

BULLETIN DE L'INSTITUT ROYAL
DES SCIENCES NATURELLES
DE BELGIQUE

BULLETIN VAN HET KONINKLIJK
BELGISCH INSTITUUT VOOR
NATUURWETENSCHAPPEN

SCIENCES DE LA TERRE
AARDWETENSCHAPPEN
VOL. 59

BRUXELLES 1989 BRUSSEL



BULLETIN DE L'INSTITUT ROYAL
DES SCIENCES NATURELLES
DE BELGIQUE

BULLETIN VAN HET KONINKLIJK
BELGISCH INSTITUUT VOOR
NATUURWETENSCHAPPEN

SCIENCES DE LA TERRE
AARDWETENSCHAPPEN
VOL. 59

BRUXELLES 1989 BRUSSEL



Rédacteur en chef – Hoofdredacteur – *Editor* :

Annie V. DHONDT

Secrétaires de rédaction – Redactiesecretarissen – *Associate editors* :

Paul HAESAERTS

Francine MARTIN

Comité de rédaction – Redactiecomité – *Editorial board* :

Pierre BULTYNCK

Daniel CAHEN

Michel DELIENS

André LEGUEBE

Paul SARTENAER

Comité international – Internationaal comité – *Consulting editors* :

C. Howard C. BRUNTON (London, UK)

William T. DEAN (Cardiff, UK)

Iginio DIENI (Padova, Italy)

Gerhard HAHN (Marburg, FRG)

Hans-Jørgen HANSEN (København, Denmark)

Thomas R. WALLER (Washington DC, USA)

BULLETIN
DE L'INSTITUT ROYAL DES SCIENCES NATURELLES DE BELGIQUE
SCIENCES DE LA TERRE

BULLETIN
VAN HET KONINKLIJK BELGISCH INSTITUUT VOOR NATUURWETENSCHAPPEN
AARDWETENSCHAPPEN

Vol. 59 - 1989

ISSN 0374-6291

© Edition de
l'Institut Royal des Sciences Naturelles
de Belgique
Rue Vautier 29
B-1040 Bruxelles, Belgique

© Uitgave van het
Koninklijk Belgisch Instituut voor
Natuurwetenschappen
Vautierstraat 29
B-1040 Brussel, België

TABLE DES MATIÈRES

INHOUDSTAFEL

BULTYNCK, P., Conodonts from a potential Eifelian/Givetian Boundary Stratotype at Jbel Ou Driss, southwestern Ma'dern, Morocco 95

CASIER, J.-G., Biostratigraphie et paléoécologie des Ostracodes du niveau de la limite des étages Frasnien et Famennien, à Senzeilles 79

COEN-AUBERT, M., Description de quelques rugueux coloniaux du Couvinien supérieur de Wellin (bord sud du Bassin de Dinant, Belgique) 15

DELIENS, M., Les Minéralisations du Gisement de Mutoshi (ex-Ruwe), Shaba méridional, Zaïre 207

DHONDT, A.V., Late Cretaceous *Limea* (*Pseudolimea*) species of Europe 105

GEYS, J., Hemicidaroid Echinoids from Upper Cretaceous Deposits in the Wadi Qena-Area (Eastern Desert, Egypt) 127

LEGUEBE, A., ORBAN, R. SIMONET, P., Un premier métatarsien droit découvert à Sclayn (Belgique) 191

LINGHAM-SOLIAR, T. & NOLF, D., The Mosasaur *Prognathodon* (Reptilia) from the Upper Cretaceous of Belgium 137

MARTIN, F., Systematic Revision of *Elektoriskos williereae* and *Dilatosphaera williereae* (Acritarchs) and its bearing on Silurian (Llandoveryan) Stratigraphy 5

SARTENAER, P. & XU H.-K., The Upper Famennian genus *Trifidorostellum* SARTENAER, 1961, from China, North America, and the USSR 37

SARTENAER, P. & XU H.-K., The Upper Famennian Rhynchonellid genus *Planovatiostrum* SARTENAER, 1970, from Africa, China, Europe and USSR 49

SARTENAER, P., Deux genres Rhynchonellides nouveaux d'âge frasnien moyen et supérieur, résultant du brisement de *Calvinaria* STAINBROOK, 1945 61

Systematic Revision of *Elektoriskos williereae* and *Dilatisphaera williereae* (Acritarchs) and its bearing on Silurian (Llandoveryan) Stratigraphy

by Francine MARTIN

Abstract

Revision of *Elektoriskos williereae* (G. & M. DEFLANDRE) VANGUESTAINE, 1979 and *Dilatisphaera williereae* (MARTIN) LISTER, 1970, the primary types of which come from the Brabant Massif in Belgium, underlines the evidence for their stratigraphic value in the Llandovery, lowest Series of the Silurian. Data indicate that in Belgium and Great Britain the species appear, respectively, slightly above the base of the Rhuddanian and in the upper part of the Aeronian. The stratigraphic level at which they appear in eastern North America, although less well documented, is compatible with the above.

Key-words : *Elektoriskos williereae*, *Dilatisphaera williereae*, Acritarchs, Silurian, Llandovery.

Résumé

La révision d'*Elektoriskos williereae* (G. & M. DEFLANDRE) VANGUESTAINE, 1979 et de *Dilatisphaera williereae* (MARTIN) LISTER, 1970, dont les types primaires proviennent du Massif du Brabant, en Belgique, met en évidence leur valeur stratigraphique dans le Llandovery, série inférieure du Silurien. Les données indiquent que ces espèces apparaissent respectivement peu au-dessus de la base du Rhuddanien et dans la partie supérieure de l'Aeronien en Belgique et en Grande-Bretagne. Leur niveau d'apparition dans l'est de l'Amérique du Nord, bien que moins documenté, est compatible avec les informations précédentes.

Mots-clefs : *Elektoriskos williereae*, *Dilatisphaera williereae*, Acritarches, Silurien, Llandovery.

Introduction

A revision is provided of two Silurian (Llandoveryan) acritarch species from Belgium, the primary types of which, from boreholes in the Brabant Massif, Flanders, were insufficiently described and illustrated for modern requirements. *Elektoriskos williereae* (G. & M. DEFLANDRE) VANGUESTAINE, 1979 and *Dilatisphaera williereae* (MARTIN) LISTER, 1970 were founded some twenty years ago without using the scanning electron microscope. The latter, as first demonstrated by LOEBLICH & TAPPAN (1969) and LOEBLICH (1970), is indispensable for establishing the detailed taxonomy of acritarchs whose ornamentation is too dense and too small to be correctly observed under the optical microscope.

The geographic position of the Belgian Llandoveryan localities yielding these two species was illustrated by MARTIN

(1969, text-figs. 2, 5); four boreholes are situated in the Brabant Massif, at Kortrijk, Deerlijk, Heule and Steenkerke, and one outcrop area is sited in the Condroz Strip, at Neuville-sous-Huy. The vertical range of the taxa is shown (Fig. 1) with reference to their biostratigraphic and chronostratigraphic range in the lowest Silurian series. Proposals by the International Ordovician - Silurian Boundary Working Group and Subcommittee on Silurian Stratigraphy, revising the base of the Silurian and the limits of the stages of the Llandovery Series, as presented by COCKS *et al.* (1971), were stated by HOLLAND (1984). Accepted by the International Commission on Stratigraphy in 1984, summarised by BASSETT (1985), and often criticised, notably by LESPERANCE *et al.* (1987), they are followed here because of their formally recognised status and their easy application in Belgium.

