PERISPHINCTID AMMONITES OF THE UPPER CALCAREOUS GRIT (UPPER OXFORDIAN) OF NORTH YORKSHIRE

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ABSTRACT. Twenty-three species of perisphinctid ammonite, belonging to the genera *Perisphinctes*, *Decipia* and *Microbiplices*, are described from the lowest Upper Oxfordian Upper Calcareous Grit Formation of North Yorkshire. A new species, *Decipia ravenswykensis*, is described, and *Pseudopomerania* is proposed as a new subgenus of *Perisphinctes*, to include some until now little understood perisphinctids previously assigned to *Decipia*. A comparison is made with successions of the same age elsewhere in Britain and in continental Europe. Revised correlations are proposed with the standard successions in the Wash area of England and in the French Jura.

DURING the 1960s and '70s, extensive quarrying of the Middle Oxfordian Malton Oolite and Coral Rag was carried out for lime and road building materials at a number of localities along the northern side of the Vale of Pickering (Text-fig. 1). These operations made available substantial exposures of the overlying Upper Calcareous Grit, the sandstones and siltstones of which were of no use to the quarrymen, and were dumped and could be picked over at leisure by collectors. As a result, the author, accompanied by Mr D. N. Wright, was able to collect some 370 Late Oxfordian ammonites from the Upper Calcareous Grit during the course of numerous visits extending over 20 years. Many of the quarries have now ceased production, or no longer work ammonite-yielding beds. The bulk of the ammonites are cardioceratids belonging to the genus *Amoeboceras*. This group has been dealt with by Sykes and Callomon (1979), and will not be considered further here. The present work is based on the author's collection of 152 perisphinctids.

Arkell (1935–48) described many species of Late Oxfordian perisphinctids from Dorset, the Midlands and North Yorkshire. However, much of the present Yorkshire material is of a slightly older date than the specimens described by Arkell and it includes a number of previously undescribed species; other specimens extend the range of variation in Arkell's species. Hancock (1954) recorded perisphinctids of a similar age from Cambridgeshire. The extensive literature of continental Europe which concerns Late Oxfordian perisphinctids will be referred to below under Systematic Palaeontology.

STRATIGRAPHY

Summary of the succession

The Upper Calcareous Grit Formation was divided by Wright (1972) into three members: the predominantly argillaceous Newbridge Beds, overlain successively by the Spaunton Sandstone and the Snape Sandstone. There is no single exposure which reveals the complete succession. However, a complete cored section through the formation was drilled at West Newton Grange [SE 628 802] by the Yorkshire River Authority in 1973, and the author's log of the borehole core is given below as a standard section of the Upper Calcareous Grit (total thickness 11·2 m).

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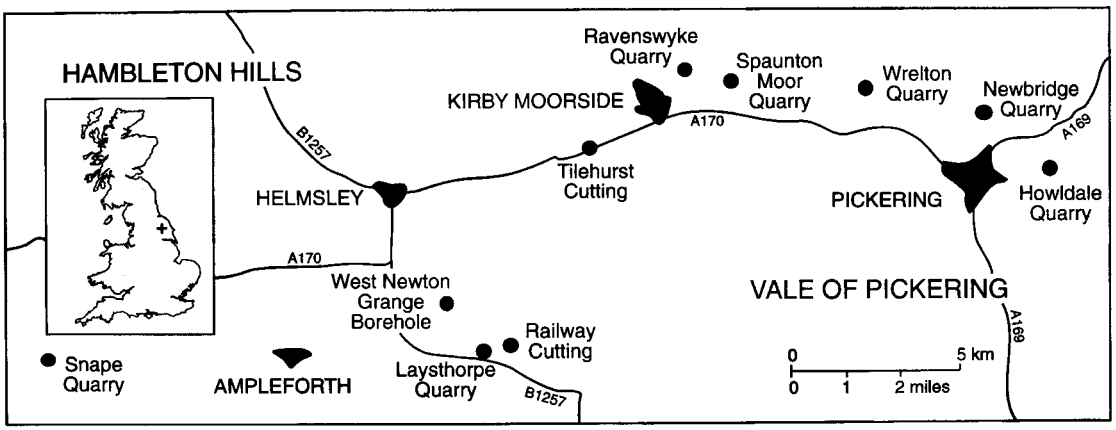
(AMPTHILL CLAY – dark grey clay with *Meleagrinella* sp. and *Serpula* sp. – seen to many metres)
SNAPE SANDSTONE
4. Grey, very tough, calcareous, laminated, bioturbated sandstone with white, infilled burrows, becoming argillaceous in top 0·5 m and passing up into Ampthill Clay. 3·95
SPAUNTON SANDSTONE
3. Massive, yellow, highly bioturbated, decalcified sandstone 2·1
2. Grey, partially bioturbated sandstone, becoming argillaceous towards base; bivalve fragments. 2·75
NEWBRIDGE BEDS
1. Grey, clayey silt passing up into laminated, clayey sandstone; bottom few tens of millimetres sandy and spicular. 2·4
– bored, erosive junction –
(CORAL RAG – creamy white, micritic limestone containing scattered coral colonies: 8·8 m).

This sequence of predominantly argillaceous beds, succeeded by a massive sandstone, and then a laminated, calcareous sandstone often with belemnites, is traceable across the western half of the Vale of Pickering, from Pickering westwards to Snape, and southwards to Laysthorpe (Text-fig. 1).



TEXT-FIG. 1. Map showing the localities mentioned in the text.

Details of exposures

The quarry sections are described from east to west, starting at Pickering.

Newbridge Quarry [*SE 800 860*]

	m
SPAUNTON SANDSTONE MEMBER	
4. Rubbly, nodular, silicified, very fossiliferous sandstone containing *Amoeboceras nunningtonense* Wright, *A. glosense* (Bigot and Brasil), *A. ilovaiskii* (M. Sokolov), *A. transitorium* (Spath), *A. newbridgense* Sykes and Callomon, *Perisphinctes* (*Dichotomosphinctes*) spp., *Microbiplices* sp., *Myophorella clavellata* (Parkinson), *Pleuromya uniformis* (J. Sowerby), *Chlamys midas* (Damon), *C. fibrosus* (J. Sowerby), *Lucina lirata* Phillips, *Nanogyra nana* (J. Sowerby), *Camptonectes lens* (J. Sowerby), *Meleagrinella ovalis* (Phillips), *Goniomya literata* (J. Sowerby) and '*Pentacrinus*' sp.	seen to 1·0
3. Moderately tough, flaggy sandstone, strongly bioturbated towards the top, containing *Amoeboceras* sp., *Perisphinctes* (*P.*) *cautisnigrae* Arkell, *P.* (*Pseudarisphinctes*) *pachachii* Arkell, *Decipia decipiens* (J. Sowerby), *D. lintonensis* Arkell and *Modiolus pulchrum* Phillips.	1·2
NEWBRIDGE BEDS	
2. Flaggy, sandy siltstone with occasional *Decipia ravenswykensis* sp. nov.	3·0

1. Flaggy, sandy, sporadically oolitic limestone or marl, with numerous bored pebbles of the underlying Coral Rag limestone. Rare *Chlamys* sp. 0·6–0·9

(CORAL RAG – blue-grey, fine grained limestone with scattered *Rhabdophyllia phillipsii* Milne Edwards and Haime).

The Newbridge Beds weather readily, and form sloping ledges of soft material, making examination difficult. Numerous bored pebbles of Coral Rag, encrusted by *Nanogyra nana*, weather from this debris, and are scattered over the slopes. Most of the perisphinctids were collected from Bed 3. Bed 4 contains silicified masses of chert, the spicules of *Rhaxella* being readily visible in thin section. Ammonites and bivalves are extremely abundant in this bed, though the shells are commonly broken and distorted due to compaction.

Wrelton Quarry [*SE 760 867*]

	m
SPAUNTON SANDSTONE	
2. Well bedded, poorly fossiliferous, fine grained sandstone.	seen to 1·2
NEWBRIDGE BEDS	
1. Flaggy, shaley sandstone with *Decipia ravenswykensis*.	2·0

(CORAL RAG – massive, smooth textured, fossiliferous limestone).

The Newbridge Beds rest on a well developed, bored erosion surface cut in Coral Rag. Ammonites are not common.

Spaunton Moor Quarry [*SE 722 868*]

	m
(AMPTHILL CLAY – pale grey clay with perisphinctid fragments seen to 0·5 m)	
SNAPE SANDSTONE	
5. Very flaggy, silty, very fine grained, decalcified sandstone with abundant poorly preserved bivalves, belemnites and ammonites: *Amoeboceras* aff. *serratum* (J. Sowerby), *Microbiplices* sp. and *Chlamys midas*.	1·5
SPAUNTON SANDSTONE	
4. Oolitic sandy limestone with *Perisphinctes* (*Arisphinctes*) *osmingtonensis* Arkell, *P.* (*Pseudarisphinctes*) *pachachii*, *P.* (*P.*) *damoni* Arkell, *Decipia decipiens*, *D. lintonensis* and *Myophorella clavellata*.	0·25
3. Massive, heavily bioturbated, fine grained sandstone, blue-hearted and calcareous when fresh, containing *P.* (*Dichotomosphinctes*) spp., *P.* (*Pseudarisphinctes*) *damoni*, *P.* (*Pseudopomerania*) *dewari* (Arkell), *D. decipiens*, *D. lintonensis* and *Amoeboceras* sp.	5·0
NEWBRIDGE BEDS	
2. Soft, flaggy, fine grained sandstone with sporadic *Decipia ravenswykensis*.	1·2
1. Soft, blue-grey marl containing *P.* (*Pseudopomerania*) *dewari*.	1·0

(CORAL RAG – tough, massive, blue-hearted limestone).

This description of the section is a revised version of that published previously by the author (Wright 1972). Most ammonites have been collected from the top of Bed 3 and from Bed 4. Bed 5 comprises only a remnant of the Snape Sandstone, presumably due to erosion beneath the Ampthill Clay. The upper half of the measured section was seen in an outlier on a hill between two valleys. The outlier has now been quarried away completely, and the quarry only rarely yields interesting ammonites.

Ravenswyke Quarry [*SE 707 874*]

	m
NEWBRIDGE BEDS	
2. Flaggy, very fine grained, laminated sandstone with *Decipia ravenswykensis* and *Myophorella clavellata*.	seen to 0·9
1. Dark grey, shaley siltstone.	1·2

(CORAL RAG – flaggy calcilutite).

This quarry has yielded the best specimens of *Decipia ravenswykensis*, first figured by Wright (1972) as *Decipia* sp.

Snape Quarry [*SE 507 786*]

	m
SNAPE SANDSTONE	
7. Massive, fine grained *Rhaxella* spiculite containing siliceous or calcified spicules in a calcareous matrix, and with characteristic argillaceous laminae and lustre mottling; *Belemnites* aff. *explanatus* Phillips very common.	seen to 4·5
– fault – unknown gap –	
SPAUNTON SANDSTONE	
6. Tough, yellow-weathering, siliceous spiculite; occasional *Belemnites* sp. and shell fragments.	seen to 1·5
5. Thin bedded to flaggy, shelly argillaceous spiculite with *Decipia* sp. and *Chlamys midas*.	1·3
4. Rubbly weathering, massive spiculite.	1·0
NORTH GRIMSTON CEMENTSTONE	
3. Pale grey, fine grained ?peloidal limestone.	0·5
2. Grey-brown, impure limestone with flaggy intercalations.	1·0
1. Grey, brown weathering, silty, shaley flags with alternations of more and less calcareous, flaggy bands	seen to 9·0

The North Grimston Cementstone is an impure limestone facies present immediately above the Coral Rag throughout the Howardian Hills, and probably equivalent in age to the Newbridge Beds. Arkell (1947*b*) recorded *Perisphinctes* (*Ampthillia*) *ampthillensis* Arkell and *P.* (*Arisphinctes*) aff. *kirkdalensis* Arkell from this quarry. Sykes and Callomon (1979) recorded *Amoeboceras transitorium*, *A. newbridgense* and *A. glosense*. These probably came from Bed 4.

Laysthorpe Quarry [*SE 646 785*]

	m
SPAUNTON SANDSTONE	
6. Fine grained, spicular sandy limestone with septarian cracks; fauna including *Amoeboceras nunningtonense*, *A. glosense*, *A. ilovaiskii*, *A. transitorium* and *Perisphinctes* (*?Arisphinctes*) sp.	seen to 0·05
5. Flaggy, spicular sandstone with occasional *Amoeboceras* sp. and *P.* (*Pseudarisphinctes*) *pachachii*.	approx. 2·0
4. Massive, pale brown weathering, spicular sandstone full of infilled *Thalassinoides* burrows, and with *Amoeboceras glosense*, *A. ilovaiskii*, *A.* sp., *Perisphinctes* (*Dichotomosphinctes*) sp. and numerous bivalve fragments, including *Chlamys* sp.	1·0
NEWBRIDGE BEDS	
3. Massive, white, blocky, homogeneous spiculite containing *Amoeboceras glosense*, *A. transitorium*, *A. nunningtonense*, *A. ilovaiskii*, *A.* sp., *Perisphinctes* (*P.*) aff. *parandieri* de Loriol, *P.* (*P.*) *uptonensis* Arkell, *P.* (*Arisphinctes*) *kirkdalensis*, *P.* (*A.*) sp., *P.* (*Dichotomosphinctes*) aff. *elizabethae* de Riaz, *P.* (*D.*) spp. and *Nanogyra nana*.	0·6
2. White, laminated sandstone with frequent flattened, distorted ammonites, including *Amoeboceras* aff. *transitorium*, *A. ilovaiskii*, *Perisphinctes* (*P.*) aff. *parandieri*, *P.* (*A.*) *kirkdalensis*, *P.* (*D.*) sp. and *Decipia ravenswykensis*.	0·3
1. Soft, flaggy, decalcified laminated sandstone.	approx. 0·6
(CORAL RAG – massive, coralliferous micrite).	

The Upper Calcareous Grit of this quarry has yielded one of the most interesting Late Oxfordian perisphinctid faunas found in England, coming between the two well known faunas described by Arkell (1935–48) from the Osmington Oolite and the *Trigonia clavellata* Beds [= Clavellata Beds] of Dorset. It thus fills a significant gap in British Oxfordian biostratigraphy. Unfortunately, the quarry is no longer being worked, access is difficult, and the quarry face dangerous. The nearby Nunnington Railway Cutting Quarry [SE 648 787] and Nunnington Railway Cutting [SE 649 788] both show similar sections, though both are becoming overgrown.

Conditions of deposition

The base of the Upper Calcareous Grit is marked by a widespread erosion surface. The indurated Coral Rag was raised in a basin-wide, block uplift. On a regional scale, the uplift was uniform, but on a localized scale it was irregular, with areas of substantial erosion of the Coral Rag. The most

notable of these is at Howldale Quarry near Pickering, where the Coral Rag is reduced to a 0·23 m remnant resting on eroded Malton Oolite. Elsewhere, active erosion seems to have been in progress while the Newbridge Beds were accumulating, bored pebbles of Coral Rag being incorporated into the marls of that member at nearby Newbridge Quarry. The Coral Rag is thin again at Laysthorpe and, 5 km to the east at East Ness, mapping by the author shows it to be absent altogether.

The marine transgression which heralded the deposition of the Upper Calcareous Grit was sluggish, and the sea poorly circulated. The calcareous mudstones of the North Grimston Cementstones pass northwards into the variably argillaceous Newbridge Beds – soft, grey, pebbly marls at Pickering, and laminated, silty clays and siltstones further west. The marine incursion in the Vale of Pickering area was thus nowhere profound. Pebbles formed on beaches fringing islands of Coral Rag, and were swept into the surrounding poorly circulated muddy lagoonal areas. Only at the western end of the Vale of Pickering are ammonites common, and conditions assumed to have been more open marine. The change to fine grained, offshore sand deposition in the Spaunton Sandstone seems therefore to have been due to uplift and erosion of source areas rather than to any shallowing of an already shallow basin. The highest Spaunton Sandstone, very shelly and occasionally oolitic, indicates a well circulated shelf sea with sediments affected by wave action during storms. The Snape Sandstone is laminated and bioturbated, with randomly orientated belemnites, and indicates a return to deeper conditions.

Preservation

The Upper Calcareous Grit ammonite fauna is, unfortunately, rarely well preserved. Rapid compaction has often flattened all but the body chamber, and even this is commonly well compacted, with blunting of the ribs. Allowance has to be taken for this when studying the figured specimens.

