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The Hauterivian (Lower Cretaceous) biostratigraphy of the Speeton Clay of Yorkshire, England

By Peter Rawson

with 3 figures

Summary: A bed-by-bed collection of over 900 Hauterivian ammonites from the type section of the Speeton Clay has enabled the stratigraphic ranges of nearly 50 species to be accurately determined. The faunal sequence now established differs significantly in detail from that published by Spath (1924). The Hauterivian clays are divided into the *Endemoceras* beds below and the *Simbirskites* beds above; Spath's biostratigraphic divisions are abandoned in favour of a division of the *Endemoceras* beds into three zones (based on Pavlow 1892 and Thiermann 1963) and of the *Simbirskites* beds into five zones (Rawson 1971). The ammonite fauna of each of these zones is reviewed. There is a clear correlation between the north German and Speeton ammonite successions, and it is suggested that a much-needed revision of the German zonal sequence could lead to a zonal scheme common to the whole of north-west Europe, based on species of *Endemoceras* and *Simbirskites*.

Zusammenfassung: Eine horizontierte Aufsammlung von über 900 Ammoniten aus dem Hauterive des Typus-Profiles des Speeton Clay machte die Erfassung der stratigraphischen Reichweite von nahezu 50 sauber bestimmten Arten möglich. Die so aufgestellte Faunen-Abfolge unterscheidet sich in Details auffällig von der von Spath (1924) veröffentlichten Gliederung. Die Hauterive-Tone gliedern sich in die unten befindlichen Endemoceras-Schichten und in die oben liegenden Simbirskiten-Schichten. Die biostratigraphische Gliederung von Spath muß zugunsten einer Gliederung der Endemoceras-Schichten in 3 Zonen (nach Pavlow 1892 und Thiermann 1963) und der Simbirskiten-Schichten in 5 Zonen (Rawson 1971) aufgegeben werden. Die Ammoniten-Fauna jeder dieser Zonen wurde revidiert. Danach besteht eine klare Korrelation der Ammoniten-Abfolgen von Norddeutschland und Speeton, und alles deutet darauf hin, daß die sehr nötige Revision der deutschen Zonenabfolgen zu einem in ganz Nordwesteuropa gültigen Zonen-Schema führen würde, das sich auf die Arten von *Endemoceras* und *Simbirskites* gründet.

1. Introduction

The type locality of the Speeton Clay lies at the southern end of Filey Bay, in the Parish of Speeton, Yorkshire, where the clay forms low cliffs along a 1.2 kilometre coastal section. Although the sequence is incomplete and the succession disturbed by faulting and landslip, the section is the most continuous exposure of marine Lower Cretaceous strata in north-west Europe and provides a useful reference for the Berriasian to Barremian succession in the Boreal Province. The Aptian and Albian, so well developed in marine facies in south-east England, are only fragmentarily represented at Speeton.

It is over 80 years since LAMPLUGH (1889) published his classic account of the subdivisions of the Speeton Clay and nearly 50 years since he reviewed the succession (LAMPLUGH 1924) and SPATH (1924) discussed the ammonite fauna. Renewed interest in the succession, particularly in the micropalaeontology and ammonite fauna, is mainly a result of research instigated by the Department of Geology, University of Hull. For all this recent work, LAMPLUGH's (1889) detailed subdivisions of the Speeton Clay (with the modifications discussed below) have provided a sound framework for the stratigraphic localisation of macrofossils and microfaunal samples. LAMPLUGH's (1889: 581) major divisions were biostratigraphic ones, the A, B, C, and D Beds being distinguished according to their belemnite faunas. The base of the clay is marked by Bed E (the coprolite bed), a 10 centimetre thick phosphatic nodule bed which rests on Upper Kimmeridge Clay.

LAMPLUGH's belemnite subdivisions are as follows (listed from the top downward):

A Beds Zone of *Belemnites minimus (Neohibolites minimus)* and allies
B Beds Zone of *Belemnites semicanaliculatus? (Oxyteuthis brunsvicensis)* and allies
C Beds Zone of *Belemnites jaculum (Hibolites jaculoides)* and varieties
D Beds Zone of *Belemnites lateralis (Acroteuthis lateralis)* and allies

Acroteuthis and *Oxyteuthis* are migrants from the Boreal Ocean and *Hibolites* and *Neohibolites* migrants from Tethys.

LAMPLUGH distinguished lithostratigraphic subdivisions of the above, though even these minor subdivisions are partly characterised by their fauna. Thus the B Beds were divided into Upper B, the Cement Beds and Lower B, the C Beds into C1 to C11 (from the top downward) and the D Beds into D1 to D8. LAMPLUGH's B Beds subdivisions were further divided by KAYE (1964), the C Beds by FLETCHER (1969) and the upper D Beds by NEALE (1960). The Hauterivian stage is represented by the top part of the D Beds (D2D—D1), the whole of the C Beds and the lowest part of the Lower B Beds (LB6—LB5E).

Since 1963 I have collected about 1100 Hauterivian ammonites, the horizon of over 900 of which is accurately recorded according to NEALE's, FLETCHER's and KAYE's refinements of LAMPLUGH's original subdivisions. The *Simbirskites* fauna has already been described and a biostratigraphic division of the upper part of the Hauterivian proposed (RAWSON 1971). In the present paper the whole of the Hauterivian ammonite fauna is reviewed and a zonal scheme presented. The faunal sequence now established differs significantly in detail from that previously published by SPATH (1924).

This work was commenced under the supervision of Dr. J. W. NEALE during the tenure of a NERC research studentship at the University of Hull (1963—66) and continued during the tenure of a NERC research fellowship at Queen Mary College, University of London (1966—67). I am very grateful to Mr. C. W. WRIGHT for his continued interest and encouragement, and for placing his valuable collection at my disposal. Dr. BRIAN FLETCHER has given me considerable assistance in the field, and Dr. FRIEDRICH SCHMID (Hannover) and Dr. E. KEMPER (Hannover) made my visits to Germany both memorable and successful.

Professor J. F. KIRKALDY and Dr. F. A. MIDDLEMISS kindly criticised the initial manuscript.

2. Previous work

LECKENBY's (1859) brief description of the Speeton section and its fauna and JUDD's (1868) more detailed work have subsequently been overshadowed by the publications of LAMPLUGH (1889, 1896) and PAVLOW and LAMPLUGH (1892), in which the stratigraphy and faunal sequence were more firmly established. Their information was modified by DANFORD (1906b) who extended the stratigraphic ranges of some of the previously recorded ammonite species. DANFORD's work was superceded in turn by SPATH's (1924) much more extensive and detailed record, which has remained the standard reference on the Speeton ammonite sequence. My own work has largely, though not completely, confirmed LAMPLUGH's observations on the faunal sequence but contradicts many of the details of SPATH's and DANFORD's records.

