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The Upper Turonian–Lower Coniacian (Upper Cretaceous) ammonites from the condensed phosphate beds of Mangyshlak, NW Kazakhstan

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ABSTRACT:

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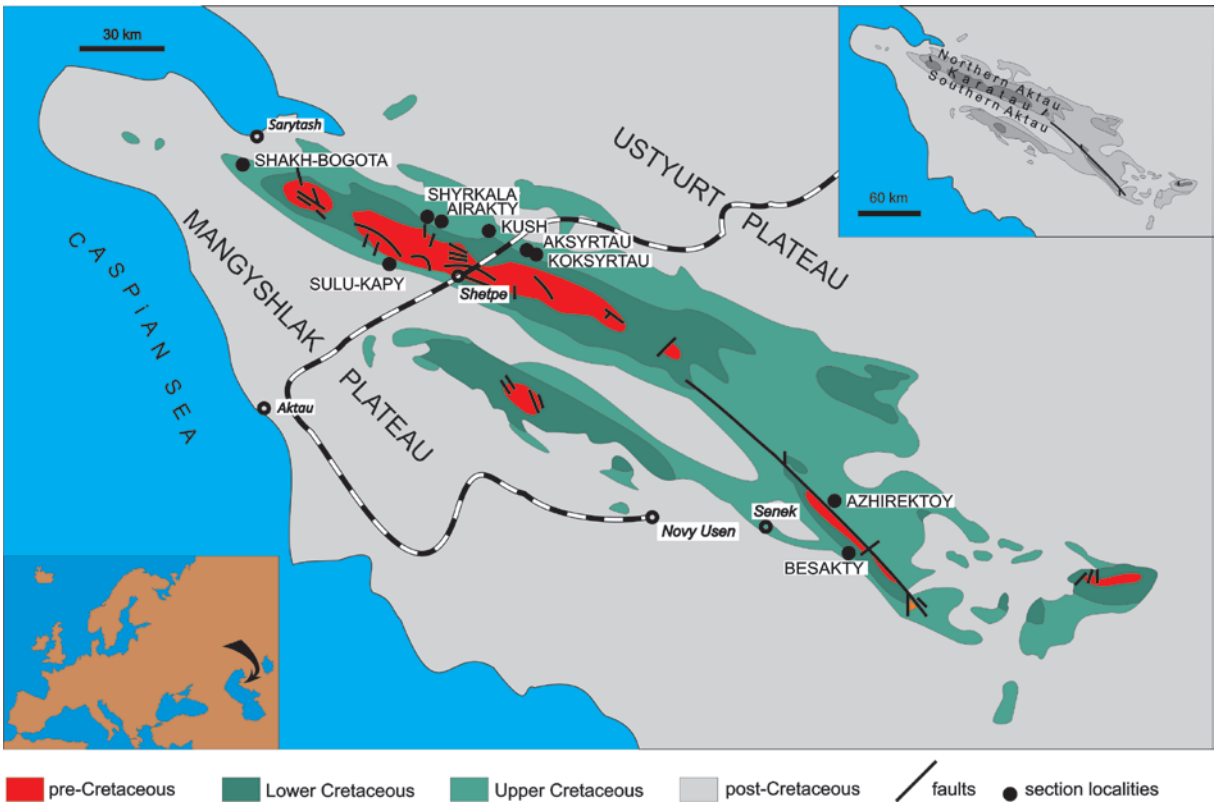
Eleven ammonites species are described from the condensed phosphate beds of Mangyshlak (in north-western Kazakhstan): *Lewesiceras mantelli* (Wright and Wright, 1951), *Subprionocyclus neptuni* (Geinitz, 1849), *Prionocyclus* spp., *Allocrioceras angustum* (J. de C. Sowerby, 1850), *Hyphantoceras* (*Hyphantoceras*) *reussianum* (d'Orbigny, 1850), *Hyphantoceras* (*Hyphantoceras*) cf. *flexuosum* (Schlüter, 1872), *Eubostrychoceras* (*Eubostrychoceras*) cf. *saxonicum* (Schlüter, 1875), *Scalarites*? *bohemicus* (Fritsch, 1872), *Sciponoceras bohemicum bohemicum* (Fritsch, 1872), *Scaphites geinitzii* d'Orbigny, 1850, and *Scaphites kieslingswaldensis* Langenhan and Grundey, 1891. They provide an incomplete record that spans at maximum upper Middle Turonian to Lower Coniacian and at minimum Upper Turonian to Lower Coniacian. Associated inoceramid bivalves span an interval from upper Middle Turonian (based on the known first occurrence of *Inoceramus inaequivalvis* Schlüter, 1872) to the lower and middle Lower Coniacian, based on the known last occurrence of *Cremnoceramus crassus inconstans* (Woods, 1912), in the lower and middle parts of the Lower Coniacian.

Key words: Ammonites, Inoceramids; Cretaceous; Turonian; Coniacian; Kazakhstan.

INTRODUCTION

The Mangyshlak Anticlinorium is one of the key areas to characterise the Upper Cretaceous of the eastern peri-Caspian region, which closes the North European Palaeobiogeographical Province to the southeast (Text-fig. 1). The area is commonly quoted as a documenting site for various palaeontological groups, however, for various reasons, the ammonites of the area, with few exceptions, have never been thoroughly studied. These few exceptions apply to the Cenomanian (Marcinowski 1980; Gale *et al.* 1999; Kennedy 2013), whereas the rest of previous reports are mostly limited to faunal lists (e.g., Atabekian and Likhatcheva 1961; Balan 1979; Naidin *et al.* 1984; Atabekian 1986; Marcinowski *et al.* 1996) or brief descriptions and/or illustrations of the most representative taxa (e.g., Balan 1982; Marcinowski *et al.* 1996).

This aim of this paper is partly fill this gap and to present the taxonomic description of the ammonites from the Upper Turonian through Coniacian of Mangyshlak, mostly from the condensed successions of the eastern part of the anticlinorium (Marcinowski *et al.* 1996; Text-figs 1 and 2). The material presented herein was previously studied by Ryszard



Text-fig. 1. Geological sketch-map of the Mangyshlak Anticlinorium (originally after Bespalov, V.F. *et al.* 1965; adopted herein after Marcinowski *et al.* 1996).

Marcinowski, who included his preliminary results in the 1996 report (Marcinowski *et al.* 1996), but his premature death prevented him from completing this work.

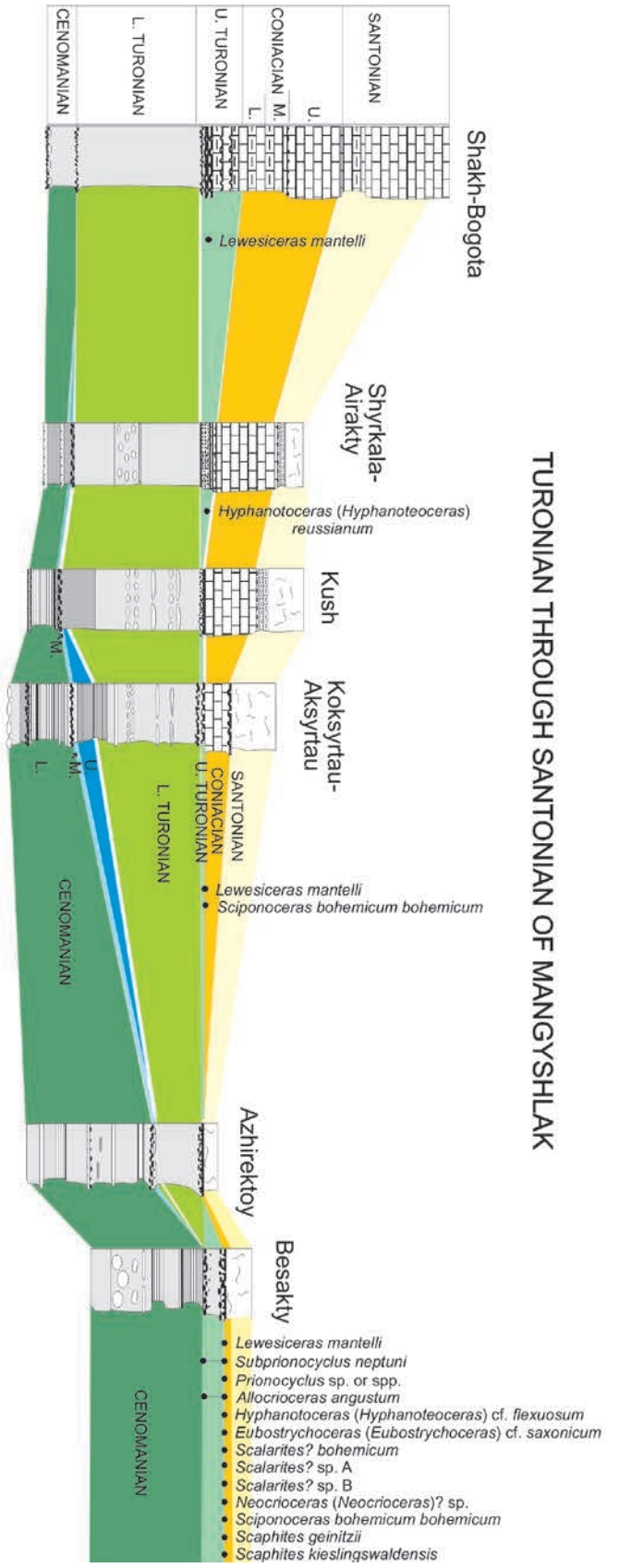
The ammonite collection studied herein is of moderate size (around 180 specimens, but with more than 100 represented by fragmentary *Sciponoceras*) and, due to the nature of the geological record (from condensed intervals), devoid of refined stratigraphical information. In spite of these limitations, however, the material allows for a comprehensive palaeontological report on the ammonites from the Upper Turonian through Coniacian interval of the Mangyshlak Cretaceous.

The ammonites studied come from a few good sections scattered all along the anticlinorium (Text-figs 1 and 2; Trifonov and Burago 1960; Naidin *et al.* 1984; Marcinowski *et al.* 1996). The majority of the material comes, however, from the strongly condensed Upper Turonian–Coniacian succession of the Besakty section, in the south-eastern part of Mangyshlak (Text-fig. 2).

GEOLOGICAL SETTING

The Mangyshlak Mountains represent a late Neogene anticlinorium, running from the Mangyshlak Peninsula, on the shores of the Caspian Sea in the NW, towards the SE, where it plunges below the Turan Plain (Text-fig. 1). The anticlinorium is a part of the epi-Variscan cover of the Turan Platform (e.g., Trifonov and Burago 1960; Muromtzev 1973; Bogdanoff and Khain 1981), which stretches between the Peri-Caspian Depression in the north and the Transcaspian Alpine Belt in the south (Text-fig. 1).

The axial part of the anticlinorium is composed of Permian–Triassic and Jurassic deposits, forming the highest elevations of the area (Text-fig. 1). The dark colours of these deposits give distinct dark hills, known as Karatau (Black Mountains). The Cretaceous builds the northern and southern limbs of the anticlinorium. Up to the Middle Turonian the Cretaceous succession is dominantly siliciclastic, whereas its upper part is carbonate. The carbonates of the Upper Cretaceous and of the overlying



Text-fig. 2. Upper Turonian and Coniacian ammonite occurrences on the background of the NW-SE cross section through the Cenomanian (part) to Santonian succession of the Mangyshlak Anticlinorium (cross-section based on Marcinowski *et al.* 1996).

SANT.		AMMONITE ZONES Europe	AMMONITE ZONES East African region	INOCERAMID ZONES Europe	INOCERAMID ZONES East African Region
CONIACIAN	upper	*Texanites pseudotexanus*	*Pseudoschloenbachia bidichotoma*	*Sphenoceramus cardissoides*	*Inoceramus africanus*
		Paratexanites serratomarginatus	*Prionocycloceras guyabanum*	*Magadiceramus subquadratus*	
	middle	*Gauthiericeras margae*	*Gauthiericeras margae*	*Volviceramus involutus* *Volviceramus koeneni*	*Platyceramus* sp.
	lower	*Peroniceras tridorsatum*	*Peroniceras dravidicum*	*Inoceramus gibbosus* *Cremnoceramus c. crassus*	*Inoceramus hoepeni* *Inoceramus nukeus* *Tethyoceramus ernsti*
		Forresteria petrocoriensis	*Kossmaticeras theobaldianum* - *Barroisiceras onilahyense*	*Cremnoceramus c. inconstans* *Cremnoceramus w. hannovrensis* *Cremnoceramus deformis erectus*	*Tethyoceramus basseae* *Tethyoceramus madagascariensis*
T.	u.			*Cremnoceramus w. waltersdorfensis*	*Tethyoceramus modestoides*

Text-fig. 3. Ammonite and inoceramid zonations of the Upper Turonian and Coniacian of the Euramerican biogeographic region.

Palaeogene form white-coloured hilly ranges, known as Aktau (White Mountains), running parallel to the Karatau (Text-fig. 1). The mid-Turonian transition from the siliciclastic to carbonate successions is associated with a distinct northwestward shift in a depocentre and slowing down of the sedimentation rate (Marcinowski *et al.* 1996; see also Text-fig. 2). The Middle Turonian is missing from almost an entire region, but its traces (documented by redeposited fragments of the Middle Turonian ammonite *Collignoniceras woollgari* (Mantell, 1822) are locally present (see Marcinowski *et al.* 1996). Within the Upper Turonian–Coniacian part, the condensation is most extensive in the eastern and central parts of the area (Text-fig. 2); westwards of the Koksyrtau-Aksyrtau section, the highly condensed Upper Turonian is followed by gradually less condensed Lower Coniacian, which in Shakh-Bogota, the westernmost section studied (Text-figs 1 and 2), gives the complete, at the substage level, record of the interval (see Marcinowski *et al.* 1996, fig. 14).