Systematics

Genus *Elektoriskos* LOEBLICH, 1970

Type species :

Elektoriskos aurora LOEBLICH, 1970 by original designation.

Elektoriskos williereae (G. & M. DEFLANDRE)
VANGUESTAINE, 1979, emend.
(Plate 1, Figures 1-16)

- 1963 *Baltisphaeridium* aff. *polytrichum* (VALENSI) - STOCKMANS & WILLIERE, p. 460, pl. 3, figs. 24, 25; text-fig. 16.
1965 *Michrhystridium williereae* G. & M. DEFLANDRE nom. nov. (hic) - DEFLANDRE, G. & M., fiche n° 2437.
1966 *Baltisphaeridium* aff. *polytrichum* (VALENSI) - MARTIN, p. 357, text-fig. 3.
1967 *Michrhystridium williereae* - MARTIN, p. 327 in part.
1969 *Michrhystridium williereae* Deflandre & Deflandre - Rigaud - Martin, p. 82, 83 in part, pl. 4, fig. 175; pl. 7, fig. 324; pl. 8, fig. 387; text-fig. 32.
1969 *Baltisphaeridium chiggerum* CRAMER, 1968 - CRAMER, pl. 70, fig. 18 (invalid species, no description).

SYSTEM		SERIES		BRITISH STAGES (Cocks et al. 1971)		I.U.G.S. STANDARD STAGES (1984)		BRITISH GRAPTOLITE ZONES AND EQUIVALENT SHELLY FACIES NUMBER		Elektoriskos williereae					Dilatysphaera williereae		
SILURIAN (part)		LLANDOVERY		TELYCHIAN	TELYCHIAN	M. crenulata	C6	BELGIUM					BELGIUM				
ORDOVICIAN (part)	ASHGILL (part)	FRONIAN	AERONIAN					M. griestonensis	C5	ENGLAND, WALES					ENGLAND, WALES		
RHUDDANIAN				RHUDDANIAN	RHUDDANIAN	M. crispus	C4	NORWAY					N.E. U.S.A.				
		IDWIAN	AERONIAN			M. turriculatus	C2-3	CANADA (Quebec)					CANADA (Quebec)				
				RHUDDANIAN	RHUDDANIAN	R. maximus		C1	Dotted line					Dotted line			
		RHUDDANIAN	RHUDDANIAN			M. sedgwickii	B3		Dotted line					Dotted line			
				RHUDDANIAN	RHUDDANIAN	M. convolutus		B2	Dotted line					Dotted line			
		RHUDDANIAN	RHUDDANIAN			M. gregarius	B1		Dotted line					Dotted line			
				RHUDDANIAN	RHUDDANIAN	D. magnus		A4	Dotted line					Dotted line			
		RHUDDANIAN	RHUDDANIAN			M. triangulatus	A3		Dotted line					Dotted line			
				RHUDDANIAN	RHUDDANIAN	C. cyphus		A2	Dotted line					Dotted line			
		RHUDDANIAN	RHUDDANIAN			L. acinaces	A1		Dotted line					Dotted line			
				RHUDDANIAN	RHUDDANIAN	A. atavus (= O. vesiculosus)		A1	Dotted line					Dotted line			
		RHUDDANIAN	RHUDDANIAN			P. acuminatus	A1		Dotted line					Dotted line			
				RHUDDANIAN	RHUDDANIAN	G. persculptus		A1	Dotted line					Dotted line			

Fig. 1. - Geographic distribution and stratigraphic range of *Elektoriskos williereae* and *Dilatysphaera williereae* [broken lines indicate uncertain macrofossil age control; (Hirnantian) is not an IUGS standard stage].

- 1970 *Comasphaeridium williereae* (G. & M. DEFLANDRE, 1965) CRAMER (New combination) - CRAMER, p. 121 in part (not text-fig. 37).
- 1970 *Elektoriskos pogonius* LOEBLICH, n. sp. - LOEBLICH, p. 718, 719, fig. 13 A, B.
- non 1970 *Filisphaeridium williereae* (DEFLANDRE & DEFLANDRE-RIGAUD, 1965) comb. nov., emend. - LISTER, p. 73, pl. 7, figs. 1-4.
- non 1973 *Elektoriskos pogonius* LOEBLICH, 1970 - THUSU, p. 804, pl. 105, fig. 10.
- 1974 *Micrhystridium williereae* DEFL. & DEFL.-RIG., 1963 (sic) - MARTIN, p. 26.
- non 1974 *Elektoriskos pogonius* LOEBLICH, 1970 - THUSU & ZENGER, p. 841.
- 1974 *Elektoriskos pogonius* LOEBLICH, 1970 - HILL, p. 12.
- 1976 *Comasphaeridium williereae* CRAMER 1970 - EISENACK, CRAMER & DIEZ, p. 135 - 137 in part.
- 1977 *williereae* CRAMER 1970: *Comasphaeridium* - DIEZ & CRAMER, p. 27 in part.
- 1979 *Elektoriskos williereae* (DEFLANDRE & DEFLANDRE-RIGAUD) VANGUESTAINE nov. comb. - VANGUESTAINE, p. 247, pl. 1, figs. 13, 14, non pl. 3, fig. 20.
- 1982 *Elektoriskos pogonius* LOEBLICH, 1970 - MILLER & EAMES, p. 237, pl. 1, fig. 2.
- non 1984 *Comasphaeridium williereae* (DEFLANDRE & DELANDRE-RIGAUDE, 1965) CRAMER, 1970 (sic) - SHESHEGOVA, p. 31, pl. 2, figs. 11 - 13.
- 1984 *Elektoriskos pogonius* - HILL & DORNING, p. 176; text-fig. 20.
- 1987 *Elektoriskos pogonius* LOEBLICH, 1970 - SMELROR, p. 145, pl. 2, fig. 4.
- 1989 *Elektoriskos williereae* (DEFLANDRE & DEFLANDRE-RIGAUD) VANGUESTAINE, 1979 - MARTIN, p. 209, Fig. 149 in part (not W38 and W65), Fig. 151: A.

TYPE HORIZON

Telychian Stage; *Monograptus turriculatus* Zone of the Brabant Massif, Belgium; depth of 188.50 m in borehole at the Lust Brewery, Kortrijk.

EMENDED DIAGNOSIS (based on 300 Belgian specimens)

Vesicle globular, with circular outline, clearly distinct from processes. Vesicle wall thin, apparently single-layered, psilate. Processes numerous, usually about one hundred or more, homomorphic, flexuous, filiform, psilate, fragile, of nearly constant diameter from proximal to distal end, apparently solid and without communication with the vesicle cavity. Length of processes at least one and a half times the vesicle diameter.

DIMENSIONS (based on seventy specimens)

Vesicle diameter: 14 (25) 46 μm ; length and width of processes: up to 30 μm (commonly broken) and 0.3 - 0.9 μm ; vesicle wall thickness: less than 0.2 μm .