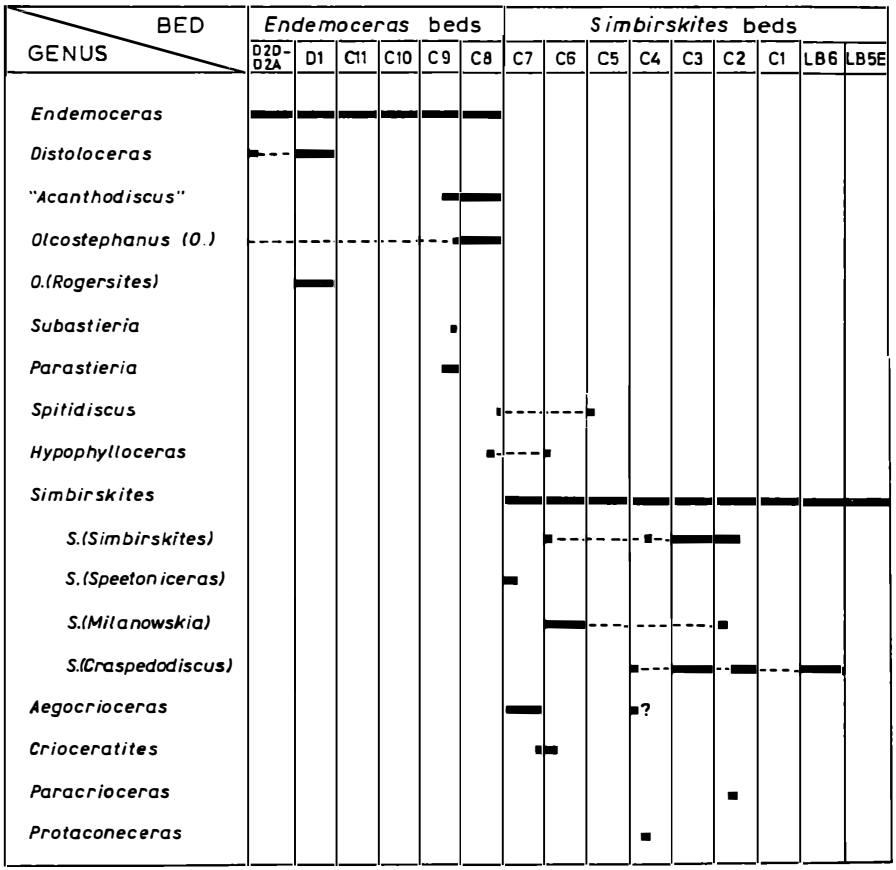


Figure 1. Distribution of Hauterivian ammonite genera in the Speeton Clay.

The discrepancies between SPATH's "bed-by-bed" list of species and that now established reflects SPATH's lack of first-hand knowledge of the section, and his consequent reliance upon other workers' collections. He wrote (SPATH 1924: 73—74) "By the courtesy of the authorities of many Public Museums and numerous private collectors — I have been able to examine a great number of ammonites of the Speeton Clay — I was also enabled to inspect the cliff-section at Speeton — the primary object of the visit, namely the uppermost beds, with the Gault, were very poorly exposed last year —. This revision would have been impossible without the study of the splendid collections accumulated by Mr. C. G. DANFORD and Mr. G. W. LAMPLUGH, F. R. S. To the latter I am particularly indebted for continuously placing at my disposal his unrivalled knowledge of the succession, and, in the course of many discussions, both before and after *my visit* (author's italics) to Speeton, criticising my views."

LAMPLUGH's specimens (now in the British Museum (Natural History)) are carefully labelled, but the collection is relatively small (about 400 specimens). DANFORD's collection (in the Geological Survey Museum) is useful, but the labels are often generalised and it appears from published work that DANFORD was not always able to identify LAMPLUGH's subdivisions in the field because of poor exposure (see also section 3.2 below). Most of the other collections which SPATH referred to were accumulated before the publication of LAMPLUGH's subdivisions of the Speeton Clay; among the most important of these, the Bean collection (split between the British Museum, the Sedgwick Museum (Cambridge) and the Yorkshire Museum (York)) and the Leckenby collection (Sedgwick Museum) date from the earlier part of the nineteenth century.

Thus although SPATH gave a valuable general impression of the succession of species the detailed accuracy suggested by his "bed-by-bed" record is spurious and casts doubt on the value of his zonal scheme (SPATH 1924: table facing page 80). This was a comprehensive zonation for the Berriasian to Barremian of north-west Europe (Speeton and north Germany). The German scheme (KOENEN 1902; STOLLEY 1908), slightly modified, provided a framework in which the "gaps" were filled by additional zones based on the (doubtfully accurate) Speeton occurrences. The resultant faunal succession is a hypothetical one because some of the zonal species are known only from Germany or from Speeton. Subsequent work has shown that several of the zones are essentially lateral equivalents of others rather than being separated in time.

The Hauterivian divisions in SPATH's north-west European scheme are as follows:

zone	Speeton	Germany
clypeiformis	(Tealby Limestone of Lincolnshire:	
discofalcatus	absent at Speeton)	
progredicus	x (C1—3)	
phillipsi	x (C4)	x
rotula	x (C5)	
speetonensis	x (C6)	
capitanei	x (C7)	
capricornu	x (C7)	x

(unnamed gap)	x (C7)	
sulcosa	x (C8)	
regale	x (C9)	
ebergensis	x (C10—11)	x
noricum	x (D1—2)	x
radiatus		x

Some of these zones are based on species which are difficult to interpret *(Aegocrioceras capricornu, Simbirskites (Craspedodiscus) phillipsi)* or invalid *(A. capitanei, S. (C.) clypeiformis)* while several of the Speeton index species were recorded from beds additional to those which they "typify" (see 3.2.1. and 3.2.2. below). SPATH's choice of zone fossils has been discussed at length by CHERNOVA (1951: 62) who concluded that he had "based his division of the sequence not on the principle of the appearance of new ammonite species, but on a purely statistical and arbitrary method based on the abundance of one or another form in the sequence" (translated from the Russian). CHERNOVA tentatively proposed an alternative zonation for the Speeton succession (figure 3 here) though as this was based on SPATH's published records and incorporated some rare species, it is of limited value. She also pointed out that PAVLOW's (1892: figure 3 here) Speeton zones more satisfactorily reflect the faunal characteristics than do SPATH's apparently more sophisticated subdivisions.

