FORAMINIFERAL BIOSTRATIGRAPHY OF THE CHADIAN STAGE STRATOTYPE (DINANTIAN), CHATBURN, NORTHWEST ENGLAND

by

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ABSTRACT

This paper presents a detailed appraisal of the foraminiferal assemblages in the Chadian stratotype and describes three new species, Latitendothyronymopsis lancastria sp. nov., Omphalotis marchanti sp. nov. and Palaeospiroplectammina cravenensis sp. nov. The assemblages correlate with the C74a1 Subzone (late Tournaisian). This subzone is considerably thicker at Chatburn than in its type area in the Dinant Basin of Belgium and shows differences in the order of appearance of individual taxa. It is possible that the base of the C74 Foraminiferal Zone and the Molinian Stage as recognised by the first appearance of the definitive conodont Mesoognathus praebuckmanni, may not be coincident. There is no biostratigraphical or lithostratigraphical identity to the Chadian/Courceyan stage boundary and only the late Chadian has a distinct biostratigraphical signature. The Chadian Stage needs replacing and various proposals to achieve this are discussed.

KEYWORDS

Biostratigraphy, Carboniferous foraminifera, algae, Chadian, Moliniacian, Eoarastaffella C74 Foraminiferal Zone.

1. INTRODUCTION

The Chadian Stratotype (Fig. 1) proposed by George et al. (1976, p. 7-9) lies in a road cutting at Chatburn, Lancashire. The basal boundary is situated, «on the west side... 80 m from the northern end of the cutting» (National Grid Reference SD 7743 4442). Few details of the section were given, however two significant observations were reported. Firstly that the basal boundary was taken at the «first change in lithology below the first entry of the foraminiferal genus Eoarastaffella» and secondly that the basal boundary coincided with the junction between the Horrocksford Beds and the overlying Bankfield East Beds.

The aim of this paper is to demonstrate that neither reports of these two significant observations are supported by the present study, which includes the most detailed description of the stratotype’s foraminiferal assemblages yet published. This has serious implications for lithostratigraphical recognition of the base of Chadian Stage in its type region and biostratigraphical recognition of the stage elsewhere. Furthermore, these new foraminiferal data allow comparison with the Moliniacian and Viséan stratotypes in Belgium (Paproth et al., 1983). When compared with the Moliniacian interval (late Courceyan-Arunadian) of the Craven Basin (Riley, 1990), the Belgian stratotypes are much thinner sequences. This difference plays an important part in understanding the discrepancies in the relative appearance of foraminiferal taxa between the Craven and Dinant Basins as documented from the latter by Conil et al., (1991).

2. REGIONAL SETTING

The stratotype lies on the southern limb of the Clitheroe Anticline, a structure emplaced during the late

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Carboniferous, Variscan inversion of the Craven Basin, a Dinantian extensional basin, bounded by the Southern Lake District High and Askigg Block to the north, and the Central Lancashire High to the south (Fig 1). The most recent review of the basin's Dinantian stratigraphy, and its tectonic and depositional history was given by Riley (1990), who also formalised the lithostratigraphy of the Worston Shale Group, which overlies the Chatburn Limestone Group. The Chatburn Limestone Group represents a thick sequence (1500 m proved) of ramp carbonates. Its base is unproven, despite a deep borehole to the east of Clitheroe in the core of the Swinden Anticline (Swinden 1 Bh., Charsley, 1984). The stratotype shows all the typical lithologies and depositional features of the group.

3. LITHOSTRATIGRAPHY

Although the term Chatburn Limestone was first used by Parkinson (1926), it was Earp et al., (1961) who later assigned its group status. These authors gave a thorough account of the earlier nomenclature and regional correlatives, such as the Haw Bank and Skipton Castle limestones of the Skipton Anticline (Fig. 2). Fewtrell and Smith (1980) however, recognised the Chatburn Limestone as a formation, defining the type section as the quarries just west of Chatburn (SD 765 443). This practise was followed by Arthurton et al. (1988), but not by Riley (1990) who followed Earp et al. (1961). This was because Riley (1990) recognised that the Stockdale Farm Formation, a sequence of red beds, evaporites and peritidal limestones present in the northern part of the Craven Basin, transitional to the Askigg Block (Arthurton et al., 1988), lay within the Chatburn Limestone.

Figure 2. Simplified lithostratigraphy of the Chatburn Limestone.

Of particular relevance to the Chadian Stratotype was the subdivision of the group into the following informal lithostratigraphical units by Earp et al. (1961, p. 24),
based on faunal observations in the quarries west of Chatburn previously mentioned. From the top downwards these subdivisions are:

«Bold Venture Beds. Limestone characterised by the brachiopod Productus humerosus (top 150 ft not exposed): 'Four-Foot Shale' of Parkinson (1926) at the base, 408 ft.»

«Bankfield East Beds. Limestone, poorly fossiliferous, 536 ft.»

«Horrocksford Beds. Limestones with subsidiary shales: yielding the coral Cyathocelis tabernaculum, 80 ft.»

Earp et al. (1961, p. 26) expanded these descriptions emphasising that the top of the Horrocksford Beds was characterised by the coral Cyathocelis tabernaculum (now C. modavensis). Despite this clear definition of the junction of the Horrocksford Beds with the Bankfield East Beds, George et al. (1976, p. 8-9) never mentioned the coral. Moreover, they introduced new

Figure 3. Photographs of the basal boundary of the Chadian Stage (dotted line) at the stratotype on the east side of the Chatburn by-pass road (A59) cutting (SD 7743 4442), in September 1992. This is the boundary as photographed in Ramsbottom (1981). Vertical scale (on the second photo) is 1 m.
Figure 4. Lithological log of the Chadian stratotype, Chatburn by-pass road (A59) cutting (SD 7743 4442). Location points such as; east side, west side, traffic signs and bridge are reference points along the section and refer to the column on the immediate right. The fault is a small reverse fault and the log has been corrected to remove the repeated section. The Chadian/ Courceyan Boundary is arrowed. The abbreviations BVB, FFS and BEB refer to the Bold Venture Beds, Four Foot Shale and Bankfield East Beds respectively. All the section below the Four Foot Shale is in the Bankfield East Beds.
observations which they attributed to Earp et al. (op. cit.) but which were not, in fact, derived from the reference cited, namely:

«The top of the Horrocksford Beds contains much fine-grained and algal limestone and in the lower part of the Bankfield East Beds the limestones are crinoidal and interbedded with calcareous muststones (Earp et al. 1961, p. 24)».

In fact, crinoid components are present across the basal Chadian boundary, as are oncolitic algae, and there is no record of C. modavensis. Geometric relations between the stratotype and the lithostratigraphic reference sections in quarries west of Chatburn, show that the lowest beds in the roadcut still lie within the Bankfield East Beds. The lithostratigraphical basis for recognising the base of the Chadian is thus invalid and it has not been possible to recognise the bed at which the base of the Chadian is defined at the stratotype in any other section, even near by at Horrocksford Quarry (SD 7600 4445), 1 km southwest of the Chadian stratotype, where the three divisions recognised by Earp et al. (1961) can still be observed.

Further confusion as to the lithological identity of the boundary has arisen from a field guide produced for the IUGS Subcommission on Carboniferous Stratigraphy meeting held in Leeds during 1981 (Ramsbottom, 1981, p. 6.1-6.5). Firstly, the photograph of the boundary shows the eastern side of the cutting, rather than the western side as defined in George et al. (1976) and secondly the position of the boundary is wrongly drawn on the accompanying graphic section (32.9 m above the base instead of 6.9 m). Because it is the only published photograph of the basal bed, this photographed boundary is taken to be the basal Chadian boundary in the present account (Figs 3, 4).

