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RECOGNITION OF THE TOURNAISIAN-VISEAN BOUNDARY IN NORTH AMERICA AND BRITAIN

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(3 figs. and 2 plates)

RÉSUMÉ

La recherche de la limite Tournaisien-Viséen en Amérique du Nord et en Angleterre est entravée par des différences fauniques avec la succession type de la Belgique. Cette limite est à situer au sein de la zone à *Bactrognathus-Taphrognathus*, c'est-à-dire dans la partie supérieure de la Formation de Burlington. Il est suggéré que les différences observées dans les séquences de conodontes, entre l'Amérique du Nord et l'Europe, reflètent la présence de lacunes à la base de la Formation de Sedalia et peut-être aussi dans et sur la Formation de Burlington; ces différences peuvent également être le fait de remplacements homéomorphiques de conodontes.

Les foraminifères de l'Avon Gorge, en Angleterre, situent la *Caninia* Dolomite au niveau du *V2a* de la Belgique; la *Caninia* Oolite repose en discordance sur le Tournaisien terminal (*Tn3c*) ou sur les premières couches du Viséen. D'autres stratotypes devraient compléter la coupe type d'Angleterre.

ABSTRACT

Recognition of the Tournaisian-Viséan boundary in North America and Britain has been hampered by the faunal differences between these areas and Belgium. The boundary between the Tournaisian and Viséan in North America is best drawn within the *Bactrognathus-Taphrognathus* Zone, which is represented by the upper part of the Burlington Formation of the Mississippi Valley. It is suggested that differences in conodont sequences between North America and Europe reflect the influence of the sub- « Sedalia » unconformity, and possible unconformity within and above the Burlington; they may also indicate homeomorphic replacement of conodont elements. New foraminifera faunas from the Avon Gorge, England, show that the *Caninia* Dolomite of the British type section is of *V2a* age. The *Caninia* Oolite rests non-sequentially upon strata of highest Tournaisian (*Tn3c*) or lowest Viséan age. Further stratotypes are required to supplement the present British type section.

CONTENTS

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INTRODUCTION

One of the outstanding problems of Carboniferous stratigraphy is the recognition of the Tournaisian-Viséan boundary in places other than the type area of Dinant. The difficulties arise from a number of causes. One of these, which is common to most other stratigraphic classifications, has been the lack of precision, and even agreement in the detailed description of the type area. The position of the Tournaisian-Viséan boundary in the Dinant area has now been resolved as a result of the detailed studies of Conil, Pirlet, and Lys (1967) and Conil (*in* Conil *et al.* 1969), who defined and described the stratotypes. The subcommission of Carboniferous Stratigraphy accepted at Sheffield in 1967 (p. 188, 189) a proposal made by Conil, Pirlet, Lys and their co-workers that the base of the Viséan be redefined, since the definition given by earlier workers was imprecise (see Conil *et al.* 1969). This position was confirmed by the Congress at Krefeld (1971). The base of the Viséan is now located along the zigzag path between the Bastion Rock and the Lambert Quarry, Dinant (see Conil *in* Conil *et al.* 1969, fig. 4) at a somewhat lower level than was generally accepted before 1967, and is recognized by the first appearance of *Pachysphaerina*. In other and richer successions, this boundary corresponds approximately to the first appearance of *Dainella* and the primitive Fusulinacea. These latter are the best foraminiferal guide fossils to the Lower Viséan, but their absence in the present « type section » will make it necessary to designate an alternative boundary stratotype.

A second difficulty in recognizing the boundary in places other than the type area involves the facies variation which is characteristic of these rocks. The standard Lower Carboniferous cephalopod zonal sequence established in Germany is difficult to apply in Belgium, France, Great Britain, and, to a lesser extent, in North America, because cephalopods are usually rare or absent in the coral-brachiopod carbonate facies of these countries. Even within the coral-brachiopod facies, correlation has been dfficult, and there has been little agreement concerning the exact equivalence of the North America Mississippian and British Avonian successions to the type areas of the Viséan and Tournaisian.

A third difficulty arises from the effects of epeirogenic movements at about this time. These were widespread in both North America and Europe, producing local disconformities, marked in places by karst topography, and rapid faunal migration and replacement which is not always easy to distinguish from evolutionary change of endemic faunas.

FAUNAL CHARACTERISTICS OF THE TOURNAISIAN — VISÉAN BOUNDARY IN THE TYPE AREA OF DINANT

The work of CONIL, PIRLET and LYS (1967, pp. 29-32 and Pl.I) and CONIL and PIRLET (1971, pp. 20-23) has shown that various macrofossil groups are of varying value in the definition of the Tournaisian-Viséan boundary. These include only a small number of forms which are diagnostic of the boundary itself, and few of these are common. In the highest division of the Tournaisian (*Tn3c*) the corals *Siphonophyllia cylindrica cylindrica*, *Cyathaxonia cornu*, *Hapsiphyllum delanouei* and *Zaphrentoides konincki* extend up to, but not beyond the boundary, as does the brachiopod *Spirifer konincki.* The facies of VIa is however, different from those of *Tn3* and precise macrofaunal information on the *VIa* is lacking. Other such characteristic fossils as *Michelinia megastoma* extend into the Viséan, and are not therefore truly diagnostic. In the overlying Viséan, only the brachiopods *Chonetes papilionaceus* and *Daviesiella münsteri* are found in the basal *VIa,* although other distinctive brachiopods appear at higher levels within the *VIa* succession. Caution is needed, however, in interpreting the Belgian macrofaunas as they are in need of restudy both in terms of taxonomic revision and also for precise location.

The microfaunas according to European geologists offer a far more refined basis for recognizing the boundary, and the first appearance of the following foraminifera has been show to be diagnostic of the lowermost *VIa* in Belgium : *Dainella* and *Eoparastaffella, Pachysphaerina pachysphaerica,* Pseudoammodiscidae (by migration), *Palaeospiroplectammina mellina, Endospiroplectammina conili.* (This genus appears very rarely in the uppermost beds of *Tn3c*) and *Valvulinella.* Other new foraminifera are rare, or appear at higher levels of *VIa.* GROESSENS (1971, 1971a) has shown that the conodont species *Doliognathus latus, Dollymae bouckaerti* and *Scaliognathus anchoralis* are diagnostic of the upper *Tn3c,* while the overlying *VIa* is characterized by the first appearance of *Gnathodus* cf. *G. homopunctatus* and *Mestognathus beckmanni.* Other widespread conodont species occur near, but not at, the boundary.

REVIEW OF THE RECOGNITION OF THE TOURNAISIAN-VISÉAN BOUNDARY IN NORTH AMERICA

WELLER *et al.* (1948) have summarized earlier attempts at correlation between the Belgian and Mississippian successions. They wrote (1948, p. 108) « The American Meramecian is almost certainly of Viséan age, and the crinoids and brachiopods of the Osagean appear to ally this series with the Tournaisian. » They drew the Viséan-Tournaisian boundary between the Keokuk and the Warsaw (Fig. 1).

COLLINSON, SCOTT and REXROAD (1962, p. 14) in their pioneer studies of Mississippian conodont zones wrote as follows : « Perhaps the most precise and definite correlation to Europe that can be made is that of the Viséan-Tournaisian boundary which, on the basis of the highest occurrence of the genus *Siphonodella,* is placed at the top of the Chouteau Formation. » Recent conodont studies in Belgium (CONIL *et al.,* 1969 and GROESSENS, 1971) have shown that the youngest *Siphonodella* in the type succession at Yvoir, near Dinant is found at the base of *Tn3a,* and is separated, at this place, from the base of the Viséan by more than 80 meters of conodont-bearing strata of *Tn3a-c* age, in which *Siphonodella* is unrepresented. The 'cut-off point' for *Siphonodella* marks a major unconformity in the Mississippi Valley and we believe that this accounts for the absence of some Tournaisian strata in the Mississippi Valley (AUSTIN and RHODES *in* CONIL *et al.*, 1969, p. 62). The lower *Tn3a* faunas, characterized by the upward extension of *G. delicatus*, are presumably unrepresented in the Mississippi Valley.

