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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, *Latiendothyranopsis lancastria* sp. nov., *Omphalotis marchanti* sp. nov. and *Palaeospiroplectammina cravenensis* sp. nov. The assemblages correlate with the Cf4a1 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 Cf4 Foraminiferal Zone and the Moliniacian Stage as recognised by the first appearance of the definitive conodont *Mestognathus praebeckmanni*, 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, *Eoparastaffella* Cf4 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 *Eoparastaffella*» 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-Arundian) 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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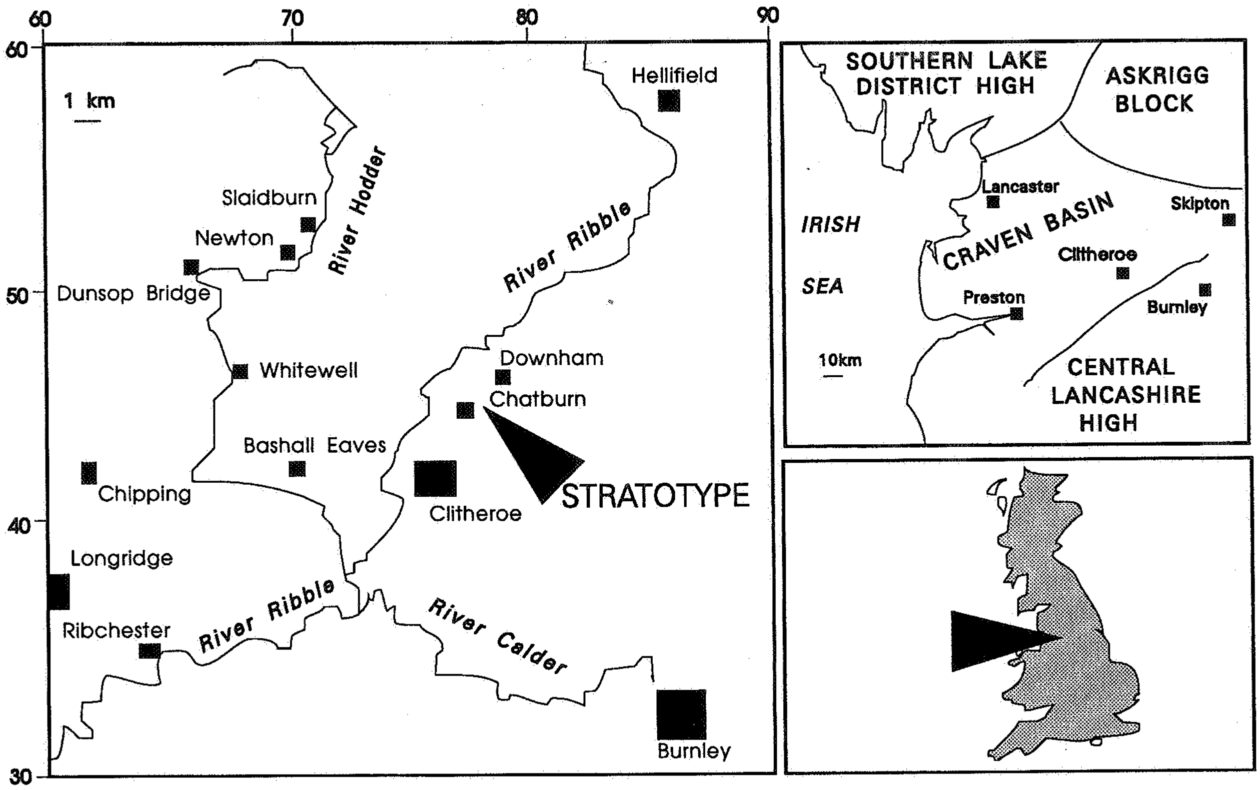


Figure 1. Location of the Chadian stratotype. The palaeotectonic setting during the mid-Dinantian is represented in the top right of the figure. The numbers surrounding the left hand part of the figure relate to the 10 km square UK National Grid (100 km sector SD) with grid north at the top of the figure.

Carboniferous, Variscan inversion of the Craven Basin, a Dinantian extensional basin, bounded by the Southern Lake District High and Askrigg 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 Askrigg Block (Arthurton *et al.*, 1988), lay within the Chatburn Limestone.

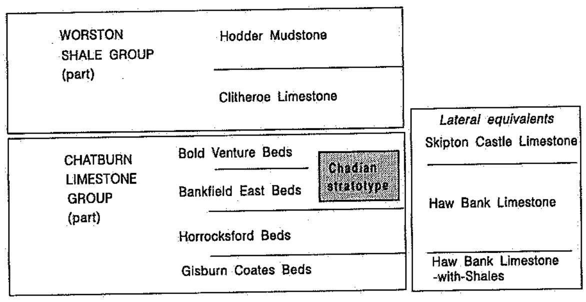


Figure 2. Simplified lithostratigraphy of the Chatburn Limestone.

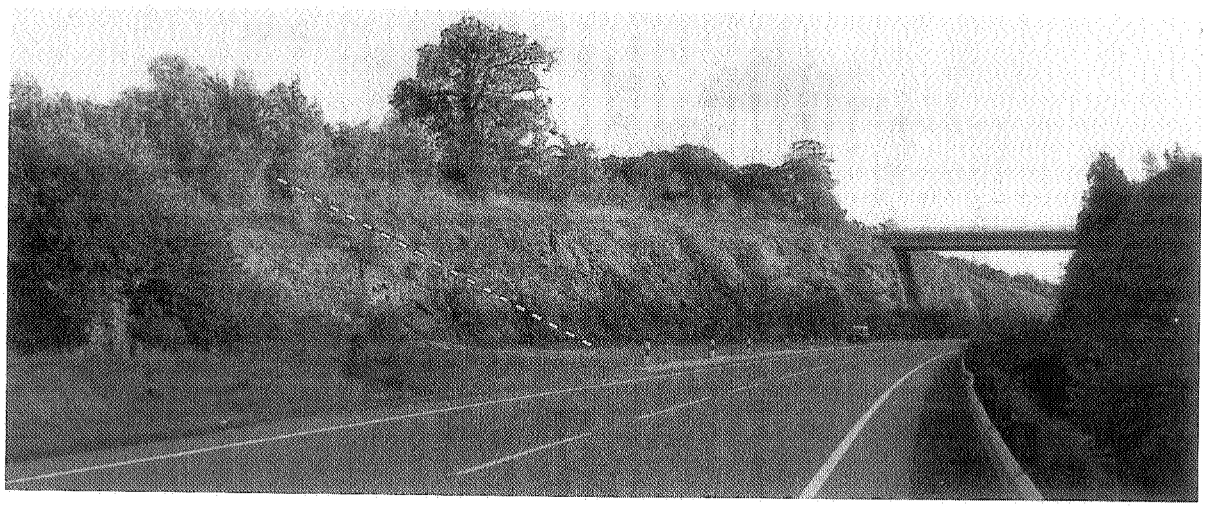
Of particular relevance to the Chadian Stratotype was the subdivision of the group into the following informal lithostratigraphical units by Earp *et al.* (1961, p. 24), based on faunal observations in the quarries west of Chatburn previously mentioned. From the top downwards these subdivisions are :

«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 *Cyathoclisia 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 *Cyathoclisia 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



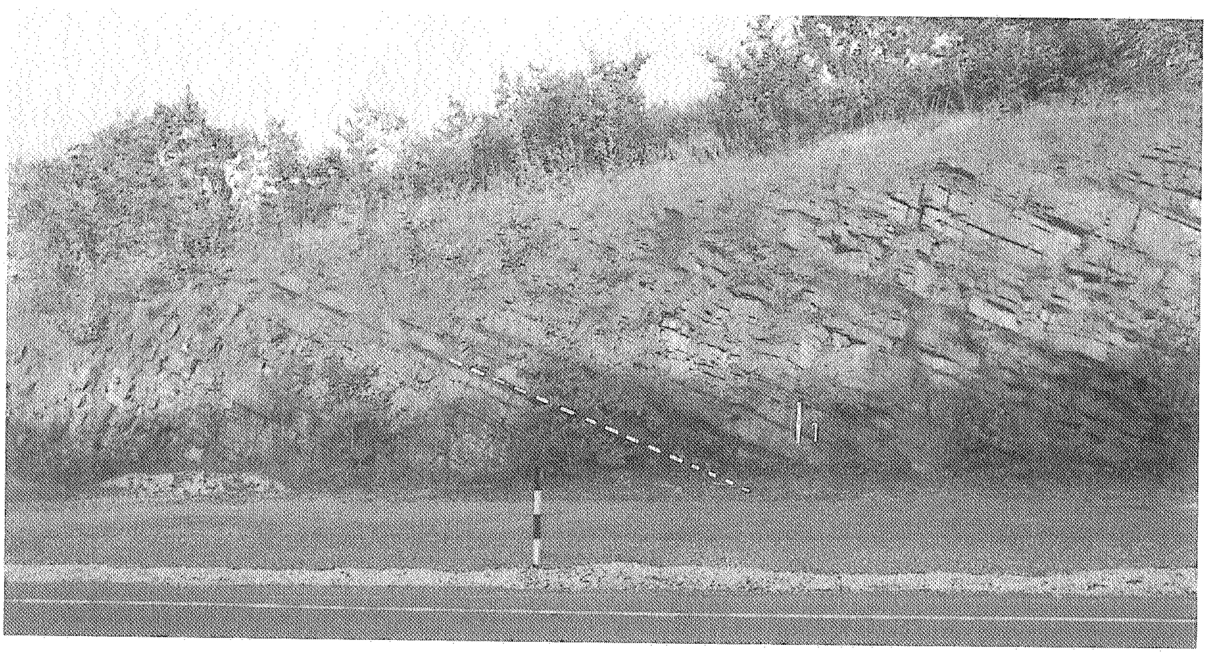


Figure 3. Photographs of the basal boundary of the Chadian Stage (dotted line) at the stratotype on the east side of the Chatburn by-pass road (A59) cutting (SD 7743 4442), in September 1992. This is the boundary as photographed in Ramsbottom (1981). Vertical scale (on the second photo) is 1 m.

