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The chitinozoan biostratigraphy of the Silurian of the Ronquières–Monstreux area (Brabant Massif, Belgium)

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Abstract

A major outcrop area in the Silurian of the Brabant Massif (part of the Anglo–Brabant Deformation Belt) lies along the Sennette valley, from the hamlet Fauquez to the area around Ronquières, and along the Samme and the Thisnes valleys, around the city of Nivelles and its hamlets Monstreux and Bornival. Recent lithostratigraphical mapping in the study area has shown the presence of nine Silurian formations (from bottom to top the Brutia, Bois Grand-Père, Fallais, Corroy, Petit Roeulx, Steenkerque, Froide Fontaine, Vichenet and Ronquières formations, the latter in its type locality). One sample from presumably the Huet Formation, one of the three Upper Ordovician formations present in the Monstreux area is also studied. The presumed presence of Upper Ordovician in an area poor in outcrops in the north of the Monstreux area is confirmed by the chitinozoans in that one sample. Fifty one samples from seven Silurian formations were dissolved to extract chitinozoans and 37 proved to be fossiliferous. Two formations remain unstudied. The chitinozoan assemblages are poorly to moderately preserved due to the high anchizonal metamorphism in the outcrop area. The assemblages are diverse and can be abundant, with a content of between 0.1 and 23 chitinozoans per gram of rock. They can be correlated with the global Silurian chitinozoan biozonation (the *Angochitina longicollis, Margachitina margaritana, Cingulochitina cingulata* biozones are recognised), with the Welsh chitinozoan biozones for the Wenlock in the Builth district where the graptolite biozonation was described at first, for the Ludlow with the chitinozoans biostratigraphy in the chronostratigraphical type sections of the Ludlow series at Ludlow, Shropshire, and with the local Silurian chitinozoans biozonation in the Brabant Massif. The presumed Late Ordovician age of these three poorly outcropping and previously poorly dated formations in the Monstreux area is confirmed with the chitinozoans. Four of the nine Silurian formations in the study area were previously dated with graptolites (Brutia and Ronquières Formations), with acritarchs (Fallais Formation) or with chitinozoans (Steenkerque Formation). The ages of the latter two formations was confirmed or refined with the chitinozoans. Three other formations (Corroy, Petit Roeulx and the combined Froide Fontaine and Vichenet formations) are dated for the first time in the study area. The Ronquières Formation was dated previously with graptolites as lower Ludlow, which is confirmed by the chitinozoans and refined to the lower middle part of the Gorstian. A very rapid sedimentation of this thick turbiditic formation is deduced. Only one Silurian formation (Bois Grand-Père Formation) remains undated in the study areas. A new species is described: *Conochitina pumilio* sp. nov.

Keywords: chitinozoans; Llandovery; Wenlock; Ludlow; biozonation; Brabant Massif

1. Introduction and area description

The results of a biostratigraphical study of chitinozoans from two Silurian outcrop areas in the

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Brabant Massif, Belgium, a part of the Lower Palaeozoic Anglo–Brabant Deformation Belt, are presented. The first area is called herein the Ronquières area and contains the Silurian and outcrops in the lower parts of the valley of the Sennette River and the Samme River, around the village of Ronquières. In the upper parts of the valleys, Palaeogene sediments are present. The area is bounded to the north by the Fauquez Fault, which brings the Silurian into contact with the Upper Ordovician, and unconformably to the south by Devonian strata (Fig. 1). There are two well known large outcrops: the Mont Godart section, which outcrops east of the bridge of Ronquières, and the 1.6-km long trench dug for the Plan Incliné (inclined ship lift) of Ronquières. In the latter the unconformity is clearly visible between the folded and cleaved fine siliciclastic rocks of the Silurian and the covering Middle Devonian conglomerates, sandstones and shales (Givetian). The second area, called herein the Monstreux area, outcrops in the lower part of the Rhisnes Valley, an tributary of the Samme River, near the village of Monstreux, near the city of Nivelles (Fig. 2). This area is bounded to the south by the unconformable covering of Devonian and elsewhere by the Palaeogene. The outcrops in the area are mostly Silurian, but the

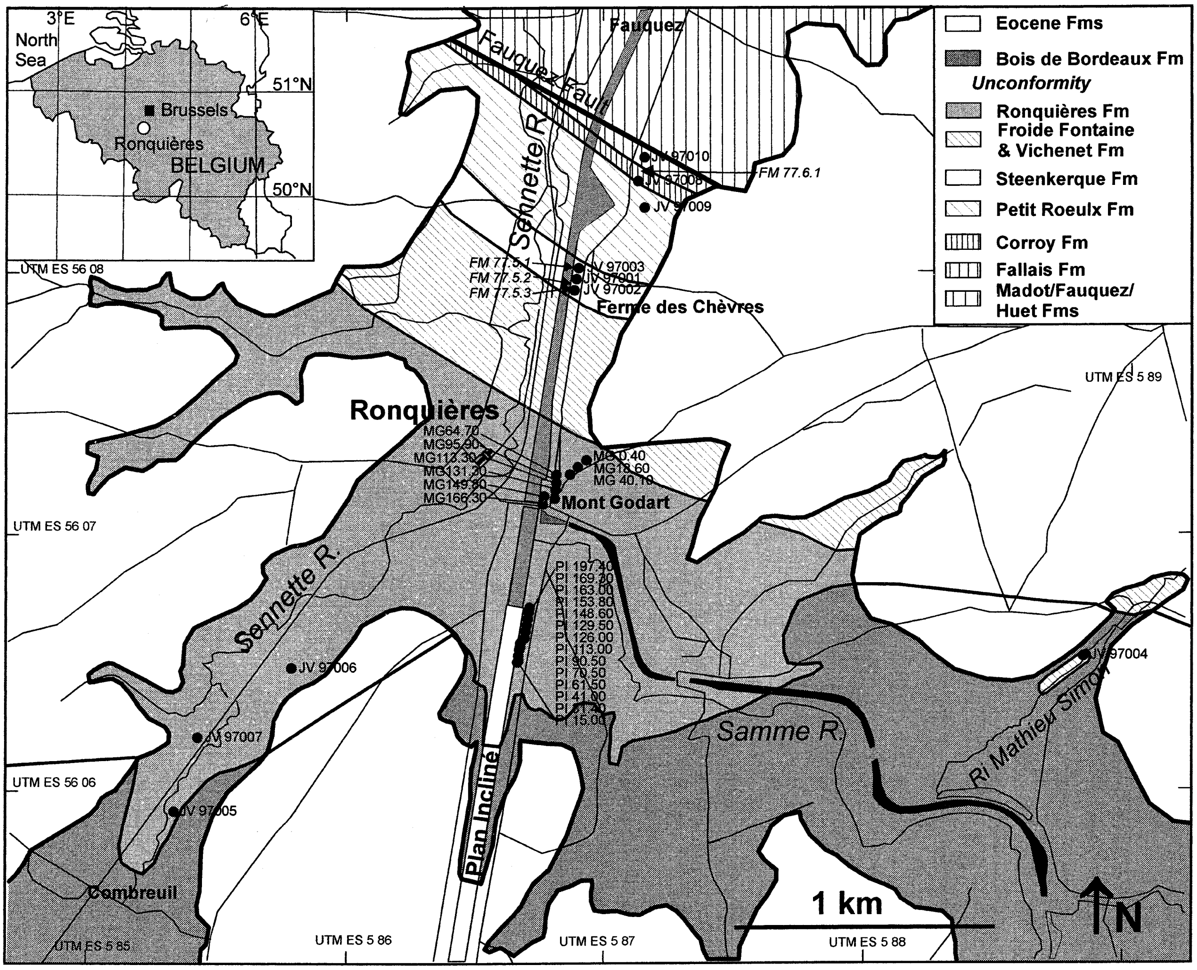


Fig. 1. Location of the sections and samples in the Ronquières study area, on a topographical and geological map after own mapping. The inset shows the position within Belgium. The sampling place of Martin and Rickards (1979) is also shown (numbers beginning with FM77.-).

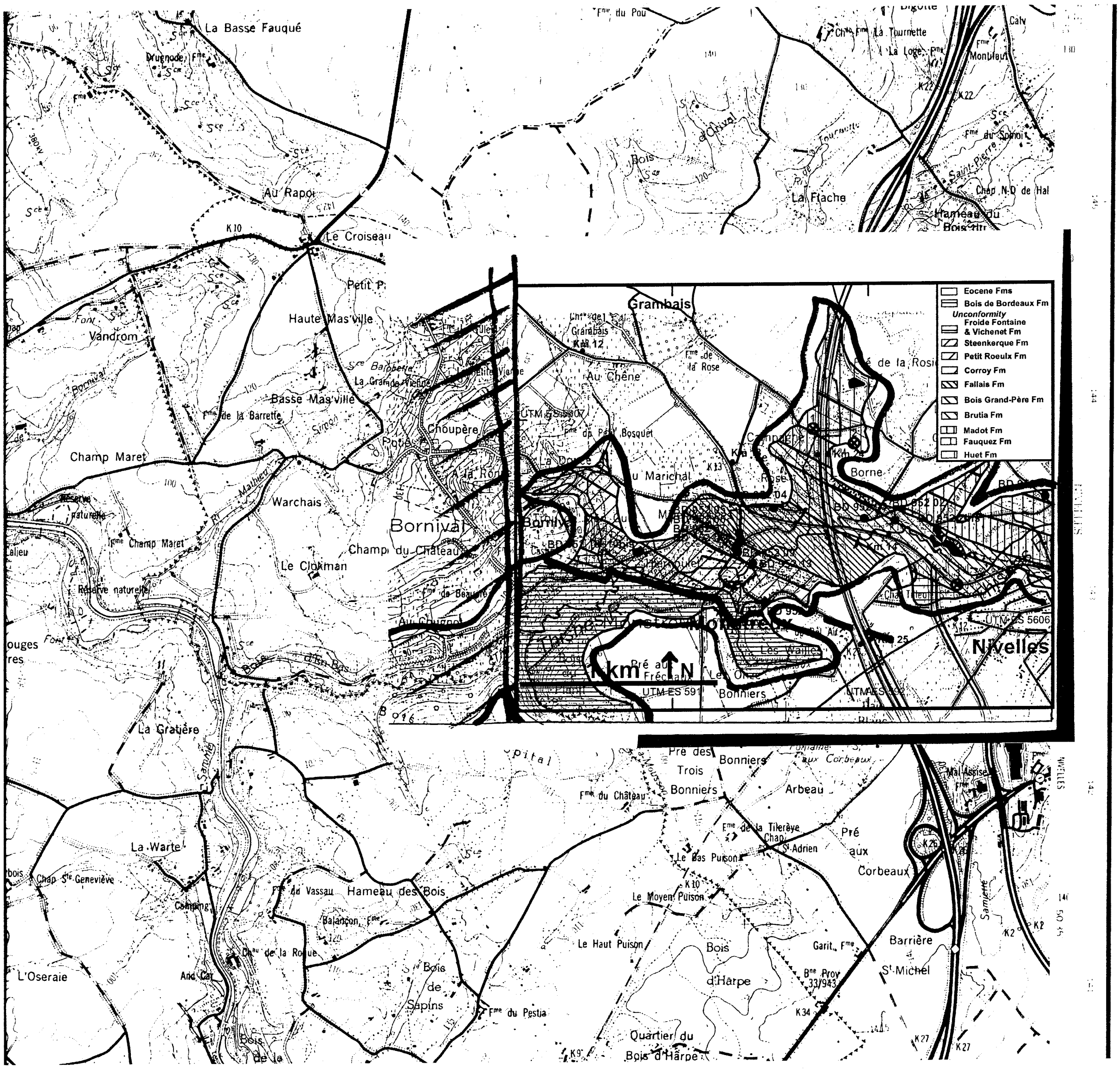


Fig. 2. Location of sections and samples in the Monstreux study area, on a topographical and geological map after our own mapping. The numbers 1–3 indicate the graptolite localities in the literature or archives of the Belgian Geological Survey (see text). This figure is situated east of Fig. 1 with a strip 950 m wide in between.

Upper Ordovician is present also in the north, although poorly exposed.

Until recently palaeontological data from the two study areas were sparse. Dumont (1848) was the first author who described the Ronquières outcrops, but Malaise (1873) was the first to mention the presence of fossils: badly preserved graptolites, which resemble '*Graptolithus priodon*'. These findings are probably from outcrops 1.3 to 1.4 km north of the bridge section, north of the Ferme des Chèvres (Louwye et al., 1992). Three authors (Gosselet, 1888; Cuvelier and Paquet, 1908) wrongly attributed these graptolites to the Mont Godart section. Leriche (1912) was the first to find graptolites in the Mont Godart section: *Monograptus bohemicus* Barrande, *M.* cf.

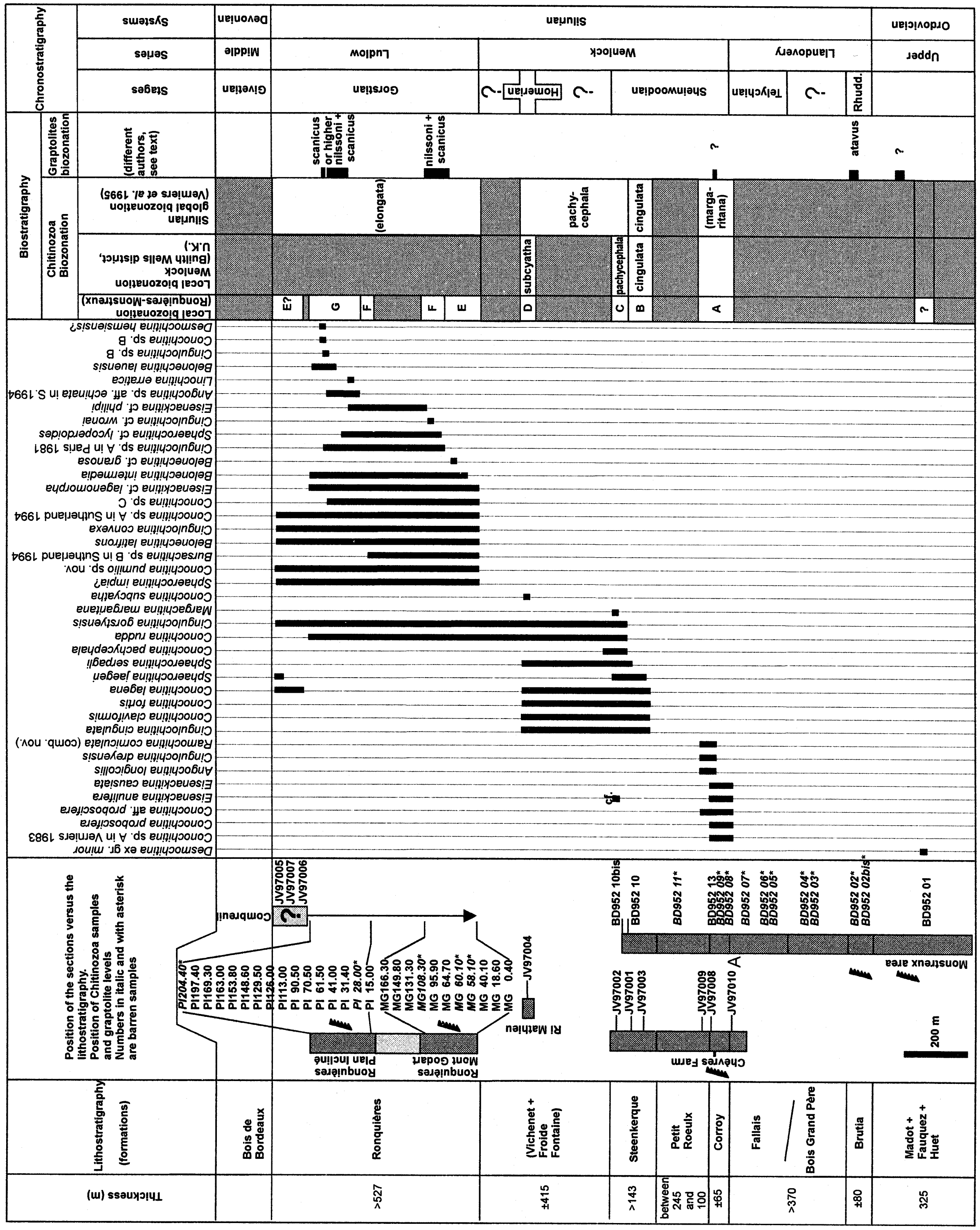
Table 1
Amount of chitinozoan species or genera, the total number of chitinozoans counted, the total weight of dissolved rock examined and the number of chitinozoans per gram of rock

