A THESIS ENTITLED

PALYNOLOGY OF THE UPPER WENLOCK SERIES (SILURIAN) OF THE MUCH WENLOCK AND LUDLOW AREAS OF SHROPSHIRE, ENGLAND.

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BY

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PALYNOLOGY OF THE UPPER WENLOCK SERIES (SILURIAN) OF THE MUCH WENLOCK AND LUDLOW AREAS OF SHROPSHIRE.

ABSTRACT.

Palynomorphs have been recovered from six localities from the type Wenlock and Ludlow series of the Much Wenlock and Ludlow areas in the Welsh Borderland, England. The assemblages contained an abundant and diverse palynoflora and palynofauna constituting elements from both the marine and terrestrial realms. Palynomorphs recovered included acritarchs, prasinophycean algae, chitinozoans and plant sporomorphs associated with scolecodonts and various palynodebris types. The samples were investigated qualitatively, semi-quantitatively, quantitatively and with fully statistical methodology.

Acritarchs were recovered from all the samples and exhibited excellent preservation. The acritarchs, prasinophytes and spores are pale yellow to brown in colour, dependent on wall thickness. The chitinozoans and scolecodonts are black while the detrital amorphous organic matter is predominantly yellow/orange. The diversity and absolute abundance of the acritarchs was high throughout the sections from the Coalbrookdale, Much Wenlock Limestone and Lower Elton formations. The effect of lithofacies and palaeoenvironment and palaeoecological tolerances upon palynomorph assemblages was apparent both in restricted distribution of some species and from lower abundances recorded from the coarse sparitic limestones.

The biostratigraphical distribution of the acritarchs and prasinophytes showed that many of the forms recovered belonged to long ranging, cosmopolitan species such as *Dictyotidium dictyotum*, *Duvernaysphaera aranaides*, *Diexallophasis simplex*, *Diexallophasis denticulata* formgroup, *Helosphaeridium pseudodictyum*, *Leiosphaeridia* spp. *Michrystridiumstellatum*, *M. inflatum*, *M. salopiense*, *Multiplicisphaeridium variabile*, *Salopidium granuliferum*, *Tasmanites* spp. and *Quadraditum fantasticum*.

A number of species with more restricted distributions were also recovered including the biozonal species *Dictyotidium amydrum* and *Eisenackidium wenlockensis*. Other species with a more restricted distribution included previously described forms such as *Muraticavea wenlockia* and *Wrensnestia ornata* along with a number of new species and genera, which are mostly retained in open nomenclature. Species of the new genus *Bellidium* were recorded with a distribution throughout the assemblages from the upper Wenlock Series. The distinctive forms defined as new species have potential use as biostratigraphic indicators. Forty-five new species of acritarch have been described systematically.
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The final dedication goes to one who heard me at every worried moment, who provided his microscope for my photos and his knowledge at any time of day and night, who came with me to Gotland, who was there with me in Pisa. Ken Dorning it is also dedicated to you!
"On Wenlock Edge the wood's in trouble..."
by A. E. Housman (1859-1936)

On Wenlock Edge the wood's in trouble
His forest fleece the Wrekin heaves;
The gale, it plies the saplings double,
And thick on Severn snow the leaves.

'Twould blow like this through holt and hanger
When Uric on the city stood:
'Tis the old wind in the old anger,
But then it threshed another wood.

Then, 'twas before my time, the Roman
At yonder heaving hill would stare:
The blood that warms an English yeoman,
The thoughts that hurt him, they were there.

There, like the wind through woods in riot,
Through him the gale of life blew high;
The tree of man was never quiet:
Then 'twas the Roman, now 'tis I.

The gale, it plies the saplings double,
It blows so hard, 'twill soon be gone:
To-day the Roman and his trouble
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Frontpiece
A View of Wenlock Edge from Caer Caradoc
from
'The Silurian System'
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2. Shadwell Quarry.
3. Coates Quarry.
4. Shadwell Quarry.
5. Mortimer Forest & Pitch Coppice.

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1. Farley Dingle.
2. Harley Hill.
3. Coates Quarry.
4. Shadwell Quarry.
5. Mortimer Forest & Pitch Coppice.

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1. Farley Dingle.
2. Shadwell Quarry.
3. Coates Quarry.
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“A party of 29 members left the Gaskell Arms at 9.45am by motor-coach, and drove 4 miles south-west along the dip slope of Wenlock Edge to Ippiken’s rock at Hilltop, where a fine view was obtained. Tea was taken at the Plough Inn. After the return to Much Wenlock, Miss Johnston showed some members to the party the conodont horizon at the foot of the north-west wall in Shadwell Rock Quarry.”

Friday September 27th, 1935.

Report of “Coral Reef” meeting at Wenlock Edge.

Director Miss D. Hill, M.Sc. Ph.D.

from Hill et al. 1936.
CHAPTER ONE

1. INTRODUCTION AND GEOLOGICAL HISTORY

1.1 LOCATION OF STUDY

The study was undertaken on Silurian rocks of late Wenlock to early Ludlow age from the type areas of Much Wenlock (SO 000 623) and Ludlow (SO 504 705) in the Shropshire Welsh Borderland. The sections studied were Farley Dingle, Harley Hill, Coates Quarry, Shadwell Quarry, Pitch Coppice and Mortimer Forest Geological Trail.

1.2 AIMS AND OBJECTIVES

The aims of the project were:

1. To establish a detailed palynomorph biostratigraphy for the upper part of the Homerian Stage of the Wenlock Series.

2. To sample and observe changes in palynomorph assemblages over the Wenlock/Ludlow boundary.

3. To relate the palynomorph assemblages to the environment of deposition.

4. To produce systematic descriptions of the palynomorphs present in the samples.

5. To evaluate the palynological data in terms of correlative value both laterally within the Welsh Basin and internationally and thus assess the value of correlation between sample localities.

Systematic descriptions and plates of the palynomorphs are presented. Taxonomy and quantitative analysis concentrate on the acritarchs and to a lesser extent the sporomorphs and chitinozoans. The presence of scolecodonts, melanosclerites and banded tubes was recorded for palynofacies interpretation, but those fossils are not described in detail.
1.3 THE SILURIAN OF THE WELSH BORDERLANDS.

Roderick Impey Murchison introduced the term Silurian in 1835 and referred to the subdivisions Llandeilo, Caradoc, Wenlock and Ludlow in his publication 'The Silurian System' (1839). The term Llandovery was first introduced by the British Geological Survey in 1857. Lapworth (1879) excluded the Caradoc and confined the Silurian to the rocks between the base of the Llandovery and the base of the Old Red Sandstone, calling the lowest group of strata the 'Valentian'. Almost a century later this was rejected by Toghill (1969) in favour of Llandovery. The Silurian System is now recognised internationally as being divided into four Series; the Llandovery, Wenlock, Ludlow and Prfdoli (Holland & Bassett 1989), (Text-fig. 1). It has a duration of about 30 million years, from 409 Ma to 439 Ma, according to Harland et al. (1989), but there is some uncertainty about the exact dates. The base of each series is defined in the British Isles (Lawson & White 1989) with the exception of the Prfdoli, which is defined at Pozary in the Czech Republic (Kríf 1989 p. 90). Each series with the exception of the Pridoli is divided into stages. The location of the boundary stratotypes is presented in Text-fig. 1.

1.4 THE WENLOCK SERIES

Murchison (1833, 1834, 1835, 1854) introduced the term Wenlock for the rocks in the Shropshire area between the 'Caradoc Sandstone', now the Llandovery Series, and the Ludlow rocks. In 1839 with the publication of The Silurian System, he grouped the Wenlock rocks as a single formation. The term was formally ratified by the International Commission on Stratigraphy in 1981 (Martinnson et al. 1981), following the revision of the sequence in the Much Wenlock area by Bassett et al. (1975). Outcrops of Wenlock strata extend from North Wales (Gwynedd) into central Wales (Ceredigion) through to South West Wales. The Wenlock also outcrops in inliers in the central and southern Welsh Borderland and Wales, including the Malvern Hills, Usk and Tortworth inliers. In the type area of the Welsh Borderlands the regional trend of the Silurian rocks is one of south easterly dip from the Much Wenlock area through Craven Arms before it is interrupted by the Ludlow anticline (Bassett. 1989), (Text-fig. 2).

1.4.1. CHRONOSTRATIGRAPHY

The Wenlock Series was divided chronostratigraphically by Bassett et al. (1975). The boundary stratotypes were defined for the bases of the divisions including the base of the Wenlock Series. Sheinwoodian and Homerian stratotypes were defined in the Wenlock area; the base of the Sheinwoodian Stage is the base of the Wenlock Series. The base of the Ludlow Series, defined at Pitch Coppice (SO 4723 7298) is coincident with the base of the Lower Elton Formation which defines the top of the Homerian Stage and the top of the Wenlock Series. The Homerian Stage is further subdivided into the Whitwell and Gleedon chronozones.
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<td></td>
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<td>Sheinwoodian</td>
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<td></td>
<td>Telychian Cefn Ceriog</td>
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<td></td>
<td>Cefn Coed, Aeron Farm</td>
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Text - fig. 1 Classification of the Silurian System showing the localities for the basal boundary stratotypes, after Holland (1989, p. 24).
Text-fig. 2. Map of Wales and the Welsh Borderlands, showing Wenlock Outcrops. (After Bassett 1974)
1.4.1.a. The Sheinwoodian Stage.
The standard section for the base of the Wenlock Series and the base of the Sheinwoodian Stage is defined in Hughley Brook, 200m south east of Leasows Farm (SO 5688 9839). The macrofauna recovered from this section was detailed by Bassett et al. (1975).

1.4.1.b. The Homerian Stage.
The Homerian stage is divided into the Whitwell and Gleedon chronozones. The boundary stratotype for the base of the Whitwell Chronozone is coincident with that for the base of the Homerian Stage and is defined at Whitwell Coppice (SO 6194 0204). In the type area the Whitwell Chronozone is related to the *Cyrtograptus lundgreni* Biozone. The standard section for the base of the Gleedon Chronozone, the upper part of the Homerian Stage, is defined in a track east of Eaton Church (SO 5016 8999) and coincides with the *lundgreni/nassa* Biozone boundary. The Gleedon Chronozone correlates with the *Gothograptus nassa* and *Monograptus ludensis* biozones. The fauna recovered from this section was detailed by Bassett et al. (1975).

Correlation of the upper boundary of the Gleedon Chronozone in the Much Wenlock area is difficult because the diagnostic graptolite faunas have not been recovered from the Much Wenlock Limestone Formation. It should be noted though that the key graptolites of the succeeding Ludlow *nilssoni* graptolite zone are known from a few metres above the Much Wenlock Limestone Formation in some localities (White 1974). A new set of graptolite biozones has recently been introduced by Zalasiewicz and Williams (1999) for the Builth Wells area, which could prove relevant to future studies in this region.

1.4.2. LITHOSTRATIGRAPHY.
The Wenlock Series succession is divided into an ascending sequence of lithostratigraphic units: the Buildwas Formation; the Coalbrookdale Formation (divided into the lower Apedale Member and upper Farley Member); and the uppermost Much Wenlock Limestone Formation. The Wenlock sequence is followed by the four lithostratigraphic units of the Ludlow Series; the Elton, Bringewood, Leintwardine and Whitcliffe groups, the base of each being identified by lithology or facies changes and the top defined at the base of the succeeding unit. It should be noted that some lithostratigraphical boundaries are not defined at points of lithological change (Holland et al. 1963). The lithostratigraphy of the Wenlock Series is shown in Text-fig. 3. The derivation of lithostratigraphic units recognised in the type Wenlock (and Ludlow) areas were described by Bassett et al. (1975).

1.4.3. GEOCHRONOLOGY.
The geochronology of the Wenlock Series has been based on fission track dates of zircons from bentonite bands from the Much Wenlock area (Ross et al. 1978, 1982, from Lawson & White 1989), (Text-fig. 3.).
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<td>Gorstian</td>
<td></td>
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<td>Buildwas Formation</td>
<td>Cymatosphaera pavimenta</td>
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Text-fig. 3. Chronostratigraphic, lithostratigraphic and biostratigraphic classification of the Wenlock Series in the Welsh Basin (from Bassett 1989), acritarch biozones from Dorning & Bell (1987), radiometric dates from Ross et al. 1978.
1.5 THE LUDLOW SERIES

Though the main focus of this research concentrates on the rocks of the Wenlock Series the basal part of the Ludlow Series has been sampled at the international boundary stratotype, Pitch Coppice (SO 4723 7255) and Shadwell Quarry, in the Much Wenlock area. The biostratigraphy chronostratigraphy and lithostratigraphy of the Ludlow Series are shown in Text-fig. 4. Only the lowermost beds of the Ludlow Series have been sampled.

1.6 PALAEOGEOGRAPHY

During the Silurian the Welsh Borderlands were part of a contracting depositional basin, elongate in a NE-SW direction, situated at the southern margin of the Iapetus Ocean. Palinspastic reconstructions indicate that southern Britain, Wales and the Welsh Borderland were situated in sub-tropical palaeolatitudes south of the equator (Cocks & Fortey 1982, Cocks & Scotese 1991).

The Llandovery Epoch commenced with a transgression, recorded over most of central Wales. In the Welsh Borderland the Llandovery rocks include poorly exposed mudstones and siltstones representative of a shelf facies. By the Wenlock Epoch, marine conditions had extended to cover most of the Welsh Borderlands (McKerrow 1979). This led to extensive development of a shallow shelf facies all along the area of Silurian outcrop in the Welsh Borderland. The rocks mainly comprise carbonates and soft shales with carbonate accumulation becoming significant at some horizons during Wenlock and Ludlow times. During the late Wenlock, reef growth became notable on parts of the shelf.

During the Wenlock Epoch the Welsh Basin is inferred to have had a steeper southern margin and a broader, more gentle shelf margin to the east as suggested by the distribution and the width of the facies belts (Bassett 1974, Siveter et al. 1989). There were two main periods of carbonate accumulation during the Wenlock, represented in the Welsh Borderland by the early Wenlock Buildwas Formation (Sheinwoodian), and the late Wenlock Much Wenlock Limestone Formation (Homerian).

The early Wenlock carbonate deposition extended discontinuously from the West Midlands through the Welsh Borderlands to the south at May Hill, Woolhope and the Malverns. Sheinwoodian strata in the Pembrokeshire area represents a bioturbated offshore shelf to deltaic succession of grey shelly calcareous silts and sandstones. The Coalbrookdale Formation, which succeeds the Buildwas Formation in the Shropshire area, marks a spread of the offshore facies into that area.

Palaeogeographic reconstructions indicate that during the late Wenlock (Homerian) the type area was situated on the eastern shelf close to the shelf edge. Sediments deposited in this environment are characterised by the limestones of the Much Wenlock Limestone Formation with patch reef development on the carbonate mud dominated shelf from the Dudley area westwards to Much Wenlock and also in the south at Usk, in South Wales.
<table>
<thead>
<tr>
<th>Formation</th>
<th>Thickness</th>
<th>Lithology</th>
<th>Benthic Association s</th>
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<td>Upper Whitcliffe</td>
<td>30m</td>
<td>Flaggy calcareous siltstones with shelly limestone bands</td>
<td>Protochonetes ludoviiensis Association</td>
<td>Visbysphaera whitcliffense</td>
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<td>leintwardinensis</td>
<td>L3</td>
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<td>30m</td>
<td>Thinely flaggy calcareous siltstones</td>
<td>Sphaerirhynchia wilsoni Association</td>
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<td>Kirkidium knightii Association</td>
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<td>Flaggy calcareous siltstones with limestone nodules</td>
<td>Mesopholidostrophia lepisca/incipiens Association</td>
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<tr>
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<td>45-105m</td>
<td>Conchoidally fracturing, shaly and thinly flaggy, muddy siltstones</td>
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<tr>
<td>Lower Elton</td>
<td>30-45m</td>
<td>Irregularly bedded, shaly and flaggy calcareous silty mudstones</td>
<td>Glassia obovata Association</td>
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Text-fig. 5. Palaeogeography of Southern Britain, at the level of the late Wenlock (Homerian), after Bassett (1992).
The fauna represented in the bioherms includes tabulate and rugose corals, stromatoporoids and bryozoa. West of this succession in the Welsh Basin, limestones of Wenlock age are absent and the sediments are represented by deep, offshore graptolitic muds as exposed, for example, in the Long Mountain succession (Siveter et al. 1989).

In east central Wales, in the area of the Church Stretton lineament offshore, shallow water algal carbonates (Dolyhir Limestone) formed in the early Wenlock, on a fault-bounded topographic high. Turbidites are found in the central part of the Welsh Basin from the late Llandovery to Wenlock. This system was defined and constrained by the Welsh Borderland Fault System, principally the Twyi Lineament. (Dimberline & Woodcock 1987, Siveter et al. 1989). The Precambrian basement of the southern landmass Pretannia has been proposed to be the source of these southern sediments. The source of the Wenlock turbidites in the Denbigh Trough is thought to be a south-western delta; from evidence of east-west sediment transport (Cummings 1957). The turbidites are interspersed with unbioturbated and unfossiliferous hemipelagites which are thought to represent cyclic deposition from spring algal blooms and winter silt discharge (Dimberline and Woodcock 1987). The palaeogeography of the late Wenlock is shown in Text-fig. 5.

The Ludlow rocks in the Ludlow and Much Wenlock areas of the Welsh Borderland are also representative of shelf environments. Palaeogeographic reconstructions indicate that the type area, characterised by carbonate deposition, was situated close to the shelf edge, whilst to the west and south in the Welsh Basin, calcareous muds rich in graptolites were deposited (Holland 1962). The early Ludlow commenced with a transgression followed by a gradual silting up of the basin (Calef & Hancock 1974). Lawson & White (1975, 1989) recorded an increase in sea level from the Middle Elton Formation followed by a shallowing, represented by the Lower Bringewood Formation. The waters deepened once more at the start of the Lower Leintwardine Formation with a broad regression until the end of the Ludfordian. This led to a change from open marine shelf facies to marine influenced mudflats during the Pridoli. Thus the broad sequence from the Ludlow to the Pridoli and the end of the Silurian is one of regression culminating with the onset of redbed fluviatile sedimentation of the early Devonian, and is representative of the closing of the Iapetus Ocean. The detailed palaeogeography is discussed in Siveter et al. (1989).

1.7 THE WENLOCK AREA

1.7.1. GEOLOGICAL SETTING.

The type area for the Wenlock Series is along Wenlock Edge which extends 29 km south west of Much Wenlock, Shropshire (Text-fig. 6.). The Wenlock Series in the Much Wenlock area comprises a sequence of highly fossiliferous limestones and shales. Limestones form the prominent escarpments such as the Wenlock and Benthall Edges (Text-fig. 7), whilst the topographically lower areas of Coalbrookdale and Apedale are where the softer shales and siltstones of the upper Llandovery and lower Wenlock outcrop. (Bassett et al. 1975).
Text-fig. 6. Geological sketch map of the type Wenlock and Ludlow areas, Shropshire, England, adapted from Siveter et al. (1989).
Text-fig. 7. A sketch of a geological section of the Wenlock Edge area showing the interrelation of the geology and the topography, prominent ridges formed from limestones and the denuded shale valleys.
1.7.2. LITHOSTRATIGRAPHY OF THE MUCH WENLOCK AREA.

The derivation of the lithostratigraphic units recognised in the type Wenlock area is described in Bassett et al. (1975). The Coalbrookdale and Much Wenlock Limestone formations together reach a maximum thickness of 330 m in the Much Wenlock area. A schematic geological section showing the rocks of the Wenlock and Ludlow series in the type area is presented in Text-fig. 8.

1.7.2.a. Coalbrookdale Formation.

The Apedale Member of the Coalbrookdale Formation consists of a sequence of monotonous, well-bedded, conchoidally fracturing, soft, olive grey to blue grey silty mudstones, with sporadic calcareous siltstones and nodular horizons. There are also numerous intercalated shaly partings and relatively thin bentonite horizons. This unit gradually becomes more calcareous upwards and there is an increase in the frequency of calcareous bands and nodular horizons of the Farley Member. The limestones occur both in coalesced nodular beds and as discreet nodular horizons and are blue grey when fresh but weather to a buff yellow, whilst the shales and siltstones weather to olive grey. The Farley Member is named after a locality where the beds are well developed in Farley Dingle (SJ 6370 0270), north of Much Wenlock. The stratotype for the base of the Farley Member is located at Harley Hill, Much Wenlock and is defined at the base of the first coalesced nodular limestone horizon at the exposure on the south side of the A458 (SJ 6090 0035). The upper 2-3m of the Farley Member grades from nodular limestones and shales into the limestones of the Much Wenlock Limestone Formation, Text-fig. 8, Text-Plate 1. a - c.

1.7.2.b. Much Wenlock Limestone Formation.

The Much Wenlock Limestone Formation has a maximum thickness of 29 m along the north-east edge of Wenlock Edge, gradually thinning to 21m south-west of Easthope at the River Onny, south of Craven Arms. The base of the Much Wenlock Limestone Formation is designated at the occurrence of the first regular, continuously bedded limestone (Text-fig. 8). This horizon is exposed on Harley Hill (SJ 6090 0035) which is the boundary stratotype for the base of the Much Wenlock Limestone Formation.

The sequence consists of grey nodular limestones of variable thickness ranging from thinly bedded, impure argillaceous limestones to thickly bedded, bioclastic, sparitic, shallow water reef limestones with shale and mudstone partings. Bioherm development occurs along Wenlock Edge in the interbedded more argillaceous lithofacies and reef development is widespread into the northern Much Wenlock area, at Benthall Edge. Both of these lithofacies are absent to the south west in the Ludlow area (Scoffin 1971). (Text-plate. 2, a - b.)

1.7.2.c. Lower Elton Formation.

The limestones of the Much Wenlock Limestone Formation are succeeded by alternating olive grey calcareous siltstones, mudstones and thin limestones of the Lower Elton Formation and are well exposed at Shadwell Quarry (SO 6270 0095). The rocks of the Lower Elton Formation are representative of a deeper water offshore shelf (Text-fig. 8).
Text-fig. 8. Wenlock and Ludlow series in the type areas, showing a schematic sea level curve. After Siveter et al. (1989).
Text-plate 1. Harley Hill locality showing: a. the Coalbrookdale Formation, with the transition from the b. the Apedale Member to c. the Farley Member.
Text-plate. 2. a. Coates Quarry showing the reef limestones of the Much Wenlock Limestone Formation and b. Shadwell Quarry showing: i. The reef limestones of the Much Wenlock Limestone Formation and ii. the shales and calcareous siltstones of the Lower Elton formation.
facies. The transgressive event bringing on the onset of deeper water conditions terminates the carbonate deposition (Text-fig. 8). The rocks show an increase in thickness from the SE to NW being 122 m thick in the Wenlock area and 244 m in the Leintwardine area (Earp & Haines 1971, p. 67).

1.7.2.d. Summary of Lithological Information.
The Apedale Member and the lower portion of the Farley Member were deposited below wave base, whilst the higher portion of the Farley Member and Much Wenlock Limestone Formation show storm horizons with bioclastic limestone lags and were therefore deposited above storm base. The increase in carbonate in the lower part of the Farley Member may be due to shallowing from deep shelf to moderately deep shelf environments, though the increasing amount of carbonate could be climatically driven, with a change in climate from P to S cycle conditions (Aldridge et al. 1993, Jeppsson 1990, Jeppsson et al. 1995). Thus this sequence is indicative of shallowing or climate change, Text-fig. 8. The wave base evidence is useful because it gives an indication that the depth of the water was not shallow, therefore there was probably continuous deposition. Thus it is likely that the palynomorph record is more reliable in this area in providing evidence of changing climatic conditions, compared to other sections where there may be minor breaks in deposition, (Dorning pers. comm.).

1.8 THE LUDLOW AREA:

1.8.1. GEOLOGICAL SETTING:
The Silurian sequence exposed in the type Ludlow area of Shropshire comprises a minimum of 750 m of alternating siltstones and limestones, of which approximately 265 m encompasses rocks of Wenlock age. These rocks form the Ludlow anticline (Text-fig. 9.), an asymmetric fold of which the northern limb dips at 10 - 40°N while the southern limb dips at an average 10° SE. There are two main directions of faulting associated with the anticline, one approximately parallel and the other perpendicular to the fold axis, which plunges ENE below the town of Ludlow. As in the Much Wenlock area, limestones also form prominent ridges. For further details, White & Lawson (1978) discussed the stratigraphy of sections in the Ludlow area.

1.8.2. CHRONOSTRATIGRAPHY:
The international boundary stratotype for the base of the Ludlow Series is at Pitch Coppice (SO 4723 7298), near Ludlow. The base of the Ludlow Series is coincident with the base of the Gorstian Stage and thus by definition the top of the Homerian Stage. The boundary at this locality is defined at the change from the indurated limestones of the Much Wenlock Limestone Formation (Homerian Stage of the Wenlock Series) to the argillaceous calcareous siltstones and intercalated mudstones of the Lower Elton Formation (Gorstian Stage of the Ludlow Series) (Holland 1980).
1.8.3. LITHOSTRATIGRAPHY OF THE LUDLOW AREA:

The Wenlock Series in the Ludlow area is represented by exposures of shales and mudstones of the Coalbrookdale Formation, which occupy the denuded core of the anticline. These rocks pass gradually up into the nodular limestones of the Much Wenlock Limestone Formation, which forms a V-shaped wooded escarpment. The shales are of typical shelf development whereas the Much Wenlock Limestone Formation is more argillaceous and less fossiliferous than its equivalent on Wenlock Edge. (Holland et. al. 1963).

The rocks of the Coalbrookdale Formation are poorly exposed except for a section at a farm track near Burrington. They comprise olive grey calcareous thinly bedded silty mudstones with irregular nodular limestones (Text-fig. 8). Fossils recovered from the Coalbrookdale Formation include; Dalmanites myops (Konig), Calymene sp., Phacops sp., Pristiograptus dubius (Suess) and solitary corals (Holland et al. 1963).

The lower part of the Much Wenlock Limestone Formation comprises bands of irregularly bedded, hard, olive grey, silty limestones, alternating with rocks similar to those of the underlying Coalbrookdale Formation. The limestone bands represent coalesced nodular horizons. The Much Wenlock Limestone Formation in its upper part is represented by hard nodular limestone, medium grey in colour when fresh. In contrast to the Much Wenlock area there is no reef development indicating that the area was deeper and probably closer to the shelf edge. Brachiopods, bryozoans and corals such as Favosites spp. and Heliolites interstinctus (Linnaeus) may be present but are notably fewer than in the same formation of the Wenlock Edge area. In the lower portion the brachiopods Atrypa reticularis (Linnaeus), Dolerorthis rustica (J. de C. Sowerby), Eospirifer radiatus (J. de C. Sowerby) and Sphaerirhynchia wilsoni (J. Sowerby) amongst others may be present. Graptolites recorded from the Much Wenlock Limestone include Monograptus ludensis (Murchison) (Holland et al. 1963).

Early Ludlow (Gorstian) sediments comprise fine siltstones and mudstones of the Lower Elton Formation overlain by impure limestones, succeeded by flaggy calcareous siltstones (Text-fig. 8.). These sediments are characteristic of a mid shelf environment. The characteristic fauna comprises small brachiopods and trilobites, especially long ranging forms that also occur in the rocks of the Wenlock Series, such as Atrypa reticularis (Linnaeus) and Dalmanites myops (Konig). Bentonites in the upper part of the Much Wenlock Limestone Formation and through the Elton Group provide evidence of volcanism.
Text-Fig. 9. Geological map of the eastern part of the Ludlow anticline, showing Pitch Coppice, Mortimer Forest Geological Trail and Goggin Road, based on Lawson & White (1989), adapted from Sutherland (1992).
1.9 PREVIOUS BIOSTRATIGRAPHICAL WORK

British Silurian rocks have been zoned using both macrofaunal and microfossil groups (Text-figs. 3, 12.). The details of the biostratigraphical use of macrofossils is discussed and presented graphically in a synopsis of the details of their distribution across the Wenlock/Ludlow boundary in Lawson & White (1989, p. 57), Shergold & Shirley (1968) and Shergold & Bassett (1970), and is not covered here. For details of correlation using graptolites refer to Lawson et al. (1969), Warren (1971) and Zalasiewicz & Williams (1999).

1.9.1. A BRIEF HISTORY OF LOWER PALAEOZOIC PALYNOLOGICAL AND MICROPALAEONTOLOGICAL STUDIES.

Lower Palaeozoic palynological investigations began with a study of acanthomorph and sphaeromorph acritarchs obtained from Baltic drift pebbles by Alfred Eisenack (1931). Eisenack (1954) was also the first to describe acritarchs from the Silurian rocks of the British Isles, from Wren's Nest, Dudley (Eisenack 1977). For a comprehensive history of pioneering palynological studies see Sarjeant (1961) and Deflandre (1947).

Charles Downie initiated British studies of palynomorphs in the Welsh Borderland (Downie 1958, 1959, 1960, 1963) and published extensively on the subject (1973, 1984); he was first to use palynomorphs biostratigraphically in this region (Downie 1963). Palynomorphs from the British Wenlock Series were first studied by Downie (1959, 1963) who concentrated on the acritarchs from the Buildwas and Coalbrookdale formations. Further detailed studies of Wenlock acritarchs were made by Lister (1968), who utilised the restricted ranges of certain acritarchs and chitinozoans to establish assemblage biozones in the type Wenlock and Ludlow sequences, concentrating on the standard succession around Ludlow. Lister (1970) published a monograph on the acritarchs from the British Ludlow Series in which he revised several taxa and erected new genera. Lister & Downie (1974) described the stratigraphic distribution of acritarchs from the Ludlow Series of the type area and detailed the ranges of 84 stratigraphically important species. Aldridge et al. (1979) also produced a range chart of selected acritarch species, whilst Mabillard & Aldridge (1982, 1985) studied the microfossil distribution at the base of the Wenlock Series and produced a microfossil biostratigraphy for the Llandovery / Wenlock boundary in the type area. Other work on the palynology of the Wenlock Series has been published by Aldridge et al. (1979, 1981), and Dorning (1981a, 1981b, 1981c, 1986, 1987). Hill & Dorning (1984) recognised nine distinct acritarch biozones for the Llandovery and basal Wenlock series, whilst Dorning & Bell (1987) erected 17 acritarch and prasinophyte biozones for the Silurian in Shropshire with 10 biozones for the Wenlock and Ludlow Series, of which five are in the Wenlock Series and five in the Ludlow Series (Text-fig. 10).
Text-fig. 10. Range chart of the research projects carried out on the micropalaeontology and palynology of the Silurian System as part of the Nottingham/Leicester research initiative.
The regional distribution of British Silurian acritarchs and chitinozoa was discussed by Aldridge et al. (1979), while Dorning (1981a) examined the distribution of acritarchs from the shelf area in the Welsh Borderlands correlating the deeper water, offshore and shallower, nearshore assemblages with periods of transgression and regression. Dorning also reported that low diversity assemblages are typical of nearshore and deep water environments, while diverse assemblages of moderate abundance are representative of an offshore shelf environment (Aldridge et al. 1981). Swire (1990, 1991, 1993) studied the acritarchs, chitinozoans and spores of a shelf basin transect of rocks from the Lower Wenlock Series in the type area and over a shelf basin transect. A succession of studies of the palynology and micropalaeontology of the upper Ordovician and Silurian epochs has also been undertaken as part of a research initiative at Nottingham and Leicester Universities, presented in the theses of Elliott (1996), Fielding (1996), Mabillard (1981), Mullins (1997), Sutherland (1992), Swire (1991), (Text-fig. 10).

1.9.2. PALYNOLOGICAL AND MICROPALAEONTOLOGICAL BIOSTRATIGRAPHY.

1.9.2.a. ACRITARCHS

To date the only published biozones for the acritarchs of the complete Wenlock and Ludlow series are those of Dorning & Bell (1987), (Text-fig. 11). The Coalbrookdale and Much Wenlock Limestone formations are included in the W2 - *Cymatiosphaera pavimenta*, W3 - *Eisenackidium wenlockensis* and W3 - *Dictyotidium amydrum* acritarch biozones of Dorning (1981b), Dorning (1986) and Dorning & Bell (1987). The *Cymatiosphaera pavimenta* biozone was considered recognisable as covering the total range zone of the prasinophyte *Cymatiosphaera pavimenta* along with the acme of the acanthomorphic acritarch species *Tylotopalla wenlockia* (Dorning 1981a). This biozone spans the upper Buildwas to upper Coalbrookdale formations. The *Eisenackidium wenlockensis* biozone is defined by the first appearance of *Eisenackidium wenlockensis* Dorning 1981a, with assemblages of common species including *Estiastrea granulata* (Downie) Dorning 1981a, *Hogklintia cylindrica* Dorning 1981a, *Multiplicisphaeridium wrensneistenis* Dorning 1981a, *Leptobrachion arbusculiferum* Dorning 1981a, *Dateriocradus polydactylus* Tappan & Loeblich 1971, *Cymbosphaeridium euernes* Jardine et al. 1974, *Percultisphaera pilosa* (Downie) Dorning 1981a; with other species occurring as 'rare types' in the assemblages include *Wrensneista ornata* Dorning 1981a. The base of this biozone is recognised as being close to the base of the Farley Member (Bassett in Lawson & White 1989). The *Dictyotidium amydrum* biozone is defined by the presence of the eponymous species along with common occurrences of *Dictyotidium stenodictyum* Eisenack 1965a and *Muraticavea wenlockia* Dorning 1981a. The top of this biozone extends through the Much Wenlock Limestone to the overlying Lower Elton Formation (Dorning & Bell 1987).

The Lower Elton Formation encompasses the earliest part of the L1 biozone (Dorning 1981b), and all of the *Leptobrachion longhopense* acritarch Biozone (Dorning & Bell 1987). The junction between the W3 and L1 biozones of Dorning (1981a) is 0.6m above the Series boundary at Pitch Coppice (Lawson & White 1989). The *Leptobrachion longhopense* Biozone is characterised by abundant *L. longhopense* Dorning 1981a and *Veryhachium pertonensis* Dorning 1981a, with additional occurrences of *Dateriocradus tribrachiata* (Lister) Dorning 1981a and *Neovervachium mayhillensis* Dorning 1981a. (Dorning 1981b, Dorning & Bell 1987), (Text-fig. 11).
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<td>L4 Whitcliffe Fm.</td>
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<td>Leoniella carminae</td>
<td>L3 Leintwardine Fm.</td>
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<td>Gorstian</td>
<td>Florisphaeridium castellatum</td>
<td>L2 Bringewood Fm.</td>
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<td>Homerian</td>
<td>Dictyotidium amydrum</td>
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<td>Cymatiosphaera pavimenta</td>
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<td>Formation</td>
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<td>Deunffia brevifurcata</td>
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<td>Oppilata eoplanktonica</td>
<td>Pentamerus Beds</td>
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<td>Multiplicisphaeridium fisheri</td>
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<td>Tylotopalla robustispinosa</td>
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<td>Helosphaeridium citrinipeltatum</td>
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Text-fig. 11a Acritarch biozones of Dorning 1981b and Dorning & Bell 1987.
1.9.2.b. CHITINOZOANS.

Acritarchs dominate palynomorph assemblages from Lower Palaeozoic sediments, but chitinozoans are also abundant in Silurian rocks. Chitinozoans were first studied by Eisenack in 1931 in a report on the Baltic Lower Palaeozoic. Love (1976) studied chitinozoans from rocks of the Wenlock to Ludlow series in the Welsh Borderlands. Domning (1981c) recorded the ranges of 35 chitinozoan taxa from the Wenlock and Ludlow series and recognised four chitinozoan assemblages. These assemblages are less distinctive and offer less resolution than the acritarch zones (Domning 1981a). Rombouts (1982) looked specifically at Chitinozoa of the Gleedon Chronozone from northern Europe, including data from the Welsh Borderlands, the Lake District, Sweden and Poland in his summary paper and analysing the factors controlling their distribution. Swire (1990) described chitinozoan taxa from the Sheinwoodian Stage of the Wenlock Series in the Welsh Borderland. He produced a fuller account of the chitinozoa of this interval in his unpublished thesis (1991), erecting total range biozones, including one for *Cingulochitina cingulata* Eisenack 1937 which has its first occurrence at the base of the Coalbrookdale Formation and extends into the Much Wenlock Limestone Formation (Domning 1981c).

Sutherland (1992, 1994) in a detailed study of the chitinozoans from the type Ludlow area recorded 42 species belonging to 12 genera and reported a peak in diversity at the base of the Ludfordian, in the Lower Elton Formation, decreasing through the Middle Elton and absent from the top of the formation. Chitinozoans are rare at the base of the Upper Whitchcliffe Formation and even rare or absent at the top of the formation in the Welsh Borderlands (Sutherland 1992). He also noted that chitinozoans are common in the sediments of the lowermost Ludlow Series though they become sparse through the Ludfordian, particularly in the Upper Whitchcliffe Formation (Sutherland 1992). Chitinozoans are an important biostratigraphic tool and have been studied from wide ranging areas (Taugourdeau & De Jekhowsky 1960, Magloire 1968, Paris 1981, De Bock 1982, Verniers 1981, 1982, 1999; Grahn 1996, 1997 and many others). Originally much of the data on chitinozoan biozones was restricted to localised schemes until Verniers *et al.* 1995 produced the global scheme defined upon first occurrence of short ranging indicator species. This well constrained, useful scheme proposes that the Wenlock Series be subdivided into four zones, though no zonal fossil has been ascribed to the interval covering the Wenlock/Ludlow boundary (Text-fig. 12). Further refinement of this scheme has been produced by Verniers (1999) focussing on the chitinozoan faunas of the Builth Wells area.

1.9.2.c. SPOROMORPHS.

A synopsis of the research into sporomorphs and plants from the Silurian has been detailed by Richardson & Edwards 1989). Sporomorphs form the late Wenlock Series have been studied by a number of authors in a variety of areas. In the Welsh Borderland and the Welsh Basin, reports and studies on the occurrence of sporomorphs (miospores and cryptospores) and other terrestrial debris were carried out by Downie (1963); Richardson & Lister (1969) and Burgess (1987); Burgess (1991), Burgess & Edwards (1991), Burgess & Richardson (1991) and Turner *et al.* (1995). Further North, Wenlock age sporomorphs have been reported from Scotland by Barron (1989) and Wellman (1993, 1995) and to the west in Ireland a late Wenlock poorly preserved assemblage was described by Edwards *et al.* (1983) after studies by Smith (1975. In other areas of the world Richardson & Ioannides (1973) studied samples from Libya whilst McGregor & Camfield (1976), McGregor & Narbonne (1978), Strother & Traverse (1979) and Richardson & McGregor (1986) looked at...

The use of sporomorphs and plant fossils in biostratigraphy of the Silurian commenced with a short publication by Richardson (1974) who made stratigraphic use of some spores for the Silurian and Devonian. By the mid 1980's when a number of authors were working on biostratigraphic uses of spores, a broad scheme was published by Gray (1985), who referred to Microfossil Assemblage Zones II (post mid late Llandovery to Late Wenlock series) and III (late? Wenlock to Pridoli), and Richardson (1985) published a short paper on the stratigraphic distribution of Lower Palaeozoic forms. Evidently, this was not too specific and a more detailed approach was published the following year as a biozonal scheme based upon seven sporomorph Assemblage Biozones, erected by Richardson & McGregor (1986). This scheme is detailed in Text-fig. 12. This scheme has proven international correlative value. The Assemblage Biozone that covers this area of study (Wenlock/Ludlow Boundary, Homarian to early Gorstian stages) is the *Artemopyra brevicosta* (?E. cf. *protophanus*)-*Hispanaediscus verrucatus* (cf. *S. verrucatus*) Assemblage Biozone. The zone covering the Gorstian and Ludfordian *Synorisporites libycyus*? - *Lophozonotriletes poecilomorphus* Assemblage Biozone is recorded in the Welsh Borderlands at the point of incoming of muronate sculpture.


1.8.2.d. CONODONTS.
Conodonts from the Wenlock and Ludlow Series of the British Isles have been described by Aldridge *et al.* (1980), and Aldridge (1975, 1985, 1989). Conodonts have proved useful in biostratigraphy because of their small size and ease of recovery from their host rock. Conodont biozones for the Silurian were first published on material from Austria by Walliser (1962, 1964), further details of the history of conodont research is detailed in Aldridge & Schonlaub (1989, p. 278), noting the upper Homarian common occurrence of the species *Ozarkodina bohemica bohemica* (Walliser). Recoveries of conodonts from the Wenlock/Ludlow boundary are poor (Aldridge & Schonlaub 1989, p. 227). Assemblages of these fossils have been reported from Pitch Coppice but the fauna is of low diversity and restricted to long ranging species such as *Ozarkodina excavata* (Branson & Mehl) and *Panderodus* spp. Thus it can be seen that conodonts are of limited biostratigraphic use at the interval of the Wenlock/Ludlow boundary (Aldridge 1975) in the type area though it is possible that occurrences are more prolific outside the Welsh Basin. This is exemplified by the work by Jeppsson *et al.* (1994) who used
conodonts to correlate between the Swedish island of Gotland in the mid Baltic and the Estonian island of Saaremaa. This emphasises the usefulness of an integrated approach to biostratigraphy, where conodont data is combined with palynomorph data from sections in order to gain a complete insight into the microflora and fauna, then where facies controls occurrence of fossil types, the related associations can be taken into account.

1.8.2.e. OSTRACODS.

Characteristic ostracod assemblages from the late Wenlock and early Ludlow series have been discussed in detail by Siveter (1978). Ostracod occurrences in the type areas have also been reported by Siveter (1978, 1980, 1984, 1988, 1989), Aldridge et al. (1979, 1981), Mabillard & Aldridge (1985) with further research carried out by Petersen & Lundin (1981, 1982) and Lundin & Petersen (1982). Further afield a number of authors have studied ostracods of Wenlock age, reference to these is made in Lundin et al. 1991, p. 173. A biostratigraphy based on nonpalaeocope ostracods was produced by Lundin et al. (1991), showing clear differences in assemblage faunas between the Sheinwoodian and Homerian rocks, the details of which are covered on p. 184.

Faunas from the upper part of the Apedale Member of the Coalbrookdale Formation include first appearances of species such as Undipila subspissa, Equicastanea lappacea (and Tropidotoxotis arga. (Siveter 1989, p. 256). Assemblages show increasing diversity through the Farley Member to the onset of the Much Wenlock Limestone Formation with species such as Beyrichia clausa, 'Thlipsura' v-scripta (Jones and Holl) and Promitiopsis valida (Jones and Holl). These forms have been used to correlate between the different facies of Wales and the Welsh Borderland (Siveter 1978). Specimens recovered from Pitch Coppice have been reported by Siveter (in Aldridge et al. 1980). Species included poorly preserved specimens of Beyrichia clausa (Jones & Holl) and Beyrichia sp. nov. 1 (Siveter 1978). Both of these forms range from the Wenlock into the Ludlow series, (Text-fig. 12). The correlative value of ostracods is ever increasing with further studies published increasing the knowledge on the distribution of faunas. Much work has been done in the Baltic area and Europe and this is detailed in Siveter 1989, p. 256.
<table>
<thead>
<tr>
<th>Series</th>
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<th>Conodont Biozones</th>
<th>Sporomorph Biozones</th>
<th>Chitinozoan Biozones</th>
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<td></td>
<td></td>
<td>O. crispa</td>
<td>O. snadjeri</td>
<td>poecilocomorphus-libycus</td>
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<tr>
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<td>O. snadjeri</td>
<td>P. siluricus</td>
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<td></td>
<td></td>
<td>A. ploeckensis</td>
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<tr>
<td>Ludlow</td>
<td>Ludfordian</td>
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<td></td>
<td>Gorstian</td>
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<td>Homerian</td>
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<td></td>
<td>Rhuddanian</td>
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1.10 LOCALITIES

The Wenlock Edge area is covered by the Ordnance Survey topographical maps, 1:50,000 sheet 126 (Shrewsbury) and 137 (Ludlow and Wenlock Edge). British Geological Survey geological sheets; 1: 50,000 sheets 152 (Shrewsbury) and 166 (Church Stretton) and 1: 25,000 sheets SO 59 for Wenlock Edge and parts of SO 47 and SO 57 for the Ludlow area. There is no continuous exposure in the type area thus composite sections were sampled in both the Wenlock and Ludlow areas, (Text-fig. 13.).

1.10.1 MUCH WENLOCK AREA

An overview geological sketch map of the Wenlock area with the spatial arrangement of the sample localities is presented in Text-fig. 14.

LOCALITY 1. Farley Dingle: SJ 6370 0270

Coalbrookdale Formation (Farley Member).

The roadcut at Farley Dingle on the east side of the A4169 provides an excellent section of rocks from the Farley Member of the Coalbrookdale Formation, (Text-fig. 15). This section was sampled at one metre intervals, with closer spaced samples at marked lithological changes. Twenty seven samples were collected. The sedimentological logs and sampling points are presented in Text-fig. 16, Text-plates 3 - 4. Sampling commenced at the base of the section at the northern end of the outcrop, (left hand side of Text-plate 3). The sequence was collected by means of climbing the ledges, moving southwards (to the right on Text-plates 3 and 4), though these may now be too weathered to allow such a collection technique.

LOCALITY 2. Harley Hill Farley Member Stratotype: SJ 6090 0035

Harley Hill Quarry: SJ 6127 0028

Coalbrookdale Formation and Much Wenlock Limestone Formation.

The quarry on the north side of the A 458 (SJ 6127 0028) at the crest of Wenlock Edge, exposes the Much Wenlock Limestone Formation. The roadside exposures continue down the road exposing the Farley Member of the Coalbrookdale Formation (Text-Plates 5 - 6). This section is the stratotype for the base of the Farley Member, which is located at the base of the first coalesced nodular limestone horizon at the exposure on the South side of the A458 (SJ 6090 0035). The standard section for the basal boundary of the Much Wenlock Limestone Formation is also designated at Harley Hill (SJ 6090 0035) at the first regularly bedded limestones above which nodular horizons are uncommon, (Text-fig. 18). The sampling strategy was the same as for Farley Dingle with 21 samples being collected from four composite sections along the length of the road. The first section (HH1) was collected on the right hand side of the road (facing West) the exposure being 3m E from a telegraph pole and public footpath (SJ 6095 -0034), (Text-plate 6. d – where the cones are in the background of
the photograph). Section HH2 was 4m East of this exposure, again on the right hand side of the road (SJ 6100 0032), (Text-plate 6d. foreground). While HH3, collected at the sharp bend in the road was initially collected on the left hand side of the road (facing West) and then uppermost beds were collected from the equivalent units on the right hand side of the road (6110 0031), (Text-plate 5). The lithological logs showing the sampling points are presented in Text-fig. 18.

LOCALITY 3. Coates Quarry: SO 6046 9935

Much Wenlock Limestone Formation.

Quarry on the north side of the B4371 road approximately 1.5 km south-west of Much Wenlock, (Text-fig. 19). The Much Wenlock Limestone Formation is exposed in a very good section on the north-east side of the quarry (SO 6030 9942), (Text-Plate 7). The Much Wenlock Limestone Formation here exhibits reef development with various lithofacies including interbedded nodular limestones and silty mudstones and well developed bentonites. The section collected was from the north east side of the quarry and extends to within a metre or two of the top of the Much Wenlock Limestone Formation. 12 samples were collected at approximately two metre intervals through the Much Wenlock Limestone Formation. Additional samples were collected over lithological changes. The actual exposure sampled is no longer present in Coates Quarry. The lithological logs with sampled localities are presented in Text-fig. 20.

LOCALITY 4. Shadwell Quarry: SO 6270 0095

Much Wenlock Limestone Formation and Lower Elton Formation.

Shadwell Quarry is situated 1 km north of Much Wenlock, Shropshire on the east side of the A4169 Ironbridge road (Text-fig. 21). The top of the Much Wenlock Limestone Formation and thus the base of the Lower Elton Formation is defined in the Ludlow area but is exposed in the Wenlock area here at Shadwell Quarry where units belonging to the Homerian and Gorstian stages are clearly visible. The boundary between the strata of the Much Wenlock Limestone Formation (Wenlock Series) and the Lower Elton Formation (Ludlow Series) is well exposed in this quarry. The junction is clearly differentiated lithologically, with pale reef limestones of the Much Wenlock Limestone Formation being conformably overlain by dark mudstones and siltstones of the Lower Elton Formation, (Text-Plate 8). Two sections were collected at Shadwell Quarry comprising 25 samples. The section crossing the Wenlock/Ludlow Boundary was selected for study. Eleven samples were processed from this section, (Text-fig. 22). Due to quarrying activity, this exposure is no longer present in the form in which it was sampled.
1.10.2. LUDLOW AREA

The localities sampled in the Ludlow area are shown in the sketch map, Text-fig. 23.

LOCALITY 5. Pitch Coppice Quarry: SO 4723 7298
Much Wenlock Limestone Formation/Lower Elton Formation.
Pitch Coppice is the stratotype for the Wenlock/Ludlow boundary, (Text-fig. 1). This locality is a disused quarry situated on the south side of the Ludlow-Wigmore Road, approximately one mile east of Aston Church (Text-fig. 24). The exposure comprises approximately 3 metres of the Much Wenlock Limestone Formation and 2 metres of the Lower Elton Formation. The Wenlock/Ludlow boundary is clearly defined at a lithological change (Text-plate. 10). The nodular Much Wenlock Limestone Formation is overlain by the olive - grey siltstones of the Lower Elton Formation and the boundary is located 22 cm below a bentonite layer (Holland et al. 1963 p. 139-140, Lawson and White 1989, Siveter et al. 1989). A total of 16 samples were collected from this section. The sampling was closely spaced at this locality, up to 10 cm intervals at the Wenlock/Ludlow boundary, because of the international importance of the section. Sampling was dictated by lithology, each significant change in rock type being sampled. The sample points and details of the lithology at Pitch Coppice are shown in Text-fig. 25.

LOCALITY 6. Mortimer Forest Geological Trail: SO 4716 7301 & SO 4722 7304
Much Wenlock Limestone Formation.
A series of roadside localities exist along the Ludlow - Wigmore Road, Mortimer Forest, exposing the Much Wenlock Limestone Formation and the transitional sequence from the underlying Coalbrookdale Formation. Mortimer Forest Geological Trail 1 (MFGT1), (SO 4716 7302), exposes 6 metres of alternating bands of limestone and mudstones of the Much Wenlock Limestone Formation. The change from the lower flaggy limestone to the upper nodular limestone can be observed in the section Mortimer Forest Geological Trail 2, (MFGT 2), (SO 4722 7304), (Text Fig 24). Samples were collected from the two localities the details of which are presented on the lithological logs (Text-fig. 26 a and b.), Text-Plate 11. At each locality the base of the exposure was determined as the datum, (TD) and sampling refers to height above this point.

7. HURST HILL BOREHOLE.
Samples were processed for palynological analysis from cores DH 104 and DH 105 drilled at Hurst Hill in the West Midlands by Foundation and Exploration Services, Consett. The cores are dominated by medium grey calcareous siltstones, often bioturbated with occasional calcareous nodules, laminated bands and bands of disarticulated brachiopods, other shelly debris and calcareous fragments. This section has not been systematically logged to date, but is included here because preliminary studies upon the palynofacies have been commented on in this work.
**Text-fig. 13.** Composite sections sampled in order to cover the late Wenlock/early Ludlow interval.

<table>
<thead>
<tr>
<th>Chronostratigraphy</th>
<th>Lithostratigraphy</th>
<th>Localities Ludlow Area</th>
<th>Localities Much Wenlock Area</th>
<th>Locality West Midlands</th>
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<td><strong>WHITWELL</strong></td>
<td><strong>Buildwas Formation</strong></td>
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<td><strong>SHEINWOODIAN</strong></td>
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**Sections sampled**
- PC- Pitch Coppice
- GR- Goggin Road
- MFGT - Mortimer Forest Trail
- CQ- Coates Quarry
- SQ- Shadwell Quarry
- HH- Harley Hill
- FD- Farley Dingle
- LHF Lower Hill Farm borehole (Paul Swire)
- DH104- Hurst Hill borehole (available for further research)
- BU - Burrington Track (3 spot samples collected).
Text-fig. 15 Locality map of Farley Dingle, Much Wenlock, Shropshire, England.
Grid Reference SJ 6370 0270. Scale: 12cm to 1km. (Ordnance Survey Chest Agreement: 244147.)
Text-fig. 16. Lithological Log of Farley Dingle Roadcut (grid reference: Sj 633 021), showing sample points.
Text-plate. 3. Farley Dingle roadcut, showing the excellent exposure of nodular limestone bands from the Farley Member of the Coalbrookdale Formation.
Text-plate. 4. Farley Dingle Roadcut showing, a. the excellent exposure of the Farley Member and b. the accessibility of the section enabling sampling up the stratigraphic sequence.
Text-fig. 17. Locality map of Harley Hill, Much Wenlock, Shropshire, England, showing the sample positions HH1 (Grid Reference: 6095 0034); HH2 (Grid Reference: 6100 0032); and HH3, (Grid Reference SJ 6110 0031/0032). Scale: 12cm to 1km. (Ordnance Survey Chest Agreement: 244147.)
Text Fig. 18. Lithological log showing sample localities for the composite section Harley Hill, Much Wenlock, Shropshire, England. (SJ 610 003).
Text-plate 6. A selection of views at Harley Hill, Much Wenlock, Shropshire:
a. sample point HH2-800; b. sample point HH3-200; c. The Farley Member;
d. sample locality HH2; e. sample point HH3 100; f. sample locality - part of HH3;
g. sample point HH3-100.
Text-plate 5. Harley Hill locality. The road climbs up the scarp of the softer Coalbrookdale Formation over the hill crest of the resistant capping Much Wenlock Limestone Formation.
Text-fig. 19 a. Location of Coates Quarry, Much Wenlock, Shropshire, England. Grid reference SO 6046 9935. (Ordnance Survey Chest Agreement: 244147.) Scale: 10 cm = 1 km

Text-fig. 19 b. Sketch map of Coates Quarry showing the sample locations a. (CT1-9) and b. (CT11-12).
Text Fig. 20. Lithological log showing sample locations, Coates Quarry, Much Wenlock, Shropshire, England (SO 6046 9935). The prominent bentonite horizon, is a useful marker at this locality and is approximately 12.5m below the top of the Much Wenlock Limestone Formation.
Text-fig. 21 Locality map of Shadwell Quarry, Much Wenlock, Shropshire, England. Grid Reference SJ 6270 0095. Scale: 12cm to 1km. (Ordnance Survey Chest Agreement: 244147.)
Text-fig. 22. Lithological log showing sample points for locality Shadwell Quarry 2. Grid reference: SJ 6270 0095.
Text-plate 8. Photos of Shadwell Quarry, Much Wenlock, south-east face, showing:

a. The sampled section and b. a close up of the exposure showing the difference in lithology between the lower reef limestones of the Wenlock Series and shales and siltstones of the overlying Ludlow Series.
Text-plate 9. Geologically historical Ludlow as seen from Whitcliffe Common.
Text-fig 23. Localities in the Ludlow area, showing the international boundary stratotype at Pitch Coppice and Mortimer Forest Geological Trail sites. Adapted from Sutherland 1994.

Text-fig. 25. Profile of the section at Pitch Coppice (SO 4723 7298), adapted from Siveter et al. (1989).
Text-fig. 26 a. Lithological log of locality Mortimer Forest Geological Trail 1, showing sample points.
Text-fig. 26 b. Lithological log of locality Mortimer Forest Geological Trail 2, showing sample points.
Text-plate. 11. Localities Mortimer Forest Geological Trail 1: photographs a - d; and Mortimer Forest Geological Trail 2: photographs e - h, showing the Much Wenlock Limestone Formation in the Ludlow area.
CHAPTER TWO

METHODS

2.1 FIELD AND LABORATORY METHODOLOGY

2.1.1. SAMPLING

At each locality sedimentological logs were constructed and photographs were taken. A combination of channel and spot sampling techniques were used. Samples were collected from the sections at one metre intervals with closer sampling intervals where there were changes in lithology. Sampling was increased to every 10 cm over important lithostratigraphical and chronostratigraphical intervals such as the Wenlock/Ludlow boundary at Pitch Coppice. Each sample comprised, where possible, less than 5 cm vertical thickness of rock. The object was to compare the palynology of the samples both within a locality and between localities. The lithologies sampled included calcareous siltstones, argillaceous limestones, nodular limestones, reef limestones, shales and bentonites. Weathered horizons were avoided, as palynomorphs may be lost due to oxidation. Standard quantitative palynological preparation techniques were used to process the samples. Details of the samples including sample depth/height relative to a datum level set at the section, lithological description and dry weight processed are presented in appendix one.

2.1.2. PREPARATION TECHNIQUES

"We assume that the need for cleanliness and great care in the laboratory is appreciated in order to prevent contamination of samples and preparations" (Batten & Morrison 1983).

A summary diagram of palynological laboratory preparation techniques is presented in text-fig. 27. Efforts were made to collect fresh unweathered samples that were not contaminated by recent plant growth. Even so, some modern contaminants may have been collected thus the samples were further cleaned, which involved the removal of plant debris, lichens and mosses from the samples. Rocks were cleaned using Decon™ detergent to remove any further modern contaminants. The rock samples were then crushed until pea-sized using a pestle and mortar, a hammer or, for indurated samples, a fly press. The crushed rock was then weighed and transferred to hydrofluoric acid-resistant polypropylene containers. The labelled pots were fitted with screw tops loosely at first, to prevent pressure build up. Dissolution of the rock samples was carried out in fume cupboards. Hydrochloric acid was used first to dissolve carbonates and hydrofluoric acid to dissolve silicates. Care was taken at all stages to avoid contamination by ensuring all surfaces and equipment were clean.

For each sample 40g of crushed rock were covered with a small amount of water followed by incremental additions of 200 ml, cold hydrochloric acid (35%) to avoid an over-vigorous reaction. Strong 'effervescent' reactions were calmed by the addition of deionised water. Carbonate-rich samples produced strong reactions whereas the calcareous silts reacted quietly. The samples were left for up to 3 days to ensure that the ferroan carbonates were dissolved. It
was necessary to ensure the complete removal of carbonates to avoid the precipitation of insoluble calcium fluoride at later stages of the preparation. Hydrochloric acid was removed by repeated decanting with water until neutral and the residue was left to settle. After neutralisation dissolution of the silicates was effected by adding 200 ml of cold 40% hydrofluoric acid. The samples were stirred daily using a polypropylene rod to accelerate the reaction. Once the mineral matter was dissolved the acid was neutralised by repeated decanting with water. Care was taken not to disturb the residue. Neither oxidation nor ultrasonic treatments were carried out on the samples so that they remained suitable for quantitative palynofacies analysis.

Residues were collected in 50 ml centrifuge tubes, allowed to settle, and the excess water was poured off, the centrifuge tubes were then filled with sodium polytungstate solution (specific gravity = 2.00) for heavy liquid separation. Samples were centrifuged for 10 minutes at 2200 r.p.m. to separate the lighter organic residue from the remaining mineral matter. The organic fraction, concentrated at the top of the sodium polytungstate was carefully removed and passed through a sieve tower, which was placed on an airtight rubber bung fitted to a specially designed polypropylene Buchner Filter Flask. The flask was then attached to a pump, a vacuum created by a flow of water from the tap, in order to speed up the filtering of the sample. Filtering and washing of the residue was carried out by washing the sample through with deionised water. This facilitated reclamation of residual sodium polytungstate. This technique was developed with initial advice from Rae Jones from the Centre for Palynological Studies, Sheffield. A 53 \( \mu \text{m} \) sieve was used to separate most of the chitinozoans while sieve meshes of aperture 10 \( \mu \text{m} \) and 5 \( \mu \text{m} \) were used for the concentration of acritarchs. Separation of the acritarchs and chitinozoans was rarely complete.

2.1.3. QUANTITATIVE SLIDE PREPARATION

Standard proportions/weights of the sample were processed to maintain the quantitative aspect to the study. The residues were collected in graduated vials. The vials were filled to the upper graduation line with deionised water. The residue and deionised water was thoroughly mixed using a pipette. Using the graduation lines on the each vial a quarter of the residue was collected with the pipette and mounted on 22 mm x 22 mm coverslips. This procedure was repeated for each of the 53 \( \mu \text{m} \) and 10 \( \mu \text{m} \) fractions. The 10 \( \mu \text{m} \) fractions were usually strew mounted over four coverslips while the 53 \( \mu \text{m} \) residues were mounted over two. Where abundances dictated, the number of mounts was altered accordingly. Cellosizer\textsuperscript{TM} was used as a dispersal agent and the coverslips and the slides were cooled slowly to avoid clustering of the organics. The coverslips were mounted onto microscope slides using Petropoxy\textsuperscript{TM} 154 resin. The remaining residue and the 5 \( \mu \text{m} \) fractions were kept for future use. The slides were not stained.

2.1.4. ANALYTICAL PROCEDURE

Logging was carried out using a Leitz Aristoplan photomicroscope. The 10-53 \( \mu \text{m} \) fractions and the 53 \( \mu \text{m}+ \) fractions were logged separately for acritarchs/prasinophycean algae and chitinozoans. A complete log of the entire sample was not possible due to time constraints, therefore a 500+ count was made for the acritarchs/prasinophycean algae and an equivalent number of traverses per slide for the chitinozoans. Logging commenced two traverses into the slide because strew mounting may result in an uneven distribution at the edge of a coverslip. A record was kept of the number of traverses per slide for each sample.
Palynological Preparation Procedure

1. Sample cleaned with detergent (Decon) and crushed to 5 - 10mm pieces.
2. 40g (dry weight) digested using HCl(aq) 40%.
3. Digestion of silicates using HF(aq) 35%.
4. Residue placed in centrifuge tube with Sodium Polytyrositite S.G. 2.0.
5. Sample agitated to mix fully with the Sodium Polytyrositute. Centrifuged at 2200rpm for 10 min.
8. Residue transferred to 22 x 22 mm coverslips using a pipette and dried slowly on a hotplate.
9. Residue sieved on a tower separating first the 53 micron fraction then the 10 micron fraction. Procedure carried out using a sieve pump system with polypropylene conical flask and Buchner ring.
10. 10 and 53 micron fractions transferred by pipette to graded phials.

Text Fig. 27. Palynological sample preparation technique flow chart.
2.1.5. SAMPLE DOCUMENTATION AND SLIDE REPOSITORY

Samples were numbered with a code for the location; i.e. Pitch Coppice = PC then assigned a number, referring to position in the section - PC 100 = Pitch Coppice 100 cm from the base of the section. Slides were documented with the sample number and a number reference for the slide, 1-4. Samples and slides of figured specimens have been assigned British Geological Survey ‘MPK’ accession numbers (appendix 8). The slides have been deposited in the collection at British Geological Survey, Keyworth, Nottingham, England.

2.1.6. SPECIMEN LOCATION

Specimens were located using Rivelin Finder references (Dorning 1990), which approximate to the first three digits of the England Finder reference. In the code PC100/10/1 - D40, PC100 refers to the sample location, 10/1 refers to the 10 μm fraction slide one, and D40 refers to the Rivelin Finder reference. The small size of some acritarchs makes relocation difficult, but possible with care. This was achieved by making sketches of most acritarchs deemed worthy of relocation.

2.1.7. PHOTOGRAPHY

Light photomicrographs were taken with an Olympus BH-2 photomicroscope, at Pallab Research, Sheffield, using Kodacolor gold 100 ASA film, exposed for approximately 2 seconds. The negatives were commercially processed. All photomicrographs were taken with the co-operation of Ken Doming.

2.2 METHODS OF DATA ANALYSIS

Palynology is a tool that can be used in attempting to solve a wide variety of geological problems, for instance indicator species can be used to provide precise geological ages whilst groups of species (assemblages) can be used as facies indicators, for depth estimates or evidence of the degree of primary productivity and are thus of great use in palaeoenvironmental interpretation. Acknowledging the many uses of palynomorphs in palaeontological investigations, perhaps their main advantage over all other groups is their abundance and consistency of recovery throughout rocks of the marine realm. The numerical abundances of palynomorphs ensure that they are not only of use in qualitative analytical methods but are also one of the few palaeontological tools that can provide quantitatively and statistically reliable data for interpretation. The methodology applied herein employed a holistic approach, where all the samples were looked at qualitatively and quantitatively with statistical methods applied in order to see whether any patterns in the abundance, diversity and distribution of the palynomorphs could be ascertained.
Initially the counts from the log sheets were transcribed into the Excel and Tilia spreadsheets as raw data. These were then transformed in both packages to relative abundances (percentages of the total count). The spreadsheet packages enabled different methods of data manipulation to be carried out. The varying methods used are detailed as follows:

2.2.1. QUALITATIVE ANALYSIS

An overall qualitative look at the assemblage was undertaken at the outset of the investigation. It started with the first impression a palynologist gets during the logging of the samples. It is at this primary stage that initial insights are gained such as; the species present, the degree of specific or generic dominance, palynomorph diversity and the general kind of palynomorph assemblage present. Lower Palaeozoic palynomorph assemblages are composed of acritarchs, prasinophytes, chitinozoans, plant sporomorphs, scolecodonts, foraminiferal remains and other miscellaneous palynodebris, all of which were assessed in qualitative analyses of the samples in this study.

Qualitative palynology dealt with both palynomorph assemblages and palynofacies analysis. Samples were also studied qualitatively in terms of degree of thermal alteration, palynomorph degradation, fungal disintegration and pyrite deformation. An initial qualitative assessment of the palynofacies involved studying the broad spectrum of palynodebris, noting the presence/absence and type of amorphous organic matter, melanosclerites, banded 'annular' tubes, graptolite and arthropod fragments, and other more indeterminate matter. The sum total of all these factors was then used to infer the environment of deposition, palynomorph provenance and post depositional/burial history.

2.2.1. a. THERMAL MATURATION.

Thermal maturation was determined qualitatively in order to assess the burial history of the area. As this area of palynology is a growing field in post-depositional interpretations it is dealt with in a little more detail here. The analysis of palynological data in the Lower Palaeozoic in terms of determining organic thermal maturity has been discussed by Cramer and Diez (1976b), Dorning (1986b) Legall et al. (1981), Rahmaniantari (1990) and Staplin (1969).

Palynomorphs are constructed of organic material which undergoes changes in physio-chemical structure under the influence of elevated temperatures. This leads to a change in appearance relative to different temperature regimes. This area has been studied by many researchers, in particular concerning its value in understanding and predicting areas of oil generation (Corriera 1969). In acritarchs, thermal alteration is exemplified by a progressive colour change; with increasing temperature a palynomorph will change from almost colourless, through pale yellow, golden brown, dark brown to black/opaque with a concomitant decrease in translucency, those forms that appear black also being opaque. Gutjahr (1966) has also discussed colour of acritarchs while Corriera (1970) has reported the varying degrees of colour alteration over the vesicle body of individual palynomorphs. Legall et al. (1981) introduced the first acritarch alteration index (AAI) which used the colour changes of species of Leiosphaeridia. This index was calibrated with the Conodont Alteration Index (Epstein et al. 1977), (Legall et al. 1981 p. 501). Dorning (1986) further expanded studies by comparing the progressive changes in colour in the acanthomorphic acritarchs and
comparing them to the index of Legall et al. (1981), he reported that acanthomorphs undergo the same changes as sphaeromorph forms but at higher temperatures. The effect of elevated temperature on palynomorphs has also been discussed by Staplin (1977) and with reference to the effects on spores (1982).

In this study, analysis of the degree of thermal alteration was carried out solely on the acritarchs; neither chitinozoans nor sporomorphs were used in the assessment, which was confined strictly to qualitative, 'observational' interpretations. No attempt was made at an exact calibration. The analysis was carried out during the initial stages of logging by noting the colour of various acritarch species. This included sphaeromorph forms such as Leiosphaeridia spp., thin, single walled acritarchs including Michrystridium spp. and thick double walled forms including Visbysphaera spp. All these forms were observed in order to ensure that wall thickness was not a discriminating factor when assessing the colour of the acritarchs. It should be noted that for the effective analysis of thermal maturation samples should not be oxidised, as oxidation leads to thinning of the palynomorph walls and a resultant change in colour, i.e. lightening of the specimens. None of the samples studied herein were oxidised, thus all samples were suitable for the study of palaeotemperatures.

2.2.1. b. REWORKING

Of the palynomorph groups studied, acritarchs in particular are readily reworked because of their resistant composition. Acritarchs as reworked forms are often easily recognisable because the derived forms often have a different appearance, in this particular instance the older forms have undergone higher degrees of thermal alteration. Hence this visible change allowed acritarchs to be used in assessing reworking rather than chitinozoans. A qualitative look at reworking was undertaken in this study because the presence of reworked forms and the degree to which such forms are recovered in palynological samples, can be used to infer the source area and age of the sediments in question, (McCaffrey et al. 1992), thus giving some insight into the depositional history of an area. In the Welsh Basin, Turner (1982), studied reworked Ordovician forms, but other than this, there has been little published work on reworking of palynomorphs within this area.

2.2.1. c. SYSTEMATIC PALYNOLOGY

As part of the systematic descriptions all the previously recorded taxa have been described in full and the newly described forms have mostly been treated informally. All the data referred to in the synonymy lists have been fully checked with the reprint material available. Palynology is notorious for providing the worker with a 'crockful of malign junior synonyms' (Eisenack et al. 19XX, this quote attributed to co-author Fritz Cramer), so an accurate fully checked synonymy list is desirable. However, but due to the large amount of literature the synonymy lists presented herein may by no means be complete. In the systematic descriptions, comparisons to other forms are made, measurements of the palynomorphs presented and their occurrences in the study area and in previous palynological records documented. In this instance, all records noted have been checked thoroughly and where the author is in agreement with the original record, it has been included. Again these lists are subject to data available to the author for cross checking at the time of the study.
2.2.1. d. TILIAGRAPH AS A TOOL TO AID QUALITATIVE ANALYSIS

Tilia is a package designed for palynological use, primarily aimed at Quaternary and Tertiary research the program is of excellent use for the lower Palaeozoic palynologist. Despite the usefulness of the program though it has some inherent instabilities which can result in loss of data, but after extensive familiarisation with the program and its idiosyncrasies it is seen as a valuable tool for the presentation of large datasets graphically. The data from Tilia and Tiliagraph can be analysed qualitatively in the presentation of presence absence charts, for indicating ranges of species and genera. The output from Tilia can produce kite diagrams, histograms of species occurrence and ratio indices such as Marine to Terrestrial ratios and inshore indices along with summary diagrams of the proportions of palynomorph groups, in this instance acanthomorphs, sphaeromorphs, netromorphs etc. This allows for ease of seeing the major changes in the assemblages.

The outputs from the Tiliagraph program were used in qualitative assessment of the samples. Once logging sheets were collated and the numerical data entered, the Tiliagraph charts provide the first graphical synthesis of the data in terms of presence/absence spot diagram plots, relative abundance kite diagrams and relative diversities of species and genera.

2.3. NUMERICAL ANALYSES

Qualitative data, though useful, are further enhanced by the application of numerical analyses. The importance of quantitative methodology was emphasised by Batten & Morrison (1983, p. 45), who noted that; 'it appears that palynologists seldom weigh their material prior to processing, thus comparison between studies in these terms is subjective'. Palynomorphs are unique in the palaeontological world in that they are one of the few groups of fossils that occur consistently in such high numbers that statistical analyses are valid. Both semi-quantitative as well as quantitative and fully statistical methods have been employed in the analysis of data for this study.

2.3.1. SEMI QUANTITATIVE ANALYSIS

Semi quantitative analyses of assemblage diversity, relative palynomorph abundance and palynomorph dominance were calculated from the initial data sets. The methodology is detailed here:

2.3.1. a PALYNOMORPH DIVERSITY

Palynomorph diversity is the total number of species in an assemblage. Diversity was calculated semi-quantitatively as the total number of species and genera represented in the count for the palynomorph assemblage of each sample. Diversity was calculated only for the palynofloral portion of the palynomorph assemblage. This data was used to make comparisons between assemblages.
2.3.1. b. PALYNOMORPH DOMINANCE

Palynomorph dominance was calculated as the sum of the total number of log count value for the two most abundant species logged divided by the total number of species represented in the count for each sample. Dominance was only calculated for the palynoflora. Where one species prospers at the expense of others it is seen to dominate the assemblage. The degree of dominance can be an indicator of the prevailing environmental conditions, which could either encourage or discourage certain species from flourishing or likewise affect the preservation potential of a species. Thus the degree of dominance is a valuable indicator of the environment at the time of deposition, either in terms of preferential biotic or physical conditions.

The Palynomorph Dominance Equation:

\[ D = \frac{a+b}{T} \]

where

- \( D \) = Dominance
- \( T \) = Total number of species in a sample
- \( a+b \) = Number of specimens for the two most abundant species.

2.3.1. c. RELATIVE ABUNDANCES

The relative abundances of the species and genera were expressed as percentages of the total palynomorph counts. In this way the occurrences could be compared both within an assemblage and between assemblages allowing relative abundances to be used both as an interpretative tool and as a correlative indicator.

2.3.1. d. TILIAGRAPH AS A TOOL TO AID SEMI-QUANTITATIVE ANALYSIS.

The programme Tilia was used to present the relative abundance data in the form of silhouette charts for each locality for both individual species and data grouped to generic level.
2.4 QUANTITATIVE AND STATISTICAL ANALYSIS

Quantitative and statistical analyses were used in order to deal with the large numerical data sets that resulted from logging approximately 500 acritarchs per sample. This allowed for comparisons between samples where the large number of variables (species and sample localities) involved can obscure trends. Basic procedures of several statistical methods in palaeoecology have been discussed by Shui (1993). This methodology has been followed herein. A recent useful publication on statistics, followed herein is Harper (1999).

2.4.0. METHODOLOGY OF DATA ACQUISITION AND MANIPULATION.

The data collected during the process of logging was first recorded as raw count data (presence/) on log sheets. This was then transferred to Excel™ and Tilia™ spreadsheets, still as raw counts. The raw counts were then converted to percentage occurrences and relative abundances. Care taken at this stage provided one of the most important prerequisites for carrying out quantitative and statistical analyses in that the primary data set has to be mathematically and ecologically sound (Shui 1993). The data from the log sheets was well constrained both taxonomically and biostratigraphically thus fulfilling these requirements. In addition cross checks were made between the Tilia and Excel spreadsheets to ensure consistency between the two, and moreover to minimise the inclusion of errors at this stage. The resultant data sets were then dealt with in a variety of methods that had varying degrees of quantitative/statistical value. Each method of data manipulation is detailed as follows:

Quantitative studies of the palynomorph assemblages included the following analytical methods:

1. Absolute Palynomorph Abundances.
2. Degree of Marine Influence.
   2b. Inshore Index.
   2c. Marine Influence Index.
   3a. Ratio of leiospheres and tasmanitiids to acritarchs and prasinophytes.
   3b. Ratio of prasinophytes to other marine species.
   3c. Ratio of large acritarchs to other marine species.

Statistical studies of the palynomorph assemblages used the following statistical methods and indices:

4. Diversity Indices:
   i. Fisher Index of Diversity.
   ii. Simpson’s Index of Diversity and Equitability.
5. Hierarchical Cluster Analysis
   5a. Ward’s Method.
   5b. Stratigraphically constrained cluster analysis using CONISS™.
   i. Simple Ratios
   ii. Stratigraphically constrained cluster analysis using CONISS\textsuperscript{TM}.

7. Rank abundance charts.

8. Indicator species.

2.4.1 ABSOLUTE PALYNOMORPH ABUNDANCES

Absolute abundance data for palynomorphs was calculated as numbers per gram of dry weight rock processed using the counts from the logging sheets. Absolute abundance was calculated for both acritarchs and chitinozoans; this data was used to make comparisons between the assemblages. In order to calculate absolute abundances it is necessary to control systematically the way the sample is processed and then studied. Firstly, a known weight of rock needs to be processed. In this instance normally 40 g of dry weight rock was prepared. Once the dissolution of the rock was effected and the palynomorph residues recovered, a known fraction of the total residue was mounted over a known number of coverslips, thus each slide had an equivalent residue of the fraction of the total rock weight, e.g. with 40g of original sample, of which 1/4 of the resultant residue was distributed over 4 coverslips would mean that each slide had the equivalent of 2.5g of original dry weight rock. The multi task methodology behind palynomorph preparation indicates that there are various points where loss of residue is possible; it is therefore emphasised that all efforts were made to reduce errors at this stage. As already stated in the analytical methodology, logging commenced at a known distance into the coverslip. In this case logging commenced at the equivalent traverse of 'T' on the Rivelin and England Finder reference. This was carried out to avoid bias through uneven dispersal at the edges of the slide, a factor which was also countered by the addition of a dispersant and slow drying of the residues on the coverslip. Once logging commenced a record was kept of the number of traverses per slide for each count, hence the proportion of the residue covered by the logging. From all these known factors the number of palynomorphs per gram of sediment was calculated using the following formula.

<table>
<thead>
<tr>
<th>Absolute Acritarch Abundance Equation:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbers per gram (No/g \textsuperscript{-1}) = \frac{\text{Total Palynomorph Count (acritarchs)}}{(g/slide \textsuperscript{-1}) \times (\text{no. of traverses/total no. possible})}</td>
</tr>
</tbody>
</table>
2.4.2. DEGREE OF MARINE INFLUENCE

In order to assess the degree of marine influence, a number of different methods were applied and evaluated including simple marine to terrestrial ratios, along with the Marine Influence Index and the Inshore Index adapted from Richardson & Rasul (1990). Despite the fact that a full Marine Influence Index was calculated, it was evident during the sample logging (the qualitative stage of analysis), that simple marine to terrestrial ratios were just as valid a technique, because the numerical abundance of plant sporomorphs and other matter indicative of terrestrial provenance was so low as to be deemed insignificant at qualitative levels. Hence, the low abundance of terrestrially derived material would have minimal effect on known statistical techniques. Thus simpler methods such as ratios of marine palynomorphs to terrestrially derived palynomorphs were also employed.

2.4.2.a. SIMPLE MARINE/TERRESTRIAL RATIOS.

The marine/terrestrial ratio was calculated as a simple ratio of all the marine derived palynomorphs against all the sporomorphs logged.

2.4.2. b. INSHORE INDEX.

Richardson & Rasul (1990 p. 676) developed the inshore index as an indicator of the proximity of the sediment accumulation area to the palaeoshoreline. It was calculated utilising the various marine forms using the following formula:

\[
\text{Inshore Index} = \frac{\text{sphaeromorphs + tasmanitiids + michrystriids}}{\text{above + outer neritic forms} (\text{netromorphs + acanthomorphs + polygonomorphs})} \times 100
\]

In its most simplistic form this index reflects the greater or lesser degree of terrestrial input and therefore nearshore influence to the assemblage and does not account for the many diverse factors that affect whether or not a taxon is preserved, whether or not reworking of taxa has occurred perhaps leading to a biased dataset or at the last stage of the analysis, whether a taxon has actually been counted. The index was calculated because the usage of as many analytical tools as possible on such a good data set would help evaluate the methods and would add to the datasets available for assessing such indices. In this instance the terrestrial input was negligible so for the Inshore Index sporopmorphs were not included, though it is thought by some authors that some sphaeromorphs may be of terrestrial origin.
2.4.2.c. MARINE INFLUENCE INDEX.
The marine influence index was calculated using the relative abundances of the acritarchs, chitinozoans and other marine forms divided by the above plus terrestrial forms.

\[
\text{Marine Influence Index} = \frac{\text{acritarchs + chitinozoans}}{\text{acritarchs + chitinozoans + sporomorphs}}
\]

This equation was adapted from Richardson & Rasul (1990). Swire (1991) included thin walled leiospheres in the equation as part of the terrestrial input, following the belief that these represent algal spores, this approach was not followed here as it is felt that it could unduly influence the results, without clear evidence for its basis. It has been reported that thin walled leiospheres are most abundant in nearshore environments (Dorning 1981b); this does not preclude a land plant origin but whether or not they are algal spores is conjectural.

This equation could be further enhanced by adding other elements from the palynofacies counts such as the presence of scolecodonts or banded tubes and land plant fragments, but for now the simpler approach where just the planktonic element of the assemblage was included was followed.

2.4.3. SIMPLE RATIOS OF PALYNOMORPH GROUPS
A number of other ratios were employed and plotted graphically to see if any patterns could be observed. Such ratios included:

2.4.3a. Ratio of leiospheres and tasmanitiids to acritarchs and prasinophytes.
2.4.3b. Ratio of prasinophytes to other marine species.
2.4.3c. Ratio of large acritarchs to other marine species.

2.4.4. PALYNOMORPH DIVERSITY.
Palynomorph diversity was studied quantitatively because the results can be of value in palaeoenvironmental interpretations. Many factors affect fossil species diversity: physio-chemical environmental conditions such as light, nutrient availability, temperature regimes, current activity etc.; biotic interactions including: competition, predation; and strictly geological conditions such as compaction rates and sedimentation rates, higher rates resulting in sediment dilution with resultant masked diversities, and degree of palynomorph preservation potential.

2.4.4. i. FISHER INDEX.
In order to assess quantitatively the degree of palynomorph diversity, two different methods were evaluated: the Fisher Index and Simpson's Index of Diversity and Equitability. The Fisher Index proved too time consuming to calculate for so many samples. Many authors have used the Fisher Index to infer the degree of marine influence. On
looking at this method, it was decided that to create a program to calculate the index as in Sutherland (1992) or to read off from a chart as carried out by Swire (1991) would be of little consequence as shown by the semi-quantitative analysis of palynomorph diversity for the samples. Hence it was decided that the considerably simpler Simpson's Index of Diversity and Equitability coupled with the semi-quantitative insight into sample diversity would be sufficient.

2.4.4. ii. SIMPSON'S INDEX OF DIVERSITY AND EQUITABILITY.

Simpson's Index of Diversity and Equitability has been used widely by biologists, ecologists and environmental scientists for the interpretation of population dynamics in terms of their diversity and equitability. The raw data from which species diversity is calculated is termed 'species richness', or in this case the number of species occurring in the palaeocommunity or palynomorph assemblage. In this instance, the Simpson's Diversity calculation accounts for both the species richness and the number of species/individuals recorded in the logging count. By comparison, Simpson's Equitability index looks at how evenly the individuals counted are spread amongst the species recorded (Simpson 1949). It is calculated as the proportion of the maximum value of the diversity (Broxap 1999). One notable factor about this index is that it is affected by rare types, but for example where a rare type accounts for 0.01% of an assemblage it does not greatly affect the calculation when compared to a more abundant species with say 5%+ occurrence. It is therefore important to consider the effect of common/dominant species on this index (Peet 1974) as this can result in an overestimate of similarity between samples (Shui 1993).

The Diversity index was calculated using the formula:

\[
D = \frac{1}{\sum_{i=1}^{S} \frac{1}{P_i^2}}
\]

where:

\(D\) = Simpson's Index of Diversity.

\(P_i\) = Proportion for \(i\) th species.

\(S\) = Total number of species in a sample.

The Equitability Index was calculated as follows:

\[
E = \frac{D}{D_{\text{max}}} = \frac{1}{\sum_{i=1}^{S} \frac{1}{P_i^2}} \cdot \frac{1}{S} = \frac{D}{S}
\]

where:

\(E\) = Simpson's index of Equitability

\(D_{\text{max}} = S\) (the maximum possible value of \(D\) (diversity) if the individuals were evenly distributed throughout the species present in the sample).
2.4.5. HIERARCHICAL CLUSTER ANALYSIS

Cluster analysis provides graphs of similarities and hierarchical relationships between the variables (taxa or samples). For a discussion of the problems inherent in cluster analysis see Shui (1993, p. 215 - 216, Parkes 1974). Hierarchical Cluster analysis, the graphic output of which is the dendrogram, was the chosen method for defining the following variables into groups, termed here 'clusters'. This type of analysis shows which variables (assemblages/sample localities) interrelate. There are two types of hierarchical cluster analysis; divisive and agglomerative. Divisive cluster analysis is used for large 'heterogeneous datasets' and can be used to identify outliers (Shui 1993, p. 214), thereby reducing the raw data into a size where agglomerative methods can be employed. This is where the sample data are compared statistically to those of stratigraphically adjacent samples. Other methods (minimum variance cluster and principal component analysis) have been published recently (Smith 1999), as case studies of the use of statistics in palynofacies analysis, but these have not been tested herein.

2.4.5. a. WARD’S METHOD

Ward's method of clustering (Ward 1963) was used herein, with unweighted pair group clustering, upon advice from palynologist Rochelle Broxap of Sheffield University Computing Centre. This method groups the samples on the basis of 'more average similarity between variables'. This method was confirmed as the best approach for palynological interpretations by Swann (Swann & Sandilands 1995) to Gary Mullins (pers. comm.) The analytical procedure used was that defined by Fürsich and Flessar (1991, p. 79 - 88).

All the sample localities were considered for cluster analysis and 256 species were identified from these samples; poorly defined or extremely rare forms were excluded because the spreadsheet could not hold the data for more than 256 columns. The raw abundance data were recalculated as percentage data.

Two types of analysis were carried out:

i. Q Mode Analysis of Sample Localities.

ii. R Mode Analysis of Species Relations.

i. Q mode analysis uses the sample localities as variables, based on the similarity of their component acritarch assemblages thus clustering 'like' localities. The resultant clusters in the dendrogram show which samples are more closely related. Samples with assemblages that are almost identical in composition and abundance grouping together within a cluster.

ii. R mode analysis looks at the co-occurrence of species within the samples, thus clustering species that have a tendency to associate together. Where species occur in together in samples they group together whilst species which are not found together in palynomorph assemblages will form different clusters. This analysis can therefore be used to define species associations.

The procedures for both of the above were carried out using the program SPSS and the methodology described by the statistical guide for palynologists worksheet by Rochelle Broxap (unpublished 1998).
2.4.5. a. i. HIERARCHICAL CLUSTER ANALYSIS DATA MANIPULATION

The manipulation and editing of the raw data from logging sheets for input into Hierarchical Cluster Analysis programs is open to several methodological approaches. The following approach has been employed here.

a. Data Editing

Raw data needs to be edited to some degree, though it was felt here that the least changes to the raw data the better. Editing of data sets includes the following procedures; the advantages and disadvantages of each are dealt with in turn.

1. Deletion of outliers
2. Transformation of raw data

1. Deletion of Outliers

Outliers in statistical terms are gaps in the dataset or data that differ significantly in some aspect from the norm. Examples of outliers in palynological terms include barren samples, samples where losses have occurred during processing or where a locality has not been sampled to the same intensity as other sites. Consistency in approach is the main key in interpretation. In this study the outliers have been maintained within the statistical analyses and not deleted, as the differences from the norm appear to be valid. For example sample HH3 1000 is clearly an outlier with low abundance and diversity of palynomorphs, but this is almost certainly due to lithology as this sample is from a biosparitic reef limestone. This approach follows that of Shui (1993) who stated that the removal of genuine outliers is disputable. In addition, Shubin & Sues (1991) proposed that the removal of outliers has little effect on dendrogram geometry. This has not been tested herein and provides room for further work on understanding the quantitative palynology of the area. Consequently all the raw data values from the logging sheets were included in the analysis whether or not they deviated considerably from the norm, such as those localities with extreme low abundances, taxa of restricted occurrence and barren samples.

2. Transformation of Raw Data.

Ideally data should be normalised to remove noise, for example deviations generated by outliers or the effects of sample size. In this study the data was used in the format of relative abundances and not absolute counts. Proportional data can have a number of effects on statistical analyses, so the data was transformed in Excel using the formula log(x+1); where (x+1) was used because it is not possible to make logarithms of zero (no shows). Advice on transformation of the raw data was given by Mullins (pers. comm.).
2.4.5.a. ii. DATA INTERPRETATION OF HIERARCHICAL CLUSTER ANALYSIS

Interpretations of statistical data are notoriously subjective and it is noted that the results are only 'indicative of a degree of resemblance between samples in terms of taxonomic composition' (Shui 1993).

Hierarchical cluster analysis was used to attempt to define groups of samples and groups of species in the samples collected from the type Wenlock and Ludlow areas in the Welsh Borderland. The primary focus of this objective was to see if cluster analysis was of use in analysis of lower Palaeozoic palynological samples and species assemblage, having been used extensively by Fürsich and Flessar (1991) on recent and Pleistocene molluscan faunas, p. 80. These authors further noted a potential use of this analysis in looking at the geographical distribution of communities. Hence rather than treat each sample locality separately all the localities were included in the analysis in order to see if the geographically distant areas of Wenlock and Ludlow produced different community groupings.

In analysing the dendrogram it is noted that, relative to the rescaled distance bar, a small distance cluster has a high degree of similarity whilst a high distance cluster has a low similarity. No checks were made to demonstrate that these methods are foolproof, ecologically sound or not prone to error. This task was undertaken as an initial look into statistical analyses and the more specific use of hierarchical cluster analysis on Palaeozoic microflora.

2.4.5. b. TILIAGRAPH AS A STATISTICAL TOOL.

The plots from the Tiliagraph show species frequency and species and marine terrestrial ratios. It is also possible to carry out statistical stratigraphically constrained cluster analyses and produce dendrograms.

2.4.5. b. i. STRATIGRAPHICALLY CONSTRAINED CLUSTER ANALYSIS USING CONISS.

Coniss is a cluster analysis program available within the Tilia/Tiliagraph package. The analysis was carried out on the relative abundance data for each section and was plotted as a dendrogram at the end of each Tiliagraph chart. Tilia proved of use in statistical interpretations with the application of stratigraphically constrained cluster analysis using the Coniss programme for the samples from each locality (Grimm 1987). The dendrograms cluster samples with statistically similar palynomorph assemblages, but in a stratigraphically constrained analysis it compares the data for adjacent samples. Therefore it is a useful tool for the stratigraphic palynologist.
2.4.6. RANK ABUNDANCE CHARTS.

Rank abundance was calculated using the data from the log sheets using the Rank and Percentile analysis tool in Excel. This operation facilitated recognition of the two most abundant species in each sample, the numbers of species for each sample and ranked the species in order of relative abundance.

2.4.7. INDICATOR SPECIES.

Indicator species were defined qualitatively for this study. They were used in conjunction with other qualitative and numerical analyses in palaeoenvironmental, palaeoecological and biostratigraphical analyses. Future work would see investigation into more statistical methods for identifying indicator species, or using such in a statistical method.