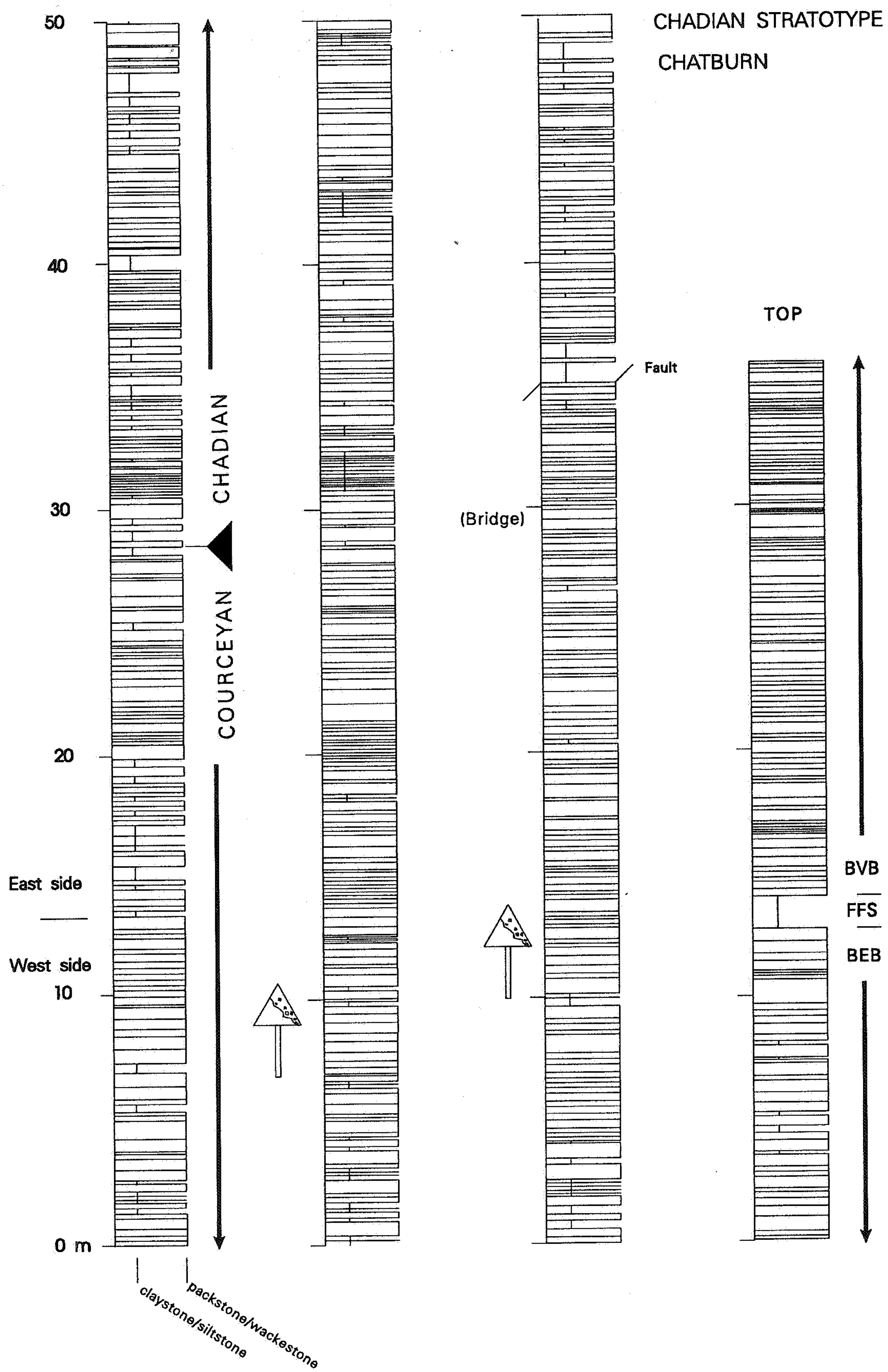


Figure 4. Lithological log of the the Chadian stratotype, Chatburn by-pass road (A59) cutting (SD 7743 4442). Location points such as ; east side, west side, traffic signs and bridge are reference points along the section and refer to the column on the immediate right. The fault is a small reverse fault 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 mustones (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 rela-tions 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 Arthurton, 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. Kamaeniids and stacheiinids 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. *Cyathoclisia modavensis* has not been found. Brachiopods tend to be mud tolerant «recliners» (Rudwick, 1970), such as productoids, orthotetoids and chonetoids. Fenestellid bryozoan 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 chondritiform types are noticed in thin section.

Micritisation of bioclasts is common and some beds contain peloids. Stylolites are common, particularly in silty limestones and siltstones, where many grain contacts are corroded and stylolitic. 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. *barsae* (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. *parakosvensis*, *Palaeospiroplectammina* 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., *Chernobaculites* sp., *Eblanaia michoti*, *Eblanaia* sp., cf. *Eblanaia* sp., *Endothyra bowmani* Phillips, *E. concava* Malakhova, *E. laxa* (Conil & Lys), *E. lensi* (Conil & Lys), *E.* aff. *paraspinosa* Skipp, *E.* spp., *Eotextularia diversa* (N. Tchernysheva), *Glomospiranella* cf. *barsae* (Conil & Lys), *G.* cf. *uralica* (Lipina), *Granuliferella* aff. *campinei* (Conil & Lys), *Latiendothyranopsis* sp., *Septabrunsiina* (*Spinobrunsiina*) cf. *ramsbottomi* Conil & Longerstaey, cf. *Septabrunsiina* (*Spinobrunsiina*) sp., *Spinochernella* cf. *brencklei* Conil & Lys, *Spinoendothyra mitchelli* Conil, *Spinoendothyra praeclara* Conil & Longerstaey (holotype), *Spinoendothyra* sp. and *Tuberendothyra* sp. These records were accompanied by their lithostratigrahical 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* Arthurton *et al.*, 1988, p.40) reported Foraminifera from the Chatburn Limestone of the Slaidburn Anticline. Her record (Strank *in* Arthurton *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*, *Florennella* 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 (=Horrocksford Beds) contains *Lugtonia* and *E. laxa*, according to Fewtrell & Smith (1978), implying a Cf4á1 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 Gisburn Coates Beds included; *Cyathoclisia tabernaculum*, *Productus* (*Dictyoclostus*) aff. *vaughani* Muir-Wood, *Fasciculophyllum* sp. , aff. *Koninckophyllum praecursor* Howell, *Spirifer* (*Palaeochoristes*) 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. omaliusi* (Edwards & Haime), *F.* cf. *densum* (Carruthers), *Productus* (*Pustula*) aff. *pyxidiformis* de Koninck, *Schuchertella* aff. *aspis* Smyth, *S. wexfordensis* Smyth and *Spirifer tornacensis* de Koninck. The Bold Venture Beds marked the entry of *Productus* (*Plicatifera*) *humerosus* J. Sowerby (now *Levitusia*), other taxa included *Chonetes* cf. *papilionaceus*, *Fasciculophyllum* cf. *omaliusi*, *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 Bh. which included : *Buxtonia* sp., *Caninophyllum* ?, *Fasciculophyllum omaliusi*, *Megachonetes* sp., *Pugilis* sp., *Pustula* sp., *Syringothyis* cf. *elongata* North, *Syringopora* cf. *ramulosa* Goldfuss, *S.* cf. *vaughani* Hudson, and *Zaphrentites delanouei*. Mitchell (*in* Arthurton *et al.*, 1988) recorded the following from the Chatburn Limestone, Stockdale Farm Formation ; *Delepinea* 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*, *Mitchelinia favosa* (Goldfuss), *Paleacis* cf. *cuneiformis* Haime, *Sychnoelasma hawbankensis* Mitchell & Somervile, *S. konincki*, *Syringopora favositoides* Vaughan, *S. reticulata* Goldfuss, *S. vaughani* Hudson and *Zaphrentites delanouei*. Interestingly from this interval Poty (in Paproth *et al.*, 1983, p. 189) recorded *Haplolasma* aff. *subibicinum*, *Palaeosmilia murchisoni* and *Sychnoelasma urbanowitschi* although Mitchell (pers. comm., 1990) points out that the sample of *P. murchisoni* contains archaedscid foraminifera and therefore could not have come from the Haw Bank Limestones; certainly this record is anomalous with mine and all other observations (Fewtrell & Smith, 1978 ; Fewtrell *et al.*, 1981 ; Arthurton *et al.*, 1988). 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 controversial 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 *Scaliognathus anchoralis* Conodont Zone equivalent to the Cf3 Foraminiferal Zone. According to Conil *et al.*, (1991) *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 pyxidiformis* 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 praebeckmanni* (recorded as *Mestognathus* cf. *beckmanni*, Sevastopulo pers. comm., 1991). *Levitusia humerosa*, which enters in the Bold Venture Beds characterises brachiopod faunas around the Tournaisian/Viséan Boundary interval (Legrand-Blain, 1991).

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 gnathodids and is maintained in the shallow water and long ranging *Pseudopolygnathus mehli* 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 *Cloghergnathus 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), *Clydagnathus ? hudsoni* Metcalfe, *Polygnathus communis communis* Branson & Mehl (Haw Bank Limestone only), *P. lacinatus asymmetricus* 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.

Brunsia and *Septabrunsiina* (*Spinobrunsiina*) are the commonest. This contrasts with rare presence of *Brunsia* 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 *Pseudotaxis* 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 *Eotextularia diversa* and *Spinoendothyra praeclara* recorded by Conil *et al.* (1980) from this section, has not been confirmed in this study, although large fragments of *Eotextularia* 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. *introjactans*, *Eotextularia 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 archaediscidae 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 *Koninckopora* 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 Cf4bSubzone 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 sedimentological 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 praebeckmanni* Sandberg, Johnson, Orchard & Von Bitter. Conil *et al.* (1989, 1991) correlate this with the base of the Cf4 Foramininiferal 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 entry 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 praebeckmanni* 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.

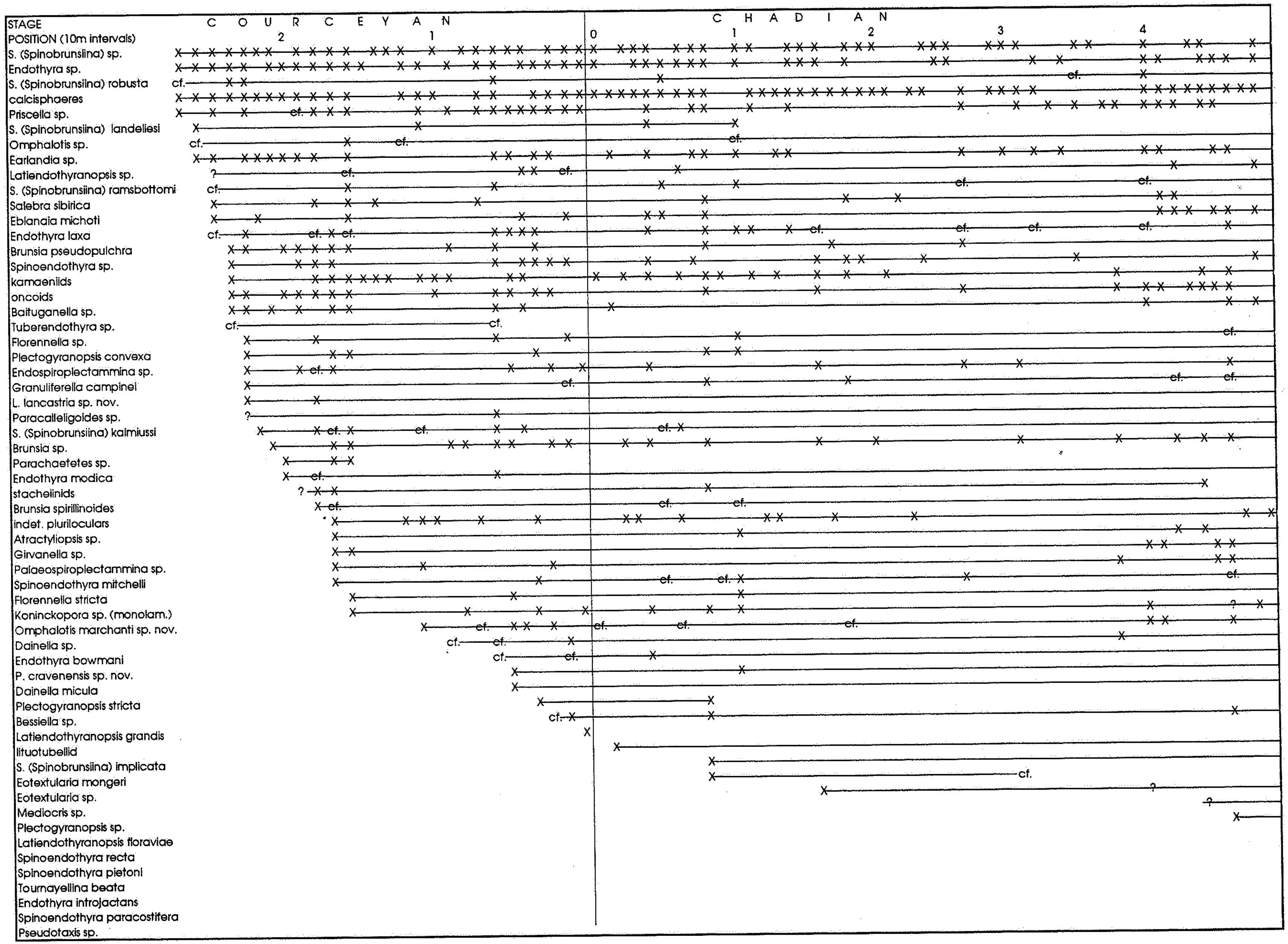
Until a thick carbonate ramp sequence yielding abundant conodonts, corals and foraminifera is studied in detail, the relationship between the Moliniacian as defined by conodonts and recognised by the other groups will remain unresolved. It is possible that this relationship may be severely diachronous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