Formation	Ronquières Formation																										F	Steenkerque Fm					P	C		F	H
Sample	JV97005	JV97007	JV97006	PI197.40	PI169.30	PI163.00	PI153.80	PI148.60	PI129.50	PI126.00	PI113.00	PI90.50	PI70.50	PI61.50	PI41.00	PI31.40	PI15.00	MG166.30	MG149.80	MG131.30	MG113.30	MG95.90	MG64.70	MG40.10	MG18.60	MG0.40	JV97004	BD95210bis	BD95210	JV97002	JV97001	JV97003	JV97009	BD95213	JV97008	JV97010	BD95201
Ancyrochitina spp.	3											1	3	1	1			13	5	7			8	6			1						5		1	3	
Angochitina sp. aff. *echinata* in Sutherland 1994								3							2																						
Angochitina longicollis																																	1	7			
Angochitina spp.								5																													
Belenochitina cf. *granosa*																						1															
Belenochitina intermedia				1		2	2							2		1		4	1	4				1	1												
Belonechitina latifrons	8			1		2		3		1						1		1				1	1			1											
Belonechitina lauensis				1						1	1																										
Bursachitina sp. B in Sutherland 1994																		2	2			4				6											
Cingulochitina cingulata																											19	17	3	99	6	64					
Cingulochitina convexa	30	57	8	45	9	2		6	5	8	5			11	9		121	372	180	775	1		1	32	18	3											
Cingulochitina dreyensis																																	65	9			
Cingulochitina gorstyensis	36	28	6	8	4	1	1	4		3				2	2		72	109	129	275							30	3									
Cingulochitina cf. *wronai*																				1																	
Cingulochitina sp. A in Paris 1981					2										2		1	8	7	30																	
Cingulochitina sp. B								1																													
Cingulochitina spp.	1	1		23	8			2	7	1	2			5	1		74	283	44	786	2		11	6	3		1			3							
Conochitina claviformis																											3		3	5	4	7					
Conochitina fortis																											2	6	4	22	26	6					
Conochitina lagena	1	1	1																								1			7	4	5					
Conochitina pachycephala																												1		1							
Conochitina proboscifera																																			13	14	
Conochitina aff. *proboscifera*																																	1		6	13	
Conochitina pumilio sp. nov.	3		1							1			1				1	17	32	23		23	2	4	3	6											
Conochitina rudda				2			1	2		3	1		6	1					1			1						5									
Conochitina subcyatha																											2										
Conochitina sp. A in Verniers 1983																																			1	5	
Conochitina sp. A in Sutherland 1994	3	1	1					1															1	1	1	1											
Conochitina sp. B						1																															
Conochitina sp. C							1	1										5	2	4			1			3											

Table 1 (*Continued*)

Formation	Ronquières Formation																										F	Steenkerque Fm					P	C		F	H
Sample	JV97005	JV97007	JV97006	PI197.40	PI169.30	PI163.00	PI153.80	PI148.60	PI129.50	PI126.00	PI113.00	PI90.50	PI70.50	PI61.50	PI41.00	PI31.40	PI15.00	MG166.30	MG149.80	MG131.30	MG113.30	MG95.90	MG64.70	MG40.10	MG18.60	MG0.40	JV97004	BD95210bis	BD95210	JV97002	JV97001	JV97003	JV97009	BD95213	JV97008	JV97010	BD95201
Conochitina spp.	10	2	4	3	2	8	6	17	2	6	2	3	6	1	3		1	31	23	17		19	26	2	2	21	2	1	4	5	7	5	6		4	8	
Desmochitina hemsiensis?						1																															
Desmochitina ex gr. *minor*																																					1?
Eisenackitina anulifera																														cf1					4	3	
Eisenackitina causiata																																	3	1	1	7	
Eisenackitina cf. *lagenomorpha*				1			2					1		6		1		1	1	3				1		1											
Eisenackitina cf. *philipi*								1								1		2																			
Eisenackitina spp.			2	1	1	2	2											5	1				1			1	2			2							
Linochitina erratica														2																							
Margachitina margaritana																								2		2				2							
Ramochitina corniculata																																	2	1			
Ramochitina spp.																																				1	
Sphaerochitina impia?	11	1	2										1					3	1	1			1	2		2											
Sphaerochitina jaegeri	3																													1		3					
Sphaerochitina cf. *lycoperdoides*	1											1							2																		
Sphaerochitina serpagli	1																										3			4	1						
Sphaerochitina spp.	3	1															1	2	1			1	1		2	1	3			3	2	2					
Chitinozoa spp.	16	7	8	1	2	6	4		1					1		1	2	111	6	395	2	5	17	6	4	2	10	3	6	13	8	13	5	1	1	25	
Total Chitinozoa	130	99	33	87	28	25	19	46	15	24	11	6	17	32	20	5	273	969	438	2321	5	55	71	63	34	50	79	36	20	167	58	105	88	19	31	79	1
Weigth sample (g)	64	40	37	100	50	53	82	100	52	100	69	60	100	51	100	63	100	100	100	100	100	100	100	89	92	100	41	34	51	71	36	33	42	51	30	40	84
Chitinozoa/g	2,0	2,5	0,9	0,9	0,6	0,5	0,2	0,5	0,3	0,2	0,2	0,1	0,2	0,6	0,2	0,1	2,7	9,7	4,4	23,2	0,1	0,6	0,7	0,7	0,4	0,5	1,9	1,1	0,4	2,4	1,6	3,2	2,1	0,4	1,0	2,0	0,0

The position of the samples in the Steenkerque Formation are given per section, below the Ferme des Chèvres section and above the section in Rue de Hiernoulet. The relative position of the samples in the two sections could not be established accurately.


Chronostratigraphy
Systems
Series
Stages
Ordovician
Silurian
Devonian
Upper
Llandovery
Wenlock
Ludlow
Middle
Rhudd.
Telychian
Sheinwoodian
Homerian
Gorstian
Givetian
Biostratigraphy
Graptolites biozonation
(different authors, see text)
atavus
nilssoni + scanicus
scanicus or higher nilssoni + scanicus
Chitinozoa Biozonation
Silurian global biozonation (Verniers et al. 1995)
(marga-ritana)
cingulata
pachy-cephala
(elongata)
Local biozonation Wenlock (Builth Wells district, U.K.)
cingulata
pachycephala
subcyatha
Local biozonation (Ronquières-Monstreux)
A
B
C
D
E
F
G
E?
Desmochitina hemsiensis?
Conochitina sp. B
Cingulochitina sp. B
Belonechitina lauensis
Linochitina erratica
Angochitina sp. aff. echinata in S. 1994
Eisenackitina cf. philipi
Cingulochitina cf. wronai
Sphaerochitina cf. lycoperdoides
Cingulochitina sp. A in Paris 1981
Belonechitina cf. granosa
Belonechitina intermedia
Eisenackitina cf. lagenomorpha
Conochitina sp. C
Conochitina sp. A in Sutherland 1994
Cingulochitina convexa
Belonechitina latifrons
Bursachitina sp. B in Sutherland 1994
Conochitina pumilio sp. nov.
Sphaerochitina impia?
Conochitina subcyatha
Margachitina margaritana
Cingulochitina gorstyensis
Conochitina rudda
Conochitina pachycephala
Sphaerochitina serpagli
Sphaerochitina jaegeri
Conochitina lagena
Conochitina fortis
Conochitina claviformis
Cingulochitina cingulata
Ramochitina cornicula (comb. nov.)
Cingulochitina dreyensis
Angochitina longicollis
Eisenackitina causiata
Eisenackitina anulifera
Conochitina aff. proboscifera
Conochitina proboscifera
Conochitina sp. A in Verniers 1983
Desmochitina ex gr. minor
cf.
Position of the sections versus the lithostratigraphy. Position of Chitinozoa samples and graptolite levels. Numbers in italic and with asterisk are barren samples
Comblain
Ronquières Plan Incliné
Ronquières Mont Godart
Ri Mathieu
Chèvres Farm
Monstreux area
200 m
JV97005
JV97007
JV97006
JV97004
JV97002
JV97001
JV97003
JV97009
JV97008
JV97010
BD952 10bis
BD952 10
BD952 11*
BD952 13
BD952 09*
BD952 08*
BD952 07*
BD952 06*
BD952 05*
BD952 04*
BD952 03*
BD952 02*
BD952 02bis*
BD952 01
PI204.40*
PI197.40
PI169.30
PI163.00
PI153.80
PI148.60
PI129.50
PI126.00
PI113.00
PI 90.50
PI 70.50
PI 61.50
PI 41.00
PI 31.40
PI 28.00*
PI 15.00
MG166.30
MG149.80
MG131.30
MG108.30*
MG 95.90
MG 64.70
MG 60.10*
MG 58.10*
MG 40.10
MG 18.60
MG 0.40
Lithostratigraphy (formations)
Bois de Bordeaux
Ronquières
(Vichenet + Froide Fontaine)
Steenkerque
Petit Roeulx
Corroy
Fallais
Bois Grand Père
Brutia
Madot + Fauquez + Huet
Thickness (m)
>527
±415
>143
between 245 and 100
±65
>370
±80
325

nilssoni Barrande and *M. colonus* Barrande, which are characteristic species for the lower Ludlow. With this find, he also established for the first time the presence of lower Ludlow rocks in the Brabant Massif. A fact to note is that Leriche (1912) found specimens, which he attributed to *M.* cf. *nilssoni*, but that afterwards no other author (including Leriche, 1922) retains this informal species assignment. Mailleux (1933) mentions the presence of *Saetograptus colonus* (Barrande), *M. bohemicus* (Barrande), *Lobograptus scanicus* (Tullberg) and *Pristiograptus dubius* (Suess) in the Ronquières area, but it is not clear, however, if the two latter species were collected at the Mont Godart outcrop (Louwye et al., 1992). Michot (1954, 1957) assigns the lower part of the Mont Godart outcrop to the *M. Nilssoni* (sic)(Barrande) graptolite zone, sensu Elles and Wood (1901–1918).

During the enlargement of the canal between 1963 and 1966 Legrand (1967), found *Neodiversograptus nilssoni* (Barrande), *M. bohemicus* Barrande and *P. dubius* (Suess) in the Mont Godart section. He did not recover many fossils from the large Plan Incliné section: only graptolites attributed to *P. dubius* (Suess) near profile 75 and one specimen of a *Siphocrinites*, without precise location. On the basis of the new graptolite finds in the Mont Godart and the Plan Incliné sections, Legrand (1967) attributed the Silurian rocks of both sections to Zone 33 of Elles and Wood (1901–1918) (*N. nilssoni* biozone, Ludlow). Martin (1969) looked for acritarchs in four samples (RON-81, -82, -85, -90) from the Ronquières Formation, but it is not clear whether they come from the Mont Godart or from the Plan Incliné section. Neither yielded chitinozoans nor acritarchs.

Martin and Rickards (1979) studied acritarchs and chitinozoans from the sections around the Ferme des Chèvres. The acritarchs indicate a Telychian age for her sample FM 77.6.1 from the outcrops north of the Ferme des Chèvres (Fig. 1), which we mapped as the top of the Fallais Formation. The chitinozoans indicate the middle to Upper Wenlock for samples FM 77.5.1 to 3 from the outcrops east of the Ferme des Chèvres (Fig. 1), which we mapped as the Steenkerque Formation.

The area has been investigated extensively by our team, with fieldwork, mapping and detailed logging of the lithostratigraphy. Detailed descriptions of all the outcrops of the Ludlow part of the Ronquières area, the detailed stratigraphical logs and a study on the metabentonites, are presented in Verniers et al. (1992). The re-evaluation and redefinition of the Ronquières Formation and the interpretation of the sedimentary environment is shown in Louwye et al. (1992). In the Mont Godart and the Plan Incliné sections, 21 graptolites levels were discovered. We refer to the latter two publications for the location of these levels in the detailed logs and maps. The state of preservation of the graptolites is mostly very poor and species characteristic for the Gorstian biozones *Neodiversograptus nilssoni*, *Lobograptus scanicus* and possibly *Pristiograptus tumescens* are reported (Rickards, personal communication in Louwye et al., 1992). An overview of the two major outcrops is published in an excursion field guide (Herbosch et al., 1991a,b).

In the Monstreux area, graptolites have been found at three levels. First in an outcrop (number 3 on Fig. 2) that has disappeared since, but which is interpreted herein as having exposed the Bois Grand-Père Formation. Some of the poorly preserved graptolites were erroneously determined by Malaise (1900) as the Ludlow species *Monograptus colonus*, which gave rise to the definition of the 'Assise of Monstreux' with a Ludlow age. Later Malaise (1910) redetermined them as *Climacog-*

