AMMONOIDEA FROM THE LOWER D BEDS (BERRIASIAN) OF THE SPEETON CLAY

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ABSTRACT. The subdivision of the Lower D Beds is outlined and ammonites are shown to occur at nine horizons in D6 and D7. The ten species of ammonites fall into four genera and have links with faunas found in Lincolnshire, Russia, and Greenland. Four existing species are recorded, three are compared or have affinities with existing species, and three species are new. It is shown that this fauna is of Subcraspeditan (Berriasian) age and that the lowest ammonites are earlier than any yet recovered from the Spilsby Sandstone of Lincolnshire.

HITHERTO the lowest ammonites from the Speeton Clay have come from D4 where the beds have yielded various species of *Polyptychites* indicative of the *ascendens* subzone of Valanginian age (Spath 1924, p. 81). Lamplugh (in Pavlow and Lamplugh 1892, p. 15) notes that 'très petites Ammonites ne sont pas rares dans la partie inférieure de la Zone (D4, D5, D6, D7), mais elles sont difficiles à déterminer' and goes on to say that Pavlow considers that they resemble the inner whorls of *Olcostephanus subditus* and *O. okensis*. Later, however, Lamplugh (1924, p. 26) states that 'from the lowest part of D no ammonites whatever have been obtained'.

Recently ammonites have been found at nine horizons in D6 and D7 confirming the separation of these beds from those above, already made on other grounds (Neale 1962). In order to localize the material accurately it has been necessary to subdivide Lamplugh's original divisions. The subdivision of the upper D Beds has already been covered in a recent paper (Neale 1960). Brief notes on the subdivision of the Lower D Beds are given below and the positions of the ammonite horizons are shown in text-fig. 1. The subdivisions are designated by suffixes added to Lamplugh's original divisions and, in conformity with that author's usage, read from the top (i.e. youngest) bed downwards.

D6A	22″.	Pale bluish-buff mudstone. This bed is one of the best ammonite-bearing beds in the lower part of the section and the occurrence of two distinct horizons has led to further subdivision:
D6Aα	1″.	Thin bed at junction with D5.
D6Aβ	7″.	Brown, well-laminated mudstone with pale-green mottling, the mottling being smaller than in the bed below. *Tollia stenomphala* (Pavlow) and *T.* cf. *tolmatschowi* Pavlow occur.
D6Aγ	1–2″.	Strongly mottled bed.
D6Aδ	13″.	Greenish or bluish fairly homogeneous mudstone with some streaks of darker material or large-scale mottling. Breaks with a blocky fracture and yields *Tollia pseudotolli* sp. nov. and large lamellibranchs.
D6B	2″.	Pale band of streaky mudstone.
D6C	2¼″.	Dark shale which contrasts markedly with the above.
D6D	3¾″.	Pale-blue mudstone.
D6E	4″.	Dark mottled shale.
D6F	3½″.	Shaly mudstone which is somewhat darker than the bed below.
D6G	8″.	Pale-blue shale which breaks with a blocky fracture and has yielded *Paracraspedites subtzikwinianus* (Bogoslowsky).

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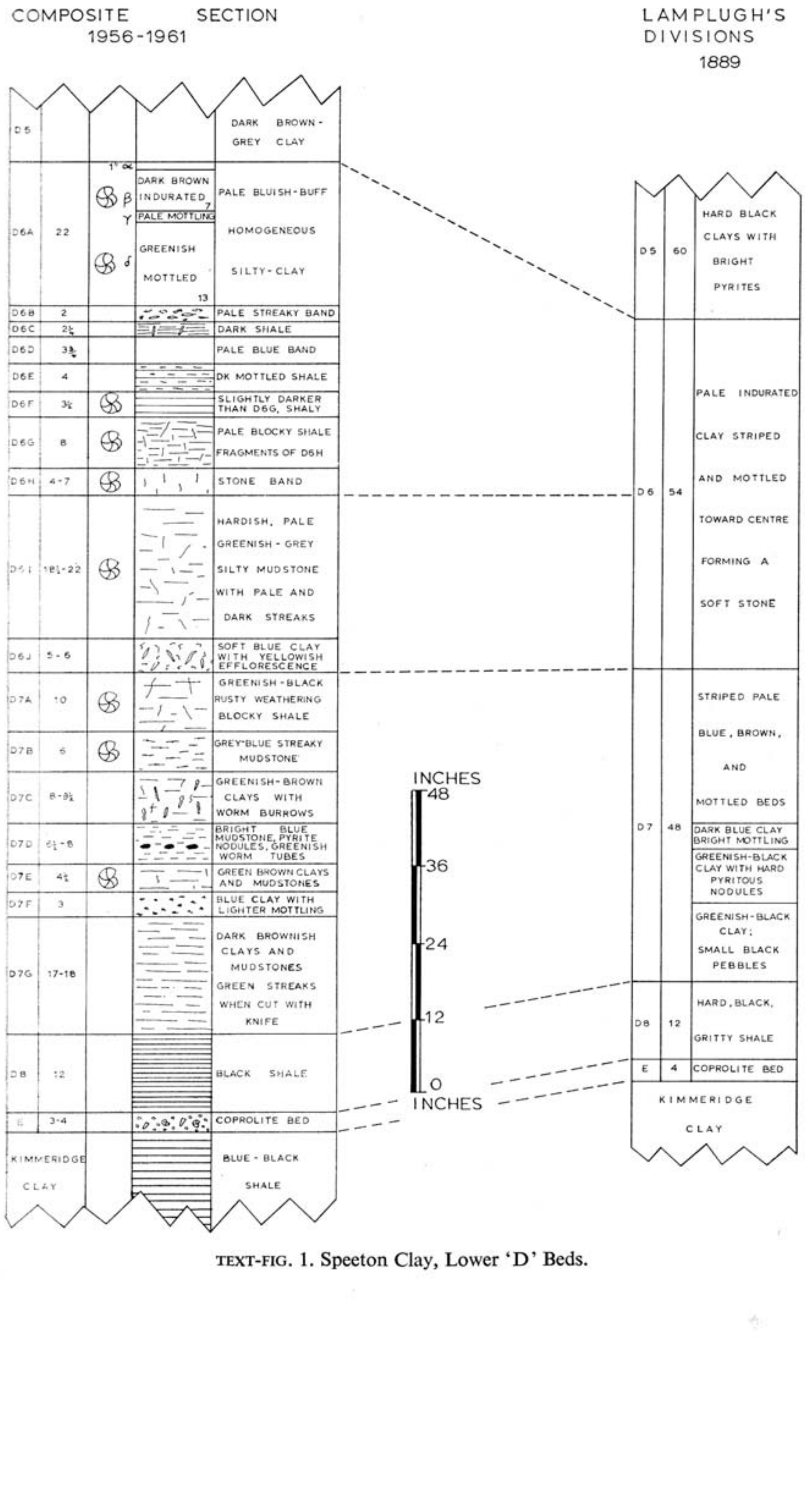


TEXT-FIG. 1. Speeton Clay, Lower 'D' Beds.

D6H	4–7″.	The Stone Band. This consists of a layer of hard, pale, limestone lenticles, usually between 2 and 3 feet long and about 6 inches thick, which are developed at intervals and separate the similar mudstones above and below. The band itself yields *Paracraspedites stenomphaloides* Swinnerton and forms one of the most important marker bands in the section.
D6I	18½–22″.	Pale-blue mudstones. Small ammonites belonging to *Subcraspedites* aff. *cristatus* Swinnerton are fairly common in this bed.
D6J	5–6″.	Very soft, bright-blue clay which develops a yellow efflorescence on exposure to the weather. This is one of the best guides to the interpretation of the lower beds and forms another important marker band in the D beds.
D7A	10″.	Greenish-black shaly mudstone. *Tollia wrighti*, *Paracraspedites prostenomphaloides*, and *Laugeites? sp.* (all new species) occur here and in the bed below.
D7B	6″.	Grey-blue streaky mudstone with *Tollia wrighti* sp. nov.
D7C	8–9½″.	Greenish-black blocky shale.
D7D	6½–8″.	Very bright-blue clay with pyrite nodules which have a marked greenish sheen. The clay is riddled with greenish burrows or worm tubes and forms a very distinctive horizon when this part of the section is well exposed.
D7E	4½″.	Greenish-brown shaly mudstone. This is the lowest stratum from which ammonites have so far been obtained and has yielded *Laugeites? sp.*
D7F	3″.	Blue clay with lighter mottling.
D7G	17–18″.	Dark-brown clays and mudstones, somewhat shaly and containing glauconite.
D8	12″.	Very hard, black shale which contains some glauconite and some quartz grains.
E	3–4″.	The Coprolite Bed. This is fully described by Lamplugh (1889) and is one of the most important marker horizons. It consists essentially of a mass of pyritized and phosphatized material and was worked in the last century for the phosphate content.

The ammonites occur as flattened impressions in the mudstones of D6 and D7. In general they are small, measuring between 18 and 70 mm. in diameter in the case of the best-preserved specimens, and in some cases retaining the original shell material. Larger forms have been found in the lower beds, one from D7B having an estimated whorl height of about 55 mm., but these specimens are less complete than the nuclei from higher up. No perfect three-dimensional forms have been found and none of the specimens show suture-lines. Specimens are not common and prior to the good exposures of April 1960 intensive collecting of these 11 feet of beds for some fourteen or fifteen days produced only twenty-nine specimens, many of them mere fragments, together with a number of counterparts from six horizons. The exposures in the spring of 1960 provided some better specimens as well as three new ammonite horizons. No ammonites have so far been found in D5 or D8 and the very nature of these beds renders their occurrence here unlikely. The Lingula Bed (D5) appears to have formed under shallow, rather stagnant water conditions and contains little besides this inarticulate brachiopod. At most an occasional pyritized drifted ammonite might be expected. The lowest bed (D8) consists of 1 foot of hard, gritty glauconitic shale and represents the first deposit of the Cretaceous sea overlying the Coprolite Bed (E). Sedimentation was slow, as is evidenced by the presence of glauconite and the relative abundance of quartz compared with the higher beds, and suggests shallow water affected by current action.

SYSTEMATIC DESCRIPTIONS

Family PERISPHINCTIDAE Steinmann 1890
Genus LAUGEITES Spath 1936

Type species. *Laugeites groenlandica* (Spath).

Discussion. Originally designated *Kochina* (preoccupied) this genus was introduced for a fine ribbed, fairly evolute form from the Lingula Bed some 70 metres above the base of the Hartzfjaeld Sandstone north of Cape Leslie in Greenland. Spath considered it to be a derivative of *Dorsoplanites* and a forerunner of *Kachpurites* and *Subcraspedites*. The development of the ribbing, however, suggests closer affinities with *Paracraspedites* from which it differs mainly in the somewhat finer ribbing which swings forward gracefully towards the venter, the proportionately wider whorl section and somewhat wider umbilicus. The present genus becomes smooth in the adult. The specimens tentatively assigned to this genus represent the lowest forms obtained from the Speeton Clay and these differ in certain respects from the type species as indicated below. The age of the genus has been the basis of an interesting discussion by Spath (1936, p. 164; 1946, p. 4; 1947, p. 58; 1952, pp. 6, 17 et seq.) and Maync (1947, p. 29; 1949, pp. 228–9) and is examined after the systematic descriptions.

