Cambrian Furongian Series acritarchs from the Comley area, Shropshire, England

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ABSTRACT – Acritarch assemblages are reported for the first time from the Cambrian of Comley, Shropshire, England, a historically important area for British Cambrian biostratigraphy. Three assemblages are described from the Furongian Shoot Rough Road Shales. Horizons within the Shoot Rough Road Shales have in the past yielded Parabolina spinulosa and Orusia lenticularis indicative of the Parabolina spinulosa trilobite Zone. Two distinct microfloras are identified, one is characterized by the common occurrence of Trunculumarium revinium and diacrodian taxa, the other, by an absence of T. revinium and a general paucity of diacrodians but with a significant presence of Scalenadiacrodium comleyense gen. et sp. nov. The microfloras are compared with trilobite-controlled Furongian sequences in eastern Newfoundland and the Nuneaton area, England and are found to support the P. spinulosa Zone assignment for the Shoot Rough Road Shales. The microfloras are also compared with those from localities lacking direct P. spinulosa Zone trilobite control, principally the Ardennes and the East European Platform. Acritarch based recognition of the two trilobite subzones of the P. spinulosa Zone remains problematic, but independent subdivision of the zonal interval based on acritarchs is supported. A new acritarch genus Scalenadiacrodium gen. nov. and a new species S. comleyense sp. nov. are described. J. Micropalaeontol. 31(1): 1–28, February 2012.

KEYWORDS: acritarchs, Cambrian, Furongian, Comley, P. spinulosa Zone, trilobite

INTRODUCTION AND GEOLOGICAL BACKGROUND

The Comley area and surrounding districts provide one of a small number of Cambrian outcrops in England, all of limited geographical extent (Fig. 1), but Comley’s geological importance is disproportionate to its size. Lapworth (1888) described the first early Cambrian trilobites to be found in Britain from Comley Quarry (Fig. 2) and the condensed carbonate section exposed there is still a major reference for Cambrian biostratigraphy world-wide. With the exception of the quarry section, the solid geology of the area is very poorly exposed and knowledge of the succession is owed mainly to the studies of E. S. Cobbold, undertaken with the aid of numerous excavations, during the early part of the twentieth century. A discontinuous sequence of Terreneuvian to Furongian sedimentary rocks is present.

An account of the Cambrian sequence in the area is provided by Greig et al. (1968) and is used as the basis for the geological description given below. A concise description of the Comley Quarry outcrop is given by Rushton (in Rushton et al., 1999). The very poorly exposed Furongian Shoot Rough Road Shales are the subject of the present investigation (Fig. 3). The shales were deposited in a relatively shallow-marine environment and represent a transition between the dominantly shallow-marine, more arenaceous, Terreneuvian to Series 3 sediments of the area and the deeper-marine facies of Furongian and Lower Ordovician deposits. Although the true thickness is not determinable, 28.93 m (94’11”) of the shales are seen to be resting without-sequence on the Series 3 Shoot Rough Road Flags in the Geological Survey inclined borehole [National Grid 4889 9645] at Shoot Rough (Greig et al., 1968). The Shoot Rough Road Shales are succeeded by the Tremadocian (Lower Ordovician) Shineton Shales in the Comley area, known from stream sections in woodland north of Shoot Rough, which have yielded a fauna including Rhabdimopora flabelliformis (Eichwald, 1840). To the north of the area, at Bentleyford Brook, black Furongian shales (Bentleyford Shales) separate the Shoot Rough Road Shales from the overlying Tremadocian Shineton Shales (Stubblefield, 1930). The apparent absence of these shales in the Comley area is most probably due to faulting, a faulted contact being tentatively suggested to occur between the Shineton Shales and older strata in Cobbold’s Excavation 62 in Shoot Rough Wood (Cobbold, 1927).

Recent palaeontological investigations have again focused on the mainly Series 2 carbonate succession exposed at Comley Quarry. Hinz (1987) described the phosphatic microfossils and Siveter et al. (2001) report exceptionally well-preserved phosphatocopid crustaceans. The Furongian clastic sequence has been largely neglected since the time of Cobbold’s work, although the acritarchs from the Tremadocian Shineton Shales north of the study area have been thoroughly investigated (Downie, 1958; Rasul, 1979). In this contribution we describe acritarch assemblages from three samples of the Shoot Rough Road Shales. Cobbold (1927) recovered the trilobite Parabolina spinulosa (Wahlenberg, 1821), diagnostic of the Parabolina spinulosa Zone (Furongian Series, Cambrian Stage 9, of recently introduced chronostratigraphical terminology, Cocks et al., 2010) from two excavations in the shales and two of the acritarch sample sites were located in the close neighbourhood of these excavations. The presence of P. spinulosa in the Shoot Rough Road Shales, as reported in Cobbold (1927), is indicative of the upper P. spinulosa Subzone of the P. spinulosa Zone (A.W.A. Rushton, pers. comm. 2009). Whilst the subdivision of the zone was introduced by Westergård in 1922, it was formally treated as a subzone by Westergård (1944) after Cobbold’s death. The zonal subdivision is summarized by Henningsmoen (1957). C. J. Stubblefield, who identified the trilobite material reported by Cobbold, would have been aware of the description of Parabolona brevispina (Westergård, 1922), the index fossil for
the lower subzone, and would not have confused the two taxa (Rushton, pers. comm. 2009). Unfortunately the excavations are now completely obscured and their exact location cannot be identified with certainty. The aims of the investigation were to characterize the Comley microfloras and to determine the potential of acritarchs as a tool for biostratigraphy in the Comley area by comparison with assemblages that have an established relationship with trilobite zones in other areas. The assemblages are compared with those from eastern Newfoundland (Martín & Dean, 1981, 1988; Parsons & Anderson, 2000) and with one from the Nuneaton area of the English Midlands (briefly reported by Bridge et al., 1998 and unpublished material), these being the only other Avalonian sequences with reliable P. spinulosa Zone control together with acritarch data. In addition, comparison is made with similar microfloras elsewhere, notably from the Ardennes and Estonia, where the trilobite evidence is more tenuous or absent.

**SAMPLING**

Three samples, L1, L2 and L3, were collected from the Furongian Shoot Rough Road Shales of the Comley area and prepared for palynological investigation. The sampling was based primarily on the fieldwork carried out by E. S. Cobbold, published between 1909 and 1933 and summarized with additional borehole information by Greig et al. (1968). Cobbold’s map (Cobbold, 1927) shows the location of 63 excavations. A previous palynological investigation of the Series 3 and Furongian of the Comley area by one of the authors (Potter, unpublished PhD thesis, University of Sheffield, 1974) was also used in the selection of sample sites. The very limited exposure proved the greatest constraint on site selection. Map references are according to the Ordnance Survey 1: 10,560, 6 inches to the mile, Sheet SO 49 NE. A simplified map showing the sample sites is given in Figure 2. The samples were all collected from small exposures of dark grey shale reported by Cobbold (1921) as *Orusia* Shales Horizon Ca, now and previously (see Cobbold 1921, table 1, ‘Shoot-Rough Road Shale’) called Shoot Rough Road Shales (Cowie et al., 1972). Greig et al. (1968) employ the term Grey (*Orusia*) Shales for the same lithological unit. The position of the Shoot Rough Road Shales in relation to the Cambrian stratigraphy of the Comley area is shown in Figure 3.

- L1: SO 49 NE 4857 9671. West bank of Comley Brook, approximately 2 m north of the junction between Comley Brook and a small tributary running west from Shoot Rough. Site L1 is situated at or close to Excavation 60 reported by Cobbold (1927, p. 555). Excavation 60 yielded only a minute *Lingulella*, but the rock exposed was none the less provisionally assigned to the *Orusia* horizon, Ca. Excavation 59, c. 0.27 m to the south in Comley Brook, yielded *Parabolina spinulosa* (Wahlenberg, 1821), *Orusia lenticularis* (Wahlenberg, 1821) and *Acrothele* cf. *coriacea* Linnarsson, 1876 (Cobbold, 1916, p. 122; 1927, reporting work of C. J. Stubblefield, p. 557).

- L2: SO 49 NE 4871 9653. North bank of a tributary of Comley Brook running WNW from Shoot Rough Farm where it flows just to the south of and parallel to Shoot Rough Road. It is some 30 m downstream from the point where the stream initially converges with the road. Some of Cobbold’s excavations just to the north of Shoot Rough Road exposed shales he assigned to the Shoot Rough Road Shales. Excavation No. 21, located some metres north of location L2 in the bank of Shoot Rough Road (now concealed), yielded a small form ‘approaching’ *Orusia lenticularis*, *Kutorgina* sp. and a small *Acrothele* (Cobbold, 1910, p. 185).

![Fig. 1. Distribution of Cambrian outcrops in England and Wales (after Rushton in Rushton et al., 1999).](image-url)
Fig. 2. Map showing sampled localities in the Comley area, Shropshire, UK (after Ordnance Survey map 1: 10,560, 6 inches to the mile, Sheet SO 49 NE).

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<td>Wrekin Quartzite</td>
<td>up to 40m</td>
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Fig. 3. Stratigraphy of the Cambrian sedimentary succession in the Comley area (after Greig et al., 1968; Cowie et al., 1972; Rushton pers. comm., 2008). Asterisk (*) indicates the provenance of samples L1, L2 and L3 of the present study.
The taxa recorded from the Comley samples are listed below.

Species list
The taxa recorded from the Comley samples are listed below.