Fig. 3. Range chart of most of the chitinozoans from the Ronquières and the Monstreux areas in relation to the lithostratigraphical thickness, with the location of the samples, formation names, chitinozoan and graptolite biozonations, other fossil levels (symbol for graptolites and A for acritarchs), and deduced chronostratigraphy also being shown. The position of the Combreuil samples within the Ronquières Formation is unclear. For clarity of the data it is put high in the sequence, but the chitinozoans indicate a position low in the formation (see arrow). For the authors of the graptolite biozonation we refer to the text. Chitinozoan biozones put between brackets indicate that the index zonal fossil was not found, but that the associated characteristic species have been found.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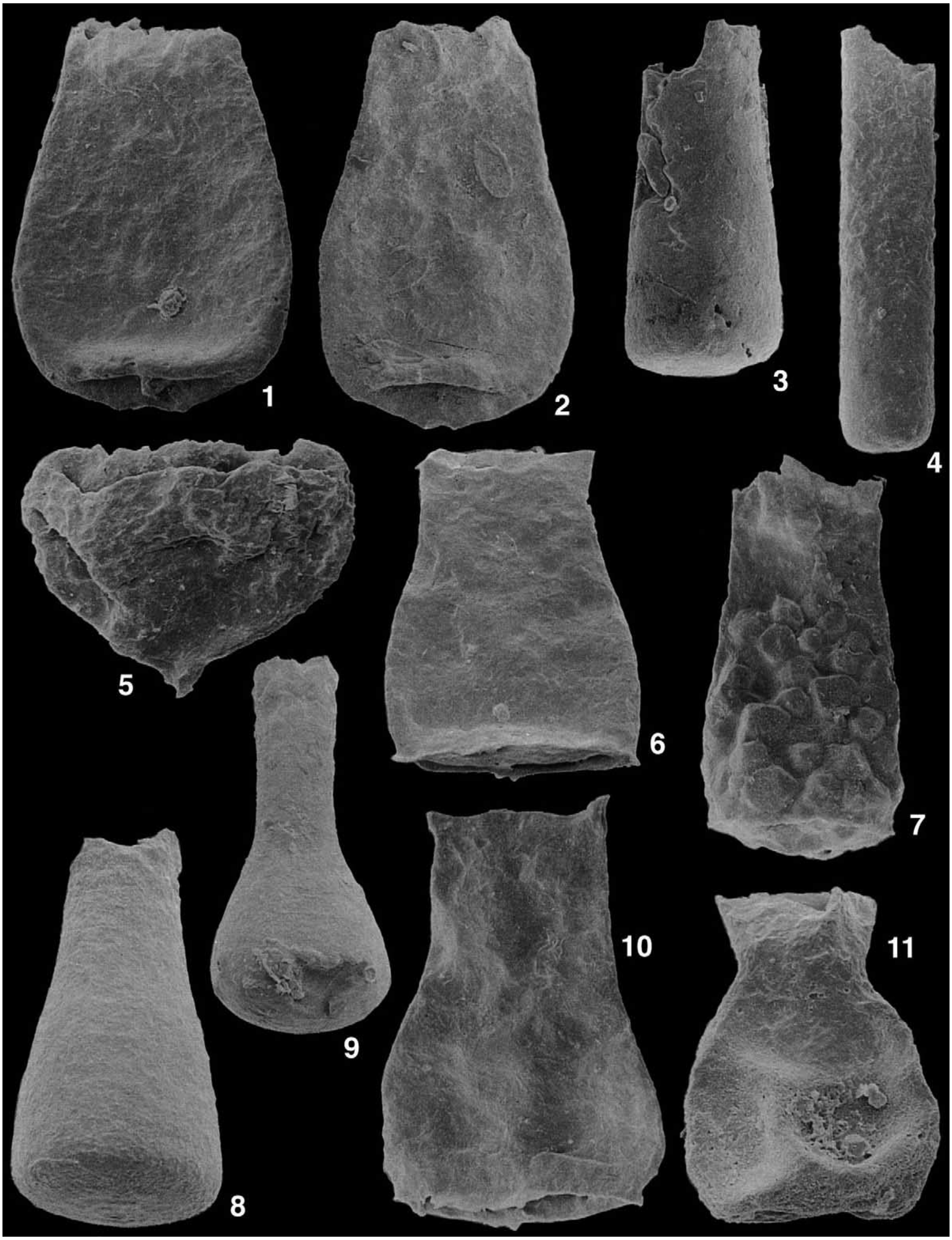
raptus scalaris, a Llandovery species, and the term 'Assise of Monstreux' was abandoned. In Verniers and Van Grootel (1991) graptolites are described in a weathered, fine-grained, volcanic rock in the so-called 'eurite of Nivelles' (Tarlier and Wauters, 1862; Corin, 1965; Ladeuze, 1990). The volcanic rock represents the top part of the Brûtia Formation. Rickards (personal communication in Verniers and Van Grootel, 1991) determined the graptolites and considered them typical of the Rhuddanian *atavus* Biozone. The archives of the Geological Survey of Belgium mention the presence of graptolites in black shales at two outcrops, both no longer visible, NE of Monstreux (archive numbers 128E134 and 128E135, marked as number 1 and 2 on Fig. 2). On our map they are interpreted as having exposed the Fauquez Formation, the only unit with dark grey slates and frequently occurring graptolites in the Brabant Massif.

As a result of our fieldwork, the two study areas are mapped (Figs. 1 and 2) using the list of lithostratigraphical units for the Lower Palaeozoic of Belgium as recently accepted by the Stratigraphical Commission of Belgium (Verniers et al., in press). The Silurian formations encountered in the Ronquières area are, from bottom to top, the Fallais, Corroy, Petit Roeulx, and Steenkerque formations; the probably present, but not outcropping, Froide Fontaine and Vichenet formations, and the Ronquières Formation. The Mont Godart Formation, just below the Ronquières Formation, defined in Louwye et al. (1992), was considered to be too thin a unit and too similar to the Ronquières Formation, and was not retained by the Stratigraphical Commission. It is included in the basal strata of the Ronquières Formation (Verniers et al., in press).

The Monstreux area contains from bottom to top: the Huet, Fauquez, Madot, Brutia, Bois Grand-Père, Fallais, Corroy, Petit Roeulx and Steenkerque Formations. In the Rue des Gendarmes in Monstreux the succession was already described by Dumont (1848), de la Vallée-Poussin and Renard (1876) and Corin (1965) and also in the archives of the Geological Survey of Belgium (wherein Corin, unpublished, describes in 1963 archive number 128E109). It shows the top of the Fallais Formation with a superposition of >10 m of greenish soft slate and mudstone in medium to thick bedded distal turbidites. South of a fault contact, a weathered volcanoclastic bed occurs, the 'Monstreux porphyroid'. The coarse volcanoclastic rock is often not visible, but it

Plate I.

1. *Cingulochitina dreyensis*, Petit Roeulx Formation, sample JV97009; SEM stub preparation 970035, Ch3 (Chitinozoa number Ch3 on the stub) (Photo 06); 520×.
2. *Cingulochitina dreyensis*, Petit Roeulx Formation, sample JV97009; SEM stub preparation 970035, Ch16 (Photo 10); 520×.
3. *Cingulochitina dreyensis*, Petit Roeulx Formation, sample JV97009; SEM stub preparation 970035, Ch4 (Photo 07); 690×. Note that the cingulum is only faintly present on this specimen.
4. *Conochitina* sp. A in Verniers (1983), Fallais Formation, sample JV97010; SEM stub preparation 970034, Ch1 (Photo 46); 280×.
5. *Eisenackitina anulifera*, top Corroy Formation, sample JV97008; SEM stub preparation 970033, Ch14 (Photo 41); 420×.
6. *Eisenackitina anulifera*, top Corroy Formation, sample JV97008; SEM stub preparation 970033, Ch10 (Photo 39); 350×.
7. *Conochitina proboscifera*, top Corroy Formation, sample JV97008; SEM stub preparation 970033, Ch27 (Photo 44); 280×.
8. *Conochitina* aff. *proboscifera*, Fallais Formation, sample JV97010; SEM stub preparation 970034, Ch20 (Photo 03); 235×.
9. *Cingulochitina dreyensis*, Petit Roeulx Formation, sample JV97009; SEM stub preparation 970035, Ch6 (Photo 08); 850×.
10. *Conochitina* aff. *proboscifera*, top Corroy Formation, sample JV97008; SEM stub preparation 970033, Ch1 (Photo 37); 280×.
11. *Conochitina proboscifera*, top Corroy Formation, sample JV97008; SEM stub preparation 970033, Ch12 (Photo 41); 235×.
12. *Eisenackitina causiata*, Fallais Formation, sample JV97010; SEM stub preparation 970034, Ch10 (Photo 4); 520×.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was located during our fieldwork. It passes upward into a few beds of fine-grained light coloured rock (named 'eurite') and higher into about 11 m of purplish mudstone. It is the only place where purple sediments occur in the Silurian of the Brabant Massif. At the top of the purple shales an intercalated metric 9 m of greenish mudstone and slate of the top of the Fallais Formation occurs. Via a thin transition zone, the sediments change drastically into the very thinly bedded Corroy Formation, with grey slates, mudstones, siltstones, and fine sandstones in beds often only a few centimetres thick (Fig. 2).

It is worth mentioning that the Braine-le-Comte/Feluy geological map sheet, where the study area is situated, is being published (Hennebert, in press).

2. Methods and material studied

Five out of seven Silurian formations in the Ronquières area, and nine out of nine Ordovician–Silurian formations of the Monstreux area, are not yet accurately dated. The purpose of this study is to establish the biostratigraphical position of most of the formations in the Ronquières and Monstreux areas by using chitinozoans and to present the systematics of selected chitinozoans that are important because of their frequent occurrence or stratigraphical range.

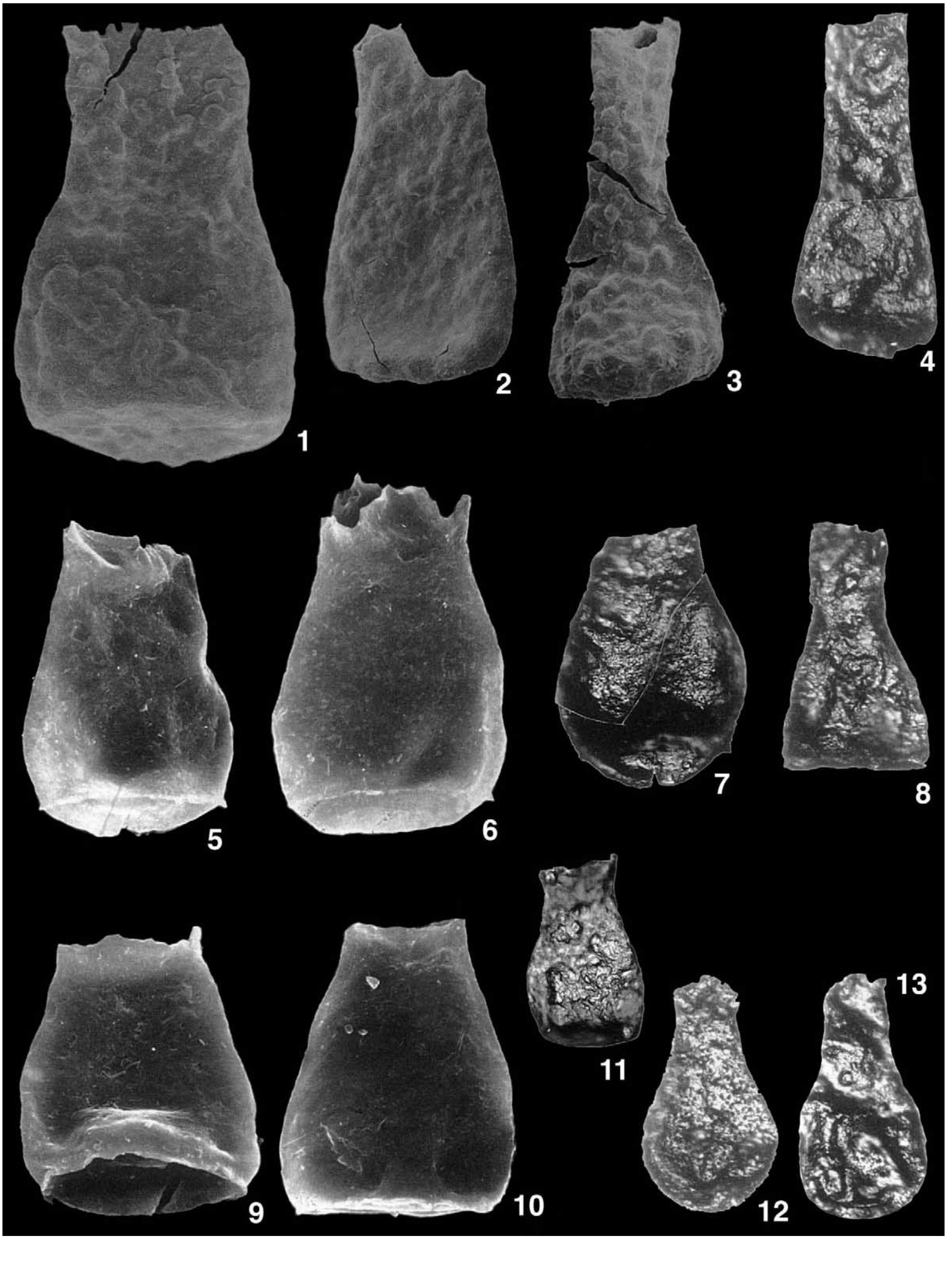
From the 51 samples prepared, 37 samples were fossiliferous (73%). The general position in the lithostratigraphy of the samples is given in Fig. 3, and the general location in Figs. 1 and 2. The detailed locations of the samples are given in Appendix 2. Between 30 and 100 g of fine-grained rocks were prepared in our laboratory, according to standard palynological techniques for separation of chitinozoans as described in Paris (1981) and Verniers (1983). No heavy liquid separation was applied to the residues and oxidation with nitric acid was avoided. The chitinozoans were studied with a JEOL JMS 6400 scanning electron microscope (SEM) and/or with a Leitz Orthoplan microscope with incident and transmitted light. The residues and slides are kept in the Laboratory of Palaeontology, Ghent University.

3. Results and analyses

Table 1 lists the results for each fossiliferous sample, with amount of dissolved rock, the number of each chitinozoan taxon retrieved and the concentration of chitinozoans per gram of dissolved rock. The chitinozoan assemblages are poorly to moderately preserved due to the high

Plate II.

1. *Eisenackitina lagena*, Vichenet and Froide Fontaine Formation, sample JV97004; SEM stub preparation 970038, Ch20 (Photo 45); 520×.
2. *Eisenackitina lagena*, Steenkerque Formation, sample JV97002; SEM stub preparation 970030, Ch23 (Photo 52); 420×.
3. *Conochitina fortis*, Steenkerque Formation, sample JV97002; SEM stub preparation 970045, Ch15 (Photo 24); 420×.
4. *Conochitina claviformis*, Vichenet and Froide Fontaine Formation, sample JV97004; SEM stub preparation 970038, Ch13 (Photo 30); 280×.
5. *Margachitina margaritana*, Steenkerque Formation, sample JV97002; SEM stub preparation 970045, Ch26 (Photo 26); 690×.
6. *Cingulochitina gorstyensis*, Vichenet and Froide Fontaine Formation, sample JV97004; SEM stub preparation 970038, Ch19 (Photo 34); 690×.
7. *Cingulochitina cingulata*, Steenkerque Formation, sample JV97002; SEM stub preparation 970045, Ch10 (Photo 21); 690×.
8. *Conochitina subcyatha*, Vichenet and Froide Fontaine Formation, sample JV97004; SEM stub preparation 970038, Ch11 (Photo 29); 420×.
9. *Sphaerochitina jaegeri*, Steenkerque Formation, sample JV97002; SEM stub preparation 970045, Ch12 (Photo 22); 520×.
10. *Cingulochitina cingulata*, Steenkerque Formation, sample JV97002; SEM stub preparation 970045, Ch4 (Photo 19); 690×.
11. *Eisenackitina* sp., Steenkerque Formation, sample JV97002; SEM stub preparation 970045, Ch14 (Photo 23); 520×.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anchizonal metamorphism in the outcrop area, which was deduced by illite crystallinity studies (Van Grootel et al., 1997). However, the chitinozoans can occur frequently, with a mean concentration of 1.86 chitinozoan per gram of rock, ranging between 0.1 and 23. The concentration is more than in the Silurian of the Mehaigne area, where a mean of 1.0 chitinozoans per gram of rock was found, but where the metamorphism was determined as fully epizonal by illite crystallinity studies (Van Grootel et al., 1997). The concentration of chitinozoans in a sample from close to the bridge of Ronquières is the highest number found to date in the Silurian of the Brabant Massif. The assemblages are generally diverse, and between 1 and 11 species per sample are recorded.

3.1. Biozonation

Three very different groups of species succeed each other throughout the Silurian in the studied sections (Fig. 3): *Conochitina* aff. *proboscifera* dominates below, *Cingulochitina cingulata* and *Conochitina fortis* in the middle and *Cingulochitina convexa* above. These assemblages can be divided in local biozones, with letters A–G and are described below. Several of these local biozones can be grouped in global biozones (as defined by Verniers et al., 1995).

It should be mentioned that below in the stratigraphical section, probably from the Huet Formation, a sample (BD 95201) contains only one *Desmochitina* ex gr. *minor*. This is too poor to be described as a local biozone.

The samples JV97010 from the top of the Fallais Formation and JV970008 from the top of the Corroy Formation are characterised by *Conochitina* sp. A in Verniers, 1983 (Plate I, 4), typical forms of *Conochitina proboscifera* (Plate I, 7, 11), forms similar to the latter, but thin-walled, which are called herein *Conochitina* aff. *proboscifera* (Plate I, 8, 10), *Eisenackitina anulifera* (Plate I, 5, 6), and *E. causiata* (Plate I, 12). Sample BD95213 also from the top of the Corroy Formation contains *Angochitina longicollis*, *Cingulochitina dreyensis* (Plate I, 1–3, 9), *Eisenackitina causiata* and *Ramochitina corniculata*. Sample JV97009 from the base of the Petit Roeulx Formation contains besides these four latter species also *Conochitina* aff. *proboscifera*. The four samples are grouped into the local biozone A, dominated by either *C.* (aff.) *proboscifera* or *C. dreyensis*.

