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OUTSTANDING PROBLEMS OF DINANTIAN CONODONT BIOSTRATIGRAPHY IN THE BRITISH ISLES, WITH SUGGESTIONS FOR THEIR SOLUTION

by

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ABSTRACT

Current understanding of British Dinantian conodont biostratigraphy is assessed and attention is drawn to 5 aspects which remain to be resolved. Classification of Dinantian rocks in Britain is in need of reappraisal and criteria for the recognition of stratal units need to be clearly defined. Recent changes concerning the location of the stratotype and the criteria adopted for recognition of the base of the Carboniferous System are of particular relevance to South West England. Reconstruction of multielement apparatuses for Lower Carboniferous genera appears to have little biostratigraphic use. Application of morphometric techniques to the Pa elements is more likely to provide the basis for refinement of taxonomic division and biostratigraphic precision. 45 Dinantian palaeobiological events may be recognised in Britain related to the appearance and disappearance of conodont genera. Conodont lineages provide a framework for future biostratigraphic studies in Britain. Integrated micropalaeontological studies related to seismic, sedimentological and chemical data should be referenced to stratotype sections. The influence of facies on conodont distribution will be better understood following integrated sedimentological and microfaunal studies and by the application of new techniques to provide greater yields of conodonts from non-carbonate lithotypes.

RESUME

L'évaluation de l'échelle biostratigraphique des conodontes dinantiens a attiré l'attention sur cinq problèmes importants à résoudre.

Une révision de la subdivision lithostratigraphique du Dinantien est nécessaire, suivant des critères clairement définis. Des modifications récentes dans le choix du stratotype et des critères de reconnaissance de la base du système carbonifère sont d'importance primordiale pour le S.O. de l'Angleterre.

La reconstitution de multiéléments dans les faunes à conodontes du Carbonifère inférieur ne semble présenter que peu d'intérêt biostratigraphique. Par contre, l'application de techniques morphologiques à l'élément Pa est mieux indiquée pour améliorer la classification taxonomique et la précision biostratigraphique.

45 évènements paléobiologiques, basés sur les moments d'apparition et de disparition des conodontes, peuvent être reconnus dans le Dinantien de la Grande-Bretagne.

Les linéations phylogéniques des conodontes fournissent un canevas pour les études biostratigraphiques futures.

Des études micropaléontologiques intégrant des données sismiques, sédimentologiques et géochimiques devraient être appliqués aux stratotypes. L'influence du faciès sur la distribution des conodontes serait mieux comprise après l'intégration des études sédimentologiques et micropaléontologiques et par l'utilisation de techniques nouvelles facilitant l'extraction des conodontes de roches non-carbonatées.

KEY WORDS

Biostratigraphy, conodonts, Dinantian, Carboniferous, British Isles, facies control.

MOTS CLE

Biostratigraphie, conodontes, Dinantien, Carbonifère, Grande Bretagne, contrôle de faciès.

1. INTRODUCTION

Twenty years have elapsed since the publication of a description of British Avonian conodonts from the type Avonian sequence at the Avon Gorge, Bristol (Rhodes *et al.*, 1969). Much new informa-

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tion is now available concerning the distribution of Dinantian conodonts in the British Isles. Varker & Sevastopulo (1985) provide a useful update and important publications have appeared subsequently (Armstrong & Purnell, 1987 ; Sevastopulo & Nudds, 1987 ; Mitchell *et al.*, 1986 ; Waters & Lawrence, 1987 ; Dickson *et al.*, 1987; Austin, 1987).

This contribution focuses attention on five aspects of British Dinantian conodont biostratigraphy which currently are in need of resolution. These may be summarised as follows :

a) classification of Dinantian rocks in the British Isles ;
b) the base of the Carboniferous System and its recognition in the British Isles ;
c) the taxonomy of Dinantian conodonts with reference to multielement apparatuses ;
d) the evolutionary sequence of Dinantian conodonts and the definition and recognition of conodont biozones related to Dinantian events ;
e) the recognition of facies-control on the distribution of Dinantian conodonts.

a) Classification of Dinantian rocks in the British Isles

Before correlating strata there has to exist a well established standard which may be based for example on biostratigraphic, chronostratigraphic, magnetostratigraphic, E-logs, seismic or tephrochronologic subdivision.