REMARKS

Re-examination of *Elektoriskos williereae* from the Llandovery of Belgium indicates that *E. pogonius* is a junior

synonym, as was suspected by LOEBLICH (1970), CRAMER (1970) and MILLER & EAMES (1982). Using the optical microscope LOEBLICH (1970) interpreted as granulate or pustulate ornamentation of the vesicle wall what are either contracted bases of broken processes (Pl. 1, Fig. 2) or the effect of irregular oxidation (Pl. 1, Fig. 9); this so-called ornamentation reflects, in fact, differences in preservation. Re-examination of material determined by MARTIN (1967, 1969) shows that the rare specimens from the Wenlock of the Mehaigne valley (sample Fallais-16), in the Brabant Massif, and from the Wenlock and Ludlow at Neuville-sous-Huy (samples NEU-4, NEU-24, NEU-31) in the Condroz Strip, are too poorly preserved for reliable identification. Some of the reworked specimens from the Lower Devonian of the Dinant Synclinorium, Belgium, figured as *E. williereae* by VANGUESTAINE (1979, pl. 3, fig. 20) have conical processes and are omitted here from the synonymy. The presence of endoderm and ectoderm in the vesicle was recorded by CRAMER (1970) but is not accepted here, not having been observed in specimens used for the species revision. Of the North American specimens determined by CRAMER (1970), only those originating from Pennsylvania and the Niagara Falls region are included in the present synonymy list; material from the former area was illustrated by CRAMER (1969), and from the latter by MILLER & EAMES (1982).

Gorstian and Ludfordian specimens from the Ludlow Series in Shropshire, England, attributed by LISTER (1970) to *Filisphaeridium williereae*, differ from the species in having shorter, more widely-spaced, occasionally branched processes. Wenlockian acritarchs from southeastern Ontario, Canada, assigned to *Elektoriskos pogonius* by THUSU (1970) have processes that taper distally, and do not belong to the species; consequently the record by THUSU & ZENGER (1974) from the middle Silurian of east central New York State, USA, is not considered valid.

Material from the Wenlock of northern Siberia determined as *Comasphaeridium williereae* by SHESHEGOVA (1984) is badly preserved. Of the three figured specimens, two (SHESHEGOVA, 1984, pl. 2, figs. 11, 12) have processes with variably widened bases and an apparently reticulate vesicle; the third specimen (*loc. cit.*, pl. 2, fig. 13) is opaque and resembles *Baltisphaeridium lamellum* SHESHEGOVA, 1984 figured in the same publication (*loc. cit.*, pl. 1, figs. 11 - 13).

GEOGRAPHIC AND STRATIGRAPHIC DISTRIBUTION

Revision of specimens of *E. williereae* determined by STOCKMANS & WILLIERE (1963) and by MARTIN (1966, 1967, 1969, 1974) has enabled the range of the species in the Llandovery of Belgium to be established.

In the Brabant Massif, the species is known from the lower, but not basal Rhuddanian (*Atavograptus atavus* Zone) to the lower Telychian (*Monograptus crispus* Zone). It has been identified in four boreholes in Flanders, an account of which is found in the synthesis by LEGRAND (1968).

E. williereae is rare in the Rhuddanian at Deerlijk (samples DEE-83-E-18: - 182, - 180, - 176, - 167.50 in MARTIN,

1974), in strata dated by LEGRAND (1966) as *Diplograptus modestus* and *Orthograptus vesiculosus* Zone (now *Atavograptus atavus* Zone) and *Monograptus cyphus* Zone. The species is abundant at Heule in an unlocalised sample (sample HEU-6 in MARTIN, 1969) within a 48 m boring, one level of which belongs, according to LEGRAND (1949), to the *Monograptus gregarius* Zone, basal Aeronian. The species occurs frequently at Kortrijk, in the borehole at the Lust Brewery (sample LUS-223, -210, -189.50, -172.50, -158, -148.30 in MARTIN, 1969) which contains between 203.50 m and 159 m, according to LEGRAND (1961), the *Monograptus sedgwickii*, *M. turriculatus* and *M. crispus* zones, from the upper Aeronian to the lower Telychian. It is also abundant at Steenkerke (samples STE-267, -266.90, -266.70 in MARTIN, 1969) in deposits of the *M. crispus* Zone, as determined by LEGRAND (1964).

In the Condroz Strip *E. williereae* is rare in the Telychian part of the Dave Formation. In the ravine 700 m east of the ponds at Neuville-sous-Huy it is present in one sample (NEU-34 in MARTIN, 1966, 1969), localised between levels g9 and g10 of MAES *et al.* (1979, p. 34) which belong, respectively, to the *Monoclimacis griestonensis* Zone and to the *Monograptus turriculatus* Zone. East of the northern pond at Neuville-sous-Huy *E. williereae* has been identified in units J (NEU-12 in MARTIN, 1966, 1969) and K (NEU-14, -3 in MARTIN, 1966, 1969) of MAES *et al.* (1979, p. 32, 33), both of which lack graptolites. According to the last-named authors, the same units in the ravine 1200 m east of the ponds are localised within deposits attributed to the *Monoclimacis crenulata* Zone.

Specimens of *E. williereae* in the Lower Devonian of the eastern part of the Dinant Synclinorium, Belgium, were considered by VANGUESTAINE (1979) to be reworked; the stratigraphic level from which they originated cannot be established reliably. The same author determined acritarch assemblages of heterogeneous age in the Siegenian of the Bois d'Ausse Formation and in the Emsian of the Burnot Formation. He accepted (*loc. cit.*, p. 250) that *E. williereae* is reworked there from the Wenlock - Ludlow to the Gedinian, basing his conclusions, in the absence of data specified for the holotype, on the synonymy published by DIEZ & CRAMER (1977) and following that by CRAMER (1970); both are only partially accepted here.

The statements by CRAMER (1970) and by EISENACK *et al.* (1976) that the species ranges from the Wenlock to the Lower Devonian in north-western Spain, and from the Wenlock to the top of the Silurian in Georgia, Alabama and Kentucky, USA, in Libya and in Saudi Arabia are either founded on palynological dating without macrofossil age control or have insufficient information on the source of the material. These stratigraphic range are not considered further here.

E. williereae was listed by HILL (1974) from unspecified localities ranging from the upper Rhuddanian to the lower Telychian in the Llandovery type area, Wales, and in the Welsh Borderland, England. The records were repeated in the list of index acritarchs by HILL & DORNING (1984, text-fig. 70) for the Llandovery type-area. There the species ranges from the Rhuddanian to the Aeronian, in strata of

the Goleugoed and Rhydings formations, correlated by COCKS *et al.* (1984) with, respectively, the *Atavograptus atavus* Zone and the *Monograptus sedgwickii* Zone. *E. williereae* is present also (personal observation) in the Wormwood Formation, 1.20 m above the base of the Telychian (sample WAL-162-3; Pl. 1, Fig. 6) at the latter's type section in the old quarry west of the Cefn Cerig road, southern Llandovery area.

SMELROR (1987) has illustrated the species from the Llandovery of the Oslo region, Norway, where it ranges from the upper part of the Sælabonn Formation to the upper part of the Vik Formation. The correlation of these two units, based principally on the evolution of the brachiopod *Stricklandia* as proposed by COCKS *et al.* (1984), with the Aeronian and the Telychian was established by WORSLEY *et al.* (1983).