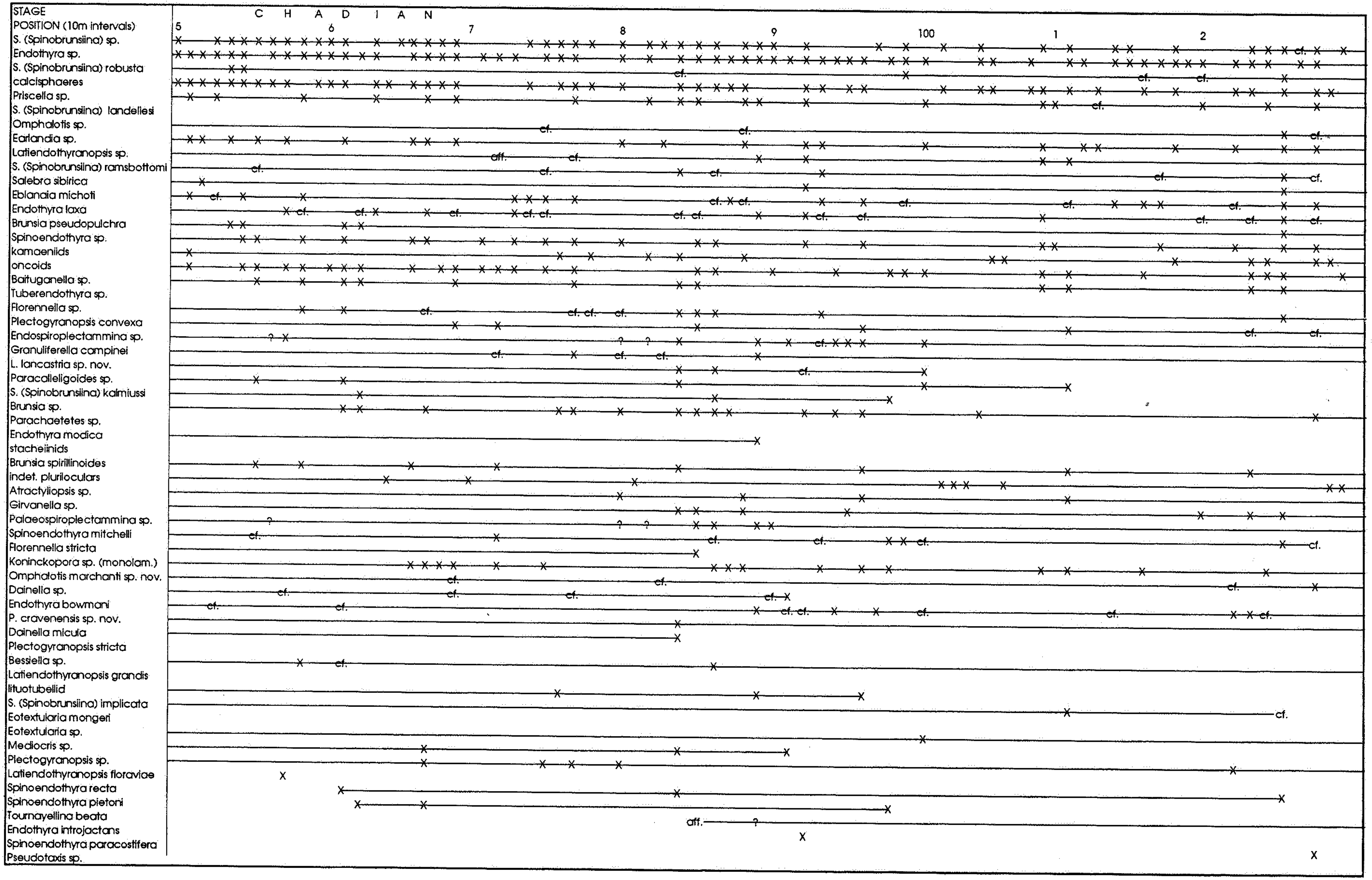
In terms of current understanding of foraminiferal zonation, the Chadian stratotype foraminifera fall within the Cf4a1 Subzone of the *Eoparastaffella* Cf4 Foraminiferal Zone. Significant components include the combination of *Bessiella*, *Brunsia*, *Dainella*, *Florennella*, *Mediocris*, *Omphalotis* and *Plectogyranopsis*. Species present which from published data enter at or above the Cf4 Foraminiferal Zone include *Endothyra laxa*, *E.* cf. *introjactans*, *E. modica*, *Florennella stricta*, *Granuliferella campinei*, *Latiendothyranopsis floraviae*, *Plectogyranopsis convexa*, *P. stricta*, *Spinobrunsiina implicata*, *S. kalmiussi*, *S. landeliesi*, *S. ramsbottomi*, *Spinoendothyra mitchelli* and *S. pietoni*. Unfortunately it has not been possible to resolve the precise identity of the *Endospiroplectammina* and lituotubellid 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 *Brunsia* 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 tetrataxids known, are reported from Ireland by Marchant *et al.* (1984), in the *Dollymae bouckaerti* Conodont Subzone around the base of the Cf3 Foraminiferal Zone, slightly preceeding their entry in Belgium. The absence of the tetrataxid *Valvullinella* 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. *Eotextularia* is another component which ranges into the Cf4 Foraminiferal Zone from Cf3, *Eotextularia mongeri* is associated with late Tournaisian 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 *Palaeospiroplectammina cravenensis* sp. nov. Of these only *P. cravenensis* has been recognised elsewhere, from the late Tournaisian to early Viséan interval in Ireland (Marchant *op. cit. in* Fewtrell *et al.*, 1981), Wales (Davies *et al.* 1989) and Turkey (Dîl, 1975).

Of the algae, the dasyclad *Koninckopora* is unknown from strata below the Cf4a1 Subzone, and hitherto monolaminar *Koninckopora* has been used as a Chadian guide. It is here recorded from Courceyan rocks for the first time.


STAGE
C O U R C E Y A N
C H A D I A N
POSITION (10m intervals)
2
1
0
1
2
3
4
S. (Spinobrunsiina) sp.
Endothyra sp.
S. (Spinobrunsiina) robusta
calcisphaeres
Priscella sp.
S. (Spinobrunsiina) landeliesi
Omphalotis sp.
Earlandia sp.
Latiendothyranopsis sp.
S. (Spinobrunsiina) ramsbottomi
Salebra sibirica
Eblanaia michoti
Endothyra laxa
Brunsia pseudopulchra
Spinoendothyra sp.
kamaeniids
oncoids
Baituganella sp.
Tuberendothyra sp.
Florennella sp.
Plectogyranopsis convexa
Endospiroplectammina sp.
Granuliferella campinei
L. lancastria sp. nov.
Paracalleigoides sp.
S. (Spinobrunsiina) kalmiussi
Brunsia sp.
Parachaetetes sp.
Endothyra modica
stacheiinids
Brunsia spirillinoides
indet. pluriloculars
Atractyliopsis sp.
Girvanella sp.
Palaeospiroplectammina sp.
Spinoendothyra mitchelli
Florennella stricta
Koninckopora sp. (monolam.)
Omphalotis marchanti sp. nov.
Dainella sp.
Endothyra bowmani
P. cravenensis sp. nov.
Dainella micula
Plectogyranopsis stricta
Bessiella sp.
Latiendothyranopsis grandis
lituotubellid
S. (Spinobrunsiina) implicata
Eotextularia mongeri
Eotextularia sp.
Mediocris sp.
Plectogyranopsis sp.
Latiendothyranopsis floraviae
Spinoendothyra recta
Spinoendothyra pietoni
Tournayellina beata
Endothyra introjactans
Spinoendothyra paracostifera
Pseudotaxis sp.


STAGE
C H A D I A N
POSITION (10m intervals)
5
6
7
8
9
100
1
2
S. (Spinobrunsiina) sp.
Endothyra sp.
S. (Spinobrunsiina) robusta
calcisphaeres
Priscella sp.
S. (Spinobrunsiina) landeliesi
Omphalotis sp.
Earlandia sp.
Latiendothyranopsis sp.
S. (Spinobrunsiina) ramsbottomi
Salebra sibirica
Eblanaia michoti
Endothyra laxa
Brunsia pseudopulchra
Spinoendothyra sp.
kamaeniids
oncoids
Baituganella sp.
Tuberendothyra sp.
Florennella sp.
Plectogyranopsis convexa
Endospiroplectammina sp.
Granuliferella campinei
L. lancastria sp. nov.
Paracalleligoides sp.
S. (Spinobrunsiina) kalmiussi
Brunsia sp.
Parachaetetes sp.
Endothyra modica
stacheiinids
Brunsia spirillinoides
indet. pluriloculars
Atractyliopsis sp.
Girvanella sp.
Palaeospiroplectammina sp.
Spinoendothyra mitchelli
Florennella stricta
Koninckopora sp. (monolam.)
Omphalotis marchanti sp. nov.
Dainella sp.
Endothyra bowmani
P. cravenensis sp. nov.
Dainella micula
Plectogyranopsis stricta
Bessiella sp.
Latiendothyranopsis grandis
lituotubellid
S. (Spinobrunsiina) implicata
Eotextularia mongeri
Eotextularia sp.
Mediocris sp.
Plectogyranopsis sp.
Latiendothyranopsis floraviae
Spinoendothyra recta
Spinoendothyra pietoni
Tournayellina beata
Endothyra introjactans
Spinoendothyra paracostifera
Pseudotaxis sp.
cf.
aff.
?