The samples JV97003, JV97001 and BD95210 from the Steenkerque Formation contain an assemblage dominated by *Cingulochitina cingulata* (Plate II, 7, 10), and/or *Conochitina fortis* (Plate II, 3), with possibly, in addition, *Conochitina claviformis* (Plate II, 4), *C. lagena* (Plate III, 1, 2), and *Sphaerochitina jaegeri* (Plate II, 9). These samples are referred to the local biozone B.

Samples JV97002 and BD95210bis from the top of the Steenkerque Formation can contain, in ad-

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Plate III.

1. *Belonechitina latifrons*, Ronquières Formation, sample JV97005; SEM stub preparation 970046, Ch17 (Photo 49); 520×.
2. *Belonechitina latifrons*, Ronquières Formation, sample JV97005; SEM stub preparation 970046, Ch16 (Photo 48); 350×.
3. *Sphaerochitina impia*?, Ronquières Formation, sample JV97005; SEM stub preparation 970046, Ch20 (Photo 50); 520×.
4. *Conochitina* sp. A in Sutherland, 1994, Ronquières Formation, sample PI 90.50; preparation GVG84B; 290×.
5. *Cingulochitina convexa*, Ronquières Formation, sample PI 15.00; preparation GVG84C; 530×.
6. *Cingulochitina convexa*, Ronquières Formation, sample PI 15.00; preparation GVG84C; 580×.
7. *Cingulochitina* sp. B, Ronquières Formation, sample PI 148.60; preparation GVG84A; 290×.
8. *Eisenackitina* cf. *philipi*, Ronquières Formation, sample PI 166.30; preparation GVG84D; 210×.
9. *Cingulochitina gorstyensis*, Ronquières Formation, sample PI 15.00; preparation GVG84C; 560×.
10. *Cingulochitina gorstyensis*, Ronquières Formation, sample PI 15.00; preparation GVG84C; 600×.
11. *Conochitina pumilio* sp. nov. holotype; Ronquières Formation, sample MG166.30; preparation SL84A (co-ordinates 56.6×109.6); 240×.
12. *Angochitina* sp. aff. *echinata* in Sutherland, 1994, Ronquières Formation, sample PI 41.00; preparation GVG84E; 300×.
13. *Angochitina* sp. aff. *echinata* in Sutherland, 1994, Ronquières Formation, PI 148.60; preparation GVG84A; 300×.

dition, *Conochitina pachycephala*, *Margachitina margaritana* (Plate II, 5), *C. rudda*, *Cingulochitina gorstyensis* (Plate II, 6, Plate III, 9, 10), and *Sphaerochitina serpagli* and they are referred to the local biozone C.

Sample JV97004 from a very small outcrop, cannot undoubtedly be attributed to the Ronquières, Vichenet and Froide Fontaine formations from the lithology only. It contains a similar assemblage as the two previous assemblages from the Steenkerque Formation, with, in addition, *Conochitina subcyatha* (Plate II, 8). This assemblage is called the biozone D. Because it did not contain the typical assemblage of the Ronquières Formation (biozones E, F or G), it was mapped as Vichenet and Froide Fontaine formations.

Most samples from the Mont Godart section (MG 0.40 to MG 166.30), the Plan Incliné section and the area north of Combreuil, belonging to the Ronquières Formation, yielded assemblages dominated by *Cingulochitina convexa* (Plate III, 5, 6), with, in addition, *Conochitina rudda* and *Cingulochitina gorstyensis* (both species present also in the underlying biozones), and *Sphaerochitina impia*? (Plate III, 2), *Conochitina pumilio* sp. nov. (Plate III, 11), *Bursachitina* sp. B in Sutherland, 1994, *Belonechitina latifrons* (Plate III, 1, 2), *Conochitina* sp. A in Sutherland, 1994 (Plate III, 4), and *Conochitina* sp. C. These species occur in biozones E, F and G. However, additional appearances of other species allow the distinction of three biozones. The biozone E is characterised by the above-mentioned species.

In the biozone F appear, in addition to the species often present in biozone E, *Belonechitina intermedia*, *Cingulochitina* sp. A in Paris, 1981 and the very rare *Belonechitina* cf. *granosa*. The first appearance of *Cingulochitina* sp. A in Paris, 1981 is chosen to indicate the base of the biozone. They are present in the larger middle part of the Ronquières Formation.

In the biozone G appear in addition to the often occurring species of biozone E, six only rarely occurring new species: *Angochitina* sp. aff. *echinata* in Sutherland, 1994 (Plate III, 12, 13), *Linochitina erratica, Belonechitina lauensis, Cingulochitina* sp. B (Plate III, 7), *Conochitina* sp. B and *Desmochitina hemsiensis*? The first appearance of *Angochitina* sp. aff. *echinata* in Sutherland, 1994 is selected as the base of the biozone G. It is present in the middle and upper part of the Plan Incliné section, upper part of the Ronquières Formation.

The three local biozones E–G defined herein, were called previously by Van Grootel (unpublished Ph.D. thesis, Ghent University, 1990), Van Grootel in Herbosch et al. (1991a,b) and Louwye et al. (1992), the *Cingulochitina convexa–Cingulochitina serrata* assemblage zone, subdivided in three subzones (1–3). The name of the biozone and its subdivision is now obsolete.

3.2. Correlation with other chitinozoan biozonations

The local chitinozoan biozones can be correlated with the following chitinozoan biozonations from neighbouring or more distant areas (with their respective palaeocontinents): (1) on the Avalonia palaeocontinent: the Mehaigne area in the Brabant Massif, part of the Anglo–Brabant Deformation Belt (Verniers, 1981, 1983; reinterpreted in Verniers, 1999), the type areas of the Wenlock and Ludlow in the Welsh Basin (Dorning, 1981; Sutherland, 1994), the type area for the Wenlock graptolite biozonation of the Builth Wells district, Wales, UK (Verniers, 1999); (2) on the Baltica palaeocontinent: the uppermost Llandovery to Ludlow succession on Gotland, Sweden (Laufeld, 1974), the Llandovery–Wenlock succession in Estonia and north Latvia (Nestor, 1994) and the Ludlow succession of the same area (Nestor, 1990); (3) the global chitinozoan biozonation by Verniers et al. (1995). The respective authors of the biozonations will not be repeated in the chapter below.

The local biozone A, from the top of the Fallais Formation to the base of the Petit Roeulx Formation can be correlated on the basis of (parts of) the assemblage present (as for the rest of the correlation below), with subzone C (subzones C1, C2 and C3), or the combined *margaritana*, *bouniensis*, *burdinalensis* biozones of the Mehaigne area; with the lower Wenlock chitinozoan assemblages from the Buildwas Formation, with the combined *margaritana*/*mamilla*/*burdinalensis* biozones of the Builth Wells district, with the *margaritana*/*mamil-*

la assemblages on Gotland, with the combined *proboscifera*/*margaritana* Biozones of Estonia and north Latvia, and with the *margaritana* Biozone of the global chitinozoan biozonation.

The samples JV97003, JV97001 and BD95210, from the Steenkerque Formation, referred to the local biozone B can be correlated with Biozone D (Subzone D1) or the *lagena* Biozone, corresponding to the lower part of Subzone D1, of the Mehaigne area; with the *cingulata* Biozone of the Builth Wells district, with the *cingulata* assemblage on Gotland, the *lagena* Biozone of Estonia and north Latvia and the *cingulata* Biozone of the global chitinozoan biozonation.

Samples JV97002 and BD95210bis, from the top of the Steenkerque Formation, referred to the local biozone C, can be correlated with Biozone D (Subzone D1), or the *pachycephala* Biozone, corresponding to the upper part of Subzone D1 of the Mehaigne area; the *pachycephala* Biozone of the Builth Wells district, the *pachycephala* assemblage of Gotland, the *pachycephala* Biozone of Estonia and north Latvia and the *pachycephala* Biozone of the global chitinozoan biozonation.

The local biozone D, in sample JV97004 from the Vichenet and Froide Fontaine formations, can be correlated with the Biozone D (subzone D2) or the *subcyatha* Biozone of the Mehaigne area, where it occurs in the Fumal Formation, the postulated lateral equivalent of the Froide Fontaine Formation (Verniers et al., in press). The local biozone D can be correlated with the *subcyatha* Biozone of the Builth Wells area, Wales, UK, with part of the *pachycephala* assemblage of Gotland, with the *subcyatha* Biozone of Estonia and north Latvia and with part of the *pachycephala* Biozone of the global chitinozoan biozonation.

The local biozones E–G in the samples from the Ronquières Formation, can be correlated with Biozone E of the Ronquières Formation (former MB9 formation) of the Mehaigne area, and with the unnamed assemblage in the middle and lower upper part of the Hemse Beds, Gotland. *Angochitina elongata*, the index species of a global biozone, appears at a lower level in Gotland than in the Ludlow type area, and *Cingulochitina convexa* and *Belonechitina lauensis* appear at the same level in Gotland, whilst the latter appears later in the Ludlow area, making detailed correlation of the local biozones E–G with Gotland difficult.

But with other areas the biozones can be correlated. The biozones E and F of the Ronquières area can be correlated with Biozone 3 (Middle Elton Formation) of the Ludlow area, and with the Gorstian interzone below the *elongata* Biozone of the global chitinozoan biozonation.

The biozone G can be correlated by the co-occurrence of *C. convexa* with *B. lauensis* and *A*. sp. aff *echinata* in Sutherland, 1994, with the lower part of Biozone 4 (in the top of the Middle Elton Formation) in the Ludlow area, UK, with the *latifrons* Biozone in the Paadla Formation of Estonia and north Latvia, and because of the first appearance of *Belonechitina intermedia* with the *elongata* Biozone of the global chitinozoan biozonation.

4. Chronostratigraphy

From the correlation of the biozones with other biozonations, which are calibrated vis-à-vis chronostratigraphical standard sections or vis-à-vis other biostratigraphies, the following ages can be proposed for the formations in the Ronquières–Monstreux areas. The top of the Fallais Formation, the Corroy Formation and the base of the Petit Roeulx Formation belong to the uppermost Telychian (upper Llandovery) to lower Sheinwoodian (lower Wenlock). The *lagena* Biozone in the Builth Wells district belongs to the major part of the upper Sheinwoodian, middle Wenlock (Verniers, 1999) giving this age for the lower part of the Steenkerque Formation. The *pachycephala* Biozone in the Builth Wells district belongs to the uppermost part of the upper Sheinwoodian, middle Wenlock (Verniers, 1999), assigning the upper part of the Steenkerque Formation to this age. The *subcyatha* Biozone of sample JV97004, Ri Mathieu Simon, belongs to the lower Homerian (upper Wenlock). The outcrop was too small to determine its lithostratigraphical unit. The composition of the chitinozoan assemblage excludes this sample from the Ronquières Formation. It does not, however, allow differentiation between the Froide Fontaine or Vichenet formations, because detailed chitinozoan studies on the assemblages of both formations are not yet published.

The assemblages from the Ronquières Formation closely resemble the assemblages of the Middle Elton Formation, described by Sutherland (1994). The assemblages in the lower two thirds of the Ronquières Formation resemble the assemblages in most of the Middle Elton Formation (chitinozoan Biozone 3 in Sutherland, 1994), except at its top, and the assemblage in the top third of the Ronquières Formation resembles the topmost part of the Middle Elton Formation (lower part of chitinozoan Biozone 4 in Sutherland, 1994). In the type locality of the Ludlow, at Ludlow, the two chitinozoan biozones (3 and lower part of 4) correspond exactly with the *scanicus* graptolite Biozone, which corresponds with the lower part of the Gorstian (Sutherland, 1994). This is confirmed by the graptolite data (Rickards personal communication in Louwye et al., 1992), where a *nilssoni* or *scanicus* Biozone was established for most of the Ronquières formation, except for the highest levels where a *scanicus* or higher biozone was established. The chitinozoans seem to indicate that the Ronquières Formation could correspond to only the *scanicus* graptolite biozone. The more than 527 m thick turbiditic sequence of the Ronquières Formation could, hence, have been deposited in a much shorter time interval than previously accepted; Louwye et al. (1992) proposed the whole length of the Gorstian Stage. Time estimates of the Ludlow are in the order of 4.0 Ma (Tucker and McKerrow, 1995). The interval of time in which the thick Ronquières Formation was deposited could, hence, be in the order of several hundred ka.

5. Conclusion

Three Upper Ordovician formations were mapped in the Monstreux area. A single specimen of chitinozoan does not contradict the supposed Late Ordovician age of the lowest of the three formations, the Huet Formation, which was dated with chitinozoans much more accurately as middle–upper Caradoc in the Sennette Valley, Ronquières area (Van Grootel et al., 1997).

Nine Silurian formations have been mapped in the two study areas. The chitinozoan biostratigraphy has allowed the confirmations of the ages of two of the formations (Fallais and Ronquières), which were determined by graptolites or acritarchs. One formation (Brutia) the top of which has been dated accurately by graptolites (*atavus* Biozone, middle Rhuddanian, lower Llandovery; Rickards in Verniers and Van Grootel, 1991), did not contain chitinozoans. The age of one formation (Steenkerque) was previously determined with chitinozoans by Martin and Rickards (1979) as middle or late Wenlock. The age has been restricted by our study to the middle Wenlock. Three previously undated formations (Corroy, Petit Roeulx and the combined Vichenet/Froide Fontaine) were dated for the first time. One formation (Bois Grand-Père) remains undated in the two study areas.

The topmost part of the Fallais Formation was dated with acritarchs as Telychian by Martin and Rickards (1979), but is attributed more precisely with chitinozoans, in the Ronquières area, to the top of the Telychian. Indirectly this dates also to the upper Telychian, the previously undated purplish mudstones and porphyroid of Monstreux, situated slightly lower in the top of the Fallais Formation than the studied sample. The Corroy Formation is dated in the study areas for the first time as Lower Wenlock. Unexpectedly, the basal Petit Roeulx Formation is also dated as Lower Wenlock, whilst in the Mehaigne area the transition from the Corroy to the overlying Les Vallées Formation occurs later, in the middle Wenlock. This apparent diachronism needs to be studied in more detail.

The chitinozoans from sample JV97004, in the northern part of the Ri Mathieu Simon Silurian inlier (Fig. 2), clearly indicate the middle or upper Wenlock. Hence it probably belongs to the Vichenet and Froide Fontaine formations.

The 23 samples from the Ronquières Formation clearly confirm the lower Ludlow attribution obtained from the graptolites (for the authors, see above). Additionally, chitinozoans indicate the same age for the lower and higher parts of the formation, where no graptolites were found. The chitinozoans from the three small outcrops north of Combreuil, tentatively located in the Ronquières Formation, indicate the same age as that formation and confirm the lithostratigraphical attribution. The presence of the species *Conochitina lagena* and *Sphaerochitina jaegeri* indicates a position low in the formation.

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Appendix 1. Systematics of selected taxa

Abbreviations used:

Lm: maximal length; Lmc: maximal length; Bm: maximal width; Bmc: maximal width, corrected for flattening by multiplying by 0.7 (as suggested by Paris, 1981); Bo: oral width; Boc: oral width, corrected for flattening (see above); min.: minimal value; max.: maximal value; range: range in dimension between minimum and maximum; aver.: average value; std: standard deviation (1σ). All measurements of chitinozoans are in μm.

CHITINOZOA Eisenack, 1931
Order Operculatifera Eisenack, 1972
Family Desmochitinidae Eisenack, 1931 emend. Paris, 1981
Subfamily Desmochitininae Paris, 1981

Genus ***Bursachitina*** Taugourdeau, 1966 restrict. Paris, 1981

Bursachitina sp. B in Sutherland, 1994.