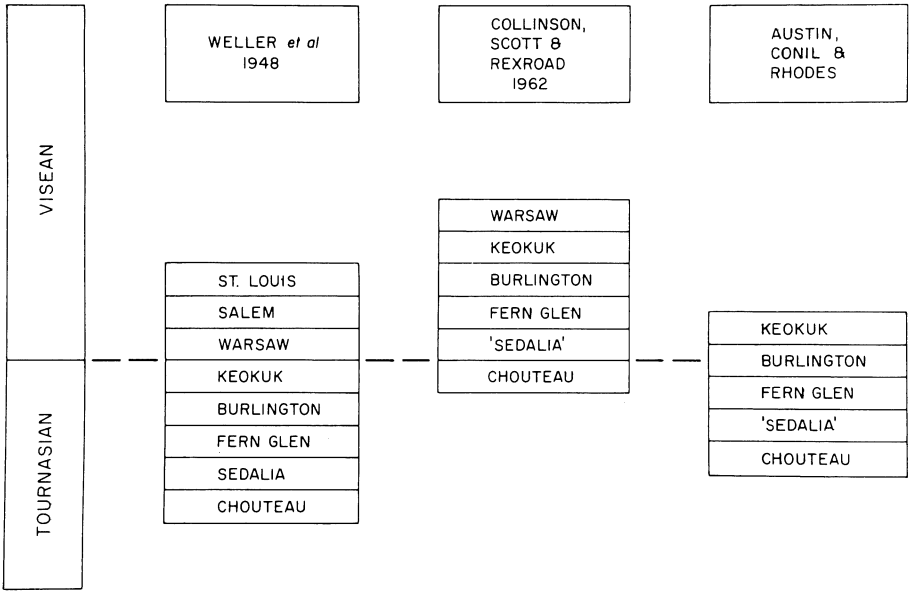


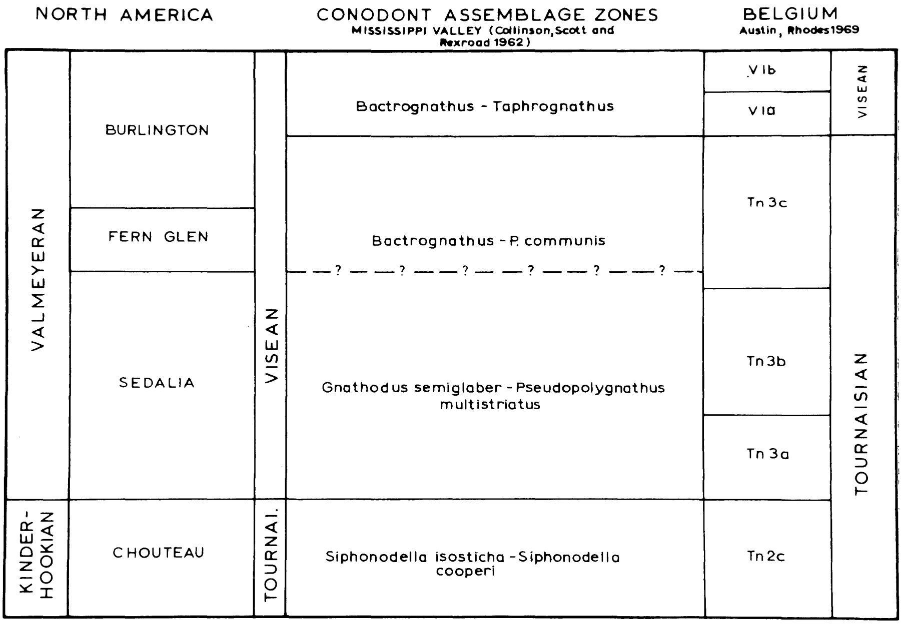
Fig. 1. — Position of the Tournaisian-Viséan boundary in the Mississippian of North America as suggested by Weller *et al.* 1948, Collinson, Scott and Rexroad 1962, and Austin, Conil and Rhodes this paper.

The implications of these new correlations is that the position of the Tournaisian-Viséan boundary in the Mississippi Valley is higher than is currently supposed. Various authors, especially SANDO, MAMET and DUTRO (1971) and MAMET and SKIP (1971) have made correlations between North America and Europe. AUSTIN and RHODES (*in* CONIL *et al.*, 1969) first suggested that the evidence favoured the placing of the Tournaisian-Viséan boundary within the *Bactrognathus-Polygnathus communis* Assemblage Zone of North America, and it was thus located in the lower middle unit of the Burlington Formation. Later these authors (RHODES and AUSTIN 1971) favoured locating the boundary at the base of the *Bactrognathus-Taphrognathus* Zone of the Upper Burlington Formation (cf. PIERCE and LANGENHEIM, 1972).

COLLINSON, REXROAD and THOMPSON (1971, pp. 378-379), have refined the *Bactrognathus-Taphrognathus* Zone to include all but « the lower few feet of the Haight Creek (middle) Member and all of the Cedar Fork (upper) Member of the Burlington Limestone in southeastern Iowa. » Although COLLINSON, REXROAD and THOMPSON (1971) continue to equate the basal Viséan with the *Gnathodus semiglaber-Pseudopolygnathus multistriatus* Zone, their data suggest to us that the boundary should be placed within the *Bactrognathus-Taphrognathus* Zone, which is slightly higher than our earlier estimate, but considerably higher than that of COLLINSON *et al.*, 1971. We discuss this in detail below (p. 170).

CORRELATION OF THE BELGIAN SUCCESSION WITH NORTH AMERICA

The stratigraphy and age of some of the off-reef Waulsortian beds in Belgium from which Austin and Rhodes (*in* Conil *et al.* 1969) reported conodonts has been modified (Groessens 1971 and Austin and Groessens, 1972). New conodont information is also now available from Belgium (Groessens, 1971) and from North America (Thompson and Goebel, 1968; Thompson and Fellows, 1970 and Collinson, Rexroad and Thompson, 1971). These new studies permit a more precise correlation between Belgium and North America.



NORTH AMERICA			CONODONT ASSEMBLAGE ZONES MISSISSIPPI VALLEY (Collinson, Scott and Rexroad 1962)	BELGIUM Austin, Rhodes 1969	
VALMEYERAN	BURLINGTON	VISEAN	Bactrognathus - Taphrognathus	V Ib	VISEAN
				V Ia	
	FERN GLEN		Bactrognathus - P. communis	Tn 3c	TOURNAISIAN
	SEDALIA		Gnathodus semiglaber - Pseudopolygnathus multistriatus	Tn3b	
				Tn 3a	
KINDER-HOOKIAN	CHOUTEAU	TOURNAI.	Siphonodella isosticha - Siphonodella cooperi	Tn2c	

Fig. 2. — Conodont assemblage Zones of the Mississippi Valley (Collinson, Scott and Rexroad, 1962) and the position of the Tournaisian-Viséan boundary as suggested by Austin and Rhodes (in Conil, 1969).

The earliest *Siphonodella* in Belgium appear near the base of *Tn1b* (Austin *et al.*, 1971) and the youngest representatives of the genus occur at the base of *Tn3a* (Conil, 1967). The Kinderhookian Series of North America is therefore at its maximum development equivalent to the *Tn1b*-basal *Tn3a* interval in terms of the Dinantian stratotypes of Belgium.