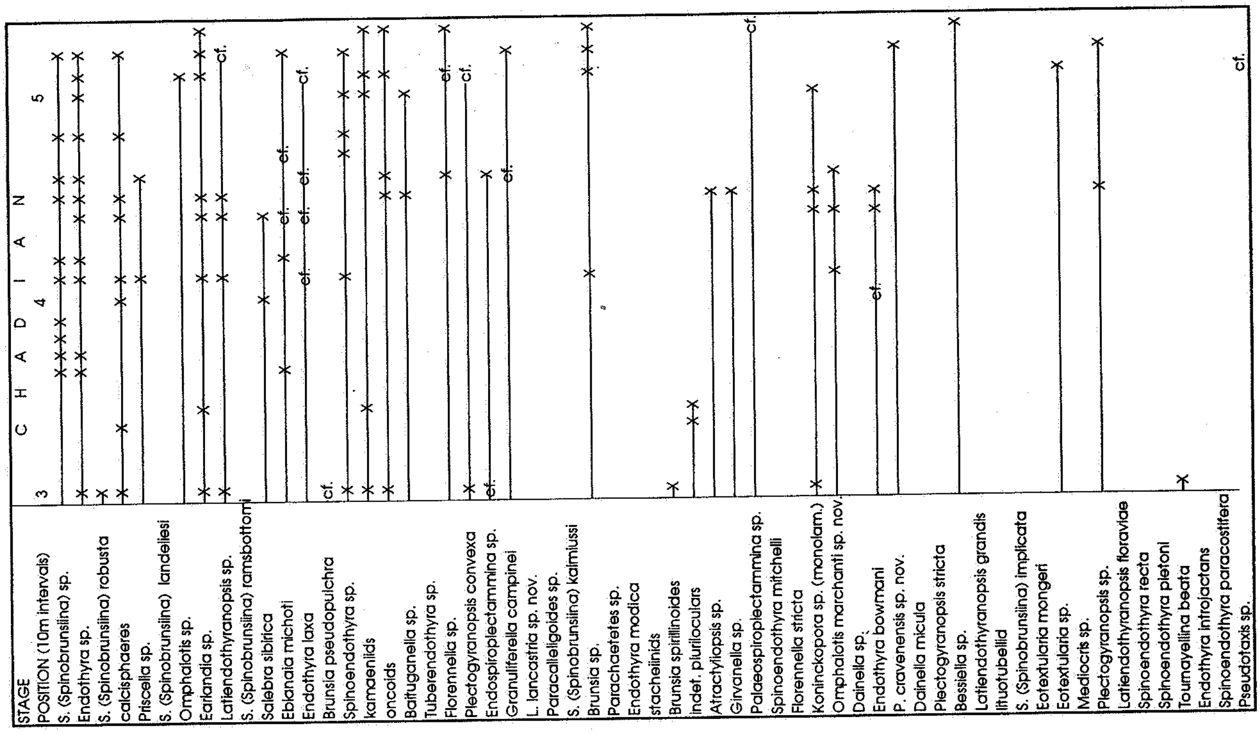


Figure 5. Summarized total ranges of foraminifera and algal components in the Chadian stratotype, based on the samples investigated in the present study. Single figures denote 10m intervals from the basal Chadian boundary. Abbreviations ; X, cf., ? denote presence in each meter interval. Genera ; L., *Latiendothyranopsis* ; P., *Palaeospiroplectammina* ; S., *Septabrunsiina.*

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 archaediscids 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 Courceyan 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 praebeckmanni* in conodont assemblages, limiting its usefulness as a definitive guide.

As a minimum requirement it is necessary to abandon the Chadian, extend the Courceyan 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 Tournaisian, the base of which could be recognised using the first appearance of the widespread and easily identifiable conodont *Scaliognathus*.

At present the Tournaisian/Viséan boundary interval is being investigated by the IUGS Subcommission on Carboniferous Stratigraphy as a global interval for subdivision of the Lower Carboniferous (Brenckle, 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 archaediscids. Clearly it would be desirable for formal chronostratigraphical revision of the late Courceyan 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 Tournaisian 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

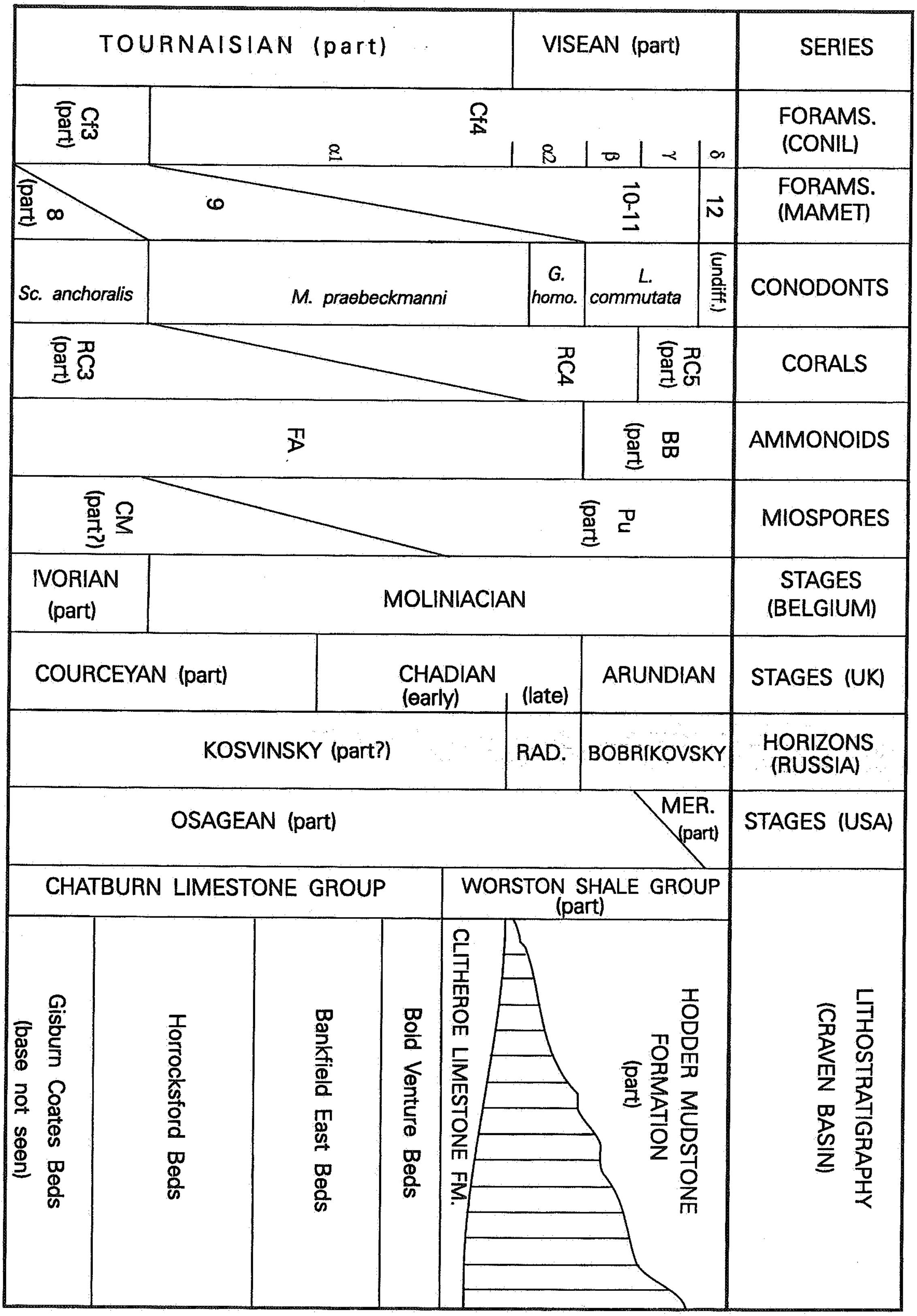


Figure 6. Chronostratigraphic correlation of the Tournaisian/Viséan boundary interval derived from various sources. The bases of the *Mestognathus praebeckmanni* Zone and the Cf4 Foraminiferal Zone are equated following current practice, however it is possible that base of the Cf4 Foraminiferal Zone preceeds 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-sequence. 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 Chernyshinellinae Reitlinger, 1958
Genus *Palaeospiroplectammina* Lipina, 1965
Palaeospiroplectammina cravenensis sp. nov.
(Pl. 2, fig. 14)

1975 *Palaeospiroplectammina mellina* (Malakhova); Dîl: pl. 3, fig. 33.
1977 cf. *Palaeospiroplectammina mellina* (Malakhova); Conil: pl. 2, fig. 15.
1981 *Paleospiroplectammina mellina* (Malakhova) subsp.; Fewtrell *et al.*: pl. 3.3, figs. 9-10.
1989 *Palaeospiroplectammina* 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 *Palaeospiroplectammina* 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 Tournaisian, Chatburn, northwest England. Paratype, BGS specimen JD 5007 (Davies *et al.*, 1989, fig. 10m), Lwyn-y-frân (SJ 188 586), N. Wales, Foel Formation, Cf4a2 Subzone, Late Chadian.

Occurrence : Cf4a1-2 subzones in the Craven and Dublin basins (Fewtrell *et al.*, 1981), and Wales (Riley *in* Davies *et al.* 1989; Riley *in* Barclay, 1989). Dîl'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 synonomy. 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 Endothyrinae Brady, 1884
Genus *Omphalotis* Schlykova, 1969
Omphalotis 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 (A59) by-pass road cutting, Chadian stratotype, 126.6 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, Cf4a1 Subzone.

Occurrence : Chatburn Limestone Group, Cf3-Cf4 zones, Craven Basin, northwest England and possibly Cf4 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 assignation to *Latiendothyranopsis*. The new species is regarded 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. «*Globoendothyra*» ?*paratrachida* Mamet *in* Mamet *et al.* (1986) from the late Tournaisian 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 terminal spine, but this may be due to inappropriate orientation.

Tests figured by Conil & Lys (1964, pl. 31, figs. 607,608) as *Plectogyra kosvensis* (Lipina) var. *mosana* from the V1b at Dinant may belong to this form. Marchant's (*in* Charsley 1984) record of *Eblanaia* sp. A is here interpreted as an immature example of *O. marchanti* sp. nov.

Subfamily Endothyranopsinae 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 Lancashire the county to which the type locality belongs.

Diagnosis : A moderate sized *Latiendothyranopis* 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 Tournaisian, 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 *Latiendothyranopsis 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.

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APPENDIX

SAMPLE	RH1352	AL5878	RH1353	AL5879	RH1354	AL5880	AL5881	RH1355	AL5882	RH1356	RH1357	AL5883	RH1358	AL5884	RH1359	AL5885	RH1360	AL5886	RH1361	AL5887	RH1362	RH1363	AL5888	RH1364	AL5889	RH1365	AL5890	RH1366	AL5891	RH1367	AL5892	RH1368	AL5893	RH1369	AL5894
POSITION (m) to base Chadian	-11.4	-10.6	-10.4	-9.6	-9.4	-8.7	-7.8	-7.2	-6.6	-6.4	-6.4	-5.6	-5.5	-4.6	-4.6	-3.7	-3.4	-2.7	-2.44	-1.75	-1.44	-0.6	-0.5	0.36	0.42	1.6	1.8	2.4	2.8	3.42	3.86	4.4	4.82	5.4	5.8
Spinobrunsina sp.		X				X	X		X			X	X	X	B				X		X	X	X	X					X		X	X	X		
Endothyra sp.	X			X			X		X	X	X			X			X	X			X	X	X	X							X	X	X	X	X
Spinobr. robusta										X																								X	
calcispheres	X	X	X				X	X	X	X	X				A		X	X		X			X		X	X	X		X		X	X	X		X
Priscella sp.	X				X		X		X				X	X			X		X		X		X									X			
Spinobr. landellesi	X																															X			
Omphalotis sp.															R																				
Earlandia sp.										X			X				X	X								X						X			
Lattendothyranopsis sp.														X			X				cf.														
Spinobr. ramsbottomi										X					R																				X
Salebra sibirica							X																												
Eblanaia michoti														X							X												X	X	
Endothyra laxa										X			X	X	E		X																		
Brunsia pseudopulchra					X					X							X																		
Spinoendothyra sp.										X				X			X	X	X		X												X		
kamaenids	X	X		X									X	X	N									X				X				X			
oncoids			X						X	X	X		X				X	X	X																
Baituganella sp.									X					X												X									
Tuberendothyra sp.										cf.																									
Florennella sp.									X												X														
Plectogyranopsis convexa																	X																		
Endospiroplectammina sp.													X					X					X									X			
G. campinei																					cf.														
L. lancastria sp. nov.																																			
Paracaligelloides sp.									X																										
Spinobr. kalmiussi	cf.								X	X				X																				cf.	
Brunsia sp.					X	X			X				X					X			X								X				X		
Parachaetetes sp.																																			
Endothyra modica										X																									
stachelinids																																			
Brunsia spirillinoides																																		cf.	
Indet. pluriloculars			X					X								X												X		X					
Atractyliopsis sp.																																			
Girvanella sp.																																			
Palaeospiroplectammina sp.	X																		X																
Spinoendothyra mitcheli																	X																	cf.	
Florennella stricta													X																						
Koninckopora sp. (monolam.)						X											X						X									X	X		
O. marchanti sp. nov.	X						cf.						X	X				X						cf.											
Dainella sp.					cf.					cf.											X														
Endothyra bowmani										cf.											cf.												X		
P cravenensis sp. nov.													X																						
Dainella micula													X																						
Plectogyranopsis stricta																	X																		
Bessiella sp.																			cf.		X														
Lattendothyranopsis grandis																							X												
Illuotubella																										X									
Spinobrunsina implicata																																			
Eotextularia mongeri																																			
Eotextularia sp.																																			
Mediocris sp.																																			
Plectogyranopsis sp.																																			
Lattendothyranopsis floraviae																																			
Spinoendothyra recta																																			
Spinoendothyra pietoni																																			
Tournayellina beata																																			
Endothyra introjactans																																			
Spinoendothyra paracostifera																																			
Pseudotaxis sp.																																			

