Reprinted from

The Boreal Lower Cretaceous

Edited by

R. Casey

and

P. F. Rawson

R. CASEY

The ammonite succession at the Jurassic-Cretaceous boundary in eastern England

The ammonite succession at the Jurassic-Cretaceous boundary in eastern England

R. Casey

Eastern England (Spilsby province) is the only region in northwest Europe where a sequence of ammonite faunas may be followed across the Jurassic-Cretaceous boundary. Ten chronozones ranging from high Middle Volgian to topmost Ryazanian (Tithonian-Berriasian) are established in the Spilsby Sandstone (Lincolnshire) and Sandringham Sands (Norfolk) and arranged in a new zonal scheme that illuminates occurrences in Siberia and eastern Europe. The basal Speeton Clay (Yorkshire) is placed high in the Ryazanian. Assimilation of the Spilsby province into the North Sea basin system was marked by the arrival in England of basal Valanginian ammonites of Russo-German affinities.

Ost England (die Spilsby Region) ist das einzige Gebiet NW Europas, in dem die Jura-Kreide-Grenze in einer Ammoniten führenden Abfolge verläuft. Zehn Chronozonen können vom hohen Mittel Wolga bis zum obersten Ryazan (Tithon-Berrias) im Spilsby Sandstone (Lincolnshire) und in den Sandringham Sands (Norfolk) unterschieden werden. Mit Hilfe dieses neuen Zonenschemas ist auch eine neue Wertung der äquivalenten Ablagerungen in Sibirien und Ost Europa möglich. Der tiefe Speeton Clay (Yorkshire) muß in das hohe Ryazan gestellt werden. Die Einbeziehung der Spilsby Provinz in das Beckensystem des Nordsee-Raumes wird gekennzeichnet durch das Auftreten von frühen Valangin-Ammoniten, die deutliche Beziehungen zu russischen und deutschen Gruppen erkennen lassen.

L'Angleterre orientale (province de Spilsby) est la seule contrée d'Europe du Nord-Ouest où une séquence faunique d'Ammonites peut être suivie de part et d'autre de la limite Jurassique-Crétacé. Dix chronozones s'échelonnant du sommet du Volgien moyen au Ryazanien le plus élevé (Tithonique—Berriasien) sont crées dans les Grès de Spilsby (Lincolshire) et les Sables de Sandringham (Norfolk) et disposées en un schéma zonal nouveau qui explicite les récoltes de Sibérie et d'Europe orientale. La base des Argiles de Speeton (Yorkshire) est placée à un niveau élevé du Ryazanien, Enfin, l'intégration de la province de Spilsby au Bassin de la Mer du Nord fut marquée au Valanginien basal par l'arrivée en Angleterre d'Ammonites d'affinités russo-germaniques.

1. Introduction

In eastern England the Kimmeridge Clay (Jurassic) is succeeded unconformably by a group of sands and clays which had long been regarded as marking the base of the British marine Cretaceous. Chief among these is the Spilsby Sandstone of Lincolnshire and its correlatives in Norfolk, the lower divisions of the Sandringham Sands. Poorly exposed, their fossils indifferently preserved, these beds have hitherto attracted little attention from palaeontologists. The age and systematic position of the few ammonites described from the Spilsby Sandstone continue to be a subject of international controversy.

Although the Sowerbys had illustrated ammonites from the Spilsby Sandstone as long ago as 1822–23, attempts to evaluate the fauna in terms of biostratigraphical correlation were not made until late in the century. It was then that A. P. Pavlov, the distinguished ammonite specialist of Moscow University, entered into collaboration with G. W. Lamplugh of the Geological Survey of the United Kingdom (now the Institute of Geological Sciences) in studying the Speeton Clay of Yorkshire and its presumed correlatives in Lincolnshire. Based on Pavlov's determinations of the ammonites (Pavlov 1889, 1896; Pavlov *in* Pavlov and Lamplugh 1892) and Lamplugh's interpretation of the stratigraphy (*ibid.* 1892; Lamplugh 1896), the conclusion was reached that the Spilsby Sandstone of Lincolnshire afforded a passage from the Jurassic to the Cretaceous. With the possible exception of Woodward (1895), who had described the Spilsby Sandstone as a marine equivalent of the Purbeck Beds, British geologists were unimpressed by Pavlov and Lamplugh's conclusions; the majority continued to take the view that the Jurassic record in eastern England was cut off abruptly in the Kimmeridge Clay and that the Spilsby Sandstone, Sandringham Sands and Speeton Clay marked the beginning of a new sedimentary cycle in the Cretaceous.

The idea that the topmost marine Jurassic with its distinctive fauna of craspeditid ammonites was missing, not only in Britain, but throughout the whole of northwest Europe, received its greatest support from the writings of Spath (1924a). This author rejected Pavlov's determination of an Upper Volgian ("Aquilonian") *Craspedites* in the Spilsby Sandstone and declared the ammonite to belong to a different genus, *Subcraspedites,* to which he referred also the Sowerbys' *A. plicomphalus*, Pavlov's *Olcostephanus stenomphalus* and certain species from the Cretaceous Ryazan Beds of the Moscow region. This position was reaffirmed in 1935, when Swinnerton described the ammonites found in two successive beds near the base of the Spilsby Sandstone in a boring at Fordington, a few kilometres north of Spilsby. Though some of the ammonites found only a few centimetres above the Kimmeridge Clay (and named *Paracraspedites*) looked remarkably like Jurassic pavloviids, their association with *Subcraspedites* and supposed similarity to forms from the Ryazan Beds were thought to establish the Cretaceous age of the assemblage. Subsequently the name *Paracraspedites* was applied to ammonites from the lowest Cretaceous of Greenland, the Moscow Basin, West Siberia, Transcaspia (Spath 1947, 1952; Donovan 1957; Sazonova 1961; Arkell 1957; Saks *et al.* 1963; Luppov and Drushchits 1958), and the Speeton Clay of Yorkshire (Neale 1962). For forty years the Spilsby Sandstone thus assumed international status as the type-horizon for the basal Cretaceous "Subcraspeditan Age" and its index-fossils. Such was the confidence with which this position was accepted that the student reading the chapter on the Jurassic-Cretaceous boundary in Arkell's monumental "Jurassic System in Britain" (1933) would be unaware that different ideas had ever been entertained.

Ten years ago I offered a short paper outlining my reasons for believing that *Paracraspedites* was merely the nucleus of a Portlandian-type pavloviid, well down in the Jurassic, and that *Subcraspedites* was also a Jurassic ammonite (Casey 1962). The views then expressed were further elaborated by a revised correlation whereby the basement-beds of the Spilsby Sandstone and Sandringham Sands were linked to the Upper Lydite Bed at the base of the Portland Beds of the southern Midlands and the newly-defined base of the marine British Cretaceous aligned with the "Cinder Beds" horizon in the middle of the Purbeck Beds, traditionally regarded as wholly Jurassic (Casey 1963). During the intervening years I have been given the opportunity to pursue this research both at home and in the U.S.S.R., picking up the threads where Pavlov and Lamplugh left off. The original museum material on which my conclusions were based has been augmented by collections from new exposures, especially in Norfolk, where excavations for waterways, roads and gas pipelines have revealed a substantial body of stratigraphical and palaeontological information (Casey 1971; Casey and Gallois 1973). In the meantime, the discovery of *Paracraspedites* in the Portland Beds of Dorset (Casey 1964), re-assessment of the Greenland occurrences of *Subcraspedites* (Donovan 1964) and independent dating of the "Cinder Beds" horizon as basal Cretaceous (Bielecka and Sztejn1966; Anderson, this volume) have confirmed the essential details of this correlation. Nevertheless, in the absence of fuller documentation and illustrations, scepticism concerning my interpretation of the ammonite chronology has been voiced in some quarters (e.g. Jeletzky 1965). In a recent authoritative work on the Jurassic-Cretaceous boundary in the Boreal Realm (Saks *et al.* 1972) the Spilsby Sandstone is still dated as wholly Cretaceous on the strength of misidentified Siberian ammonites. The first aim of the present paper is therefore to illustrate and discuss the field and laboratory evidence on which the Spilsby succession is based.

It is shown below that the Spilsby Sandstone and the equivalent parts of the Sandringham Sands contain an unexpectedly full sequence of ammonite faunas spanning the Jurassic-Cretaceous boundary. Although the sedimentary and faunal facies of these deposits are closely parallelled in the Russian Platform (Casey 1971), the sequence also combines elements of the Greenland and Siberian successions. It is thus a key sequence for international correlation and is especially critical in the present state of knowledge for integration of the classic occurrences of the Moscow region with those currently being brought to light in Siberia.

2. Stratigraphical and zonal succession

2a. Zonal classification

The observed distribution of ammonites in the Spilsby Sandstone and correlated strata in eastern England permits the division of the succession into 10 chronozones spanning the Jurassic-Cretaceous boundary, as follows:

	Substages	Chronozones
Cretaceous	Upper Ryazanian	*Peregrinoceras albidum** *Surites (Bojarkia) stenomphalus* *Surites (Lynnia) icenii**
	Lower Ryazanian	*Hectoroceras kochi* *Runctonia runctoni**
Jurassic	Upper Volgian	*Subcraspedites (Volgidiscus) lamplughi** *Subcraspedites (Subcraspedites) preplicomphalus** *Subcraspedites (Swinnertonia) primitivus**
	Middle Volgian (pars)	*Paracraspedites oppressus** *Titanites giganteus*

In view of the fact that seven of these zones (marked *) are named for the first time, it should be explained that this extended zonal sequence is not a result of splitting of previously established zones. It results from the recognition of ammonite faunas previously undescribed or wrongly placed in the succession. The scheme here presented is, in short, an amplification of knowledge of the ammonite chronology and offers a more refined instrument for both national and international correlation than hitherto. Nevertheless, the Spilsby Sandstone and its equivalents in Norfolk, the Roxham, Runcton and Mintlyn Beds, represent a condensed, marginal facies, their remanié nodule-beds reflecting numerous breaks in deposition. It is unlikely that the sequence is complete. The top of the Volgian, for example, is eroded all over the region and it is possible that neither the highest Jurassic nor the lowest Cretaceous is present. Minor breaks characterize the contacts of the *runctoni*, *kochi* and *icenii* Zones with superjacent strata.

The Upper Volgian-Ryazanian zones of the Spilsby Province are based on successive dominance of one genus or subgenus, in many cases to the exclusion of other ammonites. All these genera belong to a single boreal plexus, the Craspeditinae and their descendants (Tolliinae), and the successive faunas appear to offer examples of evolutionary progression; for example, the lineage starting with *Swinnertonia* and passing through *Subcraspedites* s.s. and *Volgidiscus* to *Runctonia* and *Hectoroceras*, and that from *Surites* (*Bojarkia*) to *Peregrinoceras*. In these circumstances the zonal scheme is more likely to reflect a true chronological sequence than is one based on heterogeneous immigrants.

The following stratigraphical section of the paper supplies the field evidence on which the zonal scheme is based. Its main purpose is to demonstrate the order of succession of the various assemblages. Where bounded by strata lacking ammonites, the limits of the zones are, naturally, arbitrary.

2b. Distribution of outcrops

The Spilsby Sandstone and its correlatives occupy a tract along the western margin of the group mapped as "Lower Greensand and Speeton Clay" on the 10 miles to 1 inch Geological Survey map on which Figure 1 is based. The whole region may be regarded as the emergent edge of a large synclinal structure ("Wolds Syncline" of Donovan 1963), the greater part of which lies below the North Sea. The outcrop falls naturally into three parts:

1. Speeton Clay (Beds E-D6) (Yorkshire), north of the River Humber.
2. Spilsby Sandstone (Lincolnshire), between the River Humber and The Wash.
3. Sandringham Sands (Roxham, Runcton and Mintlyn Beds), south of The Wash.

the name *Paracraspedites* was applied to ammonites from the lowest Cretaceous of Greenland, the Moscow Basin, West Siberia, Transcaspia (Spath 1947, 1952; Donovan 1957; Sazonova 1961; Arkell 1957; Saks *et al.* 1963; Luppov and Drushchits 1958), and the Speeton Clay of Yorkshire (Neale 1962). For forty years the Spilsby Sandstone thus assumed international status as the type-horizon for the basal Cretaceous "Subcraspeditan Age" and its index-fossils. Such was the confidence with which this position was accepted that the student reading the chapter on the Jurassic-Cretaceous boundary in Arkell's monumental "Jurassic System in Britain" (1933) would be unaware that different ideas had ever been entertained.

Ten years ago I offered a short paper outlining my reasons for believing that *Paracraspedites* was merely the nucleus of a Portlandian-type pavloviid, well down in the Jurassic, and that *Subcraspedites* was also a Jurassic ammonite (Casey 1962). The views then expressed were further elaborated by a revised correlation whereby the basement-beds of the Spilsby Sandstone and Sandringham Sands were linked to the Upper Lydite Bed at the base of the Portland Beds of the southern Midlands and the newly-defined base of the marine British Cretaceous aligned with the "Cinder Beds" horizon in the middle of the Purbeck Beds, traditionally regarded as wholly Jurassic (Casey 1963). During the intervening years I have been given the opportunity to pursue this research both at home and in the U.S.S.R., picking up the threads where Pavlov and Lamplugh left off. The original museum material on which my conclusions were based has been augmented by collections from new exposures, especially in Norfolk, where excavations for waterways, roads and gas pipelines have revealed a substantial body of stratigraphical and palaeontological information (Casey 1971; Casey and Gallois 1973). In the meantime, the discovery of *Paracraspedites* in the Portland Beds of Dorset (Casey 1964), re-assessment of the Greenland occurrences of *Subcraspedites* (Donovan 1964) and independent dating of the "Cinder Beds" horizon as basal Cretaceous (Bielecka and Sztejn1966; Anderson, this volume) have confirmed the essential details of this correlation. Nevertheless, in the absence of fuller documentation and illustrations, scepticism concerning my interpretation of the ammonite chronology has been voiced in some quarters (e.g. Jeletzky 1965). In a recent authoritative work on the Jurassic-Cretaceous boundary in the Boreal Realm (Saks *et al.* 1972) the Spilsby Sandstone is still dated as wholly Cretaceous on the strength of misidentified Siberian ammonites. The first aim of the present paper is therefore to illustrate and discuss the field and laboratory evidence on which the Spilsby succession is based.

It is shown below that the Spilsby Sandstone and the equivalent parts of the Sandringham Sands contain an unexpectedly full sequence of ammonite faunas spanning the Jurassic-Cretaceous boundary. Although the sedimentary and faunal facies of these deposits are closely parallelled in the Russian Platform (Casey 1971), the sequence also combines elements of the Greenland and Siberian successions. It is thus a key sequence for international correlation and is especially critical in the present state of knowledge for integration of the classic occurrences of the Moscow region with those currently being brought to light in Siberia.

2. Stratigraphical and zonal succession

2a. Zonal classification

The observed distribution of ammonites in the Spilsby Sandstone and c[illegible] strata in eastern England permits the division of the succession into 10 c[illegible]

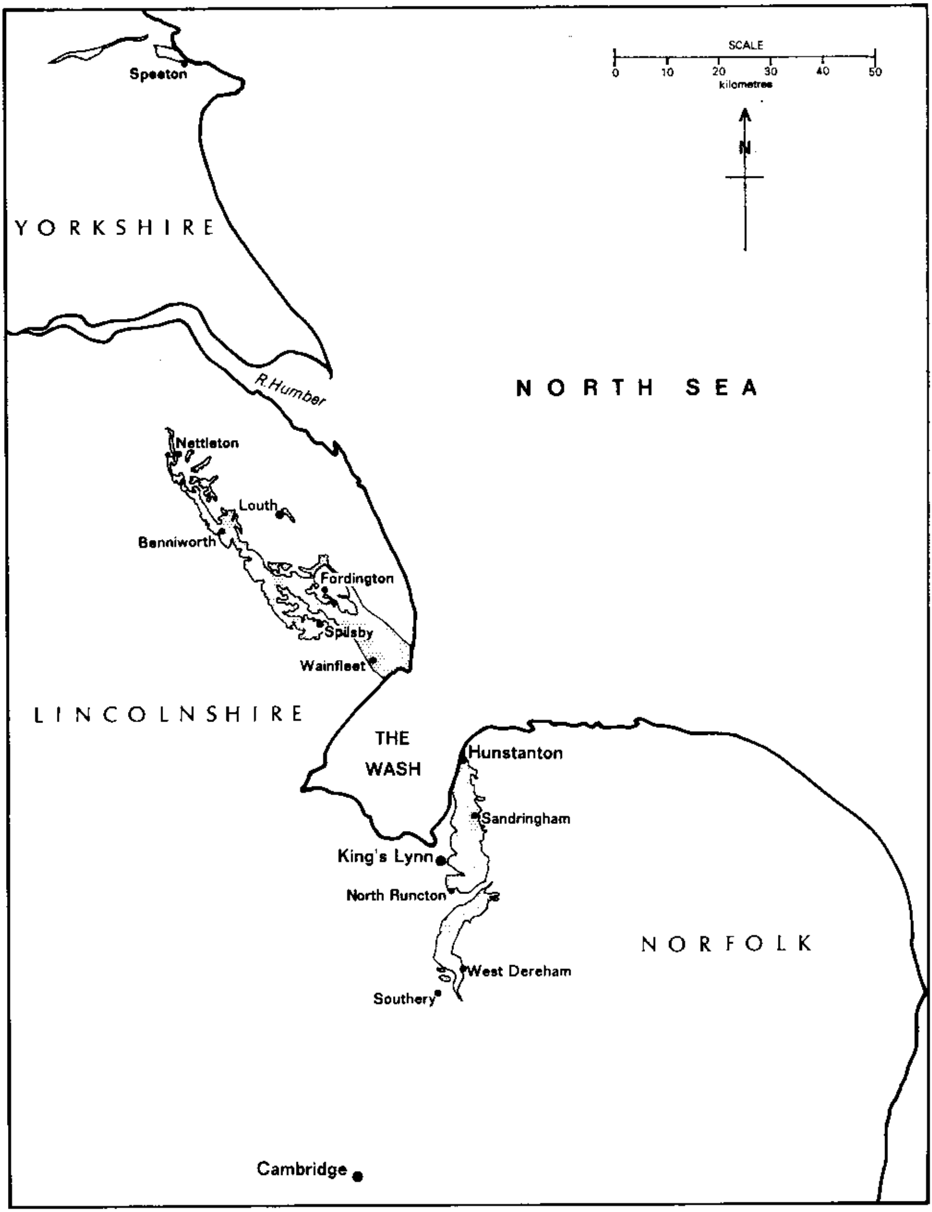


Fig. 1. Map of eastern England showing outcrop of strata between the Kimmeridge Clay and Gault/Red Chalk (based on Geological Survey 10 miles to 1 inch map).

The Speeton Clay area was marked off from areas of contemporaneous deposition to the south by an intermittently active positive region, the Market Weighton upwarp.

The lower D beds crop out for a few hundred metres along the slipped and faulted coastal section of the Speeton Clay at the southern end of Filey Bay, about 75 kilometres north of the nearest Spilsby Sandstone occurrence.

From a very narrow belt north of Caistor the outcrop of the Spilsby Sandstone widens as it trends southeastwards through Lincolnshire for another 50 kilometres, disappearing under the alluvium fringing The Wash a few kilometres beyond Spilsby. On the other side of The Wash the equivalent beds emerge as the Roxham, Runcton and Mintlyn Beds divisions of the Sandringham Sands. Their outcrop swings westwards to take up a north-south orientation across Norfolk and is traceable for about 50 kilometres to near Southery, at the southern boundary of the county.

A supposed outlier of Spilsby Sandstone at Elsham, north of Caistor, was shown by Kent and Casey (1963) to be a sandy lense in the Kimmeridge Clay (Elsham Sandstone).

2c. Sandringham Sands

An up-to-date account of the stratigraphy of the Sandringham Sands Group, with references to previous literature, is given by Casey and Gallois (1973). These authors divide the group into the following four formations, which provide a framework for discussion of the ammonite zonation:

Leziate Beds (up to 35 m) (Valanginian)	—predominantly incoherent quartz sands
Mintlyn Beds (up to 15 m) (Ryazanian)	—glauconitic clayey sands with bands of brown-weathering clay-ironstone and (especially near base) seams of phosphorite nodules
Runcton Beds (up to 2 m) (Upper Volgian)	—Bright green glauconitic clayey sands with much nodular phosphorite
Roxham Beds (up to 6 m) (Middle Volgian)	—Grey and yellow-green silty sands with pyrite. Persistent hard band at base incorporating derived Kimmeridgian debris

At the southern end of the outcrop the Ryazanian part of the sequence was probably bevelled off during the initial Valanginian transgression. More extensive erosion took place in the Aptian and Lower Albian and the beds are now truncated and overstepped southwards by the Carstone. In addition, there are ample signs of contemporaneous movements in the numerous internal erosion-surfaces, seams of phosphatic nodules and lateral variations in thickness. The most striking is the attenuation of the *kochi* Zone when traced northwards from West Dereham to King's Lynn; others are the localized distribution of the *runctoni* Zone and the areal disconformity at the junction of the Roxham and Runcton Beds (Fig. 2).

Natural exposures of the Sandringham Sands are few and knowledge of the stratigraphy has been built up over the last decade by observation of temporary openings. In the following summary of the succession the bed-numbers of Casey and Gallois (1973) have been retained.

(*i*). *West Dereham*

Excavations for the Fenland Flood Relief channel at West Dereham in 1961–2 provided an extensive section between Wissington Railway Bridge and Pratt's Bridge, Roxham (TL 662996 639995), as follows:

		Metres
LOWER GREENSAND (CARSTONE) (ALBIAN)		
Beds 19–31	Brown and grey pebbly sands and sandstone with some phosphatic nodules. Rare derived *Subcraspedites*.	c. 7·50
Bed 18	Basement-bed. Pebbles and nodules with residual crags and boulders of Mintlyn Beds. Remanié Lower Albian brachiopods and Lower Aptian ammonites; rare Hauterivian ammonites and *Hectoroceras* cf. *kochi kochi* Spath, *H.* cf. *kochi tenuicostatum* Spath, *H.* cf. *kochi magnum* Spath, *H. larwoodi* sp. nov. enclosed in nodules.	*0·025 to 0·20*
MINTLYN BEDS (LOWER MINTLYN BEDS)		
Hectoroceras kochi Zone		
Beds 7–17	Glauconitic, sandy clay with bands of reddish-brown clay-ironstone and a few phosphatic nodules and lignite. Bivalves (mostly *Neocrassina* and *Myophorella*) abundant. *Hectoroceras kochi kochi*, *H.* cf. *kochi tenuicostatum*, *H.* cf. *kochi magnum*, *H.* spp. nov. (*Borealites* (*Borealites*) cf. *fedorovi* Klimova in bed 16).	6·00 to 6·45
Bed 6	Basal Cretaceous nodule-bed. Thickly clustered black phosphatic nodules (derived from destruction of Runcton Beds) in green sandy clay; fossil wood, remanié bivalves and ammonites—*Subcraspedites* (*S.*) *sowerbyi* Spath, *S.* (*S.*) *preplicomphalus* Swinnerton, *S.* (*S?*) *claxbiensis* Spath, *S.* (*S.*) spp. nov., *S.* (*Volgidiscus*) *lamplughi* Spath, *S.* (*V.*) spp. nov., *Craspedites* sp. Friable brown nodules with *Hectoroceras* spp. nov. and *Borealites*? sparsely distributed at top of bed. Channelled into Roxham Beds below.	0·15 to 0·30
ROXHAM BEDS		
Paracraspedites oppressus Zone		
Beds 2–5	Grey-green, glauconitic, silty sands with pyritic nodules. *Paracraspedites oppressus* sp. nov., *P. stenomphaloides* Swinnerton, *P.* cf. *bifurcatus* Swinnerton, *P.* spp. indet., *Glottoptychinites? trifurcatus* (Swinnerton).	3·00 to 3·50
Bed 1	Grey, pyritic and glauconitic sandstone with derived Kimmeridgian *Pavlovia* and lydite pebbles at base.	0·15

(ii). North Runcton

The following section was measured in the No. 2 Gas Feeder Main trench at Manor Farm, North Runcton (TF 6515 1555):

		Metres
UPPER MINTLYN BEDS		
Bed 13	Lilac-grey clay with glauconitic "rafts" seen	1·00
Surites (*Lynnia*) *icenii* Zone		
Bed 12	Buff and grey phosphatic nodules in grey-green, glauconitic sandy clay. *Surites* (*Lynnia*) *icenii* sp. nov. *S.* (*L.*) spp. nov.	0·05 to 0·10
Bed 11	Buff, sandy clay-ironstone. *Surites* (*Lynnia*) spp. nov.	0 to 0·10
Beds 9–10	Grey sandy clay with clay-ironstone at base.	0·45 to 0·55
LOWER MINTLYN BEDS		
Hectoroceras kochi Zone		
Bed 8	Small phosphatic nodules clustered in glauconitic sandy clay. *Hectoroceras* sp.	0·05 to 0·10
Bed 7	Dark green, glauconitic, sandy clay.	1·00
Runctonia runctoni Zone.		
Bed 6	Basal Cretaceous nodule bed. Gritty phosphatic nodules in glauconitic clayey sand. Irregular base. Ammonites in three types of preservation, (i) indeterminable shards of irridescent shell (? *Runctonia*), (ii) black phosphorite with traces of irridescent shell (*Runctonia runctoni* sp. nov., *R.* spp. nov., *Subcraspedites* (*Volgidiscus*) sp. nov)., (iii) black phosphorite only (*Subcraspedites* (*V.*) sp. nov.)	0·10 to 0·15

RUNCTON BEDS		
	Subcraspedites (Volgidiscus) lamplughi Zone	
Bed 5	Vivid green glauconitic clayey sand.	0·15
Bed 4	Friable brown phosphatic nodules. *Subcraspedites (V.) lamplughi S. (V.)* spp. nov.	0·025 to 0·10
Bed 3	Dark green glauconitic clayey sand	0·75
	Subcraspedites (Subcraspedites) preplicomphalus Zone	
Bed 2	Rough black phosphatic nodules. *Subcraspedites (S.)* cf. *sowerbyi.*	0·15
ROXHAM BEDS		

In this area the Roxham Beds may reach a thickness of 6–7 metres. The basal hard band, with *Paracraspedites*, was exposed in the No. 4 Gas Feeder Main trench (TF 6505 1710) about 1·9 kilometres north of the Manor Farm site. At Constitution Hill, 2 kilometres to the northwest, beds 5 and 6 of the Manor Farm section are combined into a single band of nodules at the base of the Mintlyn Beds (Casey and Gallois 1973).

(*iii*). *The King's Lynn Bypass*

A very important section through the Mintlyn Beds was made accessible during excavations for the King's Lynn Bypass in 1964, when the following was measured:

800 m N 40 W of Church Farm, Bawsey (TF 6563 2089)

		Metres
	Peregrinoceras albidum Zone	
	Buff clay-ironstone with brown weathered crust. *Peregrinoceras* sp. nov., *P.* cf. *albidum* sp. nov., *P.* cf. *pseudotolli* (Neale).	0·30
	Yellow-green clayey sand seen	0·60
Gap	... ... estimated	3·00

Western end of Galley Hill, west of Mintlyn Wood (TF 6508 1987–TF 6530 2010)

Beds 14–18	Buff, slightly glauconitic, clayey sands with clay-ironstone bands.	4·05
	Surites (Bojarkia) stenomphalus Zone	
Bed 13	Dark grey, glauconitic sandy clay with vivid green sandy bands.	1·60
Bed 12	Buff clay-ironstone. *Surites (Bojarkia) stenomphalus* (Pavlov), *S. (B.)* sp.	0·1 to 0·20
Bed 11	Glauconitic sands and clays with carbonized wood.	0·45 to 0·60
Bed 10	Lenses (up to 1 m.) of clay-ironstone with carbonized wood; fossils plentiful, mainly bivalves. *Surites (Bojarkia) tealli* sp. nov. *S. (B.)* spp.	0·15 to 0·20
Beds 7–9	Glauconitic sands and clays with *Chondrites*-type burrows and clay-ironstone in bands and "doggers". Indeterminable Tolliinae.	4·65 to 4·85
	Surites (Lynnia) icenii Zone	
Bed 6	Black, rolled phosphatic nodules resting on irregular surface of bed below. *Surites (Lynnia) icenii* sp. nov., *S. (L.)* spp. nov., *S. (Bojarkia)* sp.	0·05
Bed 5	Putty-coloured, sandy, clay-ironstone with semi-phosphatized knobs on upper surface. *Surites (Lynnia)* sp. nov.	0·10 to 0·20
Bed 4	Blue-green glauconitic clayey sand.	0·40
	Hectoroceras kochi Zone	
Bed 3	Small black and brown phosphatic nodules, much abraded, crowded in dark green clayey sand. *Hectoroceras* cf. *kochi*, *H.* spp. indet., *Borealites* sp. juv.?, in small fragments.	0·15 to 0·20
Beds 1–2	Brown and buff clayey sands, becoming greener below.	0·65

Ammonites being lacking in beds 13–18 of this section, the boundary between the *albidum* and *stenomphalus* Zones is drawn at an arbitrary level. Excavations on the nearby Fairstead Estate (TF 6430 1945) permitted the succession to be followed downwards through the basal Cretaceous nodule-bed, Runcton Beds and Roxham Beds to the Kimmeridge Clay. Here the basal hard bed of the Roxham Beds yielded fragmentary *Paracraspedites*. Only rolled *Subcraspedites* (*Volgidiscus*) spp. were found in the limited exposure of the basal Cretaceous nodule-bed, suggesting a condensed and reworked *lamplughi-runctoni* horizon as seen at Constitution Hill. From the single line of nodules which represents the tail-end of the *kochi* Zone at Castle Rising, 6 km N.E. of King's Lynn, W. Whitaker collected *Hectoroceras* cf. *kochi* during the original survey in 1883. Erratic blocks of basal Roxham Beds/Spilsby Sandstone are particularly abundant in the Drift deposits capping the massive British Industrial Sand pits at Leziate (Bawsey) (TF 675193). These have yielded *Paracraspedites oppressus* sp. nov., *P. stenomphaloides*, *P.* cf. *bifurcatus*, *P.* spp nov., *Glottoptychinites? trifurcatus*, the belemnite *Acroteuthis*, the brachiopod *Rouillieria ovoides* (J. Sowerby) and a rich assemblage of bivalves, largely undescribed.

2d. Spilsby Sandstone

The name Spilsby Sandstone was used by Strahan (1886) for the group of strata between the Kimmeridge Clay and the Claxby Beds of Lincolnshire which Dikes and Lee (1837) had called "Greensand and Sandstone" and Judd (1867) "Lower sand and sandstone". This usage anticipated the formal proposition of the name by Jukes-Browne in the Geological Survey Memoir of 1887. The group has its fullest development in the southern part of the Wolds, where, mainly on the evidence of boreholes and road-cuttings, Swinnerton (1935, 1936) recognised a tripartite division, as follows:

$$\text{Spilsby Sandstone} \quad \begin{cases} \text{Ferruginous Grit} & 1\text{ m} \\ \text{Glauconitic Sands} & 22\text{ m} \\ \text{Basement Beds} & 1\text{ m} \end{cases}$$

Casey (1963) divided the group into a Lower Spilsby Sandstone and an Upper Spilsby Sandstone, taking as the dividing-line an important bed of nodules and pebbles (Mid-Spilsby nodule-bed)[1] about the middle of Swinnerton's Glauconitic Sands, first found by Dr. R. G. Thurrell. The stratigraphical classification used hereunder is as follows:

Upper Spilsby Sandstone	
5. Ferruginous Grit	Coarse, grey or brown pebbly sandstone with some iron-ooliths.
4.	Fine- to medium-grained buff, yellow and white sands with sparse calcreted "doggers", becoming coarser and greener near base.
3. Mid-Spilsby nodule-bed	Band of phosphatic nodules of several generations, with small pebbles, mostly chert.
Lower Spilsby Sandstone	
2.	Predominantly coarse, pebbly glauconitic sands and sandstone with calcreted "doggers". Few phosphatic nodules, mostly at top.
1. Basement-beds	Grey sandstone with phosphatic nodules. (Beds A-D of Swinnerton 1935).

[1]In its original connotation (Casey 1963) the term Mid-Spilsby nodule-bed was extended to include the Basal Cretaceous nodule-beds of the Mintlyn Beds.

The Mid-Spilsby nodule-bed may be traced throughout the whole of the southern Wolds and was located in the IGS Skegness borehole (TF 5711 6398). Important changes in the succession take place along the outcrop, the whole of the Upper Spilsby Sandstone disappearing north of Tealby (Fig. 2). Where the Upper Spilsby Sandstone is developed, in the southern Wolds, its junction with the Claxby Beds (Hundleby Clay facies) is perfectly conformable and in places gradational. Erosion of the Lower Spilsby Sandstone must have commenced in the Ryazanian and continued in the Valanginian. During the Carstone transgression (Lower Albian) the Lower Spilsby Sandstone was denuded down to its base at the northern end of the outcrop.

Except for the calcite guards of belemnites, fossils are generally poorly preserved in these beds, the ammonites of the lower horizons being especially prone to distortion. Most of the older museum material was obtained from small quarries now defunct or from the spoil of the Bardney-Louth railway cutting and is invariably without precise stratigraphical data.

A key section through the Spilsby Sandstone was provided by a series of wells sunk for Boston Corporation Waterworks at Fordington, about 8 kilometres north of Spilsby (TF 416714), mostly by wells No. 1 and No. 2, sunk 3 metres apart in 1933 and 1934 respectively. Drilling commenced at 51·2 metres O.D. and the Spilsby Sandstone (about 22 m thick) was entered at depths of about 52 metres. The following summarized log combines information from both these wells and has been compiled from published sources (Swinnerton 1935, 1941), together with Swinnerton's palaeontological samples deposited in the British Museum (Natural History), the Institute of Geological Sciences and the Department of Geology, University of Nottingham, and specimens and data collected independently by the Borings Department of I.G.S.

CLAXBY BEDS		
UPPER SPILSBY SANDSTONE		
Peregrinoceras albidum Zone		Metres
Bed 12	Ferruginous Grit. Hard grey ferruginous sandstone, coarse and pebbly. *Peregrinoceras albidum* sp. nov.	0·90
Bed 11	Grey clayey sand with marcasite	2·75
Bed 10	Hard grey glauconitic sandrock. *P. albidum*, *P.* cf. *wrighti* (Neale), *P.* sp., *Surites* (*Bojarkia*) sp.	4.10
Surites (*Bojarkia*) *stenomphalus* Zone		
Bed 9	Fine to medium-grained, glauconitic, grey clayey sands with calcreted "doggers". *Surites* (*Bojarkia*) cf. *stenomphalus*	3·20
Surites (*Lynnia*) *icenii* Zone		
Bed 8	Mid-Spilsby nodule-bed. Coarse, pebbly sand with phosphatic nodules, partly indurated. *Surites* (s.l.). sp.	0·60
LOWER SPILSBY SANDSTONE		
? *Subcraspedites* (*Volgidiscus*) *lamplughi* Zone		
Bed 7	Coarse glauconitic and pebbly sands becoming finer below	0·90
Subcraspedites (*Subcraspedites*) *preplicomphalus* Zone		
Bed 6	Glauconitic, pyritous grey sand with calcreted "doggers". *Subcraspedites* (*S.*) *sowerbyi* (coarse form), *S.* (*S.*) spp. in "doggers".	5·65
Bed 5	Loose grey sand.	2·75
BASEMENT-BEDS		

	Subcraspedites (Swinnertonia) primitivus Zone	
Bed 4	Hard grey calcareous sandstone, richly fossiliferous, fossils partly phosphatized. *Subcraspedites (Swinnertonia) cristatus* Swinn., *S. (Sw.) precristatus* Swinn., *S. (Sw.) primitivus* Swinn., *S. (Sw.) undulatus* Swinn., *S. (Sw.) subundulatus* Swinn. *S. (Sw.) parundulatus* Swinn., *S. (Sw.)* sp. nov. (= *S* aff. *subpressulus* Swinn. *non* Bogoslovsky).	0·30
Bed 3	Friable grey argillaceous sandstone with small phosphatic nodules. *Subcraspedites (Sw.)* cf. *cristatus*, *S. (Sw.)* cf. *intermedius* (Donovan), *S. (Sw.)* sp. juv. ("*preplicomphalus*" Swinnerton 1935 pl. iii fig. 2*a–b*, *non* fig. 1a), Gen. nov.? (between *Subcraspedites* and Dorsoplanitidae) spp. nov.	0·10
	Paracraspedites oppressus Zone	
Bed 2	Friable grey sand and sandrock, passing down into hard calcareous sandstone. *Paracraspedites oppressus* sp. nov. *P. stenomphaloides*, *P. bifurcatus*, *P.* spp. nov., *Glottoptychinites? trifurcatus*.	0·30
	Titanites giganteus Zone	
Bed 1	Band of black lydite pebbles and phosphatic nodules in hard grey sandstone. Burrows descend into bed below. Rolled Kimmeridgian *Pavlovia*. *Kerberites* cf. *kerberus* Buckman in grey phosphorite.	0·15
	Total	c. 22·00

KIMMERIDGE CLAY

(In the above section Bed 1 = Bed A and lower part of Bed B of Swinnerton 1935; Bed 2 = lower part of Swinnerton's Bed C and upper part of his Bed B; Bed 3 = upper part of his Bed C; Bed 4 = his Bed D).