In northeastern USA and southeastern Canada *E. williereae* is known in the Llandovery, from the lower but not basal Rhuddanian to the Telychian. In the Niagara Falls region of Ontario and of New York State the species occurs, according to CRAMER (1970) and MILLER & EAMES (1982), in the Medina Group, from the Power Glen Formation onwards. The Medina Group lacks index fossils and its attributed Rhuddanian age is deduced from that of the underlying Ashgillian Queenston Shale, and of the overlying Aeronian deposits in the basal Clinton Group, dated by means of conodonts as *Icriodina irregularis* Zone (POLLOCK *et al.*, 1970, p. 746). LOEBLICH (1970) found *E. williereae* in the Maplewood Shale of Rochester, New York State, a lenticular unit without diagnostic macrofossils that was correlated with the Aeronian (B2) by RICKARD (1975) and with the Telychian (C4) by BERRY & BOUCOT (1970). CRAMER (1969) illustrated *E. williereae* from an unspecified biostratigraphic level in the upper part of the Rose Hill Formation near Millerstown, Pennsylvania. On the basis of the evolutionary lineage of the brachiopod *Eocoelia*, the whole of this formation was correlated with the Telychian (C3 - C6) by BERRY & BOUCOT (1970). In the Chaleur Bay area, Gaspé Peninsula, Quebec, *E. williereae* is recorded by MARTIN (1989) from the Clemville Formation and the Anse Gascon Formation; these strata correspond to the Rhuddanian - Telychian (A3 - C2) according to the conodont evidence (NOWLAN, 1981), and to the Telychian (C5) on the basis of the brachiopods (BOUCOT & BOURQUE, 1981). The species is illustrated here (sample BC-1-4; Pl. 1, Fig. 9) from the middle mudstone member of the Anse Gascon Formation.

Genus *Dilatisphaera* LISTER, 1970

Type species :

Dilatisphaera laevigata LISTER, 1970, by original designation.

Dilatisphaera williereae (MARTIN)

LISTER, 1970, emend.

(Plate 2, Figures 1-15)

- 1966 *Hystrichosphaeridium williereae* nov. sp. - MARTIN, p. 389, 390, pl. 1, fig. 23; text-figs. 33, 34.
 1969 *Hystrichosphaeridium ? williereae* MARTIN - MARTIN, p. 142, pl. 7, figs. 317, 318; text-fig. 87.
 1970 *Dilatisphaera williereae* (MARTIN 1966a) - LISTER, p. 65.
 1974 *D. williereae* (MARTIN) LISTER, 1970 - HILL, p. 12.
 1976 *Hystrichosphaeridium williereae* MARTIN 1965 - ACHAB, p. 1311, pl. 2, fig. 20.
 non 1978 *Hystrichosphaeridium williereae* MARTIN, 1966 - KIRJANOV, p. 90, 91, pl. 8, fig. 11; pl. 9, figs. 1, 2, 4.
 non 1981 *Dilati. willierii* (sic) - DORNING, p. 180.
 1984 *Dilatisphaera williereae* - HILL & DORNING, p. 175, 176; text-fig. 70.
 1989 *Dilatisphaera williereae* (MARTIN) LISTER 1970 - MARTIN, p. 209, Figs. 149, 151 : J, L.

TYPE HORIZON

Aeronian Stage; Brabant Massif, Belgium; depth of 210 m in borehole at the Lust Brewery, Kortrijk.

EMENDED DIAGNOSIS (based on 250 Belgian specimens)

Vesicle globular with circular outline, clearly distinct from processes. Vesicle wall apparently single-layered, originally covered with very fine, hair-like projections that form a low, peripheral network surrounding the vesicle. Five to thirteen homomorphic, psilate processes, of almost constant diameter from proximal to distal end, and originally cylindrical. They are hollow, do not communicate with the vesicle cavity, and are distally open. Process length four to seven times the width and 1.1 to 1.7 times the vesicle diameter. Apical excystment opening.

DIMENSIONS (based on 45 specimens)

Vesicle diameter: 12 (17) 29 μm ; length and width of processes: up to 26 μm and 3.5 - 7 μm ; height of network on vesicle wall: up to 5 μm ; thickness of vesicle wall: less than 0.5 μm .

REMARKS

The original generic diagnosis indicated that the vesicle is composed of a double membrane; this is not observed in *D. williereae*, and the fact that the central body appears darker than the processes seems due to the ornamentation that covers it. The apical excystment aperture controlled by sutures, also noted in the generic diagnosis, has been observed in Welsh specimens (Pl. 2, Fig. 6); one compressed specimen from Belgium, the vesicle ornamentation of which is only partly preserved (Pl. 2, Figs. 1, 5), shows polygonal plates delimited by suture lines.

D. williereae differs from *D. dameryensis* DORNING, 1981 and *D. laevigata* LISTER, 1970, respectively from the Llan-

doverly and from the Wenlock and Ludlow of England, mainly by the ornamentation of the vesicle wall. The record by DORNING (1981) of *D. williereae* from the Ludlow in its type area in England is doubtful, and is not accepted here. It was not supported by any illustration, and my examination of about ten samples from the Ludlow area confirmed only *D. laevigata*.

KIRJANOV (1978) put *?Ozotobrachion podolicus* SHESHEGOVA, 1974 in synonymy with *Hystrichosphaeridium williereae*, identified by him from the Ludlow in boreholes in the Volhyn - Podolia area, USSR. Neither the diagnosis of the former species by SHESHEGOVA (1974, p. 66, pl. 20, figs. 9-10, 12-14; pl. 21, figs. 5, 6, 21; pl. 24, figs. 24-27) nor the description of the latter species by KIRJANOV (1978) mentioned anastomosed hair-like projections on the surface of the vesicle. Judging from the illustrations given by the two authors their specimens may belong to *Dilatisphaera laevigata*.

GEOGRAPHIC AND STRATIGRAPHIC DISTRIBUTION

D. williereae is present, and sometimes abundant, in uncondensed Llandoveryan deposits in the borehole at the Lust Brewery, Kortrijk, in the Brabant Massif, Belgium. The oldest level at which the species is recognized lacks graptolites but is assigned here to the Aeronian, according to the occurrence of the *Monograptus sedgwickii* Zone 6.60 m above. The species extends into the Telychian, 11.70 m above strata belonging to the *M. crispus* Zone.

HILL (1974) recorded the species from the Telychian (C3 - C5) of the Llandovery district. Elsewhere in Wales, HILL & DORNING (1984) noted its extension from the Rhydings Formation to the Cerig Formation, in strata corresponding to the highest Aeronian and the lowest Telychian. *D. williereae* is illustrated here (sample WAL-162-3; Pl. 2, Figs. 6, 9) from 1.20 m above the base of the Telychian at the latter's type section in the old quarry west of Cefn Cerig road, southern Llandovery area.

In western Ireland, CLAYTON *et al.* (1980) illustrated numerous reworked acritarchs from Lower Carboniferous rocks in a borehole in County Clare. The material included one incomplete specimen of *D. williereae*, the original stratigraphic level of which is assumed to have been Llandoveryan but could not be established reliably by the authors. In the Telychian of eastern Canada, *D. williereae* was illustrated by ACHAB (1976) from the Awantjish Formation of the Gaspé Peninsula, and by MARTIN (1989) from the Jupiter Formation of Anticosti Island. The strata were respectively correlated with C3 - C5 by LAJOIE *et al.* (1968) and with C5 by UYENO & BARNES (1981).

Conclusions

The diagnoses of *Elektoriskos williereae* and *Dilatisphaera williereae* are emended to take account of additional information on the primary types from the Brabant Massif, Belgium. A consequence of this revision is that the strati-

graphic range of the two species is limited to the Llandovery.