SYSTEMATIC PALAEONTOLOGY

The perisphinctid genera and subgenera recognized in the North Yorkshire Late Oxfordian are listed below, with brief diagnoses. Fuller descriptions are given in the references cited. Specimens from the Newbridge Beds and the Spaunton Sandstone are then described separately, as almost all the species are exclusive to only one of these formations. All specimens whose numbers are prefixed by 'U.' or 'D.C.' are in the author's collection housed at Royal Holloway College. Arrangements have been made to donate this collection eventually to The Yorkshire Museum, York. All specimens whose numbers are prefixed by 'M' are in the geology collection at Woodend Natural History Museum, Scarborough. The usual convention for expressing shell dimensions is followed, i.e. after a given diameter, whorl height, whorl breadth, and then umbilical width are listed as decimal fractions of that diameter.

In the course of conventional, morphogenic/morphospecific studies, as undertaken by Arkell (1935–48), genera, subgenera and species are based purely on morphological similarities and differences. Generic ranges have no phylogenetic significance, and separate subgeneric and specific taxa are used in most cases for dimorphs. Such isochronous diversity may in fact be wholly artificial (see discussion on p. 460). However, the present feeling amongst workers on this ammonite group, summed up by Atrops and Melendez (1993), is that the typological taxonomy, as adopted by earlier workers, is a useful tool for recognizing and characterizing morphologies, and such an approach is used here.

Superfamily PERISPHINCTACEAE Steinmann, 1890
Family PERISPHINCTIDAE Steinmann, 1890

Genus PERISPHINCTES Waagen, 1869
Subgenus PERISPHINCTES Buckman, 1920

Type species. Ammonites biplex Sowerby, 1821, designated by Buckman 1920, p. 26.

Diagnosis. Macroconch perisphinctids with standard biplicate ribbing on inner whorls changing at beginning of body chamber to large, swollen, sometimes cuneiform ribs (Arkell 1936, pp. lii–liv).

Subgenus DICHOTOMOSPHINCTES Buckman, 1926

Type species. Perisphinctes antecedens Salfeld, 1914, designated by Buckman 1926, pl. 650.

Diagnosis. Medium sized, microconch perisphinctids with biplicate ribbing ending in lappets (Arkell 1936, pp. xlv–xlvi, 1937*a*, pp. xlvii–xlviii); microconchs of *Perisphinctes s.s.* included in this subgenus except those of *P. variocostatus* group, which are included in *Dichotomoceras.*

Subgenus ARISPHINCTES Buckman, 1924

Type species. Arisphinctes ariprepes Buckman, by original designation (Buckman 1924, p. 33 and pl. 511).

Diagnosis. Large macroconch perisphinctids with biplicate or triplicate ribbing. Secondary ribbing gradually lost. Large, swollen simple ribs on body chamber (Arkell 1939, pp. lvi–lvii). Microconchs of this subgenus included in *Dichotomosphinctes.*

Subgenus PSEUDARISPHINCTES Arkell, 1939

Type species. Perisphinctes (*Pseudarisphinctes*) *shortlakensis*, by original designation (Arkell 1939, pp. lxiii–lxiv).

Diagnosis. Large (macroconch) and medium–small (microconch) perisphinctids with coarse, biplicate or triplicate ribbing on inner whorls and, in macroconch, large, swollen ribs on body chamber. Suture very simple.

Subgenus PSEUDOPOMERANIA subgen. nov.

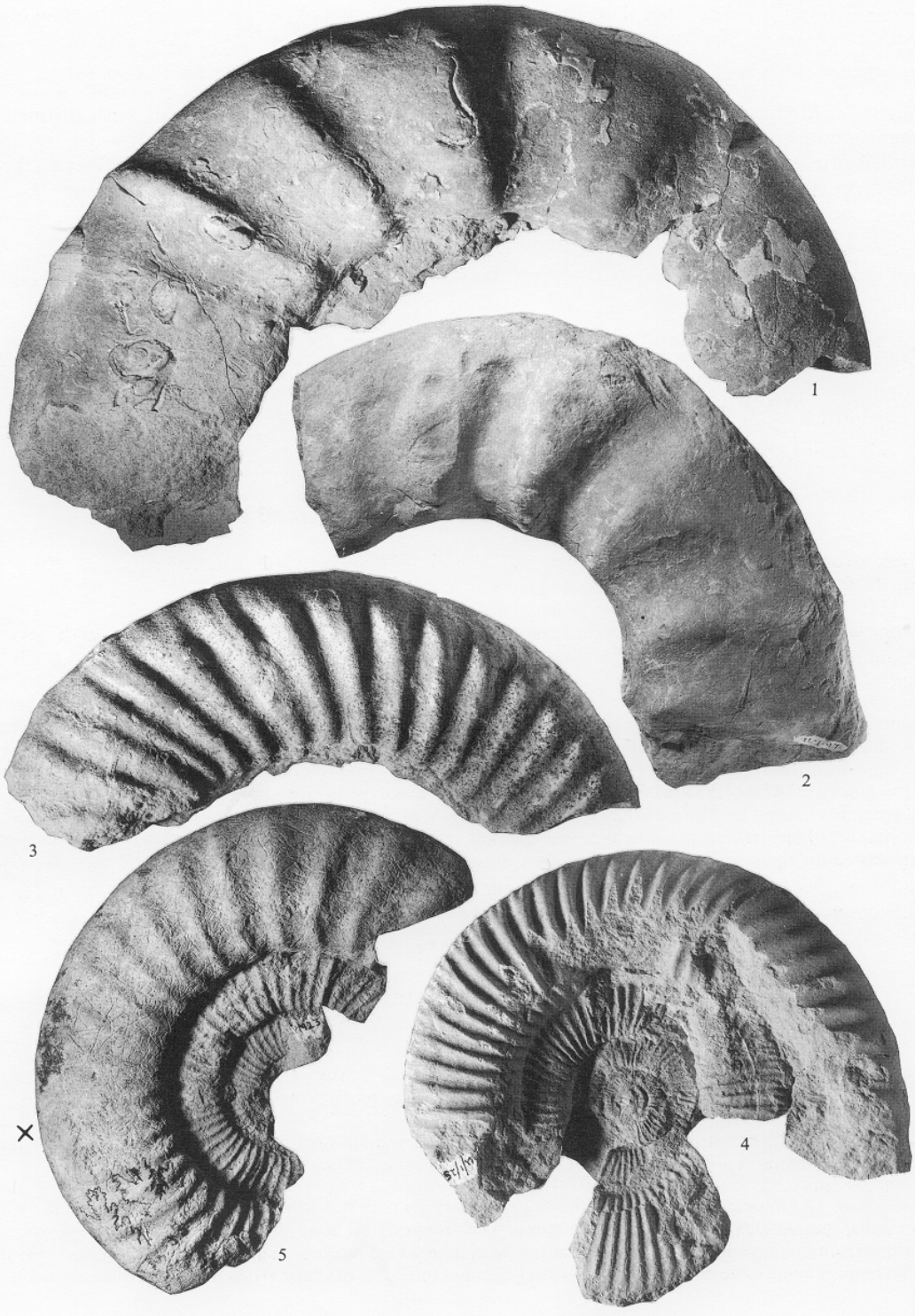
Type species. Decipia (*Pomerania*) *dewari* Arkell, 1947*b*, p. 375, pl. 77, fig. 1a–b).

Diagnosis. Medium-sized, macroconch perisphinctids with standard, biplicate ribbing on inner whorls, passing into smooth area near last septum. Coarse simple ribbing developed on body chamber. Sides and venter flat; whorl section quadrate. Microconch probably included in *Dichotomosphinctes.* Originally included by Arkell (1947*b*, pp. 374–377) in *Pomerania* as a subgenus of *Decipia.*

EXPLANATION OF PLATE 1

Fig. 1. *Perisphinctes* (*Perisphinctes*) *uptonensis* Arkell; M25; fragment of body chamber; ×0·4.
Fig. 2. *Perisphinctes* (*Perisphinctes*) aff. *parandieri* de Loriol; U.1.97; fragment of body chamber; ×0·4.
Figs 3–4. *Perisphinctes* (*Arisphinctes*) *kirkdalensis* Arkell. 3, U.1.107; fragment of body chamber. 4, U.1.25 probable immature specimen; suture visible on inner whorls but not on last half whorl; both ×0·5.
Fig. 5. *Perisphinctes* (*Arisphinctes*) sp. A; M23; ×0·5.
All specimens from the Newbridge Beds (Bed 3) of Laysthorpe Quarry, North Yorkshire.

Note: On this and following plates, the end of the phragmacone is marked by an ×. Specimens that are wholly septate and portions of non-septate body chambers are described as such in the plate descriptions; in all other cases, the presence and extent of suture lines cannot be determined.



WRIGHT, *Perisphinctes*

Subgenus DECIPIA Arkell, 1937*a*

Type species. Ammonites decipiens Sowerby, 1821, designated by Arkell (1937*a*, p. 68, 1938, p. 69).

Diagnosis. Medium-sized (macroconch) and small (microconch) perisphinctids with distinctive separation of groups of three or four secondary ribs, in bundles or sheaves, from widely spaced, swollen primary ribs. The macroconch adopts coarse simple ribs on the body chamber (Arkell, 1937*a*, pp. 44–45).

Genus MICROBIPLICES Arkell, 1936

Type species. Ammonites microbiplex Quenstedt, 1887–88, p. 876, pl. 94, fig. 36, designated by Arkell (1936, p. xli).

Diagnosis. Small (*c.* 100 mm) to very small (*c.* 40 mm) microconch perisphinctids with coarse biplicate ribbing and lappets.

Perisphinctids of the Newbridge Beds

Genus PERISPHINCTES Waagen, 1869
Subgenus PERISPHINCTES Buckman, 1920

Perisphinctes (*Perisphinctes*) *uptonensis* Arkell, 1935

Plate 1, figure 1

1935 *Perisphinctes* (*Perisphinctes*) *uptonensis* Arkell, p. 10, pl. 2, fig. 1a–b.
1936 *Perisphinctes* (*Perisphinctes*) *uptonensis*; Arkell, pl. 7, figs 2a–b, 3.
1963 *Perisphinctes* (*Perisphinctes*) *uptonensis* Arkell; Malinowska, p. 73, pl. 41.

Material. One body chamber fragment from Bed 3 at Laysthorpe Quarry (M25).

Description. The specimen consists of the final two-fifths of a whorl of an individual of 340 mm maximum diameter (Pl. 1, fig. 1). Although the aperture is broken away, the final 100 mm of whorl has two simple, fading ribs and numerous striations parallel to the aperture, showing that it was a mature adult. Three of the large, swollen cuneiform ribs, which are characteristic of this species, are preserved, matching closely those present in the holotype (Arkell 1935, pl. 2, fig. 1a). However, the holotype is larger, being an adult at 405 mm, as is the specimen figured by Malinowska (1963). Arkell (1936, pl. 7, figs 2a–b, 3) figured two specimens of a size comparable to the present specimen as a 'small variety' of *P. uptonensis*, considering that no new specific name was needed for these smaller forms.

Perisphinctes (*Perisphinctes*) aff. *parandieri* de Loriol, 1903

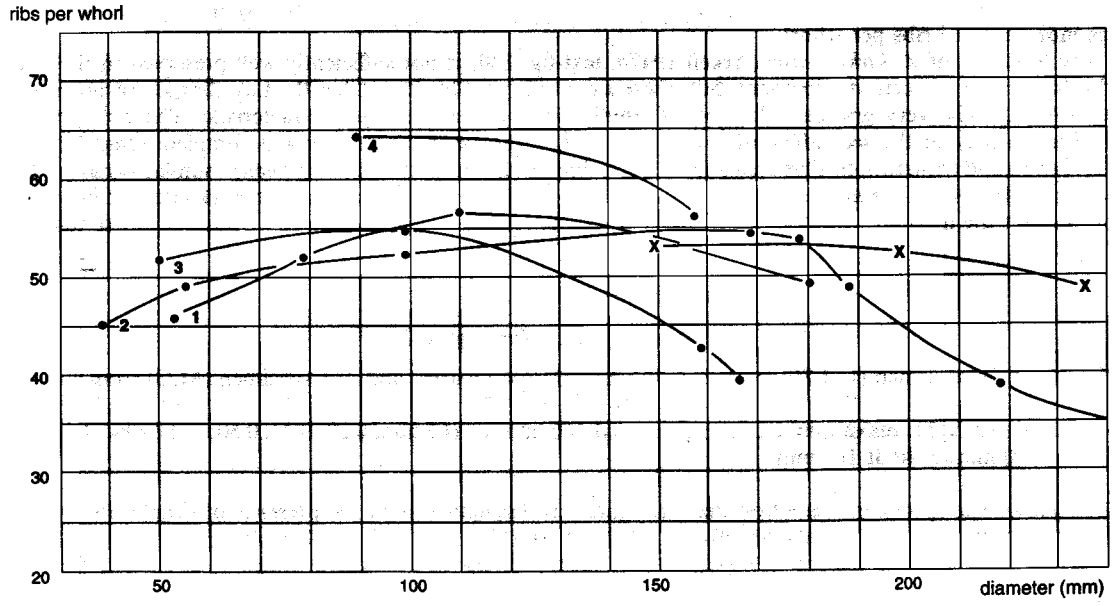
Plate 1, figure 2

1903 *Perisphinctes parandieri* de Loriol [*partim*], p. 90, pl. 7 only.
1939 *Perisphinctes* (*Perisphinctes*) *parandieri* de Loriol; Arkell, p. 105, figs 28–33 [includes detailed synonymy].
1966 *Perisphinctes* (*Perisphinctes*) *parandieri* de Loriol; Enay, p. 357, pl. 5, figs 1–3, pls 6–7.

Material. Two fragmentary specimens from Laysthorpe Quarry, U.1.97, a body chamber fragment from Bed 2, and U.1.111, the impression of part of the mid-whorl, from Bed 3.

Measurements. U.1.111.: ribs estimated at 68 per whorl at a diameter of 165 mm; U.1.97.: original whorl diameter *c.* 290 mm. Approximately eight ribs per half whorl at 290 mm diameter.

Description. The fragment of mid-whorl shows strong wiry primary ribs which bifurcate in most cases, but with occasional simple ribs and slight constrictions. The fragment of body chamber (Pl. 1, fig. 2) shows the characteristic ribbing with strong, swollen ridges developing at a diameter of approximately 240 mm. These are much more numerous than in *P. uptonensis*, and are not cuneiform in shape. They fade somewhat towards the



TEXT-FIG. 2. Rib curves of *Perisphinctes* (*Arisphinctes*) spp. from the Newbridge Beds; ×, *P.* (*A.*) *kirkdalensis* (holotype, after Arkell (1947*b*)); 1, *P.* (*A.*) *kirkdalensis* (U.1.106); 2, *P.* (*A.*) sp. B (M26); 3, *P.* (*A.*) sp. A (M23); 4, *P.* (*A.*) *kirkdalensis* (U.1.25).

aperture, which is partly present in this specimen. Most specimens of *P. parandieri* are adult at around 350 mm, but Arkell (1939, p. 107) refers to a smaller variety probably adult at less than 300 mm.

Subgenus ARISPHINCTES Buckman, 1924

Perisphinctes (*Arisphinctes*) *kirkdalensis* Arkell, 1947*b*

Plate 1, figures 3–4; Text-figure 2

1947*b* *Perisphinctes* (*Arisphinctes*) *kirkdalensis* Arkell, p. 367, text-fig. 130.

Material. Seven specimens from Bed 3 at Laysthorpe Quarry, U.1.25, U.1.107, U.1.89, U.1.92, U.1.93, U.1.105 and U.1.106.

Measurements. U.1.25: maximum diameter preserved 162 mm; at 155 mm, 0·30, –, 0·48; 56 ribs at 158 mm, 64 at 90 mm; U.1.106: specimen badly crushed, maximum diameter preserved *c.* 180 mm; 46 ribs at 53 mm, 52 at 80 mm, 56 at 111 mm, 49 at 180 mm.

Description. The coiling is moderately evolute, and the bifurcation points are high on the whorl side so that they are well hidden by the umbilical seam. At 50 mm, 45 ribs per whorl is the norm, though occasionally young individuals may have as many as 65 at this diameter. When the secondaries are first seen, at 70 mm, there is the standard bifid pattern. Occasional intercalated secondaries appear by 95 mm. By 130 mm, the secondary ribbing is beginning to fade. On U.1.25 (Pl. 1, fig. 4), faint bifid ribs run up on to the ventro-lateral edge at 150 mm, the venter being almost smooth. On other specimens, faint, trifid sheaves of secondaries are present at this stage, but fade rapidly. The change from bifid ribbing to strong, simple ribs is the feature which places these specimens in *Arisphinctes*. Bifid ribbing continues to the aperture in *Dichotomosphinctes*. U.1.25 is a substantially complete individual, and may be immature. Most specimens are still septate at this diameter (155 mm).