The Basement-beds may be seen in the Lymn Valley, whence Dr. R. G. Thurrell collected from the basal nodule-bed *Kerberites* cf. *kerberus* and *Kerberites* sp. (in a grey sandy-clay phosphorite with nacreous test) along with the usual Kimmeridgian debris. *Subcraspedites (Sw.) cristatus* was also found. These beds, together with the lower part of the *preplicomphalus* Zone, were exposed in a road-cutting at Blue Hill, Partney, about 1·2 kilometres north of Spilsby (TF 401 675) (Oakley 1941). In addition to fossils of the *oppressus* and *primitivus* Zones, the following ammonites from the overlying "doggers" of the *preplicomphalus* Zone were collected by Swinnerton, Oakley and others: *Subcraspedites (S.) sowerbyi*, *S. (S.)* cf. *claxbiensis*, *S. preplicomphalus*, *S. (S)*. sp. nov., and *Craspedites plicomphalus* (J. Sowerby). A similar assemblage has been found in old quarries and roadside exposures at Spilsby, Old Bolingbroke, Toynton, Holton, Salmonby and West Keal. In the southern Wolds the *lamplughi* Zone appears to be preserved only locally beneath the plane of erosion marked by the Mid-Spilsby nodule-bed. The complex character of this bed is clearly illustrated in the old quarry east of the Manor House (formerly The Rectory) at Winceby, near Horncastle (TF 321687). Here, a band of phosphatic nodules and pebbles, about 0·3 metres thick, rests on the guttered surface of the Lower Spilsby Sandstone (Fig. 2). The nodules yield fairly well-preserved *Subcraspedites (S?) claxbiensis* and *S. (S.)* cf. *sowerbyi* either in fragments in light-brown phosphorite or enclosed in friable whitish phosphorite. *Subcraspedites (Volgidiscus) lamplughi* occurs in rolled fragments, while *Surites (Lynnia) icenii*, *Surites (Surites)* cf. *spasskensis* (Nikitin) and *Surites* spp. are found in brown phosphorite, fragmentary, but with relatively slight abrasion. Unphosphatized *Surites* fragments occur in the matrix of the nodules, together with *Pholadomya* and other bivalves, the whole *mélange* representing an intensive episode of bottom-scour at the beginning of the Upper Ryazanian.

Outcropping crags in the fields northeast of Goulceby (TF 260797) yield *Subcraspedites* (*S.*) cf. *claxbiensis* and *Craspedites thurrelli* sp. nov. at an estimated 3 metres from the base of the formation, followed upwards by a horizon with phosphatized *Subcraspedites* (*Volgidiscus*) aff. *lamplughi*.

The best exposure of the Spilsby Sandstone and Claxby Beds in this area is found along the disused railway cutting between Benniworth and Donington-on-Bain, where the section detailed below may be examined in two high banks (TF 224825; 227824):

		Metres
CLAXBY BEDS (HUNDLEBY CLAY)		
Bed 11	Deeply weathered brown clay — seen	2·00
Bed 10	Buff rubbly iron-shot clay crowded with fossils, mostly bivalves.	0·57
Bed 9	Brown clay with iron-ooliths, streaks of iron-pan at top. [Presumed source of *Paratollia* cf. *kemperi* sp. nov., *Propolyptychites* sp. and *Pseudogarnieria* ("*Proleopoldia*") cf. *kurmyschensis* (Stchirowsky).]	0·60
Bed 8	Brown clay	0·24
Bed 7	Soft blue clay, yellow and brown weathering. Slip-plane at base.	0·28
UPPER SPILSBY SANDSTONE		
Bed 6	Pale yellowish (in places almost white) medium-grained sand, patchily cemented into sandrock; sparse calcreted "doggers". Source of *Surites* (*Bojarkia*) *stenomphalus*, *S.* (*B.*) *suprasubditus pavlovi* subsp. nov., *S.* (*B.*) spp. nov., *Buchia volgensis* (Lahusen). — estimated	7·50
Bed 5	Coarse, pebbly ferruginous sandstone.	0·20
Bed 4	Medium-grained, yellow-brown sandrock.	0·24
Bed 3	Band of small quartz and chert pebbles.	0·05
Bed 2	Mid-Spilsby nodule-bed. Conspicuous band of small pebbles (mostly black and white chert) and phosphatic nodules, locally cemented into lumps.	0·10
LOWER SPILSBY SANDSTONE		
Bed 1	Coarse, pebbly sands and sandstone with scattered small pebbles of black chert; decalcified "doggers" full of *Entolium* near base; line of incipient whitish phosphatic nodules with *Subcraspedites* 0·15 metres from top. — seen	2·50

Apart from belemnite phragmocones the Mid-Spilsby nodule-bed contains few fossils at this locality; phosphatic nodules are less in evidence than at Winceby, 16 kilometres to the southeast, and contact with the underlying sands is more regular.

This section and its fossils were mentioned briefly by H. Keeping (1882) and W. Keeping (1883 p. 64) and is of importance as the source of two ammonite faunas otherwise poorly known in Lincolnshire. Attributed variously to "Donington", "Benniworth", "Benniworth Haven" or "Little Benenden", the rich haul of fossils obtained from this railway cutting in the last century includes a suite of ammonites from near the base of the Claxby Beds [*Paratollia*, *Pseudogarnieria* ("*Proleopoldia*"), *Propolyptychites*] and another from the calcareous "doggers" of bed 6 (*stenomphalus* fauna). The lectotype of *Surites* (*Bojarkia*) *stenomphalus* (Pavlov), labelled as from Donington, almost certainly came from here. Other localities which yielded the *stenomphalus* fauna to the early collectors are North Willingham, South Willingham and Tealby.

Owing to the slipped or faulted junction with the Claxby Beds, the Ferruginous Grit cannot be observed in this cutting, though it was seen by Dr. Thurrell in the roadside bank south of Asterby (TF 263789), where it yielded *Peregrinoceras* cf. *wrighti*. This horizon underlies the gravel-pits at Biscathorpe, about 2½ kilometres north of the Benniworth cutting, and unusually well-preserved fossils, including the ammonites *Surites* (*Bojarkia*) sp. nov., *Peregrinoceras albidum* sp. nov., *P. subpressulum* (Bogoslovsky) and allies, in a grey-green, pebbly, argillaceous matrix, are occasionally brought to the surface by the excavators. *Peregrinoceras* cf. *pseudotolli* (Neale) and congeneric forms occur in the clay-ironstone at the bottom of the Hundleby Clay in the old brickyard at East Keal (TF 370638). The same fauna, in a Hundleby Clay lithology, was found at an unspecified locality in the Wainfleet area.

A new sandpit opened at Nettleton Top Barn, southwest of Caistor (TF 108988), examined in collaboration with Mr. S. Kelly, gave a complete section through the Lower Spilsby Sandstone, as detailed below. The non-sequential junction with the Claxby Ironstone could be observed in trial trenches in the adjacent fields.

		Metres
CLAXBY BEDS (CLAXBY IRONSTONE)		
Bed 7	Basement-bed. Conglomerate of small quartz, lydite and derived phosphatized pebbles set in coarse sand and buff marl, pocketed into bed below. Abundant bivalves. up to	0·30
LOWER SPILSBY SANDSTONE		
	Subcraspedites (*Volgidiscus*) *lamplughi* Zone	
Bed 6	Coarse, pebbly, yellow-brown sands with partly decalcified "doggers" (up to 1 m); irregular top, about *Subcraspedites* (*Volgidiscus*) *lamplughi* Spath, *S.* (*V.*) spp., *S.* (*Subcraspedites*) sp. trans. to *Volgidiscus*.	2·50
	Subcraspedites (*Subcraspedites*) *preplicomphalus* Zone	
Bed 5	Coarse, pebbly, yellow-green sands with "carstone" in seams, concretions and interlaced veins.	3·80
Bed 4	Yellow-green, clayey sands with iron-cemented "doggers"	0·30
	Subcraspedites (*Swinnertonia*) *primitivus* Zone	
Bed 3	Band of grey-green and yellow-green, red-weathering, argillaceous sandstone with small pebbles, mostly in nests, and grey-buff-pinkish phosphatic nodules. *Subcraspedites* (*Sw.*) *primitivus*, S. (*Sw.*) *undulatus*, *S.* (*Sw.*) *subundulatus*, *S.* (*Sw.*) *precristatus*.	0·90 to 1·00
Bed 2	Grey-green clayey sands with sparse buff phosphatic nodules. ? *S.* (*Sw.*) *primitivus* (large fragments), *S.* (*Sw.*) *cristatus* (loose on tip).	1·10
	Titanites giganteus Zone	
Bed 1	Basement-bed. Grey-green, brown-weathering sandy clay with black and brown, white-skinned phosphatic nodules, some cemented into clotted masses by blue-grey, gritty phosphorite. *Kerberites* cf. *kerberus* and *Crendonites* sp. in matrix of cementing agent. *Pavlovia* spp., *Pectinatites* spp. in rolled fragments.	0·15
KIMMERIDGE CLAY		

The Zone of *S.* (*S.*) *preplicomphalus* appears to be represented here mainly by unfossiliferous sands and the *oppressus* Zone is lacking altogether. Between Caistor and Melton Ross the Carstone (Lower Albian) incorporates in its pebbly base phosphatized *Subcraspedites* (*Subcraspedites*) spp. and *S.* (*Volgidiscus*) spp., together with debris from the Spilsby Sandstone Basement-beds (rolled *Pavlovia* etc.). Judging by its matrix, the holotype of *S. claxbiensis* Spath (1936 p. 85) originated from the basal Carstone rather than from the Claxby Beds.

2e. Speeton Clay

The clays of the Speeton Cliffs in Filey Bay, on the Yorkshire coast, provide the most complete and best documented single section of the Lower Cretaceous in northwest Europe. Reviews of previous work on this important exposure have been published by Lamplugh (1924) and Swinnerton (1936). It will be unnecessary, therefore, to re-trace the history of controversy concerning the age of the basal beds and their relationship to the Spilsby Sandstone. Suffice to say that Spath's (1924a) assertion that the lowest ammonite bearing beds of the Speeton Clay are Cretaceous is upheld by the present investigation, while his view that these beds are younger than the Spilsby Sandstone requires only slight qualification. The discovery of Berriasian (Ryazanian) ammonites in the lower D beds of Speeton was reported by Neale (1962). He described and illustrated a large assemblage of crushed specimens under the generic names *Laugeites?*, *Paracraspedites, Subcraspedites* and *Tollia.* These were obtained from an interval about 3 metres thick (Beds D6–7) 0·8 metres above the basal nodule-bed ("Coprolite Bed") and 2·12 metres below Bed D4, with rare *Platylenticeras.* Neale believed that the vertical distribution of the ammonites showed a division into two horizons, beds with *Paracraspedites* and *Tollia* below and beds with *Tollia* but without *Paracraspedites* above. Furthermore, the evidence was thought to confirm that *Tollia tolli* pre-dated the *stenomphalus* fauna (as indicated in Spath's zonal table of 1924).

The Speeton fauna of Neale was listed and discussed briefly by Saks and Shulgina (1972 p. 94). Despite the crucial nature of this fauna in the Spilsby Sandstone controversy, no attempt was made by these authors to undertake a systematic revision of the ammonites in question, Neale's species merely being quoted under a more modern generic nomenclature. Saks and Shulgina's conclusion from these ammonites that Beds D6–D8 correspond roughly with the Siberian zones of *Bojarkia mesezhnikowi* and *Surites analogus* does not accord with my own reading of the evidence. More unfortunate is their unqualified acceptance of the records of *Paracraspedites* and *Subcraspedites* from the lower D beds in support of a Berriasian age for these genera.

Neale's original identifications of these lower D beds ammonites are tabulated here against Saks and Shulgina's revised nomenclature and my own determinations (Table 1). It will be seen that apart from a few specimens referred (mostly with reservation) to *Surites* (*Bojarkia*), all generally determinable ammonites are now identified as species of *Peregrinoceras.* In my opinion the whole assemblage belongs to the Tolliinae; there are no craspeditids in the strict sense, let alone dorsoplanitids such as *Laugeites.* In general aspect this lower D beds fauna can be matched in the *albidum* Zone at the very top of the Ryazanian. In terms of the Lincolnshire succession its position falls at the junction of the Spilsby Sandstone and the Hundleby Clay (Fig. 2).

2f. Summary of zonal succession

(*i*). *Relationship with underlying strata:* Titanites giganteus *Zone.*

Everywhere the Spilsby Sandstone and Sandringham Sands rest on the Kimmeridge Clay with a seam of nodules, rolled fossils and lydite pebbles at the junction. The fossils in this junction-bed are mostly ammonites. In the Sandringham Sands area (Norfolk) only the genus *Pavlovia* has yet been found, indicative of the highest horizons of the Kimmeridge Clay, and these are in a phosphatized mudstone mode of preservation consistent with their origin in an argillaceous environment. In Lincolnshire the faunal content at the bottom of the Spilsby Sandstone is more complex. Here, in addition to the usual Kimmeridgian debris, are Portlandian (Middle Volgian) fossils, among which Spath (1947) identified from Nettleton the ammonites *Crendonites* and *Kerberites.* Examples of *Kerberites* have been collected

Neale 1962	*Saks and Shulgina 1972*	*Casey this paper*	*Horizon*
Laugeites ?	—	Tolliinae indet.	D7A, 7B, 7E.
Paracraspedites stenomphaloides Swinn.	*Paracraspedites stenomphaloides* Swinn.	Tolliinae juv. ? *Surites* (*Bojarkia*)	D6H, 6G.
Paracraspedites prostenomphaloides Neale	—	*Peregrinoceras prostenomphaloides* (Neale)	? D7A.
Paracraspedites subtzikwinianus (Bogosl.)	*Surites* (*Surites*) *subtzikwinianus* (Bogosl.)	*Surites* (*Bojarkia*) sp.	D6G.
Subcraspedites preplicomphalus Swinn.	*Subcraspedites* (*Swinnertonia*) *preplicomphalus* Swinn.	*Peregrinoceras* sp. nov.	D6Aδ, D6G–H.
Subcraspedites aff. *cristatus* Swinn.	—	*Peregrinoceras* sp. nov.	D6I.
Subcraspedites sp.	*Subcraspedites* sp.	*Peregrinoceras* sp. nov.	D6Aδ.
Tollia wrighti Neale	*Tollia wrighti* Neale	*Peregrinoceras wrighti* (Neale)	D7A?, 7B, 6I.
Tollia cf. *payeri* Toula	*Bojarkia* cf. *payeri*	Tolliinae juv.	D6F.
Tollia stenomphala (Pavlov)	*Surites* (*Bogoslovskia*) *stenomphalus* (Pavlov)	? *Surites* (*Bojarkia*) spp. juv.	D6Aβ.
Tollia pseudotolli Neale	*Tollia pseudotolli* Neale	*Peregrinoceras pseudotolli* (Neale)	D6Aδ.
Tollia cf. *tolmatschowi* Pavlov	*Tollia* cf. *tolmatschowi* Pavlov	Tolliinae indet.	D6Aβ.
Tollia sp.	*Tollia* sp.	Tolliinae indet.	D6Aβ.

Table 1. Ammonites from the lower D Beds of the Speeton Clay (Upper Ryazanian, *albidum* Zone).

from this bed in the Lymn Valley and from the Fordington cores. All examples of this genus examined from the Spilsby Sandstone, though incomplete and showing some signs of reworking, are not badly damaged and most of them retain patches of nacreous test. Furthermore, they are preserved in a blue-grey, slightly sandy, glauconitic and phosphatized rock identical with that of the cementing agent of the bed itself. Some of the "*Crendonites*" recorded by Spath are in a similar lithology (though these may include forms more properly assigned to other genera).

In the past the fossils in the junction-bed have been too readily dismissed as "derived" and of no stratigraphical significance. Lamplugh (1896) believed that the contents of this bed were not so much "derived" as condensed, resulting from the prolonged drifting to and fro of material on the sea-bottom. He pointed out that fossils in beds of this type invariably belonged to the "missing" zones. I have previously (Casey 1962) endorsed Lamplugh's views in so far as acknowledging that *Kerberites* and other Portlandian ammonites in the junction-bed are not much older than *Paracraspedites,* the earliest unquestionably indigenous ammonite in the Spilsby sequence. At Worth Matravers, Dorset, *Kerberites* (GSM 109556) has since been found directly underlying *Paracraspedites* in the unbroken lithological sequence of the "Shrimp Bed", at the top of the Portland Stone. *Kerberites* is one of the best known ammonites in the main mass of the Portland Stone, currently assigned to the Zone of *Titanites giganteus.* The Spilsby-Kimmeridge junction-bed marks the long interval of inhibited deposition that followed the Mid-Volgian uplift of Britain. Evidently a shallow sea had re-occupied parts of Lincolnshire already by *giganteus* Zone times (or even earlier) and the former extension of the Portlandian far beyond its present outcrop in southern England may be deemed established.

Sowerby's *A. giganteus* is the type-species of *Gigantites* Buckman 1921 (= *Titanites* Buckman 1921) and was obtained from the Portland Beds of the Vale of Wardour, not, however, from the restricted *giganteus* Zone of Arkell (1935) but from the underlying *Kerberites okusensis* Zone (House 1958). The present paper follows Arkell (1957) in merging the *okusensis* horizon into the *giganteus* Zone.

(*ii*). Paracraspedites oppressus *Zone.*

Throughout Norfolk and South Lincolnshire this zone consists of glauconitic clayey sands locally indurated into sandstone and without phosphatization. It has a maximum thickness of 6 metres south of King's Lynn (Roxham Beds), but diminishes northwards to about 0·3 metres in the Spilsby Sandstone Basement-beds around Spilsby and has disappeared altogether at Nettleton, near the northern end of the outcrop. In Norfolk the zone appears from beneath the Cretaceous disconformity at West Derham, where it comprises the basal remnants of the Roxham Beds, about 3·5 metres thick. Fossils, including the diagnostic ammonite *Paracraspedites,* are invariably crushed, whether occurring as pyritic moulds in the sand, as at West Dereham, or in the basal sandstone, as at North Runcton and King's Lynn. In Lincolnshire the zone is best known from its occurrence in the Spilsby Sandstone Basement-beds of the Fordington wells and in the Partney road-cutting. This zone accounts for the bulk of the Spilsby Sandstone-basal Roxham Beds erratics found in the Drift of Norfolk and Suffolk. Judging by their size (up to 2 m) and distribution and their obvious identity with the indurated base of the Roxham Beds seen *in situ,* they are not far-travelled (Casey and Gallois 1973). Possibly they originated in the off-shore region of South Lincolnshire. Large *Paracraspedites* from these erratics, indistinguishable from the well-known

Portland "giants", have found their way into East Anglian museums (King's Lynn, Norwich, Ipswich) or have been used as garden ornaments (photographs in I.G.S.).

Besides the ammonites *Paracraspedites oppressus, P. stenomphaloides, P. bifurcatus, P.* spp. nov., and *Glottoptychinites*? *trifurcatus*, the zone yields a rich fauna of bivalves and belemnites. The associated brachiopods include the large *Rouillieria ovoides* which gives an independent check on the Middle Volgian dating of the fauna (Ager 1971).

In the Southern Basin the zone is present in the top part of the "Shrimp Bed" of the Portland Stone of Dorset (Casey 1964) in a sublithographic stone quite unlike the Spilsby Sandstone. Here the zone passes down imperceptibly into the *giganteus* Zone, characterized by species of *Titanites*, *Kerberites*, and others.

(*iii*). Subcraspedites (Swinnertonia) primitivus *Zone.*

This basal division of the Upper Volgian substage has been identified in England only in Lincolnshire. It is essentially Swinnerton's Bed D (with the top few centimetres of Bed C) of the Spilsby Sandstone Basement-beds, first described from the Fordington wells and subsequently found at Partney, the Lymn Valley and Nettleton Top. The same horizon was evidently encountered in the Donington borehole, whence Pringle (1919) recorded "*Craspedites* cf. *nodiger*", subsequently identified by Swinnerton with his *S. cristatus*. Species of *Subcraspedites* found in this zone, mostly crushed, belong exclusively to the subgenus *Swinnertonia*, endemic to this horizon (*S. cristatus, S. precristatus, S. primitivus, S. undulatus, S. parundulatus, S. subundulatus* Swinnerton spp.). In the lower part of the zone there are poorly preserved ammonites which may prove to be a new form linking *Subcraspedites* with the Dorsoplanitidae. The zone consists of grey argillaceous sand or sandstone with phosphorite and has its maximum observed thickness of 2 metres at Nettleton. The apparent absence of *Swinnertonia* among the Kimmeridgian-Spilsby Sandstone derivatives at the base of the Carstone north of Caistor may suggest that the *primitivus* Zone did not extend as far north as the overlying divisions of the Upper Volgian.

(*iv*). Subcraspedites (Subcraspedites) preplicomphalus *Zone.*

This zone occupies the middle part of the Upper Volgian substage and appears to be present throughout the whole length of the Sandringham Sands-Spilsby Sandstone outcrop. Originally of wider extent, its boundaries were clipped back by erosion at the end of the Jurassic and again during the Lower Albian. At West Dereham its fossils are found only as a phosphatized remanié in the basal Cretaceous nodule-bed along with forms of the succeeding *lamplughi* Zone (Fig. 2). Its presence is inferred at the base of the Runcton Beds of the King's Lynn area. The zone has its fullest development in the Lincolnshire Wolds in the 4–8 metres of Lower Spilsby Sandstone above the Basement-beds, consisting of coarse glauconitic sands, locally cemented into "doggers". Ammonites are fairly common in the "doggers", though generally crushed, and comprise *S.* (*S.*) *sowerbyi, S.* (*S.*) *preplicomphalus, S.* (*S.*) cf. *claxbiensis, S.* (*S.*) spp. nov., *Craspedites plicomphalus* and *C. thurrelli* sp. nov. This zone also provides some of the erratic blocks of Spilsby Sandstone found in the Norfolk Drift.

(*v*). Subcraspedites (Volgidiscus) lamplughi *Zone.*

Representing the top part of the Upper Volgian substage and the highest horizon of the British Jurassic, this zone has the same areal distribution as the *preplicomphalus*

Zone below. In Lincolnshire it takes in the top few metres of the Lower Spilsby Sandstone, though its junction with the *preplicomphalus* Zone is here arbitrary. The coarse glauconitic sands of this zone contain many pebbly layers and 'doggers". Unlike those of the zone below, fossils on this horizon commonly have a phosphorite infilling (and are consequently less crushed) and low-grade phosphorite cements patches of the sand. This zone indicates an episode of shallowing of the sea prior to the interval of erosion that terminated the Jurassic. Throughout the region its junction with the overlying beds is sharp and disconformable and in places it was eroded away completely by the Lower Ryazanian transgression. Fossils from this zone account for the bulk of the rolled debris in the basal Cretaceous nodule-bed of Norfolk. Ammonites collected *in situ* belong exclusively to *Volgidiscus* or to forms transitional between *Volgidiscus* and *Subcraspedites* s.s.

(*vi*). Runctonia runctoni *Zone.*

This zone has been traced for about 3 kilometres in the neighbourhood of North Runcton, near King's Lynn, where it forms the local representative of the basal Cretaceous nodule-bed at the bottom of the Mintlyn Beds. Usually less than 0·3 metres thick, in places it contains material derived from the underlying *lamplughi* Zone. Ammonites were apparently abundant on this horizon, though mostly reduced to shards of irridescent shell. Preservation of this zone at North Runcton, albeit vestigial, was probably as fortuitous as its discovery. Originally it may well have been spread over the whole of the Norfolk area and then swept away by one of the strand-line oscillations that marked the Jurassic-Cretaceous transition (reflected in the Durlston Beds "marine bands"). The diagnostic ammonite *Runctonia* gen. nov. being known nowhere else, the zone is referred to the Cretaceous on *a priori* grounds, as discussed in the section on correlation.

(*vii*). Hectoroceras kochi *Zone.*

First described from Greenland by Spath (1947), the *kochi* Zone has since been found widely over North and West Siberia (Saks *et al.* 1963). In Britain it has been found only in Norfolk. Uplift and erosion at the end of the Lower Ryazanian had reduced it to a southwards-thickening wedge of strata, and this was further attacked during the Aptian and Lower Albian. At West Dereham it forms the bottom 8 metres of the Mintlyn Beds, truncated by the Carstone; its original thickness is not known.

Hectoroceras kochi and congeneric forms occur throughout this thickness as clay-ironstone or phosphorite steinkerns in a fauna dominated by the bivalve *Neocrassina*. Species of *Borealites* occur as rarities in the highest clay-ironstone band and phosphatic nodules enclosing *Hectoroceras* contribute to the basal conglomerate of the Carstone. The zone dwindles away northwards to a line of nodules, traceable to Castle Rising (Casey and Gallois 1973).

(*viii*). Surites (Lynnia) icenii *Zone.*

This zone is taken to mark the base of the Upper Ryazanian. It is best known from exposures in the vicinity of King's Lynn, where it forms about a metre of glauconitic sands and clay with clay-ironstone and seams of phosphatic nodules. The Mid-Spilsby nodule-bed of South Lincolnshire represents an even more marginal facies of this zone. *Surites* of the subgenus *Lynnia* nov. are the characteristic ammonites of this horizon, though *Surites* (*Surites*) and *Surites* (*Bojarkia*) both occur as minority elements.

(*ix*). Surites (Bojarkia) stenomphalus *Zone*.

The term "*stenomphalus* Zone" is adopted from Pavlov (1891) but with a narrower meaning, as explained below. As used herein, the zone corresponds to a large part of the Upper Spilsby Sandstone, consisting of about 4–6 metres of fine to medium sands, commonly glauconitic and with a few calcreted "doggers". These "doggers" are the principal source of fossils and their scarcity makes it difficult to fix a boundary with the *albidum* Zone above. In Norfolk the zone, in Mintlyn Beds facies, is about 10 metres thick in the King's Lynn neighbourhood. Here it is seen to rest on the *icenii* Zone, but its junction with the *albidum* Zone cannot be determined at present owing to the lack of a continuous ammonite-bearing sequence. *Surites* (*Bojarkia*) *stenomphalus, S.* (*B.*) *suprasubditus pavlovi* subsp. nov., and other undescribed *Bojarkia* characterize the zone. This is the horizon of *Buchia volgensis* figured by Woods (1905) from the Spilsby Sandstone of Donington.

(*x*). Peregrinoceras albidum *Zone*.

This zone is considered to terminate the Ryazanian and includes the topmost part of the Mintlyn Beds and the topmost part of the Upper Spilsby Sandstone. Restricted to the southern end of the Lincolnshire Wolds and an area south of King's Lynn, the outcrop of these beds must have extended over a wider territory in Pleistocene times. This is suggested by the distribution of *Peregrinoceras albidum* and allies in Drift deposits as far afield as Letchworth, Hertfordshire, and Highgate Hill, London. *Peregrinoceras albidum* sp. nov., *P. rosei* sp. nov., *P. subpressulum, P. wrighti, P. pseudotolli*, together with a few undescribed *Bojarkia*, are the characteristic ammonites of this zone. In South Lincolnshire a similar fauna ranges up into the Claxby Beds (Hundleby Clay) and the base of that formation is therefore assigned to the *albidum* Zone. In the present state of knowledge the crushed *Peregrinoceras* fauna found in the lower D beds (D6–7) of the Speeton Clay can be correlated only with this broad *albidum* Zone.

(*xi*). *Relationship with overlying strata:* Paratollia *horizon*.

In Norfolk the Ryazanian Mintlyn Beds are succeeded by sands of presumed Valanginian age (Leziate Beds) (Casey and Gallois 1973), but they lack determinable ammonites. In north Lincolnshire the Valanginian Claxby Ironstone rests disconformably on Lower Spilsby Sandstone. It is only at Speeton and in the southern Lincolnshire Wolds that the sequence holds promise of elucidating the Ryazanian/Valanginian boundary in Britain. At Speeton the highest *Peregrinoceras* (Ryazanian) is separated from the "*Astarte* Bed" (D4) with rare *Platylenticeras* (Valanginian) by an interval of about 2 metres of clay ("*Lingula* Bed" or D5) which has so far yielded no ammonites (Neale 1962). Near Benniworth and Donington, northwest of Horncastle, indications have been obtained of the presence of an important early Valanginian ammonite fauna in the basal Claxby Beds (Hundleby Clay). This fauna comprises species of *Paratollia* gen. nov., *Propolyptychites* and *Pseudogarnieria* ("*Proleopoldia*"), which equates simultaneously with occurrences in the *Pseudogarnieria undulatoplicatilis* Zone of the Russian Platform and the Platylenticeras Schichten and Bentheim Sandstone of northwest Germany. Only *Paratollia* has yet been collected *in situ* in Lincolnshire and it is too early to say whether the apparent absence of *Platylenticeras* in the assemblage is significant. Further investigation of the Valanginian sequence is beyond the scope of the present study, but the need for search to be redoubled in D4–5 at Speeton and at Benniworth is obvious.

(*xii*). *Zonal correlation within the Spilsby Province.*

The complex zonal stratigraphy of the Sandringham Sands, Spilsby Sandstone and basal Claxby Beds and its relationship to the Speeton Clay is illustrated by five critical sections (Fig. 2), representing the southern and northern ends of the Norfolk and Lincolnshire outcrops and the Lower D beds of the Filey Bay exposure (Speeton). The chief features to be noted are that, despite the better development of the *oppressus* Zone at the top of the Middle Volgian in Norfolk, the Upper Volgian is here thin and incomplete. This substage reaches its greatest thickness in the Nettleton area of north Lincolnshire. Conversely, the Lower Ryazanian has its fullest development in the south and appears to be totally absent in eastern England north of The Wash. The Upper Ryazanian is well represented in the area around King's Lynn and in the southern part of the Lincolnshire Wolds, but is absent from the two extremities of the combined Lincolnshire-Norfolk outcrop; it reappears in the lower D beds of the Speeton Clay.

3. Evolution of the Spilsby Province

The Spilsby Sandstone and its correlatives were laid down in a shallow arm of the sea that remained in occupation of eastern England after the Middle Volgian uplift of Britain had isolated the region from the Portland-Purbeck basin to the south (Casey 1971). This was only one of a number of large-scale movements, possibly connected with a critical phase in North Atlantic sea-floor spreading, that reshaped European geography at that time. Reactivated areas of uplift that dominated the physiography of the Spilsby province were (i) the London-Ardennes massif to the south, (ii) the Pennines to the west and (iii) the east-west trending Northumbrian arch or Mid-North Sea high to the north. A more direct control on sedimentation in the Spilsby province was exercised by the Market Weighton upwarp: whether the Mid-Netherlands ridge to the southeast had any influence is unknown.

Among the ammonites, these great changes in the distribution of land and sea had the effect of accentuating faunal provincialism by the creation of new areas of endemic evolution. Thus, the widespread *Pavlovia* regime of the Boreal Realm was replaced by many new local developments such as the virgatitids of the Russian Platform and other specialised dorsoplanitid and craspeditid offshoots, distributed in different areas from Siberia to southern England.

Within the framework of the palaeobiogeographical classification introduced by Krimgolts and others (1968) for the Jurassic of the U.S.S.R. and adjoining territory, the Spilsby region may be regarded as having formed during the Upper Volgian-Lower Ryazanian an independent province of the Arctic Subrealm allied to the Greenland Province. In the Upper Ryazanian the Spilsby Province became part of the Boreal-Atlantic Subrealm, having strong faunal links with the Volgian and West Siberian Subprovinces of the East European Province. It disappeared as a separate entity after the Ryazanian. These links with Greenland and Siberia suggest that the Spilsby sea was open to the north. Tenuous connections with southern England by way of the Bedfordshire straits appear to have been maintained until the end of the Middle Volgian and another corridor may have remained open through Denmark and Poland to the Moscow-Volga area, permitting circulation of the dorsoplanitid *Paracraspedites*. These channels of communication were severed during the phase of marine regression of the Upper Volgian. The Spilsby Province was then taken over by the true craspeditids, apparently immigrants from the

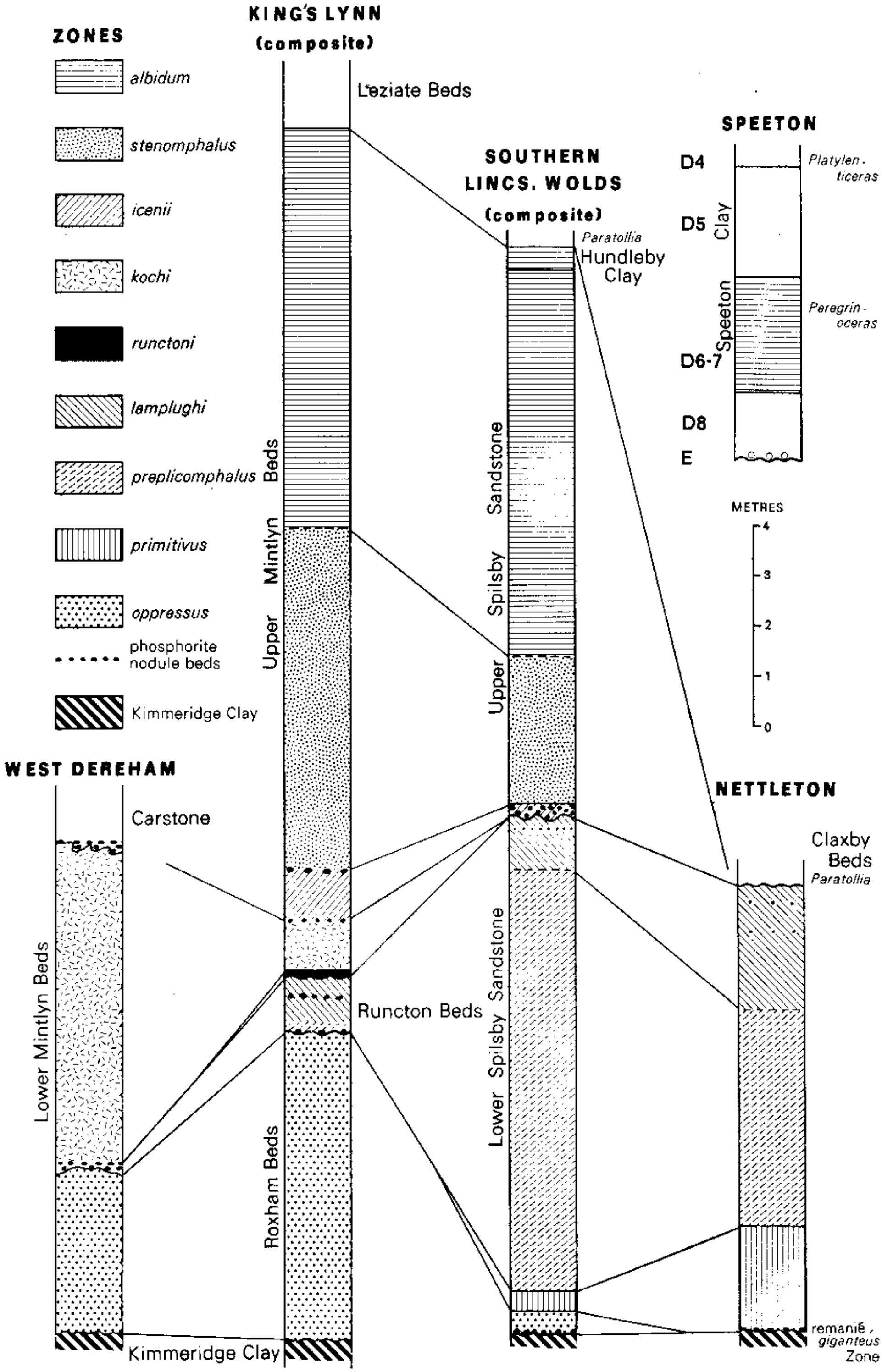


Fig. 2. Comparative vertical sections of Spilsby Sandstone and correlatives in eastern England.

north. The main stock (*Subcraspedites*) appears to have evolved from laugeitid ancestors well represented in East Greenland. Thence onwards, until the end of the Lower Ryazanian, the Spilsby sequence was characterized by an endemically evolving lineage—*Swinnertonia*—*Subcraspedites* s.s.—*Volgidiscus*—*Runctonia*—*Hectoroceras*—and the province may indeed have been at or near the centre of dispersal of these ammonites. *Craspedites* of the *nodiger* and *subditus* types, groups well represented in the Upper Volgian of the Boreal-Atlantic Subrealm (Russian Platform and West Siberia), may have infiltrated into the Spilsby province by rounding the northern lobe of the Scandinavian Shield, but evidence of an interchange of ammonites with the south is wholly lacking. Even the Ryazanian transgression, which carried the berriasellid *Riasanites* northwards across Poland and flooded the Lower Saxony and Purbeck Basins with brackish seas (Upper Serpulit and "Cinder Beds"), failed to break the craspeditid monopoly in the Spilsby Province.

