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THE DISTRIBUTION OF TOURNAISIAN AND EARLY VISÉAN
(CARBONIFEROUS) CORAL FAUNAS FROM THE BRISTOL
AND SOUTH WALES AREAS OF BRITAIN

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The Tournaisian and early Viséan (Carboniferous) faunas of Britain have been divided into a sequence of four assemblage biozones, the *Vaughania vetus*, *Zaphrentites delanouei* and *Caninophyllum patulum* assemblage biozones which are of Tournaisian age, and the *Siphonophyllia cylindrica* Assemblage Biozone of Viséan (Chadian) age. This sequence of biozones established at Burrington Combe in the Mendips is used to correlate the Tournaisian and early Viséan rocks from eight sections in the Bristol and South Wales areas. Several sections can be shown to be incomplete with a northward widening non-sequence present between the top of the Black Rock Limestone and the base of the succeeding Gully Oolite. One new species *Sychnoelasma clevedonensis* sp.n. and one new subspecies *Caninophyllum patulum greent* sub-sp.n. are named.

Key words: Rugosa, biostratigraphy, Tournaisian, early Viséan, Britain.

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DISTRIBUTION AND STRATIGRAPHY

The Dinantian of Britain occurs in two main areas divided by the west-east lying Wales-Brabant Island. In the north, the Dinantian rocks were deposited in a complex area of blocks and basins, but the Tournaisian and early Viséan coral faunas are poor throughout this northern area. These faunas however are well developed in the southern area, around Bristol and in South Wales, where the rocks were laid down on a broad carbonate shelf between the Cornubian basin of south-west England to the south, and the Wales-Brabant Island to the north. This area includes the classic sections of the Avon Gorge at Bristol and Burrington Combe in the Mendips. The earliest Dinantian rocks in this area are of Old Red Sandstone facies with no coral faunas and these are succeeded by the Lower Limestone Shale consisting of shales and thin limestones in which corals