The rib curve (Text-fig. 2) thus shows the number of primary ribs rising gently to 55 to 65 ribs per whorl at 100 to 120 mm, and falling away to 50 ribs per whorl at 200 mm. This distinguishes this species from the

slightly younger *A. ringsteadensis* Arkell, figured by Arkell (1935, pls 3–4, 1936, pls 7–8). *A. ringsteadensis* never has more than 45 ribs per whorl.

The holotype of *A. kirkdalensis* (Arkell 1947*b*, text-fig. 130) is not sufficiently well preserved in the inner whorls to make an accurate rib count, but where a count is possible it matches the Laysthorpe specimens well (Text-fig. 2). The very gradual adoption of simple ribbing is a common characteristic. The holotype has bifurcation only of the secondary ribs, whereas the Laysthorpe specimens show a complete range between bifurcation and trifurcation. This seems to be a variable feature in species of *Arisphinctes*; similar variation also occurs in the allied *A. ringsteadensis* (Arkell 1936, pl. 8). The exact horizon in the Kirkdale Cutting is not known, but the holotype probably came from the Spaunton Sandstone, as the Newbridge Beds are thin and shaly here.

Perisphinctes (*Arisphinctes*) sp. A

Plate 1, figure 5; Text-figure 2

Material. One specimen (U.1.80) from Bed 2 at Laysthorpe Quarry, and one specimen (M23) from Bed 3.

Measurements. M23: maximum diameter preserved 166 mm; at 165 mm, 0·29, 0·22, 0·50; *c.* 52 ribs at 50 mm, *c.* 55 at 100 mm, *c.* 40 at 166 mm.

Description. The specimen figured on Plate 1, figure 5 is distinguished by the presence of simple ribs with an almost smooth venter at a diameter of only 130 mm. At 165 mm, large, swollen ribs appear. The rib curve diverges markedly from that of *A. kirkdalensis* (Text-fig. 2). Specimen U.1.80, which is an entirely flattened body chamber not suitable for illustration, continues the rib pattern at the point where M23 is broken. The simple ribs present in the area of the last septum continue to at least 270 mm, becoming gradually more widely spaced so that there are only ten ribs on the last half whorl. The ribs are slightly raised and bulbous at the ventro-lateral edge. The venter is smooth. The maximum original diameter was probably 300 mm. There is insufficient material at present to decide whether these specimens represent a variant of *A. kirkdalensis*, or whether they belong to a new species.

Perisphinctes (*Arisphinctes*) sp. B

Plate 2, figure 1; Text-figure 2

Material. One large natural mould (M26) from Bed 3 at Laysthorpe Quarry, from which the figured Vinamould cast was made.

Measurements. Maximum diameter 330 mm complete with aperture; at 325 mm, 0·26, –, 0·51; 45 ribs at 38 mm, *c.* 49 at 55 mm, *c.* 52 at 100 mm, 54 at 170 mm, 53 at 180 mm, 49 at 190 mm, 38 at 220 mm, 28 at 320 mm.

Description. This specimen appears to be closely related to *A. kirkdalensis*, having the same very gradual appearance of simple ribbing. However, it adopts large swollen ribs at a diameter (230 mm) where *A. kirkdalensis* still has much less prominent ribs, and thus at this diameter M26 has 13 ribs per whorl fewer than the holotype of *A. kirkdalensis* (Text-fig. 2). Further material will be required before it will be possible to decide whether M26 is the adult body chamber of *A. kirkdalensis*, or whether U.1.80, described under *Arisphinctes* sp. A, represents the adult.

EXPLANATION OF PLATE 2

Fig. 1. *Perisphinctes* (*Arisphinctes*) sp. B; Vinamould cast of the original natural mould, M26; specimen complete, including part of aperture; ×0·36.

Figs 2–3. *Perisphinctes* (*Dichotomosphinctes*) aff. *elizabethae* de Riaz; 2, U.1.24; crushed inner whorls. 3, U.1.91; partial body chamber, with impression of inner whorl; both ×1.

Fig. 4. *Perisphinctes* (*Dichotomosphinctes*) sp. A; U.1.102; largely complete, markedly flattened specimen showing approximately three-quarters of body chamber; ×0·5.

All specimens from the Newbridge Beds (Bed 3) of Laysthorpe Quarry, North Yorkshire.

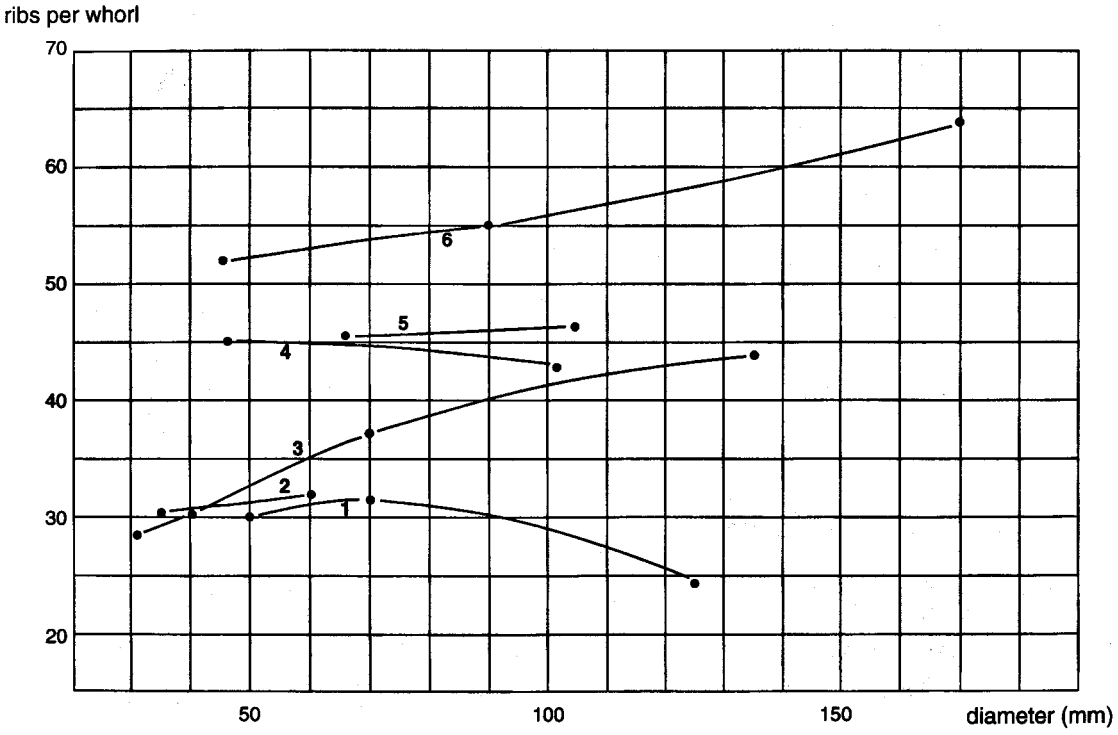
1

2

3

4

WRIGHT, *Perisphinctes*



TEXT-FIG. 3. Rib curves of *Decipia ravenswykensis* sp. nov. and *Perisphinctes* (*Dichotomosphinctes*) spp. from the Newbridge Beds: 1–2, *Decipia ravenswykensis* (U.5.7 and U.5.1 (holotype)); 3, *P.* (*Dichotomosphinctes*) sp. C (U.1.100); 4–5, *P.* (*D.*) sp. B (U.1.28, U.1.103); 6, *P.* (*D.*) sp. A (U.1.102).

Subgenus DICHOTOMOSPHINCTES Buckman, 1926

Perisphinctes (*Dichotomosphinctes*) aff. *elizabethae* de Riaz, 1898

Plate 2, figures 2–3; Plate 4, figure 3

1898 *Perisphinctes elizabethae* de Riaz, p. 22, pl. 12, figs 4 [lectotype], 5.
1966 *Perisphinctes* (*Dichotomosphinctes*) *elizabethae* de Riaz; Enay, p. 490, pl. 30, figs 4–5, pl. 31, figs 2–6 [includes detailed synonymy].
1977 *Perisphinctes* (*Dichotomosphinctes*) *elizabethae* de Riaz; Matyja, pl. 8, fig. 11.
1980*b* *Perisphinctes* (*Dichotomosphinctes*) *elizabethae* de Riaz; Brochwicz-Lewinski, p. 210, pl. 1, fig. 1.
1989 *Perisphinctes* (*Dichotomosphinctes*) *elizabethae* de Riaz; Fisher and Gygi, p. 1588, fig. 5B.

Material. Three specimens, the compressed inner whorls (U.1.24) and a fragment of body chamber (U.1.91) from Bed 3 at Laysthorpe Quarry, and a body chamber fragment (U.1.88) found loose at Oswaldkirk.

Measurements. U.1.24: 56 ribs per whorl at 80 mm: U.1.88: preserved to *c.* 145 mm diameter, estimated as originally having 89 ribs per whorl at 145 mm.

Description. Both Laysthorpe specimens show fine, wiry, prorsiradiate ribbing bifurcating at about two-thirds of the whorl height, and with strong constrictions and simple ribs developing on the body chamber. This rib style and rib density match closely those of *P. elizabethae*, though the fragmentary nature of the material means that the identification must remain tentative. However, the high density of the ribbing of U.1.88, unique in the British Oxfordian, matches closely that of Enay's (1966) specimens, which have between 80 and 95 ribs per whorl at this diameter. The ribbing also matches closely that of the inner whorls of *P.* (*Perisphinctes*)

densecostatus Enay, and this is almost certainly the microconch of that species. *Lithacoceras* (*Larcheria*) spp. are similarly densely ribbed, but the characteristic fading of the ribs about the mid-point of the whorl side is not present in these specimens.

Perisphinctes (*Dichotomosphinctes*) sp. A

Plate 2, figure 4; Text-figure 3

Material. One largely complete, crushed specimen which has most of the body chamber preserved, from Bed 2 at Laysthorpe (U.1.102), and one whorl fragment from Bed 3 (U.1.90).

Measurements. U.1.102: maximum diameter preserved 175 mm; 52 ribs at 45 mm, 55 at 90 mm, 64 at 170 mm.

Description. The coiling is quite evolute, with the umbilical seam only just covering the bifurcation points. The secondaries bifurcate normally, with occasional simple ribs. At 170 mm, bifurcation is strongly developed, with prominent wiry ribs, and the number of primary ribs is still increasing. Close to the aperture, which is partly visible on the reverse of the specimen, there is one more widely spaced simple rib.

Remarks. P. (*Dichotomosphinctes*) sp. A has broader, more rounded, less prorsiradiate ribbing than *P.* (*D.*) *elizabethae*, and has no marked constrictions, only occasional simple ribs. However, these are rather variable features in *Dichotomosphinctes*, and species of this subgenus are distinguished principally by means of rib curves. Enay (1966) figured rib curves for a number of species of *Dichotomosphinctes* from the Jura, including *D. elizabethae*, *D. luciaeformis* Enay, *D. wartae* Bukowski, *D. dobrogensis* Simionescu and *D. antecedens* Salfeld. The rib curve of *D.* sp. A (Text-fig. 3) comes close to few of these. The increase in number of ribs per whorl with increasing diameter is only moderate, so that the curve of *D.* sp. A does not match the steep increase in rib density of *D. dobrogensis* or *D. wartae*. *D.* sp. A has only 64 ribs on the last whorl as against an average of 80 in *D. wartae*. *D. elizabethae* has 85 to 95 ribs per whorl at this diameter. The closest fit is with *D. antecedens* var. C of the Middle Oxfordian, described by Enay (1966, p. 476) as having more densely ribbed inner whorls than is typical of this species. *D.* sp. A may well prove to be a new Late Oxfordian species closely related to *D. antecedens*. Enay (1966) did not specify the age of his var. C, although he recorded '*D. antecedens*' from the Parandieri Subzone.

Perisphinctes (*Dichotomosphinctes*) sp. B

Plate 3, figures 3–4; Text-figure 3

Material. One almost complete but poorly preserved specimen from Bed 2 at Laysthorpe Quarry (U.1.28), and one near complete specimen (U.1.103) and three whorl fragments (U.1.12, U.1.87, and U.1.112) from Bed 3.

Measurements. U.1.28: maximum diameter preserved 102 mm, with one third of a whorl of body chamber; at 95 mm, 0·37, –, 0·43; 43 ribs at 102 mm, *c.* 45 at 45 mm. U.1.103: maximum diameter preserved 118 mm, with half a whorl of body chamber; at 102 mm, 0·32, –, 0·45; 46 ribs at 105 mm, 45 at 65 mm.

Description. The strong, rectiradiate primary ribs may bifurcate at just below two-thirds of the whorl height or, commonly, they may carry on as simple ribs over the venter. Two or three bifurcating primary ribs are followed by a simple rib. One marked constriction is visible on U.1.103 (Pl. 3, fig. 4) and on U.1.12. The ribs run strongly over the venter. This bold, moderately spaced ribbing is very characteristic of the species. There are some 15 ribs per whorl fewer than on *P.* (*D.*) sp. A at the largest diameter seen. The probable maximum original diameter was *c.* 120 mm.

Remarks. None of the species of *Dichotomosphinctes* figured by Enay (1966) from the Jura, by Polish authors, or by Arkell (1935–48) from the English Corallian Beds, matches *P.* (*D.*) sp. B in its moderately dense and bold ribbing and flat rib curve (Text-fig. 3). This may well be a new species, although better material is required to differentiate it.

Perisphinctes (*Dichotomosphinctes*) sp. C

Plate 3, figure 2; Text-figure 3

Material. One almost complete specimen from Bed 3 at Laysthorpe Quarry.

Measurements. U.1.100: maximum size 135 mm; at 130 mm, 0·28, –, 0·46; 44 ribs at 135 mm, 37 at 70 mm, *c.* 30 at 40 mm, *c.* 28 at 30 mm.

Description. The specimen consists of a complete, microconch adult with the usual poor preservation of the inner whorls characteristic of the Newbridge Beds, though with a fairly well preserved body chamber. Although the inner whorls are poorly preserved, coarse, prorsiradiate primary ribs can be distinguished even at very small diameters. On the body chamber, the stout primary ribs generally bifurcate at two-thirds of the whorl height, with the secondaries running strongly over the venter. Every fourth or fifth primary rib continues as a simple rib, though marked constrictions are not evident. The ribbing coarsens slightly towards the aperture, where a flared final rib is visible, though any lappets, if originally present, appear to have been broken off.

Remarks. Dichotomosphinctes sp. C is unique amongst the Newbridge Beds material in its coarse ribbing (Text-fig. 3). It has 30 ribs per whorl at a diameter of 40 mm, whereas *P.* (*D.*) sp. B has 45 at this diameter. As with some of the other *Dichotomosphinctes* from these beds, comparison is more easily made with other Middle Oxfordian rather than Upper Oxfordian forms. Thus, the coarse early ribbing matches quite closely that of *P.* (*D.*) *rotoides* Ronchadzé *sensu* Arkell (1938, p. 90), though this species is mature at 100 mm with a more steeply rising rib curve than that of *P.* (*D.*) sp. C. *P.* (*D.*) *ouatius* (Buckman) is similarly coarsely ribbed, though mature at an even earlier diameter (Arkell 1936, p. xliv). Nothing similar appears to have been figured by French, German or Polish authors, and I am driven to the conclusion that this is a new species, although it would not be proper to define a new species on the basis of just this one specimen.

Subgenus PSEUDOPOMERANIA subgen. nov.

Perisphinctes (*Pseudopomerania*) *dewari* (Arkell, 1947)

Plate 3, figure 1a–b

1974*b* *Decipia* (*Pomerania*) *dewari*, Arkell, p. 375, pl. 77, figs 1, 5.

Material. One incomplete specimen consisting of the crushed inner whorls and an outer whorl fragment showing the first third of the body chamber, from Bed 1 at Spaunton Moor Quarry (U.3.19).

Measurements. U.3.15: maximum diameter preserved 215 mm; at 215 mm, 0·24, –, 0·56; 37 ribs at 40 mm, 44 at 55 mm.