2.5. ERRORS

Batten (1981) has reported on areas where errors can arise in palynological analysis and those factors he detailed are recognised as problems that were encountered. Even though the sampling technique was chosen to avoid bias in data collection it cannot be ruled out that an element of bias could have occurred. Batten (1981) noted that, 'inconsistencies can be expected between two microscopists working on the same material' and 'single individual working on the same material on different occasions'. This being acknowledged, care was taken to account for these problems by using a systematic approach with specially prepared logging sheets and strict methodology interpretation so inconsistencies could be kept to a minimum. One factor of particular note is that working on different microscopes that are set up for different uses is an avoidable difficulty. After an initial start using two different models, it was decided that the only way to maintain a uniform approach during the logging of the samples was to re start using only one set of equipment. It is universally appreciated that preferential logging of the more abundant easily recognised forms or the more obvious thicker walled forms can be a factor in inducing bias into a sample data set. Every attempt was made to reduce this possibility. In addition the slides were scanned proportionally for rare types in an attempt to counter bias towards the dominant abundant forms, but perhaps this in turn could lead to a counter bias. An additional issue is that of lithology as a controlling factor on palynofacies output. Care was taken to avoid misconstruing ideas about the palynofacies output and the lithology of the sample taken into consideration when formulating the results. It is believed that the methodology used herein countered any possibilities of extremes in bias, but the problems of potential errors that can occur during the methodological and analytical stage of the study are acknowledged.
CHAPTER THREE

3. SYSTEMATIC PALYNOLOGY

3.1 INTRODUCTION

The systematic descriptions for the acritarchs, prasinophycean algae, sporomorphs and chitinozoans are arranged alphabetically. No definitive classification was undertaken, though broad classification schemes (Downie 1963) were used as a descriptive tool and used when producing Tilia charts from the statistics. Previously recorded taxa have been dealt with in a fully systematic format whilst most of the new species recorded herein have been described informally. A diagnosis has been given for each genus, with the type species and most recent emended name. Systematic descriptions of the species assigned to each genus and references to the original species diagnoses have been provided. Remarks and comparisons have been made to the original diagnosis. The dimensions of the specimens and their occurrence within the study section are presented. Where possible at least ten specimens were measured for each species, from within the logging count. In rarer forms, the total number of specimens logged were measured (as few as one specimen). The total number of specimens recorded in the quantitative logging for each species is documented in the raw count data, presented as appendix three.

Some taxa belonging to the genera *Diexallophasis* and *Veryhachium* have been included as formgroups. This is where a range of forms were recovered varying in some respects but sharing common characteristic features, and form a morphological continuum, whose end members may vary considerably, (Cramer 1964). For example specimens belonging to the species *Diexallophasis denticulata* vary in the size and number of echinae on the processes; the process length and process number, whilst taxa in the *Veryhachium trispinosum* and *Veryhachium wenlockium* formgroups all possess a triangular vesicle and the required number of processes, but vary in process length and vesicle size. Formgroups are not recognised by the ICBN or ICZN but the presence of continuous variation is clearly apparent throughout the populations, therefore it is felt that the best way to treat these species despite the rules is to refer to them as formgroups. Thereby acknowledging their morphological nature.

3.2 GROUP ACRITARCHA

The Group Acritarcha was established by Evitt (1963) to encompass palynomorphs that are not attributed to any well-founded class. Downie, Evitt & Sarjeant (1963), proposed the subgroups Acanthomorphitae, Polygonomorphitae, Prismatomorphitae, Diacromorphitae, Oomorphitae, Herkomorphitae, Pteromorphitae and Sphaeromorphitae (Text-fig. 28). This classification scheme was further discussed by Eisenack (1969a) and Downie (1973). In this systematic study acritarchs have not been split into subgroups but have been arranged alphabetically in view of the difficulty of assigning many genera to subgroups. Herkomorphs and pteromorphs are now included by many authors in the Class Prasinophyceae. The classification schemes are acknowledged though as being useful in categorising forms.
Text-fig. 28. Acritarch Morphology. Acanthomorphs a-d, Sphaeromorphs e-f, Netromorphs g-h, and the large ?benthic forms i-j.
Text-fig. 29. Acritarch cyst and process morphology after Eisenack et al. (1973)
Acritarchs are a polyphyletic group of eukaryotic, monovesiculate organic walled fossils of uncertain affinity. They are the longest ranging fossil group, occurring in sediments from the late Proterozoic to Recent and are the dominant fossils from the marine sediments of the Lower Palaeozoic. Commonly associated with the prasinophytes (green algae), acritarchs are probably algal cysts (Martin 1993, Colbath & Grenfell 1995); they are therefore classified as plants and are therefore treated under the International Code of Botanical Nomenclature (ICBN) classification rules (Deflandre 1936, Downie et al. 1963). Acritarchs have been allocated to the Cyanophyceae, Chlorophyceae, Prasinophyceae and the Dinophyceae by different authors but in reality there is little evidence available to assist in assigning the group to any existing class, though more recently molecular evidence suggests that they may be the forerunners to the dinoflagellates (Moldowan et al. 1996). Pirozynski (1976) and Colbath & Grenfell (1995) have suggested that some, though not all, acritarchs may have a fungal origin. Tappan (1980) and Downie (1984), have also discussed possible affinities for the acritarchs. Tappan (1980) also discussed the classification of acritarchs with reference to their morphology. For a full review of the acritarchs refer to Martin (1993).

3.2.1. STRUCTURE AND MORPHOLOGY

Structure and morphology are important in the diagnosis of acritarch genera and species. Acritarch walls are composed of a resistant organic compound broadly similar to sporopollenin (Niklas & Chaloner 1976), and are colourless to pale yellow in specimens that have not been thermally altered (Traverse 1988). Acritarch cysts can be single walled, double walled with the two walls in contact or double walled, with the walls separate. The body shape has been discussed by Cramer & Diez (1968) and the ornament by Tappan & Loeblich (1971) and Cramer (1970). Lister (1970) suggested terms for different process types, and produced a glossary of terms for morphological characteristics (Lister 1970, p. 24-26). Structure morphology were also described by Eisenack et al. (1973, p. 9-18) and (Williams et al. 1978). The terminology included by these authors has been used in this work, as shown by Text-fig. 29, for the general morphology and Text-fig. 30 for the different types of surface sculpture.

The general structure and morphology of the prasinophycean algae, ‘herkomorph and pteromorphs’ are distinctive from the other acritarch groups. They are characterised by having a central vesicle which bears diaphanous fields, crests or ridges. Their morphology has been discussed by Deflandre (1954), Downie et al. (1963) and in brief by Al Ameri (1984). The crests, flanges or ridges delimit vesicles into polygonal fields, crests and flanges are thinner walled than the central vesicle body, whilst ridges are similar in form but are more robust. The typical prasinophyte morphotypes recovered herein are presented in Text-fig. 31.:

a. **Cymatosphaera** Type - thicker walled central body surrounded by an outer shell composed of a thin walled ectophragm delimited into fields
b. **Glyptosphaera** Type 1. - Medium to thick walled central body ornamented with a network of anastomosing ridges formed with no preferential pattern.
c. **Glyptosphaera** Type 2. Central body delimited into a series of maze like fields by a series of anastomosing ridges.
d. *Glyptosphaera* Type 3. - Central body delimited by a radially patterned ridge, circumnavigating the cyst.

e. *Dictyotidium* like. Central body ornamented with numerous polygonal fields delimited by a series of low ridges.

f. *Dichonozonata* Type - Thick walled central body surrounded by a thin diaphanous flange arranged into a series of ridges running sinuously over the inner vesicle body with no preferential pattern, thickenings at the cyst boundary are evident.

g. *Duvernaaysphaera* Type - Inner central body surrounded by a thin diaphanous flange supported by processes radiating from the central body.

h. *Quadraditum* Type - Quadrate inner central body surrounded by a thin diaphanous flange supported by the four corners of the vesicle.

i. *Pterospermella* Type - Spherical central body bounded by an outer equatorial diaphanous flange.

### 3.3. ANTEURMA SPORITES & ANTEURMA TRICHIFORMIS

Silurian miospores were first recorded by Hoffmeister (1959) in samples from Libya. They have also been recorded by Downie (1963), Cramer (1966), Richardson & Lister (1969) and Chaloner (1970). Trilete miospores have been found in situ with *Cooksonia pertoni* in the Upper Silurian (Fanning et al. 1988). The derivation of cryptospores remains unknown. Permanent tetrads are also recovered from the Silurian (Richardson & Lister 1969, Strother & Traverse 1979, Wellman 1993). The terminology used in this study is that proposed by Potonie and Kremp (1954), the work by Strother (1991) has also been noted. The spores recorded from this stratigraphic interval are usually smooth or with very fine sculpture, such as species of *Ambitisporites* or *Retusotriletes* but during the late Wenlock Series, the proliferation of the more strongly sculptured verrucate forms becomes evident, such as species of *Synorisporites*. The typical morphotypes are presented in Text-fig. 32.

In addition to the spores, branched and unbranched tubes of organic origin, that are believed to be derived from plant matter, possibly from the terrestrial realm were studied as part of the palynofacies analysis. Systematic discussion of these forms is limited to a brief identification of different types recovered, though these divisions were not documented during the logging stage. The study of these forms follows the work of Burgess & Edwards (1991)
Text-fig 30. Acritarch surface ornament types adapted from Eisenack et al. (1973).
Text-fig. 31. Typical prasinophyte genera, showing their distinctive morphologies:

a. Cymatosphaera Type, b-d. Glyptosphaera Types 1-3, e. Dictyotidium Type, f. Dichonozonata Type, g. Quadradium Type, h. Duvernaysphaera Type, i. Pterospermella Type.
3.4. GROUP CHITINOZOA

Chitinozoans are exclusively marine microfossils (50 - 2000 μm), of unknown biological affinities, ranging from the lower Ordovician to the lower Carboniferous. Their organic composition enables the recovery of these microfossils from acid insoluble residues. The accepted view is that chitinozoans belong to the animal kingdom and they are therefore treated under ICZN rules.

3.4.1. STRUCTURE AND MORPHOLOGY

Chitinozoans have flask shaped pseudochitinous walls of variable thickness which are opaque and resistant to decay. Pseudochitin is a compound of carbon, hydrogen, oxygen and nitrogen of uncertain structural formula which behaves like chitin and sporopollenin (Collinson & Schwalb 1955). Three layers have been recognised to the chitinozoan wall; the periderm or external membrane; the ectoderm or inner membrane and the endoderm which includes internal structures such as the prosome Paris (1981). Chitinozoans range in length between 50 and 1800 m and are concentrated in the coarser fraction of the organic residues. In this study the chitinozoans were concentrated in the 53+ fraction of the residue. The wall can be psilate or sculptured and there may also be simple or complex processes. The wall may be perforated and it is often thinner orally. Internally, structures may include an operculum, prosome (Paris 1981) and/or ‘opisthosome’, (Jansonius 1964, 1967, 1969; Combaz et al. 1967, Sutherland 1992). The terminology proposed by Combaz et al. (1967, Laufeld 1974, Paris 1981) is used here. A diagram of chitinozoan structure and morphology is presented in Text-fig. 33.

3.4.2. AFFINITIES


3.5. SCOLECODONTS

Scolecodonts are elements of the polychaete feeding apparatuses of extinct Paulinitidae (polychaete annelids), (Bergman 1989) and are treated under the ICZN rules. The form taxonomy is based on isolated elements. Scolecodonts range from Cambrian to Recent, the greatest abundance being in the Palaeozoic. They are common in Silurian marine sediments from a wide range of facies; reefs, lagoons, shallow shelf, open marine and both soft and hard substrates.

Scolecodont presence has been recorded on the logging sheets (appendix 3) and counted for the palynofacies analysis; but no attempt at systematic classification has been made.
Text-fig. 32. Typical spore structure and morphology, for forms recovered in the late Wenlock/early Gorstian: a. - dyads; b, h. - loose fused tetrads; c. Hispanaediscus/Synorisporites Type - mononate/verrucate ornament; d. Emphanisporites Type - radial muri ornament; e. Tetrahedraletes Type - dark/thick inner walled, closely fused tetrads; g. - Ambitisporites Type; h. - Muronate Tetrad Type; i. - Large Tetrad Type, j. - Laevaeolancis Type.
Chitinozoan Morphology

Lagenochitinidae

- Neck
- Petaloid Neck Appendage
- Flexure
- Shoulder

Desmochitinidae

- Oral Pole
- Collarette
- Operculum
- Aboral Margin
- Aboral Pole
- Mucron

Conochitinidae

- Aperture
- Neck
- Body
- Flanks
- Body Flanks
- Mucron

Surface Ornament/Structure

- i. Smooth
- ii. Rugose
- iii. Felt
- iv. Spongy
- v. Cones & Granules
- vi. Spiny
- vii. Simple - Filose & Ramified - Branchiole elements
- viii. Bi and multipodal filose elements

3.6 SYSTEMATIC DESCRIPTIONS

Genus **ACANTHODIACRODIUM** Timofeev 1958
emend. Deflandre & Deflandre-Rigaud 1962

*Type Species.* *Acanthodiacrodium dentiferum* Timofeev 1958, p. 831, pl. 1 figs 2 - 3, pl. 3 figs. 2 from the early Cambrian.

*Original Diagnosis.* (see Timofeev 1958, p. 831, Translation from Eisenack *et al.* 1976, p. 1). "Elliptical membrane with symmetrically drawn out ends which are ornamented with spines."

*Emended Diagnosis.* (Deflandre & Deflandre-Rigaud 1962, p. 194. Translation from Eisenack *et al.* 1976, p. 1.) "Globular - ellipsoidal micro organisms; equatorial zone smooth or folded; poles similar, ornamented with hairs spines or horns; transverse wrinkles present or absent; membrane thin or with double outline."

*Remarks.* These large acritarchs have bipolar structure and well defined processes.

**Acanthodiacrodium redivivus** sp. nov.

Plate 30, fig. 2.

*Derivation of name.* The specific epithet ‘redivivus’ meaning coming back to life, from the adjective rediviv returned to life, renewed

*Holotype.* Plate 30, fig. 2. from sample CT7/10/1, Rivelin Finder reference E48, from the Much Wenlock Limestone Formation of Coates Quarry, Much Wenlock, Shropshire, England.

*Diagnosis.* A large acritarch with an elliptical vesicle of bipolar aspect bearing an ornament of short, proximally flared processes tapering to a simple acuminate tip. The processes have a triangular outline. The centre of the vesicle appears to be constricted. Mode of excystment not observed.

*Remarks.* This acritarch is only rarely recovered in Silurian strata and has been regarded as evidence of reworking as it is generally accepted that it is an Ordovician genus. An open mind as to whether the form recovered has been reworked; it has a golden yellow vesicle appearance, indicative of having undergone comparable
thermal gradients to the accompanying palynoflora, whereas obviously reworked forms are considerably darker, to dark brown in colour. It is therefore possible that this is a genuine but rare member of the palynoflora. The forms differ from large species of *Michrystridium* in the bipolar aspect to the vesicle body. *Salopidium* is generally smaller, with a spherical vesicle with proximally flared simple processes, similar in aspect in some species to those of *Acanthodiacrodium* but is not a diacromorph.

**Dimensions.**

- Vesicle diameter: 54 x 40 µm
- Process length: 8 - 12 µm
- Process base width: 10 - 12 µm
- Process Number: 11 +
- Number of specimens measured: 1.

**Occurrence.** This form was recovered as a rare type from sample CT 7/10/1 (E48), from the Much Wenlock Limestone Formation of Coates Quarry, Much Wenlock, Shropshire, England.

**Acanthodiacrodium sp. B**

Plate 30 fig. 3.

**Description** Subspherical to elliptical thick walled vesicle bearing numerous short acuminate processes, proximally flared, tapering to a simple tip. The mode of excystment not observed.

**Remarks** This form closely resembles *Acanthodiacrodium redivivus*, but does not have the restricted central portion to the vesicle or the bipolar aspect. It is likely that the form as separated here is a polar compression of the latter species, but as only one specimen was seen in this aspect, then this was not testable. As with *Acanthodiacrodium* sp. B., this may be a reworked form, but it does not show a different thermal history from unequivocal indigenous specimens.

**Dimensions.**

- Vesicle diameter: 50 µm
- Process length: 8 - 12 µm
- Process base width: 8 - 12 µm
- Process Number: 10 +
- Number of specimens measured: 1.

**Occurrence.** This form was recovered as a rare type (single specimen) from sample CT 7/10/1 (E48), from the Much Wenlock Limestone Formation of Coates Quarry, Much Wenlock, Shropshire, England.
Note: Specimens of *Acanthodiacrodium* spp. have been recorded as reworked forms from the late Sheinwoodian of the Southern Uplands (White *et al.* 1991). These have not been viewed, but perhaps they too are also not actually reworked but part of the assemblage proper.

**Genus AMMONIDium** Lister 1970.

*Type Species.* *Ammonidium microcladum* (original designation *Baltisphaeridium microcladum* Downie 1963, p. 645 pl. 92 fig. 6) Lister 1970 comb. nov., p. 48 - 50, from the Coalbrookdale Formation, Harley Brook, Shropshire.

*Diagnosis.* (Lister 1970, p. 48). "Vesicle hollow, spherical to ellipsoidal, single walled; vesicle wall smooth or sculptured. Processes numerous, evenly spaced, more or less rigid, hollow, tapering, communicating freely with the vesicle cavity; distally the processes have equifurcate distal terminations. Excystment by cryptosuture, apical or near equatorial."

*Remarks.* The genus *Ammonidium* differs from *Multiplicisphaeridium* Staplin, Jansonius & Pocock 1965 in having only one order of branching arising from a single node at the distal end of the processes. On each process the branches are all of equal length. Processes appear homomorphic in individual specimens, which contrasts with the variable irregular branching pattern of processes in specimens belonging to the genus *Multiplicisphaeridium*. Species belonging to the genus *Salopidium* Dorning 1981a differ from those assigned to *Ammonidium* by having simple processes.

*Ammonidium bifurcatum* sp. nov.

*Plate 3, figs. 1 & 2.*

*Derivation of name.* With reference to the simply bifurcate process terminations.

*Holotype.* Plate 3 figs. 1 & 2, sample FD3000/10/1, Rivelin Finder reference R44 from the Coalbrookdale Formation (Farley Member) of the Wenlock Series, Much Wenlock, Shropshire, England.
Diagnosis. Spherical to subspherical, single and medium walled finely granulate vesicle body bearing numerous long slender processes. The processes have restricted bases that are more or less equal to the vesicle diameter in length. The processes branch up to first order only, usually just with simple, low angle bifurcation of the process tips. The branching occurs from 3/4 of the way along the process length and is heteromorphic within a single specimen. Mode of excystment not observed.

Remarks. This species differs from other species assigned to this genus in the nature of the processes. The branching is simple to first order with a low angle.

Dimensions.  

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<tr>
<td>Vesicle diameter</td>
<td>16 - 20 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>12 - 16 μm</td>
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<tr>
<td>Process number</td>
<td>10 - 16</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
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Occurrence. This form was recovered in low numbers from the Much Wenlock Limestone Formation from the type area, Much Wenlock, Shropshire: Shadwell Quarry (2SH -2, 2SH -1.15) Harley Hill (HH2 600, HH3 800), and Coates Quarry (CT6). Only 5 specimens were recorded in the logging and scanning of the slides.

**Ammonidium gracilis** sp. nov.

Plate 2, fig. 2.

Derivation of name. From the Latin ‘gracia’ meaning graceful. This species was first recorded under this name by Swire (1991 unpublished Ph.D. thesis). The name has been retained here for consistency within the unpublished literature.

Holotype. Plate 2, fig. 2, sample FD1700/10/1, Rivelin Finder reference R40 from the Coalbrookdale Formation (Farley Member) of Farley Dingle, Much Wenlock, Shropshire, UK.

Diagnosis. Spherical to subspherical, thin to medium, single walled laevigate to microgranulate vesicle body bearing numerous slender, long, tapering processes which terminate in an aculeate branched tip. The process bases are wide at the junction with the vesicle body but taper rapidly and are equal to or less than the diameter of the vesicle. The processes communicate freely with the central body cavity. Mode of excystment is by simple split.
**Remarks.** This species differs from others assigned to *Ammonidium* in the slender flexuous nature of the processes and the laevigate vesicle body. *Ammonidium microcladum* has a more granulate vesicle.

**Occurrence.** This form has been recorded previously as *Ammonidium gracilis* by Swire (1991 unpublished) from the Wenlock Series (Sheinwoodian Stage) of the type area.

This form was recovered in low numbers from the Coalbrookdale and Much Wenlock Limestone formations of Wenlock Series (Homerian), from the type area, Much Wenlock, Shropshire. Shadwell Quarry; Farley Dingle.

*Ammonidium ludlovensis* (Lister 1970) Dorning 1981a

Plate 2 figs, 1, 3.

1970 *Ammonidium rigidum ludlovensis* Lister, p.50, pl. 1. figs. 6, 12-14.


1981a *Ammonidium ludlovensis* Dorning; n. stat. p. 183, no fig.

1987 *Ammonidium cf. ludlovensis* Dorning, Priewalder, p. 24, pl. 1. fig. 10 -12. text - fig. 6.

1987 *Ammonidium listerii* sp. nov. Smelror, p. 141 - 142, pl. 3, figs. 1 - 3.

1990 *Ammonidium ludlovensis*; Fensome, p. 59, no fig.

1991 *Ammonidium palmitella* Cramer & Diez 1972; Swire (unpublished), p. 163 - 164, pl. 16 figs. 9 - 10; pl. 34, fig. 1.


*Diagnosis.* (Lister 1970 p. 50). "A small variety of *Ammonidium rigidum* with an ellipsoidal vesicle; vesicle wall smooth with expanded bases (c. 2 μ), merging with vesicle, and about 15% of vesicle diameter in length; processes tapering distally and with small bifurcate to trifurcate terminations; span of terminal furcations 1-3 μ”.

*Description.* Thin, single walled ellipsoidal to subspherical, laevigate vesicle, bearing numerous short processes. The processes have slightly flared bases and taper to capitate tips. The processes are homomorphic within a single specimen. The processes communicate freely with the central body cavity. Mode of excystment by median split.
Remarks. The observed specimens conform generally to the original diagnosis. This form differs from others assigned to the genus in the very short nature of the processes and the form of the distal terminations. Except for having more processes than Lister's original material the specimens are essentially the same having an ellipsoidal vesicle and short, smooth, tapering, multifurcate processes with expanded bases. This species was only recovered as a rare type typically less than 0.1% of an assemblage where present.

**Dimensions**
- Vesicle diameter: 22 - 26 μm
- Process length: 4 - 6 μm
- Process number: 15+
- Number of specimens measured: 5

**Occurrence**
Much Wenlock Limestone Formation to the Upper Bringewood Formation of the Ludlow and Millichope areas (Lister 1970); Ludlow Series of Brittany (Deunff 1980); Upper Elton to Bringewood formations of the Ludlow Series of the Welsh Borderland (Dorning 1981a; Downie 1984); Upper Llandovery of Austria as _Ammonidium cf. ludloviensis_ (Priewalder 1987); Silurian of Ringerike, Norway (Smelror 1987 as _Ammonidium listerii_); late Ludfordian of the Whitcliffe Common Borehole (Washington-Evans 1991). This form was recorded by Swire (1991) as _A. palmitella_ from the Buildwas to Coalbrookdale formations (Sheinwoodian to Homerian) of the type area.

This species has been recovered from the upper part of the Much Wenlock Limestone Formation to the lowermost part of the Lower Elton Formation as a rare type. This species was recovered in low numbers from the Much Wenlock Limestone to Lower Elton formations from the type area, Ludlow, Shropshire: Pitch Coppice, PC 300, PC 315. and the Lower Elton Formation of Shadwell Quarry in the type Wenlock area (2SH 230).

Known Range: Wenlock to Ludlow series.

_Ammonidium microcladum_ (Downie 1963) Lister 1970.

Plate 1, figs. 3, 4, 5.

1963 *Baltisphaeridium microcladum* Downie p. 645, pl. 91, fig. 3 pl. 92, fig 6, text - fig. 3g.
1967 *Baltisphaeridium microcladum*; Lister & Downie, p. 173, no fig.
1970 *Ammonidium microcladum*; Lister, p. 49, pl. 1, figs. 1 - 5, 7 - 11, text - figs. 17, a - d.
1979 *Multiplicisphaeridium microcladum* Downie; Cramer _et al._ p. 44, no fig.

Diagnosis. (Downie 1963, p. 645). ‘Test slightly ellipsoidal, smooth or granular, spines moderately long and numerous, narrow and slightly tapering. Forking only at the tips, bifurcate, trifurcate or quadrifurcate, branches very short and thin but second order branching may occur’.

Remarks. Vesicle single walled, ellipsoidal and smooth to microgranulate. The processes are evenly spaced and rigid, communicating freely with the central body cavity. On each process the distal terminations are of equal length. Ammonidium palmitella (Cramer & Diez 1972) Doming 1981 has shorter, more numerous processes. Ammonidium waldronense (Tappan & Loeblich 1971) Doming 1981 has larger and generally bears a greater number of processes.

Dimensions. 
- Vesicle diameter: 22 - 28 μm
- Process length: 12 - 16 μm
- Process width: 1.5 μm
- Process number: 10 - 30
- Distal branches: 1 - 2.5 μm
- Number of specimens measured: 8

Occurrence. Ammonidium microcladum was first recorded from the Buildwas to Coalbrookdale formations (Sheinwoodian) of the type Wenlock Area (Downie 1963); followed by Lister (1970) who recorded occurrences from the Lower Wenlock (Buildwas Formation) Sheinwoodian to the Lower Ludlow (Elton Formation); but the figured specimens (Pl. 1, fig 1 - 5, 7 - 9 and 11) are considered to be Ammonidium waldronense, also (Pl. 1, fig. 10) does not appear to be Ammonidium microcladum. This occurrence is questioned herein, though the assemblage that the author recorded as associated with this species conforms to the assemblage characteristics witnessed in the type Wenlock area. Other records include the Wenlock to Ludlow series of Normandy, France (Rauscher & Robardet 1975); Llandovery to Wenlock Series of the Eastern USA, (Loeblich 1970, Tappan & Loeblich 1971, Cramer & Diez 1972); Wenlock Series (Much Wenlock Limestone Formation) to Ludlow Series (Lower Leintwardine Formation) of the Ludlow area (Lister & Downie 1974); Llandovery to Upper Wenlock series (Homerian) of Gotland Sweden, (Cramer
et al. 1979 as Multiplicisphaeridium microcladum; upper Llandovery Series (Hughley Shales) to the Wenlock Series (lower Much Wenlock Limestone Formation) of the Silurian of the type Wenlock and Ludlow areas, Shropshire, England (Dorning 1981a, Hill & Doming 1984); early Sheinwoodian, Wenlock Series of Scotland (Dorning 1982); Much Wenlock Limestone Formation in Dudley, Central England (Dorning 1983); Llandovery Series (Purple Shales to Wenlock Series (Buildwas Formation) of the Welsh Borderlands (Mabillard & Aldridge 1985); Much Wenlock Limestone formation of the Welsh Borderlands (Dorning & Bell 1987); Ringerike Area of Norway (Smelror 1987a); upper Llandovery to lower Wenlock Series of Austria (Priewalder 1987); Llandovery to Homerian of the Cheviot Hills, North East England (Barron 1989); upper Llandovery (När) to Ludfordian (Hemse) of Gotland (Le Hérisse 1989); Buildwas and Coalbrookdale Formations in the type Wenlock area, Woolhope Limestone and Coalbrookdale Formation of the Eastnor Park borehole, Nant-ysgollon Shales of Central Wales and the Dolyhir Limestone of the Old Radnor area, all Sheinwoodian age (Swire 1991); Silurian of the Southern Uplands (White et al. 1991); late Ludfordian of Whitcliffe Common Borehole (Washington-Evans 1992), Ludlow Series of Leinthall Quarry, Ludlow Area (Donoghue 1993).

This species has been recorded from the Coalbrookdale, Much Wenlock Limestone to lower Elton formations in the type area, Much Wenlock, Shropshire; Localities: Farley Dingle, FD 1760; Shadwell Quarry, 2SH 360; and Harley Hill HH3 300. This species varies in abundance in samples.

Known Range: Upper Llandovery to Ludlow


Plate 1, figs. 1, 2, 6.; Plate 2, figs. 4, 5, 6.

1970 Ammonidium microcladum (Downie 1963) comb. nov. Lister p. 49 - 50, pl. 1, figs. 1 - 5, 7 - 9, 11; text - figs. 17 a - d.


1972 Michrystridium clarkii Cramer & Diez, p. 167, pl. 36, fig. 66 only.


1981a *Ammonidium waldronense* (Tappan & Loeblich); Dorning n. comb. p. 183.

1983 Ammonidium microcladum; Dorning, p. 268, pl. 1, fig. 2.

1987 *Ammonidium waldronense*; Priewalder, p. 25, pl. 2. figs. 4, 5.

1989 *Ammonidium waldronense*; Le Hérisse pp. 82 - 83, pl. 7, figs. 10 - 13.

1990 *Ammonidium waldronense*; Fensome et al. p. 60, no fig.

*Holotype. Caiacorymbifer waldronensis* Tappan & Loeblich. 1971, pl. 3, fig. 1; from the late Wenlock Series, Waldron Shale of Jennings County, Indiana, USA.
Diagnosis (Tappan & Loeblich 1971, p.392). 'Vesicle ovate to subcircular in outline, ornamented with numerous processes, more than 40 visible form one side; processes hollow and communicating freely with the vesicle interior, 5 - 10 μ in length, rather rigid, up to about 2 μ in diameter at the base, tapering slowly to a furcate tip. With the light microscope the true nature of the termination is barely indicated, but with the scanning electron microscope the distal termination is shown to be a division into six small aculeate branches up to 0.35 μ in length arranged into a rosette. Wall thin slightly less than 1μ in thickness; both vesicle and process walls laevigate; excystment by a simple rupture and splitting of the vesicle wall.'

Dimensions.
- Vesicle diameter: 18 - 38 μm
- Process length: 8 - 12 μm
- Process width: 1.5 - 2 μm
- Process number: 14 - 21
- Number of specimens measured: 5

Remarks. Under the light microscope the process terminations appear capitate, the vesicle thin walled. The surface ornament of the specimens observed is foveolate to scabrate and not laevigate as recorded in the diagnosis of Tappan & Loeblich 1971. The figured specimens in Tappan & Loeblich (1971, pl. 3, fig.) also appear to be foveolate. Some of the specimens assigned to this species are large forms, (see dimensions). Le Hérisse 1989, considers A. waldronense to be a junior synonym of A. microcladum explaining the variations in specimens as being examples of intraspecific variation. The author believes this species to be distinct as Ammonidium waldronense has more processes and is larger than Ammonidium microcladum.

Occurrence. The following forms attributed to Ammonidium microcladum (Lister 1970) are here considered to be Ammonidium waldronense (Lister 1970, pl. 1 figs. 1-5, 7-9, 11.); Ammonidium waldronense has been recorded from the Upper Wenlock Series, Waldron Formation, Indiana, eastern USA. (Tappan & Loeblich 1971a); middle Wenlock Series (Coalbrookdale Formation) to early Ludlow Series (Middle Elton Formation) from the Welsh Basin (Dorning 1981a), Much Wenlock Limestone Formation in Dudley, Central England (Dorning 1983); Armstrong & Dorning (1984) reported specimens from the Chester Berg Formation (Wenlock) in Greenland; upper Llandovery to lower Wenlock of Austria (Priewaldner 1987); Sheinwoodian to Homarian of the Cheviot Hills, North East England (Barron 1989); upper Llandovery (Nâr) to Ludfordian (Hemse) of Gotland (Le Hérisse 1989); Swire (1990) recorded this species from the Buildwas and Coalbrookdale Formations (Sheinwoodian) of the Wenlock type area and the Woolhope Limestone (Sheinwoodian to Homarian) of the Eastnor Park borehole; Whitcliffe Common Core Samples, Late Ludfordian Ludlow, Shropshire (Washington-Evans 1990); Leinthall Quarry, Ludlow Series, Ludlow Area Shropshire (Donoghue 1992); Coalbrookdale Formation (Homarian), Wenlock Series from Buildwas Bank, Holbrook Coppice, near Ironbridge, Shropshire (Turner et al. 1995).
Ammonidium waldronense was recovered from the Coalbrookdale, Much Wenlock Limestone and Lower Elton formations from the Wenlock type area: Farley Dingle (FD 1760, FD2650), Shadwell Quarry; (2SH 230, 2SH 360), Harley Hill; (HH3 200). In the Ludlow area specimens were recorded from the Much Wenlock Limestone Formation of Mortimer Forest; (MFGT1 50, MFGT2 TD).

Known range: Late Llandovery to Ludlow Series.

Ammonidium sp.

Remarks. Poorly preserved specimens conforming to the generic description but not to assigned to a species are placed here.

Occurrence. Throughout the sections sampled. For further details see Tilia graphs (Appendix 5)

Genus BALTISPHAERIDIUM (Eisenack 1958) ex Eisenack 1959
emend. Staplin, Jansonius & Pocock 1965

Type Species. Ovum hispidum var. longispinosum Eisenack 1931, p. 110 - 111, pl. 5, figs 6 - 17; from an Ordovician erratic recovered in the Baltic area. Holotype lost during World War II. Neotype: Baltisphaeridium longispinosum (ex filifera) (Eisenack 1959a, p. 194, pl. 15, fig. 1), from Öland, Sweden.

Diagnosis. (Downie and Sarjeant 1963, p.89) "Hystrichospheres with spherical to oval shells not divided into fields or plates, bearing +/- numerous processes, simple, branching or ramifying, hollow to solid, always with closed tips. The processes are not connected distally and no outer shell, complete or incomplete, is present. The processes are most often of a single basic type, but processes of two or more types may be present. Mean and modal diameter of the shell greater than 20 µ"

Diagnosis. (Eiserhardt 1989, p. 89 - 90). "1. Features of major importance (represented by type material) are: Primary form of the vesicle is spherical with some tendency to polygonality. A multi-layered membrane composition is possible - but not proven. Angular proximal process contact with the vesicle, but tendency to basal
expansion is represented. The processes are homomorph, simple, evenly distributed over the vesicle, hollow and distally closed; no communication between processes and central bodies cavity. In typical cases the processes are long and slender, with narrow central lumen and solid base, which seems to be derivated from the process membrane. Process membrane more delicate and transparent than vesicle membrane.

2. Supplemented generic inventory by deducted features: Variation of vesicle geometry tends to two different final stages; these are i) a perfect spherical vesicle outline, ii) a vesicle outline of distinct irregular polygonality. Even very thin and transparent vesicle membranes are reliably deducted. If vesicle membrane is developed in this way, the process membrane is reduced analogically. Unsymmetrical process distribution and heteromorphous process outline (i.e. rare bifurcations and variation in process size) are truly within generic bounds. In the course of process multiplying, the reduction of process length seems to be a frequent attendant phenomenon. If developed, membrane ornamentation is a fine one (i.e. microgranulae, -echinae etc.).

3. Features of presumed congenerity are (present state of knowledge):
   a) processes with hollow bases,
   b) solid processes (if they can considered being derivated from hollow types),
   c) hollow processes with initial communication to the vesicle cavity (but only if such perforated base can be declared as ‘being’ derivated from a proximally closed process type)

A subcategory is characterised by constricted process bases (B. constrictum type). A second subcategory is represented by constricted and plugged process bases (B. perclareum type)- seeming a very characteristic and consistent form group. A third subcategory is represented by Baltisphaerids having a very rigid and nearly opaque vesicle membrane, whereas the processes are remarkably delicate and transparent, but without constriction and plug (Actipilion type).

Especially the congenerity of the third subcategory (Actipilion type) seems to be rather questionable - but the present state of knowledge does not permit generic exclusion: the ultrastructure of the vesicle membrane seems to be in good accordance to those of the longispinosum morphogroup (compare to Jux 1971 and note 4.1 and plate 1: 1 - 2).

The excystment mode remains one major problem in the classification of Baltisphaerids: All basic types of excystment mode are represented i.e. partial rupture, median splitting on the vesicle into two different halves, and (very rare) cyclopylomes. Nevertheless, the major part of all baltisphaerid taxa shows no distinct excystment mode (but >50% of the Öjelmyr-Baltisphaerids excysted by median or partial split). In chapter 3.4 reasons are given for the impossibility of a further subdivision on the base of excystative criteria (at the present state of knowledge).

1. The generotype (holotype and neotype) shoes no excystment aperture.
2. A cyclopylome is not constituent part of the generic protologue.
3. The major part of the specimen belonging to the longispinosum - morphogroup shows partial splitting and
only a few are to be said having a cyclopylome (the present author must emphasise that - to his knowledge such a specimen has never been pictured.)

4. The Baltisphaerosum-concept of Turner (1984) is not applicable:

4.1 Sensu ICBN gen. Baltisphaerosum is invalid because of striking differences between the diagnosis and the type material (holotype without any excystative aperture).

4.2 A classification concept which is only based on one single ontogenetic instable discriminating feature is not helpful. Validation of gen. Baltisphaerosum by designation of a suitable generotype would effect the following: the generotype of Baltisphaeridium Eis. would automatically become a nomen dubium."

Remarks. Eiserhardt (1989) provides a full summary of previous emendations of this genus. Baltisphaeridium differs from Multiplicisphaeridium in the double walled nature of the vesicle and the variable nature of the processes, i.e. in Baltisphaeridium they tend to be simple and are usually restricted from communicating freely with the vesicle interior. Oppilatale has internally restricted branching processes but is single walled. Leptobrachion has branched processes and is generally thinner walled.

Baltisphaeridium muldiensis Le Hérissé 1989

Plate 4, figs. 3, 4, 5, 6.; Plate 5, fig. 2.

1989 Baltisphaeridium muldiensis n. sp.; Le Hérissé p. 85 - 86, pl. 5, figs. 17, 18, pl. 6, figs. 1, 2.


Diagnosis. (Translated from Le Hérissé 1989, p. 85). "This species of the genus Baltisphaeridium is of small size, with a thick walled spherical vesicle ornamented with 30 - 40 narrow, cylindrical, hollow, transparent processes, the majority form simple sharp points, whilst some are bifurcate, the processes length is smaller than the diameter of the vesicle. The processes have an angular contact with the vesicle and do not communicate with the central body cavity; they are not plugged or restricted at the bases. Under the S.E.M. the trunk of the processes appear ornamented with longitudinal crests, in relief; the surface of the vesicle bears a dense, irregular microgranulation."

Description. Vesicle body subspherical, double walled with an thick inner wall and a thin outer wall. In transmitted light the vesicle wall appears laevigate. The outer wall forms the processes which do not communicate
with the central body cavity, tapering distally to fine points. The processes are heteromorphic within a single specimen most being simple but a few with distal bifurcations. The process length is generally equal to or less than the vesicle diameter. Mode of excystment is a simple split.

Remarks. The specimens recovered in this study essentially conform to the original diagnosis but differ in having fewer than the 30 - 40 processes described by Le Herissé (1989); in fact the holotype has only approximately 14 processes visible in the figure (pl. 5, fig. 17 - 18). There is a similarity between Baltisphaeridium muldiensis and Leptobrachion woolhopense Dorning 1981 p. 194, pl. 2, 8, though the vesicle and processes are of greater dimensions in the latter. There is also a visual similarity to the figured specimen of Baltisphaeridium archaicum (Cramer et al. 1972), but this species is considerably larger.

Dimensions

<table>
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<tbody>
<tr>
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<tr>
<td>Process length</td>
<td>10 - 20 μm</td>
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<tr>
<td>Process base width</td>
<td>1.5 - 2 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>7 - 16</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

Occurrence. Mulde, Klinteberg and the base of the Hemse formations, upper Wenlock to lower Ludlow Series, Gotland, Sweden (Le Herissé 1989);
This species was recovered from the Coalbrookdale, Much Wenlock Limestone and lowermost portion of the Lower Elton formations from the type Wenlock and Ludlow areas of Shropshire, England.
Known Range: Wenlock (Sheinwoodian?) to Ludlow (Gorstian) Series

Baltisphaeridium sp. B

Plate 4, fig. 2.

Description. Spherical to subspherical thick walled laevigate, matt pale brown vesicle wall in unstained specimens, bearing extremely short echinate simply terminated processes, with restricted bases.

Remarks These forms differ from B. muldiensis in the vesicle size and the very short process length.
**Baltisphaeridium sp. C**

Plate 5, fig. 1.

*Description.* Thin to medium walled vesicle body bearing numerous fine processes formed solely from the outer wall. The processes are split, a function of their extremely thin form.

*Remarks.* *B. muldiensis* has more robust processes with restricted bases and a thicker walled central body. During the logging some specimens were logged as *Leptobrachion* sp. H and some as *Baltisphaeridium* sp. C. there is a great deal of similarity between these two types and thus in retrospect it could be perhaps inferred that they are conspecific. In logging sheets, excel charts and Tiliagrams that both these names appear although they could possibly be combined

**Dimensions.**

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<td>Vesicle body diameter</td>
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<tr>
<td>Process length</td>
<td>10 - 20 μm</td>
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<td>Process width</td>
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<tr>
<td>Process number</td>
<td>8 - 12</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

*Occurrence.* This form has been recovered from the Farley Member of the Coalbrookdale Formation of Farley Dingle, Much Wenlock.

**Baltisphaeridium sp. D**

Plate 30, fig. 6.

*Description.* Robust, medium - thick walled, dark golden yellow to brown vesicle bearing a number of blunt processes with rounded process terminations. The majority of the processes are simple whilst one appears to
bifurcate distally into two short tips; this could be a preservational feature. Mode of excystment not observed.

Remarks. This form was only recovered as a rare type (single specimen in counts). It is placed with the baltisphaerids due to the thick walled vesicle body and blunt simple processes which are the characteristics that most distinguish this form.

**Dimensions.**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle body diameter</td>
<td>22 - 24 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>8 - 12 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>3 - 4 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>7</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

**Occurrence.** This form was recovered as a rare type (single specimen) from sample FD 500/10/1, from the Farley Member of the Coalbrookdale Formation of Farley Dingle, Much Wenlock, Shropshire, England.

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**Baltisphaeridium sp. E**

Plate not available.

**Description.** Vesicle body of medium thickness bearing numerous short spinose processes.

**Remarks.** Possibly a michyrstriid, recorded provisionally in open nomenclature and on the logging sheets as *Baltisphaeridium* sp. E, though it should be noted that a closely similar but a thinner walled smaller form that could be considered part of a morphological continuum has been logged as *Michrystridium* sp. E.

**Dimensions.**

<table>
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<tr>
<td>Vesicle body diameter</td>
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<td>Process length</td>
<td>4 - 6 μm</td>
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<td>Process number</td>
<td>20 +</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>2</td>
</tr>
</tbody>
</table>

**Occurrence.** This form was recovered from the Farley Member of the Coalbrookdale Formation. Sample: FD 700.
Baltisphaeridium sp. F & G

Plate 6, fig. 12.

Description. Matt dull brownish vesicle body bearing numerous short simple processes. The smaller forms are pale lemon yellow in colour.

Dimensions.  
- Vesicle diameter: 18 - 30 µm  
- Process length: 6 - 10 µm  
- Process base width: 2 - 4 µm  
- Number of specimens measured: 2

Occurrence. This form was recorded from the Much Wenlock Limestone Formation of Harley Hill in the Much Wenlock area. HH3 900/2/10/1, and also noted from a section collected from Gotland Sweden at Slitebrottet, sample SB 39.

Genus BELLIDIUM n. gen.

Derivation of name. For palynologist Graham Bell who studied the palynomorphs of the type Wenlock area, and first figured this form (Bell 1973, M.Sc. thesis, unpublished).

Type Species. Bellidium laevigatum sp. nov.

Diagnosis. Thin to moderately thick, double walled spherical to subspherical vesicle body. The outer vesicle wall is a thin ectophragm. Processes hollow, translucent, laevigate, formed from an extension of the outer thinner wall forming cup like structures, short in length with wide process bases. Processes split distally to form a serrated margin with up to 10 points. Mode of excystment simple split.

Remarks. This genus is similar to Cymbosphaeridium, Leptobrachion, Baltisphaeridium and Dilatisphaera in the double walled nature of the vesicle but here the similarities end. The other genera mentioned have distinctly different process morphology; Cymbosphaeridium and Dilatisphaera differ in having nominally cauliflorate process terminations and a pylome sensu stricto. Dilatisphaera is very similar but has tubular processes which do not expand distally. Baltisphaeridium generally has simple, slender processes with closed terminations and Leptobrachion has long flexible, hollow branched processes which are closed distally and the process wall is sufficiently thin to let the
processes flatten out. *Florisphaeridium* has very short flared processes. The processes in *Bellidium* are robust and tubular in form. Thus in preservation they stay three dimensional whereas the processes in *Dilatisphaera* and *Leptobrachion* collapse.

**Bellidium laevigatum** sp. nov.

Plate 6, figs. 1, 2, 3

*Derivation of name.* Form the form of the vesicle body which is laevigate.

*Holotype.* Plate 6, figs. 1 and 2 from sample CT6/10/1, Rivelin finder reference RS 29, from the Much Wenlock Limestone Formation of Coates Quarry, Much Wenlock, Shropshire, UK.

*Diagnosis.* Double walled spherical to subspherical laevigate to finely microgranulate ornamented vesicle body. The outer vesicle wall is a thin ectophragm, while the inner wall is moderately thicker and more robust. Processes hollow, translucent, laevigate formed from an extension of the outer thinner wall forming cup like structures of short length with wide process bases. Processes split distally to form a serrated margin with up to 6 points. Excystment by median split.

*Remarks.* This taxon is distinguished from others belonging to this genus by its short processes and laevigate to finely ornamented vesicle body.

**Dimensions.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>Process length</td>
<td>4 - 8 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>5 - 9</td>
</tr>
<tr>
<td>Process aperture width</td>
<td>1 - 6 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>2</td>
</tr>
</tbody>
</table>

*Occurrence.* This taxon has been recovered as a rare component (less than 0.1%) of the assemblages from the Coalbrookdale to Much Wenlock Limestone formations (Homerian) of the type area in the Welsh Borderlands. Samples: Farley Dingle, Much Wenlock - FD 1400, Coates Quarry, CT 6; Mortimer Forest, Ludlow - MFGT 1 400, Pitch Coppice PC 315. 17 specimens were recorded as part of the quantitative logging. Other specimens were observed as part of the scanning procedure, but these were not counted. Only two specimens were recorded as part of the quantitative logging procedure, though other specimens were documented as part of the scanning procedure. This taxon has also been recorded consistently by Ken Dorning (pers. comm.).
Bellidium spinosum sp. nov.

Plate 6, fig. 9

Derivation of name. For the form of the vesicle body which has a short spinose ornament.

Holotype. Plate 6, fig. 9 from sample FD 300/10/1, Rivelin Finder Reference T45, from the Coalbrookdale Formation (Farley Member), Wenlock Series of Farley Dingle, Much Wenlock, Shropshire, England.

Diagnosis. Thin to moderately thick, double walled, spherical to subspherical vesicle. The vesicle bears a widely spaced sparse echinate ornament, up to 1.5 μm in length. Between the echinae the vesicle wall is laevigate to finely microgranulate. The outer vesicle wall is a thin ectophragm. Processes hollow, translucent, laevigate formed from an extension of the outer thinner wall forming cup like structures of short length with wide process bases. Processes split distally to form a serrated margin with up to 6 points. The short ornament appears to be formed solely from the outer wall. Mode of excystment not observed.

Remarks. This species differs from Bellidium parvum in the presence of the echinae on the vesicle body.

Dimensions. Vesicle diameter 16 - 22 μm
Process length 4 - 8 μm
Process number 5 - 8
Process aperture width 1 - 6 μm
Number of specimens measured 2

Occurrence. This species has been recovered in low numbers from the Coalbrookdale Formation (Farley Member) upper Wenlock Series of Farley Dingle, Much Wenlock, Shropshire, England.

Bellidium sp. A

Plate 6, figs. 4 - 6.

Description. Quadratic outline to laevigate vesicle body.

Remarks. Specimens have been left in open nomenclature because the distinctive appearance of the form could be preservational and only two specimens have been recovered.

Occurrence. This species has been recovered as a rare type from the Much Wenlock Limestone Formation, upper Wenlock Series of Coates Quarry, Much Wenlock, Shropshire, England.
Genus **BUEDINGISPHAERIDIUM** Schaarschmidt 1963, emend.

Type species. **Buedingisphaeridium permicum** Schaarschmidt, 1963, p. 70, pl. 20, figs. 4 - 6, text-fig. 26; Permian (Zechstein) of Germany.

Emended Diagnosis. (Lister 1970 p. 59-61) ‘Vesicle spherical, of moderate size, wall firm, ornamented with low verrucae or conical hollow tubercles, closed at the tip, sometimes thickened at the tip, but always partially hollow, communicating with the vesicle interior’.

Emended Diagnosis. (Sarjeant & Stancliffe 1994, p. 24). "Vesicle spherical, of small to moderate size. Eilyma ornamented by numerous low verrucae or conical tubercles, closed at the tip, often thickened or solid, sometimes hollow, or partially so, and with cavities communicating with the vesicle interior. Height of verrucae or tubercles typically less than 2 μm."

Remarks. The genus **Buedingisphaeridium** is easily distinguished with its characteristic short but hollow ornament. This genus most closely compares to **Lophosphaeridium** but differs in that the ornament is hollow and not solid, see also the discussion in Sarjeant & Stancliffe (1994, p. 24, 32). **Tylotopalla**, the only other genus that could be broadly compared to this group, generally has longer processes that are ornamented along their length and are easily distinguished from **Buedingisphaeridium**.

**Buedingisphaeridium pyramidale** Lister 1970

Plate 28, figs 8, 9, 12.

1970 *Buedingisphaeridium pyramidale* sp. nov. Lister, p. 61, pl. 3, figs 11 -14, text - figs 17h, 20e.
1976 *Buedingisphaeridium pyramidale*; Eisenack et. al., p. 109.
1981a **Tylotopalla pyramidale** n. comb.; Dorning, p. 200, no fig.
1987 *Buedingisphaeridium* sp.; Priewalder, p. 26, pl. 2, figs, 6, 7.
1990 *Tylotopalla pyramidalis* (Lister) Dorning 1981; Fensome et al., p. 500, no fig.

Holotype. Lister 1970, p. 61, pl. 3 fig 12, Lower Elton Beds, Ludlow Series, Millichope, Shropshire.
Diagnosis. (Lister 1970, p. 61). ‘Vesicle hollow, subspherical, thin walled; unilayered, smooth to faintly striate; numerous hollow pyramidal outgrowths ornament the test; the tips of these outgrowths appear to be solid; their bases are coincident. Excystment is by cryptosuture, apical or near equatorial. Total dehiscence, resulting in a removal of the operculum was not seen.’

Remarks. The specimens recovered and assigned to *B. pyramidale* conform to the original diagnosis and have a thin, laevigate, single walled, hollow, subspherical, diaphanous vesicle body ornamented with the distinctive short ornament of broad cones tapering to a solid point. Mode of excystment by simple split. This species differs from all species of *Lophosphaeridium* in the hollow nature of the ornament. The recombination of this form to *Tylotopalla* is not followed here because it is believed that the forms are clearly distinguished on the ornament type and forms with echinate processes were not recorded, though thickenings at the distal end of the process, especially at the terminal point, was noted in some specimens.

**Dimensions.**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>22 - 38 µm.</td>
</tr>
<tr>
<td>Process height</td>
<td>2 - 4 µm.</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 - 3 µm.</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

Occurrence. This thin species has previously been recorded from the following areas: top of the Lower Elton Formation in the Ludlow and Millichope areas (Lister 1970); Llandovery Series of the Karnic Alps in Austria (Priewalder 1987 as *Buedingiisphaeridium* sp.); Elton Formation, Ludlow Series of the Welsh Borderland (Dorning 1981a).

This form was recorded from the Much Wenlock Limestone to Lower Elton Formations in the type Wenlock and Ludlow.

Known range: Llandovery Series to middle Ludlow Series (late Ludfordian).

Genus COMASPHAERIDIUM Staplin, Jansonius & Pocock 1965

1949 *Michrystridium cometes* Valensi, p. 545, fig. 5, no 6.

Type Species. *Comasphaeridium cometes* Valensi 1949, p. 545, fig. 5, no. 6; from the Bathonian Stage, Upper Jurassic of France.
**Diagnosis.** (Staplin et al. 1965, p. 192). “Vesicles spherical to ellipsoidal, sometimes of large size; with densely crowded, thin, solid, usually simple, more or less flexible hair-like spines.”

**Remarks.** This genus differs from *Elektoriskos* in that it has more processes. This was considered within the realms of intra generic variation by Sarjeant & Stancliffe (1994). The two are retained here as no direct comparisons could be made. Those authors also made comparisons for this genus with others they considered to be synonymous, for further details see Sarjeant & Stancliffe (1994), but retained the distinction between this genus and *Filisphaeridium* (p. 25 - 28) the same approach is followed here, the most distinguishing characteristic being that the species herein regarded as belonging to *Comasphaeridium* have simple process terminations, whereas those believed to belong to the genus *Filisphaeridium* have more complicated distal terminations. The forms attributed to this genus herein typically lack the 'densely crowded' aspect to their ornament but as stated by Eisenack *et al.* 1973 p. 125, this contrast is subjective and not followed for the specimens described herein.

**Comasphaeridium sp. A**

Plate 18, fig. 12.

cf. 1987 *Elektoriskos* sp. A; Smelror, p. 142, pl. 2. fig. 6.

**Description.** Vesicle thin walled, ellipsoidal to subspherical, 18 - 24 μm in diameter bearing numerous, 30+, fine, slender, flexuous, solid, hair like processes, 8 - 10 μm in length. Mode of excystment not observed.

**Remarks.** The specimen recovered most closely fits this genus, but the ornament is so fine that detailed analysis of the process type was not possible using a light microscope.

**Dimensions.**

Vesicle diameter 18 - 24 μm
Process length 8 - 10 μm
Process width 1 μm
Process number 30+
Number of specimens measured 5.

**Occurrence.** The occurrence recorded by Smelror was from the Llandovery Series of Ringerike, Norway (Smelror 1987). This form was recorded as a rare type from the Farley Member of the Coalbrookdale Formation, Homerian Stage of the Wenlock Series, at Harley Hill, Much Wenlock, Shropshire, England.
**Comasphaeridium sp. B**

Plate 18, fig. 6.

*Description.* Thin walled, laevigate, small, spherical vesicle bearing a number of very short hair like processes. Excystment by simple split.

*Remarks.* This form differs from *Comasphaeridium* sp. A in that the vesicle is smaller, spherical and the processes are more clearly defined.

*Dimensions.*

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>20 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>2 - 4 µm</td>
</tr>
<tr>
<td>Process width</td>
<td>1 µm</td>
</tr>
<tr>
<td>Number of Processes</td>
<td>&gt;20</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

*Occurrence.* This species was recorded as a rare type from the Farley Member of the Coalbrookdale Formation, Homerian Stage of the Wenlock Series, of Farley Dingle, Much Wenlock, Shropshire, England.

**Genus CORYPHIDIUM** Vavradová 1972

*Type Species.* *Coryphidium bohemicum* Vavradová, 1972, p. 84 - 85, pl. 1 figs. 1, 2, text - fig. 4, from the Klabva Shales, Arenig Stage, Ordovician of Central Bohemia.

*Diagnosis.* (Vavradová 1972, p. 84.) "Acritarchs with polyhedral main body, angles rounded. Wall thin, single layered, in places sculptured with very fine ribs. Numerous processes, equal in length, symmetrically distributed at angles of polyhedron and adjoining edges. Processes are conical, proximally opened, distally heteromorphic (truncate, bifurcate, plurifurcate)."

*Remarks.* This genus was recorded as a reworked specimen.
Coryphidium spp.

Plate 18, fig. 10

Description. Dark brown, medium walled vesicle, quadrate in outline bearing an ornament of short spines and folded 'striations' sub parallel to the vesicle sides.

Remarks. The specimen recovered conforms to the generic diagnosis for Coryphidium. The specimen recovered is brown in colour indicative of having reached a greater degree of thermal maturation, than the rest of the assemblage. This is believed to be indicative of this form having been reworked from Ordovician sediments. The form recovered resembles Coryphidium bohemicum and Coryphidium baraka; examination of these forms in more detail would enable accurate assignment.

Process length 1.5 - 2 μm.
Number of specimens measured 1.

Occurrence. A similar form was reported from the Arenig of Morocco (Cramer & Diez 1976b); in this study the one specimen was recovered from sample HH3/800/10/1 from the Much Wenlock Limestone Formation of Harley Hill, Much Wenlock, Shropshire, England.

Genus CYMATIOSPHAERA (Wetzel 1933) emend. Deflandre 1954

1933b Cymatiosphaera n. gen.; Wetzel, p. 24, pl. 4, fig. 8

Type Species. Cymatiosphaera radiata Wetzel 1933 p. 27, pl. 4 fig. 8, Baltic, Cretaceous to Palaeocene.

Diagnosis (Translated from Deflandre 1954, p. 257 - 258.). ‘Vesicles of organic material often brown and globular (spherical - ellipsoidal), the external surface is divided into polygonal fields delimited by membranes perpendicular to the surface; the membrane junctions (corners of the polygonal areas) are generally thickened and give, in lateral view (compression), the impression of rods or small columns; no equatorial differentiation of fields; neither horns nor spines; the margin of the membranes is often sharp and parallel to the surface of the vesicle, sometimes a little concave, possibly serrated or corroded; surface of the vesicle body is smooth, punctate, or granulate; dimensions vary between a few μ and a few tens of μ, sometimes over 100μ crests included.’
Description. (Deflandre & Cookson 1955, p. 288.) ‘Shell globular, spherical to ellipsoidal, the external surface divided into polygonal fields by membranes perpendicular to the surface, without any equatorial differentiation of the fields or processes of any kind; the outer margins of the membranes straight or slightly concave, entire, serrated or somewhat corroded. Surface of the shell smooth punctate, or granular.’

Remarks. Distinctive members of the palynoflora with a two fold structure. Internally there is generally a spherical to elliptical central body, which is surrounded by a thin flange. This thin flange subdivides the central body into lacunar fields by membranes perpendicular to the vesicle surface. The fields can be polygonal or irregular but they are generally irregular in outline. Other prasinophytes differ from this genus in a number of ways; Muraticavea have fields which are delineated by folds in the vesicle wall rather than crests of an outer flange, similarly in Dictyotidium the fields are bounded by solid crests. Duvernaysphaera has an equatorial flange which is supported by radiating processes/spines which emerge from the central body. In Pterospermella the central body is surrounded by a thin equatorial flange, whilst species belonging to the genus Polyedryxium lack the distinct central body. Dictyotidium differs from Cymatiosphaera by having polygonal fields delineated by solid ridges not membranes; the fields in Muraticavea are defined by folding of the vesicle wall; Pterospermella differs in having an equatorial flange and Duvernaysphaera has an equatorial flange and spines from the central body.

Cymatiosphaera blaisdonica Dorning 1981a

Plate 9, figs. 1, 2

1981a  Cymatiosphaera blaisdonica n. sp. Dorning, p. 183; pl. 3, figs. 9, 13.
1990  Cymatiosphaera blaisdonica Dorning; Fensome et. al. p. 168, no fig.

Holotype. Dorning 1981a, p. 183; pl. 3, figs. 9, 13; from the Ludlow Blaisdon Beds, Wood Green, May Hill, Gloucestershire (SO 6950 1655).

Diagnosis. (Dorning, 1981a, p. 183) “Vesicle spherical, 22 - 28 μm in diameter, laevigate, divided into numerous (12 - 16 per hemisphere) polygonal fields 4 - 6 μm across by laevigate flanges 1.5 - 2 μm high; excystment by a straight split.”

Remarks. The few specimens recovered conform to the original diagnosis and closely resemble those specimens figured by Dorning (1981a), the slightly larger dimensions (2 μm), recorded here are believed to be within the realm of variation from those described by the original diagnosis, and within error margins from usage of
different equipment. *Cymatiosphaera blaisdonica* differs from *Cymatiosphaera pavimenta* by its lower membrane height, whilst *Cymatiosphaera gorstia* is much larger than this species. This form was logged as *Cymatiosphaera* sp. B.

**Dimensions.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Central body</td>
<td>18 - 30 µm</td>
</tr>
<tr>
<td>Entire vesicle plus flange</td>
<td>24 - 36 µm</td>
</tr>
<tr>
<td>Outer Flange Height</td>
<td>2 - 3 µm</td>
</tr>
<tr>
<td>Field width</td>
<td>6 - 12 µm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

**Occurrence** Blaisdon Beds, Ludlow Series, Silurian of the May Hill Inlier, Gloucestershire, England. (Doming, 1981a). This species was recovered from the Farley Member of the Coalbrookdale Formation to the upper part of the Much Wenlock Limestone Formation and the lowermost beds of the Lower Elton Formation, in the Wenlock and Ludlow areas of Shropshire..

*Cymatiosphaera callimorpha* sp. nov.

Plate 10, figs. 1 - 3.

**Derivation of name.** Meaning beautifully shaped, from the Greek ‘callos’ - beauty; with ‘morphe’ - form, shape, figure, appearance.

‘beautiful crest’ from the Greek ‘callos’ - beauty; with ‘lophos’ - back of the neck/crest of a hill or helmet’.

**Holotype.** Plate 10, figs. 1 - 3 (same specimen); from sample FD 1500/10/1, Rivelin Finder reference U 28.5, from the Farley Member of the Coalbrookdale Formation of Farley Dingle, Much Wenlock, Shropshire, England.

**Diagnosis.** Thin to medium walled, laevigate vesicle body; relatively large (24 - 28 µm), bearing low, undulatory crests (4 - 6 µm). The crests delimit approximately 10 fields (known to date). The fields are subpolygonal in outline and the undulatory nature gives the lacunar fields ‘wavy’ edges. The field width varies from 10 - 16 µm. The points where the crests join, at the junction of the lacunar fields, exhibits an apparent thickening of the flange, due to multiple layers being viewed. Mode of excystment is by a simple split.
Remarks. This form is most closely comparable to *C. blaisdonica* Dorning 1981a, being of an overall similar size but *C. blaisdonica* has lower crests which form regular fields. This form was logged originally as *Cymatiosphaera* sp. G.

**Dimensions.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Central body</td>
<td>24 - 28 μm</td>
</tr>
<tr>
<td>Entire vesicle plus flange</td>
<td>28 - 36 μm</td>
</tr>
<tr>
<td>Outer flange</td>
<td>4 - 6 μm</td>
</tr>
<tr>
<td>Field width</td>
<td>12 - 16 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

Occurrence. This species was recorded from the Farley Member of the Coalbrookdale Formation from Farley Dingle

*Cymatiosphaera clandestina* sp. nov.

Plate 8, fig. 9; Plate 10, fig. 15; Plate 12, fig. 5.

**Derivation of name.** From the Latin ‘clandestinus’ meaning hidden/secret referring to the obscure nature of the outer flange.

**Holotype.** Plate 10, fig. 15, from sample FD 900/10/1, Rivelin Finder reference QR 36, from the Farley Member of the Coalbrookdale Formation of Farley Dingle, Much Wenlock, Shropshire, England.

**Diagnosis.** Large, thick walled, dull matt vesicle body measuring 32 - 40 μm, with a thin diaphanous flange surrounding the vesicle body, measuring 1 - 2 μm. The entire vesicle dimensions being 34 - 44 μm. The fields are irregular in outline and are often delimited as folds in the ectophragm.

**Remarks.** This species differs considerably from other species of *Cymatiosphaera* with the low indistinct fields and dull aspect. This form was logged as *Cymatiosphaera* sp. C.

**Dimensions.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Central body</td>
<td>32 - 40 μm</td>
</tr>
<tr>
<td>Entire vesicle plus flange</td>
<td>34 - 44 μm</td>
</tr>
<tr>
<td>Outer flange</td>
<td>1 - 2 μm</td>
</tr>
<tr>
<td>Field width</td>
<td>Indistinct</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>
**Occurrence.** This species was found from the Farley Member of the Coalbrookdale Formation through the Much Wenlock Limestone Formation to the lowermost portion of the Lower Elton Formation, from the Wenlock and Ludlow areas of Shropshire.

**Cymatiosphaera cornifera** Deunff 1955

Plate 7, figs. 4, 5, 6, 10

1955 *Cymatiosphaera cornifera* Deunff p. 147, fig. 23
1969 *Cymatiosphaera cornifera* Stockmans & Willière p. 36, pl. 2, fig. 8.
1977 *Cymatiosphaera cornifera* Playford p. 17 pl. 4, fig. 4 - 14
1984 *Cymatiosphaera cornifera* Amirie p. 18 - 19, pl. 1, fig. 15.
1989 *Cymatiosphaera cornifera* Deunff; Le Hérissé, p. 73, pl. 1, figs. 11 - 13, 18 - 20.
1990 *Cymatiosphaera cornifera* Fensome *et al.* p. 169, no fig.

**Holotype.** *Cymatiosphaera cornifera* Deunff 1955 p. 147, fig. 23, Onondaga Formation, Middle Devonian of Ontario, Canada.

**Diagnosis.** (Translated from Deunff 1955 p. 147). ‘Spherical test of diameter of 15 μm. Surface ornamented with polygonal fields ornamented with separating membranes of 5 μm in height. All of the polygons possess in the centre a short spine measuring 2 μm in height.’

**Description.** Hollow spherical vesicle bearing membranous crests which delimit a number of polygonal fields and give a polygonal to subcircular outline to the entire cyst. Mode of excystment not observed.

**Remarks.** The specimens recorded were considered to sufficiently fill all the criteria required by the diagnosis to be assigned to this species, though it should be noted that examination of the holotype material has not been conducted. It should therefore be emphasised that reassignment of the specimens as grouped herein could happen once examination of the holotype material is completed. It is possible that this predominantly Devonian form and the Silurian *C. ledburica* Dornin 1981 are synonymous as they are very similar and are only differentiated on the latter having a thicker, laevigate vesicle wall than the specimens assigned to this species. This diminutive form is smaller than *Cymatiosphaera pavimenta* and has a polygonal outline, whereas *C. pavimenta* tends to be subcircular. *Cymatiosphaera gorstia*, *Cymatiosphaera heloderma* and *Cymatiosphaera wenlockia* are all larger forms. *C. canadensis* (Deunff 1955) closely resembles this form by is only depicted as a line drawing, so no conclusions as to synonymy have been made. The line drawing of *C. cornifera* on the other hand shows larger crests than those seen here, but this could be within the realms of intra-specific variation.
Dimensions.  
- Vesicle body: 14 - 18 μm  
- Entire dimensions of vesicle plus flange: 20 - 22 μm  
- Field Width: 4 - 6 μm  
- Number of Fields: 6 - 8  
- Crest Height: 2 - 4 μm  
- Number of specimens measured: 5.

Occurrence. Middle Devonian of Ontario, Canada (Deunff 1955); Devonian of Tunisia, and Europe (Deunff 1966, 1966b, 1967); lower Famennian of Belgium (Stockmans & Willière 1969); top Siegenian to middle Givetian (Devonian) of the Moose River Basin, Ontario, Canada (Playford 1977); Devonian of Ohio (Wicander & Wood 1981, Wicander & Wright 1983); lower Devonian of France (Le Hérissé & Deunff 1988); Visby Formation, Llandovery to Wenlock series of Gotland, Sweden (Le Hérissé 1989);  

This species was recovered from the Coalbrookdale Formation (Farley Member) from Farley Dingle and Harley Hill; and the Much Wenlock Limestone Formation from Coates Quarry.  

Known range: Silurian to Devonian if the forms are representative of the same species.  

Cymatosphaera cubus (Deunff 1961)  

Plate 8, fig. 3; Plate 9, fig. 4; Plate 60, fig. 8  

1959  Cymatosphaera cubus Deunff; Downie, pl. 11, fig. 3.  
1990  Cymatosphaera cuba Deunff; Fensome et al. p.169, no fig.  

Holotype. Cymatosphaera cubus Deunff (1954) designated by Deunff 1961, p. 218; see Deunff 1954, p. 1065, text - fig. 1. from the middle Devonian (Onondaga formation) of Canada.  

Diagnosis. (Translated from Deunff 1961, p. 218) Spherical yellow test, composed of fine membranes which delimit the polygonal areas on the surface of the test. The aspect is generally cubic.  

Remarks. The specimens recovered conform to the original diagnosis. This is a distinctive form with few fields when compared with the other species of Cymatosphaera recorded in this study. This form also includes the specimens logged as Cymatosphaera sp. S.
**Dimensions.**

<table>
<thead>
<tr>
<th>Description</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central body</td>
<td>22 - 24 μm</td>
</tr>
<tr>
<td>Entire vesicle plus flange</td>
<td>28 - 36 μm</td>
</tr>
<tr>
<td>Outer flange</td>
<td>2 - 6 μm</td>
</tr>
<tr>
<td>Field width</td>
<td>14 - 20 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Occurrence.** Devonian of Canada (Deunff 1955); Wenlock Series of England (Downie 1963), the Devonian of Tunisia (Deunff 1966); Llandovery Series of Belgium (Martin 1968); Wenlock (Much Wenlock Limestone Formation) to Ludlow Series (lower Whitcliffe Formation) of the Ludlow area (Lister & Downie 1974); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); upper Llandovery Series (Purple Shales) to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985).

This species was recovered from the Coalbrookdale Formation (Farley Member) of Farley Dingle and the Much Wenlock Limestone Formation of Harley Hill and Coates Quarry, upper Wenlock Series (Homerian) of the type area.

Known Range: Silurian - Devonian.

*Cymatiosphaera eltonensis* Dorning 1981a

Plate 8, figs. 4, 5, 6.


1990  *Cymatiosphaera eltonensis* Dorning 1981a; Fensome *et al.* p. 170, no fig.

**Holotype.** Dorning 1981a., p. 183, pl. 3, fig. 14; LE1A, K39/0; MPK 2941, from the Ludlow Series, Lower Elton Beds of Ledbury Hill, Herefordshire (SO 716 384).

**Diagnosis.** (Dorning 1981a p. 183). “Vesicle spherical 15 - 20 μm in diameter laevigate, divided into numerous small polygonal fields 1.5 - 2 μm across by flanges 1.5 - 2 μm high; excystment method not observed.”

**Remarks.** The specimens recovered are consistent with the diagnosis of Dorning (1981a). This species has more numerous fields than most other species of *Cymatiosphaera*. This is a smaller form than the form recorded here as *V. connexa-hirsuita*. Because this species was only rarely recovered it was not recognised as a form distinct from the specimens logged as *V. connexa-hirsuita* until post logging studies of the material.

109
Occurrence. Previously recorded from the Lower Elton Formation of Ledbury in Shropshire (Dorning 1981a). This species was recorded from the Much Wenlock Limestone Formation of the Much Wenlock and Ludlow areas of Shropshire, including samples from Coates Quarry, Pitch Coppice & Mortimer Forest.

Cymatiosphaera gorstia Doming 1981a

Plate 60, fig. 10.

1981a Cymatiosphaera gorstia n. sp. Doming, p. 185. pl. 2, fig. 7.
1990 Cymatiosphaera gorstia Doming 1981a; Fensome et al. p. 170, no fig.

Holotype. Doming 1981a. pl. 2, fig. 7; LE25K, S36/3; MPK 2918, from the Ludlow Series, Bringewood Beds of Ledbury Hill, Herefordshire (SO 713 386).

Diagnosis. (Dorning 1981a p. 185 ) “Vesicle spherical 35 - 45 μm in diameter laevigate, divided into 14 - 18 polygonal fields by flanges 3 - 5 μm high; excystment is by a straight split.”

Remarks. The specimens recovered are consistent with the diagnosis of Doming (1981a). This is a relatively large species with thin low membranous crests, hollow, laevigate, spherical to ellipsoidal vesicle. The fine membranes divide the vesicle surface into numerous, large, polygonal fields. Mode of excystment by straight split. C ledburica, C. pavimenta and C. octoplana are all smaller with fewer fields and larger crests. This form was logged as Cymatiosphaera sp. T.

Dimensions. Central body
Entire vesicle plus flange
Height of flange
Field width
Number of fields
Number of specimens measured

24 - 30 μm
32 - 38 μm
2 - 4 μm
6 - 12 μm
12 - 18
10

Occurrence. C. gorstia has been recorded from the late Llandovery to the early Ludlow series by Doming (1981a); it has also been recorded by Swire (1991) from the Buildwas and Coalbrookdale formations of the Wenlock type area (Sheinwoodian to Homerian stages).

This species was recorded as a rare type from the Much Wenlock Limestone Formation of Harley Hill.

Known Range: Llandovery to Ludlow series
**Cymatiosphaera heloderma** Cramer & Diez 1972

Plate 12, fig. 6.

1972 *Cymatiosphaera heloderma* n. sp. Cramer & Diez, p. 158, pl. 32, fig. 22, pl. 34, fig. 46.

1989 *Cymatiosphaera heloderma* Cramer & Diez; Barron, p. 85 - 86, fig. 3D.

1990 *Cymatiosphaera heloderma* Cramer & Diez; Fensome *et al.* p. 170, no fig.

**Holotype** Cramer & Diez de Cramer 1972, p.158, pl. 34, fig. 46, from the Alger Shale, (late Llandovery) of Ohio, USA.

**Diagnosis** (Cramer & Diez 1972, p.158). “The central body is variable in form: spherical to polygonal, most commonly spherical. The campi are of variable dimensions and outline, but tend to be subsquare or irregularly pentagonal. The surface of the campi is regularly and densely foveolate, almost foveo-reticulate; the foveolae have a depth of about one micron and a diameter of one micron or somewhat less. The muri have essentially straight bases and show smooth or crenulate crests. The muri have conspicuously radially oriented narrow folds...... The body wall is about two microns thick; the muri are less than 0.5 microns thick.”

**Remarks.** The observed specimens conform to the above diagnosis. This species differs from other species assigned to the genus because of the distinctive ornament, the central portion of the fields bearing a fine foveo-reticulate sculpture. *Cymatiosphaera gorstia* has more numerous fields, *C. pavimenta* is smaller with lower flanges as is *C. blaisdonica.*

**Dimensions**
- Total diameter: 40 - 63 μm
- Vesicle diameter: 25 - 38 μm
- Polygonal fields: 6 - 10 μm
- Number of specimens measured: 10

**Occurrence.** Alger shale, Llandovery of Ohio USA (Cramer & Diez 1972); Wenlock Series of Podolia, Ukraine (Kiryanov 1978), Ordovician and Silurian of Belgium (Martin & Rickards 1979); Wenlock Series of Gotland, Sweden (Cramer *et al.* 1979); late Llandovery to early Wenlock series of the type area in the Welsh Borderlands (Dorning 1981a); Ludlow Series of Argentina (Pôthe de Baldis 1981); Llandovery Series of Ringerike Norway (Smelror 1987b), Llandovery to the base of the Wenlock Series of Gotland, Sweden (Le Hérissé 1984,
1989); Wenlock Series of the Cheviots Hills, England (Barron 1989); Sheinwoodian to Homerian (Wenlock Series) of the Welsh Borderland (Swire 1991); upper Silurian of San Juan, Argentina (Rubinstein 1993).

This species was recorded sporadically in this study, refer to the Tilia charts in the appendix.

**Cymatosphaera aff. heloderma**

Not figured.

**Remarks.** The specimens recovered herein comply with the diagnosis for *C. heloderma* having a central body ornamented with a fine granulation, but are considerably smaller.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
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<tbody>
<tr>
<td>Central body</td>
<td>10 - 12 μm</td>
</tr>
<tr>
<td>Entire vesicle plus flange</td>
<td>22 - 26 μm</td>
</tr>
<tr>
<td>Outer flange</td>
<td>8 - 10 μm</td>
</tr>
<tr>
<td>Field width</td>
<td>12 - 16 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>2</td>
</tr>
</tbody>
</table>

**Occurrence.** This rare type was recovered from the Much Wenlock Limestone Formation of Mortimer Forest, in the Ludlow area.

**Cymatosphaera ledburica** Dorning, 1981a

Plate 9, fig. 7.

1981a *Cymatosphaera ledburica* n. sp. Dorning; p. 185, pl. 2, figs. 13 - 14.

1978 *Cymatosphaera pentagonalis* Kiryanov, p. 30 - 31, pl. 5, fig. 5, only.

1978 **cf.** *Cymatosphaera subrotunda* sp. nov.; Kiryanov, p. 31 - 32, pl. 5, fig. 7 only. fig. 8 = *C. subrotunda*.

1990 *Cymatosphaera ledburica* Dorning, 1981a, Fensome et al., p 171, no fig.
**Holotype.** Doming 1981a, p. 185; pl. 2, figs. 14; from the Bringewood Formation, Ludlow Series Ledbury Hill, Hereford (SO 713 386).

**Diagnosis.** (Doming, 1981a, p. 185) "Vesicle spherical to subspherical, 25 - 30 \( \mu m \) in diameter, laevigate, divided into 8 fields by thin flanges 10 - 12 \( \mu m \) high; excystment by a straight split."

**Remarks:** The specimens recovered are pentagonal in outline with a subspherical, laevigate, medium to thick walled (often dark) central body. The outer flanges are formed of thin membranes which delimit 6 - 8 large fields. Mode of excystment not observed. There is a strong similarity between this species and the *C. pentagonalis* Kiryanov 1978 (pl. 5, fig. 5) but it is believed that the two forms are sufficiently distinctive in their morphology to be retained as separate species until further examination of holotype material is undertaken. This form is also similar to *Cymatosphaera mariae* (Cramer *et al.* 1976), which has also been reported by Le Hérisse (1989) from the Silurian of Gotland, Sweden, but these forms have a strong central ornament to the fields. The holotype of this species needs re-examination before deciding whether or not this form is a synonym.

**Dimensions.**

<table>
<thead>
<tr>
<th>Description</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>22 - 26 ( \mu m )</td>
</tr>
<tr>
<td>Entire dimensions</td>
<td>28 - 33 ( \mu m )</td>
</tr>
<tr>
<td>Crest height</td>
<td>6 - 8 ( \mu m )</td>
</tr>
<tr>
<td>Field width</td>
<td>12 - 16 ( \mu m )</td>
</tr>
<tr>
<td>Number of fields</td>
<td>6 - 10</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Occurrence.** *C. ledburica* has been recovered from the Elton to Leintwardine formations, Gorstian to Ludfordian Stages, of the Ludlow Series of the Welsh Borderlands, Shropshire, England (Doming, 1981a); Ludlow Series of Podolia, Ukraine (Kiryanov 1978, as *C. subrotunda*); upper Silurian of San Juan, Argentina (Rubinstein 1993). This species has been recovered from the Much Wenlock Limestone formation at Coates Quarry. Known range: Much Wenlock Limestone - Middle Elton formation.

**Cymatosphaera aff. ledburica**

Not figured.

**Description.** A large species of *Cymatosphaera* with a thin vesicle wall. Central body bearing a broad flange.
Remarks. A single specimen showing affinity to the species \textit{C. ledburica} but of poor preservation, making identification difficult. This form was logged questionably as \textit{Cymatosphaera} sp. U.

\textbf{Dimensions.}

- Central body: 18 \textmu m
- Entire vesicle plus flange: 30 \textmu m
- Outer flange: 8 \textmu m
- Number of specimens measured: 1

\textbf{Occurrence.} This specimen was recovered from the Much Wenlock Limestone Formation at Coates Quarry.

Known range: Much Wenlock Limestone Formation.

\textbf{Cymatosphaera longhopica} Dorning 1981a

Plate 8, figs. 1, 2.

1981a \textit{Cymatosphaera longhopica}; n. sp. Dorning 1981 p. 185, pl. 3 figs. 11, 12.

1990 \textit{Cymatosphaera longhopica} Dorning; Fensome \textit{et al.} p. 172, no fig.

\textbf{Holotype.} Dorning 1981a, p.185, pl. 3 fig. 11, from the Leintwardine Formation of May Hill, Gloucestershire (SO 694 185).

\textbf{Diagnosis} (Dorning 1981a, p.185.) 'Vesicle spherical, 18 - 25 \textmu m in diameter, laevigate, divided into numerous polygonal fields about 2 \textmu m across by flanges 2 - 3 \textmu m high; excystment method not observed.'

\textbf{Remarks.} The specimens recovered conform to the original diagnosis. Vesicle hollow, laevigate, spherical to ellipsoidal, medium to thick walled, golden yellow/brown in unstained specimens, bearing low membranous crests which form indistinct polygonal fields. Excystment by simple split. \textit{C. eltonensis} differs in having smaller fields and lower crests. The larger dimensions recorded herein are probably due to compression elongating the vesicle in one dimension. \textit{C. prismatica} is larger with a prismatic arrangement of the membranes, which form fewer, triangular rather than polygonal fields. The holotype of \textit{C. eltonensis} appears to have a solid grana in the centre of each field. This is not present on the paratype and is not mentioned in the specific diagnosis. This form was originally logged as \textit{Cymatosphaera} sp. K.
**Dimensions**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>20 - 32 (\mu m)</td>
</tr>
<tr>
<td>Including flange</td>
<td>24 - 26 (\mu m)</td>
</tr>
<tr>
<td>Outer flange</td>
<td>2 - 3 (\mu m)</td>
</tr>
<tr>
<td>Field width</td>
<td>2 (\mu m)</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Occurrence**

This species has been recorded from the Wenlock and Ludlow Series of Shropshire (Dorning 1981a not shown on table 1); upper Silurian of San Juan, Argentina (Rubinstein 1993)

This species has been recovered from the Coalbrookdale to Much Wenlock Limestone formations in samples from Pitch Coppice and Farley Dingle, Much Wenlock and Ludlow, Shropshire, England.

**Cymatiosphaera cf. multisepta** Deunff 1955

Plate 7, fig. 13.

<table>
<thead>
<tr>
<th>Year</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1955a</td>
<td>Cymatiosphaera multisepta n. sp.; Deunff, p. 147, fig. 25.</td>
</tr>
<tr>
<td>1959</td>
<td>Cymatiosphaera celtica, Deunff, p. 33 - 34, pl. 6 figs. 54 - 56.</td>
</tr>
<tr>
<td>1990</td>
<td>Cymatiosphaera multisepta Deunff 1955a; Fensome et al., p. 172, no fig.</td>
</tr>
</tbody>
</table>

**Holotype.** Deunff 1955 p. 147, fig. 25, from the middle Devonian (Onondaga Formation) of Canada.

**Diagnosis.** (Translated from Deunff 1955 p. 147) "Spherical vesicle, 8 \(\mu m\) in diameter, in optical section there are seen to be membranes of 2 \(\mu m\) height determining regular polygonal fields on the surface of the vesicle, with a number of approximately 20 on the proximal surface.

**Remarks.** This species is comparable to those described in the original diagnosis. The specimens found herein are thin to medium walled small forms with numerous fields formed from low membranes, but the small polygonal fields have a central grana and there is a wider range in vesicle size. Previously this form has only been recorded up to 14 \(\mu m\) Martin (1968 p. 135), but here the maximum is 24 \(\mu m\). Nevertheless this is still a diminutive form. Mode of excystment not observed. C. celtica Deunff 1958 has a very similar appearance (in line drawing) to this form, and for this reason it has been included in the synonymy list. C. gorstia, C. heloderma C. pavimenta, C. prismatica, C. cornifera C. blaisdonica and C. wenlockia are all larger forms with fewer, well defined lacunar fields. C. eltonensis has small fields but is considerably larger. This morphotype was initially logged as Cymatiosphaera sp. V.
**Dimensions.**  
<p>| | |</p>
<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Central body</td>
<td>12 - 20 μm</td>
</tr>
<tr>
<td>Entire vesicle plus flange</td>
<td>22 - 24 μm</td>
</tr>
<tr>
<td>Outer flange</td>
<td>2 - 4 μm</td>
</tr>
<tr>
<td>Field width</td>
<td>2 - 4 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Occurrence.** This species has been recorded from the middle Devonian of Canada, Europe and Tunisia (Deunff 1955, 1966); Caradoc of Brittany (Deunff 1959); Ordovician and Silurian of Belgium (Martin 1968); lower Fammenian (Devonian) of Belgium (Stockmans & Willière 1969).

This species was recorded as a rare type from the Much Wenlock Limestone Formation of Coates Quarry.

**Known Range:** Wenlock Series.

**Cymatiosphaera multicampestris** sp. nov.

Plate 7, figs. 11, 12.

**Derivation of name.** Meaning multiple fields, from 'campester' - of or pertaining to fields.

**Holotype.** Plate 7 fig. 12, from sample CT 7/10/1, Rivelin Finder reference R 43 from the

**Diagnosis.** Thin walled laevigate vesicle body, relatively small in size from 16 - 24 μm. The central body is surrounded by a thin flange which forms crests that delimit multiple small fields, 2 - 4 μm in width, covering the central body. The crest height measures from 4 - 6 μm giving whole vesicle dimensions of 20 - 26 μm. The outer thin walled crests are supported by spinose ornament at the junction of the lacunar fields.

**Remarks.** The spinose projections that support the fields give the specimens an initial look of Michrystridium until careful examination for the presence of fields and the outer wall is determined. This species differs considerably from other species, particularly in the thin walled nature of the inner vesicle and the presence of numerous fields with the low membrane supported by spines. This form was logged as Cymatiosphaera sp. W.

**Dimensions.**  
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<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Central body</td>
<td>16 - 24 μm</td>
</tr>
<tr>
<td>Entire vesicle plus flange</td>
<td>20 - 26 μm</td>
</tr>
<tr>
<td>Outer flange</td>
<td>4 - 6 μm</td>
</tr>
<tr>
<td>Field width</td>
<td>2 - 6 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>
**Occurrence.** This form was recovered from the Farley Member of Coalbrookdale Formation and the Much Wenlock Limestone Formation of the Much Wenlock area of Shropshire, England.

**Cymatiosphaera octoplena** Downie 1959

Plate 9 fig. 9

1959 *Cymatiosphaera octoplena* sp. nov.; Downie, p. 63, pl. 11, fig. 2.
1987 *Cymatiosphaera cf. octoplena* Priewalder, p. 26, 27, pl. 2 figs. 11, 12.
1990 *Cymatiosphaera octoplena* Downie 1959; Fensome *et al.*, p. 173, no fig.

**Holotype.** *Cymatiosphaera octoplena* Downie 1959, pl. 11, fig. 2, from the Coalbrookdale Formation, Wenlock Series of Wenlock Edge, Shropshire.

**Diagnosis.** (Downie 1959 p. 63). 'A species of *Cymatiosphaera*, lemon yellow colour, test surface granular, divided into eight rectangular, more or less equal sized, areas by membranes about one third of the diameter in height, height of membrane varies giving a rectangular outline.'

**Remarks.** The specimens recovered conform to the original diagnosis. Thick walled central body with robust ridges bearing thin membranous flanges. Flange varies in distance from the central body. Mode of excystment not observed. *Cymatiosphaera heloderma* and *C. gorstia* are larger than *C. octoplena* and *C. heloderma* has an ornamented vesicle body.

**Dimensions.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>20 - 32 μm.</td>
</tr>
<tr>
<td>Field Width</td>
<td>12 - 18 μm</td>
</tr>
<tr>
<td>Crest Height</td>
<td>6 - 10 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Occurrence.** This cosmopolitan form has been widely reported, amongst which are the following occurrences: Coalbrookdale Formation of the type area, Shropshire, England (Downie 1959); late Llandovery to Wenlock of Canada (Achab 1976, Thusu 1973a); lower Ludlow of Bolivia (Cramer *et al*. 1974); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); late Llandovery to early Wenlock series of Gotland, Sweden (Cramer *et al*. 1979); early Sheinwoodian (Wenlock Series) of Ayrshire, Scotland (Dorning 1982); lower Silurian of Ringerike, Norway (Dorning & Aldridge 1982); Much Wenlock Limestone
Formation, Wenlock Series of Wren’s Nest, Dudley in the West Midlands of England (Dorning 1983); Telychian to Gorstian of Great Britain (Downie 1984); late Llandovery to early Ludlow series of the type areas (Dorning 1981a, Mabillard & Aldridge 1985); lower Silurian, Llandovery to Wenlock Series of Ringerike, Norway (Smelror 1987b); upper Llandovery to Ludlow series of Austria (Priewalder 1987); Wenlock Series of the Cheviot Hills, England (Barron 1989); Buildwas and Coalbrookdale formations from the Welsh Borderland (Swire 1991); upper Silurian of San Juan, Argentina (Rubinstein 1993); Wenlock Series from Holbrook Coppice, near Ironbridge, Shropshire (Turner et al. 1995).

This species has been recovered from the Coalbrookdale Formation (Farley Member) and Much Wenlock Limestone Formation of Farley Dingle and Coates Quarry, Much Wenlock Shropshire, England.

Known range: Llandovery to Pridolf series.

**Cymatiosphaera pavimenta** (Deflandre 1945) Deflandre 1954

Plate 7, figs. 7, 8, 9.

1945 *Michrystridium pavimentum* n. sp.; Deflandre, p. 68, pl. 3, figs 20 - 21, text - fig. 41.
1954 *Cymatiosphaera pavimenta* Deflandre; Deflandre n. comb. p. 258.
1959 *Cymatiosphaera pavimenta* Deflandre; Downie, p. 63, pl. 11. fig. 8 - 9.
1990 *Cymatiosphaera pavimenta* Deflandre 1945; Deflandre 1954; Fensome et al., p. 173, no fig.

*Holotype.* *Michrystridium pavimentum* (Deflandre 1945) p. 68, pl. 3, fig. 21; from the Silurian of the Montagne Noir, France.

*Diagnosis.* (See Eisenack et al. 1973 p. 323 - 324. Translation here after Deflandre 1945, p. 30, by Pascale Presumey). ‘Vesicle spherical, the surface is divided into polygons by a system of membranous crests partially preserved. The best example seen, almost intact, has unfortunately been lost and I only have a rough sketching of it. (fig. 41) which is anyway very characteristic. The other two specimens, one of which is of a different origin, are incomplete. Of the type, the centre of the polygon can be seen to have a dashed line through the centre of the polygons. This corresponds to the lower side of the vesicle, the upper part of the vesicle being absent. The crests are brown yellow, translucent but the membrane of the central body is a very dark reddish brown, even almost black for one of the specimens. The vesicle diameter is 18 - 22 μ, total diameter including the crests comprises 23 to 27 μ.’
Diagnosis. (Taken from Downie 1959, p. 63). "Test spherical, diameter 10 - 20 μ, walls thick, colour generally deep red brown, partitions 20 - 40 % of test diameter in height, polygonal fields 5 - 10 μ across, pillars formed where partitions join, nine to fourteen seen around circumference."

Remarks. The forms recovered conform to the original diagnosis. Thin walled small forms with subspherical to polygonal outline. The central body is laevigate under transmitted light and is divided by low membranes into polygonal fields. Excystment by simple split. This species differs from C. aff. pavimenta in that the thickenings at the junctions of the crests form distinct spines whereas in C. aff. pavimenta the thickenings at the junction are broad and squat. C. wenlockia differs in its larger overall size from a larger central body and wider flanges extending well outside the central body cavity and does not have spines at the crest junctions.

Cymatiosphaera sp. W has a more numerous fields delimited by lower crests but despite having low flanges it also has spines at the crest junctions. In general though, it is the diminutive form of this species that separates it from other species of Cymatiosphaera. In the original logging some specimens were split and referred to as Cymatiosphaera sp. E. Cymatiosphaera gorstia and C. heloderma are larger forms, whilst other forms such as C. blaisdonica and C. eltonensis have lower membranes.