4. SECTION DESCRIPTION

The section, which is 186.2 m thick, is exposed on both sides of the roadcut, however it is the eastern side which shows the best exposure. A small reverse fault is present 135.5 m above the base of the section. The log (Fig. 4) was made by R S Arthurson, apart from the basal 13.4 m which were logged by the author and are only exposed on the western side (not included in Ramsbottom et al., 1981). As already stated the main part of the section is in the Bankfield East Beds. The Four Foot Shale (1.4 m thick), marking the boundary with the overlying Bold Venture Beds, lies 163.1 m above the section base and only 21.7 m of Bold Venture Beds are exposed. There is little to distinguish the Bankfield East Beds from the Bold Venture Beds lithologically.

The sequence comprises well bedded, dark grey, silty limestones, calcareous siltstones and calcareous silty claystones. Beds are generally less than 50 cm thick and bed boundaries are commonly gradational. There are no thick beds. Most of the limestones are fine grained packstones. Grainstones are unusual and may well be secondary rather than primary. Wackestones are rare. One claystone horizon is pyritic and gives rise to prominent iron oxide staining of the cutting at its outcrop. Oncoid rich horizons occur and in some cases these form oncoidal floatstones some of which are dolomitised and show a vuggy porosity. The oncoids are usually less than 1 cm in diameter and are dominated by Ortonella. Other algal components commonly include monolaminar Koninckopora and Girvanella. Atractyliopsis is less common. Kamacrites and stachoeids are rare. Hyalostellid sponge spicules are common, but are usually replaced by calcite cement.

Macrofossils are predominantly fragmentary and are only a minor component of the rock; crinoid debris being the commonest. Solitary corals are present, but are not abundant. Cyathocissus modavensis has not been found. Brachiopods tend to be mud tolerant «recliners» (Rudwick, 1970), such as productoids, orthotrochids and chonetoids. Fenestellid bryoanoid hash is common in some of the claystones and siltstones. The only colonial corals are small colonies of Syringopora which are usually in situ. The most conspicuous feature is the intense bioturbation which has destroyed most of the internal structure of the beds. Because there is little contrast in grain size at bed boundaries, and bioturbation is so intense, very few individual burrows are seen, usually only chondriform types are noticed in thin section.

Micritisation of bioclasts is common and some beds contain peloids. Stylooliths are common, particularly in silty limestones and siltstones, where many grain contacts are corroded and stylolithitic. Ooids have not been seen, nor have any features indicative of emergence.

5. DEPOSITIONAL ENVIRONMENT

Deposition was in the photic zone with rapid rates of sedimentation, sourced from local carbonate production and a copious supply of terrigenous clays and silts. Benthos tolerant of sediment fouling was favoured. Very little bathymetric variation is evident, suggesting that subsidence and sediment accumulation were in phase. The intense bioturbation indicates that the substrate surface was reasonably well aerated. There is no obvious evidence of wave action, suggesting that wave fetch was probably limited, however this is
speculative, since much of the primary depositional fabric within each bed is not preserved, due to the bioturbation. Hummocky bed boundaries have not been seen.

6. BIOSTRATIGRAPHICAL REVIEW OF THE CHATBURN LIMESTONE GROUP

This paper presents the first detailed study of the foraminiferal distribution in the stratotype. Before presenting the new data, it is necessary to review published knowledge of the biostratigraphy both of the stratotype section and of the Chatburn Limestone in general. Conil et al. (1989, 1991) have refined Dinantian foraminiferal zonation in western Europe, based mainly on the Belgian sequences and it is their scheme which is referred to in the following account.

6.1 Foraminifera

As already noted George et al. (1976) defined the base of the Chadian Stage at the first lithological change below the entry of Eoparastaffella. This definition is difficult to apply since it can be interpreted as either the base of the bed in which Eoparastaffella enters, or the base of the then incorrectly perceived lithostratigraphical unit, the Bankfield East Beds. This study has also failed to confirm the log given by George et al. (1976, fig. 1). There is thus confusion as to which bed yielded the reported Eoparastaffella, although it is generally believed to be the first limestone bed at the base of the stage (Bed 16 of George et al., op. cit.). This foraminiferal record has never been illustrated or repeated by subsequent workers.

Fewtrell and Smith (1978), provided the first general account of the foraminiferal stratigraphy of the Chatburn Limestone. None of this material was figured, hence it is not possible to establish the accuracy of the determinations. Fewtrell et al. (1981, pls. 3.1-3.1) later figured material from the Haw Bank Limestones in the Skipton Anticline and the Swinden Bh. in the Swinden Anticline. Marchant (in Charsley, 1984) also reported and figured Foraminifera from the Swinden Bh., the oldest known horizon in the Chatburn Limestone. Because British Geological Survey (BGS) specimen numbers were quoted by Fewtrell et al. (1981), it is possible to relate the position of their samples to the Chadian Stratotype. Foraminiferal determinations included: ? Dainella fleronensis (Conil & Lys) from the junction between the Bankfield East and Bold Venture Beds, Glomospiranella cf. baurae (Conil & Lys), Septabrunsiina krainica (Lipina), Spinoendothyra cf. mitchelli, 6 m, 127-137 m and 67-77 m below the the top of the Bankfield East Beds respectively and Spinobrunsiina cf. ramsbottomi from 21 m above the base of the Bold Venture Beds. Further elements of the stratotype fauna were reported but not figured including; Brunsia pseudopulchra, probable Dainella, Endothyra bowmani, E. danica, E. freyeri, E. laxa, Eotextularia diversa, Latiendothyra cf. paraconoides, Palaespiroplectaminia sp., Spinobrunsiina ramsbottomi, Spinoendothyra costifera, S. recta, and Tournayella kisella. Comment was also made on the lack of Eoparastaffella in the stratotype section.

Conil et al. (1980, pls. 2-3) also figured material from the Chadian stratotype. From the Bankfield East Beds (including their Horrocksford Beds) they reported; Baituganella sp., Chernobacularites sp., Eblanaia michoti, Eblanaia sp., cf. Eblanaia sp., Endothyra bowmani Phillips, E. concava Malakhova, E. laxa (Conil & Lys), E. lesni (Conil & Lys), E. aff. paraspinosa Skipp, E. spp., Eotextularia diversa (N. Tchernysheva), Glomospiranella cf. baurae (Conil & Lys), G. cf. uralica (Lipina), Granuliferella aff. campinei (Conil & Lys), Latiendothyranopis sp., Septabrunsiina (Spinobrunsiina) cf. ramsbottomi Conil & Longerstaey, cf. Septabrunsiina (Spinobrunsiina) sp., Spinocherraelina cf. brencklei Conil & Lys, Spinoendothyra mitchelli Conil, Spinoendothyra praeclaria Conil & Longerstaey (holotype), Spinoendothyra sp. and Tubendothyra sp. These records were accompanied by their lithostratigraphical position relative to the stratotypic boundary, rather than absolute distances in the section, apart from an Endothyra sp. and a cf. Eblanaia sp., from 9 m above the base of the Bold Venture Beds.

Strank (in Artherton et al., 1988, p.40) reported Foraminifera from the Chatburn Limestone of the Slaidburn Anticline. Her record (Strank in Artherton et al., 1988, p. 42,44) of Eoparastaffella from the Clitheroe Limestone Formation (Thornton Limestone Member) appears to be incorrect. The BGS thin sections from which this record came (samples RA 963 and 975) have been re-examined by me and no Eoparastaffella is present.

Riley (1990, fig.10) presented selected taxa in a range chart which indicated that the genera Bessiella, Brunsia, Dainella, Eotextularia diversa, Florenella and Mediocris were present in the Chatburn Limestone of Chadian age. This paper also reported that Eoparastaffella was unconfirmed from the Chadian stratotype.

All of the previously published foraminiferal data, when scrutinised critically, suggest that the maximum possible age of the oldest part of Chatburn Limestone Group is towards the top of the Cf2 Foraminiferal Zone. This is based on the presence of Eblanaia in the Swinden Borehole (Marchant in Charsley, 1984). The possible presence of Dainella, however favours a Cf4 correlation. The Haw Bank Limestone that Horro-
cksford Beds) contains *Lugtonia* and *E. laxa*, according
to Fewtrell & Smith (1978), implying a Cf441
correlation. The Cf3/4 zonal boundary probably lies
within the Horrocksford Beds and equivalents, but has
yet to be located precisely (see also Section 6.3 on
conodonts).