Actinotodissus achrasii (Martin, 1973) Yin Lei-ming, 1986 (Pl. 1, figs 1, 2)
Cristallinium cambriense (Slavíková, 1968) Vanguemtaine, 1978 (Pl. 5, fig. 6; Pl. 7, fig. 11)
Cristallinium randomense Martin in Martin & Dean, 1981 (Pl. 5, figs 4, 5; Pl. 7, fig. 12)
Cymatiogalea aff. aspergillum Martin in Martin & Dean, 1988 (Pl. 4, figs 1–3)
Cymatiogalea virgulta Martin in Martin & Dean, 1988 (Pl. 3, figs 4–6; Pl. 7, fig. 6)
Dasydiacrodium obsonum Martin in Martin & Dean, 1988 (Pl. 1, figs 3, 4)
Gyalorhethium? sp. 1 (Pl. 3, fig. 9)
Impluviculus sp. 1 (Pl. 2, figs 1–3)
Leiosphaeridia spp. (Pl. 5, fig. 8)
Ninadiacrodium caudatum (Vanguemtaine, 1973) Raevskaya & Servais, 2009 (Pl. 5, fig. 7)
Ninadiacrodium aff. caudatum (Vanguemtaine, 1973) Raevskaya & Servais, 2009 (Pl. 3, fig. 1)
Ninadiacrodium dumentii (Vanguemtaine, 1973) Raevskaya & Servais, 2009 (Pl. 2, fig. 9; Pl. 7, figs 1–3)
Polygony spp. (Pl. 1, figs 5, 6; Pl. 7, fig. 4)
Scalenadiacrodium complevense gen. et sp. nov. (Pl. 2, figs 4–8)
Stelliferidium cortinulamorphum Paalits, 1995 (Pl. 4, figs 4–6; Pl. 7, fig. 7)
Stelliferidium cf. distinctum (Rasul, 1974) Pittau, 1985 (Pl. 4, figs 7, 8)
Timofeivia aff. estonica Volkova, 1990 (Pl. 3, figs 7, 8; Pl. 7, figs 8, 9)
Timofeivia phosphoritica Vanguemtaine, 1978 (Pl. 3, figs 2, 3; Pl. 7, fig. 5)
Trunculamarium revinium (Vanguemtaine, 1973) Loeblich & Tappan, 1976 (Pl. 4, fig. 9; Pl. 5, figs 1–3; Pl. 7, fig. 10)
Vulcanisphaera africana Deunff, 1961 (Pl. 6, figs 1, 3)
Vulcanisphaera turbata Martin in Martin & Dean, 1981 (Pl. 6, figs 2, 4)

INCERTAE SEDIS
Group Acritarcha Evitt, 1963

Genus Actinotodissus Loeblich & Tappan, 1978

Type species. Actinotodissus longitaleosus Loeblich & Tappan, 1978


Actinotodissus achrasii (Martin, 1973) Yin Lei-ming, 1986 (Pl. 1, figs 1, 2)
1973 Acanthodiacrodium achrasii Martin: 30; pl. V, fig. 11; pl. VI, figs 8, 11, 19; pl. VIII, figs 1, 2, 4.
1986 Actinotodissus achrasii (Martin, 1973); Yin Lei-ming, 332; pl. 84, figs 1, 3, 5, 7–11, 13, 15, 16; pl. 92, figs 1, 2, 4, 6; pl. 93, figs 1, 2, 6, 7; pl. 94, fig. 5; pl. 96, fig. 4; pl. 97, fig. 8; text-fig. 122.

Description. The vesicle outline is elongate polygonal with long, hollow, broad-based, tapering, pointed processes inserted in the polar regions, often with one or two processes located in the otherwise unornamented central region, more or less equidistant from the poles. There are equal numbers of processes in each polar region or with a difference of no more than two. One or more processes on a given individual may be significantly shorter, approximately 1/3 to 2/3 the length of the principal processes. The process cavities are in communication with the vesicle cavity
and the wall of both processes and vesicle is thin. Although the specimens are corroded, a granular, possibly finely echinate sculpture is visible on many specimens, this being most apparent on the processes. A pronounced conical polar protuberance bearing a single process is present in a small number of specimens. Excystment openings were not observed.

**Dimensions.** 36 specimens. Vesicle length 20 (28.5) 47 µm; vesicle breadth 14 (20.5) 25.5 µm; vesicle breadth: length 57 (74) 100%; maximum process length 13 (20) 37.5 µm; process length: vesicle length 43 (73) 170%; total number of processes 9 (12) 16.

**Remarks.** The processes of the Comley specimens are considerably longer than those of the Ordovician type material and frequently longer than those of specimens of Cambrian age described by Martin & Dean (1981), Parsons & Anderson (2000) and Moczydlowska & Stockfors (2004). Martin (1973, pl. VIII, fig. 2) illustrates a specimen of *A. achrasi* which appears to display centrally located process insertion and, following Parsons & Anderson (2000), such forms are herein accommodated within the species. The same illustration also displays a conical polar extension and similar forms, although to some extent displaying the features of genus *Tectitheca* Burmann, 1968, are otherwise indistinguishable from *A. achrasi* and are also herein included in the species. Some specimens show disparity of vesicle width of the polar regions with a polygonality approaching that of genus *Polygonium* (Vavrdová, 1966) Moczydlowska & Stockfors, 2004. Forms encountered in the Comley assemblages otherwise resembling *A. achrasi* but lacking a long axis and with more or less evenly distributed processes are referred to the genus *Polygonium*. The species *Actinotodissus achrasi*, *Ninadiacrodium caudatum* (Vanguestaine, 1973) Raevskaya & Servais, 2009, *Ninadiacrodium aff. caudatum*, *Dasydiacrodium obsomn Martin in Martin & Dean*, 1988, *Scalenadiacrodium comleyense gen. et sp. nov., Ninadiacrodium dumontii* (Vanguestaine, 1973) Raevskaya & Servais, 2009 and *Polygonium spp.* herein may be closely related biological entities with rather arbitrary distinctions subdividing a morphological continuum. Raevskaya & Servais (2009) discuss the continuity of morphological variation between *N. dumontii* and *N. caudatum*.

**Previous records.** *Actinotodissus achrasi* has been widely reported in Furongian and Lower Ordovician assemblages. The Furongian occurrences are listed here. Furongian, *Parabolina spinulosa* Zone to Lower Tremadocian (verified by macrofossils), eastern Newfoundland, Canada (Martin & Dean, 1981, 1988); Furongian, *Protopeltura praeceptor* Zone to Lower Tremadocian (verified by macrofossils), eastern Newfoundland, Canada (Parsons & Anderson, 2000); Furongian, China (Yin Lei-ming,
Fig. 5. Ranges of acritarch taxa in eastern Newfoundland given by Martin & Dean (1981, 1988) and Parsons & Anderson (2000). Taxa recorded in Comley assemblages unless otherwise indicated.

Genus *Cristallinium* Vanguestaine, 1978

**Type species.** *Cristallinium cambriense* (Slavíková, 1968)

*Cristallinium cambriense* (Slavíková, 1968) Vanguestaine, 1978

(Pl. 5, figs 6; Pl. 7, fig. 11)

1968 *Dictyotidium cambriense* Slavíková: 201, pl. II, fig. 1, 3 (nomen nudum).

1972 *Cymatiosphaera ovillensis* Cramer & Diez de Cramer: 44, pl. 2, figs 4, 7, 10.


**Dimensions.** 21 specimens. Vesicle size 36 (47) 55.5 µm; field size 14 (20) 24.5 µm; field number about 14–20; ornament height 1 (1.4) 2.5 µm.


*Cristallinium randomense* Martin in Martin & Dean, 1981

(Pl. 5, figs 4, 5; Pl. 7, fig. 12)

1981 *Cristallinium randomense* Martin in Martin & Dean: 18, pl. 3, figs 2, 10, 17, 24, 26 (non pl. 3, figs 12, 20; pl. 6, fig. 4, 6).

1988 *Cristallinium randomense* Martin in Martin & Dean, 1981 emend.; Martin in Martin & Dean: 36, pl. 13, figs 6, 9, 17 (non pl. 13, figs 1–5, 7, 8).

**Dimensions.** 19 specimens. Vesicle size 38.5 (47) 55 µm; process length 4.5 (5.5) 7 µm; process length: vesicle size 9 (12) 16%.

**Remarks.** The species concept employed here is that provided by Vanguestaine (2002) in his review of the taxon.

Explanations of plate 1.

**figs 1, 2.** *Actinotodissus achrasi* (Martin, 1973) Yin Lei-ming, 1986: 1, high focus, slide L1a-1 (10 µm), K63/0; 2, high focus, slide L1a-1 (10 µm), R45/0. **figs 3, 4.** *Dasydiacrodium obsonum* Martin in Martin & Dean, 1988: 3, high focus, slide L2a-1 (10 µm), M56/0; 4, high focus, slide L2a-1 (10 µm), F63/0. **figs 5, 6.** *Polygonium* spp.: 5, high focus, slide L2a-1 (10 µm), J63/0; 6, high focus, slide L1a-1 (10 µm), J42/2.
Explanation of Plate 2.

**figs 1–3.** Impluviculus sp.: 1, slide L2a-2 (5 µm), N41/1; 2, slide L2a-2 (5 µm), N48/3; 3, slide L2a-2 (5 µm), N48/4.

**figs 4–8.** Scalenadiacrodium comleyense gen. et sp. nov.: 4, paratype, slide L3c-1 (10 µm), D51/1; 5, slide L3c-2 (5 µm), F71/3; 6, slide L2a-2 (5 µm), F38/0; 7, slide L2a-1 (10 µm), Q69/0; 8, holotype, slide L3c-2 (5 µm), R42/0.