SAMPLE	RH1370	AL5895	RH1371	AL5896	RH1372	AL5897	RH1373	AL5898	AL5899	AL5900	AL5901	AL5902	AL5903	AL5904	AL5905	AL5906	AL5907	AL5908	AL5909	AL5910	AL5911	AL5912	AL5913	AL5914	AL5915	AL5916	AL5917	AL5918	AL5919	AL5920	AL5921	AL5922	AL5923	AL5924	AL5925	AL5926
POSITION (m) to base Chadian	6.34	6.84	7.44	7.8	8.4	8.96	9.44	10.2	11.2	12.2	13.25	14.2	15.22	16.2	17.36	18.04	18.3	18.82	19.7	20.7	21.7	22.7	23.76	24.8	25.56	26.56	27.56	28.56	29.56	30.56	31.56	32.76	33.76	34.7	35.7	36.7
Spinobrunsilina sp.		X		X		X		X	X			X	X	X			X		X	X				X	X	X		B	X	X	X				X	X
Endothyra sp.		X		X	X	X		X				X	X	X			X								X	X						X		X		
Spinobr. robusta																																			cf.	
calcisphaeres	X		X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X		X	X			X	A	X	X	X	X				
Priscella sp.			X	X	X	X			X			X															X				X		X		X	
Spinobr. landeliesi								X																												
Omphalotis sp.								cf.																				R								
Earlandia sp.				X	X			X			X	X															X			X		X		X		
Latiendothyranopsis sp.		X																																		
Spinobr. ramsbottomi								X																			cf.	R								
Solebra sibirica					X												X					X														
Eblanaia michoti					X																															
Endothyra laxa					cf.	X		X	X			X		cf.													cf.	E				cf.				
Brunsia pseudopulchra						X									X												X									
Sphoendothyra sp.				X										X			X		X					X											X	
kamaenids	X				X	X	X		X		X			X		X	X				X							N								
oncoids					X	X								X													X									
Baituganella sp.																																				
Tuberendothyra sp.																																				
Florennella sp.								X																												
Plectogyranopsis convexa						X		X																												
Endospiroplectammina sp.														X													X				X					
G. campinei						X											X																			
L. lancastria sp. nov.																																				
Paracaligoides sp.																																				
Spinobr. kalmiussi		X																																		
Brunsia sp.					X									X						X											X#					
Parachaetetes sp.																																				
Endothyra modica																																				
stacheiinids					X																															
Brunsia spirillinoides								cf.																												
Indet. pluriloculars	X									X	X				X								X													
Atractyliopsis sp.								X																												
Girvanella sp.																																				
Palaeospiroplectammina sp.																																				
Spinoendothyra mitchelli							cf.	X																			X									
Florennella stricta								X																												
Koninckopora sp. (monolam.)						X		X																												
O. marchanti sp. nov.		cf.															cf.																			
Dainella sp.																																				
Endothyra bowmani																																				
P cravenensis sp. nov.								X																												
Dainella micula																																				
Plectogyranopsis stricta						X																														
Bessiella sp.					X																															
Latiendothyranopsis grandis																																				
lituotubellid																																				
Spinobrunsilina implicata					X																															
Eotextularia mongeri						X																									cf.					
Eotextularia sp.														X																						
Mediocris sp.																																				
Plectogyranopsis sp.																																				
Latiendothyranopsis floraviae																																				
Spinoendothyra recta																																				
Spinoendothyra pietoni																																				
Tournayellina beata																																				
Endothyra introjactans																																				
Spinoendothyra paracostifera																																				
Pseudotaxis sp.																																				

SAMPLE	RH1376	RH1377	RH1378	RH1379	RH1380	RH1381	RH1382	RH1383	RH1384	RH1385	RH1386	RH1387	RH1388	RH1389	RH1390	RH1391	RH1392	AL5871	RH1393	RH1346	RH1394	AL5872	RH1395	RH1347	AL5873	RH1396	RH1348	AL5874	RH1349	AL5875	RH1350	AL5876	RH1351	AL5877
POSITION (m) to base Chadian	-27.9	-27.3	-26.7	-25.9	-24.8	-24.2	-23.8	-23.1	-22.3	-21.6	-21.2	-20.6	-20.2	-19.7	-19.2	-18.62	-18.26	-18	-17.62	-17.2	-17.1	-17	-16.62	-16.62	-16.1	-16.1	-15.4	-15	-14.4	-14	-13.6	-12.62	-12.5	-11.8
Spinobrunsiina sp.	X	X	X	X	X	X	X	X	X	X	X			X		X	X	cf.		X	X		X	X		X			X		X		X	
Endothyra sp.	X	X	X	X	X	X	X			X	X	X			X		X			X		X		X	X	X	X						X	
Spinobr. robusta	cf				X		X																											
calcispheres	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X							X	X
Priscella sp.	X			X			X							cf.		X						X		X	X	X								
Spinobr. landellesi			X																															
Omphalotis sp.			cf.																						X								cf.	
Earlandia sp.			X	X			X	X	X	X			X		X		X						X			X								
Latiendothyranopsis sp.				?																			cf.											
Spinobr. ramsbottomi				cf.																				X										
Salebra sibirica				X												X										X				X				
Eblanaia michoti				X					X															X										
Endothyra laxa				cf.			X									cf.				X						cf.								
Brunsia pseudopulchra					X	X	X					X			X			X			X		X			X								
Sphaeroendothyra sp.					X	X									X	X				X														
kamaenids					X											X	X	X	X				X	X			X	X		X	X			X
oncoids					X		X						X	X	X	X				X		X	X		X	X								
Baituganella sp.						X	X				X				X					X					X	X								
Tuberendothyra sp.						cf.																												
Florennella sp.							X									X									X									
Plectogyranopsis convexa							X													X				X										
Endospiroplectammina sp.							X								X	cf.				X														
G. campinei							X																											
L. lancastria sp. nov.							X									X																		
Paracaligoides sp.							?																											
Spinobr. kalmiussi									X							X				cf.				X										
Brunsia sp.											X									X					X									
Parachaetetes sp.													X						X						X									
Endothyra modica													X					cf.																
stacheinids															?	X			X															
Brunsia spirillinoides																		X		cf.														
indet. pluriloculars																			X													X		X
Atractyliopsis sp.																				X														
Girvanella sp.																				X					X									
Palaeospiroplectammina sp.																				X														
Sphaeroendothyra mitchelli																				X														
Florennella stricta																							X											
Koninckopora sp. (monolam.)																								X										
O. marchanti sp. nov.																																		
Dainella sp.																																		
Endothyra bowmani																																		
P cravenensis sp. nov.																																		
Dainella micula																																		
Plectogyranopsis stricta																																		
Bessiella sp.																																		
Latiendothyranopsis grandis																																		
lituotubellid																																		
Spinobrunsiina implicata																																		
Eotextularia mongeri																																		
Eotextularia sp.																																		
Mediocris sp.																																		
Plectogyranopsis sp.																																		
Latiendothyranopsis floraviae																																		
Sphaeroendothyra recta																																		
Sphaeroendothyra pietoni																																		
Tournayellina beata																																		
Endothyra introjactans																																		
Sphaeroendothyra paracostifera																																		
Pseudotaxis sp.																																		

SAMPLE	AL5927	AL5928	AL5929	AL5930	AL5931	AL5932	AL5933	AL5934	AL5935	AL5936	AL5937	AL5938	AL5939	AL5940	AL5941	AL5942	AL5943	AL5944	AL5945
POSITION (m) to base Chadian	37.7	38.7	39.7	40.84	41.7	42.62	43.62	44.8	45.6	46.5	47.8	48.44	49.4	50.2	51.4	52	52.8	53.8	54.7
Spinobrunsina sp.			B	X			X	X				X		X			X	X	X
Endothyra sp.				X	X			X	X	X		X		X	X	X	X	X	X
Spinobr. robusta				X														X	X
calcisphaeres			R	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X
Priscella sp.	X	X		X	X	X		X	X						X		X		
Spinobr. landeliesi																			
Omphalotis sp.			R																
Earlandia sp.				X	X				X	X					X	X		X	
Latiendothyranopsis sp.						X						X							
Spinobr. ramsbottomi			E	cf.															
Solebra sibirica					X	X										X			
Eblanaia michoti					X	X	X		X	X		X			X		cf.		X
Endothyra laxa			N	cf.						X									
Brunsia pseudopulchra																		X	X
Spinoendothyra sp.												X							X
kamaeniids		X						X		X					X				
oncoids		X		X	X		X	X	X	X					X				X
Baituganella sp.				X						X		X							
Tuberendothyra sp.																			
Florennella sp.										cf.									
Plectogyranopsis convexa																			
Endospiroplectammina sp.										X									
G. campinei						cf.				cf.									
L. lancastria sp. nov.																			
Paracaligelloides sp.																			
Spinobr. kamiussi																			
Brunsia sp.		X				X		X		X									
Parachaetetes sp.																			
Endothyra modica																			
stacheiinids								X											
Brunsia spirillinoides																			
indet. pluriloculars											X		X						
Atractyllopsis sp.						X		X											
Girvanella sp.				X	X				X	X									
Palaeospiroplectammina sp.		X							X	X									
Spinoendothyra mitchelli										cf.									
Florennella stricta																			
Koninckopora sp. (monolam.)				X						?		X							
O. marchanti sp. nov.				X	X					X									
Dainella sp.		X																	
Endothyra bowmani																	cf.		
P cravenensis sp. nov.																			
Dainella micula																			
Plectogyranopsis stricta																			
Bessiella sp.										X									
Latiendothyranopsis grandis																			
lituotubellid																			
Spinobrunsina implicata																			
Eotextularia mongeri																			
Eotextularia sp.				?															
Mediocris sp.								?											
Plectogyranopsis sp.										X									
Latiendothyranopsis floraviae																			
Spinoendothyra recta																			
Spinoendothyra pietoni																			
Tournayellina beata																			
Endothyra introjactans																			
Spinoendothyra paracostifera																			
Pseudotaxis sp.																			