### 6.2. Corals and brachiopods

Earp *et al.* (1961) provided a review of earlier records
and observations resulting from mapping by the
Geological Survey. Significant records from the
Gibson Coates Beds included; *Cyathoclisia tabernac-
ulum, Productus (Dictyoeclostus) aff. vaughani Muir-
Wood, Fasciculophyllum sp., aff. Koninckophyllum
praecursor* Howell, *Spirifer (Palaeoechristes) cf.
cinctus* Keyserling, *Zaphrentites cf. crassus Hudson,*
Z ex gr. *delanouei* (Milne, Edwards & Haime) and
«Z» *konincki* Edwards & Haime.

In the overlying Horrocksford Beds, these authors
noted the presence of *Cyathoclisia tabernaculum* and
*Chonetes cf. papilionaceus* (Phillips). The Bankfield
East Beds yielded *Fasciculophyllum ambiguum* (Carruthers),
*F. oimalusi* (Edwards & Haime), *F. cf.
densum* (Carruthers), *Productus (Pustula) aff.
pyxidiformis* de Koninck, Schuchertella aff. *aspi*
Smyth, *S. wexfordensis* Smyth and *Spirifer tornacensis*
de Koninck. The Bold Venture Beds marked the entry
of *Productus (Pictafera) numerosus* J. Sowerby (now
*Levitisia*), other taxa included *Chonetes cf. papi-
lionaceus, Fasciculophyllum cf. oimalusi, Productus cf.
nodosus* (I. Thomas) and *P. (Pustula) aff.*
*pyxidiformis*.

Ramsbottom *et al.* (1981), recorded *Megachonetes magna*
from the Bankfield East Beds.

Mitchell (in Charsley, 1984) reported the following
fauna from the Swinden Bb. which included: *Buxtonia*
sp., *Caninophyllum ?, Fasciculophyllum oimalusi, Megachonetes sp., Pugilia sp., Pustula sp., Syringo-
ghyis cf. elongata North, Syringopora cf. ramulosa
Goldfuss, S. cf. vaughani Hudson, and Zaphrentites
delanouei. Mitchell (in Arthorton *et al.*, 1988) recorded
the following from the Chatburn Limestone, Stockdale
Farm Formation; *Delepineae* sp. and *Michelinia
megastoma* (Phillips).

Mitchell & Somerville (1988) provided a review of
the corals from the Haw Bank Limestones in the
Skipton Anticline including; *Cyathoclisia modavensis*
(Salée), «Fasciculophyllum» ambiguum, *Michelinia
favosa* (Goldfuss), *Paleaecis cf. cuneiformis* Haine, *Sychnoeslasma hawbankensis* Mitchell & Somerville,
S. konincki, *Syringopora favosoides* Vaughan, *S.
reticulata* Goldfuss, *S. vaughani* Hudson and
Zaphrentites delanouei. Interestingly from this interval
Poty (in Paproth *et al.*, 1983, p. 189) recorded
*Haploasma aff. subicum*, *Palaeosmilia murchisoni*
and *Sychnoeslasma urbanowitschii* although Mitchell
(pers. comm., 1990) points out that the sample of *P.
murchisoni* contains archaescid foramifera and
therefore could not have come from the Haw Bank
Limestones; certainly this record is anomalous with
mine and all other observations (Fewtrell & Smith,
The *P. murchisoni* and related samples were supposed
to have been collected by R. Conil and E. Poty, in April
1982, from Haw Bank Quarry (also known as Skipton
Rock Quarry, and Haw Park, SE 0170 5290). In April
1993, myself, E. Poty and K. Boland revisited the
locality and were unable to corroborate these
troversial records.

The oldest coral brachiopod assemblages correlate with the
*Caninia patulum* Zone of Mitchell (1981),
according to Mitchell and Somerville (1988). This zone
extends (Sevastopulo & Nudds, 1987) from just below the
*Pseudopolygnathus multistriatus* Conodont Zone
(Varker & Sevastopulo, 1985), equivalent to the base of
the Cf2 Foraminiferal Zone, up into the *Scalio-
ognathus anchoralis* Conodont Zone equivalent to the
*Cyathoclisia modavensis* enters, outside
Belgium, at or slightly above the base of the Cf3
Foraminiferal Zone, hence the coral faunas do not
indicate anything older than this zone.

Several brachiopods are significant. The presence of
*Pustula pxyidiformis* and *Megachonetes magna* in
the Bankfield East Beds is characteristic of the
*Siphonophyllia cylindrica* Assemblage Biozone of
Mitchell (1981). The base of this zone correlates closely
with that of the Moliniacian Stage (Cf4) since the zonal base
(bed 25) at Barry Island in S. Wales (Sevastopulo in
Waters & Lawrence, 1987, p. 35) corresponds closely
with the entry (bed 27) of *Mestognathus praebeck-
mannii* (recorded as *Mestognathus cf. beckmannii*,
which enters in the Bold Venture Beds characterises
brachiopod faunas around the *Tournaisian/Viséian*

### 6.3. Conodonts

Conodonts are very rare in the Chatburn Limestone,
due probably to dilution by the rapid sedimentation,
and the exclusion of a wide bathymetric range of
faunas. The facies lacks gnathidids and is maintained
in the shallow water and long ranging *Pseudopoly-
ognathus mehil* Zone of Varker and Sevastopulo
(1985).

From the Chadian Stratotype, Metcalfe (1981, tab. 7)
recorded an indeterminate conodont from the latest Courceyan: *Apatognathus petilus* Varker and *Ozarkodina* sp., in the top of the Bankfield East Beds, and an *Apatognathus* sp. from the base of the Bold Venture Beds. Other taxa present in the Clitheroe Anticline include *Clothogomphus globenskii* Austin & Mitchell, also known for the Skipton Anticline, where other conodonts from the Haw Bank Limestone and Skipton Castle Limestone include: *C. cravenus* Metcalfe, *C. rhodesi* Austin and Mitchell (Haw Bank Limestone only), *Clydagnostus sp. hudsosti* Metcalfe, *Polygnathus communis communis* Branson & Mehli (Haw Bank Limestone only), *P. lacinatus asymmetrical* Rhodes, Austin & Druce and *Pseudopolygnathus minutus* Metcalfe.

Significant is the record of *P. communis communis* from the Haw Bank Limestone. According to Conil et al. (1991) this taxon extends to the upper part of Cf3 Foraminiferal Zone, suggesting that the Cf3/Cf4 zonal boundary lies in the Horrocksford Beds and equivalents.

7. FORAMINIFERAL AND ALGAL DISTRIBUTION IN THE CHADIAN-STRATOTYPE

A summary of the total range of taxa observed in the present study is given in Fig. 5. This is based on a study of 209 large area (7.2 X 4.8 cm) thin sections from the stratotype section. Minimum sample spacing is to the nearest metre, but around the basal Chadian boundary spacing is to the nearest 0.5m. Details of microfossil content for each sample is held on open file as a Technical Report (number WH 93/228R) at the British Geological Survey. A representative selection of microfossils is illustrated on Plates 1-6. Correlation of the stratigraphy around the Tournaisian/Viséan boundary is summarised in Fig. 6.

*Brusnia* and *Septabrunisia* (*Spinobrunisia*) are the commonest. This contrasts with rare presence of *Brusnia* in deeper water, outer ramp settings contemporary with the Chatburn Limestone, such as the Black Rock Limestone at Barry Island in South Wales (based on BGS samples). The rarity of tetrataxids in the Chadian stratotype is also due to facies, since *Pseudotaaxis* is much more common in the underlying Horrocksford Beds and yet is limited to one sample in the stratotype. Presumably the high sedimentation rates inhibited the tetrataxids with their attached mode of life. The presence of *Eoextularia diversa* and *Spinoendothyra praecincta* recorded by Conil et al. (1980) from this section, has not been confirmed in this study, although large fragments of *Eoextularia* were seen.