**fig. 9.** Ninadiacrodium dumontii (Vanguelstaine, 1973) Raevskaya & Servais, 2009. Slide L2a-1 (10 µm), P46/0.

figs 2, 3. *Timofeevia phosphoritica* Vanguesteaine, 1978: 2, high focus, 3, low focus, slide L2a-1 (10 µm), L62/0. 

figs 4–6. *Cymatiogalea virgulta* Martin in Martin & Dean, 1988: 4, high focus, slide L1a-1 (10 µm), J54/4; 5, high focus, 6, low focus, slide L1a-5 (10 µm), D62/3. 

figs 7, 8. *Timofeevia* aff. *estonica* Volkova, 1990: 7, high focus, slide L1a-1 (10 µm), J37/0; 8, high focus, slide L2a-1 (10 µm), Q44/0. 

fig. 9. *Gyalorhethium*? sp. 1. Slide L1a-6 (10 µm), J48/3.
Explanation of Plate 4.

Figs 1–3. *Cymatiogalea aff. aspergillum* Martin in Martin & Dean, 1988: 1, high focus, 2, optical section, 3, low focus, slide L2a-1 (10 µm), P49/4. Figs 4–6. *Stelliferidium cortinulamorphum* Paalits, 1995: 4, high focus, 5, optical section, slide L3c-1 (10 µm), D49/0; 6, high focus, slide L2a-1 (10 µm), P41/4. Figs 7, 8. *Stelliferidium cf. distinctum* (Rasul, 1974) Pittau, 1985: 7, high focus, slide L3c-3 (5 µm glycerine jelly), C60/1; 8, high focus, slide L2a-5 (10 µm), J 48/0. Fig. 9. *Trunculumarium revinium* (Vangu setaine, 1973) Loeblich & Tappan, 1976. Slide L1a-4 (10 µm glycerine jelly), D54/1.
**Explanations of Plate 5.**

**figs 1–3.** *Trunculumarium revinium* (Vanguestaine, 1973) Loeblich & Tappan, 1976: 1, high focus, 2, low focus, slide L1a-1 (10 µm), H41/0; 3, high focus, slide L1a-1 (10 µm), P54/1. **figs 4, 5.** *Cristallinium randomense* Martin in Martin & Dean, 1981: 4, high focus, 5, optical section, slide L1a-1 (10 µm), C52/1. **fig. 6.** *Cristallinium cambriense* (Slaviková, 1968) Vanguestaine, 1978. High focus, slide L2a-1 (10 µm), K58/3. **fig. 7.** *Ninadiacrodium caudatum* (Vanguestaine, 1973) Raevskaya & Servais, 2009. Low focus, slide L1a-5 (10 µm), F64/3. **fig. 8.** *Leiosphaeridia* sp. Slide L2a-1 (10 µm), N47/0. **fig. 9.** *Leiofusa stoumonensis* Vanguestaine, 1973. Slide L2a-5 (10 µm), T52/1. Scale bar 10 µm in figs 1–8; 50 µm in fig. 9.
Explanation of Plate 6.

figs 1, 3. *Vulcanisphaera africana* Deunff, 1961: 1, high focus, 3, lower focus, slide L2a-1 (10 μm), K63/0. figs 2, 4. *Vulcanisphaera turbata* Martin in Martin & Dean, 1981: 2, high focus, 4, lower focus, slide L2a-1 (10 μm), O45/3.
Explanation of Plate 7.

indicated in the diagnosis given by Martin (in Martin & Dean, 1988) processes also present, whereas only the latter arrangement is restricted to the angles of polygonal fields or with intergonal processes or of a sheath that may once have surrounded the membrane connecting the processes. The processes display a variable degree of distal branching, usually to digitate terminations. In a few cases there are membranous lists connecting the processes. The processes occur both at the angles and along the sides of the polygonal fields. Apertures are rarely present and are formed by the loss of a single polygonal area.

**Dimensions.** 24 specimens. Vesicle size 24 (30.5) 36.5 µm; process length 3 (4.5) 6 µm; process breadth 1 µm; process length: vesicle size 11 (15) 21%; height of process ramification: total process length 26 (32) 44%; field size 13 (16) 18.5 µm; field size: vesicle size 39 (52) 65%.

**Remarks.** The rarity of delicate translucent membranes connecting processes in the Comley specimens may be a preservational feature. *C. virgulta* is distinguished from *Timofeevia pentagonalis* (Vanguemiste, 1974) Vanguemiste, 1978 by having less complex process terminations and in its possession of a macropyle, although the presence of this latter cannot be anticipated in unopened vesicles in the absence of morphological features which would betray its location. Palacios et al. (2009) introduce a new species of a galeate taxon (*Stelliferidium albanii*) which also lacks any trace of opening structures in the encysted phase, distinguishing it from *Timofeevia* species on the presence of radiating striations from the process bases and on process shaft morphology. It is beyond the scope of the present investigation to consider the merits of this approach but, as indicated by Palacios et al. (2009), the taxonomy of Furongian specimens of *Timofeevia* should be reviewed. Such a review should include forms such as *C. virgulta* in its remit. Specimens lacking a macropyle and with slightly more complex process terminations appear transitional to *Timofeevia pentagonalis* but are included here in *C. virgulta*. It is distinguished from *Cymatiogalea virgulta*.
number of polygonal fields including pentagonal and hexagonal forms. The specimen figured as Cymatiaogalea aff. cristata by Volkova (1990, pl. IX, fig. 14) closely resembles C. virgula in the Comley assemblages.

**Previous records.** Furongian Parabolina spinulosa Zone to Leptoplastus Zone (verified by macrofossils), eastern Newfoundland, Canada (Martin & Dean, 1988), range extended to the Peltura minor zone by Parsons & Anderson (2000, not illustrated); (Cymatiaogalea aff. cristata) Furongian, East European Platform (Volkova 1990); Furongian, Belgium (Ribeccai & Vanguestaine, 1993); Furongian, St Tudwal’s Peninsula, North Wales (Martin in Young et al., 1994); Furongian, Algerian Sahara (Vecoli, 1996); Furongian, Asturias, northern Spain (Albani et al., 2006); Furongian, County Wexford, Ireland (Vanguestaine & Brück, 2008).


**Type species.** Dasydiacrodium eichwaldii Timofeev, 1959 ex Deflandre & Deflandre-Rigaud, 1962

*Dasydiacrodium obs Bombay* Martin in Martin & Dean, 1988 (Pl. 1, figs 3, 4)

1988 *Dasydiacrodium obs Bombay* Martin in Martin & Dean: 38, pl. 10, figs 6, 7, 10, 11, 13–15.

**Dimensions.** 5 specimens. Vesicle length 25.5 (30) 35 µm; vesicle breadth 21 (23.5) 27 µm; process length 10.5 (16.5) 20 µm.

**Remarks.** *Dasydiacrodium obs Bombay* displays a morphology transitional between that of Ninadiacrodium caudatum and Actinotodissus achrasii. It differs from *N. caudatum* by possessing more numerous processes around its apical pole. It can be distinguished from *A. achrasii* by a disparity in the number of processes between poles and the relatively narrower dimension of one (apical) polar region.

**Previous records.** Furongian, Parabolina spinulosa Zone to Acrococ Zone (verified by macrofossils), eastern Newfoundland, Canada (Martin & Dean, 1988); Furongian, North Estonia (Paalits, 1992a); Furongian, Belgium and France (Ribecai & Vanguestaine, 1993); Furongian, Northeast China (Martin, 1993); Furongian, Algeria (Vecoli, 1996); Furongian, Arctic Russia (Moczylowska & Stockfors, 2004); Furongian, northern Spain (Albani et al., 2006); Furongian, Iran (Ghavidel-syooki, 2006; Ghavidel-syooki & Vecoli, 2008).

Genus Gyalorhethium Loeblich & Tappan, 1978

**Type species.** Gyalorhethium spinuliferum Loeblich & Tappan, 1978

*Gyalorhethium?* sp. 1 (Pl. 3, fig. 9)

**Description.** The vesicle outline is approximately circular, the wall thin with a few broad folds. The processes are simple, hollow and appear to open into the vesicle cavity, tapering gently distally to closed, pointed tips. The processes are widely and evenly spaced, the proximal contacts are angular to slightly curved; the wall is thin. They are of more or less uniform size, one being shorter and thinner. The surface of both vesicle and processes is corroded, but vestiges remain of what was probably an originally granulate or echinate sculpture, slightly more pronounced on the processes.

**Dimensions.** 3 specimens. Vesicle diameter 48–56 µm; process length 14–21 µm; process breadth (proximal) 1.5–2 µm; process number 17–23 visible at the vesicle periphery.

**Remarks.** This form matches the diagnostic criteria of the genus Gyalorhethium although the state of preservation renders identification of the exact nature of the sculptural elements questionable. It lacks a vesicle outline modified by process insertion typical of the genus Polygonium (Vavrdová, 1966) Moczylowska & Stockfors, 2004. *Gyalorhethium?* sp. 1 resembles a specimen illustrated by Parsons & Anderson (2000, pl. 5, fig. 12) as Baltsphaeridium crinitum Martin in Dean & Martin, 1978, but has fewer, shorter processes which are open into the vesicle cavity. It also resembles the illustrated specimens of Goniopsphaeridium rasulii Welsch, 1986 (Welsch, 1986, pl. 5, figs 9, 10), but possesses a positive sculpture. *Gyalorhethium?* sp. 1 closely resembles Baltsphaeridium veratum Vecoli, 1996 but has fewer processes and has process cavities apparently in communication with the vesicle cavity. The forms may be conspecific to Goniopsphaeridium sp. illustrated by Paalits (1992a, pl. 6, fig. 2), but more material will be required for a valid comparison.