Late in Lower Ryazanian times a few primitive Tolliinae (*Borealites*) appeared in Norfolk and in the Upper Ryazanian this subfamily (*Lynnia, Surites* s.s., *Bojarkia, Peregrinoceras*) invaded the province in strength, displacing the ancestral Craspeditinae altogether. This was a period of renewed transgression both on the Russian Platform and in the Spilsby Province and the most likely date for the re-opening of direct communication between Spilsby and Moscow, as suggested by Sazonova's (1971) palaeogeographical map of eastern Europe. Unhappily, the record of *Surites* in the Warsaw region (Marek 1963) that supports this reconstruction cannot be confirmed, the relevant specimens being, in my opinion, misidentified *Riasanites* and other berriasellids. It was the Valanginian transgression, marked by the arrival of the *Paratollia* fauna to eastern England, that finally submerged the Spilsby Province in a wider European identity.

It seems, therefore, that the land barriers to marine migration erected across Europe during the Volgian were progressively broken down during the Ryazanian and Valanginian. Links between the Spilsby basin and the ammonite province of eastern Europe seem to have been re-established in the Upper Ryazanian. Schott *et al.*'s (1967, 1969) view of the palaeogeography of the German North Sea basin suggests that migration routes from southern Europe, probably via Poland, were opened at that time. The fact that Tethyan ammonites did not use them shows that geographical isolation was only one of the factors controlling ammonite provincialism (see also Rawson, this volume).

From the structural and sedimentary viewpoint, the picture presented by the Spilsby province is one of slow deposition, with shifting centres of downwarping, pauses in sedimentation with formation of phosphorite, sea-floor erosion and re-working of older deposits. In short, a typical near-shore, marginal facies, repeated in the Lower Greensand and other shallow-water deposits of the European Upper Jurassic-Lower Cretaceous. Although the influence of the Market Weighton upwarp may be seen in the disappearance of the topmost Middle Volgian and the whole of the Ryazanian near Caistor, it is important to note that activation of this upwarp was not necessarily in phase with regional movements. In the south the change from Portland to Purbeck conditions indicates a renewed period of marine regression during the Upper Volgian traceable over large areas of Europe. In Lincolnshire, however, considering the generally marginal nature of Spilsby deposits, the Upper Volgian may be described as the period of most active and widespread sedimentation, particularly well developed near Caistor. Here, only the feeble development of nodular phosphorite at the top of the Lower Spilsby Sand-

Fig. 3. Palaeogeographical reconstruction of part of the Boreal Realm during the Ryazanian, with inset map showing Britain and adjacent area of Europe. (Detail after Smith 1971; Enay 1972; Dunn *et al.* 1973.) Areas of continental deposition stippled.

stone reflects the episode of marginal deposition recorded in the condensed and incomplete Runcton Beds of Norfolk. In this respect the Norfolk occurrence accords better with the regional picture of marine retreat at the end of the Jurassic, e.g., soil-bed ("Mammal Bed") in the Lulworth Beds of Dorset, pre-Whitchurch Sands folding in Buckinghamshire and contemporary movements in the Boulonnais and the Osterwald phase of folding in Saxony (Casey and Bristow 1964; Casey 1971).

The diachronous base to the Claxby Beds, with northwards-growing disconformity, indicates another important episode of earth-movement felt in north Lincolnshire. This episode, like the wedging out of the Upper Tealby Clay and

Roach Stone and the eventual disappearance of the whole Spilsby, Tealby and Langton groups a few miles to the north illustrates the importance of the southern margin of the Market Weighton upwarp. Lack of correspondence in position of sedimentary wedges and their bounding disconformities between the north Lincolnshire and Norfolk successions may express tectonic independence in the basement-rocks (? Caledonian and Hercynian fold-systems respectively).

The Ryazanian transgression in England is another event of greater complexity than previously realised. Its correlation with the "Cinder Beds" invasion at the base of the Durlston Beds of the Purbeck Basin (Casey 1962, 1963) was based on palaeogeography and other indirect considerations. Ironically, now that there is independent palaeontological evidence for dating the "Cinder Beds" as basal Cretaceous (Bielecka and Sztejn 1966; Anderson, this volume), the problem has shifted to identifying the precise correlative of the "Cinder Beds" among the alternatives now available in the Spilsby Province. These alternatives, in order of probability, are (i) *runctoni* Zone, (ii) unnamed interval between *runctoni* and *kochi* Zones, (iii) unnamed interval below *runctoni* Zone, and (iv) *kochi* Zone. This area of research has been narrowed to the Norfolk succession, of which the vestigial *runctoni* Zone is provisionally taken as the earliest Cretaceous. The "Cinder Beds" invasion was a short-term event and was followed immediately by an episode of retreat. Destruction of the newly-formed *runctoni* Zone in Norfolk may be inferred to date from this episode.

Lower Ryazanian deposition was resumed under unstable conditions in Norfolk in the *kochi* Zone. A marine advance in the Upper Ryazanian brought the return of the sea to south Lincolnshire (and perhaps the saline episode of the "Scallop Beds" to the Purbeck basin). There is no evidence for the former presence of Ryazanian deposits in north Lincolnshire. Only the uppermost Ryazanian (*albidum* Zone) can be identified in the lowest few metres of the Speeton Clay and it is unlikely that the basal nodule-bed ("Coprolite Bed") is older than the Mid-Spilsby nodule-bed, i.e., Upper Ryazanian.

Of later movements within the Cretaceous that affected the Spilsby Province, that of the Lower Albian has left the most obvious signs. Corresponding to the mid-*tardefurcata* break of Casey (1961a), the sedimentary expression of this Lower Albian movement may be seen throughout the length of the Lower Greensand outcrop in England, in northern France and in northwest Germany. In the Spilsby Province it falls at the transgressive base of the Carstone. Closely associated with the Red Chalk, this formation marks the beginning of the so-called Upper Cretaceous transgression in the North Sea. Strahan's view that the most important break in the Lincolnshire Cretaceous series occurs at the base of the Carstone (Strahan 1886) is thus endorsed and declared to be valid also for Norfolk and probably for the whole of the North Sea basin system.

4. Correlation with the Russian platform and Siberia

4a. Introduction

Eastern England is the only region in northwest Europe where a sequence of ammonite faunas may be followed across the Jurassic-Cretaceous boundary. Its correlation with comparable regions such as the Russian Platform, North and West Siberia, East Greenland and Canada is thus of prime importance for fixing a standard ammonite chronology at that level. Since the Greenland and Canadian occurrences are dealt with in detail elsewhere in this volume, attention is concentrated here on comparison with the successions in the U.S.S.R.

The history of research into the ammonite sequences of the Russian Platform, which provides the type-localities for the Volgian and Ryazanian stages, has been reviewed by Sazonova (1961, 1965, 1967, 1971), Gerasimov and Mikhailov (1966) and Gerasimov (1971, *in* Krimgolts *et al.* 1972). Knowledge of the successions in the northern territories of the U.S.S.R. has advanced rapidly in recent years mainly through the work of Bodylevsky (1967), Voronets (1962), Shulgina (1967, 1968, 1969) and Saks and his co-workers (1959, 1962, 1963, 1965, 1967, 1969, 1972). The sequences of zones given in Table 2 are those currently employed in the two main regions of the U.S.S.R., though there are local variants and alternative nomenclature, as noted below.

Casey's (1962, 1963, 1964, 1971) dating of the Spilsby Sandstone as ranging from high Middle Volgian (*olim* Lower Volgian) to Ryazanian ("Berriasian") was not accepted by Saks and Shulgina (1972) on the following grounds: (1) Casey did not describe or illustrate the ammonites; (2) Neale's (1962) illustrations and descriptions of *Paracraspedites* and *Subcraspedites* from the Berriasian part of the Speeton Clay, which follows immediately on the Kimmeridgian, supported Spath's and Swinnerton's basal Cretaceous ("Infravalanginian") dating of the Spilsby Sandstone, which also rests directly on the Kimmeridge Clay; (3) the critical species *Paracraspedites stenomphaloides* Swinnerton and "*Subcraspedites plicomphalus* (Sowerby)" had been identified by Shulgina in the Berriasian of Siberia; (4) Jeletzky (1965) had favoured a Berriasian age for *Subcraspedites* of the Spilsby Sandstone; and (5) a typical Neocomian assemblage of belemnites is found in the lower part of the Spilsby Sandstone. These views were embodied by Saks and Shulgina (1972) in a correlation table in which the relevant strata in eastern England were equated with post-Volgian successions in the U.S.S.R. and at the same time firmly tied zone by zone to the Tethyan (Berriasian) sequence of southeast France. Volgian and Berriasian were treated as consecutive intervals and no comment was made on the fact that Casey's (1964) correlation implied a considerable overlap between these two stages.

Since the scheme of correlation proposed by Saks and Shulgina (1972) for the Spilsby Sandstone and equivalent strata in eastern England is emphatically rejected by the present author, the views on which it is based must be examined point by point.

(1, 2). The original illustrations and descriptions that enabled a Lower Cretaceous age for *Paracraspedites* and *Subcraspedites* to be confidently accepted have always been available and the publication of figures of *A. plicomphalus* J. Sowerby and other critical Lower Spilsby Sandstone ammonites by Donovan (1964) did not overcome entrenched opinion. The fact that Neale's (1962) pictures of *Peregrinoceras* and allies from the Speeton Clay were accepted as evidence of the occurrence of *Paracraspedites* and *Subcraspedites* in the Berriasian speaks for itself.

(3). Shulgina's "*Subcraspedites plicomphalus* (Sowerby)" is a nomenclatorial hybrid of *Subcraspedites sowerbyi* Spath (= *A. plicomphalus* J. de C. Sowerby 1823) and *Craspedites plicomphalus* (J. Sowerby 1822) and the Siberian ammonite to which the name was applied belongs to a later, homoeomorphous group referred in the systematic section of this paper to *Borealites* (*Ronkinites*). Her "*Paracraspedites*" also have only a superficial resemblance to the Middle Volgian genus that correctly bears the name and are no more *Paracraspedites* than the Hauterivian *Speetoniceras* is a Kimmeridgian *Pavlovia*.

(4). Jeletzky's (1965) comments on Casey's dating of the Spilsby Sandstone are now largely irrelevant and were modified in a subsequent paper (Jeletzky 1966).
(5). Analysing the belemnite distribution, Saks and Nalnyaeva (1972) were more cautious about the age of the Spilsby Sandstone than were Saks and Shulgina in the same work. In an earlier publication Saks and Nalnyaeva (1966) had placed the belemnites of the Lower Spilsby Sandstone in the Volgian. Although they have now assigned both the upper and lower divisions of the formation to the Berriasian, the lower part is qualified by "(? Volgian beds)". They listed nine species of *Acroteuthis* from the Spilsby Sandstone, seven in the lower part and six in the upper, with four species common to both divisions. Of the four species shown as ranging into the upper beds, three are forms recorded in the U.S.S.R. only from "Berriasian" strata, namely *A. lateralis* (Phillips), *A. sublateralis* Swinnerton and *A. explanatoides* (Pavlov).

Saks and Nalnyaeva drew their data on the Spilsby belemnites from Swinnerton's monograph (1936–55), which is now out of date so far as the stratigraphy of the Spilsby Sandstone is concerned. Moreover, it was written before Gustomesov's (1956) isolation of the subgenus *Microbelus*, which characterises the lower levels of the Spilsby Sandstone. In his monograph Swinnerton treated members of this subgenus as juvenile *Acroteuthis* s.s., though he had originally identified the Portlandian-Volgian *A. mosquensis* (Pavlov), a typical *Microbelus*, from the Spilsby Sandstone Basement-beds (Swinnerton 1935).

The horizons of *A. lateralis, A. sublateralis* and *A. explanatoides* were determined by Swinnerton mainly from spoil from one of the Fordington wells, near Spilsby, and are too vague to fix positions in terms of the present zonation. Excepting certain "juveniles" from the Basement-beds, all specimens of the three critical species were recorded individually as having been collected from depth-ranges that start in the *albidum* or *stenomphalus* Zone and terminate downwards in Bed 7 (see p. 202). No ammonites are preserved from Bed 7 and this horizon is assigned to the topmost Upper Volgian (*lamplughi* Zone) with reservation. Whether any of the relevant belemnites did originate as low as Bed 7 is not known. Equally uncertain is the significance of Swinnerton's (1936) statement that *A. lateralis* is associated with species of *Subcraspedites* in the middle of the Spilsby Sandstone, his broad interpretation of the ammonite genus covering both Volgian and Ryazanian forms. All that can be said at present is that these three typical Ryazanian belemnites appear together in or just below the Mid-Spilsby nodule-bed. When these dubious records are put aside the "typical Neocomian" aspect of the Lower Spilsby Sandstone belemnite fauna vanishes.

4b. Middle Volgian

Despite the discovery in recent years of new ammonite links, a final solution to the long-standing problem of integrating the Tithonian, Portlandian and Volgian stages has yet to be reached. As a step towards recognition of a global standard for the terminal Jurassic, the Russians extended the Volgian stage down to the *Gravesia* horizon at the base of the Tithonian and introduced a tripartite division of the Volgian, the old Lower Volgian becoming Middle Volgian (Gerasimov and Mikhailov 1966). Gerasimov and Mikhailov's correlation of the *zaraiskensis, virgatus* and *nikitini* Zones of the type Middle Volgian with the Portland Beds of Dorset was challenged by Casey (1967). Pointing out that the Dorset sequence was more than ten times as thick as the Middle Volgian succession with which it was compared, Casey suggested that the Volgian stage in its type-section at Gorodishche, in the middle reaches of the River Volga, was not only greatly condensed, but incomplete. Identification of the genera *Crendonites*, *Behemoth* and *Kerberites*, indicative of the *giganteus* and *gorei* Zones of the Portland Beds, in the Middle Volgian of the Russian Platform (Mikhailov 1957) was considered unsound; it was inferred that the upper part of the Portland Beds was unrepresented at Gorodishche, there being a hiatus between the *nikitini* and *fulgens* Zones. Casey (1968) subsequently reported the presence of crushed ammonites indistinguishable from *Paracraspedites* (Pl. 1, fig. 4) in the topmost Middle Volgian at Gorodishche. This means that the postulated gap in the Russian section does not fall at the Middle/Upper Volgian boundary, but perhaps at the thick band of phosphatic nodules at the base of the unit currently assigned to the *nikitini* Zone.

Gerasimov and Mikhailov (1966) abolished the *Lomonossovella blakei* Zone, which previous authors had placed above the *nikitini* Zone as the topmost Middle Volgian (*olim* Lower Volgian). Possibly a more profound analysis of the fauna of the *nikitini* Zone at Gorodishche and its relationship to the *nikitini* Zone of the Moscow synclise will lead to the re-instatement of the *blakei* Zone (as in Table 2) or to the recognition of another unit corresponding to the *Paracraspedites oppressus* Zone.

Correlation of the remanié *giganteus* Zone of the basal Spilsby Sandstone and the overlying *oppressus* Zone of Lincolnshire and Norfolk with the Dorset sequence is firmly established by the occurrence of conspecific and allied species of *Kerberites* and *Paracraspedites* in the topmost part of the Portland Stone. The change from Portland to Purbeck conditions was not synchronized over the whole of southern England and it is improbable that in Dorset this event happened to coincide with the beginning of the Upper Volgian. The basal part of the Purbeck (Lulworth) Beds may also fall within the *oppressus* Zone. With the termination of normal marine conditions at the end of the Portland Beds southern England was closed to ammonite immigration until the Aptian.

4c. Upper Volgian

There is no direct evidence from the U.S.S.R. for placing the Zone of *Subcraspedites* (*Swinnertonia*) *primitivus* at the base of the Upper Volgian. This correlation relies on the occurrence of a primitive form of *Swinnertonia* in the Laugeites Beds of East Greenland, at the junction of the Middle and Upper Volgian, on the fact that the zone follows conformably on the *oppressus* Zone and on the dating of the overlying *S.* (*S.*) *preplicomphalus* Zone. Future work may show the need to recognize a separate faunal band at the base of the *primitivus* Zone, where poorly preserved ammonites apparently intermediate between Craspeditidae and Dorsoplanitidae occur. It is uncertain, therefore, whether the main development of *Swinnertonia* coincided with the appearance of the Russian *Kachpurites* at the base of the Upper Volgian. Possibly the *primitivus* Zone corresponds wholly or in part to the combined Zones of *Kachpurites fulgens* and *Craspedites subditus* of the Russian Platform. This idea is supported by the presence in the *preplicomphalus* Zone of *Craspedites plicomphalus* (J. Sowerby), an analogue of *C. nodiger* (Eichwald), the index ammonite for the highest Upper Volgian of the Russian Platform.

Since Rosanov (1909) demonstrated the wide extent of the *Craspedites nodiger* Zone in the Moscow region, comparable faunas of *Craspedites* (*C.* cf. *nodiger*, *C. pseudonodiger* Shulgina, *C. bodylevskyi* Ershova) have been found at about the same level (*taimyrensis* Zone) in North Siberia and West Spitsbergen (Shulgina 1969; Ershova 1969). Above the *nodiger* Zone s.s. an additional horizon may be recognized locally beneath the transgressive Ryazan Beds in the Volga region, characterized by *Craspedites kaschpuricus* (Trautschold) (Sazonov 1962). Until recently "*Garniericeras*" *tolijense* (Nikitin) was commonly listed as a fossil of this horizon. It is a matter for speculation whether this record relates to a species of *Garniericeras*, *Shulginites*, *Volgidiscus* or some other form. The general absence of *Volgidiscus* in the Moscow and Leningrad collections from these very fossiliferous beds (cf. Gerasimov 1969) makes it more likely that the English *Subcraspedites* (*Volgidiscus*) *lamplughi* Zone is missing in this region. It is assumed provisionally that it falls within the erosional gap found at the Volgian/Ryazanian boundary throughout the Russian Platform. In terms of the Siberian sequence, this gap is currently assumed to be filled by the *Chetaites sibiricus* Zone (Saks and Shulgina 1972), but for reasons given below it is here tentatively assigned to the *Chetaites chetae* Zone. That is to say, the missing interval in the Russian Platform sequence is credited to the Volgian rather than to the Ryazanian or "Berriasian" *sensu rossico*.

4d. Ryazanian

On the Russian Platform generally and especially in the type-area along the right bank of the River Oka, in Ryazan province, southeast of Moscow, the Ryazan Beds are greatly condensed (in places less than 1 m thick). Ammonites are abundant, but owing to reworking of the sediments division into beds is to some extent subjective and the vertical distribution of certain species is still obscure (Gerasimov 1971). Two zones are recognized in the Ryazan Beds: the *Riasanites rjasanensis* Zone (Lower Ryazanian) and the *Surites spasskensis* Zone (Upper Ryazanian). Owing to the highly condensed sequence and to provincialism of the ammonite faunas, especially in the Lower Ryazanian, correlation of these zones in terms of the ammonite zonations worked out in Siberia and other northern territories (Table 2) is difficult, as is reflected in the two contrasting interpretations emanating recently from the U.S.S.R. (Sazonova 1971; Saks and Shulgina 1972).

Gerasimov (1971) pointed out that the occurrence of *Surites* (*Surites*) *spasskensis* (Nikitin) already in the *rjasanensis* Zone (upper part, personal communication) makes this an unsuitable index-fossil for the Upper Ryazan Beds and proposed that *Surites tzikwinianus* (Bogoslovsky) (here referred to the subgenus *Bojarkia*) be used instead. The occurrence of *Surites* (*S.*) *spasskensis* or a close ally low in the *kochi* Zone of the River Boyarka section (Saks and Shulgina 1972) in northern Siberia would seem to support Gerasimov's assertion and at the same time suggest that the *kochi* Zone represents only part of the *rjasanensis* Zone or even overlaps with the *spasskensis* Zone as defined by Sazonova (1971) for its type-area. Saks and Shulgina (1964) and Saks and others (1965) had originally regarded the *sibiricus, kochi* and *analogus* horizons of the north as divisions of a broad *spasskensis* Zone that embraced the whole Ryazanian, with the *sibiricus* level treated as a straightforward lateral replacement of the *rjasanensis* Zone of the Volga region. This concept of the relationship of the *sibiricus* and *rjasanensis* Zones was repeated by Shulgina (1967). Much the same view was taken by Sazonova (1971), who saw the *rjasanensis* Zone (with a missing interval at its base) covering the same time-span as the *sibiricus* Zone, and the *kochi* and *analogus* horizons as divisions of a restricted *spasskensis* Zone. The occurrence of rare *Hectoroceras* in the top part of the *sibiricus* Zone (Shulgina *in litt.*) indicates that there is no break of importance between this zone and the *kochi* Zone. Sazonova (1971) also makes the point that there is no hiatus between the *rjasanensis* and *spasskensis* Zones. It is hard to understand why Saks and Shulgina (1972) now equate the *kochi* Zone with the

Table 2. Suggested correlation of the Jurassic-Cretaceous boundary zonations of eastern England, Siberia and the Russian Platform.

EASTERN ENGLAND			N. & W. SIBERIA	RUSSIAN PLATFORM	
LEZIATE BEDS (pars)	Claxby Beds (pars)	*Paratollia*	*Neotollia klimovskiensis*	*Pseudogarnieria undulatoplicatilis*	VALANGINIAN (pars)
MINTLYN BEDS	Upper Spilsby Sandstone	*Peregrinoceras albidum*	*Surites (Bojarkia) mesezhnikowi*	*Surites (Surites) spasskensis*	UPPER RYAZANIAN
MINTLYN BEDS	Upper Spilsby Sandstone	*Surites (Bojarkia) stenomphalus*	*Surites (Bojarkia) mesezhnikowi*	*Surites (Surites) spasskensis*	UPPER RYAZANIAN
MINTLYN BEDS	Upper Spilsby Sandstone	*Surites (Lynnia) icenii*	*Surites (Caseyiceras) analogus*	*Surites (Surites) spasskensis*	UPPER RYAZANIAN
MINTLYN BEDS		*Hectoroceras kochi*	*Hectoroceras kochi*	*Riasanites rjasanensis*	LOWER RYAZANIAN
MINTLYN BEDS		*Runctonia runctoni*	*Chetaites sibiricus*	*Riasanites rjasanensis*	LOWER RYAZANIAN
RUNCTON BEDS	Lower Spilsby Sandstone	*Subcraspedites (Volgidiscus) lamplughi*	*Chetaites chetae*		UPPER VOLGIAN
RUNCTON BEDS	Lower Spilsby Sandstone	*Subcraspedites (Subcraspedites) preplicomphalus*	*Craspedites (Taimyroceras) taimyrensis*	*Craspedites nodiger*	UPPER VOLGIAN
	Lower Spilsby Sandstone	*Subcraspedites (Swinnertonia) primitivus*	*Craspedites okensis*	*Craspedites subditus* *Kachpurites fulgens*	UPPER VOLGIAN
ROXHAM BEDS	Lower Spilsby Sandstone	*Paracraspedites oppressus*	*Epivirgatites variabilis*	*Lomonossovella blakei*	MIDDLE VOLGIAN (pars)
ROXHAM BEDS ?	Lower Spilsby Sandstone	*Titanites giganteus*	*Epivirgatites variabilis*		MIDDLE VOLGIAN (pars)

whole of the *rjasanensis* Zone and place the latter above the *sibiricus* Zone. Possibly they wished to have a post-Volgian zone to fit the theoretical basal Berriasian interval below the *rjasanensis* Zone postulated by Jeletzky (1965, 1968). Contrary to the opinion of Shulgina and her colleagues, who place the *Chetaites chetae* Zone in the Jurassic, Sazonova (1971) thought that this zone should be placed in the Lower Cretaceous, quoting Bodylevsky in support. In the present writer's opinion this question is academic, since if current concepts of the Berriasian stage are adhered to, the *chetae* Zone is simultaneously Jurassic (Volgian) and Cretaceous (Berriasian *sensu gallico*) (Table 2).

The five zones of the English marine Ryazanian are apportioned among the two zones of the condensed Ryazan Beds, the *runctoni* and *kochi* Zones being regarded provisionally as representing the *rjasanensis* Zone (Lower Ryazanian), and the *icenii*, *stenomphalus* and *albidum* Zones as equivalent to the *spasskensis* Zone (Upper Ryazanian).

With its erosion surfaces above and below and its remanié, endemic ammonite fauna, the *Runctonia runctoni* Zone cannot be placed in terms of the Russian zonations except by indirect evidence. One line of approach is to fix its position in relation to the "Cinder Beds" transgression of southern England, independently dated as basal Ryazanian on ostracod evidence and palaeogeography (Casey 1963; Bielecka and Sztejn 1966). This is highly suggestive of a basal Ryazanian age also for the *runctoni* Zone, but is not conclusive (see stratigraphy section). The ancestral position of *Runctonia* in relation to *Hectoroceras* and *Praetollia* and its apparent descent from *Volgidiscus* would seem to offer little alternative to equating the *runctoni* Zone with the *sibiricus* Zone as the correlatives of the lower part of the *riasanensis* Zone. This is the arrangement adopted in Table 2, though its tentative nature should be stressed.

Present usage of the term *kochi* Zone means little more than *Hectoroceras*-beds. The East Anglian *kochi* Zone is incomplete and possibly represents only part of its Siberian namesake. The presence of rare *Borealites* (*Borealites*) and the absence of *Borealites* (*Ronkinites*) in England may indicate that our *kochi* horizon falls within the lower part of the zone.

Yet another erosion surface marks the base of the English *icenii* Zone, characterized by species of *Surites* (*Lynnia*), a subgenus apparently endemic to eastern England. Approximate correspondence of this zone to the Siberian and Trans-Uralian Zone of *Surites* (*Caseyiceras*) *analogus* is suggested by the similarity of *Lynnia* and *Caseyiceras*, which may well be divergent offshoots from a single parent stock. The closest English ammonite to *Caseyiceras analogus* is *Surites* (*Bojarkia*) *tealli* sp. nov., which occurs in the lower part of the *stenomphalus* Zone. *Caseyiceras* is well represented in the condensed *spasskensis* Zone of the Russian Platform. It is in the *icenii* Zone that the *Surites* (*S.*) *spasskensis* group appears for the first (and only) time in the English sequence.

The Zone of *Surites* (*Bojarkia*) *stenomphalus* follows conformably on the *icenii* Zone; the characteristic subgenus *Bojarkia* appears as a rarity at the top of the *icenii* Zone and ranges upwards into the *albidum* Zone. Besides the index-ammonite, the English *stenomphalus* fauna includes *S.* (*Bj.*) aff. *bodylevskii* (Shulgina), *S.* (*Bj.*) *suprasubditus* (Bogoslovsky) *pavlovi* subsp. nov., *S.* (*Bj.*) cf. *mesezhnikowi* (Shulgina), *S.* (*Bj.*) *tealli* sp. nov. and a number of allied, undescribed forms, the whole assemblage showing a striking similarity to that of the *S.* (*Bj.*) *mesezhnikowi* horizon of North Siberia. So close are these two faunas that re-instatement of the term *stenomphalus* Zone in place of *mesezhnikowi* Zone should be considered by the appropriate Soviet committee. In the condensed *spasskensis* Zone of the Ryazan Beds the *stenomphalus* fauna is represented by *S.* (*Bj.*) *suprasubditus*, *S.* (*Bj.*) *kozakowianus* (Bogoslovsky), *S.* (*Bj.*) *tzikwinianus* (Bogoslovsky) and *S.* (*Bj.*) *subtzikwinianus* (Bogoslovsky).

The discovery that the true *S.* (*Bj.*) *stenomphalus*, based on the Lincolnshire lectotype, characterizes the middle part of the Upper Ryazanian is an important result of the present investigation. Pavlov's Zone of "*Olcostephanus stenomphalus*" of the Russian Platform had been referred to the Valanginian already by Bogoslovsky (1902). The neotype of the Russian "*stenomphalus*", now called *Surites* (*Bogoslovskia*) *pseudostenomphalus* (Sazonova), said at first to have been obtained from the upper part of the *spasskensis* Zone (Sazonova 1971), has since been assigned to the basal Valanginian *Pseudogarnieria undulatoplicatilis* Zone (Sazonova 1972). Owing to the long-standing confusion between the two species to which the name *stenomphalus* has been applied and the difficulty of assigning definite horizons to the remanié Ryazanian-Valanginian beds of the Volga region, there is still some doubt about the range of *S.* (*B.*) *pseudostenomphalus*. I am inclined to regard this ammonite as a juvenile "*Stchirowskiceras*", a genus placed firmly in the Valanginian by Sazonova (1971, 1972).

Except when it has been used as a replacement name for *spasskensis* Zone (e.g. Sazonova 1961; Glazunova 1963), it is difficult to give a meaning to the widely quoted Russian "*stenomphalus* Zone". Judging by its faunal associates, for example, Bodylevsky's (1967) "*Tollia stenomphala*" from Novaya Zemlya is a Valanginian form, though the position accorded "*Surites stenomphalus*" by Saks and Shulgina (1964) in their correlation chart agrees better with that of the true *stenomphalus* (= *mesezhnikowi*) horizon.

Above the *stenomphalus* Zone in England the genus *Peregrinoceras* enters in strength (*P. albidum* sp. nov., *P. rosei* sp. nov., *P. subpressulum*, *P. wrighti*, *P. prostenomphaloides*, *P. pseudotolli*) and dominates the ammonite faunas of the topmost Spilsby Sandstone, topmost Mintlyn Beds and basal Hundleby Clay. The genus is an analogue of *Tollia*, which replaces it in Siberia and Greenland. Study of the published sections of the *mesezhnikowi* Zone (Basov *et al.* 1970, 1972) reveals that the zone-fossil and its allies occur only in the lower part of the zone and that the genus *Tollia* characterizes the higher levels, ranging up into the *Neotollia klimovskiensis* Zone at the base of the Siberian Valanginian. There is thus room for the equivalents of the *albidum* Zone above a restricted *mesezhnikowi* Zone. *Peregrinoceras* is well represented in the *spasskensis* Zone of the Russian Platform, *P. subpressulum* being common to the two regions.

The *Surites spasskensis* Zone of the Russian Platform thus combines in its remanié beds elements of all three zones of the English Upper Ryazanian. The *mesezhnikowi* (= *stenomphalus*) fauna, while not indicative of the highest Ryazanian, was correctly placed by Saks and Shulgina (1969) below the Valanginian and cannot be of post-Ryazanian age as indicated in Sazonova's (1971) correlation chart.

In the Trans-Uralian region of north Russia the *mesezhnikowi* Zone is replaced by a "Zone of *Bojarkia payeri*" (*Tollia payeri* in Golbert *et al.* 1972). The supposed occurrence of an equivalent horizon of "*Bojarkia* cf. *payeri*" above the *stenomphalus* Zone in eastern England (Saks and Shulgina 1972) presumably rests on the identification of "*Tollia* cf. *payeri* (Toula)" from the Speeton Clay (Neale 1962). The solitary English ammonite so-named is an indeterminate juvenile tolliinid of the *albidum* Zone.

The basal Valanginian *Pseudogarnieria undulatoplicatilis* Zone of the Russian Platform seemingly corresponds in position with the *Neotollia klimovskiensis* Zone of Siberia. An equivalent horizon is present near the base of the Claxby Beds of Lincolnshire, yielding *Pseudogarnieria* ("*Proleopoldia*") cf. *kurmyschensis* (Stchirowsky), *Paratollia* cf. *kemperi* sp. nov. and species of *Propolyptychites*, and in bed D4 of the Speeton Clay, with rare *Platylenticeras*. These isolated finds afford a link also with the Platylenticeras Schichten of northwest Germany.

Saks and Shulgina (1972) have invented an horizon of "*Tollia* cf. *tolmatschowi*" at the base of the English Valanginian. Here again, this seems to have its origin in the record of "*T.* cf. *tolmatschowi* Pavlov" in the D beds of the Speeton Clay (Neale 1962), perhaps coupled with a similar record from the Platylenticeras Schichten of Germany (Kemper 1964). The English record refers to indeterminate Tolliinae of the Upper Ryazanian *albidum* Zone; it is the German occurrence, here described as *Paratollia kemperi* gen. et sp. nov., that belongs to the Valanginian.

5. Correlation with the Tethyan Realm

During the passage from the Jurassic to the Cretaceous the Spilsby Province was part of the Boreal Realm and for geographical and/or ecological reasons was closed to ammonite exchange with the Tethys. Correlation of the Spilsby sequence with the standard Tithonian-Berriasian of the Mediterranean region is therefore indirect and speculative.

5a. Correlation with the marine facies

From the foregoing section it is clear that correlation of the Jurassic-Cretaceous boundary beds of the Russian Platform with those of northern U.S.S.R. is still far from certain. To attempt to carry this correlation over many thousands of kilometres to link isolated regions and diverse faunas is at present premature. Much of the published grounds for integration of Tethyan and Boreal occurrences at this level rest on subjective ammonite determinations for the most part inadequately described and illustrated, if at all. The biochronological significance of some other ammonites is uncertain or in dispute.

At the centre of this controversy has always been the Ryazan Beds of the Russian Platform, which contain among a dominantly craspeditid sequence ammonites (*Riasanites, Euthymiceras*) belonging to the Tethyan family Berriasellidae. Nikitin (1888) referred both *Riasanites rjasanensis* of the Lower Ryazan Beds and *Surites spasskensis* of the Upper Ryazan Beds to his Volgian formation, which, under the influence of Mikhailski, he had transferred from the Jurassic to the Cretaceous. It was because of this jumble of Jurassic and Cretaceous strata in Nikitin's "Volgian" that Pavlov renounced this term and substituted Portlandian for what was then called Lower Volgian and coined the name "Aquilonian" for the terminal part of the Jurassic (Upper Volgian). Pavlov (1892) pointed out that the Ryazan Beds were much younger than the horizon of *Virgatites virgatus* with which they had been confused and probably belonged to the Lower Neocomian. The main level of *R. rjasanensis* he subsequently referred to the lower Berrias horizon and the upper, so-called *stenomphalus* (= *spasskensis*) Zone, to the upper Berrias (Pavlov 1896), treating the Berriasian as a buffer-stage between the Jurassic and the Cretaceous. This siting of the Jurassic-Cretaceous boundary through the middle of the Ryazan Beds thus accorded with Kilian's (1895) announcement of the re-discovery of "*Hoplites*" *rjasanensis* in the Upper Tithonian of the Rhône Valley (since refuted). Because he published his results in western Europe, Pavlov's works enjoyed a wide circulation outside Russia and his opinions echoed down the years (Spath 1924a; Arkell 1957; Casey 1962). Bogoslovsky (1897, 1902) had shown, however, that the Ryazan Beds pass transgressively over the Volgian and form a natural base to the Cretaceous.

In the Tethyan Realm, Kilian (1907–10) had concluded that the only practicable base for the Berriasian of southeast France was the lower limit of the *Fauriella boissieri* Zone, which he divided into three horizons. These became the basis for Mazenot's (1939) subzones of *Berriasella grandis*, *B. boissieri* s.s. and *Kilianella* aff. *pexiptycha*. Although Mazenot's revision of the ammonites showed that Kilian had set the point of entry of the *boissieri* fauna too low, his field line, picked out by a lithological change at the base of the *grandis* Subzone, was adhered to.