The initial rapid burst in the entry of microfaunal and microfloral components in the basal 27.9 m of the section (Fig. 5) is thought to be more a product of the way in which the data is acquired and presented, rather than having any biostratigraphical significance. The curved, almost parabolic profile of the burst, results from the cumulative recording of random appearances in thin section. This burst would be far more significant if it was higher up in the stratotype and preceded by a long run of widely spaced entries. Furthermore, many of the taxa present in this "burst" are present in the older Horrocksford Beds exposed in Horrocksford Quarry, 1 km to the southwest. The only taxa with significant first appearances in the stratotype include; *Endothyra* cf. *interjectans*, *Eoextularia mongeri* and *Mediocris* sp.

7.1. BIOSTRATIGRAPHICAL IMPLICATIONS

Conil et al. (1989, 1991) have refined Dinantian foraminiferal zonation in western Europe, based mainly on the Belgian sequences. Their scheme is adopted here, although this is not entirely satisfactory over the Tournaisian-Viséan boundary interval when applied to the Craven Basin. This is because the type Moliniacian and Viséan stratotypes are relatively starved sequences (see below). Although ideal for conodont biostratigraphy, and used as international reference sections for foraminifera they provide virtually no information on coral-brachiopod, miospore, ammonoid and trilobite zonations.

An important synthesis of Moliniacean foraminiferal sequences in the Dinant Basin was conducted by Hance (1988), comprising around twenty outcrop sections. Although this revealed a sequence of assemblages which could be correlated in general terms, it did show that the first entry and occurrences of the rapidly evolving archaeodiscidae varied between sections. These variations I suggest are linked more to depositional control rather than ecological tolerance. Such effects also explain the different interpretations of the first entry of bilaminar *Koninckkopora* between the Dinant Basin and the British Isles noted by Davies et al. (1989) and Riley (1990).

Indeed the degree of sediment starvation and sequence condensation is spectacular when one considers that the interval encompassing the Cf3/4 zonal boundary up to the base of the Cf4/5 subzone is in excess of 1.5 km in the Craven Basin compared to 69.3 m at Salet (type Moliniacian) and 91.8 m at Bastion (type Viséan) in Belgium (Conil et al., 1989, fig. 2). Similar thin sequences are encountered in the other Dinant Basin sections documented by Hance (1988), some of which contain slumps (basin slope?). My own preliminary observations at Bastion and Salet lead me to suspect the presence of limestone turbidites. A sedimen-
ological study to investigate the precise depositional mechanisms is urgently required, bearing in mind the importance of these sections.

Some hint of difficulties arising from these factors can be gleaned from the attempted application of the Belgian zonations to relatively shallow water carbonate sequences in Siberia and China (Shilo et al., 1984 and Conil et al., 1988) resulting in the inability to locate precisely the CF3/CF4 zonal boundary there.

Similar difficulties are encountered in applying the zonation to the mid-Dinantian of the Craven Basin. Detailed comparison of the Chatburn Limestone foraminiferal assemblages reveals differences in the order of appearance of some key taxa. Although the stratigraphical implications of these differences can be assessed in the Clitheroe Limestone Formation and Hodder Mudstone Formation, due to the presence of conodont guides (Riley, 1990), this is less easily resolved in the Chatburn Limestone where diagnostic conodonts are virtually absent and within which the CF3/CF4 zonal boundary apparently lies.

The definitive biostratigraphical event for the base of the Moliniacian Stage is the appearance of the conodont *Mestognathus praebekmanni* Sandberg, Johnson, Orchard & Von Bitter, Conil et al. (1989, 1991) correlate this with the base of the CF4 Foraminiferal Zone. This conodont has not been found in the Chatburn Limestone Group, but occurs in the lower part of the overlying Clitheroe Limestone Formation (Riley, 1990). Because of the scarcity of conodonts in the Chatburn Limestone Group, this event is probably facies-related (coincident with the initiation of Waulsortian buildups) and therefore does not correlate with the base of the Moliniacian. This interpretation is also supported by the occurrence of «Moliniacian» (CF4) corals and foraminiferal assemblages in the Chatburn Limestone Group.

An alternative view is that the first entry of *Mestognathus praebekmanni* in the Clitheroe Limestone Formation is closely isochronous with its appearance in the Moliniacian Stratotype and that the foraminiferal and coral assemblages of «Moliniacian» character in the Chatburn Limestone Group represent assemblages so far unrecognised in the Belgian reference sections due to unfavourable facies and condensed stratigraphy.

Until a thick carbonate ramp sequence yielding abundant conodonts, corals and foraminifera is studied in detail, the relationship between the Moliniacian as defined by conodonts and recognised by the other groups will remain unresolved. It is possible that this relationship may be severely diachronous with the «Moliniacian» foraminiferal and coral-brachiopod faunas preceeding the conodonts.

In terms of current understanding of foraminiferal zonation, the Chadian stratotype foraminifera fall within the CF4a1 Subzone of the *Eoparastaffella* CF4 Foraminiferal Zone. Significant components include the combination of *Bessiella*, *Brusnia*, *Dainella*, *Florennella*, *Mediocris*, *Omphalotis* and *Plectogyranopsis*. Species present which from published data enter at or above the CF4 Foraminiferal Zone include *Endothyra laxa*, *E. cf. introjectans*, *E. modica*, *Florennella stricta*, *Granuliferella campinei*, *Latiendothyranopsis floraviae*, *Plectogyranopsis convexa*, *P. stricta*, *Spinobrunsiina implicata*, *S. kalmiussi*, *S. landeliesi*, *S. ramsbottomii*, *Spinoendothyra michelli* and *S. pietoni.* Unfortunately it has not been possible to resolve the precise identity of the *Endothyroplectectamina* and *litoutubellid* tests; species which also have zonal significance in the CF4 Foraminiferal Zone. *Eoparastaffella* characteristic of the overlying CF4a2 Subzone is lacking. There is no significant change in the foraminiferal population associated with the base of the Chadian.

In contrast to Belgium, *Plectogyranopsis* precedes *Mediocris*. This is the case in Siberia where primitive *Plectogyranopsis* first enters in the CF2 Foraminiferal Zone (Conil et al., 1982). The appearance of *Brusnia* is different than in Belgium; this genus is also known in the CF2 Foraminiferal Zone of Russia. The entry of *Pseudotaxis*, near the top of the section, is a facies entry as this genus occurs in the underlying Horrocksford Beds at Horrocksford Quarry (SD 7600 4445), Chatburn. The oldest tetraxids known, are reported from Ireland by Marchant et al. (1984), in the *Dollymae bouckaertii* Conodont Subzone around the base of the CF3 Foraminiferal Zone, slightly preceding their entry in Belgium. The absence of the tetraxid *Valvulinella* at Chatburn is almost certainly due to facies, its appearance is characteristic of the CF4a1 Subzone in Belgium in some Waulsortian and peri-Waulsortian settings. *Eoextularia* is another component which ranges into the CF4 Foraminiferal Zone from CF3, *Eoextularia mongeri* is associated with late Tournaissian and possibly earliest Viséan assemblages in Canada (Mamet, 1976). This is the first record of *E. mongeri* in Europe.

New taxa include *Latiendothyranopsis lancastria* sp. nov., *Omphalotis marchanti* sp. nov., and *Palaeo- spiroplectectamina cravenensis* sp. nov. Of these only *P. cravenensis* has been recognised elsewhere, from the late Tournaissian to early Viséan interval in Ireland (Marchant op. cit. in Fewtrell et al., 1981), Wales (Davies et al. 1989) and Turkey (Dill, 1975).