The base of the *Gnathodus semiglaber* — *Polygnathus communis carina* Zone lies above the Kinderhookian and represents the oldest Valmeyerian strata recorded to date (Collinson, Rexroad and Thompson, 1971, p. 374). This zone was originally described from the lower part of the Pierson Formation of southwestern Missouri (Thompson, 1967). The lower part of the zone has an abundance of *Polygnathus communis carina*. Groessens (1971) has reported that in Belgium *P. communis carina* appears in *Tn3a*. It therefore appears that the stratigraphic break known to exist below the « Sedalia » Formation is greatest in central-western Illinois and central-eastern Missouri (Collinson *et al.*, 1962) and is less developed in south-western Missouri, where only part of the *Tn3a* is lacking.

The correlation of the younger zones in North America with those of Belgium is assisted by the description of faunas of south-western Missouri and adjacent areas given by Thompson (1967) and Thompson and Fellows (1970). Thompson has shown that, although the basic faunal successions of the Mississippi Valley and south-western Missouri are similar, there are important differences between the two areas. Thus Thompson has combined the upper part of the *G. semiglaber* — *P. multistriatus* Zone (found in the Mappin Formation of Illinois) and the *Bactrognathus* — *P. communis* Zone of the Mississippi Valey (found in the Fern Glen Formation and the Lower Burlington Limestone) into a single zone, the *Bactrognathus* — *P. multistriatus* Zone in Missouri. This zone as originally defined occurs in the upper part of the Pierson Formation, throughout the Elsey Formation and in the lowermost part of the Burlington Limestone. The zone is subdivided into an underlying *P. multistriatus* Subzone and an overlying *Doliognathus latus* Subzone. The former subzone is characterised by the presence of *Bactrognathus, Gnathodus antetexanus* and *Polygnathus communis communis.* This subzone is present in the lower *Tn3c* rocks of Belgium. The *Doliognathus latus* Subzone contains *Bractrognathus, Doliognathus, Gnathodus antetexanus, Polygnathus communis communis, Scaliognathus, Staurognathus,* and *Pseudopolygnathus triangulus pinnatus.* This later subzone equated by Thompson (1967, p. 18) with the Lower Burlington of Illinois, correlates well with the *Doliognathus latus* Subzone of the *Scaliognathus anchoralis* — *Hindeodella segaformis* Zone recognized by Groessens (1971) in the Upper *Tn3c* rocks of Belgium.

A major anomaly is the absence from Belgium of *Bactrognathus,* which is characteristic of the *Bactrognathus* — *P. multistriatus* Zone in North America. Its absence from Belgium may be the result of its ecological or geographical restriction, but it may also be the result of homeomorphic replacement or other causes. It is interesting to note that Groessens (1971) established a *Spathognathus bultyncki* Assemblage Zone in Belgium. *S. bultyncki* is similar in lateral view to *Bactrognathus perplanus.* The *Spathognathodus bultyncki* Zone is present in the lower *Tn3c* rocks of Belgium, and therefore first appears at a similar horizon to the first appearance of *Bactrognathus* in North America.

Groessens (1971) also recognized a *Dollymae bouckaerti* Assemblage Zone between his *Spathognathodus bultyncki* and *Scaliognathus anchoralis* — *Hindeodella segaformis* Zones. This zone was very restricted stratigraphically and was characteristic of the middle *Tn3c* in Belgium. Forms resembling *D. bouckaerti* of Groessens (1972) were not reported by Collinson, Rexroad and Thompson (1971). However, Thompson, Ford and Sweet (1971) described *Gnathodus reversus* from the basal limestone of the Rushville Formation of Ohio. *G. reversus* has a number of similarities with *D. bouckaerti.* The basal limestone conodont fauna according to Thompson, Ford and Sweet belonged to the *Doliognathus latus* Subzone of the *Bactrognathus* — *P. multistriatus* Zone.

The *Bactrognathus* — *Taphrognathus* Zone recognized by Collinson, Scott and Rexroad (1962) in the upper part of the Burlington Limestone of the Mississippi Valley can be divided into three parts (Collinson, Rexroad and Thompson, 1971, p. 379). The lower part is distinguished by the presence of *Bactrognathus distortus,* accompanied by relatively faintly ribbed representatives of *Polygnathus mehli. Bactrognathus hamatus, Polygnathus communis* and a spathognathodid closely related to *Spathognathodus crassidentatus* occur throughout. The middle subzone lies between the range of *Bactrognathus distortus* below and the range of a commonly occurring *Pelekysgnathus*-like new genus and species above. *Spathognathodus* cf. *S. crassidentatus*, *G. cuneiformis*, *G. antetexanus* and *P. mehli* occur in the subzone. The upper subzone is distinguished by abundant *P. mehli* (wide specimens with distinct ribs), *Spathognathodus* cf. *S. crassidentatus* and the *Pelekysgnathus*-like new genus. *Doliognathus*, *Scaliognathus*, *Staurognathus* and *Pseudopolygnathus triangulus pinnatus* occur in the lower subzone. *Polygnathus communis* has its youngest occurrence in the middle subzone and *Taphrognathus* appears in the upper part of the upper subzone.

Groessens (1971) has reported a new genus related to *Staurognathus* and *Pelekysgnathus* n. sp. A. (Voges, 1959) from the lower part of his *Doliognathus latus* Subzone. From the upper part of the *Scaliognathus anchoralis-Hindeodella segaformis* Zone of Belgium and in younger horizons Groessens has reported an interesting new *Spathognathodus*.

We therefore equate the Tournaisian-Viséan boundary of Belgium with part of the *Bactrognathus-Taphrognathus* Zone of the Mississippi Valley. The middle part of the zone seems, on balance, the most appropriate position to place the boundary. It is therefore located within the upper Burlington Limestone in the Mississippi Valley. This correlation is supported by the correspondence of conodont zones below the Burlington and also the correspondence and parallellism of the archaediscid zones of Hewitt and Conil (1969) when they appear in overlying formations.

Thompson (1967) recognized a *Bactrognathus distortus-Gnathodus cuneiformis* Zone in the Elsey Formation, and the lower part of the Burlington Limestone, all of which are diachronous units in south-western Missouri. Two subzones, the *B. distortus* Subzone and the *G. cuneiformis* Subzone were recognized. The *B. distortus* Subzone is characterized by *G. antetexanus*, *Doliognathus*, *Bactrognathus* and *Scaliognathus anchoralis*. We equate the Tournaisian-Viséan boundary with the base of the *G. cuneiformis* Subzone in south-western Missouri. The lower Viséan gnathodids, are similar to those of the *G. cuneiformis* Subzone and the overlying *G. bulbosus* Zone.

The lowest Viséan (*V1a*) of Belgium is characterized by the first appearance of *Gnathodus* cf. *G. homopunctatus* in the stratotype and of *Gnathodus* cf. *G. homopunctatus* and *Mestognathus beckmanni* in the parastratotype. *Polygnathus inornatus* and a variety of gnathodids also occurs. It is extremely difficult to relate the *V1a* faunas of Belgium to those of the Mississippi Valley. The genus *Taphrognathus*, which first appears in the upper subzone of the *Bactrognathus* — *Taphrognathus* Zone in the Mississippi Valley, has not, to date, been found in Belgium. *Gnathodus homopunctatus* and *Mestognathus beckmanni* have not, as yet, been found in the Mississippi Valley.