Working from the Boreal Realm, Casey (1963) drew attention to the reported overlap in the Caucasus of the *Riasanites* fauna with that of "*Subthurmannia*" *boissieri* (Rengarten 1951) and suggested acceptance of the *boissieri* Zone s.s. as the starting point for the Tethyan Cretaceous, the underlying Subzone of *B. grandis* (now Zone of *Pseudosubplanites grandis*) being better placed in the Tithonian. At the Lyon Colloquium this point of view was not without support (e.g. Allen 1965; Wiedmann *in* Barbier and Thieuloy 1965), though it was decided to elevate Mazenot's *K.* aff. *pexiptycha* Subzone to the Valanginian and to take the *grandis* Zone as the provisional base of the Berriasian (Rat 1963). According to Casey 1964, Table 4) the Berriasian stage as thus defined overlaps with the upper part of the Volgian. This view has been endorsed by Zeiss (1965) and Enay (1972), who accept only the Lower and Middle Volgian as equivalent to the Tithonian.

Highlights of ammonite discoveries relevant to the Jurassic-Cretaceous boundary problem since the Lyon Colloquium include the "*Virgatosphinctes*" fauna in the Upper Volgian of North Siberia (Shulgina 1965, 1967), further mixed faunas in the Caucasus (Khalilov 1965, 1971; Egoyan 1971), and Berriasian *Spiticeras* in the Canadian Western Cordillera (Jeletzky 1964). Furthermore, the Tithonian-Berriasian ammonites of southeast France have again been revised (Le Hégarat 1971a, 1971b; Donze and Le Hégarat 1972). According to the last authors, the *boissieri* Zone (with three subzones) should be placed at the top of a new tripartite Berriasian based by the *grandis* Zone.

If we take the base of the Valanginian to be fixed roughly in both realms by the incoming of the Platylenticeratinae and the boreal *rjasanensis* Zone as equivalent to part of the Tethyan *boissieri* Zone, there is little room left in the Berriasian to accommodate the *spasskensis* Zone or Upper Ryazan Beds. There is, however, a large Berriasian interval (*Tirnovella occitanica* and *Pseudosubplanites grandis* Zones) which is either missing on the Russian Platform or embraces strata of Volgian age. Jeletzky (1965) and Sazonova (1971) have assumed that the *grandis* Zone interval is absent below the transgressive *rjasanensis* Zone, while Casey (1964) and Zeiss (1965) saw the *grandis* Zone as equivalent to part of the Volgian. The ammonites of the *rjasanensis* Zone have not been monographed for three-quarters of a century and until such records from this level as "*Neocomites* ex gr. *occitanicus*" (Sazonova 1971) have been clarified it is impossible to say how much of the Berriasian is missing between the *nodiger* and *rjasanensis* Zones.

In parts of southern Russia (Crimea, Transcaspia) *Riasanites* occurs in an ammonite fauna dominated by *Euthymiceras*, a genus diagnostic of high Berriasian (*boissieri* Zone). Both the *rjasanensis* and *spasskensis* Zones are represented in the 12–40 metres of sandstone of the *Euthymiceras euthymi* Zone in the Mangyshlak Peninsula, Transcaspia (Savelev and Vasilenko 1963), if the ammonites are correctly identified.

It may be of significance that in a recent analysis of the distribution of ammonites at the Jurassic-Cretaceous boundary in the Northern Caucasus, Khalilov (1971) does not list *R. rjasanensis* in association with *Fauriella* ("*Subthurmannia*") *boissieri*.

Such typical Ryazan species as *R. rjasanensis* and *Euthymiceras transfigurabilis* (Bogoslovsky) are shown as part of a faunal assemblage in the northwestern part of the region that comprises species of *Pseudosubplanites*, *Berriasella*, *Tirnovella*, *Malbosiceras* and *Mazenoticeras* in the terminology of Nikolov (1966) and Le Hégarat (1971a, 1971b). This enlarges the picture given by earlier authors such as Grigorieva (1938), Rengarten (1951), Eristavi (1952), Mordvilko (1960) and Drushchits and Mikhailova (1966) and suggests the possibility that the *rjasanensis* Zone is a condensed version of more than one Berriasian zone. A more enlightened commentary on these important areas of faunal overlap may be possible when the relevant ammonites have been fully documented and illustrated.

Returning to the far north, it may be noted that Saks and Shulgina (1972) rely heavily on the extinction of the "*Virgatosphinctes*" fauna simultaneously at the end of the Tithonian and at the top of the *chetae* Zone of Siberia as evidence for synchronizing the beginning of the Cretaceous in the two realms. The point of extinction of a given taxon is perhaps the least satisfactory method of dating available to palaeontologists. A generation ago the giant ammonites of the Portland Beds (terminal Middle Volgian) were thought to be the expiring effort of the Dorsoplanitinae (Arkell 1957). Today it is known that relict Dorsoplanitinae (*Chetaites*) remained in occupation of this same region of Siberia throughout the Upper Volgian and the earliest Ryazanian, if the *sibiricus* Zone is correctly dated. It is not known what relationship these Siberian "*Virgatosphinctes*" bear to the *Virgatosphinctes* of the *transitorius* group recorded from the Tithonian of the Caucasus (Egoyan 1971; Khalilov 1971), still less to the macroconch forms of the Himalayan group of *V. broilii* (Uhlig), to which the name *Virgatosphinctes* properly applies (Enay 1973). Zeiss (1968) found the Siberian forms an odd group, not strictly congeneric with any of the known Tethyan faunas and possibly younger than the Tithonian. Even if these Siberian "*Virgatosphinctes*" could be attached firmly to a Tethyan source, these facies-ammonites would be useful for dating only if it could be shown that they were sterile expatriate communities replenished by waves of immigrants from the south. Their numbers and persistence suggest that they were endemically breeding populations and for the present they cannot be taken as proof of a Tithonian age. The same applies to the few berriasellids found with "*Virgatosphinctes*".

Jeletzky (this volume) places the Jurassic-Cretaceous boundary in the Canadian northwest between occurrences of *Borealites* (*Borealites*) (= *Praetollia antiqua* Jeletzky) and *Borealites* (*Ronkinites*) (= *Subcraspedites* aff. *suprasubditus* Jeletzky). In this he is supported by study of *Buchia* faunas which may be traced into the Tithonian-Berriasian of northern California. Judging by the known distribution of the ammonites elsewhere, this puts the Canadian boundary in the middle of the *kochi* Zone, or at the lowest, at the base of that zone, i.e., well above the base of the European boreal Cretaceous according to current opinion. If Jeletzky's (1964) Berriasian *Spiticeras* from Vancouver Island are Tithonian *Proniceras*, as Enay (1973) conjectures, the problem of intercontinental correlation at the Jurassic-Cretaceous boundary becomes particularly acute (see Casey and Rawson, this volume).

5b. Correlation via the continental facies

Areas of contact of marine Berriasian or Ryazanian and non-marine Purbeckian are known in southeast France and Poland and provide vital data for correlation. In the Alpine-Mediterranean Province (Cluse de Chaille and Mont Salève) Berria-

Table 3. Suggested correlation of the marine and continental facies at the Jurassic-Cretaceous boundary in England, N.W. Germany and Poland.

		YORKS.	LINCS.	NORFOLK	DORSET		N.W.GERMANY	POLAND	
VALANGINIAN (pars)	D 5-4	Speeton Clay (pars)	Claxby Beds (pars)	Leziate Beds (pars)		Hastings Beds (pars)	Platylenticeras Schichten 'Wealden' 6	Marine Valanginian	VALANGINIAN (pars)
UPPER RYAZANIAN	E D 8-6	Speeton Clay (pars)	Upper Spilsby Sandstone	Mintlyn Beds	U.PURBECK	Durlston Beds	'Wealden' 1-5	Marine 'Berriasian'	? BERRIASIAN
LOWER RYAZANIAN				Mintlyn Beds	M.PURBECK	Cinder Beds	Upper Serpulit	*Riasanites*	BERRIASIAN
UPPER VOLGIAN			Lower Spilsby Sandstone	Runcton Beds	L.PURBECK	Lulworth Beds	Lower Serpulit Münder Mergel	Brackish & Brackish-marine	BERRIASIAN ?
MIDDLE VOLGIAN (pars)			Lower Spilsby Sandstone	Roxham Beds		Portland Stone	Münder Mergel	Brackish-marine 'Portlandian'	TITHONIAN (pars)

sian berriasellids are followed by brackish-water sediments with Lower Purbeck or basal Middle Purbeck ostracods, suggesting that the lower limit of the Berriasian (*grandis* Zone) falls somewhere within the Lower Purbeck (Lulworth) Beds (Donze 1958; Donze and Le Hégarat 1972). In Poland, boreholes west of Warsaw have penetrated a thick series of Purbeck-type strata overlain conformably by marine Ryazanian (Raczynska 1961; Marek 1961). Here the basal Ryazanian ammonite *Riasanites* enters above an ostracod assemblage equivalent to that found just below the "Cinder Beds" of the Dorset Purbecks (Bielecka and Sztejn 1966). Combined ammonite/ostracod data thus puts the Volgian/Ryazanian boundary at the base of the "Cinder Beds" and the Tithonian/Berriasian boundary somewhat more vaguely at a lower level—in the Lower Purbeck (Lulworth) Beds (Table 3). This agrees with the picture presented by the overlapping Tethyan/Boreal ammonite faunas in south Russia, i.e., that the Volgian/Ryazanian boundary is stratigraphically higher than the Tithonian/Berriasian. The importance of the Dorset Portland-Purbeck sequence in this respect is that both reference points (albeit one imprecise) are located in one section. And the inference is clear that between the Middle Volgian (Upper Tithonian) Portland Beds and the basal Ryazanian (Middle or Upper Berriasian) "Cinder Beds" there cannot be room for both the entire Upper Volgian and the full sequence of Lower (and perhaps Middle) Berriasian.

Attempts to find a microfloral solution to this knotty problem of trans-facial correlation at the Jurassic-Cretaceous boundary (Norris 1969) have produced corroborative evidence for a Lower Cretaceous age for the upper half of the Purbecks (Durlston Beds of Casey 1963), but do not take us any further in fixing the Tithonian-Berriasian contact. The palynology of these levels is discussed briefly elsewhere in this volume (Hughes).

Concerning the upper limit of the Berriasian in Dorset, Donze and Le Hégarat (1972) place this at the junction of "Wealden 3 and 4" of the German non-marine sequence, which, following Wolburg (1959), they locate in the lower part of the English Hastings Beds. Correlation of the German "Wealden" with the English Purbeck-Wealden was re-assessed by Anderson and Hughes (1964)[1] on the basis of ostracods and palaeobotany. According to these authors the upper limit of the Berriasian should be drawn at the top of Wealden 5" of the German sequence and well within the Hastings Beds. This is where Allen (1955, 1959) put it in the Hastings Beds on sedimentological and other grounds and its placing agrees better with the German entry of *Platylenticeras* (basal Valanginian) at the top of "Wealden 6". Only a small thickness of brackish-water sediment ("Wealden 6") is left undated; in the Speeton Clay of Yorkshire a similar brackish interval (bed D5) precedes the incoming of *Platylenticeras*.

6. Stage nomenclature at the Jurassic-Cretaceous boundary

A standard terminology for strata at the Jurassic-Cretaceous boundary will not be possible until the base of the Berriasian has been fixed by international consent and its boreal counterpart identified. I am not convinced that the time has come to dispense with regional stage terms; for the present the dual nomenclature Tithonian/Berriasian and Volgian/Ryazanian should be used for the Tethyan and Boreal Realms respectively. The hybrid "Volgian/Berriasian" corresponds to nothing in nature and its use should be discouraged.

The term Ryazanian was proposed (in its Russian form) by Sazonov (1951) for the Ryazan Beds of the Russian Platform. It is a particularly useful term, superior to Kilian's (1895) "Infravalanginian", which if it has a type-locality, falls in the Tethyan Realm. Adherents of the stratotype concept will point out that their condensed and transgressive characters render the Ryazan Beds even less suitable as a stratigraphical standard than the Volgian of the same region. Moreover, their correlation within the Boreal Realm poses the same problems, albeit on a smaller scale, encountered with the Berriasian. Nevertheless, the basal Cretaceous (post-Volgian) ammonite sequences of the Russian Platform, Siberia, Spitsbergen, Greenland and England have a community of character that requires expression in stratigraphical terms. There is no better word than Ryazanian and this name may be considered acceptable as an interim aid towards ultimate recognition of a global Berriasian.

Should the *grandis* Zone be ratified as the lower limit of the Berriasian and the postulated overlap of that stage and the Volgian (Table 3) confirmed, the name of the terminal Jurassic stage in the Boreal Realm would need further consideration. In this event the term Portlandian has obvious merits.

[1] To avoid possible misunderstanding, it should be pointed out that the term Middle Valanginian as used by Anderson and Hughes corresponds to the German "Mittelvalendis" and is the Lower Valanginian of English and other ammonite workers. Similarly, the term Lower Berriasian has been applied to the Polish *Riasanites* horizon (Lower Ryazanian) (Marek and Raczyńska, this volume), though this level does not correspond to the Lower Berriasian of current French usage.

7. Systematic palaeontology

The following systematic notes are intended to validate new names used in this paper and to clarify usage of existing ones where necessary. They cover only that part of the Spilsby ammonite fauna on which the zonal succession and correlation are based.

The following abbreviations indicate the repositories of cited specimens: GSM = Geological Survey Museum (Institute of Geological Sciences, London); BM = British Museum (Natural History), London; SM = Sedgwick Museum, Cambridge.

Family Perisphinctidae Steinmann
Subfamily Dorsoplanitinae Arkell
Genus *PARACRASPEDITES* Swinnerton 1935

Type-species: P. stenomphaloides Swinnerton, Spilsby Sandstone Basement-beds, Fordington Well, Lincolnshire.

Remarks. The additional material now available shows how much the original finds of *Paracraspedites* at Fordington and Partney had been altered by distortion in the rock and other damage. All of Swinnerton's type-specimens and his unfigured material from these localities are severely flattened juveniles or microconchs. The type of *P. stenomphaloides* is crushed obliquely, the ribs appearing longer on the side not figured; the short secondary ribs on the last half-whorl are worn away in places, enhancing its resemblance to those craspeditids which lose the secondaries with age. The whorl-section was drawn to resemble that of a craspeditid and an incomplete suture-line of this species, though correctly figured, was misinterpreted as showing a craspeditid inversion.

It is now evident that the whorl-shape of *Paracraspedites* is rounded-rectangular, with flattened sides and broadly convex venter as in *Pavlovia.* The ribs are clear-cut and sharply elevated, maintaining their strength throughout. Compared with the ribbing of the Craspeditidae, the elevation is especially noticeable on the venter; here the ribs occasionally exhibit the zig-zag pattern observed in some *Pavlovia* (e.g. Spath 1936 pl. 39 fig. 16). The suture-line has the umbilical retraction typical of the Dorsoplanitinae (Pl. 6 fig. 1; Fig. 4n). Combined with the long straight primaries, strength and rigidity of the secondaries, and the gigantic size of the adult, these features make it impossible to admit the genus to the Craspeditidae. Specimens up to 650 mm diameter have now been collected from the Spilsby Sandstone, making it clear that *Paracraspedites* belongs to the family of "Portland giants", i.e., the Perisphinctidae. A resemblance between *Paracraspedites* and Upper Jurassic pavloviids was noticed by Spath (1947, 1952). At first he explained this by suggesting that the base of the Spilsby Sandstone might include fossils derived from some Portlandian or post-Portlandian deposits not known to occur *in situ* at present day. Later (1952) he abandoned this idea and considered that Basement-bed C (with *Paracraspedites*) could not be much older than the higher beds of the Spilsby Sandstone on account of the occurrence in it of *Subcraspedites preplicomphalus,* a supposed Cretaceous ammonite.

Although the recorded association of *Paracraspedites* and *Subcraspedites* is no longer considered an obstacle to accepting the Jurassic age of the Spilsby Sandstone Basement-beds, it happens that re-examination of the Fordington material (for the most part with depths recorded) does not confirm this association. Here, as in the outcrop sections, *Paracraspedites* and *Subcraspedites* are both obviously native to the rock, but their stratigraphical separation is sharp and definite.

Since publication of my 1962 paper the widespread use of the name *Paracraspedites* in Soviet literature for Ryazanian *Surites* (e.g., Saks *et al.* 1963) has been dropped. Nevertheless, Shulgina (1972) has re-asserted the Cretaceous age of the genus on the strength of its supposed occurrence in the "Berriasian" of Spitsbergen and Siberia.

The Spitsbergen record is based on "*Polyptychites*" *hoeli* Frebold (1929 pl. 2 fig. 3), which Shulgina (1972 p. 155) synonymized with *Paracraspedites stenomphaloides* Swinnerton. Frebold's ammonite was figured in side-view only; its resemblance to Swinnerton's species is superficial and its strongly inverse suture-line with numerous auxiliaries obviates the need for further comparison with *Paracraspedites.*

As for the two Siberian forms figured from the *analogus* and *sibiricus* Zones by Shulgina as conspecific or comparable with *P. stenomphaloides,* the former lacks the venter and in this condition is not distinguishable generically from contemporary *Surites.* Her "*P. stenomphaloides*" from the *sibiricus* Zone (R. Kheta section of the Khatanga depression) agrees more closely with Swinnerton's species, but lacks the rigid, *Pavlovia*-like course of the ribs, especially in the gentle forward curvature of its secondaries. The ventral aspect is also unlike that of *Paracraspedites* (cf. Shulgina 1972 pl. 8 fig. 1b and Pl. 1 fig. 3b herein). Though this ammonite is not a *Paracraspedites*, it bears a remarkable resemblance to the dorsoplanitid *Taimyroceras*, described by Mesezhnikov (1972) from the Middle Volgian of the same region of Khatanga depression (cf. Mesezhnikov 1972, pl. 10 fig. 1 and pl. 11 fig. 1b). Forms with pavloviid sculpture but craspeditid suture-lines have been figured from the Ryazanian Lower Niesen Beds of East Greenland by Donovan (1964 pl. 7) under the generic name '*Surites*'.

Pending investigations of the numerous nominal genera created by S. Buckman for the Portland "giants", the status of *Paracraspedites* must remain uncertain. There are a number of dorsoplanitids that in a crushed condition would be hard to distinguish from Swinnerton's genus, including the Russian *Lomonossovella* and the group of "*Epivirgatites*" *bipliciformis* (Nikitin).

Paracraspedites oppressus sp. nov. Pl. 1 figs 1, 2a–b; Pl. 6 fig. 1

1935 *Paracraspedites* aff. *stenomphaloides* Swinnerton p. 39 pl. 4, fig. 2a.

Holotype. GSM 87564, Portland Stone, "Shrimp Bed", St. Alban's Head, Dorset (W. Heap Collection).

Description. Moderately evolute *Paracraspedites;* at 100 mm diameter umbilicus 32% diameter. At that size ribs about 30 per whorl, round-topped, arising from umbilical seam and crossing flanks with slight forward inclination. Just below mid-flank (on crushed specimens) ribs bifurcate of trifurcate (roughly 3 bifurcations to 1 trifurcation); trifurcation rarely virgatitid. Ribs pass straight over venter with strong elevation. At larger diameters umbilicus progressively widens and ribs close up, venter becoming more convex. Suture-line typically dorsoplanitid, with "suspensive" umbilical lobe.

Remarks. This species differs from *P. stenomphaloides* mainly in its closer ribbing and smaller umbilicus. The secondaries appear abnormally short in the holotype of Swinnerton's species, as also in the original of his pl. 4 fig. 2a, due to oblique crushing. Because of the potential complications introduced by post-mortem deformation in these ammonites, I am figuring both sides of an example of *P. oppressus* from the Bawsey erratics. Specific distinction of the adults of this and allied species may not be possible without breaking the specimen to extract the nucleus. The fragment illustrated in Pl. 6 fig. 1 is the inside of a large segment from the Norfolk Drift, still septate at an estimated diameter of 260 mm.

Genus *KERBERITES* S. Buckman 1924

Type-species. *K. kerberus* S. Buckman, Portland Beds (*giganteus* Zone), Wiltshire.

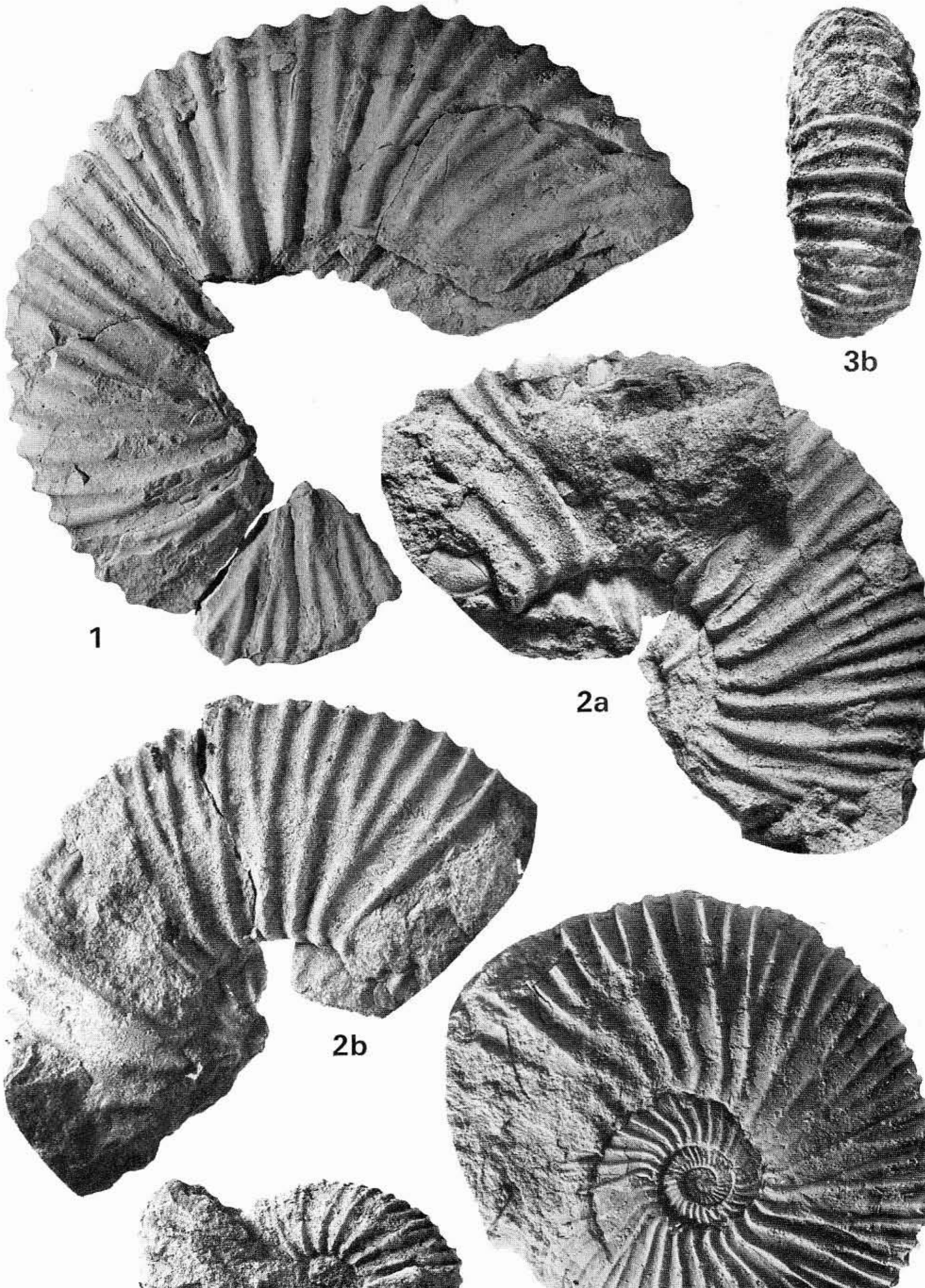
Kerberites cf. *kerberus* S. Buckman. Pl. 8, figs 6a–b.

Remarks. The example illustrated in Pl. 8 figs 6a–b, is typical of the fragmentary *Kerberites* fauna present in the remanié *giganteus* Zone of Lincolnshire. It was obtained from the base of the Spilsby Sandstone (bed 1) in one of the Fordington wells and other, slightly larger, fragments have been collected from the same level in the Lymn Valley and at Nettleton. There is good agreement with the inflated variety of *K. kerberus* from the Portland Stone figured by

Plate 1 all figs × 0·9.

1, 2a–b. *Paracraspedites oppressus* sp. nov.
1 Side view of crushed holotype, Portland Stone, "Shrimp Bed" (*oppressus* Zone), St. Alban's Head, Dorset. W. Heap colln, GSM. 87564.
2a–b Two sides of crushed example, Lower Spilsby Sandstone (Basement-bed: *oppressus* Zone), erratic block, British Industrial Sand pit, Bawsey, Norfolk. GSM. Ce3592.
3a–b, 4 *Paracraspedites* sp.
3a–b Side and venter of ventro-dorsally crushed juvenile. Base of Roxham Beds (*oppressus* Zone), No. 4 Gas Feeder Main trench, north of Manor Farm, North Runcton, near King's Lynn, Norfolk. GSM. Ce5744.
4 Crushed example. Middle Volgian (bed 13) ("*Epivirgatites nikitini*" Zone = *Lomonossovella blakei* Zone), right bank of River Volga, Gorodishche, near Ulyanovsk, U.S.S.R. (Photo Geological Institute, Academy of Sciences U.S.S.R., Moscow).

Plate 1



Spath (1936 pl. 18 figs 2a–b), but comparison with Buckman's type-specimen is difficult owing to the differences in sizes. Spilsby examples in which the umbilical swellings of the ribs have been removed by abrasion show great resemblance to *Lomonossovella*, which Arkell (1957) considered as a possible Russian equivalent of *Kerberites*. The relationship of the latter to *Titanites* S. Buckman is no clearer than when Spath (1936) discussed the problem and will probably not be elucidated until the Portland Stone ammonites have been monographed.

Genus *GLOTTOPTYCHINITES* S. Buckman 1923

Type-species. *G. glottodes* S. Buckman, Portland Beds (*giganteus* Zone), Long Crendon, Buckinghamshire.

Glottoptychinites ? trifurcatus (Swinnerton)

1935 *Paracraspedites* (?) *trifurcatus* Swinnerton, p. 40, fig. 5

Remarks. The genus *Glottoptychinites* resembles *Kerberites* in starting with coarse triplicate ribs on the inner whorls, but the ribbing is more distantly spaced, more elevated, and lacks umbilical swellings. The wretched Spilsby Sandstone specimen which served as a basis for Swinnerton's restored drawing of *Paracraspedites ? trifurcatus* is now supplemented by a few better examples from the Roxham Beds and the basal Spilsby Sandstone erratics of Bawsey. All show strongly elevated ribs that are sharper than those of *G. glottodes*, though Swinnerton's and Buckman's species may well prove to be congeneric.

Family Craspeditidae Spath 1924

This family is taken to comprise an Upper Volgian root-stock (*Craspedites, Subcraspedites, Kachpurites, Taimyroceras, Garniericeras*) with its Ryazanian derivatives *Hectoroceras, Pronjaites, Runctonia* gen. nov. and *Shulginites* gen. nov. etc. The problems involved in classifying the Craspeditidae have been touched upon by Spath (1947) and Jeletzky (1966) and there is something to be said for adopting the facile solution of attempting no suprageneric division at all. Certainly there is little point in following Spath (1952) and Arkell (1957) in separating various heterochronous oxycone offshoots in a "vertical" subfamily Garniericeratinae. It seems useful, nevertheless, to recognise the subfamily Tolliinae (= Suritidae Sazonova). This includes the Upper Ryazanian-Valanginian *Tollia*, its analogue *Peregrinoceras* and its forerunners *Surites, Borealites*, and probably *Praetollia*, which appear to have evolved from the Craspeditinae by a process of proterogenesis judging by the tolliine nucleus of *Borealites*. There are a number of borderline genera insufficiently known for certain allocation to one subfamily or the other, notably *Pronjaites*, best retained in the Craspeditinae. *Craspedites* has been reported from the Middle Volgian of the Rybinsk area (Gerasimov 1960), but the specimens are small and unconvincing.

Subfamily Craspeditinae
Genus *CRASPEDITES* Pavlov 1892

Type-species. *Ammonites okensis* d'Orbigny, Upper Volgian, Russian Platform.

Craspedites plicomphalus (J. Sowerby). Pl. 2 figs 1, 2; Figs 4a–b.

1822 *Ammonites plicomphalus* J. Sowerby, p. 82, pl. 359.
non 1823 *Ammonites plicomphalus* J. de C. Sowerby, p. 145, pl. 404.
1837 *Ammonites ptychomphalus* T. Brown, p. 17 (*pars*) (pl. xiii, fig. 2 only).
1924a *Subcraspedites ptychomphalus* Spath, p. 78.
1962 *Craspedites plicomphalus* Casey, p. 98.

Holotype. B.M. 43892a, Spilsby Sandstone, Bolingbroke, Lincolnshire.

Remarks. J. Sowerby's original was re-figured by Donovan (1964 pl. 9 fig. 2). I have since been permitted to clean out the umbilicus, which shows only about 8 blunt nodes on the inner whorl, agreeing with the nucleus of a topotype (Pl 2 fig. 2). This confirms what Spath knew already in 1924 and has been repeated by Casey (1962), *viz*., that J. Sowerby's ammonite could not possibly be the same species figured by his son the following year (J. de C. Sowerby 1823). Now that the inner whorls and suture-line of *A. plicomphalus* are known (Pl. 2 fig. 2;

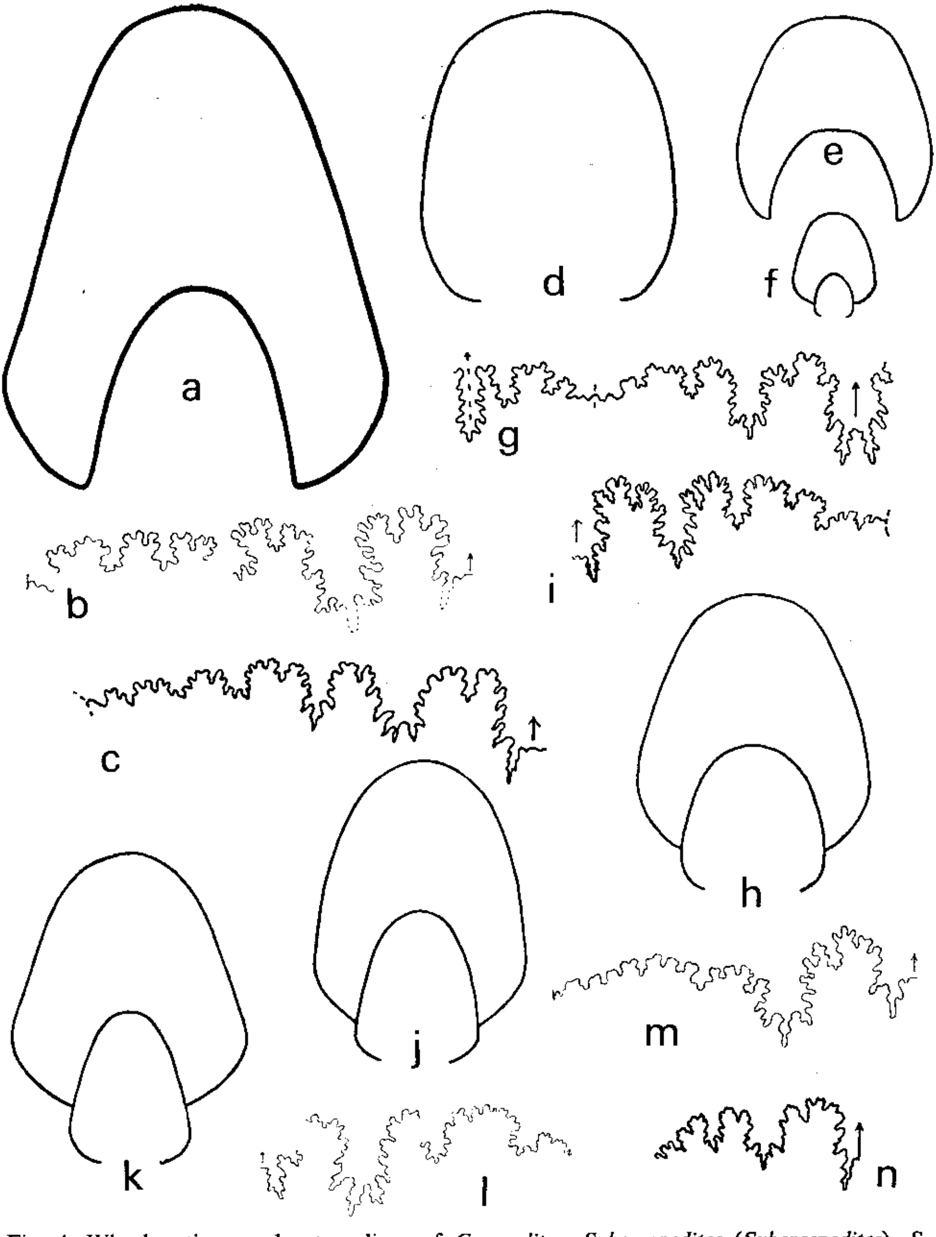


Fig. 4. Whorl-sections and suture lines of *Craspedites*, *Subcraspedites* (*Subcraspedites*), *S.* (*Swinnertonia*) and *Paracraspedites*.

a–b *Craspedites plicomphalus* (J. Sowerby), restored whorl-section of holotype (X 1) and suture-line of topotype figd Pl. 2 fig. 2 (X 1·5). **c** *C. krylovi* Prigorovsky, Upper Volgian, near Moscow, suture-line after Spath 1947 (X 2). **d–g** *Subcraspedites* (*Swinnertonia*) *primitivus* Swinnerton, whorl-sections (X 1) and complete suture-line (X 1·5) of four examples from *primitivus* Zone, Nettleton Top, Lincs. (GSM 107961, 107958, 114744, 114815). **h–i** *Subcraspedites* (*Swinnertonia*) *undulatus* Swinnerton, whorl-section of topotype (GSM 114816) (X 1) and suture-line of holotype after Spath 1947. **j** *Subcraspedites* (*Subcraspedites*) cf. *sowerbyi* Spath, whorl-section (X 1) of example figd Pl. 8 fig. 8. **k–l** *Subcraspedites* (*Subcraspedites*) *sowerbyi* Spath, whorl-section of example figd Pl. 5 fig. 2 (X 1) and suture-line of topotype (GSM 114817) (X 1·5). **m** *Subcraspedites* (*Subcraspedites*) *preplicomphalus* Swinnerton, suture-line of example figd Pl. 3 fig. 4 (X 1·5). **n** *Paracraspedites stenomphaloides* Swinnerton, suture-line of paratype after Swinnerton 1935, with umbilical portion completed.

Fig. 4b) the species is seen to fall easily into the group of *Craspedites nodiger* (Eichwald), *C. mosquensis* Gerasimov and *C. parakaschpuricus* Gerasimov, characteristic of the *nodiger* Zone of the Russian Platform (Gerasimov 1969), thus confirming the view already expressed (Casey 1962).

Craspedites thurrelli sp. nov. Pl. 5 figs 4a–b

Holotype. GSM 100512, *preplicomphalus* Zone, estimated 3 m above base of Spilsby Sandstone, crag in field northeast of Goulceby (TF 260 797), near Donington, Lincolnshire (R. G. Thurrell collection).

Specific characters. Differs from *C. krylovi* Prigorovsky in its slightly closer, less flexuous ribbing, having about 27 primary rib-stems at 60 mm diameter, each rising to two or three secondaries.

Dimensions of holotype.

Diameter (in mm)	*Whorl-height (as % of diam.)*	*Whorl-thickness (as % of diam.)*	*Umbilicus (as % of diam.)*
62	46	c. 35	21

Remarks. The unique holotype is slightly crushed; the suture-line, though imperfectly preserved, shows the tops of the auxiliaries crossing the flank in a straight line parallel with the ribbing and is normal for *Craspedites.* Comparison with *C. krylovi* Prigorovsky (1907) is not intended to imply close relationship, for other species, e.g., *C. unschensis* (Nikitin), have a similar aspect, though combining this with bi-dichotomy of the ribbing (cf. Gerasimov 1969). The straight ribs of *C. thurrelli* foreshadow the costation of *Subcraspedites* (*Volgidiscus*) *lamplughi* Spath, which is also involute in the young, but the smooth venter and strongly ascending suture-line of *Volgidiscus* prevent confusion of the two forms.