Of the algae, the dasyclad *Konincskopora* is unknown from strata below the CF4a1 Subzone, and hitherto monolaminar *Konincskopora* has been used as a Chadian guide. It is here recorded from Courceyan rocks for the first time.
<table>
<thead>
<tr>
<th>STAGE</th>
<th>COURSEYAN</th>
<th>CHADIAN</th>
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</thead>
<tbody>
<tr>
<td>POSITION (10m intervals)</td>
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<tr>
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<td>(Spinobrunusina) sp.</td>
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<td>Endothyme sp.</td>
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<td>(Spinobrunusina) robusta</td>
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<tr>
<td>7</td>
<td>calcotapheres</td>
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<tr>
<td>8</td>
<td>Tsetka sp.</td>
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<tr>
<td>5</td>
<td>(Spinobrunusina) landeskti</td>
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<tr>
<td>9</td>
<td>Omphalolella sp.</td>
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<tr>
<td>10</td>
<td>Erkanidio sp.</td>
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<tr>
<td>11</td>
<td>Latidendothyanopsis sp.</td>
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<tr>
<td>5</td>
<td>(Spinobrunusina) rambottomi</td>
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<tr>
<td>12</td>
<td>Saelebra aborica</td>
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<tr>
<td>13</td>
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<td>14</td>
<td>Endothyme licei</td>
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<tr>
<td>15</td>
<td>Brunus pseudopulchra</td>
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<td>16</td>
<td>Spinnoendothyme sp.</td>
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<td>19</td>
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<td>21</td>
<td>Rosnerella sp.</td>
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<td>23</td>
<td>Endaspinophylytenminia sp.</td>
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<td>24</td>
<td>Gruncharilla campalis</td>
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<tr>
<td>25</td>
<td>L. lanceri sp. nov.</td>
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<tr>
<td>26</td>
<td>Parocatagiloides sp.</td>
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<td>27</td>
<td>(Spinobrunusina) kamusi</td>
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<td>Brunus sp.</td>
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<td>29</td>
<td>Paracharactides sp.</td>
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<td>fchorekida</td>
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<td>Brunus splendivides</td>
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<td>33</td>
<td>Isot. punctolata</td>
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<td>Akrolykites sp.</td>
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<td>Giavanella sp.</td>
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<td>36</td>
<td>Palaospinophylytenminia sp.</td>
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<td>Spinnoendothyme mitchelli</td>
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<td>38</td>
<td>Rosnerella iricta</td>
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<td>39</td>
<td>Karinophylytenminia sp. (monotam.)</td>
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<td>40</td>
<td>Omphalotates marchantii sp. nov.</td>
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<tr>
<td>41</td>
<td>Danellia sp.</td>
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<tr>
<td>42</td>
<td>Endothyme bowmani</td>
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<tr>
<td>43</td>
<td>P. cravenensis sp. nov.</td>
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<tr>
<td>44</td>
<td>Danella micula</td>
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<tr>
<td>46</td>
<td>Basitekia sp.</td>
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<td>Latidendothyanopsis grandis</td>
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<td>48</td>
<td>Thryptoteki</td>
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<td>49</td>
<td>S. (Spinobrunusina) implicata</td>
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<td>50</td>
<td>Genebutoria mongaeri</td>
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<td>51</td>
<td>Ectoelukaria sp.</td>
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<td>52</td>
<td>Mediscros sp.</td>
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<td>53</td>
<td>Plagotogynonops sp.</td>
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<td>54</td>
<td>Latidendothyanopsis floraviae</td>
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<td>55</td>
<td>Spinnoendothyme recta</td>
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<td>56</td>
<td>Spinnoendothyme pletoni</td>
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<td>57</td>
<td>Tsumayakli neota</td>
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<td>58</td>
<td>Endothyme intragallina</td>
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<td>59</td>
<td>Spinnoendothyme paracetifica</td>
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<tr>
<td>60</td>
<td>Neudrales sp.</td>
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</table>
8. CONCLUSIONS

This study supports and adds to previous reports of difficulties associated with recognition of the base of the Chadian (Fewtrell et al., 1981, Riley, 1990). These difficulties include: (1) the inability to confirm the alleged association of Eoparastaffella with the basal boundary; (2) the lack of faunal change in any other stratigraphically useful groups; and (3) the misinterpretation of the lithostratigraphy by George et al. (1976). Correlation of the base of the Chadian Stage is thus impossible and unqualified use of the stage is of little value. Despite these difficulties, some known for more than 10 years, the Chadian Stage is commonly applied uncritically in current publications.

It was the intention of George et al. (1976) to recognise a stage boundary closely coincident with Eoparastaffella. This is desirable since this event also marks the base of the Viséan Series. The interval between the appearance of Eoparastaffella and the appearance of primitive archaeosids was termed «late Chadian» by Riley (1990).

Adoption of the Moliniacian Stage as an alternative to the Chadian is not desirable because of the following: (1) the base of the Moliniacian does not coincide with the base of the Viséan Series, in contrast to the original intention; (2) the stage spans a considerable thickness of strata in Britain (see previous discussion) comprising the late Courcayan through to the base of the Holkerian; (3) the relative scarcity of the non-conodont guides and their distribution in the Moliniacian stratotype; (4) the general scarcity of Mestognathus praebecmanni in conodont assemblages, limiting its usefulness as a definitive guide.

As a minimum requirement it is necessary to abandon the Chadian, extend the Courcayan up to the base of the «late Chadian», and propose a new stage for the late Chadian interval. It may also be desirable to define a new stage within the late Tournaissian, the base of which could be recognised using the first appearance of the widespread and easily identifiable conodont Scaliognathus.

At present the Tournaissian/Viséan boundary interval is being investigated by the IUGS Subcommission on Carboniferous Stratigraphy as a global interval for subdivision of the Lower Carboniferous (Brenchle, 1991). An international boundary is likely to be chosen at the first appearance of Scaliognathus or at a level between it and the arrival of primitive archaeosids. Clearly it would be desirable for formal chronostratigraphical revision of the late Courcayan to Chadian interval in Britain to complement this investigation and be co-ordinated with it. In the meantime it seems that only the late Chadian sensu Riley (1990) is a pragmatically correlatable unit, within the original definition of the Chadian Stage.

Because of the paucity of conodonts in the Tournaissian of the Craven Basin this region is unlikely to provide a suitable stratotype area for a boundary associated with the entry of Scaliognathus; the most promising...
Figure 6. Chronostratigraphic correlation of the Tournaisian/Viséan boundary interval derived from various sources. The bases of the *Mestognathus praebeckmanni* Zone and the Cf4 Foraminiferal Zone are equated following current practice, however it is possible that base of the Cf4 Foraminiferal Zone precedes that of *M. praebeckmanni*. The oldest *M. praebeckmanni* in the Craven Basin occur near the base of the Clitheroe Limestone Formation. *Eoparastaffella* and *Gnathodus homopunctatus* enter in the basal part of the Hodder Mudstone Formation (for further discussion see Section 7.1). Vertical hatching denotes non-kinght. Some boundaries are difficult to correlate with precision, these are denoted by oblique lines, corresponding to the stratigraphic range of uncertainty. Vertical scale is non-linear. Abbreviations: FORAM, Foraminifera; G., *Gnathodus*; L., *Lochriea*; M., *Mestognathus*; MER., Meramecian; RAD., Radaevsky; Sc., *Scaliognathus*; (undiff.). (undifferentiated).
area in Britain for such an event is in the thick outer ramp sequence of the Black Rock Limestone in South Wales and the southeast Mendips.

9. SYSTEMATIC PALAEONTOLOGY

This section deals with the systematic description of new species of foraminifera. The following prefixes to sample numbers AL, RH, MPK, refer to samples in the Biostratigraphy Collection, British Geological Survey (BGS), Keyworth, Nottingham, UK, NG12 5GG. Figured BGS samples have a binomial registration number. Numbers prefixed AL or RH refer to the thin section, whereas the number prefixed MPK refers to the figured specimen on the slide.