Laugeites? sp.

Plate 40, fig. 3; Plate 41, figs. 2, 3; Plate 42, figs. 8, 9

Material. One large pyritized internal mould of part of a large whorl and the previous whorl (HU.8942), two flattened specimens and their counterparts (HU.8941a, b; S.1888a–d), three fragmentary external moulds (HU.8948, HU.8949).
Horizons. Speeton Clay, D7A, D7B, D7E.

Description. An evolute form in which the ribs usually show regular bifurcation and swing forward as they approach the venter. Umbilicus fairly wide (40 per cent. of diameter). The most complete specimen shows that the final diameter cannot have been less than 120 mm., whilst the largest specimen from D7B (HU.8942) has a whorl height of approximately 55 mm. (making due allowance for flattening) and must have reached a diameter of at least 160 mm. In this latter specimen the dorsum on the last whorl is impressed to a depth equal to about one-third of the whorl height. The specimen from D7A (HU.8941a, b) shows constrictions on the first formed whorl (Plate 41, fig. 2) which is interesting in view of Spath's remarks (1936, p. 82) on *L. groenlandica* that there are 'one or two constrictions visible in [the] umbilicus'.

Remarks. The material is fragmentary and poorly preserved so that its assignment to this genus is questionable. It does, however, agree exactly in evolution with the most complete specimen of *Laugeites groenlandica* figured by Spath (1936, pl. 38, fig. 1) and the ribbing agrees closely with *L. groenlandica* in nature and swing of the secondary ribs but differs in density, the ribs being much more widely spaced on the inner whorls. *Laugeites? sp.* might well be placed in *Paracraspedites* but for the fineness of the ribbing, the swing on approaching the venter (which is not wholly due to the preservation), and the width of the umbilicus. The various measurements of the species mentioned, together with those of *Paracraspedites* aff. *stenomphaloides* Swinnerton and *P. bifurcatus* Swinn., are tabulated below for comparison.

There is an approach to *Paracraspedites bifurcatus* in many respects, particularly in the width of the umbilicus and in the nature of the rib bifurcation, and the lower part of Swinnerton's specimen does show the secondary ribs swinging forward distinctly at the ventro-lateral margin, presumably due to crushing. In the Speeton material, however, the ribs swing forward much more markedly, even if allowance is made for compression, and the rib density (see below) is very different in the early whorls. Nevertheless, the close affinities between the two species should be stressed.

Measurements in mm.	*Diameter*	*Height of last whorl*	*Thickness*	*Width of umbilicus*
		%	%	%
Laugeites? sp.	85	34	—	40
L. groenlandica (Spath)	175	33	29	42
P. bifurcatus Swinnerton	72	33	28	43
P. stenomphaloides Swinnerton	89	37	27+	34
P. aff. *stenomphaloides* Swinnerton	74	38	26+	28

Rib density

Diameter subtended (in mm.)	6·5	8	11·5	13	15	21	31
Laugeites? sp.	—	—	10	12	15	15	17
L. groenlandica (Spath)	—	—	18	—	*c.* 20	*c.* 23	*c.* 18–19
Paracraspedites aff. *stenomphaloides*	12	12	—	12	—	16	—
P. bifurcatus Swinnerton	—	—	22	—	18	—	17

Family CRASPEDITIDAE Spath 1924

For generic distinctions in the Craspeditidae good three-dimensional forms are generally necessary so that the nature of the adult body whorl, and preferably also the form of the suture, can be seen. The compressed nature of the Speeton specimens thus makes the assignment of some of the material to genera dubious although the general relationships are easily ascertainable. The genera and subgenera of immediate concern are *Subcraspedites* Spath 1924, *Paracraspedites* Swinnerton 1935, and the members of the subfamily Tolliinae Spath 1952. The distinction between *Paracraspedites* on the one hand, and *Subcraspedites* and the Tolliinae on the other is easily made on the early whorls which have strong well-spaced primary ribs in the former, while the latter show fine close ribbing in the early whorls. There is also a difference to be seen in the body whorl, the rib strength being maintained in *Paracraspedites*, while in *Subcraspedites* the primary ribs become accentuated but the ribbing on the outer part of the whorl fades. In *Tollia* the body chamber becomes smooth and the ribbing completely disappears in the last-formed part of the shell.

The Tolliinae includes the genera *Tollia* Pavlow 1914, *Praetollia* Spath 1952, *Hectoroceras* Spath 1947, and *Homalsomites* Crickmay 1930. Imlay (1956, 1960) has recently resurrected Crickmay's genus for a group of American forms which appear to be of

EXPLANATION OF PLATE 40

All figures natural size.

Figs. 1, 2. *Paracraspedites stenomphaloides* Swinnerton. 1, Latex cast of S.1541. Speeton Clay, D6H. 2, Latex cast of HU.9050. Speeton Clay, D6G.

Fig. 3. *Laugeites? sp.* Latex cast of S.1542. Speeton Clay, D7B.

Fig. 4. *Tollia wrighti* sp. nov. Holotype. S.1884b. Speeton Clay, D7B.

Fig. 5. *Tollia* cf. *payeri* (Toula). Latex cast of HU 9051. Speeton Clay, D6F.

Fig. 6. *Tollia pseudotolli* sp. nov. Paratype. Latex cast of S.1885a. Speeton Clay, D6Aδ.

middle or late Valanginian age and occur in association with species of *Sarasinella* and *Polyptychites*. The main differences from *Tollia*, to which it is closely related, lie in the longer, stronger primary ribs to which the secondary ribs are more commonly joined than in *Tollia*, its generally smaller size and failure to become smooth in the adult. Neither this genus nor the easily distinguished *Hectoroceras* and *Praetollia* have been found at Speeton. The problem of distinguishing *Tollia* and *Subcraspedites* is outlined after the descriptions of species of *Paracraspedites*.

Subfamily CRASPEDITINAE Spath 1925
Genus CRASPEDITES Pavlow 1892
Subgenus PARACRASPEDITES Swinnerton 1935

Large specimens from the uppermost part of D7 and D6 show strong ribbing in which the strength of the secondary ribs is maintained and the primary ribs are not unduly accentuated. Where preserved the primaries of the inner whorls appear to be well spaced and these specimens are here referred to *Paracraspedites*.

Paracraspedites prostenomphaloides sp. nov.

Plate 43, fig. 3

Derivation of name. A reference to the fact that this precedes *P. stenomphaloides* Swinnerton.
Holotype. One external mould, HU.9049.
Horizon of holotype. Speeton Clay D7A? This specimen was obtained by Mr. Doyle from what was originally thought to be a loose block, so that some uncertainty existed regarding its horizon. A later visit to the section suggested that this was in fact from D7 *in situ* and from the lithology, rusty weathering blue-grey shales, there is little doubt that this is from D7A.

Diagnosis. A species of *Paracraspedites* with the ribs on the later whorls (estimated whorl height 38 mm.) usually bidichotomous, the posterior branch springing from the mid-rib nearer the venter than anterior branch. On occasions the ribs bifurcate not trifurcate. The costae are markedly crescentic in which respect this species resembles *Laugeites* more than *Paracraspedites*. The specimen appears to be somewhat crushed so that it is difficult to estimate the umbilical width. As far as it is possible to ascertain there are about thirteen ribs subtending a diameter of approximately 40 mm.

Remarks and affinities. This species is clearly closely related to *Laugeites? sp*. on the one hand and *P. stenomphaloides* on the other. From the former it differs in the more crescentic ribbing and much coarser development of secondaries, the primary ribs generally splitting into three and not two. From *P. stenomphaloides* it differs in the denser, finer, more crescentic ribbing. Neverthless, the latter is very closely related and is probably a derivative of this species. *P. stenomphaloides* occurs higher in the section in D6H and D6G. It is of interest that another part of the slab of shaly mudstone containing this specimen (Plate 43, fig. 2) also shows the presence of two complete, compressed *Tollia wrighti* sp. nov., two fragments of the present species, a piece of fossil wood, and a *Lingula*.

Paracraspedites stenomphaloides Swinnerton 1935

Plate 40, figs. 1, 2; Plate 45, figs. 7, 8

1935 *Paracraspedites stenomphaloides* Swinnerton, p. 38, pl. iv, figs 1a, b.

Material. Four fragmentary specimens, S.1541, HU.9050, S.1545A, S.1546a, b (probably belonging to the same specimen as S.1545A).
Horizons. Speeton Clay, D6H, D6G.

Remarks. The two most complete specimens (Plate 40, figs. 1, 2) agree well with Swinnerton's figures and description of his type specimen. The rib density is the same and the ribs show the same curvature at similar whorl height. As with other species, the Speeton specimens appear to reach larger proportions than the Lincolnshire material. The best-preserved Speeton specimen (Plate 40, fig. 1) occurs as an impression on the underside of an *Exogyra*. This species is fairly common at Speeton where it reaches a large size—well over 170 mm. in diameter, and the author has seen specimens as much as a foot across. Unfortunately the blocky blue mudstones crumble as soon as any attempt at extraction is made and it has so far proved impossible to cast the impressions *in situ*.

Paracraspedites subtzikwinianus (Bogoslowsky 1902)

Plate 41, figs. 1*a*, *b*, *c*

1902 *Olcostephanus subtzikwinianus* Bogoslowsky, pp. 25, 125, pl. v, figs. 2*a*, *b*; pl. vi, figs. 1*a*, *b*.

Material. Two parts of a flattened shell. The larger part has a whorl height of about 22 mm. (allowing for crushing). The smaller fragment shows the ribbing at the umbilical edge at a smaller diameter. HU.8940a, b.
Horizon. Speeton Clay, D6G.

Remarks. This single specimen has the actual shell preserved and both sides of the specimen are seen (Plate 41, figs. 1*a*, *b*). The shell material is brownish and the rib pattern corresponds with that of Bogoslowsky's species. The ribs swing gently forward at the umbilical margin in both the Russian and Speeton forms at comparable whorl heights.

Bogoslowsky's specimens came from the Rjasan Horizon of Tzykwino and Swinnerton (1935, p. 39) has noted the resemblance of some of the smaller forms of *P.* aff. *stenomphaloides* from Bed C of the Spilsby Sandstone to this species.

Paracraspedites? sp.

Plate 45, figs. 5, 6

These two fragments (S.1886, S.1544a) are too small to do more than questionably

EXPLANATION OF PLATE 41

All figures natural size.

Fig. 1. *Paracraspedites subtzikwinianus* (Bogoslowsky). Speeton Clay, D6G. *a*, *b*, HU.8940a. Specimen flattened but preserving original shell, seen from left and right sides. *c*, HU.8940b. Part of earlier whorl of the same specimen seen from the left side and showing the relatively coarse ribbing at the umbilical edge.

Figs. 2, 3. *Laugeites? sp.* Whitened with MgO. 2, HU.8941a. Internal and part of external mould showing the constrictions on the first whorl. Speeton Clay, D7A. 3, HU.8942. Heavily pyritized internal mould; Speeton Clay, D7B.

Fig. 4. *Subcraspedites* aff. *cristatus* Swinnerton. HU.8409. Part internal, part external mould. Speeton Clay, D6I.