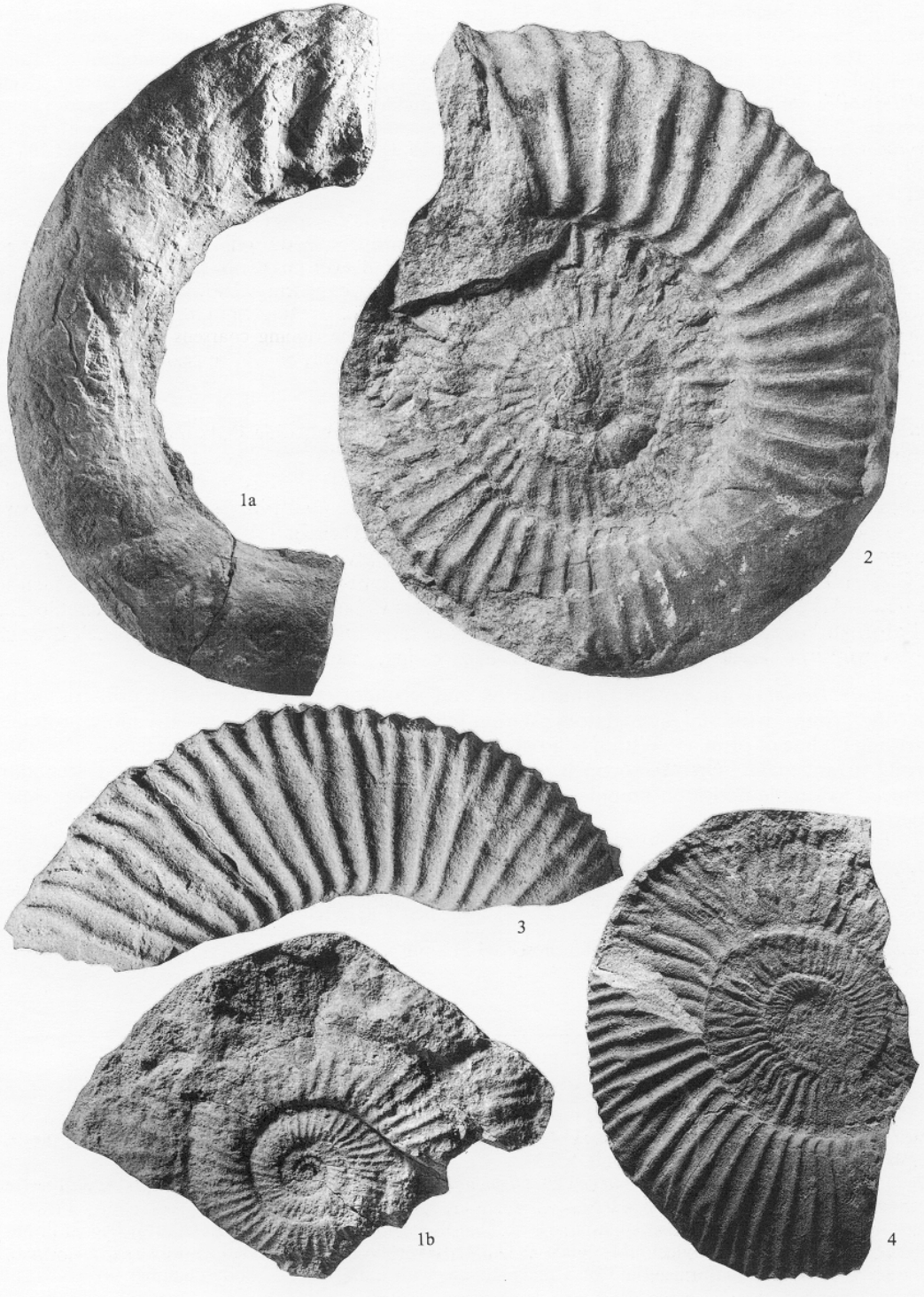
EXPLANATION OF PLATE 3

Fig. 1a–b. *Perisphinctes* (*Pseudopomerania*) *dewari* (Arkell); U.3.19; Spaunton Moor Quarry, Bed 1; 1a, body chamber showing absence of ribs in area of last septum; ×0·5. 1b, inner whorls of same specimen, showing biplicate perisphinctid style ribbing; ×1.

Fig. 2. *Perisphinctes* (*Dichotomosphinctes*) sp. C; U.1.100; Laysthorpe Quarry, Bed 3; specimen complete, including aperture; inner whorls are crushed but body chamber still retains true cross section; ×0·8.

Figs 3–4. *Perisphinctes* (*Dichotomosphinctes*) sp. B; Laysthorpe Quarry, Bed 3; 3, U.1.112; fragment of body chamber; ×1. 4, U.1.103; specimen with crushed inner whorls and part of body chamber; ×0·7. Both body chambers substantially flattened.

All specimens from the Newbridge Beds.



WRIGHT, *Perisphinctes*

Description. Although the inner whorls of U.3.15 are badly crushed, sufficient is visible to determine most of the characters of the species (Plate 3, fig. 1b). The primary ribbing is quite fine and dense. No constrictions are visible. The junction between the primary and secondary ribs is crushed beneath the umbilical seam of the overlapping whorl, but the secondary ribs (two per primary) are visible on the venter at 60 mm. Regular bifurcation is not present as far as can be seen; some secondaries are not connected to the primaries but run between them. The body chamber (Pl. 3, fig. 1a) is almost smooth for the first quarter of a whorl, but then develops increasingly prominent prorsiradiate primary ribs which pass gently over the venter. Probably one third of a whorl is missing up to the aperture. The match with Arkell's (1947*b*) pl. 78, fig. 5 is very close.

Remarks. The specimens figured by Arkell (1947*b*, pl. 78) as *Decipia* (*Pomerania*) *dewari* came from the Ampthill Clay of Cambridgeshire, and are body chambers very similar to that of Plate 3, figure 1a, but not immediately associated with inner whorls. Arkell (1939, p. lxiv) reported that 'the ribbing of *Pomerania* is believed to be like that of *Decipia* on the inner whorls' but specimens have now been found in Yorkshire which show that the inner whorls have normal, biplicate, *Perisphinctes*-type ribbing (Pl. 3, fig. 1b). *Pomerania*, as defined by its type species, came from the Upper Jurassic of Pomerania thought by Arkell to be of Late Oxfordian age, presumably Pseudocordata Zone, but possibly Kimmeridgian. Thus its connection with Nunningtonense and Cautisnigrae Subzone forms from England is very tenuous. A new subgenus, *Pseudopomerania*, is established here as a subgenus of *Perisphinctes* to include the English forms which have a body chamber like *Pomerania*, but normal *Perisphinctes*-type inner whorls.

Genus DECIPIA Arkell, 1937

Decipia ravenswykensis sp. nov.

Plate 4, figures 1, 4–6; Plate 8, figure 5; Text-figure 3

1972 *Decipia* sp.; Wright, pl. 14, fig. 4.
1976 *Decipia* cf. *lintonensis* Arkell; Sykes and Surlyk, p. 431, fig. 5B.

Diagnosis. Decipia with very bold primary ribs, and secondaries which connect to primaries in bifid or trifid groups, with one intercalatory. Within bifid pair, one secondary usually more prominent, carrying on line of primary. Within trifid group, secondaries may join up in characteristic pitchfork prong arrangement. On macroconch, secondary ribs fade at about 100 mm, and secondaries reduced to simple nodes on umbilical edge by about 130 mm. Faint simple ribs develop close to aperture.

Material. The holotype (U.5.1, Pl. 4, fig. 1) plus seven other specimens (U.5.2–U.5.7, U.5.10) from Bed 2 at Ravenswyke Quarry. Three specimens (U.3.14, U.3.33 and U.3.44) from near the top of Bed 2 at Spaunton Moor Quarry; two specimens (U.6.1 and U.6.2) from Bed 1 at Wrelton Quarry; two specimens (M9 and U.1.94) from ?Bed 2 at Nunnington Railway Cutting Quarry, and two specimens (U.2.42–U.2.43) from Bed 2 at Newbridge Quarry.

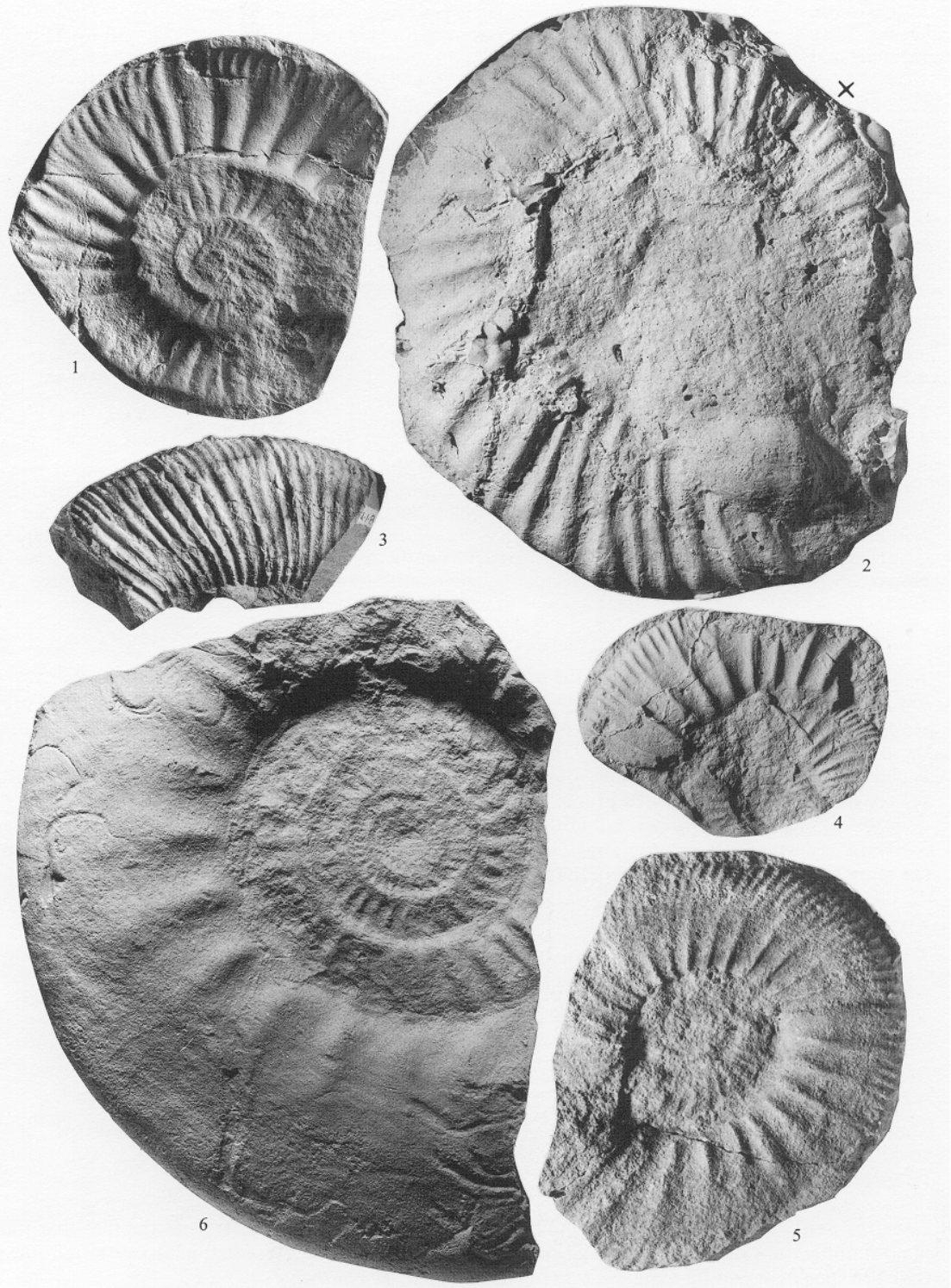
EXPLANATION OF PLATE 4

Fig. 1. *Decipia ravenswykensis* sp. nov; U.5.1, holotype; Newbridge Beds; Ravenswyke Quarry, Bed 2; Plasticine squeeze of original natural mould; × 1.

Fig. 2. *Perisphinctes* (*Arisphinctes*?) sp., U.1.110; Spaunton Sandstone; Laysthorpe Quarry, Bed 6; plaster of Paris cast of original natural mould; × 0·34.

Fig. 3. *Perisphinctes* (*Dichotomosphinctes*) aff. *elizabethae* de Riaz; U.1.88; ?Newbridge Beds; specimen found loose in a field at Oswaldkirk; × 0·52.

Figs 4–6. *Decipia ravenswykensis* sp. nov.; Newbridge Beds; 4, U.2.42; Newbridge Quarry, Bed 2; Plasticine squeeze of original natural mould; × 0·8. 5, U.5.4; Ravenswyke Quarry, Bed 2; × 1. 6, U.5.7; Plasticine squeeze of original natural mould of a macroconch, with initial part of body chamber preserved; inner whorls crushed; × 1.



WRIGHT, *Decipia*, *Perisphinctes*

Measurements. U.5.1 (holotype): maximum diameter preserved 63 mm; at 60 mm, 0·30, –, 0·47; 30 ribs at 35 mm, 32 at 60 mm. U.5.7: maximum diameter preserved *c.* 133 mm; at 133 mm, 0·29, –, 0·43; 24 ribs at 125 mm, *c.* 31 at 75 mm, 30 at 50 mm.

Description. The holotype consists of a well preserved natural mould (figured as a Plasticine squeeze in Pl. 4, fig. 1) and a counterpart showing poorly preserved inner whorls only. The coiling is moderately involute. The primary ribs are strong, wiry and widely spaced, 30 ribs per whorl being average for the species (Text-fig. 3). A spiral band of only slightly raised ribs follows the mid-point of the whorl side, and each succeeding whorl overlaps onto this band. There are 3·2 secondary ribs per primary on the last quarter whorl visible. Each primary rib will link up with a secondary if there is one suitably placed; otherwise, there may be an indistinct bifurcation at about the mid-point of the whorl side, or the secondaries may run down between the primaries and fade. The secondary ribs are strongly developed over the venter. Marked constrictions with a strong, simple rib occur two or three times per whorl. Sutures can be made out indistinctly in the counterpart, and the last quarter of a whorl is body chamber; the holotype is thus a microconch.

Specimen U.5.7 is a natural mould of a macroconch, and a plasticine squeeze is figured (Pl. 4, fig. 6). The inner whorls are nearly flattened, but the first third of the body chamber is present, enabling estimation of the maximum original size at probably 190 mm. The secondary ribs are just visible at the start of the body chamber, but rapidly fade away, leaving fairly widely spaced, rounded umbilical nodes as the only ornament. The coiling is slightly more involute than in the holotype. Specimen U.5.10 (Pl. 8, fig. 5) is heavily encrusted with oysters, but shows the body chamber close to the aperture at 230 mm. The umbilical nodes are more swollen than in U.5.7, and faint simple ribs are developed close to the aperture, which is not preserved.

One individual from Ravenswyke Quarry (Pl. 4, fig. 5) shows more delicate ribbing than is usual, and is thus transitional to *D. decipiens*. The bold primary ribs which link up with suitably placed secondary ribs are well seen in a fragment from Newbridge Quarry (Pl. 4, fig. 4). Specimens from Spaunton Quarry and Wrelton Quarry tend to be more coarsely ribbed, a specimen from the latter locality having only 2·3 secondaries per primary. A poorly preserved macroconch from Nunnington Railway Cutting Quarry shows the suture, with slender lobes lacking florid development and with wide saddles. The external, lateral and suspensive lobes are of equal length.

Remarks. Decipia ravenswykensis is distinguished from other species of *Decipia* by the sharp, rod-like primary ribs present on the inner whorls each linking up directly to one secondary, with other secondaries branching off in either a backwards or a forwards direction, or running down between the primaries. In *D. decipiens* and *D. lintonensis*, described below (pp. 456–460), the primary ribs broaden and flatten at the mid-point of the whorl side, and bundles of three or four secondaries arise in sheaves from each broadened primary. Specimen U.5.4 is intermediate in this respect, having the delicate ribbing of *D. decipiens*, but not having secondaries arising in sheaves. The macroconchs are easily distinguished, *D. ravenswykensis* having umbilical nodes on its body chamber, as distinct from the simple ribs of *D. decipiens* (compare Pl. 8, fig. 5 with Pl. 7, fig. 1).

Perisphinctids of the Spaunton Sandstone

Genus PERISPHINCTES Waagen, 1869
Subgenus PERISPHINCTES Waagen, 1869

Perisphinctes (*Perisphinctes*) *cautisnigrae* Arkell, 1935

1935 *Perisphinctes* (*Perisphinctes*) *cautisnigrae* Arkell, p. 14, pl. 1, figs 1a–b, 2; pl. 3, figs 1–2.

Material. One septate whorl fragment (U.2.117) from Bed 3 at Newbridge Quarry; the diameter of the complete whorl was approximately 160 mm. The fragment still shows strong, biplicate ribbing with about 70 primary ribs per whorl.