Genus *SUBCRASPEDITES* Spath 1924

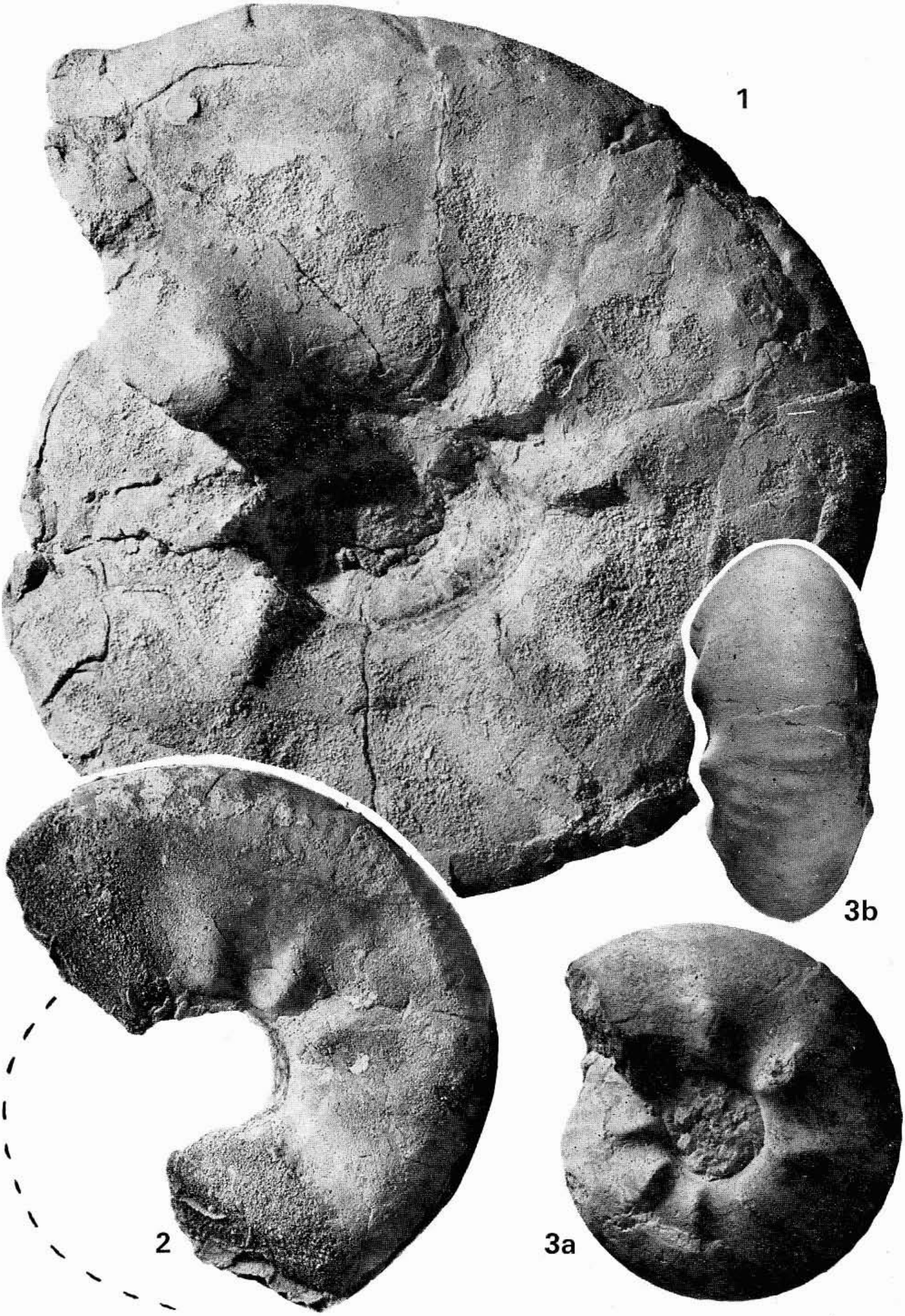
Type-species. Subcraspedites sowerbyi Spath (1952 p. 18) (= *A. plicomphalus* J. de C. Sowerby 1823 *non* J. Sowerby 1822), Spilsby Sandstone, Bolingbroke, Lincolnshire.

Remarks. Misunderstanding of the type-species of this genus, its systematic affinities and precise stratigraphical position have been the biggest obstacles to solving the problem of the age of the Spilsby Sandstone. The nomenclatorial technicalities are the subject of an application to the International Commission on Zoological Nomenclature (Casey 1974) and have been touched upon elsewhere (Spath, 1952; Casey 1962). In retrospect, it would appear that Spath had intended to introduce the name *Subcraspedites* in his paper on the Blake Collection of ammonites from Kachh, India (Spath 1924b), but owing to delay in publication, he anticipated the formal proposition of the name in two earlier papers (Spath 1923, 1924a). Despite the fact that *A. plicomphalus* J. de C. Sowerby 1823, pl. 404, was expressly cited (Spath 1924a) as type-species in preference to *A. plicomphalus* J. Sowerby 1822, most authors have persisted in citing *A. plicomphalus* J. Sowerby 1822, as the type. Others (e.g. Shulgina 1972 p. 121) have disregarded the assertions of Spath (1924a, 1924b, 1947, 1952) and Casey (1962) that the two ammonites belong to different species. In consequence an erroneous concept of *Subcraspedites* has grown up, the adult supposedly possessing the characters of *Craspedites plicomphalus.* In recent Soviet literature the error is compounded by confusing the Sowerbys' ammonites with certain Cretaceous homoeomorphs.

Plate 2 all figs × 0·9.

1, 2 *Craspedites plicomphalus* (J. Sowerby).
1 Crushed holotype with matrix removed from umbilicus. Spilsby Sandstone, Old Bolingbroke, near Spilsby, Lincolnshire. BM. 43892a.
2 Inner whorls of crushed topotype. Lower Spilsby Sandstone (*preplicomphalus* Zone), Spilsby Hill, Old Bolingbroke, near Spilsby, Lincolnshire. H. H. Swinnerton colln, GSM. 114729.
3a–b *Craspedites parakaschpuricus* Gerasimov (= *C. nodiger* Auctt. *non* Eichwald).
Upper Volgian (*nodiger* Zone), Kaschpur, near Moscow, U.S.S.R. GSM. FOR 390 (donated by A. P. Pavlov, 1891).

Plate 2



Subgenus *SUBCRASPEDITES* s.s.

Remarks. In whorl-section and costation this subgenus is close to *Craspedites*, but whereas the latter remains involute and tends to become feebly ribbed or smooth towards the end, *Subcraspedites* is generally more evolute and has a slightly uncoiling outer whorl with coarse sculpture. Typically the costation on the ventral half of the ammonite is largely a feature of external sculpture and may be only feebly impressed on the internal mould, if at all. This is one of the features that helps to distinguish *Subcraspedites* s.s. from *Borealites*, *Ronkinites* and other Ryazanian homoeomorphs. Siberian forms lately referred to *Subcraspedites* s.s. (Shulgina 1972) are discussed below under *Borealites* (*Ronkinites*) and *Peregrinoceras*.

Subcraspedites (*Subcraspedites*) *sowerbyi* Spath. Pl. 3 figs 2a-b, 3; Pl. 4 fig. 6; Pl. 5 figs 1, 2; Figs 4k–l.

non 1822 *Ammonites plicomphalus* J. Sowerby, p. 82, pl. 359.
1823 *Ammonites plicomphalus* J. de C. Sowerby, p. 145, pl. 404.
1837 *Ammonites ptychomphalus* T. Brown, p. 17 (pars) (pl xiii, fig. 11 only).
1924a *Subcraspedites plicomphalus* Spath, p. 78.
1952 *Subcraspedites sowerbyi* Spath, p. 18.

Holotype. B.M. 43892b, Spilsby Sandstone, Bolingbroke, Lincolnshire.

Remarks. The original of *A. plicomphalus* J. de C. Sowerby (*non* J. Sowerby), i.e. the holotype of *S.* (*S.*) *sowerbyi* Spath, the type-species of *Subcraspedites*, is here figured photographically for the first time. It is a normal Spilsby Sandstone steinkern with a film of test in places. J. de C. Sowerby's restored figure was quite successful, but comparison with Pl. 2, figs 1–2 will show that this ammonite is not the inner whorls of J. Sowerby's *A. plicomphalus*, though it may well have been broken from the matrix of that ammonite.

According to Spath (1947, 1952), Brown (1837) had realised that the Sowerby's ammonites belonged to different species and had renamed the original of J. Sowerby (1822) as *A. ptychomphalus*, a nomenclature adopted by Spath in 1924. On the contrary, Brown's crude copies of the Sowerby's figures were expressly used to illustrate the inner and outer whorls of one and the same species. The manifest spelling error "*ptychomphalus*" ("*plichomphalus*" in the index) was applied to *both* specimens and was in no way intended as a taxonomic revision.

At a diameter of about 80 mm the holotype of *S.* (*S.*) *sowerbyi* shows groups of four to six secondaries which connect indefinitely with elongated primary bullae or rib-stems, 17 on the outer whorl. Due to distortion and imperfect preservation, the ribbing makes an unnatural chevron on the venter and is erased near the end on the flank. Where undistorted, the ribs pass straight over the venter, as in *S.* (*S.?*) *claxbiensis* Spath.

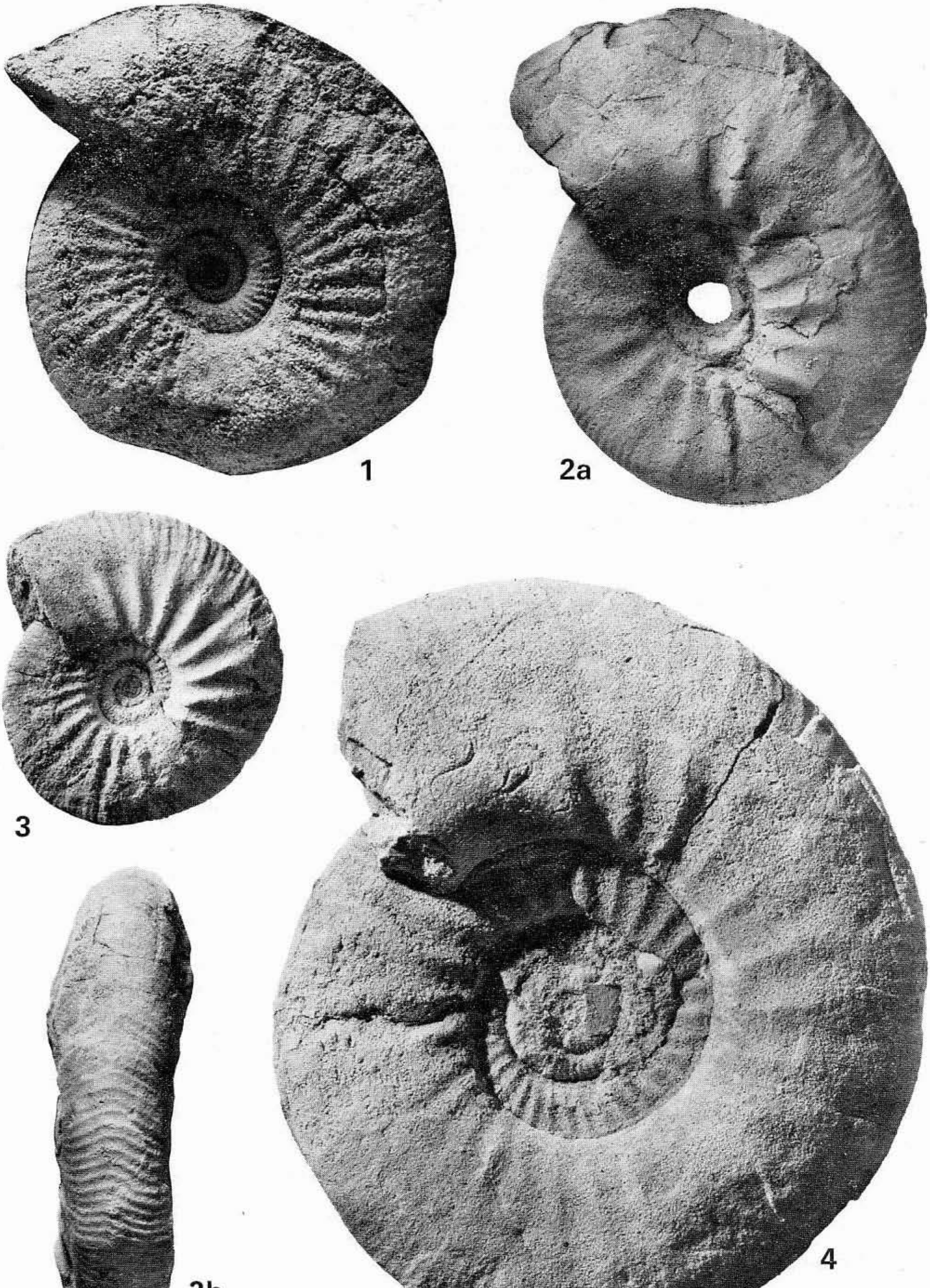
The species is a common form of the *preplicomphalus* Zone (Lower Spilsby Sandstone) and does not occur in the upper beds of the Spilsby Sandstone as conjectured by Spath (1952) and Jeletzky (1965). The example figured by Donovan (1964 pl. 9 fig. 1) is absolutely typical of the state of preservation of the *preplicomphalus* Zone in the southern Wolds. Even in the adult example figured herein (Pl. 5 fig. 1) the ribbing on the outer half of the ammonite is but feebly impressed on the coarse sandstone infilling.

Shulgina's "*Subcraspedites* (*S.*) *plicomphalus*" from the Ryazanian *kochi* Zone of the Boyarka River section of Siberia (Shulgina 1972 pl. 2 figs 1a, b, v) shows a strong superficial resemblance to *S.* (*S.*) *sowerbyi;* the sharpness of the primary ribbing as revealed in the umbilicus, its smoothing outer whorl and the suture-line betray it, however, as a species of *Ronkinites*.

Plate 3 all figs × 0·9.

1 *Subcraspedites* (*Subcraspedites*) sp. nov. cf. *claxbiensis* Spath.
Lower Spilsby Sandstone (*preplicomphalus* Zone), field northeast of Goulceby, near Horncastle, Lincolnshire. R. G. Thurrell colln, GSM. 100516.
2a–b, 3 *Subcraspedites* (*Subcraspedites*) *sowerbyi* Spath.
2a–b Side and venter of holotype (original of *A. plicomphalus* J. de C. Sowerby 1823, *non* J. Sowerby 1822). Spilsby Sandstone, Old Bolingbroke, near Spilsby, Lincolnshire. BM. 43892b.
3 Immature topotype showing ribbing of inner whorls. Lower Spilsby Sandstone (*preplicomphalus* Zone), Old Bolingbroke, Lincolnshire. GSM. 114733.
4 *Subcraspedites* (*Subcraspedites*) *preplicomphalus* Swinnerton.
Example with body-chamber. Lower Spilsby Sandstone (*preplicomphalus* Zone), erratic block with *S.* (*S.*) *sowerbyi* (Pl. 5 fig. 1), British Industrial Sand pit, Bawsey, Norfolk. GSM. Ce3157.

Plate 3



Subcraspedites (Subcraspedites) preplicomphalus Swinnerton Pl. 3 fig. 4; Fig. 4m.

Holotype. BM 36364, Spilsby Sandstone (bottom 2 m), Partney road-cutting, Spilsby, Lincolnshire.

Remarks. The poorly preserved holotype of this species was picked up on a tip heap. I agree with Spath (1952) that it belongs to an evolute member of the same species-group as *S.* (*S.*) *sowerbyi*. *Subcraspedites* (*S.*) *preplicomphalus* is not part of the *cristatus-primitivus* (*Swinnertonia*) plexus as Swinnerton supposed, nor is it ancestral to *S.* "*plicomphalus*" (=*S. sowerbyi*), the two species occurring together on the same horizon at Partney and elsewhere. The example figured in Pl. 3 fig. 4 was associated in an erratic block with numerous *S.* (*S.*) *sowerbyi*, one of which is illustrated in Pl. 5 fig. 1. The nucleus from Basement-bed C referred to *S.* (*S.*) *preplicomphalus* by Swinnerton (1935 p. 37 pl. 3 figs 2a, b) belongs to an indeterminable species of *Swinnertonia*. Being an easily recognized and characteristic fossil of the interval between the *primitivus* and *lamplughi* Zones, *S.* (*S.*) *preplicomphalus* is chosen as zonal index rather than *S.* (*S.*) *sowerbyi* on account of the prior use of the term *sowerbyi* Zone in the British Jurassic for a well-known Bajocian horizon.

Subcraspedites (Subcraspedites ?) claxbiensis Spath. Pl. 4 figs 7a–b.

1936 *Subcraspedites claxbiensis* Spath, p. 85, pl. 36, figs 6a–b.

Holotype. BM C996, Normanby, Lincolnshire (? base of Carstone, ex Spilsby Sandstone).

Remarks. This species is known only by phosphatized nuclei, found either as derived fossils at the base of the Carstone (Albian) in north Lincolnshire or as part of the remanié at the base of the Ryazanian in south Lincolnshire and Norfolk. It differs from typical *Subcraspedites* in having the ribbing equally strong on the internal mould and the test and in its strongly ascending suture-line with well differentiated auxiliaries, as in *Volgidiscus*. The relatively simple ribbing recalls that of *Craspedites okensis crassus* Prigorovsky as figured by Ershova (1969 pl. 2, figs. 2a–b) from the Upper Volgian of Spitsbergen. Some crushed examples from the *preplicomphalus* Zone of south Lincolnshire (e.g. Pl. 3 fig. 1) are provisionally attached to this species, though it is probable that the true *S.* (*S. ?*) *claxbiensis* is of higher horizon. I have been unable to confirm the presence of this species as a derivative at the base of the Claxby bed (see p. 205).

Subgenus *SWINNERTONIA* Shulgina 1972

Type-species. Subcraspedites cristatus Swinnerton, Spilsby Sandstone Basement-beds, Fordington Well No. 1, Lincolnshire.

Remarks. The nominal subgenus *Swinnertonia* was introduced by Shulgina (1972 pp. 123, 138) in the running text of a systematic contribution. Since her concept of the age and characters of the subgenus differ somewhat from those expressed herein, my original MS. diagnosis of *Swinnertonia* (made in 1964) is reproduced as follows:

"Differs from *Subcraspedites* s.s. in more broadly convex ventral area without tendency to smoothness on internal mould; ribbing of inner whorls of more uniform relief and with fewer secondaries (as in *Laugeites*), primaries pinched up or flared on outer whorl; suture-line not markedly ascending".

Swinnertonia comprises a group of early *Subcraspedites* having sutural characters, whorl-shape and ribbing suggesting affinities with the Dorsoplanitinae, especially *Laugeites*. The subgenus includes the forms described by Swinnerton (1935) from Bed D of the Spilsby Sandstone of the Fordington Well (*S. cristatus*, *S. precristatus*, *S. undulatus*, *S. parundulatus*, *S. subundulatus* and *S. primitivus*). These represent a single plexus in which there is a continuous gradation from *S.* (*Sw.*) *primitivus*, in which the laugeitid stage persists to at least 115 mm diameter, and forms like the paratype of *S.* (*Sw.*) *cristatus* (Swinnerton 1935 pl. 3 fig. 5) which has a coarsely ribbed body-chamber with flared primaries already at 35 mm diameter, thus resembling *Dorsoplanites dorsoplanus* (Vischniakov) (Mikhailski 1890 pl. 11 fig. 2a) in miniature. Swinnerton's originals are all more or less crushed. Whorl-sections and suture-lines taken from uncrushed examples from Nettleton are illustrated in this paper (Figs 4d–i).

The attribution of *S. primitivus* to *Ronkinites* (Shulgina 1972 p. 148) is altogether miscarried.

Donovan (1964) has commented on the close relationship between *Subcraspedites* and the genus *Laugeites*. The latter has a wide distribution in the Middle Volgian and basal Upper Volgian of the Arctic regions and differs from *Subcraspedites* in its whorls of subrectangular cross-section that become smooth in the adult. It is now asserted that the examples of

"*Subcraspedites* aff. *preplicomphalus*" and "*Laugeites* sp. nov." figured by Spath (1952 pl. 4) from the Basal Conglomerate (Laugeites Beds) of Wollaston Forland, East Greenland, are the outer and inner whorls respectively of a species of *Swinnertonia*. To explain the occurrence of a supposed Cretaceous ammonite (*Subcraspedites*) in the same nodule as a Jurassic one (*Laugeites*), Spath assumed that both must be derived. This assumption, already questioned by Maync (1949) and Donovan (1957) on the basis of stratigraphical evidence, has since been refuted (Casey 1962; Donovan 1964).

The aptly named *Laugeites intermedius* Donovan (1964) from Kuhn Island, East Greenland, probably represents an early form of *Swinnertonia* close to that figured by Spath from Wollaston Forland. There is some indication of the presence of a comparable fauna of nascent *Swinnertonia* in the Spilsby Sandstone Basement-beds (e.g. Bed 3 of Fordington).

My examination of the collections does not confirm the recorded association of *Swinnertonia* ("*Subcraspedites* cf. *undulatus*") with *Riasanites*, *Berriasella* and *Neocosmoceras* in the "Infra-valanginian" of northern Poland (Dembowska 1964).

Subgenus *VOLGIDISCUS* nov.

Type-species. Subcraspedites lamplughi Spath, Spilsby Sandstone, Spilsby, Lincolnshire.

Subgeneric characters. Compressed, involute *Subcraspedites* with closely spaced ribbing and smooth venter. Sculpture only feebly impressed on internal mould, coarsening on uncoiling adult body-chamber. Suture-line with strongly ascending series of auxiliary elements.

Remarks. Volgidiscus characterizes the topmost part of the Lower Spilsby Sandstone and is represented by *S.* (*V.*) *lamplughi* and a number of undescribed forms differing mainly in degree of inflation. Nuclei of some of the more compressed internal moulds were at first mistaken for "*Garniericeras*" of the group of "*G.*" *tolijense* (Nikitin) (Casey 1970), but study of larger collections, aided by casts and photographs of Nikitin's types, has revealed important differences (see *Shulginites* gen. nov.). *Volgidiscus* carries to extreme the tendency seen in *Subcraspedites* s.s. for the ribbing to be a feature of external ornament only. This is well shown in the example figured in Pl. 6 fig. 2a–b, in which a large part of the (calcite) test still covers the phosphorite internal mould. The coarse umbilical nodes of the adult are illustrated in the phosphorite steinkern from Nettleton shown in Pl. 5 fig. 3. The true *Garniericeras* is an involute oxycone with a sweeping forward curve to the septal edge (Fig. 5m).

Subcraspedites (*Volgidiscus*) *lamplughi* Spath. Pl. 4 figs 8a–b, 9a–b; Pl. 5 fig. 3; Pl. 6 figs 2a–b; Figs 5j–k.

1892 *Craspeditus subditus* Pavlov, p. 116, pl. xiii (vi), fig. 5.
1924a *Subcraspedites* sp. nov. Spath, p. 78.
1936 *Subcraspedites lamplughi* Spath, pp. 81, 180.

Holotype. B.M. C 34981, Spilsby Sandstone, Spilsby, Lincolnshire (G. W. Lamplugh colln)

Remarks. This species is based upon the original "*Craspedites subditus*" from which Pavlov (1892) correctly inferred the Volgian ("Aquilonian") age of the Lower Spilsby Sandstone. The specimen is a fragmentary white phosphorite steinkern with patches of calcite test adhering to the (detachable) inner whorl, i.e., the normal mode of preservation of the *lamplughi* Zone ammonites. In order to confirm that ventral smoothness is a feature of external ornament from an early diameter, phosphorite moulds of this species from the West Dereham basal Cretaceous nodule-bed were dissected to expose the testiferous inner whorls (Pl. 4 figs 9a, b).

The compressed species of *Volgidiscus* illustrated in Pl. 6 fig. 3, provided the suture-line attributed to a new species of *Subcraspedites* between *S. primitivus* and *S. lamplughi* (Spath 1947 text-fig. 6f).

Genus *SHULGINITES* nov.

Type-species. Oxynoticeras tolijense Nikitin, presumed Lower Ryazanian, River Tolya, West Siberia. Lectotype: original of Nikitin 1884 p. 65 pl. 2 fig. 7 (Klimova *in* Saks *et al.* 1972 p. 202).

Generic characters. Involute, very compressed, discoidal, with venter subacute in young, narrowly rounded in adult. Subdued costation of close, almost straight, forwardly-inclined primary stems, with gently curved secondaries bifurcating or trifurcating at low angle from just above middle of sides. Suture-line strongly ascending, with curved septal edge, as in *Hectoroceras*.

Remarks. Despite its frequent quotation in the literature, the generic affinities and geological horizon of "*O*." *tolijense* have remained obscure. Under the name *Garniericeras tolijense*, the species has been commonly quoted from the Upper Volgian of the Russian Platform, more particularly from the topmost beds above the main development of the *nodiger* Zone (Sazonov 1961, 1962). Bodylevsky (1936), however, was of the opinion that in the Trans-Uralian region the glauconitic sandstone with "*G*". *tolijense* was of lowest Cretaceous age and it is listed as such by Mesezhnikov and others (*in* Saks *et al.* 1963, chart). More recently, Klimova (1969) has recorded the species (as *Hectoroceras tolijense*) in association with *Borealites* in the *kochi* Zone of the same region (River Yatriya section). Examples described and figured by Klimova (*in* Saks *et al.* 1972 p. 202 pl. 40 figs 1–4) subsequently, however, do not agree with Nikitin's originals and indicate instead a form closer to *Hectoroceras kochi tenuicostatum* Spath.

Since much of the confusion surrounding "*O*." *tolijense* has been caused by lack of modern illustrations, I am, in Pl. 6 figs 4a–b, figuring one of Nikitin's metatypes from the collections of the Leningrad Mining Institute, which I was permitted to examine in 1963. The photographs were kindly supplied by Dr. N. I. Shulgina of the Institute of Geology of the Arctic, Leningrad.

Shulginites has the sutural characters of *Hectoroceras* and the ribbing of that genus in shadow form, though it lacks the funnel-shaped umbilicus and strength of ribbing of *Hectoroceras*. The Upper Volgian *Garniericeras* is a true oxycone and its suture-lines show a degree of "degeneration" not found in *Hectoroceras* or *Shulginites*. In the Spilsby *Volgidiscus*, another Upper Volgian group wrongly attached to "*O*." *tolijense*, resemblance to *Shulginites* is confined to the juvenile internal mould (Pl. 4 figs 8a–b). The suture-line of *Volgidiscus* is different again (Fig. 5k, l) and the test has strong ribbing concentrated on the lower half of the flank, the umbilicus noded in the adult.

Future investigation will show whether the Volgian records of "*G*." *tolijense* on the Russian Platform pertain rightly to *Volgidiscus*. The "*Garniericeras* aff. *tolijense*" figured by Shulgina (1969 pl. 38 figs 1a, b) from the topmost Volgian Zone of *Chetaites chetae* in the basin of the River Kheta, Siberia, appears to be a *Shulginites*.

The genus is named in honour of Dr. N. I. Shulgina of Leningrad.

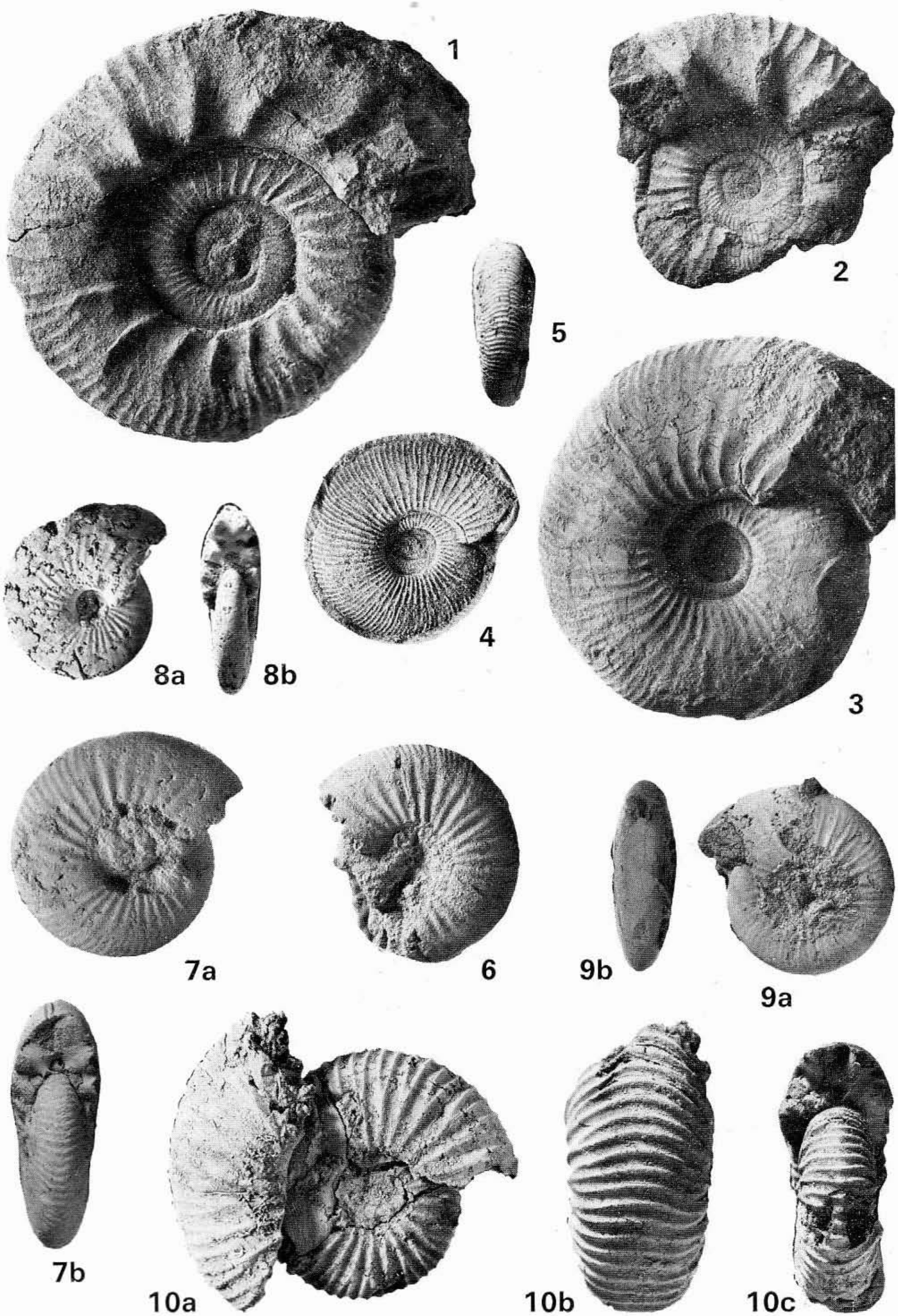
Genus *RUNCTONIA* nov.

Type-species. *R. runctoni* gen. et sp. nov., Lower Mintlyn Beds (*runctoni* Zone), North Runcton, near King's Lynn, Norfolk.

Plate 4 — all figs × 0·9.

1 *Subcraspedites* (*Swinnertonia*) *subundulatus* Swinnerton.
Topotype with body-chamber. Lower Spilsby Sandstone (*primitivus* Zone), depth 70 m, Fordington No. 2 Well, Lincolnshire. GSM. 114742.
2 *Subcraspedites* (*Swinnertonia*) *cristatus* Swinnerton.
Topotype with part of body-chamber. Horizon and locality as Fig. 1. H. H. Swinnerton colln, GSM. 114743.
3 *Subcraspedites* (*Swinnertonia*) *primitivus* Swinnerton.
Septate holotype. Horizon and locality as Fig. 1. BM. 36350.
4, 5 *Subcraspedites* (*Swinnertonia*) sp. juv.
Lower Spilsby Sandstone (*primitivus* Zone).
4 Impression of natural negative. Horizon and locality as Fig. 1. GSM. Zq280.
5 Ventral view of a specimen from Nettleton Top Barn, showing dorsoplanitine nucleus of *Swinnertonia*. GSM. 114744.
6 *Subcraspedites* (*Subcraspedites*) sp.
Immature example for comparison with Figs 4, 5. Lower Spilsby Sandstone (*preplicomphalus* Zone), Old Bolingbroke, Lincolnshire. GSM. 114734.
7a–b *Subcraspedites* (*Subcraspedites?*) *claxbiensis* Spath.
Side and front views of phosphatized nucleus (abraded at the end). Base of Carstone (ex Spilsby Sandstone), Nettleton Valley, Lincolnshire. P. F. Rawson colln, GSM. 114735.
8a–b *Subcraspedites* (*Volgidiscus* subgen. nov.) aff. *lamplughi* Spath.
Phosphatized nucleus illustrating involute juvenile stage of compressed form. Basal nodule-bed (bed 6) of Mintlyn Beds (ex Runcton Beds, *lamplughi* Zone), Fenland Flood Relief Channel, West Dereham, Norfolk. GSM. Ce1966.
9a–b *Subcraspedites* (*Volgidiscus* subgen. nov.) *lamplughi* Spath.
Side and venter of nucleus with test (which ends at bleb of phosphate on venter), dissected from outer whorls to demonstrate that ventral smoothness is not merely a feature of internal mould. Horizon and locality as Fig. 8. GSM. Ce 1903.
10a–c *Surites* (*Bojarkia*) *tealli* sp. nov.
Side, ventral and front views of holotype. Mintlyn Beds (bed 10 *stenomphalus:* Zone), King's Lynn Bypass, Galley Hill, Mintlyn Wood, near King's Lynn, Norfolk. GSM. Ce4407.

Plate 4



Generic characters. Moderately compressed craspeditids with narrow umbilicus and poorly defined umbilical wall. Whorl-section at first subelliptical with narrowly arched venter, becoming subrectangular with flattened or feebly convex venter. Narrow flexuous ribs lean forwards from above the umbilical seam and bifurcate at a low angle from about middle of sides to form sickle-shaped curve; a few short intercalatories occur. Ribs at first absent on venter, but with change in whorl-shape they pass over venter with forward bend. Adult whorls poorly known, apparently tending to smoothness with concentration of sculpture at umbilical and ventrolateral areas. Suture-line strongly ascending, with numerous shallow auxiliaries.

Remarks. Great interest attaches to *Runctonia* as affording a clue to the ancestry of *Hectoroceras* and its associate *Praetollia*. In morphological features it stands almost half-way between *Volgidiscus* and *Hectoroceras*. The sickle-shaped ribbing directed forwards on the venter, and subacute venter of the young are characters linking *Runctonia* with *Hectoroceras*, while the normal umbilicus and suture-line point to a connexion with *Volgidiscus*. In the middle growth-stages there is perhaps even closer resemblance to *Praetollia*, enhanced by the tendency in both *P. maynci* and *R. runctoni* for the secondaries to increase in number during growth. *Praetollia* is still incompletely known, and the suite of crushed specimens from Wollaston Forland, E. Greenland, on which Spath (1952) based his diagnosis of the genus, remains practically the only source of information. Examination of this material (in the Universitetets Mineralogisk-Geologiske Institut, Copenhagen) shows the ribbing to be sharper than that of *R. runctoni*, with less emphasis on the primaries, and the venter is rounded and ribbed in the juvenile.

Since the holotype-mould of *P. maynci* Spath, the type-species of *Praetollia*, is distorted and the original illustration (Spath 1952 pl. 3, fig. 2) gives a misleading idea of the ribbing, I am figuring an impression in which the distortion has been corrected (Pl. 7 fig. 8). The group of "*Olcostephanus*" *bidevexus* Bogoslovsky (1897 pl. 3 figs 1a, b, 2a, b, 3, 4) (= *Pronjaites* Sazonova 1971), which Gerasimov (*in* Sazonova 1962) attaches to *Praetollia*, has a wider umbilicus, narrowly arched venter and ribbing of a different type, branching from low on the flank and with numerous intercalatories.

Runctonia runctoni gen. et sp. nov. Pl. 7 figs 5a–b, 6a–b, 7a–b; Figs 5f–h.

Holotype. GSM. Ce 5348, basal nodule-bed of Mintlyn Beds, North Sea gas pipe-line trench, Manor Farm, North Runcton, near King's Lynn, Norfolk.