Fig. 5. *Tollia pseudotolli* sp. nov. HU.8943a. Speeton Clay, D6Aδ. Paratype.

include them in the present genus. Both were obtained from D6H which also yields *P. stenomphaloides* and *S.* aff. *preplicomphalus*.

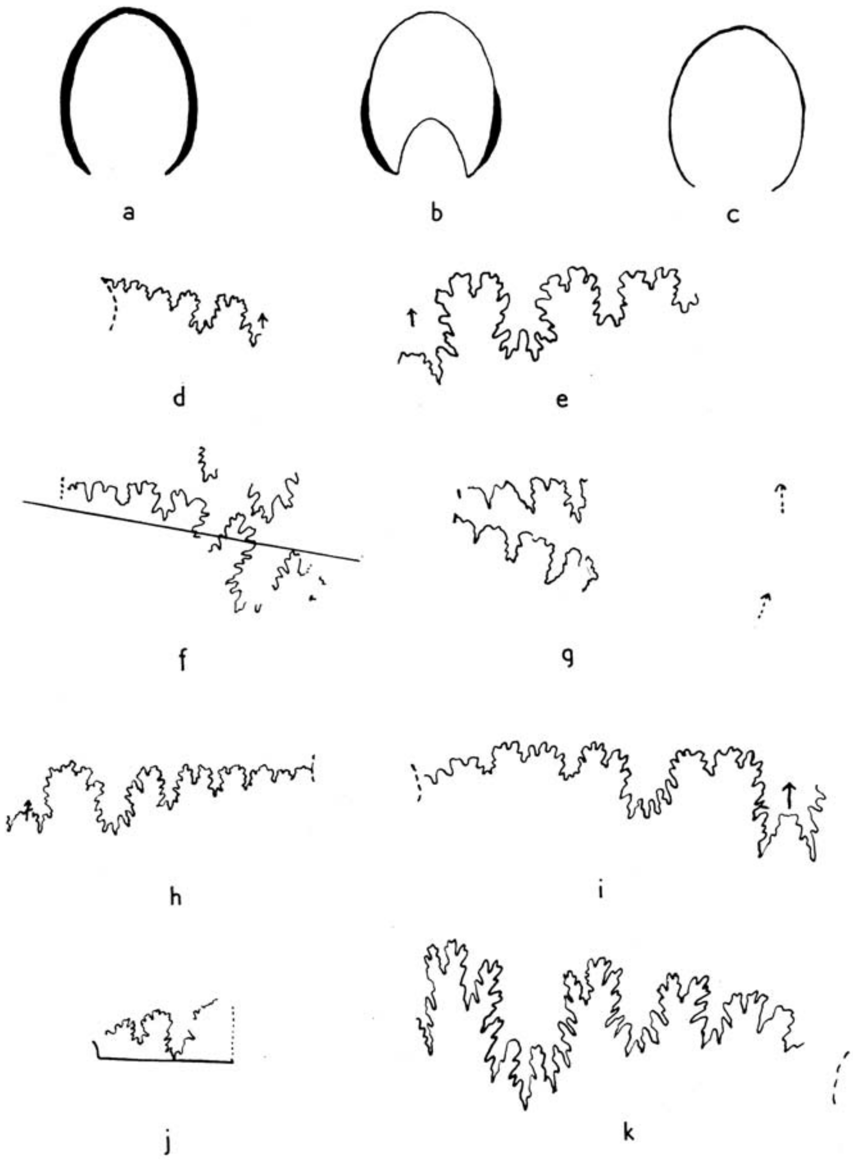
The Genera *Subcraspedites* and *Tollia*

Pavlow created the genus *Tollia* (type species *T. tolli*) in 1914 for a group of forms from the Lower Cretaceous of northern Siberia in which the body whorl became smooth and the suture contained long saddles, a high external lobe and many graded auxiliary elements in the suspensive lobe.

The genus *Subcraspedites* (based on *Amm. plicomphalus* J. Sow.) was introduced by Spath ten years later for forms in which the primary ribs are strongly accentuated in the body whorl while the secondary ribs fade so that the ventral part of the flanks becomes smooth. Two specimens of *Ammonites plicomphalus* were figured in volume IV of Sowerby's *Mineral Conchology*: *Ammonites plicomphalus* J. Sowerby 1822, p. 82, pl. 359, and *A. plicomphalus* J. de C. Sowerby 1823, p. 145, pl. 404, both from the Spilsby Sandstone of Lincolnshire. Originally these were thought to be two parts of the same specimen, but Spath has re-examined the evidence and concludes that they are not only different specimens but also different species. *A. plicomphalus* J. de C. Sowerby has now been designated *Subcraspedites sowerbyi* Spath (1952, p. 18). This latter is more finely ribbed than the true *S. plicomphalus* in which Spath notes that the inner whorls are 'bluntly tuberculate at the umbilical edge as they are in the adult'. Both these forms occur in the upper beds of the Spilsby Sandstone, a fact of some importance which is discussed later. The suture-line of the type species has never been figured, although the suture-lines of a number of species which have been referred to this genus have been figured by Swinnerton (1935), Spath (1952), and others. Two are figured here (text-fig. 2) and reference should also be made to Swinnerton (1935, pl. ii). The main difference between *Subcraspedites* and *Tollia* in this respect lies in the suspensive lobe where a large number of auxiliaries occurs in the latter. Spath (1947, p. 28) suggested that *S. primitivus* Swinnerton was probably a *Tollia* and this suggestion must certainly be upheld on the grounds of suture and fading of the ribbing on the body whorl. The suture of '*Subcraspedites stenomphalus* (Pavlow)' figured in text-fig. 2 is of *Tollia*-like aspect and it is perhaps significant in this respect that Spath (1947, p. 62) refers to the zone of '*Tollia stenomphala*'. Reference to Pavlow's original description (1889, p. 117) confirms that they should be referred to *Tollia*.

From Lincolnshire, Greenland, and Russia a considerable number of species has been described and variously referred to *Subcraspedites* and *Tollia*. Many of these have been poorly preserved and even more poorly illustrated, and their interpretation raises considerable difficulties from a taxonomic point of view. Where the final whorl and/or suture can be seen the problem is relatively simple. Where, as in many cases, only the earlier whorls or part of the earlier whorl(s) are present their true assignation is a matter of difficulty or sometimes impossible at the generic level. A study of all the available material and illustrations suggests that distinction between the two genera based on the nature of the early rib pattern may be practicable in some cases.

The species of *Tollia* all appear to show a very fine hair-thin termination of the primary ribs which 'kick-forward' characteristically as they run in to the umbilical edge, whereas the ribs in *Subcraspedites* are generally somewhat stronger and more prorsiradiate. The distinction, however, is not always easy or clear cut but in certain cases it provides a



TEXT-FIG. 2.

convenient means of differentiating between the two genera and is exemplified by Plate 40, fig. 4 and Plate 44, fig. 8 which are *Tollia* and Plate 45, fig. 4 which is a typical *Subcraspedites*. The forms figured as Plate 42, fig. 3, and Plate 44, figs. 2, 5, 7, amongst others are classified as *Subcraspedites*. In *Tollia* the ribbing on the intermediate whorls appears to be finer than that in the typical *Subcraspedites*.

The majority of the Speeton specimens belong to *Tollia* and this has been confirmed in the case of D6A by the presence of adults showing the smooth body chamber. The greatest difficulty occurs in connexion with the small forms obtained from D6I.

Subcraspedites preplicomphalus Swinnerton 1935

Plate 42, fig. 5B

1935 *Subcraspedites preplicomphalus* Swinnerton, pp. 36–37, pl. iii, figs 1a, b, 2a, b.

Material. Two specimens. S.1547a, b. HU.9047.
Horizons. Speeton Clay, D6Aδ, D6G–H.

Remarks. These two specimens are large and consist of fragments of ammonites which had a whorl height of not less than 60 and 50 mm. respectively. They cannot have reached a final diameter of much less than twice the size of Swinnerton's largest specimen. Nevertheless, they agree in the density of the ribbing, and particularly in the rib pattern in which, as Swinnerton says, the primary ribs 'flatten out and merge into groups of three peripheral ribs without intermediaries' (1935, p. 37). Swinnerton's material came from tip heaps made from the bottom 6 feet of the Spilsby Sandstone of Partney, Lincolnshire, with the addition of one specimen from Bed C of the Spilsby Sandstone in the Fordington boring.

Subcraspedites aff. *preplicomphalus* Swinnerton

Plate 42, fig. 4

Aff. 1952 *Subcraspedites preplicomphalus* Swinnerton, Spath, p. 17, pl. iv, fig. 1.

Material. One fragment. S.1543a, b.
Horizon. Speeton Clay, D6H.

Remarks. The Speeton fragment agrees well with Spath's figure and this author notes that the Greenland specimen is identical with some of the Spilsby Sandstone ammonites which he would include in *S. preplicomphalus*, and comments on the poor preservation of Swinnerton's holotype. This differs from Swinnerton's description and figures of *S. preplicomphalus* in having four secondary ribs to each primary instead of three. On these grounds, when well-preserved material becomes available, it may later be advantageous to make this a separate species or sub-species.

TEXT-FIG. 2. Rib projection and suture. *a–c*, Rib projection on the body whorls of certain genera; diagrammatic, partly after Swinnerton. *a*, *Paracraspedites*. *b*, *Subcraspedites*. *c*, *Tollia*. *d–k*, Sutures. *d*, *T. stenomphala* (Pavlow), Pavlow 1889, pl. 3, fig. 10*c*. *e*, *S. lamplughi* Spath, ×2, Spath 1947, fig. 6*e*. *f–g*, *T. tolli* Pavlow, 1914, pl. 12. *f*, fig. 2*c*. *g*, fig. 1*a*. *h*, *P. spasskensis* (Nikitin), Nikitin 1888, pl. 1, fig. 11. *i*, *T. primitivus* (Swinnerton), Spath 1947, fig. 6*d*. *j*, *P. stenomphaloides* Swinnerton 1935, pl. 4, fig. 1*b*. *k*, *T. latelobata* Pavlow, Spath 1947, fig. 7*b*.

Subcraspedites sp.

Plate 42, fig. 5A

This individual (HU.9046) from D6Aδ is a fragment of a large whorl of height about 30 mm. (allowing for compression) and lies on the reverse side of HU.9047 figured here as Plate 42, fig. 5B. The two figured examples belong to different individuals as can be ascertained by examining the thickness of the specimen. The other individual belongs to *S. preplicomphalus* but the present example shows a number of distinct differences. The ribbing is markedly crescentic and appears to bifurcate rather than trifurcate. The primary ribs are close together and there is nothing comparable figured in the literature. It is possible that this is a variety of *S. preplicomphalus* that has been affected by crushing in such a way as to give marked crescentic and apparently denser ribbing. In this case the bifurcation would need to be explained away by some means such as modification on the adult whorl or gerontism. In view of the even larger form on the opposite side this seems unlikely and the nomenclature is here left open.

Subcraspedites aff. *cristatus* Swinnerton

Plate 42, fig. 3; Plate 44, figs. 2, 5, 8, 9, 12, 13; text-fig. 3

Aff. 1935 *Subcraspedites cristatus* Swinnerton, pp. 33–34, pl. iii, figs. 4*a–c*, 5.