Elektoriskos williereae appears in Belgium (MARTIN, 1974) slightly above the base of the Rhuddanian, in strata dated by means of graptolites as *Atavograptus atavus* Zone, and in deposits of similar age in Wales (HILL & DORNING, 1984). The species is known also from the lower stage of the Llandovery in northeastern USA and Ontario (CRAMER, 1970; MILLER & EAMES, 1982) and in Quebec, Canada (MARTIN, 1989). In the Oslo region, Norway (SMELROR, 1987), it is found from the lower Aeronian to the Telychian.

Dilatisphaera williereae has a more limited range in the Llandovery than has *Elektoriskos williereae*. The level at

which it appears in Belgium (MARTIN, 1966, 1969) is attributed to the upper Aeronian, in strata below those of the *Monograptus sedgwickii* Zone. In Wales (HILL, 1974; HILL & DORNING, 1984), it appears in the latter graptolite zone. In Quebec, both in the Gaspé Peninsula (ACHAB, 1976) and at Anticosti (MARTIN, 1989), the species is known from the Telychian.

Acknowledgements

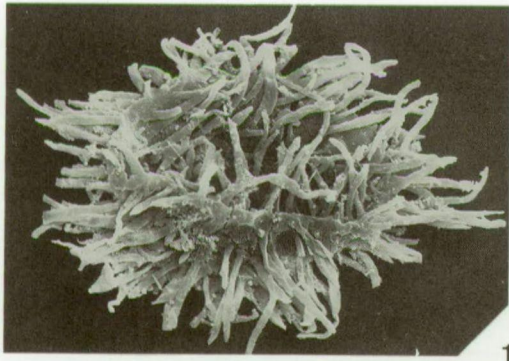
The author is indebted to Warren S. DRUGG (Chevron Oil Field Research Company, California) for kindly providing samples from the Maplewood Shale used by A.R. LOEBLICH for his 1970 paper, and containing *Elektoriskos williereae*.

References

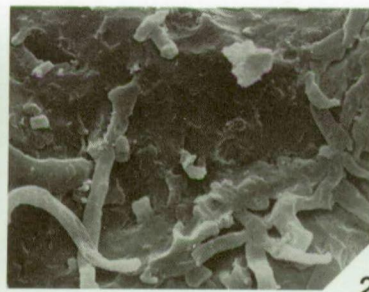
- ACHAB, A., 1976. Les acritarches de la Formation d'Awantjish (Llandoveryen supérieur) du sondage Val Brillant, Vallée de la Matapédia, Québec. *Canadian Journal of Earth Sciences*, 13 (9) : 1310-1318.
- BASSETT, M.G., 1985. Towards a "Common Language" in Stratigraphy. *Episodes*, 8 (2) : 87-92.
- BERRY, W.B.N. & BOUCOT, A.J., 1970. Correlation of the North American Silurian Rocks. *The Geological Society of America*, Special Paper 102, 289 pp.
- BOUCOT, A.J. & BOURQUE, P.-A., 1981. Brachiopod biostratigraphy of the Llandoveryan rocks of the Gaspé Peninsula. In : LESPERANCE, P.J. (Editor), Field Meeting, Anticosti-Gaspé, Québec, 1981, 2 : Stratigraphy and Paleontology, I.U.G.S. Subcommission on Silurian Stratigraphy Ordovician-Silurian Boundary Working Group, Montréal, pp. 315-321.
- COCKS, L.R.M., HOLLAND, C.H., RICKARDS, R.B. & STRACHAN, I., 1971. A correlation of Silurian rocks in the British Isles. *Geological Society of London*, Special Report n° 1 : 103-136.
- COCKS, L.R.M., WOODCOCK, N.H., RICKARDS, R.B., TEMPLE, J.T. & LANE, P.D., 1984. The Llandovery Series of the Type area. *Bulletin of the British Museum (Natural History)*, Geology Series, 38 (3) : 131-182.
- CLAYTON, G., JOHNSON, I.S., SEVASTOPULO, G.D. & SMITH, D.G., 1980. Micropalaeontology of a Courceyan (Carboniferous) borehole section from Ballyvergin, County Clare, Ireland. *Journal of Earth Sciences Royal Dublin Society*, 3 (1) : 81-100.
- CRAMER, F.H., 1969. Possible implications for Silurian paleogeography from phytoplankton assemblages of the Rose Hill and Tuscarora formations of Pennsylvania. *Journal of Paleontology*, 43 (2) : 485-491.
- CRAMER, F.H., 1970. Distribution of selected Silurian acritarchs. *Revista Española de Micropaleontología*, Número extraordinario, 202 pp.
- DEFLANDRE, G. & M., 1965. Fichier micropaléontologique général - Série 13. Acritarches 2. Acanthomorphitae 1. Genre *Micrhystridium* Deflandre sens. lat. *Archives originales Centre de Documentation Centre national de la Recherche scientifique*, Paris, N° 402 : p. 1-5, Fiches 2176-2521.
- DIEZ, M.C.R. & CRAMER, F.H., 1977. Range chart of selected Lower Paleozoic acritarch taxa. II. Index to parts I and II. *Review of Palaeobotany and Palynology*, 24 (1) : 1-48.
- DORNING, K.J., 1981. Silurian acritarchs from the type Wenlock and Ludlow of Shropshire, England. *Review of Palaeobotany and Palynology*, 34 (2) : 175-203.
- EISENACK, A., CRAMER, F.H. & DIEZ, M.C.R., 1976. Acritarcha 2. In : EISENACK, A. (Editor), Katalog der fossilen Dinoflagellaten, Hystrichosphären und verwandten Mikrofossilien, IV, Schweizerbart (Nägele u. Obermiller), Stuttgart, pp. I-XXIV, 1-863.
- HILL, P.J., 1974. Stratigraphic palynology of acritarchs from the type area of the Llandovery and the Welsh Borderland. *Review of Palaeobotany and Palynology*, 18 (1/2) : 11-23.
- HILL, P.J. & DORNING, K.J., 1984. Appendix 1. Acritarchs. In : COCKS, L.R.M., WOODCOCK, N.H., RICKARDS, R.B., TEMPLE, J.T. & LANE, P.D., The Llandovery Series of the Type area. *Bulletin of the British Museum (Natural History)*, Geology Series, 38 (3), pp. 174-176.
- HOLLAND, C.H., 1984. Steps to a standard Silurian. *Proceedings of the 27th International Geological Congress*, Moscow 4-14 August 1984, 127-156.
- KIRJANOV, V.V., 1978. The acritarchs of the Silurian of Volhynopodolia. *Academy of Sciences Ukrainian S.S.R., Institute of Geological Sciences*, Kiev "Naukova Dumka", 115 pp. (In Russian).
- LAJOIE, J., LESPERANCE, P.J. & BELAND, J., 1968. Silurian stratigraphy and paleogeography of Matapédia, Temiscouata region, Québec. *The American Association of Petroleum Geologists Bulletin*, 52 (4) : 615-640.
- LEGRAND, R., 1949. Le socle paléozoïque au sondage de Heule (Flandre Occidentale). *Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie*, 58 (1) : 162-164.
- LEGRAND, R., 1961. Le Tarannonien à Graptolithes reconnu sous Courtrai (Flandre Occidentale). *Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie*, 70 (2) : 174-185.
- LEGRAND, R., 1964. Mise au point concernant l'Ashgillien de Belgique. *Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie*, 73 (2) : 191-192.