Synonymy:

1991 – *Conochitina* aff. *brevis brevis* – Herbosch et al., p. 312, fig. 35.
1994 – *Bursachitina* sp. B – Sutherland, 1994 pp. 26–27, pl. 1, figs. 5 and 6.

Material: 12 specimens; Ronquières Formation, Mont Godart section, sample MG 0.40, MG 95.90, MG 149.80 and MG 166.30.
Dimensions: see Table 2.
Description and remarks: *Bursachitina* sp. B in Sutherland, 1994 is a short, broad form, with a reduced or absent neck. The chamber is generally ovoid but tends to be conical in some specimens. A flexure is lacking and the shoulders are very broad. The maximal width is situated about half-

Table 2
Dimensions of *Bursachitina* sp. B in Sutherland, 1994

	n	Minimal	Maximal	Range	Average	Std.
Lm	12	103	235	132	160	43
Bm	12	87	122	335	105	12.3
Bo	12	49	100	51	73	16.9
Bmc	12	61	85	25	73	9
Boc	12	34	70	36	51	11.8
Bmc/Lm	12	0.35	0.64	0.29	0.48	0.08
Lm/Bmc	12	1.56	2.89	1.33	2.15	0.37

way along the chamber when the latter is ovoid. The basal margin is sharp and the base slightly convex or invaginated. The tegument is thin and has a fine rugose ornamentation. No mucron has been observed nor has an impression of a prosomal structure. *Bursachitina* sp. B in Sutherland, 1994 differs from *Conochitina* sp. A in Sutherland, 1994 by its length and the absence of a distinct neck. Some forms may have a distinct and sharp basal margin, resulting in a more aboral position of the maximal width.
Occurrences: *Bursachitina* sp. B was found in the Middle Elton Formation and possibly in the Lower Bringewood Formation in Ludlow, Shropshire, UK (Sutherland, 1994). We found *Bursachitina* sp. B in the lower part of the Ronquières Formation in the Mont Godart section, as is also indicated in Herbosch et al. (1991a,b).

Genus ***Desmochitina*** Eisenack, 1931

Desmochitina hemsiensis? Laufeld, 1974

Synonymy:

1974 – *Desmochitina hemsiensis* sp. nov. – Laufeld, p. 78, pl. 40, figs. A–C.

Material: two specimens; Ronquières Formation, Plan Incliné section, sample PI 163.00.
Dimensions: Lm: 108–106 μm, Bm: 93–106 μm, Bo: 33–58 μm.
Description and remarks: *Desmochitina hemsiensis*? has a spheroid or slightly ovoid chamber. The margin of the very short neck curls and forms a collar. The convex walls pass directly into a round bottom without a basal margin. The vesicle wall has a granulate to verrucate texture which closely resembles that of *Desmochitina hemsiensis* in Laufeld (1974, pl. 40). The dimensions of the two specimens found in this study differ from those of *D. hemsiensis* in Laufeld (1974). The total length of *D. hemsiensis* in Gotland ranges from 50 to 70 μm, this is much smaller than the length observed in our specimens. The maximal width and oral width of our specimens, also is larger, even after correction for the flattening (see above). Although flattening has influenced the total width of our specimens, the considerable difference in length ($>50\%$), between our specimens and *D. hemsiensis* in Laufeld, 1974 cannot be explained solely by this deformation, hence the question mark for the specific attribution.
Occurrences: *Desmochitina hemsiensis* in Gotland ranges from units b and c of the Hemse Limestone up to the middle part of the Eke Beds, with a peak of abundance at the Hemse–Eke transition (Laufeld, 1974, p.78). In this study, *D. hemsiensis*? is present in one sample from the Plan Incliné section, in the Ronquières Formation, just above levels attributed to the *M. scanicus* graptolite Biozone or higher (middle Gorstian, Ludlow).

Subfamily Eisenackitininae Paris, 1981

Genus ***Eisenackitina*** Jansonius, 1964 restrict. Paris, 1981

Eisenackitina* cf. *lagenomorpha (Eisenack, 1931)
Synonymy:

1991 – *Eisenackitina lagenomorpha* – Herbosch et al., p. 312, fig. 35.

Table 3
Dimensions of *Eisenackitina* cf. *lagenomorpha*

	n	Minimal	Maximal	Range	Average	Std.
Lm	14	75	174	99	113	30.1
Bm	14	70	160	90	92	22.8
Bo	14	33	71	38	50	11
Bmc	14	49	112	63	64	16
Boc	14	23	50	27	35	7.7
Bmc/Lm	14	0.39	0.7	0.34	0.58	0.09
Lm/Bmc	14	1.38	2.59	1.22	1.77	0.32

Material: 18 specimens; Ronquières Formation, Mont Godart section: samples MG0.40, MG40.10, MG131.30, MG 149.80 and MG 166.30; Ronquières Formation, Plan Incliné section: samples PI 31.40, PI 61.50, PI 113.00, PI 153.80 and PI 197.40.
Dimensions: see Table 3.
Description and remarks: *Eisenackitina* cf. *lagenomorpha* has a stocky silhouette, with a short widening neck and a broad conical chamber. A flexure is present, but the shoulders are very broadly rounded or may be absent. The flanks are convex. The basal margin is clear, but rounded, and the is bottom flat to slightly convex. The oral part of the neck is widened. The vesicle wall is covered with a coarse granulate ornamentation which increases in density oralwards. The specimens from the Ronquières area have a fine granulate to verrucate ornamentation.

E. cf. *lagenomorpha* differs from *Conochitina* sp. C. by the presence of ornamentation. It differs from *Belonechitina intermedia* by its smaller Lm to Bmc ratio, the presence of a flexure and its convex flanks; *B. intermedia* has straight flanks. The criteria we used for the separation of *Eisenackitina* cf. *lagenomorpha* and *Belonechitina intermedia* were the presence of the flexure and the straightness of the flanks. The dimensions of *E.* cf. *lagenomorpha* and *B. intermedia* do not completely coincide.
Occurrences: In the Baltic region, *E. lagenomorpha* is present in the Beyrichia Limestone (Eisenack, 1955). In southern Sweden Eisenack (1964) reports *E. lagenomorpha* in the Öved-Ramsåsa Group. In Gotland, atypical specimens are found in the Hemse Marl, typical specimens appear in the lower part of the Eke Beds and it ranges through to the Sundre Beds (Laufeld, 1974). In Estonia it occurs in the upper Gorstian, Ludfordian and Prídolí (Nestor, 1990). In Ludlow, Shropshire, UK, *E. lagenomorpha* is present from the Lower Bringewood Formation to the Lower Leintwardine Formation, Upper Gorstian to lower Ludfordian (Sutherland, 1994). In northern Wales, Llangollen, *E. lagenomorpha* is found in the Whitcliffian Dinas Bran Beds (Swanson and Dorning, 1977).

E. cf. *lagenomorpha* is rare to present through the Ronquières Formation in the Mont Godart and the Plan Incliné sections (Gorstian), as is also indicated in Herbosch et al. (1991a,b).

Eisenackitina cf. ***philipi*** Laufeld, 1974

Plate III, 8.

Synonymy:

1991 – *Eisenackitina philipi* (*sic*) – Herbosch et al., p. 312, fig. 35.

Material: four specimens; Ronquières Formation, Mont Godart section, sample MG 166.30; Ronquières Plan Incliné section, samples PI 31.40 and PI 148.60.
Dimensions: see Table 4.
Description and remarks: *Eisenackitina* cf. *philipi* has a cylindro–conical silhouette with a short flexure and broadly rounded shoulders. The cylindrical neck comprises about 40% of the total length. The oral opening is fringed and tends to widen slightly. The flanks are convex and the aboral

Table 4
Dimensions of *Eisenackitina* cf. *philipi*

	Sample	Minimal	Maximal	Range	Average	Std.
Lm	4	93	162	69	130	27.4
Bm	4	80	130	50	96	20.2
Bo	3	30	62	32	45	13.1
Ln	1	69	69	0	69	0
Bmc	4	56	91	35	67	14.1
Boc	3	21	43	22	32	9.2
Bmc/Lm	4	0.42	0.6	0.18	0.52	0.07
Lm/Bmc	4	1.66	2.39	0.73	1.95	0.28

margin is sharp. The convex bottom has often a protruding central part, which is not visible on the figured specimen. The vesicle wall is covered with an ornamentation consisting of short, coarse granulae, which are more densely concentrated on the aboral part of the chamber.

Occurrences: *Eisenackitina philipi* is a characteristic species of the Eke Beds in Gotland, but it first occurs in the upper part of the Hemse Marl and ranges into the lower part of the Burgsvik Beds. Its total range is hence, upper Gorstian to lower Ludfordian, Ludlow (Laufeld, 1974). In Estonia it is found in the Paadla and the lowermost Kuresaare formations (upper Gorstian to lower Ludfordian (Nestor, 1990). In Ludlow, Shropshire, UK, *E. philipi* is present from the top of the Upper Leintwardine Formation to the Upper Whitcliffe Formation, Ludfordian (Sutherland, 1994). De Bock (1982) found *E. philipi* in an upper Ludlow assemblage from the Castelsec section (Laurens Plateau), Montagne Noire, France. Schweineberg (1987) described it in the possibly Ludlow Los Arroyacas Formation, Valencia, NW Spain. In the Algerian Sahara, *E. philipi* is found in two levels (Ludlow–Prídolí) of the Oued Saret borehole, in the Mehaiguène Formation (Boumendjel, 1987). We found *E.* cf. *philipi* in three levels from the middle and upper part of the Ronquières Formation, Gorstian, lower Ludlow. Previously they were described as *E. philipi* (sic) with the same range, as indicated in Herbosch et al. (1991a,b).

Subfamily Margachitininae Paris, 1981

Genus ***Linochitina*** Eisenack, 1968 restrict. Paris, 1981

Linochitina erratica (Eisenack, 1931)

Synonymy:

1931 – *Desmochitina erratica* sp. nov. – Eisenack, p. 92, pl. 3., figs. 6–8.
1934 – *Desmochitina erratica* – Eisenack, 1934, p. 67, pl. 4, figs. 4–6.
1962 – *Desmochitina erratica* – Eisenack, p. 307, pl. 17, figs. 10 and 11.
1966 – *Eremochitina? erratica* – Taugourdeau, 1966, p. 38.
1968 – *Linochitina erratica* – Eisenack, p. 170, pl. 31, fig. 17.
1968 – *Linochitina erratica* – Jardiné and Yapaudjian, pl. 6, fig. 15.
1982 – *Linochitina erratica* – Nestor, pl. 17, fig. 3.
1987 – *Linochitina erratica* – Schweineberg, p. 31–33, pl. 6, figs. 5 and 7.
1991 – *Linochitina erratica* – Herbosch et al., p. 312, fig. 35.

Material: One chain of two individuals; Ronquières Formation, Plan Incliné section, sample PI 61.50.

Dimensions: averages of the two specimens Lm: 133 μm, Bm: 73 μm.

Description and remarks: *Linochitina erratica* has a cono–ovoid silhouette with a widening neck. The flexure is inconspicuous and the flanks are convex. The basal margin is rounded and the bottom is flat. A small mucron is observed on the bottom. The vesicle wall is thin and smooth. No cingulum was observed at the base of the lower individual. The dimensions of *L. erratica* vary considerably. Eisenack (1931) gave an average Lm/Bm ratio of approximately 3.1 as a specific element. In 1962 Eisenack defines a neotype with a maximal Lm/Bmc ratio of 3.2 (when applying a correction factor of 0.7, and assuming that it is completely flattened). The other chain of *L. erratica* in Eisenack (1962) is considerably larger, with an average Lm/Bmc ratio (correction factor: 0.7) of 3.6 and an average length of 157 μm in contrast with a Lm of 109 μm for the neotype. Nestor (1982, pl. 17, fig. 3) figured a chain of four specimens of *L. erratica*. The average total length of each vesicle was 103 μm, the average maximal width 44 μm, giving a Lm/Bmc ratio of 2.4. Schweineberg (1987) gave biometrical data for only a small sample (2%) of his *L. erratica* population. The average total length of that group is 155 μm, the average maximal width 58 μm and the Lm/Bmc ratio, recalculated with a correction factor of 0.7, averages 3.8. The two specimens analysed here have a Lm/Bmc ratio of 2.6. This is in the lower range of the ratio of the examples found in the literature and best comparable with the specimens figured in Nestor (1982, pl. 17, fig. 3). *L. erratica* differs from *Linochitina klonkensis* Paris and Laufeld, 1981 by its more elongated ovoid chamber and less conspicuous flexure.

Occurrences: Eisenack (1931) found *L. erratica* in the 'Graptolithengestein', with *Pristiograptus colonus* Barrande, *P. bohemicus* Barrande, *P. beckii*

Barrande and *Retiolites* sp., in the Baltic area. In the Algerian Sahara, Jardine and Yapaudjian (1968) reported it from the uppermost part of the Medarba Formation and in the Oued Tifist Formation, Lower Ludlow to Prídolí/Lochkovian. Nestor (1982) reported it in the *Conochitina lagena* chitinozoan Biozone, which correlates broadly with the *C. ellesae* graptolite Biozone, latest Sheinwoodian, Wenlock. In the Las Arroyacas Formation of Northern Spain, Schweineberg (1987) recorded *L. erratica* in three successive separated ranges in the Ludlow and Prídolí. We found *Linochitina erratica* in only one sample in the Ronquières Formation, in the Plan Incliné section, Gorstian, Ludlow. It was erroneously mentioned to occur in the middle and upper part of the Ronquières Formation in Herbosch et al. (1991a,b).

Subfamily Pterochitininae Paris, 1981
Genus ***Cingulochitina*** Paris, 1981

Cingulochitina convexa (Laufeld, 1974)

Plate III, 5, 6.

Synonymy:

1974 – *Linochitina convexa* sp. nov. – Laufeld, p. 97–98, pl. 58, figs. A–F.
1981 – *Linochitina convexa* – Verniers, pl. 2, fig. 27.
1982 – *Cingulochitina convexa* – Verniers, p. 22, pl. 6, figs. 126, 127A,B.
1991 – *Cingulochitina convexa* – Herbosch, et al., p. 312, fig. 35.