STRATIGRAPHIC CONSTRAINS ON THE AMMONITE MATERIAL

Ammonite dating

In spite of the abundance of ammonite fragments in the condensed phosphate beds at the Turonian–Coniacian boundary in the Mangyshlak Mountains, their dating is disappointingly imprecise compared with that of the inoceramids. The degree of condensation is best demonstrated by the fauna recorded by Marcinowski *et al.* (1996, text-fig. 12) from bed 40 at Besakty, where Middle Cenomanian *Acanthoceras rhotomagense* (Brongniart, 1822) and *Cunningtoniceras* Collignon, 1937 are associated with what is interpreted herein as lower Upper Turonian *Subprionocyclus neptuni* (Geinitz, 1849) (Text-fig. 2; = *Collignoniceras woollgari* and *C. carolinum* (d'Orbigny, 1841) of Marcinowski *et al.* 1996). The ranges of the better dated species recognised here are summarised below (see Text-fig. 3 for the zonations and substage subdivision):

Lewesiceras mantelli (Wright and Wright, 1951): Upper Turonian, *neptuni and germari* zones.

Subprioncyclus neptuni (Geinitz, 1849): Upper Turonian *neptuni* Zone.

Prionocyclus spp.: Upper Turonian, *neptuni* and *germari* Zones.

Allocrioceras angustum (J. de C. Sowerby, 1850): Upper Turonian, *neptuni* Zone in Europe. Also recorded from the Middle Turonian of Natrona County, Wyoming, and the Lower Coniacian of KwaZulu-Natal, South Africa.

Hyphantoceras (*Hyphantoceras*) *reussianum* (d'Orbigny, 1850): Upper Turonian, *neptuni* Zone.

Hyphantoceras (*Hyphantoceras*) cf. *flexuosum* (Schlüter, 1872): Upper Turonian *neptuni* and *ger-*

mari zones. The holotype is from the *cuvieri* Pläner, which suggested Lower Coniacian to Wiese (2000, p. 410), as did records from the Erwitte Formation of the Münsterland Basin to Kennedy and Kaplan (2019, p. 90). The species ranges into the Lower Coniacian *tridorsatum* Zone in the Czech Republic.

Eubostrychoceras (*Eubostrychoceras*) cf. *saxonicum* (Schlüter, 1875): Upper Turonian *neptuni* and *germari* zones.

Scalarites? *bohemicus* (Fritsch, 1872): Lower and Middle Coniacian.

Sciponoceras bohemicum bohemicum (Fritsch, 1872): Upper Turonian *neptuni* Zone to upper Lower Coniacian *tridorsatum* Zone.

Scaphites geinitzii: Middle Turonian *woollgari* Zone, Upper Turonian *neptuni* and *germari* zones, possibly extending into Lower Coniacian.

Scaphites kieslingswaldensis: Lower and Middle Coniacian.

The total range of the phosphatised ammonites in bed 42 of the Besakty section, which yielded the largest assemblage, could thus be interpreted as spanning an interval from the first occurrence of *Scaphites geinitzii* in the Middle Turonian to the last occurrence of *Scaphites kieslingswaldensis* in the Middle Coniacian *margae* Zone at one extreme, or to the interval from the last occurrence of *Scaphites geinitzii* in the Upper Turonian *neptuni* Zone to the first occurrence of *Scaphites kieslingswaldensis* in the Lower Coniacian part of the *petrocoriensis* Zone.

There are no diagnostic elements of the Middle Turonian *woollgari* Zone fauna (although there is a phosphatised fragment of *C. woollgari*, i.e., MWGUW ZI/63/0676, from bed 15 of the Sulu-Kappy section), nor of the *germari* and *haberfellneri* Zones, and the Turonian part of the *petrocoriensis* Zone. The absence of ammonites, but presence of contemporaneous inoceramids is a widespread phenomenon, for example in the chalks of the Anglo-Paris Basin. There, as in the Mangyshlak Mountains it may reflect either their absence at the time of deposition, or the differential dissolution of their originally aragonitic shells prior to burial.

Inoceramid and *Didymotis* bivalve dating

The Upper Turonian–Coniacian of the Mangyshlak Anticlinorium yielded rich assemblages of inoceramids and of *Didymotis* Gerhardt, 1897 bivalves (see Marcinowski *et al.* 1996; Walaszczyk *et al.* 2013). The most complete record of the interval is known from the Shakh-Bogota and Sulu-Kappy sections from the western part of the anticlinorium (Naidin *et al.* 1984; Marcinowski *et al.* 1996; Walaszczyk *et al.* 2013), which gives a good basis for the calibration of the condensed sections in the central and eastern parts of the area.

Bed 42 of the Besakty section, where most of the ammonites treated here come from, yielded: *Inoceramus perplexus* Whitfield, 1877, *Inoceramus* ex gr. *inaequivalvis* Schlüter, 1877, *Inoceramus* sp., *Mytiloides* cf. *incertus* (Jimbo, 1894), *Mytiloides herbichi* (Atabekian, 1969) (Text-fig. 4H), *Mytiloides* cf. *scupini* (Heinz, 1930), *Mytiloides* sp. (Text-fig. 4D), *Cremnoceramus crassus inconstans* (Woods, 1912) (Text-fig. 4A, G), *Cremnoceramus deformis erectus* (Meek, 1877) (Text-fig. 4F), *Cremnoceramus* sp., *Tethyoceramus* sp., and *Volviceramus* cf. *involutus* (J. de C. Sowerby, 1828). The stratigraphic ranges of these taxa are as follows (see Text-fig. 3 for the zonation and substage subdivision):

Inoceramus perplexus Whitfield, 1877 is a marker of the base of the Upper Turonian and ranges at least up to the mid-upper third of the substage.

Inoceramus inaequivalvis Schlüter, 1877 first appears in the upper Middle Turonian and is common in the lower Upper Turonian; the precise range is unknown.

Mytiloides incertus (Jimbo, 1894) is a middle Upper Turonian form (see Wiese *et al.* 2020).

Mytiloides herbichi (Atabekian, 1969) (Text-fig. 4H) is an upper Upper Turonian taxon; it disappears immediately before the first appearance of *Cremnoceramus waltersdorfensis* (Andert, 1911) lineage at the very high Upper Turonian.

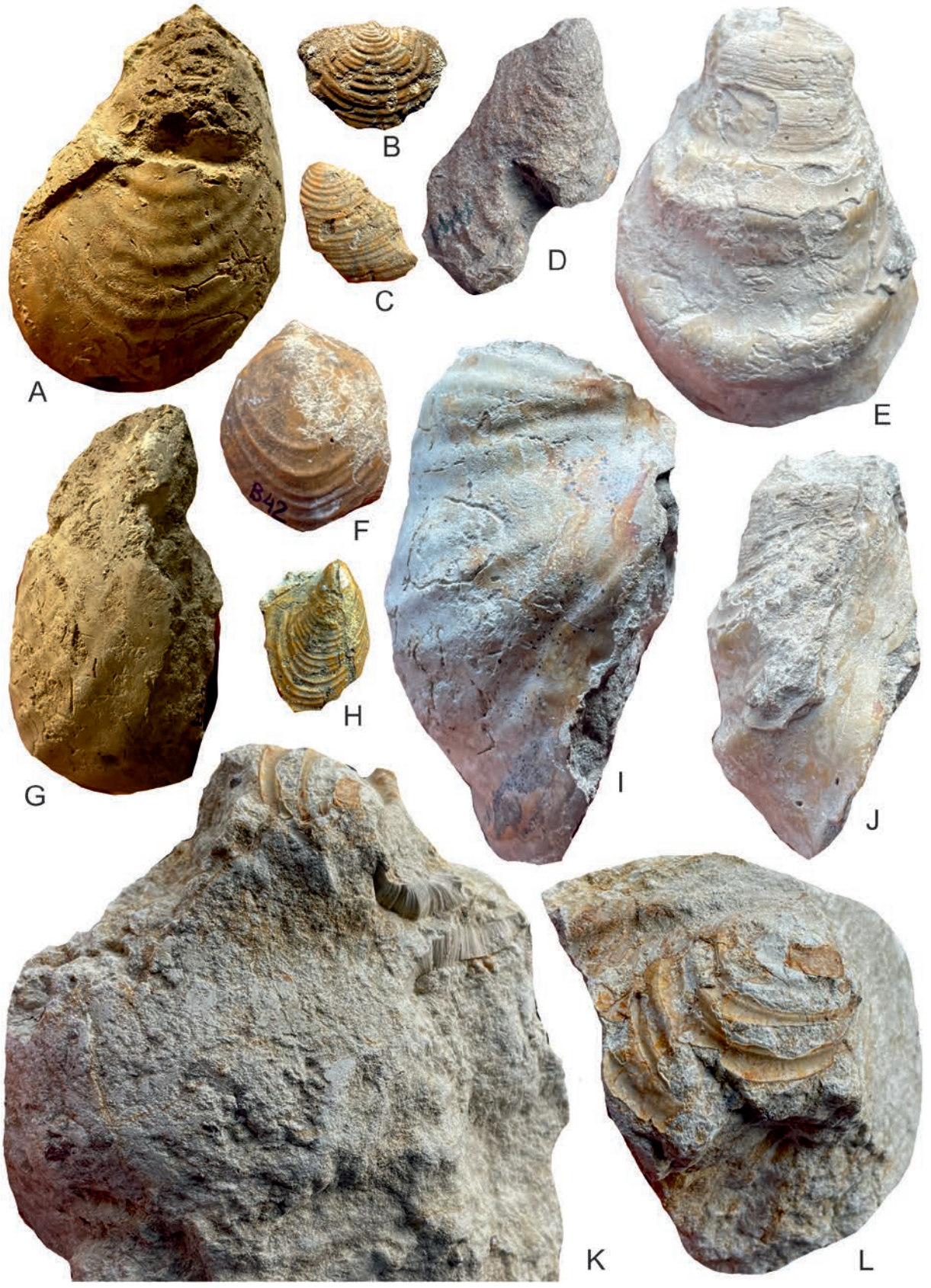
Mytiloides scupini (Heinz, 1930) another upper Upper Turonian taxon; it first appears slightly earlier than *M. herbichi*.

Cremnoceramus deformis erectus (Meek, 1877) (Text-fig. 4F) is the primary marker of the base of the Coniacian (e.g., Walaszczyk *et al.* 2010, 2022) and is a phyletic predecessor of *C. deformis deformis* (Meek, 1877) which appears in the middle Lower Coniacian.

Cremnoceramus crassus inconstans (Woods, 1912) (Text-fig. 4A, G) is the older of the members of the *C. crassus* (Petrascheck, 1903) lineage, which ranges through the lower part of the Lower Coniacian (but first appears distinctly above the base of the stage); it is followed by *C. crassus* in the upper half of the substage.

Tethyoceramus sp. (Text-fig. 4E, I, J): in Europe, the genus first appears in the *C. waltersdorfensis hannovrensis* Zone and ranges seemingly high in the Lower Coniacian.

Volviceramus cf. *involutus* (J. de C. Sowerby,


A
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1828) (Text-fig. 4K, L): the first appearance of the species is in the lower part of the Middle Coniacian (Kauffman *et al.* 1996). It ranges high into the lower Upper Coniacian (e.g., Tröger 1989; Walaszczyk and Cobban 2006; Walaszczyk *et al.* 2017, 2018).

To summarise, based on inoceramids, the maximum stratigraphic range of bed 42 spans the topmost Middle Turonian to high in the Upper Coniacian. However, it is well-documented only in the lower and middle part of the Lower Coniacian, up to the *Cremnoceramus crassus inconstans* Zone. Higher portions of the stage are documented by a single *Volviceramus* specimen. In Marcinowski *et al.* (1996), the specimen was referred to *V. koeneni* (Müller, 1888), and consequently, the upper range of bed 42 was assumed to be lower Middle Coniacian. Further examination of the specimen does not confirm its original determination, and the specimen is referred to as *Volviceramus* cf. *involutus* (Sowerby, 1828).

Additionally, there are two specimens of the bivalve *Didymotis* (Text-fig. 4B, C), representing the morphotypes characteristic of the *Didymotis* Event I and/or II, both of the uppermost Turonian (Wood *et al.* 1984; Kauffman *et al.* 1996; Walaszczyk and Wood 1998).

Repositories of specimens

BMNH: The Natural History Museum, London, UK.
PIB: Institut für Geowissenschaften, Rheinische Friedrich-Wilhelms Universität, Bonn, Germany.
MNHP: Muséum National d'Histoire Naturelle, Paris, France.
MWGUW: Museum of the Faculty of Geology, University of Warsaw, Poland.

SYSTEMATIC PALAEONTOLOGY
(W.J. KENNEDY)

Conventions

Dimensions are given in millimetres: D = diameter; Wb = whorl breadth; Wh = whorl height; U = umbilicus. The suture terminology is that of Korn *et al.* (2003): E = external lobe; A = adventive lobe; U = umbilical lobe; I = internal lobe.