George *et al.* (1976) proposed a new classification for British Dinantian rocks based on defined stratotyped stages, to provide the framework of a comprehensive reorganisation as a standard for correlation by any convenient means. Their divisions are chronostratigraphic. The new stages replaced Vaughanian and other comparable divisions. Only two of the stage-boundaries proposed by George *et al.* (1976) for the British Dinantian correspond with zonal boundaries, thus causing difficulties in correlation of sequences with the defined stratotypes ; difficulties which are increased by the absence of faunal lists for the stratotypes. To a large extent the disadvantages of the system which has been proposed by George *et al.* are a direct consequence of the introduction of stage names by definition before the faunas and floras had been adequately studied. Details of the faunas in the stratotype sections have appeared slowly (for example Ramsbottom, 1981 ; Fewtrell *et al.*, 1981 ; Austin, 1987 ; Simpson & Kalvoda, 1987).

The approach of George *et al.* (1976) to Dinantian subdivisions was essentially different from that adopted by one of us (Austin, 1973) and by continental geologists. On the continent the macrofossil and microfossil distributions were studied in detail before proposals were made concerning sub- divisions of the Dinantian Subsystem. A stratigraphic chart for the Dinantian Subsystem presented by

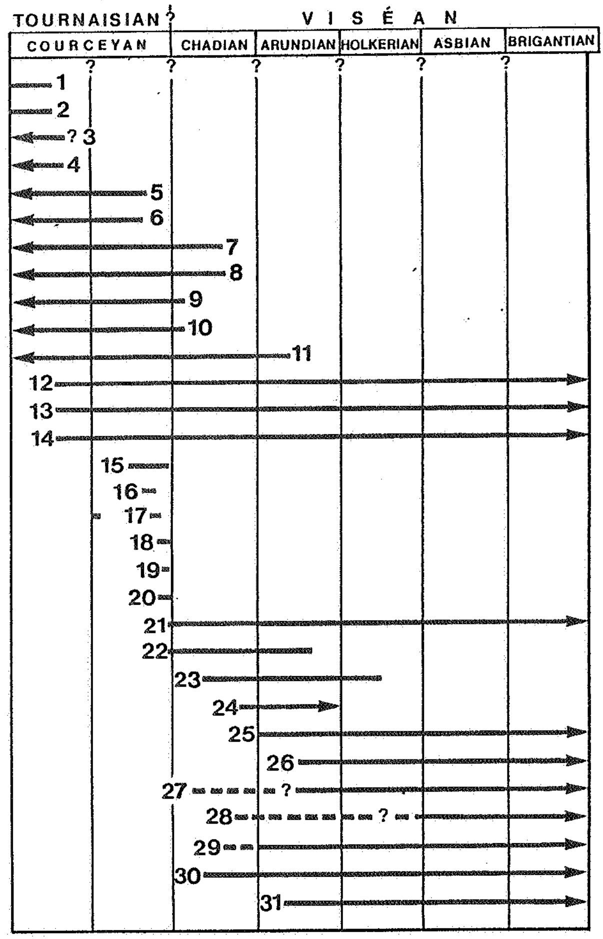

Figure 1. Range of Dinantian Conodont genera in Great Britain:

1. *Elictognathus*
2. *Nodognahthus*
3. *Protognathodus*
4. *Siphonodella*
5. *Branmehlia*
6. *Mehlina*
7. *Bispathodus*
8. *Patrognathus*
9. *Clydagnathus*
10. *Pseudopolygnathus*
11. *Polygnathus*
12. *Hindeodus*
13. *'Apatognathus'*
14. *Gnathodus*
15. *Bactrognathus*
16. *Pelekysgnathus*
17. *Dollymae*
18. *Eotaphrus*
19. *Doliognathus*
20. *Scaliognathus*
21. *Mestognathus*
22. *Cloghergnathus*
23. *Taphrognathus*
24. *Embsaygnathus*
25. *Lochriea*
26. *Cavusgnathus*
27. *Kladognathus*
28. *Idioprioniodus*
29. *Diplognathodus*
30. *Vogelgnathus*
31. *Geniculatus*

Conil *et al.* (1977) has subdivisions which relate to faunas and the Stage boundaries usually coincide with faunal changes. Increasingly it has become recognised that the proposals made by George *et al.* should be reappraised (see for example Austin, 1987 ; Austin & Davies, 1984).