**Type species.** Impluviculus milonii (Deunff, 1968) Loeblich & Tappan, 1969

*Impluviculus* sp. 1 (Pl. 2, figs 1–3)


**Description.** The vesicle is circular to rounded subangular in outline, is thin-walled and has a smooth to weakly shagreenate surface. Four to seven simple, hollow processes with a length approximately 40–60% of the vesicle diameter are inserted equatorially and in the same plane. The points of insertion are generally not equidistant. The process tips are slightly rounded, the proximal contacts angular and the process cavities appear to be in communication with that of the vesicle. No well defined excystment openings were observed.

**Dimensions.** 5 specimens. Vesicle diameter 12–20 µm; process length 8–12 µm.

**Remarks.** The small number of specimens recorded here could not be assigned with confidence to any formally described species of Impluviculus. They closely resemble specimens of Impluviculus...

**Previous records.** Impluviculus sp. A in Martin & Dean (1988), Furongian, Parabolina spinulosa Zone to the Pelatura Zones (verified by macrofossils), eastern Newfoundland. Impluviculus sp. cf. I. milonii, Furongian, Parabolina spinulosa Zone, P. spinulosa Subzone to Tremadocian (verified by macrofossils), eastern Newfoundland (Parsons & Anderson, 2000).

Genus Leiofusa (Eisenack, 1938)
Combaz, Lange & Pansart, 1967

**Type species.** Leiofusa fusiformis (Eisenack, 1934) Eisenack, 1938

*Leiofusa stoumonensis* Vanguerstaine, 1973
(Pl. 5, fig. 9)


**Dimensions.** 28 specimens. Vesicle length 36.5 (60.5) 76 µm; vesicle breadth 15 (26.5) 31.5 µm; vesicle breadth: length 34 (45) 54%; process length 33 (58) 77 µm; process length: vesicle length 66 (97) 136%.

**Previous records.** Furongian, Stavelot, Belgium (Vanguerstaine, 1973; Ribecai & Vanguerstaine, 1993); Furongian, Parabolina spinulosa Zone to Lower Tremadocian (verified by macrofossils), eastern Newfoundland (Martin & Dean, 1981, 1988); Parabolina spinulosa Zone; Furongian, central Sardina (Albani et al., 1985; Di Milia, 1991); Furongian, East European Platform (Volkova, 1990; Paalits, 1992a & b); Furongian, St Tudwal’s Peninsula, northwestern Wales (Martin in Young et al., 1994).

Genus Leiosphaeridia Eisenack, 1958 emend.

**Type species.** Leiosphaeridia baltica Eisenack, 1958

*Leiosphaeridia* spp.
(Pl. 5, fig. 8)

**Dimensions.** 43 specimens. Vesicle diameter 28 (56.5) 137 µm.

**Remarks.** Most of the specimens have extremely thin wrinkled walls. No attempt has been made herein to identify individual species of the genus Leiosphaeridia.

Genus Ninadiacrodium Raevskaya & Servais, 2009

**Type species.** Ninadiacrodium dumontii (Vanguerstaine, 1973) Raevskaya & Servais, 2009.

*Ninadiacrodium caudatum* (Vanguerstaine, 1973)
Raevskaya & Servais, 2009
(Pl. 5, fig. 7)

1973 *Dasdyiacrodium caudatum* Vanguerstaine: 30, pl. 1, figs 9, 13.
Nov.; Raevskaya & Servais: 226, pl. 1, figs 1–3; text-fig. 3.

**Dimensions.** 13 specimens. Vesicle length 23.5 (30) 35 µm; vesicle breadth 18.5 (23) 29 µm; apical process length 7 (11.5) 17.5 µm; antapical process length 10 (13) 18.5 µm; antapical process number 7 (9) 11.

**Remarks.** Ninadiacrodium caudatum is a distinctive and stratigraphically important taxon. To avoid any potential dilution of the specific concept a possibly closely related form encountered in the Comley samples is treated separately below as N. aff. caudatum.

**Previous records.** Furongian, Belgium and France (Vanguerstaine, 1973; Ribecai & Vanguerstaine, 1993); Furongian, Parabolina spinulosa Zone to Lower Tremadocian (verified by macrofossils), eastern Newfoundland (Martin & Dean, 1981, 1988); Furongian, Parabolina spinulosa Zone, P. spinulosa Subzone (verified by macrofossils), eastern Newfoundland (Parsons & Anderson, 2000); Furongian, East European Platform (Volkova, 1990); Furongian, North Estonia (Paalits, 1992a); Furongian, southern Tunisia (Vecoli, 1999); Furongian, southwestern Sardina (Ribecai et al., 2005); Furongian, Arctic Russia (Raevskaya & Servais, 2009).

*Ninadiacrodium* aff. caudatum (Vanguerstaine, 1973)
Raevskaya & Servais, 2009
(Pl. 3, fig. 1)

**Description.** The vesicle outline is elongated subtriangular to elliptical with a single process at one (apical) pole of the long axis and four to eight processes of variable length clustered around the antapical pole. The wall of both vesicle and processes is thin and bears a finely granular ornament. The processes are mostly hollow with generally angular proximal contacts and taper distally to pointed tips. The process cavity is in communication with that of the vesicle. Some of the smallest processes may be solid. No excystment openings were observed.

**Dimensions.** 13 specimens. Vesicle length 28 (34.5) 41 µm; vesicle breadth 21 (25.5) 30.5 µm; apical process length 4.5 (10) 13 µm; antapical process length 3.5 (6) 9.5 µm; antapical process number 4 (6) 8.

**Remarks.** This form is distinguished from Ninadiacrodium caudatum by its more elliptical outline and generally fewer and shorter antapical processes which are often more variable in length. N. aff. caudatum differs from Dasdyiacrodium setensis Paalits, 1992b in possessing shorter, generally more numerous
and more variable processes. A small number of specimens were encountered in the Comley assemblages that bear some resemblance to *N. aff. caudatum* but are not described here. Some may be compressed and distorted specimens of *Scalenadiacrodium comleyense* whilst others may be extreme variants of the *Ninadiacrodium/Scalenadiacrodium* morphologies formally identified.

*Scalenadiacrodium dumontii* (Vanguestaine, 1973) Raevskaya & Servais, 2009  
(Pl. 2, fig. 9; Pl. 7, figs 1–3)  
1973 *Veryhachium dumontii* Vanguestaine: 28, pl. 1, figs 1, 2, 8.  
1992b *Veryhachium incus* Paalits: 47, pl. 2, fig. 6.  
2009 *Ninadiacrodium dumontii* (Vanguestaine, 1973) emend. nov.; Raevskaya & Servais: 228, pl. 1, figs 4, 5, 7–12; pl. 2, figs 1–11; text-fig. 3.

**Dimensions.** 16 specimens. Vesicle length 29 (35.5) 44 µm; vesicle breadth 23.5 (30) 41 µm; apical process length 7 (10.5) 14.5 µm; antapical process length 7 (11.5) 15 µm.

**Remarks.** Questions concerning the generic assignment of this species are reviewed by Servais et al. (2007) who concluded that the species should be regarded as a diacrodian acritarch. Raevskaya & Servais (2009) duly proposed the new genus *Ninadiacrodium* and recombined, with emendation, the species *V. dumontii* Vanguestaine, 1973 as type species. Raevskaya & Servais (2009) regard *Veryhachium incus* Paalits, 1992b as a junior synonym of *N. dumontii*, an opinion accepted herein.

**Previous records.** Furongian, Belgium and France (Vanguestaine, 1973; Ribecai & Vanguestaine, 1993); Furongian, *Parabolina spinulosa* Zone to *Acerocare* Zone, possibly Tremadocian (verified by macrofossils) eastern Newfoundland (Martin & Dean 1981, 1988); Furongian, *Parabolina spinulosa* Zone, *P. spinulosa* Subzone to *Acerocare* Zone (verified by macrofossils), eastern Newfoundland (Parsons & Anderson, 2000); Furongian, East European Platform (Volkova, 1990; Paalits, 1992b); Furongian, North and northwestern Estonia (Paalits, 1992a; Mens et al., 1997); Tremadocian (considered reworked), central Sardinia (Di Milia & Tongiorgi, 1993); Furongian, Algerian Sahara (Vecoli, 1996); Furongian, Arctic Russia (Raevskaya & Golubkova, 2006; Raevskaya & Servais, 2009); Furongian, northern Spain (Albani et al., 2006); Furongian, southern Iran (Ghavidel-syooki & Vecoli, 2008).


**Polygonium** spp.  
(Pl. 1, figs 5, 6; Pl. 7, fig. 4)

**Description.** The vesicle outline is polygonal being strongly modified by the broad-based processes. The thin wall of both vesicle and processes bears a granulate sculpture variably expressed. The processes are simple, hollow and open into the vesicle cavity, tapering distally to closed pointed tips. No regular openings were observed.

**Dimensions.** 11 specimens. Vesicle size 22 (26.5) 33 µm; process length 10.5 (17) 24.5 µm; process breadth 1.5–3.5 µm; process length: vesicle size 37 (65) 100%; process number 10 (12) 16.