Order Ammonoidea Zittel, 1884
Suborder Ammonitina Hyatt, 1889
Superfamily Desmoceratoidea Zittel, 1895
Family Pachydiscidae Spath, 1922
Genus *Lewesiceras* Spath, 1939

TYPE SPECIES: *Ammonites peramplus* Mantell, 1822, p. 200, by original designation by Spath (1939a, p. 296).

Lewesiceras mantelli Wright and Wright, 1951
(Text-fig. 5)

pars 1853. *Ammonites peramplus* Mantell; Sharpe, p. 26, pl. 10, figs 2, 3 only.
1951. *Lewesiceras mantelli* Wright and Wright, p. 20.
2019. *Lewesiceras mantelli* Wright and Wright; Kennedy, p. 57, pl. 13, figs 8–15, 18–26; pl. 14, figs 1–13; pl. 15, figs 1–5; pl. 16, figs 1–5; pl. 26, figs 3–5; text-figs 29–33; 34d–f.
2019. *Lewesiceras mantelli* Wright and Wright, 1951; Kennedy and Kaplan, p. 39, pl. 6, figs 1–13; pl. 7, figs 1, 2, 4–7, 11–16; pl. 16; text-fig. 17a–c.

TYPE: The holotype, by monotypy, is BMNH 88587, the original of Sharpe (1853, pl. 10, fig. 3), from Oldbury Hill, Wiltshire (Kennedy 2019, pl. 13, figs 18–20; Kennedy and Kaplan 2019, text-fig. 17a–c).

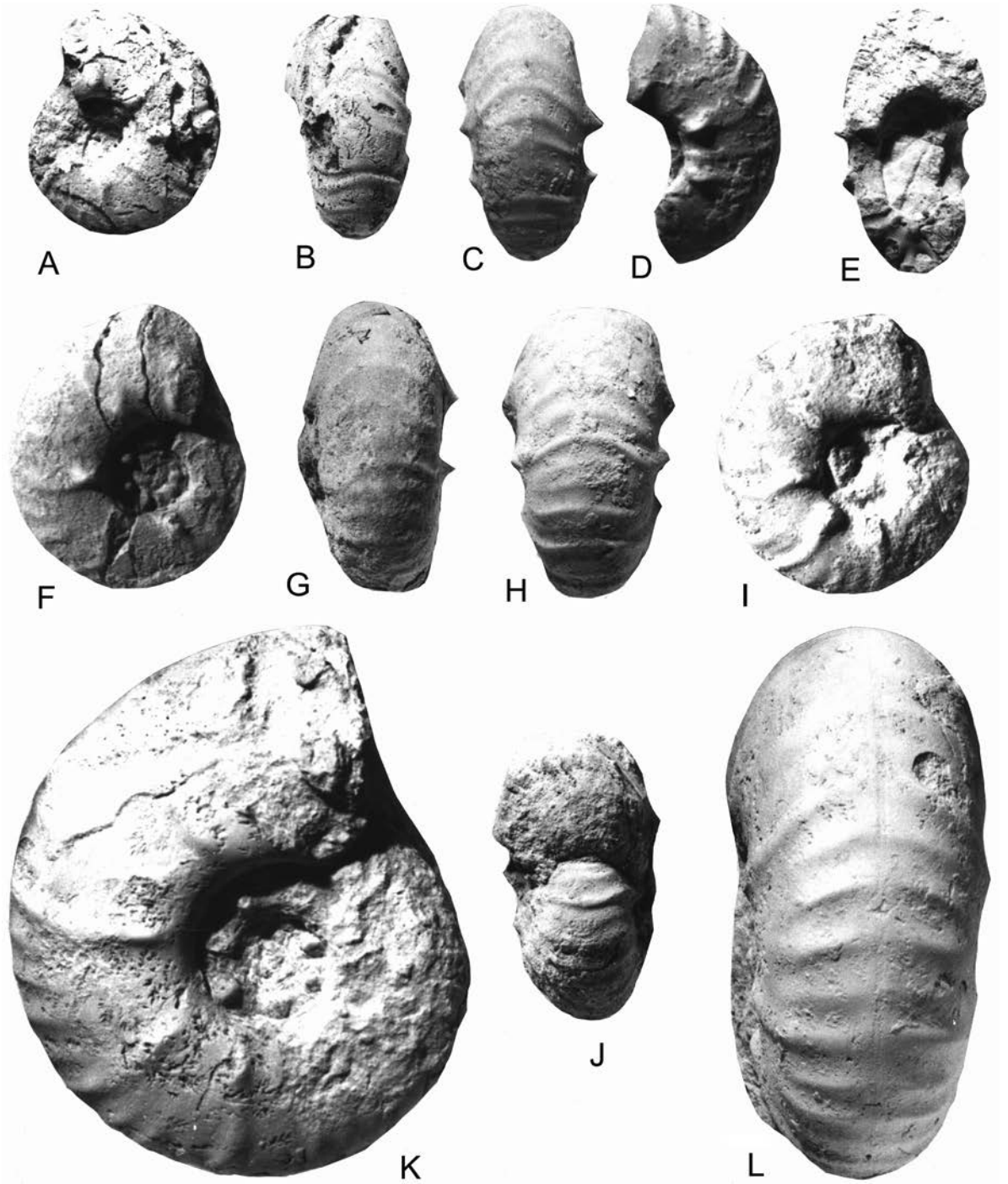
MATERIAL: MWGUW ZI/63/0735–40, from bed 12 of the Shakh-Bogota section. MWGUW ZI/63/0444, 0477, 0478, 0481 and 0484, from bed 37 of the Aksyrtau section. MWGUW ZI/63/1000–1004 from bed 42 of the Besakty section.

DIMENSIONS:

	D	Wb	Wh	Wb:Wh	U
MWGUW ZI/63/1000 c	40.1 (100)	23.9 (55.5)	17.5(43.6)	1.37	11.0 (27.4)
MWGUW ZI/63/0737	45.6 (100)	– (–)	20.3(44.5)	–	12.7 (27.9)
MWGUW ZI/63/0739	93.6 (10)	– (–)	40.4(43.2)	–	27.1 (29.0)

DESCRIPTION: Specimens are up to 93.6 mm in diameter; most are phragmocones, the largest, MWGUW ZI/63/0739 (Text-fig. 5K, L) retaining a short sector of body chamber. Coiling is moderately

← Text-fig. 4. Upper Turonian–Coniacian inoceramids. **A**, **G** – *Cremnoceramus crassus inconstans* (Woods, 1912), MWGUW ZI/63/3059. **B**, **C** – *Didymotis* sp.; B – MWGUW ZI/63/3060, C – MWGUW ZI/63/3061. **D** – *Mytiloides* sp.; MWGUW ZI/63/3062; **E**, **I**, **J** – *Tethyoceramus* sp., E, J – MWGUW ZI/63/3063, I – MWGUW ZI/63/3066; **F** – *Cremnoceramus deformis erectus* (Meek, 1877), MWGUW ZI/63/3064; **H** – *Mytiloides herbichi* (Atabekian, 1969), MWGUW ZI/63/3065; **K**, **L** – *Volviceramus* cf. *involutus* (Sowerby, 1828), MWGUW ZI/63/3067. A–C, E–L are from bed 42 of the Besakty section; D is from bed 41 of the Azhirektoy section. All figures are × 1.



Text-fig. 5. *Lewesiceras mantelli* Wright and Wright, 1951. A, B – MWGUW ZI/63/1000; C–E – MWGUW ZI/63/0737; F, G – MWGUW ZI/63/0738; H–J – MWGUW ZI/63/0735; K, L – MWGUW ZI/63/0739. A, B is from bed 42 of the Besakty section. C–L are from bed 12 of the Shakh-Bogota section. All figures are × 1.

involute, the umbilicus comprising around 28% of the diameter, deep, with a concave wall and broadly rounded umbilical shoulder, the whorl section depressed reniform in intercostal section. Eight massive bullae perch on the umbilical shoulder and give rise to pairs of strong, concave, prorsiradiate ribs that strengthen progressively and cross the venter in a broad convexity. The adapical rib of each pair of

ribs is stronger than the adapertural, the interspace between deepened into a constriction in the smaller individuals (Text-fig. 5A–I) that is less conspicuous in the largest specimen (Text-fig. 5K, L). There are two or three intercalated ribs separating successive pairs of bullate ribs to give a total of 14 ribs per half whorl in MWGUW ZI/63/0737, and 18 in the largest specimen, MWGUW ZI/63/0739. Only fragments of the deeply incised suture are exposed.

DISCUSSION: See Kennedy (2019, p. 65) and Kennedy and Kaplan (2019, p. 41). *Lewesiceras woodi* Wright, 1979 (p. 312, pl. 3, fig. 21; pl. 6, fig. 6; Kennedy 2019, p. 66, pl. 9, figs 8–10; pl. 13, figs 1–7, 16, 17; text-fig. 36) is a diminutive species with weak or no umbilical tuberculation and weak ribbing.

OCCURRENCE: Upper Turonian, *Subprionocyclus neptuni* and *Prionocyclus germari* zones. The geographic distribution extends from Northern Ireland to southern and eastern England, France, Germany, the Czech Republic, Poland, Ukraine (Crimea), European Russia, Kazakhstan, and, possibly, Austria.

Superfamily Acanthoceratoidea de Grossouvre, 1884
Family Collignoniceratidae Wright and Wright, 1951
Subfamily Collignoniceratinae Wright and Wright, 1951
Genus *Subprionocyclus* Shimizu, 1932

TYPE SPECIES: *Prionocyclus hitchinensis* Billinghurst, 1927 (p. 516, pl. 16, figs 1, 2), by the original designation of Shimizu (1932, fig. 2).

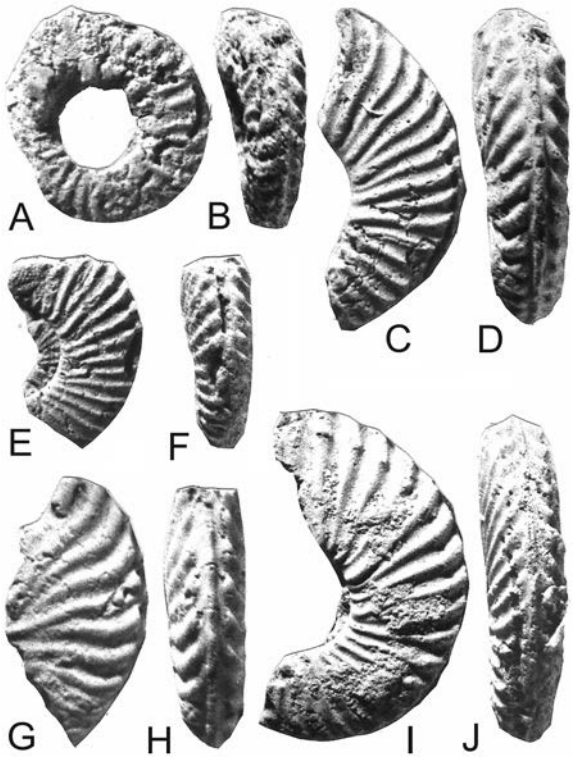
Subprionocyclus neptuni (Geinitz, 1849)
(Text-fig. 6)

1849. *Ammonites Neptuni* Geinitz, p. 114, pl. 3, fig. 3.
2014. *Subprionocyclus neptuni* (Geinitz, 1849); Wilmsen and Nagm, p. 224, text-fig. 13a, c, d.
2019. *Subprioncyclus neptuni* (Geinitz, 1849); Kennedy, p. 99, pl. 35, figs 7–11, 28, 29; pl. 36, figs 1–4, 10–13, 20, 21, 24; text-figs 55b, c, d; 57b, d (with full synonymy).
2019. *Subprionocyclus neptuni* (Geinitz, 1849); Kennedy and Kaplan, p. 70, pl. 1, fig. 6; pl. 38, figs 2–4, 7–9, 11; pl. 39, figs 14, 15; text-fig. 27b–d.
2020a. *Subprioncyclus neptuni* (Geinitz, 1849); Kennedy, p. 75, pl. 31, figs 1–13; text-fig. 24a.

TYPE: The holotype, by monotypy, is SaK 10032, the original of Geinitz (1849, pl. 3, fig. 3), housed in the collections of the Staatliches Museum für Mineralogie und Geologie, Dresden, Germany, from the Upper Turonian Strehlen Limestone Member, Saxony, Germany, recently refigured by Wilmsen and Nagm (2014, text-fig. 13c), Kennedy and Kaplan (2019, text-fig. 27d) and Kennedy (2019, text-fig. 55d).

MATERIAL: MWGUW ZI/63/1767–70 from bed 40 of the Besakty section; MWGUW ZI/63/1772–75 from bed 42 of the Besakty section.