Foraminiferida
Family Tournayellidae Dain, 1953
Subfamily Cherynshinellinae Reitlinger, 1958
Genus Palaeospiropectactamina Lipina, 1965
Palaeospiropectactamina cravenensis sp. nov.
(Pl. 2, fig. 14)

1975 Palaeospiropectactamina mellina (Malakhova); Dil: pl. 3, fig. 33.
1977 cf. Palaeospiropectactamina mellina (Malakhova); Conil: pl. 2, fig. 15.
1981 Palaeospiropectactamina mellina (Malakhova) subsp.; Fewtrell et al.: pl. 3.3, figs. 9-10.
1989 Palaeospiropectactamina sp. nov.; Davies, Riley & Wilson: fig. 10, m.

Derivation of name: From Craven - a regional name for northwest England in which the Chadian stratotype lies.

Diagnosis: A Palaeospiropectactamina with a twist to the uncoiled portion of the test.

Type material: Holotype specimen MPK 9352 (sample AL 5898, Pl. 2, fig. 14), Bankfield East Beds, Chadian stratotype, 10.2 m above the base of the Chadian Stage, late Touraisian, Chatsburn, northwest England. Paratype, BGS specimen JD 5007 (Davies et al., 1989, fig. 10m), Lwyl-y-fran (SJ 188 586), N. Wales, Foel Formation, Cfy4a2 Subzone, Late Chadian.

Occurrence: Cfy4a1-2 subzones in the Craven and Dublin basins (Fewtrell et al., 1981), and Wales (Riley in Davies et al. 1989; Riley in Burden 1989). Dil's (1975) material was recorded from the V1a of Gokgol, Turkey.

Description: The test is free, of average size for this genus, with an initial streptospiral juvenarium (seen in the paratype) succeeded by a biserial longitudinal portion up to 450 μm long and 100-200 μm width, consisting of up to fifteen chambers. Between the fifth

and ninth chamber the biserial axis twists through ninety degrees. The septae are long, curved, with inflated tips. The wall is dense, microgranular and delicate, less than 15 μm thick.

Remarks: The twisting of the uncoiled axis is unique and very distinctive. This justifies the erection of a new species despite the few tests so far recognised in the above synonymy. No other tests were found at Chatburn and the orientation of the section obscures the juvenarium. A previously figured specimen from another locality, which does show this portion of the test, has been chosen as a paratype.

Family Endothyridae Brady, 1884
Subfamily Endothyridinae Brady, 1884
Genus Omphalotis Schlykova, 1969
Ompalotis marchanti sp. nov.
(Pl. 3, fig. 14, Pl. 6, figs. 11, 14, 18, 19, 20)

1984 Eblanaia sp. A; Marchant: pl.1, figs. 14, 15.

Derivation of name: In honour of T. C. Marchant, who first figured this form.

Diagnosis: A species of Omphalotis with irregular coiling until the final whorl.

Type material: Holotype specimen MPK 9430 (sample AL 6019, Plate 6, fig. 20) Chatburn (AS9) by-pass road cutting, Chadian stratotype, 126.5 m above the base of the Chadian Stage, Bankfield East Beds, Chatburn Limestone Group, Chatburn, northwest England; paratypes; specimens MPK 9373, MPK 9428 and MPK 9426, all from the same section as the holotype, 11.40 m below and 10.20, 18.30 m above the Chadian Stage boundary respectively, Chatburn Limestone Group, Bankfield East Beds, Cfy4a1 Subzone.

Occurrence: Chatburn Limestone Group, Cfy3-Cfy4 zones, Craven Basin, northwest England and possibly Cfy4 Foraminiferal Zone, Belgium.

Description: The test is large, 700-800 μm diameter. Coiling is irregular until the final whorl when it is oscillant. There are four to five whorls. Whorl expansion is moderate. There are six and a half to nine chambers in the last whorl, and they are well developed and inflated. The septae are thick, slightly inflated with blunt tips. The septae are anteriorly directed and slightly curved, making the chambers bulge. Supplementary deposits occur in the form of corner fillings, lateral deposits and basal nodes. These nodes become blunt spines in the penultimate three to four chambers terminating in a large thick hooked spine in the last chamber. Sutures are prominent and incised. The wall is 25-35 μm thick. There is a thin outer tectum, a thick
median layer which is granular and perforate, and a
thin dark inner layer.

Remarks: This form has a superficial resemblance to
Latiendothyranopsis. However, the well developed
basal deposits and the large terminal hooked spine in
the last chamber, together with the finely perforated,
triple layered wall are features which exclude assigna-
tion to Latiendothyranopsis. The new species is rega-
darded as a primitive member of Omphalotis in that
' the coiling does not become planispiral until the last
volution, unlike stratigraphically younger examples
where planispiral coiling is dominant. «Globoen-
doorthyra» ? paratrachida Mamet in Mamet et al. (1986)
from the late Tourmaisian and early Viséan deposits of
British Columbia shows fine perforations in the wall
(see the outermost whorl figured by Mamet et al. 1986,
pl. 6, fig. 13) and may well be an Omphalotis, but has
a thicker wall than O. marchanti sp. nov. None of the
sections figured by Mamet et al. (1986) show a termi-
nal spine, but this may be due to inappropriate orienta-
tion.

Tests figured by Conil & Lys (1964, pl. 31, figs.
607,608) as Plectogyra kosvensis (Lipina) var. mosana
from the V 1b at Dinant and early Viséan deposits of
British Columbia shows fine perforations in the wall
(see the outermost whorl figured by Mamet et al. 1986,
pl. 6, fig. 13) and may well be an Omphalotis, but has
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a thicker wall than O. marchanti sp. nov. None of the
sections figured by Mamet et al. (1986) show a termi-
nal spine, but this may be due to inappropriate orienta-
tion.

Subfamily Endothyranopsideae Reitlinger, 1958
Genus Latiendothyranopsis Lipina, 1977
Latiendothyranopsis lancastria sp. nov.
(Pl. 4, figs. 15, 17, 22)
1980 Latiendothyranopsis sp. : Conil et al., pl. 2, fig.4.

Derivation of name: From the latin name for Lan-
cashire the county to which the type locality belongs.

Diagnosis: A moderate sized Latiendothyranopsis with
subquadrate coiling.

Type material: Holotype specimen, MPK 9394
(sample RH1382, Pl. 4, fig. 17) 23.8 m below the base
of the Chadian Stage; paratypes MPK 9393, 9395,
respectively 84.40 and 86.40m above the base of the
Chadian Stage, Chatburn (A59) by-pass road cutting,
Chatburn, Lancashire, northwest England, Bankfield
East Beds, Chatburn Limestone Group, late Tourna-
sisian, Cf4a1 Subzone.

Occurrence: Cf4a1 Subzone, England.

Description: The test is moderate sized, 520-620 μm
diameter, with three to four whorls. Whorl expansion
is moderate but slow in the final whorl. Coiling is
streptospiral until the final whorl, which is aligned but
slightly oscillant and subquadrate. There are eight to
eight and a half chambers per whorl. These chambers
are slightly inflated and subquadrate. The septae are
anteriorly directed and long, with wedge shaped tips.
The sutures are weak. The wall is granular, 20 μm thick,
with an outer tectum and a thin inner dark layer.

Remarks: This species is similar to Latiendothy-
ranopsis menneri (Bogush & Juferev, 1962) in the size,
number of chambers and subquadrate periphery. The
new species differs however in being much thinner
walled, with fewer inclusions and more delicate septae.
The closest species is L. shiloi Conil in Shilo et
al.(1984), from the late Tournaisian of Siberia.
However L. shiloi has a greater diameter (650-800 μm)
and lacks the thin dark inner layer to the wall.

