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On some Late Turonian and Early Coniacian (Upper Cretaceous) heteromorph ammonites from Germany

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ABSTRACT:

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Five heteromorph ammonite taxa belonging to the Nostoceratidae and the Diplomoceratidae are described from the Upper Turonian and Lower Coniacian of northern Germany and Saxony. The investigation serves the presentation of additional material of *Hyphantoceras flexuosum*, *Neocrioceras paderbornense* and *Scalarites turoniense* that are rarely documented in northern Germany and Saxony. Furthermore, one new species, *Hyphantoceras ernsti* sp. n., is introduced. One taxon is described in open nomenclature as nostoceratid gen. et sp. indet.

Key words: Upper Cretaceous, Germany, Turonian, Coniacian, Ammonite Taxonomy, Nostoceratidae, Diplomoceratidae

INTRODUCTION

The description of the Turonian and Coniacian ammonite faunas from Germany has a long tradition. The first monographic treatment on Upper Cretaceous ammonites was that of SCHLÜTER (1867) in which he also described Turonian and Lower Coniacian material. From Saxony in southeastern Germany, Turonian to Coniacian ammonites were investigated and figured by, amongst others, REUSS (1845), GEINITZ (1843, 1849-1850), PETRASCHECK (1902), WANDERER (1909) and ANDERT (1934). Only a few subsequent papers dealt with Turonian and Coniacian ammonites (e. g. HALLER 1963, PRESCHER 1963, TRÖGER 1968, LOMMERZHEIM 1976). In the mid-eigthies, the ammonite faunas were re-investigated and systematically revised by KAPLAN (1986, 1988, 1989), KAPLAN & SCHMID (1988), KAPLAN & KENNEDY (1994) and KAPLAN *& al.* (1987), especially that of the *Hyphantoceras* Event (ERNST *& al.* 1983) in the middle Upper Turonian Lower Limestone Unit of northern Germany (WOOD *& al.* 1984), which attracted the attention of collectors and palaeontologists because of its abundant and highly diverse invertebrate fauna (DAHMER & ERNST 1986, KAPLAN 1992, METZDORF 1992, 1993). Above the *Hyphantoceras* Event, in the uppermost part of the Lower Limestone Unit and the succeeding marl/limestone alternations, the Grau-Weiße Wechselfolge (WOOD *& al.* 1984), in the remainder of the Upper Turonian and Lower Coniacian, ammonites become suddenly and significantly rarer and less diverse. Only scaphitids, some nostoceratids/diplomoceratids and collignoniceratids were figured by KAPLAN *& al.* (1987), KAPLAN (1988), KAPLAN & SCHMID (1988) and KAPLAN & KENNEDY (1994). New collecting in Upper Turonian strata (upper part of the Lower Limestone Unit and the Grau-Weiße-Wechselfolge; Text-fig. 2) yielded some interesting heteromorphs (Nosostoceratidae and Diplomoceratidae), albeit badly preserved, which are desribed here; scaphitids and baculitids are not considered. One new species, *Hyphantoceras ernsti* sp. n., is introduced. Furthermore, this work serves to document the Upper Turonian to Lower Coniacian ammonites from Lower Saxony and, to some extent, from Saxony. The heteromorph ammonite assemblages in the Upper Turonian and Lower Coniacian shows a distinct succession, and its stratigraphic value is briefly discussed.

