paris, **1965**.

CRAMER, F.H.: Microplankton from three Paleozoic formations in the province of León (NW Spain).- *Leidse Geol.Meded.*, 30, 255-361, 56 fig., 24 pl., Leiden, **1964**.

CRAMER, F.H.: Chitinozoans of a composite section of Upper Llandovery to basal Lower Gedinnian sediments in northern León, Spain. A preliminary report.- *Bull., Soc. belge Géol.*, 75, 69-129, 7 fig., 5 pl., Brussels, **1967a**.

- DUFKA, P.: Lower Silurian Chitinozoans of the Prague Basin (Barrandian, Czechoslovakia). Preliminary Results.- *Rev. Micropaléont.*, 35, 117-126, 1 fig., 3 tab., 3 pl., Paris, **1992**.
- DUFKA, A.P & FATKA, O.: Chitinozoans and acritarchs from the Ordovician-Silurian boundary of the Prague Basin (Barrandian area, Czechoslovakia). – In S.G. MOLYNEUX & K.J. DORNING (eds.): Contributions to acritarchs and chitinozoan research. – Special Papers in Palaeontology, 48, 17-28, 1 fig., 4 pl. London **1993**.
- EISENACK, A.: Neotypen baltischer Silur-Chitinozoen und neue Arten.-*N.Jb.Geol.Paläont.: Abh.*, 108, 1-20, 4 fig., pl.1-3, Stuttgart, **1959**.
- EISENACK, A.: Neotypen baltischer Silur-Chitinozoen und neue Arten.-*N.Jb.Geol.Paläont.: Abh.*, 114, 291-316, 8 fig., 1 tab., pl.14-17, Stuttgart, **1962**.
- EISENACK, A.: Mikrofossilien aus dem Silur Gotlands, Chitinozoen.-*N.Jb.Geol.Paläont.: Abh.*, 120, 308-342, 9 fig., 7 tab., pl.26-30, Stuttgart, **1964**.
- EISENACK, A.: Über Chitinozoen des baltischen Gebietes.- *Paläontographica A*, 131, 137-198, 13 fig., 2 tab., pl. 24-32, Stuttgart, **1968**.
- EISENACK, A.: Beiträge zur Chitinozoen-Forschung.- *Paläontographica A*, 140, 117-130, 1 fig., pl. 32-37, Stuttgart, **1972**.
- ELAOUAD-DEBBAJ, Z.: Chitinozoaires Ashgilliens de l'Anti-Atlas (Maroc).- *Geobios*, 17, 45-48, 5 fig., 3 pl., Lyon, **1984**.
- FERRETTI, A. & HISTON, K.: Cephalopod Limestone Biofacies, Carnic Alps, Austria.- In GUTIÉREZ-MARCO, J.C. & RÁBANO, I. (eds): Proc.6th Int.Grapt.Conf. & 1998 Field Meeting, IUGS Subcomm. Sil.Strat.- *Temas Geol.-Miner. ITGE*, 23, 76-79, 3 fig., Madrid **1998**.
- GRAHN, Y.: Chitinozoan stratigraphy in the Ashgill and Llandovery.- In COCKS, L.R.M. & RICKARDS, R.B. (eds.): A Global Analysis across the Ordovician-Silurian boundary.- *Bull.Br.Mus.nat.Hist.(Geol.)*, 43, 317-323, 27 fig., London, **1988**.
- HISTON, K.: Cellon Section. Cephalopod Limestones.- In SCHÖNLAUB, H.P. (ed.): IGCP 421 Inaugural Meeting Vienna, Guidebook.- *Ber.Geol.B.-A.*, 40, 92-99, 3Fig., Wien **1997**.
- HISTON, K.: Die Nautiloideen-Fauna aus dem Silur der Karnischen Alpen.- *Geol.Paläont.Mitt.Innsbruck*, 23, 105-115, 4 fig., 2 Pl., Innsbruck **1998**.
- HISTON, K & SCHÖNLAUB, H.P.: Taphonomy, Paleoecology and Bathymetric Implications of the Nautiloid Fauna from the Silurian of the Cellon Section (Carnic Alps, Austria).- In: Proceedings of the First International Conference on North Gondwanan Mid-Palaeozoic Biodynamics (IGCP Project 421), *Abh. Geol.B.-A.*, **1999** (in press).
- JAGLIN, J.C.: Chitinozoa from the late Ordovician glacio-marine deposits from North Africa.- *Chit.Newsletter*, 8, 5-6, Uppsala, **1987**.