DESCRIPTION: A series of fragments of phragmocones have whorl heights of up to 11 mm; the most complete, MWGUW ZI/63/1770 (Text-fig. 6I, J) is a half whorl, 22.2 mm in diameter. Coiling is involute, the umbilicus comprising 27% of the diameter, shallow, with a low, feebly convex wall and quite narrowly rounded umbilical shoulder. The whorl section is weakly compressed, with a costal whorl breadth to height ratio of 0.6 approximately, the greatest breadth at the umbilical bullae. The intercostal section has very feebly convex flanks, broadly rounded ventrolateral shoulders and a feebly convex venter with a strong siphonal keel. Around 16 crowded primary



Text-fig. 6. *Subprionocyclus neptuni* (Geinitz, 1849). A, B – MWGUW ZI/63/1767; C, D – MWGUW ZI/63/1768; E, F – MWGUW ZI/63/1769; G, H – MWGUW ZI/63/1772; I, J – MWGUW ZI/63/1770. A–F, I, J are from bed 40 of the Besakty section; G, H is from bed 42 of the Besakty section. All figures are × 2.

ribs are present on the umbilical shoulder, a minority with well-differentiated umbilical bullae, the majority narrow and delicate. The ribs are straight and prorsiradiate, feebly concave on the outer flank and ventrolateral shoulder, where there is a small but well-differentiated inner ventrolateral tubercle from which a strong rib projects forwards and links to a well-developed outer ventrolateral clavus, the clavi separated from the crenulated siphonal keel by a feebly ornamented zone. MWGUW ZI/63/1772 (Text-fig. 6G, H) has more markedly falcoid ribs, some weakly linked in pairs at umbilical bullae. Even the smallest fragments (including MWGUW ZI/63/1769: Text-fig. 6E, F) have clearly differentiated inner and outer ventrolateral tubercles.

DISCUSSION: The fragments compare well with the holotype (see above), and find a match in other specimens of comparable size assigned to *S. neptuni* (for instance Kennedy 2019, pl. 35, figs 7, 8; pl. 36, figs 1, 2). *Subprionocyclus hitchinensis* (Billinghurst, 1927) (pl. 16, fig.1; holotype refigured by Kennedy 2019, pl. 37, figs 6–9) has very fine, crowded falcoid ribs, and lacks inner ventrolateral tubercles. *Subprionocyclus branneri* (Anderson, 1902) of comparable size (see for example Kennedy 2019, pl. 35, figs 1–6) have straight, coarse, predominantly single and feebly bullate primary ribs. For a discussion of the relationship between *S. neptuni* and *S. bravaisianus* (d'Orbigny, 1841) (p. 308, pl. 91, figs 3, 4) see Kennedy (2019, pp. 103, 104).

OCCURRENCE: Upper Turonian, *Subprionocyclus neptuni* Zone, southern England, and correlatives in northern and south-eastern France, ?northern Spain, Germany, Poland, ?Bulgaria, Kazakhstan, north-eastern Algeria, Central Tunisia, Japan, California and Oregon in the United States.

Genus *Prionocyclus* Meek, 1876

TYPE SPECIES: *Ammonites serrato–carinatus* Meek, 1871, p. 298, *non* Stoliczka (1864, p. 47, pl. 32, fig. 3 = *Prionocyclus wyomingensis* Meek, 1876, p. 452).

Prionocyclus spp.
(Text-fig. 7)

MATERIAL: MWGUW ZI/63/1776 and 1777, from bed 42 of the Besakty section.

DESCRIPTION: MWGUW ZI/63/1776 (Text-fig. 7A, B) is a nucleus 23.5 mm in diameter, with most of the surface of both flanks concealed by phosphatic encrustations. The whorl section is compressed, the ventrolateral shoulders quite narrowly rounded, the venter flattened, with a low siphonal keel. Ornament on the outer part of the flanks consists of fine, even, prorsiradiate ribs that flex forwards and are concave on the ventrolateral shoulders and venter. The rib terminations are separated from the siphonal keel by a well-developed, smooth groove. Small ventrolateral bullae are preserved on some ribs, and towards the adapertural end of the specimen, strengthen markedly and give rise to a prorsirsdiate, declining rib. MWGUW ZI/63/1777 (Text-fig. 7C, D) is a poorly preserved, corroded and encrusted 120º sector of phragmocone with a whorl height of 14 mm approximately at the adapertural end of the fragment. The umbilical wall is feebly convex, the umbilical shoulder broadly rounded, the intercostal whorl section rounded-trapezoidal. Only a single primary rib is completely preserved. It arises at the umbilical seam and is well-developed on the umbilical wall, strengthening into an umbilical bulla that gives rise to a blunt rib that weakens across the flanks before strengthening into a conical/clavate ventrolateral tubercle from which a narrow rib projects forwards and declines before reaching the siphonal keel.

DISCUSSION: These poor fragments are undoubtedly *Prionocyclus*, and were referred to as *Prionocyclus hyatti* by Marcinowski *et al.* (1996, text-fig. 12). The larger fragment (Text-fig. 7C, D) certainly agrees with individuals of the gracile form of comparable size from the United States Western Interior (Kennedy *et al.* 2001, text-fig. 52i, j), and if it is accepted that the nucleus belongs to the same species, there is also a match (Kennedy *et al.* 2001, text-fig. 52a–f). But there are also close similarities to nuclei of *Prionocyclus albinus* (Fritsch, 1872) of a comparable size (Kennedy *et al.* 2001, text-fig. 62) and those of *Prionocyclus germari* (Reuss, 1845) (Kennedy *et al.* 2001, text-fig. 109). Accordingly, a conservative position is adopted here.

Text-fig. 7. *Prionocyclus* spp. A, B – MWGUW ZI/63/1776; C, D – MWGUW ZI/63/1777. Both specimens are from bed 42 of the Besakty section. All figures are × 1.

OCCURRENCE: As for material. *Prionocyclus* ranges throughout the Upper Turonian, with records from the United States Western Interior and Gulf Coast, northern Mexico, Brazil, Germany, the Czech Republic, Spain, Croatia, Kazakhstan, central Tunisia, Madagascar, central India, and Japan

Suborder Ancyloceratina Wiedmann, 1966
Superfamily Turrilitoidea Gill, 1871
Family Anisoceratidae Hyatt, 1900
Genus *Allocrioceras* Spath, 1926

TYPE SPECIES: *Crioceras ellipticum* Woods, 1896, p. 84 (*non Hamites ellipticus* Mantell, 1822, p. 122), by the original designation of Spath (1926, p. 80), renamed *Allocrioceras woodsi* Spath (1939b, p. 598 = *Hamites angustus* J. de C. Sowerby, 1850, p. 346, pl. 29, fig. 12).

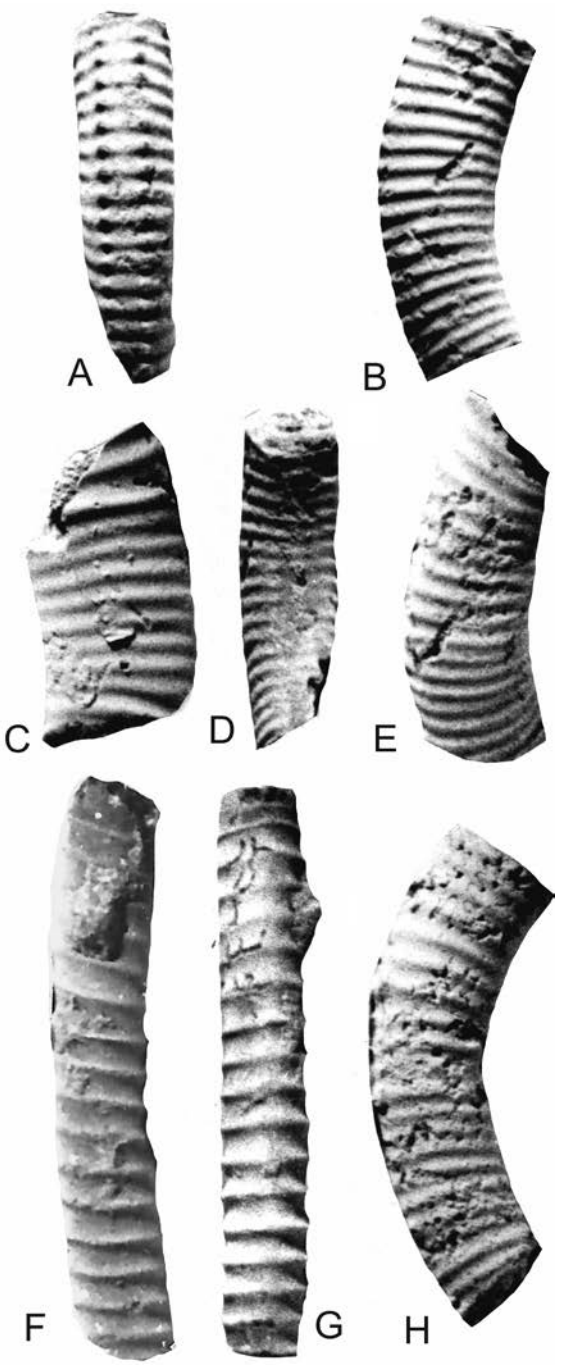
Allocrioceras angustum (J. de C. Sowerby, 1850)
(Text-fig. 8A, B, H)

1850. *Hamites angustus* J. de C. Sowerby in Dixon, p. 346, pl. 29, fig. 12.
2019. *Allocrioceras angustum* (J. de C. Sowerby, 1850); Kennedy and Kaplan, p. 79, pl. 44, figs 10, 11; pl. 52, figs 15–18.
2020b. *Allocrioceras angustum* (J. de C. Sowerby, 1850); Kennedy, p. 113, pl. 38, figs 1–8, 10–17; pl. 39, figs 7, 8, 28, 29; text-fig. 62d, e.

TYPE: The holotype, by monotypy, the original of J. de C. Sowerby in Dixon (1850, p. 346, pl. 29, fig. 12), presumed to be from the Chalk of Sussex, is lost.

MATERIAL: MWGUW ZI/63/1771, from bed 40 of the Besakty section; MWGUW ZI/63/1008, from bed 42 of the Besakty section.

DESCRIPTION AND DISCUSSION: MWGUW ZI/63/1771 (Text-fig. 8A, B) is a 26 mm long fragment of body chamber with a maximum preserved whorl height of 9 mm, the whorl section weakly compressed oval, with a whorl breadth to height ratio of 0.8. Ornament is of crowded ribs, the rib index six. The ribs are weak and transverse on the dorsum, strengthening across the dorsolateral margin, and straight, recti- to feebly rursiradiate on the flanks. All bear a conical ventral tubercle, the tubercles linked across the venter by a strong, straight rib. MWGUW ZI/63/1008 (Text-fig. 8H) is a comparable but larger, worn fragment of phragmocone 35 mm long with a maximum preserved whorl height of 9 mm and a whorl breadth to height ratio of 0.8.



Text-fig. 8. **A**, **B**, **H** – *Allocrioceras angustum* (J. de C. Sowerby, 1850). A, B – MWGUW ZI/63/1771; H – MWGUW ZI/63/1008. **C** – *Scalarites*? sp. B, MWGUW ZI/63/1012. **D**, **E** – *Eubostrychoceras* (*Eubostrychoceras*) cf. *saxonicum* (Schlüter, 1875), MWGUW ZI/63/1019. **F**, **G** – *Scalarites*? sp. A, MWGUW ZI/63/1129. A and B are from bed 40 of the Besakty section; C–H are from bed 42 of the Besakty section. All figures are × 2.

See Kennedy (2020b, p. 117) for a discussion of difference between *angustum* and other *Allocrioceras* species.

OCCURRENCE: Upper Turonian *Subprionocyclus neptuni* Zone of southern England and Yorkshire. Also known from the *neptuni* Zone of the Münsterland Basin, Westphalia, and Saxony in Germany, and Poland. Upper Turonian or Lower Coniacian of Kazakhstan. There are also possible records from the Upper Turonian of South Dakota, USA, and the Coniacian of KwaZulu-Natal, South Africa.

Family Nostoceratidae Hyatt, 1894
Genus and subgenus *Hyphantoceras* Hyatt, 1900

TYPE SPECIES: *Heteroceras roissyanum* Schlüter, error for *Hamites reussianus* d'Orbigny, 1850, p. 216, by the original designation of Hyatt (1900, p. 587).

Hyphantoceras (*Hyphantoceras*) *reussianum*
(d'Orbigny, 1850)
(Text-fig. 9J–L)

1845. *Helicoceras plicatilis* Sow.; Reuss, p. 23, pl. 7, figs 5, 6.
1850. *Hamites Reussianus* d'Orbigny, p. 216.
2019. *Hyphantoceras* (*Hyphantoceras*) *reussianum* (d'Orbigny, 1850); Kennedy and Kaplan, p. 86, pl. 45, fig. 5; pl. 47, figs 1–7.
2020b. *Hyphantoceras* (*Hyphantoceras*) *reussianum* (d'Orbigny, 1850); Kennedy, p. 126, pl. 40, figs 1–11, 14–18; text-figs 61a, 68a, d–g; 69a–d (with full synonymy).

TYPE: D'Orbigny (1850, p. 216) referred to pl. 7, figs 5 and 6 in Reuss (1845), when introducing his species *Hamites Reussianus*. The originals have not been traced (Kaplan and Schmid 1988, p. 53). Kennedy and Kaplan (2019, p. 87, pl. 47, figs 6, 7) designated RE320 A1085 as neotype (see also Kennedy 2020b, text-fig. 68e, f), a macroconch, in the collections of the Ruhr Museum (Essen, Germany) from the Upper Turonian *Subprionocyclus neptuni* Zone, *Hyphantoceras* Event, Steinbruch Foerth, Halle, Westphalia, Germany.

MATERIAL: MWGUW ZI/63/705, from bed 26 of the Shyrkala-Airakty section.