SAMPLE	AL5946	AL5947	AL5948	AL5949	AL5950	AL5951	AL5952	AL5953	AL5954	AL5955	AL5956	AL5957	AL5958	AL5959	AL5960	AL5961	AL5962	AL5963
POSITION (m) to base Chadian	55.8	56.8	57.8	58.8	59.8	60.8	61.8	62.8	63.8	64.8	65.8	66.8	67.8	68.8	69.8	70.8	71.8	72.8
Spinobrunsina sp.	X	X	X	X	X	X	X		X		X	X	X	X	X			
Endothyra sp.		X	X	X	X	X	X	X	X			X	X	X	X		X	X
Spinobr. robusta																		
calcisphaeres	X	X	X		X	X	X		X	X		X	X	X	X			
Priscella sp.				X					X				X		X			
Spinobr. landeliesi																		
Omphalotis sp.																		
Earlandia sp.	X		X				X					X	X		X			
Latiendothyranopsis sp.																		aff.
Spinobr. ramsbottomi	cf.																	
Solebra sibirica																		
Eblanaia michoti				X														
Endothyra laxa			X	cf.				cf.	X				X		cf.			
Brunsia pseudopulchra							X	X										
Spinoendothyra sp.	X			X			X					X	X				X	
kamaeniids																		
oncoids	X		X	X		X	X	X				X		X	X		X	X
Baituganella sp.	X			X			X	X							X			
Tuberendothyra sp.																		
Florennella sp.				X			X						cf.					
Plectogyranopsis convexa															X			X
Endospiroplectammina sp.		?	X															
G. campinei																		cf.
L. lancastria sp. nov.																		
Paracaligelloides sp.	X						X											
Spinobr. kamiussi								X										
Brunsia sp.							X	X					X					
Parachaetetes sp.																		
Endothyra modica																		
stacheiinids																		
Brunsia spirillinoides	X			X								X						X
indet. pluriloculars										X						X		
Atractyllopsis sp.																		
Girvanella sp.																		
Palaeospiroplectammina sp.		?																
Spinoendothyra mitchelli	cf.																	X
Florennella stricta																		
Koninckopora sp. (monolam.)												X	X	X	X			X
O. marchanti sp. nov.															cf.			
Dainella sp.			cf.												cf.			
Endothyra bowmani							cf.											
P cravenensis sp. nov.																		
Dainella micula																		
Plectogyranopsis stricta																		
Bessiella sp.				X			cf.											
Latiendothyranopsis grandis																		
lituotubellid																		
Spinobrunsina implicata																		
Eotextularia mongeri																		
Eotextularia sp.																		
Mediocris sp.													X					
Plectogyranopsis sp.													X					
Latiendothyranopsis floraviae			X															
Spinoendothyra recta							X											
Spinoendothyra pietoni								X					X					
Tournayellina beata																		
Endothyra introjactans																		
Spinoendothyra paracostifera																		
Pseudotaxis sp.																		

SAMPLE	AL5964	AL5965	AL5966	AL5967	AL5968	AL5969	AL5970	AL5971	AL5972	AL5973	AL5974	AL5975	AL5976	AL5977	AL5978	AL5979	AL5980	AL5981	AL5982	AL5983	AL5984	AL5985	AL5986	AL5987	AL5988	AL5989	AL5990	AL5991	AL5992	AL5993	AL5994	AL5995	AL5996	AL5997	AL5998	AL5999	AL6000
POSITION (m) to base Chadian	73.8	74.8	75.4	76.4	77.4	78.4	79.4	80.4	81.4	82.4	83.4	84.4	85.4	86.4	87.4	88.4	89.4	90.4	91.4	92.4	93.4	94.4	95.4	96.4	97.4	98.4	99.4	100.4	101.4	102.4	103.4	104.4	105.4	106.4	107.3	107.3	108.2
Spinobrunsina sp.		X	X	X	X	X	B	X		X	X	X	X	X		X	X	X		X					X		X		X			X			B	B	
Endothyra sp.	X		X	X	X			X		X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X				X	X				X
Spinobr. robusta												cf.															X										
calcisphaeres		X		X	X	X	A	X				X	X	X	X	X				X	X		X	X					X			X	X		A	A	X
Priscella sp.					X					X		X	X			X	X			X								X									
Spinobr. lancellesi																																					
Omphalotis sp.			cf.				R									cf.																			R	R	
Earlandia sp.								X			X					X				X	X							X									
Lattendothyranopsis sp.					cf.												X			X																	
Spinobr. ramsbottomi			cf.				R					X		cf.							X														R	R	
Salebra sibirica																				X																	
Eblanaia michoti	X	X	X		X									cf.	X	cf.					X			X			cf.										
Endothyra laxa	X	cf.	cf.				E					cf.	cf.				X			X	cf.			cf.											E	E	
Brunsia pseudopulchra																																					
Spinoendothyra sp.	X		X		X			X					X	X						X				X													
kamaenids				X		X	N			X		X				X																	X	X	N	N	
oncoids	X		X		X								X	X				X				X				X	X	X									
Baltuganella sp.					X							X	X																								
Tuberendothyra sp.																																					
Florennella sp.					cf.	cf.		cf.				X	X	X							X																
Plectogyranopsis convexa													X											X													
Endospiroplectammina sp.								?		?		X					X		X		cf.	X	X	X				X									
G. campinei					X			cf.			cf.						X																				
L. lancastria sp. nov.												X		X						cf.								X									
Paracaligeloides sp.												X																X									
Spinobr. kalmiussi														X												X											
Brunsia sp.				X	X			X				X	X	X	X					X		X		X								X					
Parachaetetes sp.																																					
Endothyra modica																	X																				
stacheiinids																																					
Brunsia spirillinoides												X												X													
Indet. pluriloculars									X																				X	X	X			X			
Atractyliopsis sp.								X								X								X													
Girvanella sp.												X	X			X							X														
Palaeospiroplectammina sp.								?		?			X	X			X	X																			
Spinoendothyra mitchelli														cf.							cf.					X	X	cf.									
Florennella stricta													X																								
Koninckopora sp. (monolam.)			X											X	X	X					X			X		X											
O. marchanti sp. nov.											cf.																										
Dainella sp.					cf.													cf.	X																		
Endothyra bowmani																	X		cf.	cf.		X			X			cf.									
P cravenensis sp. nov.												X																									
Dainella micula												X																									
Plectogyranopsis stricta																																					
Bessiella sp.														X																							
Lattendothyranopsis grandis																																					
lituotubellid				X													X							X													
Spinobrunsina implicata																																					
Eotextularia mongeri																																					
Eotextularia sp.																												X									
Mediocris sp.												X							X																		
Plectogyranopsis sp.			X		X			X																													
Lattendothyranopsis floraviae																																					
Spinoendothyra recta												X																									
Spinoendothyra pietoni																										X											
Tournayellina beata													aff.				?																				
Endothyra introjactans																				X																	
Spinoendothyra paracostifera																																					
Pseudotaxis sp.																																					

SAMPLE	AL6001	AL6002	AL6003	AL6004	AL6005	AL6006	AL6007	AL6008	AL6009	AL6010	AL6011	AL6012	AL6014	AL6015	AL6016	AL6017	AL6018	AL6019	AL6020	AL6021	AL6022	AL6024	AL6025	AL6026	AL6027	AL6028	AL6029	AL6030	AL6031	AL6032	AL6034	AL6035	AL6036	AL6037	AL6038	AL6040	AL6041
POSITION (m) to base Chadian	109.4	110.4	111.4	112.4	113.4	114.3	115.4	116.4	117.4	118.4	119.6	120.4	122	123	124	125	125.6	126.6	127.6	128.8	130.4	133	134.8	136.8	137.8	138.8	139.8	140.8	141.8	142.8	144.8	145.8	146.8	147.8	148.8	150.8	151.8
Spinobrunsina sp.	X		X			X	X			X				X	X	X	cf.	X		X				X	X	X	X		X	X		X	X		X		
Endothyra sp.			X	X		X	X	X	X	X	X	X	X	X	X		X	X			X			X	X				X	X	X	X	X		X	X	X
Spinobr. robusta								cf.				cf.				X					X																
calcisphaeres	X		X		X			X		X			X	X		X		X	X		X	X						X	X		X	X			X		
Priscella sp.	X	X			cf.							X			X			X											X				X				
Spinobr. landellesi																																					
Omphalotis sp.																X		cf.																			X
Earlandia sp.	X			X	X					X			X			X		X			X		X						X		X	X					X
Lattendothyranopsis sp.	X		X																		X								X		X	X					
Spinobr. ramsbottomi									cf.							X		cf.																			
Salebra sibirica																X												X			X						
Eblanaia michoti			cf.			X		X	X				cf.			X		X						X						X	cf.			cf.			
Endothyra laxa	X											cf.		cf.		X		cf.											cf.		cf.		cf.				cf.
Brunsia pseudopulchra																X					cf.																
Spinoendothyra sp.	X	X							X				X			X		X			X								X					X	X	X	
kamaenids										X				X	X			X	X		X		X													X	X
oncolds	X		X					X						X	X	X				X	X											X	X				X
Baituganella sp.	X		X											X		X																X				X	
Tuberendothyra sp.																																					
Florennella sp.																X																	X				cf.
Plectogyranopsis convexa			X											cf.				cf.			X																cf.
Endospiroplectammina sp.																					cf.												X				
G. campinei																																	cf.				
L. lancastria sp. nov.																																					
Paracaligeloides sp.			X																																		
Spinobr. kalmiussi																																					
Brunsia sp.																		X											X								X
Parachaetetes sp.																																					
Endothyra modica																																					
stachelinids																																					
Brunsia spirillinoides			X											X							X																
Indet. plurilocular																			X	X		X	X														
Atractyliopsis sp.			X																													X					
Girvanella sp.												X		X		X																X					
Palaeospiroplectammina sp.																																					
Spinoendothyra mitchelli																X		cf.																			
Florennella stricta																																					
Koninckopora sp. (monolam.)	X		X					X							X						X										X	X				X	
O. marchanti sp. nov.													cf.					X											X		X		X				
Dainella sp.																																					
Endothyra bowmani						cf.							X	X	cf.													cf.			X	X					
P. cravenensis sp. nov.																																					
Dainella micula																																					
Plectogyranopsis stricta																																					
Bessiella sp.																																					
Lattendothyranopsis grandis																																					
Lituotubella																																					
Spinobrunsina implicata			X													cf.																					
Eotextularia mongeri																																					
Eotextularia sp.																																					X
Mediocris sp.																																					
Plectogyranopsis sp.													X																			X					
Lattendothyranopsis floraviae																																					
Spinoendothyra recta																X																					
Spinoendothyra pietoni																																					
Tournayellina beata																					X																
Endothyra introjactans																																					
Spinoendothyra paracostifera																		X																			
Pseudotaxis sp.																																					cf.

SAMPLE	AL6042	AL6043
POSITION (m) to base Chadian	152.8	153.8
Spinobrunsiina sp.	X	
Endothyra sp.	X	
Spinobr. robusta		
calcisphaeres	X	
Priscella sp.		
Spinobr. landellesi		
Omphalotis sp.		
Earlandia sp.	X	X
Latiendothyranopsis sp.	cf.	
Spinobr. ramsbottomi		
Salebra sibirica		
Eblanaia michoti	X	
Endothyra laxa		
Brunsia pseudopulchra		
Spinoendothyra sp.	X	
kamaenids		X
oncoids		X
Baituganella sp.		
Tuberendothyra sp.		
Florennella sp.		X
Plectogyranopsis convexa		
Endospiroplectammina sp.		
G. campinei	X	
L. lancastria sp. nov.		
Paracaligeloides sp.		
Spinobr. kalmiussi		
Brunsia sp.	X	X
Parachaetetes sp.		
Endothyra modica		
stacheinids		
Brunsia spirillinoides		
Indet. pluriloculars		
Atractyliopsis sp.		
Girvanella sp.		
Palaeospiroplectammina sp.		cf.
Spinoendothyra mitchelli		
Florennella stricta		
Koninckopora sp. (monolam.)		
O. marchanti sp. nov.		
Dainella sp.		
Endothyra bowmani		
P cravenensis sp. nov.	X	
Dainella micula		
Plectogyranopsis stricta		
Bessiella sp.		X
Latiendothyranopsis grandis		
lituotubella		
Spinobrunsiina implicata		
Eotextularia mongeri		
Eotextularia sp.		
Mediocris sp.		
Plectogyranopsis sp.	X	
Latiendothyranopsis floraviae		
Spinoendothyra recta		
Spinoendothyra pietoni		
Tournayellina beata		
Endothyra introjactans		
Spinoendothyra paracostifera		
Pseudotaxis sp.		