Specific characters. Runctonia with smooth venter to c. 30 mm diameter. Ribs at first almost regularly bifurcating, in ratio of 17 primaries to 36 secondaries per half-whorl at 50 mm diameter. With increase in diameter intercalatories appear, primaries become emphasised, and ribs cross feebly convex venter with arcuate bend.

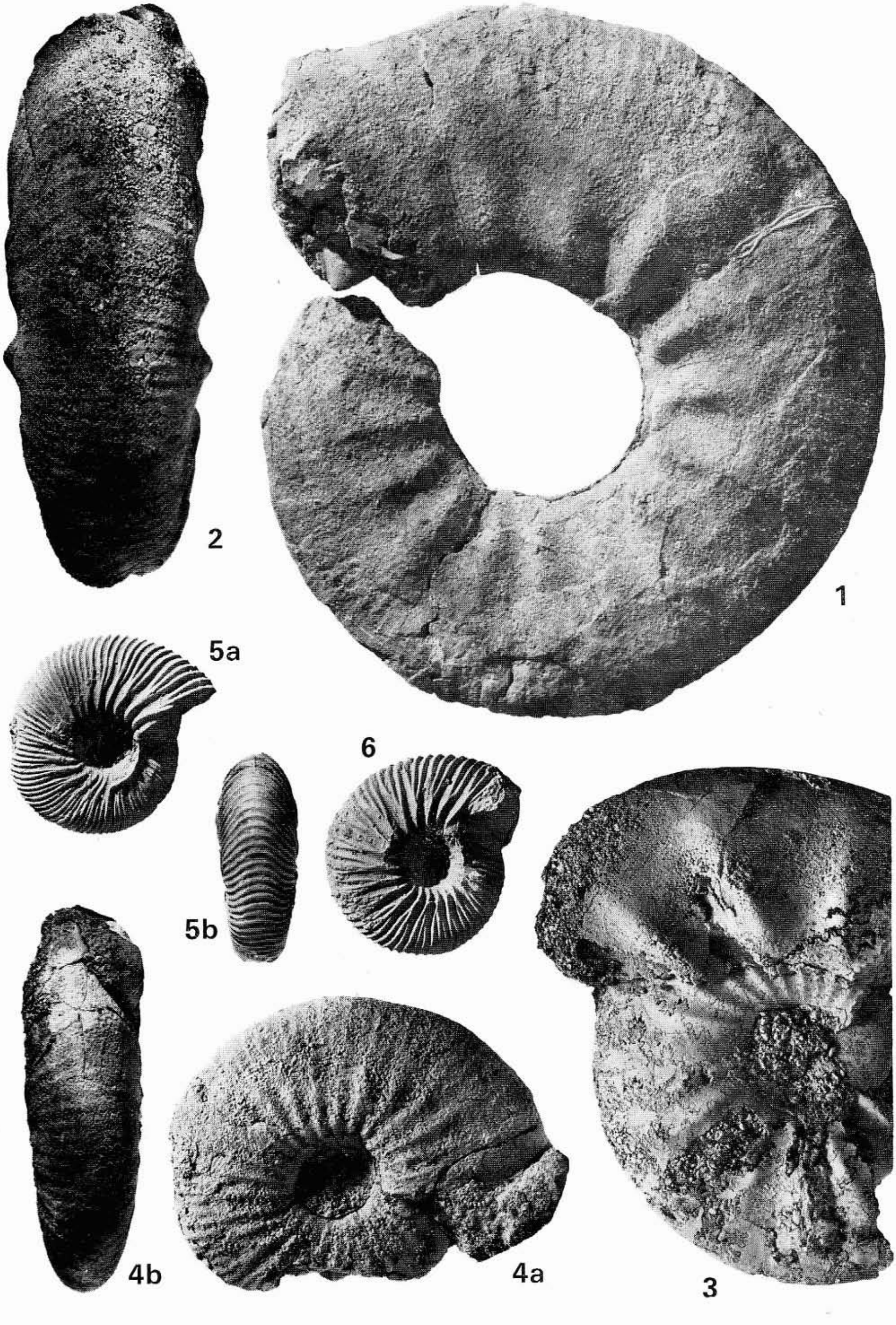
Dimensions of holotype.

Diameter (in mm)	*Whorl-height (as % of diam.)*	*Whorl-thickness (as % of diam.)*	*Umbilicus (as % of diam.)*
50	46	29	21

Plate 5 all figs × 0·9.

1, 2 *Subcraspedites* (*Subcraspedites*) *sowerbyi* Spath.
Lower Spilsby Sandstone (*preplicomphalus* Zone).
1 Example with body-chamber (abraded at end). Erratic block with *S.* (*S.*) *preplicomphalus* (Pl. 3, fig. 4), British Industrial Sand pit, Bawsey, Norfolk. GSM. Ce3188.
2 Venter of uncrushed body-chamber. Field northeast of Goulceby, near Horncastle, Lincolnshire. R. G. Thurrell colln, GSM. 100514.
3 *Subcraspedites* (*Volgidiscus* subgen. nov.) aff. *lamplughi* Spath.
Compressed form showing umbilical folds on outer whorl, strongly ascending suture-line and short body-chamber. Lower Spilsby Sandstone (*lamplughi* Zone: bed 6), Nettleton Top Barn. S. Kelly colln, GSM. 114731.
4a–b *Craspedites thurrelli* sp. nov.
Holotype, side and ventral views. Horizon and locality as fig. 2. R. G. Thurrell colln, GSM. 100512.
5a–b *Paratollia* cf. *kemperi* gen. et. sp. nov.
Side and venter of juvenile example. Claxby Beds, Bardney-Louth Railway cutting, "Little Benenden", near Donington-on-Bain, Lincolnshire. SM. B12222.
6 *Propolyptychites* sp.
Juvenile. Claxby Beds, *Paratollia* horizon, Bardney-Louth Railway cutting, Benniworth Haven, near Donington-on-Bain, Lincolnshire. SM. B11120.

Plate 5



Remarks. The type material consists of six phosphatised examples with patches of nacreous test, none complete. In addition there is a large number of nacreous chips from the fragmentation of this or some allied ammonite having a body-chamber comparable with that of *Surites* (*Bojarkia*) *suprasubditus pavlovi* subsp. nov. (Pl. 9) in size and sculpture.

Genus *HECTOROCERAS* Spath 1947

Type-species. H. kochi Spath, presumed "Infravalanginian" (Ryazanian), S. W. Jameson Land, East Greenland.

Remarks. Following the original discovery of this genus in Greenland (Spath 1947), it was reported in the "Berriasian" of eastern England (Casey 1961b) and has since proved to be a characteristic fossil in the basal Cretaceous succession in North and West Siberia. Its oxycone form, funnel-like umbilicus, and sickle-shaped ribs bifurcating high on the flank make this an easily recognized ammonite. Hitherto only the type-species, *H. kochi,* with its subspecies, *magnum* Spath and *tenuicostatum* Spath, has been described, apart from certain Siberian forms referred to *H. tolijense* (Nikitin) (Klimova *in* Saks *et al.* 1972). All the well-preserved and photogenic English examples of *Hectoroceras* were obtained from a single temporary exposure of the Mintlyn Beds at West Dereham, Norfolk. It is therefore not known whether the vertical distribution of the many undescribed species, with and without *H. kochi,* reflects a natural sequence or fortuitous local detail. These will be described in a future publication.

Hectoroceras larwoodi sp. nov. Pl. 7 fig. 4.

Holotype. GSM Ce 5096 (external mould), base of Carstone (Bed 18, *ex* Mintlyn Beds, *kochi* Zone), Fenland Flood Relief channel, West Dereham, Norfolk.

Specific characters. Similar to *H. kochi tenuicostatum* Spath (1947 pl. 1, fig. 1a) but with feebler, more flexuous ribbing, showing periodic bi-dichotomy from low on the flank.

Remarks. This distinctive species of *Hectoroceras* is illustrated because it occurs above the main development of *H. kochi* in the Mintlyn Beds and may prove of biostratigraphical value. The species is named in honour of Dr. G. P. Larwood, who assisted in the original reconnaissance of the Flood Relief channel at West Dereham.

Subfamily Tolliinae Spath 1952
Genus *BOREALITES* Klimova 1969

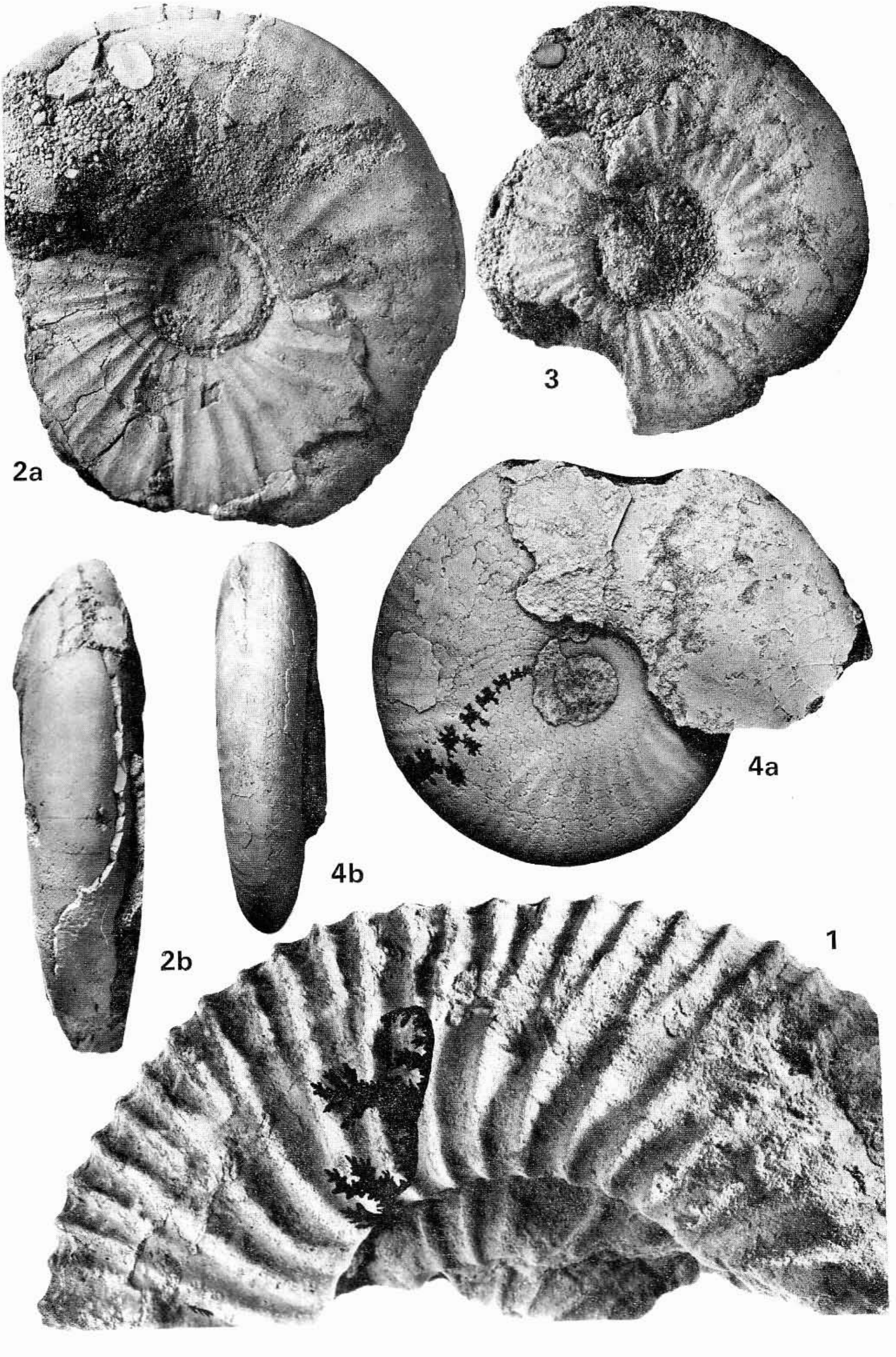
Type-species. B. fedorovi Klimova, Ryazanian, *kochi* Zone, West Siberia.

Remarks. Borealites was originally defined to include *B. fedorovi* Klimova, "*Olcostephanus*" *suprasubditus* Bogoslovsky of the Ryazan Beds and "*Tollia* (*Subcraspedites*) aff. *suprasubditus*" and "*T.* (*S,?*) cf. *payeri*" of Jeletzky (1964) from Berriasian rocks in Arctic Canada. To these were later added *B. radialis* Klimova, *B. mirus* Klimova and *B, explicatus* Klimova (Klimova 1972) and *B. ? suritiformis* Klimova (*in* Golbert *et al.* 1972) from the *kochi* Zone of the Trans-

Plate 6 all figs. × 0·95.

1 *Paracraspedites* cf. *oppressus* sp. nov.
Portion of inner whorls of large example, still septate at c. 260 mm diameter. Drift (ex Spilsby Sandstone Basement-bed, *oppressus* Zone), Dunham, near Swaffham, Norfolk. C. B. Rose colln, Norwich Castle Museum.
2a–b *Subcraspedites* (*Volgidiscus* subgen. nov.) *lamplughi* Spath.
Side and venter of example with portions of (calcite) test, Spilsby Sandstone, Claxby, Lincolnshire. SM. B12205.
3 *Subcraspedites* (*Volgidiscus* subgen. nov.) aff. *lamplughi* Spath.
Phragmocone of compressed form (suture-line Fig. 51), Spilsby Sandstone, Normanby, Lincolnshire. BM. C73374.
4a–b *Shulginites tolijensis* (Nikitin).
Side and venter of topotype. Jurassic-Cretaceous boundary beds, River Toliya, eastern slope of northern Urals, U.S.S.R. Museum of Mining Institute, Leningrad. (Photo by courtesy of N. I. Shulgina).

Plate 6



Uralian border of West Siberia. As conceived by the present author, the genus *Borealites* s.s. comprises Klimova's species from West Siberia, the North Siberian form attributed to *suprasubditus* by Shulgina (1972 pl. 5 figs 1–2, pl. 6 figs 3–6); ammonites illustrated by Voronets (1962 pl. 31 figs 2a, b, v. pl. 45 figs 1–2, pl. 52 fig. 2) as *Taimyroceras ? bodylevskyi* Voronets and *Subcraspedites* ex gr. *bidevexus* Bogoslovsky, from an horizon in the Lena-Anabar region subsequently assigned to the *sibiricus* Zone by Basov and others (*in* Saks *et al.* 1972 p. 32), and the Canadian *Praetollia antiqua* Jeletzky, assigned by its author to the Jurassic (Jeletzky, this volume).

While the original "*O.*" *suprasubditus* (Bogoslovsky 1897 pl. 1) has the characters of *Surites* (*Bojarkia*), the Canadian form attached to this species is here regarded as a form of *Ronkinites* allied to *R. anglicus* (Shulgina).

Ronkinites and *Borealites* are closely associated in geological occurrence, geographical distribution and in morphological features and are treated as only subgenerically distinct. Both have tolline inner whorls, and judging by casts of *B. fedorovi* kindly sent me by Dr. V. N. Saks, these exhibit constrictions in some specimens, as in *Ronkinites*. Data from Siberia suggests that the more strongly ribbed *Borealites* s.s. is the first to appear, in the *sibiricus* Zone, and become more diversified in the lower part of the *kochi* Zone. The primitive *B.* (*B.*) *bodylevskyi* (Voronets) leans towards *Ronkinites* and may be seen as a generalized from near the root-stock of late *Borealites* s.s. and *Ronkinites*. The latter appears in the *kochi* Zone (? upper part) and ranges into the succeeding *analogus* Zone. This agrees with the Canadian sequence, in which *Borealites* s.s. (= *Praetollia antiqua* Jeletzky, this volume) is found below *Ronkinites*. In Greenland, also, crushed ammonites probably referable to *Borealites* s.s. have been obtained from a level near the base of the *kochi* Zone (Surlyk this volume, Pl. 1 fig. 3).

The tolline inner whorls and suture-line of *Borealites* s.s. point to closer affinities with *Surites* than with the Volgian *Subcraspedites*, to which it was subordinated as a subgenus by Shulgina (1972). The relationship of *Borealites* to *Praetollia*, a form of much the same age, is hard to assess at present. So far as is known, the umbilicus of *Praetollia* remains small throughout and the thin, close ribbing of its type-species, *P. maynci* Spath, remarkably *Hectoroceras*-like in the middle growth-stages, does not develop the thickened primaries of *Borealites*. The basal Valanginian *Surites* (*Bogoslovskia*) produces a similar morphology in the young, though with bolder ribbing projected in a tongue-like extension on the venter. In the adult *Bogoslovskia* (= *Stchirowskiceras* Sazonova 1971) the ribbing becomes closer and feebler on the ventral half of the shell, the final stage resembling in sculpture that of *Surites* (*Bojarkia*) *suprasubditus* (Bogoslovsky).

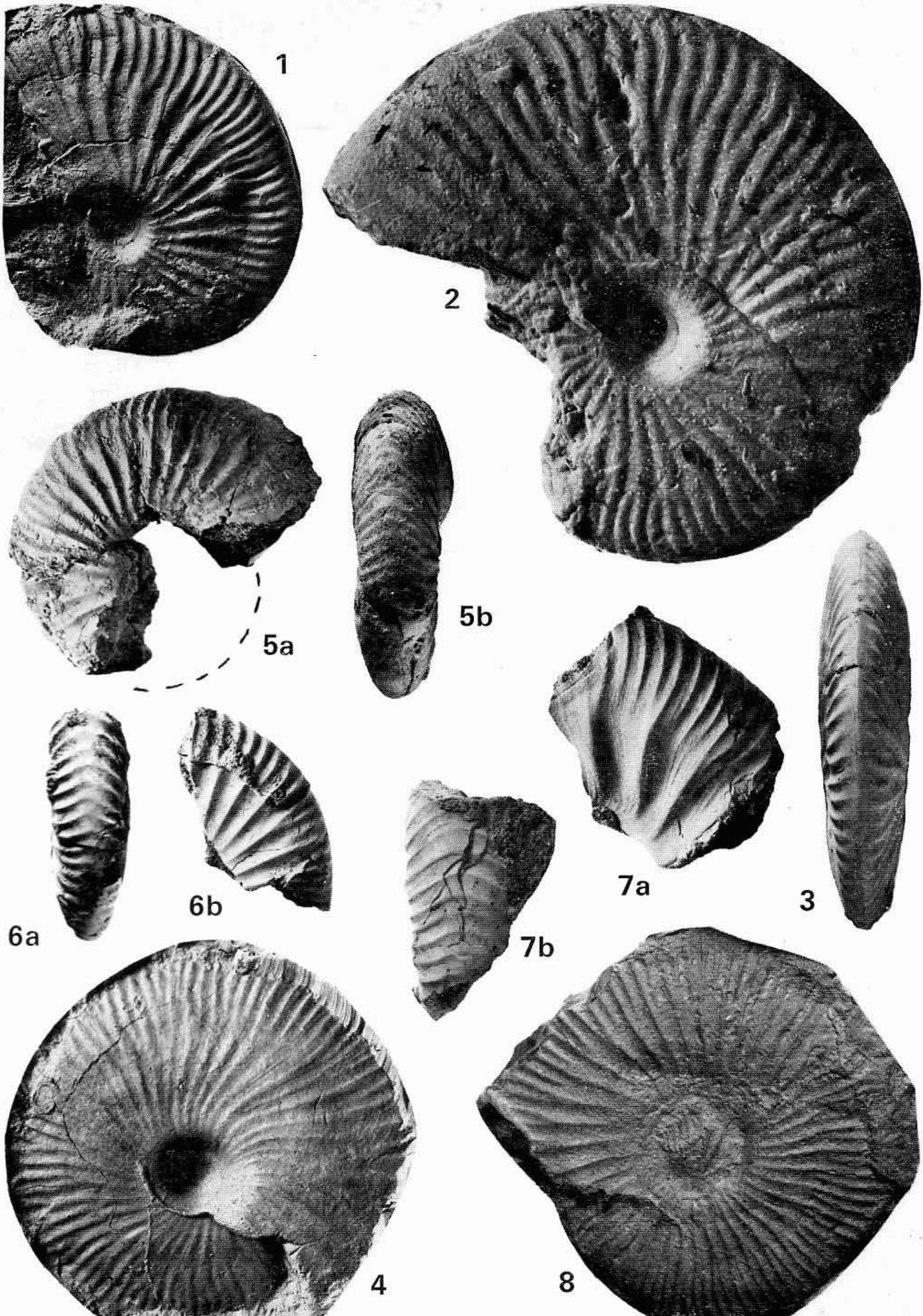
Subgenus *BOREALITES* s.s.
Borealites (*Borealites*) cf. *fedorovi* Klimova. Pl. 8 fig. 7.

Remarks. A fragment from the top of the Lower Mintlyn Beds (Bed 16, *kochi* Zone) of the Flood Relief channel at West Dereham (GSM Ce 3092) has an estimated diameter of 40 mm. In its oval whorl-section and the forwards projection of the ventral ribbing it compares well with *B. fedorovi* or *B. surítiformis* Klimova; but in the relatively early aquisition of dominantly triplicate ribs it shows better agreement with *B. suprasubditus* Shulgina *non* Bogoslovsky (Shulgina 1972 pl. 5 figs. 2a, b). The characteristic feature of this fragment, however, is its

Plate 7 all figs × 0·9.

1–3 *Hectoroceras kochi* Spath.
Impressions from natural negatives and venter of clay-ironstone steinkern. Mintlyn Beds (*kochi* Zone), Fenland Flood Relief Channel, West Dereham, Norfolk. GSM. Ce3818, GSM. Ce1946, GSM. Ce2428.
4 *Hectoroceras larwoodi* sp. nov.
Impression from holotype-mould. Base of Carstone (bed 18) (ex Mintlyn Beds, *kochi* Zone), Fenland Flood Relief Channel, Abbey Station, West Dereham, Norfolk. GSM. Ce5096.
5a–b, 6a–b, 7a–b *Runctonia runctoni* gen. et. sp. nov.
Basal nodule-bed of Mintlyn Beds (bed 6: *runctoni* Zone), No. 2 Gas Feeder Main trench, Manor Farm, North Runcton, near King's Lynn, Norfolk.
5a–b Side and venter of holotype, GSM. Ce5348.
6a–b Side and venter of paratype, showing beginning of ventral union of ribs. GSM. Ce5347.
7a–b Side and venter of body-chamber fragment. GSM. Ce5343.
8 *Praetollia maynci* Spath.
Impression from holotype-mould, Ryazanian, north coast of Wollaston Forland, Lindemans Fjord, East Greenland. Specimen illustrated Spath 1952 pl. 3 fig. 2, but ventrolateral distortion here corrected. Universitetets Mineralogisk-Geologiske Institut, Mineralogisk Museum, Copenhagen.

Plate 7



almost virgatitid mode of trifurcation, which occurs, though less markedly, in *B. fedorovi* and *B. mirus* Klimova (*in* Saks *et al.* 1972 pl. 35 fig. 3a). A larger example of possibly the same or a more inflated species of *Borealites* was collected by Mr. J. Doyle from the *Hectoroceras* beds of West Dereham (GSM Zm7976). In this specimen the tolliid nucleus, with regularly bifurcating ribs, is preserved as a hollow mould; the outer whorl agrees with *B. fedorovi* so far as it goes, but is too badly crushed for critical comparison. A piece of a *Tollia*-like nucleus found in the *kochi* Zone of the King's Lynn Bypass (Mintlyn Wood, Bed 3) may or may not belong to *Borealites*. Another doubtful nucleus was found at the base of the zone (bed 6) at West Dereham.

Subgenus *RONKINITES* Shulgina 1972

Type-species. Subcraspedites (*Ronkinites*) *rossicus* Shulgina, Ryazanian, *kochi* Zone, R. Boyarka, N. Siberia.

Remarks. Formally proposed in 1972 by Shulgina (1972 p. 147) as a subgenus of *Subcraspedites*, with *S.* (*R.*) *rossicus* as type-species, the name was first used in 1970 (*in* Basov *et al.* 1970 p. 21) in connexion with *Taimyroceras ? bodylevskyi* Voronets of the *sibiricus* Zone of the Anabar section. From photographs and specimens kindly supplied by Dr. N. I. Shulgina, I have concluded that this subgenus of *Borealites* should be enlarged to include "*S.* (*S.*) *plicomphalus*" and "*S.* (*S.*") *anglicus* of the same author (Shulgina 1972 pls 1, 2, 3, pl. 4 fig. 1), and perhaps also her "*Praetollia maynci*" (*ibid*, pl. 6 fig. 1).

Compared with *Subcraspedites* s.s., the diagnostic features of *Ronkinites* are its *Surites*-like nucleus, with tardy appearance of umbilical thickening to the ribs, well-differentiated auxiliaries in the suture-line, and the nature of the outer whorls, which are devoid of sculpture except for umbilical bullae. There are minor differences of ribbing and whorl-shape, and faint constrictions, when present, are another distinguishing feature. In accordance with this concept of *Ronkinites*, the type-species, *B.* (*R.*) *rossicus*, is regarded as an extreme form in which the appearance of umbilical bullae is unusually delayed. Resemblance of *Ronkinites* to *Subcraspedites* is in the middle growth-stages only. Reference of *B.* (*R.*) *anglicus* and *B.* (*R.*) "*plicomphalus*" (Shulgina) to *Subcraspedites* s.s. results from a faulty concept of the type-species of that genus, produced by combining the characters of the small, finely ribbed *A. plicomphalus* J. de C. Sowerby (= *Subcraspedites sowerbyi* Spath) and those of the large *A. plicomphalus* J. Sowerby (= *Craspedites plicomphalus*), with its ribless and coarsely noded outer whorl.

Borealites (*Ronkinites*) is represented in the *Buchia okensis* Zone of Arctic Canada by "*Tollia* (*Subcraspedites*) aff. *suprasubditus*" and "*Tollia* (*Subcraspedites*) aff. *spasskensis*" of Jeletzky (1964 pl. 2 figs 1 a–c; pl. 3 figs 2 a–d).

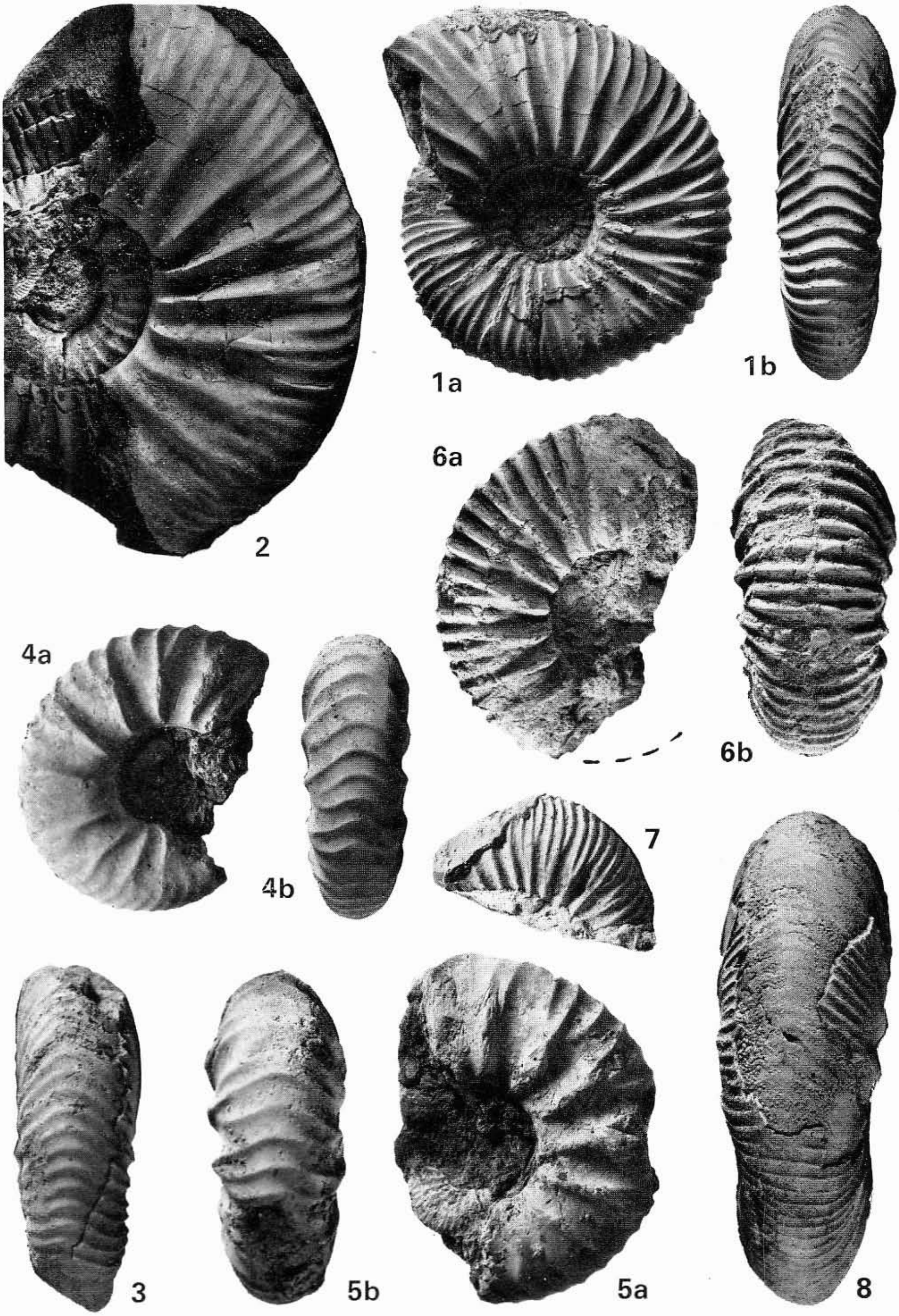
Genus *SURITES* Sazonov 1951

Type-species. Surites pechorensis Sazonov, Ryazan Beds, Russian Platform.

Plate 8 all figs × 0·9.

1a–b, 2, 3 *Surites* (*Bojarkia*) *stenomphalus* (Pavlov).
Upper Spilsby Sandstone (*stenomphalus* Zone).
1a–b Side and venter of slightly crushed lectotype, with matrix cleaned from umbilicus. Donington-on-Bain, Lincolnshire. SM. B11111.
2 Fragmentary example from the Bardney-Louth railway cutting, Benniworth Haven, near Donnington-on-Bain, Lincolnshire. SM. B93301.
3 Example showing uncrushed venter. North Willingham, Lincolnshire. GSM. 30896.
4a–b, 5a–b *Surites* (*Lynnia* subgen. nov.) *icenii* sp. nov.
Mintlyn Beds (bed 12: *icenii* Zone), No. 2 Gas Feeder Main trench, Manor Farm, North Runcton, near King's Lynn, Norfolk.
Side and venter of paratype, GSM. Ce5311. (4a–b) and holotype, GSM. Ce5298 (5a–b).
6a–b *Kerberites* cf. *kerberus* S. Buckman.
Side and venter of typical fragment. Lower Spilsby Sandstone (Basement-bed: *giganteus* Zone), depth 71·9 m, Fordington No. 2 Well, Lincolnshire. GSM. Zq275.
7 *Borealites* (*Borealites*) cf. *fedorovi* Klimova.
Impression from natural mould. Mintlyn Beds (bed 16: *kochi* Zone), Fenland Flood Relief Channel, West Dereham, Norfolk. GSM. Ce3092.
8 *Subcraspedites* (*Subcraspedites*) aff. *sowerbyi* Spath.
Ventral view of example with (calcite) test removed in places. Note that ribbing is greatly reduced in strength on the internal mould. Lower Spilsby Sandstone, Claxby, Lincolnshire. SM. B11112.

Plate 8



Remarks. This genus has been fully discussed and illustrated by Sazonova (1971) from material from the Moscow-Volga region. In the present paper the scope of the genus is widened to embrace certain species-groups (subgenera) originally described as independent genera. These are: *Bogoslovskia* Sazonova 1965 (=*Stchirowskiceras* Sazonova 1971), *Caseyiceras* Sazonova 1971, and *Bojarkia* Shulgina 1969, to which is added *Lynnia* subgen. nov., described below. These all possess moderately compressed or slightly depressed whorls and a suture-line with an ascending series of auxiliaries. The ribs are regularly biplicate in the young and bend forwards on the venter; a more complex ribbing generally develops in mid-life but only umbilical and/or ventro-lateral remnants of it survive at large diameters.

Subgenus *BOGOSLOVSKIA* Sazonova 1965

Type-species. Bogoslovskia pseudostenomphala Sazonova 1971 (=*Olcostephanus stenomphalus* Pavlov 1889 p. 59 pl. 3 fig. 10 only), basal Valanginian, Russian Platform.

Remarks. The nominal genus *Bogoslovskia* was first used without diagnosis (Sazonova 1961) for "*Olcostephanus*"*stenomphalus* Pavlov; this species was based on two examples, one from the Spilsby Sandstone of Lincolnshire, the other from the Lower Valanginian of the Russian Platform (Pavlov 1889). When the genus was formally and validly proposed in 1965 Sazonova made it clear that it was based on Pavlov's Russian syntype, despite the fact that Spath (1947) had designated the English specimen as lectotype. As stated by Jeletzky (1968), the two ammonites are subgenerically distinct, and as the original Russian "*O.*" *stenomphalus* is lost I had considered seeking authority of the International Commission on Zoological Nomenclature to designate the Lincolnshire example as the taxonomic basis for *Bogoslovskia* under Article 70. In the meantime, the proposition of the name *Bojarkia* for the species-group that includes this Lincolnshire form (Shulgina *in* Saks and Shulgina 1969) and the selection of a neotype for Pavlov's missing Russian one (renamed *B. pseudostenomphala*) by Sazonova (1971) changes the situation. I am now of the opinion that stability of nomenclature is best served by adhering to the type-species *pseudostenomphala* Sazonova, which is to be regarded as a replacement name for *Bogoslovskia stenomphala* Sazonova *non* Pavlov (Article 70 (b) (i)) on transference of both Sazonova's and Pavlov's species to *Surites*.

From photographs and specimens kindly supplied by Dr. I. G. Sazonova and Dr. N. T. Sazonov and from examination of their material in Moscow, I have concluded that the ammonites described by Sazonova under the generic name *Stchirowskiceras* represent the adult stages of species of *Bogoslovskia*.

Subgenus *BOJARKIA* Shulgina 1969

Type-species. Bojarkia mesezhnikowi Shulgina, Upper Ryazanian, *mesezhnikowi* Zone, R. Boyarka, West Siberia.

Remarks. In my interpretation, *Bojarkia* comprises the Arctic species *S.* (*Bj.*) *mesezhnikowi* (Shulgina), *S.* (*Bj.*) *bodylevskii* (Shulgina) and *S.* (*Bj.*) *payeri* (Toula, of Russian authors), the English Upper Ryazanian *S.* (*Bj.*) *stenomphalus* (Pavlov), *S.* (*Bj.*) *surprasubditus pavlovi* subsp. nov., and *S.* (*Bj.*) *tealli* sp. nov., together with a number of species described by Bogoslovsky (1897, 1902) from the Ryazan Beds, e.g., "*O.*" *suprasubditus, kozakowianus, tzikwinianus* and *subtzikwinianus*. These differ from typical *Surites* such as *S.* (*S.*) *pechorensis* Sazonova and *S.* (*S.*) *spasskenisis* (Nikitin) notably in their flat, subparallel whorl-sides, broadly rounded venter and relatively early loss of coarse biplicate ribbing, though there are a number of transitional forms in the Ryazan fauna.

Surites (*Bojarkia*) *stenomphalus* (Pavlov). Pl. 8 figs 1a–b, 2, 3; Figs 6a–b.

Lectotype. Sm B 11111, Spilsby Sandstone, Donington, Lincolnshire, designated Spath 1947, p. 23.

Dimensions of lectotype.