Material: 1693 specimens; Ronquières Formation, Mont Godart section, samples MG 0.40, MG 18.60, MG 40.10, MG 64.70, MG 113.30, MG 131.30, MG 149.80 and MG 166.30; Ronquières Formation, Plan Incliné section, samples PI 15.00, PI 41.00, PI 61.50, PI 113.00, PI 126.00, PI 129.50, PI 148.60, PI 163.00, PI 169.30 and PI 197.40.
Dimensions: see Table 5.
Description and remarks: A *Cingulochitina* species with a clear separation between a subcylindrical neck and an elongated ovoid chamber, with a cingulum situated aborally of the maximal width. The flexure is distinct, but the shoulders are broadly rounded or absent. The bottom is convex and without a clear aboral margin; in most specimens there is no marked change in the curvature at or near the cingulum. The neck sometimes widens towards the oral opening. A reduced mucron is present. *C. convexa* differs from *C. gorstyensis* by its elongated ovoid chamber, its greater total length and its less apparent, or even absent, aboral margin. The histogram for the total length shows a clear peak around 95 μm for *C. convexa* and a broader peak for *C. gorstyensis* with a maximum around 78 μm. The histograms for the maximal and oral width of *C. convexa* and of *C. gorstyensis* are more comparable. The shift towards shorter dimensions is clearer when comparing the Lm–Bm plots of both species. The species differs from *C.* sp. aff. *convexa* in Paris (1981) by its rounded aboral margin, more convex base and less prominent mucron.
Occurrences: Verniers (1982) found *C. convexa* frequently dominating samples from in formation MB9 of the Mehaigne area. It is one of the characteristic species of his Zone E, attributed to the lower to middle Ludlow. In Gotland, *C. convexa* ranges from unit c of the Hemse Beds and the northwestern part of the Hemse marl through to

Table 5
Dimensions of *Cingulochitina convexa*

	n	Minimal	Maximal	Range	Average	Std.
Lm	498	67	194	127	101	12.3
Bm	522	38	94	56	65	6.2
Bo	329	26	67	41	41	5.3
Bmc	522	27	66	39	46	4.3
Boc	329	18	47	29	29	3.7
Bmc/Lm	494	0.27	0.93	0.66	0.45	0.06
Lm/Bmc	494	1.08	3.71	2.64	2.24	0.28

the Eke Beds, with a peak in abundance in the Eke Beds (Laufeld, 1974). This range can be correlated with the upper part of the *M. nilssoni* to *S. leintwardinensis* graptolite zones, Gorstian to middle Ludfordian (Laufeld and Jeppson, 1976). Dating of the peaks in abundance of *C. convexa* in the Ronquières outcrops and Gotland is not accurate enough to conclude whether they are simultaneous or diachronous. In Ludlow, Shropshire, UK, *Cingulochitina convexa* is restricted to the Middle Elton Formation, Gorstian (Sutherland, 1994). *C. convexa* is present in very low numbers in the Mehaiguène Formation, Algerian Sahara, at the base of the Prídolí (Boumendjel, 1987). We found *C. convexa* throughout the Ronquières Formation in the Ronquières area. It has a high peak in abundance in both the Ronquières sections in the samples MG 131.30, MG 149.80 and MG 166.30 of the Mont Godart section and the sample PI 15.00 of the Plan Incliné section, as also is indicated in Herbosch et al. (1991a,b).

Cingulochitina gorstyensis Sutherland, 1994

Plate II, 2, Plate III, 9, 10.

Synonymy:

1960 – *Desmochitina cingulata var. serrata* nov. var. – Taugourdeau and de Jekhowsky, 1960, p. 1226, pl. 6, figs. 76–79, 81.
1991 – *Cingulochitina serrata* – Herbosch et al., p. 312, fig. 35.
1994 – *Cingulochitina gorstyensis* sp. nov. – Sutherland, 1994 p. 39–40, pl. 4, figs. 13–15; pl. 5, figs. 1–7

Material: 713 specimens; Ronquières Formation, Mont Godart section, samples MG 0.40, MG 18.60, MG 40.10, MG 113.30, MG 131.30, MG 149.80 and MG 166.30; Ronquières Formation, Plan Incliné section, samples PI 15.00, PI 41.00, PI 61.50, PI 126.00, PI 148.60, PI 153.80, PI 163.00, PI 169.30 and PI 197.40.
Dimensions: see Table 6.
Remarks: The silhouette of *Cingulochitina gorstyensis* is a combination of a short conical to cylindrical neck with a discoid chamber. The shoulders are less developed than those of *C. convexa*. The basal margin is sharp and a short cingulum, if not broken off, is located at or near it. The bottom is convex. In only a few cases was the specimen orientated in a manner that the short basal process could be seen. The oral opening is straight and widens. The oralwards migration of the maximal width, caused by flattening, occurs also in the Brabant Massif. It was first noticed by Boumendjel (1987) for another species, *Cingulochitina serrata*, with a similar form. *C. gorstyensis* is shorter than *C. convexa* and its maximal width occurs just above the basal margin, which is moreover better developed. The histograms for the maximal and oral width show the same peak as for *C. convexa*, but the peak of the total length is displaced towards the smaller dimensions; from 95 μm for *C. convexa* to 78 μm for *C. gorstyensis*.
Occurrences: *Cingulochitina gorstyensis* occurs from the Middle Elton Formation to the Lower Bringewood Formation; it can dominate up to 80% of the assemblage. Both units are Gorstian in age. In the Ronquières Formation it occurs from the Steenkerque until the top of the Ronquières formations (upper Sheinwoodian to Gorstian, Wenlock to Ludlow). Herbosch et al. (1991a,b) mentioned specimens determined as *C. serrata*, which are considered herein as synony-

Table 6
Dimensions of *Cingulochitina gorstyensis*

	n	Minimal	Maximal	Range	Average	Std.
LM	203	62	124	62	85	10.5
Bm	206	40	89	49	66	5.7
Bo	142	29	79	50	41	5.7
Bmc	206	28	62	34	46	3.9
Boc	142	20	55	35	29	4
Bmc/Lm	202	0.32	0.7	0.38	0.55	0.06
Bmc/Boc	202	1.43	3.15	1.73	1.84	0.23

mous to *C. gorstyensis* all over the Ronquières Formation.

Cingulochitina cf. ***wronai*** Paris and Kriz, 1984

Synonymy:

?1974 – *Linochitina erratica* – Laufeld, p. 99–100, pl. 59, figs. A,B.
1991 – ?*Cingulochitina* sp. – Herbosch et al., p. 312, fig. 35.

Material: one specimen; Ronquières Formation, Mont Godart section, sample MG 131.30.
Dimensions: Lm: 140 μm, Bm: 64 μm, Bo: 36 μm.
Description and remarks: *Cingulochitina* cf. *wronai* has a clear cylindro–ovoid silhouette with a sharp basal margin. This basal margin is ornamented with a clear cingulum. The bottom is flat with a distinct mucron. The silhouette of the specimen from Ronquières is very similar to that of *Linochitina erratica* of pl. 59, figs A and B in Laufeld (1974) but is about 30% longer. Schweineberg (1987) places these *L. erratica* in synonymy with *Cingulochitina* aff. *wronai* Paris and Kriz, 1984 on the basis of their short cingulum and more stocky silhouette than typical *C. wronai*. The cingulum of our specimen is longer than 1 μm, its basal margin is sharp and the bottom flat; this is not the case for *C. wronai* Paris and Kriz, 1984. Schweineberg (1987) points to the vague difference between *Linochitina erratica* sensu Laufeld (1974) and *C. wronai*. We agree to attribute the latter to the genus *Cingulochitina* because of the presence of a clear cingulum. *Cingulochitina* cf. *wronai* differs from *Cingulochitina* sp. A in Paris (1981) by its elongated, distinct cylindro–ovoid silhouette, its greater dimensions and its more aborally situated maximal width.

Occurrences: *Cingulochitina* cf. *wronai* is found in the Ronquières Formation, at the sample MG 131.30 of the Mont Godart section (Gorstian, lower Ludlow), as also is indicated in Herbosch et al. (1991a,b).

Cingulochitina sp. A in Paris, 1981

Synonymy:

1981 – *Cingulochitina* sp. A. – Paris, p. 174–175, text fig. 78, pl. 19, fig. 18; pl. 20, fig. 18; pl. 21, figs. 9, 21; pl. 29. fig. 4.
1991 – *Cingulochitina* sp. A – Herbosch et al., p. 312, fig. 35.

Material: 50 specimens; Ronquières Formation, Mont Godart section, samples MG 131.30, MG 149.80 and MG 166.30; Ronquières Formation, Plan Incliné section, samples PI 15.00, PI 41.00 and PI 169.30.
Dimensions: see Table 7.
Remarks: *Cingulochitina* sp. A is characterised by its elongated silhouette, with a conical neck and slightly convex to straight flanks. The flexure is not very pronounced. The slightly ovoid form of the chamber is the result of flattening. Well preserved specimens have a collarette. The short cingulum is situated at the sharp basal margin. The bottom is flat to slightly convex. A small mucron can be observed. Although the specimens from the Brabant Massif fit the description of Paris (1981, p. 174) their dimensions differ. The average total length of *C.* sp. A from the Contenças and Ponte do Mata sections of the Buçaco Synclinal, Portugal (Paris, 1981) are 122 μm while the Brabant Massif specimens have an average total length of 100 μm. The difference for the average maximal width is less pronounced, 66

Table 7
Dimensions of *Cingulochitina* sp. A in Paris, 1981

	n	Minimal	Maximal	Range	Average	Std.
Lm	31	84	118	43	101	7.1
Bm	30	51	76	25	62	5.8
Bo	25	22	47	25	37	4.8
Bmc	30	36	53	18	44	4.1
Boc	25	15	33	18	26	3.4
Bmc/Lm	30	0.35	0.56	0.21	0.44	0.05

μm for the Portuguese specimens and 62 μm for the Brabant Massif specimens.
Occurrences: *Cingulochitina* sp. A is found in the basal part of the Sazes Formation, Buçaco Synclinal, Portugal, in the zones 21 and 20, Ludlow, of Paris (1981). In the Brabant Massif, *C.* sp. A is found in Ronquières, Mont Godart section, above the bentonite levels and in three samples of the Plan Incliné section (PI 15.00, PI 41.00 and PI 169.30), as also indicated in Herbosch et al. (1991a,b); it occurs in very low numbers (less than 2%).

Cingulochitina sp. B
Plate III, 7.

Material: One incomplete specimen; Ronquières Formation, Plan Incliné section, sample PI 148.60.
Dimensions: Lm: 154 μm, Bm: 113 μm, Lm/Bmc: 1.94.
Description and remarks: The specimen is unfortunately incomplete, but it has a characteristic form and differs from all other *Cingulochitina* species. It has a large ovoid chamber and a partially conserved cylindrical neck, separated from each other by a clear flexure. The bottom is convex and no mucron is observed. The vesicle wall is coarsely ornamented. A clear cingulum, more than 5 μm wide, is situated at about 1/5, and the maximal width is at 2/5, of the chamber length from the bottom. *Cingulochitina* sp. B differs from *Cingulochitina convexa* by its larger dimensions, its coarsely ornamented vesicle wall and its wider cingulum (5 μm).
Occurrences: The only specimen of *Cingulochitina* sp. B was recorded from the Ronquières Formation, in sample PI 148.60 from the Plan Incliné section; Gorstian, lower Ludlow.

Order Prosomatifera Eisenack, 1972
Family Conochitinidae Eisenack, 1931 restrict. Paris, 1981
Subfamily Belonechitininae Paris, 1981
Genus ***Belonechitina*** Jansonius, 1964

Belonechitina* cf. *granosa (Laufeld, 1974) comb. nov.

Synonymy:

1991 – *Conochitina* cf. *granosa* – Herbosch et al., p. 312, fig. 35.

Material: One specimen; Ronquières Formation, Mont Godart section, sample MG 95.00.
Dimensions: Lm: 235 μm, Bm: 136 μm, Bo: 71 μm.
Description: This species has a cylindrical neck and a broadly rounded ovoid chamber. The basal margin is rounded. The vesicle wall is medium thick and covered with short spines, interconnected at their base by an irregular network of ridges. The ornamentation is less dense at the base. A flexure is present but not very distinct and the shoulders are broadly rounded. The maximal width is near the basal margin. An imprint of a prosome is visible in the neck.
Remarks: The shape of the vesicle and the ornamentation points to affinities with *Conochitina granosa* (Laufeld, 1974). However, we decided to classify it as *B.* cf. *granosa* for three reasons. The dimensions are more than twice those of the holotype and fall outside the size range given by

Table 8
Dimensions of *Belonechitina intermedia*

	n	Minimal	Maximal	Range	Average	Std.
Lm	18	81	150	69	119	20.2
Bm	18	51	105	54	77	14.5
Bo	18	30	79	49	51	13.1
Bmc	18	36	74	38	54	10
Boc	18	21	55	34	36	9.2
Bmc/Lm	18	0.34	0.64	0.3	0.46	0.09

Laufeld (1974). The typical oral widening of the species is not present in the Ronquières specimen, which has, furthermore, a more distinct flexure. The presence of ornamentation of spines justifies the transfer of the species into the genus *Belonechitina*.

Occurrences: In Gotland, *B. granosa* ranges from the lower part of the Eke Beds to unit a of the Hamra Beds, Ludfordian Stage, Ludlow (Laufeld, 1974). Our only specimen of *B.* cf. *granosa* was found low in the Ronquières Formation (Gorstian, Ludlow), in the Mont Godart section, Ronquières. It erroneously was indicated to occur in the middle and upper part of the Ronquières Formation by Herbosch et al. (1991a,b).

Belonechitina intermedia (Eisenack, 1955)

Synonymy:

1955 – *Conochitina intermedia* sp. nov. – Eisenack, p. 161–162; pl. 3, fig. 8.
1964 – *Conochitina intermedia* – Eisenack, p. 317–318, pl. 26, figs. 14 and 15.
non 1967 – *Conochitina intermedia* – Cramer, 1967, pl. II, figs. 41, 46; pl. III, fig. 62.
1968 – *Conochitina intermedia* – Eisenack, p. 161, pl. 25, figs. 26 and 27.
1972 – *Conochitina intermedia* – Eisenack, 1972, p. 123, pl. 34, figs. 10–15.
1974 – *Conochitina intermedia* – Laufeld, p. 63–65, pl. 26, figs. A–D.
1982 – *Conochitina intermedia* – De Bock, p. 852, pl. 1, figs. 9–11.
1991 – *Conochitina intermedia* – Herbosch et al., p. 312, fig. 35.
1994 – *Eisenackitina intermedia* comb. nov. – Sutherland, 1994 p. 30–31, pl. 1, figs. 16–18; pl. 2, figs. 1–7.

Material: 18 specimens; Ronquières Formation, Mont Godart section, samples MG 18.60, MG 40.20, MG 131.30, MG 149.80 and MG 166.30; Ronquières Formation, Plan Incliné section, samples PI 31.40, PI 61.50, PI 153.80, PI 163.00 and PI 197.40.

Dimensions: see Table 8.

Remarks: The silhouette of this species is in general conical, in most cases with a short cylindrical or widening oral tube that forms an often distinct collarette. The basal edge is rounded and the bottom flattened or slightly invaginated. An impression of a prosome is visible on almost every specimen. Some of the specimens are ornamented with small conical spines or granules on the lower two thirds of the vesicle. The bases of the spines are sometimes interconnected. *Belonechitina intermedia* can be distinguished from *Belonechitina latifrons* by its smaller proportions and from *B. lauensis* by its less dense ornamentation.

Occurrences: *B. intermedia* was first described from the Beyrichia Limestone of the Baltic Silurian (Eisenack, 1955). According to Eisenack (1964, 1968) the species ranges from the Hemse Beds to the Hamra Beds in Gotland, but it was restricted to the Burgsvik and Hamra Beds by Laufeld (1974). Nestor (1990) reported it from the Ludfordian and Prídolí of Estonia. Beju and Danet (1962) report it from the Silurian of the Moldova Platform, Romania. In the Silurian of the Montagne Noire, France, *B. intermedia* is present in association with *Eisenackitina philipi, E. lagenomorpha* and *Cingulochitina convexa,* an assemblage of late Ludlow age (De Bock, 1982). In Ludlow, Shropshire, *Belonechitina* cf. *intermedia* ranges throughout the Gorstian and Ludfordian. It is present from the Middle Elton Formation (lower Gorstian) and, more importantly, in the upper Gorstian and until the Upper Whitcliffe Formation, Ludfordian (Sutherland, 1994). In

Table 9
Dimensions of *Belonechitina latifrons*

	n	Minimal	Maximal	Range	Average	Std.
Lm	14	140	275	135	205	35.5
Bm	13	65	136	71	91	18.6
Bo	6	56	74	18	64	5.9
Bmc	13	46	95	50	64	13
Boc	6	39	52	13	45	4.1
Bmc/Lm	13	0.24	0.41	0.18	0.32	0.05

Ronquières, *B. intermedia* ranges through the Ronquières Formation in both studied sections, as indicated in Herbosch et al. (1991a,b).

Belonechitina latifrons (Eisenack, 1964) Sutherland, 1994
Plate III, 1, 2.