**Remarks.** Specimens assigned to *Polygonium* spp. lack the prominent echinate ornament of *Stellichinatum uncinatum* (Downie, 1958) Molyneux, 1987. Specimens included here in *Polygonium* spp. range from those with a subquadrangular outline but with processes seemingly randomly disposed over the vesicle surface, to those with an essentially subcircular outline strongly modified by the processes. It is possible that some specimens of *Actinotodissus achrassi* and *D. obsconum* in polar compression might resemble *Polygonium* spp. Specimens figured as *Stellichinatum* or *Polygonium* sp. and *Polygonium* sp. in Parsons & Anderson (2000, pl. 3, figs 5, 6) appear to closely resemble the Comley specimens. Similarly, a specimen figured as *Stellichinatum uncinatum* (Downie, 1958) Martin in Martin & Dean (1988, pl. 17, figs 14, 15) has a subdued ornament and may resemble the Comley forms.

Genus *Scalenadiacrodium* gen. nov.

**Type species.** *Scalenadiacrodium comleyense* sp. nov.

**Derivation of name.** Latin, *scalens* = unequal, reflecting the variation in length of the processes on the antapical polar area of this diacromorph genus.

**Diagnosis.** The vesicle outline is elongate-triangular (isosceloid) with rounded apices. The wall of both vesicle and processes is single-layered, shagreenate or with a finely granular ornament. The process distribution is ‘heteropolar’. The antapical pole bears a single, simple, hollow process tapering to a closed, pointed tip. The process cavity freely communicates with the vesicle cavity. A morphologically similar process, of approximately equal or longer length, is located at one of the apices of the antapical pole, arising at an angle to the polar axis. There may be no additional processes or one or a small number of ‘secondary’ processes, often concentrated in the neighbourhood of the antapical pole not bearing the ‘primary’ process, and often not in the same plane as the two primary processes. The ‘secondary’ processes are considerably smaller than the ‘primary’ processes, have a similar morphology to the ‘primaries’ but may be solid. No excystment opening has been observed.

**Comparison.** *Scalenadiacrodium* gen. nov. is distinguished from *Ninadiacrodium* Raevskaya & Servais, 2009 by possessing only two as opposed to three or more ‘primary’ processes, the third angle of the elongate triangular vesicle is either without processes or with one or a small number of ‘secondary’ processes of considerably smaller size. In most other respects *Scalenadiacrodium* resembles *Ninadiacrodium* with which it may have a close phylogenetic relationship. *Sylvanidium* Loeblich, 1970 resembles *Scalenadiacrodium* but has a generally ‘bean-shaped’ vesicle, ‘secondary’ processes arising uniformly at right angles to the two ‘primaries’ and a smooth wall (Loeblich, 1970, p. 736).
Scalenadiacrodium is distinguished from Leiofusa (Eisenack, 1938) Combaz, Lange & Pansart, 1967 by its elongate triangular outline and from Veryhachium (Deunff, 1954) Turner, 1984 by its possession of only two ‘primary’ processes.

Remarks. The systematic position of Ninadiacrodium is discussed in detail by Raevskaya & Servais (2009) and their arguments generally apply to Scalenadiacrodium. The possession of two rather than three ‘primary’ processes is here considered sufficient for the generic separation, reflecting some morphographical similarities with leiofusid acritarchs. Emending Ninadiacrodium to encompass the elongate triangular forms with two ‘primary’ processes would represent a major dilution of the original concept.

Scalenadiacrodium comleyense sp. nov.  
(Pl. 2, figs 4–8)

1988 Dasydiacrodium caudatum Vanguemestane, 1973; Martin & Dean: pl. 16, figs 5, 8.  
1988 Veryhachium dumontii Vanguemestane, 1973; Martin & Dean: pl. 16, figs 3, 13, 14 (non pl. 16, figs 2, 7, 10–12, 15–18).  

Derivation of name. After the type area, the Comley area, Shropshire, England.

Diagnosis. The compressed vesicle has a rounded, elongate-triangular outline. The wall of the vesicle and processes is thin, single-layered, with a shagreenate to granulate surface. In some instances there is a suggestion of alignment of the granular ornament parallel to the polar axis of the vesicle. Two primary processes of equal or unequal length are always present, one, generally shorter, located at the apex of the vesicle, the other at one of the antapical angles. The primary processes are hollow, have subangular proximal contacts, are open into the vesicle cavity and taper to closed, pointed tips. The antapical process is not aligned with the apical process, but at an angle to and away from the vesicle long axis. One to four secondary processes, considerably smaller than the primary processes, may or may not be present and, whilst generally clustered in the neighbourhood of the third antapical angle of the vesicle, they are often not in the same plane as the primary processes. No definitive excystment openings have been observed.

Holotype. Slide L3c-2 (5 µm), England Finder (EF) reference: K34/3 (Pl. 2, fig. 8).

Paratype. Slide L3c-1 (10 µm), EF ref.: Y25/1 (Pl. 2, fig. 4).

Locality and horizon. Shoot Rough Road Shales, Locality L3, SO 49 NE 4825 9534, Comley, Shropshire, UK.

Dimensions. 28 specimens. Vesicle length 28 (38.5) 47 µm; vesicle breadth 21 (27.5) 37.5 µm; ‘primary’ process length (near broader, antapical, pole of vesicle) 7 (14.5) 23.5 µm; ‘primary’ process length (narrower, apical, pole of vesicle) 6 (12) 17.5 µm; ‘secondary’ process length (longest of any secondaries present) 2.5 (4) 7 µm.

Stratigraphic range. Furongian Series, most probably Parabolina spinulosa trilobite Zone.

Comparison. Scalenadiacrodium comleyense is distinguished from Ninadiacrodium dumontii (Vanguemestane, 1973) Raevskaya & Servais, 2009 by its possession of two rather than three primary processes. S. comleyense resembles Ninadiacrodium caudatum (Vanguemestane, 1973) Raevskaya & Servais, 2009 but has a different arrangement of antapical processes which are of non-uniform size. Species attributed to the genus Nellia Golub & Volkova in Volkova & Golub, 1985 have a more symmetrical subtriangular outline and recurved processes (Volkova & Golub, 1985). S. comleyense is distinguished from Sylvanidium paucibrachitum Loeblich, 1970 by its considerably smaller size, thin wall, surface sculpture and less fusiform vesicle outline, and from Sylvanidium? hawbanense Miller & Al-Ruwaili, 2007 by the less uniform size and distribution of its processes (Miller & Al-Ruwaili, 2007). S. comleyense closely resembles several of the specimens figured as Veryhachium dumontii Vanguemestane, 1973 by Martin (in Martin & Dean, 1988). Specimens of S. comleyense which lack secondary processes and with a poorly expressed subtriangular outline resemble Leiofusa cf. L. gravida Pittau, 1985 of Martin in Young et al. (1994) and Leiofusa sonniculata Pittau, 1985 (Pittau, 1985, pp. 190–192). However, all specimens attributable to S. comleyense have an asymmetrical vesicle outline tending towards subtriangularity, processes in an angular relationship and frequently more than two processes.

Remarks. This species was informally described by one of the authors in his unpublished PhD thesis (Potter, University of Sheffield, 1974) under the name Leiofusa scalenabullata, although the possible presence of secondary processes was not included. It was subsequently compared with ?Leiofusa sp. in the Furongian Ulge Formation of Estonia by Paalits (1995). He also reports that a similar species was found by M. G. Parsons in sequences assigned to the lower and middle parts of the spinulosa Zone in Newfoundland (Paalits, 1995, p. 89). Care must be exercised in distinguishing S. comleyense from damaged specimens of N. dumontii from which the second ‘primary’ antapical process has been lost.

Previous records. Veryhachium dumontii Vanguemestane, 1973 in Martin & Dean, 1988, pl. 16, figs 3, 13, 14, Furongian, Parabolina spinulosa Zone (verified by macrofossils), eastern Newfoundland, Canada (Martin & Dean, 1988); ?Leiofusa sp. in Paalits, 1995, p. 89; pl. II, figs 4, 6, Furongian, North Estonia (Paalits, 1995).

Genus Stelliferidium Deunff et al., 1974

Type species. Stelliferidium striatulum (Vavrdová, 1966) Deunff et al., 1974

Stelliferidium cortinulumorphum Paalits, 1995  
(Pl. 4, figs 4–6; Pl. 7, fig. 7)

Stelliferidium distinctum (Rasul, 1974) Pittau, 1985

Description. The vesicle outline is circular in polar view, with a flattened apical area in lateral view when the operculum is missing. The wall varies in thickness between specimens and has a smooth to shagreenate surface. The processes are well separated, of more or less uniform size and are evenly distributed on the vesicle surface including the apertural margin but excluding the operculum. A low collar surrounding the macropyle is visible in some specimens. Opercula, when observed in place, have a diameter of about 14 µm to 19 µm. In one case an operculum was observed fallen inside a vesicle, having a more or less circular outline and a diameter of 21 µm. It is probable that the rim of the operculum is folded together with the apertural margin of the vesicle, resulting in a prominent collar and in an apparently reduced opercular diameter. The processes, in the order of 40 to 60, have conical bases with cylindrical to slightly tapering shafts, are mainly simple or with a single brief bifurcation or trifurcation and have terminations being divided into a number of brief, rounded pinnae. The processes appear generally solid but may, in some cases, be thick-walled with a narrow cavity. In the latter case it is not clear whether the process and vesicle cavities are in communication. In some cases, variably developed striae radiate from the bases of the processes; their absence in others may be due to poor preservation.