ACKNOWLEDGEMENTS

I would like to thank F. Brenckle, E. Groessens, L.
Hance, M. Laloux, M. Legrand-Blain, E. Poty & G.
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for this study was collected by a former colleague, M.
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PLATE 1

All magnifications are X75 unless otherwise stated
All specimens are from the Bankfield East Beds unless otherwise stated

*Brunzia pseudopulchra* (Lipina, 1955)
1. Courceyes, 9.4 m below top, near sagittal section, MPK 9312 (RH 1354).
2. Chadian, 125 m above base, axial-tangential section, MPK 9313 (AL 6017).
3. Courceyes, 3.4 m below top, ex axial-tangential section, MPK 9314 (RH 1360).
4. Chadian, 27.56 m above base, ex sagittal section, juvenile MPK 9315 (AL 5917).
5. Chadian, 10.2 m above base, axial section, juvenile, MPK 9316 (AL 5898).
6. Courceyes, 9.4 m below top, sagittal section, MPK 9317 (RH 1354).
7. Courceyes, 3.4 m below top, ex axial-tangential section, MPK 9318 (RH 1360).
22. Chadian, 27.56 m above base, tangential section, juvenile, MPK 9319 (AL 5917).

*Eotextularia mongeri* Mamet, 1976
4. Chadian, 8.96 m above base, longitudinal section, MPK 9320 (AL 5897).

*Parachaetites* sp.
13. Courceyes, 16.1 m below top, MPK 9321 (AL 5873), X25.

*Brunzia spirillonoides* (Grozdilova & Glebovskaya, 1948).
7. Chadian, 84.4 m above base, axial section, MPK 9322 (AL 5975).
25. Chadian, 17.56 m above base, ex axial section, MPK 9323 (AL 5905).

*Atractyloopsis* sp.
8. Chadian, 10.2 m above base, MPK 9324 (AL 5898), X25.
23. Chadian, 111.4 m above base, MPK 9325 (AL 6003).

*Salebra sibirica* Bogush, 1976
9. Courceyes, 13.6 m below top, MPK 9326 (RH 1350).
12. Courceyes, 25.9 m below top, MPK 9327 (RH 1379).
15. Chadian, 42.62 m above base, MPK 9328 (AL 5932).

*Koninckopora* sp. (monolaminar)
11. Chadian, 8.96 m above base, MPK 9329 (AL 5897), X25.
16. Chadian, 145.8 m above base, Bold Venture Beds, MPK 9330 (AL 6035), X25 (the apparent presence of a bilaminar wall in this specimen and Fig. 19 is not primary, but an artefact due to incomplete filling of the pores by sediment).
19. Chadian, 150.8 m above base, Bold Venture Beds, MPK 9331 (AL 6040), X25.
20. Chadian, 124.0 m above base, MPK 9332 (AL 6016), X25
26. Chadian, 88.4 m above base, MPK 9333 (AL 5979), X25.

*Ortonella* sp.
14. Chadian, 40.84 m above base, MPK 9334 (AL 5930).
17. Chadian, 80.4 m above base, MPK 9335 (AL 5971).

*Girvanella* sp.
21. Chadian, 122.0 m above base, MPK 9336 (AL 6014).

*Paracaligelloides* sp.
24. Chadian, 90.4 m above base, MPK 9337 (AL 5981).
PLATE 2

All magnifications are X75
All specimens are from the Bankfield East Beds unless otherwise stated

Granuliferella campinei (Conil & Lys, 1964)
1. Chadian, 72.8 m above base, slightly ex sagittal section, MPK 9338 (AL 5963).
3. Courcayan, 3.4 m below top, sagittal section, MPK 9339 (RH 1360).
10. Chadian, 152.8 m above base, Bold Venture Beds, sagittal section, MPK 9340 (AL 6042).
16. Chadian, 77.4 m above base, sagittal section, MPK 9342 (AL 5968).
19. Courcayan, 23.8 m below top, ex-sagittal section, MPK 9343 (RH 1382).

Endothyra sp.
2. Chadian, 10.2 m above base, near axial section, MPK 9356 (AL 5898).

Endothyra laxa (Conil & Lys, 1964) (see also pl. 5, fig. 5)
5. Courcayan, 23.8 m below top, sagittal section, MPK 9349 (RH 1382).

Latiendothyranopsis sp.
6. Chadian, 109.4 m above base, ex-axial section, MPK 9357 (AL 6001).
7. Chadian, 130.4 m above base, sagittal section, MPK 9358 (AL 6022).

Plectogyranopsis convexa (Rauer-Chernousova, 1948)
4. Chadian, 10.2 m above base, slightly ex-sagittal section, MPK 9345 (AL 5898).
8. Chadian, 8.96 m above base, sagittal section, MPK 9346 (AL 5987).
9. Chadian, 8.96 m above base, sagittal section, MPK 9347 (AL 5987).
11. Chadian, 85.4 m above base, slightly ex-sagittal section, MPK 9348 (AL 5976).

Tournayellina beata (Malakhova, 1956)
12. Chadian, 46.5 m above base, sagittal section, MPK 9350 (AL 5936).

Mediocris sp.
13. Chadian, 91.4 m above base, axial section, MPK 9351 (AL 5982).

Palaeospiroplectammina cravenensis sp. nov.
14. Chadian, 10.2 m above base, longitudinal section, holotype MPK 9352 (AL 5898).

Granuliferella sp.
15. Chadian, 8.96 m above base, sagittal section, MPK 9341 (AL 5897).

Plectogyranopsis stricta (Conil & Lys, 1964)
17. Chadian, 8.96 m above base, sagittal section, MPK 9344 (AL 5897).

Latiendothyranopsis floraviae Conil in Groessens et al., 1982
20. Chadian, 57.8 m above base, sagittal section, MPK 9353 (AL 5948).

Latiendothyranopsis grandis (Lipina, 1955)
21. Courcayan, 0.5 m below top, sagittal section, MPK 9354 (AL 5888).

Endospiroplectammina sp.
18. Chadian, 94.4 m above base, longitudinal section, MPK 9355 (AL 5986).
PLATE 3

All magnifications are X75
All specimens are from the Bankfield East Beds unless otherwise stated

*Endothyra* sp.
1. Chadian, 10.2 m above base, sagittal section, MPK 9359 (AL 5898).
2. Chadian, 8.96 m above base, axial section, MPK 9360 (AL 5897).
4. Chadian, 6.84 m above base, axial section, MPK 9361 (AL 5895).
5. Chadian, 32.76 m above base, axial section, MPK 9362 (AL 5922).
6. Chadian, 125 m above base, sagittal section, MPK 9363 (AL 6017).
8. Chadian, 10.2 m above base, sagittal section, MPK 9364 (AL 5898).

*Florennella* sp.
3. Chadian, 61.8 m above base, near axial section, MPK 9374 (AL 5952).

*Septabrusiina (Spinobrausiina)* sp.
7. Chadian, 125 m above base, axial-tangential section, MPK 9365 (AL 6017).
11. Chadian, 125 m above base, axial-tangential section, MPK 9372 (AL 6017).

*Eblanaia michoti* (Conil & Lys, 1964)
9. Chadian, 141.8 m above base, Bold Venture Beds, near sagittal section, MPK 9366 (AL 6031).
12. Chadian, 8.4 m above base, axial section, MPK 9367 (RH 1372).
13. Chadian, 126.6 m above base, axial-tangential section, MPK 9368 (AL 6019).
15. Chadian, 40.84 m above base, near sagittal section, MPK 9369 (AL 5930).
16. Chadian, 114.3 m above base, near tangential section, MPK 9370 (AL 6006).
17. Courceyan, 4.6 m below top, ex axial-tangential section, MPK 9371 (AL 5884).

*Florennella stricta* (Conil & Lys, 1964) (see also Pl. 5, figs. 3,4)
10. Chadian, 85.4 m above base, oblique axial section, MPK 9375 (AL 5976).