- JENKINS, W.A.M. & LEGAULT, J.A.: Stratigraphic ranges of selected Chitinozoa.- *Palynology*, 3, 235-264, 6 fig., Dallas, **1979**.
- KREUTZER, L.H.: Photo-Atlas of the Variscan Carbonate Sequences in the Carnic Alps (Austria/Italy).- *Abh.Geol.B.-A.*, 47, 129 p., 9 fig., 3 tab., 46 pl., Wien, **1992**.
- KREUTZER, L.H.: Cellon Section. Facial differentiation and bathymetric environment.- In SCHÖNLAUB, H.P. & KREUTZER, L.H. (eds.): IUGS Subcomm.Silurian Stratigraphy, Field Meeting 1994.- *Ber.Geol.B.A.*, 30, 85-88, Wien, **1994**.
- KRIZ, J.: Silurian Field Excursions. Prague Basin (Barrandian), Bohemia.- *Geol.Ser.Nation.Mus.Wales*, 13, 111 p., 86 fig., 4 pl., Cardiff, **1992**.
- KRIZ, J., DUFKA, P., JAEGER, H. & SCHÖNLAUB, H.P.: The Wenock/Ludlow Boundary in the Prague Basin (Bohemia).- *Jb.Geol.B.-A.*, 136, 809-839, 18 fig., 1 tab., 3 pl., Wien, **1993**.
- KRIZ, J., JAEGER, H., PARIS, F. & SCHÖNLAUB, H.P.: Pridoli - the Fourth Subdivision of the Silurian.- *Jb.Geol.B.-A.*, 129, 291-360, 44 fig., 1 tab., 6 pl., Wien, **1986**.
- LAUFELD, S.: Silurian Chitinozoa from Gotland.- *Fossils and Strata*, 5, 130 p., 78 fig., Oslo, **1974**.
- LAUFELD, S.: Biogeography of Ordovician, Silurian and Devonian Chitinozoans.- In GRAY, J. & BOUCOT, A.J. (eds.): *Historical Biogeography, Plate Tectonics, and the Changing Environment*, 75-90, 14 fig., (Oregon State University Press), o.O., **1979**.
- MOLYNEUX, S.G. & PARIS, F.: Late Ordovician Palynomorphs.- In THUSU, B.T. & OWENS, B. (eds.): *The Palynostratigraphy of Northeast Libya*. *J.Micropalaeont.*, 4, 11-26, 7 pl., London, **1985**.
- NESTOR, V. & K.: Correlation of the East-Baltic and Gotland Silurian by Chitinozoans.- In KALJO, D. & KLAAMAN, E. (eds.): *Ecostratigraphy of the East Baltic Silurian*.- *Acad.Sci.Estonian S.S.R.*, 89-96, 3 fig., Tallinn, **1982**.
- NESTOR, V.: Silurian Chitinozoans.- In KALJO, D. & NESTOR, H.N.(eds.): *An excursion guidebook*, 80-83, fig. 15, pl. 14, 15, Tallinn, **1990**.
- NESTOR, V.: Chitinozoan diversity dynamics in the east Baltic Silurian.-*Proc.Estonian Acad.Sci.Geol.*, 41, 215-224, 5 fig., 2 tab., Tallinn, **1992**.
- NESTOR, V.: Early Silurian Chitinozoans of Estonia and North Latvia.- *Academia*, 4, 163 p., 29 fig., 32 pl., 3 tab., Tallinn, **1994**.
- PARIS, F.: Les Chitinozoaires dans le Paléozoïque du sud-ouest de l'Europe.- *Mém.Soc.géol.minéral.Bretagne*, 26, 412 p., 134 fig., 45 tab., 41 pl., Rennes, **1981**.
- PARIS, F.: Chitinozoans.- In HOLLAND, C.H. & BASSETT, M.G. (eds.): *A Global Standard for the Silurian System*.- *Geol.Ser.Nation.Mus Wales*, 9, 280-284, fig. 174, 175, Cardiff, **1989**.