Dimensions

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>10-22 μm</td>
</tr>
<tr>
<td>Entire vesicle plus flange</td>
<td>20 - 24 μm</td>
</tr>
<tr>
<td>Height of crests</td>
<td>2 - 4 μm</td>
</tr>
<tr>
<td>Field width</td>
<td>6 - 8 μ</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

Occurrence Wenlock Series of Montagne Noir, France (Deflandre 1945, 1954); Coalbrookdale Formation, Wenlock Series, Wenlock Edge, Shropshire (Downie 1959); Caradoc of Brittany (Deunff 1959); San Pedro and La Vid formations, upper Silurian to lower Devonian of north-west Spain (Cramer 1964b); Silurian of Belgium (Martin 1966c); Silurian of Brittany (Lefort & Deunff 1974); Wenlock to Ludlow Series of the Ludlow area (Lister & Downie 1974); Buildwas to Coalbrookdale formation of the Wenlock type area (Dorning, 1981a); Much Wenlock Limestone Formation, Wenlock Series of Dudley, West Midlands (Dorning 1983); late Sheinwoodian to early Homerian of the type area in the Welsh Borderlands (Dorning & Bell 1987); late Llandovery to early Wenlock series of Ringerike, Norway (Smelror 1987b); Coalbrookdale Formation of the Wenlock Series from Buildwas Bank and Holbrook Coppice, Ironbridge Shropshire (Turner et al. 1995); Swire 1990 extends the range to include the early Sheinwoodian, collected from the type area and the Malverns, possibly even to the Telychian to Sheinwoodian of the North Wales and the Welsh Borderland (Swire 1991); lower Wenlock Series of the type Wenlock area (Swire 1993); upper Silurian of San Juan, Argentina (Rubinstein 1993).
This species was recovered consistently throughout the sections sampled from the Coalbrookdale, Much Wenlock Limestone and lowermost part of the Lower Elton formations from Farley Dingle, Harley Hill, Coates Quarry, Shadwell Quarry and Pitch Coppice. Dorning & Bell (1987) reported that the first appearance of this species marked the base of the *C. pavimenta* Biozone. This range was extended by Swire see above.

Known Range: Llandovery to Wenlock Series.

**Cymatiosphaera aff. pavimenta**

Plate 7, figs. 1, 2.

*Description.* Thin walled small form, spherical, laevigate central body bearing low crests which delimit polygonal fields. At the margins of the central vesicle the membranous crests form a flange which at the points of cross over between membranes have a distinctive thickening point. Excystment mechanism not observed.

*Remarks.* This form shows affinity to the species *C. pavimenta* in having low crests often bearing spines. The flanges though were generally lower than those recorded as *C. pavimenta* in this study. In addition the point of thickening crest junctions also served to distinguish these forms from *C. pavimenta* sensu stricto. It is possible that these two groups could be combined, but as a difference was clearly notable in this study the separation has been retained for future reference.

*Dimensions.*

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central body</td>
<td>18 - 24 μm</td>
</tr>
<tr>
<td>Outer flange</td>
<td>1 - 2 μm</td>
</tr>
<tr>
<td>Field width</td>
<td>6 - 8 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

*Occurrence.* This small form was recovered consistently throughout the assemblages from the Coalbrookdale to Lower Elton formations in the Wenlock and Ludlow areas of Shropshire.

**Cymatiosphaera pavimenta sensu lato**

Not figured.

*Description.* Thin walled small from...
Remarks. A form smaller than allowed for by the specific diagnosis of *C. pavimenta* which have now been accepted and included as *C. pavimenta* are noted here to clarify their separation on the logging sheets.

**Dimensions.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Central body</td>
<td>14 μm</td>
</tr>
<tr>
<td>Entire vesicle plus flange</td>
<td>20 μm</td>
</tr>
<tr>
<td>Outer flange</td>
<td>2 - 3 μm</td>
</tr>
<tr>
<td>Field width</td>
<td>6 - 8 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

**Occurrence.** This forms was recovered from the Coalbrookdale formation of the type area from Farley Dingle (FD 1400).

*Cymatosphaera cf. pentagonalis* Kiryanov 1978

Plate 10, fig. 4 - 6; Plate 60, fig. 9.

cf. 1978 *Cymatosphaera pentagonalis* Kiryanov, p. 30 - 31, pl. 5, fig. 5 only non. fig. 3.
cf. 1989 *Cymatosphaera cf. pentagonalis* Kiryanov, Barron, p. 87, fig. 3, E.
cf. 1990 *Cymatosphaera pentagonalis* Kiryanov; Fensome et al. p. 173, no fig.

**Holotype.** *Cymatosphaera pentagonalis* Kiryanov, p. 30 - 31, pl. 5, fig. 5. Borehole Schidlovse 1690, 2 depth 270.5. Lower Silurian, middle Wenlock.

**Diagnosis.** (See Kiryanov, p. 30 - 31, in Russian.)'Vesicle compressed in outline, spherical to subpolygonal more often subpolygonal (four or five sided). Some deformed specimens have sub-polyhedral form. In optical section the membranes have a general polygonal form. The diameter of vesicle is 25 - 30 μm (holotype 30 μm) and the wall thickness = 1 μm. Membranes are situated radially and so that the basal part of the membrane is quite coincident with the surface of vesicle in polygonal fields.

The specimens mostly have 5 sides but here are also forms with four. The number of the fields = 6 - 8 (holotype has 6). Again in the angle of the membranes they have spines, between 12 - 14 (holotype has 12). The surface of the vesicle inside each field is laevigate. The membranes have very fine striated ornamentation. The striation is rare, radial and undulating. The outside part of the membrane is even or a little concave. Pylome and other opening not observed.'
Comparisons: This species differs from *pentaster* by having a radial formation to the spines, which show no polarity and no distal widening.

Remarks. Thin walled form bearing two sets of fields with an indistinct thin walled, subspherical, laevigate central body. Folds in the vesicle body are a distinguishing feature. The specimens recovered are pentagonal in outline. The outer flanges are wide, extend far beyond the inner vesicle and are formed of thin membranes which delimit 6 - 8 large fields. The forms also depicted by Kiryanov (1978, pl. 5, fig. 5) as being *C. pentagonalis* are here believed to be more akin to those forms considered in this study as belonging to *C. ledburica*. *C. octoplena* Downie 1959 differs in having an ornamented vesicle and smaller crests which do not extend as far from the central body, while *C. gorstia* Dorning 1981a is larger with lower crests and has more lacunar fields. This form is similar to *C. wenlockia* and *C. ledburica* but has a less well defined central body. It is possible that the larger forms recorded by Barron (1989) have herein been assigned to *C. wenlockia* though those forms also do not bear the foveolate ornament usually associated with *C. wenlockia*.

This form was logged originally as *Cymatosphaera* sp. H.

**Dimensions.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Central body</td>
<td>14 - 22 μm</td>
</tr>
<tr>
<td>Entire vesicle plus flange</td>
<td>26 - 30 μm</td>
</tr>
<tr>
<td>Outer flange</td>
<td>8 - 12 μm</td>
</tr>
<tr>
<td>Field width</td>
<td>8 - 10 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

Occurrence. This form was first recorded from the late Llandovery to Wenlock series of Podolia, Ukraine, (Kiryanov 1978); Specimens comparable have also been recorded from the middle Wenlock of the Cheviot Hills north east England (Barron 1989 as *C. cf. pentagonalis*), late Sheinwoodian to early Homerian of the Welsh Borderlands (Swire 1991).

This species has been recorded from the Coalbrookdale Formation (Farley Member) of Farley Dingle and the Much Wenlock Limestone Formation of Harley Hill.

Known Range: Upper Llandovery - Wenlock Series.
Cymatiosphaera prismatica Deunff 1961b

Plate 10, fig. 8.

1966 Cymatiosphaera prismatica sp. nov. Deunff, p. 132, pl. 12, fig. 130.
1989 Cymatiosphaera cf. prismatica Deunff; Le Hérisse, p. 76 - 77, pl. 1 figs. 14, 15.
1990 Cymatiosphaera prismatica Fensome et al., p. 174, no fig.

Holotype. Deunff 1961, p. 218, pl. 1065, text - fig. 6, from the Onondaga Formation, middle Devonian of Canada.

Diagnosis. (Deunff 1961, p. 218, Translated by Pascale Presumey). "Test spherical, yellow, translucent, microperforated, ornamented with membranes surrounding the organism in a prismatic form. The membranes determine the surface of the test two triangular fields poles oppose and two fields rectangular in opposition."

Remarks. The specimens recovered are spherical, laevigate to finely granulate, thick walled central body, bounded by a thin membrane divided into four triangular fields. Mode of excystment not observed. This form is distinguished by its prismatic shape and relatively small vesicle size.

Dimensions. Vesicle diameter 25 µm
Diameter including flange 29 µm
Crest Height 2 µm
Diameter of polygonal fields 12 µm
Number of specimens measured 4

Occurrence. Devonian of Canada (Deunff 1961, 1966); Wenlock Series of the Welsh Borderlands (Downie 1963); Ludlow Series of the Ludlow area (Lister & Downie 1974); Devonian of Canada (Deunff 1955); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); Ludlow Series of Argentina (Poth de Baldis 1981); upper Llandovery Series (Purple Shales) to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985); base of the Wenlock Series to the top of the Ludlow Series of Gotland (Le Hérisse 1989).

This species has been recovered from the Coalbrookdale formation (Farley Member) of the type area, Much Wenlock, Shropshire (FD2000).
**Cymatiosphaera pyramidalis** sp. nov.

Plate 8, figs. 11, 12.

*Holotype.* Plate 8, fig. 12, from sample MFGT1 300/10/1. Rivelin finder reference O42 from the Much Wenlock Limestone Formation of Mortimer Forest, Ludlow, Shropshire, England.

*Diagnosis.* Central vesicle body spherical to ellipsoidal (14 - 18 μm), medium to thick walled and is either laevigate to having a finely granulate ornament. The central body is surrounded by a thin diaphanous outer membrane, not divided into distinct fields, the outline of which forms a pyramidal shape, the long axes of which appear to have a slightly thicker supportive folding/thickening of the thin membrane. The entire vesicle plus flange measures between 34 - 40 μm.

*Remarks.* The specimens recovered differ from *C. prismatica* in the pyramidal form of the outer diaphanous membrane.

*Dimensions.*

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central body</td>
<td>14 - 18 μm</td>
</tr>
<tr>
<td>Entire vesicle plus flange</td>
<td>34 - 40 μm</td>
</tr>
<tr>
<td>Outer flange</td>
<td>10 - 14 μm</td>
</tr>
<tr>
<td>Field width Indistinct</td>
<td></td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

*Occurrence.* This species was recovered as rare types from the Much Wenlock Limestone Formation of Coates Quarry and Mortimer Forest in the Much Wenlock and Ludlow areas of Shropshire.

**Cymatiosphaera cf. subrotunda** Kiryanov 1978

Plate 8, figs. 7, 8.; Plate 9, fig 8.

cf. 1978  *Cymatiosphaera subrotunda* sp. nov.; Kiryanov, p. 31-32, pl. 5, fig. 8 only, non fig. 7.
1990       *Cymatiosphaera subrotunda* Kiryanov 1978; Fensome et al., p. 172, no fig.
Remarks. This species has only been compared to Kiryanov (1978) figure 8 and not figure 7. It is believed that figure 7 represents a form similar to Cymatiosphaera ledburica. The forms recovered are pale yellow, thin walled, spherical central body surrounded by a fine membrane, forming crests. The crests formed from the flange are undulose which delineate fields which therefore also have undulating boundaries rather than the polygonal form often seen in species belonging to the genus Cymatiosphaera. Mode of excystment not observed.

Dimensions.  

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>36 μm</td>
</tr>
<tr>
<td>Crest height</td>
<td>4 μm</td>
</tr>
<tr>
<td>Field width</td>
<td>6 -10 μm</td>
</tr>
<tr>
<td>Number of fields</td>
<td>17+ μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

Occurrence. Early Ludlow Series of Podolia in the Ukraine (Kiryanov 1978); from the Hemse and Eke Formations (upper Ludlow Series) of Gotland, Sweden (Le Hérisse 1989 as Cymatiosphaera. sp. B). This species was recovered as a rare type from the Much Wenlock Limestone Formation of Coates Quarry in the type area, Much Wenlock, Shropshire.

Known range: Wenlock - Ludlow Series

Cymatiosphaera wenlockia Downie 1959

Plate 8, fig. 10; Plate 60, fig. 11.

1959 Cymatiosphaera wenlockia sp. nov.; Downie, p. 63 - 64, pl. 11, fig. 4.
1970b Cymatiosphaera wenlockensis; Downie; Cramer, p. 746, no fig.
1972 Cymatiosphaera wenlockensis Cramer & Diez, p. 141, no fig.
1989 Cymatiosphaera wenlockia; Downie; Le Hérisse, no page description, pl. 1, figs 9, 10.
1990 Cymatiosphaera wenlockia; Downie; Fensome p. 176, no fig.

Holotype. Downie (1959), p. 63, pl. 11 fig. 4. from the Coalbrookdale Formation of Wenlock Edge, Shropshire.

Diagnosis. (Downie 1959, p. 63). "A species of Cymatiosphaera, diameter 18 - 35 μm, walls moderately thick, partitions 15 - 20 percent of the diameter, polygonal fields 10 - 20 μm across, number variable, always more than eight."
Remarks. The specimens recovered conform to the original diagnosis. Mode of excystment not observed. Doming (1981a) stated that this form is a junior synonym of *C. octopiana* Downie 1959, however it is considered here that the two species are distinct. The specimens called *C. wenlockia* here are smaller than those described by Downie (1959). Perhaps it is possible that this species along with *C. heloderma*, that the significantly greater size reported in the original diagnoses is the result of the effects of oxidation upon the specimens as noted by Dodsworth (1995).

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central body</td>
<td>18 - 36 μm</td>
</tr>
<tr>
<td>Entire vesicle plus flange</td>
<td>48 - 60 μm</td>
</tr>
<tr>
<td>Outer flange</td>
<td>8 - 12 μm</td>
</tr>
<tr>
<td>Field width</td>
<td>15 - 30 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

**Occurrence.** This species has been widely recorded, the following reports have been checked; Wenlock Series of Wenlock Edge, Shropshire (Downie 1959); upper Silurian to lower Devonian of northwest Spain (Cramer 1964 p); Llandovery to Wenlock series of Belgium (Martin 1968, Stockmans & Willière 1969); Llandovery Series of USA and Canada (Cramer 1969a, Cramer & Diez 1970); upper Llandovery to Wenlock Series of Nova Scotia and eastern USA (Cramer 1970); upper Llandovery to Ludlow series of the USA (Cramer & Diez 1972); Wenlock Series of Ontario (Thusu 1973a); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); Wenlock (Homerian) to Prîdolf Series of the Ludlow area (Lister & Downie 1974); Upper Llandovery of Quebec, Canada (Achab 1976); middle Llandovery to the lower Ludlow series of Britain and Ireland (Aldridge et al. 1979); Wenlock Series of Gotland, Sweden (Cramer et al. 1979); Wenlock Series (Slite Formation) of Gotland, Sweden (Le Hérisse 1989); upper Silurian of San Juan, Argentina (Rubinstein 1993).

This species has been recovered consistently from the samples studied, from the Farley Member of the Coalbrookdale Formation through the Much Wenlock Limestone Formation to the lowermost Lower Elton Formation of the Wenlock and Ludlow areas of Shropshire.

**Known Range.** Llandovery to Ludlow series, Silurian.

**Cymatosphaera cf. wenlockia** Downie 1959

Plate 9, fig. 5

Remarks. The specimens placed herein are those damaged forms that conform broadly to the specific diagnosis but are damaged or insufficiently visible to enable an accurate identification, such as the form figured
which has lost its central body. The form logged as *Cymatiosphaera* sp. J has been included here.

**Dimensions.**

<table>
<thead>
<tr>
<th>Description</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire vesicle plus flange</td>
<td>24 μm</td>
</tr>
<tr>
<td>Field width</td>
<td>12 - 16 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

**Occurrence.** Specimens were found sporadically through samples from the study area.

---

**Cymatiosphaera sp. F**

Plate 10, fig. 7.

*Description.* Thin walled for bearing two sets of fields with no differentiated central body. The vesicle is cubic and laevigate. The folds in the vesicle body are a distinguishing feature.

*Remarks.* This form is similar to *Polyedryxium cf. embudum* Cramer 1964b, but the form was only depicted with a line drawing. Only one specimen was recovered hence this form is retained under open nomenclature within the genus *Cymatiosphaera* in order to maintain consistency with the logging sheets.

**Dimensions.**

<table>
<thead>
<tr>
<th>Description</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle size</td>
<td>18 - 22 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

**Occurrence.** This form was recorded as a rare type from the Farley Member of the Coalbrookdale Formation of Farley Dingle and the Much Wenlock Limestone Formation of Pitch Coppice.

---

**Cymatiosphaera sp. Q**

Plate 9, fig. 3.

*Description.* Thick walled central body 13 - 22 μm bearing diaphanous flanges supported by robust spines 8 - 10 mm in length. The flange width is variable in extent around the central body 4 - 6 μm. The flanges delimit 6 - 8 polygonal fields 10 - 12 μm across.
Remarks. This form differs from *Cymatiosphaera pavimenta* in that it is much more robust, thicker walled with considerably wider flanges extending much further from the central body.

**Dimensions.**

- Central body: 20 - 26 μm
- Entire vesicle: 26 - 32 μm
- Flange width: 4 - 6 μm
- Field width: 10 - 12 μm
- Number of specimens measured: 5

Occurrence. This species has been recovered as a single specimen from the Coalbrookdale Formation (Farley Member) of Farley Dingle (FD Bent 10/1, S 33).

---

**Cymatiosphaera sp. R**

Not figured.

Description. This form, as separated in the logging sheets is now deemed to possibly be a broken form of a species of *Pterospermella*.

**Dimensions.**

- Central body: 14 μm
- Outer flange: 2 - 4 μm
- Number of specimens measured: 1

Occurrence. This was recorded as a single specimen, recovered from sample HH3 800/10/1 from the Much Wenlock Limestone Formation of Harley Hill.

---

**Cymatiosphaera sp. X**

Plate 9, fig. 6.

Description. Thick walled dark spherical vesicle body (32 - 36 μm), yellow to brown and matt in appearance, bearing an outer thin walled flange (4 - 8 μm) that divides the vesicle into 5 - 8 fields; lacunar field width 10 - 12 μm. Mode of excystment, not observed.
Remarks. Only one specimen was recovered of this distinctive form, hence the specimen is described in open nomenclature as an informal species of the genus *Cymatosphaera*.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central body</td>
<td>32 - 36 µm</td>
</tr>
<tr>
<td>Outer flange</td>
<td>4 - 8 µm</td>
</tr>
<tr>
<td>Field width</td>
<td>11 µm</td>
</tr>
<tr>
<td>Number of</td>
<td>1</td>
</tr>
<tr>
<td>specimens</td>
<td>measured</td>
</tr>
</tbody>
</table>

**Occurrence.** This specimen was recovered from the Wenlock Ludlow boundary beds at Pitch Coppice - sample PC 315/10/1 - P45.5, Ludlow, Shropshire, England.

*Cymatosphaera* sp.

**Remarks.** Poorly preserved specimens that were not assigned to a species were recorded informally during the logging as *Cymatosphaera* sp.

Genus **DATEIROCRADUS** Tappan & Loeblich 1971.

**Type Species.** *Dateriocradus polydactylus* Tappan & Loeblich 1971; p. 396, pl. 5; 1 - 7; Waldron Formation, upper Wenlock Series, Indiana, USA.

**Diagnosis.** (Tappan & Loeblich 1971, p. 394). ‘Central vesicle subtriangular in outline commonly with three long hollow processes in plane of vesicle, rarely a fourth arising from the broad face of the vesicle; processes distally bifurcating up to the fifth or sixth order; wall surface laevigate; excystment by development of an epityche, an arcuate splitting of the wall resulting in a flaplike opening between two processes similar to that in *Veryhachium*.’

**Remarks.** This genus is similar in morphology to *Veryhachium*, but differs in having multifurcate processes. *Multiplicisphaeridium* differs from *Dateriocradus* in having a subspherical rather than tetrahedral or triangular vesicle body shape. *Diexallophasis* have digitate, not ramified process terminations and ornamented vesicles. *Dateriocradus* differs from *Oppilatala* Loeblich & Wicander 1976 in having fewer processes and a triangular to subtriangular vesicle body.
Dateriocradus monterrossae (Cramer 1969 a) Dorning 1981a

Plate 15, fig. 6.

1969 a Baltisphaeridium monterrosae n. sp. Cramer p. 490. pl. 70, figs. 5 - 7, figs. 1 d, e, f.
1970 a Baltisphaeridium monterrosae; Cramer p. 129 - 130, pl. 8, fig. 127, 128, 130, 132 only; text - fig. 39 j.
1971 Dateriocradus polydactylus n. sp.; Tappan & Loeblich, p. 396, pl. 5, figs 5 & 7 only.
1973 Evittia monterrosa (Cramer) n. comb.; Thusu, p. 815, pl. 106, fig. 7.
1973 Multiplicisphaeridium monterrosae; Eisenack et al., p. 693 - 694.
1981a Dateriocradus monterrossae; Dorning n. comb., p.186, no fig.
1981 Dateriocradus monterrossae; Pothé de Baldis, p. 238, pl. 3, fig 5.
1989 Oppilatala monterrossae; Le Hérisse n. comb., p. 176-177, pl. 23, figs 14 - 15, text-fig. 14: 4.
1990 Dateriocradus monterrossae; Fensome et al. p. 187, no fig.

Holotype. Cramer 1969 a, p. 490, pl. 70, fig. 5; Rose Hill Formation, upper Llandovery Series, Millerstown, Pennsylvania, USA.

Diagnosis. (Cramer 1969 a, p. 490). ‘Central portion of vesicle subtriangular, clearly differentiated from processes. The processes are located at the corners of the central portion of the vesicle. The processes are generally of the same length as or slightly longer than a side of the central portion; they are cylindrical but have a broad conical base which grades from the central portion of the vesicle into the process proper through a distance of about 1/10 of the process length. At the distal portion, pinnae and pinnulae (up to the second order) are present; characteristically, there are three or four sets of pinnae. The splitting angle between pinnae and processes varies from 90 - 120 degrees; however, the configuration and complexity is a fairly constant morphologic character for the species. The pinnulae of the last order tend to be split in a dichotomous fashion. The only branching is distal. The processes are entirely hollow as are the basal portions of the pinnae; the tops of the pinnae and pinnulae are solid. The process cavity and the vesicle cavities are continuous; no complex unions between both morphographic units were seen. Characteristically, the central portion of the vesicle possesses a fracture, which divides it in two almost equal parts. This fracture is interpreted as a straight slit pylome, similar to that which is found in many species of Veryhachium and Michrystridium. The processes and the central portion of the vesicle are unilayered and are apparently uniform; however, a consistent difference of colour was observed: all the processes are transparent (colorless to translucent-brown), whereas the central portion is always much darker (translucent to opaque). The vesicle wall is psilate and is about 1µ thick. No internal cysts were observed.’
Remarks. The specimens recovered conform broadly to the original diagnosis. They have laevigate vesicles with a convex triangular outline. The processes taper and can be plugged or communicate freely with the central vesicle cavity. It is in this aspect that the forms differ slightly from the original diagnosis. The processes extend from the apices of the vesicle body. The processes are branched from 2/3 of the process length. The form of branching is highly ramified from 3rd - 6th order. This pattern of branching conforms to that observed on the holotype, but which is inconsistent with the original diagnosis, which states up to second order. The mode of excystment was not observed.

It is believed that Dateriocradus monterrossae as currently accepted is representative of a form group. There is a wide variation in the form, amount and position of the branching of the process branching. There is extensive confusion between D. monterrossae and D. polydactylus in the literature and it is believed here, that the form of the distal branching and the distance along the processes where the branching occurs, is significantly different in individual specimens to create a split and define the different forms as separate species. The features that are believed to distinguish D. monterrossae from D. polydactylus are the following:

Dateriocradus monterrossae has:

i. Short cylindrical processes

ii. Broad conical bases

iii. Branching is greater than second order.

Hence here it is considered that D. polydactylus differs enough from D. monterrossae to be validly retained as a separate species, as it lacks the ramified branching observed in the holotype and the branching in the former is initiated much further down the process than observed in specimens of D. monterrossae.

There is a strong case to transfer Dateriocradus to Oppilatala. as Le Hérisse did in 1989 (p. 176 - 177). In the original diagnosis Cramer (1969 a) states that the processes of D. monterrossae are hollow, but it is not possible to ascertain from the photograph of the holotype whether or not the figured specimen has plugged or hollow processes. All the forms considered synonymous from Cramer 1970 a (pl. 8, figs 127, 130 and 132) have plugged processes, while his pl. 8, fig. 128 is a further figure of the holotype specimen where it is not possible to observe the whether or not the processes are plugged because of the dark vesicle wall. The forms considered to be D. monterrossae in the present work have both freely communicating, hollow and restricted - plugged processes. The figured specimen herein (plate 15 fig. 6), exhibits plugged processes. All the forms attributed to D. monterrossae here have the characteristic triangular vesicle body and multifurcate process terminations. While there may be strong case to transfer Dateriocradus to Oppilatala it must be remembered that Dateriocradus is senior to Oppilatala. Until further work has been done. D. monterrossae is used in preference to O. monterrossae Cramer 1969, (Le Hérissé 1989).
**Dimensions**

- Vesicle diameter: 20-24 μm
- Process length: 18 - 26 μm
- Process base width: 2 μm
- Process number: 3
- Number of specimens measured: 5

**Occurrence.** Wenlock Series of north west Spain (Cramer 1963, 1964 b, 1970 a); Llandovery of Belgium (Martin 1966); Upper Llandovery to Pridol series of eastern USA (Cramer 1968a, 1969 a, 1970 a; Cramer & Diez 1972), Wenlock Series of Ontario, Canada (Thusu 1973a); lower Ludlow Series, Los Espejos Formation of Argentina (Pothé de Baldis 1981); Buildwas to Coalbrookdale formations, Wenlock Series (Sheinwoodian) of the Welsh Borderland (Dorning 1981a); lower Silurian of Ringerike, Norway (Dorning & Aldridge 1982); Much Wenlock Limestone Formation, Wenlock Series, Dudley, West Midlands, England (Dorning 1983d); Wenlock Series (Sheinwoodian) of the Wenlock type area (Swire 1993); Wenlock Series, Coalbrookdale Formation from Holbrook Coppice, near Ironbridge, Shropshire (Turner et al. 1995 as *D. cf. monterrosae*).

This species was recorded from the Much Wenlock Limestone Formation of Mortimer Forest near Ludlow and the Much Wenlock Limestone Formation of Shadwell Quarry, and the Coalbrookdale Formation of Farley Dingle of the Much Wenlock area of Shropshire.

Known range: Llandovery - Pridol series.

**Dateriocradus polydactylus** Tappan & Loeblich 1971.

Plate 15, fig. 5.

1970 *Evittia remota* (Deunff 1955) comb. nov. Lister, p. 69 - 70, pl. 4, fig. 11, pl. 5, fig 1.
1970 *Baltisphaeridium* sp.; Cramer; pl. 12, fig 176.
1971 *Dateriocradus polydactylus*; Tappan & Loeblich p. 396, pl. 5; 1 - 4 and 6 only.
1973 *Evittia monterrosa*, n. comb.; Thusu, p. 815, pl. 106, fig. 2.
1976 *Dateriocradus polydactylus*; Eisenack et al. p.185, no fig.
1990 *Dateriocradus polydactylus*; Fensome et al. p. 187, no fig.

**Holotype.** *Dateriocradus polydactylus* Tappan & Loeblich 1971; p. 396, pl. 5, fig. 1; Waldron Formation, upper Wenlock Series, Silurian, Indiana, U.S.A.
Diagnosis. (Tappan & Loeblich, p. 396) ’Central vesicle subtriangular in outline, with side slightly convex; in life vesicle inflated but probably lens-shaped, with three long processes arising in the plane of the central vesicle, rarely a fourth process arising from the face of the vesicle; processes hollow throughout their entire length except for the fine tips, which are probably solid, and communicating freely with the vesicle. Terminally the processes are variously multifurcate, bifurcating up to the sixth order. Wall surface laevigate; excystment by formation of an epityche, resulting from a low, arched, slit like rupture of the vesicle wall between two processes and the opening out of a broad tongue like flap.’

Dimensions. 

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>16 - 25 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>23 - 45 μm</td>
</tr>
<tr>
<td>Process width</td>
<td>2 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>4 rarely 5</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

Remarks. Four processes branching from second to third order with rare branching at the very tip of a processes. Branching is initiated 1/2 to 2/3 of the way along the process length. Processes communicate freely with the central body cavity. Dateriocradus monterrosae (Cramer), Doming 1981a, has wider processes and exhibits multifurcate highly ramified branching that generally occurs from 2/3 of the way along the length of the process.

The assignment of this species as a junior synonym to D. monterrosae (Eisenack et. al 1976, p. 185) is rejected as the holotypes of the two species are clearly distinct. D. monterrosae branches up to 6th order whereas D. polydactylus which exhibits relatively simple first to second with rare third order branching. The ‘isotype’ of D. polydactylus (Tappan & Loeblich 1971, pl. 5 fig. 5 and 7), is here synonymised with D. monterrosae as it exhibits the greater degree of branching and the characteristic triangular vesicle body and only three processes. In D. polydactylus three processes arise from the corners of the vesicle body a fourth emerges from the centre of the vesicle body. Dateriocradus algerensis (Cramer & Diez 1972) Doming 1981a is larger than D. polydactylus which has been reported by Cramer & Diez (1972) from the eastern USA. It is possible that this morphotype could be synonymised with D. polydactylus but this would necessitate re-examination of the holotype of D. algerensis.

Occurrence. Wenlock and Ludlow series of the Welsh Borderland (Lister 1970); late Wenlock Series, Waldron Formation, Jennings County, Indiana, U.S.A. (Tappan & Loeblich 1971); Wenlock (Homerian Stage) to Ludlow (Gorstian Stage) series of the Welsh Borderland (Doming 1981a); Much Wenlock Limestone Formation, Wenlock Series, Dudley, West Midlands UK (Doming 1983); Los Espejos Formation, late Silurian of San Juan Province, Argentina (Rubinstein 1993); Buildwas and Coalbrookdale formations of the type area and Eastnor Park Borehole in the Malverns (Swire 1991, as D. algerensis); Wenlock Series from Holbrook Coppice, near Ironbridge, Shropshire (Turner et al. 1995).
In this study this species has been recovered from the Coalbrookdale Formation (Farley Member) of Farley Dingle (FD 1600) to Much Wenlock Limestone Formation of Coates Quarry (CT6) and Harley Hill (sample HH3 100) of the type area, Much Wenlock, Shropshire.

*Dateriocradus tribrachiata* (Lister 1970) Dorning 1981a

Plate 15, fig. 3

1970 *Evittia tribrachiata* sp. nov. Lister, p. 71 pl. 5, fig 5, fig. 20 c.

1973 *Multiplicisphaeridium tribrachiata*; Eisenack et al., p. 817.

1974 *Diexallophasis tribrachiatum*; Lister & Downie, p. 26, no. fig.

1981 *Dateriocradus tribrachiata*; Dorning n. comb; p. 186. no fig.

1981 *Evittia longispinosa*; Pôthe de Baldis, p. 240 pl. 3, fig. 10.

1990 *Dateriocradus tribrachiata*; Fensome et al., p. 187, no fig.

**Holotype.** *Evittia tribrachiata* Lister 1970, p. 71, pl. 5, fig. 5, from the Lower Elton Formation, Ludlow Series of the Ludlow area of Shropshire.

**Diagnosis.** (Lister, 1970 p.) 'Vesicle hollow, more or less inflated, triangular, thin walled; angles of body extended into hollow tubular processes about equal in length to the body diameter; distally, processes divided more or less regularly up to fourth order; wall of body and process faintly granular to echinate. Excystment by cryptosuture.'

<table>
<thead>
<tr>
<th>Dimensions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>16 - 22 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>32 - 60 µm</td>
</tr>
<tr>
<td>Process width</td>
<td>2 µm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 - 4 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>3</td>
</tr>
<tr>
<td>Number of specimens</td>
<td>5</td>
</tr>
</tbody>
</table>

**Remarks.** The forms conform generally to the specific diagnosis though the echinate sculpture noted in Lister's remarks (1970, p. 71) has not been observed. The forms being recovered having a laevigate to finely granulate wall. Processes branch up to generally up to second order with rare branching at the very tip of a processes. Branching is initiated $1/2$ to $2/3$ of the way along the process length. Processes communicate freely with the central body cavity.
D. monterrosae has wider processes and exhibits multifurcate branching. The holotype needs re-examination to determine the number of processes present. The individuals recovered here are distinctive in having three processes but the holotype for D. tribrachiata seems to have a fourth process arising from the centre of the vesicle body. It is noted though that the holotype also has the distinct ornamented vesicle which is also a distinguishing factor for this speciation. This species of Dateriocradus is essentially a species that contains forms intermediate between Veryhachium and Oppilatala. The mid Devonian form Multiplicisphaeridium furcillatum (Deunff 1955) is similar, having a triangular, three processed vesicle but the branching occurs more towards the distal portion of the processes than in D. tribrachiata. The holotype would need to be examined before any definition of synonymy could be decided upon.

**Occurrence.** Much Wenlock Limestone Formation to the Lower Elton Formation of England (Lister 1970 as Evittia tribrachiata); Elton Formation, Ludlow Series of the Ludlow area (Lister & Downie 1974 as Diexallophasis tribrachiatum); from the Elton Formation of the Welsh Borderland (Doming 1981 a); lower Ludlow Series of Argentina (Póthe de Baldis 1981); Buildwas and Coalbrookdale formations of the type area and Eastnor Park Borehole (Swire 1991 as D. algerensis). This species is present in low numbers from the Much Wenlock Limestone Formation of Harley Hill in the Much Wenlock area.

**Dateriocradus sp. E**

Plate 15, figs. 1, 2.

1970  
*Baltisphaeridium* sp. Cramer; pl. 12, fig. 173.

**Description.** Vesicle hollow, single and thin-medium walled, laevigate, subpolygonal with convex sides. Four to six slender, multifurcate processes extend from the apices of the vesicle, communicating freely with the central body cavity. The form and arrangement of the processes giving the vesicle body a polygonal shape. Branching is of several orders generally to second or third order (maximum fourth) and is not uniform. The processes taper distally. Branching is initiated from 2/3 along the process length to that which occurs at the tip of the process. Process length is greater than the vesicle diameter. Excystment is by a simple split.

**Remarks.** D. monterrosae has fewer, shorter processes that exhibit a greater degree of branching. *D. polydactylus* has fewer processes that branch from half way along the process length. It is similar to species belonging to the genus Veryhachium but this form has multifurcate processes. *D. algerensis* has a larger vesicle body and fewer processes.
**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>14 - 30 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>18 - 36 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 - 6 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>5+</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Occurrence.** In the Ludlow area this species was recovered from the Much Wenlock Limestone Formation at Pitch Coppice Quarry (samples PC 240), while from the Much Wenlock area of Shropshire it was recovered from the Much Wenlock Limestone Formation, in samples from Harley Hill (sample HH3 800), Coates Quarry (samples CT2, CT 5) and Shadwell Quarry (sample 2SH 110).

*Dateriocradus* sp.

**Remarks.** These are poorly preserved forms not assigned to a particular species.

**Occurrence.** Other forms assigned to *Dateriocradus* sp., have been reported from the Llandovery to Wenlock Series of Ireland (Smith 1981); upper Ordovician (Ashgill Series) to lower Silurian (Llandovery Series) of north-east Libya (Hill & Molyneux 1987). Rare throughout the study sections in the type Wenlock and Ludlow areas.

**Genus DICHONOZONATA** Kiryanov 1978

*Type Species. Dichonozonata* (Kiryanov 1978, p.37 - 38, pl. 15 fig. 9.)

**Diagnosis.** (Translated from Kiryanov 1978 p. 37.) Vesicle spherical, unilayered with reticulate membrane which is of the same composition as the vesicle. The fields are between the fields the membrane and are cylindrical in outline. The surface of the vesicle is divided in two parts by low ridges formed from crest membranes and another membrane surrounds the exterior of the entire vesicle. On both sides of the vesicle the ridges are asymmetric. Excystment mechanism not observed. Comparisons; this genus differs by the presence of the middle ridge.

**Remarks.** This genus is distinctive for its thick wall structure and ornament of thin walled membranous crests which divide the vesicle body into reticulate pattern. This genus differs from *Cymatiosphaera* in not having an inner central body and outer flanges and from *Dictyotidium* in that the fields are not regular polygons.
**Dichonozonata paripartita** Kiryanov 1978

Plate 10, fig. 10; Plate 11, fig. 5.

1978 *Dichonozonata paripartita* sp. nov., Kiryanov, p. 38, pl. 15, fig. 9.
1990 *Dichonozonata paripartita* Kiryanov; Fensome *et al.* p. 191, no fig.

**Holotype.** Kiryanov 1978, p. 38, pl. 15 fig. 9, from Borehole Schidlovze 16902, Lower Silurian Wenlock Series of Podolia in the Ukraine.

**Diagnosis.** (Translated from Kiryanov 1978 p. 38.) Vesicle is compressed but in general has a rounded or ellipsoidal outline when not folded. Spherical, three dimensional specimens are not known. Vesicle dimensions in holotype: Thickness of wall is 1 μm. The surface is ornamented by a reticulate membrane that forms more or less polygonal fields, these fields commonly have five sides, usually more than four. They are about 3 μm wide and 5 - 7 μm in length. The height of the membranes is 2 - 4 μm. At the field junctions the membranes have a height of 4 μm. The overall height of the membrane is low and becomes lower in the middle part. The surface of the vesicle is divided by ridges with 3 - 4 μm wide (holotype 4 μm) and height 2 - 2.5 μm. There is no symmetry. The ridges go through the fields and divide them in an irregular fashion. Sometimes this surface is broken with a longitudinal split along the ridge.

**Remarks.** Dark thick walled vesicle body, endophragm surrounded by a thin translucent ectophragm. Central body ridged and folded, fields indistinct, spines and large flat topped truncated grana are sometimes present formed from the endophragm.

**Dimensions.**

<table>
<thead>
<tr>
<th>Description</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central body</td>
<td>38 - 40 μm</td>
</tr>
<tr>
<td>Entire vesicle plus flange</td>
<td>40 - 42 μm</td>
</tr>
<tr>
<td>Outer flange</td>
<td>2 μm</td>
</tr>
<tr>
<td>Field width</td>
<td>2 - 4 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Occurrence.** Llandovery and Wenlock series in Podolia (Kiryanov 1978). This species has been recovered from the Coalbrookdale Formation of Farley Dingle and the Much Wenlock Limestone Formation of Coates Quarry.

Known Range: Late Llandovery to Wenlock series.
Dichonozonata cf. paripartita

Plate 11, fig. 4.

Remarks. The specimens recovered are large forms of Dichonozonata and are therefore compared to D. paripartita.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>36 - 54 μm</td>
</tr>
<tr>
<td>Wall thickness</td>
<td>2 μm</td>
</tr>
<tr>
<td>Ornament height</td>
<td>2 μm</td>
</tr>
<tr>
<td>Ornament width</td>
<td>4 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>4</td>
</tr>
</tbody>
</table>

Occurrences. This form was recovered from the Much Wenlock Limestone to Lower Elton formations in the type areas of Much Wenlock and Ludlow, from localities at Farley Dingle, Shadwell Quarry, Coates Quarry and Pitch Coppice.

?Dichonozonata spp.

Plate 12 fig. 4.

Description. Double walled vesicle with a thick robust endophragm and thin ectophragm. The walls are closely adpressed and the thinner outer wall does not produce fine flanges but with the inner wall forms muronate ridges which sinuously cover the entire vesicle body.

Remarks. This form is tentatively assigned to this Dichonozonata because, though the surface is ridged, the ornament is in fact considerably thicker and thus quite distinct from that seen in species belonging to Dichonozonata sensu stricto.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>38 - 47 μm</td>
</tr>
<tr>
<td>Ridge thickness</td>
<td>3 - 6 μm</td>
</tr>
<tr>
<td>Ridge height</td>
<td>2 - 3 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

Occurrences. This form was recovered as a rare type from sample MFGT/TD/10/1, Much Wenlock Limestone Formation of Mortimer Forest, in the Ludlow area of Shropshire.
Genus **Dictyotidium** Eisenack 1955 a emend. Staplin 1961


*Type Species. Dictyotidium dictyotum* Eisenack, 1938, p. 27 - 28, pl. 3, figs. 8a - c; Holotype lost (Eisenack, 1955, p. 179 - 180).

*Emended Diagnosis.* (Staplin 1961 p.417). ‘Vesicle spherical; surface reticulate, ridges low, distinct, lacunar areas polygonal; some species with two distinctly smaller lacunae, one at each pole; small apiculae or spines may arise from the edges; papillae may be present in the floors of the lacunae.’

*Remarks. Dictyotidium* has more numerous fields than *Cymatiosphaera.*

**Dictyotidium amydrum** Tappan & Loeblich 1971

Plate 12, figs. 1 - 3.

1971 *Melikeriopalla amydra* n. sp.; Tappan & Loeblich, p. 396 - 398, pl. 6, figs. 1 - 4
1979a *Dictyotidium amydrum* (Tappan & Loeblich 1971); Eisenack et al., p.157 - 158.
1986 *Dictyotidium coarctatum* (Kiryanov); Martin, p. 339 - 340, pl. 3, fig 6.
1990 *Dictyotidium amydrum;* Fensome et al., p. 193, no fig.

*Holotype. Tappan & Loeblich 1971; pp. 396, 398, pl. 6, fig. 3; Wenlock Series, (Waldron Formation), Silurian, Indiana, USA.*

*Diagnosis.* (Tappan & Loeblich 1971, p. 396, 398). ‘Vesicle spherical to subspherical; surface of vesicle reticulocrisitate, divided by low, apparently solid ridges into small, irregular, polygonal fields, four to six sided and commonly 2 - 3μ across. Commonly the fields are subdivided by low and discontinuous ridges that give the periphery a serrate appearance. Wall thin, about 1μ in thickness; surface sculpture cristate, with small scattered granules and discontinuous microridges within the fields; excystment by a simple rupture of the vesicle.’

*Remarks* The spherical to subspherical vesicle generally has a thick walled vesicle body divided into numerous small polygonal fields by very low ridges. There may be a granulate ornament in the centre of each field. Mode of excystment by simple unornamented split, often arcuate in form. At low magnifications this species could be mistaken for thick walled species of *Leiosphaeridia.*
Dimensions

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>30 - 70 µm</td>
</tr>
<tr>
<td>Width of lacunar fields</td>
<td>1 - 4.µm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10.</td>
</tr>
</tbody>
</table>

Occurrence. Amongst previously reported occurrences then following have been checked; Late Wenlock Series, Waldron Formation of Indiana, USA (Tappan & Loeblich 1971); upper Wenlock to lower Ludlow series, Welsh Borderland (Dorning 1981a); Much Wenlock Limestone Formation, upper Wenlock Series from Dudley, West Midlands, England (Dorning 1983); Much Wenlock Limestone Formation of the Welsh Borderlands (Dorning & Bell 1987). Interestingly, this species was not reported from Gotland by Le Hérissé (1989).

This species was recorded from the Coalbrookdale Formation through the Much Wenlock Limestone Formation to the Lower Elton Formation in samples collected from Farley Dingle, Harley Hill, Shadwell Quarry, Coates Quarry Mortimer Forest and Pitch Coppice; Much Wenlock and Ludlow type areas, Shropshire, England. Known range: Wenlock Series.

Dictyotidium biscutulatum Kiryanov 1978

Plate 7, fig. 3.

1978 Dictyotidium biscutulatum Kiryanov p. 39 - 40, pl. 5, figs 1 a - b, 6 a - b.
1986 Dictyotidium biscutulatum; Wicander p. 339, pl. 3, figs 1, 2.
1987 Dictyotidium biscutulatum; Priewalder p. 28 - 29, pl. 3 figs. 9-12, pl. 17 figs. 1 - 2, pl. 18,fig. 1.
1987 Dictyotidium cf. biscutulatum; Priewalder, p. 29, pl. 3 figs. 1 - 4.
1990 Dictyotidium biscutulatum; Fensome p. 193, no fig.

Holotype. Kiryanov 1978, pl. 5, figs 1a - b; from the Volynia borehole, Upper Silurian, Skala Stage, Darakhov Formation, Podolia, Ukraine.

Diagnosis. (Translation from Kiryanov 1978, p. 39 - 40) Vesicle is compressed, subspherical in outline, without compression folds. Some specimens have no deformation and are almost spherical. Vesicle diameter - 31 - 52 µm (holotype 31 µm), wall thickness 1 - 1.5 µm (holotype 1 µm). The surface has a net-like ornamentation which consists of relatively numerous polygonal fields of irregular shape and different sizes. Layers of thin membranes serve as sides of each polygon. Size of fields varies from 5 up to 10 µm on the same vesicle. Height of membrane is about 1 µm. In the elevation of the polygonal angles are situated thin, (about 0.5 µm), radial stakes of the same height which give support to the membrane. The surface inside the polygonal fields has secondary, considerably smaller,
reticulate ornamentation formed by the polygonal structure, these are uniform in size, diameter 1 - 2 μm (holotype 1μm). Pylome or other excystment mechanism for the cyst not observed.

**Remarks.** The pale yellow thin walled vesicle is spherical to ellipsoidal in form, divided into numerous, polygonal fields by thin low membranes perpendicular to the vesicle surface. Excystment is by simple split. The specimens assigned to this species are slightly smaller and thinner walled than those seen in Kiryanov (1978), though they fit the diagnosis.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Central body</td>
<td>22 - 38 μm</td>
</tr>
<tr>
<td>Entire vesicle plus flange</td>
<td>24 - 40 μm</td>
</tr>
<tr>
<td>Outer flange</td>
<td>2 - 4 μm</td>
</tr>
<tr>
<td>Field width</td>
<td>8 - 12 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

**Occurrence.** Wenlock Series, Silurian of Podolia, Ukraine (Kiryanov 1978); Lower Devonian of Oklahoma USA (Wicander 1986); upper Llandovery to lower Wenlock and Pridolf series, Austria (Priewalder 1987 also as D. cf. biscutulatum); Visby to Slite formations, Llandovery to Wenlock series (Sheinwoodian Stage) of Gotland, Sweden (Le Hérisé 1989).

This species has been recorded from the Farley Member of the Coalbrookdale Formation, Wenlock Series (Homerian Stage) of the type area, in samples from Farley Dingle.

Known Range. Late Silurian to early Devonian.

**Dictyotidium dictyotum** (Eisenack 1938 a) Eisenack 1955 a.

Plate 11, figs. 3, 6.

1938 a  *Leiosphaeridia dictyota* sp. nov. Eisenack, p. 27, pl. 3 fig. 8
1955 a  *Dictyotidium dictyotum*; Eisenack, p. 179, pl. 4, figs. 12, 13.
1965 a  *Dictyotidium dictyotum*; Eisenack, p. 265, pl. 22, fig. 1.
1979  *Dictyotidium dictyotum*; Eisenack et al. p. 161 - 162. (*op. cit.* for full synonymy)
1990  *Dictyotidium dictyotum*; Fensome et al. p. 194, no fig.

**Holotype.** Eisenack 1938a, p. 27 - 28, pl. 3, a - c, holotype lost (Eisenack 1955a).
Diagnosis. (Translated from original Eisenack 1979 p. 162.) "The spherical vesicle is ornamented with low but generally distinct ridges which form a net consisting of relatively large polygons. As a rule the sides of the polygons are straight but they may be curvilinear as well; small thorns protrude from the intersection points of the polygons. These thorns are so low that they can hardly be noticed but only become clearly visible in optical section. Forms whose ridges are indistinct do exist but are rare."

Remarks. Specimens recovered in this study conform to the original diagnosis. Dictyotidium faviforme is smaller with less distinct fields, while Dictyotidium stenodictyum is larger with larger polygonal fields and more robust ridges. Looking at the photograph of the holotype of this species there may be a case to synonymise D. stenodictyum with D. dictyotum and re-assign those forms attributed to D. dictyotum herein, which are considerably smaller than those described in the diagnosis of diameter 60 - 100 μm.

Dimensions. Vesicle diameter 32 - 48 μm
Crest height 2 - 3 μm
Field width 4 - 6 μm
Number of specimens measured 10.

Occurrence. upper Ludlow Series of the Baltic (Eisenack 1955a); Llandovery of Belgium (Stockmans & Willière 1963); Wenlock Series of Gotland, Sweden (Eisenack 1965a); Silurian of Belgium (Martin 1968); Ludlow Series of Brittany (Deunff et al. 1971); upper Llandovery to Ludlow series of the USA (Cramer & Diez 1972); Wenlock Series of Ontario, Canada and New York, USA (Thusu 1973a & b); Givetian of Ontario, Canada (Legault 1973); middle Silurian of New York (Thusu & Zenger 1974); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); Silurian of the Southern Uplands (White et al. 1991); lower Silurian of Ringerike, Norway (Smelror 1987).

This species has been recorded from the Coalbrookdale, Much Wenlock Limestone formation and lower Elton formations (Homerian to Gorstian Stages) of the type Wenlock and Ludlow Areas at Farley Dingle, Harley Hill, Coates Quarry, and Pitch Coppice.

Dictyotidium eurydictyotum Kiryanov 1978

Plate 10, figs. 13, 14

1978 Dictyotidium eurydictyotum sp. nov., Kiryanov, p. 41 - 42, pl. 5, fig. 2.
Holotype. Dictyotidium eurydictyotum Kiryanov, p. 41 - 42, pl. 5, fig. 2. from borehole Schidlovze, no 16902, depth 297.5, from the Lower Silurian (upper Llandovery), of Podolia in the Ukraine.

Diagnosis. (See Kiryanov 1978 p. 41 - 42 in Russian, translated by V. Viira). Vesicle spherical. On the surface there is net like ornament. The diameter of the vesicle is 31 - 48 μm (holotype = 40 μm). The thickness of the wall is about 1 μm. The netlike reticulate ornament is formed from numerous polygonal fields, which are five-sided + polygons. They have elongate (10 - 20 μm) sides. The height of the membranes between the fields is 1.5 μm at the angle/corner of each polygonal field. There is an ornament of low crests (‘-thin about one radial’). They are close to the membranes and have a height of 2.5 - 3 μm. The height is greater in the central part of the crest.

Remarks. The specimens recovered conform to the original diagnosis.

Dimensions.  

- Vesicle diameter: 30 - 34 μm
- Field width: 14 - 16 μm
- Crest height: 2 - 4 μm
- Number of specimens measured: 5


This form was recovered as rare types from the Coalbrookdale Formation (Farley Member) of Farley Dingle (FD 1900), Much Wenlock, Shropshire.

Known Range: Late Llandovery to Wenlock Series.

Dictyotidium faviforme Schultz 1967

Plate 10, fig. 9, 12.

1967  Dictyotidium faviformis n. sp., Schultz, p. 183, pl. 1, fig. 16.
1972  Dictyotidium faviformis; Cramer & Diez 1972; p. 161, no fig.
1977  Dictyotidium cavernosulum sp. nov.; Playford. p. 18, pl. 5,
1990  Dictyotidium faviforme; Fensome et al., p. 194, no. fig.

Holotype. Schultz 1967, p. 183, pl. 1, fig. 16; upper Llandovery Series of Dalarne, Sweden.
**Diagnosis.** (Translated from Schultz 1967, p. 183). Hollow spherical vesicle mostly preserved with the vesicle compressed. The vesicle bears a honeycomb like sculpture on the upper surface. The honeycomb ornament of the vesicle is more or less uniformly distributed.

**Remarks.** Spherical to subspherical laevigate vesicle wall of medium thickness. Lacunar fields are small, polygonal to irregular in outline formed from low ridges and have a central ornament of raised solid grana. The ridges sometimes form spine like protrusions at the junctions of the polygon sides. Excystment by simple split.

**Dimensions.**

<table>
<thead>
<tr>
<th></th>
<th>Vesicle diameter</th>
<th>Wall thickness</th>
<th>Ridge height</th>
<th>Field width</th>
<th>Number of specimens measured</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20 - 26 μm (single specimen 54 μm)</td>
<td>2 μm</td>
<td>2 μm</td>
<td>2 - 4 μm</td>
<td>10</td>
</tr>
</tbody>
</table>

**Occurrences.** Upper Llandovery Series of Dalame, Sweden (Schultz 1967); upper Llandovery to Ludlow series of the USA (Cramer & Diez 1972); Stooping River Formation (Emsian Stage) lower Devonian of Ontario (Playford 1977); upper Llandovery to the upper Ludlow series of Gotland Sweden (Le Hérisse 1989).

This species has been recovered from the Coalbrookdale Formation (Farley Member) through the Much Wenlock Limestone Formation to the Lower Elton Formation of the type area Much Wenlock, Shropshire: Farley Dingle, Harley Hill, Shadwell Quarry, Coates Quarry, Pitch Coppice and Mortimer Forest.

Known range: Upper Llandovery to Ludlow Series.

**Dictyotidium stellatum** Le Hérisse 1989

Plate 13, figs. 5, 6.

? 1978 *Cymatiosphaeropsis reticulosa* Kiryanov p. 32 pl. 7, fig. 6a, 6b.

? 1983 *Cymatosphaera reticulosa* Kiryanov; Colbath p. 253, pl. fig. 16.

? 1984 *Baculattreticulatus baculatus.* p. 143 - 144, pl. 1, figs. 12, 15, 19.

? 1986 *Cymatosphaera reticulosa* Kiryanov; Wicander p. 335, pl. 2, figs 1 - 4.

1989 *Dictyotidium stellatum* n. sp. Le Hérisse, p. 110 - 111, pl. 4, figs 1 - 5.
Holotype. Le Hérisse, p. 110 - 111, pl. 4, figs. 4 - 5, from the Eke Formation, Ludlow Series of Gotland, Sweden.

Diagnosis. (Translated from Le Hérisse 1989, p. 110 - 111). Species of the genus Dictyotidium with a spherical to subspherical thin walled vesicle, the surface of which has a reticulum of a small network of polygons, delineated by low and narrow walls from place to place, the outgrowths are formed at the nodes of the intersections, around these elements in relief the walls are of a radiating pattern (star like); the floor of the polygonal fields is fine. The opening is typical of the genus with a line of suture bordered by fine lips.

Remarks. The specimens recovered conform to the original diagnosis, subspherical to ellipsoidal vesicle body ornamented with ridges which often radiate from solid projections. The specimens were assigned to the taxon D. stellatum early in the investigation, and are retained therein for consistency with the log sheets, but since then the forms C. reticulosa (Kiryanov 1978) and B. baculatus (Al Ameri 1984 - only poor quality photocopy available) were seen to be very closely comparable to the specimens recorded herein and could in fact be synonymous taxa. Further work in this area will focus on sorting out this problem.

Dimensions.  
- Vesicle diameter: 42 - 76 µm
- Ridges: 2 - 4 µm
- Lacunar field width: 8 - 14 µm
- Stellate ornament: 2 - 6 µm
- Number of specimens measured: 10

Occurrence. This taxon was first separated as a distinct species by Le Hérisse (1989) from the Llandovery to Wenlock Series of Gotland, Sweden. The two other potential occurrences are from the Silurian of Podolia (Kiryanov 1978), Silurian of Missouri, USA (Colbath 1983) and Wenlock Series of Libya (Al Ameri 1984).

This species has been recorded from Shadwell Quarry, Coates Quarry, Mortimer Forest (MFGT1-300) and Pitch Coppice (PC 280); Farley Member of the Coalbrookdale Formation to lowermost portion of the Lower Elton Formation of the Wenlock and Ludlow type areas.

Known Range: Llandovery to Wenlock Series, Silurian.

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**Dictyotidium stenodictyum** Eisenack 1965 a

Plate 13, figs. 1 - 3

1965a  *Dictyotidium stenodictyum* n. sp.; Eisenack, p. 264 - 265, pl. 22, figs. 2 - 3.
1965b  *Dictyotidium stenodictyum* Eisenack, pl. 2, figs 9 - 10, pl. 9, figs 17 - 18
1984  *Dictyotidium stenodictyum* Eisenack, 1965a; Le Hérissé, p. 230, pl. 2, figs 9 -10.
1989  *Dictyotidium stenodictyum* Eisenack; Le Hérissé, p. 111-112, pl. 4, figs 6 - 8.
1990  *Dictyotidium stenodictyum* Eisenack 1965a; Fensome et al., p. 196, no fig.

**Holotype.** Eisenack 1965a, pp. 264 - 265, pl. 22, fig. 2; Silurian (Sphaerocodian Marl) of Burgsvik, Gotland, Sweden.

**Diagnosis.** (Translation of Eisenack 1965 a, p. 264 by Eisenack et al. 1979, p. 169). ‘A species of *Dictyotidium* with essentially a smaller polygonal reticulum than in *D. dictyotum*.’

**Remarks.** Subspherical to ellipsoidal thick walled laevigate vesicle body, The vesicle is divided into a reticulate pattern by numerous, irregularly spaced, polygonal fields delimited by ridges. Excystment is by simple split. These forms have been separated according to the manner adopted by Le Hérissé (1989), though I believe there is a question of synonymy between this species *D. dictyotum*.

**Dimensions**  
- Vesicle diameter: 46 - 65 μm
- Wall thickness: 2 μm
- Ornament height: 2 - 4 μm
- Ornament width: 2 μm
- Lacunar Field width: 4 - 10μm
- Number of specimens measured: 5

**Occurrence.** This is a relatively widely reported form, amongst the many reports the following have been checked: Llandovery to Wenlock series (Silurian) of Gotland, Sweden (Eisenack 1965 a & b); Llandovery to Wenlock series of Belgium (Martin 1966, 1968); Wenlock to Ludlow series in the Ludlow area (Lister & Downie 1974); Llandovery to lower Wenlock series of the type Llandovery area (Hill 1974, Hill & Dornig 1984); upper Llandovery, Wenlock and early Ludlow series of the Wenlock type area (Dornig 1981a; Mabillard & Aldridge 1985); Much Wenlock Limestone Formation, Wenlock Series of Dudley, West Midlands, England (Dornig 1983); Silurian (Wenlock Series) of Gotland, Sweden (Le Hérissé 1984); Llandovery Series to Ludlow Series, of Gotland, Sweden (Le Hérissé 1989):
This species has been recorded from the Coalbrookdale, Much Wenlock Limestone to lower Elton formations (Homerian to Gorstian) in samples from Farley Dingle, Harley Hill, Shadwell Quarry, Much Wenlock Limestone formation of Coates Quarry and Pitch Coppice, in the type Wenlock and Ludlow areas of Shropshire.

Known Range: Llandovery to Ludlow Series.

**Dictyotidium sp.**

*Remarks.* Poorly preserved specimens belonging to this genus were not assigned to a species.

*Occurrence.* Throughout the study section.

Genus **DIEXALLOPHASIS** Loeblich 1970.

*Type Species.* *Diexallophasis denticulata.* (Stockmans & Willière 1963, p. 458, pl. 1, fig. 4, text-fig. 13); from the Silurian of Courtrai, Belgium.

*Diagnosis.* (Loeblich 1970 p. 714). 'Central body inflated, in life probably spherical or subspherical, of variable outline when compressed; wall thin no differentiation in wall between central body and processes except in ornamentation, surface of central body with grana and that of processes with small spines; the 4 - 10 commonly 6, hollow processes communicate freely with the central body, processes are of two types, one smaller, smooth and unbranched and the other spinose, bifurcate or multifurcate and extremely variable in diameter; excystment by simple rupture of the central body.'

*Remarks.* *Diexallophasis* differs from *Multiplicisphaeridium* in having irregular granulate ornamentation of the vesicle and processes and the digitate form of branching. The genus differs from *Baltisphaeridium* in that the processes communicate freely with the central body cavity and branching style. The process are variable, within a specimen there can be simple or branched processes. The species recovered exhibit branching to a lesser or greater degree. *Diexallophasis* is distinguished from *Evittia* by the longer length of its processes.
Diexallophasis denticulata (Stockmans & Willière 1963) Loeblich 1970a

Plate 16, figs. 2, 4; Plate 17, figs. 2, 3.

1963 Baltisphaeridium denticulatum sp. nov. Stockmans & Willière p. 458, pl. 13, fig. 1, fig. 4, text - fig. 13.

1966a Baltisphaeridium denticulatum (Stockmans & Willière) forma ridgidum Cramer, p. 36 - 37, pl. 3, figs. 6 - 8.

1970a Baltisphaeridium denticulatum denticulatum Cramer, p. 138, pl. 11, fig. 162, 163, 165; pl. 12, fig. 179, 180; pl. 20, fig. 300, text - fig. 43a.

1970b Baltisphaeridium denticulatum denticulatum; Cramer p. 746, no fig.

1970a Diexallophasis denticulata (Stockmans & Willière) n. comb.; Loeblich, p. 715, fig. 8 A - E, fig. 9 A - C.

1972 Baltisphaeridium denticulatum denticulatum; Cramer & Diez, p. 147, no fig.

1973 Multiplicisphaeridium denticulatum; Eisenack et al., p. 587 - 591, (q.v. for full synonymy).

1973 Multiplicisphaeridium denticulatum denticulatum; Eisenack et al., p. 593, (q.v. for full synonymy).

1980 Diexallophasis denticulata; Deunff, p. 500, pl. 4 fig. 6, pl. 7 fig, 7, 9, 10, pl. 8 fig. 12.

1989 Evittia denticulata denticulata (Cramer) comb. nov.; Le Hérisse, p. 126-127, pl. 11, figs 1-6.

1990 Diexallophasis denticulata; Fensome et al. p. 197, no fig.

1995 Baltisphaeridium denticulatum; Tongiorgi et al. p. 17, no fig.

Holotype. Baltisphaeridium denticulatum Stockmans & Willière (1963), p. 458, pl. 1, fig. 4; from the Silurian of Courtrai, Belgium.

Diagnosis. (Loeblich, 1970a, p. 715-716). ‘Central body inflated, in life probably spherical or subspherical, preservation giving an extremely variable outline to the central body, which is commonly quadrate (recalling Veryhachium), stellate, tetrahedral or spherical to subspherical; wall thin, 0.5µm or less in thickness, wall of central body covered with small low grana, but these are also variable; in some specimens the grana are very prominent and give the margin a serrate appearance, whereas in others the grana are more subdued, other specimens show all gradations between the two extreme types, grana die out or become sparse near the base of the processes to be replaced by numerous small prickles or spines, up to 1.3 µm in length, on the process walls, no differentiation between process wall and that of the central body except for type of ornamentation; the 4 - 10 processes, commonly 6, are hollow and communicate freely with the central body, processes extremely variable (even on the same specimen) in width, especially at their proximal ends, and variable in the bifurcation at the distal end; rarely smaller, smooth and unbranched processes occur, processes bifurcate and may be secondarily bifurcated, the secondary bifurcations terminating in 2 - 4 small incipient bifurcations; excystment by simple rupture of the central body. Diameter of central body ranges from 16-32 µm, commonly 22 µm, and overall diameter ranges from 61 - 100 µm.’
Remarks. This species is being treated herein as a formgroup with forms logged as *D. robustispinosa* but not treated separately in the systematic descriptions. The specimens recovered show a wide variety of morphological characteristics but the essential characteristics are irregularly spaced granulae or echinae on long variable furcate processes and a variable vesicle size. Processes communicate freely with the central body cavity. It could be included as a formgroup with *Diestallophasis aff. denticulata* which has fewer echinae and a more psilate appearance. This formgroup comprises individuals belonging to the genus *Diestallophasis* with robust, numerous, variably branching processes, the vesicle body and processes bearing granulate ornamentation. *D. simplex* formgroup by comparison includes individuals that have fewer processes, reduced ornamentation and thinner walled. The processes often less branched. The reason for including these as a formgroup is because of the wide morphological gradation of forms from sparse ornamentation and simple processes to those with well developed granulate ornamentation with complex branching apparent. Despite the fact that the end members are distinguishable from their morphology, there is no obvious way to differentiate the gradational forms. *D. denticulata* form-group was recovered from all the samples morphotype is extremely long ranging. It is possible that unrelated forms are considered together on the basis of their form.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>18 - 38 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>28 -34 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2- 6 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>6 - 10</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10.</td>
</tr>
</tbody>
</table>

Occurrence. See Eisenack *et al.* (1973) for a full list of occurrences prior to 1973. In addition lower Devonian of Uruguay (Martinez-Macchiavello 1968); Wenlock Series of Wenlock Edge, Shropshire (Downie 1963); Silurian of Belgium (Martin 1967 as *B. denticulatum*); upper Wenlock to Ludlow Series of the Ludlow and Millichope areas of Shropshire (Lister 1970; Downie 1984); Llandovery Series of New York, USA, (Loeblich 1970); Upper Llandovery to Wenlock series of Nova Scotia and eastern USA (Cramer 1970a &b, Cramer & Diez 1972); Wenlock Series of Libya (Richardson & Ioannides 1973); Wenlock of Argentina (Pöthe de Baldis 1975); Silurian and Devonian of France (Rauscher & Robardet 1975); Llandovery of Quebec (Achab 1976); Gedinnian of Oklahoma, USA (Wicander 1976); Llandovery to Ludlow Series of Turkey (Erkmen & Bozdogan 1979); Gedinnian of Brest (Deunff 1980); late Llandovery to early Wenlock series of Ghana (Bar & Riegel 1980); Gedinnian of Brest (Deunff 1980); Silurian of the Welsh Borderlands (Dorning 1981a); from the Llandovery to Wenlock of Ireland (Smith 1981); Gedinnian of France (Moreau - Benoit & Poncet 1982); early Sheinwoodian (Wenlock Series) of Scotland (Dorning 1982); West Midlands of the UK (Dorning 1983); upper Llandovery Series (Purple Shales) to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderland (Mabillard & Aldridge 1985); Ashgill (Ordovician of Anticosti Island, Canada (Jacobson & Achab 1985); Ludlow Series of Libya (Wood & Tekbali 1987); Ashgill to Llandovery series (Ordovician to Silurian) of north-east Libya (Hill & Molyneux 1988);
late Llandovery Series to upper Ludlow of Gotland (Le Hérisé 1989); middle Wenlock Series of the Cheviots, North East England (Barron 1989); Buildwas and Coalbrookdale formations of North Wales, the type area of the Welsh Borderland, Central Wales and Old Radnor (Swire 1991); Silurian of the Southern Uplands (White et al. 1991); upper Silurian of San Juan, Argentina (Rubinstein 1993); Wenlock Series from Holbrook Coppice, near Ironbridge, Shropshire (Turner et al. 1995); Llandovery to Wenlock series of Gotland (Eriksson & Hagenfeldt 1997).

In the Ludlow area this species was recovered from the Much Wenlock Limestone Formation (all samples from Mortimer Forest); Much Wenlock Limestone Formation to Lower Elton Formation (all samples from Pitch Coppice). In the type Wenlock area from the Coalbrookdale Formation (all samples from Farley Dingle); Coalbrookdale Formation to Much Wenlock Limestone Formation (all samples from Harley Hill); Much Wenlock Limestone Formation, Coates Quarry (samples: CT 1, 2, 7, 10); Much Wenlock Limestone Formation to Lower Elton Formation (all samples except 2SH 260, from Shadwell Quarry).

Known Range: Early Llandovery to Early Gedinnian of Europe and North America

**Diexallophasis granulatisspinosa** (Downie 1963) Hill 1974

Plate 16, fig. 1.

1963 *Baltisphaeridium granulatisspinosum* sp. nov. Downie, p. 640 - 641, pl. 91, 1, 7; fig. 3c.
1970 *Evittia granulatisspinosa* (Downie 1963); comb. nov. Lister, p. 67 - 69, pl. 4, figs 2, 3, 5 only; pl. 5, fig. 2, text - fig. 20 b, not 17 o.
1972 *Baltisphaeridium rojensis* sp. nov., Yankauskas & Vaitekunene, p. 121, pl. 7 figs. 10, 11.; text-fig. 3.
1973 *Multiplicisphaeridium granulatisspinosum* Eisenack et al., p. 653.
1974 *Diexallophasis granulatisspinosa* comb. nov.; Hill, p. 12, no fig.
1990 *Diexallophasis granulatisspinosa* Downie; Fensome, p. 198, no fig.

**Holotype.** Downie 1963, p. 640 - 641, pl. 91. fig. 1, from the Coalbrookdale Formation (Harley Brook), Much Wenlock, Shropshire, England.

**Diagnosis.** (Downie 1963, p. 640). "A hollow spherical, ellipsoidal or rarely polygonal test with hollow spines about equal or greater in length than the test diameter. Spines simple, rarely branching, but terminating in nearly every instance in short finger like digitations. Invariably the surface of the spines all along their length is ornamented with granules about 1μm in size."
Remarks. The specimens recovered conform to the original diagnosis with broad variations in the degree and type of ornamentation on the processes. It is believed that this variety of *Diexallophasis* is easily distinguished from the *D. denticulata* formgroup with the more prominent echinate ornamentation on wide broad processes and vesicle body.

**Dimensions**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>24 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>30 -36 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2- 4 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>6 - 10</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

Occurrence. Silurian of Belgium (Martin 1967 as *B. granulatispinosum*); Ludlow Series of Brittany (Deunff *et al.* 1971); Silurian of the Baltic (Yankauskas & Vaitekunene 1972 as *Baltisphaeridium rojensis*); Wenlock (Much Wenlock Limestone Formation) - Pridolf series (Downton Castle Sandstone Formation), Ludlow (Lister & Downie 1974); Armstrong and Dorning (1984) reported specimens from the Chester Berg Formation (Wellock) in Greenland; upper Llandovery Series (Purple Shales) to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985); Ludlow Series of Libya (Wood & Tekbali 1987); Llandovery Series of north-east Libya (Hill & Molyneux 1988), Silurian of the Southern Uplands (White *et al.* 1991).

In the Ludlow area this species was recovered from the Much Wenlock Limestone Formation - Lower Elton Formation boundary at Pitch Coppice (PC 300, 340); in the type Wenlock Area from the Coalbrookdale Formation (samples from Farley Dingle: FD 100, 500, 700, 1200, 1600, bentonite, 2300) and the Much Wenlock Limestone Formation (2SH -2, from Shadwell Quarry).


Plate 17, fig. 1; Plate 30, fig. 5.


1990 *Diexallophasis ontariensis* Cramer ex. Fensome *et al.* p. 198, no fig.

Diagnosis. (Cramer 1970 p. 140.). 'Central portion of the vesicle spherical rigid, clearly differentiated from the processes. Process distribution regularly. The number of processes varies from three to more than twenty: commonly, there are about ten processes. The processes are long, slender and flexible. They are cylindrical with an essentially square basal angle. The branching pattern varies from simple to manate. All pinnae are concentrated at the very distal portion of the processes. The processes are hollow and the process cavities communicate freely and directly with the central vesicle cavity. The ectoderm is unilayered and shows a sub regular sculpture distribution in that the body wall is psilate, (elements from less than 0.5 up to 1 µm high). The ectoderm is about 0.5 - 1 µm thick. No pylomes or preferred splitting patterns were found.’

Dimensions:  
- Vesicle diameter: 30 - 34 µm  
- Process length: 30 - 36 µm  
- Process base width: 2 - 4 µm  
- Process number: 10 - 16  
- Number of specimens measured: 10  

Remarks. The essential characteristics are irregularly spaced granulae or echinae on long variable furcate processes. The body and the processes have fewer echinae and a more psilate appearance, less ornament on the vesicle wall than Diezallophasis denticulata. The specimens show variable vesicle size but generally they have a spherical to subspherical central body bearing processes which communicate freely with the central body cavity. Individuals have been noted during systematic logging, as having a star like appearance. This is due to the rigid form and ray-like orientation of the processes. This species could be included as a formgroup with Diezallophasis denticulata as there is a slight gradation in the amount of ornament and process morphology between end members of the two species. Le Hérisse included this species in his synonymy for Evittia denticulata denticulata (Cramer 1970) Le Hérisse nov. comb 1989 with a question mark. It is retained here as a separate form species because of its distinct form.

Occurrence. Upper Llandovery to Wenlock series of Nova Scotia, Canada and eastern USA (Cramer 1970 a & b); additional reported occurrences include the following: Wenlock Shales (Homerian) of England (Dorning 1981a), Wenlock Series of Gotland and the Wenlock of Podolia (Eisenack et al. 1973); Lower Devonian of Oklahoma USA (Wicander 1986) and the Wenlock Series of Gotland, Sweden (Le Hérisse 1989).

In the Ludlow area this species was recovered from the Much Wenlock Limestone Formation (MFGT1 /TD, 300, 400; MFGT2 /TD, 2-180 from Mortimer Forest); Much Wenlock Limestone Formation - Lower Elton Formation
Diexallophasis robustispinosa

Remarks. Specimens recorded in the log sheets and Tiliagraphs herein as belonging to this taxon are probably part of the D. denticulata formgroup.

Occurrence. In the Ludlow area this species was recovered from the Much Wenlock Limestone Formation - Lower Elton Formation. In the type Wenlock Area from the Coalbrookdale Formation - Much Wenlock Limestone Formation.

Diexallophasis simplex Wicander & Wood, 1981

Plate 17, fig. 4.

1981 Diexallophasis simplex sp. nov. Wicander & Wood, p. 33 - 34, pl. 5, fig. 7, pl. 6 figs. 1 - 3.
1990 Diexallophasis simplex; Fensome et al. p. 200, no fig.

Holotype. Diexallophasis simplex Wicander & Wood, 1981, p. 33-34, pl. 5, fig. 7; from the Givetian (Middle Devonian) Silica Formation of Ohio.

Diagnosis. (Wicander and Wood, 1981, p. 33). Vesicle circular to sub-quadrate in outline, 26 - 47 μm in diameter (34 μm average), wall lightly scabrate, 0.8 μm thick; 5 - 9 (6 average) flexible, hollow processes, 35-47 μm long, 5 - 8 μm wide at base, that freely communicate with vesicle interior; processes taper to sharp or blunt tips which are rarely bifurcated; processes ornamented with small, sharp grana, or short spines 1μ long; excystment by equatorial split of vesicle wall.
Remarks. The specimens recorded here are those that have relatively psilate vesicle bodies and processes. The vesicle is of medium wall thickness and subspherical in outline. The processes are hollow, communicating with the vesicle interior, straight to slightly flexuous. The processes are in the main simple but may exhibit a lesser degree of branching than forms attributed to *D. denticulata* formgroup or *D. granulatispinosa*. Branching is heteromorphic with simple and branched processes occurring in a single specimen. Excystment is by simple split.

Occurrence. Late Siegenian to early-middle Givetian of Ontario, Canada (Wicander & Wood 1981); Much Wenlock Limestone Formation of Mortimer Forest (samples; MFGT1 TD, 50, 300); Much Wenlock Limestone - Lower Elton formations of Pitch Coppice (samples; PC 240, 280, 310, 315, 340) in the Ludlow area. Also from the Coalbrookdale Formation of Farley Dingle (all samples); Much Wenlock Limestone Formation of Coates Quarry (samples; CT2, 7); Shadwell Quarry (samples; SH -2.0, -1.15, 110, 230, 360); Harley Hill, (sample; HH1 TD; HH2 100, 200, 300, 400, 500, 600, 700, 800; HH3 200, 300).

Known Range Silurian to Devonian.

**Diexallophasis sp.**

Remarks. Poorly preserved specimens belonging to the genus but not assigned to a species are placed here.


Genus **DOMASIA** Downie 1960

Type Species. *Domasia trispinosa*, Downie 1960, p. 199.

Diagnosis. (Downie 1960, p. 199.) 'Shell hollow, elongate, ellipsoidal, more or less smooth, about 20 µm in length. Body composed of pale yellow to brown organic membrane. Ornament consisting of two relatively long hollow spines arising near one pole and a single spine of variable length at the opposing pole.'

Plate 25 fig. 1

1960 Domasia trispinosa sp. nov. Downie, p. 199, pl. 1, fig. 7.
1960 Domasia elongata sp. nov. Downie, p. 200, pl. 1, fig. 5.
1973 Domasia trispinosa (Downie); Eisenack et al. p. 427
1973 Domasia elongata (Downie); Eisenack et al. p. 419
1973 Domasia cf. trispinosa; Richardson & Ioannides, p. 306, pl. 15, fig. 9.
1973b Domasia elongata (Downie); Thusu, p. 138, pl. 1 fig. 4.
1974 Domasia elongata (Downie); Hill, p. 17.
1987 Domasia trispinosa (Downie); Priewalder, p. 35, pl. 7 fig. 3. text - fig. 11.
1990 Domasia trispinosa (Downie); Fensome p. 203, no fig.

Holotype. Domasia trispinosa Downie 1960, p. 199, pl. 1, fig. 7. from the Buildwas Formation of Harley Brook, Shropshire, UK.

Diagnosis. (Downie 1960, p. 427), 'The hollow ellipsoidal body is pale yellow - green with a smooth matte surface. In every specimen the interior is empty. The longer dimension of the body is about 17 μm. Two similar hollow spines of a length about equal to that of the body occur at one end (anterior). The spine bases are separate and merge with the test wall, distally they narrow steadily to a point. In some instances these spines are divided by internal septa. The single posterior spine is only a little shorter but is much narrower and it cannot be determined whether it is hollow or not.

Remarks. The specimen recovered conforms to the original diagnosis. There is a strong similarity between this species and Domasia limaciforme (Cramer 1970). Re examination of the holotypes is necessary for further work on this species, but the classification as it stands is deemed satisfactory as only one specimen was recovered.

Dimensions

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>25 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>20 μm - 30 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>1.5 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>3</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

Occurrence. There are many reports of this species which include the following: Buildwas Formation, Harley Brook, Shropshire, UK (Downie 1960); Llandovery to Wenlock Series of Belgium (Martin 1966, 1967.

1961 **Duvernayphaera** Staplin 1961.


Type species. **Duvernayphaera tenuicingulata** Staplin, 1961, p. 415-416; pl. 49, figs 10-11; Woodbend Formation (Duvernay Member), late Devonian of Alberta, Canada.

Original Diagnosis. (Staplin, 1961, p. 415-416) ‘Vesicle circular in outline, surrounded by an adpressed diaphanous membrane that extends beyond the vesicle margin as a flange, the flange supported by simple rods or spokes arising from the vesicle that are present only in the equatorial plane, much like the fin of a fish.’

Emended Diagnosis. (Translated from Le Hérisse, 1989, p. 118) A vesicle of generally discoid outline, the cyst has a double-layered wall; the inner wall or endophragm is relatively thick, delimiting a lenticular central body of circular outline (with a strongly convex face) processes or pillars emerge radially from the equator, the number varies according to
species. The pillars are equidistant and of equal length, hollow and communicate freely with the central body cavity; the central body is enveloped by an outer membrane or periphragm, thin and transparent, which projects slightly beyond the ends of the processes at the equator; the outer layer appears compressed and tightly coupled to the inner layer which is composed of the processes and the central body; it is probable that just prior to fossilisation, the two supporting layers separated, the outer layer forms a sac, enveloping the central body and the processes; the structure of the wall and the vesicle is the like type seen in certain dinoflagellate cysts; on one of the faces, plano-convex, one observes a tear in the outer wall, corresponding with a simple split, which cuts the central body at the median line; this endostructure is interpreted as the mode of excystment for species of the genus Duvernaysphaera.

Remarks. The specimens recovered conform to the diagnosis of this species. Pterospermella differs from this genus in that it lacks the characteristic ring of processes adjoining the membrane. The genus Duvernaysphaera was considered by Le Hérissé (1989, p. 119 - 120) to be a senior synonym of Helios, following the transfer of the type species Helios aranaides to become Duvernaysphaera aranaides by Cramer (1970b, Cramer & Diez 1972, p. 162-163). This conclusion is accepted in this study despite the fact that the species Helios aranaides has been retained by Fensome et al. (1990, p. 205). Duvernaysphaera is also considered a senior synonym of Veliferites Brito 1967a (Fensome et al. 1990 p. 204). This species differs from species of Cymatosphaera in that the central body is not bounded by flanges but by an outer membrane which completely encloses it.


Plate 14, figs. 6, 8.

1964 b Helios aranaides n. sp. Cramer, p. 329, pl. 5, fig. 9; pl. 14, fig. 7; text - figs 36, 1, 2.
1966 c Duvernaysphaera gothica sp. nov. Martin, p. 323, pl. 1, figs 6, 15.
1972 Duvernaysphaera aranaides (Cramer 1964b); n. comb. emend.; Cramer & Diez, p. 162 - 163, pl. 35, fig. 55.
1975 Duvernaysphaera jelinii n. sp. Pothe de Baldis p. 495, pl. 4, figs 1-2, 4, 5.
1981 Helios aranaides (Cramer 1964b); Pothe de Baldis, p. 243, pl. 4, figs 10, 11, 12.
1986 Duvernaysphaera o.; Wicander, p. 343, pl. 3 fig. 10.
1990 Helios aranaides (Cramer 1964b); Fensome et al., p. 245, no fig.
1993 Helios aranaides (Cramer 1964b); Rubinstein, p. 70.
**Holotype.** Helios aranaides Cramer, 1964b, p. 329-330, pl. 14, fig. 7; Ludlow-Early Gedinnian of the San Pedro Formation, north-west Spain.

**Diagnosis.** (Translated from Le Hérisse, 1989, p. 119) Acritarchs of the genus Duvernaysphaera are characterised by a double layer wall; the inner layer is relatively thick, delimiting a central body of lenticular form, circular outline, with at the equator, a ring of 9 to 16 radiating processes, short \((p = 1/7d)\), of equal length, and equidistant, the width of the process varies from 1 to 2.5\(\mu m\); the cylindrical, hollow processes communicate freely with the central body cavity. The surface of the central body is smooth or granulate. The outer wall, thin and transparent, envelopes the central body and the processes; it is depressed and coupled to the inner body. The mode of excystment, visible on the flattened face, is represented by a simple split, which crosses the central body and coincides with a tear in the external wall.

**Remarks.** The specimens recovered conform to the original diagnosis, though preservation, especially of the thinner outer layer is variable and is often incomplete. This outer diaphanous membrane which loosely encompasses the inner body and processes is fragile and often damaged or lost in poorly preserved specimens. The inner body is subspherical not quadrangular as in Quadraditum or Veliferites. Mode of excystment not observed.

**Dimensions**

- Inner vesicle diameter: 16 - 26\(\mu m\),
- Outer membrane width: 10 - 16\(\mu m\).
- Process length: 4 - 8\(\mu m\)
- Process number: 10 - 18.
- Number of specimens measured: 10

**Occurrence.** Duvernaysphaera aranaides has been recorded many localities, in addition to those listed here that have been verified by the author, see Eisenack et al. 1976, p. 239. This species has been previously recorded from the following: Llandovery to Ludlow series of north-west Spain (Cramer: 1964b, 1966a); Devonian of the Polignac Basin in the Sahara (Jardiné & Yapaudjian 1968 as Helios aranaides); Llandovery Series of Algeria north-west Africa (Magloire 1968); Llandovery to Ludlow series of Pennsylvania and eastern States of the USA (Cramer 1969a, Cramer & Diez 1972); Ross Brook Formation, Llandovery Series of Nova Scotia, Canada (Cramer 1970b); Wenlock Series of Ontario, Canada and New York, USA (Thusu 1973a, 1973b); Ludlow Series of Algeria (Jardiné et al. 1974); Silurian of Belgium (Martin 1966, 1969); Wenlock to Ludlow series of San Juan Argentina (Pôthe de Baldis 1971, 1975, 1981, Rubinstein 1993); Silurian of Podolia, Ukraine (Kiryanov 1978); Visby and Hökglint formations, Wenlock Series of Gotland, Sweden (Cramer et al. 1979); lower Devonian of Oklahoma USA (Wicander 1986); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); Wenlock (Much Wenlock Limestone Formation) to Prídlůf series (Downton Castle Sandstone Formation), Ludlow (Lister & Downie 1974); Much Wenlock Limestone Formation, Wenlock Series of Wrens Nest, Dudley in the West Midlands of England (Dorning 1983); Llandovery Series of the Llandovery type area (Hill & Dorning 1984); lower Silurian of Ringerike, Norway (Smelror 1987); upper Llandovery Series (Purple Shales)
to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985); upper Llandovery to Ludlow series of Gotland, Sweden (Le Hérisse 1989); Sheinwoodian of the type Wenlock Area, Shropshire (Swire 1991 unpublished); Silurian of the Southern Uplands (White et al. 1991); Leinthall Quarry, Ludlow, Shropshire (Donoghue 1992 unpublished); upper Silurian of San Juan, Argentina (Rubinstein 1993); Coalbrookdale Formation, Wenlock Series, of Buildwas Bank, Holbrook Coppice Shropshire (Turner et al. 1995).

In this study Duvernayysphaera aranaides was recovered consistently but in low numbers from samples collected at Farley Dingle, Shadwell Quarry, Coates Quarry and Harley Hill in the Much Wenlock Area and Pitch Coppice, Mortimer Forest Geological Trail in the Ludlow area, Shropshire; Homerian to Gorstian Stages of the Wenlock to Ludlow series.

Known Range: Early Llandovery-Early Gedinnian (Silurian-Devonian).


1968 Eisenackidium Cramer & Diez, p. 558 - 559

Type Species. Baltisphaeridium triplodermum Cramer 1966 a, p. 248 - 249, pl. 1, fig. 12, text-fig. 4: 5; from the Emsian Stage, La Vid Formation, of north-west Spain (Eisenack et al. 1973, p. 435).

Revised Diagnosis. (Translated from Le Herissé 1989, p. 120). 'Acritarchs whose wall is composed of two layers definitely separated (chambered structure). The two layers are composed of the endophragm, thick layer which delimits the internal body which is spherical, triangular or polyhedral, smooth or finely ornamented; and the mesophragm, fine and transparent, often folded, which forms the processes. The form of the central body is the function of the number of processes. For certain species the endophragm develops short, divaginations at the base of the processes. The processes number from 3 to 12 and are cylindrical, hollow, simple or bifurcate; ornamentation on the process is sometimes present and is short and fine, sometimes present. Mode of excystment not known."

Remarks. The specimens recovered have the characteristic double wall, the inner robust thick wall bounded by the outer diaphanous membranous wall which forms the delicate processes.
Eisenackidium wenlockensis Dornig 1981a

Plate 5, fig. 6.; Plate 6 figs. 8, 10, 11

1970 Crameria cf. duplex (Cramer 1964) comb. nov. Lister, p. 62, pl. 5, fig 1 only.
1981a Eisenackidium wenlockensis n. sp. Dornig; p. 188 - 189, pl. 2, fig. 12.
1983 Eisenackidium wenlockensis Dornig; Dornig, pl. 6 fig. 7.
1990 Eisenackidium wenlockense Dornig 1981; Fensome et al., p. 208, no fig.

Holotype. Dornig 1981a, pl. 2, fig. 12; from the Much Wenlock Limestone Formation, Wenlock Series of Wrens Nest, Dudley, West Midlands UK (SO 935 917).

Diagnosis. (Dornig 1981a, pp. 188-189). “Vesicle spherical to subspherical, 25 - 35 μm in diameter, two layered wall; inner wall thick, rigid, laevigate, outer wall thin, flimsy, poorly attached to the inner wall; 3 - 6 processes, 14 - 20 μm long, 4 - 12 μm wide at base, formed of the same membrane as the outer vesicle wall, process base ill defined; processes simple or digitate, the 2 - 5 branches of one order; as preserved the processes are flattened, and often show longitudinal folds. Processes may be all simple or all branching, but often both will be found on the same specimen.”

Description. Double walled acritarchs, variable in appearance but generally with a thicker walled central body surrounded by a split thin walled outer wall that forms the groups of indistinct processes which often form a flame like outline. Excystment is by a simple split.

Remarks. The specimens observed conformed to the original diagnosis. Eisenackidium ludlovensis differs in having a smaller vesicle body and longer processes which have blunt terminations rather than the simple or digitate processes. This form is similar to those logged as Leptobrachion sp. A, further consideration of these two species needs to be undertaken. The specimens recovered in this study differ slightly to those figured by Le Hérisse (1989), this could be a preservational feature, the Gotland specimens being three dimensional, although the grouped flared processes are not apparent on those figured specimens.

Occurrence. Wenlock (Sheinwoodian Stage) to Ludlow (Gorstian Stage) series, Welsh Borderland (Dornig 1981a); Much Wenlock Limestone Formation, Wenlock Series of Wrens Nest, Dudley, West Midlands, England (Dornig 1983); Much Wenlock Limestone Formation of the Welsh Borderlands (Dornig & Bell 1987); Slite Formation (Sheinwoodian), Mulde Formation (Homerian Stage, top of the Wenlock Series) and the Hemse Formation (Gorstian Stage, base of the Ludlow Series (Le Hérisse 1989); Coalbrookdale Formation (late Sheinwoodian to early Homerian) of the Wenlock Series from the type area (Swire 1991, 1993).
This species has been recovered in low numbers from the Much Wenlock Limestone Formation - lower Elton Formation in samples from Mortimer Forest Geological Trail and Pitch Coppice in the Ludlow area; Coalbrookdale to lower Elton Formations of Farley Dingle and Shadwell Quarry in the type Wenlock area of Shropshire, UK.

Known range: Wenlock (Sheinwoodian) to Ludlow (lower Gorstian) series.

**Eisenackidium cf. wenlockensis** Dorning 1981a

Plate 5, figs. 4, 5.

1970  *Crameria cf. duplex* (Cramer 1964) comb. nov. Lister, p. 62, pl. 5, figs. 11, 12 & 16 only text-fig. 17j.

?1989 *Eisenackidium wenlockensis* Dorning; Le Hérisse p. 121 - 122, pl. 9 figs. 14 - 16.

**Description.** Spherical to subspherical double walled vesicle with a thicker walled central body surrounded by a loosely attached ectophragm. The central body bears thin diaphanous branched/digitate processes numbering between four and 8. The actual number is indistinct because the processes emanate from wide thin bases and split in heteromorphic fashion from almost all the way along their length. Hence the division of the outer membrane into distinct processes is arbitrary. Mode of excystment not observed.

**Remarks.** This morphotype is problematic. Its form corresponds somewhat to between being assigned to either the genus *Eisenackidium* or *Leptobrachion* (Dorning 1981a). The processes of the former are not branched though, but the specimens recorded herein are often digitate and torn and have a seemingly branched nature. As the specimens recovered were logged as *Eisenackidium cf. wenlockensis* they have been retained under that grouping 'informally' within these systematic descriptions to maintain a consistency between the logging sheets, spreadsheets and Tiliagraph datasets but a revision of this grouping is believed to be necessary.

**Dimensions.**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle body diameter</td>
<td>18 - 24 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>10 - 24 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>4 - 10 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>4 - 6 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>
Occurrence. This form has been recovered consistently in moderate numbers throughout the sections sampled from the Coalbrookdale Formation and through the Much Wenlock Limestone Formation to the Lower Elton Formation, samples from Farley Dingle, Mortimer Forest, Harley Hill, Shadwell Quarry.

Eisenackidium ludlovensis Dorning 1981a

Plate 5, fig. 3.; Plate 6, fig. 7.

1981a Eisenackidium ludlovensis n. sp. Dorning p. 188, pl. 1 fig. 6.
1990 Eisenackidium ludlovense Dorning; Fensome et al. p. 208, no fig.

Holotype. Eisenackidium ludlovensis n. sp. Dorning 1981 p. 188, pl. 1 fig. 6

Diagnosis. (Dorning 1981a p. 188.) "Vesicle spherical to subtriangular in outline with a two layered wall, 20 - 25 in diameter; inner wall thick, fairly rigid, apparently laevigate; outer wall thin, somewhat flimsy, loosely attached to the inner wall; laevigate; 3 - 4 processes, 25 - 35 long, 8 - 10 wide at base simple, taper to a blunt distal termination, thin walled, laevigate, with a tendency to have longitudinal folds; the process bases are not well defined, but the wall is continuous with the outer vesicle wall. Excystment method not observed.