PLATE 1

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

Brunsia pseudopulchra (Lipina, 1955)
1. Courceyan, 9.4 m below top, near saggital section, MPK 9312 (RH 1354).
2. Chadian, 125 m above base, axial-tangential section, MPK 9313 (AL 6017).
3. Courceyan, 3.4 m below top, ex axial-tangental section, MPK 9314 (RH 1360).
5. Chadian, 27.56 m above base, ex saggital section, juvenile MPK 9315 (AL 5917).
6. Chadian, 10.2 m above base, axial section, juvenile, MPK 9316 (AL 5898).
10. Courceyan, 9.4 m below top, saggital section, MPK 9317 (RH 1354).
18. Courceyan, 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).

Parachaetetes sp.
13. Courceyan, 16.1 m below top, MPK 9321 (AL 5873), X25.

Brunsia spirillinoides (Grozdilova & Glebovskaya, 1948).
7. Chadian, 84.4 m above base, axial section, MPK 9322 (AL 5975).
25. Chadian, 17.36 m above base, ex axial section, MPK 9323 (AL 5905).

Atractyliopsis 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. Courceyan, 13.6 m below top, MPK 9326 (RH 1350).
12. Courceyan, 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).

lituotubellid?
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).

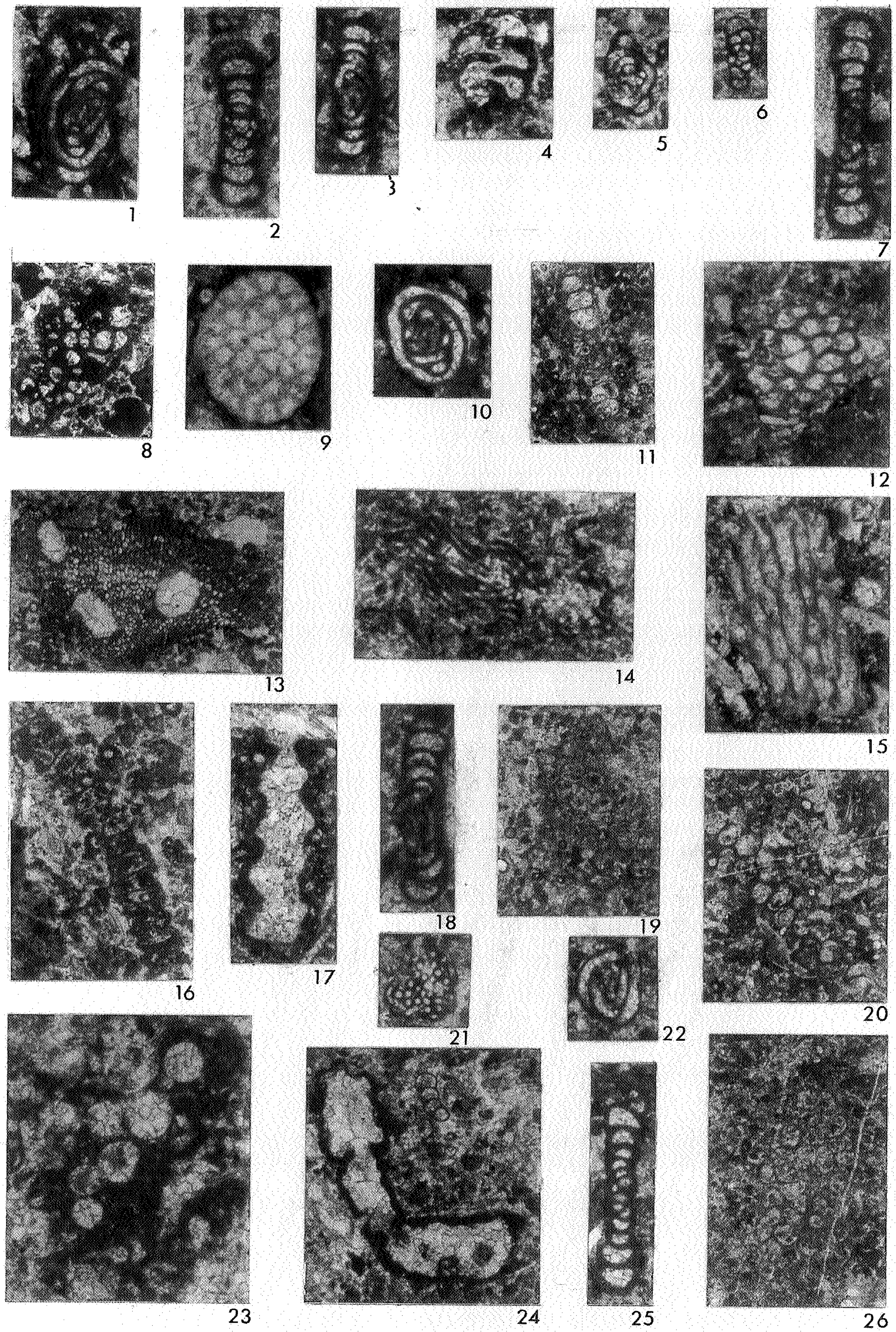
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PLATE 2

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 saggital section, MPK 9338 (AL 5963).
3. Courceyan, 3.4 m below top, saggital section, MPK 9339 (RH 1360).
10. Chadian, 152.8 m above base, Bold Venture Beds, saggital section, MPK 9340 (AL 6042).
16. Chadian, 77.4 m above base, saggital section, MPK 9342 (AL 5968).
19. Courceyan, 23.8 m below top, ex-saggital 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. Courceyan, 23.8 m below top, saggital 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, saggital section, MPK 9358 (AL 6022).

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

Tournayellina beata (Malakhova, 1956)
12. Chadian, 46.5 m above base, saggital 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, saggital section, MPK 9341 (AL 5897).

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

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

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

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

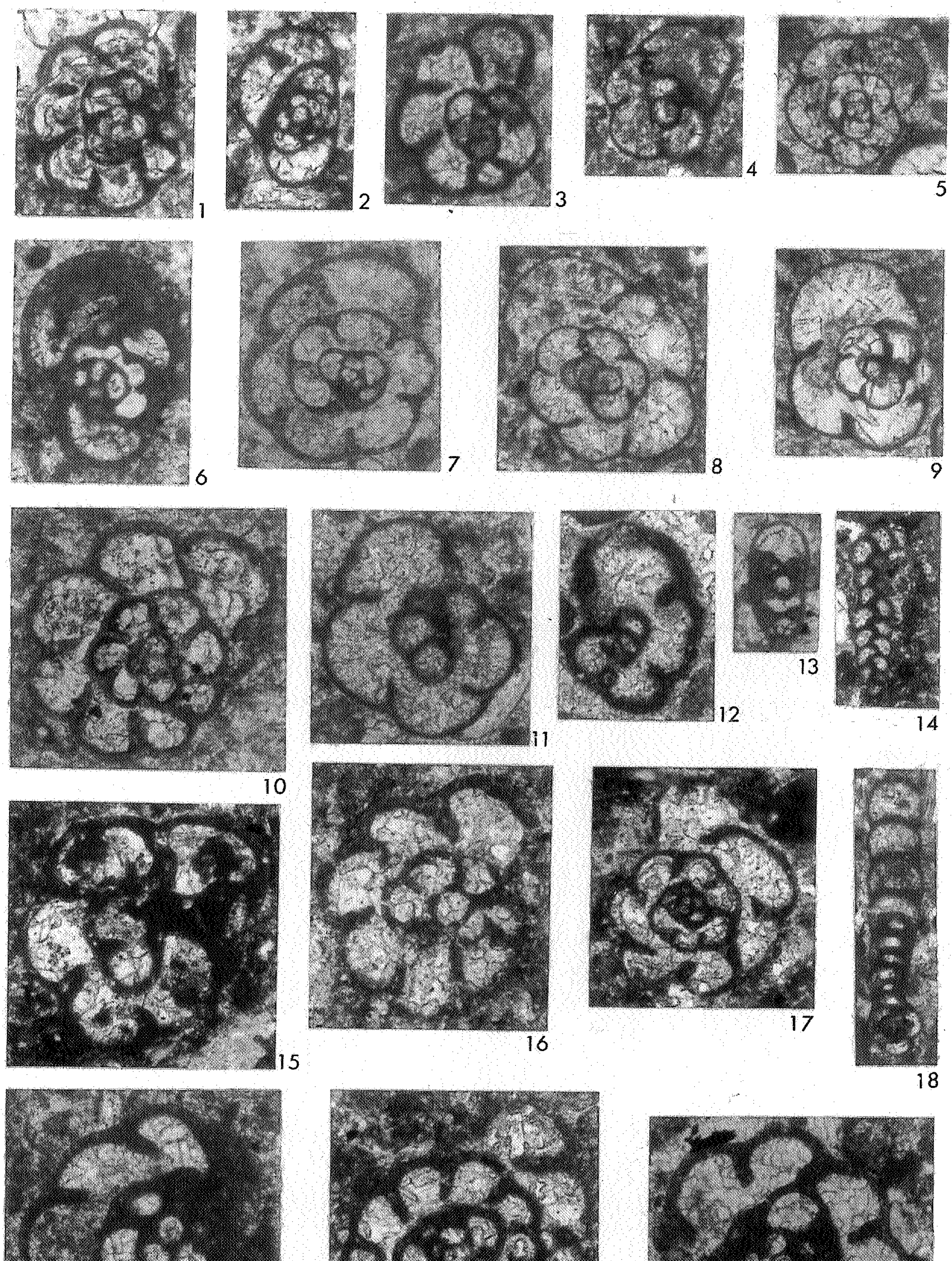
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PLATE 3

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

Endothyra sp.
1. Chadian, 10.2 m above base, saggital 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, saggital section, MPK 9363 (AL 6017).
8. Chadian, 10.2 m above base, saggital section, MPK 9364 (AL 5898).

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

Septabrunsiina (*Spinobrunsiina*) 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 saggital 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 saggital 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-saggital section, paratype MPK 9373 (RH 1352).