Material. Six specimens and some counterparts. HU.8409, HU.8410, HU.8414, HU.8415a, b, HU.8417a, b, HU.9045.

Horizon. Speeton Clay, D6I.

Remarks. These nuclei show a very characteristic ornament and the rib development shows obvious affinities with Swinnerton's Lincolnshire Subcraspeditids so that they may be placed in this genus (and not *Tollia*) with some degree of confidence. No nuclei of this size have been figured so that one must rely on descriptions for comparisons. The most striking feature is the development of well-spaced primaries at an early stage, a feature only paralleled in *S. cristatus* Swinnerton. The latter species shows seven ribs per half whorl at an umbilical diameter of 24 mm., while the present material shows eight ribs at an umbilical diameter of $9\frac{1}{2}$ mm., and nine at a diameter of 28 mm. For this reason the Speeton nuclei are considered to have some affinities with the Lincolnshire species.

The development of the rib pattern may be traced from the protoconch and occurs in four stages which are detailed below. The diameters given must be regarded as approximate.

EXPLANATION OF PLATE 42

All figures natural size.

Figs. 1, 2, 7. *Tollia stenomphala* (Pavlow). 1, HU.9048. 2, HU.9042. Two specimens. 7, HU.9043. All, Speeton Clay, D6Aβ.

Fig. 3. *Subcraspedites* aff. *cristatus* Swinnerton. HU.9045; Speeton Clay, D6I.

Fig. 4. *Tollia* cf. *tolmatschowi* Pavlow. HU.9044; Speeton Clay, D6Aβ.

Fig. 5A. *Subcraspedites sp.* HU.9046; Speeton Clay, D6A.

Fig. 5B. *Subcraspedites preplicomphalus* Swinnerton. HU.9047, Ammonite on the reverse side of the above specimen; Speeton Clay, D6A.

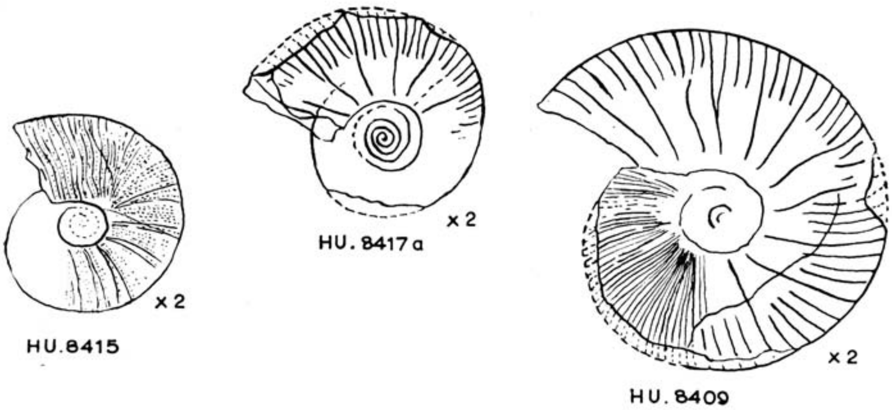
Fig. 6. *Tollia sp.* HU.9041b; Speeton Clay, D6Aβ.

Figs. 8, 9. *Laugeites? sp.* 8, Latex cast of HU.8949. 9, Latex cast of HU.8948. Both, Speeton Clay, D7E.

Stage 1. Up to a diameter of 11 mm. the shell is smooth (Plate 44, figs. 9, 13).

Stage 2. From a diameter of 11 to 12½ mm. the ribs are convex rectiradiate. In some specimens there is a tendency for some ribs to show strengthening near the umbilicus (Plate 44, figs. 9, 13).

Stage 3. From a diameter of 12½ to 16 mm. the ribs are equally developed and there is little or no differentiation into primaries and intercalatories. The ribs spring from the umbilicus and are delicately biconvex, changing to biconcave as the next stage develops (Plate 44, figs. 5, 13).



TEXT-FIG. 3. Development of rib pattern in *Subcraspedites* aff. *cristatus* from Speeton Clay, D6I.

Stage 4. From this stage onwards every fourth rib becomes accentuated and as size increases the primaries become more and more prorsiradiate. These tend to bifurcate and form two secondary ribs with which are associated two intercalatory ribs. For a time the intercalatory ribs run right in to the umbilicus but gradually they become more closely associated with the primaries. The best specimen (HU.8409) consists of an internal mould retaining the actual shell and occupying about half the height of the last preserved whorl, while outside this the shell has spalled off and the secondary and intercalatory ribs are seen on the external mould. The growth-lines are very well displayed on the internal mould and run parallel to the primary ribs. At a diameter of 28 mm. there are nine primaries per half whorl.

Line drawings of specimens showing the characteristic development are given here as text-fig. 3.

Subfamily TOLLIINAE Spath 1952

This subfamily contains compressed, involute craspeditids with fine, regular, well-differentiated ribbing.

Genus TOLLIA Pavlow 1914

Type species. Tollia tolli Pavlow 1914.

Original diagnosis. 'By this name, bringing to mind the journeys of a traveller, lost without trace in the icy wastes of Asiatic Siberia, I propose to call an interesting group of *Olcostephanidae*, close to *Simbirskites* and distinguishing themselves by the absence of clearly expressed tubercles at the place of splitting of the umbilical ribs, distinctly expressed pulling away [? evolution] and suture line with a greater number of auxiliary saddles than in *Simbirskites* (on the second) and coming forward graded from the siphonal margin up to the first auxiliary saddle.

'The forms being dealt with here, reveal a considerable resemblance to *Simbirskites* of the group *Discofalcati* and apparently are genetically related to them. *Simbirskites Payeri* with very feebly expressed tubercles and with involution on the inner whorls represents forms standing close to the boundary of both genera.

'Representatives of the genus *Tollia* are extraordinarily numerous in the Lower Neocomian deposits of European Russia and the zone of *Olcostephanus stenomphalus*. They are described by me in one other work. The presence of this genus in northern Siberia may be considered to indicate the existence there of lower zones of the Neocomian than the zone of *Polyptychites Keyserlingi*.' (Pavlow 1914, p. 38; translated from the Russian.)

Tollia wrighti sp. nov.

Plate 40, fig. 4; Plate 43, fig. 2; Plate 44, fig. 8; Plate 45, fig. 3

? 1897 *Olcostephanus bidevexa* Bogoslowsky, pl. iii, fig. 2*a* only. Non, figs. 1, 3.

Holotype. Specimen and counterpart, S.1884a, b.
Paratype. Specimen and counterpart, S.1893a, b.
Horizon of holotype and paratype. Speeton Clay, D7B.
Other material. Two specimens (HU.9049b) from D7A?, and one example (HU.8412) from D6I.
Derivation of name. In honour of Mr. C. W. Wright for his contributions to our knowledge of British Cretaceous palaeontology.

Diagnosis. A species of *Tollia* in which the number of secondary costae is reduced from 5–7 per primary rib in the young stage to about 2½ per primary rib before the ribbing finally fades.

Description. The material available enables an almost complete picture of this species to be obtained. The ribbing is fine and sharp with the characteristic swing forward of the primary ribs at the umbilical edge. At a whorl height of approximately 15 mm. there are from five to seven secondary ribs to each primary, the number steadily reducing until at a whorl height of about 18½ mm. there are about four per primary, and at a height of approximately 27 mm. 2½ to each main rib. In the intermediate stage the secondary ribs give the impression of being associated with the primary rib anterior to

EXPLANATION OF PLATE 43

All figures natural size.
Fig. 1. *Tollia pseudotolli* sp. nov. Paratype. Latex cast of S.1890; Speeton Clay, D6Aδ.
Fig. 2. *Tollia wrighti* sp. nov. Two specimens in association with a piece of fossil wood, HU.9049b Speeton Clay, D7A?.
Fig. 3. *Paracraspedites prostenomphaloides* sp. nov. Holotype. Latex cast of HU.9049a; Speeton Clay, D7A?.
Fig. 4. *Tollia pseudotolli* sp. nov. var. (?). Paratype. Latex cast of 1889a; Speeton Clay, D6Aδ.

them and the general situation seems to indicate bifurcation of the primary rib to give a posterior branch with the addition of two intercalatories.

Affinities and differences. This species clearly has close affinities with *Tollia bidevexa* from the Rjasan Horizon of Russia and there is virtual identity between the intermediate whorls and those of Bogoslowsky's second specimen (1897, pl. iii, fig. 2*a*). Bogoslowsky's first figured specimen (1897, fig. 1a) shows significant differences in its early development, the primary ribs in the first whorls bifurcating with later increase in the number of secondaries consequent on increase in size. Bogoslowsky's second specimen on the other hand shows what appears to be the commencement of a reduction in the secondary/primary costal ratio with increase in size. Unfortunately this specimen consists of only one half whorl so that the nature of the early development is unknown. On the basis of this reduction in ribbing it is provisionally placed in the synonymy of the present species and removed from the true *T. bidevexa*. There is some resemblance between the new species and *Subcraspedites subpressulus* in the number of secondary ribs associated with the primaries in the early stages but in the latter the reduction in the costal ratio takes place at a later stage and the ribbing is stronger and more prorsiradiate.

Tollia cf. *payeri* (Toula)

Plate 40, fig. 5

Cf. 1874 *Perisphinctes Payeri* Toula, pp. 498–9, pl. 1, figs. 1*a–c*.
Cf. 1952 *Tollia payeri* (Toula) Spath, pl. iv, fig. 8.

Discussion. This small specimen (HU.9051), only 22 mm. in diameter, is beautifully preserved and is the only ammonite so far recovered from D6F. It differs from any of the other species of *Tollia* at Speeton particularly in the high density of the ribbing, sixteen primary ribs per half whorl being present at this diameter. The primaries split into two's and three's and become increasingly prorsiradiate. In density and nature of the ribbing there is a close correspondence between the Speeton specimen and the original specimen figured by Toula (1874, pl. 1, fig. 1*a*) at comparable sizes. The comparison with Spath's specimen (1952, pl. iv, fig. 8) is less close, the ribbing in the latter being somewhat denser and the point of bifurcation of the primaries lying higher up the flanks, features in which it also differs from Toula's example. It is questionable whether the specimen from Niesen figured by Spath should be referred to Toula's species. The difficulties that arise with regard to the taxonomy and horizon of the Greenland specimens are discussed later.

In view of these difficulties and the small size of the single specimen from Speeton it would be unwise to do more than compare it with Toula's species until more is known about the true nature of the species and larger material is available from Speeton.

Tollia pseudotolli sp. nov.

Plate 40, fig. 6; Plate 41, fig. 5; Plate 43, figs. 1, 4; Plate 44, fig. 1; Plate 45, figs. 1, 2; text-fig. 4

Holotype. Specimen S.1887a.
Paratypes. Six specimens and some counterparts. S.1883, S.1885a–h, S.1889a, S.1890, S.1892, HU.8943a, b.
Horizon of holotype and paratypes. Speeton Clay, D6Aδ.

Diagnosis. A species of *Tollia* which greatly resembles *T. tolli* in the final stages of development, but shows progressive decrease of the secondary/primary rib ratio during development. One specimen (S.1885, Plate 40, fig. 6) suggests that there may be a final increase in this ratio immediately before the ribbing fades on the body whorl.