The absence of the distinctive *V1a* fauna from the Mississippi Valley is an anomaly, which might suggest either an unconformity within the Burlington or geographical restriction of the Belgian fauna or both. The Burlington has an unconformable base in parts of Illinois, and Collinson, Rexroad and Thompson (1971, p. 381) have noted that there is lithologic and faunal evidence for a non-sequence at the top of the Burlington in the Mississippi Valley and that this non-sequence may represent the *G. bulbosus* interval, which Thompson (1967, p. 19) found in Missouri. Collinson, Rexroad and Thompson (1971, p. 380, 381) also suggested that the *G. bulbosus* Zone of Missouri may be the result of local biologic phenomena of little biostratigraphic importance. The absence of the basal Viséan fauna from the Mississippi Valley is puzzling, as a similar fauna has been reported from Missouri by Canis (1968). Our studies, particularly at higher stratigraphic levels, support the idea that geographic or ecologic restriction of conodonts is widespread. This is particularly noticeable in the Upper Valmeyeran, where the conodont faunas of the Mississippi Valley are dominated by the genera *Cavusgnathus*, *Apatognathus* and *Spathognathus*. Similar faunas occur in the Avon Gorge of Great Britain (Rhodes, Austin and Druce 1969), in Canada (Globensky, 1967) and in the Bonaparte Gulf Basin of Australia (Druce, 1970). However, in Germany and in Ireland faunas of similar age continue to be dominated by *Gnathodus*. There is an urgent need to study the influence of depositional environments on conodont distribution in the Carboniferous.

REVIEW OF THE RECOGNITION OF THE TOURNAISIAN-VISÉAN BOUNDARY IN BRITAIN

Vaughan (1915) attempted to relate his coral — brachiopod zonation of the Avonian rocks to the Belgian succession. He drew the Tournaisian-Viséan boundary within horizon δ, which was a zone of overlap between the C and S Zones as shown in the table of succession (Vaughan, 1905), but its limits and faunal characters were not defined. He pointed out, that in horizon δ, the Tournaisian fauna survived and the Viséan fauna was initiated. Below horizon δ, the fauna was Tournaisian and above horizon δ, Viséan. Horizon δ thus represented the passage from Tournaisian to Viséan and no single line within it would have satisfied all the requisites of a dividing line between the two series (Fig. 3).

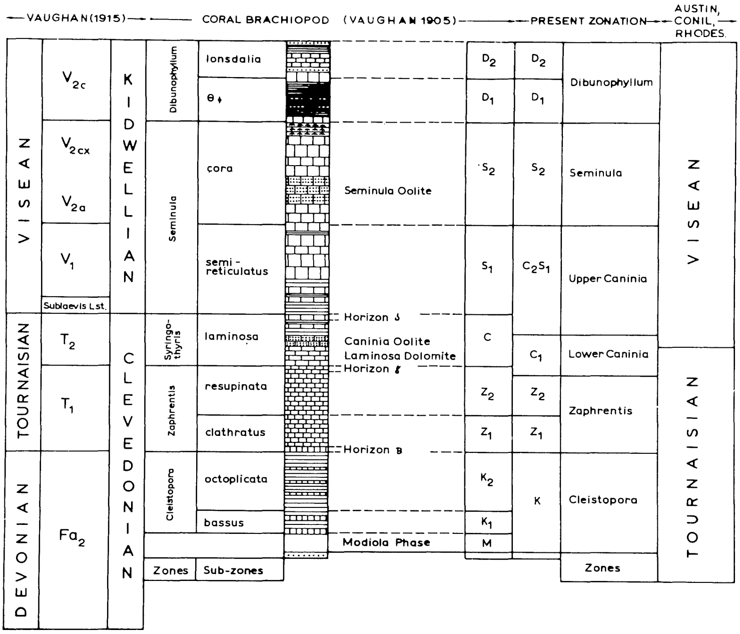


Fig. 3. Avonian zonation after Vaughan (1905 and 1915) and the position of the Tournaisian-Viséan boundary as suggested by Austin, Conil and Rhodes this paper.

Vaughan showed (1915) that this boundary coincided approximately with his

Lower and Upper Avonian divisions. DIXON (1911) had already suggested that the abrupt faunal and sedimentological changes at the base of the C_2 lagoon phase in Gower provided the best division between the Lower and Upper Avonian. He justified this by his belief that this was the position at which emergence gave way to subsidence in the western part of the South West Province. The subsequent discovery in Gower of goniatites in the *Caninia* Oolite and low in the overlying Upper *Caninia* beds (GEORGE and PONSFORD, 1935 and GEORGE and HOWELL, 1939) suggested that the Viséan-Tournaisian boundary was approximately equivalent to the C_1-C_2S_1 boundary at the top of the *Caninia* Oolite, a position rather lower than that originally proposed by VAUGHAN (see also GEORGE, 1952, p. 39, and GEORGE, 1958, p. 235). There is no firm evidence that these goniatites are respectively of high Tournaisian and low Viséan age. More recently MITCHELL and GREEN (in GREEN and WELCH 1955, p. 195-196) have suggested that the *Caninia* Oolite may be of younger age, and that the Tournaisian-Viséan boundary at Burrington Combe lies at, or possibly even below, the base of the « Burrington Oolite. » This is in contrast to the views of VAUGHAN, who placed the boundary about 75 feet above the base of the « Burrington Oolite. »

The age of the « Oolite » in one area need not imply a similar age in other areas. The base of the « Oolite » may be transgressive. MITCHELL (1967) has pointed out that the corals from part of the *Caninia* Oolite of Caswell Bay in Gower indicate that this oolite is equivalent to non-oolite beds of the Upper *Caninia* Zone (C_2S_1) in the Avon Gorge. On the other hand, the similarity of foraminifera collected by CONIL from the *Caninia* Oolite of Bristol and Gower suggests that the *Caninia* oolites are of the same age in these two areas.

MICROFAUNAS FROM THE AVON GORGE, ENGLAND, AND THE POSITION OF THE TOURNAISIAN-VISÉAN BOUNDARY

In their description of the conodont faunas of the British Avonian rocks, RHODES, AUSTIN and DRUCE (1969) established a zonal scheme, and noted, that in spite of a broad resemblance between the conodonts of Britain and other countries there were also significant differences. One of the most conspicuous of these was the absence of the *Scaliognathus anchoralis* fauna from the Avonian succession. This fauna which was described by BISCHOFF (1957) and VOGES (1959), is distinctive and widespread (MANZONI, 1966; ZIKMUNDOVA, 1967; THOMPSON, 1967; BURTON, 1964; GROESSENS, 1971, 1971A; MATTHEWS, 1969; HILL, 1971).

The reason for its absence from the Avonian of the Avon Gorge is critical in attempting to recognise the Tournaisian-Viséan boundary, since GROESSENS (1971) has shown that in Belgium *S. anchoralis* is diagnostic of the uppermost Tournaisian. Three possible explanations for its absence from the Avon Gorge section were advanced by RHODES, AUSTIN and DRUCE (1969, p. 65). Subsequent research has been directed towards resolving this problem and it is now possible to discuss in some detail the three possible explanations advanced by RHODES, AUSTIN and DRUCE in 1969. Firstly, its absence may be the result of limited geographic, or ecological distribution of the *anchoralis*-bearing conodontifer (animal). The *anchoralis* fauna, though known from three continents, has a curiously anomalous distribution in other areas, but its presence elsewhere in South West England (MATTHEWS, 1961, 1969, 1969a; MATTHEWS and THOMAS, 1968), in Northern England (MORRIS, 1969) and in Ireland (HILL, 1971) makes such a limited geographical explanation improbable

The *anchoralis*-bearing conodontifer was probably rare in the carbonate shelf environment, but that it existed in this environment has been shown by the results of the work by Hill (1971) and by Groessens (1971). A limited ecological distribution is therefore unlikely to account for the absence of *Scaliognathus anchoralis*.