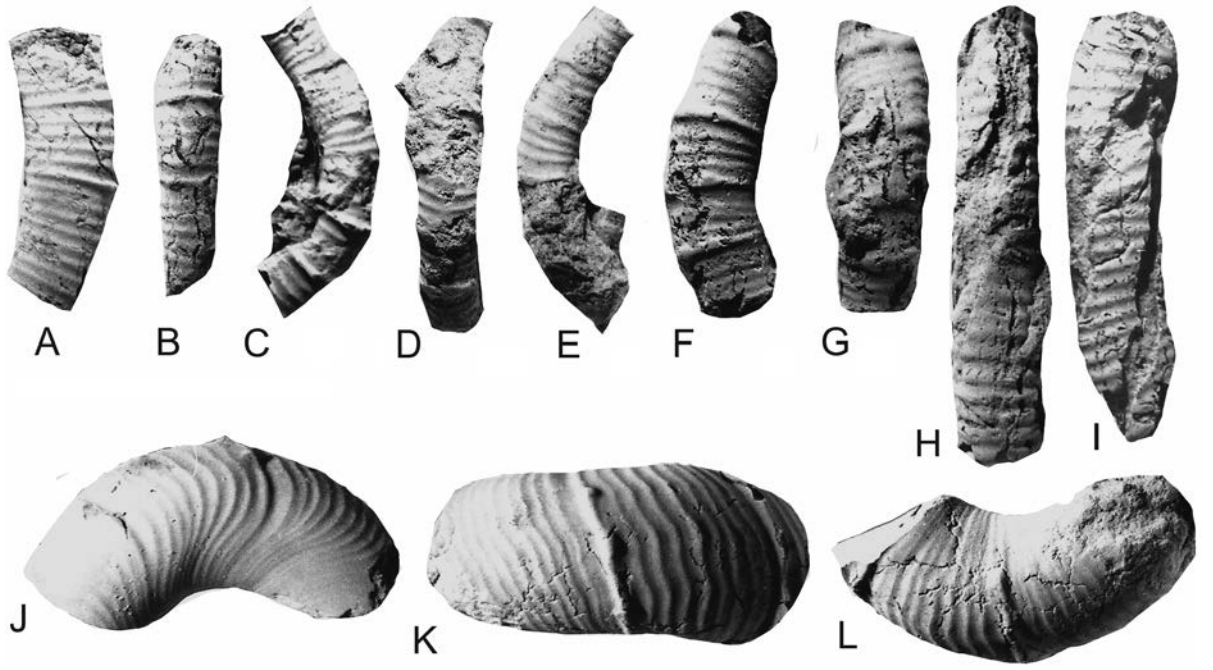
DESCRIPTION: The specimen is a 120º sector of a body chamber, the whorl section slightly compressed oval with a maximum preserved whorl height of 25.7 mm and a whorl breadth to height ratio of 0.8. Ornament consists of two types of rib. There are two major ribs on the fragment, the adapical one preceded by nine minor ribs, and separated from the second by eight minor ribs. Both major ribs are preceded by a well-developed constriction. The inner surface of the whorl is ornamented by delicate lirae. They link in pairs at a small, well-developed bulla at the junction of lower and outer whorl faces that gives rise to the adapical major rib. Much coarser than the adjacent minor ribs, they are straight, oblique, and link to a second bulla low on the outer whorl face, a third row in the middle of the outer whorl face, and a fourth on the upper part of the outer whorl face, from which the ribs sweeps forwards, weaken, and are markedly concave on the junction of the outer and upper whorl faces and the upper whorl face. The minor ribs parallel the major ones, and are strengthened into long, low, barely differentiated bullae in positions that correspond to those of the bullae on the major ribs.

DISCUSSION: The distinctive ornament of the fragment, with delicate bullae on the minor ribs, agrees with that of a fragment of a macroconch body chamber from the Upper Turonian Chalk Rock of southern England (Kennedy 2020b, pl. 40, fig. 17), and, like that specimen, it is interpreted as a variant of *H. reussianum*. For further discussion see Kennedy and Kaplan (2019, p. 88) and Kennedy (2000b, p. 129). *Hyphantoceras flexuosum* (Schlüter, 1872) (p. 108, pl. 32, figs 13, 14) is discussed by Wiese (2000), Kennedy (2000b, p. 130), and Kennedy and Kaplan (2019, p. 88). It has a very high apical angle and a lower expansion rate.

OCCURRENCE: Upper Turonian *Subprionocylus neptuni* Zone, southern England, Linconshire and Yorkshire, northern and south-eastern of France, northern Spain, Germany, Poland, the Czech Republic, Kazakhstan, northern Algeria, Tunisia, and the uppermost Turonian or Lower Coniacian of Madagascar.

Hyphantoceras (*Hyphantoceras*) cf. *flexuosum*
(Schlüter, 1872)
(Text-fig. 9C–G)

compare:
1872. *Helicoceras flexuosum* Schlüter, p. 108, pl. 32, figs 13, 14.
2019. *Hyphantoceras flexuosum* (Schlüter, 1872); Kennedy



Text-fig. 9. **A**, **B** – *Neocrioceras* (*Neocrioceras*)? sp., MWGUW ZI/63/0907. **C**–**G** – *Hyphantoceras* (*Hyphantoceras*) cf. *flexuosum* (Schlüter, 1872); C–E – MWGUW ZI/63/0924; F, G – MWGUW/ZI/63/0921. **H, I** – *Scalarites*? *bohemicus* (Fritsch, 1872), MWGUW ZI/63/1130. **J**–**L** – *Hyphantoceras* (*Hyphantoceras*) *reussianum* (d'Orbigny, 1850), MWGUW ZI/63/0705. A–I are from bed 42 of the Besakty section; J–L are from bed 26 of the Shyrkala section. All figures are × 1.

and Kaplan, p. 88, pl. 42, fig. 2; pl. 44, fig. 1; pl. 48, figs 1–3, 5–11; pl. 52, fig. 12.

2020. *Hyphantoceras flexuosum* (Schlüter, 1872); Kennedy, p. 130, pl. 40, figs 12, 13; text-fig. 70a–g.

TYPE: The lectotype of *Hyphantoceras flexuosum*, by the subsequent designation of Wiese (2000, p. 409), is no. x5687 in the collections of the Bundesanstalt für Geowissenschaften und Rohstoffe, Berlin, Germany, the original of Schlüter (1872, p. 108, pl. 32, figs 10–12) from the Upper Turonian or Lower Coniacian *cuvieri* Pläner of the Salzgitter area, Germany. It was refigured by Wiese (2000, pl. 2, figs 1–3).

MATERIAL: MWGUW ZI/63/0921 and ZI/63/0924, from bed 42 of the Besakty section.

DESCRIPTION: MWGUW ZI/63/0924 (Text-fig. 9C–E) is a curved, very feebly helicoid fragment 47.5 mm long, with a maximum preserved whorl height of approximately 9 mm. The whorl section is circular. Major ribs are weak on the dorsum, strengthen across the dorsolateral margin and are coarse and straight across the flanks, linking to coarse flat-topped ventrolateral bullae, linked across the venter by a coarse transverse rib. There is the faintest trace of a ventrolateral tubercle on one rib. Successive major ribs are separated by up to four minor ribs. These are weak, narrow, and parallel the major ribs. MWGUW ZI/63/0921 (Text-fig. 9F, G) is a more obviously feebly helicoid curved 42.5 mm long fragment from the adapertural end of the phragmocone. The maximum preserved whorl height is 15.5 mm. The major ribs are straight on the flanks, and markedly oblique on the venter. They bear well-developed flat-topped ventral bullae and are separated by three or four minor ribs.

DISCUSSION: The presence of only two rows of well-developed tubercles on the primary ribs distinguishes these specimens from typical *H. flexuosum*, hence the qualified identification.

OCCURRENCE: As for material. *H.* (*H.*) *flexuosum* is known from the Upper Turonian *Subprionocylus neptuni* Zone of southern England, the Upper Turonian and Lower Coniacian of Germany, the Upper Turonian of south-eastern France, the Lower Coniacian of the Czech Republic, and the Upper Turonian or Lower Coniacian of Kazakhstan.

Genus and subgenus *Eubostrychoceras* Matsumoto, 1967

TYPE SPECIES: *Eubostrychoceras indopacificum* Matsumoto, 1967 (p. 333, pl. 18, fig. 1), by original designation.

Eubostrychoceras (*Eubostrychoceras*) cf. *saxonicum* (Schlüter, 1875)
(Text-fig. 8D, E)

1875. *Turrilites saxonicus* Schlüter, p. 30.
2019. *Eubostrychoceras* (*Eubostrychoceras*) *saxonicum* (Schlüter, 1872); Kennedy and Kaplan, p. 84, pl. 46, figs 1–7.
2020b. *Eubostrychoceras* (*Eubostrychoceras*) *saxonicum* (Schlüter, 1872); Kennedy, p. 132; pl. 41, figs 1–25; text-figs 67b, 71a–g (with full synonymy).

TYPE: The lectotype, by the subsequent designation of Kaplan and Schmid (1988, p. 50), is the original of Geinitz (1840, pl. 13, fig. 1), no. SaK10098 in the collections of the Senckenberg Museum für Mineralogie und Geologie, Dresden, Germany, from the Upper Turonian Strehlen Limestone Member, Saxony, Germany. It was refigured by Wilmsen and Nagm (2014, text-fig. 15d).

MATERIAL: MWGUW ZI/63/1019, from bed 42 of the Besakty section.

DESCRIPTION and DISCUSSION: The specimen is a 25 mm long fragment of a body chamber with a maximum preserved whorl height of 9 mm approximately and a circular whorl section. Ornament is of crowded narrow ribs, weak on the inner whorl face, strengthening across the junction of inner and upper whorl faces, sweeping forwards and markedly prorsiradiate on the outer whorl face. The rib index is six. Slight as the material is, it finds a match in juvenile *E.* (*E.*) *saxonicum* from the Upper Turonian Chalk Rock of southern England, for example the originals of Kennedy (2020b, pl. 41, figs 3, 4, 15), with which it is compared.

OCCURRENCE: As for material. *Eubostrychoceras* (*E.*) *saxonicum* is known from the Upper Turonian *Subprionocylus neptuni* Zone of southern England, northern France, the southern Corbières in Aude, France, northern Spain, the Münsterland Basin, Westphalia, and elsewhere in Germany, Poland, the Czech Republic, Kazakhstan, and northern Algeria. It is also recorded from the Coniacian of Madagascar, and possibly the Upper Turonian and Coniacian of Japan, as *E.* (*E.*) aff. *saxonicum*.

Family Diplomoceratidae Spath, 1926
Subfamily Diplomoceratinae Spath, 1926
Genus *Scalarites* Wright and Matsumoto, 1954

TYPE SPECIES: *Helicoceras scalare* Yabe 1904 (p. 9, pl. 3, figs 2, 3), by the original designation of Wright and Matsumoto (1954, p. 115).

Scalarites? *bohemicus* (Fritsch, 1872)
(Text-fig. 9H, I)

1872. *Hamites bohemicus* Fritsch, p. 44, pl. 13, fig. 20.
1893. *Hamites bohemicus* Fri.; Fritsch, p. 77 (*pars*), *non* text-fig. 58.
1897. *Hamites bohemicus* Fr.; Fritsch, p. 39, text-fig. 21.
1925. *Hamites bohemicus* Fritsch; Diener, p. 66.

TYPES: Fritsch based his species on several specimens and figured one (1872, pl. 13, fig. 20), from the Coniacian "*gelben Sandstein der Chlomeker Schichten vom Tannenberg bei Falkenau*", no. 03183 in the collections of the Národní Museum, Prague, Czech Republic.

MATERIAL: MWGUW ZI/63/1130, from bed 42 of the Besakty section.

DESCRIPTION: MWGUW ZI/63/1130 is a 67 mm long slightly curved fragment, the greatest preserved whorl height 17.3 mm, the adapertural half body chamber. The whorl section is slightly depressed oval. The rib index is six, the ribs equal, even, straight and transverse on the dorsum, strengthening across the dorsolateral margin, straight and feebly rursiradiate across the flanks and venter.

DISCUSSION: There are a number of named species from the Coniacian of Western and Central Europe, based on curved sectors of shell, differentiated only on the basis of little more than rib density and direction. The present specimen is assigned to *S.*? *bohemicum* on the basis of comparable rib direction and density to that of the poorly preserved figured syntype, an external mould. The poorly preserved, crushed lectotype of *Scalarites turoniense* (Schlüter, 1872), PIB Schlüter original 69b, the original of Schlüter (1872, p. 103, pl. 31, fig. 4), refigured by Kaplan and Kennedy (1994, pl. 39, fig. 1), is from the Coniacian Cuvieri Pläner of Rothenfelde, Westphalia,

Germany. It differs from *bohemicus* only in having slightly prorsiradiate rather than slightly rursiradiate ribs; the rib index is four.

OCCURRENCE: Coniacian of the Czech Republic; condensed Upper Turonian–Lower Coniacian of the Mangyshlak Mountains of Kazakhstan.

Scalarites? sp. A
(Text-fig. 8F, G)

MATERIAL: MWGUW ZI/63/1129, from bed 42 of the Besakty section.