Remarks. D6Aδ provides the best preserved, as well as some of the largest, ammonites to be obtained from the lowest Speeton Clays. In degree of involution, density of primary ribs, swing of the ribbing, and point of fading the English specimens agree almost exactly with the true *T. tolli* to which the final shell bears a strong general resemblance. The ribbing starts to fade at a diameter of about 78 mm., at which size the shell shows twenty-four or twenty-five primary ribs and an umbilical width which is approximately 25 per cent. of the diameter. In the development of the rib pattern, however, the differences are marked and recall those between *T. wrighti* sp. nov. and *T. bidevexa* (Bogoslowsky), the final form being attained by a reduction and not an increase in the costal ratio. The smallest specimen from Speeton (Plate 44, fig. 1) shows a secondary/primary ratio of 4 at a whorl height of 11 mm. Other specimens show that this is later reduced to 3·5 at about 24 mm. whorl height, and 3 at 28 mm. As noted above, the best specimen showing the fading in the last whorl suggests that there may be some increase in this ratio shortly before the ribbing completely disappears. In contrast the Russian specimen of similar size (Pavlow 1914, pl. xii, fig. 2*a*) shows a rib ratio of 3 at a whorl height of 24 mm., increasing with size to 3·5, 4, and even (in the largest specimen) to 4·5. Line drawings of the rib pattern in one of the Speeton forms and Pavlow's specimen of comparable size are given here as text-fig. 4.

Whereas it has been found convenient to separate the English and Russian forms from this and lower horizons as separate species, it is not unlikely that they represent two geographically isolated races of one vast interbreeding plexus of forms which are reaching the same end point by rather different routes—the one by a reduction, the other by an increase in the costal ratio. In this case they might properly be regarded as subspecies rather than full species. Much more material is needed from England, Greenland, and Russia before the variation acceptable in a single species can be worked out, however, and the full significance in the variation of rib patterns in the whole group assessed. At present, therefore, less problems would seem to be created if *T. wrighti* and *T. pseudo-*

EXPLANATION OF PLATE 44

All figures twice natural size.

Fig. 1. *Tollia pseudotolli* sp. nov. Paratype. HU.8943b, External mould; Speeton Clay, D6Aδ.

Figs. 2, 5, 7, 9, 12, 13. *Subcraspedites* aff. *cristatus* Swinnerton; Speeton Clay, D6I. 2, HU.8410, External mould. 5, Plasticene squeeze of HU.8409. 7, HU.8417a, External mould. 9, HU.8415b, External mould. 12, HU.8414, Actual shell. 13, HU.8415a, Internal mould and part of external mould.

Figs. 3, 6. *Tollia? sp.* 3, HU.8413, External mould; Speeton Clay, D6I. 6, HU.8944b, External mould; Speeton Clay, D6A.

Figs. 4, 11. Incertae sedis. 4, HU.8529. Specimen from D6A showing ribbing passing across the venter without interruption. 11, HU.8419a, Internal mould; Speeton Clay, D6I.

Fig. 8. *Tollia wrighti* sp. nov. HU.8412, Plasticene squeeze of external mould; Speeton Clay, D6I.

Fig. 10. *Subcraspedites sp.* HU.8422, External mould; Speeton Clay, D6I.

Fig. 14. *Subcraspedites? spp.* HU.8421a, Part external and part internal moulds of two specimens; Speeton Clay, D6I.

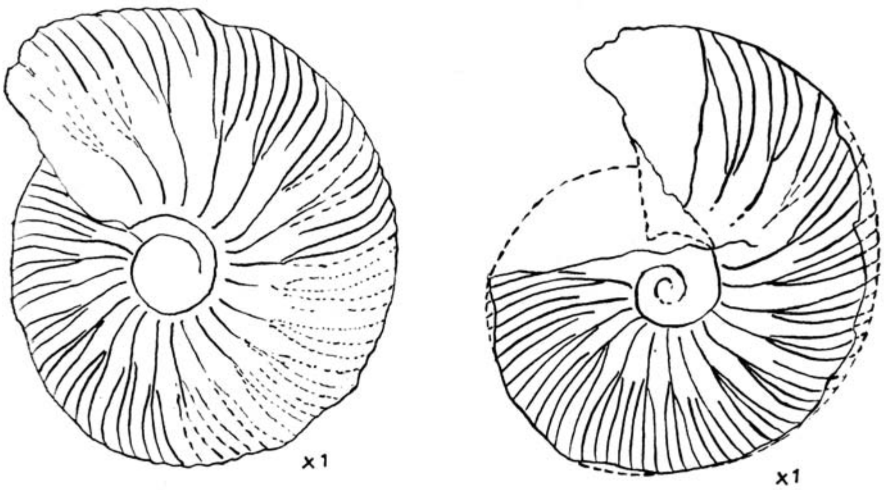
tolli are given full specific rank than if any of the several taxonomic alternatives are adopted.

Tollia stenomphala (Pavlow)

Plate 42, figs. 1, 2, 7

1889 *Olcostephanus stenomphalus* Pavlow, p. 117, pl. iii, figs. 1, 10*a–c*.

Material. Four specimens. HU.9042a, b, HU.9043, HU.9048.
Horizon. Speeton Clay, D6Aβ.



TEXT-FIG. 4. Comparison of rib pattern. *a*, *Tollia tolli* Pavlow 1902, pl. 12, fig. 2*a*; north Siberia. *b*, *T. pseudotolli* sp. nov., Speeton Clay, D6Aδ; holotype, S.1887a.

Remarks. These four specimens are all small, the largest being 38 mm. in diameter. The pattern of rib development corresponds with that seen in *T. stenomphala*, the ribs bifurcating or trifurcating in almost regular alternation. At almost the same whorl height the density of the secondary ribbing is exactly the same in the holotype and the best Speeton specimen. The ammonites at this horizon show a different type of development in the rib pattern from those in the preceding bed, the ribs gradually increasing from simple bifurcation in the earliest whorls to alternate bifurcate and trifurcate ribs in the latest part, i.e. an increase in the secondary/primary rib ratio from 2 to 2·5. This mode of increase corresponds with the situation seen in the Russian forms such as *T. bidevexa*, *T. tolli*, *T. tolmatschowi*, &c.

Pavlow's holotype came from the Spilsby Sandstone and his second specimen from the *Bel. corpulentus* beds of the Simbirsk area of Russia. The horizon at Speeton is in accord with this since Spath (1952, p. 18) has stated that this form together with *S. plicomphalus* and *S. sowerbyi* occurs in the Upper Spilsby Sandstone above the beds with *Paracraspedites stenomphaloides*.

Tollia cf. *tolmatschowi* Pavlow 1914

Plate 42, fig. 4

Cf. 1914 *Tollia tolmatschowi* Pavlow, p. 40, pl. xii, fig. 3; pl. xiii, figs. 1*a–e*.

Material. One specimen. HU.9044

Horizon. Speeton Clay, D6Aβ.

Remarks. Preservation is not good and specific identity is not certain. This single specimen agrees with *T. tolmatschowi* in the density of the primary ribbing (which is much denser than in the preceding form) and the ribs become very strongly prorsiradiate on the last part of the Speeton specimen, a feature emphasized by Pavlow who stated that 'this species is very like the preceding (*T. tolli*) but distinguishes itself in its . . . straighter, more forwardly inclined ribs. This inclination is conditioned by the fact that the siphonal ribs are not deflected back from the direction which they have at the umbilicus, continuing in this direction almost as far as the siphonal margin, not far from which they are still bent forward and pass across it without interruption.' (Pavlow 1914, p. 40; translated from the Russian.)

The following rib counts bring out the differences between the two different species at this horizon quite clearly:

	Diameter in mm.	*Ribs per whorl*
T. tolmatschowi (Pavlow 1914, pl. xiii, 1*e*) .	41	30–31
T. cf. *tolmatschowi* Speeton Clay, HU.9044 .	45	32–34
T. stenomphala Speeton Clay, HU.9048 . .	38	20

There is also a resemblance to *Praetollia maynci* var. *contigua* Spath as noted later.

Tollia sp.

Plate 42, fig. 6

Material. One poorly preserved specimen HU.9041b.

Horizon. Speeton Clay, D6Aβ.

Remarks. In this specimen the secondary ribs are very long and more in the nature of intercalatory ribs than truly bifurcatory and the ribbing is dense and very fine. This may merely be a variety of the foregoing but until more material is available in a better state of preservation and completeness it is impossible to assess its relationships and taxonomic position.

INCERTAE SEDIS

Here are included a number of specimens from various horizons which, due either to

EXPLANATION OF PLATE 45

All figures natural size.

Figs. 1, 2. *Tollia pseudotolli* sp. nov. Speeton Clay, D6Aδ. 1, Paratype, S.1883; 2, Holotype, S.1887a.

Fig. 3. *Tollia wrighti* sp. nov. Counterpart of holotype. S.1884a. Speeton Clay, D7B.

Fig. 4. *Subcraspedites* aff. *preplicomphalus* Swinnerton. Latex cast of S.1543b; Speeton Clay, D6H.

Figs. 5, 6. *Paracraspedites sp.* Speeton Clay, D6H. 5, Latex cast of S.1886. 6, Latex cast of S.1544a.

Figs. 7, 8. *Paracraspedites stenomphaloides* Swinnerton. Speeton Clay, D6H. 7, S.1546a. 8, S.1546b.

size or to poor preservation, or to both, are of uncertain affinities. Brief comments are given below.

HU.8313. Speeton Clay, D6I. Very poorly preserved, fine ribbed form. Possibly *Tollia wrighti* (Plate 44, fig. 3).

HU.8529. Speeton Clay, D6A. Crushed shell showing the ribbing passing across the venter without interruption (Plate 44, fig. 6).

HU.8422. HU.8421a (left). Speeton Clay, D6I. Nuclei showing a fairly distinct sinuous curve and splitting of the primary ribs. Possibly related to *S. groenlandica* Spath (Plate 44, figs. 10, 14 [left]).

HU.8419a. Speeton Clay, D6I. Nucleus of unknown affinities (Plate 44, fig. 11).

HU.8421a (right). Speeton Clay, D6I. Possibly related to the other forms from this horizon placed as *S.* aff. *cristatus* (Plate 44, fig. 14).

THE SIGNIFICANCE OF THE AMMONOIDEA

Whilst the abundance and preservation of the ammonoids from the lowest D beds leave much to be desired, their significance is considerable. The age of the lowest 17 feet of beds (D5–D8) has remained a problem even though Spath (1947, p. 63) has stated categorically that 'I showed that the Spilsby Sandstone was of even earlier age than the lowest part of the Speeton Clay'. What in fact Spath (1924, p. 81) did show was that the Spilsby Sandstone of Lincolnshire contained ammonites that were older than any found in D4 and the beds above at Speeton. Unfortunately he lumped D5 and D6 with D4 and later, by inference, D7 and D8 also. The beds below D4, however, differ considerably in lithology and faunal content (Neale and Kilenyi 1961, Neale 1962) from those above and in this respect the Lingula Bed (D5) is significant in indicating a radical change in conditions. This separates the blue mudstones and dark and pale mottled and striped clays of D6 and D7 which contain good marine faunas, from the higher parts of the section, which also contain good, but different, marine faunas.