Discussion as to Series names is at this time superfluous. As noted by George *et al.* (1976), in the discussion of George & Wagner (1972) and in Bouroz *et al.* (1978), the status of Dinantian, Tournaisian and Viséan continues to change and doubtless will be considered again in the near future. However, George *et al.* (1976) imply usage of the Courceyan as a Series name "a new term (Courceyan) is proposed to include all the strata of that part of the Tournaisian which is of Dinantian age". Ramsbottom & Mitchell (1980) published a paper entitled "The recognition and division of the Tournaisian Series in Britain", response to which appeared a year later in contributions from Fewtrell & Smith (1981) and Clayton & Sevastopulo (1981). Chlupac *et al.* (1981) discussed the use of Series or Stage names within the Carboniferous System, as have Lane & Manger *in* Lane & Ziegler, 1985.

b) The base of the Carboniferous System and its recognition in the British Isles

The Subcommission on Carboniferous Stratigraphy has clearly stated (George & Wagner, 1972) that there should be coincidence of System, Series and Stage boundaries at the base of the Carboniferous System. In Western Europe the base of the Carboniferous System, by definition, has for a long time been taken at the first appearance of *Gattendorfia subinvoluta*, following a recommendation made by the 1935 Heerlen Carboniferous Congress and subsequently endorsed by later meetings of the same body (George & Wagner, 1972). Meetings of the Subcommission on Carboniferous Stratigraphy have long held the opinion that when considering subdivision of the Carboniferous System, goniatites are to be given priority. Nevertheless one of us backed a proposal made at a meeting of the 7th Carboniferous Congress held in Krefeld in 1971 that the base of the Carboniferous System be redefined at a point in an evolutionary sequence of conodonts where the species *Siphonodella sulcata* arises from *Siphonodella praesulcata*. The selection of a horizon in a boundary stratotype for the base of the Carboniferous System subsequently has been considered by a working group of the International Union of Geological Sciences (Paproth, 1978 ; Paproth & Streel, 1984 ; Flajs *et al.*, 1988). Should the proposal that the first appearance of *Siphonodella sulcata* be accepted as the definitive criterion for the base of the Carboniferous System, it may not in itself greatly assist correlation of British sections with the agreed stratotype, the reason being that the genus *Siphonodella* is not present in many British rock sequences of late Devonian to early Carboniferous age. *Siphonodella* is sparse in the British Lower Carboniferous sequences of shelf aspect. However, the genus is relatively common in Lower Carboniferous sequences of South West England and it is in rocks (probably subsurface) of this region of the British Isles that eventually the *S. praesulcata* - *S. sulcata* evolutionary sequence may be found (see Stewart *in* Varker & Sevastopulo, 1985). Sections lacking the *Siphonodella* evolutionary sequence may be correlated with the stratotype using spores, since sections which demonstrate the *S. praesulcata* - *S. sulcata* conodont lineage also contain spores. Kasig & Paproth (1981) have shown a sequence of LL, LE, LN and VI spore associations in four rock sequences of Upper Devonian age in Germany. In Ireland the base of the VI Biozone (Higgs *et al.*, 1988a, 1988b) is marked by the disappearance of a distinctive group of taxa. The base of the zone approximates to the Devonian-Carboniferous boundary and also equates with the base of the Courceyan Stage (see also Neeves *et al.*, 1972 ; Clayton *et al.*, 1978 and Marchant *et al.*, 1984).

c)The taxonomy of Dinantian conodonts with reference to multielement apparatuses

Since the publication of Rhodes *et al.* (1969), systematic taxonomic study of Dinantian conodonts within the British Isles has remained relatively static. A few new species and subspecies have been described in terms of form-taxa, but there have been few alternative approaches to species-definition of conodonts. Hill (1974) published a preliminary report of a biometric approach, following a study of gnathodoid populations, but this approach has not been taken up and developed by other researchers.