Remarks. Although the specimen is only a small fragment, the rib density, and the fact that there is no modification of the ribs at a diameter where it would be well marked in *Arisphinctes*, means that the specimen can be assigned quite confidently to *P. cautisnigrae*.

Subgenus ARISPHINCTES Buckman, 1924

Perisphinctes (Arisphinctes) osmingtonensis (Arkell, 1936)

1936 *Perisphinctes (Dichotomosphinctes) osmingtonensis* Arkell, p. 31, pl. 9, figs 1–4.
1947 *Perisphinctes (Arisphinctes) osmingtonensis*; Arkell, p. 369.

Material. One inner whorl fragment (U.3.3) from Bed 4 at Spaunton Moor Quarry.

Measurements. U.3.3: maximum diameter preserved 110 mm; at 110 mm, 0·31, –, 0·48; *c.* 54 ribs at 110 mm.

Description. This non-septate whorl fragment shows the characteristic high whorl side, strong, closely spaced primary ribs, and secondaries arising at rather indistinct furcation points at two-thirds of the whorl height. As in the specimens figured by Arkell (1936), the anterior secondary will commonly continue the line of the primary while the posterior of the pair will branch from it in a backwards direction. Trifurcation is also common, as are constrictions and a simple rib.

Perisphinctes (Arisphinctes?) sp.

Plate 4, figure 2

Material. One mould of a nearly complete body chamber (U.1.110) from a calcareous concretion from Bed 6 at Laysthorpe Quarry.

Measurements. U.1.110: maximum diameter preserved 275 mm; at 270 mm, 0·29, –, 0·48; estimated as having 52 ribs at 210 mm.

Description. The last quarter of a whorl of the septate part of the shell is visible but poorly preserved, with 13 strong, rounded primary ribs. These bifurcate or trifurcate, two or three secondaries per primary being seen indistinctly. At the position of the last septum, the primary ribs become slightly bolder and simple, swelling slightly at the ventro-lateral edge, and then largely fading on the venter. Thirty of these ribs are present in the two-thirds of a whorl of body chamber preserved. The whorl section is flat sided and flat ventered, although the width of the whorl is not known.

Remarks. Even placing this specimen into a subgenus is difficult, especially as the suture is very indistinct. Considering all the macroconch subgenera of *Perisphinctes*, the group of *P. (Arisphinctes) helenae* de Riaz and *P. (A.) vorda* Arkell fits best, having the same change from biplicate to simple ribs of exactly this number and style at the same diameter, and having a similar whorl section.

Subgenus DICHOTOMOSPHINCTES Buckman, 1926

Perisphinctes (Dichotomosphinctes) sp. D

Plate 5, figure 3; Text-figure 4

Material. Two poorly preserved but largely complete specimens, one from Bed 4 at Newbridge Quarry (U.2.119) and one from Bed 3 at Spaunton Moor Quarry (U.3.50).

Measurements. U.3.50: maximum diameter preserved 92 mm; at 90 mm, 0·28, –, 0·49; 51 ribs at 90 mm, 44 at 35 mm.

Description. The better specimen (Pl. 5, fig. 3) consists of a poorly preserved, almost complete, microconch adult *Dichotomosphinctes* of maximum original size of about 95 mm. The primary ribs are strong and wiry, and bifurcate quite regularly at about two-thirds of the whorl height. An unconnected secondary followed by a simple rib is present about every fifth primary. Marked constrictions are not evident. The secondaries run strongly over the venter.

Remarks. This species compares quite closely with *Dichotomosphinctes* sp. B from the Newbridge Beds, having a very similar rib style, but having slightly more ribs to the whorl (Text-fig. 4), and being adult at 95 mm rather than 135 mm as in *D.* sp. B.

Perisphinctes (*Dichotomosphinctes*) sp. E

Plate 5, figure 2; Text-figure 4

Material. Three specimens, one almost complete, from Bed 3 at Spaunton Moor Quarry (U.3.13, U.3.22, U.3.52), and one specimen (M18, a complete, internal mould) from Bed 4 at this locality; six specimens from Bed 4 at Newbridge Quarry (U.2.27, U.2.126, U.2.132, U.2.134, U.2.135 and U.2.137).

Measurements. M18: maximum size preserved 92 mm; at 89 mm, 0·24, –, 0·49; 34 ribs at 92 mm, 32 at 63 mm, 32 at 30 mm. U.3.13: 37 ribs at 95 mm, 33 at 50 mm. U.3.52: *c.* 39 ribs at 75 mm, *c.* 33 at 25 mm.

Description. This distinctive species is one of the most common perisphinctids in the Spaunton Sandstone. It has bold, widely spaced primary ribs and a very gently rising rib curve so that there are never more than 40 ribs per whorl (Text-fig. 4). The primary ribs bifurcate or trifurcate at about two-thirds of the whorl height with, on average, three bifurcations to two trifurcations. The secondary ribs are also bold, and run strongly over the venter. Simple ribs and constrictions are developed close to the aperture. The whorl section is slim, flat-sided, with a rounded venter. Specimen M18 (Pl. 5, fig. 2) is adult, showing uncoiling of the umbilical seam and a closing up of the primary ribs close to the aperture. It is thus adult at 90 mm, though these features are seen at 100 mm in specimen U.3.22.

Remarks. As in *P.* (*Dichotomosphinctes*) sp. C, the comparison is best made with previously described Middle Oxfordian, rather than Upper Oxfordian forms. *P.* (*D.*) *rotoides sensu* Arkell (1938) has a similar number of ribs per whorl at early diameters, but has a steeply rising rib curve (Arkell 1938, text-fig. 23), rather than the flat curve of *P.* (*D.*) sp. E. The latter species is distinguished from *P.* (*D.*) sp. C by its smaller size, being adult at 90–100 mm, rather than at 135 mm. The microconch of *Pseudarisphinctes damoni* (Pl. 6, figs 1, 5) is similarly coarsely ribbed, but *P. damoni* has a distinctive round whorl section, rather than the flat-sided whorl section of *P.* (*D.*) sp. E.

Subgenus PSEUDARISPHINCTES Arkell, 1935

Perisphinctes (*Pseudarisphinctes*) *pachachii* Arkell, 1935

Plate 5, figures 4–5; Plate 8, figure 2a–b; Text-figure 5

1935 *Perisphinctes* (*Biplices*?) *pachachii* Arkell, p. 26, pl. 2, fig. 2.

Material. Eight specimens, six (U.3.26, U.3.35, U.3.49, U.3.54, U.3.57 and U.3.63) from Bed 4 at Spaunton Moor Quarry, one specimen (U.2.122) from Bed 3 at Newbridge Quarry, and one from Bed 5 at Laysthorpe Quarry (U.1.104).

Measurements. U.3.57: maximum diameter preserved 108 mm; at 108 mm, 0·26, –, 0·49; 34 ribs at 109 mm. U.3.35: maximum diameter preserved 204 mm; 20 ribs at 200 mm, 30 at 115 mm. U.3.63: maximum diameter

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EXPLANATION OF PLATE 5

Fig. 1. *Perisphinctes* (*Pseudopomerania*) *dewari* (Arkell); U.3.65; Bed 3; Plasticine squeeze of original natural mould; ×0·48.

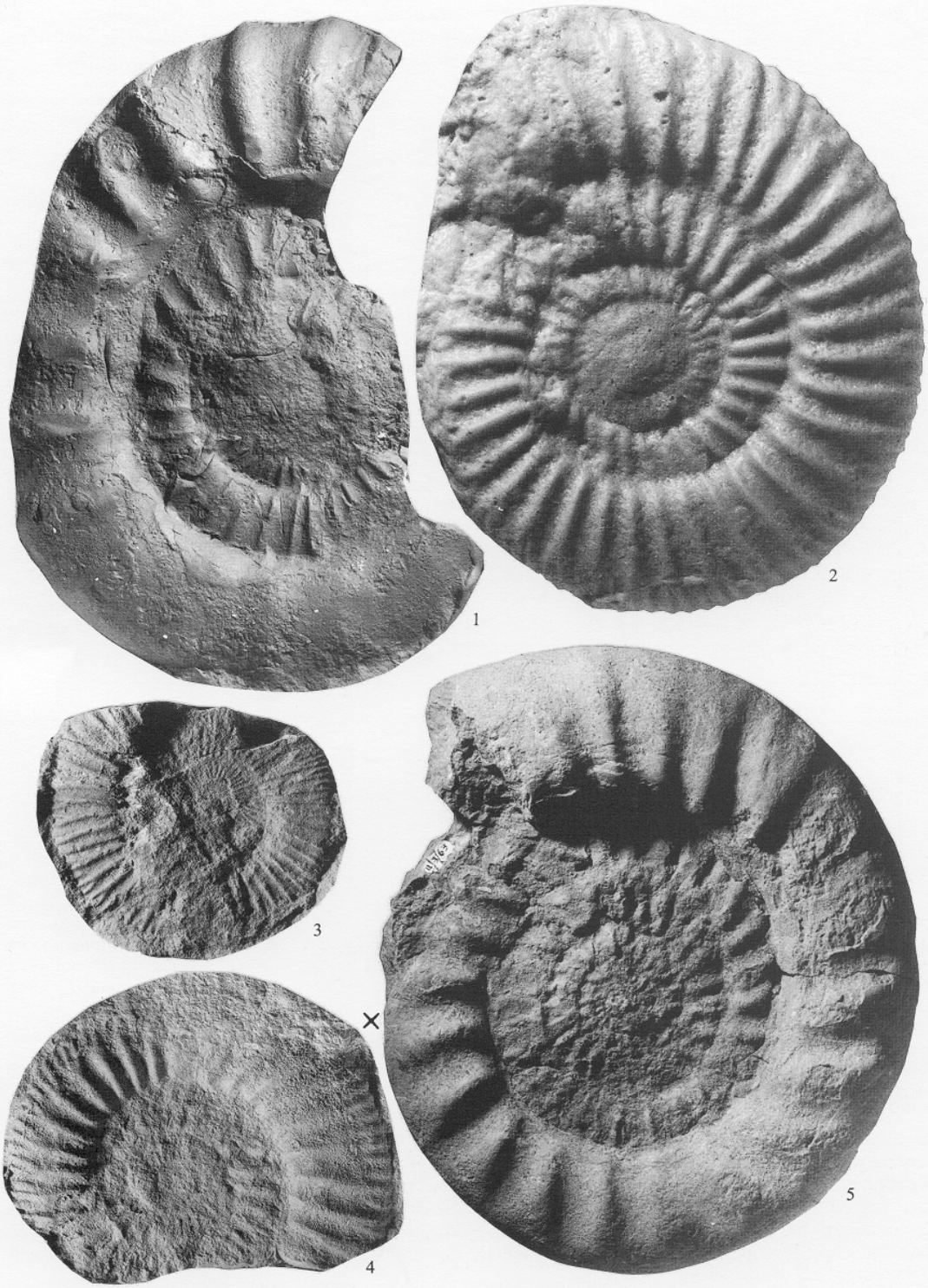
Fig. 2. *Perisphinctes* (*Dichotomosphinctes*) sp. E; M18; Bed 4; Vinamould cast of original natural mould; a substantially complete, microconch adult showing uncoiling of umbilical seam; ×1.

Fig. 3. *Perisphinctes* (*Dichotomosphinctes*) sp. D; U.3.50; Bed 3; ×0·52.

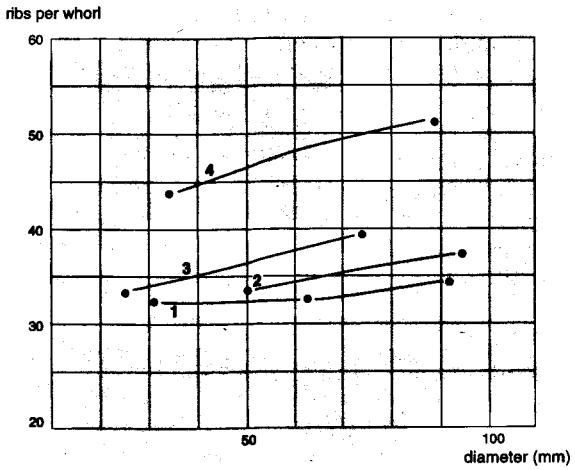
Fig. 4. *Perisphinctes* (*Pseudarisphinctes*) *pachachii* Arkell; U.3.57; Bed 4; Plasticine squeeze of original natural mould; ×0·57.

Fig. 5. *Perisphinctes* (*Pseudarisphinctes*) *pachachii* Arkell; U.3.63; Bed 4; substantially complete macroconch adult; inner whorls crushed, but body chamber largely uncrushed; aperture not preserved; ×0·33.

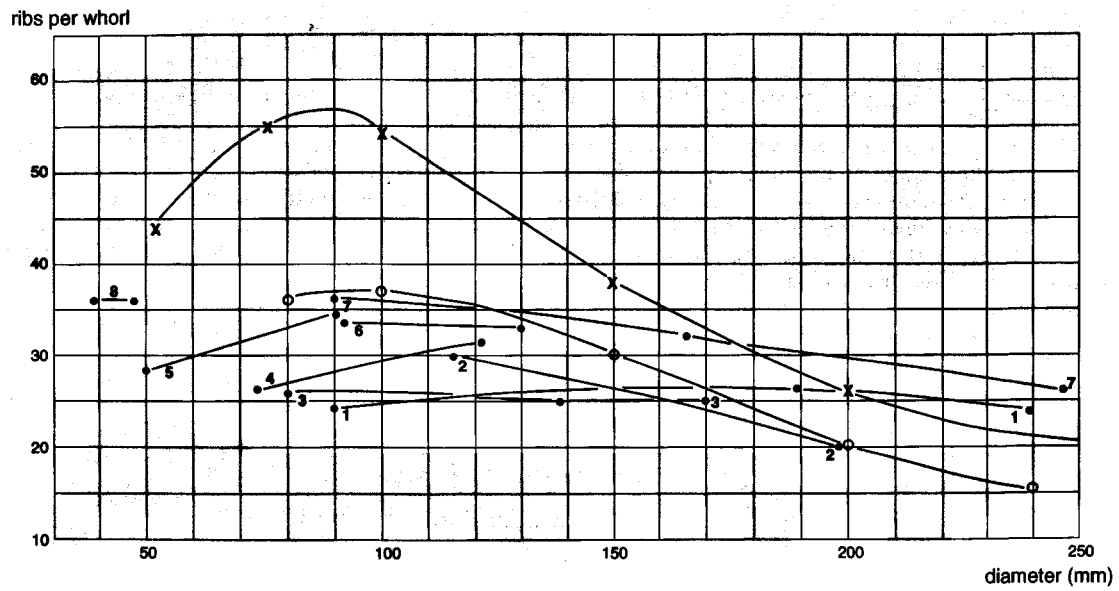
All specimens from the Spaunton Sandstone of Spaunton Moor Quarry, North Yorkshire.



WRIGHT, *Perisphinctes*



TEXT-FIG. 4. Rib curves of *Perisphinctes* (*Dichotomosphinctes*) spp. from the Spaunton Sandstone: 1–3, *P.* (*D.*) sp. E; 4, *P.* (*D.*) sp. D.



TEXT-FIG. 5. Rib curves of *Perisphinctes* (*Pseudarisphinctes*) spp. and *Decipia* spp. from the Spaunton Sandstone and Clavellata Beds: ×, *P.* (*P.*) *durnovariae* (holotype, after Arkell 1935); ○, *P.* (*P.*) *shortlakensis* (holotype, after Arkell (1935)); 1–2, *P.* (*P.*) *pachachii* (U.3.63, U.3.35); 3, *D. decipiens* (U.3.64); 4. *P.* (*P.*) *damoni* (U.3.34); 5, *D. decipiens* (U.2.31); 6, *D. lintonensis* (U.2.34); 7–8, *D. decipiens* (U.3.17, U.3.1).

preserved 300 mm; at 300 mm, 0·28, –, 0·55; 22 ribs at 300 mm, 24 at 240 mm, *c.* 26 at 190 mm. *c.* 24 at 90 mm.

Description. The coiling is quite involute, with the umbilical seam running just above the mid-point of the previous whorl side. A fragment of inner whorl (Pl. 5, fig. 4) shows the typical ribbing, with strong, widely spaced primaries, and three secondaries per primary with true trichotomous separation of the secondaries. The whorl section is rounded. An immature adult (U.3.35) shows the style of ribbing up to 200 mm. At 130 mm, the secondaries have disappeared, and the primary ribs are stouter and more widely spaced. The fully grown adult (Pl. 5, fig. 5) has almost bullate primary ribs on the inner half of the whorl side, the ribs fading completely on the outer half of the whorl.