Swinnerton (1937, xxvii) has drawn attention to the fact that the true *Acroteuthis lateralis* is restricted to D6, D7, and D8, reaching its greatest abundance in D7, and in contrast to Spath suggests that these beds should be placed in or near the *stenomphalus* Subzone of the 'Infra-Valanginian'. Spath (1947, p. 63) dismisses the evidence of the belemnites as unconvincing, but detailed palaeontological work has confirmed Swinnerton's views on the significance of the difference in the belemnite faunas. It will suffice here to mention that the foraminiferal, ostracod, and lamellibranch faunas all differ from those higher in the section, i.e. above the Lingula Bed.

Examination of the distribution of ammonites at Speeton shows the following succession:

D5 and D6A*a*	*c.* 7′	Barren Beds.
D6Aβ	8″	*Tollia stenomphala* (Pavlow). *Tollia* cf. *tolmatschowi* Pavlow. *Tollia sp.*
D6Aγ	1–2″	No ammonites obtained.
D6Aδ	1′ 2″	*Tollia pseudotolli* sp. nov. *Subcraspedites preplicomphalus* Swinnerton. *Subcraspedites sp.*

D6B–D6E	1′ 2″	No ammonites obtained.
D6F	3½″	*Tollia* cf. *payeri* (Toula).
D6G–D6H	1′ 0″–1′ 3″	*Subcraspedites preplicomphalus* Swinnerton. *Subcraspedites* aff. *preplicomphalus* Swinnerton. *Paracraspedites stenomphaloides* Swinnerton. *Paracraspedites subtzikwinianus* (Bogoslowsky). *Paracraspedites? sp.*
D6I	1′ 6½″–1′ 10″	*Subcraspedites* aff. *cristatus* Swinnerton. *Tollia wrighti* sp. nov.
D6J	5–6″	No ammonites obtained.
D7A and D7B	1′ 4″	*Tollia wrighti* sp. nov. *Paracraspedites prostenomphaloides* sp. nov. *Laugeites? sp.*
D7C and D7D	1′ 2½″–1′ 5½″	No ammonites obtained.
D7E	4½″	*Laugeites? sp.*
D7F, D7G, D8	2′ 8″–2′ 9″	Barren Beds.

It will be seen that at Speeton three species are regarded as new, four species described from other areas are considered to be present, and three other described species are probably present, whilst in a number of cases the nomenclature is left open.

In the boreal province, marine Berriasian (Infravalanginian, Riasanian) rocks occur in a number of areas, three of which, Lincolnshire, Russia, and Greenland, merit comparison with Speeton. The smaller areas in Spitsbergen, the King Charles and Lofoten Islands are too poorly known to make comparison profitable. A recent note by Casey (1961, p. 1100) suggests that new discoveries in the Sandringham Sands near West Dereham in Norfolk will be of considerable interest and importance when the details are known. Analysis shows that the Speeton ammonites are claimed to have links with the three areas as follows:

Lincolnshire. Specific identity in the case of three and probably in the case of a fourth species.
Russia. Specific identity in two cases and probably in the case of a third.
Greenland. One species comparable with a Greenland form.

Lincolnshire. As might be expected this area provides the closest faunal comparison with Speeton. The relevant ammonite faunas come from the base of the Spilsby Sandstone, from which Swinnerton (1935) described two distinct faunas. In the Fordington Boring the Spilsby Sandstone reaches a thickness of 72 ft. 6 in., and the principal ammonite faunas described occur in Beds D and C in the basal 3 feet. Clearly the Lincolnshire Paracraspeditid fauna from Bed C corresponds most closely with D6G and D6H at Speeton which also yield *Paracraspedites stenomphaloides* and *Subcraspedites preplicomphalus*. The lower beds at Speeton yield *Tollia wrighti*, *Laugeites? sp.*, and if its horizon is interpreted correctly, *Paracraspedites prostenomphaloides*, all new species. If the above correlation is accepted there are 11 inches of sandstone and clay below the Paracraspeditid fauna in Lincolnshire, whereas at Speeton there are some 5 feet of beds below which contain a different fauna, together with 2 feet 9 inches of underlying barren beds before the basal Coprolite Bed is reached. This suggests that, contrary to the statement made by Spath, the early Cretaceous sea may well have entered the Speeton area earlier than Lincolnshire. While the Coprolite Bed at Speeton and the blue clay with sand tubes together with the phosphatic nodules at the base of Bed B in Lincolnshire may be regarded as equivalents, this is probably a diachronic deposit and in consequence later in age in the latter area. The lower Spilsby Sandstone thus becomes an inshore equivalent of part of D6, the different facies reflecting the different situation with regard to the shoreline and possibly also a different source of detritus (De Boer, Neale, and Penny 1958, p. 176). This fits in with the generally accepted picture of the palaeogeography of this period and also confirms Strahan's suggestion (1886, p. 490) that 'the Tealby Beds and Spilsby Sandstone become then the equivalents of the Speeton Series, the sandstone being thinned out or replaced by clay towards the north'.

In Lincolnshire *T. stenomphala* is recorded from the Upper Spilsby Sandstone together with *S. plicomphalus* and *S. sowerbyi*. The two latter have not been proved at Speeton but *T. stenomphala* occurs in D6Aβ. At Nettleton (Lincs.) Mr. C. W. Wright has recorded the *T. stenomphala* fauna between 20 and 30 feet above the fauna characteristic of Swinnerton's bed D (Donovan 1957, pp. 145–6). Taking the minimum thickness of 20 feet, this means that this fauna occurs 21 feet at least above that of Bed C with which the fauna occurring in D6G and D6H has close connexions. At Speeton only 3 ft. 9½ in. of deposits intervene between the occurrence of the latter fauna and *T. stenomphala*. Whilst further corroborative evidence is needed from both Lincolnshire and Speeton before reliance can be placed on the thicknesses given, the implications are clear and suggest that the equivalent beds of the Spilsby Sandstone in Yorkshire are much thinner. This would be expected in a clay facies, and it follows that the successive faunas will lie closer together vertically in this reduced thickness of beds. The exact equivalent of Bed D, the principal Subcraspeditid horizon in Lincolnshire, has not been determined and is not obvious at Speeton, but if the evidence is interpreted correctly it must lie somewhere in the range D6B to D6F.

Before turning to the Russian area it will be convenient to summarize the Lincolnshire ammonite succession where the following has been definitely established:

3. *Tollia stenomphala* and *Subcraspedites sp.*
2. Principal *Subcraspedites* horizon (Bed D).
1. *Paracraspedites* with *Subcraspedites* (Bed C).

Hectoroceras has not so far been found in Lincolnshire but the recent discoveries of this genus in the Sandringham Sands (Casey 1961) augur well and may eventually lead to its discovery farther north. This would enable the vexed question of the relationships between the horizon of this genus and that of the three genera quoted above to be more accurately resolved. Casey's note suggests that search should be made within or just above the Spilsby Sandstone.

Russia. The general correspondence between the Lincolnshire fauna and that of Russia has been noted by Swinnerton (1935) and comparison is usually made with the Rjasan Beds south-east of Moscow where a condensed succession occurs. The Rjasan Horizon has been treated exhaustively by Bogoslowsky (1897) and has been discussed by many authors including Spath (1936, 1947, 1952), Maync (1949), and Arkell (1956). In general the accepted division is into an upper group of beds looked on as Lower Cretaceous and characterized by *Paracraspedites spasskensis* and a lower group which are regarded as Upper Jurassic (Volgian) and typified by *Riasanites rjasanensis*. The Paracraspeditid horizon (Bed C) of Lincolnshire is usually correlated with the *Spasskensis* Zone and the fact that *P. subtzikwinianus* which occurs in the uppermost Rjasan beds (*Spasskensis* Zone) also occurs at Speeton along with *P. stenomphaloides* in D6G confirms the general correlation of this part of the section with the Russian horizon. *Tollia wrighti*, which appears to belong to the *T. bidevexa* group, adds further confirmatory evidence, since *T. bidevexa* occurs in the same bed as *P. subtzikwinianus* (Bogoslowsky, 1902, p. 96).

In 1889 Pavlow described *Olcostephanus stenomphalus* from both Lincolnshire and the Simbirsk area of Russia and it has been customary to recognize an Upper *stenomphalus* zone in the Infravalanginian. All the evidence is in accord with this and the following may be regarded as established:

Zone of *Tollia stenomphala*	Cretaceous
Zone of *Paracraspedites spasskensis*	
Zone of *Riasanites rjasanensis*	Jurassic

In 1914 Pavlow described a large fauna from northern Siberia consisting mainly of Cardiocerates and Polyptychitids, but also including *Tollia tolli* and *T. tolmatschowi*. *T. pseudotolli* is so close to the true *T. tolli* that they can differ but little, if at all, in horizon, and at Speeton *T. stenomphala* and a species compared with *T. tolmatschowi* occur in the overlying bed. This has a considerable bearing on the postulated succession in Greenland.

Greenland. The distribution of the genus *Tollia* in Russia and England, as noted above, raises certain problems in view of the succession of faunas put forward in east Greenland where Spath (1952, p. 20) has postulated the following:

Valanginian	Polyptychites zones
	- - - - - - - - - -
'Infravalanginian'	*Tollia payeri*
	Hectoroceras zone
	Praetollia zone
	Subcraspedites
	S. (*Paracraspedites*)
Jurassic	(*Laugeites*)

In this he assumes the *Tollia payeri* zone to be generally equivalent to the Siberian *T. tolli* zone. Later (p. 33) he gives the following generalized scheme for the succession of faunas in the Boreal province:

Platylenticeras
Tollia
- - - - - - - -
Hectoroceras
- - - - - -
Praetollia
- - - - - -
stenomphalus
- - - - - -
spasskensis
- - - - - - -
- - - - - - -
rjasanensis

As shown earlier, from the nature of the suture-line *Olcostephanus stenomphalus*

Pavlow must be regarded as falling within the genus *Tollia*, and forms considered to be co-eval with *Tollia tolli* pre-date *T. stenomphala* at Speeton. It has also been shown that the genera *Paracraspedites* and *Tollia* (*T. wrighti*) coexisted at Speeton so that the recognition of a *Tollia* fauna, separated from a *Paracraspedites* fauna by *stenomphala*, *Praetollia*, and *Hectoroceras*, has no validity at Speeton. The position established at Speeton by the new data may be summarized:

4.		*Platylenticeras*	
	3.	*Tollia stenomphala*, *T.* cf. *tolmatschowi*	*Tollia* without *Paracraspedites*
3.	2.	*Tollia pseudotolli*	
	1.	*Tollia* cf. *payeri*	
2.		*Paracraspedites spp.*, *Tollia wrighti*	*Paracraspedites* with *Tollia*
1.		*Laugeites? sp.*, *Tollia wrighti*	

Thus a *Tollia* fauna, which includes the *T. stenomphala* zone, may be recognized above the *Paracraspedites* horizons. Whilst three zones or subzones based on species of *Tollia* may be recognized at Speeton, the highest of which is that of *T. stenomphala*, only further collecting and research will show if these can be maintained as separate zones. Having thus established the essential identity of the *Tollia* fauna and the *stenomphala* zone, it becomes imperative to reconsider the evidence bearing on the mutual relationships of '*Tollia payeri*', *Hectoroceras*, and *Praetollia* and the lower faunas from Greenland.