A second possible explanation may be the lack of limestones yielding conodonts in critical parts of the Avonian succession, which might then account for the absence of the *anchoralis* fauna especially in view of its limited stratigraphic range elsewhere. Rhodes, Austin and Druce (1969, p. 65) stated « It seems possible, however, that the *anchoralis* horizon is equivalent to the lower part of the *Caninia* Dolomite of the Avon Gorge, wihch has yielded no conodont faunas. »

In order to test this possibility the *Caninia* Dolomite of the Avon Gorge was examined for foraminifera and the results rule out this possibility. The upper *Caninia* Dolomite contains foraminifera and algae, which are similar to those of the V_2a of Belgium. The following foraminifera and algae have been recovered from the *Caninia* Dolomite of the Avon Gorge :

Girvanella densa Conil & Lys
Koninckopora sahariensis Chanton
Parathurammina suleimanovi Lipina
Archaesphaera ex gr. *minima* Suleimanov
Palaeocancellus sp.
Radiosphaera sp.
Pachysphaerina pachysphaeroides (Pronina)
Earlandia minor (Rauser)
Earlandia vulgaris (Rauser & Reitlinger)
Brunsia sp.
Brunsia spirillinoides (Grozdilova & Glebovskaia)
Brunsia pulchra Mikhailov
Tournayellidae (cf. *Brunsiina*, cf. *Spinotournayella*, etc...)
Archaediscus (*Nudarchaediscus*) *eospirillinoides* (Brazhnikova)
Archaediscus (*Archaediscus*) *stilus* Grozdilova & lebedeva
Endothyra sp.
Endothyra laxa (Conil & Lys)
Endothyra ex gr. *recta* (Lipina)
Loeblichia (*Urbanella*) *fragilis* (Lipina)
Paraendothyra sp.
Dainella sp.
Dainella chomatica (Dain)
Dainella cognata Ganelina
Dainella exuberans (Conil & Lys)
Mediocris sp.
Eostafella sp.

From the upper part of the Burrington Oolite in the Mendips the following foraminifera and algae have been observed :

Girvanella cf. *densa* Conil & Lys
Koninckopora sahariensis Chanton
Pachysphaerina pachysphaeroides (Pronina)
Brunsia sp.
Brunsia spirillinoides (Grozdilova & Glebovskaia)
cf. *Palaeospiroplectammina diversa* (N. Tchernysheva)

Archaediscus (*Archaediscus*) *stilus* Grozdilova & Lebedeva
Nodosarchaediscus (*Nodosarchaediscus*) sp.
Endothyra sp.
Endothyra rectiformis (Bogush & Juferev)
Endothyra bowmani Phillips
? *Mikhailovella* sp.
Dainella sp.
Dainella elegantula Brazhnikova
Dainella fleronensis (Conil & Lys)
Quasiendothyra (?) *nibelis* Durkina
Eostaffella sp.

The presence of a *Dainella* assemblage suggests an age comparable to the *Caninia* Dolomite of the Avon Gorge, However, the presence of *Qu.* (?) *nibelis* and *Nodosarchaediscus* is anomalous as these appear in *V2b* in Belgium. A similar contradiction was found by Conil in organoclastic beds between the *Caninia* Oolite and the *Caninia* Dolomite of Gower.

A third possibility to account for the absence of the *anchoralis* fauna may be the presence of disconformities within the type Avonian. Rhodes, Austin and Druce (1969, p. 65) suggested that the absence of the *anchoralis* fauna may be explained by the *anchoralis* Zone being represented in the Avonian by the *Z2* Fish Bed, which would thus represent a considerable non-sequence. This possibility is now discounted since microfaunas recovered from immediately below and above the Fish Bed are older than the Tournaisian horizon (Upper *Tn3c*) which in Belgium yields *S. anchoralis*.

Rhodes and Austin (1971) wrote as follows :

> « The absence of the *anchoralis* fauna in the type Avonian of Britain, the sharp lithological break at the base of the *Caninia* Oolite, and the comparison of foraminifeara and conodonts from the Avon Gorge with those of the Dinantian type section, all suggest a stratigraphic hiatus in the British succession. The *Laminosa Dolomite* of soutwestern England has a microfauna of *Tn3c* age and the overlying *Caninia* Oolite has one of probably *V2a age*. No undoubted *V1* faunas are known from the British type section, and the precise Tournaisian-Viséan boundary is apparently marked by a disconformity ».

The stratigraphic break between the *Laminosa* Dolomite and the *Caninia* Oolite of Southwest England was recognized by Conil on the basis of foraminifera. This information was reported by Austin, Conil & Rhodes in Morris (1969) and by Rhodes & Austin (1971). The presence of *Globivalvulina* (?) *bristolensis* in the *Caninia* Oolite of Bristol is of interest as this form occurs with *V1a* foraminifera in the Gower area. This, however, does not confirm a *V1a* age for the *Caninia* Oolite of the Bristol area.

Conil and Hallet (in Conil 1966a) suggested that the *Caninia* Oolite was younger than was generally supposed. In collaboration with George (Conil and George *in press*) Conil has investigated the foraminifera of Gower and in collaboration with Rhodes and Austin the foraminifera of Bristol and the Mendips. We believe that the base of the *Caninia* Oolite at Bristol overlies a substantial non-sequence. This has also been confirmed by Mitchell (1972) who has studied the macrofauna. This non-sequence could account for the absence of the *S. anchoralis* fauna. However, the work of Groessens (1971) has shown that in Belgium the base of the Viséan in the parastratotype at Salet is recognized by the first appearance of *Mestognathus*. *Mestognathus* first appears in the Avon Gorge section in the uppermost part of the *Laminosa* Dolomite and suggests that Viséan strata are present beneath the *Caninia* Oolite in the Avon Gorge (see discussion of the paper by CONIL and GEORGE *in press*). We have also found *Mestognathus* in the upper part of the *Laminosa* Dolomite of Fall Bay, Gower.

We believe that the Tournaisian-Viséan boundary in Britain is located in the upper part of the *Laminosa* Dolomite. However, we have still not accounted for the absence of the *S. anchoralis* fauna. Two possibilities exist at this time. The first is that there is a non-sequence within the *Laminosa* Dolomite, which because of the poor fossil record from this horizon has not yet been detected, and the second is that *Scaliognathus anchoralis* is ecologically controlled in its distribution. It was stated above that this latter possibility was unlikely.

INTERPRETATION OF THE BRITISH TYPE AVONIAN SECTION

The presence of a non-sequence below the *Caninia* Oolite might well be confirmed by detailed stratigraphic and petrographic studies in the Avon Gorge and adjacent areas. The base of the Oolite certainly represents a marked change in sedimentary régime, resting as it does on the *Laminosa* Dolomite. In the general area of Bristol and the Mendips the Oolite is very variable in thickness, and current bedding, coarse crinoidal débris and pebbles of limestone and mudstone are locally common.

It is interesting to compare this situation with that known to occur at about the same time in Belgium, where *Tn3c* movements resulted in the erosion of the summits of some of the Waulsortian reefs. Subsequent movements in early Viséan times resulted in the formation of karst topography, breccias, disconformities and penecontemporaneous faults within the Lower Viséan sequence. These movements are not isolated phenomena, but correspond to widespread paleogeographic changes, involving a northward marine transgression in Western Europe including the British Isles, northern Belgium and Denmark, and foraminferal migration between Russia and Western Europe.

If the presence of such a non-sequence is accepted it has important implications in the interpretation of the Avon Gorge section as the type locality of the British « Lower Carboniferous ». It would require, for example, additional parastrotypes to provide the « missing » conodont sequences required to supplement the zonal scheme of RHODES, AUSTIN and DRUCE (1969). These have been partially provided by a study of Irish foraminifera and conodont faunas (AUSTIN, HUSRI and CONIL, 1970).

CONODONTS FROM BRITAIN AND IRELAND

The following new conodont faunas have been described from Britain and Ireland. These faunas are unrepresented in the Avon Gorge section and are thought to come from strata close to the Tournaisian-Viséan boundary, as they contain either *S. anchoralis* or an associated fauna.