DESCRIPTION: The specimen is a very slightly curved body chamber fragment just over 40 mm long, with a maximum preserved whorl height of 6.7 mm; the whorl section is circular. The rib index is three, the ribs weak and transverse on the dorsum, strengthening across the dorsolateral margin, strong, narrow, prorsiradiate and straight on the flanks, and passing straight across the venter.

DISCUSSION: Low rib density distinguishes the specimen from *Scalarites turoniense* (Schlüter, 1872), and rib direction from *Scalarites bohemicus* (Fritsch, 1872), both discussed above. *Scalarites* sp. B, described below has a much higher rib density.

OCCURRENCE: As for material.

Scalarites sp. B
(Text-fig. 8C)

MATERIAL: MWGUW ZI/63/1012, from bed 42 of the Besakty section.

DESCRIPTION and DISCUSSION: A further species of *Scalarites* is represented by a 22 mm long fragment of a body chamber with a maximum preserved whorl height of 11.8 mm, the whorl section oval, the whorl breadth to height ratio of 0.8, the rib index eight, the ribs recti- to very feebly prorsiradiate. There is a constriction at the adapical and adapertural end of the fragment. These features distinguish the species from those described above.

OCCURRENCE: As for material.

Genus and Subgenus *Neocrioceras* Spath, 1921

TYPE SPECIES: *Crioceras spinigerum* Jimbo, 1894 (p. 184, pl. 24, fig. 1), by the subsequent designation of Diener (1925, p. 192).

Neocrioceras (*Neocrioceras*)? sp.
(Text-fig. 9A, B)

MATERIAL: MWGUW ZI/63/0907, from bed 42 of the Besakty section.

DESCRIPTION: MWGUW ZI/63/0907 is a curved fragment of body chamber 38.5 mm long, with a maximum preserved whorl height of 13 mm. The whorl section is compressed ovoid, the dorsum more broadly rounded than the venter, the greatest breadth below mid-flank. The rib index is eight, the ribs transverse and straight on the dorsum, straight and feebly rursiradiate to feebly prorsiradiate on the flanks and transverse on the venter. There are two major ribs on the fragment. These strengthen across the flanks and develop into feeble ventral bullae, linked across the venter by a strong rib, and are succeeded by a feeble constriction. They are separated by four minor ribs that vary little, if at all, in strength across the flanks, dorsum and venter. There are nine minor ribs preceding the adapical major rib.

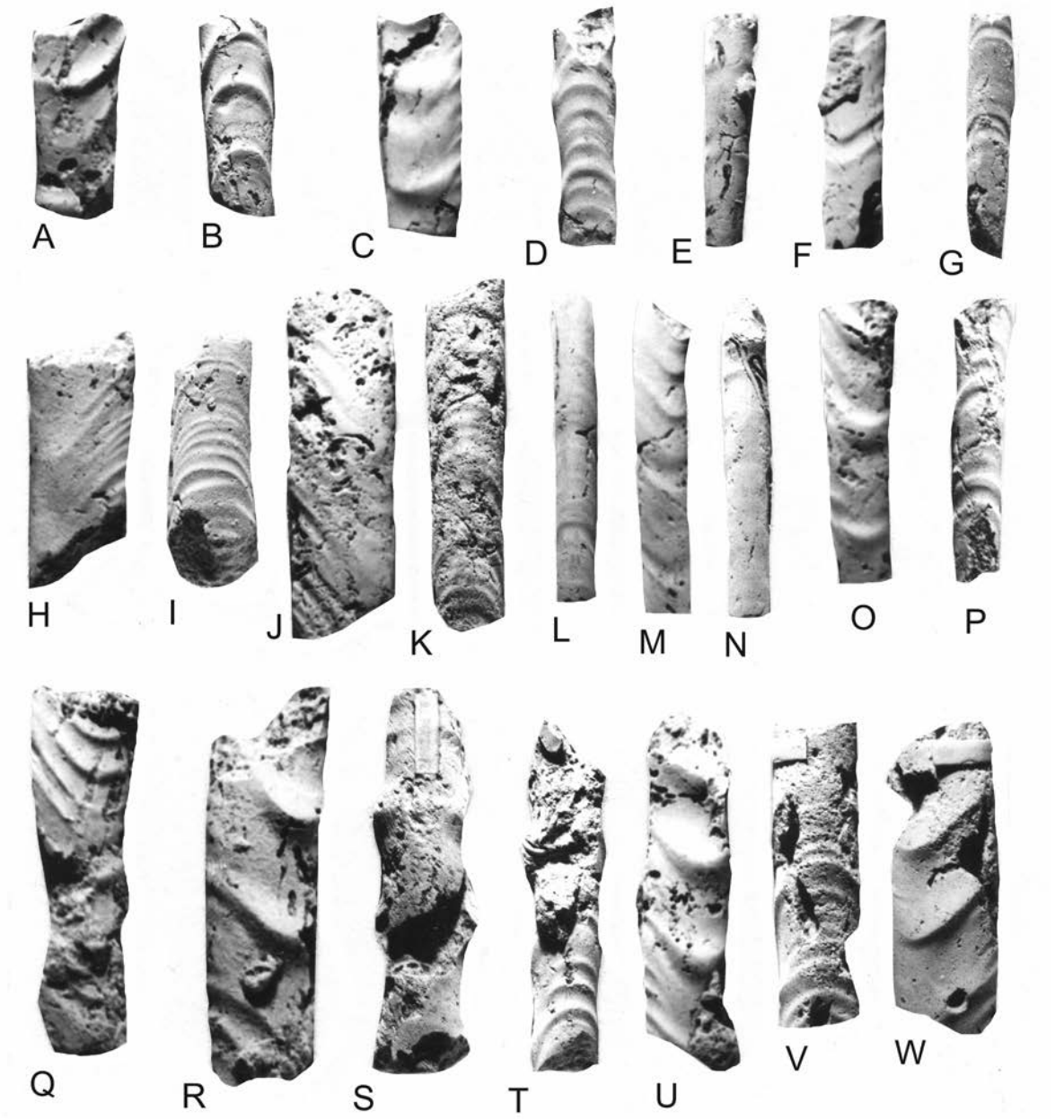
DISCUSSION: This fragment is problematic. It could be a species of *Allocrioceras* with, apparently, as many as nine minor ribs between successive tuberculate ribs, a far higher number than in any other species referred to the genus (see discussion in Kennedy and Kaplan 2019, p. 79), or a species of *Neocrioceras* (*Neocrioceras*) with ventrolateral tubercles only. It is provisionally referred to the latter on the basis of the comparable style of ribbing to that of the lectotype of *N.* (*N.*) *paderbornense* (Schlüter, 1872) (pl. 30, figs 1, 2; see Kaplan and Kennedy 1994, pl. 39, fig. 8).With such slight material its position remains unresolved.

OCCURRENCE: As for material.

Family Baculitidae Gill, 1871
Genus *Sciponoceras* Hyatt, 1894

TYPE SPECIES: *Hamites baculoides* Mantell, 1822 (p. 123, pl. 23, figs 6, 7), by the original designation of Hyatt (1894, p. 578).

Sciponoceras bohemicum bohemicum
(Fritsch, 1872)
(Text-figs 10, 11A)



Text-fig. 10. *Sciponoceras bohemicum bohemicum* (Fritsch, 1872). A, B – MWGUW ZI/63/0870; C, D – MWGUW ZI/63/0931; E–G – MWGUW ZI/63/0893; H, I – MWGUW ZI/63/0476; J, K – MWGUW ZI/63/0441; L–N – MWGUW ZI/63/0189; O, P – MWGUW ZI/63/0922; Q – MWGUW ZI/63/0927; R, S – MWGUW ZI/63/0876; T, U – MWGUW ZI/63/0930; V, W – MWGUW ZI/63/0720. A–G, L–U are from bed 42 of the Besakty section; H–K are from bed 37 of the Aksyrtau section; V, W is from bed 17 of the Sulu-Kappy section. All figures are × 1.

1872. *Baculites faujassi* Lamarck var. *bohemica* Fritsch, p. 49, pl. 13, figs 23–25, 29, 30.

2019. *Sciponoceras bohemicum bohemicum* (Fritsch, 1872); Kennedy and Kaplan, p. 93, pl. 49, figs 1–14, 18, 20; text-fig. 25d, e.

2020b. *Sciponoceras bohemicum bohemicum* (Fritsch, 1872); Kennedy, p. 167, pl. 51, figs 1–7, 9, 14–22, 26–28, pl. 52, figs 1–13 (with full synonymy).

TYPE: The lectotype, by the subsequent designation of Wright (1979, p. 285), is the original of *Baculites faujassi* Lamarck var. *bohemica* of Fritsch (1872, p. 49, pl. 13, fig. 25). Fritsch figured four additional specimens which are paralectotypes, and mentioned numerous other specimens. All are from the Lower Coniacian Baculitenthonen of the 'Priesener Schichten von Leneschitz [Lenešic] bei Lauen' SW

of Usti nad Labem, Czech Republic, and are housed in the collections of the Národni Museum, Prague, Czech Republic.

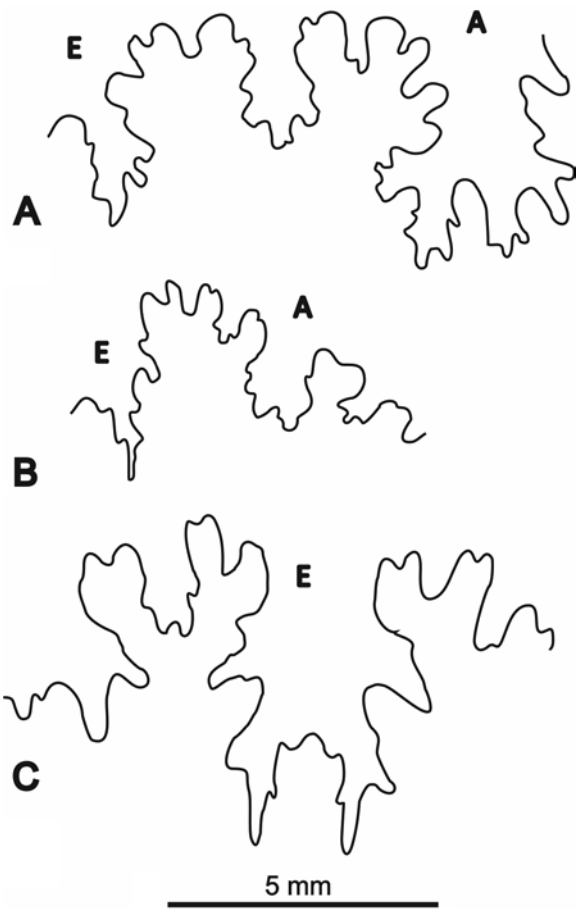
MATERIAL: Over 100 specimens from bed 42 of the Besakty section, including MWGUW ZI/63/0189, 0870, 0876, 0893, 0922, 0927, 0928, 0930, and 0931. MWGUW ZI/63/0441, 0455, 0473, and 0476, from bed 37 of the Aksyrtau section. MWGUW ZI/63/0720 from bed 17 of the Sulu-Kappy section.

DESCRIPTION: The abundant material is almost exclusively fragments of the body chamber with only a few phragmocone sections. Whorl heights range from 5 mm approximately to 19.5 mm; it is not possible to differentiate between fragments of the body chambers of small adults and those of juveniles. A single specimen, MWGUW ZI/63/0189 (Text-fig. 10L–N) retains an adult aperture at a whorl height of 9.7 mm and is interpreted as an adult microconch; the largest body chamber fragments, with whorl heights of up to 19.5 mm are interpreted as parts of macroconchs. There is wide morphological variation within the material, which is interpreted as intraspecific variation.

Variant 1 (Text-fig. 10H–K) has delicate ribs in two orders. In MWGUW ZI/63/0746 (Text-fig. 10H, I) the major ribs are effaced on the dorsum, strengthening into concave incipient dorsolateral bullae, projecting forwards, straight and strongly prorsiradiate on the flanks, strengthening, flexing back, and convex on the ventrolateral shoulder, and very feebly convex over the venter. They are associated with a clearly differentiated constriction on outer flanks, ventrolateral shoulders and venter that is succeeded by a strengthened rib. These are succeeded by up to seven weaker ribs that are effaced on the dorsum and dorsal part of the flanks.

Variant 2 (Text-fig. 10Q) is poorly represented in the collections, and is characterised by much stronger ribbing, all ribs extending to the dorsolateral margin and dorsum, with better differentiated long dorsolateral bullae.

Variant 3 (Text-fig. 10A–G, L–P, R–W) is characterised by the development of widely separated crescentic dorsolateral bullae that vary from blunt (Text-fig. 10R, U) to sharp (Text-fig. 10A, C, W). They extend across the inner flanks, and give rise to coarse single ribs or a pair of ribs, with additional coarse ribs intercalating on the ventrolateral shoulders. In some specimens, the interspace adapertural to the primary ribs is deepened into a constriction (Text-fig. 10L–N) that varies in expression between individuals.



Text-fig. 11. Suture lines of selected ammonites. **A** – *Sciponoceras bohemicum bohemicum* (Fritsch, 1872), MWGUW ZI/63/0870. **B** – *Scaphites geinitzii* d'Orbigny, 1850, MWGUW ZI/63/1125. **C** – *Scaphites kieslingswaldensis* Langenhan and Grundey, 1891, MWGUW ZI/63/1114.