Dimensions. 19 specimens. Vesicle size (equatorial) 29 (34.5) 42 µm; process length 3.5 (4.5) 6.5 µm; process breadth 0.5 (1) 1.5 µm; process separation 2.5 (3) 4.5 µm; process length: vesicle size (equatorial) 10 (13) 18%; wall thickness 0.5 (1) 2.5 µm.

Remarks. The specimens were insufficiently well preserved for precise determination but closely resemble Stelliferidium distinctum. The process style matches that shown by Rasul (1974, pl. 7, fig. 3) but may be less complex than that described by Rasul and illustrated on the holotype. The processes may, in some cases, possess a narrow cavity, a feature not mentioned by Rasul. Stelliferidium sp. B in Parsons & Anderson (2000) closely resembles the Comley form, the clearly hollow nature of the processes and presence of a fragmentary list on some specimens of Stelliferidium sp. B may merely be a symptom of superior preservation. The Comley specimens also resemble Priscogalea chevronensis Vanguestaine, 1974 but may have more numerous processes with less complex process terminations, and a vesicle wall which is shagreenate rather than possessing an ornament of granules. They also resemble Stelliferidium simplex (Deunff, 1961) Deunff et al., 1974 but may possess thicker-walled processes with more complex process terminations. The Comley specimens differ from Stelliferidium pingulum Martin in Martin & Dean, 1988 in lacking striate, spinose processes and from Stelliferidium sp. A of Parsons & Anderson (2000) in possessing considerably fewer processes.
Previous records. Stelliferidium distinctum, Tremadocian, Shropshire, England (Rasul, 1974).

Genus Timofeevia Vanguystaine, 1978

Type species. Timofeevia lancarae (Cramer & Diez de Cramer, 1972) Vanguystaine, 1978

Timofeevia estonica Volkova, 1990

1990 Timofeevia estonica Volkova: 84, pl. IX, figs 4, 5.

Timofeevia aff. estonica Volkova, 1990

(Pl. 3, figs 7, 8; Pl. 7, figs 8, 9)

Description. The vesicle outline is circular to subcircular, its surface divided by low ridges into numerous polygonal fields, about 40–60, or possibly more. The ridges probably comprise folds of the vesicle wall along lines of weakness. The folds, and the polygonal fields they help define, are not always uniformly expressed and may in some specimens be absent. The vesicle wall is thin and has a smooth to shagreenate surface. Processes are located at the angles of the polygonal fields and occasionally intergonal processes may be present. The processes are short with angular proximal contacts and taper slightly to blunt or briefly furcate tips. Whether the processes are solid or hollow is unclear. A large opening may be present resulting from the loss of several polygonal plates.

Dimensions. 20 specimens. Vesicle diameter 25.5 (31) 37.5 µm; polygonal field size 4.5 (6) 7.5 µm; process length 2.5 (3) 3.5 µm; process length: vesicle diameter 7 (10) 13%.

Remarks. Timofeevia aff. estonica differs from T. estonica Volkova, 1990 in lacking the consistent presence of intergonal processes and in possessing less complex process terminations. The latter feature may, to some extent, be a preservational artefact. Timofeevia aff. estonica has shorter processes with less complex distal terminations than those of Timofeevia manata Albani et al., 1991.

Previous records. Timofeevia estonica, Furongian, Estonia (Volkova, 1990); Furongian, North Estonia (Paalits, 1992a); Furongian, Belgium and France (Ribecai & Vanguystaine, 1993); Furongian, Parabolina spinulosa Zone, P. spinulosa Subzone (verified by macrofossils), eastern Newfoundland (Parsons & Anderson, 2000).

Timofeevia phosphoritica Vanguystaine, 1978

(Pl. 3, figs 2, 3; Pl. 7, fig. 5)

1959 Archaeohystrichosphaeridium ianischewskyi Timofeev: 33, pl. 3, fig. 2 (nomen nudum).
1959 Archaeohystrichosphaeridium minor Timofeev: 33, pl. 3, fig. 3 (nomen nudum).
1976 Cymatiogalea ianischewskyi (Timofeev, 1959); Vavrédová: 60.
1976 Cymatiogalea minor (Timofeev, 1959); Vavrédová: 60.
1978 Timofeevia phosphoritica Vanguystaine: 272, pl. III, figs 1-8, 10-12; text-fig. 11.

Dimensions. 19 specimens. Vesicle diameter 27 (32.5) 37 µm; process length 7 (9) 13 µm; process length: vesicle diameter 19 (28) 37%; field size 7 (10) 13 µm; field size: vesicle diameter 22 (30) 36%; process ramification length: total process length 33 (40) 53%.

Remarks. The specimens encountered here conform to the diagnosis except that the processes are generally longer. The process terminations are less complex than those of Timofeevia lancarae (Cramer & Diez de Cramer, 1972) Vanguystaine, 1978 and the overall process length shorter but the distinction between end-members of the two species appears arbitrary.

Previous records. T. phosphoritica is widely reported in assemblages of Cambrian Series 3 to Tremadocian age, see Vecoli (1996), who also notes that the Tremadocian records have been interpreted as reworked.

Genus Trunculumarium Loeblich & Tappan, 1976

Type species. Trunculumarium revinium (Vanguystaine, 1973) Loeblich & Tappan, 1976

Trunculumarium revinium (Vanguystaine, 1973)

Loeblich & Tappan, 1976

(Pl. 4, fig. 9; Pl. 5, figs 1-3; Pl. 7, fig. 10)

1973 Ooidium revinium Vanguystaine: 30, pl. 1, figs 3, 4, 5, 6, 10, 14.
1976 Trunculumarium revinium (Vanguystaine, 1973); Loeblich & Tappan: 305.

Dimensions. 33 specimens. Vesicle length 27 (36) 44.5 µm; vesicle breadth 22 (28.5) 36.5 µm; vesicle breadth: length 70 (79) 89%; process length 7 (11.5) 16.5 µm; process length: vesicle length 22 (32) 44%.

Remarks. T. revinium has a distinctive morphology and occurs in quantity over a limited stratigraphical range.

Previous records. Furongian, Belgium and France (Vanguystaine, 1973, 1974; Ribecai & Vanguystaine, 1993); Furongian, Parabolina spinulosa Zone (base and acme) to Pelurta Zones (verified by macrofossils), eastern Newfoundland (Martin & Dean, 1981, 1988); Furongian, Parabolina spinulosa Zone, P. spinulosa Subzone (base and acme) to Acerocare Zone (verified by macrofossils) eastern Newfoundland (Parsons & Anderson, 2000); Furongian, north Norway (Welsch, 1986); Furongian, East European Platform (Volkova, 1990); Furongian, North Estonia (Paalits, 1992a); Furongian, Poland (Szczepanik, 2001); Furongian, southern Iran (Ghavidel-syooki & Vecoli, 2008).

Genus Vulcanisphaera Deunff, 1961 emend. Rasul, 1976


Vulcanisphaera africana Deunff, 1961

(Pl. 6, figs 1, 3)

1958 Hystrichosphaeridium Downie: 340, pl. 16, fig. 10.
1961 Vulcanisphaera africana Deunff: 42, pl. 2, fig. 1, 2.
1976 Vulcanisphaera cirrita Rasul: 480, pl. 1, fig. 3; text-figs 1, 2.
Dimensions. 12 specimens. Vesicle diameter 43.5 (51) 62 µm; process length 15 (20.5) 24.5 µm; process length: vesicle diameter 28 (40) 54%.

Remarks. Three species of the genus *Vulcanisphaera* appear to differ mainly in quantitative rather than qualitative terms. *V. africana* differs from *V. cirrita* Rasul, 1976 only by possessing generally shorter processes with possibly less extensive distal ramifications, and from *V. turbata* Martin in Martin & Dean, 1981 in having usually longer processes, lacking a prominently granular vesicle wall and possibly possessing more complex process distal terminations. Both *V. africana* and *V. turbata* display a vesicle wall divided into polygonal fields (Martin in Martin & Dean, 1988, p. 43) and it is probable that weakly expressed polygonal fields are present in *V. cirrita*. The granular ornament may not be a consistently expressed feature of *V. turbata* and transitional forms between *V. turbata* and *V. africana* are recorded (Martin & Dean, 1988). The specimens recorded here as *V. africana* match the diagnosis of both *V. africana* and *V. cirrita*. They mainly bear the complex filamentous process terminations of the latter, and display a vesicle wall divided into polygonal fields, a feature most clearly observed in fragmented examples. Martin (in Martin & Dean, 1981) and Vecoli (1996) regard *V. cirrita* as a junior synonym of *V. africana*. The distinction between *V. africana* and *V. turbata* is maintained here partly on utilitarian grounds. The forms with relatively short processes and often with a granular vesicle surface ornament make their first appearance earlier in the Cambrian than *V. africana* (Martin & Dean, 1981). Most of the relatively subtle distinctions between *V. turbata* and *V. africana* summarized by Martin (in Martin & Dean, 1988, p. 43) cannot be recognized in the Comley material due to condition of preservation. Specimens of *Vulcanisphaera* with a granulat wall sculpture and those with relatively short processes are here assigned to *V. turbata*.

Previous records. *V. africana* is widely distributed in the Furongian and Tremadocian, references to Cambrian records are

COMLEY ACRITARCH ASSEMBLAGES

The Comley assemblages are numerically rich and taxonomically diverse. The species composition and approximate relative proportion of each taxon are given in Table 1. The samples yielded generally well-preserved assemblages. Sample L1 is particularly rich in amorphous organic matter.