Remarks. The holotype from the Clavellata Beds of Dorset, the only specimen known previously, consists of septate inner whorls only. A macroconch adult is figured here for the first time (Pl. 5, fig. 5). The rib curve of *P. shortlakensis* Arkell comes quite close to that of *P. pachachii* (Text-fig. 5), but *P. shortlakensis* has a very distinctive quadrate whorl section on the body chamber, with stout ribs running up onto the ventro-lateral edge. *P. durnovariae* Arkell has a very similar style of ribbing on the body chamber, but has more than 20 extra primary ribs per whorl on the inner whorls (Text-fig. 5).

A specimen of *P. pachachii* from the Clavellata Beds is figured here (Pl. 8, fig. 2a–b) as it shows clearly the stage when the secondaries, four per primary, are fading. It shows too the stout, almost perfectly rounded whorl section with whorl breadth equal to whorl height. The specimen is completely septate.

Perisphinctes (Pseudarisphinctes) damoni Arkell, 1935

Plate 6, figures 1, 5; Text-figure 5

1935 *Perisphinctes (Biplices?) damoni* n.sp.; Arkell, p. 25, pl. 1, fig. 3; pl. 6, fig. 2.

Material. Three specimens from Spaunton Moor Quarry, one from Bed 3 (U.3.2) and two from Bed 4 (U.3.12 and U.3.34).

Measurements. U.3.2: maximum diameter preserved 92 mm; at 92 mm, 0·27, –, 0·50; *c.* 29 ribs at 92 mm. U.3.34: maximum diameter preserved 120 mm; at 120 mm, 0·27, –, 0·52; 31 ribs at 120 mm, 26 at 73 mm.

Description. P. damoni has the same style of coiling as *P. pachachii*, with an almost exactly circular whorl section, and the same stout, widely spaced primary ribs, with three secondaries per primary. Prominent constrictions and simple ribs appear on the body chamber, and the species is fully grown at about 120 mm. It is very clearly the microconch of *P. pachachii.* An excellent specimen from the Clavellata Beds (Pl. 6, fig. 1) shows the simple ribs and constrictions characteristic of the last half whorl. The whorl section is slightly narrower than high; the position of the aperture (broken away) is shown by the arrow. Several septae are visible where the test is broken on the reverse of the specimen. Although the last septum is not visible, the body chamber cannot be more than two-thirds of a whorl. The specimen from Bed 4 at Spaunton Moor Quarry (Pl. 6, fig. 5) lacks the marked constrictions and simple ribs of the Dorset specimen, as far as can be seen. The inner whorls, however, are crushed, and the body chamber is preserved only as an internal mould. This gives the ribbing a much less bold appearance.

Subgenus PSEUDOPOMERANIA subgen. nov.

Perisphinctes (Pseudopomerania) dewari Arkell, 1947*b*

Plate 5, figure 1

1947*b* *Decipia (Pomerania) dewari*, Arkell, p. 375, pl. 78, figs 1a–b, 5a–b.

Material. One specimen (U.3.65) from the top of Bed 3 at Spaunton Moor Quarry.

Measurements. U.3.65: maximum diameter preserved 225 mm; at 225 mm, 0·29, –, 0·51; at 170 mm, 0·26, 0·21, 0·45; *c.* 30 ribs at 140 mm, 10 on the last half whorl visible (225 mm).

Description. The specimen was badly damaged during quarrying, and exists only as fragments. However, it was possible to collect a near-complete natural mould, preserved in a calcareous concretion, and thus not crushed. A plasticine squeeze of this is figured as Plate 5, figure 1. When first seen, at a diameter of approximately 60 mm, the primary ribs are straight, slightly prorsiradiate, and moderately dense, of the order of 40 per whorl. At 90 mm, a portion of whorl with secondary ribs is seen. There are approximately two secondaries per primary. The secondaries do not bifurcate regularly from the primaries, and may run down between two primaries if there is not a primary conveniently placed to join.

At about 140 mm, the ribbing fades completely, and for a quarter of a whorl the shell is smooth. This feature marks the early part of the body chamber. The primary ribbing then becomes increasingly strong in the half whorl towards the aperture, where the primaries run right over the venter. The whorl section is rounded-

quadrate. Although the aperture is not preserved in this specimen, the original adult size can be estimated at 230 mm.

Remarks. The specimen shows the key features of *Pseudopomerania*: smooth, unribbed shell at the start of the body chamber, and small adult size of the macroconch. Again, as in the specimen from the Newbridge Beds, the secondary ribbing of the early whorls is of the normal *Perisphinctes* type, and bears no relation to that of *Decipia*. There are 11 quite widely spaced ribs on the last half whorl seen. The holotype of *P. dewari* has 12 at a similar diameter. Faint ribbing over the venter, only loosely connected to the primary ribs, is seen as in the holotype, but is less prominent.

Genus DECIPIA Arkell, 1937*a*

Decipia decipiens (Sowerby, 1821)

Plate 6, figure 3; Plate 7, figures 1–4; Text-figure 5

1821 *Ammonites decipiens* Sowerby, p. 169, pl. 294
1937*a* *Decipia decipiens* (J. Sowerby); Arkell, p. 44, pl. F, figs 1–4
1947*b* *Decipia decipiens* (J. Sowerby); Arkell, p. 370, text-figs 132–133, pl. 78, fig. 7.

Material. Sixteen specimens, six from Bed 3 at Newbridge Quarry (U.2.1, U.2.31, U.2.46, U.2.48–U.2.49 and U.2.124), one from Bed 3 at Spaunton Moor Quarry (U.3.53), and nine from Bed 4 (U.3.1, U.3.15–U.3.17, U.3.25, U.3.27, U.3.55–U.3.56 and U.3.64).

Measurements. U.3.1: maximum diameter preserved 46 mm; at 41 mm, 0·37, –, 0·39; 36 ribs at 46 mm, 36 at 38 mm. U.3.16: maximum diameter preserved 67 mm, showing uncoiling of the umbilical seam, but the aperture broken away; at 63 mm, 0·38, –, 0·36; 26 ribs at 67 mm. U.2.31: maximum diameter 90 mm, showing the strong, simple ribs which develop close to the aperture; at 84 mm, 0·31, –, 0·44; approx. 34 ribs at 90 mm, 28 at 48 mm. U.3.17: maximum diameter *c.* 255 mm, with aperture visible; at 70 mm, 0·34, 0·20, 0·38; at 125 mm, 0·31, –, 0·47; at 255 mm, 0·24, –, 0·55; *c.* 26 ribs at 250 mm, *c.* 32 at 165 mm, *c.* 36 at 90 mm. U.3.64: maximum diameter preserved 170 mm; at 170 mm, 0·29, –, 0·50; 25 ribs at 170 mm, 25 at 138 mm, 26 at 93 mm; 26 at 80 mm.

Description. The coiling of the inner whorls (Pl. 7, fig. 4) is noticeably involute, with the umbilical seam lying at approximately two-thirds of the previous whorl height. The primary ribs are quite strong, but narrow and rod-like, with wide spaces in between them. They fade just above the mid-point of the whorl side. When the secondaries are first seen, at 24 mm, each primary passes rather indistinctly into two secondaries, with an intercalatory in between. Faint lateral constrictions, which become prominent on the venter, are common. By 43 mm, the primaries broaden and flatten at the mid-point of the whorl side, and the secondaries arise from them in groups or sheaves of three or four.

In the microconch (Pl. 6, fig. 3; Pl. 7, figs 2–3), this style of ribbing continues onto the body chamber, but becomes increasingly interrupted towards the aperture by constrictions and strong, simple ribs. Separating the

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EXPLANATION OF PLATE 6

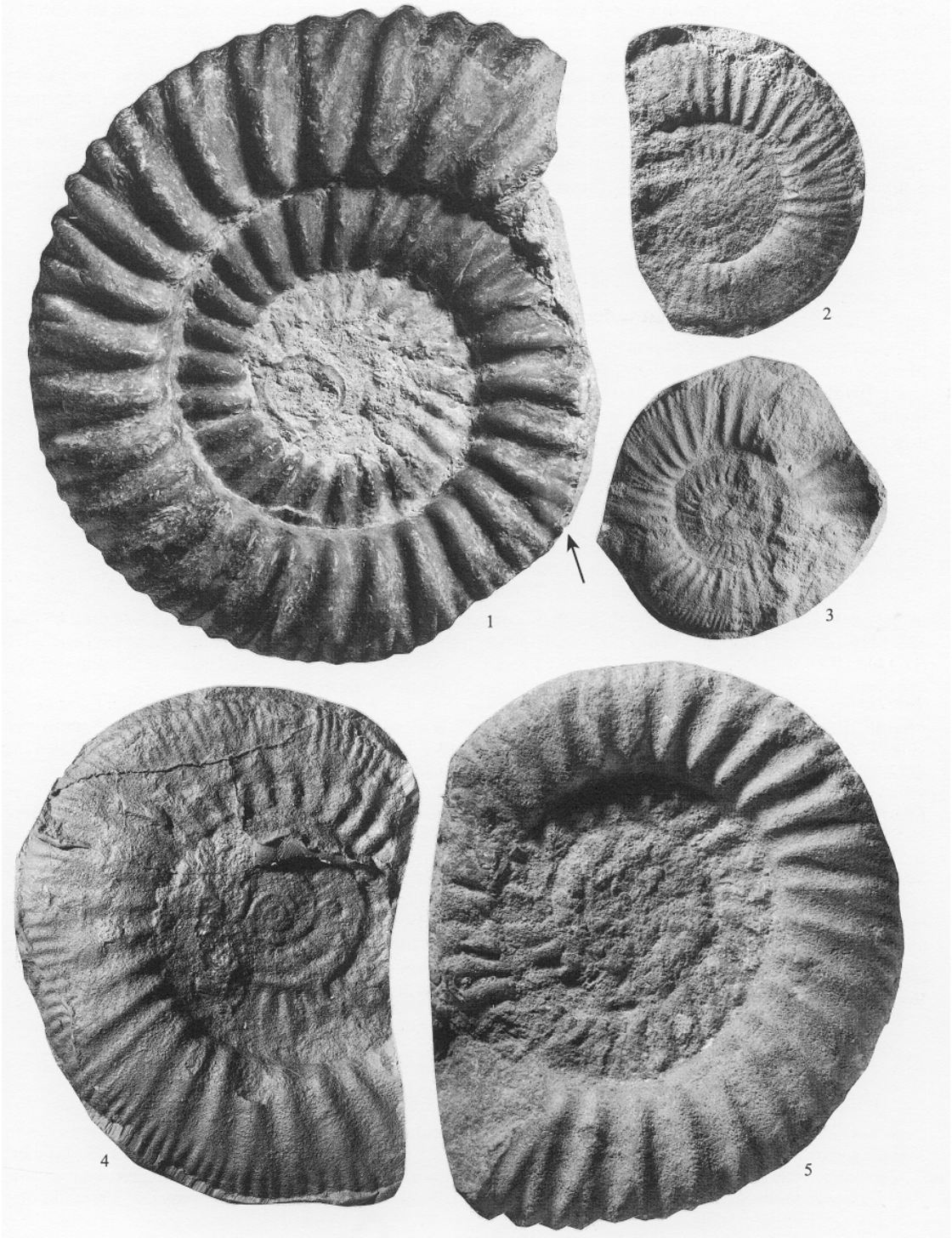
Fig. 1. *Perisphinctes* (*Pseudarisphinctes*) *damoni* Arkell; D.C.45; Chief Shell Beds, Clavellata Beds; Black Head, Dorset; largely complete microconch adult with test preserved; position of flared aperture, visible on the reverse of specimen, is arrowed; × 1.

Fig. 2. *Decipia lintonensis* Arkell; U.2.32; Spaunton Sandstone; Newbridge Quarry, Bed 3; probable microconch adult with half a whorl of body chamber; × 0·5.

Fig. 3. *Decipia decipiens* (J. Sowerby); U.2.31; Spaunton Sandstone; Newbridge Quarry, Bed 3, probably microconch adult, inner whorls crushed, but body chamber preserved in three dimensions; × 0·52.

Fig. 4. *Decipia lintonensis* Arkell; U.3.24; Spaunton Sandstone; Spaunton Moor Quarry, Bed 4; Plasticine squeeze of original natural mould; × 0·7.

Fig. 5. *Perisphinctes* (*Pseudarisphinctes*) *damoni* Arkell; U.3.34; Spaunton Sandstone, Spaunton Moor Quarry, Bed 4; largely complete, microconch adult, inner whorls crushed, but body chamber preserved in three dimensions; × 0·82.



WRIGHT, *Perisphinctes, Decipia*

simple ribs, two or three primaries continue the pattern of becoming broad and low, and passing into sheaves of four secondaries. Typical rib curves are given in Text-figure 5. These are very flat, rarely rising above 35 ribs per whorl.

In the macroconch (Pl. 7, fig. 1), the same rib style, consisting of rod-like primary ribs, fading and passing indistinctly into groups of four secondary ribs, continues until septation ceases. The body chamber has widely spaced primary ribs which fade on the outer whorl side. The venter is smooth. Unusually for the Upper Calcareous Grit, the shell of this specimen became filled with calcareous matrix before compaction, showing that its compressed nature is an original feature. The holotype, a macroconch figured by Arkell (1937, pl. F), is much less compressed than the specimen figured in Plate 7, figure 1, and is more closely matched in this respect by Plate 7, figure 3. This specimen also shows the clear linking of primary and secondary ribs which is seen in the holotype, but hard to see in the other specimens figured.

Remarks. The name *Decipia decipiens* was used by Arkell (1947) for both microconchs and macroconchs, and this usage is continued here pending a resolution of the question of whether palaeontologists should continue to use different subgeneric names for the macroconch and microconch of the same species (see discussion on p. 437). Surlyk *et al.* (1973) pointed out that most of the Yorkshire specimens differ somewhat in rib style and whorl breadth from the holotype, which came from the drift of Highgate Hill, London. As the range of variation in the Yorkshire material includes the rib style and whorl breadth of the holotype, it is not considered necessary to employ a new specific name here.

Decipia lintonensis Arkell, 1937*a*

Plate 6, figures 2, 4; Plate 7, figure 5; Plate 8, figure 1; Text-figure 5

1937*a* *Decipia lintonensis* Arkell, p. 45, pl. 12, figs 1–2
1947*b* *Decipia lintonensis* Arkell; Arkell, p. 373, pl. 78, fig. 6
1973 *Decipia* sp. nov. aff. *decipiens* (J. Sowerby); Surlyk *et al.*, pl. 1, figs 1–2.

Material. Fourteen specimens, five from Bed 3 at Newbridge Quarry (U.2.32, U.2.37, U.2.44, U.2.47 and U.2.121), one from Bed 3 at Spaunton Moor Quarry (U.3.21), seven from Bed 4 at Spaunton Moor Quarry (U.3.4, U.3.24, U.3.28–U.3.29, U.3.47, U.3.51 and U.3.58), and one (U.8.1) from Tilehouse Cutting (SE 678 850) near Kirkby Moorside, from a level high in the Spaunton Sandstone.

Measurements. U.2.32: Maximum diameter preserved 92 mm, with two-thirds of a whorl of body chamber; at 92 mm, 0·27, –, 0·50; *c.* 34 ribs at 92 mm, *c.* 30 at 60 mm. U.3.24: maximum diameter preserved 128 mm; natural mould – no sutures visible; at 115 mm; 0·30, –, 0·48; 33 ribs at 128 mm, 34 at 87 mm.

Description. D. lintonensis has much bolder ribbing than *D. decipiens*, stout primaries each passing into three or four secondaries (Pl. 6, fig. 4). The primaries do not fade at the mid-point of the whorl side but swell, and the secondaries are grouped into sheaves or bundles of three or four. A fragment from the body chamber of a larger individual (Pl. 7, fig. 5) suggests that this rib style may continue almost up to the aperture of the macroconch. Only one microconch is known (Pl. 6, fig. 2). The body chamber has similar stout primary ribs as in the macroconch figured, but there are only three secondaries per primary. The ribbing becomes bolder, with constrictions, close to the aperture. The rib curve matches that of *D. decipiens* closely (Text-fig. 5).

The figured specimen (Pl. 8, fig. 1) from the Clavellata Beds is an immature macroconch. It shows, close to the aperture, a constriction followed by a ?damaged apertural margin (arrowed), and then, very thinly developed, the beginnings of new shell growth.