Description. Spherical vesicle, laevigate, bearing an outer thin wall that forms 3 - 4 processes, wide based, tapering to blunt tips. Mode of excystment not observed.

Remarks. The specimens recovered conform to the original diagnosis, though longitudinal folds were not observed. This species differs from Eisenackidium wenlockensis in the generally smaller vesicle body with blunt, simply terminated, more well defined processes. These specimens are clearly different from species of Leptobrachion Dorning, whose processes are always branched in some way.

Dimensions.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>18 - 26 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>12 - 20 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>5 - 10 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>3 - 4</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

Occurrence. This species has been previously reported by Dorning (1981a) from the Aymestry Limestone of the Ludlow Series in Herefordshire.
*Eisenackidium ludlovensis* was recorded as a rare type from the lowermost levels of the Lower Elton Formation (Gorstian Stage, Ludlow Series) of Shadwell Quarry, Much Wenlock and the Much Wenlock Limestone Formation (Homerian Stage, Wenlock Series) of Mortimer Forest, Ludlow, Shropshire, England.

Known Range: Homerian to Ludfordian Stages. Wenlock to Ludlow series.

**Genus** ESTIASTRA Eisenack 1959 emend. Sarjeant & Stancliffe 1994

*Type species. Estiastra magna* Eisenack, 1959, p. 201-202, pl. 16, figs 17 - 20; Esthonus Limestone, lower Silurian, Kattentak, Estonia.

*Diagnosis. (Translated from Eisenack 1959, p. 201)* Star-shaped vesicle, wide conical shaped processes extending from a collective centre. There is no central body.

*Diagnosis. (Sarjeant & Stancliffe 1994, p. 50).* ‘Acritarchs of stellate aspect, composed of 4 - 10 processes arising in more than one plane. Processes very broad-based, conical to phalloid in outline; distally they may be acuminate, sometimes with a nipple-like prominence, or (rarely) briefly bifurcate, but they are never blunt or rounded and lack distinct branches. Central portion of vesicle formed by the confluence of process bases. Eilyma composed of one layer or of two layers in continuous contact; process tips may be solid or plugged. Surface psilate, punctate, granulate or pustulose, with or without striae on the processes, but not echinate and without systems of ridges connecting the process bases. Opening, where observed, by cryptosuture; when fully open, a section of the eilyma including one or two processes may be lost.’

*Remarks. Estiastra differs from Pulvinosphaeridium* (Eisenack 1954) in that *Estiastra* has a star shaped vesicle with pointed processes whereas *Pulvinosphaeridium* (Eisenack 1954) has rounded processes. *Estiastra* is not considered synonymous with *Rhiptosocherma* Loeblich & Tappan (1978), as stated in (Sarjeant & Stancliffe 1994, p. 50) because the type species and the holotype of *Rhiptosocherma improcera* (Loeblich 1970) Loeblich & Tappan 1978, has blunt processes which is excluded in the emended generic diagnosis of *Estiastra* (Sarjeant & Stancliffe 1994, p. 50)
Estiastra granulata Downie 1963

Plate 21, figs 2, 4, 6.

1963 *Estiastra granulata* sp. nov.; Downie, p. 638, pl. 91, fig. 8.

1965a *Baltisphaeridium polygonale*; Eisenack, p. 261 - 262, pl. 21, fig. 3; pl. 24, figs. 5 - 6.


1970a *Estiastra granulata*; Cramer, p. 119 - 120, fig. 34, e.

1970 *Baltisphaeridium cantabricum*; Lister, p. 58 - 59, pl. 3, fig. 7, pl. 4, figs 1, 4.

1977 *Goniosphaeridium polygonale*; Eisenack, p. 30, 32; p. 31, figs 18 - 20.

1990 *Estiastra granulata*; Fensome *et al*., p. 213, no fig.

1994 *Estiastra granulata*; Sarjeant & Stancliffe, p. 51, no fig.

**Holotype.** Downie, 1963, p. 638, pl. 91, fig. 8; Coalbrookdale Formation, Wenlock Series, Wenlock Edge, Shropshire.

**Diagnosis.** (Downie, 1963, p. 638). ‘A species of *Estiastra* 100 to 150 microns across with eight to twelve processes. The walls are thin, generally crumpled, and ornamented with a fine ornament of small closely spaced granules.’

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total vesicle diameter</td>
<td>90 - 120 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>70 - 100 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Remarks.** Stellate vesicle formed from the arrangement of 5 - 12 processes. The vesicle and processes are hollow, single walled and ornamented with a granulate sculpture. The processes are open to vesicle interior and tapering to simple, acuminate, tips. The process bases are form acute angles and the form of the central body is indistinct from the confluence of the process bases. Mode of excystment by a simple split. This species is smaller than *E. magna* has narrower process bases and bears a granular ornament. *E. barbata* has a coarser, echinate ornament and is smaller.

**Occurrence.** Previous records have *E. granulata* recorded from the Coalbrookdale and Much Wenlock Limestone formations, Upper Wenlock Series, Shropshire; (Downie, 1963); Slite Marl, Wenlock Series of Gotland, Sweden (Eisenack 1965a, as *B. polygonale*); Wenlock Series, Dudley, West Midlands, UK (Eisenack 1965a, 1977, as *B. polygonale* and *G. polygonale*); Much Wenlock Limestone Formation to the Lower Elton Formation, Ludlow and Millichope area, Shropshire (Lister 1970, as *B. cantabrica*); Much Wenlock Limestone to Lower Elton Formation, Wenlock to Ludlow Series of the Ludlow area (Lister & Downie 1974); Much Wenlock Limestone Formation of the type area (Dorning 1981a); Coalbrookdale - Lower Elton formations of the type area, Shropshire.
and the West Midlands (Dorning 1983); Coalbrookdale Formation (Sheinwoodian) of the Wenlock type area (Swire 1991).

In this study *Estiastra granulata* was recovered in samples MFGT1-50, Mortimer Forest in the Ludlow area and FD 500, Farley Dingle; 2SH - 2.0, 2SH - 1.15, 2SH -1.0, 2SH 110, Shadwell Quarry in the Much Wenlock area of Shropshire.

Known range: Wenlock to Early Ludlow series, Sheinwoodian - Gorstian stages.

**Genus EUPOIKILOFUSA** Cramer 1970a

*Type species.* Original designation *Leiofusa striatifera* now *Eupoikilofusa striatifera* (Cramer, 1964a p. 35 - 36, pl. 2, figs 9, 13), San Pedro Formation, Ludlow Series of north-west Spain. Cramer

*Diagnosis.* (Cramer, 1970, p. 83) ‘Vesicles fusiform elongated, with pointed poles. At each pole there may be a simple, equivalent process. Within the same species the length of the polar processes may vary greatly. The vesicle wall is unilayered, and the sculpture distribution symmetry is holomorphic with elements arranged in a pattern parallel to the longitudinal axis, and with a decreasing size, number and complexity of elements towards the poles. The ectoderm surface is ornamented with elements of the striate kind: rugulae, striae, fossulae, or microechinate elements in longitudinally oriented rows. The vesicle may open by splitting along the axis at approximately an equatorial position. The vesicle axis may be straight or curved, even in the same species.’

*Remarks* The views of Fensome *et al.* (1990 p. 213 - 214) that the genus *Eupoikilofusa* was not validly published and is a junior synonym of *Dactylofusa* are not followed in this study. *Eupoikilofusa* is here retained as a genus comprising fusiform acritarchs that have a striate ornament. This contrasts with leiosusids which are generally laevigate, whereas specimens belonging to the genus *Dactylofusa* bear a complex linear ornament and those included in *Poikilofusa* which have a distributed ornament of.


Plate 24, fig. 2.

1964a  *Leiofusa striatifera* Cramer p. 35 - 36, pl. 2, figs. 9, 13.

1965  *Leiofusa striata* n. sp. Brito & Santos, p. 17, pl. 1 fig. 9.
1966a *Leiofusa striatifera* Cramer, Cramer p. 42, pl. 5. fig. 1.

1967 *Leiofusa striata* n. sp. Brito, p. 475, no fig.

1970a *Eupoikilofusa striatifera* Cramer; Cramer p. 85-86, pl. 3, fig 51, 52, 53, 54, 58, 59; pl. 4, figs. 65, 72, 74; text - fig. 25g.

1972 *Eupoikilofusa striatifera var. typica* Cramer; Cramer & Diez, p. 165, pl. 35, fig. 50, 61.

1978 *Leiofusa filifera* Downie; Kiryanov p. 58, pl. 13 fig 4.

1987 *Eupoikilofusa striatifera* Cramer; Priewalder p. 36, pl. 7, figs. 5, 6, 8.


1990 *Dactylofusa striatifera* Cramer; Fensome, p. 182, no fig.

1993 *Eupoikilofusa striatifera complex*; Rubinstein p. 70.

1996 *Dactylofusa striatifera* Cramer; Molyneux *et. al.* p. 509, pl. 3. fig. 10.

**Holotype. *Leiofusa striatifera* Cramer, 1964a, p. 35-36, pl. 2, fig. 9; Ludlow Series of north-west Spain.**

**Diagnosis.** (Cramer 1970a, p. 85). 'Vesicle hollow, elongately fusiform three dimensionally to half moon shaped. A relatively short process may be present at each pole. These equivalent processes may attain up to ten percent of the length of the body proper, but the length, and the presence or absence of these processes, are variable characters even in specimens from the same sample. Vesicle walls uniform, thin (0.5 micron) and psilate except for the sculptural elements. The wall is unilayered and, in general, uniform but has longitudinally aligned thicker ribbles which apparently are bordered by areas of structural weakness and which cause numerous longitudinal wrinkles. Although the general appearance of this taxon is constant, the wrinkled striae which help determine the aspect of the species are very variable indeed: not only in length - but also in number, position and form of the wrinkles. The longitudinal axis of the vesicle may be straight or may be curved. The species opens by a straight longitudinal split pylome situated at approximately the thickest portion of the vesicles'.

**Remarks**: The specimens recovered conform to the original diagnosis. The forms recovered are elongate, unilayered, fusiform vesicles with striate ornament running parallel along the length of the vesicle body. The walls are often folded parallel to the longitudinal axis. The vesicle tapers to form hollow slender polar processes. The process tips may be hollow or solid (Cramer & Diez 1972) Excystment is by straight split in the central portion of the vesicle body.

**Dimensions.**

- Vesicle length: 100 - 190 µm,
- Maximum vesicle diameter: 25 - 40 µm,
- Number of specimens measured: 10.

**Occurrence.** Lower Wenlock, Northwest Spain (Cramer 1964a, 1966a, 1967, 1969b; Cramer & Diez 1968), Llandovery to Wenlock of Belgium (Martin 1965, 1966, 1967); Llandovery Series to lower Devonian of Brazil.
(Brito & Santos 1965 Brito 1967 as L. striata); Llandovery to early Devonian series of Algeria (Jardine & Yapaudjian 1968 as L. striatifera); Llandovery of north east Libya (Hill et. al. 1988); Llandovery and Wenlock series of eastern USA (Cramer 1968a, 1969a, 1970a); upper Llandovery to Ludlow series of the USA (Cramer 1969a as L. striatifera, Cramer & Diez 1972); Tanezzuft and Acacus Formations, Wenlock Series of Libya (Richardson & Ioannides 1973); Wenlock Series of Ontario, Canada (Thusu 1973a); Wenlock Series of New York, USA (Thusu 1973b); Ashgill Series of Canada (Jacobson & Achab 1985), Ludlow Series of Cochabamba, Bolivia (Cramer et al. 1974); Wenlock Series of Cotentin, Normandy France (Rauscher & Robertet 1975 as L. striatifera), Ludlow to Wenlock series of Argentina (Pothé de Baldis 1975a, 1981); Wenlock (Much Wenlock Limestone Formation) to Pró dol series (Downton Castle Sandstone Formation), Ludlow (Lister & Downie 1974 as Poikilofusa striatifera); upper Llandovery to lower Wenlock series of the type area (Hill 1974, Dorning 1981a, Dorning 1983, Hill & Dorning 1984); upper Llandovery Series (Purple Shales) to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985); Llandovery and Wenlock of Norway (Smelror 1987); upper Ludlow Series of the Karnic Alps, Austria (Priewalder 1987); Llandovery Series of north-east Libya (Hill & Molyneux 1987); Ludlow Series of Libya (Wood & Tekbali 1987); Llandovery to Ludlow series of Gotland, Sweden (Le Hérrissé 1989); Buildwas and Coalbrookdale formations (Sheinwoodian) of the Wenlock type area, Central Wales and the Malverns (Swire 1991); Silurian of the Southern Uplands (White et al. 1991); Ludfordian, Ludlow area (Donoghue 1992); upper Silurian of San Juan, Argentina (Rubinstein 1993).

In this study Eupoikilofusa striatifera was recovered in low numbers but as a consistent part of the assemblages from Farley Dingle, Coates Quarry, Harley Hill, Shadwell Quarry; Much Wenlock Shropshire. Pitch Coppice, Mortimer Forest and Burrington Track from the Much Wenlock Limestone Formation (Homerian), and Lower Elton Formation (Gorstian), Ludlow Area, Shropshire. Despite the typical low abundance of this species, up to 10%, it forms a significant proportion of the assemblage in samples from Harley Hill where it occurs in blooms representing of up to 20% of the specimens present in the assemblage. It is therefore proposed that blooms of Eupoikilofusa striatifera may be good regional biozonal indicator for the Welsh Basin but due to lack of information about such occurrences from other areas its use for correlating between international sections is questionable.

Known Range: Llandovery to Devonian

Genus FILISPHAERIDIUM Staplin Jansonius & Pocock 1965


Diagnosis. (Staplin Jansonius & Pocock p. 192.) "Vesicles spherical to subspherical; walls proportionally thin, smooth to chagrinate, with several to numerous more or less stiff, solid, wiry spines; spines are cylindrical,
unbranched or with distal differentiation (branching, thickening); proximally the spine base is usually thickened.

**Filisphaeridium brevispinosum** (Lister 1970).

Plate 18, fig. 1, 2, 3, 4.

1970 *Filisphaeridium brevispinosum* sp. nov.; Lister, p. 72 - 73, pl. 7, Figs 5 - 10, text-fig. 22.
1970 *Elektoriskos sp.* Loeblich 1970; p. 719, pl. 13, fig. c.
1973a *Comasphaeridium simplex* Thusu; p. 814, pl. 105 fig. 9.
1979 *Elektoriskos brevispinosum* Lister; nov. comb.; Vanguerstaine, p. 247, pl. 3, fig. 18, pl. 4, fig. 14.
1981a *Elektoriskos brevispinosum* Lister; n. comb. Dorning p. 189, no fig.
1994 *Filisphaeridium brevispinosum* Lister 1970; Sarjeant & Stancliffe, p. 29, no fig.

**Holotype.** Lister 1970, pl. 7, fig. 8; Upper Whitcliffe Formation, Ludlow Series of the Whitcliffe, Ludlow, Shropshire.

**Diagnosis.** (Lister 1970, p. 72). ‘Vesicle smooth, thin-walled, hollow, spherical; numerous solid hair-like processes, up to 10% of vesicle diameter in length; within a given individual, processes are of equal length and spacing. Excystment by cryptosuture.’

**Remarks.** Specimens recovered conform to the original diagnosis in having thin walled small, spherical to ellipsoidal vesicle body bearing numerous, 25+, short, solid, simple and branched, straight to flexuous processes, which have slightly expanded bases. Excystment is by simple split. This species has been retained in the genus *Filisphaeridium* following Sarjeant & Stancliffe (1994 p. 29).

**Dimensions.**

<table>
<thead>
<tr>
<th></th>
<th>Vesicle diameter</th>
<th>Process length</th>
<th>Number of processes</th>
<th>Number of specimens measured</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20 - 36 µm</td>
<td>2 - 8 µm</td>
<td>25 +</td>
<td>5</td>
</tr>
</tbody>
</table>

168
Occurrence. Wenlock to Ludlow series of the Ludlow and Millichope areas (Lister 1970); Wenlock (Much Wenlock Limestone Formation) to Prídlí (Downton Castle Sandstone formation) Series of the Ludlow area (Lister & Downie 1974); Devonian of Belgium (Vanguestaine 1979); Los Espejos Formation, Ludlow Series of Argentina (Pothé de Baldis 1981); upper Silurian of San Juan, Argentina (Rubinstein 1993).

Known range: Wenlock to Prídlí series.

Filisphaeridium cf. williereae Deflandre & Deflandre-Rigaud 1965; ex Lister 1970

Plate, 18 fig. 5

1963 Baltisphaeridium aff. polytrichum (Valensi 1947); Stockmans & Willière, p. 460, pl. 3, figs 24, 25, text-fig. 16.

1965 Michrystridium williereae Deflandre & Deflandre-Rigaud, fiche reference 2347.

1970a Comasphaeridium williereae (Deflandre & Deflandre-Rigaud 1965a); Cramer, p. 121 - 122, text-fig. 37.

1970 Filisphaeridium williereae (Deflandre & Deflandre-Rigaud 1965a); comb. nov. emend.; Lister, p. 73, pl. 7, figs 1 - 4.


1976 Comasphaeridium williereae Cramer 1970; Eisenack et al., p. 135 - 137.

1979 Elektoriskos williereae (Deflandre & Deflandre-Rigaud) comb. nov.; Vanguestaine, p. 247, pl. 1, figs 13, 14, pl. 3, fig. 20.

cf. 1989 Elektoriskos aurora Loeblich; Le Hérisse, p. 122, pl. 10, figs. 3, 4.

1990 Elektoriskos williereae Deflandre & Deflandre - Rigaud; ex Lister; Fensome et al., p. 210, no fig.

1990 Filisphaeridium williereae Deflandre & Deflandre - Rigaud: ex Lister; Fensome et al. p. 224 - 225, no fig.

Holotype. Stockmans & Willière 1963, pl. 3, figs 24, 25 (as Baltisphaeridium aff. polytrichum (Valensi 1947)); from the Llandovery Series, borehole material, Belgium; designated by Lister (1970, p. 73).

Diagnosis. (Lister 1970, p. 73). "Vesicle hollow, subspherical to elongate polygonal; vesicle wall unilayered, thin; numerous slender, solid, flexuous processes about 40% of vesicle diameter in length; distally the processes most often taper to a point but occasionally branch. Excystment by cryptosuture."
Description. Spherical to subspherical, thin walled, transparent vesicle ornamented with numerous fine, solid, processes which are heteromorphic in a single specimen they are branched or simple. Excystment by median split.

Remarks. There is much confusion between this genus and species and species of Elektoriskos and Comasphaeridium, to quote Cramer from the Eisenack catalogue (1973), 'a crockful of malign junior synonyms'. Thus what is assigned to this genus and species herein has been done so in comparing to other forms recovered and where they compare well they have been recorded here. Thus this division is by no means a certain recognition that all forms previously reported as this species or any other of the synonyms applicable are one and the same species. The decision to place the forms recovered in this genus was on the presence of processes which were branched.

Dimensions. Vesicle diameter 20 - 28 μm
Process length 8 - 16 μm
Process width 0.5 μm
Process number 30+
Number of specimens measured 5.

Occurrence. This species under its many guises has been recovered from many localities, of which the following have been confirmed: Llandovery to Wenlock Series of Belgium (Martin 1966a; Llandovery to Prfdolf series, of the USA (Cramer 1970; Cramer & Diez 1972); Lower Elton to Whitcliffe formations in the Ludlow and Millichope areas of Shropshire (Lister 1970); Wenlock to Prfdolf series of the Ludlow area of Shropshire (Lister & Downie 1974); Llandovery Series of the Llandovery type area (Hill & Dorning 1984), Wenlock to Prfdolf series of Gotland, Sweden (Le Hérissé 1989 as the comparable from E. aurora).

Known range Silurian to Devonian.

Genus GLYPTOSPHAERA Kiryanov 1978.

Type Species. Glyptosphaera speciosa Kiryanov 1978 p. 53, pl. 4 fig. 1 - 2.

Diagnosis. (Translation of Kiryanov 1978, p. 52-53, by V. Viira.). Vesicle spherical, unilayered, relatively thick walled. The surface is covered by low crests or ridges forming a characteristic muronate pattern, resembling sets of subparallel meanders. The crests sometimes diverge from the main direction 'bifurcate' and develop at right angles to the principle direction. Crests are rarely disrupted and on some specimens 'isolated' fields are not possible to separate. The branching pattern 'of the meandering fields' shows a tendency to symmetry.
Remarks. Glyptosphaera is similar in form to the other prasinophycean algae such as Cymatiosphaera and Dictyotidium, particularly those forms assigned to Cymatiosphaera imperfecta. The crests that form the fields though are sinuous in nature and not polygonal as in Cymatiosphaera and Dictyotidium.

Glyptosphaera callilopha sp. nov.

Plate 10, fig. 11.

Derivation of name. From the Greek 'callos' - meaning beautiful and 'lophos' meaning crest (back of neck, crest of hill, crest of helmet). Referring to the beautiful, distinct form of the crests.

Holotype. Plate 10, fig. 11 from sample FD1500/10/1, Rivelin Finder reference PQ 35, from the Farley Member of the Coalbrookdale Formation, Homerian Stage of the Wenlock Series. Locality: Farley Dingle, Much Wenlock, Shropshire, England.

Diagnosis. Dark, thick walled, vesicle body 28 - 38 μm in diameter, whose endophragm is surrounded by a thin translucent ectophragm. The central body is ridged and folded, these folds along with thin films of the ectophragm form crests 2 - 6 μm in height. These crests delineate indistinct fields, 8 - 10 μm wide. The crests sometimes coalesce at points to form spines. The fields are sinuous over the vesicle surface and are generally all interconnecting, though some blind pathways may occur. Mode of excystment not observed.

Remarks. This species differs from Glyptosphaera labyrintha which is much larger with wider fields. Glyptosphaera speciosa Kiryanov has more delicate, lower crests and finer fields. Glyptosphaera magna is larger with finely muronate fields. Glyptosphaera heliciverticata has a distinctive spiralling ornament. This form was initially logged as Cymatiosphaera sp. N.

Dimensions. Central body 28 - 38 μm
Flange height 2 - 6 μm
Field width 8 - 10 μm
Number of specimens measured 5.

Occurrence. This species was recorded from the Farley Member of the Coalbrookdale Formation to the Much Wenlock Limestone Formation, Homerian Stage of the Wenlock Series, in samples from Farley Dingle and Coates Quarry.
**Glyptosphaera helicverticata** sp. nov.

Plate 19, fig. 12.

1971 Example of cristate ornament; Tappan & Loeblich, pl. 1, figs. 15, 16.

1989 *Glyptosphaera speciosa* Le Hérisse, p. 139, pl. 14, figs. 18 - 20.

*Derivation of name.* Latin 'helix' - winding around and 'vertici-' meaning whirl, verticata = whirl like.

*Holotype.* Pl. 19, fig. 12, from Farley Dingle sample FD 2550/10/1. Coalbrookdale Formation, Homerian of the type area Much Wenlock, Shropshire, England.

*Diagnosis.* Spherical to ellipsoidal moderately thick walled vesicle ornamented with low crests 1.5 - 3 µm in height arranged in a subparallel pattern between 4 - 8 µm apart. The crests form sub concentric bands encircling the vesicle bounding low laevigate fields. The vesicle is single walled and 2.5 - 3 µm thick. Mode of excystment not observed.

*Remarks.* This species differs from *Glyptosphaera speciosa* in that the fields run in a concentric pattern around the vesicle and not branched patterns with variably closed fields. This species was initially referred to as *Glyptosphaera* sp. B, and is referred to as such in the initial documents.

*Dimensions.*

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>24 µm</td>
</tr>
<tr>
<td>Crest height</td>
<td>1 - 2 µm</td>
</tr>
<tr>
<td>Field Width</td>
<td>4 µm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1.</td>
</tr>
</tbody>
</table>

*Occurrence.* This form has been previously recorded from Gotland, Sweden as *G. speciosa* from the base of the Wenlock to the top of the Ludlow Series (Le Hérisse 1989). The specimen recovered was from the Coalbrookdale formation, Farley Member of Farley Dingle, sample FD 2550 in the type area, Much Wenlock, Shropshire, England.
**Glyptosphaera labyrinth** sp. nov.

Plate 11, figs. 1, 2.

*Derivation of name.* Labyrinth - referring to the maze like sinuous pattern of the fields.

*Holotype.* Plate 11, figs. 1, 2. from sample PC 50/10/1, Rivelin Finder reference R36, from the Much Wenlock Limestone Formation of Pitch Coppice, Ludlow, Shropshire, England.

*Diagnosis.* Thick walled, subspherical to ellipsoidal, laevigate vesicle body when viewed under transmitted light. Surface divided into labyrinth/maze like fields by low membranous crests. The fields can be both interconnected or form blind pathways, isolated by the presence of a low crest terminating the field. The crests are thin and undulose. Mode of excystment not observed.

**Glyptosphaera magna** sp. nov.

Plate 13, fig. 4.

*Derivation of name:* Latin ‘Magna’ (great/large).

*Holotype.* Plate 13, fig. 4. from the Farley Member of the Coalbrookdale Formation of Farley Dingle, Much Wenlock, Shropshire, England.

*Diagnosis.* A large spherical/subspherical species of *Glyptosphaera*. Vesicle thick walled (2 - 5 \( \mu m \)), laevigate, single walled ornamented with crests forming ridges (1 \( \mu m \)) which enclose elongated fields and anastomose to producing a labyrinthine, reticulate pattern, which resembles ‘brain like’ (cerebral) folds. Excystment mechanism is a simple split.

*Remarks.* This form differs *G. speciosa* Kiryanov, in its large vesicle size and from *G. heliciverticata* in its distinctive ornament which anastomoses in a more random, rather than spiral like pattern. This species was referred to on log sheets as *Glyptosphaera* sp. A.

**Dimensions.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Vesicle diameter</strong></td>
<td><strong>46 - 74 ( \mu m )</strong></td>
</tr>
<tr>
<td><strong>Crest height</strong></td>
<td><strong>1 - 1.5 ( \mu m )</strong></td>
</tr>
<tr>
<td><strong>Field width</strong></td>
<td><strong>4 ( \mu m )</strong></td>
</tr>
<tr>
<td><strong>Number of specimens measured</strong></td>
<td>1</td>
</tr>
</tbody>
</table>
Occurrence. Only one specimen of this form was recovered from the Coalbrookdale Formation (Farley Member) at Farley Dingle, sample FD1900 in the type area, Much Wenlock Shropshire, England.

Remarks. This species is distinctly a member of the genus Glyptosphaera and not Cymatiosphaera because of the irregular nature of the fields which form labyrinthine pathways over the surface of the vesicle. Glyptosphaera speciosa is a smaller taxon with more numerous smaller fields and Glyptosphaera heliciverticata is smaller and has concentric fields that are continuous and not terminated by crests in the maze like fashion observed in specimens belonging to this species. Mode of excystment not observed.

Dimensions. Central body 28 - 40 μm
Entire vesicle plus flange 30 - 42 μm
Outer flange 1 - 2 μm
Field width 8
Number of specimens measured 2

Occurrence. This form was recovered as a rare type from Farley Dingle (Coalbrookdale Formation, Farley Member) and Pitch Coppice Quarry, Much Wenlock Limestone Formation (Homerian) of the Ludlow area, Shropshire, England.

Glyptosphaera speciosa Kiryanov 1978

Plate 19, figs. 10 - 11.

1978 Glyptosphaera speciosa sp. nov.; Kiryanov, p. 53, pl. 4, figs 1, 2.
1989 Glyptosphaera speciosa Le Hérisse p. 139, pl. 14, fig. 17, only.
1990 Glyptosphaera speciosa Kiryanov 1978; Fensome et al., p. 232, no fig.

Holotype. Kiryanov 1978, pl. 4, fig. 1.; from the Ludlow Series, Silurian of Podolia in the Ukraine.

Diagnosis. (Translated from Kiryanov 1978, p. 53).
Etymology: speciosus (Greek) - beautiful.
Vesicle spherical, with one layer, diameter 35-43μm (holotype 36μm), thickness of wall 2-5μm (holotype 2μm). The surface is covered by low (about 1μm high) ridges, the width of which in their basal part is equal to, or a little smaller than, their height. Often the cross section of the ridges has the shape of a half-circle and so these elements of sculpture may be called low knobs. The arrangement of ridges on the vesicle surface form an ornament which is somewhat reminiscent to the folds of a brain (celebriformis). Rarely the ridges bifurcate. More frequently there have
short, lateral, thickenings (about 1 µm). These processes may be situated heterogeneously on both sides of ridges or are opposed forming peculiar nodes or crosses. Very rarely there are disruptions of the ridges which may be connected with preservation. The surface between the ridges is laevigate. Pylome or some other kind of opening for release of cyst contents has not been seen.

Remarks. Spherical vesicle thick walled body (16 - 40 µm), which is ornamented with crests of arranged subparallel and equidistant (2 - 5 µm) to each other and anatomising to form a labyrinth like pattern. Excystment by simple split. Only one of the specimens assigned to *Glyptosphaera speciosa* by Le Hérissé (1989) is accepted here as belonging to this species. The other forms he illustrated have a crest pattern that is distinguished as belonging to the new species *Glyptosphaera heliciverticata* herein which differs from *Glyptosphaera speciosa* in having a concentric pattern of crests that encircles the vesicle body. The fields of which do not anastomose to such a great degree.

**Dimensions.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>16 - 40 µm</td>
</tr>
<tr>
<td>Field width</td>
<td>2 - 5 µm</td>
</tr>
<tr>
<td>Crest Height</td>
<td>1.5 - 2.5 µm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Occurrence.** Ludlow Series of Podolia (Kiryanov 1978); Le Hérissé (1989) recovered specimens from and thereby extended the range to include the lower Wenlock (Höglint Formation) to the top of Ludlow Series to the base of the Pridolf Series (Hamra formation) of Gotland, Sweden.

This species was recorded from the Coalbrookdale Formation (Farley Member) of Farley Dingle, (FD 1200); the Much Wenlock Limestone formation of Harley Hill and Shadwell Quarry where occurrences were also reported from the lower Elton Formation. In the Ludlow area this species was found in samples from the Much Wenlock Limestone Formation of Mortimer Forest and Pitch Coppice (PC 350).

Known range. Wenlock - Ludlow series.

Genus **GORGONISPHAERIDIUM** Staplin, Jansonius & Pocock 1965  
emend. Kiryanov 1978

*Type Species.* *Gorgonisphaeridium winslowii* Staplin, Jansonius & Pocock 1965, p. 192 - 193 pl. 19, figs 11, 18-20, text-fig. 4; Banff Formation, Lower Mississippian (Carboniferous), of southern Alberta, Canada.
**Diagnosis.** (Staplin et al., 1965, p. 192) ‘Vesicles spherical; wall firm, relatively thick, smooth or with minute sculpture; spines numerous, solid, usually sinuous, slender or broad, of same material as vesicle wall. Tips simple or distally branched, flexible, bases may be slightly bulbous; vesicle size of known species relatively large.’

**Emended Diagnosis.** (Translated from Kiryanov (1978) p. 14 - 15) ‘Spherical vesicle with distinctly differentiated processes. Vesicle wall thick, smooth or with tiny external structure. Processes are numerous, solid, usually flexible, thin or thick and are formed from the same matter as the vesicle. Processes are bifurcate distally, but their terminations are always closed. Bifurcation of processes on individual vesicles is of the same type, but is somewhat variable. The basal part of the processes may be a little expanded. Mode of excystment unknown’.

**Remarks.** *Gorgonisphaeridium* differs from *Multiplicisphaeridium* as it has a thicker wall and solid processes whereas the latter has hollow processes. *Visbysphaera* has a double walled vesicle, *Baltisphaeridium* has longer processes and a double wall.

**Gorgonisphaeridium bringewoodensis** Dorning 1981a

Plate 28, fig. 11

1970  *Gorgonisphaeridium* sp. nov.; Lister, p. 75, pl. 8, figs 5-7.
1981a *Gorgonisphaeridium bringewoodensis* n. sp.; Dorning, p. 189 - 191, pl. 2, fig. 5.
1990 *Gorgonisphaeridium bringewoodense* Fensome et al. p. 238, no fig.

**Holotype.** *Gorgonisphaeridium bringewoodensis* Dorning, 1981a, p. 189 - 191, pl. 2, fig. 5; from the Lower to Upper Bringewood Formations (Ludlow Series) of Ledbury Hill, Hereford and Worcester.

**Diagnosis.** (Dorning, 1981a, p. 191) ‘Vesicle subspherical, 30 - 50 μm in diameter; wall thick; very numerous simple processes, solid, 3 - 6 μm long, base 1.5 - 2 μm wide, tapering to a sharp point, laevigate. Excystment by a straight split in the vesicle wall; the cryptosuture opening in an apical position noted by Lister (1970) has not been observed’.

**Remarks.** Forms have been recovered that conform to the original diagnosis of *Gorgonisphaeridium bringewoodensis*. They are ellipsoidal of medium thickness with a single walled vesicle body bearing an ornament of short, solid, simple processes. The tips of some of the processes bear a resemblance to those evident in *Helosphaeridium* species. Whether or not this species definitely belongs with the genus *Gorgonisphaeridium* is therefore questionable, the simple nature of the processes and the form of the vesicle does not automatically indicate
the association of these forms to the genus but is placed under this group until further material can be obtained. Mode of excystment by simple split. This species is referred to as *H. bringewoodensis* on the Tiliagrams.

*Dimensions.*

<p>| | |</p>
<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>34 - 44 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>1.5 - 3 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>1 - 1.5 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

*Occurrence.* Upper Elton to Bringewood formations of the Ludlow/Millichope areas of Shropshire (Lister 1970); upper Elton to Bringewood formations (Silurian) of the Welsh Borderlands Dorning (1981a).

This species has been recovered as a rare type from the Coalbrookdale Formation, sample FD 1900/10/1.

Known Range. Homerian to Gorstian Stages, Wenlock to Ludlow Series.

**Gorgonisphaeridium indomitum** Deunff 1980

Plate 19, fig. 7.

1980 *Gorgonisphaeridium indomitum* Deunff, p. 503 - 504, pl. 5. fig. 12, pl. 7 figs. 3, 6.

1990 *Gorgonisphaeridium indomitum* Deunff, Fensome *et al.* p. 239, no fig.

*Holotype.* Deunff 1980 p. 503 - 504, pl. 7 figs. 3, 6 From the middle Gedinnian (Devonian) of Lanveoc, Brest

*Diagnosis.* (Translated from Deunff 1980 p.503 - 504) Organic microfossil with a spherical central body of 30 - 40 μm in diameter bearing a microgranulate to microverrucate sculpture. The central body supports 70 - 100 processes of 7 to 10 μm in length, apparently hollow but they do not communicate with the central body cavity. The appendices are relatively short and squat, often fibrous at the base and polymorphic; they can be simply bifurcate at the distal extremity or weakly branched, where they are more simple they have pointed or blunt terminations.

*Description.* Vesicle medium to thick walled, laevigate, subspherical to ellipsoidal bearing numerous thick short solid processes which branch distally. Mode of excystment not observed.
Remarks. The specimens grouped herein are comparable to those belonging to the species *G. succinum* but has generally fewer, shorter, thicker processes. This form was initially referred to as *Gorgonisphaeridium succinum* var. F.

**Dimensions.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>11 - 28 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>2 - 6 µm</td>
</tr>
<tr>
<td>Process width</td>
<td>2 - 3.5 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>10+</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

**Occurrence.** The first reported occurrence of this species was from the Gedinnian of Brest (Deunff 1980).

This variety has been recovered in low numbers from the Coalbrookdale through Much Wenlock Limestone to the Lower Elton formations of the Farley Dingle, Harley Hill, Coates Quarry and Pitch Coppice in the type Wenlock and Ludlow areas.

Known Range. Homerian.

**Gorgonisphaeridium succinum** Lister 1970

Plate 19, fig. 1 - 5

1970   *Gorgonisphaeridium succinum* sp. nov.; Lister, p. 75, pl. 8, figs 1 - 4.
1973   *Multiplicisphaeridium succinum* Eisenack et al., p. 805.
1978   *Gorgonisphaeridium succinum* Kiryanov, p. 55, pl. 7, figs 7 - 9 a, b.
1990   *Gorgonisphaeridium succinum* Fensome et al., p. 240, no fig.

**Holotype.** Lister 1970, p.75, pl. 8, fig. 1; Lower Elton Formation, Ludlow Series, Pitch Coppice, Ludlow, Shropshire.

**Diagnosis.** (Lister 1970, p. 75) "Vesicle hollow, spherical, thick walled (one layer), smooth to minutely verrucate; numerous closely spaced processes less than 1/3 of vesicle diameter in length; processes appear as solid outgrowths of vesicle wall, tapering only very slightly distally and branching irregularly. Excystment by cryptosuture; no dehiscent specimens found."
Remarks. Specimens recovered conformed to the original diagnosis though there is a variation evident in wall thickness, process length, width and number. Generally the vesicle is spherical to ellipsoidal, medium to thick walled bearing numerous short multifurcate processes. The original diagnosis states that the processes 'appear' solid. As the processes are also relatively thick and therefore dark it is hard to tell whether or not they are always solid. The processes are heteromorphic and may branch up to third order. Mode of excystment is by simple split. The end members of this form group having been separated in logging have been treated separately in the systematic descriptions.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>16 - 28 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>4 - 10 μm;</td>
</tr>
<tr>
<td>Process number</td>
<td>16 - 30 +</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

Occurrence. Wenlock to Ludlow series of the Ludlow/Millichope areas of Shropshire (Lister 1970); Lower Elton Formation - Lower Whitcliffe Formation, Ludlow Series of the Ludlow area (Lister & Downie 1974); Ludlow Series of Podolia, (Kiryanov 1978); Slite (unit f) (Middle Wenlock Series) to Sundre formations (Prídolí Series) of Gotland, Sweden (Le Hérisse 1989).

This species formed a consistent part of assemblages in this study being recovered in samples collected from Farley Dingle, Harley Hill, Shadwell Quarry, Coates Quarry, Mortimer Forest and Pitch Coppice in the Wenlock and Ludlow type areas of Shropshire, Wenlock to Ludlow series (Homerian to Gorstian Stages).

Known range. Mid Wenlock Series (Sheinwoodian stage) to Prídolí Series.

Gorganisphaeridium succinum var. B

Plate 19, fig. 8

Description The specimens assigned herein exhibit all the features that would constitute belonging to G. succinum but differ in having longer mean process length, and fewer processes.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle body</td>
<td>18 - 22 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>8 - 12 μm</td>
</tr>
<tr>
<td>Process width</td>
<td>1.5 - 2.5 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>8 - 14</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>
Occurrence. This form has been recovered from the Coalbrookdale to Lower Elton formations (Homerian to Gorstian) of Farley Dingle, Harley Hill, Shadwell Quarry, Coates Quarry, Mortimer Forest, Pitch Coppice in the type Wenlock and Ludlow areas.

Known Range. Wenlock to Ludlow Series Boundary, (Homerian to Gorstian Stages.)

**Gorgonisphaeridium succinum var. E**

Plate 19, fig. 6

Description The specimens assigned herein exhibit all the features that would constitute belonging to *G. succinum* but differ in having shorter finer processes.

Remarks. It is possible that these forms are similar to those described as *Gorgonisphaeridium wenlockium* by Thusu (1973a p. 814 - 815, pl. 105, fig. 11), now *Visbysphaera wenlockia* (Dorning 1981a, p. 176). The reproduction of the plates was poor on the photocopy available, and the form was not figured by Doming (1981a) hence the forms are retained here informally as a variety of *G. succinum*.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle body</td>
<td>20 - 28 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>2 - 3 μm</td>
</tr>
<tr>
<td>Process width</td>
<td>1.5 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>20+</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

Occurrence. This form has been recovered from the Coalbrookdale to lower Elton formations in samples from Farley Dingle, Harley Hill, Shadwell Quarry, Coates Quarry, Pitch Coppice and Mortimer Forest in the type Wenlock and Ludlow areas of Shropshire.

Known Range. Wenlock to Ludlow Series Boundary, (Homerian to Gorstian Stages.)
Gorgonisphaeridium cf. ramosum Pôthe de Baldis 1981

Plate 35, fig. 5

1981  Gorgonisphaeridium ramosum n. sp.; Pôthe de Baldis, p. 243, pl. 4, fig. 4.
1990  Gorgonisphaeridium ramosum Pôthe de Baldis 1981; Fensome et al., p. 239, no fig.

Holotype. Pôthe de Baldis 1981, pl. 4, fig. 4; from the Ludlow Series of the San Juan Province, Argentina.

Diagnosis. (Translated from Pôthe de Baldis 1981, p. 243). “Vesicle contours circular (spherical) with a central body composed of a thin, even/smooth membrane. Present are numerous, homomorphic, solid, processes which do not connect to the interior of the central body, ramified up to third order at distinct areas on their length. The membrane of the central body and that of the processes is of the same type.”

Description. Spherical, thin walled, laevigate vesicle bearing numerous short robust processes. The process which taper before bifurcating 3/4 of the way along the length of the process, branching is heteromorphic within a single specimen and observed up to second order. The processes are hollow but appear thicker than the central body (they are darker), it is believed that they communicate with the interior. Mode of excystment, median split.

Remarks. The forms recovered are compared to this species but differ in that the processes are hollow, otherwise they are very similar in vesicle and process type, style and branching. The hollow nature of the processes suggests that it should be included with the multisphaeriids but as this form was more closely comparable to G. ramosum and only one specimen was recovered it has been retained here. The processes are longer than in species of G. succinum. The Devonian form G. adjunctum (Wicander & Wood 1997) is broadly similar.

Dimensions.  

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<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>18 - 24 μm</td>
<td></td>
</tr>
<tr>
<td>Process length</td>
<td>8 - 13 μm</td>
<td></td>
</tr>
<tr>
<td>Process base width</td>
<td>2 - 2.5 μm</td>
<td></td>
</tr>
<tr>
<td>Number of processes</td>
<td>14+</td>
<td></td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1.</td>
<td></td>
</tr>
</tbody>
</table>

Occurrence. This species was first recorded from the lower Ludlow Series of the San Juan Province, Argentina (Pôthe de Baldis 1981).

Known range: Wenlock - Ludlow series.
Genus **HAPSIDOPALLA** Playford 1977  
emend. Wicander & Wood 1981

*Type Species. Hapsidopalla sannemanni* (Deunff 1957), p. 6; fig. 1; p. 13, figs 5-9; p. 14. from the Devonian of France. Designated by Playford 1977, p. 25.

*Diagnosis.* (Playford 1977, p. 25). 'Vesicle hollow, apparently single-layered, originally spherical to ellipsoidal; outline circular to subcircular or oval, clearly differentiated from processes. Numerous, ± evenly spaced, hollow, essentially homomorphic and smooth processes project from vesicle wall and branch distally; tips closed. Though discrete from one another, adjacent processes are interconnected proximally by muri that form a distinct ± uniform reticulum sculpturing the vesicle surface; processes characteristically project from junctions of muri, never from lacunae. Lacunae typically triangular to polygonal. Interior of processes in free communication with vesicle cavity. Excystment by splitting of vesicle wall.'

*Emended Diagnosis.* (Wicander & Wood 1981, p. 42 - 43). "This genus is emended here to include those forms with rosette-like vesicle sculpture and acuminate processes."

*Remarks.* The genus *Hapsidopalla* differs from *Lophosphaeridium* in that the ornament in the latter is solid and *Helosphaeridium* as the ornament does not interconnect. This is a distinctive genus, but accurate interpretation of the ornament style can only be undertaken with an S. E. M.

**Hapsidopalla jeandeunffii** Le Hérissé 1989

Plate 20, fig. 6.

1989 *Hapsidopalla jeandeunffii* n. sp.; Le Hérissé, p. 142 - 143, pl. 17, figs 5-6.

*Holotype.* Le Hérissé 1989, p. 142-143, pl. 17, figs 5 &6; from the Hemse Marl; Hemse Formation, (Ludfordian Stage) of the Ludlow Series, Silurian of Gotland, Sweden.

*Diagnosis.* (Translated from Le Hérissé 1989, p. 142). "A species of the genus *Hapsidopalla* with a spherical vesicle, ornamented with numerous processes, very short, homomorphic, conical, terminating with a rosette of four filamentous spines; the processes are equidistant, connected by crests which delimit a regular network with a rosaceous motif; the walls which form the network are simple, with cylindrical cross-section; the processes are hollow and communicate with the interior of the vesicle; excystment is by a simple split."
**Description.** Spherical vesicle body of moderate thickness bearing a short evenly distributed ornament of short proximally flared cones with capitate tops and crests, which covers the entire vesicle. This ornament is very difficult to determine using the light microscope. Mode of excystment median split.

**Remarks.** This form was recorded only rarely and conforms to the original diagnosis.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>18 - 24 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>1-3 µm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Occurrence.** This species has been previously recorded from the Klinteberg and Mulde formations Homerian Stage and the Ludfordian Hemse and Eke formations, Wenlock to upper Ludlow series of Gotland, Sweden (Le Hérissé 1989); Leinthall Quarry, Ludlow Series, near Ludlow in the Welsh Borderland (Donoghue 1992 unpublished).

Known range: Wenlock Series to Ludlow Series

**Genus Helosphaeridium** Lister 1970

**Type species.** Helosphaeridium clavispinulosum Lister 1970, p. 76; pl. 8, figs 8, 12, 16, text-figs 18g, 27b; Lower Elton Formation, Ludlow Series (Silurian), Ludlow, Shropshire.

**Diagnosis.** (Lister 1970 p.76). ‘Vesicle single walled, hollow spherical to ellipsoidal with ornament of small, numerous, evenly spaced solid or hollow processes flaring distally in claviform fashion. Excystment by cryptosuture.’

**Remarks.** The flared nature of the process terminations distinguishes this genus from Lophosphaeridium which also has a solid ornament but of tubercules or small grana. This species differs from Histopalla and Hapsidopalla differ in having short clavate processes.
Helosphaeridium clavispinulosum Lister 1970

Plate 20, fig. 10.

1970 Helosphaeridium clavispinulosum sp. nov. Lister, p. 76, pl. 8, figs. 8, 12, 16, text - figs. 18g, 27b.
1990 Helosphaeridium clavispinulosum Lister 1970; Fensome et al., p. 246, no fig.

Holotype. Helosphaeridium clavispinulosum Lister, 1970, p. 76, pl. 8, fig. 12; from the Lower Elton Formation, Ludlow Series of Ledbury, Herefordshire, England.

Diagnosis. (Lister, 1970, p. 76) 'Ellipsoidal, hollow, thin-walled vesicle with ornament of small cones or tubes with capitate tips. Size of the ornament varies from 1-1.5 μ, spacing is variable from 1.7-3μ, but within a given individual spacing and size are constant. Excystment by near-equatorial cryptosuture producing hemicysts.'

Remarks. This species bears an ellipsoidal to subspherical, thin walled vesicle body bearing an ornament of short wide based echinae that appear to be capitate under transmitted light. The forms are consistent with those described in the original diagnosis. This species was logged as Helosphaeridium sp. F/G.

Dimensions. Vesicle body 28 - 38 μm
Process height 2 - 4 μm
Process width 0.5 - 1.5 μm
Number of specimens measured 10

Occurrence. This species has been reported as being rare in the Lower Elton Formation Ludlow Series of the Ludlow and Millichope areas, Shropshire, England (Lister 1970); Elton Formation of Shropshire (Lister & Downie 1974 as H. clavispinulatum); Llandovery Series, lower Silurian of Ringerike, Norway (Smelror 1987); upper Silurian of San Juan, Argentina (Rubinstein 1993 as H. cf. clavispinulosum). This species has been recovered sporadically from the Coalbrookdale and Much Wenlock Limestone formations of Farley Dingle, Shadwell Quarry, Harley Hill in the type Wenlock Area.

Known Range: Wenlock to Ludlow Series

Helosphaeridium citrinipeltatum (Cramer & Diez 1972) Dorning 1981a

184
1972  *Lophosphaeridium citrinipeltatum* sp. nov. Cramer & Diez, p. 166 - 167, pl. 35, figs. 58, 59.

1981a  *Helosphaeridium citrinipeltatum* comb. nov. Dorning, p. 192, no fig.

?1987  *Lophosphaeridium hauskae* n. sp. Priewalder, p. 37 - 38, pl. 8 figs. 5 - 8, text - fig. 14.

1990  *Helosphaeridium citrinipeltatum* Cramer & Diez; Fensome *et al.*, p. 246, no fig.

**Holotype.**  *Helosphaeridium citrinipeltatum* Cramer & Diez, p. 166 - 167, pl. 35, figs. 58; from the Alger Shale, Ohio.

**Diagnosis.** (Cramer & Diez, p. 166 - 167) "Central body hollow, spherical, densely covered with small peltate sculptural elements. The sculptural elements are distributed over the vesicle without any discernible topical preference or pattern. Some of the sculptural elements lack the expanded crests and are then indistinguishable from grana and microverrucate elements that form the ornamentation of *Lophosphaeridium citrinum*. Vesicle thickness, one micron or slightly less. The sculptural elements appear to be solid; they are up to two microns high and about equally wide at the top and base."

**Remarks.** The specimens recovered conform to the diagnosis of *H. citrinipeltatum*. Vesicle ellipsoidal, single walled, thin, laevigate bearing an ornament of numerous even and widely spaced, short capitate spines. Excystment by median split. This species is morphologically similar to *Wrensnestia ornata* Dorning 1981a but lacks the polar ornament of solid grana. *H. clavispinulosum* is morphologically very similar, but specimens belonging to this species have a shorter more densely spaced ornament than that seen on the holotype of *H. clavispinulosum*. This species was logged as *Helosphaeridium* sp. B. The species *Lophosphaeridium hauskae* (Priewalder 1987) is questionably included within the synonymy as from the photographic plates the specimens are remarkably similar, but the material has not been viewed by the author and her specimens have undergone a different regime of geothermal alteration. Also, not enough specimens of Priewalder's species have been reported elsewhere to make a definitive statement at this stage.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle body</td>
<td>38 - 50 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>1.5 - 2 µm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>
**Occurrence.** This species has been recorded from the Alger Shale (Llandovery Series) of Ohio, USA (Cramer & Diez 1972); Llandovery to Wenlock series of the Karnic Alps (Priewalder 1987 as *Lophosphaeridium hauskae*); Lower Palaeozoic of the Garhwal Himalaya, India (Sinha et al. 1996).

This species has been recovered consistently but in low numbers from the Coalbrookdale to Lower Elton formations in samples from Farley Dingle, Harley Hill, Coates Quarry, Shadwell Quarry, Pitch Coppice and Mortimer Forest.

**Known range:** Llandovery to Ludlow series.

**Helosphaeridium pseudodictyum** Lister 1970.

*Plate 20, figs. 4 & 5*

1970 *Helosphaeridium pseudodictyum* Lister, p. 76 - 77, pl. 8, figs 9 - 11, 13, 14, 17, text - figs 18d, 18e, 27a.


1990 *Helosphaeridium pseudodictyum* Lister 1970; Fensome et al., p. 246, no fig.

**Holotype.** *Helosphaeridium pseudodictyum* Lister, 1970, p. 76, pl. 8, fig. 10; text - fig. 18d; from the Lower Elton Formation, Ludlow Series, Elton Lane, Ludlow, Shropshire.

**Diagnosis.** (Lister 1970 p. 76.) "Vesicle more or less ovoid, moderately thin-walled; ornament of numerous, evenly-spaced, small, parallel-sided outgrowths which flare distally, (as shown in Text - fig. 27a), frequently making contact with those adjacent. Excystment by cryptosuture".

**Remark** Specimens recovered conform to the original diagnosis, with ellipsoidal to subspherical, thin, single walled, hollow vesicle bearing an ornament of short, solid, closely spaced 'processes', 1 - 2 μm in length. Excystment by simple split. This species differs from *Lophosphaeridium* which has solid tubercules while *Buedingiisphaeridium* has an ornament of hollow tubercules that communicate with the central vesicle. It is believed that ruptured specimens of *Helosphaeridium pseudodictyum* are often mistaken as *Percultisphaera pilosa*. It is believed that there is morphological gradation between *H. pseudodictyum* and *H. latispinosum* Lister 1970, the specific differentiation being based on the latter having a broader ornament. As undoubtedly the two end members were logged conspecifically the previous occurrences of *H. latispinosum* where found, and have been reported at the end of the occurrences section.
Dimensions.  

Vesicle diameter 28-40 μm,  
Process height 1-1.5 μm,  
Process width 1 μm,  
Number of specimens measured 10.

Occurrence. *H. pseudodictyum* has been recorded from the Wenlock Shales near Eaton (Millichope Area), Much Wenlock Limestone Formation to the Upper Bringewood Formation of the Ludlow and Millichope areas and the Leintwardine Formation of the Ludlow area, Shropshire (Lister 1970 p. 77); middle Silurian Rochester Formation, Wenlock Series of Ontario, Canada (Thusu 1973a as *H. latispinosum*); Ilion Shale, Wenlock Series of Utica, New York, USA (Thusu 1973b, as *H. latispinosum*); upper Wenlock Series to lower Ludlow Series of the Ludlow area (Lister & Downie 1974); lower Wenlock Series (Buildwas Formation) to upper Ludlow Series (Whitcliffe Formation) of the Welsh Borderlands (Dorning 1981a); Los Espejos Formation, Ludlow Series of Argentina (Póthé de Baldis 1981); Much Wenlock Limestone Formation, Wenlock Series of Dudley, West Midlands, UK (Dorning 1983); Ludlow Series of Libya (Wood & Tekbali 1987); upper Llandovery to the base of the Wenlock series of Gotland, Sweden (Le Hérisse 1989); upper Silurian of San Juan, Argentina (Rubinstein 1993, as *H. cf. pseudodictyum*); Llandovery to Wenlock Series of Gotland, Sweden (Eriksson & Hagenfeldt 1997).

This species was recovered consistently but in low numbers from the Coalbrookdale to Lower Elton formations (Homerian to Gorstian stages) in samples collected from Farley Dingle, Harley Hill, Shadwell Quarry, Coates Quarry, Pitch Coppice and Mortimer Forest, from the type Wenlock and Ludlow areas of Shropshire.

Known Range. Llandovery - Ludlow series.

Previous recorded occurrences of *Helosphaeridium latispinosum* (Lister 1970) which is possibly transitional with *H. pseudodictyum*: Upper Elton to Lower Leintwardine formation (Ludlow Series), of the Ludlow and Millichope areas, Shropshire (Lister 1970, Lister & Downie 1974); upper Silurian of San Juan, Argentina (Rubinstein 1993); Wenlock Series (Homerian) from Holbrook Coppice, near Ironbridge, Shropshire (Turner et al. 1995).

Known range: Upper Wenlock to Lower Ludlow series (Homerian to Ludfordian).
**Helosphaeridium whitwellensis** sp. nov.

Plate 18, fig. 7.; Plate 20, figs 1, 2, 7, 8, 9, 11.

1987 *Dictyotidium ?* sp. Priewalder, p.30 - 31, pl. 6, figs. 10, 11.

**Derivation of name.** Specimens conforming to this diagnosis were first recorded by Swire (1991 unpublished), as *Salopidium whitwellensis*. The specific epithet used by Swire (1991) is retained for consistency within the unpublished literature. The name refers to the locality Whitwell Coppice, Much Wenlock, Shropshire, with the adjective suffix for nouns ‘-ensis’ referring to the place of origin/habitat. This species is believed herein to be a member of the genus *Helosphaeridium* and not *Salopidium*.

**Holotype.** Plate 18, fig. 7 sample FD 1900/101, Rivelin Finder reference C 30 from the Farley Member of the Coalbrookdale formation of Farley Dingle, Much Wenlock, Shropshire, England.

**Diagnosis.** Thin, single walled ellipsoidal vesicle bearing a dense ornament of short capitate spines which overlap considerably to cover the entire ectoderm. The spines are hollow, formed from the vesicle wall and are homomorphic in a single specimen. Excystment is probably by a pylome as one good specimen was found exhibiting this structure whilst other specimens have simple splits.

**Remarks.** This species is similar to those considered to be *Hapsidopalla spongiosa* by Le Hérissé 1989 p. 143, differing in that the ornament does not appear to bifurcate. *H. pseudodictyum* has a longer wider ornament, *Helosphaeridium* sp. B has a less dense and more spinose/echinate ornament.

**Dimensions.**

- Vesicle body: 22 - 36 μm
- Process length: 1.5 - 2 μm
- Number of specimens measured: 10

**Occurrence.** This species has been previously recorded by Swire (1991, unpublished Ph.D. thesis) from the Sheinwoodian of type Wenlock area. This species was recovered consistently from the Coalbrookdale to Lower Elton formations in samples collected from Farley Dingle, Harley Hill, Shadwell Quarry, Coates Quarry, Pitch Coppice and Mortimer Forest.

Known Range: Sheinwoodian to Gorstian, Wenlock to Ludlow Series.
**Helosphaeridium sp. D**

Plate 18, fig. 8.; Plate 20, fig. 12.

*Diagnosis.* Vesicle thin, single walled, ellipsoidal to subspherical, bearing a very fine dense ornament of low broad based echinae with capitate tips. This species is a small form with a finer ornament compared to other species belonging to the genus *Helosphaeridium*.

*Remarks.* This species differs from others belonging to the genus in its small size and finer ornament. This species has a similar size ornament to that seen on the thick walled sphaeromorph *Lophosphaeridium citrinum* Downie 1963, but as it was logged separately the distinction is retained here.

*Dimensions.*
- Vesicle body: 14 x 24 – 28 µm
- Process length: 0.5 - 1 µm
- Number of specimens measured: 10

*Occurrence.* This species has been recovered sporadically throughout the sections from Farley Dingle, Harley Hill and Pitch Coppice (Coalbrookdale to Much Wenlock Limestone formations) from the type Wenlock and Ludlow areas.

Known Range: Homerian

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**Genus HISTOPALLA Playford 1981**

*Type species.* *Histopalla capillosa* Playford 1981 in Playford & Dring 1981

*Diagnosis.* (Playford & Dring 1981, p. 39.) “Vesicle hollow, apparently single layered, originally spherical or almost so; outline circular to subcircular, clearly differentiated from processes. Numerous, +/- regularly distributed, solid, essentially psilat and homomorphic processes arise from vesicle wall and have simple (i.e. unbranched) distal termini. Though normally discrete from one another, adjacent processes are interconnected proximally by muri that form a +/- uniform reticulum sculpturing the vesicle surface; processes characteristically project from junctions of muri, not from lacunae. Lacunae typically triangular to polygonal. Excystment structure: a simple split in the vesicle wall.”
?Histopalla sp.

Plate 20, fig. 3.

**Description.** Spherical thin to medium walled vesicle bearing a low ornament, indistinct in form even under high magnification, hence only questionably assigned to this genus. Mode of excystment not observed.

**Remarks.** A specimen probably belonging to this genus was recorded but it could not be assigned to a species. This specimen was roughly compared to specimens of *Histopalla* recorded by Le Hérisse from the Slite Formation of Gotland (1989, p. 145, p. 17, figs. 7, 8) but these specimens were studied using a scanning electron microscope which allowed for detailed study of the very fine ornament.

**Dimensions.**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>27 µm</td>
</tr>
<tr>
<td>Process dimensions</td>
<td>&lt; 2 µm</td>
</tr>
<tr>
<td>Number of specimens</td>
<td>1</td>
</tr>
</tbody>
</table>

**Occurrence.** This specimen was recorded as a rare type from the Much Wenlock Limestone Formation, Homerian Stage of the Wenlock Series from Coates Quarry (sample CT7/10/1), Much Wenlock, Shropshire, England.

Genus **HOGKLINTIA** Dorning 1981a

**Type Species.** *Baltisphaeridium visbyense* Eisenack, 1959a, p. 200 - 201, pl. 16, figs 12 - 14, text - fig. 7; from the Höglint Beds, Wenlock Series, Höglint, Gotland, Sweden.

**Diagnosis.** (Dorning 1981a, p. 192). ‘Vesicle subspherical to subpolygonal in outline, large, ill defined from processes, wall thin, laevigate; three to several processes, thin walled, broad ill defined base, distally branched, bifurcate to multifurcate in one to three orders; the distal termination is sharp to somewhat blunt, often with some darkening of the process wall at the tip.’

**Remarks.** Species belonging to the genus *Hogklintia* are generally larger than the majority of he acritarchs recovered and has a different wall structure when compared to species belonging to *Multiplicisphaeridium. Estiastra* (Eisenack 1959) and *Pulvinosphaeridium* are of similar size, but have simple processes, tapering in the case of *Estiastra* and blunt in the case of *Pulvinosphaeridium*. These forms are thought only to be of stratigraphic use within a sedimentary basin (Dorning 1981a).
Hogklintia ancyrea (Cramer & Diez 1972) Dorning 1981 a

Plate 21, fig. 5.

1972  Baltisphaeridium ancyreum: Cramer & Diez, p. 147 - 148, pl. 31, fig. 1.
1981a Hogklintia ancyrea; Dorning, p. 181, p. 192, no fig.
1990 Hogklintia ancyrea; Fensome p. 248, no fig.
1991 Hogklintia ancyrea; Swire, p. 186, pl. 19, fig. 1 only.

Holotype. Cramer & Diez 1972, p.147 - 148, pl. 31 fig. 1.; from the Osgood Shale, Wenlock Series, Kentucky, USA.

Diagnosis. (Cramer & Diez 1972, p. 147 - 148) ‘Central body clearly differentiated from the processes. Processes plumply columnar with simple bifurcations distally. If bifurcated, the processes may bear pinnae of up to the second order; however, generally only first order pinnae are present. There is no appreciable difference in construction between simply and complexly bifurcated processes. About 10 processes present. The body walls are uniform and psilate. Ectoderm about 1 μm thick; no differentiation between processes and central body; process are hollow as are the pinnae and pinnulae. No endoderm bearing stages known; mode of opening not known.’

Remarks Central body cavity subspherical. Numerous large, hollow processes, long and slender with a cylindrical aspect terminating in simple or bifurcate pinnae. The process branching is variable within a single specimen. The branching is confined to the distal portion of the process. The processes communicate freely with the central body cavity. The wall is psilate to finely scabrate. Excystment mechanism not observed. The specimens recovered are broadly applicable to the original diagnosis. Sometimes the branching is slightly more variable than dictated and the vesicle body is often slightly ornamented. These slight variations are deemed to be acceptable to include the forms recovered herein as H. ancyrea. H. corallinum (Eisenack 1959) and H. cf. corallinum exhibit more complex branching. H. corallinum has shorter processes than H. ancyrea

Dimensions. Vesicle diameter 40 - 60 μm
            Process length 40 - 80 μm
            Process base width 10 - 16 μm
            Entire vesicle 80 - 140 μm
            Process number 6 - 10
            Number of specimens measured 10.
Occurrence Upper Llandovery of the USA (Cramer & Diez 1972); upper Llandovery to Ludlow series of the Welsh Borderlands and Dudley, West Midlands, UK (Dorning 1981a, 1981c, 1983); Sheinwoodian Stage, Wenlock Series of the Wenlock and Eastnor Park areas of Shropshire, UK (Swire 1991); in the type Much Wenlock area of Shropshire this species was recovered from Farley Dingle (samples FD1, FD1500, FD1600, FD1760, FD1900, FD2650), Shadwell Quarry (samples 2SH -2.0, 2SH -1.15, ); and in the Ludlow area from Mortimer Forest (samples MFGT1-100, MFGT1-300, MFGT1-400, MFGT2/1, MFGT2-300) and Pitch Coppice (samples PC240, PC252, PC 300).

Hogkliintia corallina (Eisenack 1959) Le Hérissé 1989 n. comb.

Plate 21, fig. 3.

1959 Baltisphaeridium corallinum n. sp.; Eisenack, p. 201, pl. 16, figs 15 - 16.
1963 Baltisphaeridium cladum; Downie, p. 643 - 644.
1965a Baltisphaeridium corallinum; Eisenack, p. 263, pl. 21, fig. 2; pl. 24, fig. 7 only.
1967 Baltisphaeridium corallinum; Martin p. 309, pl. 1, fig. 1.
1968 Baltisphaeridium corallinum; Martin, p. 47, pl. 3, fig. 158.
1969a Multiplicisphaeridium corallinum; comb. nov.; Eisenack, p. 259-260, no fig.
1970a Baltisphaeridium corallinum; Cramer, p. 176 pl. 22, fig 315, 319; pl. 23 fig. 325, 326; fig. 55: d.
1970 Multiplicisphaeridium corallinum comb. nov.; Lister, p. 88 - 89, pl. 12, figs 5, 6, 8.
1972 Baltisphaeridium corallinum; Cramer & Diez, p. 147, pl. 31, fig. 2.
1973 Multiplicisphaeridium corallinum; Eisenack et al. p. 573.
1977 Multiplicisphaeridium corallinum; Eisenack, p. 32, fig. 24.
1989 Hogkliintia corallina n. comb. Le Hérissé; p. 146 - 147, pl. 15, figs 1-6.
1990 Multiplicisphaeridium corallinum; Fensome et al., p. 343, no fig.
1991 Hogkliintia ancyrea; Swire, p. 186, pl. 19, fig. 2 only.

Holotype. Eisenack 1959, pl. 16, fig. 15; from the Slite Formation, Slite Marl, Wenlock Series, Slite, Gotland.

Diagnosis. (Translated form Eisenack 1959, p. 201). “Central body spherical thin walled with more or less numerous processes observed, wide/cylindrical to conical in form, which are often regularly branched (dichotomous), branching occasionally to third order with short broad prong like forks ‘pinnae’.”

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**Dimensions.**

- Vesicle diameter: 40 - 60 µm
- Process length: 25 - 60 µm
- Process base width: 16 - 20 µm
- Process number: 6 - 10
- Entire specimen: 120 µm - 180 µm
- Number of specimens measured: 4

**Remarks**

The specimens recovered conform to the original diagnosis, with a subspherical to subpolygonal body bearing numerous broad, hollow processes, which show slight tapering to complexly branched terminations. The vesicle body is large, and the process length is equal to or greater than the dimensions of the central body. Mode of excystment not observed.

Specimens belonging to this species differ from those assigned to *H. cf. corallina* sp. B in that the latter has longer processes and a more restricted central body, typically formed from the fusion of the process bases. The processes of *H. cf. corallina* are equal to or greater than the dimensions of the vesicle body cavity. *H. digitifera* sensu stricto differs in the form of the process branching which has simple branching leading to acuminate tips. *H. corallina* has more complex, pinnate branching.

**Occurrence**

- Wenlock - Ludlow series of Gotland (Eisenack 1959, 1965a); Wenlock Series of Dudley, the West Midlands, UK (Eisenack 1965a, 1977); Silurian of Belgium (Martin 1966 1967); Llandovery of Anticosti, Canada; Late Llandovery to Wenlock series of eastern USA and Canada (Cramer 1968 a-c, Cramer 1970a, Cramer & Diez 1972); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); Wenlock Series of Gotland (Cramer et al. 1979 p. 47); lower Wenlock Series (Visby Formation) to Ludlow Series (Eke Formation) of Gotland (Le Hérissé 1989); Buildwas and lower Coalbrookdale formation (Sheinwoodian of the Wenlock Area (Swire 1991 as *H. ancyrea* - a typical transitional form, pl. 19 fig. 2).

This species was recovered only rarely in the study area. In the Ludlow area it was found in one sample from Mortimer Forest (sample MFGT 1 - 400); while in the type area, Much Wenlock there was a single recovery from the Coalbrookdale Formation at Farley Dingle (sample FD bentonite as a rare type).

Known range: Llandovery to Ludlow Series.
Hogklintia cf. corallina

Plate 21, fig. 1.

1965a Baltisphaeridium cf. corallinum; Eisenack p. 263, pl. 24, fig. 8.
1970a Baltisphaeridium corallinum; Cramer, p. 176, pl. 22, fig 319 only.
1970 Multiplicisphaeridium corallinum comb. nov.; Lister, p. 88 - 89, pl. 12, fig. 7.
1970 Baltisphaeridium digitatum; Cramer p. pl. 21, fig. 308, 310.
1977 Multiplicisphaeridium digitatum; Eisenack p. 32, pl. 2, fig. 23 only.

**Diagnosis.** Single walled vesicle, psilate to ornamented by a finely scabrate sculpture. Central body subspherical or formed by the fusion of the process bases. The processes are numerous, varying from 5 to 10 on a single specimen. The processes are hollow and communicate freely within the central body cavity. The processes are long, cylindrical comparatively wide, terminating with multifurcate ramified pinnae. The process branching is complex and variable, even within a single specimen. The branching is confined to the distal portion of the process, terminating in multifurcate pinnae. Mode of excystment not observed.

**Remarks.** The specimens recovered here have been assigned to *Hogklintia cf. corallina* because they are comparable to the specimen of *Hogklintia corallina* recorded by Lister (1970 pl. 12 fig. 7) for the type Ludlow area and those reported by Eisenack (1965c, 1977) from Wrens Nest in the West Midlands. These forms differ somewhat from those from the specimens of *Hogklintia corallina* from the Baltic area recorded by Eisenack (1965a) which have shorter processes, less than or equal to the central body diameter. Both *H. corallina* and *H. cf. corallina* exhibit complex branching. It is possible that *H. cylindrica* referred to in Dorning (1981a) is synonymous with this species as the range is the same.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>30 μm - 50 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>60 μm - 80 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>10 - 16 μm</td>
</tr>
<tr>
<td>Entire vesicle</td>
<td>80 - 140 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>5 - 10</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10.</td>
</tr>
</tbody>
</table>

**Occurrence** Wenlock Series of Dudley, West Midlands, UK (Eisenack 1965a, 1977); (Cramer 1970) Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974). In the type area, Much Wenlock, Shropshire this species was recovered from the Coalbrookdale Formation, Farley Dingle (samples FD 100, FD 1500, FD Bentonite); the Much Wenlock Limestone Formation of Harley Hill (sample HH2 700); and in the Ludlow area, from the Much Wenlock Limestone Formation, Pitch Coppice Quarry (samples PC 252).
Once again there is seen in this genus a gradation between forms suggesting a plexus of species with a range in characteristics whose end members overlap.

**Hogklintia sp. D**

Not figured.

*Remarks* Large acritarch species, showing affinities to the genus *Hogklintia*, though the forms logged under this division could possibly be foraminfera linings. As the presence of this morphotype is notable in samples from Shadwell Quarry it is separated here in the systematic descriptions.

*Occurrence.* These specimens were recovered from the Much Wenlock Limestone Formation of the Wenlock and Ludlow areas. There was a possible specimen in sample PC 240 and notable occurrences from Shadwell quarry at the Wenlock Ludlow boundary. Samples: 2SH -2.0; 2SH - 1.7; 2SH -1.15; 2SH -1.0; 2SH 230.


1938a *Leiofusa* Eisenack, p. 28.


*Diagnosis.* (Cramer 1970a p. 71). ‘Vesicle hollow, fusiform with simple pointed processes at each pole. Processes varying in length from less than one tenth to as much as 5 times the length of the body. Vesicle wall unilayered, psilate to microgranulate. Sculptural elements not arranged in longitudinal rows. The long axis of the vesicle coincides with the longitudinal symmetry axis. Vesicle symmetry longitudinal, holomorphic. Longitudinal axis straight or essentially so. Pylome circular, slit shaped, or formed by equatorial splitting.’
Remarks. The species belonging to the genus *Leiofusa* possesses a simple fusiform, hollow vesicle bearing simple polar processes. The vesicle body is generally laevigate but it can bear a fine ornament. Where such ornament is present the lack of order/arrangement to the sculpture distinguishes *Leiofusa* from the other fusiform acritarch genera: *Dactylofusa* (Brito & Santos 1965) which bears rows of ornament arranged in a longitudinal pattern, *Eupoikilofousa* (Cramer 1970) with the striate ornament and *Poikilofousa* (Staplin et al. 1965) with the short processed ornament distributed over the vesicle body.

**Leiofusa banderillae** Cramer, 1964a

Plate 24, fig. 6.

1964a  *Leiofusa banderilla* Cramer, n. sp. p. 36, pl. 1: 2, 4, 5. pl. 2, fig. 12.

1976  *Leiofusa banderillae* Cramer; Eisenack et al. p. 343 - 344.

1990  *Leiofusa banderillae* Cramer; Fensome, p. 261, no fig.


**Holotype.** *Leiofusa banderilla* Cramer 1964a, p. 36, pl. 1, fig. 12. from the Oblanca Cantabrie Mountains of Spain. Age: 'Probably Gedinnian'.

**Diagnosis.** (Cramer, 1964a, p. 36) ‘Species of *Leiofusa* with an inflated fusiform test, which is provided with a very long, thin spine at each pole. The wall of the test is psilate, transparent, and very thin. It consists of one layer.’

**Remarks.** The specimens recovered conform to the original diagnosis.

**Dimensions**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>16 - 25 μm</td>
</tr>
<tr>
<td>Vesicle length</td>
<td>80 - 100 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

**Occurrence.** *Leiofusa banderillae* has been recorded from the Ludlow Series of Northwest Spain (Cramer 1964 a & b, 1966 a - d, 1969; Cramer & Diez 1968); middle Silurian of USA and Canada (Cramer 1969a); Silurian of Southern Spain (Cramer 1970); Ludlow Series to Emsian Stage (Combaz et al. 1967); Llandovery Series of Tunisia (Magloire 1968); Wenlock to Ludlow Series of eastern USA (Cramer 1970); upper Llandovery to Ludlow series of the USA (Cramer & Diez 1972); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); upper Silurian of Argentina (Pöthe de Baldis 1971, 1981); Much Wenlock Limestone Formation to upper Whitelcliffe Formation. Wenlock to Ludlow Series of the Ludlow area (Lister &
Downie 1974); upper Ordovician (Ashgill Series) to lower Silurian (Llandovery Series) of north-east Libya (Hill & Molyneux 1987); Ludlow Series of Libya (Wood & Tekbali 1987); Coalbrookdale Formation (Wenlock Series) to Lower Elton Formation (Ludlow Series) of Shropshire, England (Dorning 1981a); Leinthall Quarry, Ludlow (Donoghue 1992).

This species has been recorded as a rare type from the Coalbrookdale Formation (Farley Member) of the type area at Farley Dingle, Much Wenlock, Shropshire, England.

Known Range: Wenlock Series to early Devonian.

**Leiofusa bernesgae** Cramer 1964a

Plate 25, figs. 3, 4.

1964a *Leiofusa bernesga* Cramer, p. 37, pl. 2, fig. 10.
1965 *Leiofusa bispinoides* n. sp.; Brito & Santos, p. 18, pl. 1, fig. 8.
1985 *Leiofusa* sp. A. Turner, p. 218 - 219, pl. 2. figs. 7 - 9.
1990 *Leiofusa bernesgae* Fensome *et al.* p. 262, no fig.

**Holotype.** *Leiofusa bernesga* Cramer 1964a, p. 37 pl. 2. fig. 10 from the Gedinnian of Spain.

**Diagnosis.** (Cramer 1964a, p.37.) "Species of *Leiofusa* with a flat, thinly walled, hollow test, without polar spines. The wall is transparent and psilate, it consists of one layer."

**Remarks.** The specimens recovered conform to the original diagnosis. This is a diminutive form with an inflated central body and small polar processes. *Leiofusa estrecha* has longer processes. *L. banderilla* is larger with longer polar processes. Although *L. banderilla* and *L. bernesga* are similar morphotypes they are distinct and there is little morphological gradation seen between the two forms.

**Dimensions**

- Entire vesicle length: 48 - 68 μm
- Central body length: 24 - 30 μm
- Central body width: 20 - 25 μm
- Process length: 28 - 56 μm
- Number of specimens measured: 10.
Occurrence. This species has been recorded by many authors from numerous localities including the following: Probable occurrences from the lower Gedinnian of Cantabrican Mountains of Spain (Cramer 1964a); Ludlow Series to Siegenian of north-west Spain (Cramer 1964b); Silurian and Devonian of the Maranhão Basin, Pernambuco and Amazon basins of Brazil, (Brito & Santos); Devonian of the Polignac Basin of the North African Sahara (Jardine & Yapaudjian 1968); middle Silurian of USA and Canada (Cramer 1969a); upper Llandovery to Ludlow series of the USA (Cramer & Diez 1972); Silurian of the Baltic (Yankauskas & Vaitekunene 1972); Devonian of the Armorican Massif, France (Moreau - Benoit 1974); Ludlow Series of Argentina (Pöthe de Baldis 1981); from the lower to middle Llandeilo Series of South Wales (Turner 1985 as Leiofusa sp. A); Ludlow Series of Libya (Wood & Tekbal 1987); upper Silurian of San Juan, Argentina (Rubinstein 1993); Lower Palaeozoic of the Garhwal Himalaya, India (Sinha et al. 1996).

This species is a rare type in the samples from the Welsh Borderland. Where present the species comprises typically less than 0.5% of the assemblage.

Known Range. Late Ordovician to early Devonian.

**Leiofusa estrecha** Cramer 1964a.

Plate 24, fig. 5.

1964a *Leiofusa estrecha* n. sp.; Cramer, p. 36, pl. 1 fig. 8, pl. 2 fig. 11.
1964b *Leiofusa elenae* n. sp. Cramer, p. 323, text-fig. 33: 6, no plate figure.
1965b *Leiofusa communis*; Brito & Santos, p. 17, pl. 1, fig. 10
1970 *Leiofusa elenae*; Cramer, p. 77 pl. 3, fig. 22k.
1976 *Leiofusa estrecha*; Eisenack*et al.*, p. 359-360;
1990 *Leiofusa estrecha* Cramer 1964a; Fensome*et al.*, p. 263, no fig.

Holotype. *Leiofusa estrecha* Cramer 1964a, pl. 36, fig. 11; San Pedro Formation (lower Gedinnian), León, north-west Spain.

Diagnosis. (Cramer 1964a, p. 36). ‘Species of *Leiofusa* with hollow body having form of a thick needle, there is a gradual transition from the test to the spines at each pole. The wall is psilate, consists of one layer and is not transparent. The spines at the poles are usually broken.’

Remarks. The specimens conform to Cramer’s original diagnosis. Excystment is by a median split running along the longitudinal axis of the vesicle body. Processes are often broken. Average length can be from 120 to 400 microns (Cramer 1970). *Leiofusa estrecha* is a distinctive netromorph due to its large size and laevigate vesicle but being a cosmopolitan form throughout the Silurian it is of little use in biostratigraphy. *L. parvitatis. L. banderillae*
**Dimensions.**

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>24 - 30 μm</td>
</tr>
<tr>
<td>Vesicle length</td>
<td>36 - 60 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>100 - 120 μm</td>
</tr>
<tr>
<td>Entire length</td>
<td>130 - 200 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10.</td>
</tr>
</tbody>
</table>

**Occurrence.** *Leiofusa estrecha* has been recorded from the Llandovery Series- lower Gedinnian Stage) of north-west Spain (Cramer 1964 a, b, 1966a, 1969b); Lower Devonian of Brazil (Brito 1967, Brito & Santos 1965); lower Devonian of the Sahara, North Africa (Jardine & Yapaudjian 1968); Llandovery to lower Ludlow Series of the USA (Cramer 1968b, Cramer 1970a, Cramer & Diez 1972); Llanvirn Series, middle Ordovician of Brittany (Paris & Deunff 1970); Silurian - Devonian of Germany (Eisenack 1971); Wenlock Series, New York (Thusu 1973b); Llandovery Series to the Gedinnian Stage of the Sahara (Jardine & Yapaudjian 1968); Wenlock to Ludlow series of Libya (Richardson & Ioannides 1973); upper Ordovician to Silurian of France (Moreau - Benoît 1974) Ordovician to the Silurian/Devonian boundary of France (Rauscher 1974); upper of Llandovery Series, Canada (Achab 1976); Gedinnian of Brest (Deunff 1980); Los Espejos Formation, Ludlow Series of Argentina (Pothé de Baldis 1981); Ludlow Series of the Welsh Borderland (Dorning 1981a); upper Ordovician to lower Silurian of Anticosti Island, Canada (Duffield & Legault 1981); mid Ludlow to early Gedinnian stage, ranges in the British Isles (Downie 1984); Haragan Formation, Lower Devonian (Gedinnian) of Oklahoma (Wicander 1986); Llandovery - Wenlock series, Gotland (Le Hérisse 1989); Sheinwoodian to Homerian stages (Wenlock Series), Wenlock type area (Swire 1991, ); Wenlock Series (Homerian) of Shropshire (Turner et al. 1995, as cf. *estrecha*); Leinthall Quarry (Ludlow Series) Ludlow Area, Shropshire (Donoghue 1992), Lower Elton Formation, Ludlow type area, Shropshire, (Mullins 1996).

This species was recorded from the Coalbrookdale Formation (Farley Member) to lower Elton Formation in occurrences from the following localities: Farley Dingle; Pitch Coppice; Shadwell Quarry; Harley Hill; Coates Quarry

**Known range:** Silurian (Llandovery Series) to Lower Devonian (?Gedinnian).

**Leiofusa filifera** Downie 1959

Plate 24, fig. 3, 8.
1959 Leiofusa filifera n. sp. Downie p. 65, pl. 11 figs. 6, 7.
1965b Leiofusa sommeri Brito & Santos, p. 19, pl. 1 fig. 5.
1970 Eupoikilofusa filifera Downie, Cramer, comb. nov. p. 52, no fig.
1981a Eupoikilofusa filifera Downie, Doming n. comb. p. 181, no fig.
1990 Leiofusa filifera Downie; Fensome p. 263, no fig.
1991 Eupoikilofusa cf. filifera; Swire p. 269, pl. 29, 1.


Diagnosis. Downie 1959, p. 65, ‘A species of Leiofusa with the ends drawn out to form long hollow threads, body about one third of the total length, body width about one quarter of its length.’

Remarks. The specimens assigned to this group are restricted to between 30 and 90 μm in length, though the possibility that they could be part of a formgroup, with forms ranging up to 350 μm is acknowledged. Some specimens exhibit a very fine microgranulate ornament.

Dimensions. 

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>20 - 32 μm</td>
</tr>
<tr>
<td>Central vesicle length</td>
<td>25 - 40 μm</td>
</tr>
<tr>
<td>Entire vesicle length</td>
<td>35 - 90 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>20 - 50 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10.</td>
</tr>
</tbody>
</table>

Occurrence. Leiofusa filifera has been recorded from the Wenlock Series (Coalbrookdale formation) of Shropshire (Downie 1959, 1963); Ludlow Series to Gedinnian of Northwest Spain (Cramer 1964a); upper Llandovery to Wenlock Series of Belgium (Martin 1968); Wenlock Series (Much Wenlock Limestone Formation) to Prfdolf Series of the Ludlow area (Lister & Downie 1974); Wenlock and Ludlow Series of Podolia (Kiryanov 1978); Wenlock Series of Gotland, Sweden (Cramer et al. 1979); Wenlock to Ludlow Series of the Welsh Borderlands and the West Midlands of England (Dorning 1981a, 1983); Ashgill Series (Ordovician) of Anticosti Island, Canada (Jacobson & Achab 1985); Sheinwoodian to Homerian (Wenlock Series) of Shropshire (Swire 1991 as Eupoikilofusa cf. filifera); upper Silurian of San Juan, Argentina (Rubinstein 1993).

This species was recorded from the Coalbrookdale Formation (Farley Member) to lower Elton Formation in occurrences from the following localities: Farley Dingle; Shadwell Quarry; Harley Hill; Coates Quarry

Known range. Ordovician (Ashgill) to Devonian (Gedinnian).
**Leiofusa fusiformis** (Eisenack 1934)

Plate 24, fig. 7

1934 *Ovum hispidum fusiforme* Eisenack, p. 65 - 66. pl. 4, fig. 19.
1938 *Leiofusa fusiformis* Eisenack, p. 28.
1965b *Leiofusa communis*; Brito & Santos, p. 9, 17 pl. 1. fig. 10.
1990 *Leiofusa fusiformis*; Fensome *et al.* p. 263, no fig.

**Holotype.** *Ovum hispidum fusiformis* Eisenack 1934, p. 65 - 66. pl. 4, fig. 19.

**Diagnosis.** (Eisenack 1934, translation from Eisenack *et al.* 1976, p. 366) "The body of this cyst is spindle-shaped and is drawn out into two thin and fine spines. The wall is light yellow and very thin. The total length is approximately 0.32 μm, of which the spindle shaped body occupies about seven-tenths. The width measures 0.05 μm".

**Remarks.** The specimens recovered conform to the original diagnosis. Vesicle body fusiform in outline with the two polar processes are extended into spines. Wall thin to medium and laevigate.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle length</td>
<td>60 - 78 μm</td>
</tr>
<tr>
<td>Central body length</td>
<td>36 - 48 μm</td>
</tr>
<tr>
<td>Central body width</td>
<td>14 - 18 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>30 - 46 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10.</td>
</tr>
</tbody>
</table>

**Occurrence.** Silurian of the Baltic (Eisenack 1934); San Pedro Formation (Gedinnian) of Spain (Cramer 1964a); Silurian of the Baltic (Yankauskas & Vaitekunene 1972); Arenig of Bohemia (Vavravová 1972); Wenlock Series of Ontario (Thusu 1973a); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); Ludlow Series of Argentina (Pothe de Baldis 1981); upper Llandovery Series (Purple Shales) to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985); upper Ordovician to upper Wenlock, Llandovery Series of north-east Libya (Hill & Molyneux 1987); upper Silurian of San Juan, Argentina (Rubinstein 1993).

This species was recorded from the Coalbrookdale Formation (Farley Member) from Farley Dingle.

**Known Range.** Ordovician to Silurian.

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Leiofusa granulacutis Loeblich 1970

Plate 24, fig. 4.

1970 Leiofusa granulacutis sp. nov.; Loeblich, p. 723 - 724, figs. 18 A - E.
1990 Leiofusa granulacutis Loeblich; Fensome et al. p. 263, no fig.

Holotype. Leiofusa granulacutis. Loeblich 1970, fig. 18A, Maplewood Formation, Rochester, New York, USA.

Diagnosis. (Loeblich 1970 p. 723 - 724) ‘Central body inflated fusiform in shape with a long hollow process at each pole; wall thin, less than 1 µm in thickness; surface ornamented by numerous small scattered grana, not aligned in any definite pattern, grana extend somewhat onto the processes but die out so that the distal ends of the processes appear smooth; no pylome observed.’

Remarks. The specimens conform to original diagnosis, with specimens bearing an ornament of grana of no preferred alignment. Excystment is by a median split running along the longitudinal axis of the vesicle body. The presence of the ornament distinguishes this species from other forms assigned to the genus Leiofusa.

Dimensions: Vesicle breadth 26 - 30 µm
Vesicle length 40 - 60 µm
process length 40 - 60 µm
Entire length 90 - 146 µm
Number of specimens measured 5.

Occurrence. Middle Silurian, Rochester, New York (Loeblich 1970); Lower Devonian of Oklahoma USA (Wicander 1986).

This species was recorded from the Much Wenlock Limestone Formation at Coates Quarry, in the type area, Much Wenlock, Shropshire, England.

Known Range: Middle Silurian (Fensome et al. 1990)
\textit{Leiofusa parvitatis} Loeblich 1970

Plate 24, fig. 9.

1970 \textit{Leiofusa parvitatis} n. sp.; Loeblich p. 724 - 725, figs 18 F - G.
1981a \textit{Leiofusa parvitatis} Loeblich; Dorning 1981a, p. 176, no fig.
1990 \textit{Leiofusa parvitatis} Loeblich; Fensome et al., p. 264, no fig.

\textit{Holotype.} \textit{Leiofusa parvitatis} Loeblich 1970, p. 724 - 725 fig. 18 G; Maplewood Shale (upper Llandovery Series), Rochester, New York, USA.

\textit{Diagnosis.} (Loeblich 1970, p. 724 - 725). ‘Central body fusiform in outline, with a long hollow process at each pole, processes become solid near the distal end: wall smooth, less than 1 \mu in thickness; on one specimen a small subcircular portion of the wall is broken out but remains attached; this may be the operculum covering the pylome.’

\textit{Remarks.} The forms attributed to \textit{L. parvitatis} conform to the original diagnosis. This is a small species of \textit{Leiofusa}, the vesicle body is well defined whilst one process is distinctly longer than the other. It bears a clearly defined vesicle body. The species differs from \textit{Leiofusa tumida} in having an elongate vesicle and \textit{Leiofusa banderillae} in being considerably smaller. Mode of excystment not observed.

\begin{tabular}{|c|c|}
\hline
\textbf{Dimensions.} & \\
\hline
Vesicle diameter & 8 - 16 \mu m \\
Vesicle length & 20 - 38 \mu m. \\
Process Length & 28 - 44 \mu m \\
Entire length & 30 - 60 \mu m \\
Number of specimens measured & 5 \\
\hline
\end{tabular}

\textit{Occurrence.} \textit{Leiofusa parvitatis} has been recovered from the Maplewood Shale, upper Llandovery Series, Rochester New York U.S.A. (Loeblich 1970); Wenlock and Ludlow Series of the Welsh Borderlands (Dorning 1981a); Much Wenlock Limestone Formation, Wenlock Series, Dudley, England (Dorning 1983); Purple Shales and Buildwas formation (upper Llandovery to lower Wenlock series), upper Llandovery Series (Purple Shales) to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985); Much Wenlock Limestone formation of the Welsh Borderlands (Dorning & Bell 1987); upper Llandovery Series of north-east Libya (Hill & Molyneux 1988); upper Llandovery to Wenlock Series of Gotland, Sweden (Le Hérisse 1989); Sheinwoodian of the Welsh Borderlands (Swire 1991); Leinthall Quarry, Ludlow (Donoghue 1992); Wenlock
Series (Homerian stage), Shropshire (Turner et al. 1995); Lower Palaeozoic of the Garhwal Himalaya, India (Sinha et al. 1996).

This species was recorded from the Much Wenlock Limestone Formation to lower Elton Formation in occurrences from the following localities: Pitch Coppice; Shadwell Quarry; Coates Quarry.

Known range: Llandovery - Ludlow Series.

**Leiofusa tumida** Downie 1959.

Plate 24, fig. 1.

1959  *Leiofusa tumida* n. sp. Downie, p. 65, pl. 11, fig. 5.
1963  *Leiofusa cf. tumida* Downie, p. 635, fig. 2. C. K.
1964b *Leiofusa cf. tumida* Cramer p. 324 - 325, pl. 19, fig. 9, 10, text - fig. 33: 4.
1976  *Leiofusa tumida*; Eisenack et al. p. 395 - 396
1990  *Leiofusa tumida*; Downie, Fensome et al. p. 265, no fig.

See Eisenack et al. (1976) for a full synonymy list prior to 1976.

*Holotype.* *Leiofusa tumida* Downie 1959 p. 65, pl. 11, fig. 5. Wenlock Series, Eaton Track, Wenlock Edge, Shropshire.

*Diagnosis.* Downie 1959. p. 65. ‘A species of *Leiofusa* with long terminal processes and rounded central body, overall length about 110 μm.’