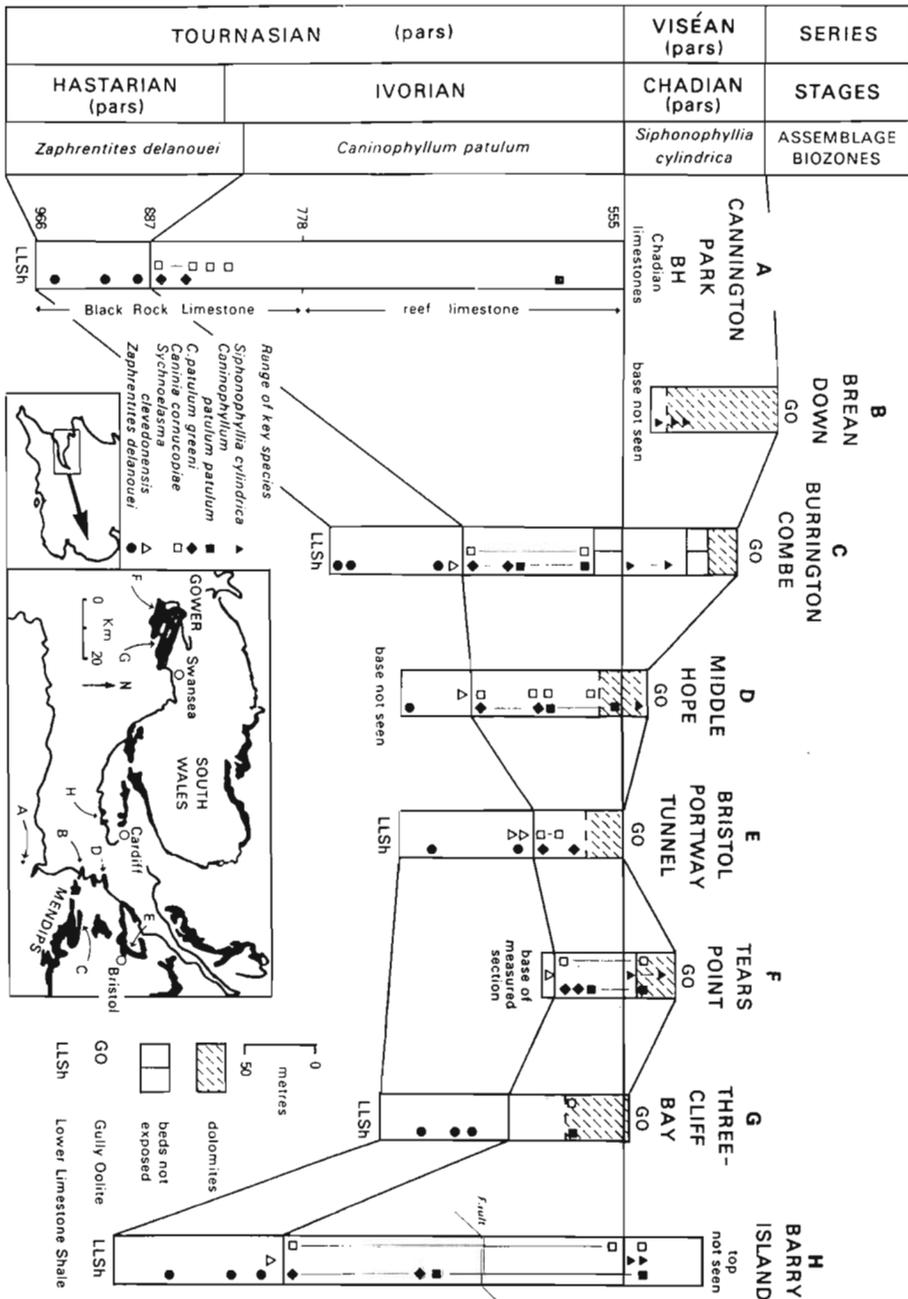


Fig. 1. A correlation of some Black Rock Limestone sections in the Bristol and South Wales areas. The stratigraphy is based on the following works: Column A, Whittaker and Scrivener 1978: 12–13, and Whittaker *et al.*, in preparation; B, Whittaker and Green, in preparation; C, Mitchell and Green 1965: 180–187; D, Whittaker and Green, in preparation; E, Bristol Sheet (264) and Mitchell 1972: 159; F, Reynolds, Mitchell and Ramsbottom, in preparation; G, Swansea Sheet (247); H, Dr R. A. Waters, Cardiff Sheet (263) in progress. The ranges of key species have been indicated and where the symbols for a species are joined by a vertical line, the species has been recorded throughout this range. Note. The apparent thickness of the *C. patulum* Biozone at Barry Island (column H) has been increased by thrust faulting but the amount cannot be determined.

are rare. The remainder of the Tournaisian and early Viséan sequence below the Gully Oolite is formed by the dark grey crinoidal Black Rock Limestone containing rich coral faunas, the sequence and distribution of which are described in this paper (fig. 1). The top part of the Black Rock Limestone is usually dolomitised.

HISTORY OF RESEARCH

The first zonal work on the Dinantian faunas of Britain was the classic 1905 paper by Vaughan who described the faunas, primarily the corals and brachiopods, from the Avon Gorge Bristol. For many years the Avon Gorge sequence was taken as the typical section for the Carboniferous Limestone (Dinantian) of Britain, but Vaughan's Bristol work is now largely of historical interest because the Avon Gorge has subsequently proved to be such an incomplete section (Ramsbottom 1973: 595).

The Burrington Combe section is more complete than that in the Avon Gorge and following the revision by Carruthers (1908) of many of the stratigraphically important coral species and the recognition of the various species of caninoids presents, the description of the faunal sequence of this section by Reynolds and Vaughan (1911) formed the standard work of reference for the lower part of the Dinantian succession. Some of the difficulties of interpreting the records of caninoids in Vaughan's earlier papers is explained by the interesting footnote in the paper on the Gower sequence by Dixon and Vaughan (1912: 545). They noted that "*Caninia cylindrica* as employed in the Bristol paper covered all the *Caninias* from the entrance of the genus at the top of the Z₂ to the maximum of *C. cylindrica* mut. S₁ in the Lower *Seminula* Zone. These would now be differentiated into *C. cornucopiae*, *C. patula* and *C. cylindrica*; at the time of our work in Gower (in 1905), however, all these forms were lumped under *C. cylindrica*."