MWGUW ZI/63/0189, interpreted as an adult microconch, preserves a damaged aperture. The venter is flexed forwards and feely convex in profile (Text-fig. 10M), the dorsolateral part of the aperture strongly concave, projecting strongly forwards, the ventral part of the margin narrow and convex.

The suture (Text-fig. 11A) is partially preserved, with broad, bifid saddles.

DISCUSSION: See Kennedy and Kaplan (2019, p. 95) and Kennedy (2020b, p. 169). Marcinowski *et al*. (1996) recorded *Baculites undulatus* d'Orbigny, 1850 from the present faunas (see revisions of the species in Kennedy and Kaplan 2019, p. 96, pl. 49, figs 15–17, 19, 21; Kennedy 2020b, p. 171, pl. 51, figs 8, 10–13, 23–25, 29–31). The holotype (refigured by Kennedy 2020b, pl. 51, fig. 8) is a 20 mm long silicified frag-

ment with delicate, wiry, equal ribs that are transverse on the dorsolateral margin and dorsal part of the flanks, then flexing forwards, straight and prorsiradiate before flexing back and very feebly convex on outer flanks and ventrolateral shoulders. Absence of differentiation of rib strength separates it from the lectotype of *bohemicum bohemicum*, and specimens assigned to variant 1 above (Text-fig. 10K–N), as does the absence of constrictions, a feature that separates *Baculites* from *Sciponoceras*. A larger, 126 mm long phragmocone fragment of *B. undulatus* figured by Breton and Bavent (1985, text-figs 1–3) shows the delicate ribbing extending to a whorl height of 21 mm, the ribs straight and prorsiradiate across the outer flanks. In contrast, Matsumoto and Obata (1963, p. 29, pl. 8, fig. 4) recorded dorsolateral bullae on a few of their large examples that they assigned to *B. undulatus*. Regrettably, the illustrations of a bullate individual are unclear. Bullate individuals from the Upper Turonian Chalk Rock of southern England (Wright 1979, pl. 1, fig. 6; pl. 7, fig. 11; Kennedy 2020b, pl. 51, figs 10, 23–25) referred to *B. undulatus* lack constrictions and have bullae that are less markedly crescentic than in some of the present specimens. I would not, however, be surprised if subsequent research revealed unequivocal *B. undulatus* in the Kazakh faunas.

OCCURRENCE: Upper Turonian, *Subprionocylus neptuni* Zone, southern and eastern England, northern France, northern Spain, Germany, the Czech Republic, Austria, Poland. Upper Turonian or Coniacian of Kazakhstan. Lowest Coniacian of the Słupia Nadbrzeżna section, Poland. Lower Coniacian of the Czech Republic.

Superfamily Scaphitoidea Gill, 1871
Family Scaphitidae Gill, 1871
Subfamily Scaphitinae Gill, 1871
Genus *Scaphites* Parkinson, 1811

TYPE SPECIES: *Scaphites equalis* J. Sowerby, 1813 (p. 53, pl. 18, figs 1–3), by the subsequent designation of Meek (1876, p. 413).

Scaphites geinitzii d'Orbigny, 1850
(Text-figs 11B, 12, 13)

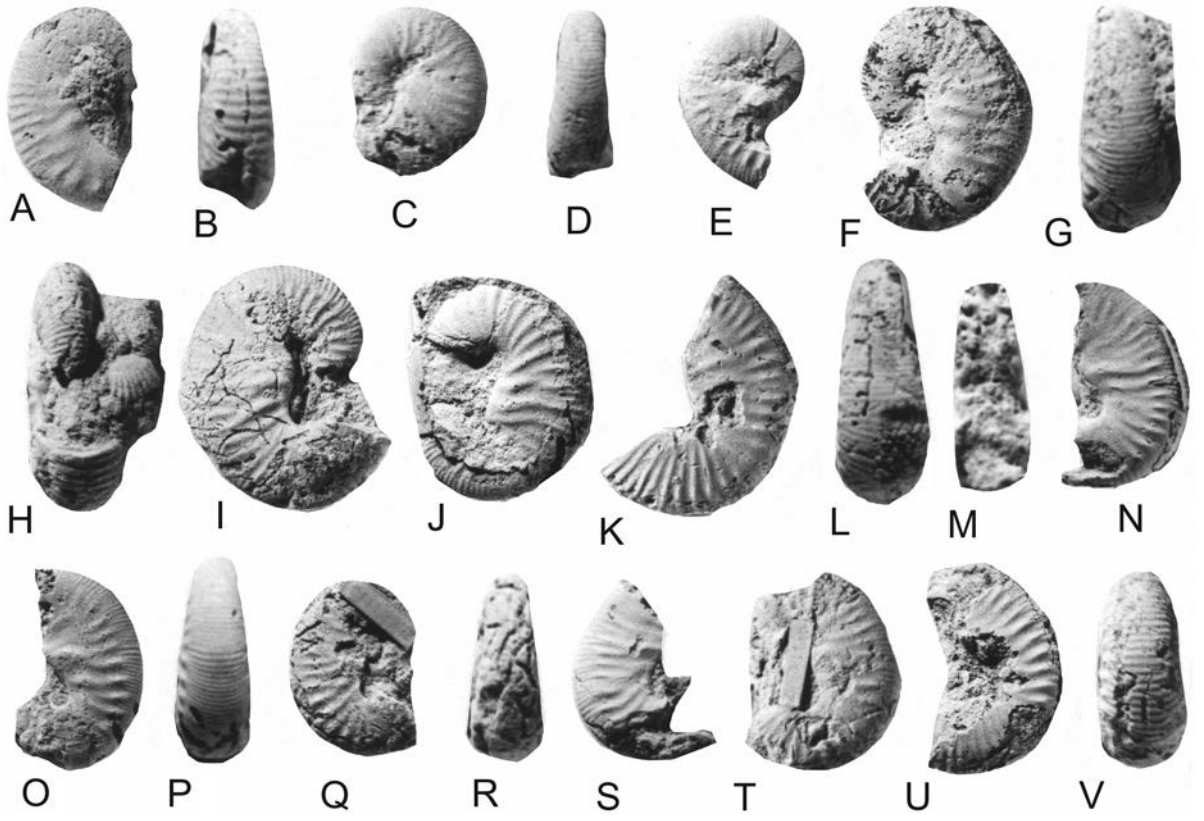
1850. *Scaphites Geinitzii* d'Orbigny, p. 214.
2019. *Scaphites geinitzii* d'Orbigny, 1850; Kennedy and Kaplan, p. 99, pl. 50, figs 14–32; pl. 51, figs 1–17; text-fig. 28a–j.
2020b. *Scaphites geinitzii* d'Orbigny, 1850; Kennedy, p. 175, pl. 55, figs 3–35; pl. 56, figs 1–19, 28–30; pl. 57, figs 1–31; text-figs 85b–d, 86d–g (with synonymy).

TYPES: The lectotype, by the subsequent designation of Wright (1979, p. 299), is MNHP.F.R01235, no. 7179 in the d'Orbigny collection, housed in the Muséum National d'Histoire Naturelle, Paris. It was recently figured by Kennedy and Kaplan (2019, pl. 50, figs 15–17) and Kennedy (2020b, pl. 55, figs 4, 5; text-fig. 86d–g). Paralectotype no. 7197a also belongs to the species. A further paratype, MNHP.F.A25665, d'Orbigny Collection 7197b (Kennedy 2000b, pl. 55, figs 1–3; text-fig. 86a–c) belongs to a different species. All are from the mid-Upper Turonian Strehlen Limestone Member of the Strehlen Formation, Dresden, Strehlen, Saxony, Germany.

MATERIAL: MWGUW ZI/63/1074, 1077, 1079, 1081–84, 1086–89, 1092, 1097, 1106, 1108–1109, 1111, 1113, 1115, 1117, 1118, 1120, 1123, 1125–8, 1131, from bed 42 of the Besakty section.

DESCRIPTION: Complete adults are from 24.3 to 32.2 mm long. Spires have compressed to feebly depressed whorls with feebly convex subparallel to convergent flanks, broadly rounded ventrolateral shoulders and a very feebly convex venter. Primary ribs are quite widely separated and prorsiradiate on the inner flank, flexing back and convex at mid-flank, straight and rursiradiate on the outer flank, where they bi- or trifurcate into delicate wiry secondary ribs which, together with intercalated ribs, project forwards and are concave on the ventrolateral shoulders and cross the venter in a shallow convexity. On body chambers, there are up to four primary ribs, which strengthen, then weaken and extend around the recurved sector. Some develop an umbilicolateral bulla. They become increasingly prorsiradiate on the shaft, may bi- or trifurcate, whilst intercalated ribs arise around mid-flank, all of these ribs strengthening into a ventrolateral bulla that varies from weak (Text-figs 12A, I, S; 13A, E) to strong (Text-figs 12K, N, O, Q; 13G–I, K). The bullae give rise to up to five delicate ribs, the adapical and adapertural only weakly attached, with additional ribs intercalating. These ribs are delicate, wiry, feebly concave on the ventrolateral shoulders, and very feebly convex over the venter. The primary ribs weaken around the recurved sector and change from rursi- to recti- and feebly prorsiradiate; the ventrolateral bullae weaken and efface.

The suture of MWGUW ZI/63/1125 (Text-fig. 11B). is only moderately incised.



Text-fig. 12. *Scaphites geinitzii* d'Orbigny, 1850. A, B – MWGUW ZI/63/1117; C, D – MWGUW ZI/63/1125; E – MWGUW ZI/63/1128; F, G – MWGUW ZI/63/1108; H, I – MWGUW ZI/63/1106; J – MWGUW ZI/63/1109; K, L – MWGUW ZI/63/1111; M, N – MWGUW ZI/63/1127; O, P – MWGUW ZI/63/1120; Q, R – MWGUW ZI/63/1113; S – MWGUW ZI/63/1126; T – MWGUW ZI/63/1118; U, V – MWGUW ZI/63/1115. All specimens are from bed 42 of the Besakty section. All figures are × 1.

DISCUSSION: The form of the umbilical margin of the body chamber is obscured or damaged in many of the specimens. MWGUW ZI/63/1106 (Text-figs 12H, I, 13E) and MWGUW ZI/63/1108 (Text-figs 12F, G, 13D) have a bulge at the adapical end of the body chamber, suggesting they may be small macroconchs, but convincing evidence of dimorphism in the present material is lacking. The range of variation in ornament is matched in the better preserved Upper Turonian material from the Münsterland Basin in Germany (Kennedy and Kaplan 2019) and the Chalk Rock of southern England (Kennedy 2020b), and the size overlaps with that of the lectotype. There is, however a difference in the size range seen in other collections, with macroconchs from the Münsterland Basin up to 58 mm long, and those from the Chalk Rock of southern England up to 50 mm long. The small adult size of the Kazakh *S. geinitzii* assemblage compared with those from Western Europe is also shown by *Scaphites kieslingswaldensis* Langenhan and Grundey, 1891, described below.

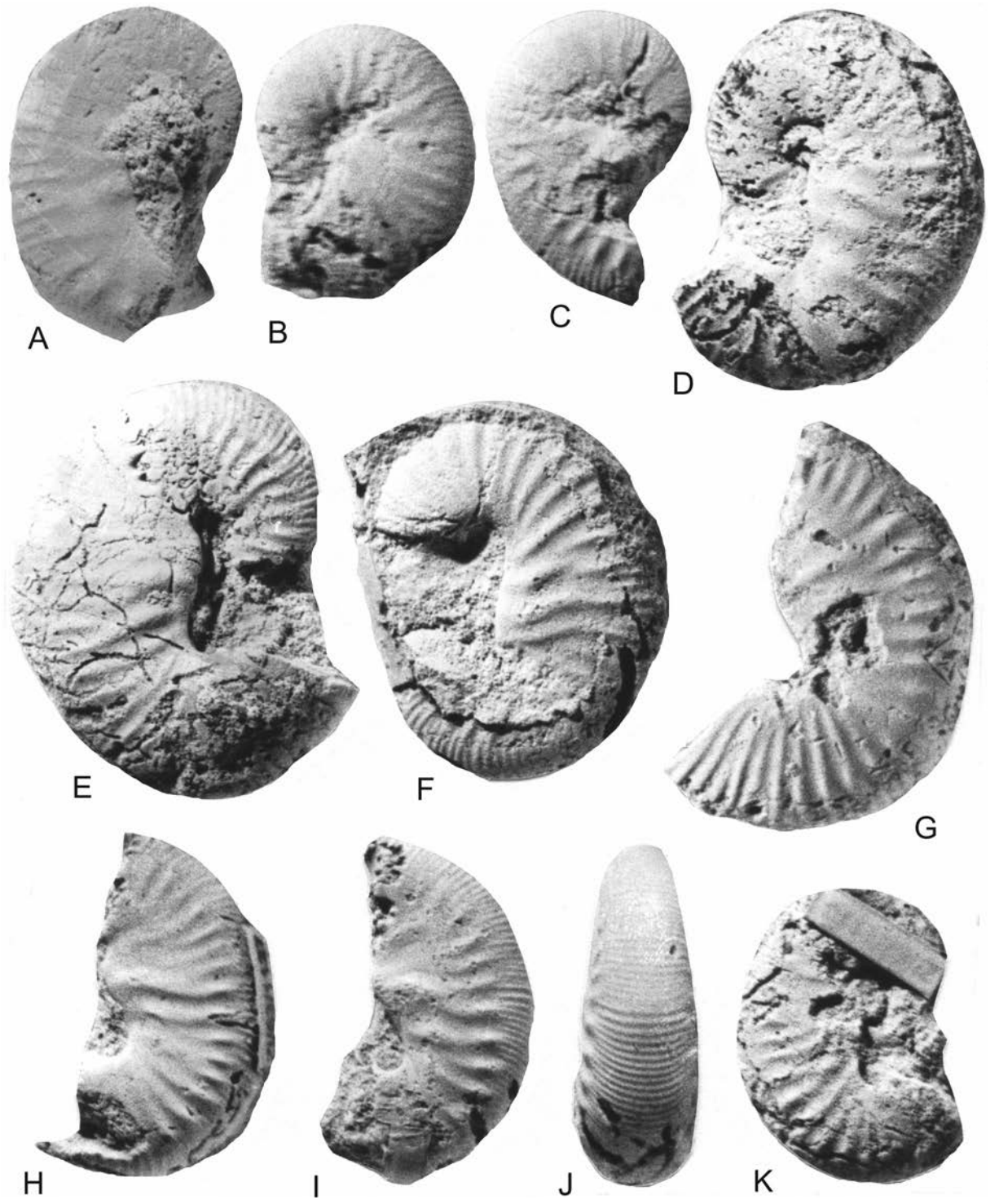
OCCURRENCE: Middle Turonian *Collignoniceras woollgari* Zone, rare in England and Germany. Upper Turonian *Subprionocylus neptuni* Zone, southern and eastern England, northern France, Germany, Poland, the Czech Republic, northern Spain, Bulgaria, Romania, Ukraine (Crimea, Donbass), Kazakhstan, Turkmenistan, and Greenland. Upper Turonian *Prionocyclus germari* Zone, south-eastern France, Germany and the Czech Republic. The species may extend into the Coniacian.