GEOLOGICAL FRAMEWORK AND STRATIGRAPHY

Most of the material investigated was collected in Lower Saxony (for localities see Text-fig. 1), especially the localities Nettlingen and Groß-Flöthe (WIESE & KRÖGER 1998), which yielded rich new material. Additionally, finds from the Saxonian and Bohemian Cretaceous basins were considered. Stratigraphically, all finds derive from Upper Turonian to Lower Coniacian successions. In NW Germany (Westphalia, Lower Saxony, Saxony-Anhalt), biostratigraphic subdivision of the Turonian and Coniacian strata is based on inoceramids and ammonites (WOOD *& al.* 1994, KAPLAN & KENNEDY 1996, WALASZCZYK & WOOD 1998). An integrated stratigraphic overview is given in Text-fig. 2. The base of the interval investigated lies in the upper part of the *Inoceramus costellatus costellatus*/*I. striatoconcentricus*/*Mytiloides labiatoidiformis* inoceramid Assemblage Zone. It ranges into the Lower Coniacian *Cremnoceramus crassus crassus*/*Cremnoceramus deformis deformis* Zone (in the text referred to as *crassus*/*deformis* Zone). In terms of ammonite biostratigraphy, it covers the latest *Subprionocyclus neptuni* Zone, the *Subprionocyclus normalis* interval, the *Prionocyclus germari* Zone and, after an interval without any biostratigraphically significant ammonites in the Turonian/Coniacian boundary interval, the lower part of the *Forresteria* (*Harleites*) *petrocoriensis* Zone (Text-fig. 2). In order to delimit the boundaries of this interval more accurately, the event stratigraphic framework of ERNST *& al.* (1983) and WOOD *& al.* (1984) is applied. It likewise aids a more precise location of distinct beds. The interval investigated begins above the top of the *Hyphantoceras* Event and ends with the facies change to the Emscherian Marls in the uppermost *crassus*/*deformis* Zone of a late Early Coniacian age.

The interval considered is characterized by a distinct succession of lithologies that can be recognized in the whole of NW Germany (Text-fig. 2). The base lies within the uppermost part of the so-called Lower Limestone Unit: thickly bedded Pläner limestones with rare intercalated marls. This is succeeded by the Grau-Weiße Wechselfolge (Grey and White Alternation): a well developed succession of thick marls alternating with white Pläner limestone beds. It is terminated by the Upper Limestone Unit of the Lower Coniacian. This succession is inferred to reflect one large transgressive-regressive cycle (ERNST & WOOD 1995, WIESE & KRÖGER 1998). Biostratigraphically, the "Grau-Weiße Wechselfolge" and the "Upper Limestone Unit", represent more pelagic environments, and equate approximately with the upper part of the Saxonian Strehlen Formation (VOIGT & HILBRECHT 1997), the upper parts of the Bohemian Teplice Formation and parts of the Rohatce Member (ČECH *& al.* 1980, ČECH 1989), the latter two represent the siliciclastic-dominated facies close the Bohemian Massif. A putative stratigraphic correlation between the different lithologies is given in Text-fig. 2.

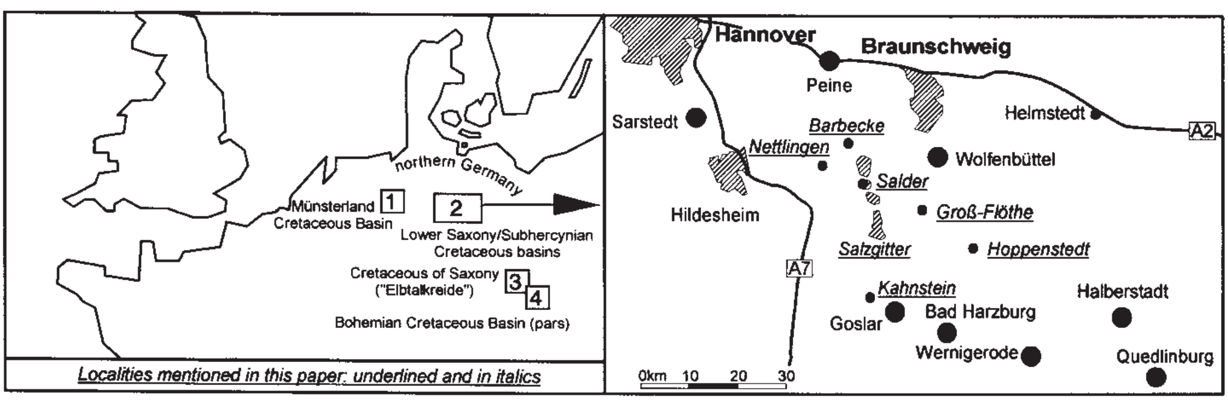

Fig. 1. Simplified geographic sketch-map of NW Europe to show the position of the Münsterland, Lower Saxony and Subhercynian Cretaceous basins, the Cretaceous of Saxony ("Elbtalkreide") and parts of the Bohemian Cretaceous Basin