The first work to list the full ranges of fossils in the Black Rock Limestone was that of Mitchell and Green (1965: 180—187, table 1) who described the faunas of the Burrington Combe succession, and recognised three faunal assemblages, the Lower Fauna, Middle Fauna and Upper Fauna. These have been given formal assemblage biozone names by Ramsbottom and Mitchell (1980) who discussed the recognition and division of the Tournaisian Series in Britain, and showed the correlation of these assemblage biozones with the Belgian sequence.

SEQUENCE OF FAUNAS

The four assemblage biozones proposed by Ramsbottom and Mitchell (1980) are in ascending order:

1. *Vaughania vetus* Assemblage Biozone. This is the name adopted for

the *Cleistopora* aff. *geometrica* (K) Zone of Vaughan (1905: 189). Corals are rare but *Vaughania vetus* Smyth occurs in thin limestones present in the upper part of the Lower Limestone Shale. The only record of zaphrentoids is by Reynolds and Vaughan (1911: 363) who note *Zaphrentites delanouei* Milne Edwards et Haime as "very rare and only at the top". Brachiopods are common and *Chonetes failandensis* Smith and *Plicochonetes stoddarti* (Vaughan) are restricted to this biozone.

2. *Zaphrentites delanouei* Assemblage Biozone. This is the name proposed for the Lower Fauna of Mitchell and Green (1965: 182; Black Rock Limestone, beds 1—9) and is approximately equivalent to the *Zaphrentis* (Z) Zone of Vaughan (1905: 190). The assemblage includes the corals *Fasciculophyllum omaliusi* (Milne Edwards et Haime), *Michelinia favosa* (Goldfuss), *Syringopora vauhani* Hudson (= S.Θ of Vaughan 1905: 268, pl. 22: 1, 1a), *Zaphrentites delanouei* and *Sychnoelasma clevedonensis* sp.n. The last named species is restricted to the top part of the biozone, and is the new species proposed for 'Z'. *konincki* forma α of Carruthers (1908: 69, pl. 5: 1, 1a; = *Zaphrentis* aff. *cornucopiae* of Vaughan 1905: 271, pl. 22: 3, 3a—d). The specimen figured by Carruthers (British Museum (Natural History) R15247—9) is taken as the holotype of *S. clevedonensis* which is distinguished from *S. konincki* (Milne Edwards et Haime) by having a taller, more upright corallum with a smaller diameter (c. 10 mm) and fewer major septa (27—33). Brachiopods are again common in the fauna, and *Pugilis vauhani* (Muir-Wood) and *Rugosochonetes vauhani* Muir-Wood are characteristic.

3. *Caninophyllum patulum* Assemblage Biozone. This is the name given to the Middle Fauna of Mitchell and Green (1965: 182; Black Rock Limestone, beds 10—15) and is equivalent to "Horizon γ" as defined at Burrington by Reynolds and Vaughan (1911: 366). In all sections that have been studied, the base of the biozone is marked by the sudden incoming of a rich coral assemblage with *Caninia cornucopiae* Michelin, *Caninophyllum patulum* (Michelin), *Cyathaxonia cornu* Michelin, *Cyathoclisia tabernaculum* Dingwall, *Fasciculophyllum densum* (Carruthers), *F. omaliusi*, *Syringopora reticulata* Goldfuss, and *Sychnoelasma konincki* (Milne Edwards et Haime). Brachiopods are again common but all are long ranging species.

Reynolds and Vaughan (1911: 374) described "two forms or varieties" of *C. patulum* and these are mutually exclusive, the closely septate form occurring in the lower part of the biozone, and the widely septate form occurring in the upper part of the biozone and in the *Siphonophyllia cylindrica* Biozone. The two are here given the status of subspecies. The widely septate form (Reynolds and Vaughan 1911: pl. 30: 5a, b; BM (NH) R15335—7, 15257—9, 19602 and 28000) is referred to *C. patulum* (Michelin) *sensu stricto* and agrees with the revision of the species by Salée (1910: 39, pls. 5, 6 and 7: 1) based on topotype material. The closely septate form is designated *Caninophyllum patulum greeni* subsp. n. (named after Mr

G. W. Green) with the specimen figured by Reynolds and Vaughan (1911: pl. 30: 6a, b: BM (NH) R15260—1) as the holotype. *C. patulum greeni* has a larger number of septa at a smaller diameter, with 67 major septa at about 25 mm, than *C. patulum patulum* which has 50 major septa at about 30 mm diameter.