- LEGRAND, R., 1966. Sondages à Deerlijk. *Professional Paper Service géologique de Belgique*, 4 : 1-17.
- LEGRAND, R., 1968. Le Massif du Brabant. *Mémoires Service géologique de Belgique*, 9 : 1-148.
- LESPERANCE, P.J., BARNES, C.R., BERRY, W.B.N., BOUCOT, A.J. & MU, En-zhi, 1987. The Ordovician-Silurian boundary stratotype : consequences of its approval by the IUGS. *Lethaia*, 20 (3) : 217-222.
- LISTER, T.R., 1970. The acritarchs and chitinozoa from the Wenlock and Ludlow Series of the Ludlow and Millichope areas, Shropshire. Part I. *Palaeontographical Society Monographs*, N° 528 : 1-100.
- LOEBLICH, A.R., Jr., 1970. Morphology, Ultrastructure and Distribution of Paleozoic Acritarchs. *Proceedings of the North American Paleontological Convention*, Part G, Ultra Microplankton : 705-788.
- LOEBLICH, A.R., Jr. & TAPPAN, H., 1969. Acritarch excystment and surface ultrastructure with descriptions of some Ordovician taxa. *Revista Española de Micropaleontología*, 1 (1) : 45-57.
- MAES, G., RICKARDS, B., ROMBOUTS, L. & VANDEVELDE, N., 1979. Silurian formations between Neuville-sous-Huy and Ombret : their correlation, age and structure. *Annales de la Société géologique de Belgique*, 101 (1978) : 31-36.
- MARTIN, F., 1966. Les Acritarches du sondage de la brasserie Lust à Kortrijk (Courtrai) (Silurien belge). *Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie*, 74 (2, 3, 1965) : 354-402.
- MARTIN, F., 1967. Les Acritarches du parc de Neuville-sous-Huy (Silurien belge). *Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie*, 75 (3, 1966) : 306-337.
- MARTIN, F., 1969. Les Acritarches de l'Ordovicien et du Silurien belges. Détermination et valeur stratigraphique. *Mémoires Institut royal des Sciences naturelles de Belgique*, 160 (1968) : 1-175.
- MARTIN, F., 1974. Ordovicien Supérieur et Silurien Inférieur à Deerlijk (Belgique). Palynofacies et microfacies. *Mémoires Institut royal des Sciences naturelles de Belgique*, 174 (1973) : 1-71.
- MARTIN, F., 1989. Silurian acritarchs. In : HOLLAND, C.H. & BASSETT, M.G. (Editors), A global standard for the Silurian System, *National Museum of Wales, Geological Series*, 9, Cardiff, pp. 207-215.
- MILLER, M.A. & EAMES, L.E., 1982. Palynomorphs from the Silurian Medina Group (Lower Llandovery) of the Niagara Gorge, Lewiston, New York, U.S.A. *Palynology*, 6 : 221-254.
- NOWLAN, G.S., 1981. Late Ordovician-Early Silurian conodont biostratigraphy of the Gaspé Peninsula - a preliminary report. In : LESPERANCE, P.J. (Editor), Field Meeting, Anticosti-Gaspé, Québec, 1981, 2 : Stratigraphy and Paleontology, IUGS Subcommission on Silurian Stratigraphy Ordovician Silurian Boundary Working Group, Montréal; pp. 257-292.
- POLLOCK, C.A., REXROAD, C.B. & NICOLL, R.S., 1970. Lower Silurian conodonts from Northern Michigan and Ontario. *Journal of Paleontology*, 44 (4) : 743-764.
- RICKARD, L.V., 1975. Correlation of the Silurian and Devonian Rocks in New York. *New York State Museum and Science Service, Map and Chart Series*, N° 24, 16 pp.
- SHESHGOVA, L.I., 1974. Acritarchs of Silurian and Lower Devonian of Podolia. *Academy of Sciences of the USSR, Siberian Branch, Transactions of the Institute of Geology and Geophysics*, 81 : 36-69 (In Russian).
- SHESHGOVA, L.I., 1984. Acritarchs of Silurian of the Northern Siberian Platform. "Nauka" Siberian Division, Novosibirsk, 197 pp. (In Russian).
- SMELROR, M., 1987. Early Silurian acritarchs and Prasinophycean algae from the Ringerike District, Oslo Region (Norway). *Review of Palaeobotany and Palynology*, 52 (2/3) : 137-159.
- STOCKMANS, F. & WILLIERE, Y., 1963. Les Hystrichosphères ou mieux les Acritarches du Silurien belge. Sondage de la Brasserie Lust à Courtrai (Kortrijk). *Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie*, 71 (3) : 450-487.
- THUSU, B., 1973. Acritarchs of the Middle Silurian Rochester Formation of southern Ontario. *Palaeontology*, 16 (4) : 799-826.
- THUSU, B. & ZENGER, D.H., 1974. Middle Silurian acritarchs in the upper type Clinton Group, east-central New York. *Journal of Paleontology*, 48 (4) : 840-843.
- UYENO, T.T. & BARNES, C.R., 1981. A summary of Lower Silurian conodont biostratigraphy of the Jupiter and Chicotte formations, Anticosti Island, Québec. In LESPERANCE, P.J. (Editor), Field Meeting Anticosti-Gaspé, Québec, 1981, 2 : Stratigraphy and Paleontology, IUGS Subcommission on Silurian Stratigraphy Ordovician - Silurian Boundary Working Group, Montréal, pp. 173-184.
- VANGUESTAINE, M., 1979. Remaniements d'Acritarches dans le Siegenien et l'Emsien (Dévonien Inférieur) du Synclinorium de Dinant (Belgique). *Annales de la Société géologique de Belgique*, 101 (1978) : 243-267.
- WORSLEY, D., AARHUS, N., BASSETT, M.G., HOWE, M.P.A., MØRK, A. & OLAUSSEN, S., 1983. The Silurian succession of the Oslo Region. *Norges Geologiske undersøkelse*, 384 : 1-57.

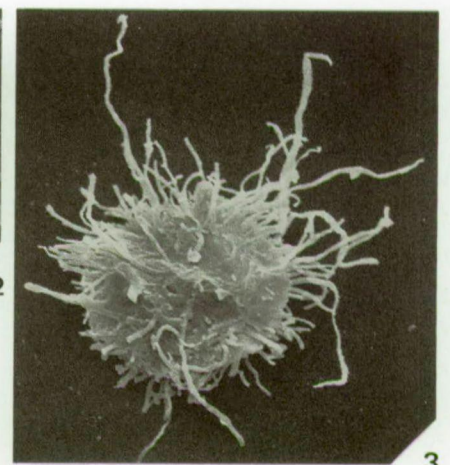
Francine MARTIN
 Section Micropaléontologie -
 Paléobotanique
 Département de Paléontologie
 Institut royal des Sciences naturelles
 de Belgique
 Rue Vautier 29
 B-1040 Bruxelles