Diameter (in mm)	*Whorl-height* (*as % of diam.*)	*Whorl-thickness* (*as % of diam.*)	*Umbilicus* (*as % of diam.*)
63·5	43	?	26

Remarks. In view of the widespread use of the term "*stenomphalus* Zone", especially in the USSR, it has been of prime importance to establish the stratigraphical position and systematic affinities of the ammonite which correctly bears this specific name. I have cleaned the matrix from the umbilicus of the lectotype (Pl. 8 fig. 1a–b) and it can now be identified as

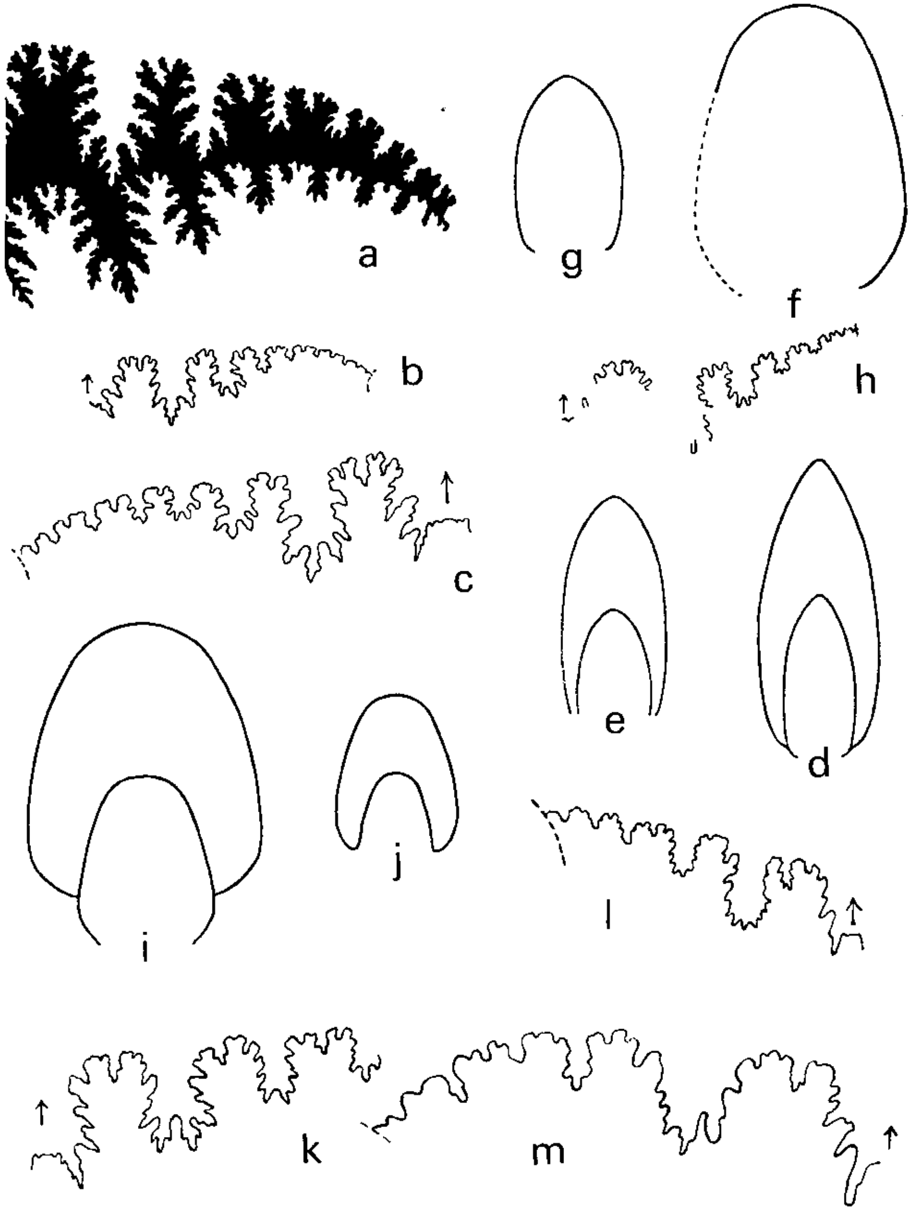


Fig. 5. Whorl-sections and suture-lines of *Hectoroceras*, *Runctonia*, *Subcraspedites* (*Volgidiscus*) and *Garniericeras*.

a *Hectoroceras* cf. *kochi magnum* Spath, *kochi* Zone, West Dereham, Norfolk (GSM GT 4), suture-lines (X 1). **b–d** *Hectoroceras kochi* Spath, suture-lines of Greenland examples after Spath 1947, and whorl-section of example figd Pl. 7 fig. 3 (X 1). **e** *Hectoroceras* cf. *kochi tenuicostatum* Spath, *kochi* Zone, West Dereham, Norfolk (GSM GT 44) (X 1). **f–h** *Runctonia runctoni* gen. et sp. nov., whorl-section of paratype figd Pl. 7 figs 7a–b, and holotype (X 1) and suture-line (composite) of holotype (X 1·5). **i** *Subcraspedites* (*Volgidiscus*) sp. nov., base of Carstone (ex Spilsby Sandstone), Caistor, Lincs. (GSM VW 565), whorl-section (X 1). **j–k** *Subcraspedites* (*Volgidiscus*) *lamplughi* Spath, whorl-section of West Dereham, Norfolk, example (ex Runcton Beds) (GSM Ce 1886) (X 1) and suture-line of holotype after Spath 1947. **l** *Subcraspedites* (*Volgidiscus*) aff. *lamplughi* Spath, suture-line of example figd Pl. 6 fig. 3, after Spath 1947. **m** *Garniericeras catenulatum* (Fischer), Upper Volgian, near Moscow, suture-line after Spath 1947.

belonging to the characteristic ammonite species of the Upper Spilsby Sandstone "doggers", which yielded numerous examples to the early collectors (British Museum, Geological Survey Museum, Sedgwick Museum, York Museum, etc.), probably mostly from the Bardney-Louth railway cutting, though labelled Donington, North Willingham, Benniworth Haven and Tealby. In recent years the species has been collected from Fulletby Manor, Lincolnshire, and from the Mintlyn Beds of the King's Lynn Bypass. An example of 175 mm diameter in typical Spilsby Sandstone lithology was obtained from the Drift of Redisham, Norfolk (Norwich Castle Museum). Comparison of the Spilsby Sandstone example illustrated in Pl. 8 fig. 2, and the Siberian *S.* (*Bj.*) *mesezhnikowi* (Shulgina) (*in* Saks and Shulgina 1969 pl. 1 fig. 2) will show that the two species are very close, if not conspecific. According to Sazonova (1971 p. 72) the latter nominal species is a subjective synonym of *Pavlovites krestensis* Aristov, proposed earlier in the same year (Aristov *in* Ivanov and Aristov 1969). Whether or not this postulated synonymy will be upheld, the identity or near identity of *S.* (*Bj.*) *stenomphalus* and *S.* (*Bj.*) *mesezhnikowi* has obvious implications in the field of biochronology and international correlation.

Having correctly described the lectotype as originating in the Spilsby Sandstone, Pavlov (*in* Pavlov and Lamplugh 1892) later said that it was obtained from the Claxby Beds, an error that was rectified in a subsequent publication (Pavlov 1896). Neale's "*Tollia stenomphala*" from the Speeton Clay (Neale 1962) is too small and too poorly preserved for identification with any of the Spilsby Sandstone or Mintlyn Beds species, though it may well belong to the subgenus *Bojarkia*.

Surites (*Bojarkia*) *suprasubditus* (Bogoslovsky) *pavlovi* subsp. nov. Pl. 9.

Holotype. SM B12202, Spilsby Sandstone *stenomphalus* Zone, Benniworth Haven, near Donington-on-Bain, Lincolnshire.

Subspecific characters. Differs from typical form in closeness of ribbing, there being about 26 umbilical plications at 125 mm diameter compared with about 20 in the lectotype of *S.* (*Bj.*) *suprasubditus* (Bogoslovsky 1897 pl. 1, fig. 1).

Dimensions of holotype.

Diameter (in mm)	*Whorl-height (as % of diam.)*	*Whorl-thickness (as % of diam.)*	*Umbilicus (as % of diam.)*
162	39	28	25

Remarks. The holotype is an almost complete adult with just over half a whorl of body-chamber, though crushed in places. The test is preserved only in the umbilical region. Its mode of preservation indicates origin in the calcreted "doggers" of the *stenomphalus* Zone, still well exposed in the Benniworth Haven cutting, where it was collected together with *S.* (*Bj.*) *stenomphalus* (Pavlov) and allies.

Comparison with Bogoslovsky's types of "*Olcostephanus*" *suprasubditus* from the Ryazan Beds, in the Chernyshev Geological Museum, Leningrad, and illustrations of a topotype (Sazonova 1971 pl. 4 figs 2, 2a) suggests that the English ammonite is merely a geographical variant or subspecies of the Russian one. Its presence in the *stenomphalus* Zone helps to establish the zonal representation in the condensed Ryazan Beds.

Surites (*Bojarkia*) *tealli* sp. nov. Pl. 4 figs 10a–c.

Holotype. GSM. Ce 4407, Mintlyn Beds (bed 10), *stenomphalus* Zone, King's Lynn Bypass, Galley Hill, Mintlyn Wood, King's Lynn, Norfolk.

Specific characters. Differs from *S.* (*Bj.*) *stenomphalus* in having depressed whorls; ribs regularly bifurcating (about 25 per whorl at 50 mm diameter) until about 60 mm diameter, when occasional trifurcation begins.

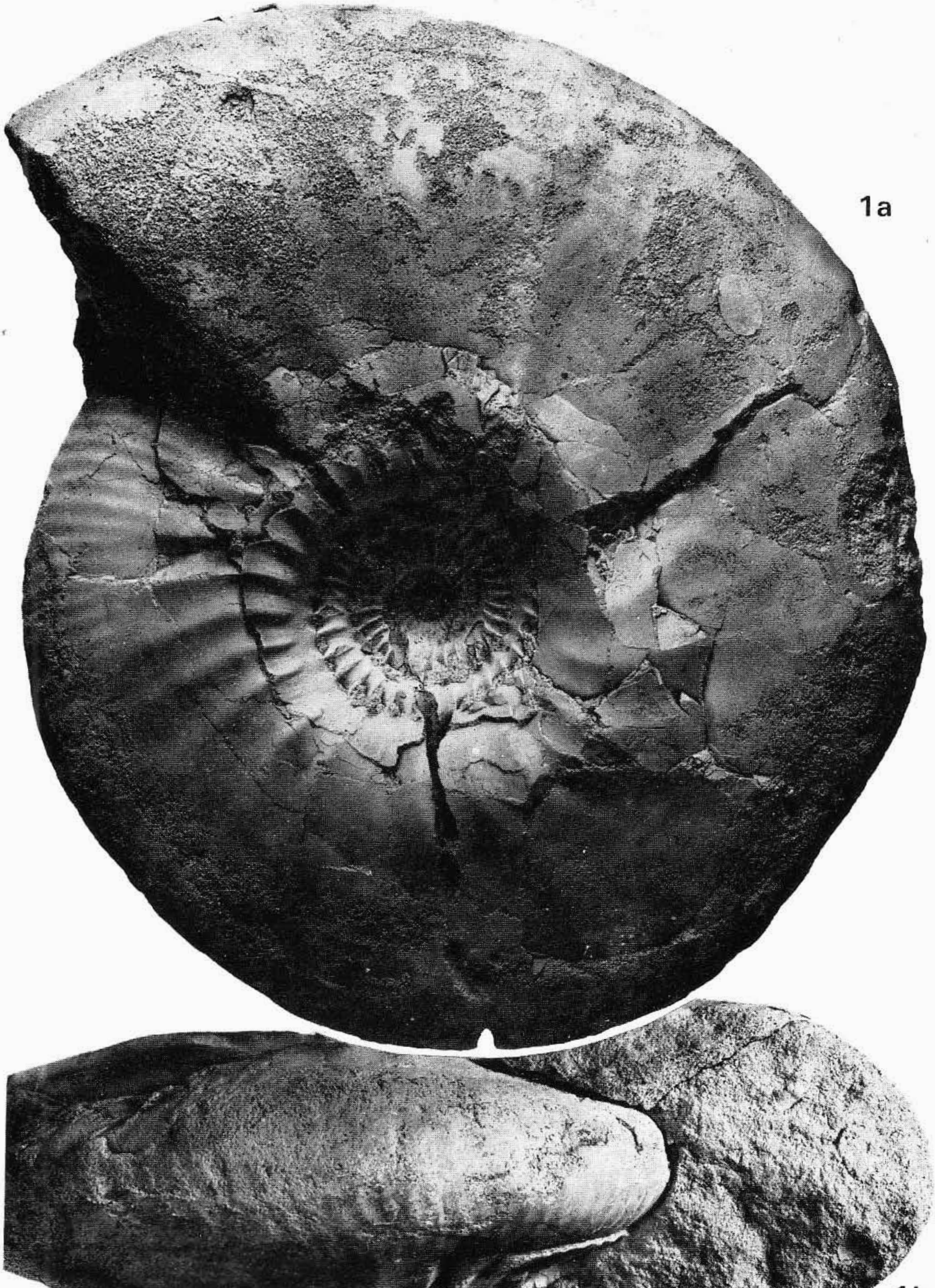
Dimensions of holotype.

Diameter (in mm)	*Whorl-height (as % of diam.)*	*Whorl-thickness (as % of diam.)*	*Umbilicus (as % of diam.)*
c. 65 (44)	41	48	28

Plate 9 all figs × 0·9.

1a–b *Surites* (*Bojarkia*) *suprasubditus* (Bogoslovsky) *pavlovi* subsp. nov.
Side and front view of holotype. Upper Spilsby Sandstone (*stenomphalus* Zone), Bardney-Louth railway cutting, Benniworth Haven, near Donington-on-Bain, Lincolnshire. SM. B12202.

Plate 9



Remarks. This species is represented by several incomplete examples from the clay-ironstone "doggers" of bed 10 of the King's Lynn Bypass (see p. 200). Its specific characters link *Bojarkia* with the subgenus *Caseyiceras*, which comprises evolute *Surites* with depressed whorls and dominantly bifurcating ribs, such as *S.* (*C.*) *caseyi* (Sazonova) and *S.* (*C.*) *analogus* (Bogoslovsky) of the Ryazan Beds. The horizon of *S.* (*Bj.*) *tealli* is low in the *stenomphalus* Zone, which accords with the position of the Siberian *S.* (*C.*) *analogus* Zone below the main development of *Bojarkia* (*mesezhnikowi* Zone).

The specific name honours J. J. H. Teall, one of the early students of Norfolk geology.

Subgenus *LYNNIA* nov.

Type-species. Surites (*Lynnia*) *icenii* sp. nov., Upper Ryazanian (*icenii* Zone), eastern England.

Subgeneric characters. Surites with subquadrate whorl-section and coarse ribs that branch mostly in threes from point high on flank.

Remarks. This subgenus is represented by a number of species in the interval between the *kochi* and *stenomphalus* Zones in England, though it does not appear among the rich *Surites* faunas of the Russian Platform. "*Olcostephanus*" *clementianus* Bogoslovsky of the Ryazan Beds is, however, an allied form with bifurcating, rather than trifurcating, ribs. A similar high furcation point and stout whorls are seen in *Surites subanalogus* Shulgina and other forms of the Siberian *analogus* Zone, though these, like the original *Surites* (*Caseyiceras*) *analogus* (Bogoslovsky), lack the coarse trifurcating ribbing of *Lynnia*.

Surites (*Lynnia*) *icenii* sp. nov. Pl. 8 figs 4a–b, 5a–b; Figs 6 l–m.

Holotype. GSM. Ce 5298, Mintlyn Beds, *icenii* Zone, bed 12, North Sea gas pipe-line trench, Manor Farm, North Runcton, near King's Lynn, Norfolk.

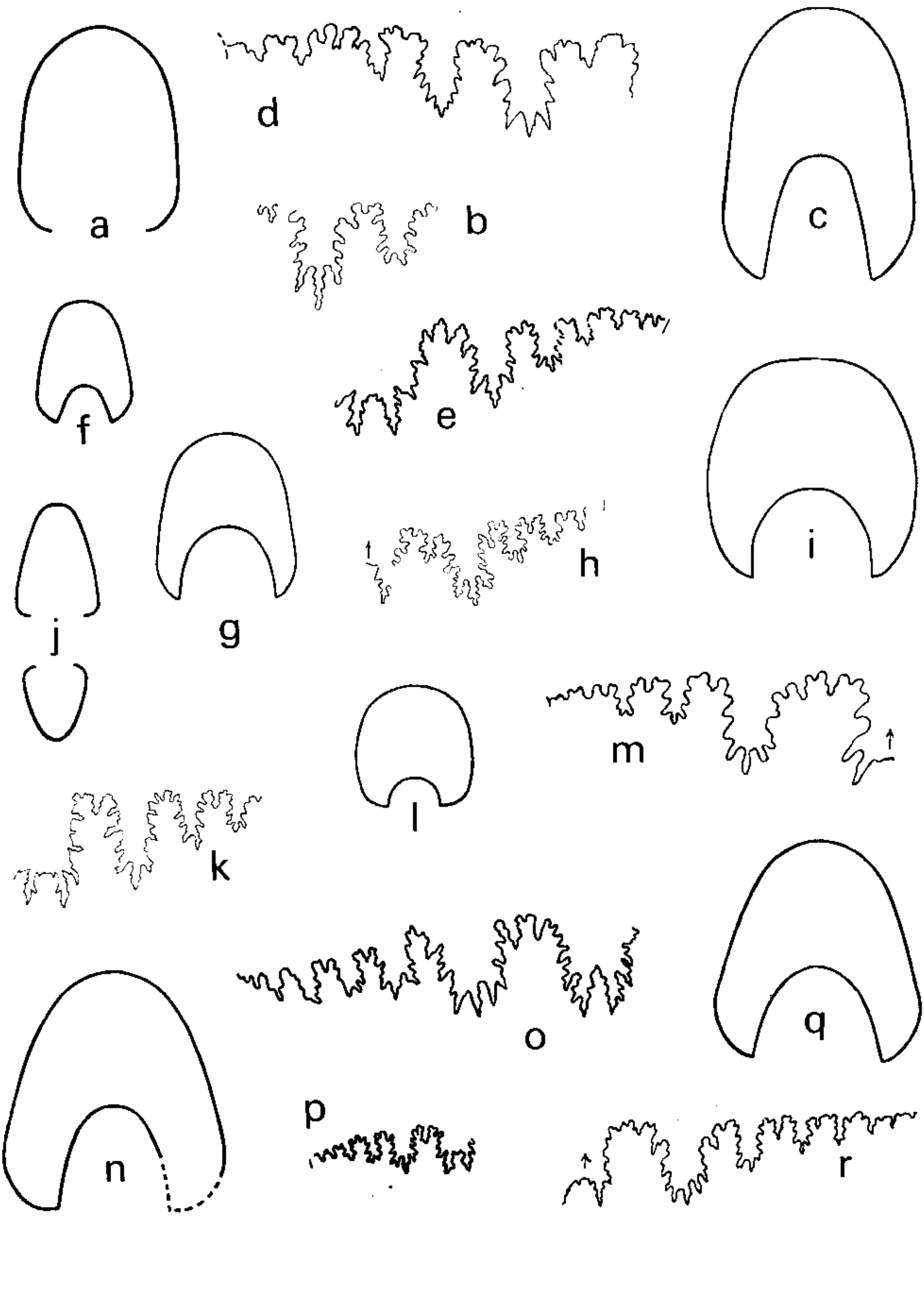
Specific characters. Small species of *Lynnia*, 42–56 mm diameter, at which size last half-whorl has about 8 strongly elevated primaries, each corresponding to 3 short secondaries. Secondaries mostly connect with primary stems, a few free-ending; all cross venter with well-marked forward bend. Umbilicus eccentric.

Dimensions of types.

	Diameter (*in mm*)	*Whorl-height* (*as % of diam.*)	*Whorl-thickness* (*as % of diam.*)	*Umbilicus* (*as % of diam.*)
Holotype GSM. Ce 5298	56	38	40	33
Paratype GSM. Ce 5311	48	37	37	34
Paratype GSM. Ce 5299	45	35	34	34
Paratype GSM. Ce 5301	42	38	38	35

Fig. 6. Whorl-sections and suture-lines of *Surites* (*Bojarkia*), *S.* (*Lynnia*), *S.* (*Surites*), *Peregrinoceras*, *Borealites* (*Borealites*), *B.* (*Ronkinites*) and *Paratollia*.
a–b *Surites* (*Bojarkia*) *stenomphalus* (Pavlov), whorl-section of example figd Pl. 8 fig. 3 (X 1) and incomplete suture-line of chorotype (GSM 30979). **c–d** *Surites* (*Bojarkia*) *suprasubditus* (Bogoslovsky), Ryazan Beds, U.S.S.R., whorl-section (X 1) and suture-line after Bogoslovsky 1897. **e** *Surites* (*Bojarkia*) *mesezhnikowi* (Shulgina), *mesezhnikowi* Zone, Siberia, suture-line after Shulgina 1972. **f** *Peregrinoceras* cf. *wrighti* (Neale), whorl-section of example figd Pl. 10 figs 9a–b (X 1). **g–h** *Peregrinoceras albidum* sp. nov., whorl-section (X 1) and suture-line (X 1·5) of holotype. **i** *Peregrinoceras rosei* sp. nov., whorl-section of holotype (X 1). **j–k** *Paratollia kemperi* gen. et sp. nov., Platylenticeras Schichten, northwest Germany, whorl-section (X ·75) and suture-line after Kemper 1964. **l–m** *Surites* (*Lynnia*) *icenii* sp. nov., whorl-section (X 1) and suture-line (X 3) of two paratypes (GSM Ce 5299, 5313). **n** *Borealites* (*Borealites*) *fedorovi* Klimova, *kochi* Zone, West Siberia, whorl-section of holotype (from plaster replica) (X 1). **o** *Borealites* (*Ronkinites*) *anglicus* (Shulgina), *kochi* Zone, West Siberia, suture-line after Shulgina 1972. **p** *Borealites* (*Ronkinites*) *plicomphalus* (Shulgina *non* J. Sowerby), *kochi* Zone, West Siberia, suture-line after Shulgina 1972. **q** *Surites* (*Surites*) *poreckoensis* Sazonov, Ryazan Beds, U.S.S.R., whorl-section of holotype (X 1). **r** *Surites* (*Surites*) *spasskensis* (Nikitin), Ryazan Beds, U.S.S.R., suture-line after Nikitin 1888.

Fig. 6.



Remarks. Bed 12 of the Manor Farm section and the corresponding nodule-bed in the King's Lynn Bypass yielded a large number of *S.* (*L.*) *icenii*, mostly as scaphitoid body-chambers, two-thirds of a whorl in length. Here, as in the Mid-Spilsby nodule-bed, examples over 50 mm diameter are exceptional. The specific name commemorates the Ancient British East Anglian tribe, the Iceni.

Genus *PEREGRINOCERAS* Sazonova 1971

Type-species. Olcostephanus pressulus Bogoslovsky, Ryazan Beds, Russian Platform.

Remarks. Peregrinoceras is a close ally of the genus *Tollia* Pavlov 1913, but whereas the latter bears periodic constrictions, becomes smooth in the adult, with narrowly rounded venter, *Peregrinoceras* maintains strong ribbing and a subrectangular, broad-ventered whorl-shape throughout. The two genera are not always easy to separate in the young or in poorly preserved material, however. Both appear more or less simultaneously late in the Ryazanian, and the range of *Tollia* in Siberia is said to extend into the Lower Valanginian. Species referable to *Peregrinoceras* have been recorded from the Mangyshlak Peninsula (Transcaspia), the Volga region and eastern England, while known Ryazanian occurrences of *Tollia* seem to be confined to its Siberian type areas and East Greenland (*T. groenlandica* Spath sp.). Possibly *Peregrinoceras* is a southern variant or dimorph of *Tollia.*

Shulgina (1972 p. 123) treats *Peregrinoceras* as a subjective synonym of *Subcraspedites* s.s. This relationship is denied by the subrectangular whorl-shape, forwards projection of the ventral ribbing, thin primary rib-stems, and tolliine nucleus of *Peregrinoceras.* Its overall characters suggest that *Peregrinoceras* is a descendant of the same stock that had earlier produced *Surites* (*Bojarkia*). In England *Peregrinoceras* is the dominant ammonite in the topmost Spilsby Sandstone, basal Claxby Beds (Hundleby Clay) and lower D beds of the Speeton Clay.

Peregrinoceras albidum sp. nov. Pl. 10 figs 7, 8a–b; Figs 6g–h.

Holotype. GSM. Zm3819, Upper Spilsby Sandstone (Ferruginous Grit), *albidum* Zone, dredged from underwater excavations, Biscathorpe Wold gravel pits, near Donington-on-Bain, Lincolnshire. R. G. Thurrell collection.

Specific characters. Moderately compressed and evolute *Peregrinoceras* with subparallel whorl-sides and broadly rounded venter. At 60 mm diameter about 22 thin, elevated primary rib-stems arise from top of low umbilical wall and cross lower half of flank with slight forwards inclination; at mid-flank (coinciding with line of involution) primaries trifurcate, with one or two intercalatories between each pair of primary bundles, making total of about 96 forward-curving secondaries per whorl. These cross venter with pronounced forwards bend. Suture-line with strongly ascending auxiliaries.

Dimensions of holotype.

Diameter (in mm)	*Whorl-height (as % of diam.)*	*Whorl-thickness (as % of diam.)*	*Umbilicus (as % of diam.)*
c.63 (60)	37	31	31

Remarks. Among previously described British species of *Peregrinoceras, P. pseudotolli* (Neale) of the Speeton Clay probably approaches the present species closest, though having a narrower umbilicus and less curved secondary ribs. The latter species, like the more densely ribbed *P. wrighti* (Neale), is difficult to compare owing to the crushed condition of these lower D beds ammonites at Speeton. In the Fordington Well *P. albidum* and a form probably conspecific with *P. wrighti* occur together. In the fauna of the Ryazan Beds *P. albidum* has its closest ally in *P. bellum* Sazonova (1971 pl. 5 figs 2, 2a), distinguished by its greater inflation, tighter coiling, and coarser umbilical plications.

Peregrinoceras rosei sp. nov. Pl. 10 figs 2a-b; Fig. 6i.

Holotype. GSM. 114730, Mintlyn Beds, *albidum* Zone, King's Lynn Bypass, north of Church Farm, Bawsey, Norforlk.

Specific characters. Moderately involute *Peregrinoceras* with subquadrate whorl-section that becomes increasingly flat-ventered with age. Rib density as in *P. albidum,* but rib-stems more prominent at the umbilical edge and ribs more feebler projected forwards on the venter.

Dimensions of holotype.

Diameter (in mm)	*Whorl-height (as % of diam.)*	*Whorl-thickness (as % of diam.)*	*Umbilicus (as % of diam.)*
78	40	40	28

Remarks. This species is named after the pioneer Norfolk geologist C. B. Rose. It is illustrated, along with sundry *Peregrinoceras* from the Hundleby Clay and topmost Spilsby Sandstone of Lincolnshire (Pl. 10) to aid the interpretation of the crushed *Peregrinoceras* fauna of the lower D beds of the Speeton Clay (Neale 1962). In a similar crushed condition, *P. rosei* would perhaps be difficult to separate from *P. pseudotolli* (Neale 1962 pl. 45 figs 1–2) at the size of Neale's types.

Subfamily Polyptychitinae Spath 1924

The inclusion of the Polyptychitinae as a subfamily of the Craspeditidae is a departure from current schemes of classification and is prompted largely by consideration of the genus *Paratollia* gen. nov., described below. There are many examples of "convergence" among the boreal Dorsoplanitinae and their craspeditid descendants on the one hand and Tethyan Berriasellidae on the other. It is not improbable that a similar parallel development gave rise to an olcostephanid morphology in both Tethyan (*Spiticeras*, *Olcostephanus*, etc.) and boreal (*Polyptychites*) stocks.

Genus *PARATOLLIA* nov.

Type-species. Paratollia kemperi gen. et sp. nov. (= *Tollia tolmatschowi* Kemper *non* Pavlov), Valanginian, Platylenticeras Schichten, NW Germany.

Generic characters. Primitive Polyptychitinae resembling *Peregrinoceras* in discoidal shape and closeness of costation, but with polyptychitine rib-bundling, and pronounced bi-dichotomy in the adult. Suture-line ascending, *Polyptychites*-like.

Remarks. Paratollia has an obvious affinity with its contemporary *Propolyptychites* Kemper, which is distinguished by its greater inflation and more pronounced bi-dichotomy. The polyptychitine mode of furcation of *Paratollia* occurs already in the Upper Ryazanian *Peregrinoceras prostenomphaloides* (Neale), though in that species true bi-dichotomy is not observed. The Russian *Chandomirovia* (Sazonov 1951), of uppermost Ryazanian-basal Valanginian age, is a more inflated analogue of *Paratollia* having strongly convergent whorl-sides and narrowly rounded venter on which the ribs have a linguiform forwards extension. To *Chandomirovia* I would refer *Polyptychites anabarensis* Pavlov (1914) and to *Propolyptychites* the *Tollia* (*Polyptychites ?*) *mira* of Voronets (1962), both from the basal Valanginian of the Lena-Anabar region of Siberia. *Neotollia* Shulgina (1969) is another Siberian ammonite of the same primitive polyptychitine stream. This combines the ventral ribbing of *Chandomirovia* with regularly bifurcating costation in the young and the ribbing of juvenile *Paratollia* in the adult. The suture-line has numerous auxiliaries. The young *Paratollia* produces a style of ribbing similar to that of the juvenile *Costamenjaites* (Sazonova 1971) from the basal Valanginian of the Volga region, but the umbilical plications and smooth outer whorls of that genus are not duplicated in *Paratollia*. Besides the type species, *Paratollia* embraces "*Tollia* cf. *pseudotolli*" Kemper (1964 pl. 2 fig. 4) and the micromorph *Polyptychites pumilo* Vogel (1959), both from the German Bentheim Sandstone.

Paratollia kemperi gen. et sp. nov. Pl. 5 figs 5a–b; Figs 6j–k.

1964 *Tollia tolmatschowi* Pavlow; Kemper p. 21, pl. 1 figs 3a–b.

Holotype. The original of Kemper 1964 pl. 1 figs 3a–b, from the Platylenticeras Schichten of Suddendorf, northwest Germany.

Specific characters. Involute, compressed *Paratollia*, with convergent whorl-sides and well rounded venter. At 35–50 mm diameter about 24 primaries, each corresponding to bundle of 3 (occasionally 4) flexuous secondaries. Branching at first from lower third of flank (above line of involution); later position of branching varies, one rib of bundle springing from mid-flank; bi-dichotomy appears at c. 40 mm diameter. All ribs thin, sharply elevated and cross venter with forwards sinus.

Remarks. Paratollia kemperi or a close ally occurs near the base of the Claxby Beds of Lincolnshire. All the English examples are small and the whorl-sides are less convergent than in the

German holotype. Specimens from Benniworth Haven were recorded by Spath (1924a p. 79) as *Dichotomites* spp. juv. The ribbing varies to some extent in these Claxby Beds nuclei and more than one species may be represented. A precocious individual from the basal Claxby Ironstone of Nettleton Top (C. W. Wright collection 6538) shows bi-dichotomy of the ribbing already at less than 25 mm diameter.

Family Berriasellidae Spath 1924
Subfamily Platylenticeratinae nov.

Spath (1947) concluded that the "degenerate oxycones of the Lower Neocomian", such as *Platylenticeras*, *Tolypeceras*, *Pseudogarnieria* and *Proleopoldia* should be placed in a separate group, *Incertae Sedis*, provisionally attached to the Craspeditidae, their peculiar suture-lines suggesting possible descent from the Jurassic *Garniericeras*. Other authors (e.g., Arkell 1957; Sazonova 1971) have subsequently placed them firmly in the Garniericeratinae, though Arkell had doubts about the inclusion of *Proleopoldia*. Luppov and others (*in* Orlov 1958) transferred this genus to the Neocomitidae.

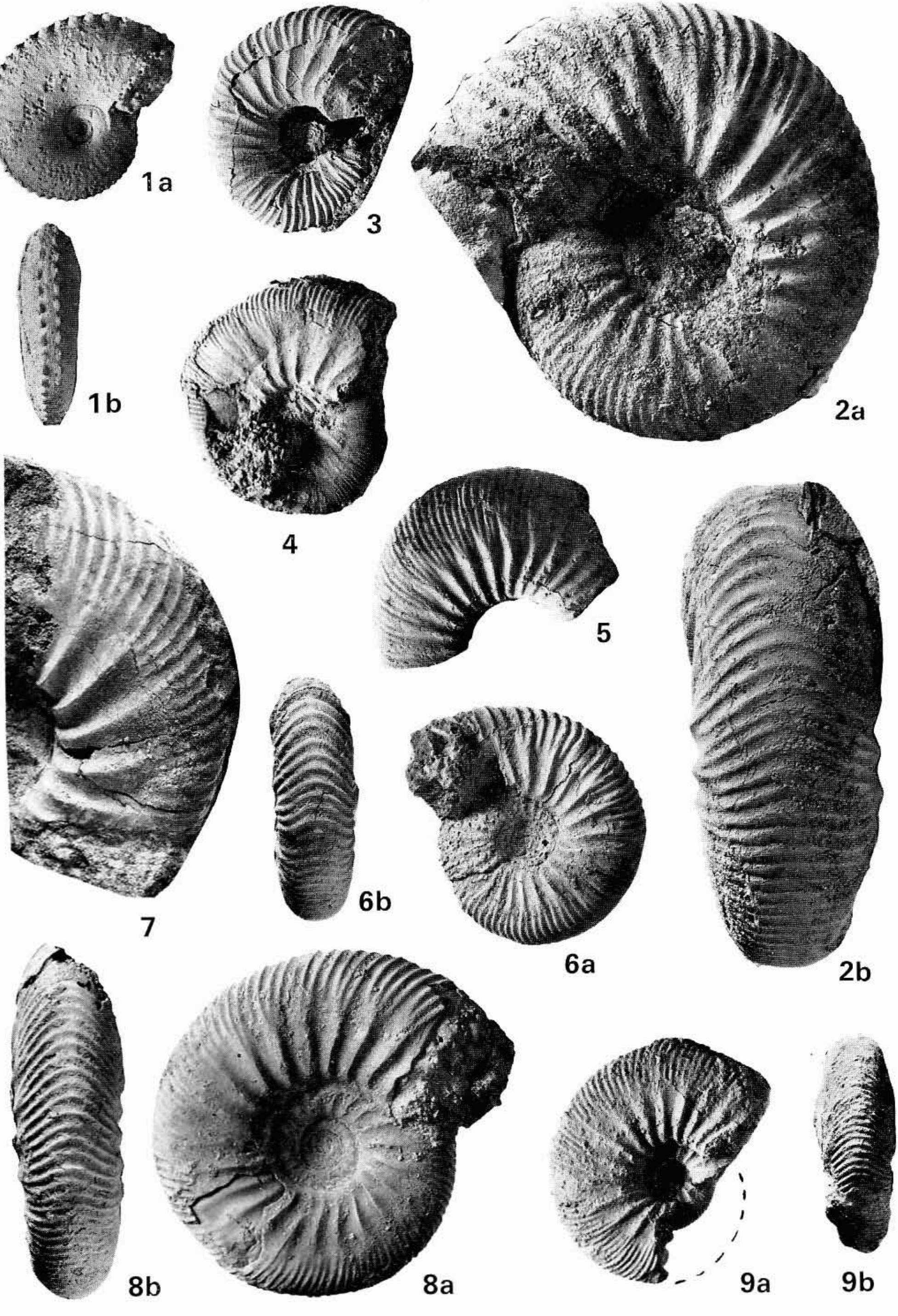
Kemper's careful study of *Platylenticeras*, based mainly on German occurrences (Kemper 1961), demonstrated the difficulty of separating generically the typical smooth forms of *Platylenticeras* such as *P. heteropleurum* (Neumayr and Uhlig) and *P. gevrilianum* (d'Orbigny) from the noded group of *A. marcousianus* Pictet and Campiche (*Tolypeceras*). There is a similar problem with the "genera" *Pseudogarnieria* and *Proleopoldia*, proposed simultaneously by Spath (1923). Stchirowsky's original material of "*Oxynoticeras*" *undulatoplicatile*, "*O.*" *tuberculiferum*, "*O.*" *marcousi* (= *P. alatyrense* Kemper sp.) and "*Hoplites*" *kurmyschensis*, illustrations of which furnished the basis of Spath's concept of *Pseudogarnieria* and *Proleopoldia*, are deposited in the M.V. and A.P. Pavlov Museum in Moscow. This material was obtained from the Lower Valanginian of the Alatyr district, near Ulyanovsk (formerly Simbirsk); its examination has convinced me that *Pseudogarnieria* and *Proleopoldia* are not separable above the species-level. Duration of the ventrally tuberculate "*Proleopoldia*" condition of the nucleus varies greatly, "*O.*" *undulatoplicatile*, the type-species of *Pseudogarnieria*, representing one extreme, "*H.*" *kurmyschensis* ("*Proleopoldia*") the other. Gerasimov (1971) has already pointed out the specific identity of "*O.*" *undulatoplicatile* and "*O.*" *menensis* Stchirowsky.