4. *Siphonophyllia cylindrica* Assemblage Biozone. The name adopted for the Upper Fauna of Mitchell and Green (1965: 182; Black Rock Limestone, beds 16—20 including dolomite) and equivalent to the part of C₁ above Horizon γ as used by Reynolds and Vaughan (1911: 366). The biozone is characterised by the presence of *Siphonophyllia cylindrica* (Scouler) *sensu stricto*, the entry of which marks the base of the biozone. *Caninophyllum patulum patulum* (in the basal part only), *Cyathoclisia tabernaculum*, *Fasciculophyllum densum*, *F. omaliusi* and *Syringopora reticulata* range up from the underlying biozone. A coral between *Sychnoelasma konincki* and *S. konincki* var. nov. of Hudson and Mitchell (1937: 9) is also recorded. The brachiopod fauna is more limited than in the lower biozones but *Megachonetes magna* Rotai (= *Chonetes* aff. *papilionacea* Phillips of Vaughan 1905: pl. 26: 3) and *Pustula pyxidiformis* (de Koninck) are characteristic. The fossils in the dolomites at the top of the Black Rock Limestone at Burrington are sparse and poorly preserved. Such fauna as is present however suggests that the *S. cylindrica* Biozone continues to the base of the Gully Oolite which contains a sparse but distinctive assemblage including *Koninckophyllum praecursor* Howell and *Michelinia megastoma* Phillips.

CORRELATION

This sequence of assemblage biozones can be used to correlate the Tournaisian and early Viséan rocks throughout the Bristol and South Wales areas and the results from eight sections that have been studied in detail are shown in figure 1. The *V. vetus* and *Z. delanouei* biozones are consistent throughout the area and show little change of fauna or thickness, but the *C. patulum* and *S. cylindrica* biozones show great thickness variations.

Burrington Combe (fig. 1: column C) still forms the best published reference for the details of the faunas of the biozones, but unfortunately there is a gap in the exposures (23 m) between the beds with *C. patulum* Biozone fauna and those with the *S. cylindrica* Biozone fauna, and these two important species do not occur together. However two sections have been studied where the beds are fully exposed across this biozonal boundary and at both there is a range of overlap, with *C. patulum patulum* occurring in the lowest 9.50 m of the *S. cylindrica* Biozone at Tears Point in south west Gower (column F) and in the lowest 10.28 m at Barry Island

south of Cardiff (column H). The evidence of overlap from these two sections suggests that at least part of the gap between the biozones at Burrington may be of *S. cylindrica* Biozone age.

The *C. patulum* Biozone in the Cannington Park Borehole (column A) includes 223 m of reef limestones comparable in lithology and age (Whittaker *et al.* in preparation) with the Waulsortian reefs of Belgium and southern Ireland. Typical *C. patulum* Biozone faunas are present below the reef but only four corals have been collected from within the reef (two specimens of *Amplexus coralloides* J. Sowerby and two of *C. patulum patulum*). The *C. patulum* Biozone is also very thick at Barry Island (240 m) where it is in typical Black Rock Limestone facies but the apparent thickness is increased to some extent by thrust faulting.

The details for the Bristol section (column E) are based on collections made from the Portway Tunnel which was constructed below the Avon Gorge and show the Avon Gorge to be the most incomplete Black Rock Limestone sequence yet studied in the Bristol area. Only the lower part of the *C. patulum* Biozone (63 m, including 27 m of dolomite), with *C. patulum greeni* is present, and by comparison with the Burrington section, the top part of the *C. patulum* Biozone and the whole of the *S. cylindrica* Biozone are missing (Mitchell 1972: 159, fig. 1). This non-sequence was also indicated by the conodont sequence (Rhodes and Austin 1971: 341). It is now clear that Vaughan was unfortunate in his choice of a type section for his Bristol area work and the fact that four substantial non-sequences can now be recognized in the Avon Gorge succession is one of the main reasons for the frequent changes that Vaughan was forced to make to his zonal scheme as he subsequently studied more complete sections away from Bristol (Ramsbottom 1973: 595).