MATTHEWS (1961, 1969, 1969a) and MATTHEWS and THOMAS (1968) have described conodont faunas from the Lower Carboniferous rocks of East Cornwall and South Devon. Two of these faunas contain *Gnathodus delicatus*, *Scaliognathus anchoralis*, *Pseudopolygnathus triangulus pinnatus* and siphonodellids; one fauna also contains *Doliognathus latus*.

Morris (1969) has obtained a fauna from the South Pennines, which contains *S. anchoralis*, *Bactrognathus perplanus*, *Pseudopolygnathus triangulus*, numerous gnathodids, *Cavusgnathus* and *Mestognathus*. The presence of *Siphonodella* in the south-western faunas and of *Cavusgnathus* in the Staffordshire fauna, suggests a relatively younger age for the latter fauna.

Austin, Husri and Conil (1970» have documented conodont faunas which one from the base of the Waulsortian Bank facies in Ireland. This fauna includes *Pseudopolygnathus triangulus*, *Polygnathus inornatus*, *Polygnathus communis carina*, *Gnathodus semiglaber*, *G. antetexanus* and *G. texanus*, but lacks *Scaliognathus anchoralis* Hill (1971) has reported *S. anchoralis* from the Waulsortian Bank of County Limerick. Hill has also found *D. bouckaerti* from the basal reef limestones in Limerick (personal communication). Austin,Husri and Conil (1970) reported the presence of *Gnathodus homopunctatus* in beds which overlie the Waulsortian Bank in County Clare, Ireland. The Waulsortian Bank facies, therefore, appears to span the Upper Tournaisian-Lower Viséan time interval. This correlation to Belgium suggested by the conodonts is in agreement with the evidence of foraminifera recovered from the same levels. In Belgium and in Ireland the lower part of the reef and associated rocks contains a poor fauna of *Endothyra* and is followed by a fauna of *Palaeospiroplectammina diversa* and *Tetrataxis*. In Belgium these faunas correspond to the lower and upper part of the range of *S. anchoralis*. This sequence of forams is followed in Belgium by primitive Fusilinacaea and these have also been found in the uppermost part of the off-reef environment of Ireland. Hill (personal communication) has a fauna dominated by *Polygnathus lacinatus* from Castletown, Ireland, in beds which are thought to be the lateral equivalents of the Waulsortian Reef. These studies of Irish conodonts have convinced us that conodonts are ecologically restricted in their distribution. *Scaliognathus anchoralis* occurs very rarely in the « Reef » facies where gnathodids are dominant. In the calcite mudstone and bioclastic rocks deposited at the same time polygnathids are dominant. It is tempting to equate the *Gnathodus antetexanus-Polygnathus lacinatus* Zone of Rhodes, Austin and Druce with the *anchoralis* Zone of Continental Europe and Ireland.

Austin and Aldridge (1969) reported conodont faunas from the Orthotetid and Kilbride Limestones of County Meath. These faunas were dominated by *Polygnathus lacinatus*. *Mestognathus beckmanni* has subsequently been found in the Kilbride Limestone.

Rhodes, Austin and Druce (1969, p. 51) mentioned conodont faunas from the main Algal « Series » of Garwood in Harden Burn. These were dominated by the *Polygnathus lacinatus* group and other species including *Cavusgnathus cristatus* and *Taphrognathus varians*. Austin (*in press*) has suggested that these faunas are probably time equivalent to the formation of the *Caninia* Dolomite.

INTERPRETATION OF THE STANDARD GERMAN SUCCESSION

Recognition of the position of the Tournaisian-Viséan boundary in the cephalopod facies of Germany is difficult. Many critical parts of the German sequence have not yielded conodonts and other parts have yielded abundant faunas, which are often reworked (Krebs, 1963, 1964, 1968). A previously mentioned, but undescribed example of reworking (Austin *in press*) has been demonstrated by Dr. H. Pirlet of the University of Liège, who has generously allowed us to quote his studies in this paper. Dr. Pirlet summarizes his results as follows (in litt. transl.) « At the base of the Lower Oese Quarry, near Homer, in the base of the Hellefelder Kalk, 50 m. below *Entogonites nasutus*, I have found foraminifera of *V3bγ* age, and, in particular, *Archaediscus vertens*, *Archaediscus saleei*, *Archaediscus grandiculus*, *Planoarchaediscus eospirillinoides*. I find in the same thin section, *Endothra inflata analoga* and *Carbonella spectabilis* of *V1a* age, as well as Frasnian forms in the minute derived fragments. Dr. VOGES has found in this limestone (in this quarry and in the lateral equivalent of these beds), the zone of *anchoralis-bilineatus interregnum* (Hellefeld Quarry). In Belgium, the *V3bγ* is found in the zone of *bilineatus*. The *V1a* forams are derived in the same way as are the Frasnian fossils and have come from limestone of *V1a* age situated towards the southwest in the Rhenisches Schiefergebirges. These *V1a* limestones were derived at the close of *V3b* (*V3bγ*). The *V3bγ* limestones do not contain, in Germany, any *V3b* conodonts (*bilineatus*) because this « depositional zone » was unfavourable to conodont life at this time. This shows that in Germany, on the northern and eastern borders of the Rhenisches Schiefergebirges, the Viséan succession is incomplete. »

MATTHEWS (1970, 1971) clarified certain Dinantian palaeontological standards and summarized the evolution of the currently employed Dinantian goniatite zonal scheme. MATTHEWS emphasised that the *Ammonellipsites*-Stufe (*cu II*) comprises *cu IIα* (the probable source of which is the late Tournaisian rocks of Belgium), *cu IIβ* (whose location in Ireland cannot be precisely defined) and *cu IIγ* and *cu IIδ* both from Germany, but from different localities. MATTHEWS correctly concluded that « the scattered nature of this evidence makes it as difficult to guarantee that these units close with one another in a coherent sequence as to exclude the alternative possibility that they might to any extent overlap with one another. »

MATTHEWS (1971, p. 1160, 1161) cited conodont evidence to recognize the relationship of some important occurrences of Lower Carboniferous caphalopods, particularly those of the *Ammonellipsites*-Stufe (*cu II*). MATTHEWS' reading of VOGES' (1951, 60) papers is of importance and is repeated here. « VOGES (1960) used DELÉPINE's (1940, 1940a) information to justify separation of a late Tournaisian *cu IIα* from an early Viséan *cu IIβ*. His further suggestion was that *cu IIβ* and *cu IIγ* need not be taken to be distinct from one another, and he concluded, tentatively, that *cu IIβ/γ* and his *anchoralis* Zone occupy much the same range of age. Thus, regarding the *anchoralis* Zone as belonging in the early Viséan, he suggested that the *Siphonodella crenulata* Zone immediately preceding is of late Tournaisian age and, again tentatively, to be equated with *cu IIα*. These equations of cephalopod and conodont units appear on the range chart in VOGES' 1959 paper. It is unfortunate that those who have referred to VOGES' proposals have not always respected the hesitations, which he expressed in making these suggestions. »

MATTHEWS also referred to the preliminary results of CONIL, LYS and MAUVIER (1964) to point out one correction to the above. MATTHEWS stated (p. 1161) « A reference to the late Tournaisian in the 1964 paper records the occurrence of *Scaliognathus anchoralis* in *Tn3b*, and indicates that the *anchoralis* Zone range, in Belgian terms, is other than VOGES suggested (see also BÖGER 1962). In fact, the *anchoralis* Zone, earlier tentatively equated with *cu IIβ/γ*, might include or even predate the part of the Belgian stratigraphic succession from which Schmidt's *cu IIα* indices came (DELÉPINE, 1940). »

Since MATTHEWS presented his paper, new conodont information from Belgium, Germany and Ireland is available.