*Remarks.* *Leiofusa tumida* is distinguished from other species of *Leiofusa* in having a hollow subspherical to ellipsoidal, inflated central body rather than a more elongate, fusiform outline with long slender processes. The vesicle body is unilayered and psilate. Excystment was by an equatorial median split in the vesicle body, perpendicular to the longitudinal axis. *L. tumida* differs from *L. banderillae* in that the latter has longer recurved processes, whilst *L. estrecha* has a central body more fusiform in outline.
Dimensions. Vesicle diameter 25 - 35 µm, Vesicle length 28 - 40 µm Process Length 30 - 90 µm Entire length 100 - 120 µm. Number of specimens measured 10

Occurrence Leiofusa tumida has been recorded from the Wenlock Series of Shropshire England (Downie 1959, 1963), Ludlow Series to Lower Gedinian of Spain (Cramer 1964b); upper Llandovery to lower Wenlock Series of Belgium (Martin 1965, 1968); lower Ludlow Series of the Polignac Basin (Sahara) (Jardine & Yapaudjian 1968); Llandovery to Ludlow Series of North America (Cramer 1968a, 1970, Cramer and Díez 1970, 1972, Thusu 1973b); Ordovician of Bohemia (Konzalová-Mazancová 1969); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); Wenlock Series of Gotland, Sweden (Cramer et al. 1979); Wenlock to Ludlow Series of the Welsh Borderlands (Dorning 1981a); Early Sheinwoodian (Wenlock Series) of Scotland (Dorning 1982); Much Wenlock Limestone formation of the Welsh Borderlands (Dorning & Bell 1987); upper Llandovery of Ringerike Norway (Smelror 1987); upper Ordovician (Ashgill Series) to lower Silurian (Llandovery Series) of north-east Libya (Hill & Molyneux 1987); Sheinwoodian to Homerian of Shropshire England (Swire 1991); upper Silurian of San Juan, Argentina (Rubinstein 1993); Llandovery to Wenlock Series of Gotland, Sweden (Eriksson & Hagenfeldt 1997); from the late Leintwardine to early Whitcliffe formations of the Ludlow area (Washington-Evans 1992).

This species was recorded from the Coalbrookdale Formation (Farley Member) to Much Wenlock Limestone Formation in occurrences from the following localities: Farley Dingle; Harley Hill; Coates Quarry

Known Range: Llandovery to Ludlow Series.
Genus **LEIOSPHAERIDIA** Eisenack 1958a; 

*Type Species.* **Leiosphaeridia baltica** Eisenack 1958a, p. 8, pl. 2, fig. 5; erratic pebble, Ashgill Series, upper Ordovician of the Baltic.

*Diagnosis.* (Turner, 1984, p. 116) 'Spherical to ellipsoidal bodies without processes, often collapsed or folded, with or without pylomes. Walls granular, or unornamented, thin or thick, without divisions into fields and transverse or longitudinal furrows or girdles'.

*Original Diagnosis.* (Downie & Sarjeant 1963). 'Spherical to ellipsoidal vesicle without processes, often collapsed or folded, with or without pylomes. Walls granular, punctate or unornamented; thin without divisions into fields and without transverse or longitudinal furrows or girdles.'

*Remarks.* A large number of leiospheres were recovered, probably belonging to a wide range of species but speciation was difficult due to the lack of distinctive morphological characteristics. Thus, the specimens recovered herein have mostly been divided into informal groups based on vesicle size and wall thickness. These informal groupings in no way imply that the individuals assigned therein are biologically related.

The production of a full synonymy list for the species assigned to the genus *Leiosphaeridia* was not deemed to be of use to the project as leiospheres are no stratigraphic use being simple in form, long ranging stratigraphically and cosmopolitan in occurrence hence they have been reported in almost every paper that reports acritarch occurrences. For a full list of species belonging to the genus *Leiosphaeridia* and their synonymies see Fensome *et al.* (1989, p. 271 - 287).

**Leiosphaeridia baltica** Eisenack 1958a

Plate 26, figs. 1, 3, 4.

*Holotype.* Eisenack 1958, p. 8 pl. 2. fig. 5.

*Diagnosis.* See Eisenack 1958a p. 8.

*Remarks.* Specimens belonging to this species were logged as thin walled large formed Leiospheres with a 'glassy' appearance.
**Dimensions.**

Vesicle diameter: > 70 µm  
Number of specimens measured: 10

**Occurrence.** These forms were recovered sporadically in low numbers throughout the study sections. Coalbrookdale to Lower Elton Formations from the type Wenlock and Ludlow areas.

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**Leiosphaeridia laevigata** Stockmans & Willière 1963

Not Figured.

1963  *Leiosphaeridia laevigata*: Stockmans & Willière 1963, p. 473 - 474, pl. 3 fig. 28.  
1964  *Leiosphaeridia laevigata*: Takahashi, p. 211, pl. 30, figs. 13, 14.  
1990  *Leiosphaeridia laevigata*: Fensome *et al.* p. 279, no fig.

**Holotype.** Stockmans & Willière 1963, p. 473 - 474, pl. 3 fig. 28.


**Remarks.** The forms recovered conform to the original diagnosis of Stockmans & Willière (1963).

**Occurrence.** Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); upper Llandovery Series (Purple Shales) to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985); lower Silurian of Ringerike, Norway (Smelror 1987b).

This form was found in moderate numbers throughout the study sections. Coalbrookdale to Lower Elton Formations from the type Wenlock and Ludlow areas.
**Leiosphaeridia wenlockia.** Downie 1959.

Plate 45 fig. 5.

1959 *Leiosphaeridia wenlockia.* Downie 1959, p. 65, pl. 12, 2 - 4.

1979 *Leiosphaeridia wenlockia.* Eisenack *et al.* p. 343 - 344.

1990 *Leiosphaeridia wenlockia.* Fensome *et al.* p. 287, no fig.

**Holotype.** Downie 1959, p. 65, pl. 12, 2. from the Coalbrookdale Formation, Eaton Track, Wenlock Edge, Shropshire.

**Diagnosis** (Downie 1959 p.65.) ‘A species of *Leiosphaeridia,* diameter 20 - 50 µm, distinct mode at 30 µm, walls yellow, 1 µm thick, smooth waxy.’

**Dimensions**  
Vesicle diameter  30 - 35 µm.  
Number of specimens measured  5

**Remarks** Specimens conform to the original diagnosis. Vesicle ranges in size between 25 µm and 50 µm in diameter. Excystment by simple split.

**Occurrence** The cosmopolitan and long range of this species makes documenting all the previous recorded occurrences of this species an unnecessary task. For further information see Eisenack *et al.* (1979 p. 344) and Fensome *et al.* (1990 p. 287). Some notable occurrences though include the following: Silurian of Belgium (Martin 1967); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); Much Wenlock Limestone formation of the Welsh Borderlands (Dorning & Bell 1987); upper Llandovery Series to lower Wenlock Series of the Wenlock type area, Welsh Borderlands (Mabillard and Aldridge 1985); lower Silurian of Ringerike, Norway (Smelror 1987); Llandovery to Wenlock Series of Gotland (Eriksson & Hagenfeldt 1997 *Leiosphaeridia* spp.)

*Leiosphaeridia wenlockia* was recovered from all the samples that yielded palynomorphs in the Ludlow and Much Wenlock areas of Shropshire.
Leiosphaeridia sp. A.

Not figured.

Remarks. An informal species of the genus Leiosphaeridia whose vesicle is greater than 50 μm in diameter. Thick walled large forms were placed in Leiosphaeridia sp. A.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Vesicle diameter</th>
<th>105 μm.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of specimens measured</td>
<td>10.</td>
</tr>
</tbody>
</table>

Occurrence Leiosphaeridia sp. A was recovered from all the samples that yielded palynomorphs in the Ludlow and Much Wenlock areas of Shropshire.

Leiosphaeridia sp. B.

Plate 26, fig. 2.

Remarks. An informal species of the genus Leiosphaeridia. Thin walled, large forms. The vesicle is usually folded due to the thin wall and the large size were placed in Leiosphaeridia sp. B. vesicle is greater than 50 μm in diameter.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Vesicle diameter</th>
<th>50 - 115 μm.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

Occurrence Leiosphaeridia sp. B. was recovered from all the samples that yielded palynomorphs in the Ludlow and Much Wenlock areas of Shropshire.
Leiosphaeridia sp. C.

Not figured.

Remarks. An informal species of *Leiosphaeridia* of less than 30 μm diameter. Thick walled, small forms were placed in *Leiosphaeridia* sp. C.

*Dimensions*  
Vesicle diameter < 30 μm.  
Number of specimens measured 10.

*Occurrence* *Leiosphaeridia* sp. C. was recovered from all the samples that yielded palynomorphs in the Ludlow and Much Wenlock areas of Shropshire.

Leiosphaeridia sp. D

Not figured.

Remarks. *Leiosphaeridia* that are thin walled, < 2 μm, small forms of less than 25 μm in diameter, were placed in *Leiosphaeridia* sp. D.

*Dimensions*  
Vesicle diameter < 25 μm.  
Number of specimens measured 10.

*Occurrence* *Leiosphaeridia* sp. D. was recovered consistently from all the samples that yielded palynomorphs in the Ludlow and Much Wenlock areas of Shropshire.

Genus LEIOPSOPHOSPHAERA Naumova 1961 validated 1968

*Type Species*. *Leiopsophosphaera convexiplicata*, Naumova 1968, p. 33 - 37, pl. 2 fig. 21.

Remarks. Specimens assigned to this genus also show affinities to some records of species belonging to the genus Protoleiosphaeridium (Timofeev 1959). Whether or not there is a synonymy between these two genera has not been investigated.

Leiopsosphphaera sp. A

Plate 27, fig. 2.

1983 *Gloecapsamorpha* sp. Dorning, p. 33, pl. 6, fig. 15.
1987 *Leiopsosphphaera* Dorning & Bell 1987, p. 271, no fig
1990 *Leiopsosphphaera* Fensome *et al.* p. 268, no fig.

Remarks. Forms with a fine irregular granulate sculpture with a vesicle of variable size. (Dorning & Bell 1987 p. 271). This form could also be similar to the Devonian taxon *Protoleiosphaeridium diaphanum* (Staplin 1961, p. 406, pl. 48, fig. 8).

Occurrence. Much Wenlock Limestone Formation of Wrens Nest (Dorning 1983); Much Wenlock Limestone formation of the Welsh Borderlands (Dorning & Bell 1987).

This form was found in moderate numbers throughout the study sections: Coalbrookdale to Lower Elton Formations from the type Wenlock and Ludlow areas.

Genus LEPTOBACHION Dorning 1981a

Type species. Basionym: *Baltisphaeridium arbusculiferum* Downie 1963, p. 644, pl. 91, fig. 5, text-fig. 3d, Coalbrookdale Formation, Wenlock Series, Eaton Lane, Wenlock Edge, Shropshire.

Diagnosis. (Dorning 1981a, p. 193). ‘Vesicle subspherical, double walled; inner wall thick, outer wall thin and continuous with processes; processes few to several thin, tapering, some or all branching up to fifth order, processes often preserved flattened. Excystment by a straight split in the vesicle wall.’

Remarks. Oppilatala differs in having more robust processes with restricted bases and *Multiplicisphaeridium* is only ever single walled. *Eisenackidium* has simple processes. There are many occurrences that have been historically reported as *Multiplicisphaeridium arbusculiferum* but it is beyond the scope of this project.
to produce a full synonymy list detailing which of these belong to the genus *Leptobrachion* and which are definitely forms of the genus *Multiplicisphaeridium*. *Baltisphaeridium* excysts by means of a pylome and has predominantly simple processes, which are never seen to be as thin walled and flexuous as those belonging to forms attributed to the genus *Leptobrachion*. It should be noted that there may be some interspecific variation between *L. arbusculiferum* and *L. longhopense* typically in vesicle form and branching nature.

**Leptobrachion arbusculiferum** (Downie 1963) Doming 1981a

Plate 22, figs. 1, 2; Plate 23, fig. 1

1963 *Baltisphaeridium arbusculiferum* sp. nov. Downie, p. 644, pl. 91, fig. 5, text-fig. 3d.
1970 *Multiplicisphaeridium dubitum* Lister pl. 3 fig. 1. text-fig. 17n
1970 *Multiplicisphaeridium arbusculiferum*; Lister, p. 59, pl. 10, fig 14, 16, 17; pl. 11, figs. 1, 2.; text-fig. 20a.
1973 *Multiplicisphaeridium arbusculiferum*; Eisenack et al., p.525 - 527.
1973 *Multiplicisphaeridium dubitum*; Eisenack et al., p. 613-614.
1976 *Multiplicisphaeridium dubitum*; Diez & Cramer p. 127, pl. 2. figs. 2, 13; pl. 3, fig. 6.
1981a *Leptobrachion arbusculiferum* n. comb.; Doming, p. 193, no fig.
1990 *Leptobrachion arbusculiferum* (Downie 1963) Doming, 1981a; Fensome et al., p. 290, no fig.

**Holotype.** Downie 1963, pl. 91, fig. 5; Coalbrookdale Formation, Wenlock Series, Wenlock Edge, Shropshire.

**Diagnosis.** (Downie 1963, p. 644). ‘Test subspherical to subpolygonal, processes long broad tapering, forking irregular at a moderate angle, branches often long and broad; forking usually bifurcate up to fourth order.’

**Remarks.** The species recovered conform to the generic diagnosis of Doming (1981) and the specific diagnosis of Downie (1963). The vesicles are double walled with the processes being formed from the thin outer membranous wall and exhibit up to third order branching in a ramified fashion. The processes do not communicate with the vesicle interior. The species recovered tend to have longer processes in proportion to the vesicle body diameter than those of the holotype but it is considered that the differences in dimensions are compatible with intraspecific variation. Mode of excystment not observed. *L. longhopense* Doming 1981 appears to exhibit similar features to this form but the specimens recorded are confined to this species herein.

**Dimensions.** Vesicle diameter 14 - 22 µm

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Occurrence. Coalbrookdale Formation, Wenlock Series of the Much Wenlock area, Shropshire UK (Downie 1963); Much Wenlock Limestone to Middle Elton formations, Wenlock to Ludlow Series of the Ludlow and Millichope areas of Shropshire, UK (Lister 1970 as *B. dubitum & M. arbusculiferum*); Ludlow Series of Spain (Diez & Cramer 1976); Much Wenlock Limestone Formation to Elton Formation, upper Wenlock to lower Ludlow series of the Wenlock and Ludlow areas of the Welsh Borderland (Dorning 1981a); Much Wenlock Limestone Formation, Wenlock Series of the West Midlands, UK (Dorning 1983); upper Slite to Klinteberg formations, middle to upper Wenlock Series of Gotland, Sweden (Le Hérisse 1989).

Much Wenlock Limestone to upper part of the Lower Elton formation of the Much Wenlock and Ludlow areas of Shropshire.

Known range: Wenlock - Ludlow series.

**Leptobrachion delicatum** sp. nov.

Plate 23, fig. 4

*Derivation of name.* From the Latin adjective delicatus, meaning delicate, referring to the thin walled nature of the vesicle and fine processes.

*Holotype.* Plate 23, fig. 4, from sample HH3/300-2/10/1, Rivelin Finder reference T 48; from the Much Wenlock Limestone Formation of Harley Hill, near Much Wenlock, Shropshire, England.

*Diagnosis.* Vesicle body subspherical to elongate, laevigate moderately thin walled despite having a double wall structure. The processes are formed from the outer wall, branching varying from simple to 2nd order. The processes are long, hollow and do not communicate with the vesicle interior. Processes length is 150 - 200% vesicle body diameter. Excytment by simple split.

*Remarks.* *L. arbusculiferum* by comparison has a more spherical thicker central body and more numerous processes. This species has longer more slender processes than *L. arbusculiferum* or *L. longhopense*. This species was logged as *Leptobrachion* sp. B var. 2.

| Process length | 14 - 36 µm |
| Process base width | 0.5 - 1.0 µm |
| Process number | 6 - 12 |
| Number of specimens measured | 5 |
**Dimensions**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>14 - 22 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>28 - 42 µm</td>
</tr>
<tr>
<td>Process base width</td>
<td>0.5 - 1.0 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>5 - 8</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Occurrence.** Coalbrookdale Formation - upper part of the Elton Formation, upper Wenlock - lower Ludlow series of the Wenlock and Ludlow areas of Shropshire.

Known range: Homerian - upper Gorstian (Wenlock - Ludlow Series).

**Leptobrachion dorningii** sp. nov.

Plate 23, figs. 2, 3.

**Derivation of name.** Named after Ken Dorning who first described this genus.

**Holotype.** Plate 23, fig. 3 sample FD 700/10/1, Rivelin Finder reference V33 from the Farley Member of the Coalbrookdale Formation of Farley Dingle. Much Wenlock, Shropshire, England.

**Diagnosis.** (Dorning 1981, p. 193). ‘Vesicle subspherical, 15 - 20 µm in diameter, inner wall thick, laevigate; outer wall thin and continuous with processes, 8 - 10 processes, 30 - 40 µm long, about 3 µm wide at base, tapering to a sharp point; some processes are simple, others bifurcate up to the second order; as preserved the processes are somewhat flattened. Excystment is by a straight split in the vesicle wall.’

**Remarks.** The species recovered conform to the diagnosis of Dorning (1981a). The vesicles are subspherical, laevigate, relatively thick, double walled with the processes being formed from the thin outer transparent membranous wall and are heteromorphic within a single specimen, varying from simple to third order branching. *L. arbusculiferum* by comparison has solely branched processes. The processes are hollow and do not communicate with the vesicle interior. The species recovered have longer processes in proportion to the vesicle body diameter. Excystment by simple split. The forms recovered herein have fewer branches than those allowed by the specific diagnosis. This taxon was logged as *Leptobrachion* sp. C initially.
**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>22 - 24 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>30 - 36 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>1.5 - 4 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>4 - 7</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10.</td>
</tr>
</tbody>
</table>

**Occurrence.** Coalbrookdale Formation - Elton Formation, upper Wenlock - lower Ludlow series of the Wenlock and Ludlow areas of Dudley in the Welsh Borderland (Dorning 1981a); Much Wenlock Limestone Formation, Wenlock Series of the West Midlands, UK (Dorning 1983); upper Slite to Klinteberg formations, middle to upper Wenlock Series of Gotland Sweden (Le Héрисé 1989 as *L. arbusculiferum*); Sheinwoodian of the type area and the Woolhope Limestone of the Eastnor Park borehole (Swire 1991 unpublished).

Much Wenlock Limestone to the upper part of the Lower Elton formation of the Much Wenlock and Ludlow areas of Shropshire.

Known range: Wenlock - Ludlow series.

**Leptobrachion malvernia** Dorning 1981a

Plate 22, fig. 5; Plate 55, figs. 3, 4.

1981a  *Leptobrachion malvernia* n. sp. Dorning; p. 193, pl. 2 fig. 9.
1990  *Leptobrachion malvernia* Dorning 1981a; Fensome *et al.* p. 290, no fig.

**Holotype.** *Leptobrachion malvernia* Dorning 1981a, pl. 2 fig. 9. Coalbrookdale Formation, Wenlock Series, Checkley, Woolhope Inlier, Herefordshire.

**Diagnosis.** (Dorning 1981a p, 193) ‘Vesicle subspherical, 15 - 30 μm in diameter, subspherical, double walled, inner wall thick, outer wall thin, laevigate, continuous with the processes, several processes 15 - 25 μm long, 5 - 8 μm wide at base, tapering to sharp points, multifurcate up to fifth order from near the base of the process. Excystment by a straight split in the vesicle wall.’

**Remarks.** Vesicle body spherical, laevigate, thick-double walled with the processes being formed from the thin outer ectophragm and are heteromorphic within a single specimen, varying from simple to 2nd order branching (possibly 3rd). The processes are hollow and do not communicate with the vesicle interior. Processes length is 100 - 150% vesicle body diameter. Excystment by simple split. *L. arbusculiferum* by comparison has solely branched
processes and has a thinner walled central vesicle. This species is closely comparable to some specimens logged as *Baltisphaeridium* sp., but it was decided that this morphotype belonged to the species *Leptobrachion* and the specimens now assigned herein were originally logged as *Leptobrachion* sp. A, before being confirmed as *L. malvernia*.

**Dimension**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Vesicle diameter</th>
<th>20 - 34μm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process length</td>
<td>16 - 26 μm</td>
<td></td>
</tr>
<tr>
<td>Process base width</td>
<td>0.5 - 1.5 μm</td>
<td></td>
</tr>
<tr>
<td>Process number</td>
<td>6 - 12</td>
<td></td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>8.</td>
<td></td>
</tr>
</tbody>
</table>

**Occurrence.** Coalbrookdale Formation - upper part of the Elton Formation, upper Wenlock - lower Ludlow series of the Wenlock and Ludlow areas of Shropshire.

Known range: Homerian - upper Gorstian (Wenlock - Ludlow Series).

**Leptobrachion cf. malvernia** Dorning 1981a.

Plate 55, figs. 5, 6.

1970 *Baltisphaeridium* sp. nov.; Lister, p. 59, pl. 2, figs 13 - 16.

1981a *Leptobrachion malvernia* n. sp. Dorning; p. 193, pl. 2 fig. 9.

1990 *Leptobrachion malvernia* Dorning 1981a; Fensome *et al.* p. 290, no fig.

**Description** Vesicle spherical in outline, laevigate, double walled. Inner wall thick and rigid while the outer wall is thin, transparent and attached to the central body cavity. Processes are thin hollow, laevigate formed from the outer ectophragm and branch in heteromorphic fashion from broad bases up to third order in a digitate fashion before tapering to simple tips. The process bases are indistinct and merge before the thick walled vesicle body in some cases. The processes do not communicate with the central body cavity. Excystment by simple split.

**Remarks.** The forms recovered are compared to *L. malvernia* because of the current confusion between this species and *E. wenlockensis* sensu lato and none of the specimens recovered exhibited fifth order branching as would be expected in *L. malvernia* sensu stricto. This species differs from *E. wenlockensis* sensu stricto in having multifurcate processes. It is thought that some forms previously considered (Dorning pers. comm.) to belong to *E. wenlockensis* are possibly synonymous with this species but without figured specimens being available it is not possible to create a synonymy of such occurrences.
**Dimensions.**

- Vesicle diameter: 18 - 26 μm
- Process length: 18 - 20 μm
- Process base width: 2 - 8 μm
- Process number: 4 - 10 indistinct
- Number of specimens measured: 10

**Occurrence** Lower Elton Formation, Ludlow Series of the Ludlow and Millichope areas of Shropshire, UK (Lister 1970); possible occurrences from the Hughley Shales to Coalbrookdale Formation (Sheinwoodian) of the Welsh Borderlands (Dorning 1981a).

This species was relatively common throughout the Coalbrookdale and Much Wenlock Limestone formations and less so in the few samples from the Lower Elton formation in the Ludlow and Much Wenlock areas of the Welsh Borderland, UK.

Known Range: Homerian to upper Gorstian. Late Wenlock to early Ludlow series.

**Leptobrachion sp. B var. 1.**

Plate 55, fig. 2.

cf. 1970 *Evittia remota*; Lister, p. 69, pl. 4 fig. 11 only.

cf. 1975b *Evittia longispinosa*, Pōthe de Baldis, p. 510, pl. 1, figs. 1 - 2, pl. 2, figs. 5 - 6.


**Description** Vesicle body polygonal, laevigate, thick-double walled with the processes being formed from the thin outer ectophragm, varying from simple to 2nd order branching. The polygonal shape to the central body is the function of the position of the processes at the four corners. The processes are hollow and do not communicate with the vesicle interior. Processes length is 150 - 200% vesicle body diameter. Excystment mechanism not observed.

**Remarks.** *L. arbusculiferum* by comparison has a spherical to subspherical central body and more numerous processes. This morphotype resembles species of *Ozotobrachion*, notably *Ozotobrachion furcillatus* (Deunff 1955) but the figured specimen (Deunff 1955, fig. 18) is a line drawing, hence without looking at the holotype material a definitive synonymy has not been made. It is also closely comparable to the form documented as *O. dicros* by Loeblich & Drugg (1968, pl. 2 fig. 3), but their material has not been studied therefore a full synonymy has not been made.
**Dimensions**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>14 - 16 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>18 - 28 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>0.5 - 1 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>4 - 5</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Occurrence.** Ludlow Series of the Welsh Borderland (Lister 1970); Silurian of the San Juan Province of Argentina (Pothe de Baldis 1981); Coalbrookdale Formation - upper part of the Elton Formation, upper Wenlock - lower Ludlow series of the Wenlock and Ludlow areas of Shropshire.

Known range: Homerian to upper Gorstian Stages, Wenlock to Ludlow Series, Silurian.

**Leptobrachion sp. E**

Plate 22, fig. 4.

**Holotype.** Plate 22 figure 4, sample number FD 900/10/1, Rivelin Finder reference ON 48, from the Coalbrookdale Formation (Farley Member) of Farley Dingle, Much Wenlock, Shropshire, England.

**Diagnosis.** Vesicle body subspherical, laevigate, double walled. Diminutive small, thin walled form almost translucent central body and processes. The processes are formed from the outer wall, multifurcate branching varying from simple to 2nd order. The processes are hollow and do not communicate with the vesicle interior. Processes length is 150 - 200% vesicle body diameter. Excystment by simple split.

**Remarks.** L. arbusculiferum by comparison has a more spherical thicker central body and more numerous considerably longer processes, which exhibit a greater degree of branching. This species has shorter wider processes than L. arbusculiferum or L. longhopense.

**Dimensions.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>12 - 14 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>12 - 14 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 - 4 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>4 - 6</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>2</td>
</tr>
</tbody>
</table>
**Occurrence.** Coalbrookdale Formation - upper part of the Elton Formation, upper Wenlock - lower Ludlow series of the Wenlock and Ludlow areas of Shropshire.

**Leptobrachion sp. X**

Plate 31, fig. 4.

*Description.* Thin walled, large, 30 μm in diameter, laevigate, vesicle bearing numerous thin walled processes, 34 - 40 μm in length. Mode of excystment not observed.

*Remarks.* Only one specimen recovered hence retained in open nomenclature. Although assigned to this genus the similarity between this form and species of *Eisenackidium* is noted.

**Dimensions.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>30 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>34 - 40 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>9</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

**Occurrence.** This morphotype was recorded as a rare type from the Much Wenlock Limestone Formation, Homerian Stage of the Wenlock Series from Harley Hill. (HH3 200/10/1 E 45).


*Type species. Lophosphaeridium rarum* Timofeev 1959, p. 29, pl. 2, fig. 5; designated by Downie 1963, p. 630; from the Ordovician of Russia.

*Diagnosis.* (Lister 1970, p. 61). "Vesicle hollow, single-walled with ornament of solid tubercles. Excystment is by cryptosuture."

*Remarks.* The specimens recovered are essentially sphaeromorph acritarchs, spherical to ellipsoidal in outline bearing an irregular ornament of low solid ornament of grana, papillae or tubercules. This genus differs from
Helosphaeridium whose species have a short usually capitate ornament; Buedingiisphaeridium which has a hollow ornament; Visbysphaera which has a variable ornament but generally hollow and Leiosphaeridia which is unornamented in the strict sense.

**Lophosphaeridium citrinum** Downie 1963

Plate 28, fig. 7.

1963 *Lophosphaeridium citrinum* sp. nov.; Downie, p. 630-631, pl. 92, fig. 3.
1971 *Buedingiisphaeridium citrinum* (Downie 1963); Cramer, pl. 3, fig. 13.
1974 *Baltisphaeridium* aff. *citrinum* (Downie, 1963) nov. comb.; Stockmans & Willière, p. 12, no fig.
1976 *Lophosphaeridium citrinum* Eisenack *et al.* p. 413 - 414.
1990 *Lophosphaeridium citrinum* (Downie 1963); Fensome *et al.* p. 301, no fig.
1990 *Baltisphaeridium citrinum* (Downie 1963) Stockmans & Willière 1974; Fensome *et al.*, p. 90 no fig.

**Holotype.** Downie 1963, pl. 92, fig. 3; from the upper Coalbrookdale Formation, Wenlock Series of Wenlock Edge, Shropshire.

**Diagnosis.** (Downie 1963, p. 630 - 631) "Vesicle ellipsoidal, lemon yellow in colour. Ornament of capitate spine (pilae). Body size about 40 by 30 microns; spine length 1 to 2 microns, spacing 1 to 2 microns."

**Description.** Spherical, single walled vesicle of medium thickness bearing a low, regularly distributed ornament. Mode of excystment not observed.

**Remarks.** The species was logged as *Lophosphaeridium citrinum* and hence is retained here in this genus for consistency throughout this work. Where other workers have synonymised this species has been noted to clearly show other peoples ideas about the status of this species. The combination proposed by Stockmans & Willière (1974) is not followed because the specimens recovered are all single walled whereas the generic diagnosis for *Baltisphaeridium* clearly describes a double walled vesicle, in addition the processes are solid in this genus and not hollow as in *Baltisphaeridium*. The specimens recovered herein are generally part of a smaller size range than quoted from the original diagnosis.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>20 - 24µm</td>
</tr>
<tr>
<td>Ornament height</td>
<td>1 - 1.5µm</td>
</tr>
</tbody>
</table>
Occurrence. Coalbrookdale Formation, Wenlock Series of Wenlock Edge, Shropshire (Downie 1963); upper Llandovery Series (Purple Shales) to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard and Aldridge 1985);

This species was recorded from the Farley Member of the Coalbrookdale Formation, the Much Wenlock Limestone Formation and the lowermost portion of the Lower Elton Formation from the type Wenlock and Ludlow areas in the Welsh Borderlands.

Known range: Middle Wenlock to early Ludlow series.

**Lophosphaeridium microspinum** (Eisenack 1954) Downie 1963

Plate 28, figs. 2, 3.

1954 *Hystrichosphaeridium microspinum* Eisenack, p. 209 - 210, pl. 1, fig. 8.
1959 *Baltisphaeridium microspinum* (Eisenack); Downie, p. 60, pl. 10, fig. 10.
1963 *Lophosphaeridium microspinum* (Eisenack); Downie p. 632, pl. 92, fig. 11.
1970 *Visbysphaera microspinosa* (Eisenack); Lister, p. 99, pl. 13 figs. 11, 12, Text - Fig. 19g, m.
1971 *Baltisphaeridium microspinum* (Eisenack); Kjellström, p. 32, pl. 2 fig. 4.
1973 *Baltisphaeridium microspinum* (Eisenack); Eisenack et al. p. 145.
1987 *Visbysphaera cf. microspinosa* (Eisenack); Priewalder, p. 62, 63.; pl. 16, figs. 2, 3, 4, pl. 21. fig. 4.
1990 *Lophosphaeridium microspinum* (Eisenack) Fensome et al. p. 304, no fig.
1990 *Visbysphaera microspinosa* (Eisenack) Fensome et al. p. 531, no fig.

Holotype. Eisenack 1954, p. 209 - 210, pl. 1 fig. 8 from the upper Llandovery Series of Gotland, Sweden.


Remarks. The specimens recovered conform to the original diagnosis. The combinations to the genus *Visbysphaera* are not followed because the specimens recovered were single walled. All the forms assigned to this
taxon herein had an extremely fine ornament. This is noted because with further investigation the forms recorded herein could be separated from the forms with a longer ornament.

**Dimensions.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>20 - 24 µm</td>
</tr>
<tr>
<td>Ornament height</td>
<td>1.5 - 2 µm</td>
</tr>
<tr>
<td>Ornament base width</td>
<td>1 - 2 µm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Occurrence.** This species has been reported from the upper Llandovery of Gotland, Sweden (Eisenack 1954) Wenlock to Ludlow series of England (Downie 1959, 1963); Caradoc and Tremadoc series of Poland (Górka 1969); Ordovician of Gotland (Kjellström 1971); Upper Llandovery to lower Wenlock series of the Welsh Borderland (Mabillard & Aldridge 1985 as *V. microspinosa*); Llandovery Series of Ringerike Norway (Dorning & Aldridge 1982), Sheinwoodian Stage (Wenlock Series) of the type area, Shropshire (Swire 1991).

This species was recorded from the Farley Member of the Coalbrookdale Formation, Much Wenlock Limestone Formation to lowermost portion of the Lower Elton Formation of the type Wenlock and Ludlow areas in the Welsh Borderlands.

Known Range: Llandovery to Ludlow Series.

**Lophosphaeridium papillatum** (Staplin 1961) Martin 1968

Plate 28, fig. 1.

1961 *Protoleiosphaeridium papillatum* Staplin 1961, p. 406, pl. 48, fig. 10
1963 *Lophosphaeridium sp. cf. P. papillatum* (Staplin); Downie, p. 631, no fig.
1966 *Leiosphaeridia papillata*; Martin, p. 27.
1968 *Lophosphaeridium papillatum*; n comb. Martin, p. 111, pl. 8 figs. 375 - 376.
1977 *Protoleiosphaeridium papillatum*; Pôthe de Baldis, p. 237, pl. 1, figs. 2, 7, 10.
1987 *Lophosphaeridium papillatum*; Priewalder, p. 39, pl. 8, figs. 12 - 13, pl. 19, fig. 6.
1990 *Lophosphaeridium papillatum*; Fensome et al. p. 304, no fig.

Diagnosis. (Staplin 1961, p. 406.) "Vesicle circular; densely papillate, papillae short, variable in size, shape and spacing, height 0.8 - 1.3 μ.

Remarks. The specimens recovered conform to the original diagnosis.

Dimensions. Vesicle diameter 20 - 24 μm
Ornament height 1.5 - 2 μm
Ornament base width 1 - 2 μm
Number of specimens measured 2

Occurrence. This species has been recorded from various locations, of which the following have been checked for consistency with the records herein: Upper Devonian of Canada (Staplin 1961); Coalbrookdale Formation, Wenlock Series of the Wenlock area (Downie 1963 Lophosphaeridium sp. cf. P. papillatum); upper Llandovery to basal Wenlock series of the Karnic Alps, Austria (Priewalder 1987).

This species was recorded consistently throughout the sections sampled from the Homerian to early Gorstian in the type Wenlock and Ludlow areas of the Welsh Borderlands.
Known Range. Late Ordovician to late Devonian.

Lophosphaeridium pulchrum sp. nov.

Plate 28, fig. 10.

Derivation of name. This species was first recorded unpublished as L. pulchrum by Swire (1991, p. 151, pl. 14, figs. 1 - 4), the name is retained herein for consistency within the unpublished literature. The specific epithet is derived from the Latin adjective 'pulchrum' meaning handsome/beautiful.

Holotype. Plate 28, fig. 10, from sample HH2/800/10/1, Rivelin Finder reference ST 40, from the uppermost Farley Member of the Coalbrookdale Formation (Homerian Stage), Wenlock Series of Harley Hill, Much Wenlock, Shropshire, England.

Diagnosis. Ellipsoidal to subspherical vesicle measuring 32 - 40 μm in diameter and of medium wall thickness. The vesicle body is ornamented by heteromorphic solid, rounded, tubercules; 2 - 4 μm variable height and
basal width; irregularly spaced over the vesicle body leaving areas with dense ornament and areas of bare laevigate vesicle surface. Mode of excystment by simple split.

**Remarks.** Although this form was only rarely recorded in this study this morphotype has been previously reported from the Sheinwoodian Stage of the type Wenlock area by Swire (1991 unpublished) as *Lophosphaeridium pulchrum*. This species differs considerably from other forms of *Lophosphaeridium* with its distinctively irregular sized, shaped and spaced ornament which leaves bare patches over the vesicle body.

**Dimensions.**

- Vesicle diameter: 32 - 40 μm
- Ornament height: 2 - 4 μm
- Ornament base width: 2 - 4 μm
- Number of specimens measured: 2.

**Occurrence.** This species has been previously recorded from the Sheinwoodian Stage, middle Wenlock Series of the Welsh Borderland (Swire 1991 as *Lophosphaeridium pulchrum* unpublished).

This species was recorded as a rare type from the Farley Member of the Coalbrookdale Formation of Harley Hill in the type Wenlock area, Shropshire, England.

Known Range. Sheinwoodian to Homerian stages, Wenlock Series.

**Lophosphaeridium tuberculatum** sp. nov.

Plate 28, figs. 4, 5, 6.

**Derivation of name.** This specific epithet is derived from the Latin noun ‘tuberculum’ meaning small bump or swelling with the adjectival suffix for nouns ‘atum’, -possessive of..., referring to the nature of the ornament.

**Holotype.** Plate 28, fig. 4, from sample MFGT1-50/10/1, Rivelin Finder reference B 33 from the Much Wenlock Limestone Formation, Homerian Stage, Silurian of Mortimer Forest, Ludlow, Shropshire.

**Diagnosis.** Spherical to ellipsoidal medium to thick walled vesicle body, lemon yellow to golden brown in colour depending on wall thickness, 28 - 40 μm in diameter. The vesicle is uniformly ornamented with numerous low, solid 'cones', 2 - 4 μm in height, that are heteromorphic in a single specimen, with both conical and flattened shapes; they are subspherical in outline with a base width of 2 - 4 μm. The ornament covers the entire vesicle. Excystment by simple split.
Remarks. This species was originally logged as *Buedingiisphaeridium* sp. A and B, incorporating end members of the intraspecific variation. The ornament was then deemed to be solid, hence the species was transferred to *Lophosphaeridium*. This species is clearly different from any other species due to its distinctive low, heteromorphic solid ornament which covers the entire vesicle.

**Dimensions.**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>28 - 40 µm</td>
</tr>
<tr>
<td>Ornament height</td>
<td>2 - 4 µm</td>
</tr>
<tr>
<td>Ornament base width</td>
<td>2 - 4 µm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

Occurrence. This species was recorded from the Farley Member of the Coalbrookdale Formation, the Much Wenlock Limestone Formation and the Lower Elton Formation, from the type Wenlock and Ludlow areas in the Shropshire Welsh Borderland.

*Lophosphaeridium sp. J*

Plate 18, fig. 11.

Description. Spherical, thick walled, robust vesicle bearing an even ornament of solid tubercules. Excystment by simple split.

Remarks. This form was recorded as a rare type, single occurrence, hence it is retained as an informal species of the genus *Lophosphaeridium*.

**Dimensions.**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>30 µm</td>
</tr>
<tr>
<td>Ornament height</td>
<td>3 µm</td>
</tr>
<tr>
<td>Ornament base width</td>
<td>3 µm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

Occurrence. This form was recorded as a rare type from the Farley Member of the Coalbrookdale Formation in sample FD bent from Farley Dingle, Much Wenlock, Shropshire, England.

Known Range: It is possible that this form is reworked.
Genus **METALEIOFUSA** Wall 1965

*Type Species.* *Metaleiofusa arcuata* Wall 1965, p. 161, fig. 18 - 20, pl. 9 fig. 1, 2.

*Diagnosis.* (Wall 1965 p. 161) "Test small, about 20 μm in length, fusiform, ornamented by an apical spine at each pole and a small number of additional subapical or lateral equatorial processes of a simple nature."

*Remarks.* Essentially fusiform acritarchs bearing more than two polar processes. This genus differs from *Leiofusa* in that it bears more than two polar processes, at least one process arises from the central vesicle body. *Domasia* differs in that all the processes arise in the same plane. This genus has longer polar processes than those seen in species of *Sylvanidium* (Loeblich 1970).

**Metaleiofusa flammula** sp. nov.

Plate 25, fig. 2

*Derivation of name.* From the Latin 'flamma' meaning flame, with 'ulus' the substantive suffix for declension nouns (ula being feminine).

*Holotype.* Plate 25, fig. 2; sample FD 2000/10/1, Rivelin Finder reference R34, from the Farley Member of the Coalbrookdale Formation, Farley Dingle, Much Wenlock, Shropshire, England.

*Description.* Thin walled, laevigate vesicle body, fusiform in outline bearing 5 processes, two of which are polar, extending from the drawn out ends of the fusiform central body. The processes are hollow, laevigate and communicate freely with the central body cavity. Mode of excystment not observed.

*Remarks.* This form was recorded rarely. It differs from *Metaleiofusa inflata* in that the vesicle is less inflated and thinner walled and has fewer processes.

*Dimensions.*

<p>| | |</p>
<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>22 μm</td>
</tr>
<tr>
<td>Vesicle width</td>
<td>10 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>20 - 26 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1.</td>
</tr>
</tbody>
</table>

*Occurrence.* This rare type was recorded from the Farley Member of the Coalbrookdale Formation (sample: FD 2000/101, R34).
**Metaleiofusa inflata** sp. nov.

Plate 25, fig. 5.

*Derivation of name.* From the Latin adjective ‘inflatus’ meaning swollen, referring to the distended central body.

*Holotype.* Plate 25, fig. 5: sample 2SH -2/10/1, Rivelin Finder reference: M33, from the Much Wenlock Limestone Formation of Shadwell Quarry, Much Wenlock, Shropshire, England.

*Diagnosis.* Thin to medium walled, pale lemon yellow, inflated, laevigate vesicle body, fusiform in outline bearing 7 processes. The processes are divided into two kinds, firstly, two polar processes, extending from the drawn out ends that give the vesicle a fusiform shape and secondly, processes which emanate from the centre of the vesicle body. The processes are long, slender and taper to a fine simple tip, they communicate freely with the central body cavity. Mode of excystment not observed.

*Remarks.* This species differs from *Metaleiofusa flammula* and *M. insignis* in it has a considerably distended central body. This species is similar to *Sylvanidium paucibrachium* (Loeblich 1970) in that they both have an inflated central vesicle and bear polar processes with secondary processes that arise from the main portion of the central body but the processes *Metaleiofusa inflata* are considerably longer.

**Metaleiofusa insignis** sp. nov.

Plate 49, fig. 3

1973 *Metaleiofusa* sp. A; Richardson & Ioannides; pl. 13, figs. 11-12.

1986 *Metaleiofusa* cf. *arcuata* Le Hérisse p. 128, fig. 12 only.

*Derivation of name.* From the Latin ‘insignis’ meaning remarkable, notable, distinguished or extraordinary.

*Holotype.* Plate 49, fig. 3. Sample FD 900/10/1. Rivelin Finder Reference, from Farley Dingle, Much Wenlock, Shropshire England.
Diagnosis. Species of Metaleiofusa with a thin walled, laevigate vesicle body, fusiform in outline, bearing two apical processes and at least one emerging from the main body, close to the equator. The processes communicate freely with the central body cavity.

Remarks. This species differs from Metaleiofusa arcuata in possessing at least three processes and from Metaleiofusa diagonalis which has four or more processes. Though this form is distinct from the genus Domasia, the specimens figured by Wall (1965) are very similar in form to species belonging to the latter genus.

Dimensions. Vesicle length 25 - 40 μm
Vesicle diameter 20 - 22 μm
Apical process length 28 - 36 μm
Mid vesicle process length 6 - 10 μm
Entire vesicle length 100 - 110 μm
Number of specimens measured 2

Occurrence. Silurian of the Baltic (Yankauskas & Vaitekunene 1972); Tanezzuft and Acacus formations, Silurian of Libya (Richardson and Ioannides 1973 as Metaleiofusa sp. A); upper Llandovery Series (Purple Shales) of the Wenlock type area, Welsh Borderlands (Mabillard and Aldridge 1985 as M. aff. arcuata); Devonian of France (Le Hérisse 1986 as Metaleiofusa cf. arcuata.).

In this study Metaleiofusa insignis occurs very rarely having only been recovered as a rare type in samples at Farley Dingle road cut (sample FD 900).

Dimensions. Vesicle diameter 25 μm
Vesicle width 18 μm
Process length 20 - 26 μm
Number of specimens measured 1.

Occurrence. This form was reported from the Much Wenlock Limestone Formation of Shadwell Quarry, sample: 2SH -2m/10/1, reference M33.

emend. Sarjeant & Stancliffe 1994

Type Species. Michrystridium inconspicuum. (Deflandre 1935) Lister 1970, p. 233 m, pl. 9 figs. 11 - 12 from the Upper Cretaceous of France.
Diagnosis. (Lister 1970 p.82). "Cysts with subspherical to polygonal vesicles; processes are closed at the tips, generally homomorphic, simple capitate or with very brief branches. Vesicle small, mean and modal diameter generally less than 20 μm; processes communicate freely with vesicle cavity; an inner wall, if present, is highly adpressed to the outer wall. Excystment by cryptosuture, dehiscence gradual by stages; position of suture apical or near equatorial."

Diagnosis. (Sarjeant & Stancliffe 1994, p. 12). "Acritarchs with a spherical, oval to rounded -subpolygonal vesicle whose outline in optical section is not significantly modified by the bases of the spines. Vesicle size small, generally less than 20 μm; larger species very rarely range above 27 μm in diameter. Eilyma typically single-layered, rarely two-layered. Surface psilate to granulate or with other fine microstructure, but not divided into fields or plates. Arising from the vesicle, generally at right angles to the eilyma, are from 9 to 35 spines with closed tips, usually simple but rarely clavate. The spines may flare somewhat at their bases. Spines hollow to solid; if hollow, their central cavity may or may not communicate with that of the vesicle. A few spines may exhibit distal bifurcations or have small holes in their mid section. The spine length can range from ca. 1.5 μm to greater than the vesicle diameter. Release of vesicle contents occurs by formation of a linear slit or a crescentic to horseshoe - shaped opening (epityche) or by opening of a cryptosuture, causing loss of an irregularly shaped portion of one surface: regularly formed circular to polygonal openings (pylomes) are not developed."

Remarks. For further details of work by other authors on this genus refer to Eisenack et al. (1979 - p.381 - 383) and also Sarjeant & Stancliffe (1994 p. 12) who emended the generic diagnosis and acknowledged the occurrence of larger forms which rarely exceed 27 μm. The transference of some species previously recorded as belonging to this genus to Dorsennidium by Sarjeant & Stancliffe (1994) has not been followed herein.

Michystridium difformis sp. nov.

Plate 35, figs. 9, 12.

Derivation of name. Meaning differing shape (compared to others of the genus): dif -between/away from; forma - noun for figure/shape; -is - latinizing suffix.

Holotype. Plate 35, fig. 12 from sample HH2/800/10/1, Rivelin Finder reference, T 40 from the Much Wenlock Limestone Formation of Harley Hill.

Diagnosis. Thin to medium walled polygonal vesicle 16 - 18 μm in diameter bearing simple processes whose length is equal to or less than the vesicle body diameter, 8 - 12 μm. The processes emanate from wide bases, 4 μm and are arranged radially. Mode of excystment - uncertain pylome observed.
Remarks. This morphotype is tentatively placed within the genus *Michrystridium*. The paratype and holotype having an appearance which could be thought of as being somewhat transitional to *Veryhachium*. This form was only recorded as a rare type and logged initially as *Michrystridium* sp. M.

**Dimensions**

- Vesicle diameter: 16 - 18 µm
- Process length: 8 - 12 µm
- Process base width: 4 µm
- Process number: 10 +
- Number of specimens measured: 4

**Occurrence.** This species was recovered as a rare type from the Much Wenlock Limestone Formation of the Wenlock and Ludlow areas, including samples from Pitch Coppice and Harley Hill.


Plate 29, fig. 7.

1959  *Michrystridium stellatum var. inflatum* var. nov. Downie, p. 61, pl. 11, fig. 12.
1963  *Baltisphaeridium longispinosum* (Eisenack) var. *parvum* var. nov. Downie, p. 639, pl. 91, fig. 2.
1970  *Michrystridium inflatum* Downie 1959 emend.; Lister, p. 79-80, pl. 10, figs 2 - 7; text-fig 19a.
1979  *Michrystridium stellatum inflatum* Downie 1959; Eisenack et al., p. 507.
1990  *Michrystridium stellatum* subsp. *inflatum* Downie 1963; Fensome et al., p. 324, no fig.
1990  *Michrystridium stellatum var. inflatum* Downie 1963; Fensome et al., p. 333, no fig.
1994  *Dorsennidium inflatum*; comb. nov. Sarjeant & Stancliffe, p. 40, no fig.

**Holotype.** *Michrystridium stellatum var. inflatum* Downie 1959, pl. 11, fig. 12; from the Coalbrookdale Formation, Wenlock Series of Wenlock Edge, Shropshire.

**Diagnosis.** (Lister 1970, p. 79). "Vesicle hollow, subspherical to polygonal, smooth, single-walled; vesicle diameter 14 - 35µ; processes smooth, slender, flexuous, tapering to a fine point, equal to or greater than the vesicle diameter in length. Excystment by cryptosuture, apical or near-equatorial in position."

**Remarks.** The specimens recovered conformed to the original diagnosis having a spherical to subspherical laevigate vesicle ornamented with numerous processes. The processes are laevigate, simple and communicate freely with the vesicle interior. Excystment is by simple split. This species differs from other species belonging to the genus
*Michrystridium*; it has a larger vesicle than *Michrystridium salopiense*, a more 'subrounded' appearance than *M. stellatum* and has a larger vesicle size and lacks the barbs on the processes that are present on *M. intonsurans*.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>14 - 18 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>14 - 22 μm</td>
</tr>
<tr>
<td>Process width</td>
<td>1 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>5 - 10</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10.</td>
</tr>
</tbody>
</table>

**Occurrence.** Wenlock Series of Wenlock Edge Shropshire (Downie 1959, 1963); San Pedro Formation, Ludlow Series of north west Spain (Cramer 1964a); Wenlock Series of Gotland (Eisenack 1965); Wenlock Series of Dudley, West Midlands UK, (Eisenack 1977); Lower Devonian of Brazil (Brito 1965, 1967); Lower Devonian of Anjou France (Moreau Benoit 1967); Llandovery to Wenlock Series of Belgium (Martin 1967); Ludlow Series of the Ludlow and Millichope areas of Shropshire, UK (Lister 1970); Much Wenlock Limestone Formation (Wenlock Series) to Downton Castle Sandstone Formation (Pridolf Series), Ludlow (Lister & Downie 1974); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); Much Wenlock Limestone Formation of Dudley, West Midlands, UK (Dorning 1983); Llandovery Series of the type Llandovery area (Hill & Dorning 1984); upper Llandovery Series (Purple Shales) to lower Wenlock Series (Buildwas Formation) of the type Wenlock area, Welsh Borderlands (Mabillard & Aldridge 1985); late Sheinwoodian to early Homerian from the Cheviots, north east England (Barron 1989); Llandovery to Ludlow series, of Gotland, Sweden (Le Hérisse 1989); Coalbrookdale Formation, Wenlock Series, of Buildwas Bank and Holbrook Coppice Shropshire (Turner et al. 1995);

Known range: Silurian to Lower Devonian.


Plate 29, figs. 5, 6.

1970 *Michrystridium stellatum* var. *intonsurans* var. nov. Lister, p. 82 - 83, pl. 9, figs 18 - 20; pl. 10, fig. 1, text-fig. 24a.

1979a *Michrystridium stellatum intonsurans*; Eisenack et al. p. 509.

1981a *Michrystridium intonsurans* n. stat.; Dorning, p. 194 no fig.

1990 *Michrystridium intonsurans* Dorning, 1981; Fensome et al., p. 324, no fig.

1994 *Multiplicisphaeridium intonsurans*; comb. nov. Sarjeant & Stancliffe, p. 32, no fig.

**Diagnosis.** (Lister 1970, p.82 - 83). "A polygonal variety of *M. stellatum* with short rigid processes; processes barbed along their median portions and at their distal extremities."

**Description.** A diminutive species of the genus *Michrystridium* with a thin walled spherical vesicle bearing numerous, hollow, very short processes, which communicate freely with the central body cavity. The processes taper distally to generally simple points but ornamented along the length by 'barbs'. Excystment by simple split.

**Remarks.** Specimens recovered conformed to the original diagnosis. The transfer of this species to *Multiplicisphaeridium* by Sarjeant & Stancliffe (1994, p. 32) has not been followed because the processes are barbed and not branched. This species is distinctive for its small size and the presence of barbs on the processes.

**Dimensions.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>8 - 12 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>5 - 10 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>15+.</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

**Occurrence.** Ludlow Series of the Ludlow and Millichope areas of Shropshire, UK (Lister 1970); Early Sheinwoodian (Wenlock Series) of Scotland (Dorning 1982); Much Wenlock Limestone Formation, Wenlock Series of Dudley in the West Midlands (Dorning 1983); Much Wenlock Limestone Formation of the Welsh Borderlands (Dorning & Bell 1987); Coalbrookdale Formation, Wenlock Series of Holbrook Coppice, near Ironbridge Shropshire (Turner et al. 1995).

This form was recorded consistently but in low numbers from the Coalbrookdale, Much Wenlock Limestone and lowermost portion of the Lower Elton formations in the Wenlock and Ludlow areas of Shropshire.

Known range: Silurian to Devonian.

**Michrystridium magnum** sp. nov.

Plate 47, figs. 10, 11, 12.

**Derivation of name.** The specific epithet 'magnum' is from the Latin adjective for large. This species is a large distinctive michrystriid.
Holotype. Plate 47, fig. 11 from sample HH3 800/10/1, Rivelin Finder reference L34, from the Much Wenlock Limestone Formation of Harley Hill, Much Wenlock, Shropshire, England.

Diagnosis. Thick to medium walled subspherical to subpolygonal, laevigate vesicle, 24 - 28 μm in diameter bearing numerous processes of length less than the diameter of the vesicle body 12 - 18 μm. The processes are numerous 18 and taper from a flared base 4 - 6 μm to a simple acuminate tip. They often arranged in a radial pattern on the vesicle. Mode of excystment not observed.

Remarks. The specimens recovered differ from previously described Michrystridiids in their greater modal size being greater than the 20 μm which is more usual for this genus.

Dimensions.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
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<tr>
<td>Vesicle diameter</td>
<td>24 - 28 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>12 - 18 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>4 - 6 μm</td>
</tr>
<tr>
<td>Number of processes</td>
<td>&gt;18</td>
</tr>
<tr>
<td>Number of specimens</td>
<td>10</td>
</tr>
</tbody>
</table>

Occurrence. This species was recovered from the Much Wenlock Limestone Formation of Harley Hill and Shadwell Quarry in the type Wenlock area.

Michrystridium reges sp. nov.

Plate 30, fig. 1.

Derivation of name. From the Latin ‘Reges’ (rex) meaning Ruler/King referring to the distinct large, thick walled form of this species, with its array of robust processes. Named for Reginald Evans, who supported me throughout this project.

Holotype. Plate 30, fig. 1. sample FD 200/10/1 M42, from the Farley Member of the Coalbrookdale Formation at Farley Dingle, Much Wenlock, Shropshire, England.
**Diagnosis.** Large spherical to ellipsoidal, thick walled, laevigate vesicle (38 x 30 μm) bearing numerous (25 +), short simple processes with flared bases (base width 4 - 7 μm). The processes length is less than the vesicle body diameter (8 - 15 μm). Mode of excystment not observed.

**Remarks.** This form was only recorded as a rare type. It differs from species of *Michrystridium* such as *M. salopiense, M. intonsurans* due to its very large vesicle size. The indication that this genus should be restricted to forms of less than 20 μm (Sarjeant & Stancliffe 1994) is not followed here and until more specimens are recovered the form is included under this genus.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>38 x 30 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>8 - 15 μm</td>
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<tr>
<td>Process base width</td>
<td>4 - 7 μm</td>
</tr>
<tr>
<td>Process Number</td>
<td>25 +</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Occurrence.** This form was recovered as a rare type from sample FD 200/10/1, from the Farley Member of the Coalbrookdale Formation of Farley Dingle, Much Wenlock, Shropshire, England.


Plate 29, fig. 3.

1970  *Michrystridium stellatum* var. *salopiense* Lister, p. 82, pl. 10 figs. 8 - 9, 12 - 13.


1990  *Michrystridium salopiense* (Lister) Dorning; Fensome *et al.* p. 332, no fig.

1990  *Michrystridium stellatum* var. *salopiense* Lister; Fensome *et al.* p. 333, no fig.

**Holotype.** *Michrystridium stellatum* var. *salopiense* Lister, 1970, p. 82, pl. 10, fig. 12 from the Whitcliffe Formation, Ludlow Series of Ludlow, Shropshire.

*Diagnosis.* (Lister 1970 p. 82). "Variety of *M. stellatum* with more or less polygonal vesicle (modal size 14 μm); spines are very numerous (24 in optical section), extremely narrow and flexuous, and may be solid in their median and distal portions with minutely capitate tips; spine bases slightly expanded, communicating freely with the vesicle interior."

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Description. Thin walled small forms with subspherical to subpolygonal, laevigate vesicles bearing numerous hollow processes which communicate freely with the vesicle interior. The processes are slender, flexuous, proximally flared and have simple terminations. Mode of excystment by simple split.

Remarks. The specimens recovered conform to the original diagnosis. These forms tend to have quite numerous processes (>12) and are easily distinguished from other michystriids.

Dimensions. Vesicle diameter 10 - 16 μm
process length 9 - 14 μm
process number 12+
Number of specimens measured 10.

Occurrence. This species has been recorded from the Silurian of the Welsh Borderland (Lister 1970, Dorning 1981, Swire 1991). In this study this form was recorded consistently from the Farley Member of the Coalbrookdale Formation through the Much Wenlock Limestone Formation to the lowermost beds of the Lower Elton Formation from all the localities studied in the Much Wenlock and Ludlow areas of Shropshire.

Michrystridium spinulosum sp. nov.

Plate 29, fig. 1

Derivation of name. The specific epithet means ‘with lots of little spines’; spinula - a small spine with ‘-osum’ - adjective suffix for nouns meaning plentitude or notable development.

Holotype. Plate 29, fig. 1. sample FD2550/10/1, Rivelin Finder reference 035, from the Farley Member of the Coalbrookdale Formation.

Diagnosis. Thin walled, spherical vesicle, 12 - 18 μm in diameter bearing numerous >25, extremely short processes, 2 - 6μm. The processes are possibly solid in part. Mode of excystment not observed.

Remarks. Determination as to the true nature of the processes is difficult due to their short nature. The short processes and spherical rather than subspherical to polygonal vesicle shape distinguish this form from the other species of Michrystridium. This form was logged as Michrystridium sp. E.

Dimensions

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Vesicle body diameter</td>
<td>12 - 18 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>2 - 6μm</td>
</tr>
<tr>
<td>Process number</td>
<td>&gt;25</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5.</td>
</tr>
</tbody>
</table>
**Occurrence.** This species has been recovered from the Farley Member of the Coalbrookdale Formation to the Much Wenlock Limestone Formation of the Wenlock area, including samples from Farley Dingle and Coates Quarry.

**Michrystridium stellatum** Deflandre 1945

Plate 29, figs. 8, 10, 11.

1942 *Michrystridium stellatum* Deflandre, p. 476, figs 7, 8 (*nomen nudum*)

1974 *Veryhachium stellatum* Deflandre 1945; Pothé de Baldis, p. 371

1975 *Michrystridium stellatum* Deflandre; Pothé de Baldis, p. 492, pl. 5, fig. 18.

1979 *Michrystridium stellatum* Deflandre; Eisenack *et al.* p. 505 - 506.

1990 *Michrystridium stellatum* Deflandre 1945; Fensome *et al.*, p. 333, no fig.

1994 *Michrystridium stellatum* Deflandre 1945; Sarjeant & Stancliffe, p. 18, no fig.

**Holotype.** Deflandre 1945, pl. 3, fig. 16; from the Wenlock Series of Montage Noire, France.

**Diagnosis.** (Deflandre 1945, p. 65, translation by Eisenack *et al.* 1979a, p. 505). “The globular central body, tending to be somewhat polyhedral bears strong simple spines which are straight or slightly curved, of length greater than half the diameter of the central body. These spines are not very numerous: a dozen or a few more; they are more or less strongly developed, according to the specimens in question; the polyhedral aspect coincides with the reduction in the number of processes. The body wall is a reddish brown or is very dark yellowish brown, the spines are almost black. The diameter of the organism, without spines, is from 11 to 16µ; it attains 25 to 28µ, spines included.”

**Remarks.** Laevigate subpolygonal vesicle bearing numerous processes gradually tapering to a sharp point. Thin to medium wall thickness, process bases are flared and are formed from the same single wall as the vesicle body. The processes communicate freely with the vesicle interior. Mode of Excystment is by simple split. *M. intonsurans* differs in having shorter barbed processes, *M. salopiense* is smaller and has a subspherical vesicle and more numerous processes while *M. inflatum* is larger bearing fewer, longer processes.

**Dimensions.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>12 - 20 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>10 - 18 µm</td>
</tr>
<tr>
<td>Process base width</td>
<td>4 - 6 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>8 - 20</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

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**Occurrence.** For details of occurrences prior to 1979 see Eisenack *et al.* (1979 p. 503 - 506). Other occurrences verified by this author include the following: Wenlock Series of the type area (Downie 1959); Lower Permian, Yorkshire (Wall & Downie 1963); Wenlock Series, Shropshire (Downie 1959, 1963); Coalbrookdale to Downton Castle Sandstone formations, Wenlock to Pridolf series, Shropshire (Lister 1970); Silurian to early Devonian of Spain (Cramer 1964a); Lower Devonian of the Polignac Basin (Sahara) (Jardine & Yapaudjian 1968); Upper Llandovery to Wenlock Series of Nova Scotia and eastern USA (Cramer 1970a); upper Llandovery to Ludlow series of the USA (Cramer & Diez 1972); Wenlock Series of Ontario (Thusu 1973a); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); Much Wenlock Limestone Formation, Downton Castle Sandstone Formation, Wenlock to Pridolf series of Ludlow, Shropshire (Lister & Downie 1974); Wenlock Series of Gotland (Cramer *et al* 1979); Ludlow Series of Argentina (Pöthe de Baldis 1981); ?from the Llandovery to Wenlock of Ireland (Smith 1981 as *Michrystridium* spp.); upper Llandovery Series (Purple Shales to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985); lower Silurian of Ringerike, Norway (Smelror 1987); Llandovery Series of north-east Libya (Hill & Molyneux 1988); upper Silurian of San Juan, Argentina (Rubinstein 1993) Wenlock Series of the Cheviot Hills in north east England (Barron 1989); Coalbrookdale Formation, Wenlock Series, of Holbrook Coppice and Buildwas Bank, Shropshire (Turner *et al.* 1995).

This species was recovered consistently from the Coalbrookdale, Much Wenlock Limestone and lowermost Lower Elton Formations in the type Wenlock and Ludlow areas.

Known range: Silurian.

**Michrystridium sp. A**

Not figured.

**Description.** Very thin walled, spherical to subspherical, pale, translucent vesicle body, 12 - 18 μm in diameter bearing a few short echinate simple processes 2 - 4 μm. Greater than 12 in number they are dispersed over the vesicle body, it is believed that they communicate freely with the central body cavity. Mode of excystment not observed.

**Remarks.** This form differs from *Michrystridium* sp. E which has many more processes. It is similar to some of the forms logged as *Baltisphaeridium* sp. B.
Dimensions. Vesicle diameter 12 - 18 \( \mu \text{m} \)
Process length 2 - 4 \( \mu \text{m} \)
Process number 12 +
Number of specimens measured 5.

Occurrence. This form was recorded from the Farley Member of the Coalbrookdale Formation at Farley Dingle.

**Michrystridium sp. B**

Plate 29, fig. 9.

Remarks. Forms that appear logged as *Michrystridium* sp. B have now been included in taxonomy as *Veryhachium bulbiferum*. As such, the taxonomy is dealt with in the section for *Veryhachium*.

**Michrystridium sp. C**

Plate 29, figs. 2, 12.

Description. Robust thick walled form with robust wide based short processes communicating freely with the central body cavity.

Remarks. The forms reported here were separated during the systematic logging of the palynoflora. The form is distinctive and has been figured to illustrate as such, though it is acknowledged that the wall thickness, the primary distinguishing feature of this form could be within the realms of intraspecific variation. As the species was logged separately it is thus treated separately in this taxonomy.

Dimensions

---

Vesicle diameter 16 - 22 \( \mu \text{m} \)
Process length 4 - 6 \( \mu \text{m} \)
Process base width 2-4 \( \mu \text{m} \)
Number of processes 10-12
Number of specimens measured 8.

Occurrence. This form was recovered rarely throughout the sections studied from the Coalbrookdale, through Much Wenlock Limestone to Lower Elton formations in the type Wenlock and Ludlow areas.
Michrystridium sp. F

Not figured.

Description. Subpolygonal vesicle body of medium wall thickness giving a golden yellow vesicle wall

Remarks. This form is now believed to be part of the Michrystridium salopiense formgroup but was logged separately. It is included here in the systematic descriptions to clarify this and as such this form is not figured separately.

Dimensions

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
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</tr>
<tr>
<td>Process length</td>
<td>10 - 18 μm</td>
</tr>
<tr>
<td>Process number approximately</td>
<td>18.</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1.</td>
</tr>
</tbody>
</table>

Occurrence. This form has been recovered from the Farley Member of the Coalbrookdale Formation to the Much Wenlock Limestone Formation of the Wenlock area, in samples from Farley Dingle; Harley Hill and Coates Quarry.

Michrystridium sp. H

Now referred to Salopidium pauciramosum sp. nov. (See Salopidium. Ibid.)

Plate 35, fig. 8.

Description. Subspherical vesicle body of thin to medium wall thickness bearing numerous short acuminate processes. The processes are mostly simple but some exhibit rare bifurcations.

Remarks. This form was only recorded rarely as Michrystridium sp. H. Other forms were logged with the genus Salopidium. Post logging these forms have been combined with some larger forms with otherwise the same features and are now referred to as Salopidium pauciramosum sp. nov. The division is detailed here for clarification with the log sheet data.

Dimensions

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>14 - 16 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>6 - 8 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>17</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>4</td>
</tr>
</tbody>
</table>
Occurrence. This form was recovered from the Farley Member of the Coalbrookdale Formation in the type Wenlock area including samples from Farley Dingle (FD 300; FD Bent).

**Michrystridium sp. J**

Plate 29, fig. 4.

*Description.* Thick walled, ellipsoidal, golden brown form with a very robust vesicle. The vesicle bears numerous >25 very short wide based simple processes which communicate freely with the vesicle interior. Mode of excystment not observed.

*Remarks.* This form differs from other species of *Michrystridium* by its thick walled nature and numerous short processes.

*Dimensions.*

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle body diameter</td>
<td>20 - 28 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>2 - 6 µm</td>
</tr>
<tr>
<td>Process base width</td>
<td>4 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>&gt;25</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1.</td>
</tr>
</tbody>
</table>

Occurrence. This species has been recovered from the Coalbrookdale Formation of Harley Hill and recorded herein as a rare type. This form has also been found from the Lower Elton Formation (Mullins pers. comm.)

**Michrystridium sp. P**

Plate 35, fig. 7.

*Description.* A small acritarch, pale lemon yellow in colour with a polygonal vesicle bearing wide based spines.
Remarks. This morphotype is possibly a species of Cymatosphaera. Not enough specimens were recovered to make a full determination of this, and also the form recovered was very small and indistinct hence a representative is figured and is treated separately in the systematic descriptions for clarity with reference to the logging sheets.

Dimensions.  
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>12 - 14 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>6 - 8 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>12+ µm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1.</td>
</tr>
</tbody>
</table>

Occurrence. The specimen was reported as a rare type from the Much Wenlock Limestone Formation of Coates Quarry, sample CT7/10/1.


Type Species. Multiplicisphaeridium ramispinosum, Staplin 1961 p. 411, pl. 48, fig. 24, text-fig. 9 - g, h; from the Late Devonian, Woodbend Formation of Alberta, Canada.

Emended Diagnosis. (Lister 1970, p. 83). ‘Vesicle hollow, spherical to ellipsoidal, single walled; processes with closed tips, heteromorphic simple or compound branching, wall smooth or with minor ornamentation; no differentiation between vesicle wall and processes; process cavity in open communication with the vesicle interior. Excystment by cryptosuture, apical or near equatorial.’

Remarks. The species belonging to the genus Multiplicisphaeridium have single walled vesicles from which numerous isolated processes emerge. They differ from Baltisphaeridium, Bellidium, Cymbosphaeridium, Dilatisphaera and Leptobrachion which posses double walled vesicle bodies, the processes being formed from the outer wall only and they do not communicate with the interior of the vesicle. There is a possibility that some species assigned to Dateriocradus could be included in Multiplicisphaeridium. This is due to the wide variation in morphology within any particular species, hence here the distinction is retained between Multiplicisphaeridium and Dateriocradus, which usually has a triangular shaped vesicle body and 3 + processes that do not communicate freely with the central body cavity, unlike Multiplicisphaeridium. The vesicle and processes have no prominent ornamentation unlike species belonging to the genera Ammonidium, Diexallophasis and Salopidium. The processes are branched having heteromorphic processes with closed tips unlike the dominantly simple process terminations.
seen in *Michyrstridium*. By comparison *Diexallophasis* has ornamented walls and processes, the processes having digitate terminations. Finally this genus also differs from *Hogklintia* in that the species belonging to the latter are considerably larger than any forms belonging to the genus *Multiplicisphaeridium*, there is also speculation that the thin vesicle wall of *Hogklintia* is of a different composition to that in *Multiplicisphaeridium* as it has a distinctly different appearance. Most of the species recovered are of little stratigraphic value within the late Wenlock to early Ludlow series.

**Multiplicisphaeridium angustosum** sp. nov.

Plate 34, fig. 1

*Derivation of name.* From the Latin 'angustatus' meaning to make narrow, with the adjectival suffix for nouns '-osus' referring to plenitude or notable development of; referring to the long narrow processes.

*Holotype* Plate 34, fig. 1, from the Farley Member of the Coalbrookdale Formation of Farley Dingle; Much Wenlock, Shropshire, England. Sample number FD 1900/10/1; Rivelin Finder Reference: PQ 35.

*Diagnosis.* Extremely thin walled pale form with a small central body, formed by the point of coalescence of the processes. Processes heteromorphic in a single specimen simple, bifurcate and digitate within a single specimen.

*Remarks.* This species differs from all others belonging to the genus *Multiplicisphaeridium* with its very long processes relative to the central body cavity which is merely the area of the junction of the processes. In this aspect this form is comparable in form to a diminutive *Hogklintia*. Originally logged as *Multiplicisphaeridium* sp. Z.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>14 - 18 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>22 - 32 µm</td>
</tr>
<tr>
<td>Process base width</td>
<td>4 - 6 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>9 - 12.</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>2</td>
</tr>
</tbody>
</table>

*Occurrence.* This species has been recovered as a rare type from the Farley Member of the Coalbrookdale Formation in the type area, Much Wenlock in the Welsh Borderlands. Though it was also accounted for outside the statistical counts.
**Multiplicisphaeridium arbusculum** Dorning, 1981a

Plate 16, fig. 3; Plate 39, figs. 5, 6.

1964b *Baltsisphaeridium arbusculiferum* (Downie); Cramer, p. 289, pl. 2 fig. 18 only.

Lister, p. 86 - 87, pl. 10, figs. 15 - 17.

Lister, p. 86 - 87, pl. 11, figs 1 - 2, text - fig. 25 c.

1970 *Multiplicisphaeridium fisherii* (Cramer 1968) n. comb. Lister, p. 89 - 90, p. 10, fig. 18,
pl. 11., fig. 3


1981a *Multiplicisphaeridium arbusculiferum* n. sp.; Doming, p. 194 - 195, pl. 1, fig. 7.


**Holotype.** *Multiplicisphaeridium arbusculum* Doming, 1981a, p. 194-195, pl. 1, fig. 7; from the Much

**Diagnosis.** (Dorning, 1981a, p. 195). ‘Vesicle subspherical, 15 - 25 μm in diameter, laevigate; 6 - 12
laevigate processes, 18-30 μm long, base about 3 μm wide, tapering to sharp points; branching is irregular up to
fourth order, and irregular within the processes of an individual; the first order of branching often occurs about one
third to one half of the length of the process. Branching angle 30 - 40°”.

**Description.** Laevigate subspherical vesicle body, thin walled. Processes are hollow and have wide bases
that constrict to 2 μm and taper gradually. Branching initiates 1/2 way along the process length in some cases.
Processes are heteromorphic in a single specimen and branching up to fourth order has been observed. Excystment
mechanism not observed.

**Remarks.** The species assigned herein cover a variety of forms which all approximate to the original
diagnosis. The speciation of *Multiplicisphaeridium* is a difficult one because of the wide variety in the appearance
and complexity of the individuals that are diagnostically conspecific. Thus to clarify, the forms assigned herein are
those with subspherical vesicle bodies with distally branched tips; branching up to third order with the processes
communicating freely with the central body cavity. This species differs from *Multiplicisphaeridium fisherii* (Cramer
1968) which is considerably larger, despite having a similar general aspect. *Multiplicisphaeridium variabile* is
generally larger bearing more processes, with a subpolygonal outline.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>14 - 24 μm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>14 - 20 μm</td>
</tr>
<tr>
<td>Process length</td>
<td></td>
</tr>
</tbody>
</table>
Process base width 2 - 4 μm
Process number 7 - 1
Number of specimens measured 10

Occurrence. This species has been recorded from the Lower Palaeozoic of north-west Spain (Cramer 1964b); upper Wenlock to lower Ludlow Series of the Ludlow and Millichope areas of Shropshire; (Lister 1970 as M. arbusculiferum); Wenlock Series of Ontario (Thusu 1973a as M. arbusculiferum); Much Wenlock Limestone to Middle Elton formations, Wenlock to Ludlow Series of the Ludlow area (Lister & Downie 1974); Coalbrookdale Formation to the Lower Bringewood Formation, Wenlock to Ludlow Series of the Welsh Borderland, England, (Dorning 1981a); Ludlow Series of Argentina (Pothe de Baldis 1981 as M. arbusculiferum); Wenlock Series, Much Wenlock Limestone Formation of Dudley in the West Midlands (Dorning 1983); Chester Berg Formation, Wenlock Series of Greenland (Armstrong & Dorning 1984); upper Llandovery Series (Purple Shales to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985); upper Llandovery Series of Austria (Priewalder 1987b); lower Silurian of Ringerike, Norway (Smelror 1987b); upper Llandovery Series of north-east Libya (Hill & Molyneux 1988); middle Wenlock Series, Cheviot Hills of north east England (Barron 1989).

This species was recorded from the Coalbrookdale, Much Wenlock Limestone and lowermost portion of the Lower Elton formations from the type areas of Much Wenlock and Ludlow in the Welsh Borderlands.

Known range: Late Llandovery to Wenlock Series

Multiplicisphaeridium brachiatum sp. nov.

Plate 32, figs. 3, 5.; Plate 34, fig. 5.

1964b Baltisphaeridium cf. arbusculiferum Cramer, p. 289, pl. 2, fig. 17.
1970a Baltisphaeridium arbusculiferum Cramer, p. 132 - 133, pl. 7 fig. 119, text - fig. 39f.
1970a Baltisphaeridium cladum Cramer, p. 126, pl. 8, fig. 126.
1987 Multiplicisphaeridium cf. arbusculum Priewalder, p. 42, pl. 7, fig. 2. abb. 7.

Derivation of name. From ‘brach’ referring to a branch or arm, with ‘-atus’ as the adjectival suffix, meaning possessive of / something with.

Holotype. Plate 32, figs. 3, 5 (same specimen) from the Coalbrookdale Formation (Farley Member) of Farley Dingle, Much Wenlock, Shropshire England. Sample number FD1200/10/1, Rivelin finder reference: I.38.

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**Diagnosis.** Thin to medium walled subpolygonal/rhomboidal to subspherical vesicle, 12 -16 µm in diameter, laevigate bearing tubular processes, 6 - 10 in number initiated with wide bases, 4 - 8 µm, tapering but with irregular branching 2/3 along the process up to fourth order. Process terminations tapering. The processes communicate freely with the central body. The vesicle body is small compared to the process length the processes being greater than twice the central body diameter, 22 - 26 µm. The shape of the central body, being so variable is a function of it being formed from the conjunction of the processes. Mode of excystment not observed.

**Remarks.** This species differs from other species of *Multiplicisphaeridium* in that the central body is equal to or less than the length of the processes. This form also differs *M. arbusculum* in that the vesicle is subpolygonal rather than subspherical, whilst the processes of other forms such as *M. variabile* are more slender rather than tubular. This form was originally logged as *Multiplicisphaeridium* sp. F/I.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>12 -16 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>22 - 26 µm</td>
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<tr>
<td>Process base width</td>
<td>4 - 8 µm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 - 4 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>6 - 10</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10.</td>
</tr>
</tbody>
</table>

**Occurrence.** This species has been previously recorded from various localities including the following; Silurian of east coast U.S.A (Cramer 1970a as *B. arbusculiferum*); upper Llandovery to Ludlow series of the USA (Cramer & Diez 1972 where *Multiplicisphaeridium osgoodensis* appears to be a similar form, but the holotype material has not been studied); from the upper Llandovery Series of Austria, (Priewalder 1987).

This form was recovered from the Farley Member of the Coalbrookdale Formation at Farley Dingle.

**Multiplicisphaeridium callospinum** sp. nov.

Plate 31, fig. 5. Plate 36, fig. 1, Plate 33, figs. 10, 11.

**Derivation of name.** From ‘callo’ Greek for beautiful and ‘spinum’ referring to the spines or processes; meaning beautiful spines. Referring to the distinctive branching of the processes.

**Holotype** Plate 36 fig. 1 from the Wenlock Ludlow Boundary at Shadwell Quarry, Much Wenlock, Shropshire, England; Sample number: 2SH 360/10/1; Rivelin Finder reference: T 43.
Diagnosis. Subspherical, laevigate vesicle body of medium wall thickness (20 - 24 μm observed to date), with numerous robust hollow processes (16 - 18 μm long with base width 2 - 4 μm), usually equal to or less than the vesicle body diameter, which communicate freely with the central body cavity. The processes are numerous, 12 +; they taper and branch distally; branching is initiated from 2/3 along the vesicle length. The processes are heteromorphic within a single specimen and tend to branch in a trifurcate pattern initially, then finely to 2nd and 3rd order. Mode of excystment not observed.

Remarks. This species resembles the North American Wenlock form Multiplicisphaeridium cymulum Cramer & Diez 1972 but those forms exhibited a fine surface ornament in some specimens and were considerably larger (50 μm) than the forms recorded from the type area. Multiplicisphaeridium aff. cymulum reported by Barron (1989) from the Wenlock Series of the Cheviots is considered to be synonymous with this species it is also much smaller than M. cymulum of Cramer & Diez 1972.

Dimensions

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>20 - 24 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>16 - 18 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 - 4 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>8 - 12 +</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

Occurrence. Late Wenlock to early Ludlow of Shropshire (Dorning 1981a as Multiplicisphaeridium cymulum); Wenlock Series of the Cheviot Hills north eastern England, (Barron 1989 as M. aff. cymulum).

This species was recorded from the Coalbrookdale, Much Wenlock Limestone and lowermost portion of the Lower Elton formations from the type areas around Wenlock and Ludlow in the Welsh Borderland. Samples including. (2SH 360).

Multiplicisphaeridium cf. cladum (Downie 1963) emend. Lister 1970

Plate 3, fig. 5

cf. 1970 Baltisphaeridium cladum; Cramer 1970a, p. 126, pl. 8 fig. 136, text - fig. 39h.
cf. 1990 Multiplicisphaeridium cladum; Fensome et al. p. 342, no fig.

Holotype (of Multiplicisphaeridium cladum) Downie, 1963, p. 643, pl. 92, fig 5, text fig. 3a.
Diagnosis. (Diagnosis of M. cladum Downie 1963 p. 643). 'Test slightly ellipsoidal, several processes with stout shanks tapering to point of forking, forks fairly wide angled, short, tips irregularly bifurcate or trifurcate.'

Remarks. The specimens recovered are only compared to M. cladum as the processes in this form are generally longer than those observed on the holotype of M. cladum which has short stubby processes. In order to make a firm decision about this grouping toptype material of Downie's work, would need to be studied in order to see how they compared to specimens of M. variabile or M. arbusculum.

Dimensions

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<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>18 - 24 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>16 - 24 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>6 - 10</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5.</td>
</tr>
</tbody>
</table>

Occurrence. This form has been recorded from middle Silurian of USA and Canada (Cramer 1969a) upper Llandovery to Ludlow series of the USA (Cramer & Diez 1972); early Sheinwoodian, Wenlock Series of Scotland (Dorning 1982); Coalbrookdale Formation (Homerian); late Sheinwoodian to early Homerian of the Cheviot Hills, north east England (Barron 1989); upper Llandovery Series (Purple Shales to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985); upper Llandovery of Austria (Priewalder 1987 as M. cf. cladum); Coalbrookdale Formation (Homerian Stage), Wenlock Series of Buildwas Bank Shropshire (Turner et al. 1995 as M. cf. cladum).

**Multiplicisphaeridium diastrophis** sp. nov.

Plate 33, figs. 1, 2, Plate 34, fig. 4.

1970  *Multiplicisphaeridium* cf. *ramusculosum* Deflandre; Lister, p. 92–93. pl. 12, fig. 1

Derivation of name. From the Greek adjective ‘diastrophos’ meaning distorted, referring to the distortion of the vesicle body into a subpolygonal outline by the process bases.

Holotype  Plate 33, fig. 2. Sample CT6/10/1, Rivelin finder reference JH 42 from the Much Wenlock Limestone Formation of Coates Quarry, Much Wenlock, Shropshire, England.

Diagnosis. Thin walled laevigate polygonal body (16 - 20 μm) bearing numerous processes measuring less than or approximately equal too the diameter of the central body cavity (8 - 10 μm). The processes form the
polygonal shape of the vesicle. The processes are numerous (7 - 10), narrow, heteromorphic in a single specimen and can be simple or multifurcate. Where the processes branch, branching is initiated half way along the process length. The initial branching is essentially a simple bifurcation. Branching is generally restricted to first order, rarely second or third. Mode of excystment not observed.

Remarks. This species differs from other species of *Multiplicisphaeridium* with its polygonal more or less planar outline formed from the process bases and the distinctive branching pattern. *M. eltonensis* differs with its subspherical vesicle, *M. variabile* is often larger with longer processes and more variable branching. The most comparable form recorded to date is *Multiplicisphaeridium escobaides* (Cramer 1954b, p. 294) but observation of the holotype shows clear differences in morphology. Originally logged as *Multiplicisphaeridium* sp. V.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Vesicle diameter</th>
<th>16 - 20 μm</th>
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<tbody>
<tr>
<td>Process length</td>
<td>8 - 10 μm</td>
<td></td>
</tr>
<tr>
<td>Process base width</td>
<td>2 μm</td>
<td></td>
</tr>
<tr>
<td>Process number</td>
<td>7 - 10</td>
<td></td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Occurrence. Much Wenlock Limestone Formation of the Ludlow and Millichope areas (Lister 1970 as *M. cf. ramusculosum*) This morphotype was recovered from the Coalbrookdale to Much Wenlock Limestone formations of the type Wenlock area, recoveries including localities Farley Dingle (FD 2300) and Coates Quarry (CT6).

**Multiplicisphaeridium elongispinum** sp. nov.

Plate 34, fig. 6. Plate 49, fig. 5.

1970 *Multiplicisphaeridium ramusculosum* Deflandre; Lister, p. 92, 93, pl. 11, fig. 13.

Derivation of name. Meaning elongate spines referring to the nature of the processes.

Holotype. Plate 34, fig. 6 from sample FD 1600/10/1, Rivelin Finder reference MN 39, from the Farley Member of the Coalbrookdale Formation of Farley Dingle, in the type area, Much Wenlock, Shropshire, England.

Diagnosis. Thin walled laevigate subspherical body measuring 20 - 24 μm bearing numerous processes; the process length is greater than the diameter of the central body cavity, 26 - 30 μm. The processes are heteromorphic in
a single specimen and are simple and bifurcate. The base of each process is restricted generally 2 µm. Where the processes branch, branching is initiated 2/3 way along the process length. Branching is restricted to first order.

**Remarks.** The most similar form recorded to date is *Multiplicisphaeridium forquillum* (Cramer & Diez 1972, p. 152, pl. 32 fig. 15) but this form is thicker walled with more robust processes. The species is distinctive because of its slender, long tapering processes with restricted bases and simply furcate branching at the process tips. This species was initially logged as *Multiplicisphaeridium* sp. U.

**Dimensions**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>20 - 24 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>26 - 30 µm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>14</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Occurrence.** This species has been recorded from the Coalbrookdale Formation (Farley Member) from Farley Dingle (FD 800, FD 1760) in the type Wenlock area.

*Multiplicisphaeridium eltonensis* Dorming 1981a

Plate 33, figs. 3, 12. Plate 35, fig. 1.

1964b *Balitisphaeridium cf. fissile* (Stockmans & Willière) Cramer, pl. 3 fig. 12.
1970 *Multiplicisphaeridium ramusculesum* (Deflandre 1945) comb. nov., emend.; Lister, p. 92 - 93, pl. 11, figs 8, 11, 13, text - fig. 25a, not 14.
1981a *Multiplicisphaeridium eltonensis* n. sp.; Dorming, p. 195, pl. 1, figs. 5, 8.

**Holotype.** Dorming 1981a, pl. 1, fig. 8; Much Wenlock Limestone Formation, Wenlock Series of Ledbury Hill, Herefordshire (SO 716 384).

**Diagnosis.** (Dorming 1981a, p. 195). "Vesicle subspherical, 20 - 25 µm in diameter, laevigate; 10 - 18 laevigate processes, 15 - 20 µm long, 2 - 3 µm wide at base, tapering distally, irregularly branching at 20 -30 up to fourth order. Excystment by an irregular split."

**Remarks.** This species differs from *M. wrensnestensis* which is a larger species whilst *M. arbusculum* has distinctly different processes, longer and more tubular. *M. variabile* is larger with more numerous and more variably
branched processes and a polygonal rather than subspherical to ellipsoidal vesicle outline. Vesicle body spherical, laevigate bearing numerous tapering processes which communicate freely with the central body cavity. The processes branch up to third order. Branching is heteromorphic within a single specimen and commences from $2/3$ along the process length. Mode of excystment not observed.

**Dimensions.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>16 - 22 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>12 - 20 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>8 - 15</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

**Occurrence.** Wenlock to Ludlow series of the Ludlow and Millichope areas of Shropshire (Lister 1970); upper Wenlock to lower Ludlow series of the Welsh Borderland (Dorning 1981a); Much Wenlock Limestone Formation, Wenlock Series of the Dudley area, UK (Dorning 1983).

Known range: Wenlock to Ludlow series.

**Multiplicisphaeridium cf. imitatum** (Deflandre 1945) Lister 1970

Not figured.

1945  *Michrystridium imitatum* sp., nov., Deflandre, p.29, pl. 3, figs 1 - 4.
1968  *Michrystridium imitatum*; Martin, p. 72, pl. 2 fig. 90, pl. 3, fig. 136.
1970  cf. *Multiplicisphaeridium imitatum* (Deflandre 1945) comb. nov., emend.; Lister, p. 90 - 91, pl. 11, figs. 17 - 18, text - fig. 26 d.
1974  *Multiplicisphaeridium imitatum*; Rauscher p. 162, pl. 5, fig. 16
1979  *Michrystridium imitatum* Deflandre; Eisenack *et al.* p. 441 - 442.
1990  *Multiplicisphaeridium imitatum* (Deflandre 1945), Fensome *et al.* p. 348, no fig.

**Diagnosis.** (Translated from Deflandre 1945, p. 29., for comparison). The vesicle globular, bearing numerous processes, the majority of which are forked. On the type specimen it is possible to count more than twenty rising outside the contour of the vesicle. The two other specimens observed bear less processes. The type has in the interior a round body (corpuscle) circular and black, seemingly is made of pyrite. The dimensions are as follows: diameter of the test without the processes 10 μm in diameter to a maximum of 20 μm; process length, maximum length 6 - 7 μm, thickness and width 0.25 - 0.5 μm approximately. It is evidently curious to find a morphology
characterised by forked processes (?) on such a small scale. Despite its smallness, this species, for that reason is very similar in physiognomy to several forms of *Hystrichosphaeridium* of which the type is *H. tubiferum*. It is nevertheless impossible to decide if in *M. imitatum* the processes are hollow or not.

**Remarks.** Vesicle spherical bearing 13 or less processes, numerous slender tapering distally heteromorphic simple and branched to 2nd order within a single specimen. *Multiplicisphaeridium lobeznum* (Cramer 1964b p. 296, pl. 2 fig. 15) seems similar but the photo is not clear enough to be certain. The specimens recovered herein had considerably fewer processes hence the forms are only compared to this species.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Vesicle diameter</th>
<th>10 - 16 µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process length</td>
<td>4 - 6 µm</td>
<td></td>
</tr>
<tr>
<td>Process base width</td>
<td>&lt; 2 µm</td>
<td></td>
</tr>
<tr>
<td>Process number</td>
<td>&gt; 12</td>
<td></td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**Occurrence.** Amongst numerous occurrences from the Ordovician and Silurian, this species has been reported as follows: Silurian of Montagne Noire (Deflandre 1942, 1945); Wenlock to Pridolf series of the Ludlow and Millichope area, Lister (1970, as *M. imitatum*); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); upper Llandovery Series (Purple Shales to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985); upper Silurian of San Juan, Argentina (Rubinstein 1993)

Known Range: Ordovician to Silurian (Fensome et al. 1990)

**Multiplicisphaeridium cf. juliae** (Cramer 1964b)

Plate 3, fig. 4

1964b *Balitisphaeridium juliae* sp. nov. Cramer, p. 296, pl. 1 fig. 4. text-figs. 19. 5; 20

**Description.** Large spherical, vesicle body; laevigate, of medium thickness bearing numerous short processes, less than half the vesicle diameter in length. The processes are heteromorphic in a single specimen, branching commences 2/3 along the process length, up to third order. Mode of excystment not observed.
Remarks. The large spherical vesicle and the very short processes distinguish this form from other species of *Multiplicisphaeridium*.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>30 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>12 - 14 µm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>15+</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

**Occurrence** This form was recorded as a rare type from the Coalbrookdale Formation (Farley Member) of Harley Hill, sample HH2/500.

**Multiplicisphaeridium kiryanovii** sp. nov.

Plate 33, fig. 9, Plate 36, fig. 5; Plate 37, fig. 5.

1978 *Hystrichosphaeridium williereae* (Martin) Kiryanov, p. 90, pl. 9 fig. 4. only.

**Derivation of name.** Named for Russian palynologist, Kiryanov, who first figured a similar form in 1978.

**Holotype.** Plate 37 fig. 5, from the Farley Member of the Coalbrookdale Formation, sample FD 1400/10/1, Rivelin Finder reference K41, from Farley Dingle, Much Wenlock, Shropshire, England.

**Diagnosis.** Yellow brown thick walled vesicle body. Processes communicate freely with the central body cavity. Wide based they taper to fine points and are heteromorphic (simple and branched) within a single specimen. Branching is initiated less than half way along the vesicle length.

**Remarks** *Multiplicisphaeridium variabile* differs in the form of the processes. This form was originally logged as *Multiplicisphaeridium* sp. K.

**Dimensions**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>14 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>18 µm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>7</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>
Occurrence. This species was recorded as a rare type from the Farley Member of the Coalbrookdale Formation to the Much Wenlock Limestone Formation of the Wenlock and Ludlow areas of Shropshire, in samples from Farley Dingle, Harley Hill, Coates Quarry and Pitch Coppice.

**Multiplicisphaeridium leptospinum** sp. nov.

Plate 33, figs. 4, 5.

Derivation of name. From ‘lepto’ meaning thin slender, and ‘spinum’ meaning slender spined, referring to the nature of the processes.