The zonation now proposed (based on PAVLOW 1892, THIERMANN 1963 and RAWSON 1971) follows LAMPLUGH (1889), PAVLOW (1892) and CHERNOVA (1951) in uitlising species of *Endemoceras and Simbirskites* alone. Although founded on carefully collected material, the upper part of the scheme (especially the gottschei zone) must still be regarded as provisional because of the scarcity of ammonites from Beds C5 and C4 of the Speeton Clay (figure 2, and section 3.2.2. below).

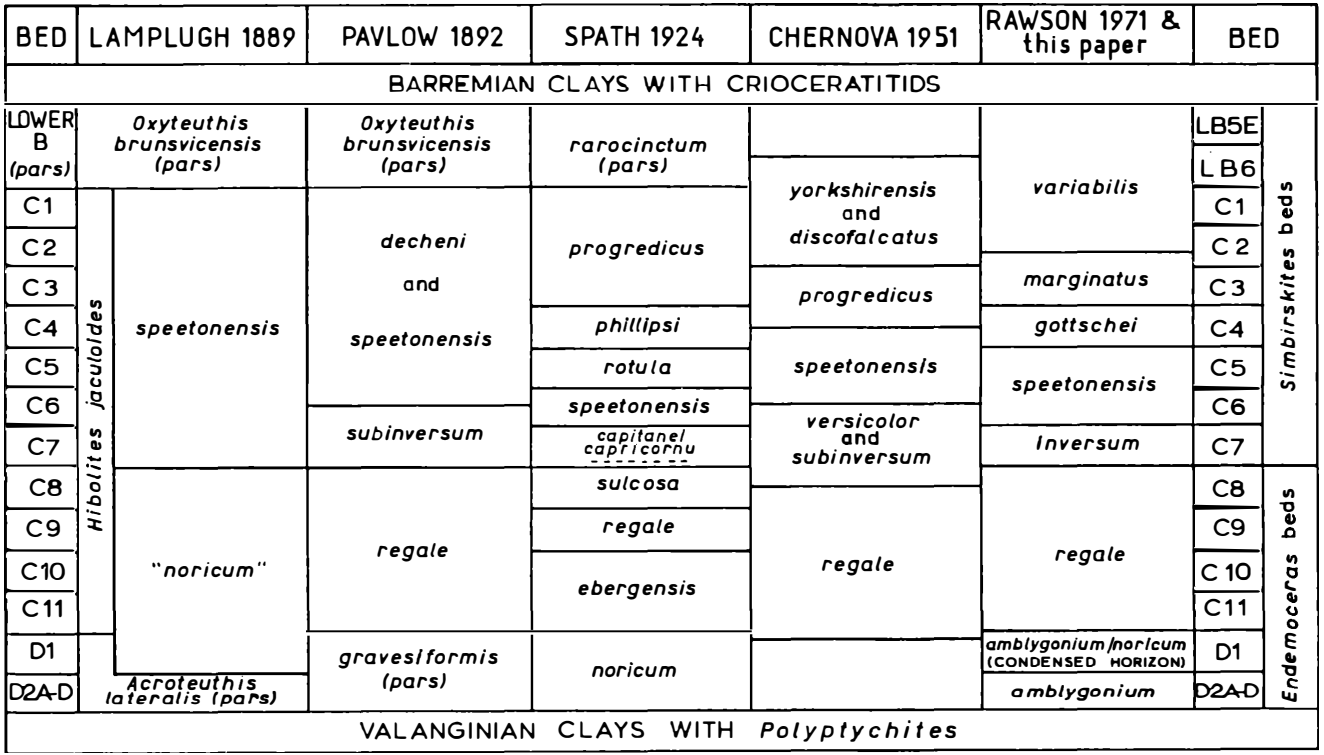
3. The Hauterivian ammonite sequence

3.1. The limits of the Hauterivian stage

A marked lithological and faunal change occurs in Bed D2, at a phosphatic nodule band forming the base of Bed D2D ("base of D2" in DANFORD's and SPATH's papers). Beneath are brown, pyritic, shaley clays (D2E) while the nodules are enclosed in, and overlain by, the grey, gritty, glauconitic clays of D2D. Bed D2E yields an ostracod fauna of German Mittel Valendis or Ober Valendis 1 age, whereas D2D contains typical early Hauterivian forms (NEALE 1962: 463); the major faunal break thus indicated is represented by, at least, Ober Valendis 2—4 of the German succession.

The ammonite evidence completely supports NEALE's assessment. The uppermost part of D2E yields crushed *Polyptychites* closely comparable wixh German Mittel Valendis forms, while the clays of D2D contain early Hauterivian *Endemoceras* and *Distoloceras*. The phosphatic nodule bed between yields fragmentary, waterworn, phosphatised steinkerns of the following ammonites: *Polyptychites (Euryptychites) gravesiformis* (PAVLOW), *Dichotomites* spp., *Neocraspedites undulatus* (KOENEN), *N.* cf. *semilaevis* (KOENEN), *N. speetonensis* SPATH, *Olcostephanus* spp., *Neohoploceras*

Figure 2. Distribution and abundance of Hauterivian ammonite species in the Speeton Clay. The figure records only specimens collected bed-by-bed by the author.



cf. *submartini* (MALLADE), *N.* cf. *jacobi* (BESAIRE), *Leopoldia* sp., and *Bochianites neocomensis* (D'ORB.). The fauna is therefore a remanié one of Upper Valanginian age, comparable with that of Ober Valendis 1—4 in Germany (the Dichotomites, Arnoldien and Astierien Schichten). The phosphatic nodules are of considerable interest and have been extensively discussed (e. g. LAMPLUGH 1889, 1892; DANFORD 1906a, 1906b; NEALE 1960). They apparently accumulated during a period (or periods) of non-deposition or current winnowing on the sea floor, phosphatisation occurring concurrently. Deposition recommenced early in the Hauterivian, for mixed with the remanié Valanginian ammonites are a few freshly preserved *Endemoceras and Distoloceras,* complete with shell material.

While the base of the Hauterivian can be drawn at the base of this remanié bed, the Hauterivian/Barremian boundary presents a more difficult problem which has recently been discussed elsewhere (RAWSON 1971). The following is essentially a summary of my previous conclusions.