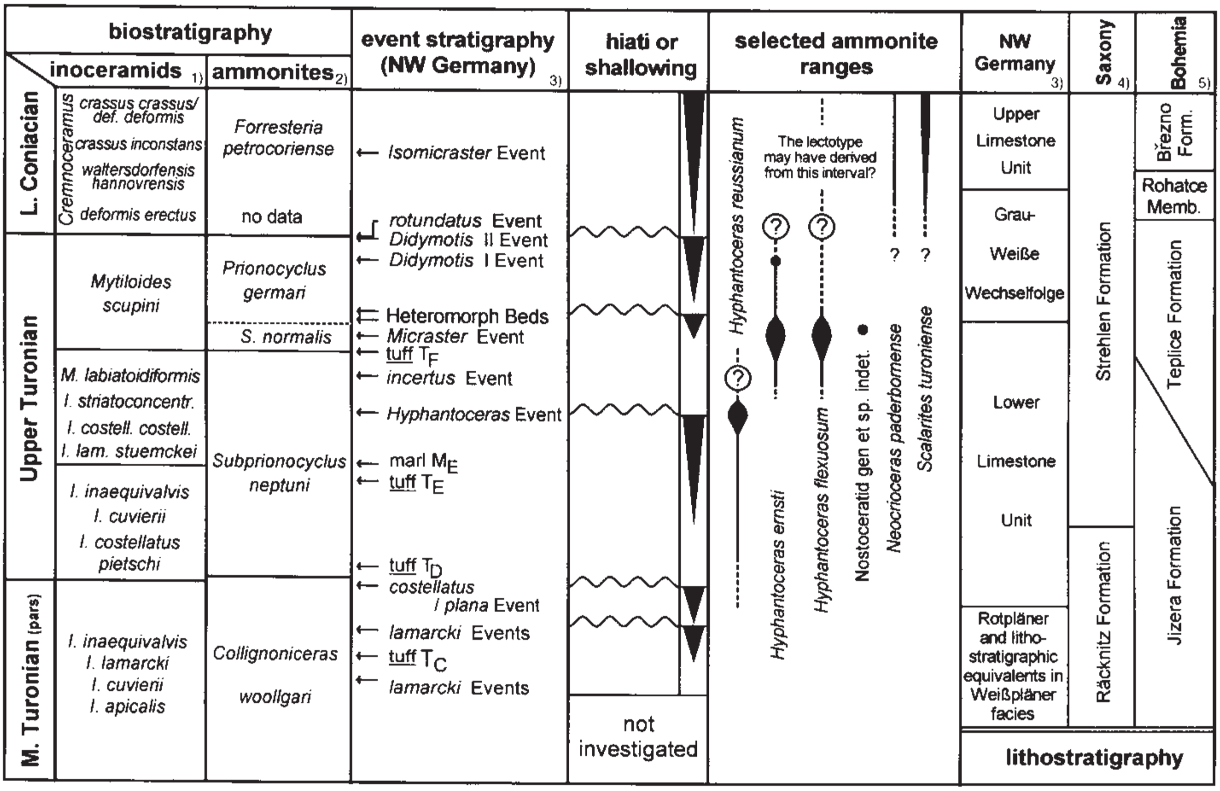

Fig. 2. Integrated stratigraphic framework (bio-, litho-, and event-stratigraphy) of the upper Middle Turonian to the Lower Coniacian of northern Germany, in context with main shallowing events and ranges of selected ammonites; compiled after WOOD & al. (1984), WALASZCZYK & WOOD (1998); KAPLAN (1986), KAPLAN & KENNEDY (1996); ERNST & al. (1993), ERNST & WOOD (1995), WIESE & KRÖGER (1998); TRÖGER & VOIGT (1995), with further references; ČECH (1989); and own data

MATERIAL

Most of the material investigated comes from the Lower Saxony and the Subhercynian Cretaceous basins; previously figured material from the Münsterland Cretaceous Basin (Westfälisches Museum für Naturkunde, WMN) and the Cretaceous of the "Elbtalzone" in Saxony was also considered (Text-fig. 1). Generally, the material is poorly preserved and only fragmentary, in part diagenetically distorted; no complete specimens have been collected.

Abbreviations:

MB.C. = Naturkundemuseum Berlin
WMN = Westfälisches Museum für Naturkunde, Münster
PIB = Paläontologische Institut der Rheinischen Friedrich Wilhelm Universität, Bonn
BGR = Bundesanstalt für Geologie und Rohstoffkunde

SYSTEMTICAL ACCOUNT

Suborder Ancyloceratina WIEDMANN, 1966
Superfamily Turrilitaceae GILL, 1871
Family Nostoceratidae HYATT, 1894
Genus *Hyphantoceras* HYATT, 1900

TYPE SPECIES: *Hamites reussianus* D'ORBIGNY, 1850, by original designation by HYATT (1900, p. 87).