Few studies have been undertaken in Britain since the work of Druce *et al.* (1972) regarding the composition of Dinantian conodont apparatuses (Alridge *et al. in* Aldridge, 1987). A limited number of Lower Carboniferous taxa have been reconstructed in recent years in terms of multielement taxonomy. They include reconstructions of the apparatus for species of *"Apatognathus"* (Nicoll, 1980), *Cavusgnathus* (Rexroad & Merrill, 1985), *Gnathodus* (Norby, 1976), *Hindeodus* (Baesemann, 1973 ; Sweet *in* Ziegler, 1977), *Idioprioniodus* (Baesemann, 1973 ; Merrill & Merrill, 1974 ; von Bitter, 1973), *Kladognathodus* (Rexroad, 1981), *Lochreia* (Norby, 1976), *Polygnathus* (Klapper & Philip, 1971 ; 1972), *Vogelgnathus* (Norby & Rexroad, 1985), *Pseudopolygnathus, Scaliognathus, Bactrognathus, Doliognathus* and *Staurognathus* (Chauff, 1981). It is doubted if such multielement refinements will lead to a more useful taxonomy for biostratigraphic or palaeoecologic investigations of Dinantian strata in Britain. Chauff (1981), for example, has suggested a multielement reconstruction for a number of Lower Carboniferous species including the biostratigraphically important forms *Polygnathus communis carina* and *Pseudopolygnathus multistriatus*. He interpreted the species as having vicareous Pb M Sa Sb and Sc elements in addition to the distinctive Pa elements. Chauff further suggested that an additional hindeodinan Sb element may also have formed part of the apparatus. The apparatuses were thus either sexi- or septimembrate in composition, but were distinctive only in terms of their Pa element.

Of more significance with regard to biostratigraphic applications have been advances in understanding the evolutionary development of the Pa element of apparatuses. The evolutionary development of the characteristic Lower Carboniferous genus *Siphonodella* has been documented (Sandberg *et al.*, 1978), as has the evolutionary development of the genera *Bispathodus* (Ziegler *et al.*, 1974), *Clydagnathus* and *Patrognathodus* (Austin & Hill, 1973). The evolutionary development of *Dollymae bouckaerti* and related forms (Groessens, 1976) and of certain species of *Pseudopolygnathus* (Rhodes *et al.*, 1969 ; Johnston & Higgins, 1981) is now reasonably well documented.

Problems remain regarding the origins of *Cavusgnathus, Taphrognathus, Cloghergnathus, Mestognathus* and related genera. The development of the zonally important Dinantian form genus *Gnathodus* and its relatives remains unresolved. Some conodont researchers (e.g. Belka, 1985) have preferred to recognise a number of separate species, but the definitions of the types often have not been adequate to distinguish precisely a particular species or subspecies from others of similar morphology. Lane *et al.* (1980), in synonomising a number of species, adopted a different approach which is convenient and may make good taxonomic sense, but which nevertheless overlooks the subtle and minor morphological changes which individual species underwent. These often have biostratigraphic significances.

Conodont taxonomists, unlike their colleagues who study the wall structure of foraminifera in minute detail in thin section, have seldom carried out detailed analysis of conodont-morphology. A detailed study of the morphology of the species *Siphonodella sulcata* and *S. praesulcata* has been published recently (Flajs & Feist, 1986 *in* Flajs *et al.*, 1988). Such a study is long overdue and others should follow. For example a morphotype *Gnathodus bilineatus* is widely recognised as being characteristic of Upper Dinantian strata but systematic biometric analysis of the species and SEM examination of its surface-development (Conway Morris & Harper, 1988) has not been undertaken. Application of morphometric techniques (e.g. Macleod & Carr, 1987 ; Klapper & Foster, 1986) to the study of Dinantian conodonts, particularly the Pa elements, should in future provide the basis for precise recognition of species and refinement of taxonomic division.

d) The evolution of Dinantian conodonts and the definition and recognition of conodont biozones related to Dinantian events

Conodont faunal zones, subzones, biozones, lineage zones (Sevastopulo & Nudds, 1987) ; local range biozone, local range subbiozone (Somerville & Jones, 1985) ; partial range biozone (Johnston and Higgins, 1981) ; Acrozone (of Groessens, 1976a ; Varker & Sevastoulo, 1985) and assemblage zones (Rhodes *et al.*, 1969) are some of the biostratigraphic terms which have been applied, following regional studies of British Dinantian conodont sequences. We believe that it is now time to standardise biostratigraphic terminology as far as possible.

Marchant *et al.* (1984) related microfossil (conodont, foraminifer and spore) data to 16 biostratigraphic events in the Irish Tournaisian Series. This integrated micropalaeontological approach with subsequent updating has much to commend it and in our opinion indicates the most useful direction for future biostratigraphic studies (both mega- and micro-faunal). Such a study should also be related to seismic, sedimentological and chemical data pertaining to Dinantian strata and referenced to stratotype sections.