Beds C6—LB5E yield a sequence of *Simbirskites* species many of which occur in the Russian *decheni* zone, which can be correlated with the Tethyan *sayni* and *angulicostata* zones (CHERNOVA 1951; DRUSHCHITZ 1964) of the standard Hauterivian succession (DEBELMAS and THIEULOY 1965). Thus the Speeton Clay Beds C6 to LB5E are of Hauterivian age and the base of the Barremian must provisionally be drawn above, at the base of the *rarocinctum* zone, a horizon which marks the reappearance of numerous (though crushed) crioceratitids in the Speeton succession. Unfortunately the *rarocinctum* zone is only provisionally recognised here (section 3.2.2.). In Germany, where it is better established, it is generally included in the Barremian. At present the Hauterivian/Barremian boundary at Speeton is in effect defined on the not very sound principle of the disappearance of a Hauterivian genus rather than on the appearance of an established Lower Barremian form.

3.2. Hauterivian biostratigraphy

Although ammonites occur throughout the Hauterivian there is a sharp diminution in numbers above C6 (LAMPLUGH 1924), and approximately 78% of the individuals recorded here, representing almost 70% of the total number of species, were obtained from D2D to C6. The distribution of genera and species is shown in figures 1 and 2 respectively. Both figures show a major faunal change at the C8/C7 boundary, and this allows a division of the Hauterivian sequence into two main units, the *Endemoceras* beds (corresponding with Beds D2D to C8) and the *Simbirskites* beds (C7—LB5E: RAWSON 1971). These divisions are intended to apply to the Speeton Clay alone, and the *Simbirskites* beds are only the *approximate* equivalents of the Simbirskitid Beds of the Volga region (CHERNOVA 1951) or the Simbirskiten Schichten of north Germany (BÄHR 1964). These new major divisions are foreshadowed in LAMPLUGH's (1889: fig. 5) work, where he recognised two ammonite zones, those of *Ammonites noricus (Endemoceras)* (Beds D1 and C11—C8), and *A. speetonensis (Simbirskites)* (Beds C7—C1). LAMPLUGH (1889) also divided the C Beds into a number of units which included the *noricus* clays and *speetonensis* clays of JUDD's (1868) earlier classification.

Despite the sharpness of the faunal change between the *Endemoceras* beds and the *Simbirskites* beds, first demonstrated by LAMPLUGH and fully confirmed here (and also by Mr. J. DOYLE, who has made an extensive collection from the lower

C Beds), SPATH (1924) recorded a mixing of *Endemoceras* with *Simbirskites* in C7 and C8. His records are based on DANFORD's collection or on DANFORD's (1906b: 108—110) specific statements that *Simbirskites* appears in C8, overlapping *Endemoceras;* the latter was recorded as high as C7.

The reason for the discrepancy is suggested by DANFORD's (1906a: 1) note that during the years he was working at Speetons beach exposures were rare and the cliff sections greatly obscured by slipped clay and mudflows. Thus the crucial boundary between C7 and C8, marked by a pale clay with nodules (C8A), would have been difficult to see, for the main exposure is a low cliff section along the south-eastern half of Middle Cliff. DANFORD clearly had difficulty in following the boundary for many of his ammonites and belemnites from this part of the clay are labelled "C7—8". Conversely, in recent years both the cliff and shore exposures have often been washed clean by the sea, so that the succession has been relatively easy to follow.

3.2.1. The *Endemoceras* beds

The *Endemoceras* beds (D2D—C8) are 9 metres thick; *Endemoceras* is the dominant genus throughout, and the succession of species allows three zones to be distinguished. THIERMANN's (1963) north German zones of *E. amblygonium* and *E. noricum* can usefully be adopted for that part of the Speeton succession which SPATH (1924) included in his *noricum* zone. Following PAVLOW's (1892) and LAMPLUGH's (1896) usage, the *E. regale* zone embraces the beds which SPATH (1924) divided into the *ebergensis* (C11—C10), *regale* (C9) and *sulcosa* (C8) zones. It is difficult to understand SPATH's reasons for such a division, for he recorded *E. regale* from C11—C7, *"Acanthodiscus" ebergensis* from C11—10 and C9, and *Subastieria sulcosa* from C9 and C8. *"Acanthodiscus"* of the *ebergensis* group are rare but certainly occur in C9C, and I have only found *Subastieria sulcosa* in C9, in SPATH's *regale* zone.

(i) The *amblygonium* and *noricum* zones (Beds D2D—D1: 1 metre thick)

The fauna of the German *amblygonium* and *noricum* zones can be recognised at Speeton, though in a very condensed succession. The combined thickness of the two zones is only 1 metre, compared with up to 20 metres in north Germany (THIERMANN 1963: fig. 23). *E. amblygonium* (NEUMAYR and UHLIG) appears at the base of D2D and also occurs in D2A, so that Beds D2D—D2A can be included in the *amblygonium* zone. *E. noricum* (ROEMER) appears in D1, where both it and *E. amblygonium* are common. The abundance of both species in D1 may represent in part a genuine time overlap (the two species occur together in the lower part of the *noricum* zone in Germany) but is apparently due mainly to condensation of the succession. Bed D1 is a very distinctive 0.3 metres thick nodular horizon, the "compound nodule band", in which small, phosphatised nodules (often partially enclosing well preserved ammonites) are incorporated in larger, cementstone nodules; both nodules and cementstones show evidence of contemporaneous submarine erosion during a period of current winnowing on the sea floor (LAMPLUGH 1889: 588). D1 is therefore referred to as the *"amblygonium — noricum* condensed horizon" (figures 2 and 3).

The uncoiled neocomitid *Distoloceras* is recorded from the base of D2D and D1, though it is not common. The majority of specimens have been collected from D1, which yields large individuals up to 0.7 metres in diameter. At least three species occur (figure 2) and the holotypes of *D. hystrix* (PHILLIPS) and *D. pavlowi* SPATH (and neotype of *D. curvinodum* (PHILLIPS); THIERMANN 1963: pl. 22, fig. 2) probably came from the same horizon.

Other genera are rare: I have collected a single *Olcostephanus (Rogersites)* sp. from D1, and the same bed has yielded the unique holotype of *Shasticrioceras? anglicum* DOYLE (DOYLE 1963: 575), a whorl fragment of *Lytoceras* (WRIGHT's collection) and *Leopoldia? heteroptychus* (PAVLOW) (DANFORD collection). SPATH's (1924: 76) *Kilianella? pexiptychoides* is an *Endemoceras* and his other "*Kilianella*" records refer to *Endemoceras* or *Distoloceras;* the true *Kilianella* is not known from Speeton.

LAMPLUGH's (1889: 614) anomalously low record of *Spitidiscus rotula* (Sow) from D1 is based on a smooth, indeterminate ammonite nucleus (LAMPLUGH collection, British Museum, nr. C. 76764).