Holotype. Plate 33 fig. 5 from the Much Wenlock Limestone Formation of Coates Quarry, sample number CT6/10/1, Rivelin Finder Reference GH 42; from the type area, Much Wenlock, Shropshire, England.

Diagnosis. Thin walled pale yellow laevigate form. Subspherical vesicle body (diameter 14 - 22 μm) bearing numerous, 20 - 25+, slender hair like processes of length 14 - 22 μm; heteromorphic within a single specimen. Branching where present is initiated 2/3 along the process length. Branching observed up to 2nd order, possibly 3rd but the processes are so fine and slender that fine detail is not easily observed. The process bases are expanded, 2 - 4 μm

Remarks. The specimens recovered are very thin walled and laevigate, bearing numerous fine hair like branches most of which are simple, but a significant proportion bifurcate thus differing from *Michrystridium rarifurcatum* (Kiryanov 1978 p. 64, pl. 8 figs 7 - 8.). This species differs from all the other forms of *Multiplicisphaeridium* recorded herein in the very thin walled body and the fine hair like nature of the processes. *Multiplicisphaeridium rarifurcatum* differs from *Multiplicisphaeridium arbusculum* in having substantially more processes 20 - 25 compared to 6 - 9 in the latter. It differs from *Multiplicisphaeridium neaghe* in that it is between 10 and 15 μm smaller than the specimens recorded by Cramer (1970) and has finer, more filamentous processes.

Dimensions. | Vesicle diameter | 14 - 22 μm |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Process length</td>
<td>12 - 14 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 - 4 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>20 - 25+</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>2</td>
</tr>
</tbody>
</table>
Occurrence. This species has been recorded from the Much Wenlock Limestone Formation of Coates Quarry.

Known Range: Wenlock Series.

**Multiplicisphaeridium paraguaferum** (Cramer 1964b) Lister 1970

Plate 37, figs. 1, 2., Plate 38, fig. 4

1964b *Baltisphaeridium paraguaferum* sp. nov.; Cramer, p. 300 - 301, pl. 2 figs. 3, 4, text - fig. 22: 2, 3.

1965a *Michrystridium paraguaferum*; Deflandre & Deflandre-Rigaud, fiche 2484

1965 *Michrystridium paraguaferum*; Martin p. 18, fig. 16.


1968 *Baltisphaeridium paraguaferum*; Cramer p. 65.

1968 *Baltisphaeridium paraguaferum*; Cramer & Diez p. 546, fig. 3

1968 *Michrystridium paraguaferum*; Martin p. 74, pl. 3 fig. 126, text - fig. 342.

1969 *Baltisphaeridium paraguaferum*; Cramer, p. 486, pl. 1 fig. 8.

1969 *Baltisphaeridium paraguaferum*; Cramer p. 66.

1970 *Baltisphaeridium paraguaferum*; Cramer; p. 126 - 127, pl. 7 figs. 113, 114.

1970 *Multiplicisphaeridium paraguaferum*; (Cramer 1964b), comb. nov. Lister, p. 72.

1990 *Multiplicisphaeridium paraguaferum*; (Cramer); Fensome *et al.* p. 351, no fig.

Holotype Cramer 1964b, p. 300 - 301, pl. 2 fig. 4. from the upper part of the San Pedro Formation, northwest Spain.

Diagnosis. (Cramer 1964b) "Central body and basal parts of the processes hollow with uniform walls. The central body is roughly spherical, moderately thin and transparent. The wall is psilate at 1200 x magnification. The processes are slender pilars ('pillars' J.W.E) that are several times irregularly bifurcated at the tips. The extreme parts of the processes are solid. Number of processes in optical section 15 to 25.

(Cramer 1970) 'Central portion of the vesicle spherical, rigid, clearly differentiated from the processes. Processes distributed regularly: fifteen to more than twenty (average about fifteen) processes visible in optical section. The
processes are columnar, and have a nearly square basal outline. The branching pattern is essentially invariable and is regular. The complexity of the branching however varies greatly from specimen to specimen and from sample to sample. The terminal branches are pinnulae of the second order. The pinnae and pinnulae split from the stem in an essentially dichotomous or trichotomous fashion at a position approximately two thirds along the entire process length. The splitting angle is variable, but falls in most specimens between 90 and 120 degrees. Processes and pinnae are hollow, pinnulae solid. The process and pinnae cavities are connected freely and directly with the central vesicle cavity. Vesicle wall is uniform and unilayered. The ectoderm surface is psilate; it is approximately 0.5 micron thick. No pylome structures or internal cysts seen.

Description. Thin to medium walled, laevigate subpolygonal vesicle body bearing numerous pillar like processes. The processes taper and branch distally up to 2nd order. The numerous processes are heteromorphic within a single specimen. Branching is initiated 2/3 along the process length. laevigate, unilayered vesicle bearing numerous distally branching processes. Process length is greater than the vesicle diameter. Branching up to fourth order. The extreme polygonal nature of the vesicle is a result of the form of the process bases. Processes communicate freely with the central body cavity.

Remarks. The specimens recovered conform broadly to the original diagnosis. The diagnosis allows for a spherical central body but the holotype shows a clear polygonal body, the angular nature being a function of the process bases and their relationship to the central body (Cramer 1964b p. 300, text-fig. 22: 2, 3. pl. 2 fig. 4), whereas the paratype is more spherical in outline, (Cramer 1964b, pl. 2 fig. 3). In this project a clear distinction has been made between these two morphotypes and hence herein the forms that more closely resemble the holotype are included here, being essentially slightly more polygonal in form whilst those with a more spherical central body have been recorded here as Multiplicisphaeridium cf. paraguaferum. This species differs from other species of Multiplicisphaeridium in having a polygonal vesicle rather than spherical to subspherical and the distinctive process morphology, with numerous pillar like processes branching at the distal terminations. The processes are also distinct in their slender form with heteromorphic branching in a single specimen. The highly variable nature in the form of species belonging to the genus Multiplicisphaeridium makes assignation to a species often difficult except with end member forms.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Vesicle diameter</th>
<th>16 - 22 µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process length</td>
<td>14 - 20 µm</td>
<td></td>
</tr>
<tr>
<td>Process base width</td>
<td>2 - 4 µm</td>
<td></td>
</tr>
<tr>
<td>Number of processes</td>
<td>8 - 12+</td>
<td></td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

Occurrence. Upper Llandovery Series to basal Gedinnian of north-west Spain (Cramer 1964, 1967, 1969, Cramer & Diez 1968); middle Silurian of USA and Canada (Cramer 1969a); Llandovery to Wenlock Series of Belgium (Martin 1965, 1966); upper Llandovery to Ludlow series of the USA (Cramer & Diez 1972); Lower Elton
Formation, Ludlow Series of the Ludlow area (Lister & Downie 1974); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); Llandovery Series of north-east Libya (Hill & Molyneux 1988); late Sheinwoodian to early Homerian of the Cheviot Hills, north east England (Barron 1989).

**Occurrence.** This taxon was recorded from the Coalbrookdale Formation (Farley Member) of Farley Dingle, in the type Wenlock area.

Known Range: Silurian to Devonian (Fensome 1990).

### Multiplicisphaeridium cf. paraguaferum

Plate 34, fig. 3

**Description.** Thin to medium walled, laevigate vesicle body bearing numerous pillar like robust processes which communicate freely with the central body cavity. The processes branch distally to third order. Mode of excystment not observed.

**Remarks.** This form differs from the forms assigned to *M. paraguaferum* herein in having a more spherical vesicle. The processes are equal to or less than the vesicle body diameter.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>18 - 20 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>12 - 14 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>1 - 2 μm</td>
</tr>
<tr>
<td>Number of processes</td>
<td>10 +μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

**Occurrence.** This form was recovered from the Coalbrookdale Formation (Farley Member) of Farley Dingle, in the type Wenlock area, Shropshire: (Samples FD 2000).
Multiplicisphaeridium parvum sp. nov.

Plate 33, figs. 7, 8. Plate 35, fig. 2.

Derivation of name. Meaning small, from the Latin 'parvus' - small, little, insignificant.

Holotype. Plate 33 fig. 7, from the Farley Member of the Coalbrookdale Formation of Farley Dingle, Much Wenlock, Shropshire, England. Sample number: FD 2000/10/1; Rivelin Finder reference T 27.

Diagnosis. A diminutive species of Multiplicisphaeridium, subspherical, thin walled vesicle body, measuring between 12 - 16 μm (observed to date). The vesicle bears a few, 6 - 10, short processes, 10 - 14 μm in length, equal to or less than the central body diameter. The processes communicate freely with the vesicle interior and are heteromorphic within a single specimen; either simple or branched to second order.

Remarks. At the risk of incurring the wrath of esteemed colleagues I have compared the forms I recovered from the Welsh Borderland to M. picorricum following Lister (1970). I admit to having not seen the holotype of the species, hence a comparison has been made and not direct attribution to the species. In clarifying my comments herein I refer to (Eisenack et al. 1973 p. 723), who wrote 'The forms reported by Lister as M. cf. picorricum are so different from the real M. picorricum that only an amateur would confuse them.' This may be the case, but the author of that statement makes no attempt to qualify it by remarking on why there are such differences from the original. Thus, whilst I have not been able to observe the holotype of the species the most closely comparable forms to those I have recovered are those reported in Lister (1970) also from the Welsh Borderlands. Thus, I make my own comparison to those illustrated forms. M. picorricum (Cramer 1964b) has longer processes. M. imitatum (Deflandre 1945) differs in having more numerous processes. This species was originally logged as Multiplicisphaeridium sp. M/Q.

Dimensions. Vesicle diameter 12-16 μm

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Process length</td>
<td>10 - 14 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 μm</td>
</tr>
<tr>
<td>Number of processes</td>
<td>6 - 10</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>2</td>
</tr>
</tbody>
</table>

257
Occurrence. Ludlow Series of the Millichope and Ludlow areas of the Welsh Borderland (Lister 1970 as *Multiplicisphaeridium cf. picorricum*); Lower Elton to Upper Whitcliffe formations, Ludlow Series of the Ludlow area (Lister & Downie 1974); upper Silurian of San Juan, Argentina (Rubinstein 1993 as *M. picorricum*).

This species was recovered from the Coalbrookdale, Much Wenlock Limestone and lowermost portion of the Lower Elton formations in the type Wenlock and Ludlow areas of the Welsh Borderlands. Including amongst others the following samples: FD 1200; FD 2000; 2SH 230.

*Multiplicisphaeridium rarifurcatum* Kiryanov 1978, comb. nov.

Plate 35 fig. 6; Plate 36, figs. 2, 3, 4, 6.

1978 *Michrystridium rarifurcatum* sp. nov. Kiryanov, p. 64, pl. 9, figs. 7 - 9.
1990 *Michrystridium rarifurcatum* Fensome et al. p. 331, no fig.

Holotype. *Michrystridium rarifurcatum* Kiryanov 1978 p. 64, pl. 9, fig. 8?, from the Ludlow Series of Podolia.

Diagnosis. (See Kiryanov p. 64, in Russian).

Description. Spherical to subspherical, medium walled vesicle of between 22 - 26 μm. Laevigate body bearing numerous process, 12 - 16 in number, 18 - 16 μm long, heteromorphic in a single specimen, both simple and branched (up to second order). The processes have flared bases, 4 - 8 μm and terminate in acuminate points. Branching occurs 1/2 to 2/3 along the process length.

Remarks. These forms have a similar process morphology to *Michrystridium rarifurcatum* (Kiryanov 1978 p. 64) but has a laevigate vesicle body. This species was recombined because of the branched nature of some of the processes. It is possible that the species assigned herein to *Ammonidium bifurcatum* could be comparable to paratype forms of *Multiplicisphaeridium rarifurcatum* but are clearly distinct from this species *sensu stricto*. This species was initially referred to as *Multiplicisphaeridium sp*.
Dimensions.

- Vesicle diameter: 22 - 26 μm
- Process length: 18 - 16 μm
- Process base width: 4 - 8 μm
- Process number: 12 - 16
- Number of specimens measured: 5

Occurrence. This species was recovered from the Farley Member of the Coalbrookdale Formation from Farley Dingle in the Much Wenlock area of Shropshire.

**Multiplicisphaeridium raspum** (Cramer 1964b) Lister 1974.

Plate 32, fig. 2.

1964b *Baltisphaeridium raspum*; sp. nov. Cramer, p. pl. 4, figs. 1 - 6, 11.
1965 *Michrystridium raspas*; Deflandre & Deflandre - Rigaud, fiche 2488.
1965 *Michrystridium raspas*; Rauscher et al. p. 312.
1968 *Michrystridium raspas*; Martin, p. 77 pl. 3, figs. 145, 146, 157, pl. 5, figs. 241, 242, pl. 8 figs. 377, 384.
1970 *Multiplicisphaeridium raspum* Cramer, Lister, p. 84.
1970 *Multiplicisphaeridium cf. picorricum* (Cramer 1964b) comb. nov.; Lister, p. 92, pl. 11, figs 15 - 16.
1973 *Multiplicisphaeridium raspas* Cramer; Eisenack p. 762.
1990 *Multiplicisphaeridium raspum* Cramer; Fensome et al. p. 354, no fig.

Holotype (Cramer 1964b) p. 301. pl. 4 fig. 1, from the La Vid Shales, Siegenian to Emsian of north-west Spain.

Diagnosis. (Cramer 1964b, p. 301) "Central body and processes hollow, with uniform walls. The central body is roughly spherical, has a moderately thin wall and is moderately transparent. The wall is psilate at 1200x magnification. The processes are simply bifurcated at the tips with branches of the second to third order. Number of processes 10 - 35 in optical section. The number and length of the processes are rather variable."
Remarks. Small spherical vesicle body bearing numerous short processes heteromorphic within a single specimen branching up to first order at the tip. Heteromorphic processes simple and branched up to first order within a single specimen, branching initiated close to the distal termination of the processes. The specimens recovered conform to the original diagnosis. They are small 'scruffy' multiplicisphaerids, laevigate hollow vesicles, bearing numerous, wide based, short, heteromorphic processes.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>12 - 18 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>6 - 14 µm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>8 - 15+</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Occurrence.** Ordovician of Belgium (Martin 1965/6); Silurian of Belgium (Martin 1967); Gedinnian of Brest (Deunff 1980); from the Llandovery to Wenlock of Ireland (Smith 1981); Lower Devonian of Oklahoma USA (Wicander 1986); upper Silurian of San Juan, Argentina (Rubinstein 1993 as M. cf. raspa); late Ordovician of Bolivia (Gagnier 1996); Lower Palaeozoic of the Garhwal Himalaya, India (Sinha et al. 1996); Llandovery to Wenlock Series of Gotland (Eriksson & Hagenfeldt 1997 as M. cf. raspa).

This form was recorded in low numbers from the Farley Member of the Coalbrookdale Formation to the Much Wenlock Limestone Formation of the type Wenlock and Ludlow areas in samples from Farley Dingle and Coates Quarry.

**Multiplicisphaeridium tubispinosum** sp. nov.

Plate 35, fig. 10.

**Derivation of name.** From the Latin 'tubus' - a tube/pipe; 'spinosa' - spine. Meaning tubular spine, referring to the shape of the processes.

**Holotype.** Plate 35, fig. 10 from the Farley Member of the Coalbrookdale Formation of Farley Dingle, Much Wenlock, Shropshire, England. Sample number: FD100/10/1, Rivelin Finder reference ON 42.

**Diagnosis.** Thin walled laevigate vesicle process length less than the diameter of the central body. The
central body is subpolygonal to subspherical depending on the process arrangement. The processes are relatively wide with tubular form and expanded bases. The distal terminations are squat digitate generally first order but up to third order has been observed. The individual branches are very short and 'stubby'. The processes are heteromorphic in a single specimen.

Remarks. This form differs from other species of Multiplicisphaeridium when the short stubby processes are compared, for example to the slender branching seen in M. variabile or M. rarifurcatum. This species is more comparable to Multiplicisphaeridium cladum but the processes are distinctly shorter and more numerous. This species was originally logged as Multiplicisphaeridium sp. X.

Dimensions

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>18 - 20 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>10 - 14 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>4 - 6 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>12 - 16</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>2</td>
</tr>
</tbody>
</table>

Occurrence. This species was recorded from the Coalbrookdale Formation (Farley Member) of Harley Hill and Farley Dingle, in the type Wenlock area.


Plate 33, fig. 6.

1970 Multiplicisphaeridium arbusculiferum var. variabile var. nov.; Lister, p. 87 - 88, pl. 11, figs. 5, 7, 10; text - fig. 25d, 26c.
1981a Multiplicisphaeridium variabile n. stat.; Dorning, p. 194, no fig.
1990 Multiplicisphaeridium variabile (Lister 1970) Dorning 1981; Fensome et al., p. 357, no fig.

Holotype. Lister 1970, pl. 11, fig. 10; Lower Elton Formation, Ludlow Series, Pitch Coppice, Ludlow, Shropshire.

Diagnosis. (Lister 1970, p. 87). ‘A generally polygonal variety of M. arbusculiferum, usually with numerous processes, more or less equal in length to the vesicle diameter. The processes may be slender, tapering with sharply pointed terminations or forking irregularly at moderate angles up to third order, branches are flexuous, tapering to a point. Excystment by cryptosuture.’
**Description.** The vesicle outline is polygonal, hollow and laevigate; generally thick walled bearing numerous, multifurcate, hollow tapering processes which are heteromorphic in a single specimen; simple or branched up to third order. The processes communicate freely with the central body cavity. Mode of excystment not observed.

**Remarks.** This is a broad group covering a wide range of morphologies, as the name describes encompasses variable morphologies.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>14 - 28 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>10 - 25 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 - 4 μm</td>
</tr>
<tr>
<td>Process Number</td>
<td>8 - 20</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

**Occurrence.** This cosmopolitan taxon is wide ranging and is of little stratigraphic use. The occurrences are world-wide a full list of pre 1976 occurrences is available in Eisenack et al. 1973 reported occurrences that have been confirmed as being consistent with the material herein include the following: Upper Llandovery Series, New York USA (Fisher 1953 Wenlock Series to Gedinnian Stage, middle Silurian to Lower Devonian, of the Polignac Basin, Sahara (Jardiné & Yapaudjian 1968); Lower Ludlow Series of England (Lister and Downie 1967); Lower Elton formation Ludlow Series, Ludlow and Millichope area of Shropshire (Lister 1970); middle Homerian to lower Gorstian stages of Britain and Ireland (Aldridge et al. 1979); Gedinnian of Brest (Deunff 1980 as *M. cf. ramusculosum*); Much Wenlock Limestone Formation, Wenlock Series, Dudley, UK (Dorning 1983); Wenlock Series, Austria (Priewalder 1987); Llandovery to Wenlock series of Gotland, Sweden (Le Hérisse 1989); upper Silurian of San Juan, Argentina (Rubinstein 1993); Lower Palaeozoic of the Garhwal Himalaya, India (Sinha et al. 1996).

This species was recovered consistently throughout the samples collected from the Coalbrookdale, Much Wenlock Limestone and lowermost levels of the Lower Elton Formation in the type Wenlock and Ludlow areas in the Welsh Borderlands.

**Multiplicisphaeridium variabile var. 1**

Plate 39, figs. 3, 4.

**Description.** Laevigate vesicle subpolygonal body branching 1/2 to 2/3 along the length of the processes from simple to third order.
Remarks. This form, separated at time of logging the samples is possibly an end member of specific variation in the species *M. variabile*.

**Dimensions.**

- Vesicle diameter: 14 - 24 μm
- Process length: 14 - 24 μm
- Process base width: 6 μm
- Process number: 7 - 15
- Number of specimens measured: 2

**Occurrence.** This morphotype was recorded from the Farley Member of the Coalbrookdale Formation to the Much Wenlock Limestone Formation of the type Wenlock area, Shropshire, England; in samples from Harley Hill, Farley Dingle and Coates Quarry. Samples:

- **Multiplicisphaeridium wrensnestensis** Dorning 1981a.

  Plate 31, figs. 1, 2, 3, 6.

1981a  *Multiplicisphaeridium wrensnestensis* Dorning, p. 195, pl. 1, fig. 3.

1990  *Multiplicisphaeridium wrensnestense* Dorning 1981a; Fensome et al. p. 358, no fig.

1997  *Multiplicisphaeridium ramusculosum*; Wicander & Wood, p. 50-51, pl. 2, fig. 11


**Diagnosis.** (Dorning 1981a p. 195) "Vesicle subspherical to subpolygonal in outline, 30 - 35 μm in diameter, laevigate; 12 - 16 processes, laevigate, 25 - 35 μm long. 4 - 7 μm wide at the broad base, tapering distally to 3 -4 μm wide before branching at about three quarters of the length, branching irregularly up to fourth order, angle 25 - 40°. Excystment by an irregular split.

**Remarks** The specimens recovered conform to the original diagnosis. Spherical laevigate vesicle body robust processes with proximally flared bases and digitate terminations heteromorphic on a single specimen branching up to fourth order. This form is different because of its large size and robust nature with wide processes.
**Dimensions**

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>24 - 28 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>22 - 28 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>10 - 14</td>
</tr>
<tr>
<td>Process base width</td>
<td>4 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

**Occurrence.** This species was recorded from the Wenlock Series of the type area in the Welsh Borderlands (Dorning 1981a); Much Wenlock Limestone Formation of Wrens Nest, Dudley England (Dorning 1983); this form was also recorded as *Multiplicisphaeridium ramusculosum* from the Devonian of Iowa, USA (Wicander & Wood 1997).

This species was recovered consistently throughout the sections studied, being found in the Coalbrookdale, Much Wenlock Limestone and lowermost portion of the Lower Elton formations of the type area. Localities included Farley Dingle, Harley Hill, Coates Quarry, Shadwell Quarry, Pitch Coppice and Mortimer Forest.

**Multiplicisphaeridium sp. 1**

Plate 32, fig. 1

**Description.** Thin walled lemon yellow vesicle body. Outline polygonal, the shape being a function of the process bases. The processes branch at the distal terminations with dichotomous and trichotomous filamentous branches.

**Remarks.** Only one specimen was recorded.

**Dimensions.**

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle body diameter</td>
<td>18 - 20 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>16 - 20 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 - 4 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>7 - 10</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1.</td>
</tr>
</tbody>
</table>

**Occurrence.** This form was recorded as a rare type from a single sample, from the Coalbrookdale Formation, (Farley Member); FD 1200, Farley Dingle, in the type Wenlock area of Shropshire.
Multiplicisphaeridium sp. J

Plate 35, fig. 11.

**Description.** Thin walled, translucent form, very pale lemon yellow easily missed in logging because of its pale form and diminutive nature.

**Remarks.** This form is so small and translucent that it is easily missed. Recorded here to clarify its occurrence on the logging sheets.

**Dimensions**

- Vesicle diameter: 12 - 14 μm
- Process length: 6 - 12 μm
- Process base width: < 2 μm
- Process number: 7 - 14
- Number of specimens measured: 8

**Occurrence.** This species has been recovered from the Farley Member of the Coalbrookdale Formation of Farley Dingle (FD300) in the type Wenlock area.

Multiplicisphaeridium sp. L

Not figured.

**Description.** Very thin walled small form. Spherical vesicle body. Process length greater than the diameter of the central body cavity.

**Remarks.** Only one specimen was recovered and was not relocated hence retained in open nomenclature. The details of which are noted here for consistency with the logging sheets.

**Dimensions**

- Vesicle diameter: 6 μm
- Process length: 10 μm
- Process base width: 1 μm
- Process number: 8
- Number of specimens measured: 1
Occurrence. This morphotype was recorded as a single specimen from sample FD 1500/10/1.

**Multiplicisphaeridium sp. O**

Plate 15, fig. 4; Plate, 34, fig. 2.

*Description* Spherical thin walled laevigate vesicle bearing very long tapering processes up to 200% of the vesicle diameter in length. Processes branch simply to first order at the very tip of the process.

Remarks. This species is similar in form to species of *Dateriocradus* but the processes are not plugged. It also has the polygonal aspect of *Veryhachium*, but has branched, not simple processes.

**Dimensions.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>18 - 24 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>26 - 50 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 - 8 μm</td>
</tr>
<tr>
<td>Process number up to</td>
<td>10</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

Occurrence. This species was recovered from the Farley Member of the Coalbrookdale Formation to the Much Wenlock Limestone Formation of the type Wenlock Area. (Samples: FD 600., FD 900, CT10).

**Multiplicisphaeridium sp. R**

Plate 32, figs. 4, 6.; Plate 38, figs 1, 2., 3.

1989 *Multiplicisphaeridium forquillum* (Cramer & Díez); Le Hérisse, p. 160, pl. 19, figs. 3 - 5.

*Description. Subtriangular laevigate vesicle of medium wall thickness whose outline formed from the position of the processes. The multifurcate branched processes emanate from the central body in two planes. Each process branches at the very tip into two or three fingers tapering and sometimes branching to further degrees. Branching observed up to 3rd order.*

266
Remarks. This species differs from *Dateriocradus monterrosae* in that the processes are not plugged and communicate freely with the central body cavity. This form could be indicative of a morphological continuum between the two genera.

**Dimensions**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>12 - 16 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>16 - 20 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>3 - 4 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>6</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

Occurrence. This species was recorded from the Coalbrookdale Formation (Farley Member) of Farley Dingle, FD 1200.

**?Multiplicisphaeridium sp.**

Plate 38, fig. 6.

**Diagnosis.** Thick walled, laevigate, polygonal vesicle body bearing numerous long slender processes, greater in length than the diameter of the central body. The processes have simple bifurcations at the very distal portion. The polygonal vesicle shape is a function of the flared process base.

Remarks This species is distinctive for its wall thickness and distal simple bifurcations of the processes. Despite being closely similar to the forms logged herein as *Multiplicisphaeridium* sp. O, it is only questionably assigned to this genus because its form is reminiscent of *Veryhachium rhomboidium* var. E.

**Dimensions**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>20 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>24 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>8</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

Occurrence. This form was recovered from the Farley Member of the Coalbrookdale Formation at Farley Dingle.

267
Multiplicisphaeridium sp.

Remarks Includes specimens that adhere to the generic diagnosis but not assigned to a species.

Occurrence. Specimens assigned to this genus but not to a species occurred variously throughout the sections studied.

Genus MURATICAVEA Wicander 1974

Type Species. Muraticavea enteichia, Wicander 1974, p14. pl. 15: 1 - 3, Late Devonian, Ohio, USA.

Diagnosis. (Wicander, 1974, p. 14) "Vesicle circular to oblong in outline, surface reticulocristate and divided into several fields; fields formed by folding of the vesicle wall to produce high ridges; excystment method not observed."

Remarks. Muraticavea is distinguished from Cymatosphaera and Dictyotidium in that the fields are formed from folds in the vesicle wall which produce the high ridges rather than slim membranous extensions of the vesicle wall. The lack of serrated edges to the membranes and ornament of projections from the vesicle separates this genus from Polyedryxium.

Muraticavea wenlockia Doring 1981a.

Plate 40, figs. 1 - 4.

1981a Melikeriopalla wenlockia Doring, n. sp.; Table 1 p. 179, p. 181.
1989 Polyedryxium wenlockium (Doring 1981); n. comb. Le Hérisse, p.181, pl. 20, figs 13 - 16
1993 Polyedryxium wenlockium Rubinstein, p. 70 - 71, no fig.
1990 Muraticavea wenlockia. Fensome et. al. p. 359, no fig.

**Diagnosis.** (Dorning 1981a p. 195) ‘Vesicle subpolygonal, 40 - 80 \( \mu \text{m} \) across, wall laevigate; flanges 18 - 22 \( \mu \text{m} \) long, 4 - 6 \( \mu \text{m} \) high, laevigate, divide the vesicle into polygonal areas up to 25 \( \mu \text{m} \) across. Overall diameter 50 - 90 \( \mu \text{m} \). Excystment mechanism not observed.’

**Remarks.** The specimens recovered in this study conform to the original diagnosis. Specimens have a large subpolygonal vesicle form, divided into 4 - 10 fields by crests formed from the vesicle wall. Mode of excystment not observed. Doming (1981a) stated that other species have smaller polygonal fields. *Muraticavea munificus* is considerably larger. The transfer of this species to *Polyedryxium* by Le Hérisse (1989) p. 180 -181 is not followed as the specimens lack the serrated edges and projections as noted in the remarks by Wicander (1974, p. 14), and the species is retained as *Muraticavea wenlockia*.

**Dimensions.**

<table>
<thead>
<tr>
<th></th>
<th>Vesicle body</th>
<th>36 - 90 ( \mu \text{m} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field width</td>
<td>2 - 26 ( \mu \text{m} )</td>
<td></td>
</tr>
<tr>
<td>Number of fields</td>
<td>4 - 10</td>
<td></td>
</tr>
<tr>
<td>Number of Specimens measured</td>
<td>10.</td>
<td></td>
</tr>
</tbody>
</table>

**Occurrence.** Much Wenlock Limestone formation (Dorning 1981a p. 183 incorrectly named this species, on Table 1, p. 179 and 181 as *Melikeriopalla wenlockia*); Wenlock Series, Much Wenlock Limestone Formation to lower Elton Formation, Dudley, England (Dorning 1983, listed as *Melikeriopalla wenlockia* on p. 33 but illustrated as *Muraticavea wenlockia*) pl. 5. fig 16.; Much Wenlock Limestone formation of the Welsh Borderlands (Dorning & Bell 1987); Mulde Formation, late Wenlock Series of Gotland, Sweden (Le Hérisse 1989 as *Polyedryxium wenlockium*); Silurian of San Juan, Argentina (Rubinstein 1993 as *Polyedryxium wenlockium*); Late Ludfordian, Whitcliffe Common (Washington -Evans 1991).

In this study *Muraticavea wenlockia* was recovered from the following sections: Farley Dingle, Harley Hill, Coates Quarry (CT1, 2, 5, 6, 7, 8, 10, 11), Shadwell Quarry, Pitch Coppice, Mortimer Forest Geological Trail. Much Wenlock Limestone Formation (Homerian) and Lower Elton Formation (Gorstian). This species when present is notably abundant and typically forms a significant proportion of the assemblage, up to 10% of the specimens present in the total assemblage. The restricted range recorded in both Gotland and the type area could make this a species of good biostratigraphic potential enabling international correlations.

Known range: Wenlock (Homerian) - Ludlow (lower Gorstian ) series.
Genus **NANOCYCLOPIA** Loeblich & Wicander 1976

*Type species.* **Nanocyclopia aspratilis** Loeblich & Wicander 1976; Haragan Formation, Lower Devonian (late Gedinnian), Coal County, Oklahoma, U.S.A.

*Diagnosis.* (Loeblich & Wicander, 1976, p. 18) ‘Vesicle spherical with a fimbrate margin, ‘processes ’ tiny, hair-like or nubby and blunt; wall thick, surface rough, scabrate, pitted to granulate; with a large circular to subcircular cyclopyle or cyclopylome with operculum, operculum simple or with inner denser portion slightly elevated and surrounded by a thin flange of less dense material’.

*Remarks* Species belonging to this genus are similar to species of **Leiosphaeridia** Eisenack 1958, but has a granulate vesicle rather than laevigate. The presence of the prominent operculum distinguishes the genus from **Lophosphaeridium**. The presence of this operculum is the prominent diagnostic feature for the genus. **Schismatosphaeridium** differs in having a pore on one surface and a longitudinal split on the other.

**Nanocyclopia alloasperata** sp. nov.

Plate 48, figs. 4, 5, 6, 7.

*Derivation of name.* Meaning another with a roughened appearance; ‘allo-’ another/other/different; and asperata from ‘aspero’ to make rough/uneven. This form being different to the type species **N. aspratilis**.

*Holotype.* Plate 48, fig. 5, from sample HH3 200/10/1 Rivelin finder reference D44 from the Much Wenlock Limestone Formation of Harley Hill, Much Wenlock, Shropshire, England.

*Diagnosis.* A species of **Nanocyclopia** with a subspherical, hollow, relatively thick, single-walled vesicle, 20 μm to 25 μm in diameter. Surface ornament is granulate to scabrate. The circular cyclopyle occupies approximately half the surface of vesicle in profile. The operculum is thin relative to the vesicle. Excystment by cyclopyle (Pylome).

*Remarks.* The circular pylome (cyclopyle) typically has a thickened margin and the operculum is often present. The forms recovered in this study differ from **N. aspratilis** and the synonymous **N. perplexa** Wicander 1986 in that the hair like surface sculpture is not present. **N perplexa** is considerably larger, 48 - 53 μm. This form was logged as **Nanocyclopia** sp. A.
**Dimensions.**

- Vesicle diameter: 25 - 32 μm
- Pylome diameter: 8 - 16 μm
- Number of specimens measured: 10.

**Occurrence.** This species was recovered in moderate numbers, in samples from Farley Dingle, Harley Hill, Coates and Shadwell Quarries, Pitch Coppice and Mortimer Forest Geological Trail.

Known Range: Wenlock Series (Homerian).

**Genus **NAVIFUSA **Combaz et al. 1967**

*Type species.* Navifusa navis Eisenack 1938b, p. 229, pl. 16, fig. 8.; Eisenack et al. 1976, p. 192.

*Diagnosis.* (see Combaz et al. 1967, p. 293, Translation from Eisenack et al. 1979, p. 53). “Shell in the form of a more or less elongated ellipse or of a rod with rounded extremities; vesicle wall simple, smooth or ornamented”.

**Navifusa scrutilla** Cramer & Diez 1972

Plate 27, fig. 1.

1990  
*Navifusa scrutilla* Cramer & Diez 1972; Fensome et al. p. 263, no fig.

*Holotype.* Cramer & Diez 1972, p. 168, pl. 36, fig. 69 from the Waldron Shale, upper Wenlock Series of Kentucky, USA.

*Diagnosis.* (Cramer & Diez 1972, p. 168). "Species of Navifusa characterised by a cylindrical vesicle with rounded terminations. The vesicle wall is smooth under 1,000 x magnification. It is approximately 1 μ thick and is entirely without apparent areas of structural weakness that could be expressed in non-randomly occurring folds. Mode of opening not known."

*Description and Remarks.* Large golden brown sacs recorded informally as Navifusa sp. 1 are now believed to be examples of Navifusa scrutilla Cramer & Diez 1972. Cramer & Diez did not observe an excystment structure.
but a pylome is apparent at one of the poles on the figured specimen herein. The walls are not particularly thick walled despite the brown colour. This is believed to be due to its composition.

**Dimensions.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle width</td>
<td>65 μm</td>
</tr>
<tr>
<td>Vesicle length</td>
<td>110 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1.</td>
</tr>
</tbody>
</table>

**Occurrence.** This form was first recorded from the Wenlock Series of Kentucky, USA (Cramer & Diez 1972). This species was recorded from the sections sampled firstly as 'large brown sacs' then *Navifusa* sp. 1, before being assigned to *Navifusa scrutilla*. The figured specimen was recorded from the Farley Member of the Coalbrookdale Formation of Farley Dingle, Homerian Stage of the Wenlock Series. Locality: Farley Dingle, Much Wenlock, Shropshire, England.

Genus **NEOVERYHACHIUM** Cramer 1970a

Sarjeant & Stancliffe 1994 emend.

**Type Species.** *Veryhachium carminae* Cramer 1964b, pp. 307-309, pl. 16, fig. 1; San Pedro Formation, Ludlow Series - lower Gedinnian Stage of north-west Spain.

**Diagnosis.** (Cramer 1970 p. 110). ‘Vesicle symmetry regular, morphology determined by number of processes. Central body polygonal. The processes are the simple and unbranched of the veryhachiid kind; ornamentation by sculpture, minor. The vesicles open through pylomes. Vesicle wall double; the ectoderm is tightly enveloped by a third wall layer, the periderm’.

**Emended Diagnosis.** (Sarjeant & Stancliffe 1994, p. 42) "Vesicle cushion shaped, triangular to quadrangular in outline, with sides convex to concave. Eilyma conspicuously separated into two layers, the endeilyma forming a distinct inner body expanding at its angles into the spine bases; a tenuous outer layer (ecteilyma) may be present or absent. The spines arise from the angles of the perielyma; an additional spine may arise from the centre of one or both of the shorter sides in species having an oblong vesicle, so that between 3 and 6 spines may be present. All the spines arise in a single plane; all are hollow and cuneiform to acuminate, distally closed, simple and pointed. The spine cavity is separated by the endeilyma from the vesicle interior. Surface of vesicle and spines laevigate of finely granulate, sometimes striate, but without verrucae or secondary spinelets. The escape structure, where developed in quadrangular forms, is a linear slit in the middle of one surface of the pad."

**Remarks.** Specimens considered to belong to this genus in this study area laevigate, unilayered vesicle rectangular in outline, bearing a number of processes (four or five) which communicate freely with the central body
cavity, they have broad bases and are not highly differentiated from the vesicle. The vesicle wall is ornamented with a linear ornament formed from a thickening of the vesicle wall. Excystment by simple split. Notably this differs from the generic diagnoses which states that the species is double walled. No double walled forms were recovered. Likewise in previous studies where the type species Neoveryhachium carminae was recovered, the vesicles were single walled. Unless examination of the holotype for the type species shows different it is worth considering that the generic diagnosis may need emending and in a more simplified manner.

**Neoveryhachium mayhillensis** Doming 1981a

Plate 51, figs. 3, 4.

1981a  *Neoveryhachium mayhillensis* n. sp. Doming, p. 196, pl. 1, fig. 13.

1990  *Neoveryhachium mayhillense* Doming 1981; Fensome et al., p. 364 no fig.

1994  *Neoveryhachium mayhillense* Doming 1981; Sarjeant & Stancliffe, p. 42, no fig.

**Holotype.** Doming 1981a, pl. 1, fig. 13; Lower Elton Formation, Ludlow Series, Wood Green, May Hill, Gloucestershire (SO 6930 1655).

**Diagnosis.** (Doming 1981a, p. 196). ‘Vesicle subrectangular in outline, 30 -35 µm wide, dorsoventrally flattened, laevigate but with striae parallel to the vesicle sides; four processes at the corners of the vesicle, 35 - 45 µm long, 4-5 µm wide at base, tapering distally to a simple sharp termination. Excystment mechanism not observed.’

**Remarks.** The specimens recovered conform broadly to the original diagnosis. Single walled quadrate shaped vesicle, with the folds parallel to the sides. Long slender laevigate processes which communicate freely with the central body cavity. Mode of excystment not observed. This species differs from *Neoveryhachium carminae* which also has linear thickenings on the vesicle surface but is considerably smaller than *Neoveryhachium mayhillense*. Specimens belonging to the *Veryhachium rhomboidium* formgroup are smaller and do not possess the linear striations. The species recovered here do not conform to the generic diagnosis in having a double walled vesicle body but do conform to the species diagnosis of Doming (1981a) and are therefore considered herein to be representative of the species *Neoveryhachium mayhillense*.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>30 - 60 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>20 - 40 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>4</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>
**Occurrence.** This species has been recorded from the Lower Elton Formation, lower Ludlow Series of the Welsh Borderland (Dorning 1981a).

This taxon was recovered from the upper Coalbrookdale and Much Wenlock Limestone formations (Homerian) to Lower Elton Formation, Wenlock to Ludlow Series (Silurian) of the type area in the Welsh Borderland:

**Known Range:** Late Wenlock (upper Homerian) to early Ludlow (lower Gorstian) series.

**Neoveryhachium sp. B**

Not figured.

**Description.** Subrectangular flattened vesicle, single walled bearing four processes extending from the corners of the vesicle. The vesicle body appears laevigate and does not have striae or folds.

**Remarks.** This form was logged separately and hence is included here in the systematic descriptions but whether or not it is a form truly distinct from *Neoveryhachium mayhillensis* is of question. This form was smaller than most of the forms considered to be *Neoveryhachium mayhillensis*.

**Dimensions.**

- Vesicle diameter: 24 - 50 μm
- Process length: 10 - 20 μm
- Process number: 4
- Number of specimens measured: 10.

**Occurrence.** This taxon was recovered from the upper Coalbrookdale and Much Wenlock Limestone formations (Homerian) to Lower Elton Formation, Wenlock to Ludlow series (Silurian) of the type area in the Welsh Borderland.

**Genus OPPILATALA** Loeblich & Wicander 1976.

**Type species.** *Oppilatala vulgaris* Loeblich & Wicander 1976, p. 20; Late Gedinnian, Lower Devonian of Oklahoma, U.S.A.

**Diagnosis.** (Loeblich & Wicander 1976, p.19) "Vesicle circular in outline, with variable number of
processes clearly delineated from the vesicle and mostly multifurcate; wall variously ornamented, double layered, the
processes formed by the outer layer, processes commonly constricted proximally and plugged for a short distance
with material resembling the vesicle wall, processes do not communicate with the vesicle; excystment by a simple
rupture of the vesicle wall."

Remarks. Species belonging to this genus are distinguished by their spherical vesicle bodies bearing slender,
distally branched processes which are plugged either at the base or within the lower portion (proximal) of the
process, excystment is generally by a simple split often equatorial in position. This genus differs from
*Multiplicisphaeridium* Staplin 1961 in the presence of proximally plugged processes, close to or at their junction
with the vesicle. *Cymbosphaeridium* Lister 1970 differs in having a pylome as mode of excystment and cauliflorate
rather than complex branched processes though is similar in having a double walled vesicle and processes which do
not communicate freely with the central body cavity. Some end members of species assigned to *Dateriocradus*
Tappan & Loeblich 1971 and *Multiplicisphaeridium* may be transitional to this genus as with but the form is usually
clearly distinguished by their subpolygonal rather than spherical vesicle form.

**Oppilatala eoplanktonica** (Eisenack 1955a) Dorning 1981a emend.

Plate 42, fig. 5.

1955a  *Hystrichosphaeridium eoplanktonicum* sp. nov. Eisenack, p. 178 - 179, pl. 4 fig. 14.
1959  *Baltisphaeridium eoplanktonicum* (Eisenack); Downie, p. 60, pl. 10, fig. 3.
1963  *Baltisphaeridium eoplanktonicum* (Eisenack); Downie, p. 643, no fig.
1968  *Baltisphaeridium eoplanktonicum* (Eisenack); Cramer p. 127.
1970  *Baltisphaeridium eoplanktonicum* (Eisenack); Cramer p. 128 - 129, pl. 8. figs. 129, 131,
134, text - fig. 39b
1973  *Multiplicisphaeridium septispinosum* (Lister); Eisenack *et al.* p. 617 - 618.
1981a  *Oppilatala eoplanktonica* (Eisenack) Dorning n. comb, p. 196, no fig.
1990  *Oppilatala eoplanktonica*; Fensome *et al.* p. 373, no fig.

*Holotype.* Eisenack, p. 36, p. 178 - 179, pl. 4 ;from a glacial erratic, Ludlovian of the Baltic.

*Diagnosis.* Translated from Eisenack 1955 p. 36. “Central body spherical, small with (here) four long
processes which are branched and extend from the corners of the vesicle.”
Remarks. The specimens observed are consistent with the original diagnosis and have spherical, hollow, smooth walled vesicles bearing few long processes distally branched usually from 2nd to 3rd order. *Oppilatala ramusculosa* (Deflandre) Dorning 1981a and *Oppilatala frondis* (Cramer & Diez) Dorning 1981a have more numerous, shorter processes that exhibit a greater degree of branching.

Dimensions. 

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>18 - 24 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>24 - 48 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 - 2.5 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>4 - 8</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

Occurrence. Ludlow Series of the Baltic (Eisenack 1955a); Llandovery to Wenlock Series of the Welsh Borderland (Downie 1959, 1963); Llandovery to Wenlock Series of eastern USA (Cramer 1968a, 1970); upper Llandovery Series of Belgium (Martin 1967, 1968 as *Baltisphaeridium aff. pilaris*); upper Llandovery to lower Wenlock series of the Welsh Borderlands (Hill 1974; Mabillard & Aldridge 1985; Hill et al. 1985); from the Welsh Borderland (Dorning 1981a); Much Wenlock Limestone Formation of the Welsh Borderlands (Dorning & Bell 1987 as *Oppilatala cf. eoplanktonica*); lower Silurian (Llandovery Series) of north-east Libya (Hill & Molyneux 1987 as *Oppilatala cf. eoplanktonica*); lower Silurian of Ringerike Norway (Smelror 1987b); Buildwas and Coalbrookdale Formations (Sheinwoodian) of the Wenlock area, Eastnor Park Borehole and Central Wales (Swire 1991).

This species has been recovered as a rare type sporadically from the Coalbrookdale Formation at Farley Dingle.

Known Range Upper Llandovery to Ludlow Series.

**Oppilatala frondis** (Cramer & Diez 1972) Dorning 1981a

Plate 42, fig. 1, Plate 43, fig. 4.

1972 *Baltisphaeridium frondis* sp. nov. Cramer & Diez, p. 152, pl. 32, figs. 18,19.
1973 *Multiplicisphaeridium frondis* (Cramer & Diez); Eisenack et al. p. 645.
1978 *Multiplicisphaeridium frondis* (Cramer & Diez); Kiryanov, p. 71, pl. 10 figs. 2, 3, 5.
1981a *Oppilatala frondis* (Cramer & Diez); Dorning n. comb. p. 196, no fig.
1987 *Oppilatala ? frondis* (Cramer & Diez); Priewalder, p. 47, pl. 10 figs. 8 - 11.
1989 *Oppilatala frondis* (Cramer & Diez); Le Hérissé p. 171 - 172, pl. 22, fig. 5, 6.
1990 *Oppilatala frondis* (Cramer & Diez); Fensome et al. p. 373, no fig.

Diagnosis. (Cramer & Diez 1972) "Central body spherical, clearly differentiated from the processes. Processes slender, profusely branched. The first pinnae are about half way the processes. The processes bear pinnae of up to the third order. Around 20 processes present. The body is psilate to microgranulate (the grana are about equidimensional, have blunt round crests and are up to 0.5 µm high); The processes are entirely psilate. Ectoderm about 1 µm thick; no differentiation between processes and central body; processes are hollow except for the thinnest portions; some of the thicker pinnae may be hollow. Endoderm about 1 - 2 µm thick. It is psilate, spherical and closely conformable and in contact with the central body ectoderm. Endoderm generally absent. Mode of opening not known."

Remarks. The specimens covered conform to the original diagnosis, though with fewer processes. These forms are characterised by their large vesicle size, microgranulate medium thickness vesicle wall and complex distal branching, numerous processes and proximally branched process bases. Oppilatala ramusculosa differs in having fewer more slender processes, thinner laevigate wall structure and smaller dimensions. Oppilatala eoplanktonica has a smaller laevigate vesicle body and longer processes with reduced branching.

Dimensions. 

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
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<tr>
<td>Vesicle diameter</td>
<td>28 - 34 µm</td>
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<tr>
<td>Process length</td>
<td>18 - 26 µm</td>
</tr>
<tr>
<td>Process base width</td>
<td>1 - 2 µm</td>
</tr>
<tr>
<td>Number of processes</td>
<td>10 - 16</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

Occurrences. Upper Llandovery to Ludlow series of eastern USA (Cramer & Diez 1972); Wenlock Series of Podolia, Ukraine (Kiryanov 1978); lower Wenlock Series (Sheinwoodian Stage) of the Welsh Borderlands (Dorning 1981a); lower Silurian of Norway (Dorning & Aldridge 1982); upper Llandovery to lower Wenlock series of the Karnic Alps, Austria (Priegwalder 1987); Wenlock Series of the Cheviot Hills of North East England (Barron 1989); Sheinwoodian of the Welsh Borderland (Swire 1991).

This species has been recovered from the Much Wenlock Limestone Formation of Harley Hill and Coates Quarry, with a bloom in sample HH3 800.

Known Range: Llandovery to Ludlow Series.
**Oppilatala gracilenta** sp. nov.

Plate 41, figs. 4, 5. Plate 42, fig. 6.

Derivation of name. Latin ‘gracilentus’ meaning slender, thin; referring to the form of the processes.

**Holotype.** Plate 41, fig. 5, slide CT6/10/1, Rivelin Finder reference: L32 from the Much Wenlock Limestone Formation of Coates Quarry, Shropshire, England.

**Diagnosis.** Spherical laevigate vesicle bearing slender fine processes branched 2/3 along the length up to fourth order. The processes are heteromorphic within a single specimen and the angle and degree of branching is variable. The processes have restricted bases at the junction with the vesicle body and do not communicate freely with the central cavity. The vesicle wall is of moderate thickness, the processes being thinner. Mode of excystment not observed.

**Remarks.** This species is a diminutive form of the genus *Oppilatala*. This form has been recovered previously by Smelror (1987 as *O. cf. eoplanktonica*) and Swire in unpublished work (1991 as *O. smelrorii* p. 198) from the Sheinwoodian Stage of the Wenlock Series in the type Wenlock area. The wider range in size described by these authors (18 - 32 µm) was not recorded herein. The specimen figured on pl. 20, fig. 7 of Swire (1991) most closely resembles the forms assigned to the taxon herein.

This species differs from *O. ramusculosa*, *O. frondis* and *O. sparsa* Wicander & Wood, by its small size and from the *O. frondis* by the laevigate nature of the ectoderm. They have more processes that exhibit a greater degree of branching than *O. septispinosa*, *O. cf. septispinosa* and *O. eoplanktonica*.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>14 - 16 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>12 - 24 µm</td>
</tr>
<tr>
<td>Process base width</td>
<td>1 µm</td>
</tr>
<tr>
<td>Number of processes</td>
<td>6 - 8</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Occurrence.** Silurian of the Ringerike district of Norway (Smelror 1987 as *O. cf. eoplanktonica*), Lower Wenlock Series (Sheinwoodian Stage) of the type Wenlock area and Wales (Swire 1991 unpublished, as *O. cf. smelrorii*).
This species has been recovered from the Coalbrookdale to Lower Elton formations of the type Wenlock area; Farley Dingle, Shadwell Quarry, Harley Hill, Coates Quarry, and the Much Wenlock Limestone to Lower Elton Formation of the Ludlow area of the Welsh Borderlands; Mortimer Forest Geological Trail and Pitch Coppice.

On the log sheets and Tilia this form appears as Oppilatala sp. B.

Known Range. Wenlock Series.

**Oppilatala insolita.** (Cramer & Diez 1972) Dorning 1981a

Plate 43, fig. 3.

1972 *Baltisphaeridium ramusculosum var. insolitum*, Cramer & Diez, p. 155, pl. 33, fig. 36, 37, pl. 34 fig. 38.
1981a *Oppilatala insolita* (Cramer & Diez) n. comb. Dorning, p. 196, no fig.
1989 *Oppilatala insolita* (Cramer & Diez); Le Hérisse p. 172, 174, pl. 22, figs. 7, 8.
1990 *Oppilatala insolita*; Fensome et al. p. 373, no fig.

**Holotype.** Cramer & Diez 1972, p. 155, pl. 34 fig. 38, from the Waldron Shale of Bardstown, Kentucky.

**Diagnosis.** (Cramer & Diez 1972, p. 155) "Central body spherical, clearly differentiated from the long and thin processes. Processes flexible, bifurcating and branching numerous times from approximately the distal half of the processes. The processes may bear pinnae of up to the fourth order; no appreciable difference in the construction between the pinnae and processes. The general pattern and morphology of branching is of the ramusculose kind. From four to ten processes are present. The body and process surface is psilate. Ectoderm 0.5 - 1 μ thick, no structural difference between the lower portion of the processes and the central body is apparent; however the upper part of the processes is often more transparent and has a lighter color than the rest of the vesicle. The processes are hollow except the thinnest pinnulae. Endoderm about 1 - 2 μ thick. It is psilate, spherical and closely conformable and in contact with the central body ectoderm. Endoderm generally absent. Mode of opening not known."

**Remarks.** The specimens recovered have spherical to subspherical laevigate vesicles bearing numerous highly ramified slender branches. Mode of excystment by simple split. This is a smaller form than *O. ramusculosum* and *O. frondis* bearing fewer longer processes. The branching is more highly ramified than that seen in *O. eoplanktonica* and *O. septispinosa* but is otherwise quite similar in form to the latter.
Dimensions.  
Vesicle diameter 22 - 30 µm  
Process length 24 - 42 µm  
Process base width 1.5 - 2.5 µm  
Number of processes 6 - 8  
Number of specimens measured 8

Occurrence. Llandovery Series of Pennsylvania (Cramer 1969a) lower Silurian of Ohio and upper Llandovery Series to Gedinnian Stage of north-west Spain (Cramer & Diez 1972); Llandovery Series of Belgium (Martin 1966, 1968);

This species has been recovered as a rare type from the Much Wenlock Limestone Formation of Harley Hill.

Known Range:

Oppilatala ramusculosa Deflandre 1945, Dorning 1981a

Plate 42. figs. 2, 4; Plate 43. figs 1, 2, 5, 6.

1942  Hystrichosphaeridium ramusculosum Deflandre, 1945, pl. 1, figs. 8 - 10 nomen nudum.
1945  Hystrichosphaeridium ramusculosum Deflandre, p. 63.
1970  Baltisphaeridium ramusculosum (Deflandre 1942) Downie 1959; Cramer, p. 127 - 128, pl. 7, fig. 120., 121, 123, 124, 125, 126, text-fig 39a
1970  Multiplicisphaeridium? cf. eoplanktonicum (Eisenack 1955) comb. nov.; Lister 1970, pl. 89, pl. 12, fig. 17, text - fig. 25 f.
1972  Baltisphaeridium ramusculosum (Deflandre 1942) ramusculosum (new variety); Cramer & Diez, p. 156 - 157, pl. 34, fig. 41
1981a  Oppilatala ramusculosa (Deflandre 1945); Dorning n. comb., p. 196, no fig.
1989  Oppilatala ramusculosa ramusculosa (Cramer & Diez) n. comb. Le Hérisssé, p. 177 - 178, pl. 23, figs 5 - 7, text-fig. 14.5.
1990  Oppilatala ramusculosa var. ramusculosa; Fensome et al., p. 373, no fig.
Holotype. Cramer & Diez 1972, pl. 34, fig. 41; Alger Shale, upper Llandovery Series of Ohio, USA.

Diagnosis. (Cramer & Diez 1972, p. 156). "Central body spherical, clearly differentiated from the processes. Processes slender, flexible, irregularly branched distally. They may bear pinnae of up to the fourth order; no appreciable difference in construction between simply and profusely branched processes. Five to twelve processes present.

The body and process surface is psilate. Ectoderm about one micron thick; no structural differentiation between processes and central body is apparent. The processes are hollow except for the thinnest portions of the pinnae. Endoderm about one to two microns thick. It is psilate, spherical and closely conformable and in contact with the central body ectoderm. Endoderm generally absent. Mode of opening not known."

Remarks. The specimens recovered conform broadly to the original diagnosis with laevigate, medium wall thickness, spherical vesicles bearing medium to long processes proximally plugged and distally branched (up to fourth order), two thirds along the length of the process and do not communicate with the central body cavity. The processes are 100 to 150% of the vesicle diameter. Excystment is by median split. The specimens recovered herein are smaller in size than those described by Cramer & Diez (1972) and the original diagnosis also states that the processes do communicate with the vesicle interior. The holotype has not been examined.

Dimensions.  

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>24 - 32 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>20 - 28 µm</td>
</tr>
<tr>
<td>Process base width</td>
<td>1.5 - 2 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>6 - 12</td>
</tr>
<tr>
<td>Branching dimensions</td>
<td>20 µm / 14µm / 4µm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10.</td>
</tr>
</tbody>
</table>

Occurrence. Upper Llandovery to upper Wenlock series of Eastern USA (Cramer & Diez 1972b); Ludlow Series of the Ludlow and Millichope areas, Shropshire (Lister 1970, as *M. cf. eoplanktonicum*); lower Wenlock to upper Ludlow series of the Welsh Borderland (Dorning 1981a); Much Wenlock Limestone Formation, Homerian Stage of the Wenlock Series from Wren's Nest, Dudley in the West Midlands, England (Dorning 1983); Chester Berg Formation, Wenlock Series of Greenland (Armstrong & Dorning 1984); upper Llandovery to lower Wenlock series of the Welsh Borderlands (Mabillard & Aldridge 1985); upper Llandovery Series (Purple Shales) to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985); lower Silurian (Llandovery Series) of north-east Libya (Hill & Molyneux 1987); lower Silurian of Ringerike Norway (Smelror 1987); Llandovery to basal Wenlock series of Gotland, Sweden (Le Hérissé 1989).
This species has been recovered from the Much Wenlock Limestone Formation of Harley Hill, Shadwell Quarry, Coates Quarry, (notable numbers in sample CT2) in the type area, Much Wenlock, Shropshire, UK.

Known range: Upper Llandovery to lower Ludlow series.

**Oppilatala schistosa** sp. nov.

Plate 41, figs. 6, 7, 8.

*Derivation of name.* Latin 'schistos' meaning 'split or divided'. Suffix '-a' adjective suffix for nouns, 'plenitude or notable development'. Referring to the wide angle of branching of the processes.

*Holotype.* Plate 41, fig. 6, from sample FD600/10/1, Rivelin Finder reference T42 from the Farley Member of the Coalbrookdale Formation, Homerian Stage of the Wenlock Series of Farley Dingle, Much Wenlock, Shropshire, England.

*Diagnosis.* Thin walled, laevigate, spherical vesicle 18 - 28 μm in diameter, bearing a few short processes 16 - 20 μm in length, being equal to or less than the vesicle diameter. The processes are plugged close to their base and do not communicate freely with the central vesicle cavity; they are slender, formed from restricted bases that are clearly differentiated from the main vesicle they taper to an initial bifurcation of the process about 3/4 of the way along the length of the process. This initial branch is generally wide angled. Further branching observed to date up to 2nd order. Branching is heteromorphic within a single specimen. Mode of excystment is by a large pylome.

*Remarks.* This species differs from other species of *Oppilatala* in the low order distinctive process branching with the initial wide angle bifurcation. Originally logged with the species *Oppilatala ramusculosa* this form was separated post logging on closer inspection of individuals highlighted for re-inspection. Therefore this species does not appear separately on the logging sheets or on the Tiliagraphs.

*Dimensions.*

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<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>18 - 28 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>16 - 20 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>1.5 - 2 μm</td>
</tr>
<tr>
<td>Number of processes</td>
<td>5 - 8</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5.</td>
</tr>
</tbody>
</table>
Occurrence. This species was recorded in low numbers from the Farley Member of the Coalbrookdale Formation to the Much Wenlock Limestone Formation of the Much Wenlock area, Shropshire, England. Localities: Farley Dingle and Coates Quarry.

Known Range. Homerian Stage, late Wenlock Series.


Plate 37, fig. 6. Plate 39, figs. 1, 2.

1970 Multiplicisphaeridium? septispinosum sp. nov.; Lister, p. 94 - 95, pl. 12, figs 9, 10, 11, 12, ?13, ?15, ?16, not 14; text-figs 19 b, c, 25 e.

1981a Oppilatala septispinosa (Lister) n. comb. Dorning, p. 196, no fig. (not valid).

1989 Oppilatala cf. septispinosa (Lister) n. comb. p. 179, pl. 24, fig. 10, text -fig. 14.1

1990 Oppilatala septispinosa (Lister) Le Hérisse; Fensome. p. 373, no fig.

Holotype. Lister 1970, pl. 12, fig. 9; Lower Bringewood Formation, Ludlow Series, Ludlow, Shropshire.

Diagnosis. Lister 1970. pp. 94, 95. “Vesicle hollow, smooth, spherical, relatively thin walled; processes, few in number, are long slender tubes which distally may become strap-like and which divide into delicate fingers sometimes regularly, sometimes irregularly; proximally the processes communicate freely with the vesicle cavity but are invariably septate about 1/4 of the way along their length.”

Remarks. The specimens observed conform to the original diagnosis. Subspherical, pale yellow laevigate vesicles of medium wall thickness bearing several long slender, hollow, distally branched processes which are thinner than the vesicle body. The processes are plugged 1/4 way up their length and do not communicate with the central body cavity. The processes are heteromorphic within a single specimen and both simple and branched processes may be present. Branching occurs 2/3 of the way down processes and ramifies up to second order. Mode of excystment is by median split. The synonymy of this species to Oppilatala eoplanktonica (Eisenack 1955) as suggested by Eisenack et al. (1979) is not followed herein. The forms are believed to be distinct with this species having broader processes which as stated in the diagnosis may become 'strap like'.

283
Dimensions. | Vesicle diameter | 18 - 26 μm |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Process length</td>
<td>24 - 46 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 - 2.5 μm</td>
</tr>
<tr>
<td>End to end</td>
<td>68 - 78 μm</td>
</tr>
<tr>
<td>Process branches</td>
<td>2 - 6 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>4 - 8</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

Occurrence. Upper Wenlock (Much Wenlock Limestone Formation) to Prídolí (Downton Castle Sandstone Formation) series of the Ludlow and Millichope areas of Shropshire (Lister 1970); Silurian of Gotland, Sweden (Le Hérissé 1989); Ludlow Series, late Ludfordian of Whitcliffe Common (Washington - Evans 1993).

This species has been recovered consistently from the Coalbrookdale through Much Wenlock Limestone to lower Elton Formations of the type Wenlock and Ludlow areas; Harley Hill, Farley Dingle, Shadwell Quarry, Coates Quarry, Pitch Coppice and Mortimer Forest Geological Trail.

Known range: Wenlock - Prídolí series.

**Oppilatala cf. septispinosa** (Lister 1970) Le Hérissé 1989

Plate 41, figs. 1, 2, 3. Plate 42, fig. 3.

1970 *Multiplicisphaeridium? septispinosum* sp. nov.; Lister, p. 94 - 95, pl. 12, figs 14, 15, 16, not 9, 10, 11, 12, 13.

1989 *Oppilatala cf. septispinosum* (Lister) n. comb.; Le Hérissé, p. 179, pl. 24, fig. 10, text - fig. 14.1

Description. Spherical to ellipsoidal vesicle body, the majority of specimens having an ellipsoidal outline due to compression. The vesicle is laevigate and bears several long (length greater than the diameter of the central body by 100 - 150 %), slender, cylindrical thin walled processes, isolated from the central body, the number of which is variable from 5 - 8 on a single specimen. The processes are heteromorphic in a single specimen and can be simple or exhibit 1st to 2nd order branching. Excystment is by simple split.

284
Remarks: This form differs from the holotypic material of *O. septispinosa* in having much longer processes which are plugged closer to the base thinner walled processes and an excystment mechanism of a simple rupture rather than a diagnostic median split. These forms were logged separately from those considered to be *O. septispinosa* sensu stricto and are herein retained as a separate morphotype though that does not imply that there is no relationship between this form and the former. Not included in the synonymy but a species whose photograph of the holotype also shows similarities to the forms considered herein is *Oppilatala grahnii* Hérissé 1989 (p. 17 pl. 23, fig. 4). These similarities are noted within the remarks and not included under synonymy until examination of the holotype has been carried out. The synonymy of this species with *Oppilatala eoplanktonica* is not followed herein because it is believed that the forms can be distinguished.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>18 - 24 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>32 - 44 µm</td>
</tr>
<tr>
<td>Process width</td>
<td>1.5 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>4 - 6</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

**Occurrence.** Ludlow and Millichope areas of the Welsh Borderland (Lister 1970); Hemse Formation (Bringewood Formation), Ludlow Series of Gotland Sweden (Le Hérissé 1989); Sheinwoodian of the type area (Swire 1991)

This species has been recovered from the Coalbrookdale, Much Wenlock Limestone and Lower Elton formations in samples from Farley Dingle, Harley Hill, Shadwell Quarry, Coates Quarry Mortimer Forest Geological Trail, Pitch Coppice, from the type Wenlock and Ludlow areas in the Welsh Borderlands.

Known Range: upper Wenlock to Ludlow Series.

**Oppilatala sp. X**

Plate 38, fig. 5.

Remarks: Single specimen recorded with a large central body, laevigate, thin walled bearing processes which do not communicate with the central body and exhibit a low order of branching. Mode of excystment - pylome.
Dimensions.  

<table>
<thead>
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<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>24 - 30 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>16 - 22 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>1.5 - 2 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>9</td>
</tr>
<tr>
<td>Pylome diameter</td>
<td>8 x 10 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

Occurrence. This form was recorded from the Farley Member of the Coalbrookdale Formation (Homerian Stage), Wenlock Series of the type Wenlock area, from Farley Dingle (FD1200), Much Wenlock, Shropshire, England.

Known Range. Homerian Stage, Late Wenlock Series.

Oppilatala spp.

Description. Thin to medium walled spherical vesicle cavities, proximally plugged thin laevigate processes equal to or greater than the vesicle body diameter.

Remarks. Specimens conforming to the generic diagnosis but unable to assign to a species due to poor preservation or partial specimens were assigned herein.

Occurrence. Poorly preserved specimens have been recovered throughout the sections but particularly in the abundant and diverse samples of Farley Dingle and Harley Hill.

Genus PERCULTISPHAERA Lister, 1970

Type species. Percultisphaera stiphrospinata Lister 1970, from the Lower Leintwardine Formation, Ludlow Series (Silurian), Ludlow, Shropshire.

Diagnosis (Lister 1970, p. 96) “Vesicle hollow, subspherical to ovoidal, moderately thin-walled. Ornamentation of two orders: a minor ornamentation comprising small (0.5 - 1 μ) close-set, evenly-spaced, uniform, subconical to tubular elements, with capitate or distally expanded terminations, and a major ornamentation of slender solid spines, irregularly spaced and which may be simple or branching. Excystment aperture apical or near equatorial in position, and of subhexagonal outline.”
Remarks. This is a very distinctive genus, with its two ornament types.

**Percultisphaera pilosa** (Downie 1963) Dorning 1981a recorded herein as **Helosphaeridium pseudodictyum** Lister 1970

Remarks. It is noted here though that forms from the Wenlock Series that have previously been attributed to *P. pilosa* (Downie 1963) Dorning 1981a belong to *Helosphaeridium pseudodictyum* Lister 1970 in its excystment state. The filaments accorded to be the fine processes of a secondary ornament are actually the result of the 'rough edge' from the tearing of the vesicle body.

Occurrence. These forms were recorded regularly throughout the study section and were reported as *Helosphaeridium pseudodictyum*.

**Percultisphaera cf. stiphrospinata** (Lister 1970)

Plate 54, fig. 11.

1970  *Percultisphaera stiphrospinata* Lister, p. 96-97, pl. 13, figs. 1-7, 9. text-figs. 19 d - f, h, 27d.
1990  *Percultisphaera stiphrospinata* Lister; Fensome *et al.* p. 388, no fig.

*Holotype. Percultisphaera stiphrospinata* Lister, 1970, p. 96 - 97, pl. 13, fig. 1; from the Lower Leintwardine Formation, Ludlow Series (Silurian), Whitcliffe, Ludlow, Shropshire.

*Diagnosis.* (Lister 1970, p. 96 as above for the genus. See also remarks and excystment, p. 96 - 97.)

*Description.* Spherical medium walled vesicle body, ornamented with a coarse 'granulation', the central body bearing a number of solid, simple, wiry processes, lacking distinctive branching of processes belonging to this species *sensu stricto*. Mode of excystment not observed.
Remarks. Only one specimen was recovered as a rare type. The specimen recovered differed from those previously recorded by the author from the Ludfordian of the Ludlow area in lacking branched terminations to the processes, a feature which was consistently recorded in Ludlow specimens.

Dimensions. Vesicle diameter 24 µm  
Process length 14 µm  
Process width 0.5 - 1 µm  
Process number 14  
Number of specimens measured 1.


This species was recorded as a rare type from the Farley Member of the Coalbrookdale Formation of Farley Dingle, Much Wenlock, Shropshire, England. Sample: FD 1200/10/1 P45.

Known Range. Uppermost Wenlock Series to Gedinnian Stage, (Silurian to Devonian).


Type species. Psenotopus chondrocheus Tappan & Loeblich 1971, p. 408, pl. 11, figs 1-6; Waldron Formation, Wenlock Series, Indiana, USA.

Diagnosis. (Tappan & Loeblich 1971, p. 406). 'Vesicle spherical, surface gemmate, ornamented with low tubercles or processes arranged in patches or bands separated by bare and laevigate areas; processes apparently solid, low, circular in plan view, varying in size, rounded and smooth to slightly knobby, with a slight tendency to appear aculeate at the tips; wall thin, smooth but commonly with microridges and small, rare, scattered granules; excystment by a simple rupture of the vesicle'.
Remarks. *Psenotopus* differs from *Lophosphaeridium* in having an ornament of varied solid tubercules arranged in bands over the vesicle whereas the latter bears a closely spaced even ornament. *Psenotopus* also differs from *Visbysphaera* in having uneven ornament distribution, despite similarities in wall thickness. The ornament does not communicate with the interior of the vesicle body. Folding of the vesicle wall tends to occur in the laevigate portion of the vesicle which suggests that the wall is thinner and/or less robust in these areas.

*Psenotopus chondrocheus* Tappan & Loeblich 1971.

Plate 45, fig. 1.

1971 *Psenotopus chondrocheus* n. sp. Tappan & Loeblich, p. 408, pl. 11, figs 1-6.
1990 *Psenotopus chondrocheus* Tappan & Loeblich 1971; Fensome et al., p. 421, no fig.

*Holotype.* Tappan & Loeblich 1971, pl. 1, fig. 3; Waldron Formation, Wenlock Series, Indiana, USA.

*Diagnosis.* (Tappan & Loeblich 1971, p. 408). ‘Vesicle spherical, in compression somewhat angular; surface gemmate, ornamented with low apparently solid tubercles or processes that occur in patches or bands separated by bare areas; tubercles low, circular in plan view, ranging in size from 0.7 μm to 1.5 μm, irregularly spaced from 0.6 to 5.3 μm apart in side view commonly tending to become aculeate, with small projections at the summit; in compression or under high vacuum in an evaporator the areas of bare surface tend to collapse, whereas the bands or patches carrying the tubercules are stronger and stand up owing to the added thickness of the wall; wall thin, about 0.5 μ in thickness, smooth or with minute spherical gemmules and a fine series of irregular ridges; excystment by a simple rupture and splitting of the vesicle wall’.

*Dimensions.*

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle body</td>
<td>68 - 80 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>0.5 - 2.5 μm</td>
</tr>
<tr>
<td>Process width</td>
<td>0.5 - 2 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>8</td>
</tr>
</tbody>
</table>

*Remarks.* The specimens recovered conform to the original diagnosis, with a relatively large, medium to thick, single walled vesicle body, spherical to elongate in outline and ornamented with tubercules arranged in restricted bands. The remaining surface of the vesicle body is laevigate. Specimens belonging to this species are easily identifiable as they bear no resemblance to any other acritarch species or genus. *Lophosphaeridium citrinum* Downie 1963 has capitae process terminations and does not exhibit localised ornament development. Mode of excystment observed as a simple rupture.
Occurrence. *Psenotopus chondrocheus* has been reported from the Waldron Formation, Wenlock Series, of Indiana, USA (Loeblich & Tappan 1971); Much Wenlock Limestone Formation (Homerian), upper Wenlock Series of the Welsh Borderland (Doming 1981a); Lower Elton Formation, Ludlow Series of Dudley, West Midlands (Doming 1983); lower to middle Wenlock Series of Gotland, Sweden (Le Hérissé 1989); Sheinwoodian to Homerian, Wenlock Series of the Wenlock Type area and the Malvern Hills (Swire 1991); Wenlock Series from Holbrook Coppice, near Ironbridge, Shropshire (Turner *et al.* 1995).

In this study *Psenotopus chondrocheus* occurs as a rare type sporadically in the following sections Shadwell Quarry, Pitch Coppice (Lower Elton Formation).

Known Range: Wenlock to Ludlow Series (Silurian).

Genus **Pterospermella** Eisenack 1972.

*Type Species.* *Pterospermella aureolata* (Cookson & Eisenack 1958) p. 49, pl. 9, figs. 11 Birdrong Formation, Lower Cretaceous of Western Australia.

*Diagnosis* (Translated from Eisenack, 1972, p. 597) Microfossil of organic substance, which on examination has a circular to oval central body in the top view, which in the axial section is mainly elongately oval, rarely it is circular. Surrounding the central body is an equatorial, concentric, ring-like, double walled, smooth-edged or serrated flange. The seam of the flange (wing) can be smooth or may have radial folds. The mode of excystment is not known.

*Remarks.* *Pterospermella* is used herein rather than *Pterospermopsis*.

*Pterospermella foveolata* Lister in Doming 1981a.

Plate 14, figs. 1, 2.

1974 *Pterospermopsis foveolata*; Hill, p. 13, (*nomen nudum*).
1975 *Duvernaysphaera magna* Pöthe de Baldis p. 495 - 496, pl. 4, fig. 3.
1981a *Pterospermella foveolata* Lister n. sp.; Dorning, p. 197, pl. 3, fig. 18.

1984 *Pterospermella martinii* Cramer 1967; Le Hérissé, p. 230, pl. 2, figs. 11 - 12, pl. 3, figs. 1, 4.

1989 *Pterospermopsis martinii* Cramer; Le Hérissé, p. 78 - 79, pl. 4, figs. 10, 14.

1990 *Pterospermella foveolata* Dorning 1981; Fensome *et al.*, p. 426, no fig.

**Holotype.** Dorning 1981a, p. 197, pl. 3, fig. 18, Ludlow Series, May Hill, Gloucestershire, England.

**Diagnosis.** (Dorning 1981a, p. 197), 'Vesicle subspherical 20 - 25 μm across, granulate; one equatorial flange, thin, laevigate 10-15 μm high, often with numerous radial folds near the vesicle margin. Excystment by a straight split in the vesicle wall'.

**Remarks.** The specimens recovered conform to the original diagnosis. Spherical central body with a diaphanous, transparent equatorial outer flange, with radial folds. Excystment by simple split. Dorning (1981a) retained Lister's unpublished name. Radial folds are also diagnostic for the species *P. martinii* (Cramer 1967). *Pterospermella onondagaensis* by comparison is smaller, thin walled and lacks the ornamentation to the central body.

**Dimensions.**

<table>
<thead>
<tr>
<th></th>
<th>Vesicle diameter</th>
<th>Flange width</th>
<th>Entire body</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16 - 30 μm</td>
<td>12 - 18 μm</td>
<td>32 - 68 μm</td>
</tr>
</tbody>
</table>

**Occurrence.** This species has been recovered from the Wenlock Series of Ontario, Canada (Thusu 1973a, as *Pterospermopsis* cf. *P. martinii*); Wenlock Series of Argentina (Pothe de Baldis 1975 as *Duvernaysphaera magna*); upper Llandovery Series of the type Llandovery area in the Welsh Borderlands (Hill 1974, Hill & Dorning 1984); upper Llandovery to Wenlock series of the Welsh Borderland (Dorning 1981a); upper Llandovery Series to lower Wenlock Series of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985); Wenlock/Ludlow series of Algeria (Jardiné *et al.* 1974); Much Wenlock Limestone Formation, Wenlock Series of Dudley, West Midlands, England (Dorning 1983); Llandovery Series of Ringerike, Norway (Smelror 1987); lower Visby to upper Hemse formations, upper Llandovery to lower Ludlow series of Gotland, Sweden (Le Hérissé 1984, as *Pterospermopsis martinii*); Coalbrookdale Formation (Homerian) of the Wenlock Series from Shropshire, England (Turner *et al.* 1995).
This species has been recovered from the Coalbrookdale formation to lower Elton Formation from the type areas of Much Wenlock and Ludlow Shropshire. Localities: Farley Dingle, Harley Hill, Pitch Coppice, Mortimer Forest and Coates Quarry. This species was recovered consistently albeit in low numbers throughout the samples.

Known range: upper Llandovery - Ludlow series.

Pterospermella onondagaensis Deunff 1955

Plate 14, fig. 4.

1955 Pterospermopsis onondagaensis Deunff, p. 148, pl. 106, fig. 16, 20, text - fig. 27.
1959 Pterospermopsis cf. onondagaensis Downie, p. 64, pl. 12, fig. 8.
1990 Pterospermella onondagaensis Fensome et al. p. 427, no fig.

Holotype. Deunff 1955, p. 148, text - fig. 27, from the Onondaga Formation, Devonian of Canada.

Diagnosis. (Translated from Deunff 195, p. 148) "Central body globular with a diameter of 10 µ encircling is a thin equatorial membrane, translucent of 5 - 6 µ in width. The border of the membrane is deformed in part, but appears to be regular."

Remarks. The specimens recovered conform to the original diagnosis. Vesicle thin walled, small, hollow, spherical, surrounded by a flat equatorial flange, thin but not folded like in P. foveolata. This species is characterised by its small size especially in relation to the width of the equatorial flange, P. foveolata. is considerably larger. Mode of excystment not observed.

Dimensions. Vesicle diameter 10 - 14 µm
Outer membrane 10 - 18 µm
Number of Specimens measured 4

Occurrence. Onondaga Formation, Devonian of Canada (Deunff 1955); Wenlock Series of England (Downie 1959, 1963); Llandovery Series, Silurian of Belgium (Stockmans & Willière 1963); Upper Ludlow to Emsian (San Pedro Formation) of north west Spain (Cramer 1964); Silurian of Belgium (Martin 1966, 1968); upper
Llandovery to Ludlow series of the USA (Cramer & Diez 1972); Wenlock Series of Ontario (Thusu 1973a); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); Ludlow Series of Brittany (Deunff 1980); Devonian of Morocco (Marhoumi & Rauscher 1984); Devonian of Boulonais, France (Le Hérisse & Deunff 1986); Ludlow Series of Argentina (Pôthe de Baldis 1981 as *P. aff. onondagaensis*); upper Silurian of San Juan, Argentina (Rubinstein 1993).

Specimens belonging to this species were rare from the Much Wenlock Limestone Formation, Coates Quarry (CT6, CT11) in the type area of Much Wenlock, Shropshire, England.

Known range. Wenlock Series (mid Silurian to Emsian Stage (mid Devonian).

**Pterospermella pertonensis** Dorning, 1981a

Plate 14, fig. 3

1981a *Pterospermella cf. pertonensis* Dorning, p. 197, pl. 3, figs. 7, 8.

1990 *Pterospermella pertonense* Fensome *et al.* p. 427, no fig.

**Holotype.** *Pterospermella pertonensis* Dorning 1981a, p. 197, pl. 3, fig. 7; Leintwardine Formation, Ludlow Series of May Hill, Gloucester, England.

**Diagnosis** (Dorning 1981a, p. 197) ‘Vesicle subspherical to ovoidal, 15 - 22 μm in diameter, laevigate to microgranulate; equatorial flange, thin, 5 - 7 μm wide, laevigate; the flange is often displaced to one side, suggesting incomplete attachment to the vesicle’.

**Remarks.** The specimens recovered conform to the original diagnosis. Vesicle small, hollow, spherical, surrounded by a thin flat equatorial flange, thin but not folded like in *P. foveolata*. This species is characterised by the lack of radial folding of the equatorial flange, a smaller flange width and the asymmetrical nature of the vesicle within the outer membrane. Excystment is by simple split. Mode of excystment not observed.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire vesicle and flange</td>
<td>16 - 50 μm</td>
</tr>
<tr>
<td>Central body diameter</td>
<td>18 - 26 μm</td>
</tr>
<tr>
<td>Flange width</td>
<td>4 - 10 μm</td>
</tr>
<tr>
<td>Excystment split</td>
<td>14 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

293
Occurrence. Specimens belonging to this species form a minor part of assemblages in samples from Farley Dingle Coates Quarry and Pitch Coppice Quarry, samples FD 1500, FD 2650 and PC 340. Coalbrookdale to lower Elton formations, upper Wenlock to lower Ludlow Series.

Known Range: Wenlock to Ludlow Series.

**Pterospermella cf. pertonensis**

Plate 14, fig. 7.

cf. 1981a *Pterospermella cf. pertonensis* Dornig, p. 197, pl. 3, figs. 7, 8.

Description. Very small form measuring 14 μm vesicle plus flange, comparable to *Pterospermella pertonensis* in form. This form is characterised by its small size.

Remarks. *P. cf. pertonense* differs from *P. pertonense* in the small size of the entire vesicle and flange.

Dimensions. Entire Vesicle 14 μm

Number of specimens measured. 1

Occurrence. *P. cf. pertonense* was a single occurrence from sample FD 1400, from the Coalbrookdale Formation (Farley Member) of Farley Dingle Much Wenlock Shropshire.

Genus **PULVINOSPHERIDIUM** Eisenack, 1954

1954 *Pulvinosphaeridium* Eisenack, p. 210 - 211.


Type species. *Pulvinosphaeridium pulvinellum* Eisenack, 1954, pp. 210 - 211, Pl. 1 fig. 10; from the Upper Visby Marl, upper Llandovery Series, (Silurian) of Lickershamn, Gotland, Sweden.
**Diagnosis.** (Translated from Eisenack, 1954, p. 210) Hystrichospheres with appendages attached to the central body. The processes are widely spaced and the bases never touch. There is no boundary between the appendages and the vesicle. The vesicle forms a star-shape with several corners.

**Description.** (Cramer 1970 p. 115) “Vesicles hollow, polygonal to pillow shaped in outline. The vesicle symmetry is essentially regular. The processes are broad based and bluntly conical and the central potion of the vesicle is formed by confluence of the basal parts of the processes. The vesicle wall may be bilayered but is generally unilayered and undifferentiated. No preferential splitting patterns or other pylome structures were found”.

**Remarks.** Pulvinosphaeridium differs from the genus Estiastra in having broad processes with blunt rounded terminations rather than the pointed process terminations of the latter. The bases of the processes are curved forming the outline of a central body unlike the process bases of Estiastra which form acute angles giving no definition to a central body cavity. Chalaziosphaeridium is not considered to be synonymous with Pulvinosphaeridium (Sarjeant & Stancliffe 1994 p. 48) because the former is similar except that the processes are restricted to within a single plane. Pulvinosphaeridium can have processes within a single plane or be tetrahedral in form.

**Pulvinosphaeridium cochinum** (Cramer 1964b) Cramer 1970

Plate 45, fig. 3.

1964b Veryhachium cochinum sp. nov. Cramer, p. 315, pl. 12: fig. 11. Text - fig. 30: 13.
1967 Veryhachium cochinum. Cramer, p. 239.
1968 Pulvinosphaeridium cochinum; Martin, pp. 86 - 87, pl. 5, figs 212, 213.
1970 Pulvinosphaeridium cochinum n. comb; Cramer, 117 - 118, Text - fig. 34: b.
1978 Pulvinosphaeridium trifidum; Kiryanov, p.82. pl. 19, fig. 1.
1990 Pulvinosphaeridium cochinum; Fensome et al. p. 433, no fig.

**Holotype.** Cramer 1964b p. 315; pl. 12, fig. 11; from the San Pedro Formation, Ludlow Series of Oblanca da Luna, Spain.

**Diagnosis.** (Cramer 1964b p. 315) “Test subtriangular, hollow, inflated with more or less concave sides. Wall rather thick, (about 1 µm), simple, moderately transparent. Surface rugulate to scabrate in an irregular pattern.”
Remarks. The specimens recovered are compared to *Pulvinosphaeridium cochinum* in having a triangular vesicle outline with all the processes arranged in the same plane, rather than the tetrahedral form expressed by *Pulvinosphaeridium oligoprojectum*. The processes have rounded distal terminations, they are of variable length in a single specimen and join to form the indistinct central body. The vesicle body exhibits random, scabrate vesicular ornament of 1 \( \mu \text{m} \) height covering the entire test. Excystment mechanism not observed. The specimens are only compared to *Pulvinosphaeridium cochinum* because the original description allows for forms up to 50 \( \mu \text{m} \) whereas specimens recovered in this study have processes up to 100 \( \mu \text{m} \).

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Length</td>
<td>50 - 100 ( \mu \text{m} )</td>
</tr>
<tr>
<td>Entire vesicle</td>
<td>80 - 100 ( \mu \text{m} )</td>
</tr>
<tr>
<td>Vesicle body is formed from junction of processes.</td>
<td></td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

Occurrence. This species has been previously recorded from the Ludlow Series to Gedinnian Stage of Spain (Cramer 1964b, Cramer 1967, Cramer 1970); Llandovery (Tarranon) to Wenlock series of Belgium (Martin 1968); Wenlock Series of the Baltic area (Kiryanov 1978). *Pulvinosphaeridium cochinum* was recovered from Coalbrookdale and Much Wenlock Limestone formations of Mortimer Forest (samples MFGT 1-50, 1-100) and the Much Wenlock Limestone Formation - Lower Elton Formation boundary at Pitch Coppice (samples PC 50, the Ludlow area; and in the type Much Wenlock area: the Coalbrookdale Formation of Farley Dingle (samples FD 300, 500, 1200, 1500, 1700, 1760, 1900, 2300, 2650) and the Much Wenlock Limestone Formation of Harley Hill (sample HH2 600); Coates Quarry, CT6.

Known Range: Ludlow Series (Silurian) to Early Gedinnian Stage (Devonian).

*Pulvinosphaeridium oligoprojectum* Downie 1959, emend.

Plate 44 figs 2, 3.

1959 *Pulvinosphaeridium oligoprojectum* sp. nov. Downie, p. 64, pl. 10, fig. 12, pl. 12, fig. 12.
1965a *Pulvinosphaeridium pulvinellum*; Eisenack, p. 264, pl. 21, fig. 8 only.
1978 *Pulvinosphaeridium striatulum* sp. nov. Kiryanov, p. 81, pl. 14, fig. 7.
1990 *Pulvinosphaeridium oligoprojectum*; Fensome *et al.* p.434, no fig.
1994 *Chalaziosphaeridium oligoprojectum*; Sarjeant & Stancliffe, p. 50, no. fig.
Holotype. Downie 1959 p. 64; pl. 10, fig. 12; Coalbrookdale Formation, Wenlock Series, Wenlock Edge, Shropshire.

Original Diagnosis. (Downie 1959 p. 64) “Hollow test, walls thin, yellow brown, surface matt, five broad hollow rounded processes unite to form the ill defined body, overall size 150 to 250 μm”.

Emended Diagnosis. Large tetrahedral acritarchs, overall size 110 - 250 μm, with a hollow, thin walled, matt vesicle which is transparent to yellow brown in colour. Processes 4 - 6 in number have broad bases which unite to form the indistinct central body. The processes taper to blunt terminations. A striate ornament is sometimes present parallel to the long axis of the processes. Mode of excystment not observed.

Dimensions.  

<table>
<thead>
<tr>
<th>Description</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Length</td>
<td>40 - 80 μm x 48 - 62 μm</td>
</tr>
<tr>
<td>Vesicle body</td>
<td>30 - 60 μm (indistinct)</td>
</tr>
<tr>
<td>Entire vesicle</td>
<td>110 - 160 μm</td>
</tr>
<tr>
<td>Process proximal width</td>
<td>20 - 40 μm</td>
</tr>
<tr>
<td>Process distal width</td>
<td>10 - 20 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>4 - 6</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

Remarks. The observed specimens have 4 - 6 hollow, wide processes. The central body is ill defined. The distinction between \( P. \) oligopjectum and \( P. \) pulvinellum is clear and the synonymy proposed by Downie (1963 p. 638) is not followed in this study. \( P. \) oligopjectum has a distinct tetrahedral form (Downie 1959) and longer, often ornamented processes whereas \( P. \) pulvinellum has short, ‘stubby’, laevigate, processes arranged in the same plane. The specimens recovered in this study often exhibit longitudinal striations along the process walls particularly on the darker specimens. Striate wall ornament is clearly present on processes of the paratype (Downie 1959, pl. 12, 12) but is less so on the holotype probably a result of the holotype being a slightly thinner walled form. The presence of these striae on the processes lead to the synonymy of \( P. \) striatulum (Kiryanov 1978 p. 81) with \( P. \) oligopjectum. The specimens recovered are often darker and possibly thicker walled than the holotype but as the wall structure/composition of species belonging to the genus appears to differ to that from most acritarch genera, the differences in colour could be the result of the different physical/compositional nature of the wall rather than just its thickness. Mode of excystment not observed. The transfer of \( P. \) oligopjectum to Chalaziosphaeridium (Sarjeant & Stancliffe 1994, p. 50) is not followed as it can be three dimensional as stated in the generic remarks.
Occurrence. *Pulvinosphaeridium oligoprojectum* has been recorded from Coalbrookdale Formation, Wenlock Series, Wenlock Edge, Shropshire (Downie 1959, Downie 1963 as *P. pulvinellum*); Wenlock Series of Gotland, Sweden (Eisenack 1965a); Silurian of Podolia Russia (Kiryanov 1978 as *P. striatulum*); Upper Llandovery (Hughley Shales to Upper Wenlock (Buildwas Formation) of the Welsh Borderlands (Dorning 1981a as *P. pulvinellum*); Coalbrookdale to the Much Wenlock Limestone Formation (Upper Quarried Limestone Member), Late Homerian Stage of the Wenlock Series, West Midlands, England. (Dorning 1983); Coalbrookdale formation (Sheinwoodian) of Wenlock Type Area and the Woolhope Limestone of the Eastnor Park borehole, Shropshire (Swire 1991 as *P. pulvinellum*). In this study *P. oligoprojectum* has been recovered from the Much Wenlock Limestone Formation of Mortimer Forest (samples MFGT1/2, 1-50) and the Much Wenlock Limestone to Lower Elton formation boundary at Pitch Coppice Quarry (samples PC - 252), near Ludlow, Shropshire. In the Much Wenlock area of Shropshire forms were recovered from the Coalbrookdale Formation of Farley Dingle (samples FD 300, 500, 1400, 1500, 1600, 1700, 1760, FD bent, 1900, 2000, 2300, 2550, 2650, 3000); the Much Wenlock Limestone Formation of Shadwell Quarry (2SH - 1.15); Harley Hill (HH2 300, 400, 600, 800) and Coates Quarry (CT 7).

Known range: Sheinwoodian - Gorstian stages.

**Pulvinosphaeridium aff. oligoprojectum** Downie 1959.

Plate 44, figs. 1, 4.

1965 *Pulvinosphaeridium pulvinellum* Eisenack 1965a p. 264 pl. 21, fig. 7 only.

Remarks. Forms bearing four processes, three arranged in one plane and the fourth emerging from the centre of the vesicle body in a distinct tetrahedral form. Hence the forms recovered differs slightly from *P. oligoprojectum* which has more processes. The figured specimen of *P. striatulum* in Kiryanov (1978) is comparable to this form. *P. striatulum* has been synonymised herein with *P. oligoprojectum*. As the forms attributed to *P. aff. oligoprojectum* are clearly distinct they have been separated here in the systematic descriptions in order to show the plexus of forms that contributes to the genus *P. oligoprojectum*.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire vesicle body</td>
<td>100 - 120µm</td>
</tr>
<tr>
<td>Process length</td>
<td>50 - 100 µm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

298
Occurrence. Wenlock Series of Gotland, Sweden (Eisenack 1955a). These forms were recovered regularly throughout the sections studied, though some samples were barren of large form acritarchs. In the Ludlow area this species was recovered from the Much Wenlock Limestone formation at Mortimer Forest (MFGT1 - 50, -100; MFGT2 - TD, 180, 300); the Much Wenlock Limestone Formation - Lower Elton Formation boundary at Pitch Coppice (samples PC, 240, 252, 280, 300, 315). In the Much Wenlock area this variety of the species was recovered from the Coalbrookdale and Much Wenlock Limestone formations of Farley Dingle (samples: FD 100, 200, 500, 700, 800, 1000, 1100, 1200 (relatively abundant in this sample), 1500, 1600, 2300, 2650); Shadwell Quarry 2SH - 1.0, Coates Quarry, CT5, CT 10.