Scaphites kieslingswaldensis Langenhan and Grundey, 1891

(Text-figs 11C; 14A–S; 15A–F)

1891. *Scaphites Kieslingswaldensis* Langenhan and Grundey, p. 9, pl. 1, fig. 1.

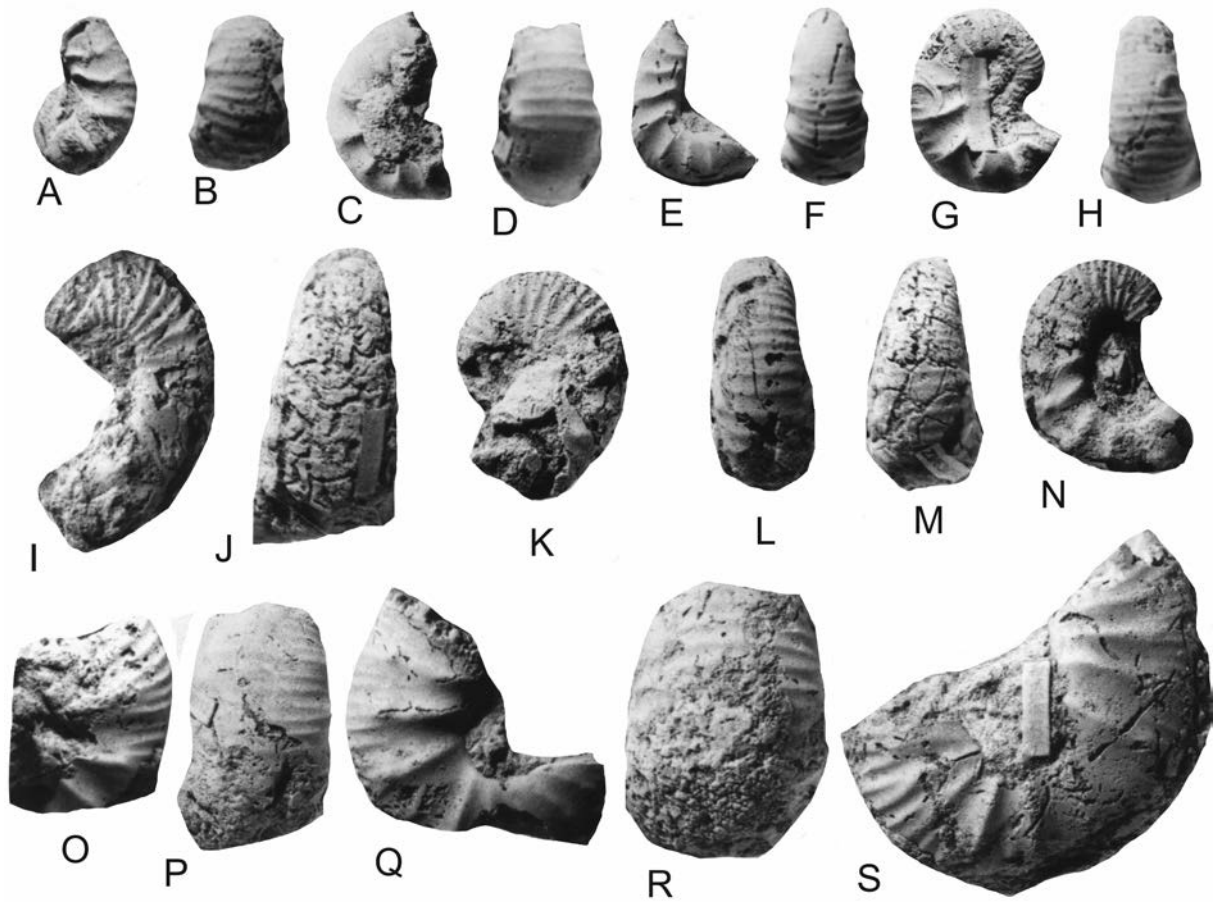
2013. *Scaphites kieslingswaldensis* Langenhan and Grundey 1891; Kennedy and Klinger, p. 529, pl. 1, figs 1–29; pl. 2, figs 1–9, 14–17; pl. 3, figs 1–17; text-fig. 6c (with additional synonymy).



Text-fig. 13. *Scaphites geinitzii* d'Orbigny, 1850. A – MWGUW ZI/63/1117; B – MWGUW ZI/63/1125; C – MWGUW ZI/63/1128; D – MWGUW ZI/63/1108; E – MWGUW ZI/63/1106; F – MWGUW ZI/63/1109; G – MWGUW ZI/63/1111; H – MWGUW ZI/63/1127; I, J – MWGUW ZI/63/1120; K – MWGUW ZI/63/1113. All specimens are from bed 42 of the Besakty section. All figures are × 2.

2016. *Scaphites kieslingswaldensis kieslingswaldensis* Langenhan and Grundey 1891; Klein, pp. 54, 80 (with additional synonymy).

TYPE: The holotype, by monotypy, is the original of Langenhan and Grundey (1891, pl. 1, fig. 1), from the Coniacian of Idzików (German: Kieslingswalde),

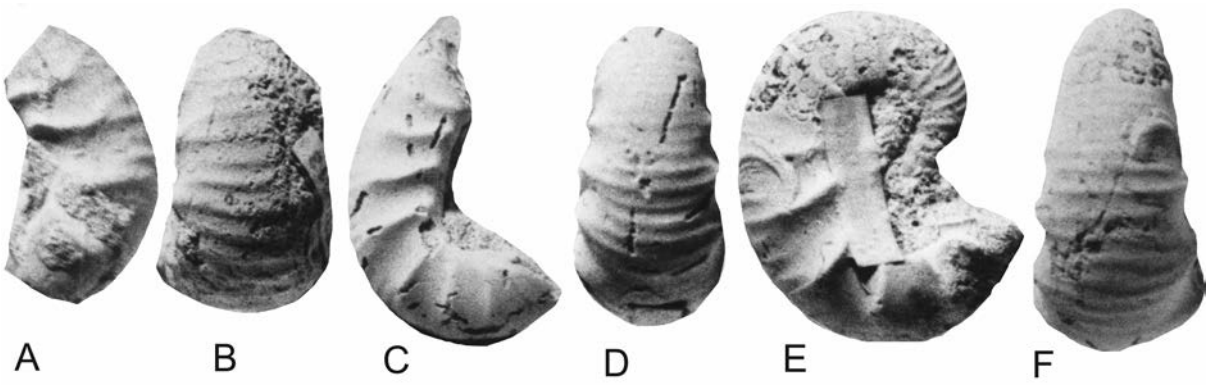


Text-fig. 14. *Scaphites kieslingswaldensis* Langenhan and Grundey, 1891. A, B – MWGUW ZI/63/1013; C, D – MWGUW ZI/63/1011; E, F – MWGUW ZI/63/1009; G, H – MWGUW ZI/63/1007; I, J – MWGUW ZI/63/0867; K, L – MWGUW ZI/63/0905; M, N – MWGUW ZI/63/0902; O – MWGUW ZI/63/0866; P, Q – MWGUW ZI/63/1112; R, S – MWGUW ZI/63/1105. All specimens are from bed 42 of the Besakty section. All figures are × 1.

southeast of Kłodzko (German: Glatz), Poland. It was refigured by Fritsch (1897, text-fig. 20), Sturm (1901, pl. 3, fig. 6), and a cast was figured by Kaplan *et al.* (1987, pl. 5, fig. 5) and Kaplan and Kennedy (1994, pl. 41, figs 1–3).

MATERIAL: MWGUW ZI/63/0866, 0867, 0902, 0905, 1007, 1009, 1011, 1013, 1070, 1105, 1107, 1110, 1112, 1114, 1116, 1119, 1121, 1122, 1124, from bed 42 of the Besakty section.

DESCRIPTION: The present material falls into two groups, small individuals from 24 to 37 mm long when complete (Text-figs 14A–N, 15A–F), and large fragments of body chambers up to 40 mm long (Text-fig. 14O–S). Spires of individuals assigned to the first group have slightly compressed to slightly depressed whorl sections, the umbilical wall feebly convex, the umbilical shoulder broadly rounded, the flanks convex, the greatest breadth below mid-flank, the outer flanks converging to broadly rounded ventrolateral shoulders and a broad, feebly convex venter. Primary ribs arise at the umbilical seam and strengthen across the umbilical wall and shoulder. They are narrow, straight and prorsiradiate, may bifurcate on the outermost flank, where additional ribs intercalate, the ribs transverse across the venter. The body chamber comprises a slightly curved, convex shaft that does not occlude the umbilicus of the coiled sector and a more markedly curved final adapertural sector; the umbilical wall concave. The whorl section is depressed reniform, the greatest breadth low on the flanks. Six to nine primary ribs arise at the umbilical seam of the body chamber, and strengthen across the umbilical wall and shoulder. They are variably prorsiradiate on the flanks of the shaft, strengthening



Text-fig. 15. *Scaphites kieslingswaldensis* Langenhan and Grundey, 1891. A, B – MWGUW ZI/63/1013; C, D – MWGUW ZI/63/1009; E, F – MWGUW ZI/63/1007. All specimens are from bed 42 of the Besakty section. All figures are × 2.

progressively and developing into ventrolateral bullae. These give rise to two or three delicate, straight to very feebly convex, narrow ribs, with additional ribs intercalating. There is some variation in ventral rib development within and between individuals. The ribs become less markedly prorsiradiate and weaken around the adapertural recurved sector.

Some of the larger body chamber fragments show a similar style of coarser ribbing (Text-fig. 14O–Q). The largest fragment seen (MWGUW ZI/63/1105; Text-fig. 14R, S) has fewer, weaker primary ribs on the shaft, the secondary and intercalated ribs well-developed.

The partially exposed suture (Text-fig. 11C) is deeply incised.

DISCUSSION: The holotype of *S. kieslingswaldensis* is a large individual, exceeding in size the largest of the present fragments, although these agree with the holotype in terms of coarse ribbing and the development of umbilical and ventrolateral tubercles. There are closer similarities in both size and ornament to the originals of *Scaphites geinitzii* of Schlüter (1872, p. 75 *pars*, pl. 23, figs 12–16, 23–25), refigured by Kaplan *et al.* (1987, pl. 5, fig. 1–4) and Kaplan and Kennedy (1994, pl. 41, figs 7–13). The latter authors describe macroconchs as up to 65 mm long, and microconchs as 42–62 mm long. It is not possible to determine if the larger fragments amongst the present material are parts of macroconchs or microconchs. In the smaller specimens in the present material (Text-figs 14A–N, 15), the umbilical wall of the shaft does not conceal the umbilicus of the spire, suggesting them to be microconchs, as does the concave umbilical wall. The larger have small ventrolateral tubercles on at least the adapertural part of the spire, and have bituberculate primary ribs on the body chamber (Text-fig. 14I–N). The smaller specimens (Text-figs 14A–H, 15) also have body chambers with a concave umbilical wall and strong bituberculate ribs. There are no ventrolateral tubercles on the spire of the only specimen that retains one (Text-figs 14G, H, 15E, F). This absence is also seen in some of the specimens of *S. kieslingswaldensis* figured by Schlüter (1872, pl. 23, figs 12, 14–16); Kaplan and Kennedy 1994, pl. 41, figs 9, 12).

OCCURRENCE: Lower and Middle Coniacian where well-dated. The geographic distribution extends from Poland to Germany, the Czech Republic, Austria, Romania(?), Armenia, Loir-et-Cher, Charente-Maritime, Aude and Var in France, northern Spain, Kazakhstan, Madagascar, and northern KwaZulu-Natal in South Africa.

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