(ii) The *regale* zone (Beds C11—C8: 8.1 metres thick)

E. regale (PAVLOW) was originally confused with *E. noricum* and a "*noricus* zone" has long been established in the English literature (JUDD 1868; LAMPLUGH 1889). PAVLOW (1892) subsequently showed that most of the English records of this species refer to *E. regale* (originally a manuscript name of Bean's) and recognised a *regale* zone, incorporating Beds C11—C8. *E. regale* definitely occurs from C11A to C8A[1], extending through a thickness of about 7 metres, but Bed C11B can only provisionally be retained in the *regale* zone on the basis of a few, poorly preserved ammonites comparable to the zonal form.

Although *E. regale* is the dominant member of the *regale* zone fauna, septate inner whorls of "*Acanthodiscus*" are common in C9 and C8 (figure 2). They include two undescribed species, "*A*" sp. nov. a (= *Ammonites furcillatus* Bean MS) being limited to C9A and the lower half of C8, while "*A*" sp. nov. b, a more strongly tuberculate form, occurs in upper C8. Larger whorl fragments of the latter have a *Distoloceras*-like appearance, though the true, uncoiling *Distoloceras* has not been found in the *regale* zone.

Rare olcostephanids occur in C9 and C8. *Parastieria peltoceroides* (PAVLOW) (C9C—A) is a monotypic genus known only from Speeton. A single *Subastieria sulcosa* (PAVLOW) is recorded from C9A and a few finely-ribbed *Olcostephanus* occur in C9 and C8. There are at least two species, *O. subfilosus* SPATH and a more inflated form closer to *O. convoluta* (KOENEN).

The holcodiscid *Spitidiscus* first appears in the top nodule band of C8 (C8A; associated with the last *E. regale*), where whorl fragments of *S. inflatiformis* SPATH are relatively common. A single *Hypophylloceras* cf. *perlobatum* (SAYN) is recorded

[1]) C8 has hitherto remained undivided (see FLETCHER 1969); it is here divided into C8A and C8B. C8A is 0.23 metre thick pale grey clay with medium sized (up to 100 mm. diameter) calcareous nodules. C8B consists of 1.8 metres of dark grey clay with small (20 mm.), brown-weathering, calcareous nodules in the middle.

from the upper part of C8B (RAWSON 1966: 455). Both *Spitidiscus* and *Hypophylloceras* occur also in the *Simbirskites* beds. The WRIGHTS' collection contains several fragments of *Lytoceras* from C8.

3.2.2. The *Simbirskites* beds

The sharp faunal change at the C8/C7 boundary, marked by the disappearance of the neocomitids and olcostephanids at the top of C8, is emphasised by the sudden appearance of numerous *Simbirskites (Speetoniceras) inversum* (M. PAVLOW) at the base of C7 (C7H) and *Aegocrioceras* only 0.3 metres higher (in C7G). Both genera are common in Bed C7 (*inversum* zone) but *Simbirskites* is the dominant genus through the rest of the *Simbirskites* beds. Ammonites appear to be very rare in C4 and C5, though the rarity is possibly emphasised by the infrequency with which these beds are exposed; they have been faulted out of the cliff and are seen only on temporary beach exposures. Whorl fragments and septate nuclei of *Simbirskites* are tolerably common in C3 and C2 and the last specimens are found in Bed LB5E.

Within the *Simbirskites* beds 5 ammonite zones, all based on species of *Simbirskites*, have recently been proposed (RAWSON 1971) and their fauna discussed in detail. The distribution of species is summarised in figure 2 here, and the section that follows is concerned mainly with records that supplement those in my earlier paper.

(i) The *inversum* zone (Bed C7: 2.9 metres thick)

This includes the *Aegocrioceras capricornu* and *A. capitanei* zones of SPATH's (1924) scheme. *A. capricornu* (ROEMER) is difficult to interpret, being a "sack" name for a variety of forms, while *A. capitanei* is an undescribed, indeterminate species known from a single crushed specimen bearing BEAN's manuscript name (RAWSON 1970: 591).

Simbirskites (Speetoniceras) inversum is limited to the lowest part of the zone, and the dominant ammonite above C7H is *Aegocrioceras*. The *Aegocrioceras* fauna is identical with that of the German *capricornu* zone. There are two main assemblages; in C7G and C7F, stout-whorled species of the *bicarinatum-quadratum-semicinctum* group are common, while in C7E—C7A more compressed forms of the "*capricornu*" group occur. The latter includes at least three species (*A.* sp. nov. RAWSON 1970, *A.* sp. a and *A.* sp. b) all of which occur in north Germany, where museum specimens are generally labelled *A. capricornu*.

At the base of the *inversum* zone, immediately beneath the first occurrence of *Aegocrioceras*, rare fragments of another crioceratitid genus occur (author's collection, DOYLE Collection). They are generally only slightly curved, circular in cross-section, and with fine, oblique, simple ribs and typical crioceratitid sutures. Although the material is too poorly preserved for positive identification, the fragments may be related to *Himantoceras*, a rare, early crioceratitid from the "*Lyticoceras*" *s. l* and *radiatus* zones of south-east France (THIEULOY 1964).

The record of *Crioceratites* spp. in text-figure 2 refers to fragmentary specimens from C7A (*inversum* zone) and lower C6 (*speetonensis* zone). Several species are represented, including *C.* cf. *wermbteri* (KOENEN), *C.* cf. *hildesiensis* (KOENEN) and

C. beani (YOUNG and BIRD). The largest examples, body chamber fragments of specimens up to 0.6 metres diameter, come from the red-weathering silty clays at the top of C7 (C7A).

(ii) The *speetonensis* zone (Beds C6 and C5: 12.9 metres thick)

The zone embraces SPATH's *speetonensis* and *rotula* zones; *Spitidiscus rotula* (the type species of *Spitidiscus*) is represented by 2 specimens from the silty clay forming the base of C5 (from which horizon it was also recorded by LAMPLUGH), together with a few museum specimens from unknown horizons. It is of little value as a zonal form, although *Simbirskites* is equally rare in C5, being represented by a few compressed nuclei in the WRIGHTS' collection.

The *speetonensis* zone is divided into two subzones (RAWSON 1971: 73), the *concinnus* subzone (LOWER C6) and the *speetonensis* subzone (upper C6 and C5). The boundary between the two approximately corresponds with that between the *subinversum* and *speetonensis* zones of PAVLOW (1892) and CHERNOVA (1951). The record of *Simbirskites (Speetoniceras) subinversum* (M. PAVLOW) and *S. (Sp.) inversum* (M. PAVLOW) from lower C6 (LAMPLUGH 1892: based on a few specimens collected by LAMPLUGH and identified by A. P. PAVLOW), upon which PAVLOW's and CHERNOVA's zonal divisions are founded, has not been confirmed.