Pulvinosphaeridium cf. oligoprojectum Downie 1959.

Not figured.

Description. P. oligoprojectum with distinct process morphology. The processes have restricted distal necks followed by flared cup like terminations.

Remarks. Only one specimen was recovered, which drawn and measured and is detailed here to clarify its appearance in the logging sheets.

Dimensions.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire vesicle body</td>
<td>100 - 120 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>60 - 100 μm</td>
</tr>
<tr>
<td>Maximum process width</td>
<td>60 μm</td>
</tr>
<tr>
<td>Number of Processes</td>
<td>4 - 6</td>
</tr>
<tr>
<td>Cup like process terminations</td>
<td>18 x 18 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

Occurrence. This form is a rare type with a single specimen being recovered from Farley Dingle (FD 2300) in the Much Wenlock area and rare occurrences noted from Mortimer Forest (MFGT1 - 50, MFGT2 - TD) near Ludlow, Shropshire.
**Pulvinosphaeridium pulvinellum** Eisenack 1954a

Plate 44, figs. 5, 6.

1954a  *Pulvinosphaeridium pulvinellum*; sp. nov. p. 210 fig. 1, fig. 10.
1966c  *Pulvinosphaeridium pulvinellum*; Martin, p. 318, pl. 1, fig. 26
1970  *Pulvinosphaeridium pulvinellum*; Cramer pp. 116 - 117, fig. 34a.
1990  *Pulvinosphaeridium pulvinellum*; Fensome *et al.* p. 433, no fig.

**Diagnosis.** (Eisenack 1954, p. 64) "Die zentralraum geht ohne grenze in einiger (4 - 6, vielleicht auch einiger mehr) breite, am Ende stumpf abgerundete Zipfel über, so dass eine etrasederartige bis sternformige Hülle und in der aufsicht (und in Präparaten) die Form eines Kissens mit +/- flachbogig einspringenden Setine zustandekommt. Die Wand ist dunn und zart und hellgelblich durchscheinend."

Translated: The central cavity merges without borders in (4 - 6 possibly more) broad extensions with blunt tips, thus forming a test of tetrahedral to star-like shape and when seen from above (and in the prepared ones) has the form of a cushion with +/ - shallow concave sides. The wall is thin and friable and light yellow translucent.

**Description.** Species of *Pulvinosphaeridium*, a large acritarch of distinctive wall appearance bearing four + processes not necessarily in the same plane but not forming the distinctive tetrahedral shape of *P. cf. oligoprojectum*. The process terminations in this species are more pointed than rounded.

**Remarks.** The specimens recovered conform to the original diagnosis. *P cf. oligoprojectum* differs in having processes in more than one plane which give the vesicle a tetrahedral outline, the terminations of which are notably well rounded and not drawn out to a point. *P cf. cochinum* is triangular in outline but the vesicle has a similar appearance to that of *P. pulvinellum* therefore it is assumed that it is of the same or similar composition, differing markedly to the majority of the acritarcha.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>100 - 130 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>60 - 65 µm</td>
</tr>
<tr>
<td>Process base width</td>
<td>20 - 35 µm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Occurrence.** This species has a wide range of occurrences including the following; Late Llandovery Series of Gotland (Eisenack 1954a); Coalbrookdale Formation, Wenlock Series of the Welsh Borderlands (Downie 1959);
Llandovery and Wenlock series of Neuville-su-Huy, Belgium (Martin 1966c); Wenlock Series of Gotland (Cramer 1970); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); Upper Llandovery to Upper Wenlock series of the Shropshire Welsh Borderlands (Dorning 1981a); Coalbrookdale Formation to the Much Wenlock Limestone Formation (Upper Quarryed Limestone Member), Late Homerian Stage of the Wenlock Series of Dudley in the West Midlands, England. (Dorning 1983).

This species was recovered rarely in samples from the Much Wenlock Limestone Formation of Coates Quarry, (sample CT8), in the type Wenlock area, Shropshire, England.

Genus QUADRADITUM (Cramer 1964b.) emend. Cramer & Diez 1972

1967 Veliferites Brito, p. 477, pl. 1 figs. 4 - 8.

Type species. Quadraditum fantasticum (Cramer 1964b) p. 334, pl. 14, figs 3 - 4, text-figs 37: 1 - 3; San Pedro Formation, Ludlovian to lower Gedinnian of north-west Spain.

Original Diagnosis. (Cramer, 1964b, p. 333) "Microfossil of uncertain affinities. It consists of an originally subspherical to ellipsoidal outer shell, formed by a very thin transparent smooth membrane that envelopes a flat subsquare central body. This central body is hollow, moderately transparent to not transparent and is smooth.”

Revised Diagnosis and Remarks. (Cramer & Diez 1972, p. 170) ‘Complex acritarch consisting of inner and outer membrane (the ectoderm and periderm respectively). In undamaged condition, the periderm is spherical to ellipsoid. It is attached to the square central body at the four angles. The periderm is psilate to slightly inflated, pillow shaped, rectangular to square and is attached at the corners to the periderm. The collapse of the body cavity may cause a consistent set of folds to form that are more or less similar to a letter H squeezed at the place of the horizontal bar. The corners of the central body may be slightly drawn out and may form short productions; these productions are hollow at the proximal part and their cavity is continuous with the central body cavity. Whether the body cavity is open at the attachment points of the two membranes and thus communicates freely with the outside, could not be determined. No preferential patterns of splitting nor pylome structures were found’.

Remarks. This is a most distinctive genus. The specimens are characteristically formed from two layers, an inner medium to thick walled subrectangular endophragm, the corners of which form short processes which are

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attached to the periphragm and surrounding this is an outer delicate transparent periphragm. Cymatiosphaera differs in having an inner body but an outer flange that delineates lacunar fields, whilst Pterospermella has an equatorial flange and a subspherical to spherical inner body that does not have connecting corners.

**Quadratidum fantasticum** Cramer 1964b

Plate 14 fig. 5.

1964b. *Quadratidum fantasticum* Cramer; p. 334, pl. 14, figs 3 - 4, text - figs 37: 1 - 3.
1964 *Duvernaysphaera tessella* Dewiff 1964; p. 212, text - fig. 5.
1967 *Veliferites tenuimarginatus* Brito, p. 477, pl. 1, fig. 4, 5 and 7 only.
1972 *Quadratidum fantasticum* Cramer; Cramer & Díez 1972, p. 170 - 171, pl. 35, fig. 63; pl. 26 fig. 75.
1975 *Veliferites jachalensis* Pöthe de Baldis, p. 496, pl. 4, figs., 4-8.
1976 *Duvernaysphaera oo* Loeblich & Wicander; p. 28, pl. 9 figs. 10 - 11.
1976 *Quadratidum fantasticum* ; Eisenack et al., p. 655 - 657.
1981 *Duvernaysphaera angalae* Wicander & Wood, p. 23, pl. 2 fig. 1 only.
1983 *Duvernaysphaera angalae*; Wicander & Wright, p. 5, fig. 3, no. 6.
1984 *Duvernaysphaera angalae*; Wicander, p. 21, pl. 1, fig. 1.
1984 *Duvernaysphaera tessella Deunff* 1964; Marhoumi & Rauscher, p. 245, pl. 1 fig. 14.
1986 *Duvernaysphaera oo*; Wicander, p. 343, pl. 3, fig. 10.
1990 *Quadratidum fantasticum* Cramer 1964b; Fensome *et al.*, p. 437, no fig.

_Holotype._ *Quadratidum fantasticum* Cramer, 1964b, p. 334, pl. 14, fig. 3; San Pedro Formation, Ludlow Series to lower Gedinnian Stage Devonian of north-west Spain.

_Diagnosis._ (Cramer, 1964b, p. 334) "Central body moderately thin and moderately transparent, psilate at 1200 x magnification. The central body has a square outline. Enveloping membrane very thin and transparent, smooth, attached at the corners of the central body. Membrane usually damaged."

_Description._ Square to rectangular vesicle shape with a laevigate inner body surrounded by a laevigate, thin, delicate, transparent, outer membrane which is often incomplete. The outer membrane is attached to the inner vesicle body at four points at mostly at the corners of the central body. The thin periderm is often damaged and may be
absent. Mode of excystment not observed because of the poor preservation of the specimens. The outer delicate wall is often damaged hence determining the difference between damage and actual excystment mechanism is difficult, though Cramer (1964) reported a simple split on the central body vesicle.

Remarks. The specimens recovered of *Quadraditum fantasticum* conform to the original diagnosis, but are often poorly preserved due to the delicate nature of the outer membrane. The poor preservation makes identification and observations on the nature of the outer membrane difficult.

*Duvernaysphaera oa* Loeblich & Wicander 1976 is described as having an equatorial flange rather than the surrounding outer periphragm, the figured specimens however are practically identical to *Quadraditum fantasticum*, therefore it is included here in synonymy with *Quadraditum fantasticum* pending examination of the holotype. The inclusion of this species extends the range of *Quadraditum fantasticum* to Late Gedinnian. *Duvernaysphaera angalae* which is possibly be a synonym of *Quadraditum fantasticum* was recorded by Wicander & Wright (1983), and Wicander (1984); though Wicander (1984 p. 21) gives a restricted range of occurrences for the form (Givetian). Inspection of the holotypes of this species would be necessary to be certain as *Duvernaysphaera angalae* has branched process corners. This feature was observed in some of the recovered specimens in this study but as this species was found in such low numbers such a feature was interpreted as of a preservational nature.

*Duvernaysphaera tessella* as reported by Marhoumi & Rauscher (1984) from the Devonian of Morocco is also considered synonymous, the figures depicted are clearly the same as these herein described as *Quadraditum fantasticum*.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Central body</th>
<th>12 - 18 μm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Entire vesicle</td>
<td>24 - 32 μm</td>
</tr>
<tr>
<td></td>
<td>Distance between vesicle and membrane</td>
<td>6 - 10 μm</td>
</tr>
<tr>
<td></td>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

Occurrence. Upper Llandovery Series to Lower Gedinnian Stage (Late Silurian to Lower Devonian) of north-west Spain (Cramer 1964b, Cramer et al. 1976); Llandovery Series of Pennsylvania, USA (Cramer 1969a); Devonian of Tunisia (Deunff 1964 as *D. tessella* Deunff 1966); Ludlow Series to Gedinnian Stage of Algeria (Jardiné & Yapaudjian 1968); Wenlock to Ludlow Series of Algeria (Jardiné et al. 1974); Silurian of Belgium Silurian of Belgium Martin 1966); Ludlow Series, of Normandy and Brittany, France, Silurian of Spain, Sahara and Belgium (Deunff et al. 1971); Llandovery to Prídolí series, of the USA (Cramer & Diez 1972); Rochester Formation, Wenlock Series of Ontario, Canada (Thasu 1973a); Mid Silurian of New York State, USA (Thasu & Zenger 1974); Tanezzuft and Acacus Formation, Wenlock to Ludlow series of Libya (Richardson & Ioannides 1973); Lower Elton Formation to Upper Whitcliffe Formation, Ludlow Series of the Ludlow area (Lister & Downie 1974); Ludlow Series of Bolivia (Cramer et al. 1974); Wenlock and lower Ludlow Series, Argentina (Pothé de Baldis 1975a, 1975b,
In this study *Quadraditum fantasticum* occurs sporadically throughout the following sections Farley Dingle, Coates Quarry, Shadwell Quarry, Harley Hill, Pitch Coppice, Mortimer Forest Geological Trail Quarries 1 and 2, Upper Coalbrookdale to lowermost Lower Elton formations (Homerian to Gorstian) in the type Wenlock and Ludlow areas.

Known range: Lower Silurian to Lower Devonian (Upper Llandovery Series to Late Gedinnian Stage).

**Genus RHACOBRACHION** Dorning 1981a

*Type species. Rhacobrachion mala,* (Cramer 1964), Dorning 1981a, Cramer 1964, p. 297, pl. 1 figs. 6, 8, 10.

*Diagnosis.* (Dorning 1981a p. 198.) "Vesicle spherical to subspherical, wall single layered; ornament of vesicle and processes irregularly microcostate; several processes, both simple and branching, hollow. Excystment by an irregular split in the vesicle wall."

*Remarks.* Dorning (1981a) states that the distinguishing feature for this genus is the microcostate ornament.


Plate 30, fig. 4.

1964b *Baltisphaeridium malum* Cramer, p.297, pl. 1, figs. 6, 8, 10.

1965 *Baltisphaeridium cf. malum*; Martin, p. 4 - 5, pl. 1 fig. 14.

1970 *Evittia mala* (Cramer 1964) comb. nov. Lister, p. 70, pl. 5, figs 8 - 14.
1973 *Hystrichosphaeridium malum*; Andreeva, p. 192. not valid.
1981 *Rhacobrachion mala* (Cramer); Dorning, p. 198, no fig.
1990 *Rhacobrachion mala*; Fensome *et al.* p. 440, no fig.

*Holotype.* Cramer 1964b p. 297, pl. 1 fig. 8, from the San Pedro Formation, Ludlow Series of Spain.

*Diagnosis.* (Cramer 1964, p. 297) "Central body and processes hollow with uniform walls. The central body is roughly spherical, thin walled and transparent. Its wall is irregularly scabrate. The processes are conical, and have the form of a stout pillar, that ends in a rounded, simple tip. Rarely some reduced secondary appendages near the ends of the processes are present. Number of processes rather variable, 10 - 26 (10) in optical section

*Remarks.* The specimens recovered conform to the original diagnosis. Large, thick walled vesicle (30 - 38 \( \mu \)m), golden to yellow/brown, bearing numerous short (6 - 8 \( \mu \)m) thick blunt processes, closed at the distal termination. Mode of excystment not observed. The vesicle body is subspherical, laevigate to microcostate, relatively thick walled with numerous processes which are blunt stubby (clavate) and short and communicate freely with the central body cavity. Excystment mechanism not observed. The other specimens recovered herein with blunt processes were logged as *Rhacobrachion malum* var. 1 and did not exhibit the definitive costate ornament.

*Dimensions.*
- Vesicle diameter: 24 - 38 \( \mu \)m
- Process length: 6 - 12 \( \mu \)m
- Process width: 3 - 6 \( \mu \)m
- Number of processes: 22 - 28
- Number of specimens measured: 4

*Occurrence.* Ludlow Series, San Pedro Formation of Spain (Cramer 1964, 1970); Silurian of Belgium (Martin 1965, 1966, 1968); Ludlow Series of the Ludlow and Millichope areas of the Welsh Borderlands (Lister 1970); Llandovery to Emsian of the USA, Brazil and Libya (in Eisenack *et al.* 1979); Ludlow Series of Shropshire (Dorning 1981a).

This species was recovered as a rare type from the Much Wenlock Limestone Formation, upper Wenlock Series of Coates Quarry in the Much Wenlock area and from sample MFGT1-300/10/1, from the Much Wenlock Limestone Formation of Mortimer Forest, Ludlow, Shropshire, England.

Known Range: Upper Wenlock to Ludlow Series. (Possible records Ordovician - Devonian).

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Rhacobrachion malum var. 1

Plate 19, fig. 9.

Description. Medium sized, medium to thick walled, laevigate vesicle (30 - 38 μm), yellow in colour bearing numerous short (2 - 4 μm) thick blunt processes, closed at the distal termination. Mode of excystment median split.

Remarks. This specimen was only recorded as a rare type.

Dimensions.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>22 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>2 - 4 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 μm</td>
</tr>
<tr>
<td>Process Number</td>
<td>21 +</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1.</td>
</tr>
</tbody>
</table>

Occurrence. This form was recovered as a rare type from sample CT7/10/1, from the Much Wenlock Limestone Formation of Mortimer Forest, Ludlow, Shropshire, England.


Type species. Salopidium granuliferum (Basionym: Baltisphaeridium brevispinosum var. granuliferum Downie 1959 p. 59, pl. 10, fig. 5) Dorning 1981a, p. 198.

Diagnosis. (Dorning 1981a p. 198). ‘Vesicle spherical to subspherical, foveolate; several to numerous laevigate processes taper distally to a simple termination. Excystment by a straight split in the vesicle wall to produce two equal halves’.

Remarks. The genera Ammonidium, Percultisphaera and Gracilisphaeridium have branched processes whereas Salopidium has simple process tips. Michrystridium is smaller and the processes are smaller in relation to the proportion of the vesicle body compared to Salopidium.
**Salopidium acuminosum** sp. nov.

Plate 47, figs. 6, 7.

*Derivation of name.* The specific epithet refers to the nature of the processes; from the Latin verb 'acumino' to make pointed, sharpen; with the adjective suffix for nouns referring to plenitude or notable development of.

*Holotype.* Plate 47, fig. 7, from sample FD 300/10/1 Rivelin Finder reference T34 from the Farley Member of the Coalbrookdale Formation of the Wenlock Series from Farley Dingle, Shropshire, England.

*Diagnosis.* Thin walled spherical to subspherical vesicle 14 - 16 μm in diameter bearing numerous, 16 - 20, processes. The processes are short 4 - 5 μm with wide bases 2.5- 4 μm tapering to a sharp simple tip. Mode of excystment not observed.

*Remarks.* This form could be compared to *Salopidium* sp. E but is has a much smaller vesicle size and is thinner walled. It differs from *Salopidium wenlockensis* in the smaller central body and shorter processes. *Salopidium granuliferum* has a more granulate vesicle body rather than laevigate whilst the laevigate form *Salopidium nanum* is much larger with longer flexuous processes.

*Dimensions.*

<table>
<thead>
<tr>
<th></th>
<th>Vesicle body diameter</th>
<th>Process length</th>
<th>Process base width</th>
<th>Process number</th>
<th>Number of specimens measured</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14 - 16 μm</td>
<td>4 - 5 μm</td>
<td>2.5- 4 μm</td>
<td>16 - 20</td>
<td>3.</td>
</tr>
</tbody>
</table>

*Occurrence.* This form was recovered as a rare type from the Coalbrookdale to Much Wenlock Limestone formations of Farley Dingle and Pitch Coppice in the Much Wenlock and Ludlow areas of Ludlow, Shropshire.

**Salopidium echinodermum** (Stockmans & Willière 1963) Priewalder 1987.

Plate 46, fig. 7. Plate 47 fig. 4.

1963 *Baltisphaeridium echinodermum* n. sp. Stockmans & Willière, p. 460 - 462, pl. 2, figs. 5-8, pl. 3 fig. 26; text. figs. 17-20.
1970  *Baltisphaeridium nanum* Stockmans & Willière, Lister, p. 54 - 56, pl. 2, figs. 11, 12. only

1979  *Gorgonisphaeridium echinodermum*; Eisenack *et al.* p. 233 - 234.

1987  *Salopidium ?echinodermum* Stockmans & Willière, Priewalder; p. 50. pl. 11, fig. 11 only.

1990  *Salopidium ?echinodermum* Stockmans & Willière, Priewalder; Fensome, p. 445. no fig.

1995  *Salopidium echiniformis* Turner *et al.* 1995 p. 312, pl. 5 fig. 15.

Holotype. Stockmans & Willière 1963 , p. 460 - 462, pl. 2, figs. 5 - 6, from the Silurian (Llandovery) of Courtrai, Belgium.

Diagnosis (See Stockmans & Willière, p. 460, Translated from Priewalder p. 50). Central body with spherical to elliptical outline, clearly differentiated from the processes. 20 - 80 processes distributed regularly, short, slender conical, +/- flexible. Distal end hair like or with a sharp point or occasionally rounded - wider processes hollow in their basal parts and communicate freely with the central vesicle cavity. Wall thin, unilayered + /- transparent and in the area of the central body variously ornamented: from being almost smooth all over (most), finely chagrinate to finely granulate, processes smooth. An equatorial tear presumably forms the opening.

Since the translation above another translation of the original diagnosis of Stockmans & Willière, p. 460, has been located in Eisenack *et al.* 1979 p. 233, under *Gorgonisphaeridium echinodermum*: 'Globular, flattened body, light brown in color, transparent, covered by elongated processes which may be more or less sinuous and which have blunt tips.'

Remarks. Subspherical vesicle, laevigate to granulate. Processes short, acuminate tapering to a sharp point with simple terminations. Proximally flared process bases with no overlapping. Excystment by median split. *S. granuliferum* and *S. nanum* have longer, broader processes.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Vesicle diameter</th>
<th>25 µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process length</td>
<td>7 µm</td>
<td></td>
</tr>
<tr>
<td>Process number</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

Occurrence. *S. echinodermum* has been recorded from the Silurian of Belgium (Stockmans & Willière 1963); lower Devonian of Uruguay (Martinez - Macchiavello 1968), Wenlock to Ludlow series of the Ludlow and Millichope areas (Lister 1970); late Llandovery to early Wenlock of Austria, (Priewalder 1987); Sheinwoodian of Shropshire (Swire 1991 unpublished); Coalbrookdale Formation (Homerian), Wenlock Series from and Holbrook Coppice, near Ironbridge, Shropshire (Turner *et al.* 1995).
In this study *Salopidium echinoderum* was recovered consistently but in variable numbers from assemblages in samples collected at Farley Dingle, Coates Quarry (CT2, CT6), Harley Hill in the Much Wenlock Area, Pitch Coppice, Mortimer Forest Geological Trail in the Ludlow area, Shropshire; upper Wenlock (Homerian) to Ludlow (Gorstian) series.

Known Range: Llandovery to Ludlow series

**Salopidium granuliferum** (Downie 1959) Dorning 1981a.

Plate 46, figs. 2, 3.

1959 *Baltisphaeridium brevispinosum* var. *granuliferum* sp. nov.; Downie, p. 59, pl. 10, fig. 5.
1966 *Baltisphaeridium granuliferum* (Downie); Martin, p. 314, pl. 1, fig. 18.
1968 *Baltisphaeridium granuliferum* (Downie); Martin, p. 54, figs. 204 - 208, text-fig. 11.
1970 *Baltisphaeridium granuliferum* (Downie) Lister, p. 56, pl. 2, figs. 2 - 5.
1971 *Baltisphaeridium echinatum* n. sp. Kjellström p. 23 - 24, pl. 1 fig. 8.
1972 *Michrystridium clarkii* n. sp. Cramer and Díez 1972; pp. 167, pl. 36. fig. 64 - 66.
1972 *Michrystridium granocentricum* n. sp. Cramer and Díez 1972; pp. 167 - 168, pl. 36. fig. 67, 68.
1979 *Baltisphaeridium granuliferum* Downie; Aldridge *et al.* p. 434, no fig.
1981a *Salopidium granuliferum* (Downie 1959) n. comb.; Dorning, p. 198, no fig.
1987 *Salopidium c.f. granuliferum* (Downie 1959) Priewalder, p. 51, pl. 11, figs. 13, 14.

**Holotype.** *Baltisphaeridium brevispinosum* var. *granuliferum* Downie, 1959, p. 59, pl. 10, fig. 5; Coalbrookdale Formation, Wenlock Series, Wenlock Edge, England.

*Diagnosis* (Downie 1959, p. 59 pl. 10) ‘A small variety of *B. brevispinosum* with relatively numerous processes, the test surface ornamented with small granules 1 μ apart.’

*Remarks.* Specimens recovered conform to the original diagnosis with foveolate/granular subspherical vesicles bearing numerous, thin, simple, tapering, laevigate processes. The processes are hollow and communicate freely with the central body cavity. Excystment is by a simple median split which often divides the vesicle into two
equal halves. *Salopidium nanum* differs as it has a laevigate vesicle. *S. cf. echinodermum* has shorter acuminate processes and is not granulate and *S. wenlockensis* has shorter processes with broader bases. *Salopidium woolhopensis* Dorming 1981a is larger with longer processes. Species belonging to the genera *Ammonidium, Multiplicisphaeridium* and *Gracilisphaeridium* have branched processes. *Ammonidium microcladum* and *A. waldronense* have branched processes, not simple as in *Salopidium granuliferum*. It is possible that there is some inter and intra specific variation. So *S. granuliferum* is considered a formgroup.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>14 - 36 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>8 - 18 µm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 - 2.5 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>15-30</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

**Occurrence.** Wenlock Series (Coalbrookdale Formation) of Wenlock Edge, Shropshire England (Downie 1959, 1963); upper Llandovery to lower Wenlock series of Belgium (Martin 1968); Ludlow Series of the Ludlow and Millichope areas, Shropshire (Lister 1970); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); Wenlock to Prídolf Series of the Ludlow area (Lister and Downie 1974); Silurian of Podolia in the Ukraine (Kiryanov 1978 as *B. nanum*); Llandovery to lower Ludlow Series of Britain and Ireland (*Aldridge et al. 1979 as Baltisphaeridium granuliferum*); late Llandovery Series (Hughley Shales) to early Ludlow Series (Elton Formation) of the Welsh Borderlands (Dorning, 1981a); early Sheinwoodian, Wenlock Series of Scotland (Dorning 1982); early Silurian, Ringerike, Norway (Dorning & Aldridge 1982, Smelror 1987); upper Wenlock Series, Much Wenlock Limestone Formation, to the lower Ludlow Series, Lower Elton Formation of Dudley in the West Midlands, England (Dorning 1983); Llandovery Series of the type Llandovery area (Hill & Dorming 1984); Armstrong and Dorming (1984) reported specimens from the Chester Berg Formation (Wenlock) of Greenland; Much Wenlock Limestone Formation of the Welsh Borderlands (Dorning & Bell 1987); upper Llandovery to Wenlock Series of Austria (Priewalder 1987); upper Llandovery Series (Purple Shales) to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985); lower Silurian of Ringerike, Norway (Smelror 1987b); upper Llandovery Series of north-east Libya (Hill & Molyneux 1988); middle Wenlock Series, Cheviot Hills of north east England (Barron 1989); upper Llandovery Series to upper Wenlock Series. (Mulde Formation) of Gotland, Sweden (Le Hérisse 1989, Jeppsson et al. 1995); Buildwas and Coalbrookdale Formations (Sheinwoodian) of the Wenlock Area, Eastnor Area and North Wales (Swire 1991); Leinthall Quarry (Ludfordian) Ludlow area (Donoghue 1992), upper Silurian of San Juan, Argentina (Rubinstein 1993); *Salopidium granuliferum* was reported from the Coalbrookdale Formation (Wenlock Series) from and Holbrook Coppice, near Ironbridge, Shropshire (Turner et al. 1995); Llandovery to Wenlock Series of Gotland (Eriksson & Hagenfeldt 1997).
In this study *Salopidium granuliferum* was recovered consistently but in variable numbers in the assemblages from samples collected at Farley Dingle, Shadwell Quarry, Coates Quarry, Harley Hill in the Much Wenlock Area and Pitch Coppice, Mortimer Forest Geological Trail in the Ludlow area, Shropshire; Homerian to Gorstian Stages of the Wenlock to Ludlow series.

Known range: upper Llandovery (Aeronian Stage) - Ludlow (Ludfordian Stage) Series.


plate 46, fig. 1

**Remarks.** Specimens recovered conform to the diagnosis for *Salopidium granuliferum*, with a subspherical granular vesicle but has notably fewer, longer processes. The specimens recovered probably represent inter specific variation towards *S. woolhopensis* Dorning 1981a.

**Dimensions.**

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<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>18 - 20 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>8 - 14 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>8 - 12</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>2.</td>
</tr>
</tbody>
</table>

**Occurrence.** This form has been recorded as rare types from Farley Dingle, Coates Quarry. Harley Hill, Shadwell Quarry in the Much Wenlock area of Shropshire and Mortimer Forest in the Ludlow area.

*Salopidium latilanceolatum* sp. nov.

plate 46, fig. 8.

1983 *Tylotopalla* sp. Dorning, p. 38, pl. 7, fig. 9.

1989 *Salopidium granuliferum* malformés; Le Héryssé, p. 215, pl. 30, fig. 12.

**Derivation of name.** Lanceolate - referring to the leaf like shape of the processes and the abundance of the processes; from the late Latin lanceolatus - narrow/tapering to a point, from lanceola - small lance with 'lati-' referring to the broad process bases.
Holotype. Plate 46, fig. 8. from sample FD 700, slide FD 700/10/1 Rivelin Finder reference S 48, Coalbrookdale Formation from Farley Dingle, in the type area, Much Wenlock, Shropshire, England.

Description. Vesicle spherical to subspherical, pale thin walled laevigate forms bearing numerous short laevigate processes with proximally flared bases that taper to a sharp point, being essentially triangular in shape. Some of the processes are distally pinched to form a sharp spinose point. Process number between 20 - 30, one specimen bears considerably more than 30 processes. Mode of excystment by simple split.

Remarks. Specimens comparable to this morphotype were referred to by Le Hérisse (1989) as malformed S. granuliferum. This form has distinct process morphology and is considered herein a separate species. The form reported by Dorning (1983) from the Much Wenlock Limestone Formation of Dudley is clearly of the same taxon. Michrystridium acuminosum Cramer & Diez 1972 is superficially similar to this species but is considerably larger.

Dimensions.

<table>
<thead>
<tr>
<th>Process</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>20 - 28 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>4 - 6 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>20 - 30 µm</td>
</tr>
<tr>
<td>Process base width</td>
<td>4 µm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>2.</td>
</tr>
</tbody>
</table>

Occurrence. This form was recorded from the Much Wenlock Limestone Formation of Dudley in the West Midlands of England (Dorning 1983 as Tylotopella sp.); also reported from the Silurian of Gotland, Sweden (Le Hérisse 1989 as Salopidium granuliferum malformés).

In this study this species has only been recovered as rare types in samples from the Coalbrookdale to Much Wenlock Limestone formations of Farley Dingle (FD 700), Harley Hill (HH2 300 / HH3 800), Shadwell Quarry (2SH 110) from the type area, Much Wenlock, Shropshire, England.

Known Range: Upper Wenlock to early Ludlow Series.
Salopidium leherisseii sp. nov.

Plate 47, fig. 8.

1989 Salopidium granuliferum malformés p. 215, pl. 30, fig. 11.

*Derivation of name.* For Alain Le Hérissé who first figured this form (1989) as 'acritarches anormaux exemple D - Salopidium granuliferum-malformés'.

*Holotype.* Plate 47, fig. 8 from sample HH3/800-2/10/1, Rivelin Finder reference P 26, from the Much Wenlock Limestone Formation of Harley Hill.

*Diagnosis.* Spherical vesicle body, laevigate to microgranulate, bearing numerous simple process, the length of which is less than the vesicle diameter. The processes appear to be ornamented with sparse microgranulae and are relatively broad then tapering to an acuminate tip.

*Remarks.* This form differs from *S. truncatum* (Swire 1993) as the processes taper to simple points and do not form truncated process tips. The processes are broader and more 'ribbon like' than those of *S. granuliferum* or *S. nanum*. This form was originally logged with *Salopidium* sp. J (now referred to as *S. truncatum*). The definitive features became apparent upon close examination of photographic material. This lead to re-examination of the original specimens, logged as *Salopidium* sp. J and this group was split but the material was not relogged to account for this.

*Dimensions.*

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>24 - 28 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>10 - 16 µm</td>
</tr>
<tr>
<td>Maximum process width</td>
<td>1.5 - 2.5 µm</td>
</tr>
<tr>
<td>process number</td>
<td>16 +</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>2.</td>
</tr>
</tbody>
</table>

*Occurrence.* This species was found rarely from the Much Wenlock Limestone Formation of Harley Hill, in the type Wenlock area.
Salopidium nanum (Deflandre 1945) n. comb.

Plate 46, fig. 12

1959 Baltisphaeridium brevispinosum var. nanum Deflandre; Downie, p. 59, pl. 10 fig. 9.
1970 Baltisphaeridium nanum (Deflandre 1945) Lister, p. 54-56, pl. 2, figs. 7, 8, 10 only, text-fig. 17k.
1971 Baltisphaeridium nanum (Deflandre); Stockmans & Willière. Kjellström, p. 35 - 36, pl. 2, fig. 7.
1985 Baltisphaeridium nanum Lister; Mabillard & Aldridge, p. 92, no fig.
1990 Baltisphaeridium nanum; Fensome et al. p. 112 no fig.

Holotype. Downie 1959, p. 59, pl. 10 fig. 9, from the from the Coalbrookdale Formation of England.

Diagnosis. (Downie 1959, p. 59) ‘A small variety of B. brevispinosum, diameter about 25μm, processes relatively few, less than 20 in optical section’.

Remarks. Specimens recovered conform to the original diagnosis. Thin walled dominantly laevigate vesicle body subspherical with numerous thin hollow hair like processes. This species differs from S. granuliferum in having a laevigate vesicle wall and long simple processes tapering to a sharp point. Vesicle spherical to subspherical. S. cf. echinodermum has shorter acuminate processes. This species is transferred to Salopidium because it exhibits an excystment into two halves even though the vesicle is apparently laevigate.

Dimensions. 

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>18 - 32 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>12 - 28 μm</td>
</tr>
<tr>
<td>Maximum process width</td>
<td>1.5 - 2 μm</td>
</tr>
<tr>
<td>process number</td>
<td>10 - 26</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

Occurrence. Wenlock Series of France (Deflandre 1945); Middle Devonian of Brittany (Deunff 1954); Silurian of Belgium (Martin 1967); Wenlock to Prídolí series of the Ludlow area in the Welsh Borderlands (Lister & Downie 1974); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); Silurian of Podolia in the Ukraine (Kiryanov 1978 as B. nanum); Caradoc of the type area in the Welsh Borderlands (Turner 1984 as Solisphaeridium nanum); upper Llandovery Series (Purple Shales) to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985).
In this study *Salopidium nanum* was recovered consistently but in low numbers from samples collected at Farley Dingle, Shadwell Quarry, Coates Quarry, Harley Hill in the Much Wenlock Area and Pitch Coppice, Mortimer Forest Geological Trail in the Ludlow area, Shropshire; Homerian to Gorstian Stages of the Wenlock to Ludlow series.

Known Range: Caradoc Series (Ordovician) to lower Ludlow Series (Silurian).

**Salopidium cf. nanum** (Deflandre 1945) n. comb.

*Remarks.* Poorly preserved specimens which were comparable to the species *S. nanum* were recorded under this grouping.

*Occurrence.* Rare occurrences throughout the sections studied.

**Salopidium pauciramosum** sp. nov.

Plate 35, fig 8. Plate 46, figs 10, 11.

*Derivation of name.* Meaning notably few branches, from: 'paucus' - few/little; 'ramus' - branch/twig; 'osum' - adjective suffix for nouns referring to the development of.

*Holotype.* Plate 46, figure 11 from sample CT6/10/1, Rivelin Finder reference T 39 from the Much Wenlock Limestone Formation of Coates Quarry, Much Wenlock, Shropshire, England.

*Diagnosis.* Spherical to subspherical laevigate, thin walled vesicle body, bearing numerous (> 30) short, echinate processes with flared bases tapering to mostly simple and occasionally bifurcate tips. The processes are laevigate and heteromorphic within a single specimen, some being simple some exhibiting the first order branching. The process bases do not overlap thus the outline of the vesicle is distinct. Mode of excystment by simple split.

*Remarks.* The specimens recorded here differ from *S. granuliferum* in the presence of short numerous processes rather than the longer flexuous process and this form is also laevigate rather than granulate. *S. nanum* has longer processes. *S. latilanceolatum* has distinct bulbous based processes tapering sharply, rather than 'triangular'
short processes. There are considerable reasons to place this species with either \textit{Salopidium}, \textit{Michrystridium}, \textit{Multiplicisphaeridium} or \textit{Ammonidium}. The wide process bases and dominantly simple processes leads to place the group with \textit{Salopidium} or \textit{Michrystridium} whereas the presence of furcate distal branching to the processes would indicate an affinity to the genus \textit{Ammonidium} or \textit{Multiplicisphaeridium}. It was decided that the features such as the broad process bases leading to sharp tips were more distinct for the genus \textit{Salopidium} and hence the forms were designated as belonging to that genus. This form was originally logged under the informal titles \textit{Salopidium sp.} K&N and \textit{Michrystridium} sp. H.

\textit{Comparisons.} This species has fewer, longer wider processes than \textit{Ammonidium ludloviensis} (Lister 1970). \textit{Salopidium priewalderae} has simple processes and a finely granulate vesicle, \textit{Salopidium stenostipatum} also has a laevigate vesicle but with fewer, longer, simple processes.

\textit{Dimensions}  
\begin{tabular}{|c|c|}  
\hline  
Vesicle diameter & 14 - 22 \(\mu\m) \\
Process length & 4 - 8 \(\mu\m) \\
Process base width & 4 \(\mu\m) \\
Number of processes & 17 - >20 \\
Number of specimens measured & 5 \\
\hline  
\end{tabular}

\textit{Occurrence.} This morphotype has been recorded sporadically from the Coalbrookdale to Much Wenlock Limestone formations of the type Wenlock area including samples from Farley Dingle (FD 300; FD Bent) and Coates Quarry (CT6) and in the type Ludlow area from the Much Wenlock Limestone Formation of Mortimer Forest Geological Trail and Pitch Coppice.

\textit{Salopidium priewalderae} sp. nov.

Plate 46, fig. 5, Plate 47 figs. 2, 3, 5.

1987 \textit{Salopidium ?echinodermum} (Stockmans & Willière), Priewalder; p. 50. pl. 11, figs. 9, 10 12, not 11.

1987 \textit{Salopidium ?sp. C.} Stockmans & Willière, Priewalder; p. 50. pl. 12, figs. 11 - 13, pl. 18 fig. 5.

\textit{Derivation of name.} Named for Helga Priewalder who first documented this form informally in samples from the Karnic Alps. The specific epithet was first used by Swire (1991 unpublished), the name is used here to maintain stability in the terminology within the unpublished literature.

**Diagnosis.** Spherical to subspherical vesicle bearing a fine granulate ornament. The vesicle is ornamented with numerous short processes, generally more than 20. The processes are broad based and taper to a fine acuminate simple point. The length of the processes is less than diameter of the vesicle body. The mode of excystment is by simple median split.

**Remarks.** The processes considerably shorter than those exhibited in *S. granuliferum* the length of which being generally less than the vesicle diameter. *Salopidium nanum* has longer processes and a laevigate vesicle. *Salopidium* sp. *H* has a similar process construction but is laevigate. *Salopidium woolhopensis* has considerably longer processes without the wide process bases and *Salopidium wenlockensis* has longer processes. This species differs from *Michrystridium* in that the process bases are separate and do not coalesce, this leaves the outline of the vesicle well defined. This form has been previously recorded by Priewalder (1987) as *Salopidium ?echinodermum* and was first accorded this specific name by Swire (1991 unpublished Ph.D. thesis.) This form was originally logged as *Salopidium* sp. D/E.

**Dimensions**

<table>
<thead>
<tr>
<th></th>
<th>Vesicle Diameter</th>
<th>Process length-</th>
<th>Process number</th>
<th>Process base width</th>
<th>Number of specimens measured</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

**Occurrence.** Previous reported occurrences include: from the late Llandovery to early Wenlock of Austria (Priewalder 1987) and from the Buildwas and Coalbrookdale formations (Sheinwoodian Stage) from the type area and the Woolhope Limestone of the Eastnor Park Borehole (Swire 1991). This species has been recovered consistently from the Coalbrookdale through Much Wenlock Limestone to the boundary of the lower Elton formation in the Wenlock and Ludlow type areas; samples from Mortimer Forest, Pitch Coppice, Farley Dingle, Harley Hill, Shadwell Quarry and Coates Quarry (CT2).
Salopidium stenostipatum sp. nov.

Plate 46, fig. 4.

1989 Salopidium granuliferum malformés; Le Hérisse, p. 215, pl. 30, fig. 17.

*Derivation of name.* From the Greek: 'stenos' meaning narrow; 'stipes' meaning post/pillar; '-atum' adjectival suffix for noun referring to the presence of or likeness of something. Referring to the narrow processes.

*Holotype.* Plate 46, fig. 4, from sample CT6/10/1, Rivelin Finder reference PQ 43, from the Much Wenlock Limestone Formation of Coates Quarry, Much Wenlock, Shropshire, England.

*Diagnosis.* Spherical to ellipsoidal medium walled laevigate vesicle body with few distinct tapering processes bearing wide bases. The processes are less than or equal to the vesicle body diameter and are also laevigate and taper to a simple tip which may be solid. Mode of excystment by simple split.

*Remarks.* Medium walled laevigate form which differs from *Salopidium latilanceolatum* sp. nov. in that there are fewer processes which are notably longer. *Salopidium wenlockensis* differs in having longer processes. This form was logged originally as *Salopidium* sp. H.

*Dimensions.*

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>18 - 24 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>6 - 10 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>12 - 15 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>4</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10.</td>
</tr>
</tbody>
</table>

*Occurrence.* This species was previously recorded as a rare type from the Silurian of Gotland (Le Hérisse 1989). In this study, this form was recorded in low numbers from the Coalbrookdale, through Much Wenlock Limestone to Lower Elton formations of Harley Hill, Coates Quarry in the type Wenlock area and the Much Wenlock Limestone to Lower Elton formations (upper Wenlock to lower Ludlow series) of Pitch Coppice, Ludlow type area.

Salopidium truncatum Swire 1993

Plate 47, fig. 9

1989 Salopidium granuliferum malformés; Le Hérisse, p. 215, pl. 30, fig. 11.

318
Holotype. Swire 1993, pl. 1, fig. 3, from the Buildwas Formation of Lower Hill Farm borehole, Much Wenlock, Area, Shropshire, England, (SO 5817 9788).

Diagnosis. (Swire 1993, p. 106). "Vesicle spherical to subspherical possessing a fine granular surface. There are 16-30 regularly distributed processes with wide bases; the processes are slightly tapered and the distal extremity is expanded and truncated (evexate).

Remarks. Spherical to subspherical laevigate to, to faintly granulate, single walled vesicle body with numerous homomorphic, columnar to clavate processes with blunt or truncated terminations. The processes are simple, homomorphic on a single specimen and are of more or less equal dimensions. Forms similar to this species were recovered by Le Hérisse (1989) and referred to as Salopidium granuliferum malformés. This form was logged originally as Salopidium sp. J.

Dimensions.

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<tbody>
<tr>
<td>Vesicle diameter</td>
<td>16 - 18 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>6 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2.5 - 3 μm</td>
</tr>
<tr>
<td>Number of processes</td>
<td>12 - 16</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

Occurrence. Le Hérisse (1989) recovered forms considered to belong within this grouping from the Silurian of Gotland, Sweden; in the type area this species has been also recorded from the Buildwas and Coalbrookdale formations, Sheinwoodian Stage (Swire 1991).

In this study this species has been recovered in low numbers in samples from the Coalbrookdale to Much Wenlock Limestone formation (Homerian) of the type Wenlock area: Harley Hill, (HH2 200 HH3 800); Coates Quarry (CT6); and the Much Wenlock Limestone Formation of Mortimer Forest Geological Trail in the type Ludlow area.

Salopidium vescifolium sp. nov.

Plate 46, fig. 9

Derivation of name. Meaning little leaves, referring to the small ovate leaf shaped processes. Latin ‘vescus’ meaning little; ‘folium’ - adjective for leaf.
Holotype. Plate 46, fig. 9 from sample FD1760/10/1, Rivelin Finder reference H42 from the Farley Member of the Coalbrookdale Formation of Farley Dingle, Much Wenlock, Shropshire, England.

Diagnosis. Spherical to ellipsoidal, laevigate vesicle of medium wall thickness, diameter 12 μm bearing numerous processes (>20), 2 μm in height with 2 μm base width. The processes have a pinched out shape to the processes, this forms a very fine point.

Remarks. This is a considerably smaller form and therefore only compared to the species Salopidium latilanceolatum. The processes are also much shorter than those seen in Salopidium latilanceolatum. It has been described formally because of the close similarities to others of the Salopidium granuliferum-malformes, recovered from Gotland by Le Hérissé (1989) and it is felt that with more investigation that more of these distinctive forms will be recovered in both areas. This form was logged originally as Salopidium sp. G.

Dimensions. Vesicle diameter 12 - 14 μm
Process length and width 2 x 2 μm
Number of Specimens measured 2.

Occurrence. This morphotype was recorded rarely from Farley Dingle.

Salopidium wenlockensis (Downie 1959) Dorning 1981a

Plate 46, fig. 6, Plate 47, fig. 1

1962b Baltisphaeridium wenlockensis (Downie) Stockmans & Willière, p, 90 pl. 2.
1981a Salopidium wenlockensis (Downie), Dorning n. comb. p. 198, no fig.
1990 Salopidium wenlockense (Downie) Dorning; Fensome, p. 445, no fig.

Holotype. Downie 1959, p. 59, pl. 10, fig. 4 from the Coalbrookdale Formation of England, (exact locality not detailed).

Diagnosis. (Downie 1959, p. 59) ‘A small variety of B. brevispinosum diameter about 25 μ, processes relatively numerous, about 25 in optical section’.
Remarks. (Downie 1959, p. 59). ‘The diameter ranged from 16 - 32 µm, the mode being 24 µm. The number of processes ranged from 16 - 36, the mode being 24, and their length ranged from 20 to 80 percent of the test diameter, most of them being shorter than the radius’.

Remarks. This form very closely resembles Salopidium granuliferum but in logging it became clear that differentiation between the two forms was quite clear, the process bases of Salopidium wenlockensis being wider than those of Salopidium granuliferum whilst the processes themselves taper to form much narrower processes than those seen in S. granuliferum.

Dimensions.

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<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>18 - 30 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>16 - 26 µm</td>
</tr>
<tr>
<td>Maximum process width</td>
<td>0.5 - 2 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>16 - 34</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5.</td>
</tr>
</tbody>
</table>

Occurrence. Ludlow Series of the Ludlow area (Lister & Downie 1974 as Baltisphaeridium nanum - wenlockium); upper Wenlock Series, Much Wenlock Limestone Formation of Dudley in the West Midlands, England (Dorning 1983); Coalbrookdale Formation, Homerian Stage of the Wenlock Series from Holbrook Coppice near Ironbridge, Shropshire (Turner et al. 1995); Llandovery to Wenlock Series of Gotland (Eriksson & Hagenfeldt 1997).

In this study Salopidium wenlockensis was recovered in low numbers from samples collected at Farley Dingle and Harley Hill in the Much Wenlock Area, Shropshire; Homerian Stage of the Wenlock Series.

Known Range. late Llandovery - Ludlow Series (Ludfordian Stage).

Genus SCHISMATOSPHAERIDUM
Staplin, Jansonius & Pocock 1965.

Type species. Schismatosphaeridium perforatum Staplin et al. 1965, p. 179, pl. 18, figs 4 - 6, 11, 12; Upper Visby Formation, upper Llandovery of Gotland, Sweden.

Diagnosis. (Staplin et al. 1965, p. 178). ‘Vesicles lenticular, ellipsoidal or spherical; one side has a rent or slit, the opposite a round pylome; wall firm, smooth or with minute sculpture; no processes, no wall canals’.
Remarks. The genus is distinguished from *Leiosphaeridia* by the presence of the pylome and a split in vesicle, on the opposite wall.

*Schismatosphaeridium longhopensis* Domning 1981a

Plate 48, figs. 8, 9

1981a *Schismatosphaeridium longhopensis* n. sp. Domning, p. 199, pl. 3, figs. 1 - 2.
1990 *Schismatosphaeridium longhopensis* Domning 1981; Fensome *et al*., p. 446, no fig.

Holotype. *Schismatosphaeridium longhopensis* Domning, 1981a, p. 199, pl. 3, fig. 2; Coalbrookdale Formation, Wenlock Series; Longhope Hill, Gloucestershire (SO 695 185).

Diagnosis. (Domning, 1981a, p. 199) 'Vesicle subspherical, 20 - 25μm across, laevigate; on one pole a pore about 4μm across, with an apparently thicker darker margin, at the other pole a straight split 10 - 15μm long'.

Remarks. The specimens observed conform to the original diagnosis. *Schismatosphaeridium perforatum* is a larger form with a longer split. This species differs from *Schismatosphaeridium rugulosum* in having a laevigate not rugulate vesicle surface.

**Dimensions**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle body diameter</td>
<td>20 - 30 μm</td>
</tr>
<tr>
<td>Pore diameter</td>
<td>2 - 4 μm</td>
</tr>
<tr>
<td>Split length</td>
<td>10 - 14 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

Occurrence. Domning (1981a) records this species from the Coalbrookdale Formation, upper Much Wenlock Limestone Formation to the Middle Elton Formation of Shropshire, England. Sheinwoodian of the type Wenlock area and Eastnor areas of Shropshire (Swire 1992).

*Schismatosphaeridium longhopensis* was recovered consistently from the Coalbrookdale and Much Wenlock Limestone formations (Homerian) to Lower Elton Formation of the type area, from the following sections; Farley Dingle, Mortimer Forest, Pitch Coppice, Shadwell Quarry, Coates Quarry and Harley Hill.

Known Range: Wenlock Series (Silurian).
Schismatosphaeridium perforatum Staplin et al. 1965.

Plate 48, fig. 10.

1965 Schismatosphaeridium perforatum n. sp. Staplin et al., p. 179, pl. 18, figs. 4 - 6, 11 - 12.
1972 Schismatosphaeridium perforatum; Cramer & Díez; p 142, 172.
1990 Schismatosphaeridium perforatum Staplin et al.; Fensome et al., p. 447, no fig.

Holotype. Schismatosphaeridium perforatum Staplin et al. 1965; p. 179, pl. 18, fig. 11, 12; Vastkinde, Upper Visby Marl Gotland, Sweden.

Diagnosis. (Staplin et al. 1965) ‘Vesicles lenticular, equatorial in outline broadly elliptical; wall firm, with granulose or chagrinate sculpture; all specimens observed show a small circular pylome bounded by a thickened rim; approximately opposite the pylome is a cleft which is closed in all specimens observed’.

Dimensions
- Vesicle diameter: 20 - 25μm
- Longitudinal split: 10 - 15μm
- Pylome: 8 μm
- Number of specimens measured: 5

Remarks. The species recovered conform to the original diagnosis, characterised by a subspherical vesicle bearing a central pore on one surface and a split on the opposite side. The vesicle wall is microgranulate. This species differs from S. mayhillensis (Dorning 1981) as it is larger, S. longhopensis Doming 1981a and S. rugulosum (Dorning 1981) because the vesicle is laevigate while S. perforatum is a larger form with a longer split while in having a laevigate not rugulate vesicle surface. The pylome is usually central in this species.

Occurrence. Upper Llandovery of Gotland (Staplin et al. 1965); Upper Llandovery Waldron Formation, Ohio USA (Cramer & Díez 1972); early Sheinwoodian, Wenlock Series of Scotland (Dorning 1982); lower Silurian of Ringerike, Norway (Smelror 1987b); Llandovery to Wenlock Series of Gotland, Sweden (Eriksson & Hagenfeldt 1997);

This species was recovered consistently from the Coalbrookdale, Much Wenlock Limestone and Lower Elton formations the following sections: Farley Dingle, Mortimer Forest, Pitch Coppice, Shadwell Quarry and Harley Hill, Wenlock and Ludlow areas of Shropshire.
Schismatosphaeridium rugulosum Dorning 1981a

Plate 48, Figs. 1 - 3

1981a Schismatosphaeridium rugulosum n. sp. Dorning, p. 199, pl. 3, fig. 4.
1990 Schismatosphaeridium rugulosum Dorning 1981; Fensome et al., p. 447, no fig.

Holotype. Dorning 1981a, p. 199, pl. 3, fig. 4; Coalbrookdale Formation, Wenlock Series, May Hill, Gloucestershire (SO 695 185).

Diagnosis. (Dorning 1981a, p. 199). 'Vesicle subspherical, 35 - 40 µm across, rugulate to foveolate; at one pole a pore 8 - 10 µm wide, at the other pole a split 25 - 30µm long'.

Remarks. Spherical to ellipsoidal vesicle body ornamented with a low granulate, solid ornament. The vesicle has two critical distinguishing features, a central pylome and a simple split in the opposite wall. Schismatosphaeridium perforatum differs from S. rugulosum in having a laevigate rather than rugulate/foveolate vesicle body and a smaller pore. S. longhopensis has a laevigate vesicle body. The degree of ornamentation varies within the species from fine to dense and can also be variable on an individual specimen.

Dimensions. Vesicle body diameter 32 - 46 µm
Pore diameter 6 - 10 µm
Split length 8 - 24 µm
Number of specimens measured 10.

Occurrence. Schismatosphaeridium rugulosum was recovered from the late Llandovery (Hughley shales) to Wenlock series (Coalbrookdale Formation) of the Welsh Borderland (Dorning 1981a); late Llandovery to mid Wenlock Series of Ringerike, Norway (Smelror 1987b); late Sheinwoodian to early Homerian (Wenlock Series) of the Cheviots Hills, north east England (Barron 1989); Llandovery to Wenlock series of Gotland, Sweden (Le Hérisse 1989); Sheinwoodian of the Wenlock and Eastnor areas of Shropshire (Swire 1992).

This species was recovered consistently from the Farley Member of the Coalbrookdale Formation, through the Much Wenlock Limestone Formation to the lowermost portion of the Lower Elton Formation in the following sections: Farley Dingle, Mortimer Forest, Pitch Coppice, Shadwell Quarry, Coates Quarry and Harley Hill.

Known range: Wenlock - lower Ludlow Series, (Silurian).

Type species. Solisphaeridium stimuliferum (Deflandre 1938) Pocock 1972.

Original Diagnosis. (Staplin et al. 1965 p. 183 - 184.). "Vesicles spherical, wall relatively firm and rigid; several to numerous firm spines, hollow or solid, relatively long and slender, tapering continuously towards the closed tips. Spines have a tendency to reduce their cavity through secondary deposition of wall material but, if present, the cavity communicates freely with the vesicle."

Emended Diagnosis. (see Sarjeant 1968, p. 222, according to Fensome p. 453).

Remarks. This genus differs from Michrystridium in that the vesicle spherical when inflated bearing processes with restricted bases, rather than the stellate spherical appearance of Michrystridium which is the result of flared process bases. Multiplicisphaeridium has branched processes and Salopidium bears processes with flared bases, though there is a similarity between the laevigate form Salopidium nanum and species of Solisphaeridium.

Solisphaeridium sp. A

Plate 4, fig. 1.

Remarks. Included here are specimens that conform to the generic description but were not assigned to a species. Vesicle double walled, spherical to subspherical surface laevigate bearing distinctive processes homomorphic, hollow tapering to simple tips. Processes do not communicate with the interior of the vesicle. Excystment mechanism not observed. Morphologically simple form. Due to the single occurrence of this species it has been left in open nomenclature.

Dimensions. Vesicle diameter 21 μm
Process length 25 μm
Process number 12+
Number of Specimens measured 1

Occurrence. Single specimen from Harley Hill (HH2 500) (Much Wenlock Limestone Formation) of the type area in the Welsh Borderlands.
**Solipsphaeridium sp. B**

Plate 49, fig. 6

*Remarks.* Laevigate hollow medium walled vesicle bearing numerous slender, flexuous processes tapering to simple points. The processes do not communicate with the vesicle interior. As only one specimen was found this form has been left in open nomenclature.

**Dimensions.**

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Vesicle Diameter.</td>
<td>26 - 32 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>30 - 42 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2.5 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>7</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>2</td>
</tr>
</tbody>
</table>

*Occurrence.* Rare type from the Coalbrookdale formation (Farley Member) from Farley Dingle, Much Wenlock, Shropshire.

**Genus STELLINIUM** Jardine, Combaz, Magloire, Peniguel & Vachey 1972

*Type species.* Original designation *Stellinium* (ex *Veryhachium*) *octoaster* Staplin 1961; Haragan Formation, Lower Devonian (late Gedinnian), Coal County, Oklahoma, U.S.A. By subsequent designation *Stellinium micropolygonale* (Stockmans & Willière 1960), Playford 1977.

*Diagnosis.* (Jardine *et al.* 1972, p. 298, translated by Eisenack *et al.* 1976) 'Central body polyhedral, hollow with a star shaped outline which is prolonged by 8 to 12 expansions in the form of a hollow horn with a sharp distal point; these expansions are of varying lengths, more or less well individualised. The expansions are placed in at least two planes; each appendix of triangular outline related to three contiguous appendices; at their junction there are slight radial crests'.

*Remarks.* Species belonging to this genus are similar to species of *Veryhachium* but differ in having broad based processes that form an ill defined central body. *Michrystridium* differs in having more processes and a subspherical vesicle. Lack of branching distinguishes this genus from *Multiplicisphaeridium.*

Plate 35, fig. 3.

1964b Polyedryxium rabians; Cramer, p. 320, pl. 15: 10 - 16, fig. 32: 3, 4.
1969 Polyedryxium rabians; Cramer, p. 75.
1969b Veryhachium daillyense; Stockmans & Willière p.
1971b Polyedryxium rabians; Deunff, p. 38, pl. 6, 14 - 19, pl. 8: 3, 4.
1972 Polyedryxium rabians; Cramer & Díez p. 142.
1976 Stellinium rabians; Eisenack et al. p. 743.
1990 Stellinium rabians; Fensome et al. p. 462, no fig.

Holotype. Cramer 1964, p. 320, pl. 15; 13. from the La Vid Shales (middle Siegenian to Emsian) of Northwest Spain.

Diagnosis. (Cramer 1964b p. 320). 'Shell cubic. The walls are of one layer; they are psilate at 1200x magnification. The intersecting edge of the shell is smooth. Rarely the shell is slightly extended at the corners, but these extensions are never longer than some 10 to 20% of the total diameter. The walls are thin and transparent'.

Remarks. The specimens recovered conform to the original diagnosis and thus is a species of Stellinium with a single-walled vesicle, 14 µm to 18 µm in diameter. The vesicle body is laevigate to scabrate. Excystment by cyclopyle. (Pylome). One of the specimens recovered had slightly greater dimensions than those of the original diagnosis but as this was only by 2 µm then it is believed to be within error margins for species assignation. This species differs from species of Veryhachium in having smaller vesicle with processes indistinct from the central body.

Dimensions. Vesicle diameter including processes 14 - 18 µm
Number of specimens measured 2

Occurrence This species was recorded from the following localities: the San Pedro and La Vid formations (Ludlovian to Emsian Stages) of north-west Spain (Cramer 1964b); Llandovery Series of east coast USA (Cramer & Díez 1972); Ludlow Series (Lower Elton Formation to the Lower Leintwardine Formation) of the Ludlow area (Lister & Downie 1974); Devonian of Morocco (Marhoumi & Rauscher 1984); upper Silurian of San Juan, Argentina (Rubinstein 1993).
This species was recovered in low numbers in samples from Farley Dingle, Harley Hill, and Shadwell Quarry, in the type area Much Wenlock, Shropshire, England.

Known Range: Wenlock to Emsian.

Genus SYLVANIDIUM Loeblich 1970

Type Species. Sylvanidium paucibrachium Loeblich p. 736.

Diagnosis. Central body of variable shape, commonly bean shaped with two main polar processes and remainder of body unadorned or with a variable number of processes arising on the central body at right angles to the main processes; wall thin, smooth; no excystment mechanism observed.

Remarks. Sylvanidium is closely comparable to Veryhachium (Loeblich 1970 p. 736), but differs in that it has an inflated 'rounded' nature of the central vesicle bodies rather than the polygonal nature of species of Veryhachium with two main polar processes.

Sylvanidium sylviae sp. nov.

Plate 54, figs. 7, 8.

Derivation of name. Named for Sylvia Evans, who provided motivational and financial support throughout this research.

Holotype. Plate 54, fig. 8; from sample FD 1600/10/1, Rivelin Finder reference S 33; from the Farley member of the Coalbrookdale Formation of Farley Dingle, Much Wenlock, Shropshire, England.

Diagnosis. Thin to medium, laevigate, single walled, hollow vesicle body robust in form with an inflated vesicle body, slightly elongate in one direction. The vesicle bears 6 short processes; two of which arise from the poles of the body and four arranged around the approximate equatorial circumference of the central body. The processes are short (less than half the vesicle body diameter), hollow and communicate freely with the central body cavity. The processes have flared bases and taper to acuminate simple tips. Mode of excystment by simple split.
Remarks. This form differs from *Sylvanidium paucibrachium* as this Devonian species is commonly bean shaped and has processes arranged in a more random fashion than in *S. sylviae*. This species differs from small veryhachiid species in that it has short processes and an inflated central body, rather than a polygonal vesicle.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Vesicle diameter</th>
<th>14 - 18 μm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Process length</td>
<td>6 - 12 μm</td>
</tr>
<tr>
<td></td>
<td>Process base width</td>
<td>2 μm</td>
</tr>
<tr>
<td></td>
<td>Number of processes</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

Occurrence. This species was recovered from the Coalbrookdale, Much Wenlock Limestone and the Lower Elton formations of the type areas of Much Wenlock and Ludlow, Shropshire, England. This species was recovered sporadically in low numbers but consistently spanning the section at Harley Hill. Rare in samples from Farley Dingle, no recoveries from the Ludlow area.

Genus **TASMANITES** Newton 1875 emend.
Eisenack 1958a

*Type species*. *Tasmanites punctatus* Newton 1875, p. 337, pl. 10, figs 2-9; from the Mersey River, Permian of Tasmania.

*Diagnosis.* (Eisenack 1958a, p. 6. Translation: Eisenack *et al.* 1979, p. 231-232). “Hollow spherical, generally comparatively thick-walled and of a very resistant, yellowish to dark red-brown hyaline organic substance consisting of organic remains which often are preserved in a disc-shaped compressed state or also irregularly folded. Wall with more or less numerous pores which rarely penetrate the entire wall, but often either end blindly in the thick wall from the outside or from the inside. Pylome present, however usually uncommon. The wall pores are not always visible in each specimen of a species; it is essential that they should occur in the majority of the species. Young examples are indeed always thin-walled and then lack the pylome. They are then not distinct from *Leiosphaeridia*.”

*Remarks* The specimens assigned to the genus *Tasmanites* have not been rigidly assigned to existing species because there is a great deal of work to be carried out in sorting out the taxonomy as there are many synonymous species in the available literature. Synonymous taxa are listed in Eisenack *et al.* 1979 p. 233 and Fenstone *et al.* 1990, p. 471. Tasmanitiids are characterised by their large size, thick wall bearing pore canals (Eisenack 1958). Some authors place Tasmanitiids in the algal class Chlorophyceae (Tappan 1971) and others Prasinophycean algae (Colbath & Grenfell 1995).

Plate 45, fig 2.

1931  
Bion medium  Eisenack, p. 109, pl. 5, fig. 1.

1938  
Leiosphaeridia media; Eisenack p. 26. pl. 3. fig. 11.

1958  
Tasmanites medius; Eisenack p. 6, pl. 2, figs. 14, 15.

1959  
Tasmanites cf. medius; Downie, p. 67, pl. 12, fig. 5, 6.

1978  
Tasmanites medius; Kiryanov p. 84, pl. 2, fig. 5a, 6.

1991  
Tasmanites medius; Fensome et al. p. 473, no fig.

Only the major changes are included in the synonymy list. For full synonymy list prior to 1979 see Eisenack et al. 1979 p. 277.

Diagnosis. (Eisenack 1931 p. 109, pl. 5, fig. 1. Translation Eisenack et al., 1979 p. 278) Spherical cyst of a diameter of 120 μm with a thick homogenous wall that is about 8 μ thick. Surface smooth, or at the most finely granulated.

Remarks. Specimens conform broadly to the original diagnosis. They are generally smaller though and thinner walled than the holotype. Vesicle spherical, relatively thick walled and smooth with a thick margin in proportion to the size of the vesicle.

Dimensions.  
Vesicle diameter  60 - 80 μm
Wall thickness  6 - 8 μm
Number of specimens measured  5

Occurrence. This taxon has been widely reported and within the literature the most relevant occurrences include the following: Ludlow Series of the Baltic (Eisenack 1931, 1955, 1958a, 1968 b, c); Ashgill Series (Ordovician) of the Baltic (Eisenack 1955); Coalbrookdale formation (Wenlock Series) Shropshire (Downie 1959, 1963); Siluro-Devonian of Germany (Eisenack 1971); Ludlow to Prêdolf of Podolia, (Kiryanov 1978) Sheinwoodian to early Homerian of Wenlock area; Malverns and Tortworth Inlier (Swire 1991).

Tasmanites cf. medius was recovered from the Farley Member of the Coalbrookdale Formation, the Much Wenlock Limestone Formation (Homerian Stage) to the lowermost levels of the Lower Elton Formation (Gorstian Stage), Wenlock to Ludlow Series (Silurian) of the type area in the Welsh Borderland, in samples from the following localities: Farley Dingle; Pitch Coppice; Mortimer Forest; Harley Hill; Coates Quarry; Shadwell Quarry.

Generic Known Range: Precambrian? to Recent
Tasmanites sp. (formgroup)

Plate 27, fig. 3. Plate 45, fig. 4.

Remarks. Large thick walled tasmanitiids of variable appearance informally assigned to the genus Tasmanites. This grouping covers a wide range of forms both ornamented and not ornamented, punctate and not punctate etc. Ornamentation in some cases could possibly be a form of degradation of the vesicle body. Due to the broad variation which is not necessarily useful in systematic taxonomy the majority of the tasmanitiids recovered as part of the palynoflora in this study have been simply recorded as Tasmanites sp. These being thick walled large sphaeromorph palynomorphs of a distinctive nature.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Vesicle diameter</th>
<th>100 - 250 μm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall thickness</td>
<td>6 - 10 μm</td>
<td></td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

Occurrence. Llandovery to Wenlock Series of Gotland (Eriksson & Hagenfeldt 1997); Specimens assigned to this group were recovered from the Farley Member of the Coalbrookdale Formation, Much Wenlock Limestone Formations (Homerian) to Lower Elton Formation (Gorstian), Wenlock to Ludlow Series (Silurian) of the type area in the Welsh Borderland. In samples from the following localities. Farley Dingle; Pitch Coppice; Mortimer Forest; Harley Hill; Coates Quarry; Shadwell Quarry.

Other divisions recorded are as follows:

Tasmanites sp. A

Not figured.

Description. Ornamented forms.

Occurrence. These were recorded from Harley Hill; Farley Dingle; Shadwell Quarry; Pitch Coppice and Mortimer Forest. From the upper part of the Coalbrookdale, Much Wenlock Limestone and Lower Elton formations
Tasmanites sp. B

Plate 27, fig. 4.

Description. The specimens recorded herein were elongate forms. It is acknowledged that this could be a result of preservational effects.

Occurrence. These forms were recorded from the Farley Member of the Coalbrookdale Formation of Farley Dingle and Harley Hill.

Genus TUNISPHAERIDIUM Deunff & Evitt 1968

Type species. Tunisphaeridium tentaculaferum, (Martin 1967, p. 312, pl. 1 fig. 23, text - fig. 3.), Cramer 1970a, p. 192 - 193, from the Llandovery Series of Belgium. Taxonomic senior synonym. Original designation: Tunisphaeridium concentricum Deunff & Evitt 1968, p. 3, pl. 1, figs 1-12; Maplewood Formation, upper Llandovery Series, Rochester, New York State.

Diagnosis. (Deunff & Evitt 1968, p. 2). 'Acritarchs with an overall spherical to ellipsoidal or pyriform outline composed of a central sphaeroidal vesicle bearing numerous rod like, apparently solid, processes whose extremities are interconnected by a diaphanous membrane alone, by a membrane reinforced with a network of faint to conspicuous filaments that radiate from the process tips, or by such filaments with only traces of a membrane. No pylome observed'.

Remarks. This genus is distinguished by the thin membrane, supported by the pinnac/processes and surrounds the vesicle distinguishes.

Tunisphaeridium tentaculiferum (Martin 1967) n. comb.

Cramer 1970a

Plate 49, figs. 2, 4.

1967 Baltisphaeridium tentaculaferum sp. nov. Martin, p. 312, pl. 1, fig. 23, text - fig. 3.
1967 Tunisphaeridium venosum Deunff 1965; Cramer, p. 235, no fig.
1968a Tunisphaeridium venosum Deunff 1965; Cramer; p. 66, pl. 1, fig. 5

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1968 *Tunisphaeridium concentricum* n. sp.; Deunff & Evitt, p. 3, pl. 1, figs 1


1972 *Tunisphaeridium tentaculiferum* Cramer; Cramer & Diez, p. 172, no fig.


1979 *Tunisphaeridium tentaculiferum*; Cramer *et al.* fig. 15.

1987 *Tunisphaeridium tentaculiferum*; Smelror, p. 141, pl. 2, fig. 8.

1986 *Tunisphaeridium tentaculiferum*; Wicander p. 357, pl. 7 fig. 7.

1988 *Tunisphaeridium tentaculiferum*; Hill & Molyneux, p. 31, no fig.

1990 *Tunisphaeridium tentaculiferum*; Cramer; Fensome *et al.*, p. 498, no fig.

**Holotype.** Martin 1967, p. 312, pl. 1, fig. 23; of probable Llandovery age from Belgium.

**Diagnosis.** (Cramer 1970a, p. 192). 'Central body spherical, hollow; clearly differentiated from the processes. Numerous (30 to 40, rarely up to 50) slender, cylindrical processes are present; about ten are visible in optical section. The processes appear to be solid. Distally, the processes are interconnected by a more or less regular set of complex pinnae forming an open-mazed net which is concentric with the central body. The net varies from widely mazed in which the braided pinnae are relatively unbranched, to a net in which the pinnae are highly branched secondarily and the mazes of the net are narrow'.

**Dimensions.**

- Vesicle diameter: 22 - 36 µm
- Process length: 10 - 16 µm
- Entire vesicle to outer margin: 40 - 58 µm
- Number of specimens measured: 8

**Remarks.** Specimens belonging to this species were thin walled, pale yellow to transparent and often poorly preserved. The membrane was often absent or fragmentary, with ragged pieces remaining attached to processes. *Tunisphaeridium tentaculiferum* exhibits filamentous net like branching to the process terminations which contrasts to the simple process terminations of *Tunisphaeridium parvum* Deunff & Evitt 1968. The name *tentaculiferum* (Cramer 1970a, Cramer & Diez 1972) as opposed to *tentaculaferum* is retained as this is the correct Latin form Dorning pers. comm.

**Occurrence.** *Tunisphaeridium tentaculiferum* has been recovered from: The Maplewood Shale, upper Llandovery Series, New York (Evitt 1961, Cramer 1968a, Deunff & Evitt 1968); the upper Llandovery Series of Belgium (Martin 1965, 1966 1967); San Pedro Formation, Ludlow Series of north-west Spain (Cramer 1966a);
middle Silurian of New York, USA to middle Devonian (Gedinnian stage) of Tunisia (Deunff & Evitt 1968); upper Silurian of Libya; upper Llandovery Series of Alabama, Georgia, Kentucky, Indiana and Ohio USA, New York and Ontario (Cramer 1970a, Cramer & Diez 1972); lower Llandovery to Wenlock Series of Ontario, Canada and New York State USA (Thusu 1973 a & b); Hamilton Formation (Devonian) of south-western Ontario, Canada (Legault 1973 as T concentricum); Wenlock (Much Wenlock Limestone Formation) to Ludlow series (Upper Whitcliffe Formation) of the Ludlow area (Lister & Downie 1974 as Tunisphaeridium sp.); late Llandovery to lower Wenlock series (Buildwas formation) of the type Llandovery type area and Welsh Borderland (Hill 1974 a); late Silurian, Wenlock to Ludlow Series of Algeria (Jardiné et al. 1974); upper Visby to Högklint formations, lower Wenlock Series of Gotland, Sweden (Cramer et al. 1979); Dadas formation (Llandovery to Ludlow Series) of South East Turkey (Erkmen & Bozdogan 1979); Ludlow Series, Los Espejos Formation of San Juan Province, Argentina (Pothé de Baldis 1981); upper Llandovery Series (Purple Shales) to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985); Devonian of Ohio (Wicander & Wood 1981, Wicander & Wright 1983, Wicander 1984); middle Llandovery Series of the Llandovery type area (Hill & Dorning 1984); Lower Devonian, of Oklahoma, USA (Wicander 1986); upper Llandovery to lower Wenlock series of Norway (Smelror 1987); Llandovery Series of north-east Libya (Hill & Molyneux 1988); Llandovery to Wenlock series of Gotland, Sweden (Le Hérissé 1989); Buildwas and Coalbrookdale formations (Sheinwoodian) of the Wenlock type area and the Woolhope Limestone and Coalbrookdale formations (Sheinwoodian) of the Eastnor Park borehole (Swire 1991); Coalbrookdale Formation (Homerian), Wenlock Series from Holbrook Coppice, near Ironbridge, Shropshire (Turner et al. 1995); Devonian of Iowa, USA (Wicander & Wood 1997).

This species has been recovered as a rare type from the Coalbrookdale Much Wenlock Limestone and lower Elton Formation, in the type areas; Much Wenlock and Ludlow, Shropshire England. Samples from Farley Dingle (FD 1900); Harley Hill (HH2 500 and HH2 600); and Mortimer Forest (MFGT1-400).

Known range: Llandovery - mid Devonian (Frasnian) series

Genus **TYLOTOPALLA** Loeblich 1970

*Type species.* Tylotopalla digitifera Loeblich 1970 pp. 738-739, fig. 33 D - E; Maplewood Shale, mid Silurian of Oklahoma, USA.

*Diagnosis.* (Loeblich 1970 p. 737). ‘An acritarch of small size, with circular to subcircular inflated central body whose interior communicates freely with the numerous short processes; processes terminate in a point or in short bifurcations with a feather or rosette of small spines just below their distal end. Surface variously ornamented, rugulate, scabrate or psilate’.

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Remarks. Differs from *Diezallophasis* in having shorter, stubby processes. *Multiplicisphaeridium* has more slender processes which branch distally. *Baltisphaeridium* has processes which do not communicate with the vesicle interior.

**Tylotopalla robustispinosa** (Downie 1959) Eisenack *et al.* 1973

Plate 49, fig. 1.

1959 *Baltisphaeridium robustispinosa* sp. nov.; Downie, p. 61, pl. 10, fig. 7.
1970a *Baltisphaeridium robustispinosa*; Cramer, p. 186 - 187, fig. 60 c.
1970 *Evittia robustispinosa* (Downie) n. comb. Lister, p. 67 no fig.
1978 *Tylotopalla tappanae* sp. nov.; Kiryanov, p. 87, pl. 13, fig. 7.
1981a *Tylotopalla robustispinosa*; Dorning, p. 200, pl. 2, fig. 4.
1989 *Evittia robustispinosa* Lister; Le Hérisse, p. 129-130, pl. 12, figs 6-10.
1990 *Tylotopalla robustispinosa*; Eisenack *et al.* 1973; Fensome *et al*., p. 500, no fig.

**Holotype.** Downie 1959, p. 61, Pl. 10, fig. 7. from the Coalbrookdale Formation, Wenlock Series, Eaton Track, Wenlock Edge, Shropshire.

**Diagnosis.** (Downie 1959), ‘A species of *Baltisphaeridium* with a more or less spherical test, diameter about 30 μm, processes about 10 μ, stout, 4 μ wide at base, 10 to 15 μ apart, about seven seen at circumference, surface of processes granular, terminated by a short hair, sometimes broken’.

**Dimensions.**

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<table>
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<tbody>
<tr>
<td>Vesicle diameter</td>
<td>24 μm - 30 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>8 μm - 12 μm</td>
</tr>
<tr>
<td>Process width</td>
<td>5 μm</td>
</tr>
<tr>
<td>Process number</td>
<td>8 - 12</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>2</td>
</tr>
</tbody>
</table>

Remarks. This species recovered are identified as *T. robustispinosa* but it is evident that there may be gradation between this species and *T. wenlockia* Dorning 1981a, which has more elongate processes than those of *T. robustispinosa*. Intermediary forms for example *T. tappanae* Kiryanov 1987 has been included here though being close in appearance to *T. wenlockia* but may have a greater number of processes. In addition, the forms reported by
Le Hérissé (1989) also more closely resemble *T. wenlockia* than *T. robustispinosa* sensu stricto. Before splitting of the species into the two or maybe three morphotypes, examination of the holotypes is necessary.

This species differs from *T. wenlockia* Dornin 1981a, which has processes more elongate than those of *T. robustispinosa*. Though it is possible that these two forms intergrade.

**Occurrence.** Coalbrookdale Formation, Wenlock Series, Eaton track, Shropshire (Downie 1959); Llandovery (Aeronian) to lower Wenlock (Telychian) series of the Llandovery type area and Welsh Borderland (Hill 1974); Llandovery to Wenlock Series of Podolia (Kiryanov 1978, as *T. tappanae*); Buildwas to Much Wenlock Limestone formations, (Sheinwoodian to Homerian Stage) of the Wenlock Series in the Welsh Borderland (Dornin 1981a); Much Wenlock Limestone Formation, Wenlock Series of the West Midlands, UK (Dornin 1983); Chester Berg Formation (Wenlock) in Greenland (Armstrong & Dornin 1984 as *T. wenlockia*); upper Llandovery Series (Purple Shales) to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985); upper Llandovery Series of north-east Libya (Hill & Molyneux 1988); Wenlock Series of the Southern Uplands (Molyneux 1987); Middle Wenlock Series, Cheviot Hills, north-east England (Barron 1989); Llandovery to Wenlock series of Gotland, Sweden (Le Hérissé 1989); upper Silurian of San Juan, Argentina (Rubinstein 1993); Coalbrookdale Formation (Wenlock Series) from Holbrook Coppice, near Ironbridge, Shropshire (Turner et al. 1995 as *T. robustispinosa* and *T. wenlockia*). Rare occurrences only, being found in low numbers from samples in the Wenlock and Ludlow areas of Shropshire. Farley Dingle (FD 200); Shadwell Quarry (2SH - 1.0); Pitch Coppice (PC200 - rare type from scan of slides).

**Known Range.** Llandovery to Ludlow series (Silurian).


**Type species.** *Veryhachium trisulcum* (Deunff, 1951) Deunff, 1959 *ex. Downie, 1959.*

**Diagnosis.** (Turner, 1984, p. 139 from Loeblich & Tappan 1969) “Vesicle thin-walled, polygonal, with processes from the angles forming an integral part of the vesicle, major processes in a single plane, commonly with accessory processes at various positions on the vesicle, processes distally closed and simple. Surface may be ornamented with grana or may be smooth. Excystment is by the formation of an epityche.”

**Remarks** Species belonging to the genus *Veryhachium* have characteristic polygonal, hollow vesicle bodies bearing processes that emerge from the corners of the vesicle body which taper to form a simple acuminate tip. The
processes vary in number between three and nine and communicate freely with the central body cavity. The vesicle body is generally laevigate but micro ornamentation may be present. The generic diagnosis is that given by Turner (1984) which omits the inclusion of forms which have an ornamented vesicle body such as *Villosacapula* (Loeblich and Tappan 1976). *Dateriocradus* Tappan & Loeblich, differs in having multifurcate processes whilst *Fractoricornula* Turner 1984 has plugged processes. The re-structuring of the genus as proposed by Sarjeant & Stancliffe (1994) and Stancliffe & Sarjeant (1995) has not been followed herein.

**Veryhachium bulbiferum** Deflandre 1945

Plate 29, fig 9

1945 *Michrystridium bulbiferum* Deflandre p. 67-68, pl. 2, figs. 10, 11.
1954b *Michrystridium bulbiferum* Deunff p. 307
1959 *Veryhachium bulbiferum* Downie, p. 68. not valid.
1963 *Veryhachium bulbiferum* Downie p. 636, no fig.
1963 *Veryhachium bulbiferum* Downie & Sarjeant p. 94, no fig.
1970a *Veryhachium bulbiferum* Cramer p. 95, fig. 28.
1990 *Veryhachium bulbiferum* Fensome p. 512, no fig.

*Holotype* Original designation, *Michrystridium bulbiferum*, Deflandre 1945 p. 67-68, pl. 2, 10 from Roquemaillère, (Silurian), Hérault, France.

*Diagnosis* (Deflandre 1945 translation from Eisenack *et al.* 1979) “Species represented by one single specimen which is rather poorly preserved (and which) possesses a quite particular characteristic: the horns which form its ornament have a suddenly widened base so as to form a kind of bulb or clearly distinct nipple. The arrangement of these horns is such that it appears very probable that they used to be six in number, deployed at the angles of two superimposed and crossed triangles.”

*Remarks* The specimens recovered were originally assigned to a provisional grouping as *Michrystridium* sp. B. Forms were also recovered with the same form in processes arrangement with longer processes.
Dimensions

- Vesicle body diameter: 16 - 20 µm
- Process length: 10 - 16 µm
- Number of processes: 6
- Number of specimens measured: 10.

Occurrence. Silurian of Montagne Noire (Deflandre 1945, 1954); Coalbrookdale formation, Wenlock Series of the Welsh Borderland (Downie 1959, 1963); Wenlock Series (upper Homerian) to Ludlow Series (upper Gorstian) of the Ludlow area (Lister & Downie 1974).

This species was recovered from the Much Wenlock Limestone Formation and the Lower Elton Formation of the type areas of Much Wenlock and Ludlow, Shropshire, England.

Known Range: Wenlock - Ludlow Series

**Veryhachium downiei** Stockmans & Willière 1962

Plate 50, figs. 1, 2.

1962a *Veryhachium downiei* Stockmans & Willière p. 47-48 pl. 2. figs. 20 - 22, fig. 2
1971 *Veryhachium* cf. *downiei* Henry & Thadeau p. 1343, pl. 1. figs. 4, 12.
1987 *Veryhachium downiei* Priewalder, p. 55, pl. 7 figs. 4, 12.
1990 *Veryhachium downiei* Fensome p. 514, no fig.

For full synonymy prior to 1979 see Eisenack et al. 1979 p. 393 - 395.

**Holotype** Stockmans & Willière 1962 p. 47-18, pl. 2 fig. 21, from Tournai, Belgium.

**Diagnosis** (Translation of original diagnosis (Stockmans & Williére 1962a) by Eisenack 1979 p. 394.)

“Triangular form with convex sides, extended by simple processes which may be straight or curved. Height of the body approximately 15 -18 µm; length of processes 10 -15 µm.”

**Remarks** The specimens recovered conform to the original diagnosis being essentially three processed veryhachiids, thin walled fat bodied short processed veryhachiids. Vesicle body triangular convex in outline, each
corner bearing a single processes. Processes taper distally to an acuminate simple tip. The processes communicate freely with the central body cavity. The processes are equal to or less than the vesicle diameter. Excystment is by simple split. The size range recovered is generally larger than that recovered by Stockmans & Willière, there may be overlap between this species and Veryhachium trispinosum suggestive of end members of a formgroup. Veryhachium trispinosum has considerably longer processes and is larger.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Vesicle body diameter</th>
<th>14 - 18 μm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process length</td>
<td>6 - 18 μm</td>
<td></td>
</tr>
<tr>
<td>Process width</td>
<td>1.5 μm</td>
<td></td>
</tr>
<tr>
<td>Number of processes</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

**Occurrence.** This species has been recovered widely throughout the world, for other occurrences see Eisenack *et al.* (1979) 394 - 395. Veryhachium downiei has been recorded from the upper Devonian of Belgium (Stockmans & Willière 1962a); late Silurian to early Devonian of Cantabrica Mountains of Spain (Cramer 1964a); Siegenian of Cotentin, France (Rauscher *et al.* 1965); Silurian of Courtrai, Belgium (Martin 1966, 1968); Ludlow Series of Brittany (Deunff *et al.* 1971); Silurian of the Baltic (Yankauskas & Vaitkevunene 1972); Ordovician of Portugal (Henry & Thadeau 1971); upper Llandovery to Ludlow series of the USA (Cramer & Diez 1972); lower Ordovician of France (Rauscher 1973); Wenlock (Homerian) to Pridolf Series of the Ludlow area (Lister & Downie 1974); Frasnian of Germany (Jux 1975); Silurian to Devonian of France (Deunff & Chataeuneuf 1976); lower Devonian of the UK (Downie 1979); Devonian of Ontario, Canada (Playford 1977); Gedinnian of Brest (Deunff 1980); Devonian of the Carnarvon Basin of Western Australia (Playford & Dring 1981); Ordovician of Shropshire (Turner 1984); Devonian of Morocco (Marhoumi & Rauscher 1984); Llandeilo Series of South Wales (Turner 1985); Sheinwoodian of the Welsh Borderlands (Swire 1991); late Ludlow Series of the type area (Washington - Evans 1992); Lower Palaeozoic of the Garhwal Himalaya, India (Sinha *et al.* 1996).

This species has been recovered consistently throughout the sections sampled from the type area and was recovered from the Much Wenlock Limestone Formation and the Lower Elton Formation of the type areas of Much Wenlock and Ludlow, Shropshire, England. Farley Dingle; Mortimer Forest; Pitch Coppice.

**Known Range:** Ordovician to Devonian
Veryhachium europaeum (Stockmans & Willière 1960)

Plate 52, figs. 3, 4.

1960  Veryhachium europaeum n. sp.; Stockmans & Willière, p. 3, pl. 2, fig. 25.
1962  Veryhachium legrandi n. sp.; Stockmans & Willière, p. 54, pl. 1, fig. 3, text - fig. 11a.
1963  Veryhachium europaeum forma 2 .Stockmans & Willière var. ; Wall & Downie, p. 782, pl. 114, fig. 6.
1967  Veryhachium europaeum var. wenlockium Martin, p. 316, no fig.
1968  Veryhachium legrandi var. pentapoda nov. var.; Martinez-Macchiavello, p. 80, text-fig. 8, pl. 1, fig. 8.
1990  Veryhachium europaeum Stockmans & Willière 1960; Fensome et al., p. 514 - 515, no fig.
1994  Dorsennidium europaeum (Stockmans & Willière 1960) comb. nov.; Sarjeant & Stancliffe, p. 40, no fig.
1994  Dorsennidium europaeum forma wenlockium (Downie 1959 ex Wall & Downie 1963) comb. nov.; Sarjeant & Stancliffe, p. 40, no fig.
1996b Dorsennidium europaeum (Stockmans & Willière 1960) Sinha et al. p. 29, no fig.

Holotype. Stockmans & Willière 1960, pl. 2, fig. 25; Frasnian Stage of borehole material from Tournai, Belgium.

Original Diagnosis. (Translated from Stockmans & Willière, 1960, p. 3 by Eisenack et al. 1979). “Form that measures from one edge to the base of the opposite ‘point’ (= process) a length of about 18 μ and ornamented with four equal points of 25 μ, three of these correspond with the angles of a triangle, the forth is the ornament of one of the faces.”

Dimensions.  
Vesicle diameter 10 - 20 μm  
Process Length 16- 34 μm  
Process base width 2 - 6 μm  
Number of processes 4  
Number of specimens measured 10

Remarks. This species is similar to Veryhachium wenlockium which also has four processes but in the latter the process that arises from the centre of the vesicle body is always smaller than those arising from the corners of the vesicle. V. europaeum is also larger than V. wenlockium. The process length is greater than the diameter of the vesicle. The process bases are wide and are indistinct from the vesicle body. The vesicle is thick walled, yellow and
laevigate. The specimens recovered conform to the original diagnosis. The new combination proposed by Sarjeant & Stancliffe (1994) has not been followed for reasons stated in the generic remarks.

**Occurrence.** In addition to the occurrences reported here pre 1979 occurrences have been documented by. V. downiei is a cosmopolitan taxon with a wide geographic distribution and is stratigraphically long ranging thus full documentation of every occurrence would be irrelevant. Thus documented here are only those reported occurrences that have been verified by the author. This species has been reported from the following areas: late Silurian to early Devonian of Cantabrian Mountains of Spain (Cramer 1964a); Siegenian of Cotentin, France (Rauscher et al. 1965); early Silurian of Belgium (Martin 1967); lower Devonian of Uruguay (Martinez-Macchiavello 1968), upper Llandovery of Nova Scotia (Cramer 1970b); Permian of Britain (Wall & Downie 1962); upper Llandovery to Ludlow series of the USA (Cramer 1969a, Cramer & Diez 1972); Ordovician, Arenig Series of Bohemia (Vavradová 1972); Silurian of the Baltic (Yankauskas & Vaitekunene 1972); Siegenian to Emsian stages, lower Devonian of Belgium (Vanguestaine 1978) lower Wenlock Series (Visby and Högklint formations) of Gotland, Sweden (Cramer et al. 1979); Devonian of Ohio, USA (Wicander & Wood 1981); lower Llandovery Series of New York (Miller & Eames 1982); Gedinnian to Siegenian of France (Moreau-Benoít & Poncet 1982); Haragan Formation, Lower Devonian of Oklahoma, USA (Wicander 1986 a & b); Silurian of Ringerike, Norway (Smelror 1987b); Llandovery to lower Wenlock series (lower Visby beds) of Gotland, Sweden (Le Hérissé 1989); Silurian of Argentina (Rubinstein 1993); Sheinwoodian of the type area in the Welsh Borderlands (Swire 1991 as part of the V. wenlockium formgroup); late Ordovician of Bolivia (Gagnier 1996); Lower Palaeozoic of the Garhwal Himalaya, India (Sinha et al. 1996); Devonian of Iowa, USA (Wicander & Wood 1997).

This species was recovered as a consistent form constituting a reasonably high proportion of the assemblage in samples from the Much Wenlock Limestone Formation and the Lower Elton Formation of the type areas of Much Wenlock and Ludlow, Shropshire, England, including Farley Dingle, Harley Hill, Mortimer Forest Geological Trail and Pitch Coppice.

Known range: Ordovician to Jurassic.
Veryhachium irregulare complex Wall & Downie 1963

Veryhachium irregulare forma irregulare Wall & Downie 1963
also referred to as:
Veryhachium sp. O.

1963 Veryhachium irregulare forma irregulare Wall & Downie p. 770 - 775, fig. 1, m.
1979 Veryhachium ? irregulare complex Eisenack et al. p. 431 fig. m.
1990 Veryhachium irregulare forma irregulare Fensome et al. p. 517. no fig.


Diagnosis. (Eisenack et al. p. 432.) “Polygonal and subpolygonal forms, generally with four to six spines. With respect to test shape of the polygonal forms, two basic series can be distinguished, one being octagonal, the other tetrahedral. Members of the first series typically have six spines projecting from their apices but may have any number from four to nine. The second series typically has four spines but may occasionally have as many as eight without losing their basic tetrahedral shape.”

Remarks. Laevigate vesicle body triangular in outline bearing three processes from the corners of the vesicle and two arising from the centre of the vesicle body. Vesicle sides straight to slightly convex.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>24 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>4 μm</td>
</tr>
<tr>
<td>Number of processes</td>
<td>5</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

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Occurrence. See Eisenack et al. 1979 p. 432 - 433 for details prior to 1979. In this study this species was a rare type, recovered from the Coalbrookdale Formation of the type area, Much Wenlock, Shropshire, England. Farley Dingle sample: FD 1200. This species was not recovered from Pitch Coppice or Mortimer Forest in the Ludlow area.

**Veryhachium irregulare forma subhexaedron** Wall & Downie 1963

also referred to as:

**Veryhachium sp. R**

Plate 53, fig. 2.

1963 *Veryhachium irregulare forma subhexaedron* Wall & Downie p. 770 - 775, fig. 1, k.

1979 *V ? irregulare* complex Eisenack et al. p. 431 fig. k.

1990 *Veryhachium irregulare forma irregulare* Fensome et al. p. 517. no fig.