On the evidence of the record of Dinantian conodont appearances and extinctions (Aldridge, 1988) a number of important events took place during the Dinantian Subperiod(see also fig. 1). Nine genera made their first appearance and ten genera became extinct. Another 13 genera appeared and disappeared. Thus at the generic level there are 45 palaeobiological events which, because of geographic and ecologic factors, may not all be represented in one particular region. Appearance and disappearance of species considerably increases the number of events. There is an urgent need for first and last appearances of conodont species to be accurately recorded within the British Dinantian succession and for conodont ranges to be accurately related to the distribution of other fossil groups.

Certain Lower Carboniferous conodont lineages are now well understood. These should be utilised to provide a framework for future biostratigraphic studies. It is suggested that the following lineages should form the basis for the establishment of zones and standardisation of biostratigraphic terminology in the British Isles :

(i) the Siphonodella lineage ;

(ii) the *Pseudopolygnathus multistriatus* - *Polygnathus mehli* lineage ;

(iii) the *Eotaphrus* cf. *bultyncki* - *Eotaphrus bultyncki* - *Dollymae bouckaerti* lineage ;

(iv) the *Scaliognathus pre-anchoralis* - *Scaliognathus anchoralis* lineage ;

(v) the *Mestognathus pre-beckmanni* - *Mestognathus beckmanni* lineage.

Two additional lineages, (vi) the *Gnathodus* lineage and (vii) the shallow-water lineages involving *Cavusgnathus* and related genera, may form the basis for future refinement, when their evolutionary sequence has become fully documented, understood and established.

The opinion of Sevastopulo & Nudds (1987), who favour use of lineage zones, is endorsed, although we are not convinced that such zones are isochronous. We wish to see lineage zones established within a framework of Dinantian events, with local range zones and local range biozones applied regionally. We favour an integrated European biozonation and restate the opinion expressed previously (Austin, 1973) that no zonation will be better for any region than one defined for use in that region and that the greater the detail of the study the greater will be its value. Recent studies of Dinantian conodonts in Ireland and South Wales support this opinion.

e) The recognition of facies control on the distribution of Dinantian conodonts

The proliferation of regionally applicable conodont biozones in the British Isles (see Varker & Sevastopulo, 1985, for a summary) provides a clear indication that facies-control has been a major influence on British Dinantian conodont-distribution. Varker & Sevastopulo (1985) provide a summary of the evidence relating to a distinction between shelf and basin faunas. In a discussion of the Courceyan of Ireland, Sevastopulo & Nudds (1987) refer to a zonal scheme for the shelf, utilizing species of *Bispathodus, Pseudopolygnathus* and *Polygnathus* whereas on the more distal parts of the shelf species of *Eotaphrus* and *Dollymae* are utilized for zonal purposes. Interestingly these authors claim that "the base of the *P. mehli* lineage zone is not facies-controlled because in the many sections where it has been recorded in Ireland it is not associated with any consistent lithological change" and "although the conodonts used to recognise distal shelf zones are environmentally restricted, the bases of the *E. bultyncki* and *D. bouckaerti* subzones and the *Sc anchoralis* Zone are not linked to lithology".

Unlike studies in Ireland, the relationship between Dinantian conodont distribution, lithology and environment of deposition has not been adequately studied in Great Britain (see Austin, 1976), since there have been few co-ordinated sedimentological and palaeontological investigations. Lees & Hennebert (1982) analysed the microfacies of the Knap Farm Borehole, similar microfacies analysis of British Dinantian sequences in South West England has been carried out by Professor Lees and his students (see Conil *et al.*, 1988). Such analyses enable the environmental conditions to be better understood and provide a framework for interpreting the distribution of faunas, both macro and micro. In the future, closer collaboration between sedimentologists and palaeontologists (Simpson & Kaldova, 1987, for example) is essential if the effect of facies (Faulkner, 1988 ; Wright, 1986, for example) on conodont-distribution in Great Britain is to be more meaningfully and accurately assessed. There are encouraging signs that such integrated studies are being undertaken (Whittaker & Green, 1983 ; Waters & Lawrence, 1987). It is also anticipated that researchers will endeavour to obtain conodonts from non-carbonate lithotypes by the use of new techniques (see Austin, 1987a).

2. CONCLUSION

To solve the problems addressed in this article, increased co-operation will be necessary between biostratigraphers working on the classic sections of Europe. The scientist honoured in this volume has been to the forefront in stimulating original biostratigraphic research and has encouraged discussion across national boundaries. Increased international co-operation which she has fostered should lead to the rapid solution of most of the outstanding problems.

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