EXPLANATION OF PLATE 7

Figs 1–4. *Decipia decipiens* (J. Sowerby). 1, U.3.17; largely complete, macroconch adult, fully preserved in three dimensions, with aperture present; ×0·5. 2, U.3.16; microconch adult showing uncoiling of umbilical seam; inner whorls crushed; ×1. 3, U.3.15; non-septate whorl fragment; ×1. 4, U.3.1; inner whorls; ×1.
Fig. 5. *Decipia lintonensis* Arkell; U.3.4; body chamber fragment of a macroconch, showing distinctive ribbing; ×1.
All specimens from the Spaunton Sandstone (Bed 4) of Spaunton Moor Quarry, North Yorkshire.

WRIGHT, *Decipia*

Remarks. Although *Pseudarisphinctes pachachii*, *P. damoni*, *Decipia decipiens* and *D. lintonensis* have been treated here as separate taxa, it is apparent from the very close grouping of rib curves in Text-figure 5 that all are closely related. Intermediate forms linking these 'species' are common. It is quite impossible, for instance, to separate *D. decipiens* and *D. lintonensis* on a statistical analysis of the number of secondary ribs per primary. It seems likely that these taxa represent one continuously variable perisphinctid species.

Genus MICROBIPLICES Arkell, 1936

Microbiplices? sp.

Plate 8, figures 3–4

1974 *Microbiplices* sp.; Brochwicz-Lewinski and Rozak, pl. 1, fig. 1.
1991 *Microbiplices* sp.; Malinowska, pl. 1, fig. 26.

Material. Five fragments from Bed 4 at Newbridge Quarry (U.2.34, U.2.60, U.2.73–U.2.74 and U.2.133), and two crushed fragments from Bed 5 (Snape Sandstone) at Spaunton Moor Quarry (U.3.5 and U.3.7).

Measurements. U.3.5: maximum diameter preserved approx. 100 mm; 11 ribs on the third of a whorl present (equivalent to 35 per whorl at 100 mm).

Description. The specimens are fragments of microconch body chambers, adult at 100 mm. The primary ribs are strong and widely spaced, and bifurcate just above the mid-point of the whorl side, with occasional simple ribs and faint constrictions which become more prominent towards the aperture. The secondary ribs run strongly over the venter. The whorl section is somewhat quadrate.

Remarks. Fragmentary remains of this interesting microconch form are common in the highest part of the Cautisnigrae Subzone. Its assignment to *Microbiplices* must be tentative due to its large size. Typical *Microbiplices* from the Pseudocordata Zone are adult at 38–45 mm (Dorn 1930, pl. 6, fig. 4; pl. 12, fig. 1; pl. 13, fig. 5; Arkell 1947*b*, pl. 76, figs 6–7; Enay 1966, pl. 40, fig. 4; Wright 1986, fig. 6H). However, larger species of *Microbiplices*, up to 60 mm in diameter, have been recorded from older beds (i.e. the specimens cited in the synonomy). The Yorkshire specimens may thus mark the first appearance of *Microbiplices*, this larger form subsequently evolving into the diminutive forms of the Pseudocordata Zone.

ZONES AND SUBZONES OF THE UPPER OXFORDIAN IN THE BOREAL AND SUB-BOREAL PROVINCES

The position of the three members of the Upper Calcareous Grit Formation within the two alternative subzonal schemes used for Late Oxfordian strata in Britain is shown in Text-figure 6. Both schemes are relevant to North Yorkshire because the *Amoeboceras* faunas of the Boreal

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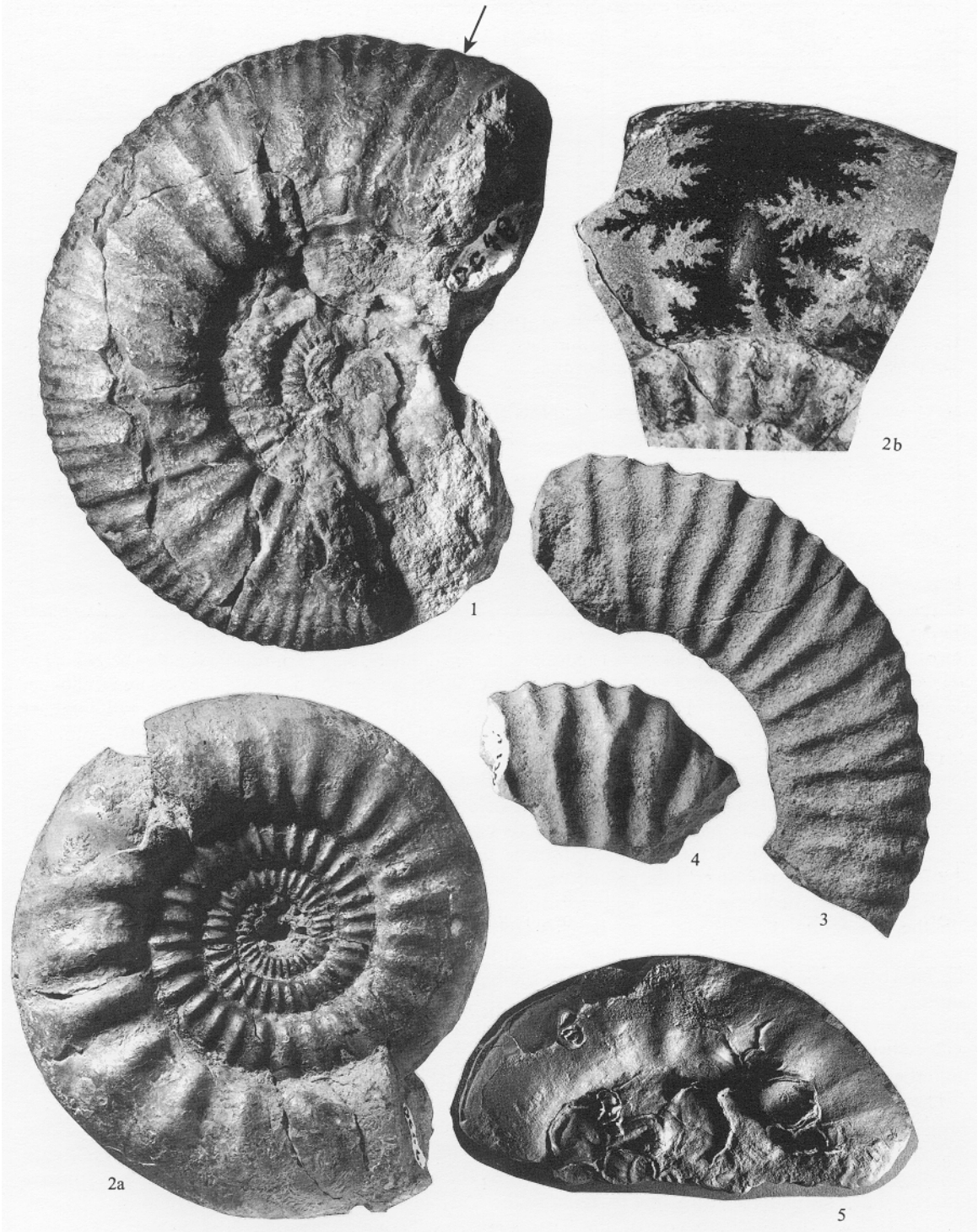
EXPLANATION OF PLATE 8

Fig. 1. *Decipia lintonensis* Arkell; D.C.48; Chief Shell Beds, Clavellata Beds; Black Head, Dorset; immature macroconch; note aperture (arrowed), followed by thinly developed growth of new shell material; ×0·75.

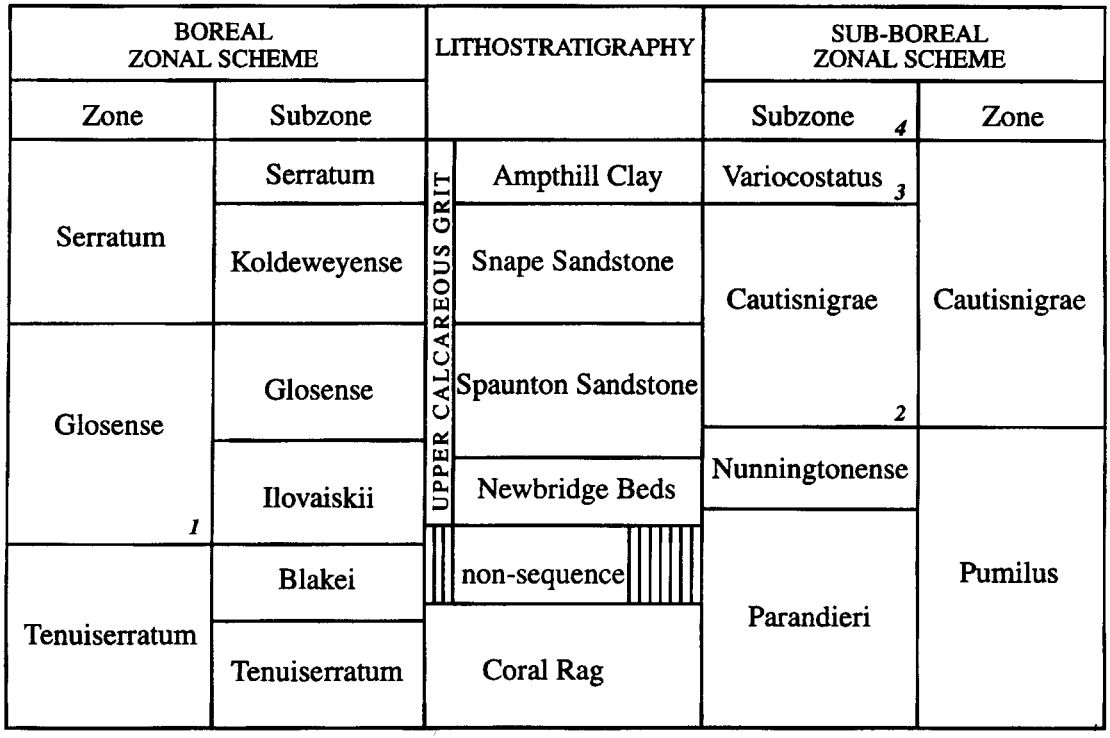
Figs 2a–b. *Perisphinctes* (*Pseudarisphinctes*) *pachachii* Arkell; D.C.46; Chief Shell Beds, Clavellata Beds, Black Head, Dorset; 2a, septate inner whorls of macroconch adult; ×0·48. 2b, reverse side of specimen showing simple suture, with short, stocky lobes; ×0·9. Specimen donated by Dr C. King.

Figs 3–4. *Microbiplices*? sp.; 3, U.3.5; Snape Sandstone; Spaunton Moor Quarry, Bed 5; fragment of body chamber, specimen markedly flattened; ×1. 4, U.2.133; Spaunton Sandstone, Newbridge Quarry, Bed 4; fragment of body chamber; ×1.

Fig. 5. *Decipia ravenswykensis* sp. nov.; U.5.10; Newbridge Beds, Ravenswyke Quarry, Bed 2; Plasticine squeeze of a natural mould of a heavily encrusted macroconch showing development of large, swollen ribs on later part of body chamber; ×0·31.



WRIGHT, *Decipia*, *Perisphinctes*, *Microbiplices*?



TEXT-FIG. 6. The position of the members of the Upper Calcareous Grit Formation of Yorkshire within the Boreal and Sub-Boreal zonal schemes. *1–4*: positions of the Middle–Upper Oxfordian boundary according to various authors; 1. Boreal Province (Sykes and Callomon 1979); 2. Malinowska 1991; 3. Sykes and Callomon (1979) – between the Sub-Mediterranean Transversarium and Bifurcatus zones, which correlates with this level in the Sub-Boreal zonal scheme; 4. Cariou *et al.* (1991), and most continental authors.

Province and the perisphinctid faunas of the Sub-Boreal Province overlap here in their occurrence; individual beds usually contain a predominance of one group or the other, but beds where a boreal fauna predominates may pass laterally into beds where a sub-boreal fauna predominates. Study of the North Yorkshire Late Oxfordian ammonite faunas is thus of considerable importance in the resolution of problems of correlation between the two zonal schemes.

Definitions of the Boreal zones and subzones were given by Sykes and Callomon (1979). In this scheme, the fauna of the Newbridge Beds is characteristic of the Ilovaiskii Subzone. The *Decipia ravenswykensis*, *Amoeboceras nunningtonense* and *A. transitorium* assemblage, so characteristic of the Newbridge Beds in Yorkshire, occurs in the highest part of that subzone in the type section at Staffin, Isle of Skye (author's collection). The Glosense Subzone is also defined at Staffin, and a good fauna of *Amoeboceras* characteristic of this subzone occurs in the highest Spaunton Sandstone at Newbridge Quarry. However, the intervening beds contain predominantly perisphinctids, and thus the precise position of the Glosense/Ilovaiskii subzonal boundary is not known in Yorkshire.

The Nunningtonense Subzone was originally proposed as a subzone of the Sub-Mediterranean Transversarium Zone by Wright (1972), but was transferred into a new Sub-Boreal Pumilus Zone by Sykes and Callomon (1979). It is characterized by the occurrence of *Amoeboceras nunningtonense* together with *Decipia ravenswykensis*, as typified by the fauna of the Newbridge Beds at Laysthorpe Quarry. The Cautisnigrae Subzone (originally the Variocostatus Zone of Arkell (1936, p. 62)) was regarded as the highest subzone of the Transversarium Zone by Wright (1972), but Sykes and Callomon (1979) transferred it into a new Sub-Boreal Cautisnigrae Zone. Its base is marked by the incoming of *Decipia decipiens* along with the other perisphinctids, particularly *D. lintonensis*

and *Perisphinctes* (*Pseudarisphinctes*) spp., which typify the Clavellata Beds in Dorset. The *P.* (*Perisphinctes*) spp. and *P.* (*Arisphinctes*) spp. of the Clavellata Beds appear to range through both the Nunningtonense and Cautisnigrae subzones. In Yorkshire, the typical Cautisnigrae Subzone fauna occurs in the Spaunton Sandstone at both Spaunton and Newbridge quarries. The junction of the Nunningtonense and Cautisnigrae subzones must lie at or just above the base of the Spaunton Sandstone.

RELATIONSHIP WITH AMMONITE FAUNAS ELSEWHERE IN THE BOREAL AND SUB-BOREAL PROVINCES

Skye and the Boreal regions

Sykes and Callomon (1979) noted that the ammonite taxa recorded from the Newbridge Beds and Spaunton Sandstone occur in Bed 31 of the Flodigarry Shale at Staffin, Isle of Skye. Although the correlation is largely based on *Amoeboceras*, *Decipia ravenswykensis* occurs 2 m above the base of the Flodigarry Shale (author's collection), and Sykes and Callomon's record of *Perisphinctes* sp. suggests that a more precise correlation of the perisphinctid faunas may be possible. *D. ravenswykensis* has also been found in the Bernbjerg Formation of Cardiocerasdal, north-east Greenland, in beds underlying those with *A. glosense* (*Decipia* cf. *lintonensis* of Sykes and Surlyk, 1976). *Decipia lintonensis* occurs in the Harleelv Formation, Falsterselv, east Greenland (*Decipia* sp. nov. aff. *decipiens* of Surlyk *et al.* 1973).

'*The Ampthill Clay region*'

In Cambridgeshire, the Ampthill Clay is very poorly exposed, and the exact stratigraphical relationships between the various faunas which have been collected from clay pits and temporary exposures have presented problems to many workers. The problems were set out by Arkell (1937*b*, pp. 70–79, 1947*b*, pp. 354–356), and discussed by Torrens and Callomon (1968, pp. 293–296), Gallois and Cox (1977, pp. 278–279), Sykes and Callomon (1979, pp. 852–853) and Wright (1980, pp. 71–72). The key to an understanding of this area lies in determining the age of the Long Stanton fauna (Arkell 1937*b*, pl. 3). In Wright (1980), I placed this fauna with that of the Newbridge Beds at the base of the Ilovaiskii Subzone, following Sykes and Callomon (1979). However, the *Decipia* of the Long Stanton fauna (Arkell 1937*b*, pl. 3, fig. 2) is close to *D. decipiens*, and is not *D. ravenswykensis* which characterizes the Newbridge Beds. This suggests that the equivalent of the Long Stanton fauna should be sought in the Spaunton Sandstone where *D. decipiens* is abundant. In fact, the *Amoeboceras* fauna of Long Stanton, particularly *A. newbridgense*, occurs near the top of the Spaunton Sandstone at Newbridge Quarry, in the Glosense Subzone, and I would now place the Long Stanton fauna at that level. The *Amoeboceras* which occur in the Ilovaiskii Subzone in North Yorkshire (Laysthorpe Quarry beds 2 to 4) have a very distinctive rib style, with simple ribs alternating with bifurcating ribs, and in some cases several simple ribs together. Such a style of ribbing does not occur in *Amoeboceras* of the Glosense Subzone.