There is an abundant *Simbirskites* fauna near the base of the *concinnus* subzone; this includes rare *Simbirskites (Milanowskia) staffi* WEDEKIND, four specimens of which have now been collected *in situ*. A single whorl fragment of *Hypophylloceras* cf. *perlobatum* (SAYN) is known from the same horizon (RAWSON 1971: 36) and *Lytoceras* cf. *subfimbriatum* (D'ORB) has been recorded from slightly higher in the subzone (WHITEHOUSE and BRIGHTON 1924). *Subsaynella* is doubtfully represented by a specimen from "probably C6", recorded by SPATH (1924: 82) as a member of the *S. sayni* group.

(iii) The *gottschei* zone (Bed C4: 9.5 metres thick)

Spath placed Bed C4 in the *phillipsi* zone; *Simbirskites (Craspedodiscus) phillipsi* (ROEMER) is difficult to interpret (RAWSON 1971: 61) and I have not been able to confirm its occurrence at Speeton, though small, rare specimens of the *phillipsi* group occur higher in the succession, in Bed C2B (*variabilis* zone).

S. (C.) gottschei (KOENEN) occurs only at the base of the zone (Bed C4L), associated with body chamber fragments of *Aegocrioceras? seeleyi* (NEUMAYR and UHLIG). Ammonites are very rare through the rest of the zone (figure 2) but I have seen crushed *Simbirskites* (some close to *S. kleini* (NEUMAYR and UHLIG)) higher in C4, and *Protaconeceras* sp. nov. CASEY (1954: 270) occurs in about the middle of the bed (author's collection; WRIGHTS' collection).

(iv) The *marginatus* zone (Beds C3 — C2D: 3.6 metres thick)

SPATH's zone of *Simbirskites (Milanowskia) progredicus* (LAHUSEN) embraces Beds C3-C1, but he also recorded the species from C4. I have been unable to collect, or to trace in museum collections, any authentic Speeton representatives of this species. *Simbirskites (Simbirskites) marginatus* (PHILLIPS) occurs through most of the

zone (figure 2) in association with small, septate specimens of *S. (C?)* sp. a (RAWSON 1971: pl. 11, fig. 1). LAMPLUGH (1889: 596, 614) regarded both forms as typical of this horizon. Rare specimens of *S. (C.)* cf. *discofalcatus* (LAHUSEN) (the largest only 30 mm in diameter) also occur, and the species in definitely known from slightly higher in the succession (LB6: *variabilis* zone).

A single *S. (S.) yorkshirensis* CHERNOVA, previously known only from the *variabilis* zone, has been found in Bed C2E, almost at the top of the *marginatus* zone.

(v) The *variabilis* zone (Beds C2C — LB5E: 2.5 metres thick)

This zone incorporates the upper part of the *progredicus* zone and the lowest part of the *rarocinctum* zone of SPATH's classification. SPATH apparently thought there was a break between the two zones at Speeton, for he recorded two intermediate zones in Lincolnshire, those of *S. (C.) discofalcatus* (LAHUSEN) and *S. (C.) clypeiformis* JUDD non D'ORB. (= *S. (C.) juddi* RAWSON). However, *S. (C.) discofalcatus* is recorded from the base of the B Beds at Speeton, i. e. from the base of SPATH's *rarocinctum zone;* the belemnite faunas suggest a similar correlation.

S. (C.) variabilis RAWSON occurs through most of the zone. There are two interesting additions to my earlier records; the occurrence of *S. (C.) discofalcatus* at the base of Lower B, previously based on a specimen collected by DANFORD (RAWSON 1971: 60) has been confirmed by the discovery of a whorl fragment *in situ* in one of the nodules of LB6. A second specimen of *S. (S.) yorkshirensis* is now known from C2C (in addition see the record from C2E, above).

(vi) The *rarocinctum* and *fissicostatum* zones

SPATH (1924) adopted the German zonal sequence for the north-west European Barremian and recognised the presence of the *rarocinctum* zone at Speeton, immediately above the *Simbirskites* beds. This zone is provisionally adopted for Beds LB5D—LB4, in which large, crushed crioceratitids occur; some have been identified (in the field) as close to the zonal species, though better preserved material is required to confirm the occurrence. Bed LB3 yields well-preserved, fragmentary specimens of *Hoplocrioceras fissicostatum* (ROEMER *sensu* NEUMAYR and UHLIG), index-fossil of the next zone in the German succession.

4. General discussion: Correlation with north Germany

The similarity between the Lower Cretaceous faunas of eastern England (Speeton and Lincolnshire) and north Germany has long been recognised (e. g. ROEMER 1841: JUDD 1870). The reassessment of the ammonite succession in the Speeton Hauterivian and the revision of the zones on the basis of bed-by-bed collecting emphasises the close relationship of the two areas but gives rise to some interesting problems of detailed correlation, especially in the lower part of the succession where the sequence of *Endemoceras* species in both England and Germany is known in detail.

THIERMANN's (1963) valuable description of *Endemoceras* included a new zonation for the German Lower Hauterivian. The zones, those of *E. amblygonium* and

E. noricum, can also be applied to the Speeton Clay (section 3.2.1.) though here the equivalent horizons are much thinner and partly condensed. However, while THIERMANN (1963: 387) believed that in Germany the *noricum* zone is directly overlain by the zone of *Aegocrioceras capricornu*, there is a well-established zone of *E. regale* at Speeton, occurring above the condensed *amblygonium-noricum* horizon and below the *inversum* zone (which is approximately equivalent to the lower part of the German *capricornu* zone). Either *E. regale* was essentially restricted to the British seas and the horizon is represented in north Germany by the upper part of the *noricum* zone (THIERMANN 1963: 387), or there is a faunal break between the German *noricum* and *capricornu* zones (SPATH 1924: 82). Sections across the critical boundary between the *noricum* and *capricornu* zones are rare (see THIERMANN 1963: 351) and the only good existing exposure is that at Ziegelei Moorberg, Sarstedt, 17 Kilometres south-south-east of Hannover (Bl. Sarstedt, Nr. 3725; R ^{35}59850, H ^{57}89750). Here, BÄHR's (1964) records and my own collecting (in 1965, 1967 and 1969) show that between clays with numerous *Endemoceras noricum* (and *Acroteuthis*) and the beds with abundant crushed *Aegocrioceras* (*capricornu* zone) are about 20 metres of clay almost devoid of ammonites. Within these 20 metres *Acroteuthis* is replaced by *Hibolites* (corresponding with the Speeton D/C Beds boundary), and at about this horizon I have collected a single, crushed *Endemoceras* cf. *regale* (now in the collections of the Niedersächsisches Landesamt für Bodenforschung, Hannover, Nr. Kh 38). Dr. KEMPER informs me that there is evidence of poorly fossiliferous clays between the *noricum* and *capricornu* zones in other parts of north Germany. It is probable that these and the clays at Sarstedt represent, at least in part, the *regale* zone.