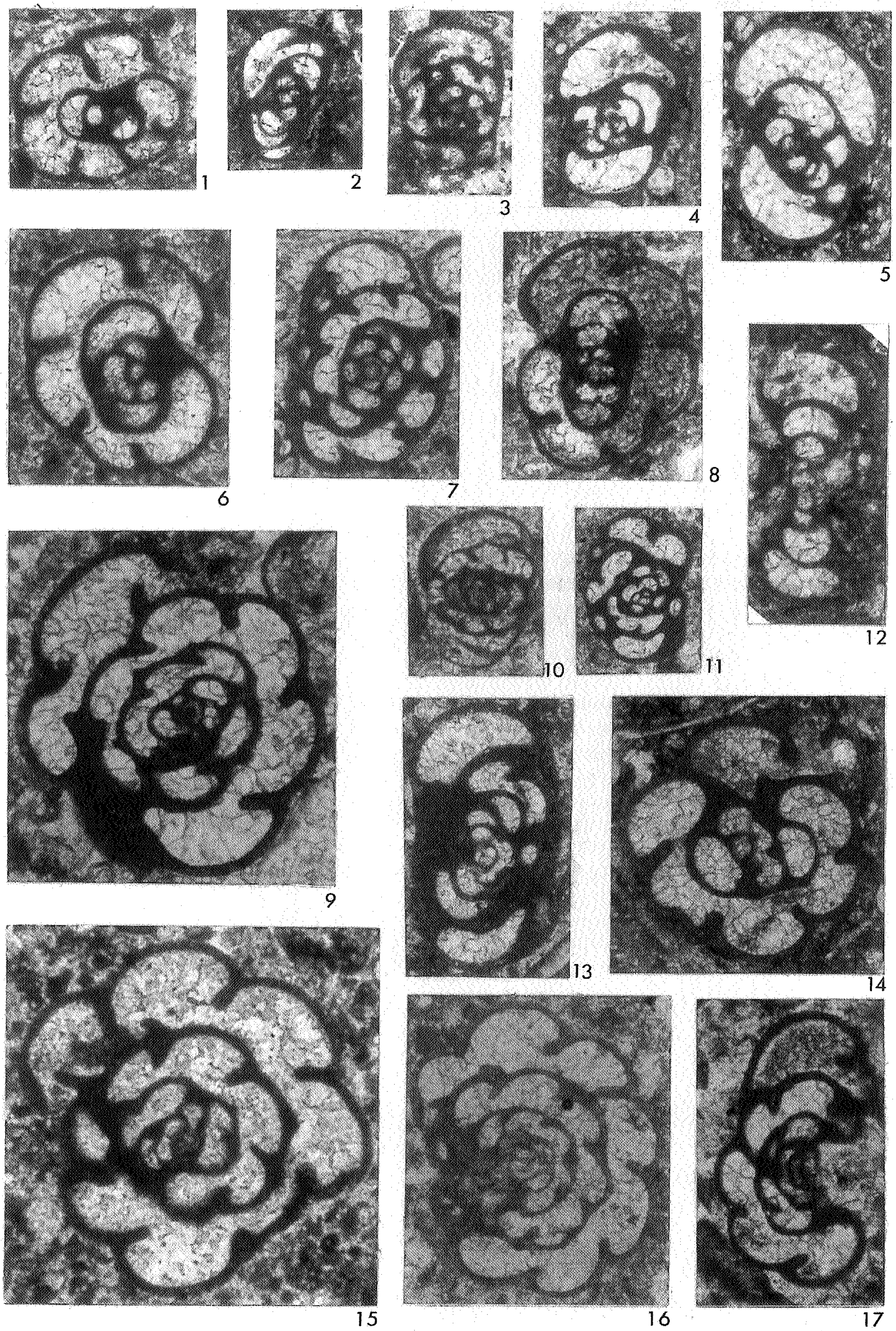
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PLATE 4

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

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

Septabrunsiina (*Spinobrunsiina*) *kalmiussi* (Vdovenko *in* Brazhnikova & Vdovenko, 1973)
2. Chadian, 86.4 m above base, saggital-tangential section, MPK 9383 (AL 5977).
9. Chadian, 6.84 m above base, saggital-tangential section, MPK 9384 (AL 5895).
11. Chadian, 62.8 m above base, axial section, MPK 9385 (AL 5953).

Spinoendothyra 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. Courceyan, 17 m below top, oblique section, MPK 9381 (AL 5872).

Septabrunsiina (*Spinobrunsiina*) *landeliesi* Conil *in* Groessens *et al.*, 1982
10. Courceyan, 11.4 m below top, ex axial section, MPK 9386 (RH 1352).

Septabrunsiina (*Spinobrunsiina*) *robusta* Conil *in* Conil *et al.*, 1981
12. Courceyan, 24.2 m below top, saggital-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).

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

Septabrunsiina (*Spinobrunsiina*) *implicata* (Conil & Lys, 1968)
18. Chadian, 114 m above base, oblique saggital section, MPK 9396 (AL 6003).

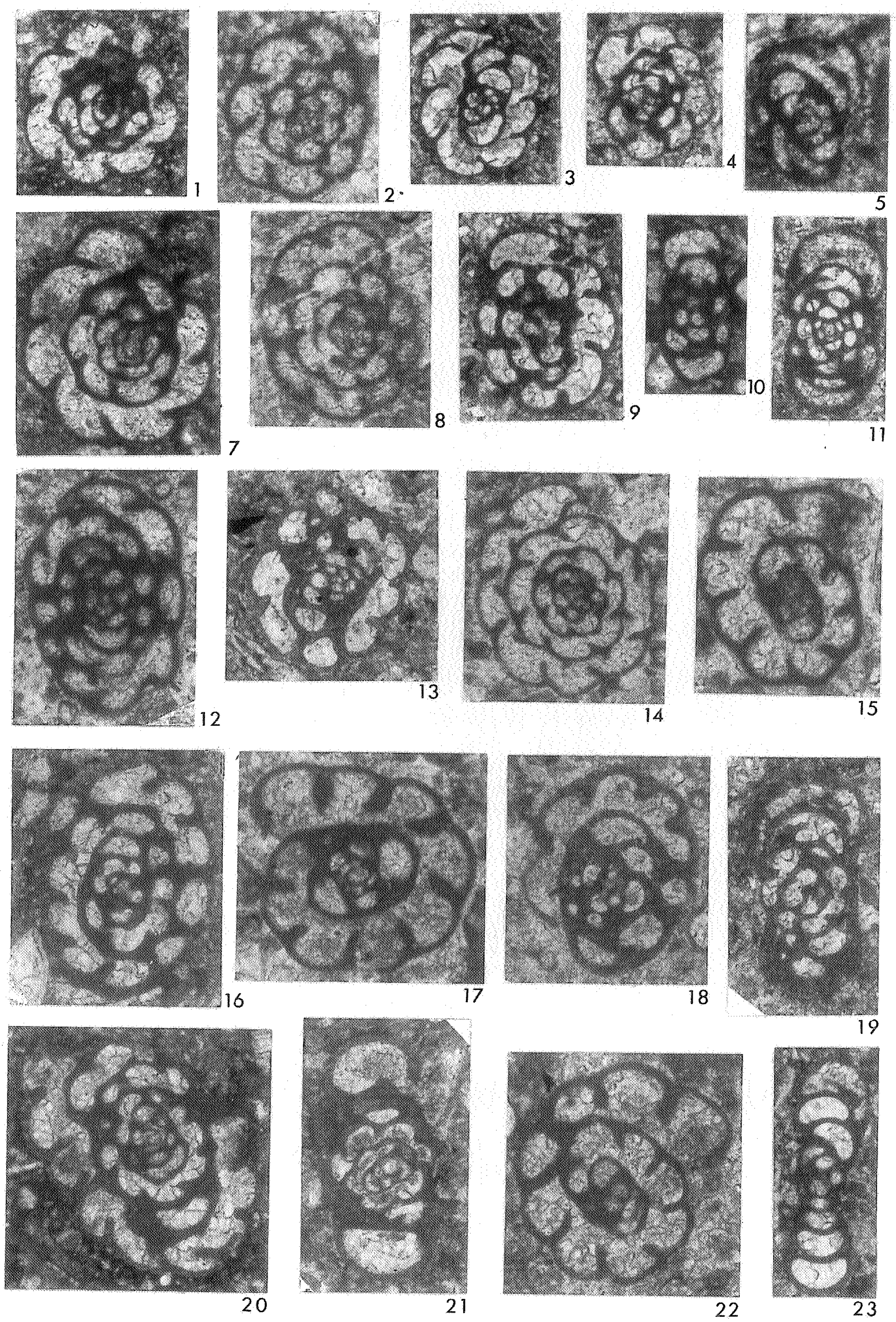
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PLATE 5

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).

Florennella stricta (Conil & Lys, 1964) (see also pl. 3, fig. 10)
3. Chadian, 86.4 m above base, near saggital 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, saggital 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, saggital section, MPK 9410 (AL 5884).

Endothyra modica Conil & Naum *in* Groessens *et al.*, 1982
10. Chadian, 89.4 m above base, near saggital section, MPK 9411 (AL 5980).

cf. *Tuberendothyra* sp.
11. Courceyan, 2.7 m below top, ex saggital section, MPK 9412 (AL 5886).

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

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

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

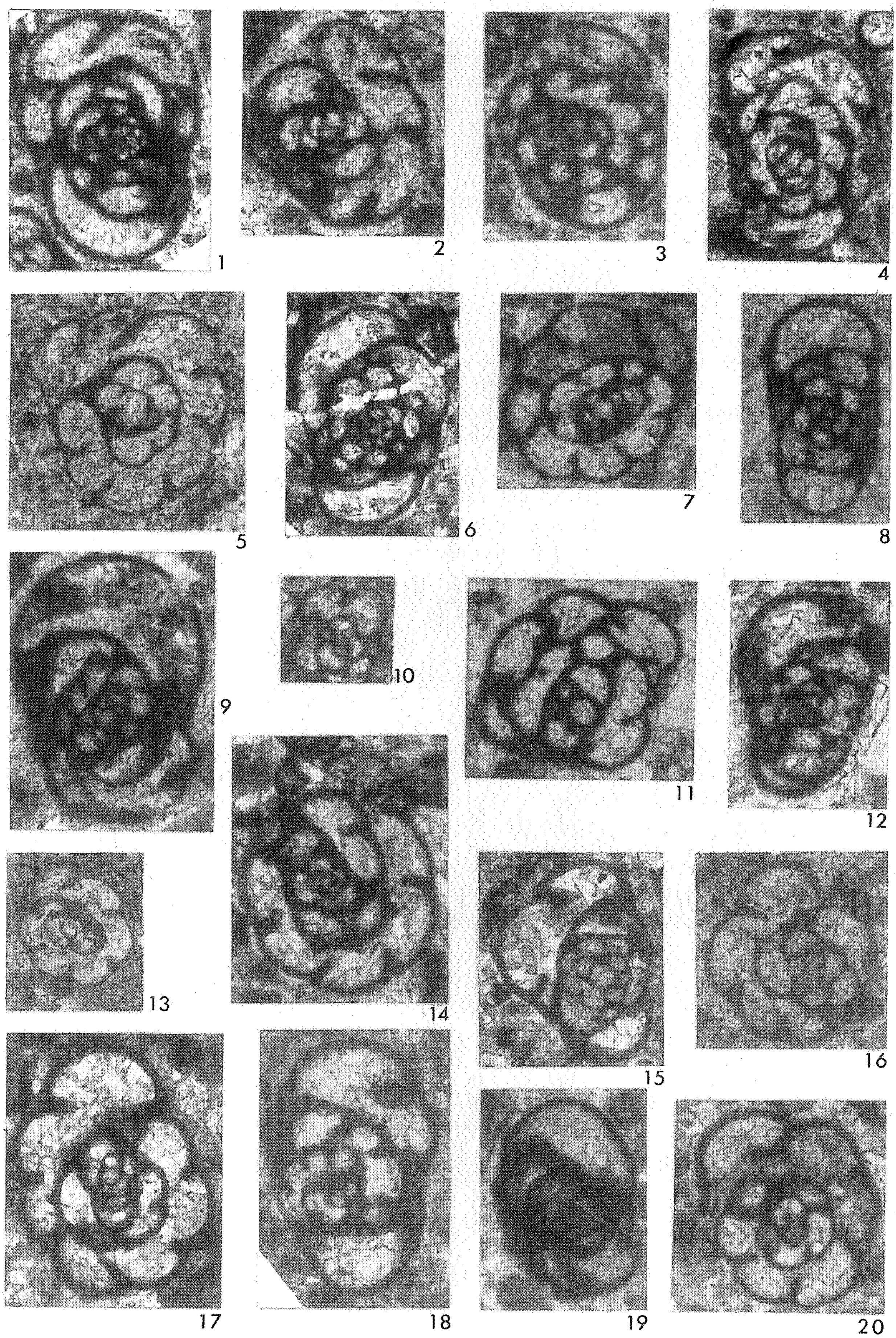
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PLATE 6

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-Chernoussova & 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. *introjactans* (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).