Scaliognathus anchoralis has been recorded in publications of preliminary results from *Tn3b* (CONIL, LYS and MAUVIER, 1964), *Tn3c* (GROESSENS, 1971) and *V1a*

(Conil *et al.*, 1969) rocks of Belgium. It is now recognized that the records of *S. anchoralis* in *Tn3b* and *V1a* are incorrect and this species in Belgium is confined to a horizon high in *Tn3c* and occurs stratigraphically higher than beds which have yielded the *cu IIα* cephalopods of the goniatite scheme.

Matthews (1971, p. 1161) noted that there was an interval in Belgium between the Hangenberg equivalent (*Tn1b*) and the site of occurence of *Ammonellipsites princeps* and its associates. The interval included *Tn2b*, and part of *Tn3*. Matthews continued « In terms of conodonts it may for the time being be treated as the *Siphonodella crenulata* Zone. » Recent studies of Belgian conodonts (Austin and Rhodes, 1970 and Groessens, 1971) over the interval *Tn2b* — *Tn3c* pre-*anchoralis* level, have shown that the genus *Siphonodella* ranges as high as the base of *Tn3a* and *Siphonodella crenulata* has to date not been found.

Dr. Eva Paproth of the Geologisches Landesant Nordrhein-Westfalen suggested to one of us (R.L.A.) that samples be taken for conodonts from an exposure at Kopfstation Neviges described by Paul (1937, 1938). The reason for this is that Böger (1962) in collecting samples from this section for his conodont study appears to have misunderstood the stratigraphy. Böger (1962, pp. 146, 147) recorded the presence of a *Siphonodella-triangulus* Zone in one limestone (layer 3) and of the *Scaliognathus anchoralis* Zone in an overlying limestone (layer 5). Böger reported that there was a 2 m mudstone interval (layer 4) between the two limestones. According to Dr. Paproth (written communication), Böger thought his layer 3 (0.5 m thickness) to be the lower part of Paul's « 1.10 m limestone stark geoschieferter Kalk. » He therefore believed his layer 4 « mudstones » were Paul's mudstones with ostrocodes, *Posidonia venusta* and *Avonia schmidti*. However, Böger's layer 1 corresponds to the 1.10 m. limestone of Paul and his layer 3 overlies the mudstones with ostracodes, *Posidonia venusta* and *Avonia schmidti*. Böger's layers 3, 4, and 5, according to Dr. Paproth are representatives of the 6.80 m « Erdbacher Kalk » of Paul (1937, p. 58). According to Böger, 2 metres of mudstone (layer 4) is present between his layers 3 and 5. Dr. Paproth recently re-excavated the exposure and found that limestone was present between layers 3 and 5 of Böger. Samples from the limestone which intervenes between the *Siphonodella-triangulus* bearing limestone (layer 3 of Böger) and the *S. anchoralis* bearing limestone (layer 5 of Böger) have yielded over 1000 conodonts. Only one specimen of *Siphonodella* has been found (in the lower part of the limestone) and there are no specimens of *Scaliognathus*. We suggest that the upper part of this limestone (recorded as a mudstone layer by Böger) is equivalent to the *Tn3a* — upper *Tn3c* interval in terms of the Belgian sequence.

Hill (1971) has reported *S. anchoralis* from the Waulsortian Reef Bank complex (lower part) of County Limerick and has also found *Dollymae bouckaerti* at the base of this lithological unit. The lower part of the Waulsortian Reef Bank complex is thus of *anchoralis* Zone age. Although the typical expression of *cu IIβ* goniatites in Ireland cannot be located with any accuracy, it is extremely unlikely that they predate the base of the Reef Bank complex.

The relative stratigraphic position of *cu IIα* and *cu IIβ* goniatite indices is therefore confirmed. It is recognized that intermediate faunas may exist. The available evidence suggest that *cu IIα* is Tournaisian (*Tn3b*- lower *Tn3c*) and *cu IIβ* is high Tournaisian (upper *Tn3c*).

When conodont workers in Germany (Bishoff, 1957; Voges, 1959, 1960) proposed their conodont zonation they recognized a *Scaliognathus anchoralis* Zone and a *Gnathodus bilineatus* Zone, with an *anchoralis-bilineatus* interregnum between.

Conodont faunas recovered from areas other than Germany in the interval between the *anchoralis* and *bilineatus* Zones have shown that the interregnum can be recognized by the presence of *Mestognathus*, *Gnathodus commutatus* and *Gnathodus homopunctatus,* as well as other gnathodids, whose synonymy is in need of revision. These forms were all reported by VOGES from the Erdbacher-Kalk (the source of the *cu II*γ cephalopods). It is suggested that the Erdbacher Kalk contains reworked conodonts and should be referred to the *anchoralis-bilineatus* interregnum, rather than to the *anchoralis* Zone as indicated by VOGES (1959).

We equate the Tournaisian-Viséan boundary with the base of the *Scaliognathus anchoralis-Gnathodus bilineatus* interregnum. It corresponds to an undetermined goniatite level below the *cu II*γ source but probably above the *cu II*β source. Dr. Dieter STOPPEL who is currently investigating Dinantian conodont faunas, informs us (oral communication) that he has located sections in Germany, where the Tournaisian-Viséan boundary can be recognized by applying the criteria which are adopted for its definition in Belgium.

CONCLUSIONS

(a) The Tournaisian-Viséan boundary is recognized by the appearance of *Eoparastaffella* and *Dainella* corresponding very closely to the appearance of *Mestognathus* and *Gnathodus* cf. *G. homopunctatus.*

(b) The Tournaisian-Viséan boundary is equated with part of the *Bactrognathus-Taphrognathus* Zone in the Mississippi Valley and is located within the upper Burlington Limestone. It also equates with the base of the *Gnathodus cuneiformis* Subzone in south western Missouri.

(c) The Tournaisian-Viséan boundary is located within the *Laminosa* Dolomite of the British Avonian succession.

(d) The distribution of certain conodonts, particularly the genera *Bactrognathus, Mestognathus* and *Scaliognathus* and some species of the genus *Gnathodus,* is controlled by environmental conditions.

(e) The *Caninia* Dolomite of the British Avonian is at the Avon Gorge of V2a age.

(f) The base of the *Caninia* Oolite in the Avon Gorge is marked by a non-sequence.

(g) Tournaisian-Viséan boundary faunas occur in the South Pennines of England and in Ireland, as in Belgium, in the Waulsortian Bank facies.

(h) *Scaliognathus anchoralis* in Germany often occurs in beds which, on other evidence, are younger than those referred to the *anchoralis* Zone in Belgium. The *S. anchoralis* specimens in many of the German successions appear to be derived.

(i) The Tournaisian-Viséan boundary is, in goniatite terms, located above the *cu II*β source, but below the *cu II*γ source.

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DEPOSITORY OF SPECIMENS

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RA Collection R. AUSTIN, Dept. of Geology, University, *Southampton*, England.

PLATE I

Bristol and Gower Regions

Layers below the Caninia Oolite

Endothyra ex gr. *latispiralis* Lipina, 1955
Fig. 1 Base of *Z2* at Bristol, RC 3851. (6700). × 75. See [18], pl. VIII, fig. 83.

Endothyra nebulosa Malakhova, 1956
Fig. 2 Lower *C1*, Gower, Tears Point, RC 4739. (5601). × 75.

Caninia Oolite (Upper C1)

Endothyra ex gr. *latispiralis* Lipina, 1955
Fig. 3 Bristol, RC 6163 (6840). × 75.

Endothyra sp.
Fig. 4 Bristol, RC 6139. (6727). × 75.

Globivalvulina (?) *bristolensis* Reichel, 1946
Fig. 5 Bristol, RC 2889. (6726). × 75.
Fig. 6 idem, RC 6138. (6728). × 75.
Figs. 7, 8 idem, RC 6164. (6838, 6839). × 75.
Fig. 9 idem, RC 6162. (6842). × 75.
Fig. 10 idem, RC 6138. (6731). × 75.