The distinctive fauna of the *E. regale* zone is represented, though sparsely, in German museum collections. The species *"Acanthodiscus" ebergensis* (WEERTH) and *"A."* cf. *confusus* SPATH, which occur in the middle of the *regale* zone at Speeton, are based on German holotypes from the Osning Sandstone of the Teutoburger Wald (WEERTH 1884). The *noricum* and *capricornu* zones were formerly exposed in a claypit at Ihme, near Hannover, from whence abundant *Endemoceras* and *Simbirskites* have been collected. 3 of the 8 known German specimens of *E. regale* (THIERMANN 1963: 383) and rare *"A."* cf. *ebergensis* came from this locality. A further suggestion that at least part of the *regale* zone fauna occurs in north Germany lies in STOLLEY's recognition of a zone of *"A." ebergensis* and *"A." bivirgatus* just beneath the *capricornu* zone.

The available evidence therefore suggests that the *regale* zone is a discrete horizon above the *noricum* zone in Germany, though there are probably local faunal breaks at this horizon, as SPATH suggested.

The faunas of the lower part of the *Simbirskites* beds of the Speeton Clay (*inversum* zone and *concinnus* subzone of the *speetonensis* zone) closely compare with those of the German *capricornu* zone. Although the distinctive *Speetoniceras* fauna at the base of the *inversum* zone is not known from Germany, the various *Aegocriceras* of the rest of the zone are identical with species from the lower part of the *capricornu* zone. The abundant *Simbirskites* of the *concinnus* subzone (*speetonensis* zone) occur in the upper part of the *capricornu* zone (e. g. at Sarstedt; RAWSON 1971: 75).

Above these horizons ammonites are uncommon in Germany and England and are generally limited to narrow bands separated by sparsely fossiliferous clays. Correlation thus becomes more difficult (RAWSON 1971: 76, fig. 9). Nevertheless, an impressive number of *Simbirskites* species are common to Speeton and Germany, and with more collecting from both regions close comparison should become possible. When KOENEN and STOLLEY were actively working, the indifferently preserved German *Simbirskites* were poorly known and the Simbirskiten Schichten were zoned mainly by crioceratitids. However STOLLEY (1925) commented on the local abundance of *Simbirskites* and recognised (STOLLEY 1908, 1925) its potential value as a zone fossil. Subsequent workers have followed the crioceratitid divisions, though crioceratitids are so rare above the *capricornu* beds that this zonation is very inadequate. BÄHR (1964: table 5) also tentatively proposed an alternative zonation based on *Simbirskites*. Such a rezonation of the Simbirskiten Schichten would be of considerable value and could lead to a common zonal scheme for the whole of the German and English Hauterivian, based on *Endemoceras* and *Simbirskites*. This would faithfully reflect the virtual identity of the Speeton and German Hauterivian ammonite faunas.

5. References

BÄHR, H. H.: Die Gattung Simbirskites (Ammonoidea) im Ober-Hauterive Nordwestdeutschlands. — Unpublished dissertation, Technischen Hochschule, Braunschweig 1964.

CASEY, R.: *Falciferella*, a new genus of Gault ammonites, with a review of the family Aconeceratidae in the British Cretaceous. — Proc. Geol. Ass., **65**: 262—277, London 1954.

CHERNOVA, E. S.: On the age and division of the Simbirskitid Beds and the Belemnite Series of the Volga Region. — Byull. mosk. Obshch. Ispyt. Prir., **26**: 46—81 (in Russian), Moscow 1951. (A translation of this paper is available from the National Lending Library, Boston Spa, number RTS 3310).

DANFORD, C. G.: Notes on the belemnites of the Speeton Clays. — Trans. Hull geol. Soc., **5**, 1: 1—14, Hull 1906 (1906 a).

— : Notes on the Speeton ammonites. — Proc. Yorks. geol. Soc., **16**: 101—114, Leeds 1906 (1906 b).

DEBELMAS, J. & THIEULOY, J.-P.: Etage Hauterivien, In: Colloque sur le Crétacé Inférieur. — Mem. Bur. Rech. Geol. Min., **34**: 85—96, 1965.

DOYLE, J. G.: A new hetermorph ammonite from the Lower Cretaceous of Yorkshire. — Palaeontology, **6**: 575—578, London 1963.

DRUSHCHITZ, V. V.: On the zonal division of the Lower Cretaceous of the south of the USSR. — Shorn. v. ch. I. S. Jovchera, 217—246, Sofia 1964.

FLETCHER, B. N.: A lithological subdivision of the Speeton Clay C Beds (Hauterivian), East Yorkshire. — Proc. Yorks. geol. Soc., **37**: 323—327, Leeds 1969.

JUDD, J. W.: On the Speeton Clay. — Q. J. geol. Soc. Lond., **24**: 218—250, London 1868.

— : Additional observations on the Neocomian strata of Yorkshire and Lincolnshire, with notes on their relations to the beds of the same age throughout northern Europe. — Q. J. geol. Soc. Lond., **26**: 326—348, London 1870.

KAYE, P.: Observations on the Speeton Clay (Lower Cretaceous). — Geol. Mag., **101**: 340—356, London 1964.

KOENEN, A. VON: Die Ammonitiden des Norddeutschen Neocom. — Abh. preuss. geol. Landesanst., n. F. **24:** 1—451, 55 pl., Berlin 1902.

LAMPLUGH, G. W.: On the subdivisions of the Speeton Clay. — Q. J. geol. Soc. Lond., **45:** 575—618, London 1889.

— : Couches surmontees de craie du nord de l'Angleterre. — In: PAVLOW, A. P. and LAMPLUGH, G. W., 1892 (see below).

— : On the Speeton Series in Yorkshire and Lincolnshire. — Q. J. geol. Soc. Lond., 52: 179—220, London 1896.

— : A Review of the Speeton Clays. — Proc. Yorks. geol. Soc., **20:** 1—31, Leeds 1924.

LECKENBY, J.: Note on the Speeton Clay of Yorkshire. — Geologist, **2:** 9—11, London 1859.

NEALE, J. W.: The subdivision of the upper D Beds of the Speeton Clay of Speeton, East Yorkshire. — Geol. Mag., **97:** 353—362, London 1960.