Name not validly published by De Jekhowsky (1961)

**Diagnosis.** As for *Veryhachium irregulare forma irregulare*. (Eisenack et al. p. 432.) “Polygonal and subpolygonal forms , generally with four to six spines. With respect to test shape of the polygonal forms, two basic series can be distinguished, one being octagonal, the other tetrahedral. Members of the first series typically have six spines projecting from their apices but may have any number from four to nine. The second series typically has four spines but may occasionally have as many as eight without losing their basic tetrahedral shape.”

**Remarks** Vesicle body of hexagonal outline bearing five processes arising from the corners of the central body. At least three process arise from the mid portion of the vesicle. The processes are proximally flared and taper to an acuminate tip. The processes communicate freely with the central body cavity.

**Dimensions**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>18 - 24 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>10 - 14 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 - 6 μm</td>
</tr>
<tr>
<td>Number of processes</td>
<td>8</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1.</td>
</tr>
</tbody>
</table>
Occurrence. See Eisenack et al. 1979 p. 432 - 433 for details prior to 1979. This species was recovered as a rare type from the Coalbrookdale Formation, Harley Hill (HH1 - TD) of the type area, Much Wenlock, Shropshire, England. This species was not recovered from Pitch Coppice or Mortimer Forest in the Ludlow area.

**Veryhachium lairdii** (Deflandre 1946, Deunff 1959) Loeblich 1970

Not figured.

1959 *Veryhachium lairdii* Deunff, p. 28, pl. 8 figs. 75 - 79
1962 *Veryhachium cf. lairdii* Wall & Downie, p. 782, text fig. 1-f.
1970 *Veryhachium lairdii* Loeblich, p. 742, no fig.
1972 *Veryhachium lairdii* Vavradová p. 80.
1990 *Veryhachium lairdii* Fensome et al. p. 517, no fig.

For a more complete synonymy list prior to 1975 see Eisenack et al. 1979 p. 437 - 438.

**Holotype.** *Veryhachium lairdii* Deunff 1958, p. pl. 8 fig. 75 from the Caradoc Series of Plage d' Veryhac'h, Brittany designated by Loeblich (1970).

**Diagnosis.** See Deunff (1959) p. 28 - 29. (Translation by Eisenack et al. 1979, p. 439.) “The central body is brownish, light brown to vivid orange in colour and measures 10 - 30 µm. The total size of the specimens observed in the formations of Veryhac’h falls between 55 and 100 µm. The general form of the central body corresponds to that of a pillow which is more or less inflated and bears a spine at each corner. Diagrammatically, the central body may be square, rectangular or lozenge shaped.”

**Remarks.** Specimens recovered conform to the original diagnosis. Small, quadrate veryhachiids having a laevigate polygonal vesicle with corners smoothly extended to form four simple, hollow, tapering processes communicating freely with the vesicle cavity. The processes are emergent within a single plane and their length is less than the vesicle size. This species differs from *V. leintwardinensis* Dorning 1981a which is smaller and has a microgranulate vesicle. This species has been considered a senior synonym to *V. valiente* (Cramer 1964b) by various authors (Martin 1969 p. 95 and Turner). There are gradations between the two species and for now these two species are being treated as part of a complex (Wall & Downie 1962).
**Dimensions.**

- **Vesicle diameter:** 16 - 26 \( \mu \text{m} \)
- **Process length:** 14 - 28 \( \mu \text{m} \)
- **Process base width:** 1.5 - 2.5 \( \mu \text{m} \)
- **Process number:** 4
- **Number of specimens measured:** 5.

**Occurrence.** This species has been recorded extensively refer to Eisenack et al. p. 441 (1979) for a comprehensive list of pre 1979 occurrences. Notable occurrences include; the Permian of Britain (Wall & Downie 1962); late Silurian - early Devonian of Cantabrica Mountains of Spain (Cramer 1964a); Siegenian of Cotentin, France (Rauscher et al. 1965); Silurian of Belgium (Martin 1967); upper Llandovery of Nova Scotia (Cramer 1970b); upper Llandovery to Ludlow series of the USA (Cramer & Diez 1972); Ordovician, Arenig Series of Bohemia (Vavradová 1972); Wenlock Series of New York State (Thusu 1973b); Wenlock Series of Ontario (Thusu 1973a); Wenlock to Ludlow series of Algeria (Jardine et al. 1974); lower to middle Devonian of Ontario, Canada (Playford 1977); Upper Visby to Högklint formations, lower Wenlock Series of Gotland Sweden (Cramer et al. 1979); lower Llandovery Series of New York (Miller & Eames 1982); Lower Llandovery of New York State, USA (Miller & Eames 1982); Ashgill Series (Ordovician) of Anticosti Island, Canada (Jacobson & Achab 1985); upper Llandovery Series (Purple Shales) to lower Wenlock Series (Buildwas Formation) of the Wenlock area, Welsh Borderlands (Mabillard & Aldridge 1985); Llandeilo Series of South Wales (Turner 1985); Silurian of Ringerike, Norway (Smelror 1987); upper Ordovician to lower Llandovery Series of north-east Libya (Hill & Molyneux 1988); (Swire 1990); Whitcliffe formation of the Ludlow area (Washington - Evans 1992); Lower Palaeozoic of the Garhwal Himalaya, India (Sinha et al. 1996).

This species was recovered from the Much Wenlock Limestone Formation and the Lower Elton Formation of the type areas of Much Wenlock and Ludlow, Shropshire, England.

**Known Range.** Late Ludfordian. Long ranging early Ordovician to Permian.

**Veryhachium cf. pertonensis** Doming 1981a

Plate 50 figs, 5, 6. Plate 53, fig. 3.

**cf.**

1981a **Veryhachium pertonensis** n. sp.; Doming. p. 201, pl., 1 fig. 4.

1990 **Veryhachium pertonense** Doming; Fensome et al. p. 520.
Holotype Doming 1981a, p. 201, pl. 1, fig. 4.

Diagnosis. (Doming 1981a p. 201.) "Vesicle subpolygonal in outline, 20 - 30 across, granulate; 4 - 6 processes in three dimensions, regularly distributed at the vesicle corners, 30 - 50; long, granulate 4 - 5 wide at base, taper to sharp simple tip."

Description. The specimens included herein are rhombic in outline, bearing four processes extending from the corners of the vesicle body and one or more (normally two processes) arise from the centre of the vesicle body, on either side. The processes dimensions are equal to or greater than the central vesicle body.

Remarks. The forms recovered are compared to the species Veryhachium pertonensis (Doming 1981a) because they are medium walled and laevigate rather than granulate, though the figured specimen of Doming (1981a) appears laevigate. This species has broader shorter processes than V. rhomboidium and more processes than V. trispinosum. This morphotype was logged as Veryhachium sp. A, C, J.

Dimensions  
- Vesicle diameter 18 - 28 μm  
- Process length 18 - 28 μm  
- Process base width 2 μm  
- Number of processes 6  
- Number of specimens measured 10

Occurrence. The occurrences reported here are those verified by the author. This species has been reported from the late Silurian to early Devonian of the Cantabrica Mountains of Spain (Cramer 1964a); Lower Elton Formation of the Welsh Borderlands (Doming 1981a); Llandovery to Wenlock series of Gotland, Sweden (Le Héissé 1989); Llandovery to Wenlock Series of Gotland (Eriksson & Hagenfeldt 1997).

This species was recorded from the Coalbrookdale, Much Wenlock Limestone and the lowermost portion of the Lower Elton formations of the type areas of Much Wenlock and Ludlow, Shropshire, England. Specimens were found consistently throughout the section at Harley Hill, Farley Dingle, and Coates Quarry, in the Much Wenlock area and Mortimer Forest, and Pitch Coppice sections in the Ludlow area.
**Veryhachium rhomboidium** Downie, 1959 *emend.* Turner, 1984

Plate 52, fig. 2

1959 *Veryhachium rhomboidium* sp. nov.; Downie, p. 62 - 63, pl. 12, fig. 10.
1960 *Veryhachium rhomboidium* Stockmans & Williere, p. 2, pl. 1, fig. 9, pl. 2, fig. 23.
1963 *Veryhachium rhomboidium* Wall & Downie p. 781, pl. 113 figs 10 - 12, (not 9), pl. 114, fig. 1 - 3; text - fig 1 a - e.
1963 *Veryhachium rhomboidium* Downie p. 636.
1969 *Veryhachium rhomboidium* Martin p. 101 - 102, pl. 8, fig. 373, fig. 49.
1984 *Veryhachium rhomboidium* p. 145, pl. 11, figs. 6, 9.
1990 *Veryhachium rhomboidium* Fensome *et al.*, p. 523, no fig.
1996 *Veryhachium rhomboidium* Sinha *et al.* p. 29, no fig.

*Holotype.* *Veryhachium rhomboidium* Downie, 1959, p. 62, pl. 12, fig. 10; Wenlock Shale (Coalbrookdale Formation), Wenlock Edge, England.

*Diagnosis.* (Downie 1959, p. 62 - 63.) “Test rhomboidal, surface smooth, walls moderately thick, test size 16 to 23µ; processes, four or six, arising from the corners of the test, simple spines, length 50 to 100 per cent. of test size.”

*Emended Diagnosis* (Turner, 1984, p. 145) “Test rhomboidal, surface smooth, walls thin to moderately thick, five to nine processes, arising at corners of vesicle; process and vesicle wall smooth.”

*Description* *Veryhachium rhomboidium* is a small medium to thick walled acritarch species. They have a hollow, rhomboidal inflated, laevigate vesicle body bearing three slender straight to flexuous hollow processes which taper distally to form a simple acuminate tip, one from each corner and some arising mid vesicle. The processes are of variable length, there are 4 - 7 in number and they communicate freely with the central body cavity. Excystment by simple split. *Veryhachium rhomboidium* is probably representative form group encompassing a wide range of multi processed veryhachiids. The size of the vesicle, number of processes and polygonal shape of the vesicle distinguishes this species from *Michrystridium inflatum* though it is possible that there is a gradation between the two. *Veryhachium lairdii* has four processes in the same plane while *V. pertonensis* (Dornig 1981a) has broader more stubby processes.
Remarks. Specimens recovered conform broadly to the diagnosis. Turner’s emendation (1984) is followed in order to allow for the greater number of processes present in the specimens recovered. Michrystridium *inflatum* has a subspherical rather than polygonal vesicle body and a greater number of processes. Species includes forms with five or more processes only. The taxonomic junior synonym of *V. trapezionarion* proposed by Turner (1984) is not accepted here and the latter has been retained as a separate species.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Vesicle dimensions</th>
<th>14 - 24 μm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process length</td>
<td></td>
<td>16 - 32 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>2 - 2.5 μm</td>
<td></td>
</tr>
<tr>
<td>Process number</td>
<td>4 - 7</td>
<td></td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

Occurrence. *V. rhomboidium* is a cosmopolitan long ranging taxon, it has been recovered from the Coalbrookdale Formation (Wenlock Series) of Shropshire (Downie 1959); Llandovery to Ludlow series of the British Isles (Downie 1984); Permian of Britain (Wall & Downie 1962); Llandovery to Wenlock series of Belgium (Martin 1967, 1969); Upper Devonian of Belgium (Stockmans & Willière 1960, 1974); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); Wenlock to Pridoli series of the Ludlow area (Lister & Downie 1974); Wenlock to Ludlow Series of Algeria (Jardiné et al. 1974); Siegenian Stage, Dinant, Belgium (Vanguestaine 1979); late Wenlock Series of Dudley, West Midlands, England (Dorning 1983); Ordovician of Shropshire (Turner 1984); late Llandovery Series of Ringerike, Norway (Smelror 1987); Wenlock Series, Cheviot Hills, England (Barron 1989); upper Llandovery Series (Purple Shales) to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985); Llandovery to lower Wenlock Series (upper Visby beds of Gotland, Sweden (Le Hérisse 1989); Buildwas and Coalbrookdale formation (Sheinwoodian) of the Welsh Borderlands (Swire 1991); Ludfordian of the Ludlow area (Washington-Evans 1992); Leinthall Quarry, Shropshire (Donoghue 1993); Coalbrookdale Formation (Wenlock Series) from Buildwas Bank and Holbrook Coppice, near Ironbridge, Shropshire (Turner et al. 1995); Lower Palaeozoic of the Garhwal Himalaya, India (Sinha et al. 1996b).

This species was recovered as a consistent form in assemblages from the Much Wenlock Limestone Formation and the Lower Elton Formation of the type areas of Much Wenlock and Ludlow, Shropshire, England, including Farley Dingle, Mortimer Forest Geological Trail and Pitch Coppice.

Known Range: Ordovician - Permian.
**Veryhachium rhomboidium var. A**

Plate 53, fig. 5.

*Remarks.* Thin walled laevigate small translucent vesicle bearing 4 - 8 very long processes. This variety of the species *Veryhachium rhomboidium* is split on the nature of the process length to vesicle body diameter. The processes being equal to or more often much greater in length than the central body diameter.

*Dimensions*

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>14 - 18 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>16 - 36 µm</td>
</tr>
<tr>
<td>Number of processes</td>
<td>6 - 8</td>
</tr>
</tbody>
</table>

*Occurrence.* This species has been recovered from Farley Dingle, FD2300, 2659, 3000; Mortimer Forest MFGT1-400 and Pitch Coppice PC 200

**Veryhachium rhomboidium var. B**

Plate 53, fig. 6.

*Description.* Robust walled laevigate form with a translucent vesicle bearing 5 - 8 simple processes.

*Dimensions*

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>20 - 32 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>18 - 36 µm</td>
</tr>
<tr>
<td>Number of processes</td>
<td>5 - 8</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

*Occurrence.* This species was recovered from the Coalbrookdale, Much Wenlock Limestone and the Lower Elton formations of the type areas of Much Wenlock and Ludlow, Shropshire, England. Localities Farley Dingle, Mortimer Forest and Pitch Coppice, samples including: FD2300, 3000, MFGT1-50, 2-TD, MFGT2-180, PC 50, 240, 3000.
Veryhachium rhomboidium var. C

Plate 54, fig. 2.

Remarks Thin walled laevigate translucent vesicle bearing 6 wide based processes.

Dimensions

- Vesicle diameter: 12 - 16 μm
- Process length: 12 - 16 μm
- Process base width: 4 μm
- Number of processes: 6
- Number of specimens measured: 1

Occurrence. This species was recovered from the Much Wenlock Limestone Formation and the Lower Elton Formation of the type areas of Much Wenlock and Ludlow, Shropshire, England.

Veryhachium rhomboidium sp. E

Plate 52, figs. 6, 7.

Description. Polygonal vesicle of medium thickness bearing at least five processes; the base of the processes forming the polygonal shape of the vesicle.

Remarks. Veryhachium formosum Stockmans & Willière 1960 has at least five processes and is similar to this form, further specimens need to be studied before the specimens recorded herein are compared with confidence to V. formosum.

Dimensions

- Vesicle diameter: 24 - 30 μm
- Process length: 30 - 48 μm
- Process base width: 4 - 6 μm
- Number of processes: 6
- Number of specimens measured: 1

Occurrence. This form was recorded from the Farley Member of the Coalbrookdale Formation of the type Wenlock area, Shropshire, England.
**Veryhachium trapezionarion** Loeblich 1970a

Plate 52, fig 1.

1970a  *Veryhachium trapezionarion*, Loeblich p. 743 - 744, figs. 38 A-C

1990  *Veryhachium trapezionarion*, Fensome et al. p. 525, no fig.

**Holotype.** *Veryhachium trapezonarion* Loeblich 1970a, p. 743, fig. 38 b.

**Diagnosis.** (Loeblich 1970 p. 743.) “Central body trapezoidal to rectangular in outline, commonly with six, rarely eight, elongate hollow processes, one at each corner of the trapezoid and in the plane of the central body, and commonly with one, rarely two processes on each of the broad faces of the central body, lying essentially at right angles to those in the plane of the central body; processes communicate freely with the central body, and are flexible, especially in the distal portion where they taper gradually to a sharp point; wall thin, about 0.5 μm in thickness, surface smooth but with small scattered pits; excystment by formation of a small epityche.

**Remarks.** Thin walled laevigate vesicle body, stellate outline bearing processes arising from the corners of the vesicle and at least three processes arising from the vesicle.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>28 - 32 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>14 - 34 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>4 - 10 μm</td>
</tr>
<tr>
<td>Number of processes</td>
<td>6 - 9</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Occurrence.** Middle Silurian of New York (Loeblich 1970a); Wenlock Series of Argentina (Póthe de Baldis 1975); Ludlow Series of Argentina (Póthe de Baldis 1981);Ordovician of Shropshire (Turner 1984 as *V. rhomboidium*).

This species was recovered from the Coalbrookdale, Much Wenlock Limestone and the Lower Elton formations of the type areas of Much Wenlock and Ludlow, Shropshire, England. It was found in low numbers, <1% of the assemblage from Farley Dingle (FD 2300); Coates Quarry (CT7); and Harley Hill (HH1-TD), in the type Wenlock area. In the Ludlow area this taxon was recorded from Mortimer Forest MFGT2 TD, 300 and Pitch Coppice, PC 200, 252, 300.
**Veryhachium trispinosum** (Eisenack, 1938) Stockmans & Willière, 1962a

included here as

**Veryhachium trispinosum formgroup**

(Eisenack 1938.) Deunff 1954 ex Downie 1959.

Plate 3, fig. 3; Plate 50, fig. 3.; Plate 54, fig. 9.

1938  *Hystrichosphaeridium trispinosum* Eisenack p. 14, figs. 2, 3.
1959  *Veryhachium cf. trispinosum* Deunff p. 29, pl. 1, figs. 5 - 7, 9.
1959  *Veryhachium trispinosum* Downie, p. 68, pl. 12, fig. 7.
1963  *Veryhachium trisphaeridium* Downie p. 493, pl. 92, fig. 7.
1971  *Veryhachium cf. trispinosum* Henry & Thadeau p. 1343, pl. 1 fig. 11.
1990  *Veryhachium trapezionarion*, Fensome *et al.* p. 525, 526, no fig.

This brief synonymy list includes only some major publications, for a full synonymy of this long ranging cosmopolitan taxon, prior to 1974 see Eisenack *et al.* (1979) p. 497-501.

*Holotype. Hystrichosphaeridium trispinosum* Eisenack, 1938 p. 14, 16, text-fig. 2; lower Silurian erratic from the Baltic region.

*Diagnosis.* (Translated from Eisenack, 1938, p. 14) “Vesicles are equilateral triangles with long drawn out curved spines. In lateral view the vesicles are often spherical in outline. The distance between two tips is 80 - 100 μm”.

*Remarks.* This formgroup includes three processed, laevigate veryhachiids of varying forms. *Veryhachium downiei* Stockmans & Willière 1962a is a thin walled fat bodied short processed smaller form than *V. trispinosum*. *Veryhachium trisphaeridium* is synonymised herein as the characteristic nature of the vesicle as described in the diagnosis and seen on the holotype is believed to be the result of compression.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Vesicle diameter</th>
<th>16 - 30 μm</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Process length</td>
<td>15-38 μm</td>
</tr>
<tr>
<td></td>
<td>Process base width</td>
<td>2 μm</td>
</tr>
<tr>
<td></td>
<td>Process number</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>
Occurrence: For a full list of reported occurrences prior to 1974 see Eisenack et al. 1979, p.499-501. In addition to those some of the important records of Veryhachium trispinosum that have been looked at by the author include the following: Ordovician of the Baltic (Eisenack 1938), Ordovician of Brittany (Deunff 1951, 1959); late Silurian to early Devonian of Cantabrican Mountains of Spain (Cramer 1964a); Siegenian of Cotentin, France (Rauscher et al. 1965); lower Devonian of Uruguay (Martinez - Macchiavello 1968), middle Silurian of USA and Canada (Cramer 1969a); upper Llandovery of Nova Scotia (Cramer 1970b); Sheinwoodian (Wenlock Series) of the Welsh Borderlands (Downie 1959); Silurian (Wenlock Series) to early Devonian (Gedinnian) of Spain (Cramer 1964a,b); Ordovician of Bohemia (Konzalová - Mazancová 1969); Llandovery to Wenlock Series of USA and Canada (Cramer 1970); Ordovician of Portugal (Henry & Thadeau 1971); upper Llandovery to Ludlow series of the USA (Cramer & Diez 1972); Silurian of the Baltic (Yankauskas & Vaitekunene 1972); Ordovician of Bohemia Vavradová 1972); Wenlock Series of Ontario (Thusu 1973a); Wenlock Series of New York State (Thusu 1973b); Wenlock to Ludlow series of Algeria (Jardine et al. 1974); Frasnian and Fammenian stages, early Devonian of Belgium (Stockmans & Willière 1974); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); Upper Visby to Höglkint formations, lower Wenlock Series of Gotland, Sweden (Cramer et al. 1979); Gedinnian of Brest (Deunff 1980); Ludlow Series of San Juan Province, Argentina (Pöthe de Baldis 1981); lower Llandovery Series of New York (Miller & Eames 1982); Early Sheinwoodian (Wenlock Series) of Scotland (Dorning 1982 ; the Chester Berg Formation (Wenlock) of Greenland (Armstrong and Dorning 1984); Wenlock Series of the West Midlands, UK (Dorning 1983); Ordovician of Shropshire (Turner 1984); Llandeilo Series of South Wales (Turner 1985); Llandovery to Wenlock Series of Norway (Smelror 1987b); upper Llandovery Series (Purple Shales) to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985); Haragan Formation, Lower Devonian of Oklahoma, USA (Wicander 1986); Ordovician to Llandovery series of north-east Libya (Hill & Molyneux 1988); Wenlock Series of the Cheviots (Barron 1989); Sheinwoodian (Wenlock Series) of North Wales and the Welsh Borderland (Swire 1991); late Ludfordian of the Ludlow area (Washington - Evans 1992); Coalbrookdale Formation (Wenlock Series) from Buildwas Bank, Holbrook Coppice, near Ironbridge, Shropshire (Turner et al. 1995); Devonian of Iowa, USA (Wicander & Wood 1997).

This species was recovered as a consistent form in assemblages from the Coalbrookdale, Much Wenlock Limestone and the Lower Elton formations of the type areas of Much Wenlock and Ludlow, Shropshire, England, including Farley Dingle, Harley Hill, Mortimer Forest Geological Trail and Pitch Coppice.

Known Range Ordovician - Devonian
Veryhachium trispinosum var. 1.

Plate 55, fig. 1

Description. Thick walled, laevigate vesicle with convex sides bearing three processes which taper to simple tips, communicate freely with the vesicle interior and are shorter than the vesicle diameter. Mode of excystment not observed.

Remarks. This form differs from Veryhachium trispinosum sensu stricto in its large size.

Dimensions. | Vesicle diameter | 38 μm |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Process length</td>
<td>25 μm</td>
<td></td>
</tr>
<tr>
<td>Process base width</td>
<td>7 μm</td>
<td></td>
</tr>
<tr>
<td>Number of processes</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Occurrence. This form was recorded as a rare type from the lowermost Lower Elton Formation at Shadwell Quarry.

Veryhachium valiente (Cramer 1964b)

Plate 52, fig. 5

1963 Veryhachium rhomboidium Wall & Downie p. 781, pl. 113, fig. 9.

Holotype. Cramer 1964b, p. 311, pl. 12, fig. 3 from the Upper Ludlovian to Emsian of the San Pedro Formation of north-west Spain.

Diagnosis. (See Cramer 1964b, p. 311.) "Central body and processes hollow, with uniform walls. Central body rectangular to square with straight sides. Four appendages at each corner, situated in the same plane. Occasionally a fifth appendage, situated near the centre of the vesicle body, is present. The processes end in a sharp tip. The wall is psilate at 1200 x magnification, moderately thick and moderately transparent."
**Description.** Thin to medium walled vesicle body rhomboidal in outline with straight to convex vesicle sides, bearing 4 - 6, hollow laevigate processes which taper to a simple tip. Four of the processes arise from the corners of the central body and 2 are located approximately centrally on the vesicle body. The process length is less than or equal to the vesicle body dimensions. Excystment by simple split.

**Remarks.** *V. cf. pertonensis* has longer processes. *V. lairdii* has concave sides. This morphotype was logged as *Veryhachium* sp. F.

**Dimensions**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>16 - 26 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>4 - 14 µm</td>
</tr>
<tr>
<td>Process base width</td>
<td>4 - 6 µm</td>
</tr>
<tr>
<td>Number of processes</td>
<td>6</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Occurrence.** This species has been recorded from the Upper Llandovery to Ludlow series of the USA (Cramer 1964b, Cramer & Diez 1972); Llandovery to lower Wenlock series of the type Llandovery area of the Welsh Borderlands (Hill 1974); Lower Palaeozoic of the Garhwal Himalaya, India (Sinha et al. 1996b).

This taxon was recovered in low to moderate numbers from the Farley Member of the Coalbrookdale Formation, the Much Wenlock Limestone and Lower Elton formations of the type areas around Much Wenlock and Ludlow, Shropshire. Occurrences were recorded from Farley Dingle, Harley Hill, and Mortimer Forest.

Known Range: Late Silurian to lower Devonian

**Veryhachium wenlockium** (Downie, 1959 ex. Wall & Downie 1963)  
Downie & Sarjeant, 1965

Plate 50, fig. 4.

1959  *Veryhachium tetraëdron* var. *wenlockium* var. nov. Downie, p. 62, pl. 12, figs 9, 11.
1962  *Veryhachium wenlockium* (Downie 1959); Stockmans & Willière, p. 28 - 29
1963  *Veryhachium europaeum* .Stockmans & Willière var. *wenlockianum* var. nov.; Wall & Downie, p. 775, no fig.
1963 *Veryhachium europaeum* Stockmans & Willière var. *wenlockium* (Downie); Downie, p. 636, fig 2.
1963 *Veryhachium tetraèdron* var. *wenlockium* Downie & Sarjeant p. 94.
1964 *Veryhachium wenlockium* Downie & Sarjeant p. 153, no fig.
1965 *Veryhachium europaeum* var. *wenlockium* Vavradová p. 351, no fig.
1966a *Veryhachium europaeum* var. *wenlockium* Martin p. 316, p. 328, no fig.
1967 *Veryhachium wenlockium* Lister & Downie, p. 173, pl. 23, fig. 10.
1967b *Veryhachium tetraèdron* Deunff. p. 22, no fig.
1970 *Veryhachium wenlockium* Cramer p. 100, fig. 28.
1972 *Veryhachium europaeum* var. *wenlockianum* Vavradová p. 80.
1973a *Veryhachium wenlockium* Thusu p. 803, pl. 106, fig. 3.
1973b *Veryhachium wenlockium* Thusu p. 138, pl. 2, fig. 9, 11.
1979 *Veryhachium wenlockium* Eisenack *et al.* p. 405 - 407.
1990 *Veryhachium wenlockianum* Fensome *et al.*, p. 527 - 528, no fig.
1994 *Veryhachium wenlockium* (Downie 1959) Downie & Sarjeant 1965; Sarjeant & Stancliffe, p. 35, no fig.

For a more complete synonymy prior to 1973 see Eisenack *et al.* 1979, p. 515 - 516.

*Holotype. Veryhachium tetraèdron* var. *wenlockium* Downie 1959, p. 62, pl. 12, fig. 9; Coalbrookdale Formation, Wenlock Series of Wenlock Edge, Shropshire, England.

*Original Diagnosis.* (Downie 1959, p. 62). “A small variety of *V. tetraèdron*, with a smooth test surface and relatively longer processes. The size of the test varies from 6 to 27 μ, the shape is always tetrahedral, the walls always smooth, yellow-green in colour. The processes range in length from 100 to nearly 500 per cent. of the test diameter.”

*Remarks.* Specimens recovered conform broadly to the original diagnosis but with a great range in size and process length, hence it is considered as a formgroup. *Veryhachium wenlockium* has a characteristic hollow, tetrahedral vesicle bearing four hollow processes, extending from each corner and one arising from the centre of the vesicle. The process length is variable but consistent in an individual specimen. The three processes arising from the corners are of similar length whereas the fourth process which arises mid vesicle is always shorter. This is taken into account in emending the diagnosis. The processes communicate freely with the central body cavity. Excystment is by a simple split. *Veryhachium trispinosum* differs in having a triangular vesicle with only three processes commonly
arising in the same plane. *V. rhomboidium* has a polygonal vesicle with a greater number of processes. *V. europaeum* is generally larger with four processes but these are all of equal length. This species should be spelt *wenlockium* as originally cited by Downie (1959), and not *wenlockianum*. The species is retained in the genus *Veryhachium* and not transferred to the genus *Dorsennidium* (Sarjeant & Stancliffe 1994).

**Dimensions.** | Vesicle dimensions | 12 - 24 µm  
| Process length | 12 - 46 µm  
| Process width at base | 1.5 - 3 µm  
| Process number | 4  
| Number of specimens measured | 10

Occurrence. Wenlock Series of Shropshire England (Downie 1959, 1963); Wenlock Series of Belgium (Martin 1966a, 1967); Ordovician, Arenig Series of Bohemia Vavradová 1965,1972); lower Ludlow Series, England (Lister & Downie 1967); Devonian of Canada (Deunff 1967a, b); Wenlock Series of Canada and USA (Thusu 1973a 1973b); Llandovery to lower Wenlock series of the Llandovery type area and Welsh Borderland (Hill 1974); Wenlock Series(Much Wenlock Limestone Formation ) to Pridolf Series (Downton Castle Sandstone Formation) of the Ludlow area, (Lister & Downie 1974); Sheinwoodian to Homerian (Wenlock Series) of the Welsh Borderland (Dorning 1981a); lower Silurian of Ringerike, Norway (Dorning & Aldridge 1982); Early Sheinwoodian (Wenlock Series) of Scotland (Dorning 1982); Wenlock Series of Dudley, West Midlands UK (Dorning 1983); upper Llandovery Series (Purple Shales) to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985); Wenlock Series of Norway (Smelror 1987); Llandovery Series of northeast Libya (Hill & Molyneux 1988); upper Visby to lower Höglint formations, lower Wenlock Series (Sheinwoodian) of Gotland, Sweden (Le Hérisse 1989); Sheinwoodian (Wenlock Series) of the type area, Malverns and North Wales (Swire 1991); late Ludfordian of the Ludlow area (Washington - Evans 1992); Coalbrookdale Formation (Wenlock Series) from Buildwas Bank and Holbrook Coppice, near Ironbridge, Shropshire (Turner et al. 1995); Lower Palaeozoic of the Garhwal Himalaya, India (Sinha et al. 1996b).

This species was recovered as a consistent form in assemblages from the Coalbrookdale, Much Wenlock Limestone and the lowermost Lower Elton formations of the type areas of Much Wenlock and Ludlow, Shropshire, England, including Farley Dingle; Mortimer Forest Geological Trail and Pitch Coppice, The species was found to be abundant and consistent in samples from Harley Hill.

Known range: Ordovician (Arenig Series) - upper Silurian (Ludfordian).
**Veryhachium wenlockium** var. 1

Plate 53, fig. 4

1963 *Veryhachium europaeum* forma 1 Downie 1959; Wall & Downie, p.782, pl. 114, figs. 4-6.

**Description.** A variety of *V. wenlockium* with processes which are less than or equal to the vesicle body diameter. Tetrahedral in form, the vesicle is often inflated with convex sides giving it a 'fat bodied' appearance. Three processes arise from the corners of the vesicle one arising from the centre of the vesicle body. Process length is less than or equal to the diameter of the vesicle.

**Remarks.** This species is broadly similar to *V. wenlockium* probably representative of an end member of a *V. wenlockium* formgroup. This morphotype was separated on the basis of the ratio of process length to vesicle body diameter. In this instance the process length being less than or equal to the dimensions of the central body cavity.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Vesicle diameter</th>
<th>18 - 22 µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process length</td>
<td>14 - 18 µm</td>
<td></td>
</tr>
<tr>
<td>Process width</td>
<td>2 µm</td>
<td></td>
</tr>
<tr>
<td>Number of processes</td>
<td>4.</td>
<td></td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

**Occurrence.** This species was recovered from the Coalbrookdale, Much Wenlock Limestone and the Lower Elton formations, Homerian Stage of the Wenlock Series of the type areas of Much Wenlock and Ludlow, Shropshire, England. *V. wenlockium* var. 1. was recovered consistently in low numbers throughout the sections studied including the following localities: consistently through Harley Hill., Farley Dingle FD 900

**Veryhachium sp. D**

Plate 51, figs. 1, 2.

1970 *Evittia remota* (Deunff 1955) comb. nov. Lister, p. 69, pl. 4, fig. 10.

**Description.** Thin walled laevigate vesicle body elongate polygonal in outline bearing 6 tapering processes two elongated in polar directions and four arranged around the central portion of the vesicle in three dimensions. The processes have wide bases making thus forming the polygonal outline to the vesicle body.
### Dimensions

- Vesicle diameter: 14 - 28 μm
- Process length: 16 - 26 μm
- Entire length: 40 - 60 μm
- Process base width: 4 - 6 μm
- Number of processes: 6.
- Number of specimens measured: 5.

### Occurrence

This form has been previously recorded from the Sheinwoodian of the type Wenlock area as *V. rhomboidium* (Swire 1991).

This species was recovered from the Coalbrookdale Much Wenlock Limestone and the Lower Elton formation of the type areas of Much Wenlock and Ludlow, Shropshire, England. Including samples from: Harley Hill, Farley Dingle; Mortimer Forest and Pitch Coppice.

#### Veryhachium sp. G

Plate 51, figs. 5, 6; Plate 53, fig. 1.

**Description.** Star shaped, laevigate vesicle, pentagonal in outline bearing 5 processes which arise from the vesicle such as to form the stellate appearance. Mode of excystment not observed.

**Remarks.** Very thin walled laevigate vesicle body *M. stellatum*? Polygonal in outline bearing 5 processes which form the polygonal shape to the vesicle body. Stellate in appearance which compressed.

**Remarks.** This form differs from other species in its stellate outline.

### Dimensions

- Vesicle diameter: 14 - 20 μm
- Process length: 16 - 24 μm
- Process base width: 2 - 3 μm
- Number of processes: 5.
- Number of specimens measured: 5.

### Occurrence

This species was recorded sporadically from the Coalbrookdale, Much Wenlock Limestone and lowermost portion of the Lower Elton formations, specimens having been recorded from Harley Hill in the Much Wenlock area with rare occurrences from Mortimer Forest in the Ludlow area.
**Veryhachium sp. H**

Plate 54, fig. 3.

*Description.* Square shaped vesicle, the shape being a function of the point of emergence of four of the processes which arise from the corners. At least one more process arising from the centre of the vesicle body. Mode of excystment by simple split.

*Remarks.* This form of the taxon has been left in open nomenclature because only rare types of the specimen were recovered, the processes of which were so short that they were almost echinate in appearance.

*Dimensions*

- Vesicle diameter: 18 - 24 μm
- Process length: 2 - 4 μm
- Process base width: 1 - 2 μm
- Number of processes: 6 - 8
- Number of specimens measured: 5

*Occurrence.* This species was recovered from the Coalbrookdale, Much Wenlock Limestone and the lowermost Lower Elton formations of the type areas of Much Wenlock and Ludlow, Shropshire, England. The species was found to be abundant and consistent in samples from Harley Hill.

**Veryhachium sp. K**

Plate 54, fig. 6

*Description.* Rhombic vesicle, thick walled bearing four processes from the corners and two from the centre of the vesicle. Mode of excystment not observed.

*Remarks.* The smaller size and thick walled nature of this form separates it from other species of *Veryhachium*. This form was only recorded as a rare type, hence maintained as an informal species of *Veryhachium*. Forms recorded herein were logged as *Veryhachium* sp. K & L.
**Dimensions.**

- Vesicle diameter: 14 - 16 μm
- Process length: 6 - 8 μm
- Process base width: 2 μm
- Number of processes: 5 - 7
- Number of specimens measured: 1

**Occurrence.** Similar forms have been recovered from the Silurian of USA and Canada (Cramer 1969, Cramer & Diez 1972); Wenlock Series to Gedinnian Stage of France (Deunff & Chataeuneuf 1976).

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**Veryhachium sp. M**

![Diagram of Veryhachium sp. M]

**Description.** Large, laevigate vesicle, thin walled, bearing four long processes. Mode of excystment not observed.

**Remarks.** This large form was only recorded as a rare type and hence retained as an informal species of *Veryhachium*. It is included here for clarity with reference to the logging sheets.

**Dimensions.**

- Vesicle diameter: 28 - 32 μm
- Process length: 26 - 30 μm
- Number of processes: 4
- Number of specimens measured: 2

**Occurrence.** This species was recovered from the Farley Member of the Coalbrookdale Formation Much Wenlock Limestone Formation of the type areas of Much Wenlock and Ludlow, Shropshire, England.
Veryhachium sp. N

Plate 54, fig. 1.

*Description.* Laevigate bearing four processes arising from the corners of the vesicle body giving the central body a rhomboidal outline. Three process arise from the centre of the central body cavity. The processes have wide bases and are generally shorter than or equal to the dimensions of the central body cavity.

*Remarks.* These forms differ from other species of *Veryhachium* in the vesicle outline and process arrangement.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>14 - 18 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>12 - 18 µm</td>
</tr>
<tr>
<td>Process base width</td>
<td>8 - 12 µm</td>
</tr>
<tr>
<td>Number of processes</td>
<td>7</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

*Occurrence.* This species was recovered from the Coalbrookdale, Much Wenlock Limestone and the Lower Elton formations of the type areas of Much Wenlock and Ludlow, Shropshire, England. At Harley Hill the occurrences were sporadic but consistent throughout the section. Specimens were also recorded from Farley Dingle and Pitch Coppice.

Veryhachium cf. sp. N

Plate 54, fig. 4.

*Description.* Laevigate bearing three processes arising from the corners of the vesicle body giving the central body a triangular outline. Three or four process arise from the centre of the central body cavity. The processes have wide bases and are generally shorter than or equal to the dimensions of the central body cavity.

*Remarks.* This form is similar to *Veryhachium* sp. N but has shorter processes and a triangular vesicle outline.
### Dimensions

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>14 - 18 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>10 - 14 µm</td>
</tr>
<tr>
<td>Process base width</td>
<td>8 - 12 µm</td>
</tr>
<tr>
<td>Number of processes</td>
<td>6 - 8</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>3.</td>
</tr>
</tbody>
</table>

**Occurrence.** This species was recovered as rare types from the Farley Member of the Coalbrookdale Formation at Harley Hill.

**Veryhachium aff. sp. N**

Plate 54, fig. 5.

**Description.** Small, thin walled, tetrahedral vesicle body bearing 6 processes, three of which emerge from the apices.

**Remarks.** This single specimen appears to have a granulate vesicle and has thus been figured separately.

**Occurrence.** Single recovery from Farley Dingle, sample FD 900.

**Veryhachium sp. P**

Plate 54, fig. 12.

**Description.** Thick walled golden yellow form, rhombic, bearing four processes from the corners of the vesicle and one arising from the central portion of the vesicle. The processes have wide bases making the differentiation between the processes at the proximal portion and the central body cavity indistinct.

**Remarks.** This form was recorded as a rare type.
**Dimensions**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>18 - 20 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>10 - 14 μm</td>
</tr>
<tr>
<td>Number of processes</td>
<td>5</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>2</td>
</tr>
</tbody>
</table>

**Occurrence.** This species was recovered from the Coalbrookdale, Much Wenlock Limestone and the Lower Elton formations of the type areas of Much Wenlock and Ludlow, Shropshire, England. Occurrences being documented rarely from Farley Dingle, sample FD Bent.

**?Veryhachium spp**

Plate 22, fig. 3

**Description.** Thin walled large form quadratic vesicle bearing 5 processes, four emerge from the corners of the vesicle and a fifth emerges from the centre of the vesicle body. The processes are very long greater than twice the dimensions of the vesicle body. This form differs from other species reported in its large form and extremely thin walled pale vesicle body.

**Remarks.** This rare type has been tentatively assigned to this genus as it is similar to specimens assigned to the genus *Leptobrachion*.

**Dimensions.**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>25 - 30 μm</td>
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<tr>
<td>Process length</td>
<td>40 - 60 μm</td>
</tr>
<tr>
<td>Process base width</td>
<td>4 - 6 μm</td>
</tr>
<tr>
<td>Number of processes</td>
<td>6</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

**Occurrence.** This form was recorded from the Farley Member of the Coalbrookdale Formation, Homerian Stage of the Wenlock Series, sample: HH3-200/10/1 C 48.5. from Harley Hill, Much Wenlock, Shropshire, England.

*Type species.* *Visbysphaera dilatispinosa* (Downie, 1963, p. 642, pl. 92, fig. 4) designated by Lister, 1970, p. 98 - 99; from the Buildwas Formation, Harley Brook, Wenlock Edge, Shropshire. Original Designation: *Baltisphaeridium dilatispinosum*

*Original Diagnosis.* "Vesicle hollow, spherical to ellipsoidal, occasionally subtriangular, smooth or sculptured, double walled. Inner wall confined to the vesicle and usually closely adpressed to the outer wall. Processes hollow, composed of the thin outer wall only usually much less than $\frac{1}{2}$ the vesicle diameter in length, generally numerous, heteromorphic and often variable in size within a single individual. Excystment by cryptosuture."

*Emended Diagnosis.* (Kiryanov 1978, p. 21, translation by V. Viira). Spherical vesicle with distinctly differentiated processes. The surface of the vesicle is laevigate or with very small structure. Processes are formed by ectoderm and do not differ from it by structure and character of surface. Processes needle-shaped, stake-shaped or flared in the basal part (angle between process and surface close to right angle). With the exception of needle-shaped processes, the other processes are widened a little in the distal part. Processes have clavate type of structure: morphology of secondary elements on the same vesicle more or less similar, with the shape of grains, which are scattered on the surface of processes and, therefore, are not joined together in the basal part. Needle-shaped processes may be simple or form non-complicated ramifications (branches). Processes are hollow, secondary elements are solid. The hollow processes are opened in the direction of the hollow vesicle. Pylome spherical, rarely seen.

*Revised Diagnosis.* (Translated from Le Hérissé, 1989, p. 199.) Vesicle spherical to subspherical with a double-layered wall of variable thickness, smooth or lightly ornamented, ornamentation consists of hollow, heteromorphic processes, formed from the thin outer layer of the vesicle wall; the length of the processes is on average less than half the diameter of the vesicle; the processes do not communicate with the interior of the vesicle, they are generally dilated: on the whole length (piriform ornament), in the medial part (spinose ornament), or distally (club like ornament with rounded extremities); the processes are simple, simple-bifurcate, with crowns of short spines or filamentous spines arranged in the same plane, occasionally anastomosing; the processes are distributed haphazardly, without preferential orientation, or aligned along ridges or folds of the vesicle wall delimiting smooth polygonal areas (restricted distribution). Many species excyst by endopylome, with a simple split, equivalent to the pylome, formed from the external wall.
Remarks. Specimens belonging to the genus *Visbysphaera* are characterised by their double walled vesicle bodies bearing heteromorphic processes. The double wall gives species of this genus a darker colour, dark yellow to golden brown appearance. Inter generic identification of *Visbysphaera* is generally not difficult although there are similarities between this genus and *Gorgonisphaeridium* the processes in the latter tend to be more or less homomorphic within a single specimen, thicker and solid' when compared to those of species belonging to *Visbysphaera* whose processes are formed from the thinner ectophragm.

Meanwhile designation between species belonging to the genus can be more problematic because of the wide variation and gradational nature of the parameters used in specific identification; for example process shape, process length and nature of the processes within a specimen, such as whether or not they are predominantly simple or bifurcating. Hence it is comparatively easy to assign end members to a species but there are specimens recovered that belong to the 'grey' intergradational area that could belong to either one of a couple of end member species. It is believed that the easiest way to approach this is to recognise the 'form group' nature of the species of *Visbysphaera* and take this into account when assessing the results of the systematic logging of the samples.

*Visbysphaera* cf. *connexa hirsuita*

Plate 9, figs. 10 - 12

cf. 1989 *Visbysphaera connexa* sp. nov. Le Hérissé, p. 204, pl. 27, figs. 15 - 18, text - fig. 18.4.

Description. Hollow, thick, single walled vesicle, spherical to ellipsoidal in outline bearing low flange/crests which define small fields formed in a reticulate fashion. The fields are indistinct. Mode of excystment not observed.

Remarks. This species appears only broadly similar to *Visbysphaera connexa hirsuita* figured by Le Hérissé, 1989 (p. 204, pl. 27, figs. 15-18), which has interconnecting trabeculae and not crests delimiting fields. There are also similarities to *Cymatosphaera eltonensis* (Dorning 1981a p. 183 pl. 3, fig. 14) which also has numerous fields that are barely visible with the transmitted light microscope. The distinction between the presence of flanges as exhibited in *Cymatosphaera* and connecting trabeculae as described for *Visbysphaera connexa* is not possible with the transmitted light microscope as the detail is too dense and fine to be distinct even under the highest magnification. It is felt that there is considerable reason to transfer the forms recorded under this division herein to the genus *Cymatosphaera*, but to be consistent with the log sheet material, for now the taxon is retained here, until further investigation with an S.E.M. has been completed.

366
**Dimensions.**

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>20 - 32 µm</td>
</tr>
<tr>
<td>Crest height</td>
<td>1 - 2 µm</td>
</tr>
<tr>
<td>Field width</td>
<td>1.5 - 2 µm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

**Occurrence.** This form has been previously recorded from the upper Silurian of San Juan, Argentina (Rubinstein 1993) This morphotype was recovered from the Coalbrookdale and Much Wenlock Limestone formations of the type areas of Much Wenlock and Ludlow in the Welsh Borderland.

**Visbysphaera dilatispinosa** (Downie 1963) Lister 1970

Plate 56, figs. 1 - 6.

1954 *Hystrichosphaeridium pirifera* n. sp.; Eisenack, p. 206, pl. 1, figs. 1.

1963 *Baltisphaeridium dilatispinosum* sp. nov.; Downie, p. 642, pl. 92, fig. 4.

1963 *Baltisphaeridium piriferum* (Eisenack. 1954) comb. nov.; Downie & Sarjeant, p. 90, no fig.

1964 *Baltisphaeridium piriferum* (Eisenack 1954); Downie & Sarjeant, p. 94, no fig.

1968 *Baltisphaeridium dilatispinosum*; Jardine & Yapaudjian, pl. 3, fig. 13.

1968 *Baltisphaeridium hermosum* n. sp.; Cramer & Diez, p. 567, pl. 3, figs 4 - 7.

1968 *Baltisphaeridium dilatispinosum*; Martin p. 50 pl. 3 figs 137, 138; pl. 8 figs. 378, 379, text-fig. 7.

1970 *Visbysphaera dilatispinosa* (Downie 1963) comb. nov. emend.; Lister, p. 98 - 99, pl. 13, fig. 16, text - figs 19 j, 27 f.

1973 *Multiplicisphaeridium dilatispinosum* (Downie 1963); Eisenack et al n. comb.; p. 611.

1973 *Multiplicisphaeridium piriferum piriferum* (Eisenack 1954); Eisenack et al., p. 737 - 739

1978 *Visbysphaera pirifera* var. *pirifera* (Eisenack 1954); Kiryanov, p. 89-90, pl. 12, figs 2, 3, 5.

1989 *Visbysphaera pirifera* Le Hérisse, p. 212 - 213, pl. 29, figs. 1 - 6, text - fig. 19.9.

1990 *Visbysphaera dilatispinosa* (Downie 1963) emend. Lister 1970; Fensome et al., p. 530, no fig.

1990 *Visbysphaera pirifera* (Eisenack 1954a) Kiryanov 1978; Fensome et al., p. 531, no fig.

**Holotype.** Downie 1963, pl. 92, fig. 4. Slide 3, Buildwas Formation, Harley Brook, Shropshire, England.

**Diagnosis.** (Lister 1970, p. 99) Vesicle smooth, rounded polygonal, relatively thick walled; processes usually distally inflated, relatively short, thin walled, transparent, the distal parts bearing numerous small spines. The
size of the processes may vary within a single individual. Proximally the processes are closed to the vesicle cavity by the inner wall of the vesicle. The processes have a polygonal arrangement. Excystment by cryptosuture.

Remarks. The specimens recovered were assigned to the species *V. dilatispinosa*, because they are consistent with the forms reported by Lister (1970) and Downie (1963) from the Welsh Borderlands. *V. pirifera* may prove to be a senior synonym but the holotype of this species is from the Llandovery of Gotland. The two species are retained upon the lack of spines on the holotype of *V. pirifera* whereas they are observed consistently in the specimens found in the Welsh Borderlands, thus, until the holotype has been studied the species recovered herein are retained as *V. dilatispinosa* for consistency within this area.

**Dimensions.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>40 - 70 µm</td>
</tr>
<tr>
<td>Process length</td>
<td>6 - 20 µm</td>
</tr>
<tr>
<td>Process width</td>
<td>8 - 10 µm</td>
</tr>
<tr>
<td>Process number</td>
<td>10+</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

**Occurrence.** This species has been widely recorded, occurrences that have been confirmed include the following: Buildwas Formation, Wenlock Series of Shropshire (Downie 1963); Silurian, Belgium (Martin 1966, San Pedro and Furada formations, Ludlow Series to lower Gedinnian Stage, of Spain (Cramer 1964b, 1966a, Cramer & Diez 1968); Silurian of Alabama, USA (Cramer 1968a); upper Llandovery Series, Tuscarora and Rose Hill formations of Pennsylvania (Cramer 1969a); Upper Ludlow Series of the Sahara (Jardiné & Yapaudjian 1968) Wenlock to Ludlow series (Much Wenlock Limestone to the Lower Elton formations with sporadic occurrences recorded from the Whitcliffe Group), of Ludlow, Shropshire (Lister 1970); upper Llandovery to Ludlow series of borehole material from eastern USA Florida, Libya and Tunisia (Cramer 1970a, Cramer & Diez 1972); Rochester Formation, Wenlock Series of Ontario, Canada (Thusu 1973a); Wenlock Series of New York, USA (Thusu 1973b); Wenlock to Ludlow Series, Much Wenlock Limestone Formation Homerian Stage of the Wenlock Series to Leintwardine Formation, Gorstian Stage of the Ludlow area (Lister & Downie 1974); Llandovery to lower Wenlock series, Welsh Borderland (Hill 1974); Tanezzuft and Acacus formations, Wenlock to Ludlow series of Libya (Richardson & Ioannides 1973); Ludlow Series of Algeria (Jardiné et al. 1974); Wenlock Series of Dudley, West Midlands, England (Eisenack 1965a, 1977 Dorning 1983); upper Llandovery to lower Ludlow series of the British Isles (Aldridge et al. 1979); lower Wenlock Series (Buildwas Formation) of the Welsh Basin (Aldridge et al. 1981); Wenlock Series of Dudley, West Midlands, England (Eisenack 1965a, Dorning 1983); Silurian of Podolia (Kiryanov 1978); lower Wenlock Series, (Upper Visby to Höglklint formations) of Gotland, Sweden (Cramer et al. 1979); late Llandovery to early Ludlow series of the Welsh Borderland (Dorning 1981a); Wenlock Series (Sheinwoodian) of Scotland (Dorning 1982); Wenlock Series of Ringerike, Norway (Dorning & Aldridge 1982); upper Llandovery to lower Wenlock series of the type area, Much Wenlock, (Mabillard & Aldridge 1985); Llandovery Series of Ringerike, Norway (Smelror 1987).
This species was recovered consistently but in low numbers from the majority of samples collected from Pitch Coppice and Mortimer Forest composite sections.

Known range: Silurian to Devonian.

**Visbysphaera meson** (Eisenack 1954)
comb. nov. Lister 1970

Plate 57, fig. 6

1954 *Hystrichosphaeridium intermedium* Eisenack, p. 208, pl. 1, figs. 3, 9, text - figs. 3, 4.
1955 *Hystrichosphaeridium meson* nom. nov. Eisenack p. 179.
1959 *Baltisphaeridium cf. meson* Eisenack; p. 60, pl. 10, fig. 8.
1970 *Baltisphaeridium meson* Eisenack; Cramer; p. 154, pl. 17 fig. 239, text - fig. 46c.
1970 *Visbysphaera meson* Eisenack; Lister, p. 100, no fig.
1973 *Multiplicisphaeridium meson* Eisenack; Eisenack et al., p. 681
1974 *Visbysphaera meson* Eisenack; Hill, p. 12, no fig.
1979 *Multiplicisphaeridium meson* Eisenack; Cramer et al. p. 44, no fig.
1981 *Visbysphaera meson* Eisenack; Dorning, p. 182, no fig.
1990 *Visbysphaera meson* Eisenack; Fensome et al. p. 530, no fig.

**Holotype.** Eisenack 1954, pl. 1, fig. 3 from the Upper Visby Marl, Upper Llandovery of Lickershamn Gotland, Sweden.

**Diagnosis.** (Eisenack 1955, p. 179 in German. Translated by Eberhard ‘Dino’ Frey). Central vesicle globular with a very dense layer of bifurcated and simple (unforked pointed) appendices.

**Description.** Ellipsoidal large, double walled vesicle bearing an ornament of low filamentous spines. The spines are usually simple or simply bifurcate and relatively thin, being formed from the outer wall only. Mode of excystment not observed.

**Remarks.** The specimens recovered conform to the original diagnosis. This form differs from *V. dilatispinosa* in the small size of both the vesicle and the processes and from *V. oligofurcata* in the simple, generally more homomorph process style.

369
**Dimensions.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>42 - 50 μm</td>
</tr>
<tr>
<td>Process length</td>
<td>2 - 6 μm</td>
</tr>
<tr>
<td>Process width</td>
<td>&lt; 2 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>

**Occurrence.** Upper Llandovery Series of Gotland, Sweden (Eisenack 1954, 1955); Coalbrookdale Formation, Wenlock Series of the type area (Downie 1959, 1963); Wenlock Series of Wrens Nest, Dudley in the West Midlands of England (Eisenack 1965a); upper Llandovery to Ludlow series of the USA (Cramer & Diez 1972); Wenlock Series, Homerian Stage to Ludlow Series of the Ludlow area (Lister & Downie 1974); Wenlock Series of Gotland, Sweden (Cramer et al. 1979); upper Llandovery to Wenlock series of Podolia, Ukraine (Kiryanov 1978 as *Baltisphaeridium listerii*); Wenlock Series of the Welsh Borderlands (Dorning 1981a); upper Llandovery of the Karnic Alps (Priewalder 1987); Llandovery to Wenlock Series of Gotland, Sweden (Le Hérissé).

This form was recorded from the Much Wenlock Limestone Formation, Homerian Stage of the Wenlock Series from the Much Wenlock and Ludlow areas of Shropshire.

**Known Range.** Upper Llandovery to Upper Ludlow.

**Visbysphaera cf. oligofurcata** (Eisenack 1954) Lister 1970

Plate 18, fig. 9. Plate 48, figs. 11, 12.

cf. 1954  *Hystichosphaeridium oligofurcatum* Eisenack 1954; p. 208, pl. 1, fig. 4, text - fig. 5.
cf. 1963  *Baltisphaeridium oligofurcatum* Eisenack; Downie, p. 642, pl. 92, fig. 9.
cf. 1964  *Baltisphaeridium oligofurcatum* Eisenack; Downie & Sarjeant, p. 94, no fig.
cf. 1970  *Visbysphaera oligofurcata* Eisenack; Lister p. 100, pl. 13 figs. 14, 15, text - fig. 19k.
cf. 1981a *Visbysphaera oligofurcata* Eisenack; Dorning, p. 182, no fig.
1990    *Visbysphaera oligofurcata* Eisenack; Fensome et al. p. 531, no fig.

**Holotype.** Eisenack 1954, p. 208, pl. 11, fig. 4 from the Upper Visby Marl, Upper Llandovery of Lickershamn Gotland, Sweden.
Diagnosis. (Eisenack 1954, p. 208 in German. Translated by Eberhard ‘Dino’ Frey). Central vesicle globular with a relatively dense layer of mostly pointed spinose appendices, in between which, single unforked processes are found. The appendices are shorter than the radius of the shell.

Description. Spherical vesicle, double walled, relatively thick bearing an ornament of numerous short heteromorphic processes, usually simple, rarely bifurcate, sometimes indistinct. Mode of excystment not observed.

Remarks. This species differs from *V. dilatispinosa* in that it has a much smaller ornament, while *V. cf. connexa* differs in its very fine ‘interconnected’ ornament.

Dimensions. 
- Vesicle diameter: 18 - 28 µm
- Process length: 2 - 4 µm
- Process width: < 2 µm
- Number of specimens measured: 5

Occurrence. Upper Llandovery of Gotland (Eisenack 1954, 1955); Wenlock Series of the type area (Downie 1963); Wenlock Series of Dudley (Eisenack 1965a); Ludlow Series of Shropshire (Lister 1970); upper Llandovery to Ludlow series of the USA (Cramer & Diez 1972); Wenlock (Homerian) to Ludlow Series of the Ludlow area (Lister & Downie 1974); Wenlock Series of Gotland (Cramer *et al.* 1979); upper Llandovery Series (Purple Shales) to lower Wenlock Series (Buildwas Formation) of the Wenlock type area, Welsh Borderlands (Mabillard & Aldridge 1985); Llandovery to Wenlock series of Gotland, Sweden (Le Hérissé 1989); Sheinwoodian Stage, Wenlock Series of the Welsh Borderland (Swire 1991 unpublished).

This form was recovered from the Much Wenlock Limestone Formation, Homerian Stage of the Wenlock Series from Shadwell Quarry, Much Wenlock, Shropshire, England.

Visbysphaera sp. A

Plate 57, fig. 5.

Description. Subspherical, compressed thick, double walled vesicle body bearing a short spinose solid ornament. The ornament more or less homomorphic in a single specimen. Mode of excystment not observed.

Remarks. This species is smaller than *V. dilatispinosa* and has a shorter ornament than *V. meson*. Forms similar have also been recorded from the lower Elton Formation of the type Ludlow area by Mullins (pers. comm.).
Dimensions. | Vesicle diameter | 22 - 36 μm |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<tbody>
<tr>
<td>Ornament length</td>
<td>2 - 4 μm</td>
<td></td>
</tr>
<tr>
<td>Ornament number</td>
<td>&gt;30</td>
<td></td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Occurrence. This rare type was recovered from the Much Wenlock Limestone Formation of Shadwell Quarry.

Genus **WRENSNESTIA** Dorning 1981a


*Diagnosis.* (Dorning 1981a p. 201) "Vesicle elongate, laevigate at one end, ornamented at the other, numerous processes present elsewhere on the vesicle. Excystment by splitting of the vesicle from one pole into four segments by straight splits."

*Remarks.* This genus is superficially comparable to *Helosphaeridium* which has a similar type of 'large' ornament but lacks the 'smaller' polar ornament.

**Wrensnestia ornata** Dorning 1981a

Plate 57, figs 1, 2, 3.


*Diagnosis.* (Dorning 1981a p. 201); "Vesicle elongate, 60 - 80 μm long, 25 - 35 μm wide, with blunt ends; one of the blunt ends is granulate for about 10μm, the rest of the vesicle is laevigate; numerous solid, simple processes about 2 μm long, 0.5 μm wide, spacing of 3-5 μm cover the vesicle apart from 10 μm at both the blunt ends, producing a bald pole opposite the granulate pole. Excystment by 4 splits in the vesicle wall at the bald end to produce four segments."
Remarks. The specimens recovered in this study conform to the original diagnosis. The vesicle body having a granulate ornament and laevigate vesicle of the opposing poles. This species is comparable to *Helosphaeridium* sp. B but this taxon does not exhibit the distinctive polar ornamentation. This is a distinctive genus that appears to have a restricted range in the Silurian rocks of the Welsh borderlands and central England, having been only recovered in samples from the uppermost, Much Wenlock Limestone Formation (Homerian).

### Dimensions

<table>
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<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicle dimensions</td>
<td>55 - 80 μm</td>
</tr>
<tr>
<td>Ornament size</td>
<td>1.5 - 2 μm x 0.5 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>10</td>
</tr>
</tbody>
</table>


In this study *Wrensnestia Ornata* was recovered from the Farley Member of the Coalbrookdale Formation to the Much Wenlock Limestone Formation (Homerian) of Farley Dingle, Coates Quarry, Shadwell Quarry and Mortimer Forest Geological Trail in the Much Wenlock and Ludlow areas of Shropshire. *Wrensnestia ornata* was not recovered from the samples collected in Gotland nor has Le Hérissé reported any presence of the species is studies on the area. Despite the restricted occurrence of this species it typically formed a significant proportion of the assemblage. It is therefore proposed that *Wrensnestia ornata* is a good regional biozonal indicator for the Welsh Basin but due to lack of occurrences from other areas its use for correlating between international sections is questionable.

Known Range: Much Wenlock Limestone Formation of the Welsh Borderlands.

### Acanthomorph Incertae sedis.

Plate 54, fig. 10

Description. Spherical vesicle body, thick walled bearing numerous solid spines less than half the vesicle diameter in length.
Dimensions.  
- Vesicle diameter: 22 μm  
- Process length: 6 - 8 μm  
- Process width: 1 - 1.5 μm  
- Number of specimens measured: 1.

Occurrence. This specimen was a rare, single occurrence from sample HH1 TD/10/1, from the Coalbrookdale Formation of Harley Hill, Much Wenlock, Shropshire, England.

Anteturma *SPORITES* Potonié 1893.

The plant sporomorphs found and recorded herein have been dealt with in less systematic detail than the acritarchs.

Genus *AMBITISPORITES* Hoffmeister 1959.

*Type Species* *Ambitisporites avitus* (Hoffmeister) Richardson & Lister 1969.

*Diagnosis:* (Hoffmeister 1959, p. 331). "Spore radial, trilete. Outline sub-circular to roundly triangular in proximal view. Ornamentation laevigate to variously sculptured. Trilete distinct, rays simple, commisure definite, narrow. Lips absent to slightly elevated, never broad as in *Gravisporites* Bharadwaj, 1954. Spore with thickened exinous equatorial band (crassitudo), of uniform width or slightly wider opposite the trilete rays. Width of crassitudo 1/10 to 1/5 spore radius. Crassitudo and remainder of spore wall may have the same or different ornamentation patterns. Spore wall, exclusive of crassitudo, from 1 - 3 microns thick."

*Ambitisporites avitus* Hoffmeister 1959

Plate 58, figs. 1, 2, 4.

For a synonymy list prior to 1993 see Wellman & Richardson (1993 p. 173).

*Holotype. Ambitisporites avitus* (Hoffmeister 1959), p.332 pl. 1 figs 1, 2.
Diagnosis. (Hoffmeister 1959, p. 332). "Spore radial, trilete, subcircular to roundly triangular in proximal view, with an equatorial crassitudo. Trilete simple rays extend to inner margin of crassitudo. Ornamentation laevigate to faintly granular. Crassitudo tends to be wider opposite trilete rays. Size ranges 35 - 65 microns."

Remarks. A. avitus differs from A. dilutus in having a 'delimited crassitudo' (Hoffmeister 1959), that is to say a A. dilutus has a thicker crassitudo than A. avitus. There does seem to be intraspecific gradation but subdivision into the two species was possible.

Dimensions. Vesicle diameter 24 - 38 \mu m  
Number of specimens measured 10

Occurrence. Numerous occurrences have been reported worldwide amongst which are those from the Siluro-Devonian Boundary of Northwest Spain (Cramer 1966 a-c); Wenlock Series to Gedinnian Stage of France (Deunff & Chataeuneuf 1976); Llandovery to Wenlock of Ireland (Smith 1981 as Ambitisporites spp.); Silurian of Ringerike, Norway (Smelror 1987b); Silurian of the Cheviot Hills northeastern England (Barron 1989); Silurian of the Southern Uplands (White et al. 1991); Silurian of the Midland Valley of Scotland (Wellman & Richardson 1993) upper Wenlock Series of the Prague Basin (Dufka 1995); Ordovician and Silurian (Ludlow Series) of Turkey (Steemans et al. 1996); Silurian of Gotland, Sweden (Hagström 1997).

Known Range: Ordovician - Silurian with a cosmopolitan distribution.

Ambitisporites dilutus (Hoffmeister) Richardson & Lister 1969

Plate 58, figs. 3, 5; Plate 59, fig. 4.

For a synonymy list prior to 1993 see Wellman & Richardson (1993 p. 174).

1969 Ambitisporites cf. dilutus Hoffmeister, Richardson & Lister, p. 229, pl. 40, fig. 3.
1986 Ambitisporites dilutus Hoffmeister Richardson & McGregor; p. 6-7, pl. 1, fig. 1.

Holotype. Punctatisporites ? dilutus Hoffmeister 1959, pl. 1, fig. 10.

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Diagnosis. (Hoffmeister 1959, p. 334). "Trilete radial miospore; equatorial outline subtriangular to subcircular; 30 to 60 microns in diameter, with simple trilete rays extending to the equator; ornamentation laevigate; peripheral area slightly darker than spore wall."

Remarks. This species differs from A. avitus in lacking the clearly limited crassitude. Subtriangular to subcircular laevigate spore with a distinctive trilete mark and equatorial crassitude. This crassitude is also present in A avitus, Hoffmeister 1959, and although in the latter the thickening is much more pronounced it is believed herein that these two species intergrade. There are broad similarities between spores of the avitus-dilutus complex and the species Archaeozonotriletes chulus (Cramer) Richardson and Lister 1969. However the latter typically has a thicker distal equatorial wall and a thin proximal wall which is frequently folded into tapering folds or is collapsed (Richardson & Lister 1969).

Dimensions. Vesicle diameter 28 - 42 µm
Number of specimens measured 10

Occurrence. Middle Llandovery of Libya (Hoffmeister 1959, Gray and Boucot 1971); Silurian of Belgium (Martin 1967 as P. ? dilutus); the middle and upper Llandovery of the USA (Pratt et al 1978, Strother & Traverse 1979, Miller & Eames 1982) middle Llandovery to upper Ludlow of the Welsh Borderlands (Aldridge et al 1980b. Richardson & Lister 1969); from the Llandovery to Wenlock of Ireland (Smith 1981 as Ambitisporites spp.); mid Llandovery to mid Prfdolf (Richardson & McGregor); Wenlock Series to Gedinnian Stage of France (Deunff & Chataeuneuf 1976); Chester Berg Formation (Wenlock) of North Greenland, (Armstrong & Dorning 1984); Wenlock of the Cheviot Hills north east England (Barron 1989); Sheinwoodian to early Homerian of Shropshire (Swire 1991); Silurian of the Southern Uplands (White et al. 1991); Wenlock Series from Buildwas Bank and Holbrook Coppice, near Ironbridge, Shropshire (Turner et al. 1995); upper Wenlock Series of the Prague Basin (Dufka 1995); Silurian of Gotland, Sweden (Hagström 1997).

Genus DYADOSPORA (Strother & Traverse 1979) Burgess & Richardson 1991

Type Species. Dyadospora murusattenuata (Strother & Traverse 1979) Burgess & Richardson 1991.

Diagnosis. Palynomorphs consisting of two inapeturate spores or spore like palynomorphs occurring in a dyad configuration; individual spores spherical to subspherical to hemispherical in outline; walls psilate overall length of flattened dyad body, 25 to 50 µm.
Dyadospora murusattenuata (Strother & Traverse 1979) Burgess & Richardson 1991.

Not figured.

Holotype. Strother & Traverse 1979, p. 15, pl. 6, fig. 9.

Diagnosis. (See Burgess & Richardson 1991, p. 614). 'A dyadospora with thin folded walls.'

Dimensions. Spore diameter 24 - 36 μm
Number of specimens measured 5

Occurrence. These forms were recovered sporadically throughout this study, but were not originally separated during the logging.

Dyadospora murusdensa (Strother and Traverse 1979) Burgess & Richardson 1991

Plate 59, fig. 6.

For a full synonymy list prior to 1993 see Wellman & Richardson (1993, p. 170.)

Holotype. Strother & Traverse, p. 15, pl. 3, fig. 7.

Diagnosis. (Burgess & Richardson 1991, p. 615). 'A dyadospora with unfolded walls'.

Remarks. Laevigate dyad spores, often folded from which other laevigate spore genera such as Laevolancis Chibrikova are probably derived (Wellman 1993). It is possible that the species D. murusdensa and D. murusattenuata are synonymous, the specific split based on folding is not a well constrained specific diagnostic.

Dimensions. Spore diameter 26 - 38 μm
Number of specimens measured 5

Occurrence. For references for occurrences prior to 1993 see Wellman & Richardson (1993, p 170); Lower Llandovery of New York State, USA (Miller & Eames 1982); Silurian of the Cheviot Hills north east England (Barron 1989); Czechoslovakia (Vavradová 1989); Libya (Richardson (1988); UK (Richardson 1988, Burgess 1991,
Genus **HISPANAEDISCUS** (Cramer) Burgess & Richardson 1991

*Type Species. Hispanaediscus verrucatus* (Cramer) Burgess & Richardson 1991.

*Diagnosis.* (Burgess & Richardson 1991, p. 608). 'Alete proximally hilate cryptospores; originally elliptical to hemispherical in equatorial view; equatorial to sub-equatorial crassitude surrounding the hilum. Hilum laevigate or with radial and/or randomly oriented muri/folds. Distal exine ornamented with verrucae and or muri.'

**Hispanaediscus wenlockensis** Burgess & Richardson 1991

Plate 58, fig. 12; Plate 60, fig. 4.

1991 *Hispanaediscus wenlockensis* Burgess & Richardson p. 611, pl. 1 figs. 4 - 9.
1993 *Hispanaediscus wenlockensis* Burgess & Richardson, Wellman, p. 54, pl. 2 figs. 1 - 4.

*Holotype. Hispanaediscus wenlockensis* Burgess & Richardson p. 611, pl. 1 fig.

*Diagnosis.* (Refer to Burgess & Richardson p. 611). 'As Hispanaediscus with short proximal radial muri and distal sculpture dominated by verrucae which occasionally coalesce into muri'.

*Remarks.* The specimens recovered conformed to the original diagnosis. Monad sporomorph with a distally sculptured exine of low verrucae and muronate ornament. 1.5 - 3 μm wide. Amb circular to subcircular. Subequatorial crassitude.

*Dimensions.*

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Vesicle diameter</td>
<td>20 - 32 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>5</td>
</tr>
</tbody>
</table>

378
Occurrence. Coalbrookdale formation, lower Farley Member (Homerian) of the type area (Burgess & Richardson 1991); upper Wenlock to lower Ludlow Series of the Stonehaven Group, Scotland (Wellman 1993); upper Wenlock Series of the Prague Basin (Dufka 1995); Ordovician and Silurian (Ludlow Series) of Turkey (Steemans et al. 1996); Barron 1989; Silurian of Gotland, Sweden (Hagström 1997).

Genus **RETUSOTRILETES** (Naumova) Richardson 1965 *non.* Streel 1964

*Type Species.* Retusotriletes pychovii Naumova 1953.

*Diagnosis.* (Refer to Naumova 1953 in Russian and the discussion of Richardson & Lister 1969).

**Retusotriletes cf. warringtonii** Richardson & Lister 1969.

*Not figured.*

*Diagnosis.* The specimens found conform to the original diagnosis in Richardson & Lister 1969.

*Remarks.* Subtriangular convex miospores. Polar and lateral compressions found. The trilete mark is emphasised by slight laesurae which are straight to sinuous in outline. The line of commisure is often indistinct, possibly the result of compression. The trilete mark equals the length of the radius. The length of the triradiate mark indicates that the curvaturae are at the margins of the miospore coinciding with the equator. As a result the limit of the contact areas is indistinct. The contact areas occupy approximately 50% of the spore area. The exine is psilate the spore body being essentially laevigate. Arcuate folding of the exine is probably due to compression.

*Dimensions*

<table>
<thead>
<tr>
<th></th>
<th>Diameter</th>
<th>25 μm</th>
</tr>
</thead>
<tbody>
<tr>
<td>length of laesurae</td>
<td>12.5 μm</td>
<td></td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

*Occurrence.* Amongst many previous reports, this species has been noted from the following areas; Late Ludfordian from the Llandovery to Wenlock of Ireland (Smith 1981 as *Retusotriletes spp.*); forms questionably assigned to this genus were reported from the Homerian age rocks from the Southern Uplands (White et al. 1991); upper Wenlock Series of the Prague Basin (Dufka 1995); Ordovician to Silurian of Turkey (Steemans et al. 1996);
Genus **SYNORISPORITES** Richardson & Lister 1969


**Diagnosis.** (Richardson & Lister 1969, p. 232). ‘Radial, trilete spores with prominent curvaturae perfectae forming a more or less equatorial crassitude. Contact areas distinct, smooth or with interradial papillae, or variously sculptured; distally sculptured with verrucae and/or, muri’.

**Synorisporites verrucatus** Richardson & Lister

Plate 60, fig. 5.

*Holotype. Synorisporites* (Hoffmeister 1959), p. 233, pl. 40, figs. 10 or 12 (unclear from text).

**Diagnosis.** (Refer to Richardson & Lister 1969, p. 233). ‘Proximal face smooth, distally sculptured dominantly by small verrucae occasionally fused into tetrads’.

**Remarks.** The specimens assigned herein conform to the diagnosis.

**Dimensions.**

- Vesicle diameter: 18 - 32 µm
- Number of specimens measured: 5

**Occurrence.** *Synorisporites verrucatus* has been reported widely by numerous authors, the following have been checked: from the Wenlock to Ludlow Series of Libya (Richardson & Lister 1973); Llandovery to Wenlock of Ireland (Smith 1981 as *Synorisporites* spp.); Ludlow to Prfdolf Series of Turkey (Steemans et al. 1996); forms questionably assigned to this genus were reported from the Silurian of the Southern Uplands (White *et al.* 1991); Silurian of Gotland, Sweden (Hagström 1997).

**Muronate tetrad**

Plate 59, fig. 2.

1993  Muronate tetrads Burgess & Richardson, Wellman, p. 58 pl. 4 figs. 4- 6.
Description. (Burgess & Richardson 1991, p. 620). 'Tetrads of closely adherent spores with muronate sculpture. Individual spores with triangular to subtriangular amb. Proximal surface not seen. Distal exine sculptured with elongate, narrow (0.5 (1) 1.5 μm wide), sinuous to convolute and anastomosing, low (<1 μm high) and rounded muri; elements discrete but occasionally closely spaced and fused. <0.5 - 3 μm apart'.

Remarks. Tetrads with muronate sculpture of irregular outline 1.5 - 2 μm wide. Hagström (1997) described a new species from Gotland called Pachytetras rugosa, it is possible that this form is similar but the reproduction of the plates is too poor to be certain.

Dimensions

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tetrad Diameter</td>
<td>44 μm</td>
</tr>
<tr>
<td>Individual spore diameter</td>
<td>26 - 28 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

Occurrence. from the Dadas Formation Ludlow to Pridolf series of Turkey (Steemans et al. 1996); Coalbrookdale to Much Wenlock Limestone Formation of the Wenlock area (Burgess & Richardson 1991); nassa to lower ludensis graptolite biozones and brevicosta - verrucata Cryptospore miospore assemblage zone Homerian Stage (late Wenlock to early Ludlow series) of Scotland (Wellman 1993).

Anteturma CRYPTOSPORITES (Richardson et al 1984) Richardson 1988

1. 'Permanently' Fused Cryptospore Tetrads:

The group comprises fused tetrads and dyads not found separately and are therefore permanently fused.

Genus TETRAHEDRALETES (Strother & Traverse 1979)

Wellman & Richardson 1993

Type Species. Tetrahedraletes medinensis Strother and Traverse 1979 of the Tuscarora formation, Pennsylvania, USA.

Emended Diagnosis. (Wellman & Richardson 1993, p. 164) “Permanent tetrahedral tetrads composed of subtriangular to subcircular spore-like units. The spores are crassitate and have a laevigate invaginated distal wall. The spores are discrete and the plane of attachment between the adjoining spores forms a distinct line of attachment at the junction between the crassitudes.”
**Tetrahedraletes medinensis** (Strother & Traverse) Wellman & Richardson 1993

Plate 58, figs. 7, 8.

For a synonymy list prior to 1993 see Wellman & Richardson p. 166.

*Type Species.* *Tetrahedraletes medinensis* Strother and Traverse 1979 of the Tuscarora formation, Pennsylvania, USA.

*Emended Diagnosis.* (Wellman & Richardson 1993, P. 166.) 'A *Tetrahedraletes* which is firmly bonded with prominent equatorial crassitudes on the individual spores and distinct lines of attachment at the junctions between adjacent spores. The distal walls of the spores are laevigate rigid and invaginated'.

*Remarks.* Thick walled, laevigate, obligate tetrads, subtriangular in outline. Within the tetrad the individual spores have a subtriangular outline. The specimens recovered conform broadly to the diagnosis of Wellman & Richardson (1991) though forms with both invaginated and inflated vesicles as described by Burgess (1991). Also refer to Traverse & Strother (1994) for comments of the nomenclature of *Tetrahedraletes*.

**Dimensions.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of tetrad</td>
<td>24 - 32 μm</td>
</tr>
<tr>
<td>Individual spore width</td>
<td>16 - 18 μm</td>
</tr>
<tr>
<td>Crassitude width</td>
<td>2 - 4 μm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

*Occurrence* For occurrences prior to 1993 refer to the synonymy list of Wellman & Richardson (1993). Medina Group of Niagara Gorge (Cramer & Diez 1972); Lower Llandovery of New York State, USA (Miller & Eames 1982); Silurian of the Southern Uplands (White et al. 1991); Silurian of the Midland Valley of Scotland (Wellman & Richardson 1993); Wenlock Series from Buildwas Bank and Holbrook Coppice, near Ironbridge, Shropshire (Turner et al. 1995 *Tetrahedraletes* spp); upper Wenlock Series of the Prague Basin (Dufka 1995); Ordovician to Silurian of Turkey (Steemans et al. 1996); Lower Devonian of Argentina (Le Hérissé et al. 1996); Silurian of Gotland, Sweden (Hagström 1997); This species occurs worldwide (Steemans et al. 1996).

These sporomorphs were recovered from the Farley Member of the Coalbrookdale Formation, the Much Wenlock Limestone Formation and the lowermost beds of the Lower Elton Formation from the Wenlock and Ludlow areas of Shropshire.

Known Range: late Caradoc (Richardson 1988) - Early Devonian (Wellman 1993) (Steemans et al. 1996).
2. Hilate Cryptospores:

*Type Species. Laevaeolancis divellomedium* (Chibrikova) Burgess 1991.

*Diagnosis.* (Burgess 1991 p.606). "Alete proximally hilate cryptospores, originally elliptical to hemispherical in equatorial view with an equatorial to subequatorial crassitude surrounding the hilum; exine laevigate."

*?Laevaeolancis sp.*

Plate 59, fig. 3.

*Remarks.* Large distinctive laevigate cryptospores, ellipsoidal amb with a wide subequatorial crassitude. Refer to figure.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter</td>
<td>70 µm</td>
</tr>
<tr>
<td>crassitude</td>
<td>8 - 10 µm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>

*Occurrence.* This form was recorded as a rare type from the Coalbrookdale Formation of Harley Hill, sample HH1 TD/10/1

*Spore Type 1*

Plate 59, fig. 1

*Remarks.* Very large distinctive form. Refer to figure.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Spore Diameter</td>
<td>64 - 70 µm</td>
</tr>
<tr>
<td>Outer margin width</td>
<td>8 - 12 µm</td>
</tr>
<tr>
<td>Trilete? or Tetrad division radius</td>
<td>25 - 40 µm</td>
</tr>
<tr>
<td>Thickness of ?trilete/tetrad mark</td>
<td>6 - 10 µm</td>
</tr>
<tr>
<td>Number of specimens measured</td>
<td>1</td>
</tr>
</tbody>
</table>
Occurrence. Only one specimen was recovered from the Farley Member of the Coalbrookdale Formation of Farley Dingle, sample FD 1500/10/1.

**Spore D**

Plate 58, fig. 9.

Remarks. Similar to species of Ambitisporites but with a thickening of the trilete mark.

**Dimensions.**

- Vesicle diameter: 26 - 38 µm
- Radius of trilete mark: 16 - 22 µm
- Number of specimens measured: 5.

Occurrence. This form was recovered from the Farley Member of the Coalbrookdale Formation in samples from Farley Dingle and Harley Hill; the Much Wenlock Limestone Formation of Coates Quarry and Shadwell Quarry; Much Wenlock Limestone Formation to lowermost Lower Elton Formation of Pitch Coppice.

**?Spore E**

Plate 58, figs. 10, 11.

Remarks. Questionable spore with a finely granulate ornament.

**Dimensions.**

- Vesicle diameter: 26 - 32 µm
- Number of specimens measured: 2

Occurrence. This form was recorded from the Farley Member of the Coalbrookdale Formation of Farley Dingle and Harley Hill.
Spore G

Plate 58, fig. 6; Plate 60, fig. 6.

Remarks. Loosely fused, laevigate tetrad sporomorphs were recorded herein.

Dimensions. Vesicle diameter of individual 20 - 28 μm
Entire dimensions 46 - 50 μm
Number of specimens measured 5

Occurrence. Farley Member of the Coalbrookdale Formation from Farley Dingle and Harley Hill; Much Wenlock Limestone Formation of Coates Quarry and Shadwell Quarry and the Much Wenlock Limestone Formation and lowermost beds of the Lower Elton Formation from Pitch Coppice and Mortimer Forest.

Spore J

Plate 59, fig. 5.

Remarks. A tetrad form, combined with Spore G on the Tiliagraphs but clearly distinct in form. Refer to the plates for details of the form.

Dimensions. Vesicle diameter 36 - 48 μm
Radius 25 - 35 μm
Number of specimens measured 1

Occurrence. This single specimen was found from the Farley Member of the Coalbrookdale Formation from Farley Dingle, sample FD 500/10/1.

Spore R

Plate 60, fig. 1, 2, 3.

Description. (Burgess & Richardson 1991, p. 618). 'Subtriangular amb with convex sides and rounded apices. Equatorial crassitude narrow, 0.5 - 3.5 μm wide. Proximal surface sculptured with convolute and anastomosing muri c. 1 μm wide and 0.5 μm apart; muri are radially aligned near the equator but are predominantly
randomly oriented over the remainder of the proximal surface. Distal exine c. 1 μm thick; laevigate in two specimens, and with scattered grana in one specimen'.

**Remarks.** This distinctive spore species of the genus *Emphanisporites*. It was first recorded as Trilete Miospore Type 1, by Burgess & Richardson (1991, Text-fig. 3 A - C). This form is also similar to *Artemopyra* sp. (Burgess & Richardson 1991) but good copies of plates were not available for examination.

**Dimensions.**

- Vesicle diameter: 20 - 38 μm
- Ornament (muri) width: 1 - 2 μm
- Crassitude: 2 - 4 μm
- Number of specimens measured: 5

**Occurrence.** Burgess & Richardson (1991) recorded this form from the Upper Coalbrookdale Formation to Lower Farley Member of the type Wenlock area. This form was recovered regularly from the Farley Member of the Coalbrookdale Formation and the lowermost Lower Elton Formation in samples from Farley Dingle, and Pitch Coppice.

**Infraturma Endomurali** Burgess & Edwards 1990.

**GENUS PORCATITUBULUS** Burgess & Edwards 1990.

**Type Species.** *Porcatitubulus annulatus* Burgess & Edwards 1990.

**Known Stratigraphic Range:** Basal Wenlock centrifugus graptolite biozone to at least Gedinnian (early Lockovian) according to Burgess & Edwards, 1990.

**Porcatitabulus annulatus** Burgess & Edwards 1991.

Plate 70, fig. 4

**Diagnosis.** (Refer to Burgess & Edwards, 1991 p. 55).
Description. Unbranched tubes at least 150 µm long, externally smooth or corrugated. Internally; narrow annular thickenings which may form complete rings. The tubes appear flattened but probably had a circular cross section in life, Burgess & Edwards, 1990.


Dimensions. Length Variable up to 120 µm

Occurrence. These forms were recovered consistently in low numbers from the Coalbrookdale, Much Wenlock Limestone and Lower Elton formations from the type Wenlock and Ludlow areas.

Porcatitubulus spiralis Burgess & Edwards 1991

Plate 70, figs. 2, 3.

Diagnosis. (Refer to Burgess & Edwards, 1990, p. 57).

Remarks. This species differs in having spiral thickenings which are less prominent and finer than those seen in P. annulatus.

Occurrence. Recorded as part of the palynofacies count in this study.

Porcatitubulus sp. Burgess & Edwards 1991

Plate 70, fig. 1.

Description. Banded annular tubes not assigned to a species.

Occurrence. Recorded as part of the palynofacies count in this study.
Anteturma **TRICHOFORMIS**
Turma **TUBIFORMIS**
Infraturma **LAEVIMURALI**
Genus **LAEIVITUBULUS** Burgess & Edwards 1991

*Type Species* *Laevitubulus tenuis* Burgess & Edwards 1991, p. 47

*Diagnosis.* Refer to Burgess & Edwards 1991, p. 45, 47.

**Laevitubulus plicatus** Burgess & Edwards 1991

Plate 70, fig. 5.

*Description.* Tubular elements counted for palynofacies.

*Occurrence.* Recorded as part of the palynofacies count in this study.

**Laevitubulus frondifera** Wellman 1995

Not figured.

*Description.* Banded tubes with branching counted for palynofacies.

*Occurrence.* Recorded as part of the palynofacies count in this study.

**Group CHITINOZOA** Eisenack 1931

Chitinozoans were logged with the acritarchs and plant sporomorphs but not studied extensively in the systematic format. On working on identification of the forms recovered, it became clear that much of the identification of chitinozoan species has been based upon features only visible using the scanning electron microscope. In this study the identifications were made using a transmitted light microscope. There also seems to be a high level of synonymy within the literature, especially where the conochitiniids are concerned. Therefore, the forms recorded herein, having been fully logged, are presented mostly at generic level or left in open nomenclature, in Table 1, and figured in the plates.
Table 1: Chitinozoans recovered from the Homerian to early Gorstian of the type Wenlock & Ludlow areas.

<table>
<thead>
<tr>
<th>Chitinozoan type:</th>
<th>Other details:</th>
<th>Plate figure:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ancyrochitina ancyrea Eisenack 1931.</td>
<td></td>
<td>Plate 64, figs. 1, 2, 3, 4.</td>
</tr>
<tr>
<td>Ancyrochitina ancyrea</td>
<td></td>
<td>Plate 65, fig. 5.</td>
</tr>
<tr>
<td>Ancyrochitina gutnica Laufeld 1974</td>
<td></td>
<td>Plate 66, figs. 3, 4.</td>
</tr>
<tr>
<td>Ancyrochitina cf. pachyderma</td>
<td></td>
<td>Plate 61, fig. 6.</td>
</tr>
<tr>
<td>Ancyrochitina sp.</td>
<td></td>
<td>Plate 65, fig. 6.</td>
</tr>
<tr>
<td>Ancyrochitina primitiva Eisenack 1964</td>
<td></td>
<td>Plate 61, fig. 4.</td>
</tr>
<tr>
<td>Ancyrochitina primitiva</td>
<td>Logged as Chitinozoan sp. E/1</td>
<td>Plate 66, fig. 1.</td>
</tr>
<tr>
<td>Cingulochitina cingulata Eisenack 1937</td>
<td>Refer to Chitinozoan sp. D.</td>
<td>Plate 65, fig. 8.</td>
</tr>
<tr>
<td>Conochitina argillophila Laufeld 1974</td>
<td></td>
<td>Plate 67, fig. 4.</td>
</tr>
<tr>
<td>Conochitina pachycephala Eisenack 1964</td>
<td>Refer to Chitinozoan sp. H.</td>
<td></td>
</tr>
<tr>
<td>Conochitina proboscifera Eisenack 1937</td>
<td></td>
<td>Plate 67, figs. 5, 6.</td>
</tr>
<tr>
<td>Eisenackitina sp.</td>
<td>Logged as Chitinozoan sp. L.</td>
<td>Plate 65, fig. 7.</td>
</tr>
<tr>
<td>Sphaerochitina sp.</td>
<td></td>
<td>Plate 65, fig. 4.</td>
</tr>
<tr>
<td>Sphaerochitina aff. sphaerocephala</td>
<td>Logged as Chitinozoan sp. A.</td>
<td>Plate 66, fig. 2.</td>
</tr>
<tr>
<td>Chitinozoan sp. A</td>
<td>Refer: Sphaerochitina aff. sphaerocephala</td>
<td></td>
</tr>
<tr>
<td>Chitinozoan sp. B</td>
<td>Ancyrochitina sp.</td>
<td>Plate 65, figs. 1, 3, 9.</td>
</tr>
<tr>
<td>Chitinozoan sp. C</td>
<td>Not figured.</td>
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<tr>
<td>Chitinozoan sp. D</td>
<td>Refer to Cingulochitina cingulata</td>
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<tr>
<td>Chitinozoan sp. E</td>
<td>Ancyrochitina sp.</td>
<td>Plate 61, fig. 1.</td>
</tr>
<tr>
<td>Chitinozoan sp. E/2</td>
<td>Ancyrochitina sp.</td>
<td>Plate 66, fig. 5.</td>
</tr>
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<td>Chitinozoan sp. F.</td>
<td>Ancyrochitina sp.</td>
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<td>Chitinozoan sp. G</td>
<td>Ancyrochitina primitiva</td>
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<tr>
<td>Chitinozoan sp. H var. 1</td>
<td>Rhabdochitina wakefieldii Sutherland</td>
<td>Plate 63, fig. 4.</td>
</tr>
<tr>
<td>Chitinozoan sp. H</td>
<td>Conochitina pachycephala</td>
<td>Plate 67, figs. 3, 7.</td>
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<td>Chitinozoan sp. J</td>
<td></td>
<td>Plate 62, fig. 4.</td>
</tr>
<tr>
<td>Chitinozoan sp. J</td>
<td></td>
<td>Plate 63, fig. 3.</td>
</tr>
<tr>
<td>Chitinozoan sp. J</td>
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<td>Plate 67, fig. 1.</td>
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<td>Chitinozoan sp. K</td>
<td>?Sphaerochitina sp.</td>
<td>Plate 61, fig. 7.</td>
</tr>
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<td>?Sphaerochitina sp.</td>
<td>Plate 62, fig. 7.</td>
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<td>Chitinozoan sp. M</td>
<td>Ancyrochitina with a very long neck</td>
<td>Plate 62, fig. 1.</td>
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<tr>
<td>Chitinozoan sp. M</td>
<td>Ancyrochitina with a very long neck</td>
<td>Plate 66, fig. 6.</td>
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<td>Chitinozoan sp. N</td>
<td>?Desmoschitina sp.</td>
<td>Plate 62, fig. 6.</td>
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<td>?Angochitina sp.</td>
<td>Plate 61, fig. 8.</td>
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<td>?Angochitina sp.</td>
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<td>Chitinozoan sp. Q</td>
<td>?Angochitina sp.</td>
<td>Plate 62, fig. 3.</td>
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<td>Sphaerochitina like</td>
<td>Plate 61, fig. 2.</td>
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<td>Plate 63, figs. 1, 2.</td>
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<td>Chitinozoan sp. T</td>
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<td>Plate 63, fig. 5.</td>
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<tr>
<td>Chitinozoan sp. V</td>
<td>Sphaerochitina like.</td>
<td>Plate 61, fig. 3.</td>
</tr>
<tr>
<td>Chitinozoan sp. W</td>
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<tr>
<td>Chitinozoan sp.</td>
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<td>Plate 68, fig. 4.</td>
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