The position of the Zone of *Perisphinctes payeri* Toula

Perisphinctes payeri remains a very problematical fossil and little new can be said about its taxonomic position. On the other hand its stratigraphical position is of considerable importance, since the placing of a *Tollia* zone at the top of the Berriasian succession in Greenland depends on this species alone. Since the Speeton specimen is too small to be more than compared with Toula's species and *Tollia payeri* has not been otherwise recorded outside Greenland the whole question of Spath's placing of the *Tollia* zone turns on the Greenland evidence. Here *T. payeri* is represented by two specimens of which the type specimen is the critical one; the horizon of this specimen is, however, not known.

The *Hectoroceras* and *Praetollia* faunas

Evidence from Greenland suggests that these faunas are probably of roughly the same age (Spath 1952, p. 13; Donovan 1957, pp. 63, 69 and fig. 13) and that they overlie beds with species of *Subcraspedites* and *Paracraspedites* (Spath 1952, p. 6). They are therefore probably of post-Spasskensis Zone age, but nothing is known of their relationships with ammonites of the Stenomphala Zone. Further collecting from Bed D6Aβ at Speeton might show that some of the more finely ribbed forms at this horizon are *Praetollia* (see above under *Tollia* cf. *tolmatschowi*, and Plate 42, fig. 4), and that this genus belongs therefore to the Stenomphala Zone.

The position of beds containing *Laugeites*

Whilst this is of some importance in regard to the Greenland succession it must be reiterated that the preservation of the Speeton specimens is not good and they can only be questionably referred to this genus. The genus (first described as *Kochina*) originally came from the Lingula Bed 70 metres above the base of the Hartzfjaeld Sandstone, north of Cape Leslie in east Greenland, and was regarded as Portlandian in age. Maync (1947, pp. 29 et seq.) showed that *Laugeites groenlandica* occurred in all four sedimentation cycles recognized in the 'Haakonshytta' section in the south-west part of Kuhn Island. The uppermost cycle (IV) also yielded *Subcraspedites* associated with *Laugeites* and was considered to be definitely Infravalanginian.

Spath (1936) regarded *Laugeites* as essentially Portlandian and the same author (1946, p. 4) records the associated ammonites as *Subcraspedites* aff. *plicomphalus* (Sowerby) and *S.* cf. *stenomphalus* (Pavlow) and goes on to state that 'the block enclosing a fragment of the first named species also contains what must be a derived Jurassic *Laugeites*'. On the other hand Maync (1949, p. 28) states that:

> According to L. F. SPATH (*op. cit.*) this Cretaceous portion of the 'Hartzfjaeld Sandstone' probably overlies the Jurassic part with an unconformity.
>
> As will be shown later, the new data evidenced by the stratigraphical investigations do not support this conjecture with regard to Kuhn Island, since the boundary between the latest Jurassic and the lowermost Cretaceous runs within a cyclic sedimentary series where it is hardly admissible to assume an important break in sedimentation. Furthermore, *Laugeites* (*Kochina*) *groenlandica* SPATH is present throughout the series, also in the uppermost cycle (IV) where it is accompanied by *Subcraspedites* ex gr *plicomphalus* (Sow.)/*S.* (*Tollia*) *stenomphalus* (Pavlow) of the Infravalanginian. That *Laugeites* (*Kochina*) should have been worked up from the underlying rocks is fairly improbable as there is no trace of an erosional gap. Rather do I therefore cling to the idea already foreshown by L. F. SPATH that there is an almost complete gradation between *Dorsoplanites-Laugeites* to *Kachpurites-Craspedites*/*Subcraspedites-Polyptychites* (*vid.* SPATH 1936), in other words, these genera represent a continuous phylogenetic sequence. The occurrence of *Subcraspedites* in the top beds in *Laugeites* Ravine, even still associated with true *Laugeites* (*Kochina*), bears witness that the latter is still more closely related to the *Craspeditidae* than to the *Pavlovinae*, and that the interval between *Laugeites* (*Kochina*) and *Subcraspedites* is even less than was assumed by L. F. SPATH (*op. cit.*).

From this it would appear that *Laugeites* may be taken to range from the Portlandian into the Infravalanginian. Thus the assignment of specimens from D7 at Speeton to this genus is not inconsistent with its known stratigraphic range.

Germany. In the case of the higher D beds at Speeton comparisons are usually made with the north German successions. In Subcraspeditan times, however, the Lower Cretaceous transgression had not reached Germany and marine beds of Platylenticeratan age are found to overlie beds of Wealden facies. No comparison can thus be made in their faunal content.

France. Correlation between the type area of the Berriasian in southern France and the northern province is at present impossible. One of the latest assessments of their relationships is due to Spath (1952) and nothing new can be said at present. The author has a large collection of material from the type area of Berrias and also from Privas near Alisas at present awaiting attention. It is obvious that correlation will not be possible on the basis of the macrofauna but certain microfaunal groups hold out considerable promise of eventual correlation between the two developments.

SUMMARY AND CONCLUSIONS

The difficulties attendant on establishing a valid succession of ammonite faunas in the northern facies of the Berriasian are self-evident from the discussion above. The faunas described from the lowest beds at Speeton represent one small additional piece in what is, in effect, a complex jig-saw puzzle. The following conclusions may be drawn:

1. D6 and D7A–E are characterized by ammonites indicating a Subcraspeditan (= Berriasian or Infravalanginian) age for these beds.
2. These ammonites belong to the genera *Paracraspedites*, *Subcraspedites*, *Tollia*, and *Laugeites?* and occur at nine different horizons.
3. Specific identity is claimed with species recorded from Lincolnshire, Russia, and Greenland, the strength of the links being in that order.
4. The *Paracraspedites* fauna of Lincolnshire from Bed C of the Spilsby Sandstone corresponds with D6G and D6H, the lower limit being about the top of D7.
5. At Speeton there is a fauna of *Tollia* and *Laugeites?* below the lowest fauna recorded in Lincolnshire (*P. stenomphaloides*).
6. The lowest Spilsby Sandstone does not pre-date the lowest Speeton Clay. The reverse relationship is much more probable and would be in accord with the usual palaeogeographical reconstructions.
7. The mudstones, striped clays, and mottled beds of D6 are a different facies of the Spilsby Sandstone and may reflect different sources of supply as well as different environments.
8. Some of the Berriasian ammonites at Speeton attained a larger size than any of the same age so far recorded from Lincolnshire.
9. Lower Cretaceous ammonites have not so far been found in D5 or below D7F.
10. The ammonites in the D beds fall into three distinct faunal groups: Craspeditidae (D6–D7), Polyptychitidae (D2D–D4), and Neocomitinae (D1–D2D).
11. Whilst these beds are of Subcraspeditan age there does not appear to be a dominant development of *Subcraspedites* nor yet a typical Subcraspeditid horizon. A subdivision can be made into beds with *Paracraspedites* and *Tollia* (*spasskensis* zone) below, and beds with *Tollia* but without *Paracraspedites* (*tolli-stenomphala* zone) above.

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Location of specimens. All specimens are deposited in the collections of the Department of Geology in the University of Hull.

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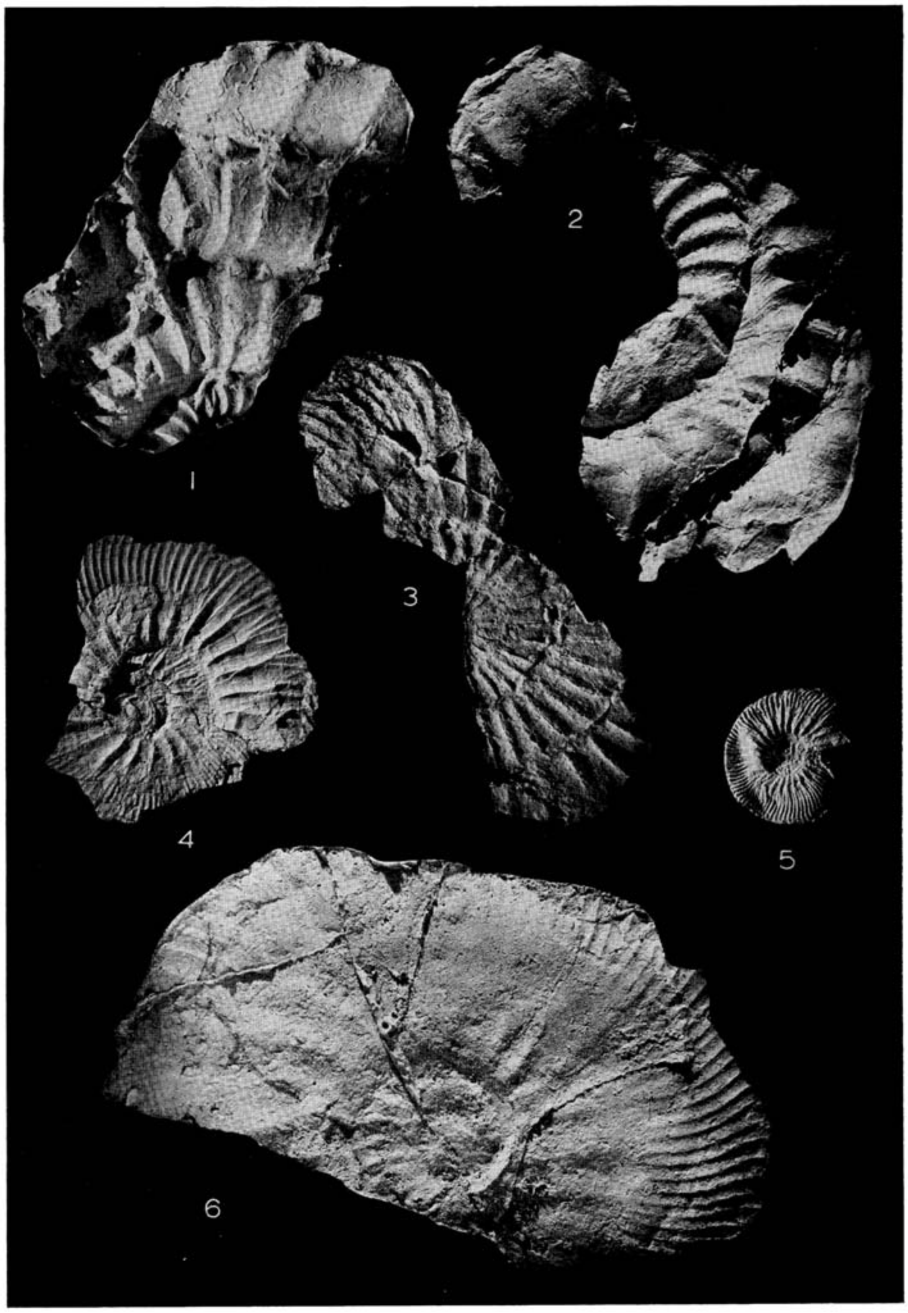
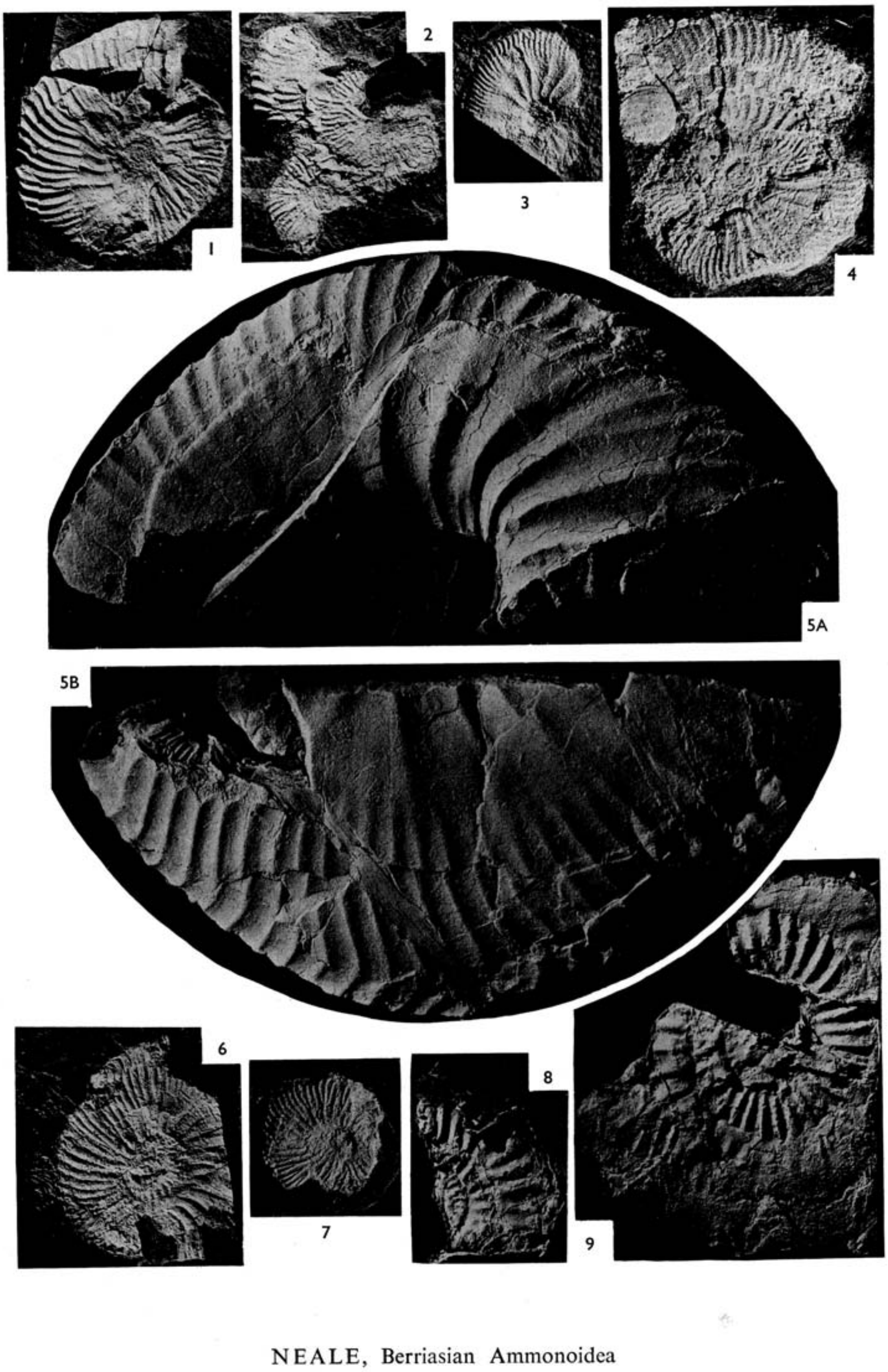