- PARIS, F.: The Ordovician chitinozoan biozones of the Northern Gondwana Domain.- *Rev. Palaeobot.Palynol.*, 66, 181-209, 4 fig., Amsterdam, **1990**.
- PARIS, F.: Application of chitinozoans in long-distance Ordovician correlations.- In WEBBY, B.D. & LAURIE, J.R. (eds.): *Global Perspectives on Ordovician Geology*, 23-33, 3 fig., (Balkema), Rotterdam, **1992**.
- PARIS, F.: Evolution paléogéographique de l'Europe au Paléozoïque inférieur: le test de Chitinozoaires.- *C.R.Acad.Sci.Paris*, t.316, Ser.II, 273-280, 4 fig., Paris, **1993**.
- PARIS, F.: Chitinozoan Biostratigraphy and Palaeoecology.- In JANSONIUS, J. & MCGREGOR, D.C. (eds.): *Palynology: Principles and Applications*, vol.2, 531-552, 9 fig., 3 pl., Salt Lake City, (Publishers Press), **1996**.
- PARIS, F. & GRAHN, Y.: Chitinozoa of the Silurian-Devonian boundary sections in Podolia, Ukraine.- *Palaeontology*, 39, 629-649, 4 fig., 4 pl., London, **1996**.
- PARIS, F. & KRIZ, J.: Nouvelles espèces de chitinozoaires à la limite Ludlow/Pridoli en Tchécoslovaquie.- *Rev.Palaeobot.Palynol.*, 43, 155-177, 8 fig., 3 pl., Amsterdam, **1984**.
- PARIS, F., LAUFELD, S. & CHLUPÁČ, I.: Chitinozoa of the Silurian-Devonian boundary stratotypes in Bohemia.- *S.G.U., Avh., Ser.Ca.*, 51, 1-28, 10 fig., 3 pl., Uppsala, **1981**.
- PARIS, F. & ROBARDET, M.: Early Palaeozoic palaeobiogeography of the Variscian regions.- *Tectonophysics*, 177, 193-213, 5 fig., **1990**.
- PRIEWALDER, H.: Acritarchen aus dem Silur des Cellon-Profiles, Karnische Alpen, Österreich.- *Abh.Geol.-B.-A.*, 40, 121 p., 39 fig., 24 pl., Wien, **1987**.
- PRIEWALDER, H.: The distribution of the Chitinozoans in the Cellon Section (Hirnantian - Lower Lochkovian).- A Preliminary Report.- In SCHÖNLAUB, H.P. (ed.): *IGCP - 421 Inaugural Meeting Vienna, Guidebook*.- *Ber.Geol.B.-A.*, 40, 74-85, 1 fig., Wien **1997a**.
- PRIEWALDER, H.: SEM-Revision of a Chitinozoan Assemblage from the Uppermost San Pedro Formation (Pridoli), Cantabrian Mountains (Spain).- *Jb.Geol.B.-A.*, 140, 73-93, 2 fig., 3 tab., 5 pl., Wien **1997b**.
- RAUSCHER, R.: Recherches micropaléontologiques et stratigraphiques dans l'Ordovicien et le Silurien en France. Etude des Acritarches, des Chitinozoaires et des Spores.- *Mém.Sci.Géol.*, 38, 224 p., 46 fig., 31 tab., 12 pl., Strasbourg, **1973**.
- SCHÖNLAUB, H.P.: Das Paläozoikum der Karnischen Alpen.- In: *Arbeitstagung der Geologischen Bundesanstalt*, **1985**, 34-52, fig. 10-15, Wien, **1985**.
- SCHÖNLAUB, H.P.: The Ordovician-Silurian boundary in the Carnic Alps of Austria.- In COCKS, L.R.M. & RICKARDS, R.B. (eds.): *A Global Analyses of the Ordovician-Silurian boundary*.- *Bull.Br.Mus.nat.Hist. (Geol)*, 43, 107-115, 4 fig., London, **1988**.
- SCHÖNLAUB, H.P.: Stratigraphy, Biogeography and Paleoclimatology in the Alpine Paleozoic and its Implications for Plate Movements.- *Jb.Geol.B.-A.*, 135/1, 381-418, 16 fig.,

Wien, 1992.