Palaeospiroplectammina ex gr. *mellina* (Malakhova), 1956
Fig. 11 Bristol, RA. (6732). × 75.

Endothyra ex gr. *bowmani* Phillips, 1846
Fig. 12 Gower, Tears Point, RC 4743. (5607). × 75.

Caninia Dolomite (C2)

cf. *Eostaffella* sp.
Fig. 13 Bristol, RC 2891. (6721). × 75.

Tournayellidae (cf. *Brunsiina* sp.)
Fig. 14 Bristol, RC 3850. (6718). × 75.

Loeblichia (*Urbanella*) *fragilis* (Lipina), 1951
Fig. 15 Bristol, RC 3850. (6698). 75.

Brunsia spirillinoides (Grozdilova & Glebovskaia), 1948.
Fig. 16 Bristol, RA. (6734). × 75.

Tournayellidea (cf. *Spinotournayella*; resembles *Endothyra recta* Lipina)
Fig. 17 Bristol, RC 3850. (6699). × 75.

Dainella chomatica (Dain), 1940.
Fig. 18 Bristol, RC 2891. (6725). × 75.

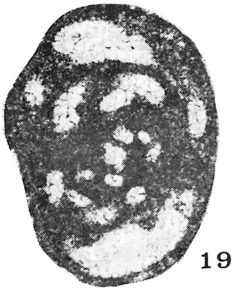
Dainella sp.
Fig. 19 Bristol, RC 2891. (6723). × 75.

Dainella cognata Ganelina, 1966
Fig. 20 Bristol, RC 3850. (5094). × 75.

Endothyra sp.
Fig. 21 Bristol, RC 2891. (6722). × 75.

The classification number is noted between brackets (fichier Lab. de Paléonthologie, Univ. Louvain).

PLATE II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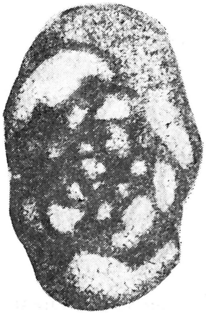
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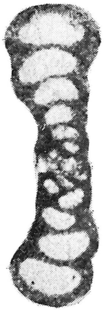
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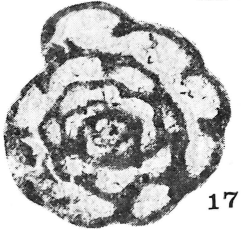
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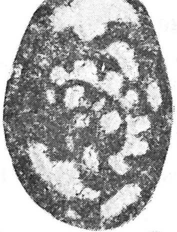
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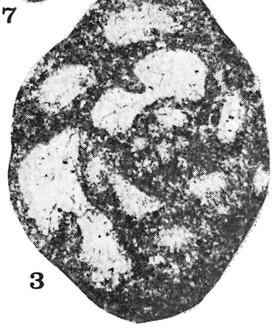
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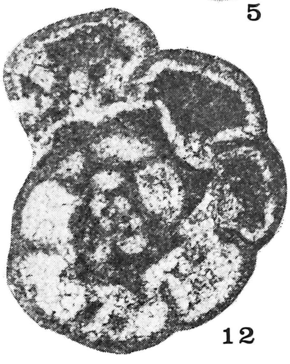
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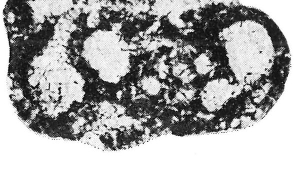
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PLATE II

MENDIP REGION

Lower C1

Tournayllidae
Fig. 22 RA. (6711). × 75.

Burrington Oolite

? *Mikhailovella* sp.
Fig. 23 RA. (6715). × 75.

cf. *Palaeospiroplectammina diversa* (N. TCHERNYSHEVA), 1949
Fig. 24 RA. (6714). × 75.

Archaediscus sp.
Fig. 25 RA. (6742). × 140.

Nodosarchaediscus (*Nodosarchaediscus*) sp.
Fig. 26 RA. (6741). × 140.

Quasiendothyra (?) *nibelis* DURKINA, 1959
Fig. 27 RA. (6702). × 75.

Endothyra bowmani PHILLIPS, 1846
Fig. 28 RA. (6709). × 75.

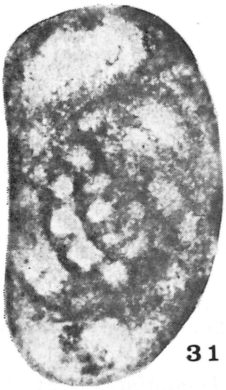
cf. *Eostaffella* sp.
Fig. 29 RA. (6707). × 75.

Dainella fleronensis (CONIL & LYS), 1964
Fig. 30 RA. (6704). × 75.

Dainella sp.
Fig. 31 RA. (6701). × 75.
Fig. 32 RA. (6705). × 75.

Dainella elegantula BRAZHNIKOVA, 1962
Fig. 33 RA. (6706). × 75.

PLATE II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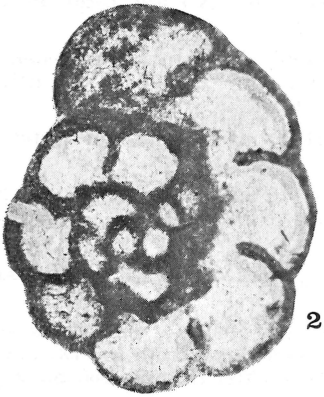
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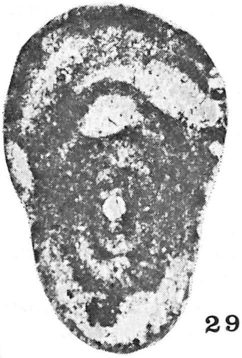
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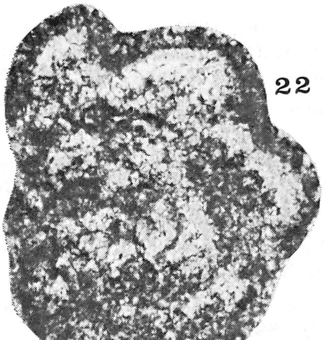
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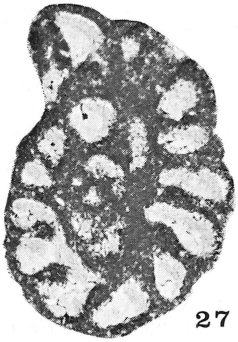
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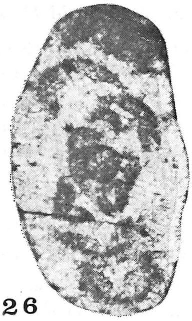
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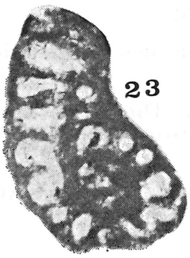
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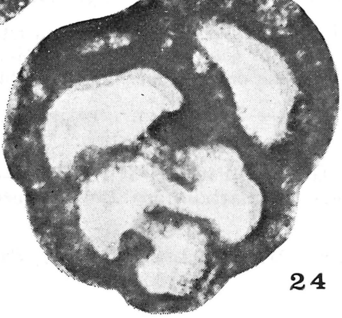
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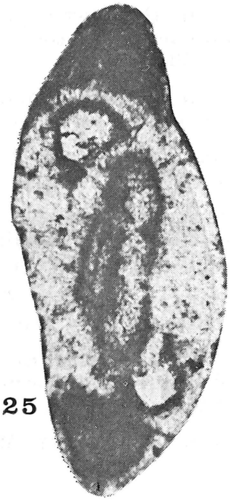
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