Now that the stratigraphical levels and ranges of these ammonites are better understood, it is clear that there is a considerable time-gap separating *Platylenticeras* and its contemporaries from *Garniericeras*, involving the whole of the Ryazanian. Moreover, the morphology of the

Plate 10 — fig. 1 × 1·35; others × 0·9

1a–b *Pseudogarnieria* ("*Proleopoldia*") cf. *kurmyschensis* (Stchirowsky).
Side and venter of septate nucleus. Claxby Beds (*Paratollia* horizon), Bardney-Louth railway cutting, Benniworth Haven, near Donington-on-Bain, Lincolnshire. SM. B12217.
2a–b *Peregrinoceras rosei* sp. nov.
Side and venter of holotype. Mintlyn Beds (*albidum* Zone), King's Lynn Bypass, north of Church Farm, Bawsey, Norfolk. GSM. 114730.
3 *Peregrinoceras* sp. nov. cf. *albidum* sp. nov.
Claxby Beds (Hundleby Clay), old brickworks, East Keal, Lincolnshire. GSM. 114747a.
4 *Peregrinoceras subpressulus* (Bogoslovsky).
Upper Spilsby Sandstone (Ferruginous Grit: *albidum* Zone), excavated material, Biscathorpe Wold gravel pit, near Louth, Lincolnshire. R. G. Thurrell colln, GSM. Zm3813.
5 *Peregrinoceras* cf. *wrighti* (Neale).
Claxby Beds (Hundleby Clay), near Wainfleet, Lincolnshire, B. Smith colln, GSM. Zg652.
6a–b *Peregrinoceras* sp. nov. cf. *albidum* sp. nov.
Glacial Drift (ex Hundleby Clay), King's Lynn Bypass, Castle Rising, near King's Lynn, Norfolk. GSM. 114748.
7, 8a–b *Peregrinoceras albidum* sp. nov.
7 Body chamber fragment, Upper Spilsby Sandstone (*albidum* Zone), depth 60 m, Fordington No. 5 Well, Lincolnshire. H. H. Swinnerton colln, GSM. 114740.
8a–b Side and venter of holotype. Horizon and locality as Fig. 4. R. G. Thurrell colln, GSM. Zm3819.
9a–b *Peregrinoceras* cf. *wrighti* (Neale)
Side and venter of uncrushed example. Upper Spilsby Sandstone (Ferruginous Grit), laneside exposure, Asterby, near Horncastle, Lincolnshire. R. G. Thurrell colln, GSM. 100518.

Plate 10



young *Pseudogarnieria* ("*Proleopoldia*") points to an origin in the Berriasellidae rather than the Craspeditidae; the suture-lines of both *Pseudogarnieria* and *Platylenticeras* may also, in my opinion, be derived more readily by simplification of a berriasellid rather than a craspeditid type. This concept of the Platylenticeratinae as berriasellid oxycones makes it easier to understand the Tethyan presence of *Platylenticeras* and to see the arrival of this genus and its allies in northwest Europe and the Russian Platform as connected with the widespread transgressive movements of the Valanginian.

Genus *PSEUDOGARNIERIA* Spath 1923 (= *PROLEOPOLDIA* Spath 1923)

Type-species. Oxynoticeras undulatoplicatile Stchirowsky, Lower Valanginian (*undulatoplicatile* Zone), Russian Platform.

Pseudogarnieria ("*Proleopoldia*") sp. juv. cf. *kurmyschensis* (Stchirowsky). Pl. 10 figs 1a–b.

Remarks. A well preserved juvenile of 23 mm diameter represents the nucleus or "*Proleopoldia*" stage of *Pseudogarnieria*, this being confirmed by its suture-line. It was obtained in the last century from the Benniworth Haven cutting and its cream-coloured calcite test and marly infilling, full of iron-ooliths, indicates origin in the same level of the Claxby Beds as the species of *Paratollia* and *Propolyptychites* collected from the same spot. This specimen (SM. B12217) was seen by Spath before I had developed it from the matrix and recorded by him (Spath 1924a p. 79) as a species of *Lyticoceras* (=*Endemoceras*).

Acknowledgements. This work has been greatly facilitated by access to the collections in the British Museum (Natural History), the Sedgwick Museum (Cambridge) and the Norwich Castle Museum. Prof. Lord Energlyn kindly made available the collection of the late Prof. H. H. Swinnerton in the Department of Geology, University of Nottingham. For the loan of specimens from their private collections I am indebted to Mr. J. Doyle, Mr. S. Kelly, Dr. G. P. Larwood, Dr. P. F. Rawson, Dr. R. G. Thurrell and Mr. C. W. Wright. Programmes organized by Academician D. V. Nalivkin and Academician V. V. Menner during visits to the U.S.S.R. permitted me to examine Upper Jurassic and Lower Cretaceous strata in the field on the Russian Platform and in the Caucasus and the Crimea, to study collections in Moscow and Leningrad and to consult with the following Soviet colleagues: Prof. V. V. Drushchits, Prof. P. A. Gerasimov, Prof. G. Ya. Krimgolts, Prof. N. P. Luppov, Dr. M. S. Mesezhnikov, Dr. N. P. Mikhailov, Prof. V. N. Saks, Dr. N. T. Sazonov, Dr. I. G. Sazonova, and Dr. N. I. Shulgina. Material from Greenland was made available for study at the Universitetets Mineralogisk-Geologiske Institut Mineralogisk Museum, Copenhagen, through the courtesy of Prof. T. Birkelund and Dr. F. Surlyk. Dr. J. Kutek of the Department of Dynamic Geology, University of Warsaw, conducted me to field exposures in the Tomaszow area, and borehole samples from Jurassic-Cretaceous boundary beds west of Warsaw were shown to me by Dr. S. Marek at the Geological Institute of the Polish Academy of Sciences, Warsaw. Mr. E. Smith has assisted in the field in Norfolk and Lincolnshire and with bibliographical research. Mrs. Jean Fyffe (Queen Mary College) drew figures 1–3 and tables 2–3. The paper is published by permission of the Director, Institute of Geological Sciences, London.

References

AGER, D. 1971. The brachiopods of the erratic blocks of Spilsby Sandstone in Norfolk and Suffolk. *Proc. geol. Ass.* **82,** 393–401.
ALLEN, P. 1955. Age of the Wealden in North-Western Europe. *Geol. Mag.* **92,** 265–281.
—— 1959. The Wealden environment: Anglo-Paris Basin. *Phil. Trans. R. Soc.* B, **242,** 283–346.
—— 1965. L'âge du Purbecko-Wealdien anglais. *Mém. Bur. Rech. géol. Minièr* **34,** 319–326.
ANDERSON, F. W. and HUGHES, N. F. 1964. The 'Wealden' of North-west Germany and its English equivalents. *Nature* **201,** 907–908.
ARKELL, W. J. 1933. *The Jurassic System in Great Britain.* Oxford. 1–681, pls 1–41.
—— 1935. The Portland Beds of the Dorset mainland. *Proc. Geol. Ass.* **46,** 301–347.
—— 1956. *Jurassic geology of the world.* Oliver and Boyd, Edinburgh and London. 1–806, pls 1–46.
—— 1957. *In* Moore, R. C. (Editor). Treatise on Invertebrate Paleontology. Part L. Mollusca 4, Cephalopoda, Ammonoidea. *Geol. Soc. Am.* and *Univ. Kansas Press* L1–L490.
BARBIER, R. and THIEULOY, J. P. 1965. Etage berriasien. *Mém. Bur. Rech. géol. minièr* **34,** 69–77.
BASOV, V. A., ZAKHAROVO, V. A., IVANOVA, E. F., SAKS, V. N., SHULGINA, N. I. and YUDOVNY, E. G. 1970. Zonal division of the Upper Jurassic and Lower Cretaceous deposits on Cape Urdyuk-Khaya (Paksa Peninsula, Anabar Bay). *Uch. Zap. NIIGA, paleont. i biostrat.* **29,** 14–31 (in Russian).
——, ——, ——, SHULGINA, N. I., and YUDOVNY, E. G. 1972. Main Berriasian sections in Boreal Realm for USSR areas. North Middle Siberia. Cape Urdyuk-Khaya. *In* Saks, V. N. (Editor). *The Jurassic-Cretaceous boundary and the Berriasian stage in the Boreal Realm.* Nauka, Novosibirsk, 32–42 (in Russian).
BIELECKA, W. and SZTEJN, J. 1966. Stratygrafia warstw przejściowych między jurą a kredą na podstawie mikrofauny. *Kwart. geol.* **10,** 97–115, pl. 1.
BODYLEVSKY, V. J. 1936. The Upper Volgian Fauna of Novaya Zemlya. *Trudy arkt. nauchno-issled Inst.* **49,** 113–136 (in Russian).
—— 1967. Jurassic and Cretaceous faunas of Novaya Zemlya. *Zap. Leningr. gorn. Inst.* **53** (2) 99–112, pls 1–10 (in Russian).
BOGOSLOVSKY, N. A. 1897. Der Rjasan-Horizont, seine Fauna, seine stratigraphischen Beziehungen und sein wahrscheinliches Alter. *Mater. Geol. Ross.* **18,** 1–158, pls 1–6.
—— 1902. Materialien zur Kenntniss der Untercretacischen Ammonitenfauna von Central- und Nord-Russland. *Trudy geol. Kom.* n.s. **2,** 1–161, pls 1–18.
BROWN, T. 1837–1849. *Illustrations of the fossil conchology of Great Britain and Ireland.* London. 1–275, pls 1–98.
CASEY, R. 1961a. The stratigraphical palaeontology of the Lower Greensand. *Palaeontology* **3,** 487–621, pls 77–84.
—— 1961b. Geological age of the Sandringham Sands. *Nature* **190,** 1100.
—— 1962. The ammonites of the Spilsby Sandstone, and the Jurassic-Cretaceous boundary. *Proc. geol. Soc. Lond.* **1598,** 95–100.
—— 1963. The dawn of the Cretaceous Period in Britain. *Bull. S.-East Un. scient. Socs.* **117,** 1–15.
—— 1964. *In* DODSON, M. H., REX, D. C., CASEY, R. and ALLEN, P. Glauconite dates from the Upper Jurassic and Lower Cretaceous. *In* The Phanerozoic Time-scale. *Q. J. geol. Soc. Lond.* **120S,** 145–158.
—— 1967. The position of the Middle Volgian in the English Jurassic. *Proc. geol. Soc. Lond.* **1640,** 246–247.
—— 1968a. The type-section of the Volgian stage (Upper Jurassic) at Gorodische, near Ulyanovsk, U.S.S.R. *Proc. geol. Soc. Lond.* **1648.** 74–75.

CASEY, R. 1968b. *In: A. Rep. Inst. Geol. Sci. (GB).*, for 1967, 104–105
—— 1971. Facies, faunas and tectonics in late Jurassic-early Cretaceous Britain. *In* Middlemiss, F. A. Rawson, P. F. and Newall, G. (Editors) *Faunal Provinces in Space and Time. Geol. J. Spec. Iss. no.* **4,** 153–168.
—— 1974. Proposed use of the plenary powers to fix the type-species of the genus *Subcraspedites* Spath 1924 (Class Cephalopoda, Order Ammonoidea). *Bull. zool. Nom.* (in press).
—— and BRISTOW, C. R. 1964. Notes on some ferruginous strata in Buckinghamshire and Wiltshire. *Geol. Mag.* **101,** 116–128.
—— and GALLOIS, R. W. 1973. The Sandringham Sands of Norfolk. *Proc. Yorks. geol. Soc.* (in press).
DEMBOWSKA, J. 1964. The stratigraphy of four bore-holes from the vicinity of Kcynia. *Biul. Inst. geol.* **175,** 108–127, pl. 7.
DIKES, W. H. and LEE, J. E. 1837. Outlines of the Geology of Nettleton Hill, Lincolnshire. *Mag. nat. Hist.* n.s. **1,** 561–566.
DONOVAN, D. T. 1957. The Jurassic and Cretaceous Systems in East Greenland. *Meddr Grønland* **155** (4), 1–214, pls 1–4.
—— 1963. The Geology of British seas. *Inaugural lecture, Univ. Hull. Publs* 1–24.
—— 1964. Stratigraphy and ammonite fauna of the Volgian and Berriasian rocks of East Greenland. *Meddr Grønland* **154** (4), 1–34, pls 1–9.
DONZE, P. 1958. Les couches de passage du Jurassique au Crétacé dans le Jura français et sur le pourtour de la "Fosse vocontienne". *Trav. Lab. Géol. Univ. Lyon* n.s. **3,** 1–221, pls 1–6.
—— and LE HEGARAT, G. 1972. Le Berriasien, étage charnière entre le Jurassique et le Crétacé; ses equivalents continentaux en Europe du Nord. *24th Int. geol. Congr., Canada 1972,* section 7, 513–523.
DRUSHCHITS, V. V. and MIKHAILOVA, I. A. 1966. *Biostratigraphy of the Lower Cretaceous of the Northern Caucasus.* Moscow Univ., 1–189 (in Russian).
DUNN, W. W., EHA, S. and HEIKKILA, H. H. 1973. North Sea is a tough theater for the oil-hungry industry to explore. Pt. 1. *Oil Gas Jour.* Jan. 8, 1973, 122–128.
EGOYAN, V. L. 1971. The boundary of the Jurassic and Cretaceous in the Northern Caucasus and some questions of methodical stratigraphical investigation. *Magy. allami földt. Intéz. Évk.* **54** (2), 125–129 (in Russian).
ENAY, R. 1972. Paleobiogeographie des ammonites du Jurassique terminal (Tithonique/Volgien/ Portlandien s.l.) et mobilité continentale. *Geobios* **5** (4), 355–407.
—— 1973. Upper Jurassic (Tithonian) ammonites. *In* Hallam, A. (Editor). *Atlas of palaeobiogeography.* Elsevier, Amsterdam, London and New York, 298–307.
ERISTAVI, M. S. 1952. The Georgian block during Lower Cretaceous times. *Trudy geol. Inst., Tbilisi* **6** (11) (in Russian).
ERSHOVA, E. S. 1969. New finds of late Volgian ammonites on Western Spitsbergen. *Uch. zap. niega paleont. i biostrat.* **26,** 52–69 (in Russian).
FREBOLD, H. 1929. Ammoniten aus dem Valanginien von Spitzbergen. *Skr. Svalbard Ishavet* **21,** 1–24, pls 1–8.
GERASIMOV, P. A. 1969. *The upper substage of the Volgian Stage of the central part of the Russian Platform: a palaeontological-stratigraphical-lithological study.* Nauka, Moscow, 1–144, pls 1–44 (in Russian).
—— 1971. Berriasian and Lower Valanginian of the Russian Platform. *Dokl. Akad. Nauk SSSR* **198,** 1156–7 (in Russian).
—— (Editor) 1972. *Stratigraphy of the U.S.S.R. The Cretaceous System.* Nedra, Moscow (in Russian).
—— and MIKHAILOV, N. P. 1966. The Volgian stage and the standard scale for the upper series of the Jurassic System. *Izv. Akad. Nauk SSSR, ser. geol.* **2,** 118–138 (in Russian).
GLAZUNOVA, A. E. 1963. Division of the lower Cretaceous deposits of the Volga region. *In* Data on the geology of the European territories of U.S.S.R. *Trudy vses. nauchno-issled. geol. Inst.* **91,** 153–168 (in Russian).
GOLBERT, A. V., KLIMOVA, I. G., SAKS, V. N. and TUBINA, A. S. 1972. New data on the boundary beds of the Jurassic and Cretaceous in West Siberia. *Geol. i Geofiz.* **1972,** no. 5, 1–17. (in Russian).
GRIGORIEVA, O. K. 1938. A Lower Valanginian ammonite fauna from the Basin of the Belaya River on the northern slope of the Caucasus (Malkop area). *In: Azov-Black sea Geological Trust. Materials on the geology and economic minerals.* Collection No. 1. Rostov-on-Don, 83–123, pls 1–17 (in Russian).
GUSTOMESOV, V. A. 1956. *Upper Jurassic belemnites of the Russian Platform.* Abstract of dissertation. Moscow University (in Russian).
HOUSE, M. R. 1958. On the Portlandian zones of the Vale of Wardour and the use of *Titanites giganteus* as an Upper Jurassic zone fossil. *Proc. Geol. Ass.* **69,** 17–19.
IVANOV, A. N. and ARISTOV, V. N. 1969. New genera of ammonites from Lower Cretaceous deposits in the neighbourhood of Yaroslavl and the origin of the simbirskitids. *Byull. mosk. Obshch. Ispyt. Prir.* No. **6,** 1969 (in Russian).

JELETZKY, J. A. 1964. Illustrations of Canadian fossils. Lower Cretaceous marine index fossils of the sedimentary basins of Western and Arctic Canada. *Geol. Surv. Pap. Can.* **64-11,** 1–101, pls 1–36.
—— 1965. Late Upper Jurassic and early Lower Cretaceous fossil zones of the Canadian Western Cordillera, British Columbia. *Bull. geol. Surv. Can.* **103,** 1–70, pls 1–22.
—— 1966. Upper Volgian (Latest Jurassic) ammonites and buchias of Arctic Canada. *Bull. geol. Surv. Can.* **128,** 1–49, pls 1–8.
—— 1968. Macrofossil zones of the marine Cretaceous of the Western Interior of Canada and their correlation with the zones and stages of Europe and the Western Interior of the United States. *Geol. Surv. Pap. Can.* **67-72,** 1–66.
JUDD, J. W. 1867. On the strata which form the base of the Lincolnshire Wolds. *Q. J. geol. Soc. Lond.* **23,** 227–250.
JUKES-BROWNE, A. J. 1887. The geology of part of East Lincolnshire. *Mem. geol. Surv. U.K.* 1–181.
KEEPING, H. 1882. On some sections of Lincolnshire Neocomian. *Q. J. geol. Soc. Lond.* **38,** 239–244.
KEEPING, W. 1883. The fossils and palaeontological affinities of the Neocomian deposits of Upware and Brickhill. *Sedgewick Prize Essey for* **1879.** 1–167, pls. 1–8. Cambridge.
KEMPER, E. 1961. Die Ammonitengattung *Platylenticeras* (-*Garnieria*). *Beih. geol. Jb.* **47,** 1–195, pls 1–18.
—— 1964. Über eine deutsche *Tollia*-Fauna und den Ursprung der Polyptychiten (Ammonoidea, Mittelvalendis). *Fortschr. Geol. Rheinld Westf.* 7, 15–26, pls 1–2.
KENT, P. E. and CASEY, R. 1963. A Kimmeridge sandstone in North Lincolnshire. *Proc. geol. Soc. Lond.* **1606,** 57–62.
KHALILOV, A. G. 1965. *Stratigraphy of the Lower Cretaceous deposits of the south-eastern end of the Great Caucasus.* Azerbaijan Acad. Sci. (in Russian).
—— 1971. On the boundary of the Jurassic and Cretaceous in the Caucasus. *Magy. allami földt. Intéz. Évk.* **54** (2), 359–368 (in Russian).
KILIAN, W. 1895. Notice stratigraphique sur les environs de Sisteron. *Bull. Soc. géol. Fr.* (3), **23,** 659–805.
—— 1907–10. Unterkreide (Palaeocretacicum). *In* Frech. *Lethaea Geognostica,* II, Mesozoic **3,** 1–168 (1907), 169–287 (1910).
KLIMOVA, I. G. 1969. The early Berriasian of Western Siberia. *Geol. i. Geofiz.* **1969,** no. **4,** 128–132 (in Russian).
—— 1972. Berriasian Marine Faunas. Ammonites from West Siberia. *In* Saks, V. N. (Editor). *The Jurassic-Cretaceous boundary and the Berriasian stage in the Boreal Realm.* Nauka, Novosibirsk, 194–204 (in Russian).
KRIMGOLTS, G. Ya. (Editor) 1972. *Stratigraphy of the U.S.S.R., The Jurassic System.* Nedra, Moscow (in Russian).
——, MESEZHNIKOV, M. S., SAKS, V. N., SHULGINA, N. I. and VAKHRAMAEV, V. 1968. Sur la méthode de l'élaboration des cartes paléobiogéographiques. *Proc. 23rd Ont. geol. Congr.* 239–256.
LAMPLUGH, G. W. 1889. On the subdivisions of the Speeton Clay. *Q. J. geol. Soc. Lond.* **45,** 575–618.
—— 1896. On the Speeton Series in Yorkshire and Lincolnshire. *Q. J. geol. Soc. Lond.* **52,** 179–220.
—— 1924. A review of the Speeton Clays. *Proc. Yorks. geol. Soc.* **20,** 1–31.
LE HÉGARAT, G. 1971a. Perisphinctidae et Berriasellidae de la limite Jurassique-Crétacé. Genres nouveaux et révision critique de quelques définitions taxonomiques antérieures. *C. r. hebd. Séanc. Acad. Sci. Paris* **273,** D, 6 sept. 1971, 850–853.
—— 1971b. Berriasellidae de la limite Jurassique-Crétacé. Revision critique de quelques définitions taxonomiques antérieures. *C. r. hebd. Séanc. Acad. Sci. Paris* **273,** ser, D, 13 sept. 1971, 919–922.
LUPPOV, N. P. 1952. Lower Cretaceous deposits of the northwestern Caucasus and their faunas. *Trudy vses, neft. nauchno-issled. geol.-razv. Inst.* n.s. **65,** 1–270, pls 1–14 (in Russian).
—— and DRUSHCHITS, V. V. 1958. *In* Orlov, Yu. A. (Editor). *Principles of Palaeontology.* Mollusca-Cephalopoda II. Ammmonoidea (Ceratites and Ammonites), Dibranchiata. Moscow (in Russian).
MAREK, S. 1961. Nowy poglad na stratygrafie neokomu w Rogoźnie. *Kwart. geol.* **5,** 345–352.
—— 1963. Infrawalanzyn Kujaw. *Arch. Inst. Geol. Warsaw.*
MAYNC, W. 1949. The Cretaceous Beds between Kuhn Island and Cape Franklin (Gauss Peninsula), northern East Greenland. *Meddr Grønland* **133** (3), 1–291, pls. 1–4.
MAZENOT, G. 1939. Les Palaeohoplitides Tithoniques et Berriasien du sud-est de la France. *Mém. Soc. géol. Fr.* **41,** 1–303, pls 1–40.
MESEZHNIKOV, M. S. 1972. A new arctic genus of Middle Volgian Dorsoplanitinae. *In* Problems of palaeozoogeography of Mesozoic of Siberia. *Trudy Inst. Geol. Geofiz.* **111,** 119–136, pls 10–12 (in Russian).

MIKHAILOV, N. P. 1957. Ammonites of the Lower Volgian stage. *Trudy geol. Kom.* **8** (2) (in Russian).

MORDVILKO, T. A. 1960. *Lower Cretaceous deposits of the Northern Caucasus and Cis-Caucasus. Part 1.* Akad. Nauk. S.S.S.R. (in Russian).

NEALE, J. W. 1962. Ammonoidea from the Lower D Beds (Berriasian) of the Speeton Clay. *Palaeontology* **5,** 272–296, pls 40–45.

NIKITIN, S. 1888. Les vestiges de la période crétacée dans la Russie centrale. *Trudy geol. Kom.* **5** (2), 1–205, pls 1–5.

NIKOLOV, T. 1966. New genera and subgenera of ammonites of family Berriasellidae. *C. r. Acad. bulg. Sci.* **19** (7), 639–642.

NORRIS, G. 1969. Miospores from the Purbeck Beds and marine Upper Jurassic of southern England. *Palaeontology* **12,** 574–620.

OAKLEY, K. P. 1941. Phosporites of Lower Cretaceous Age in Lincolnshire. *Wartime pamph. geol. Surv. Eng. Wales* **8** (2), 1–12.

PAVLOV, A. P. 1889. Etudes sur les couches Jurassiques et Crétacées de la Russie. I. Jurassique supérieur et Crétacé inférieur de la Russie et de l'Angleterre. *Byull. mosk. Obshch. Ispyt. Prir.* n.s. **3,** 61–127, pls 2–4.

—— 1891. Belemnites de Speeton et leurs rapport avec les belemnites des autres Pays. *Byull. mosk. Obshch. Ispyt. Prir.* n.s. **5,** 181–276, pls 4–8.

—— 1896. On the classification of the strata between the Kimmeridgian and Aptian. *Q. J. geol. Soc. Lond.* **52,** 542–555, pl. 27.

—— 1914. Jurassic and Lower Cretaceous Cephalopoda of Northern Siberia. *Zap. imp. Akad. Nauk.* Cl. Phys.-Math. **21** (4), 1–68, pls 1–18 (in Russian).

—— and LAMPLUGH, G. W. 1892. Argiles de Speeton et leurs équivalents. *Byull. mosk. Obshch. Ispyt. Prir.* n.s. **5,** 181–276, 455–570, pls 4–8, 13–18.

PRINGLE, J. 1919. Palaeontological notes on the Donnington borehole of 1917. *Mem. geol. Surv. Summ. Prog.* 1918, 50–52.

RACZYNSKA, A. 1961. Stratygrafia osadów dolnokredowych okolic Sompolna. *Kwart. geol.* **5,** 353–370.

RAT, P. 1963. Conclusions du colloque de stratigraphie sur le Crétacé inférieur en France, Lyon, septembre 1963. *C. r. somm. Séanc. Soc. géol. Fr.* **8,** 4 nov. 1963, 292–296.

ROZANOV, A. N. 1909. On the distribution of the Zone of *Craspedites nodiger* in the Moscow neighbourhood. *Ezheg. Geol. Miner. Ross.* **11** (in Russian).

SAKS, V. N., GRAMBERG, I. C., RONKINA, Z. Z. and APLONOVA, E. N. 1959. Mesozoic deposits of the Khatanga Depression. *Trudy arkt. nauchno-issled Inst.* **99,** 1–225 (in Russian).

—— and KLIMOVA, I. G. 1967. On the zonal division of the Lower Cretaceous of the North Sosvy River on cephalopod molluscs. *Geol. i Geofiz.* **1967** no. **7,** 76–85 (in Russian).

——, MESEZHNIKOV, M. S., and SHULGINA, N. I. 1968a. The Volgian Stage and position of the boundary between the Jurassic and Cretaceous Systems in the Arctic Zoogeographical Province. *Trudy Inst. Geol. Geofiz. sib. Otd.* **48,** 72–79 (in Russian).

——, ——, ——. 1968b. Volgian Stage in Siberia. *Geol. i. Geofiz.* **1968,** no. **3,** 29–40 (in Russian).

—— and NALNYAEVA, T. I. 1966. *Upper Jurassic and Lower Cretaceous belemnites of northern U.S.S.R. Genera* Pachyteuthis *and* Acroteuthis, Nauka, Moscow and Leningrad, 1–260, pls 1–40 (in Russian).

——, —— 1972. Berriasian marine faunas. Belemnites. *In* Saks, V. N. (Editor). *The Jurassic-Cretaceous boundary and the Berriasian stage in the Boreal Realm.* Nauka, Novosibirsk, 204–215 (in Russian).

——, RONKINA, Z. Z., SHULGINA, N. I., BASOV, V. A. and BONDARENKO, N. M. 1963. *Stratigraphy of the Jurassic and Cretaceous Systems of the Northern U.S.S.R.* Akad. Nauk. S.S S.R., Moscow and Leningrad, 1–226 (in Russian).

—— and SHULGINA, N. I. 1962. The Cretaceous System in Siberia. Proposals for its subdivision into stages and zones. *Geol. i Geofiz.* **1962,** no. **10,** 23–39 (in Russian).

——, —— 1964. On distinguishing the Berriasian stage in the Cretaceous System. *Geol. i Geofiz.* **1964,** no. **8,** 3–14 (in Russian).

——, —— 1969. New zones of the Neocomian and the boundary between the Berriasian and Valanginian stages in Northern Siberia. *Geol. i Geofiz.* **1969** no. **12,** 42–52 (in Russian).

——, —— 1972. Distribution of the Berriasian Stage in the Boreal Realm. Western Europe. *In* Saks, V. N. (Editor). *The Jurassic-Cretaceous boundary and the Berriasian stage in the Boreal Realm.* Nauka, Novosibirsk, 94–98 (in Russian).

——, ZAKHAROV, V. A., MESEZHNIKOV, M. S., RONKINA, Z. Z., SHULGINA, N. I., and YUDOVNYI, E. G. 1965. Stratigraphy of the Upper Jurassic and Lower Cretaceous deposits of the Khatanga Depression. *In: Stratigraphy and Palaeontology of Mesozoic deposits of Northern Siberia.* Nauka, Moscow, 27–60 (in Russian).

SAVELEV, A. A. and VASILENKO, V. P. 1963. The faunistic basis for the stratigraphy of the Lower Cretaceous deposits of Mangyshlak. *In* Geological structure and natural-gas potential of Mangyshlak. *Trudy vses. neft. nauchno-issled. geol.-razv. Inst.* **218,** 248–300 (in Russian).

SAZONOV, N. T. 1951. On some little-known ammonites of the Lower Cretaceous. *Byull. mosk. Obshch. Ispyt. Prir.* **56,** 57–63 (in Russian).

SAZONOV, N. T. 1961. A standard scheme of stratigraphy of the Jurassic deposits of the Russian Platform (experimental). *In* Work of the all-Union committee for establishing a standard scheme of stratigraphy for the Mesozoic deposits of the Russian Platform. *Trudy vses. nauchnoissled. geol.-razv. neft. Inst.* **29,** 5–47 (in Russian).

—— 1962. Stratigraphy of the Jurassic deposits of the European part of the U.S.S.R. within the Russian Platform. *Sov. Geol.* **1962,** no. **7,** 79–93 (in Russian).

SAZANOVA, I. G. 1961. Standardized stratigraphical scheme of Lower Cretaceous deposits of the Russian Platform. *Trudy vses. nauchno-issled. geol.-razv. neft. Inst.* **29,** 5–28 (in Russian).

—— 1965. Lower Valanginian ammonites. *In* Mesozoic and Cainozoic faunas of the European parts of the U.S.S.R. and central Asia. *Trudy vses. nauchno-issled. geol-razv. neft. Inst.* **44,** 100–106, pl. 1 (in Russian).

—— 1967. Palaeogeography of the Russian Platform in the Jurassic and Lower Cretaceous. *Trudy vses. neft. nauchno-issled. geol. razv. Inst.* **62** (in Russian).

—— 1971. Berriasian and Lower Valanginian ammonites of the Russian Platform. *In* The Berriasian of the Russian Platform (Stratigraphy, ammonite fauna and aucellids). *Trudy vses. naucho-issled. geol.-razv. neft. Inst.* **110,** 1–110, 148–157, pls 1–26 (in Russian).

—— 1972. Berriasian Marine Faunas. Ammonites from Russian Lowland. *In* Saks, V. N. (Editor). *The Jurassic-Cretaceous boundary and the Berriasian stage in the Boreal Realm.* Nauka, Novosibirsk, 175–194 (in Russian).

SCHOTT, W. *et al.* 1967, 1969. *Paläogeographischer Atlas der Unterkreide von Nordwestdeutschland mit einer Übersichtsdarstellung des nördlichen Mitteleuropa.* 306 maps (1967). Explanatory handbook with 315 pp. (1969). *Bundesanstalt für Bodenforschung*, Hannover.

SHULGINA, N. I. 1965. Bivalve and cephalopod molluscs as indicators of climatic regime in the North Siberian basin in the Jurassic and Neocomian and biogeography. *In: Fossil and Recent bivalve and gastropod molluscs as indicators of habitat.* Nauka, Moscow (in Russian).

—— 1967. Tithonian ammonites of Northern Siberia. *In: Problems of the palaeontological basis of detailed Mesozoic stratigraphy of Siberia and the Soviet Far East.* Nauka, Leningrad, 131–156, pls 1–18 (in Russian).

—— 1968. Ammonites of the genus *Chetaites* from the Jurassic-Cretaceous boundary beds of Siberia. *Trudy Inst. Geol. Geofiz. sib. Otd.*, **48,** 101–107, pls 11–19 (in Russian).

—— 1969. Volgian ammonites. *In* Saks, V. N. (Editor). *Key section of the Upper Jurassic deposits of the Kheta River basin.* Nauka, Leningrad, 125–162, pls 22–38 (in Russian).

—— 1972. Berriasian Marine Faunas. Review of ammonites of the Boreal Realm. Ammonites from the North of Middle Siberia. *In:* Saks, V. N. (Editor). *The Jurassic-Cretaceous boundary and the Berriasian stage in the Boreal Realm.* Nauka, Novosibirsk, 117–175 (in Russian).

SMITH, A. G. 1971. Alpine deformation and the oceanic areas of the Tethys, Mediterranean and Atlantic. *Bull. geol. Soc. Am.* **82,** 2039–2070.

SOWERBY, J. 1812–1822. *The Mineral Conchology of Great Britain.* Vols. **1-3,** and **4** (part), pls 1–383.

SOWERBY, J. DE C. 1823–1845. *The Mineral Conchology of Great Britain.* Vols. **4** (part) and **5-7,** pls 384–648.

SPATH, L. F. 1923. On ammonites from New Zealand. In appendix to: TRECHMANN, C. T. The Jurassic Rocks of New Zealand. *Q. J. geol. Soc. Lond.* **79,** 286–312.

—— 1924a. On the ammonites of the Speeton Clay and the subdivisions of the Neocomian. *Geol. Mag.* **61,** 73–89.

—— 1924b. On the Blake collection of ammonites from Kachh, India. *Mem. geol. Surv. India Palaeont. indica.* n.s. **9** (1), 1–29.

—— 1936. The Upper Jurassic invertebrate faunas of Cape Leslie, Milne Land. II. Upper Kimmeridgian and Portlandian. *Meddr. Grønland* **99** (3), 1–180.

—— 1947. Additional observations on the invertebrates (chiefly ammonites) of the Jurassic and Cretaceous of East Greenland, I. The *Hectoroceras* fauna of S. W. Jameson Land. *Meddr Grønland* **132** (3), 1–69, pls 1–5.

——1952. Additional observations on the invertebrates (chiefly ammonites) of the Jurassic and Cretaceous of East Greenland. II. Some Infra-Valanginian ammonites from Lindemans Fjord, Wollaston Foreland, with a note on the base of the Cretaceous. *Meddr Grønland* **133** (4), 1–40, pls 1–4.

STRAHAN, A. 1886. Notes on the relations of the Lincolnshire Carstone. *Q. J. geol. Soc. Lond.* **42,** 481–493.

SWINNERTON, H. H. 1935. The rocks below the Red Chalk of Lincolnshire and their cephalopod faunas. *Q. J. geol. Soc. Lond.* **91,** 1–46, pls 1–4.

—— 1936–1955. A Monograph of British Lower Cretaceous Belemnites. *Palaeontogr. Soc.* [Monogr.] 1–86, pls 1–18.

—— 1941. Further observations on the Lower Cretaceous rocks of Lincolnshire. *Proc. Geol. Ass.* **52,** 198–207.

WOLBERG, J. 1959. Die Cyprideen des NW-deutschen Wealden. *Senckenberg. leth.* **40,** 223–315, pls 1–5.

WOODWARD H. B. 1895. The Jurassic rocks of Britain. V. Middle and Upper Oolitic rocks of England. *Mem. geol. Surv. U.K.*
VOGEL, K. P. 1959. Zwergwuchs bei Polyptychiten (Ammonoidea). *Geol. Jb.* **76,** 469–540.
VORONETS, N. S. 1962. The stratigraphy and cephalopod molluscs of the Jurassic and Lower Cretaceous deposits of the Lena-Anabar area. *Trudy Inst. Geol. arkt.* **110,** 1–237, pls 1–61 (in Russian).
ZEISS, A. 1965. Gliederung und Grenzen des Oberen Jura in Europe. *Carp.-Balk. Geol. Ass., 7th Congr. Rep.* Sofia 107–113.
—— 1968. Untersuchungen zur Paläontologie der Cephalopoden des Unter-Tithon der Südlichen Frankenalb. *Abh. bayer. Akad Wiss., Math.-Nat. Kl.* n.f. **132,** 1–190, pls 1–27.

R. Casey, Institute of Geological Sciences, Exhibition Road, London, S.W.7., England.