1



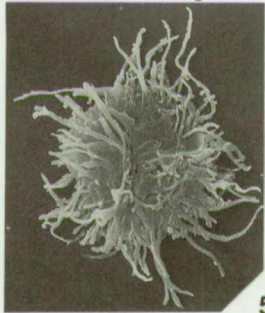
2



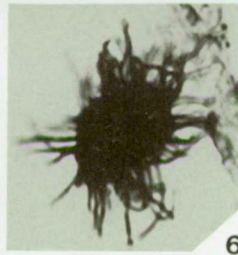
3



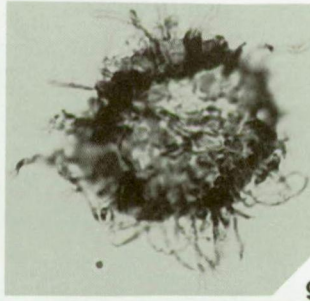
4



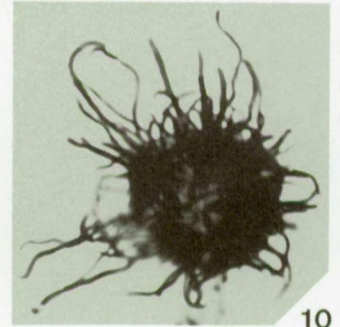
5



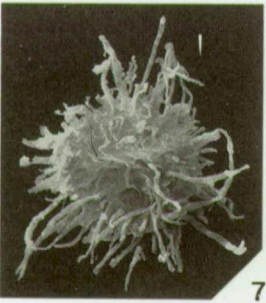
6



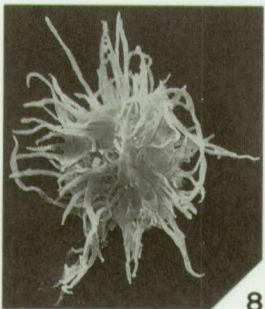
9



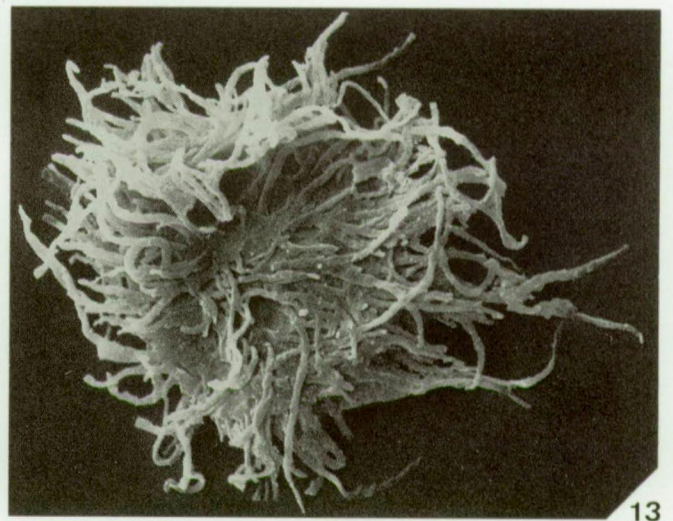
10



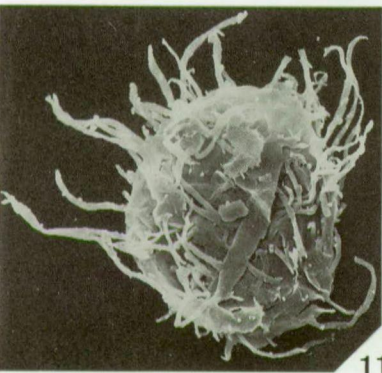
7



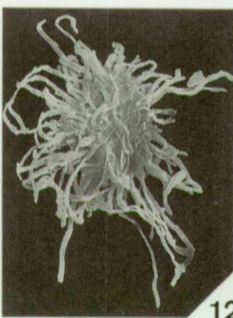
8



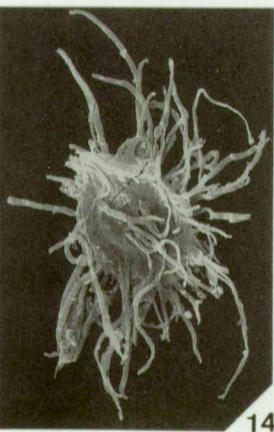
13



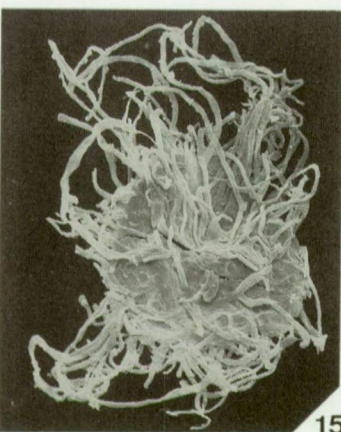
11



12



14



15



16

PLATE 1

Elektoriskos williereae (G. & M. DEFLANDRE) VANGUESTAINE, 1979, emend.

All specimens from Llandovery of Brabant Massif, Belgium, except where otherwise stated.

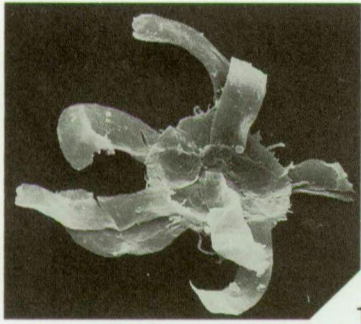
- Fig. 1. – I.R.Sc.N.B. n° b2193. LUS-172.50, × 1000.
 Figs. 2, 3. – I.R.Sc.N.B. n° b2194. LUS-158. Fig. 2 : enlargement of middle lower part in Fig. 3, × 4000. Fig. 3 : × 1000.
 Fig. 4. – I.R.Sc.N.B. n° b2195. LUS-210, × 1000.
 Fig. 5. – I.R.Sc.N.B. n° b2196. LUS-172.50, × 1000.
 Fig. 6. – I.R.Sc.N.B. n° b2197. WAL-162-3, southern Llandovery area, Wales, U.K., × 1000.
 Fig. 7. – I.R.Sc.N.B. n° b2198. LUS-210, × 1000.
 Fig. 8. – I.R.Sc.N.B. n° b2199. LUS-158, × 1000.
 Fig. 9. – I.R.Sc.N.B. n° b2200. BC-1-4, Gaspé Peninsula, Quebec, Canada, × 750.
 Fig. 10. – I.R.Sc.N.B. n° b2201. LUS-210, × 1000.
 Fig. 11. – I.R.Sc.N.B. n° b2202. STE-267, × 1000.
 Fig. 12. – I.R.Sc.N.B. n° b2203. LUS-158, × 1000.
 Fig. 13. – I.R.Sc.N.B. n° b2204. LUS-210, × 2000.
 Fig. 14. – I.R.Sc.N.B. n° b2205. LUS-172.50, × 1000.
 Figs. 15, 16. – I.R.Sc.N.B. n° b2206. LUS-172.50. Fig. 15 : × 1000. Fig. 16 : enlargement of central part in Fig. 15, × 6000.

PLATE 2

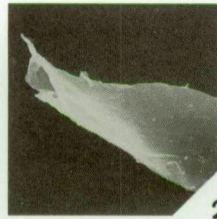
Dilatisphaera williereae (MARTIN) LISTER, 1970, emend.

All specimens from Llandovery of Brabant Massif, Belgium, except where otherwise stated.