Cymatiogalea virgulta, Timofeevia phosphoritica and Timofeevia aff. estonica are numerically important taxa in all three assemblages. *Actinotodissus achrasii* and *Trunculumarium revinium* are also numerically important in L1, *Cristallinium cambriense* in L2 and L3, and *Stelliferidium corticalmorum* in L1 and L3. Sample L1 yielded the most taxonomically diverse assemblage, distinguished from the others importantly by the presence of *T. revinium*. The L3 assemblage, in addition to the absence of *T. revinium*, lacks *A. achrasii* and *Implaviculus* sp. 1 found in the other assemblages. The stratigraphically important taxa *Cristallinium randomense*, *Ninadiacrodium caudatum* (questionable in L2), *Leiofusa stoumonensis* and *Ninadiacrodium dumontii* are present in all three assemblages. *Scalenadiacrodium comleyense* is a significant component of the L2 and L3 assemblages. *Leiofusa stoumonensis*, *Ninadiacrodium dumontii* and *Vulcanisphaera africana* are numerically more important components of the L2 assemblage, whilst *Stelliferidium corticalmorum* has its greatest numerical expression in assemblage L3.

COMPARISON WITH OTHER AREAS

The Comley area assemblages are compared here with those of known age elsewhere, as well as those less well age-controlled, but that can be related to published acritarch zonations. Eastern Newfoundland provides the most intensively studied and comprehensively trilobite dated area for correlation (Martin & Dean,

Assemblages L2 and L3 comprise, amongst other taxa, *Cristallinium cambriense*, *Cristallinium randomense*, *Ninadiacrodium dumontii*, and a form similar to *Cymatiogalea aspergillum* which, by their first appearance, define the base of Martin & Dean’s (1981, 1988) A3 microflora. *Vulcanisphaera africana* and *Implusicus sp. 1* of the Comley assemblages also make their first appearances in the A3 microflora. *Cymatiogalea aspergillum* and *Ninadiacrodium dumontii* (questionable in L2) and *Dasydiacrodium obsonum* further restricts correlation to a microflora no older than A3b of Martin & Dean, 1981, 1988, and unpublished data. Both these areas share with Comley a palaeogeographical location on the Avalonian microcontinent on the northern fringes of Gondwana (Fig. 4). Similar but less well-age-controlled assemblages are reported from the Ardennes area (mainly Belgium) and the East European Platform (primarily Estonia).

The Comley assemblages are closely comparable to those reported by Martin (in Martin & Dean, 1981, 1988) from the Manuels River and Random Island areas of eastern Newfoundland. Although Parsons & Anderson (2000) examined only one additional sample from the interval comparable with Comley, new trilobite data are reported and some of Martin & Dean’s (1981, 1988) samples are repositioned in relation to the trilobite stratigraphy. They also provide a thorough critique of Martin & Dean’s (1981, 1988) acritarch zonation and provide a zonation of their own. The implications for the age control of the Comley assemblages of the differing interpretations of the trilobite control in eastern Newfoundland suggested by Martin & Dean and by Parsons & Anderson are considered here. The relationship of the two microfloral schemes to the trilobite zones, including Parsons & Anderson’s interpretation of the Martin & Dean scheme, is shown in Figure 5.

Assemblage L1 is directly comparable to microflora RA4 of Parsons & Anderson (2000) and the lower part of microflora A4 of Martin in Martin & Dean (1988), principally defined by the presence in quantity of *Trunculumarium revinium*. In addition to common *T. revinium*, the presence of *Actinotodissus achrasi*...
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within the variability of Stellechinatum uncinatum (Downie, 1958) Molyneux, 1987 as reported from eastern Newfoundland and with a base in A3b, further supports an A3b (or younger) assignment.

The succeeding A4 microflora is distinguished from A3b almost entirely on the presence of Trunculumarium revinium. However, most taxa present in the A3b microflora range through A4 into A5 so that there are few criteria for distinguishing an A3b from a (lower part) A5 microflora. The Comley assemblages L2 and L3 are from isolated exposures in a structurally complex setting and their stratigraphical relationship to the A4 equivalent (L1) is not known. Furthermore, the nature of the microflora immediately succeeding that of A4 in eastern Newfoundland is unknown. Both Martin & Dean (1981) and Parsons & Anderson (2000) recognized a fault separating the shales assignable to the Parabolina spinulosa Zone from younger strata. The microflora (lower part A4 with common Trunculumarium revinium) below the fault occurs together with Parabolina spinulosa (Martin & Dean, 1981), the index fossil for the upper subzone of the P. spinulosa Zone. The Parsons & Anderson (2000) interpretation requires the faulting out of the Leptoplastus Zone, resulting in the succeeding Protopelurana praeursor Zone directly overlying the P. spinulosa Zone. If a sequence assignable to the Leptoplastus trilobite Zone succeeds the P. spinulosa Zone, as suggested by Martin & Dean (1981, 1988), the faulting may have only minor consequence and the nature of an immediately post-P. spinulosa Zone microflora can be characterized to a limited extent. The first appearance of Actinotodissus cf. A. ubui in the Leptoplastus Zone would assist in distinguishing the P. spinulosa Zone from younger assemblages and support an A3b assignment for the L1 and L2 acritarch microflora. Leiofusa stoumonensis, common in the L2 and present in the L3 microflora, is only present (rare) in one Leptoplastus Zone assemblage (Martin & Dean, 1988) and was not recorded in the post-RA4 samples analysed by Parsons & Anderson (2000). The two RA5 index taxa Orthosphaeridium? extensum and Ladogella rommelaerei are absent from the Comley assemblages. Timofeefia estonica Volkova, 1990 does not range above RA4, according to Parsons & Anderson (2000), thus the presence of (common) Timofeefia aff. estonica in L2 and L3 may also point towards an A3b rather than an RA5 assignment. The absence of T. revinium from L2 and L3 may be of little significance because, although missing from A3b assemblages, it is only extremely rare in those of RA5. Some discrepancies are noted. Cymatiogalea virgula (lower part of A4) and L3 microflora can be referred to the A3b microfloral subdivision of Martin & Dean (1988), equivalent to the lower part of the P. spinulosa Subzone of the P. spinulosa Zone. The L1 microflora can be referred to the lower part of the A4 subdivision of Martin & Dean (1988) and RA4 subdivision of Parsons & Anderson (2000). The lower part of A4 is equivalent to the upper part of the P. spinulosa Subzone. The upper boundary of the lithological unit assigned to the lower part A4 (and RA4) microfloral subdivisions is faulted with section missing; therefore, it is theoretically possible that the microflora could extend into the Leptoplastus Zone in Martin & Dean’s interpretation or to the Protopelurana praeursor Zone in Parsons & Anderson’s interpretation. There are no reliable macrofaunally controlled microfloras described from the Leptoplastus Zone elsewhere for comparison. Parsons & Anderson (2000) maintained that attribution of an impoverished microfloral assemblage from Norway to the Leptoplastus Zone (Welsch, 1986) is insufficiently supported by macrofaunal evidence.

One of the authors (Potter, unpublished data) has studied an acritarch assemblage from the British Geological Survey borehole Merewale No. 1 from an interval dated on trilobite evidence as belonging to the P. brevispina Subzone of the Parabolina spinulosa Zone (see Taylor & Rushton, 1972 for full details of the trilobite zonal assignment). The results from the sample at 3502" in the Mons Park Shale Formation, briefly mentioned by Bridge et al. (1998), are outlined here. The assemblage includes, amongst other taxa, Trunculumarium revinium (in quantity), Actinotodissus sp., Cristallinium cambricense, Cymatiogalea sp., Ninadiacrinustum caudatum, Impulviculus sp. 1, Leiofusa stoumonensis, Ninadiacrinustum dumontii and Timofeefia aff. estonica. This assemblage, though poorly preserved, closely resembles the L1 assemblage from Comley and the RA4 (Parsons & Anderson, 2000) and lower part A4 (Martin & Dean, 1988) microflora from eastern Newfoundland. The Merewale No. 1 acritarch assemblage is derived from a horizon near the top of an interval assigned by Taylor & Rushton (1972) to the P. brevispina Subzone and indicates that the lower boundary of an RA4 microflora can occur within the P. brevispina trilobite Subzone in England, earlier than is apparently the case in eastern Newfoundland. Published descriptions of acritarch assemblages from successions with reliable macrofaunal control to indicate a Parabolina spinulosa Zone are not currently available from other localities. However, the distinctive nature of the Comley assemblages permits comparison with others, principally from Belgium, and the East European Platform of western Russia and the Baltic states.

The Cambrian palynostratigraphy of Belgium has been extensively reported and a zonation developed by Vanguestaine (1974, 1978, 1986) Ribecai & Vanguestaine (1993) and Ribbert et al., (2001). The assemblage of Zone 5 from the Revin Group (Rn2b) of the Stavelot Massif (Vanguestaine, 1973, 1974; Ribecai & Vanguestaine, 1993) closely resembles the L1 assemblage from...
Comley. The presence of *T. revinium* without species of the genus *Ladogella* and the presence of *N. caudatum* and *N. dumontii* support the comparison. The preceding Zone 4 (Vanguesteina, 1974, subdivided into 4a and 4b in Vanguesteina, 1978) encompasses assemblages that pre-date the first appearances of *N. caudatum* and *N. dumontii* and cannot be compared with the L2 and L3 assemblages of Comley. However, Ribbert et al. (2001) mention a third subdivision, ‘4c’ of Zone 4, the microflora of which (from the Stavelot-Venn Anticline) shows some similarities with assemblages L2 and L3, containing *N. dumontii* and *Leiofusa stoumonensis* in the absence of *T. revinium*. However, the presence of *Ninadiacrodium caudatum* and *Dasydiacrodium obsconum* in the Comley samples suggests a slightly younger age for L2 and L3. The three Comley assemblages would be encompassed by the *Trunculumarium revinium–Veryhachium dumontii* Superzone V of the international zonation of Vanguesteina & Van Looy (1983), a scheme which combined the Belgian zones with others available at that time.