*Omphalotis marchanti* sp. nov. (see also Pl. 6, figs 11, 14, 18, 19, 20)
14. Courceyan, 11.4 m below top, ex-sagittal section, paratype MPK 9373 (RH 1352).
PLATE 4

All magnifications are X75
All specimens are from the Bankfield East Beds

Septabrauniina (Spinobrauniina) ramsbottomi Conil & Longerstaey in Conil et al., 1980
1. Chadian, 40.84 m above base, near sagittal section, MPK 9376 (AL 5930).
7. Courcryan, 16.62 m below top, ex sagittal section, MPK 9377 (RH 1347).
8. Chadian, 93.4 m above base, near sagittal section, MPK 9378 (AL 5984).
14. Chadian, 125 m above base, sagittal section, MPK 9379 (AL 6017).
23. Chadian, 5.8 m above base, axial section, MPK 9380 (AL 5894).

Septabrauniina (Spinobrauniina) kalmiusi (Vdovenko in Brazhnikova & Vdovenko, 1973)
2. Chadian, 86.4 m above base, sagittal-tangential section, MPK 9383 (AL 5977).
9. Chadian, 6.84 m above base, sagittal-tangential section, MPK 9384 (AL 5895).
11. Chadian, 62.8 m above base, axial section, MPK 9385 (AL 5953).

Spinoendothryra pietoni (Conil & Lys, 1964)
4. Chadian, 62.8 m above base, axial-tangential section, MPK 9382 (AL 5953).

Endothyra sp.
3. Chadian, 48.44 m above the base, slightly ex-axial section, MPK 9724 (AL 5938).
5. Courcryan, 17 m below top, oblique section, MPK 9381 (AL 5872).

Septabrauniina (Spinobrauniina) landeliesi Conil in Groessens et al., 1982
10. Courcryan, 11.4 m below top, ex axial section, MPK 9386 (RH 1352).

Septabrauniina (Spinobrauniina) robusta Conil in Conil et al., 1981
12. Courcryan, 24.2 m below top, sagittal-tangential section, MPK 9387 (RH 1381).
13. Chadian, 54.7 m above base, axial-tangential section, MPK 9388 (AL 5945).
16. Chadian, 99.4 m above base, near axial section, MPK 9389 (AL 5990).
19. Chadian, 48.44 m above base, ex-axial section, MPK 9390 (AL 5938).
20. Chadian, 8.4 m above base, oblique section, MPK 9391 (RH 1372).
21. Chadian, 99.4 m above base, slightly oblique axial section, MPK 9392 (AL 5990).

Latienothyranopsis lancastria sp. nov.
15. Chadian, 86.4 m above base, axial section, paratype MPK 9393 (AL 5977).
17. Courcryan, 23.8 m below top, near sagittal section, holotype MPK 9394 (RH 1382).
22. Chadian, 84.4 m above base, near sagittal section, paratype MPK 9395 (AL 5975).

Septabrauniina (Spinobrauniina) implicata (Conil & Lys, 1968)
18. Chadian, 114 m above base, oblique sagittal section, MPK 9396 (AL 6003).
PLATE 5

All magnifications are X75
All specimens are from the Bankfield East Beds

_Bessiella_ spp.
1. Chadian, 84.4 m above base, axial-tangential section, MPK 9397 (AL 5975).
2. Chadian, 46.5 m above base, tangential section, MPK 9400 (AL 5936).
6. Chadian, 80.4 m above base, axial-tangential section, MPK 9403 (AL 5971).
9. Courceyan, 1.44 m below top, axial-tangential section, MPK 9407 (RH 1362).
12. Chadian, 58.8 m above base, near axial section, MPK 9404 (AL 5949).
15. Chadian, 10.2 m above base, near axial section, MPK 9405 (AL 5898).
18. Courceyan, 23.8 m below top, axial-tangential section, MPK 9406 (RH 1382).

_Florenella stricta_ (Conil & Lys, 1964) (see also pl. 3, fig. 10)
3. Chadian, 86.4 m above base, near sagittal section, MPK 9401 (AL 5977).
4. Chadian, 10.2 m above base, tangential section, MPK 9402 (AL 5898).

_Endothyra cf. laxa_ (Conil & Lys, 1964) (see also Pl. 2, fig. 5)
5. Chadian, 10.2 m above base, ex-axial section, MPK 9416 (AL 5898).

_Endothyra bowmani_ Phillips, 1846
7. Courceyan, 6.4 m below top, sagittal section, MPK 9408 (RH 1356).
8. Courceyan, 6.4 m below top, axial section, MPK 9409 (RH 1356).
14. Courceyan, 4.6 m below top, sagittal section, MPK 9410 (AL 5884).

_Endothyra modica_ Conil & Naum in Groessens et al., 1982
10. Chadian, 89.4 m above base, near sagittal section, MPK 9411 (AL 5980).

cf. _Tuberoendothyra_ sp.
11. Courceyan, 2.7 m below top, ex sagittal section, MPK 9412 (AL 5886).

_Endothyra_ sp.
13. Chadian, 44.8 m above base, sagittal section, MPK 9413 (AL 5934).
17. Chadian, 69.8 m above base, near sagittal section, MPK 9398 (AL 5960).
20. Courceyan, 4.6 m below top, near sagittal section, MPK 9399 (AL 5884).

_Endothyra_ sp.
16. Chadian, 84.4 m above base, sagittal section, MPK 9414 (AL 5975).

_Dainella_ sp.
19. Courceyan, 1.44 m below top, near axial section, MPK 9415 (RH 1362).
PLATE 6

All magnifications are X75
All specimens are from the Bankfield East Beds unless otherwise stated

Tuberendothyra sp.
1. Courceyan, 6.4 m below top, tangential section, MPK 9417 (RH 1356).

Spinoendothyra cf. paracostifera (Lipina in Grodzilova & Lebedeva, 1954)
2. Chadian, 98.4 m above base, near saggital section, MPK 9418 (AL 5989).

Spinoendothyra mitchelli Conil in Conil et al., 1980
3. Chadian, 10.2 m above base, ex saggital-tangential section, MPK 9419 (AL 5898).
4. Chadian, 55.8 m above base, ex axial section, MPK 9420 (AL 5946).
8. Chadian, 125 m above base, near saggital section, MPK 9421 (AL 6017).
9. Chadian, 72.8 m above base, saggital section, MPK 9422 (AL 5963).

Priscella ex gr. prisca (Rauser-Chernousova & Reitlinger, 1936)
5. Chadian, 58.8 m above base, near saggital section, MPK 9423 (AL 5949).

Endothyra sp.
6. Chadian, 46.5 m above base, ex axial section, MPK 9424 (AL 5936).
13. Chadian, 126.6 m above base, oblique axial section, MPK 9425 (AL 6019).
15. Chadian, 141.8 m above base, Bold Venture Beds, near axial section, MPK 9427 (AL 6031).

Spinoendothyra recta (Lipina, 1955)
7. Chadian, 61.8 m above base, near saggital section, MPK 9432 (AL 5952).

cf. Spinobrunsiina sp.
10. Chadian, 84.4 m above base, tangential section, MPK 9435 (AL 5975).

Omphalotis marchanti sp. nov.
11. Courceyan, 16.1 m below top, near axial section of juvenile?, paratype MPK 9431 (AL 5873).
14. Chadian, 18.3 m above base, ex saggital section, paratype MPK 9426 (AL 5907).
18. Chadian, 10.2 m above base, saggital section, paratype MPK 9428 (AL 5898).
19. Chadian, 126.6 m above base, oblique saggital section, paratype MPK 9429 (AL 6019).
20. Chadian, 126.6 m above base, slightly ex saggital section, holotype MPK 9430 (AL 6019).

Endothyra cf. introjectans (Conil & Lys, 1964).
12. Chadian, 92.4 m above base, tangential section, MPK 9433 (AL 5983).

Dainella micula Postojalko, 1970
16. Chadian, 84.4 m above base, ex axial section, MPK 9434 (AL 5975).
17. Courceyan, 5.5 m below top, ex axial section, MPK 9435 (RH 1358).