NEALE, Berriasian Ammonoidea

NEALE, Berriasian Ammonoidea



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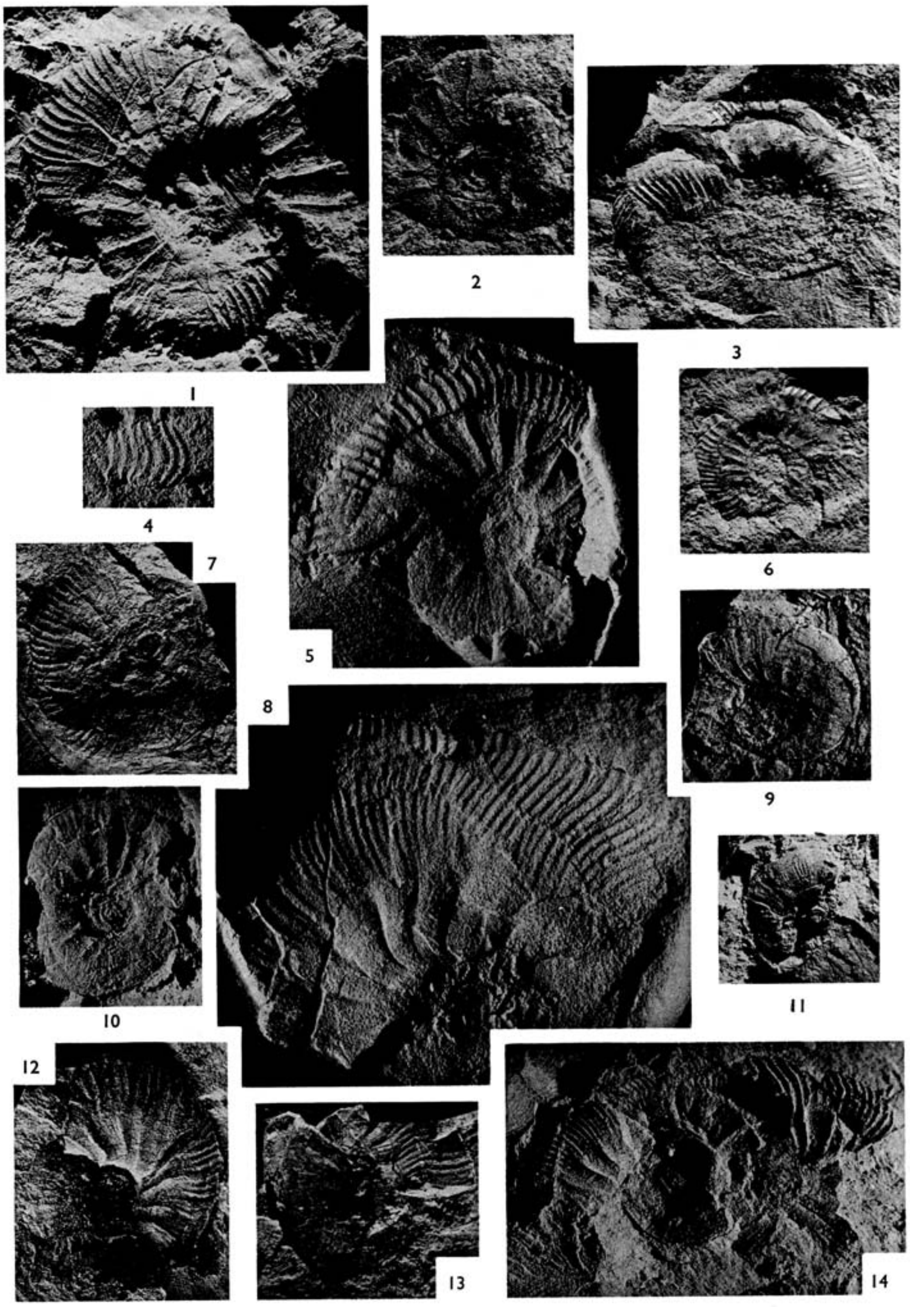

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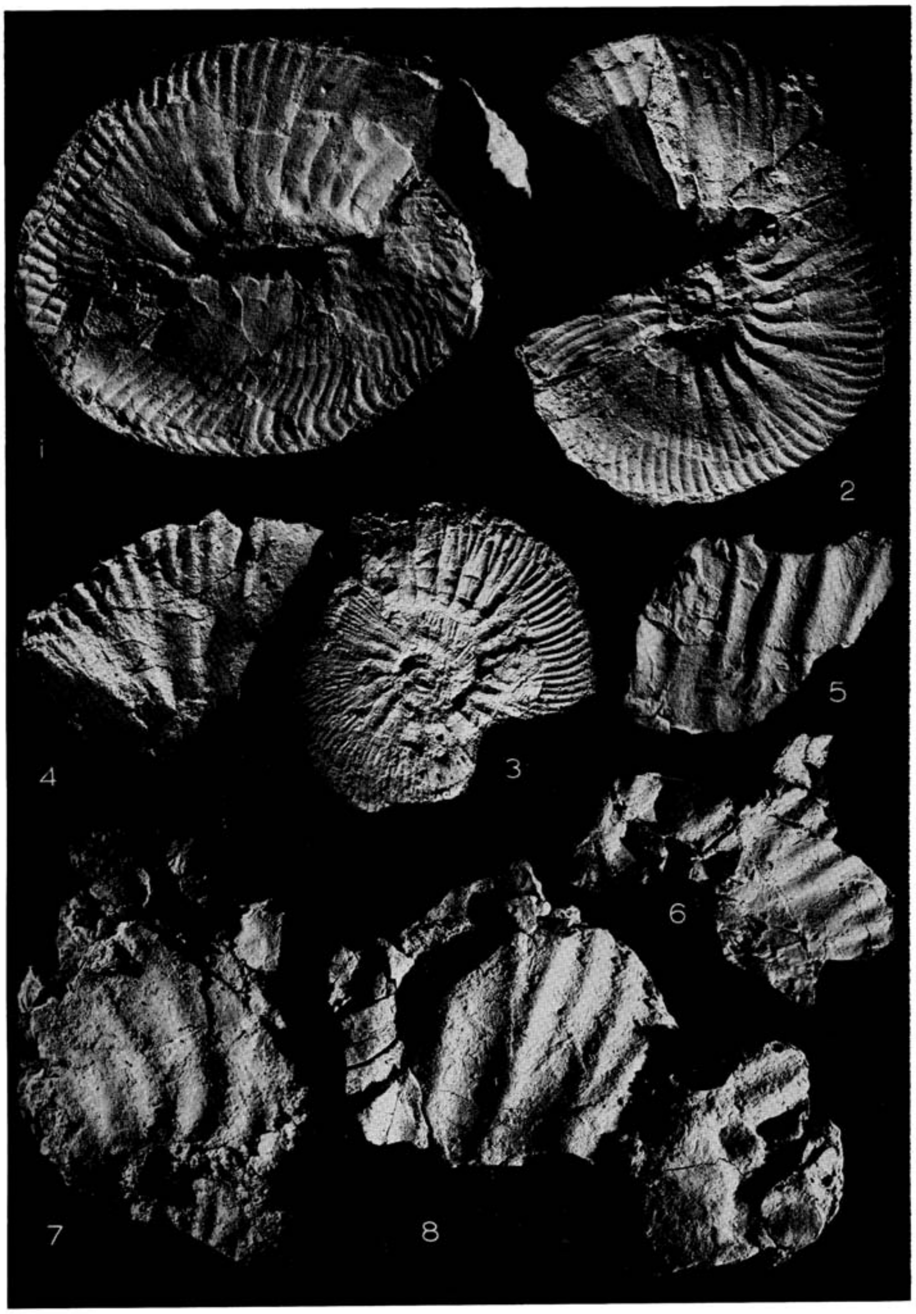

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