Similar assemblages to those at Comley have been reported from the East European Platform area, mainly from Estonia, Ukraine and western Russia. Expanding upon the data in Volkova (1990), Volkova & Kir’yanyov (1995) summarize a regional scheme for the East European Platform. Comley assemblages L2 and L3 can be compared with the upper subdivision (VK2b) of the ‘Vorchin regional horizon’ VK2 (Volkova, 1990). The base coincides with the first appearances of the taxa *Leiofusa stoumonensis*, *Ninadiacrodium dumontii* and *Timoeveia estonica*, with the species *Ninadiacrodium caudatum* and *Stellechinitum uncinatum* (Downie, 1958) Molnyeux, 1878 appearing within the zone and defining the base of the upper VK2b subdivision (Volkova & Kir’yanyov, 1995). Whilst *S. uncinatum* does not occur in the Comley assemblages (some specimens of Polygonium spp. with pronounced sculpture begin to resemble this form), an assemblage above base *N. caudatum* and below base *T. revinium* would satisfactorily describe L2 and L3 which, therefore, can be compared with VK2b assemblages.

Two assemblages described by Paalits (1992b, 1995) from western Russia and North Estonia resemble L2 and L3 of Comley. An assemblage from the Panikovitski core of the Petseri Formation in the Pskov Region of Russia (Paalits, 1992b), whilst not containing *N. caudatum* or *D. obsconum*, does include a probable dasydiacroidian *?Dasydiacrodium setuensis* Paalits, 1992b, *L. stoumonensis* and *Veryhachium incus* Paalits, 1992b, a junior synonym of *N. dumontii*. Paalits (1992b) argues that this assemblage may pre-date the inception of the genus *Impluviculus* (Loeblich & Tappan, 1969) Martin, 1977, a taxon present in the L2 assemblage of Comley. The presence of a similar species in Newfoundland from the ‘lower and middle parts of the *Parabolina spinulosa* Zone’. In overall characteristics, the A1 assemblage resembles L2 and L3 from Comley although there is a greater variety of the galeate taxa (*Cymatiogalea* and *Stelliferidium*).

Volkova (1990) presented an assemblage from the North Estonian Mardu-9 borehole (137.4–146 m), including *N. caudatum*, *N. dumontii*, *L. stoumonensis* and common *T. revinium*, which she assigned to Zone VK3. The tomost sampled includes *Lusatia dendroidea* Burmann, 1970, a form typical of younger Cambrian assemblages. The L1 assemblage corresponds well with the underlying microflora (138.4–146 m) and could thus be considered equivalent to the lower part of Zone VK3 in the Mardu-9 sequence. Parsons & Anderson (2000, p. 10) also note the anomalous occurrence of *L. dendroidea* and suggest that, as the preceding samples are from the Tsitre Formation and are separated by a considerable stratigraphical break from the overlying Mardu Member (sample with *L. dendroidea*), the latter sample should be reassigned to the younger VK5 assemblage of Volkova (1990). Parsons & Anderson (2000) explain the anomalous occurrence of common *T. revinium* together with *L. dendroidea* as a result of reworking. Parsons & Anderson (2000) also invoke reworking to explain the presence of typical VK3 taxa, including *Leiofusa stoumonensis* and *Ninadiacrodium caudatum*, in the succeeding VK4A subdivision of the Volkova (1990) zonation for the East European Platform.

An assemblage described by Paalits (1992a) from the Tsitre Formation of borehole core M-72 (112.8–119.6 m), North Estonia, is very closely comparable to Comley assemblage L1. The same core interval is adopted as stratotype for the ‘Tsitre regional horizon’ by Volkova & Kir’yanyov (1995) and assigned to their VK3 acritarch complex. As in the Comley L1 assemblage, *Trunculumarium revinium*, *Timoeveia estonica* (comparable with *T. aff. estonica* of Comley) and a form *Cymatiogalea aff. virgulta*, illustrated but not described, possibly similar to *C. virgulta*, are common and *D. obsconum*, *L. stoumonensis*, *N. caudatum* and *N. dumontii* present. Volkova & Kir’yanyov (1995) state that deposits yielding a VK3 assemblage transgressively overlie those yielding a VK2 assemblage in North Estonia. This would support the assignment of a younger age to the L1 assemblage (similar to VK3) than to the L2 and L3 assemblages (similar to VK2b).

Ghavidel-syooki & Vecoli (2008) report acritarch assemblages including *Trunculumarium revinium* from the High Zagros Mountains of southern Iran. The majority of the species comprising acritarch assemblage zone IVa are encountered in the Comley L1 assemblage but the additional presence of abundant *Lusatia dendroidea* Burmann, 1970, emend. Albani et al., 2007, would indicate a slightly younger age for the assemblage. Assuming that the presence of *L. dendroidea* is not the result of palaeogeographical or palaeoenvironmental influences on an assemblage age-equivalent to the RA4 microflora (Parsons & Anderson, 2000) of eastern Newfoundland, the Iranian assemblage may represent an unsampled or missing interval in the eastern Newfoundland succession preceding the first occurrence of *Orthosphaeridium? extensus* and *Ladogella rommelaerei* in both areas.

The microflora of the Maentwrog and Ffestiniog Flags Formation of the St Tudwal’s Peninsula and St Tudwal’s Island East in North Wales is described by Martin in Young et al. (1994) and reviewed by Martin in Young et al. (2002). The Maentwrog Formation is tentatively assigned, on trilobite evidence, to the *Olenus* Zone. The microfloras, which include *C. aspergillum*,

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C. virgulta, L. stoumonensis, T. phosphoritica and V. turbata, are compared with the upper part of the microfloras A2 and A3a of eastern Newfoundland (Olenus trilobite Zone/lower part of Parabolina spinulosa Zone). Diacrodiom taxa are absent, although N. dumontii is present elsewhere in the North Wales Ffestiniog Flags Formation. For this reason, the assemblage is here considered to pre-date those of the Comley area.

Although the assemblages are not necessarily closely comparable, some distinctive taxa in the Comley assemblages are reported from North Africa (Vecoli, 1996, 1999), northern Norway (Welsch, 1986), Poland (Szczepanik, 2001; Żylińska et al., 2006), Ireland (Vanguêstaine & Brück, 2008) and Arctic Russia (Raevskaya & Golubkova, 2006).

CONCLUSIONS

The Furongian Shoot Rough Road Shales of the Comley area yield numerically abundant, taxonomically diverse and generally well-preserved assemblages of acritarchs. The macrofossil zone assignment of the Shales to the Furongian Parabolina spinulosa trilobite Zone by Cobbold (summary in Cobbold, 1927) can now be further restricted to the Parabolina spinulosa Subzone.

Two distinct microfloras are comparable with Parabolina spinulosa Zone assemblages from Newfoundland and Nuneaton, England. The Comley L2 and L3 assemblages resemble the Newfoulndland Microflora 3b of Martin & Dean (1988) assigned to the Parabolina spinulosa Subzone (lower part). In the absence of any published definitive Leptoplastus Zone microfloras for comparison with the Comley L2 and L3 assemblages, a Leptoplastus Zone age for L2 and/or L3 cannot be entirely ruled out. The L1 assemblage resembles Microflora A4 (lower part) of Martin & Dean (1988) and Microflora RA4 of Parsons & Anderson (2000), assigned to the upper part of the Parabolina spinulosa Subzone. The L1 assemblage also resembles a microflora from the Parabolina brevispina Subzone of the Parabolina spinulosa Zone recovered from BGS borehole Merevale No. 1, Nuneaton, but differs from the assemblage that characterizes the Subzone in Newfoundland. The resolution of this discrepancy must await the acquisition of additional data to determine whether palaeoenvironmental, palaeogeographical or sampling constraints are responsible.

Similar assemblages have also been reported primarily from the Ardennes and the East European Platform. Assemblage L1 is similar to that of Zone 5 of Ribecai & Vanguêstaine (1993) from the Stavelot Massif, Ardennes, Belgium. The L2 and L3 microflora corresponds with the acritarch complex VK2b of Volkova & Kir’yanov (1995) and the L1 assemblage is comparable with the lower part of acritarch complex and VK3 of Volkova (1990) from the East European Platform.

Acritarchs are shown to have considerable biostratigraphical potential for high-resolution biostratigraphy in the classic Comley area and should be used in any further investigation of the area as new exposures are identified. This contribution extends our knowledge of the microfloral characterization of the Parabolina spinulosa trilobite Zone.

ACKNOWLEDGEMENTS

The authors wish to thank John E. Williams (London) for unfettered access to the John Williams Index of Palaeopalynology at the Natural History Museum, Adrian W. A. Rushton (London) for expert advice on the significance of the trilobite data relevant to this investigation, Martin Allbutt (Church Stretton) for kindly directing us across the eastern flank of Caer Caradoc to location L3. Thanks also to Andrew Seabury of Comley Farm and Steven Pennington of Wilsone Farm for permission to collect samples from their land. Brian Pedder gratefully acknowledges a NERC MSc grant. J.E.A. Marshall (Southampton) and M. Moczydełowska (Uppsala) reviewed the manuscript and are thanked for helpful comments.

Manuscript received 12 March 2010
Manuscript accepted 26 September 2010
Scientific editing by John Marshall

REFERENCES


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