Synonymy:

1964 – *Conochitina latifrons* sp. nov. – Eisenack, p. 316, pl. 26, figs. 11 and 12.
1968 – *Conochitina latifrons* – Eisenack, p. 161, pl. 25, figs. 21–25.
1970 – *Conochitina latifrons* – Eisenack, p. 305, fig. 10.
1974 – *Conochitina latifrons* – Laufeld, p. 65–67, fig. 27, A–E.
1991 – *Conochitina latifrons* – Herbosch et al., p. 312, fig. 35.
1994 – *Belonechitina latifrons* – comb. nov. Sutherland, 1994, p. 42, pl. 6, figs. 8–13.

Material: 20 specimens; Ronquières Formation, Mont Godart section, samples MG 0.40, MG 64.70, MG 95.90 and MG 166.30; Ronquières Formation, Plan Incliné section, samples PI 31.40, PI 70.50, PI 126.00, PI 148.60, PI 163.00 and PI 197.40.
Dimensions: see Table 9.
Remarks: The overall shape of the vesicle is cylindro–conical; the shoulders and flexure are weakly developed. The neck is less than one third of the total length; specimens with a very short neck are not uncommon. The maximal width is situated above a distinct aboral margin. The characteristic constriction above the basal margin (Laufeld, 1974) is masked due to the flattening of the specimens. The wall is smooth, except at the basal part where, in most cases, the aboral margin is covered with an ornamentation of coarse granulae to small coni. *Belonechitina latifrons* differs from *Belonechitina intermedia* in Sutherland (1994) because the latter is smaller and has a more pronounced conical silhouette and the ornamentation covers more than the aboral margin. *Belonechitina lauensis* is smaller (115–145 μm in the type material of Gotland) and the vesicle wall is thinner than in *B. latifrons*.
Occurrences: Eisenack (1964) found *B. latifrons* in the lower part of the Hemse Beds (Gotland). According to Laufeld (1974), the range of *B. latifrons* is restricted to the uppermost part of the Klinteberg Beds and the lower part of the Hemse Beds in Gotland. Eisenack (1968) reported *B. latifrons* in the 'Graptolithengestein' in northern Germany. In Estonia it was reported in a sample of Paadla age, Ludlow (Eisenack, 1970) and in the middle of the Ludlow by Nestor (1990). In Ludlow, Shropshire, *B. latifrons* is limited to the upper Gorstian. It is present from the top of the Upper Elton Formation to the top of the Upper Bringewood Formation (Sutherland, 1994). We found *B. latifrons* in small numbers throughout the Ronquières Formation, from the base of the Mont Godart section to the top of the Plan Incliné section, as was indicated in Herbosch et al. (1991a,b).

Belonechitina lauensis (Laufeld, 1974) Sutherland, 1994

Synonymy:

1964 – *Conochitina cf. intermedia* – Eisenack, pl. 26, fig. 15.
1974 – *Conochitina lauensis* sp. nov. – Laufeld, p. 66, fig. 26.
1991 – *Conochitina lauensis* – Herbosch et al., p. 312, fig. 35.
1994 – *Belonechitina latifrons* – comb. nov. Sutherland, p. 43, pl. 6, figs. 1–7.

Table 10
Dimensions of *Belonechitina lauensis*

	n	Minimal	Maximal	Range	Average	Std.
Lm	3	125	135	10	131	4.2
Bm	3	78	81	3	79	1.4
Bo	1	56	56	0	56	0
Bmc	3	55	57	2	55	1
Boc	1	39	39	0	39	0
Bmc/Lm	3	0.4	0.45	0.05	0.42	0.02

Material: Five specimens; Ronquières Formation, Plan Incliné section, samples PI 113.00, PI 126.00 and PI 197.40.
Dimensions: see Table 10.
Remarks: The silhouette of this species is conical with a short neck; there is no flexure, but shoulders may be very weakly developed. The basal angle is broad and the bottom invaginated. The vesicle wall is covered with small granules which become denser towards the basal margin. An outward impression of a prosome is visible.
Occurrences: In Gotland, *B. lauensis* ranges from unit c of the Hemse Beds to the lower middle part of the Eke Beds (Laufeld, 1974). In Estonia it is found in the middle of the Ludlow (Nestor, 1990). In Shropshire *Belonechitina lauensis* ranges from the Middle Elton Formation to the Lower Leintwardine Formation, and occurs rarely to the top of the Upper Leintwardine Formation (Sutherland, 1994). In Ronquières, *B. lauensis* is present in the upper part of the Plan Incliné section only, upper part of the Ronquières Formation, as is indicated in Herbosch et al. (1991a,b).

Subfamily Conochitininae Paris, 1981
Genus ***Conochitina*** Eisenack, 1931, restrict. Paris, 1981, emend. Paris et al., 1999.

Conochitina pumilio sp. nov.
Plate III, 11.

Synonymy:

1991 – *Conochitina pumilio* – Herbosch et al., p. 312, fig. 35. nomen nudum
1994 – *Bursachitina* sp. A – Sutherland, 1994, p. 26, pl. 1, figs. 1–4

Derivatio nominis: Latin *pumilio*, dwarf or midget: referring to the small size.
Holotype: Ronquières Formation, Mont Godart section, sample MG 166.30, lower Ludlow.
Material: 137 specimens; Ronquières Formation, Mont Godart section, samples MG 0.40, MG 18.60, MG 40.10, MG 64.70, MG 95.70, MG 131.30, MG 149.80 and MG 166.30; Ronquières Formation, Plan Incliné section, samples PI 15.00, PI 61.50, PI 70.50, PI 126.00, PI 148.60 and PI 197.40.
Dimensions: see Table 11.
Description: Small cylindro–conical body with weakly developed shoulders and flexure. The basal margin is rounded and the base is slightly convex or invaginated. The vesicle wall is thin and sometimes the remnants of a collarette, which tends to be translucent, is visible. An impression of a prosome is visible on most specimens. The maximal diameter is found at, or near, the base. The neck is generally subcylindrical to conical; its length varies between 20 and 45% of the total length. The most prominent features of this species are the broadly rounded form and the small body size.
Remarks: The population of *C. pumilio* sp. nov. in Ronquières is rather variable, with an elongated scatter of points on a Lm–Bm diagram. The frequency histograms for the maximal width and the total length show both a unimodal normal distribution, indicating the presence of only one population. *C. pumilio* sp. nov. differs from *Conochitina fortis* (which was earlier determined as *Conochitina* sp. D in Verniers, 1982; see Verniers, 1999), by the clearer differentiation between neck and chamber and the rounder basal margin. *C. pumilio* sp. nov. is also slightly smaller than *C.*

Table 11
Dimensions of *Conochitina pumilio* sp. nov.

	n	Minimal	Maximal	Range	Average	Std.
Lm	105	77	154	77	113	16.4
Bm	107	38	98	60	72	11.6
Bo	88	28	76	48	46	7.1
Bmc	107	27	69	42	46	8
Boc	88	20	53	34	32	5
Bmc/Lm	104	0.29	0.64	0.35	0.45	0.06

Table 12
Dimensions of *Conochitina rudda*

	n	Minimal	Maximal	Average
Lm	13	150	260	203
Bm	16	50	109	78
Bo	5	58	73	64
Bmc	16	41	76	55
Boc	5	41	51	45
Bmc/Lm	13	0.21	0.34	0.28
Lm/Bmc	13	4.76	2.94	3.57

fortis (*C.* sp. D in Verniers, 1982). Although *C.* sp. D in Verniers (1982) is not present in the three samples of the Ronquières Formation (previously formation MB9), and in assemblage Zone E in the Mehaigne area, it is possible that it forms part of an evolutionary lineage, from long forms of *C. fortis* (*C.* sp. D in Verniers, 1982) with a less individualised neck in the Wenlock to slightly shorter *C. pumilio* sp. nov. with a clearer neck in the Ludlow. A thorough study of both species in a suitable section is necessary to establish the stratigraphical position of this possible transition.

Occurrences: *Bursachitina* sp. A in Sutherland (1994) is present in the top of the Much Wenlock Limestone Formation, in the Lower, Middle and Upper Elton Formations, the Lower and Upper Bringewood Formations and the upper part of the Lower Leintwardine Formation in Ludlow, Shropshire (Sutherland, 1994). We found *Conochitina pumilio* ranging through the Ronquières Formation Mont Godart and Plan Incliné sections, as is indicated in Herbosch et al. (1991a,b).

Conochitina rudda Sutherland, 1994

Synonymy:

1991 – *Conochitina edjelensis elongata* – Herbosch et al., p. 312, fig. 35.
1991 – *Conochitina tuba* – Herbosch et al., p. 312, fig. 35.
1994 – *Conochitina rudda* – Sutherland, 1994, p. 48–49, pl. 7, figs. 9–14; pl. 8, figs. 1 and 2.

Material: Nineteen specimens; Ronquières Formation, Mont Godart section, samples MG 95.90 and MG 149.80; Ronquières Formation, Plan Incliné section, samples PI 61.50, PI 70.50, PI 113.00, PI 126.00, PI 148.60, PI 153.80 and PI 197.40.

Dimensions: see Table 12.

Remarks: *Conochitina rudda* in our material is long, subcylindrical to club-shaped, thin-walled and with a slightly ovoid chamber. Shoulders and flexure are only faintly present. They have gently convex chamber and a clear but bluntly rounded basal margin. A protruding mucron is clearly visible on several specimens. The wall is smooth. Some specimens with a length of 285 or 322 μm, from the top of the Ronquières Formation, are longer than the type material and are questionably put into the species.

Occurrences: *Conochitina rudda* is found in the Lower, Middle and Upper Elton formations (lower Gorstian) in Ludlow, Shropshire, UK (Sutherland, 1994). We found *C. rudda* in the Mont Godart and in the Plan Incliné sections of Ronquières Formation, lower Ludlow (Gorstian), as indicated in Herbosch et al. (1991a,b), but erroneously determined there as *C. tuba*.

Conochitina sp. A in Sutherland, 1994.
Plate III, 4.

Table 13
Dimensions of *Conochitina* sp. A in Sutherland, 1994

	n	Minimal	Maximal	Range	Average
Lm	10	177	256	79	177
Bm	10	65	118	53	93
Bo	8	46	82	36	67
Bmc	10	46	83	37	65
Boc	9	32	57	25	47
Bmc/Lm	10	0.29	0.64	0.35	0.39
Lm/Bmc	10	1.57	3.45	1.88	2.56

Synonymy:

1991 – *Conochitina* sp. A – Herbosch et al., p. 312, fig. 35.
1991 – *Conochitina armillata* – Herbosch et al., p. 312, fig. 35.
1994 – *Conochitina* sp. A in Sutherland, 1994, p. 49–50, pl. 9, figs. 10–13.

Material: Eighteen specimens; Ronquières Formation, Mont Godart section, samples MG 0.40, MG 18.60, MG 40.10, MG 131.30, MG 149.80 and MG 166.30; Ronquières Formation, Plan Incliné section, sample PI 148.60.
Dimensions: see Table 13.
Description: Typical for this species is the clearly cono–ovoid outline with a cylindrical neck, a distinct flexure and a conical chamber without shoulders. The wall is medium thick and smooth. No collarette was observed. The basal margin is rounded to sharp. The convexity of the bottom is possibly caused by the flattening of the specimens.
Occurrences: Conochitina sp. A in Sutherland (1994) occurs in Ludlow, Shropshire, UK in the topmost Much Wenlock Limestone Formation and lowermost Lower Elton Formation. We found *Conochitina* sp. A in lower and middle part of the Ronquières Formation, in the Mont Godart and Plan Incliné sections. In Herbosch et al. (1991a,b) it was indicated erroneously to occur in the lower part of the Ronquières Formation (Mont Godart section only).

Conochitina **sp. B**

Synonymy:

?1982 –*Conochitina* sp. E. – Verniers, p. 41, pl. 3, fig. 65.
1991 – *Conochitina* sp. B – Herbosch et al., p. 312, fig. 35.

Material: one specimen; Ronquières Formation, Plan Incliné section, sample PI 163.00.
Dimensions: Lm: 275 µm, Bm: 92 µm, Bo: 52 µm.
Description and remarks: The single specimen found has a characteristic cylindro–ovoid silhouette. The neck comprises about 25% of the total length. The flexure is very broad, passing into convex flanks without distinct shoulders. The maximal width is situated halfway along the chamber. The basal margin is sharp and the bottom is slightly convex. There is no ornamentation and the wall is medium thick. An impression of a prosome is visible in the neck. The specimen found has a silhouette which is similar to that one seen in *C. proboscifera* illustrated in Eisenack (1964, pl. 26, figs. 1 and 2), but *C. proboscifera* is 2.7 times longer and has a distinct mucron. *C.* sp. B differs from *C.* sp. A in Sutherland (1994) by its longer chamber in relation to the total length, and by its more convex flanks. The position of the maximal width of *C.* sp. B. is more aboral than in *C.* sp. A in Sutherland (1994). The specimen *Conochitina* sp. E. in Verniers (1982, pl. 3, fig. 65) shows similarities with *Conochitina* sp. B. Important differences with respect to *C.* sp. E in Verniers are the greater dimensions of *C.* sp. B, the shorter neck relative to the chamber and the more convex flanks. We place the specimen of *C.* sp. E in Verniers (1982, pl. 3, fig. 65) questionably in synonymy with our *C.* sp. B for the reasons mentioned above.
Occurrences: *C.* sp. E in Verniers (1982, pl. 3, fig. 65) is rare in the upper part of Fumal Formation (former formation MB7) and in the Vichenet and Ronquières Formations (former formations MB8 and MB9) from the Mehaigne area (Verniers, 1982). We found *C.* sp. B. in the Ronquières For-

Table 14
Dimensions of *Conochitina* sp. C

	n	Minimal	Maximal	Range	Average	Std.
Lm	11	134	235	101	172	26.8
Bm	11	60	136	76	90	18.7
Bo	10	40	87	47	61	13.1
Bmc	11	42	95	53	63	1.3
Boc	10	28	61	33	43	9.2
Bmc/Lm	11	0.28	0.43	0.15	0.37	0.05

mation of the Plan Incliné section. It was mentioned to occur in the Plan Incliné and erroneously in Mont Godart section as well by Herbosch et al. (1991a,b).

Conochitina **sp. C**

Material: Seventeen specimens; Ronquières Formation, Mont Godart section, samples MG 0.40, MG 149.80 and MG 166.30; Ronquières Formation, Plan Incliné section, sample PI 153.80.
Dimensions: see Table 14.
Description: Included in this species is a group of *Conochitina* with a cylindro–conical silhouette. The basal margin is rounded to sharp and the bottom convex. Flexure and shoulders are present, but are not pronounced. The wall is smooth. The maximum diameter is situated at about one third along the total length of the vesicle above the base. The neck is medium long to short, maximally one quarter of the total length; no collarette has been observed. *Conochitina* sp. C is longer than *C. pumilio* sp. nov. and shows a less distinct transition between neck and chamber. It differs from *Belonechitina intermedia* by its more ovoid chamber and its smooth surface.
Occurrences: *Conochitina* sp. C is found in the Ronquières Formation, Mont Godart and Plan Incliné sections.

Family Lagenochitinidae Eisenack, 1931
Subfamily Angochitininae Paris, 1981
Genus ***Angochitina*** Eisenack, 1931

Angochitina sp. aff. ***echinata*** in Sutherland, 1994.
Plate III, 12, 13.

Synonymy:

1981 – *Angochitina* cf. *echinata* – Paris, p. 256, pl. 20, figs. 12 and 17; pl. 21, figs. 1–4, 6, 7 and 15; pl. 37, figs. 10 and 15.
1991 – *Angochitina* cf. *echinata* – Herbosch et al., p. 312, fig. 35.
1994 – *Angochitina sp.* aff. *echinata* Eisenack, 1931 in Sutherland, 1994, pl. 14, figs. 8–12.