The Threecliff Bay section (column G) in south Gower is also incomplete and has very poor coral faunas. No *S. cylindrica* fauna has been collected but the record of *Mestognathus beckmanni* Bischoff from 2.5 m below the base of the Gully Oolite (Mr M. J. Reynolds pers. comm.) indicates that part of the dolomitised upper beds of the Black Rock Limestone belong to the *S. cylindrica* Biozone. At Tears Point (column F) both the *C. patulum* Biozone (48 m) and the *S. cylindrica* Biozone (37 m) are thin.

The Middle Hope section (column D) has a thickness of the *C. patulum* Biozone (106 m) comparable to that at Burrington but only a thin *S. cylindrica* Biozone (16 m). To the south of Weston however, the *S. cylindrica* Biozone is over 90 m thick at Brean Down (column B).

No information is available about the faunal sequence to the north of Bristol where much of the Black Rock Limestone is extensively dolomitised. However, with a widening non-sequence being present at the top of the Black Rock as the beds are traced northward, it may be that only the lowest part of the Black Rock Limestone is developed here.

Detailed correlation with the coral sequences of Belgium has not been attempted but using the evidence of the conodont faunas from both areas, a correlation of the British biozones with the Belgian succession was suggested by Ramsbottom and Mitchell (1980: fig. 1). The *V. vetus* Biozone and the greater part of the *Z. delanouei* Biozone correlate with the Hastarian Stage. The base of the *C. patulum* Biozone is drawn slightly above the base of the Ivorian Stage, the base of which is equated with the base of the *Polygnathus communis carina* conodont Biozone. The base of the *S. cylindrica* Biozone correlates with the base of the *Mestognathus beckmanni* conodont Biozone and with the Tournaisian-Viséan boundary.

PALAEOGEOGRAPHY AND CONCLUSIONS

The Black Rock Limestone of the Bristol and South Wales areas was laid down in a broad carbonate shelf environment on the southern flank of the Wales-Brabant Island. The beds are thickened in the south and thin markedly as they are traced northwards onto the shelf, with much of the reduction in thickness resulting from the absence of beds in the upper parts of the Black Rock Limestone. The diachronous development of dolomites at the top of the Black Rock were either primary, deposited in a restricted environment with limited connection with the open sea to the south, or more likely, were secondary, resulting from the alterations of the top of the existing Black Rock Limestone surface.

Ramsbottom (1973: 574) assigned the Lower Limestone Shale and the Black Rock Limestone to his First Major Cycle (= Courceyan Stage of George *et al.* 1976), with the non-sequence at the top of the Black Rock Limestone representing part of the regressive phase of this cycle, but it is now apparent that the upper part of the Black Rock Limestone is of Chadian age. In 1977 (fig. 10) he considered that the Courceyan contained three mesothemic cycles (D1a, D1b, D1c) and Ramsbottom and Mitchell (1980) stated that the D1c mesothem corresponds to the Ivorian Stage.

There is no available evidence of a break in the succession at the base of the Gully Oolite and no marked lithological changes at the horizons where the major changes of fauna occur. However at Barry Island and Middle Hope, the *C. patulum* Biozone fauna appears immediately above an irregular rolling bedding surface. This probably marks the position of a paraconformity or break of major time significance in the sedimentary record of parallel bedded rocks. It is suggested that such paraconformities are present at the base of both the *C. patulum* and *S. cylindrica* biozones and that beds missing at these horizons account for much of the reduction in thickness of the Black Rock Limestone in the north of the area.

In addition to the depositional history of the area with breaks in the sequence, local contemporary movements may also have influenced the

thickness of the beds, with the Vale of Neath structure affecting the Gower successions and the structures involved with the line of the Severn axis affecting the Avon and the Middle Hope successions.

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