— : Ostracoda from the Speeton Clay (Lower Cretaceous) of Yorkshire. — Micropalaeontology, **8:** 425—484, New York 1962.

PAVLOW, A. P.: Essai sur la stratigraphie comparée de la serie argileuse de Speeton. — In: PAVLOW, A. P. and LAMPLUGH, G. W., 1892 (see below).

PAVLOW, A. P. & LAMPLUGH, G. W.: Argiles de Speeton et leurs equivalents. — Bull. mosk. Obshch. Ispyt. Prir., n. S., **5:** 181—276; 455—570, Moscow 1892.

RAWSON, P. F.: A phylloceratid ammonite from the Speeton Clay (Lower Cretaceous) of Yorkshire. — Palaeontology, **9:** 455—457, London 1966.

— : The interpretation of some English species of *Aegocrioceras* (Cephalopoda: Ammonoidea) from the Speeton Clay (Lower Cretaceous). — J. nat. Hist., **4:** 585—591, London 1970.

— : Lower Cretaceous ammonites from north-east England: the Hauterivian genus *Simbirskites*. — Bull. Br. Mus. nat. Hist. (Geol.), **20,** 2: 25—86, London 1971.

ROEMER, F. A.: Die Versteinerungen des norddeutschen Kreidegebirges. — 145 pp., Hannover 1841.

SPATH, L. F.: On the ammonites of the Speeton Clay and the subdivisions of the Neocomian. — Geol. Mag., **61:** 73—89, London 1924.

STOLLEY, E.: Die Gliederung der norddeutschen Unteren Kreide. — Zbl. Miner. Geol. Paläont., No. 4—8, Stuttgart 1908.

— : Die leitenden Belemniten des norddeutschen Neokoms. — Jber. niedersächs. geol. Ver., 17: 112—126, Hannover 1925.

THIERMANN, A.: Die Ammonitengattung *Endemoceras* n. g. aus dem Unter-Hauterive von Nordwest-Europa. — Geol. Jb., **81:** 345—412, Hannover 1963.

THIEULOY, J. P.: Un Céphalopode remarquable de l'Hauterivien basal de la Drôme: *Himantoceras* nov. gen. — Bull. Soc. géol. Fr., 7, **6:** 205—213, Paris 1964.

WEERTH, O.: Die Fauna des Neocomsandsteins im Teutoburger Walde. — Paläont. Abh., **2:** 1—77, Berlin 1884.

WHITEHOUSE F. W. & BRIGHTON, A. G.: Notes on some Neocomian Cephalopoda from Speeton. — Naturalist, 359—360, Hull 1924.

Author's address: Dr. P. F. RAWSON, Department of Geology, Queen Mary College (University of London), Mile End Road, London, E. 1.

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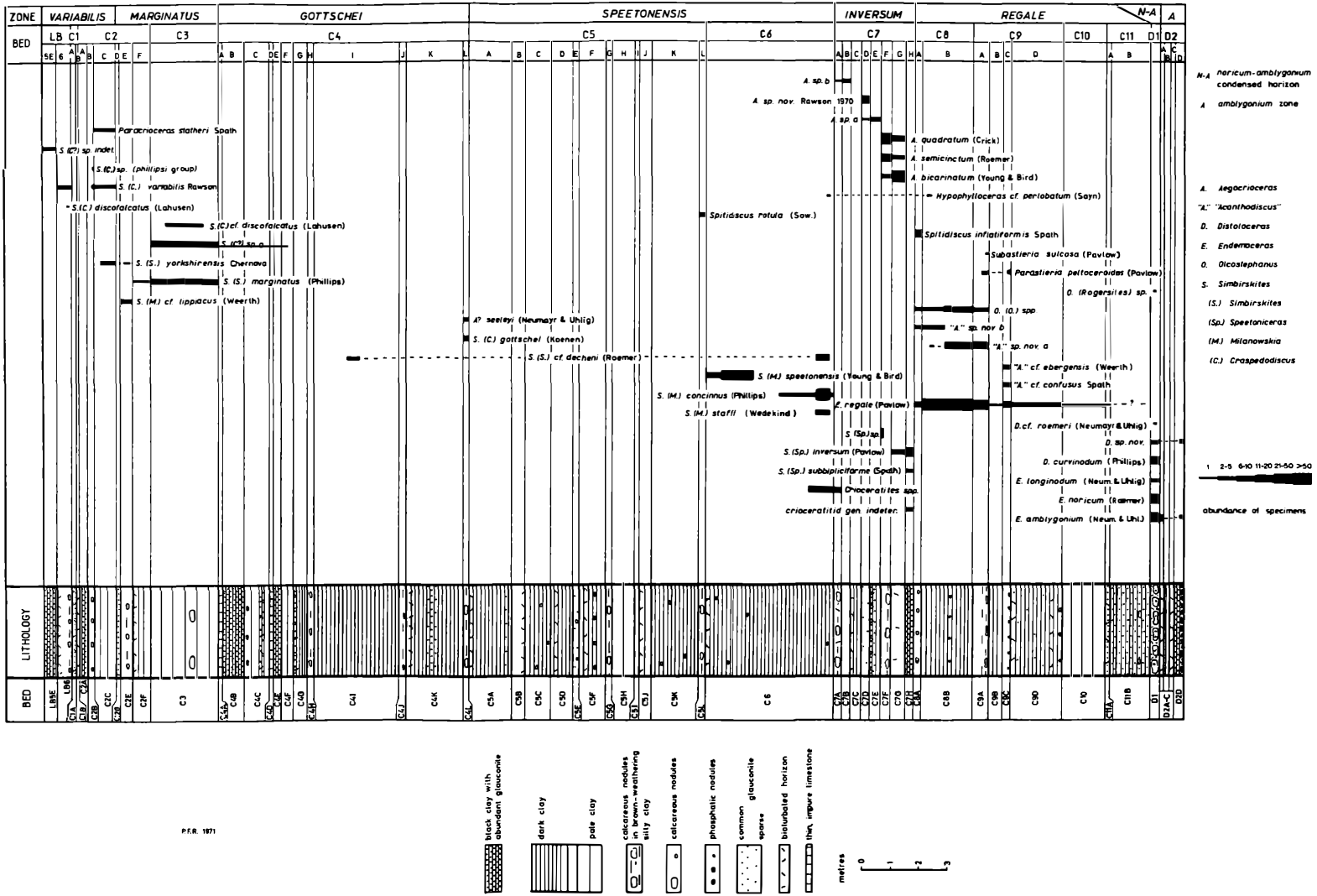

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