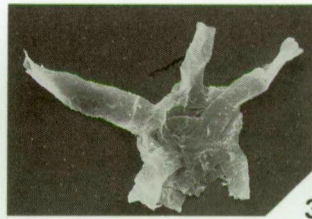
- Figs. 1, 5. – I.R.Sc.N.B. n° b2207. LUS-172.50. Fig. 1 : × 1500. Fig. 5 : enlargement of central polygonal plates in Fig. 1, × 3000.
 Figs. 2, 3. – I.R.Sc.N.B. n° b2208. LUS-158. Fig. 2 : enlargement of hollow left process in Fig. 3, × 3000. Fig. 3 : × 1000.
 Fig. 4. – I.R.Sc.N.B. n° b2209. LUS-158, × 1000.
 Fig. 6. – I.R.Sc.N.B. n° b2210. WAL-162-3, southern Llandovery area, Wales, U.K., × 750.
 Fig. 7. – I.R.Sc.N.B. n° b2211. LUS-210, × 1500.
 Figs. 8, 12. – I.R.Sc.N.B. n° b2212. LUS-158. Fig. 8 : enlargement of lower right ornamentation of vesicle in Fig. 12, × 6000.
 Fig. 12 : × 2000.
 Fig. 9. – I.R.Sc.N.B. n° b2213. WAL-162-3, southern Llandovery area, Wales, U.K., × 750.
 Fig. 10. – I.R.Sc.N.B. n° b2214. LUS-210, × 750.
 Fig. 11. – I.R.Sc.N.B. n° b2215. LUS-172.50, × 1000.
 Fig. 13. – I.R.Sc.N.B. n° b2216. LUS-210, × 2000.
 Fig. 14. – I.R.Sc.N.B. n° b2217. LUS-210, × 1500.
 Fig. 15. – I.R.Sc.N.B. n° b2218. LUS-210, × 1500.



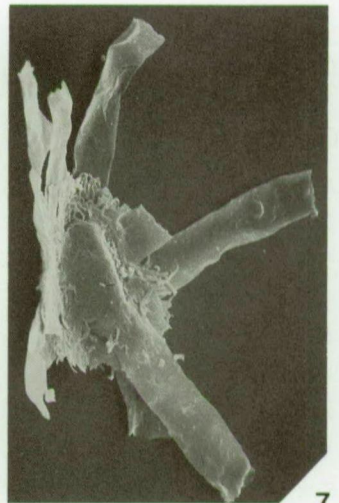
1



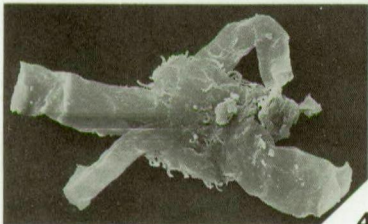
2



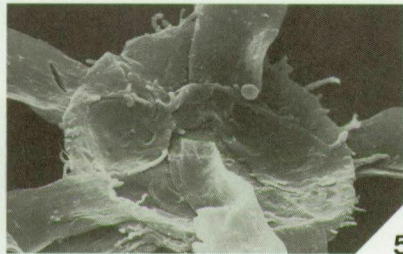
3



7



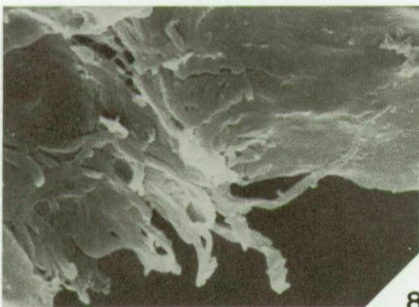
4



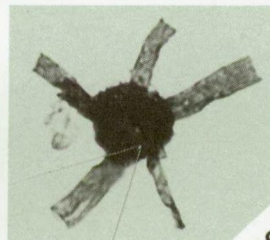
5



6



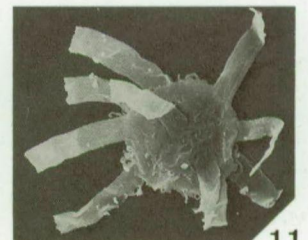
8



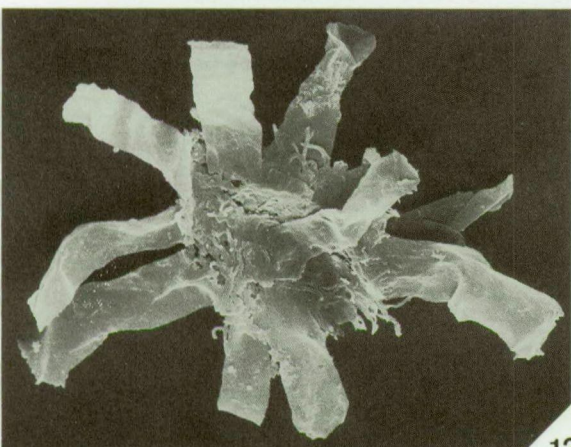
9



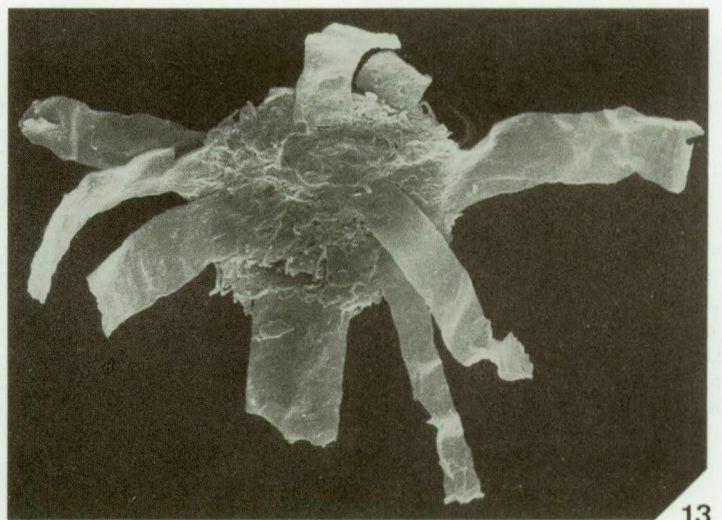
10



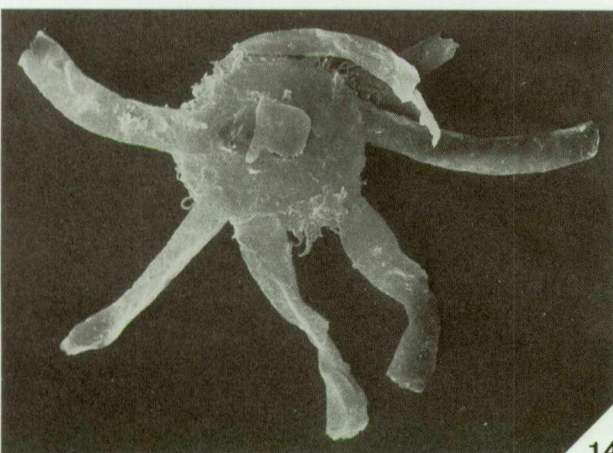
11



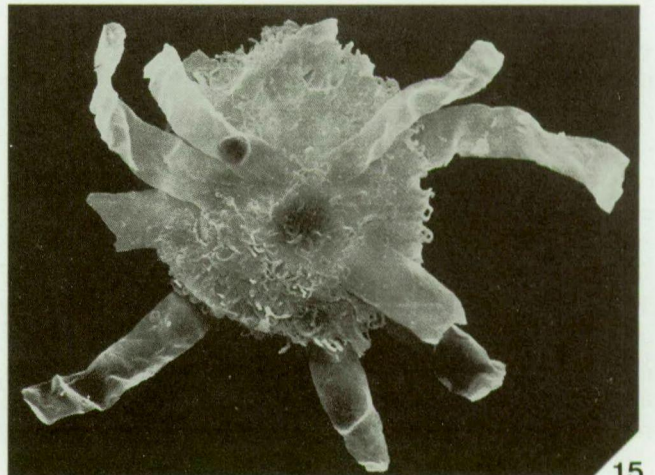
12



13



14



15