Ammonites occurring in slightly older beds in Fenland help to confirm this new age assignment for the Long Stanton fauna. Both Arkell (1947) and Gallois and Cox (1977) believed that beneath that fauna came an assemblage of *Decipia* and *Pseudarisphinctes* known as the Knapwell fauna (Hancock 1954). With its *P. pachachii*, *D. decipiens* and *D. lintonensis*, it is very similar to the fauna of the Spaunton Sandstone of Spaunton Moor Quarry (Beds 3 and 4) and Newbridge Quarry (Bed 3).

Since it is now clear that the Knapwell and Long Stanton faunas both belong to the Glosense Subzone, the junction between the Tenuiserratum and Glosense Zones (and thus the Middle/Upper Oxfordian junction) must be drawn much lower in figure 2 of Gallois and Cox (1977). Several metres of beds beneath those containing the Knapwell fauna are probably equivalent to the Nunningtonense Subzone with its *Decipia ravenswykensis*. The base of the Glosense Zone should therefore probably be drawn between Cox and Gallois' beds AC10 and AC11, or at the very highest between AC11 and AC12.

The Dorset coast

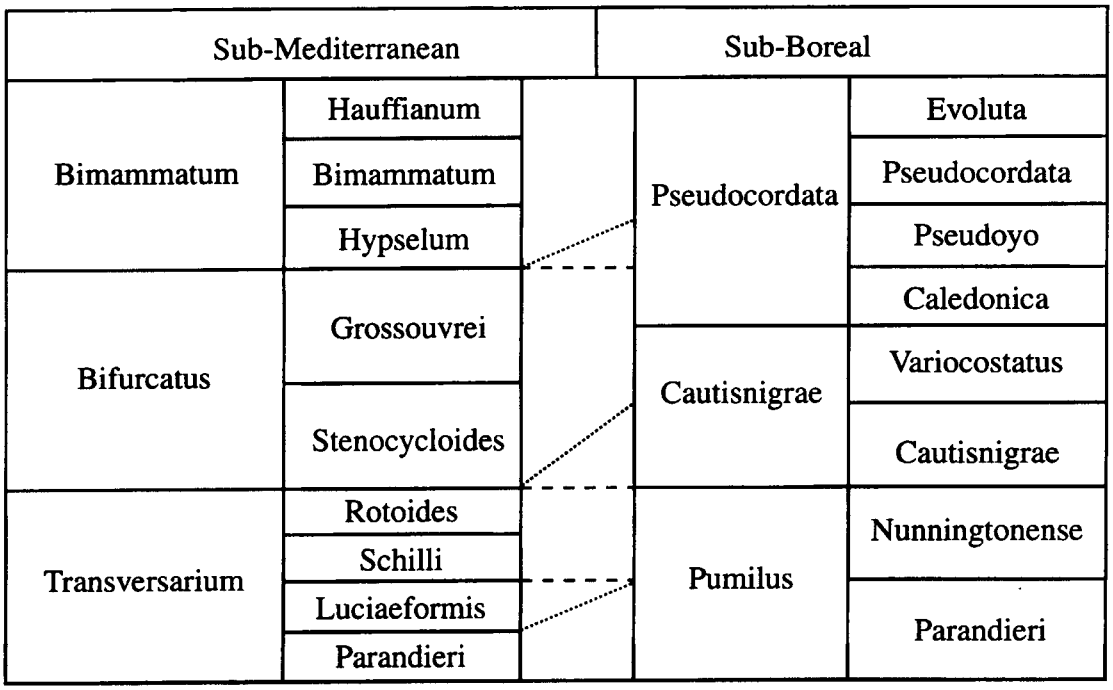
Wright (1986) has shown that the Nunningtonense Subzone is absent on the Dorset coast due to a non-sequence at the base of the Clavellata Beds. This formation yields the type Cautisnigrae Subzone fauna and, with its *Perisphinctes s.s.*, *Arisphinctes*, *Pseudarisphinctes* and *Decipia*, contains almost the exact equivalent of the fauna of the Spaunton Sandstone at Spaunton Moor Quarry.

Northern France

There is little to add to the summaries of Arkell (1937*a*, pp. 52–56 and 1956, pp. 42–43, 46), although Rioult *et al.* (1991) have refined the Oxfordian stratigraphy of the Normandy area. They noted that the highest Middle Oxfordian sediments, the Calcaire de Blangy, comprise whitish, calcareous, lagoonal muds belonging to the Blakei Subzone. There is then a hiatus, as in south Dorset, with the overlying Calcaire Gresieux de Henequeville resting on an important erosion surface. The lower Calcaire Gresieux may correlate with the Spaunton Sandstone and Clavellata Beds, but no ammonites have been recorded from it. The highest Calcaire Gresieux extends up into the Koldeweyense Subzone.

SUB-BOREAL AND SUB-MEDITERRANEAN ZONAL SCHEMES FOR THE OXFORDIAN

A considerable amount of research has been completed in recent years by workers in continental Europe on Mid and Late Oxfordian ammonites, and this has resulted in a radical re-appraisal of the sequences of faunas in the Sub-Mediterranean Province and their correlation with those of the British Late Oxfordian. The new, definitive, zonal scheme set out by Cariou *et al.* (1991) and Atrops *et al.* (1993) is shown in Text-figure 7. The Bifurcatus Zone has long been regarded as the equivalent



TEXT-FIG. 7. Comparison of the two alternative methods of correlation of the Sub-Boreal and Sub-Mediterranean Provinces currently proposed. Dashed line (Sykes and Callomon 1979; Malinowska 1990). Dotted line (Brochwicz-Lewinski 1980*a*, 1980*b*; Cariou *et al.* 1991; Atrops *et al.* 1993; and this work).

of the Sub-Boreal Cautisnigrae Subzone (Enay, 1966; Wright, 1972; Sykes and Callomon, 1979). However, Brochwicz-Lewinski (1980*a*, 1980*b*) pointed out that the rib curve of the innermost whorls of the microconch group of *P.* (*Dichotomoceras*) *bifurcatus* (Quenstedt) shows a characteristic 'U' shape, with dense initial ribbing followed by a trough at about 40 mm diameter, and then an increase in the number of ribs per whorl. Such a 'U' shape must inevitably be present in the rib curve of the equivalent *Perisphinctes s.s.* macroconch, and indeed it is present in *P.* (*P.*) *variocostatus* (Buckland) and its allies (Arkell 1947*b*, text-fig. 127). It is not present in the *P. cautisnigrae* group. Although few of the Cautisnigrae Subzone specimens figured by Arkell (1935, 1936, 1937*a*) can be traced to small enough diameters to demonstrate this, a number of specimens in the author's collection from both Yorkshire and Dorset demonstrate that this feature is not present in Nunningtonense and Cautisnigrae Subzone perisphinctids from Britain. This suggests that the Cautisnigrae Subzone correlates with the upper part of the Transversarium Zone, in which *Perisphinctes* without 'U'-shaped rib curves are common. Study of the rare *Amoeboceras* records from Switzerland (Atrops *et al.* 1993) suggests that, at the very latest, the Schilli Subzone correlates with the Cautisnigrae Subzone.

RELATIONSHIP WITH AMMONITE FAUNAS IN THE SUB-MEDITERRANEAN PROVINCE

The ammonite faunas of the Sub-Mediterranean Province were dominated in the early Late Oxfordian by such Tethyan genera as *Gregoryceras*, *Larcheria*, *Neomorphoceras* and *Epipeltoceras* which have never been found in Britain. *Perisphinctes* was common too, however, and occasional Tethyan *Perisphinctes* migrated northwards into the Sub-Boreal Province. In addition, *Amoeboceras* periodically migrated southwards as far as the Alpes Maritime. As a result, the two provinces now have a number of records in common, and these are reviewed below.

Southern side of the Paris Basin

On the southern side of the Paris Basin, extending south-west to the Aquitaine Basin, much work has been done on the sedimentology of the Oxfordian, and some new stratigraphical information has appeared. Cariou (1966*a*, 1966*b*, 1972) has published descriptions of many very fossiliferous Upper Oxfordian sections in the Poitiers region but, unfortunately, none of the material collected has been figured, and the work was undertaken on the erroneous assumption that the Bifurcatus Zone correlated with the Cautisnigrae Subzone. Cariou's records of *P. cautisnigrae* and its allies in the Bifurcatus Zone must be suspect. *Perisphinctes s.s.* does not occur in the beds underlying those containing the Bifurcatus Zone fauna, but the abundance of perisphinctid subgenera that do occur here may have some elements in common with those of the Clavellata Beds. One would require the fauna to be figured to establish this. Delance *et al.* (1982) described a section at Pont-St-Ours in which the beds equivalent to those in Yorkshire are thin (0·35 m), but do yield *P.* aff. *elizabethae* which occurs in the Nunningtonense Subzone.

The Jura

Several species of *Perisphinctes* found commonly in Yorkshire and Dorset have been recorded from the Jura by Enay (1966); these were collected from the Couches du Geissberg, beds which also contain *P.* (*Dichotomoceras*) *bifurcatus*, and are thus much too young for specific identity with the English forms to be likely. Of the specimens figured by Enay (1966), a partial body chamber (pl. 13, fig. 2) identified at *P. cautisnigrae* is not complete enough for specific identification, while the well preserved inner whorls (pl. 13, fig. 3) have 20 ribs per whorl less than Arkell's holotype. A complete specimen identified as *P. uptonensis* (pl. 15, fig. 2) has nearly twice as many ribs on the body chamber as Arkell's holotype. The inner whorls of a perisphinctid identified as *P. boweni* Arkell (pl. 15, fig. 4) have the coarse, bold rib style, with bifurcation points visible in the umbilical area, characteristic of *P.* (*Dichotomoceras*) *crassus* Enay; this feature has never been found in

perisphinctids of the Cautisnigrae Subzone in England. The species which the areas do have in common is *P.* (*Dichotomosphinctes*) *elizabethae*, and needless to say, this occurs well below the Couches du Geissberg, in the Calcaires Hydraulique. The overlying Banc Limite already yields *P.* (*Dichotomoceras*) *bifurcatoides* Enay and *P. variocostatus*, indicators of a post-Cautisnigrae Subzone fauna.

Alpes Maritime

Dardeau and Marchand (1981) figured an *Amoeboceras*, identified as *A. newbridgense*, from beds yielding numerous *P. bifurcatus*. However, as was demonstrated above, the occurrence of such a typical Cautisnigrae Subzone ammonite in the Bifurcatus Zone is very unlikely. The specimen bears a close resemblance to forms of *Amoeboceras rosenkrantzi* Spath with rursiradiate secondary ribs (Sykes and Callomon 1979, pl. 119, fig. 10; pl. 120, fig. 5). Such a correlation of the latest Bifurcatus Zone with the early Rosenkrantzi Zone (early to mid Pseudocordata Zone) is just possible, though the major part of the Pseudocordata Zone correlates with the Bimammatum Zone (Text-fig. 7).

Southern Germany and northern Switzerland

The Oxfordian of this classic area, which includes the important Couches de Birmensdorf fauna, has been the subject of detailed study by R. A. Gygi and colleagues (Gygi 1966, 1977, 1990). A comprehensive ammonite list is given in Gygi (1977). Unfortunately, *Perisphinctes* occurs only rarely in the Transversarium Zone in which the equivalents of the Newbridge Beds and Spaunton Sandstone faunas are to be sought. *P.* (*Dichotomosphinctes*) *elizabethae* is recorded, but there are no records of *Perisphinctes s.s.* Exposures of these higher beds can be very disappointing for the ammonite collector, a 70 m section in Upper Oxfordian limestones and shales at Péry, northern Switzerland having yielded only three specimens (Gygi 1990). Atrops *et al.* (1993) recorded *Amoeboceras* aff. *glosense* from quarries at Hoelderbank and at Oberehrendigen, in both cases from beds with and just below occurrences of *Larcheria schilli* (Oppel).

The Spanish Cordillera

Melendez (1978*a*, 1978*b*), Goy *et al.* (1979) and Melendez and Fontana (1993) have described a number of fossiliferous sections of limestones and shales containing a succession of *Dichotomosphinctes* and *Larcheria* faunas. These have been used to establish four new subzones of the Transversarium Zone. Apart from the ubiquitous *P.* (*D.*) *elizabethae*, there is little to enable a close correlation with the English succession.

Poland

Many ammonites of Mid to Late Oxfordian age have been collected from the classic Oxfordian limestone outcrop in the area south-east of Czestochowa. In a meticulous study, Brochwicz-Lewinski (1976*a*, 1976*b*, 1980*a*, 1980*b*) and Rozak and Brochwicz-Lewinski (1978) have produced a revised correlation of these complex exposures, which yield a fauna of mixed Sub-Boreal and Sub-Mediterranean aspects, and thus are of great importance in the correlation of the two provinces. Significantly, careful collecting has shown that *P. cautisnigrae* and *P. martelli* (Oppel) (Cautisnigrae Subzone) occur below *P. variocostatus* and *P. panthei* Enay (Variocostatus Subzone).

Numerous *Ringsteadia* spp. have been collected from the Bimammatum Zone here, enabling a reasonable correlation of the Bimammatum and Pseudocordata zones. Occasional layers crowded with *Amoeboceras* suggest that a tentative correlation with the Boreal zonal scheme is possible, and this has been confirmed by Atrops *et al.* (1993). Numerous Rosenkranti Zone *Amoeboceras* have been recorded from the lowest Bimammatum Zone (Hypselum Subzone).

In the Holy Cross Mountains area near Kielce in south-west Poland, Matyja (1977) recorded numerous Oxfordian ammonites. He noted that the Morawice Limestone, with *P.* (*D.*) *elizabethae*, *P.* (*D.*) *wartae* Bukowski and *P.* (*P.*) *martelli* (Pumilus Zone), is succeeded by similar limestones

with *P.* (*Dichotomoceras*) *bifurcatus* and *P.* (*P.*) *variocostatus* (Bifurcatus Zone). According to the original criteria of Arkell (1936, 1945), there is no definite Cautisnigrae Subzone fauna although Brochwicz-Lewinski (1980*a*, 1980*b*) would regard *P. wartae* and *P. martelli* as indicative of that Subzone.

Upper Oxfordian beds underlie large parts of central and northern Poland, and much information has been obtained from boreholes (Malinowska 1991). An abundant ammonite fauna of a substantially Boreal aspect, with some 30 species of *Amoeboceras*, has been recognized. However, the attribution of these species to those of the standard Boreal sequence described by Sykes and Callomon (1979) has proved difficult, many new species being present. Malinowska (1991) also recorded several specimens of *P. bifurcatus* from beds that are assigned to the Glosense Zone. The presence of *P. bifurcatus* at this level is surprising, and does not fit with the records of *P. bifurcatus* from other localities. However, the specimens in question have come from cores in which they were not in immediate association with known Glosense Zone *Amoeboceras* species. It should be possible to lower the upper boundary of the Glosense Zone in Malinowska's figure 3, thereby alleviating the problem. A good fauna of Ilovaiski Subzone *Amoeboceras* is recorded from these boreholes (Malinowska 1987).

DISCUSSION

This study has shown that most of the 22 species of perisphinctid from North Yorkshire described herein were endemic to the Sub-Boreal Province. None of the species of *Arisphinctes*, *Dichotomosphinctes*, *Pseudarisphinctes*, *Pseudopomerania* and *Microbiplices* has been recorded from outside the province. The closest connections were with the Boreal Province, *Decipia* being found quite commonly in Greenland (Surlyk *et al.* 1973; Sykes and Surlyk 1976). The perisphinctids seem to have been very 'reluctant' to migrate south; none of the common Yorkshire species has been recorded from the Sub-Mediterranean Province. Correlation with the south is only possible via rare records of Sub-Mediterranean species such as *P. elizabethae* and *P. parandieri* in Yorkshire, and the occasional records of Boreal *Amoeboceras* in the Sub-Mediterranean Province.

The recent division of the Sub-Mediterranean Transversarium Zone into four subzones, and some of these into faunal horizons (Cariou *et al.* 1991) has led to the previously accepted correlation of the Sub-Boreal and Sub-Mediterranean zonal schemes becoming untenable, with the Nunningtonense Subzone being equivalent to three Sub-Mediterranean subzones. The recognition of *Perisphinctes* (*Dichotomosphinctes*) *elizabethae*, a species which typifies the Luciaeformis Subzone, in the Newbridge Beds has enabled a more logical correlation of the two provinces (Text-fig. 7).

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