SCHÖNLAUB, H.P.: The Faunal Relationship of the Silurian of the Alps.- In SCHÖNLAUB, H.P. & KREUTZER, L.H. (eds.): IUGS Subcomm.Silurian Stratigraphy, Field Meeting 1994.- *Ber.Geol.B.A.*, 30, 52-60, 1 fig., Wien, 1994.

SCHÖNLAUB, H.P.: Celson Section. Lithology, Paleontology and Stratigraphy.- In SCHÖNLAUB, H.P. (ed.): IGCP - 421 Inaugural Meeting Vienna, Guidebook.- *Ber.Geol.B.-A.*, 40, 87-92, 1 Abb., Wien 1997.

SCHÖNLAUB, H.P. & HEINISCH, H.: The Classic Fossiliferous Palaeozoic Units of the Eastern and Southern Alps.- In SCHÖNLAUB, H.P. & KREUTZER, L.H. (eds.): IUGS Subcomm.Silurian Stratigraphy, Field Meeting 1994.- *Ber.Geol.B.A.*, 30, 6-51, 18 fig., Wien, 1994.

SCHWEINEBERG, J.: Silurische Chitinozoen aus der Provinz Palencia (Kantabrisches Gebirge, N-Spanien).- *Göttinger Arbeiten zur Geologie und Paläontologie*, 33, 94 p., 24 fig., 13 pl., Göttingen, 1987.

SUTHERLAND, S.J.E.: Ludlow Chitinozoans from the Type Area and Adjacent Regions.- *Monogr.Palaeontogr.Soc.*, Publ.594, 104 p., 57 fig., 18 pl., London, 1994.

TAUGOURDEAU, P.: Étude de quelques espèces critiques de Chitinozoaires de la Région d'Edjelé et compléments à la faune locale.- *Rev.Micropaléont.*, 6, 130-144, 3 pl., 4 tab., Paris 1963.

TAUGOURDEAU, P. & DE JEKHOWSKY, B.: Répartition et description des Chitinozoaires Siluro-dévonien de quelques sondages de la C.R.E.P.S., de la C.F.P.A. et de la S.N. REPAL au Sahara.- *Rév.Inst.Franc.Pétrol.*, 15, 1199 - 1260, 19 fig., 13 pl., Paris 1960.

VERNIERS, J.: The Silurian of the Mehaigne Valley (Brabant Massif, Belgium): Biostratigraphy (Chitinozoa).- *Rev.Palaeobot.Palynol.*, 34, 165-174, 1 fig., 2 pl., Amsterdam 1981.

VERNIERS, J.: The Silurian Chitinozoa of the Mehaigne Area (Brabant Massif, Belgium).- *Prof.Pap.Geol.Dienst Belgique*, 1982/6, 192, 76 p., 10 fig., 9 pl., Gent, 1982.

VERNIERS, J., NESTOR, V., PARIS, F., DUFKA, P., SUTHERLAND, S. & VAN GROOTEL, G.: A global Chitinozoa biozonation for the Silurian.- *Geol.Mag.*, 132, 651-666, 6 fig., Cambridge, 1995.

WALLISER, O.H.: Conodonten des Silurs.- *Abh.Hess.L.-Amt Bodenforsch.*, 41, 106 p., 10 fig., 2 tab., 32 pl., Wiesbaden, 1964.

WRONA, R.: Upper Silurian - Lower Devonian Chitinozoa from the Subsurface of Southeastern Poland.- *Palaeont.Polonica*, 41, 103-165, 111 fig., 13 tab., pl. 24-37, Warsaw, 1980.