Material: Five specimens; Ronquières Formation, Plan Incliné section, 41.00 and 148.60.
Dimensions: see Table 15.
Remarks: *Angochitina* sp. aff. *echinata* has a sphaero–ovoid chamber and a cylindrical neck, which is unfortunately not complete in our specimens. The flexure is broadly rounded, and shoulders and a basal margin are lacking. The maximal width is halfway along the chamber. The wall is covered with short, globule-like spines. The density of the ornamentation becomes less towards the oral part of the chamber (above the maximal width) and on the neck. Paris (1981) also noticed a change in the density of the ornamentation in his *A.* cf. *echinata*, but in the opposite way, increasing towards the neck. *Angochitina* sp. aff. *echinata* from Ronquières shows more resemblance with the specimens figured by Paris (1981) than with those figured by Laufeld (1974); the spines on our specimens are shorter, more granulae than spines, and have varying density.
Occurrences: In Gotland, *A. echinata* ranges from unit a of the Hamra Beds to the lower part of the Sundre Beds, late Ludfordian, Ludlow (Laufeld, 1974). Paris (1981) used the range of *A.* cf. *echinata* to delimit his zone 22 in the lower part of the Sazes Formation, Buçaco, Portugal, of early Ludlow age. We encountered *A.* sp. aff. *echinata* in

Table 15
Dimensions of *Angochitina* sp. aff. *echinata* in Sutherland, 1994

	n	Minimal	Maximal	Range	Average	Std.
Lm*	5	114	149	35	131	11.7
Bm	4	49	81	22	68	8
Bo	1	31	31	0	31	0

Lm* = total length of the incomplete specimens.

Table 16
Dimensions of *Sphaerochitina impia*?

	n	Minimal	Maximal	Range	Average	Std.
Lm	8	87	108	21	99	7.8
Bm	8	60	93	33	75	9.5
Bo	7	26	44	18	34	5.8
Bmc	8	42	65	23	52	6.7
Boc	7	18	31	13	24	4
Bmc/Lm	8	0.48	0.61	0.13	0.53	0.04
Lm/Bmc	8	1.63	2.07	0.44	1.91	0.14

the upper part of the Ronquières Formation, Gorstian, Ludlow, as is indicated in Herbosch et al. (1991a,b).

Subfamily Lagenochitininae Paris, 1981
Genus ***Sphaerochitina*** Eisenack, 1955

Sphaerochitina impia? Laufeld 1974
Plate III, 3.

Synonymy:

1974 – *Sphaerochitina impia* – Laufeld, p. 109–111, pl. 67, figs. A–D.
1991 – *Sphaerochitina impia*? – Herbosch et al., p. 312, fig. 35.

Material: Twenty-five specimens; Ronquières Formation, Mont Godart section, samples MG 0.40, MG 40.10, MG 64.70, MG 131.30, MG 149.80 and MG 166.30. Ronquières Formation, Plan Incliné section, sample PI 70.50.
Dimensions: see Table 16.
Description and remarks: The small numbers of *Sphaerochitina impia*? found in the Ronquières outcrops consist mostly of incomplete specimens. The chamber is subconical with more or less convex flanks. The reversed conical neck, partially broken in most cases, is separated from the chamber by a distinct flexure. A basal margin is present, but it is masked by the flattening. The bottom is slightly convex. The vesicle wall is covered with fine granules. A subconical body is typical for *S. impia* (Laufeld, 1974, p. 109), but since we found only a small population of poorly preserved specimens we prefer to label then with a question mark.
Occurrences: *Sphaerochitina impia* is present in the lower and middle part of the Hemse Beds and in units b and c of the Klinteberg Beds in Gotland (Laufeld, 1974). We found *S. impia*? in low numbers, in the Mont Godart and the Plan Incliné sections of the Ronquières Formation, as is indicated in Herbosch et al. (1991).

Sphaerochitina cf. ***lycoperdoides*** Laufeld, 1974

Synonymy:

1991 – *Sphaerochitina lycoperdoides* – Herbosch et al., p. 312, fig. 35.

Material: Four specimens; Ronquières Formation, Mont Godart section, sample MG 149.80; Ronquières Formation, Plan Incliné section, sample PI 90.50.
Dimensions: Lm: 126–152 μm, Bm: 65–69 μm, Bo: 38–41 μm.
Description and remarks: The three specimens encountered in the Ronquières sections have a spherical chamber and a slightly reversed conical neck. The vesicle walls are covered with small granulae. The bottoms are convex and the flanks are rounded. The specific attribution of the specimens is doubtful. Although they match the description of *S. lycoperdoides* in Laufeld (1974), their dimensions are different. The smallest specimen in this study is larger than the largest specimen of *S. lycoperdoides* in Laufeld (1974).
Occurrences: In Gotland, *Sphaerochitina lycoperdoides* ranges from the upper part of the Mulde Beds to the upper part of the Klinteberg Beds, late Homerian, Wenlock, to early Gorstian, Ludlow. In the Brabant Massif *S. lycoperdoides* is

found in the two levels of the Fumal Formation (former formation MB7) and the Vichenet Formation (former MB8 formation) of the Mehaigne area (Verniers, 1982). Our specimens come from two levels in the Ronquières Formation, from the Mont Godart and the Plan Incliné sections, as is indicated in Herbosch et al. (1991a,b).

Appendix 2. Detailed location of samples

Ronquières area

All samples lay on the territory of Ronquières (Braine-le-Comte), except JV97004 laying in Bornival (Nivelles); location of samples on Fig. 1 (extract of map sheet 1/25 000: 39/5–6 Braine-le-Comte-Feluy). UTM co-ordinates are only given for localities with no distinct nearby topographical features.

JV97001: Sennette Valley, west of Ferme des Chèvres, outcrop in the talus 22 m east of the canal Brussels–Charleroi, below the road 'Avenue des Tilleuls', at km 38 020 of the canal, and 1 m above the base of the outcrop, Steenkerque Formation.

JV97002: Sennette Valley, west of Ferme des Chèvres, outcrop in the talus 22 m east of the canal Brussels–Charleroi, below the road 'Avenue des Tilleuls', at km 38 072 of the canal, and 1 m above the base of the outcrop, Steenkerque Formation.

JV97003: Sennette Valley, west of Ferme des Chèvres, outcrop in the talus 22 m east of the canal Brussels–Charleroi, below the road 'Avenue des Tilleuls', at km 38 113 of the canal, and 1 m above the base of the outcrop, Steenkerque Formation.

JV97004: Valley of the Ri Mathieu-Simon, outcrop in the river bottom, where the river cuts in the NW valley flank, 60 m NE of power line (UTM co-ordinates: 588 840 mE × 5606 540 mN); Ronquières, Vichenet and Froide Fontaine Formations.

JV97005: Sennette Valley, southernmost of three outcrops in a meadow near the bottom of the valley flank, 15 m east of the river and 390 m NNE of the 'Domaine de Combreuil'; sample taken in the stratigraphically uppermost 20 cm of the outcrop (UTM co-ordinates: 585 340 mE × 5605 820 mN); Ronquières Formation?

JV97006: Sennette Valley, 25 m long series of outcrops in the gully bottom, halfway up the eastern valley flank; 1120 m NNE of 'Domaine de Combreuil' and 1080 m SSW of the church of Ronquières; sample taken in the 5 cm below the large outcropping bedding plane (UTM co-ordinates: 585 800 mE × 5606 420 mN); Ronquières Formation?

JV97007: Sennette Valley, outcrop 1.5 m long and 2 m at the foot of the western valley flank below the Ferme de Landrifosse; at the northern end of the cut off meander; 730 m NNE of the 'Domaine de Combreuil'; sample taken in the southernmost (= stratigraphically uppermost) part of the outcrop (UTM co-ordinates: 585 430 mE × 5606 140 mN); Ronquières Formation?

JV97008: Sennette Valley, east of the widening of the canal Brussels–Charleroi at km 37.4; outcrop in meadow on the eastern valley flank, 28 m S of sheep shack and about 125 m S of house No. 77; sample taken at 20 cm above base of outcrop, 1 to 5 cm above a 15 cm thick obliquely bedded very fine sandstone (UTM co-ordinates: 587 120 mE × 5608 280 mN); 3.0 m below the top of the Corroy Formation.

JV97009 Sennette Valley, east of the widening of the canal Brussels–Charleroi at km 37.4; outcrop in southern end of small quarry at the foot of the eastern valley flank, 51 m south of sample JV97008 and 31 m north of a electricity pole (UTM co-ordinates: 587 120 mE × 5608 230 mN); lower part of the Petit Roeulx Formation.

JV97010: Sennette Valley, east of the widening of the canal Brussels–Charleroi at km 37.4; outcrop in small talus of private road behind (= east of) house No. 77, 'Avenue des Tilleuls', in the middle of the curve of the road to the east; sample taken at 7 m E of the garage of the house and 1 m above the lowest beds in the outcrop (UTM co-ordinates:

587 120 mE × 5608 430 mN); top Fallais Formation.

For the samples, marked with MG, taken in the large Mont Godart sections, east of the bridge of Ronquières, and the samples marked with PI, taken in the Inclined ship lift (Plan Incliné) of Ronquières we refer for the location on a detailed map to respectively fig. 20 and fig. 16 in Verniers et al., 1992 and for the detailed stratigraphical position to the detailed logs in the same publication indicated with their page. The PI samples are taken on the east flank of the large trench between the central anticline and the Porte Avale syncline.

MG 0.40 Chapel section, sample 3 in sequence 3 (p. 45); Ronquières Formation, unit A.
MG 18.60 Chapel section, sample 4 in sequence 110 (p. 45); Ronquières Formation, unit A.
MG 40.10 Chapel section, sample 5 in sequence 220 (p. 46); Ronquières Formation, unit A.
MG 64.70 Road section, sample 8 in sequence 337 (p. 47); Ronquières Formation, unit B.
MG 95.90 Road section, sample 9 in sequence 470 (p. 49); Ronquières Formation, unit C.
MG113.30: Road section, sample 11 in sequence 471 (p. 50); Ronquières Formation, unit C.
MG149.80: Lock section, sample 13 in sequence 597 (p. 51); Ronquières Formation, unit E.
MG166.30: Lock section, sample 14 in sequence 685 (p. 52); Ronquières Formation, unit F.
PI 15.00: Lowest talus, sample 15 in sequence 163 (p. 54); Ronquières Formation, unit K4.
PI 28.00: Lowest talus, sample 16 in sequence 250 (p. 55); Ronquières Formation, unit K8.
PI 31.40: Lowest talus, sample 17 in sequence 266 (p. 55); Ronquières Formation, unit K9.
PI 41.00: Lowest talus, sample 18 in sequence 334 (p. 56); Ronquières Formation, unit K11.
PI 61.50: Middle talus, sample 19 in sequence 506 (p. 57); Ronquières Formation, unit K15.
PI 70.50: Middle talus, sample 20 in sequence 570 (p. 57); Ronquières Formation, unit L3.
PI 90.50: Middle talus, sample 21 in sequence 775 (p. 58); Ronquières Formation, unit L9.
PI 113.00: Middle talus, sample 22 in sequence 979 (p. 59); Ronquières Formation, unit L11.
PI 126.00: Middle talus, sample 23 in sequence 1077 (p. 60); Ronquières Formation, unit L13.
PI 129.50: Middle talus, sample 24 in sequence 1106 (p. 60); Ronquières Formation, unit L15.
PI 148.60: Middle talus, sample 25 in sequence 1245 (p. 61); Ronquières Formation, unit L17.
PI 153.80: Middle talus, sample 26 in sequence 1287 (p. 61); Ronquières Formation, unit M1.
PI 163.00: Middle talus, sample 27 in sequence 1348 (p. 62); Ronquières Formation, unit M4.
PI 169.30: Middle talus, sample 28 in sequence 1395 (p. 62); Ronquières Formation, unit M5.
PI 197.40: Upper talus, sample 29 in sequence 1680 (p. 63); Ronquières Formation, unit N3.
PI 204.40: Upper talus, sample 30 in sequence 1743 (p. 64); Ronquières Formation, unit N4.

Monstreux area

Samples BD95201 to BD95203 lay on the territory of Nivelles between the town centre and the hamlet Monstreux, the other samples lay in the hamlet Monstreux (city of Nivelles). The approximate location of samples is given on Fig. 2 (extract of map sheet 1/25 000: 39/5–6 Braine-le-Comte-Feluy).

BD95201: Outcrop (4 m long) in the NE talus of the road 'Chemin de Grambais', at 54 m NW of the middle of the crossing with road 'Vieux Chemin de Braine-le-Comte' and at 1.4 m above the road level.
BD95202: Outcrop around the partially filled entrance to the abandoned kaolinite exploitation tunnel (called Tombeur quarry) in the 25 m thick ignimbritic 'eurite of Monstreux ' bed

(upper part of the Brutia Formation); about 60 m E of the Ferme Haveux in a small wood a few m above the valley floor; sample taken from the transition levels between the volcanic rocks and the covering slates, SW of the tunnel entrance (UTM co-ordinates: 592 180 mE × 5606 480 mN); top Brutia Formation.

BD95202bis: Outcrop in talus on private grounds about 10 m south of the 'Vieux Chemin de Braine-le-Comte'; sample taken a few m below the 25 m thick ignimbritic 'eurite of Monstreux ' bed (UTM co-ordinates: 592 400 mE × 5606 440 mN); middle part of the Brutia Formation.

BD95203: Outcrop (55 m long) in northern talus of the 'Chemin du Grand-Bailly', about 100 m east of the motorway Brussels-Mons and 73 m east of power cabin No. 1551 (UTM co-ordinates: 591 920 mE × 5606 480 mN); Bois Grand-Père Formation.

BD95204: Outcrop in southern talus of the road 'Chemin de Bornival', sample at 0.6 m above 1.45 m high stone wall, at 19 m west of the eastern end of the 79 m long wall (UTM co-ordinates: 591 530 mE × 5606 520 mN); Fallais Formation.

BD95205: Outcrop in the western talus of the road 'Rue du Gendarme'; sample taken about 10 m N of the bifurcation with 'Rue Fourneau', at 8.95 m stratigraphically below the base of the purple shale interval of about 14.5 m thick (UTM co-ordinates: 591 380 mE × 5606 380 mN); high in the Fallais Formation.

BD95206: Outcrop in the NW talus of the 'Rue du Gendarme'; sample taken a few metre south of the bifurcation with 'Rue Fourneau', at 0.30 to 0.45 m below the base of the purple shale interval; high in the Fallais Formation.

BD95207: Outcrop in the NW talus of the 'Rue du Gendarme'; sample taken 28.5 m north of the crossing with 'Rue Hiernoulet', at 0.65 to 0.72 m above the top of the purple shale interval; high in the Fallais Formation.

BD95208: Large outcrop in the middle of the NW talus of the 'Rue du Gendarme'; sample taken in the middle of the large outcrop; low in the Corroy Formation.

BD95209: Outcrop in the SE talus of the 'Rue du Gendarme'; sample taken at 5.6 m from the crossing with 'Rue Hiernoulet'; Corroy Formation.

BD95210: Outcrop in the NW talus of the 'Rue Hiernoulet'; sample taken at 8 m east of the western end of the 19 m long outcrop, at 2.4 m above the road, at 58 m WSW of the South side of a house (UTM co-ordinates: 590 860 mE × 5606 280 mN); Steenkerque Formation.

BD95210bis: idem, taken in the same layer as BD95210, but 30 cm lower; Steenkerque Formation.

BD95211: Outcrop in the SE talus at the top of the 'Rue de Boulvint' at 20.5 m SW of house No. 54 at 1.75 m above the road (UTM co-ordinates: 591 440 mE × 5606 240 mN); high in the Corroy Formation.

BD95213: Outcrop on the eastern side and in the bed of the Thisnes river, 2.2 m north of the bridge of the street 'Rue du Moulin' (UTM co-ordinates: 591 530 mE × 5606 040 mN); Corroy Formation.

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