Hyphantoceras flexuosum (SCHLÜTER, 1872)
(Pl. 2, Figs 1-10; Pl. 3, Figs 13-14)

1872. *Helicoceras flexuosum* SCHLÜTER, p. 108, Pl. 32, Figs 10-12.
1988. *Hyphantoceras flexuosum* (SCHLÜTER); KAPLAN & SCHMID, p. 86, Pl. 13, Figs 3-4.
1991. *Hyphantoeras flexuosum* (SCHLÜTER); KAPLAN, Pl. 2, Fig. 3.
1998. *Hyphantoceras flexuosum* (SCHLÜTER); WIESE & KRÖGER, Pl. 2, Fig. 8).

TYPE: Lectotype, here designated and refigured on Pl. 2, Figs 1-3, is the specimen figured by SCHLÜTER (1872,

p. 108; Pl. 32, Figs 10-12) from the *Cuvieri* Pläner of the Salzgitter area (in the collection of the BGR Berlin-Spandau, no. x 5687). With the lectotype associated are rock fragments that yielded a fragment of a juvenile whorl. It is impossible to decide whether or not it belongs to the lectotype or to another specimen. It is figured here on Pl. 2, Fig. 4 and is regarded as a paralectotype.

MATERIAL: MB.C.2808, MB.C.2810-MB.C.2812, MB.C.2820, BGR x5687a (lectotype) and BGR x5687b (paralectotype)

DESCRIPTION: Only whorl fragments were available for this study. The largest two (lectotype BGR x5687a & MB.C.2811) belong to a single whorl. *H. flexuosum* is characterized by a helicoid phragmocone with a high apical angle and loosely coiled whorls that may have touched in earlier growth stages. Specimens representing the earliest whorls (MB.C.2808 and BGR x5687b; Pl. 2, Figs 4, 8-9), are characterized by slightly flexuous main ribs with 2-3 secondaries. With increasing size, the oblique to flexuous main ribs become stronger, and 2-5 secondaries occur. Ribbing is comparatively regular. Four rows of tubercles can be observed on the main ribs, of which the ventrolateral to lateral ones are weakly developed. Specimen MB.C. 2811 (Pl. 2, Figs 6-7) represents the middle growth stage, and it is very similar to the lectotype. It shows, however, a dextral mode of coiling, the lectotype has a sinistral coiled phragmocone. There is one large fragment that can be referred to this species (Pl. 2, Fig. 10). It may represent the adult stage. It can be seen that the main ribs strengthen with age, and 4 secondaries persist even to adulthood. The material does not permit the recognition of the body chamber orientation.

DISCUSSION: As indicated by the synonymy, only a few specimens of this taxon have been figured by previous authors. This contrasts the frequent records of this species in the literature (e. g. ELBERT 1902, STILLE 1905, SCHRAMMEN 1910). Exact stratigraphy and figures are lacking in most cases, and it is unclear whether these records really refer to *H. flexuosum*. This is especially relevant if one considers the high variability of *H. reussianum*, documentd by KAPLAN & SCHMID (1988) and METZDORF (1993), which also makes a reliable distinction between *H. reussianum* and *H. flexuosum* difficult with absence of illustrations. There is no unequivocal evidence that *H. reussianum* ranges very much higher than the stratigraphic position of the *Micraster* Event (KAPLAN & SCHMID 1988, p. 51, Text-fig. 2; METZDORF 1992). Amongst the numerous *Hyphantoceras* fragments that were collected by the author from this interval, only two specimens (e. g. Pl. 2, Fig. 11; loose around T_F at Groß-Flöthe) may be attributed to *H. reussianum*.

If material is incomplete and has suffered compaction and distorsion, generic and specific identification and separation of *H. flexuosum* from weakly ornamented *H. reussianum* is difficult. However, *H. reussianum* appears to have stronger and straight main ribs, while *H. flexuosum* has weaker and more flexuous ribs.

OCCURRENCE: *Hyphantoceras flexuosum* enters the stratigraphic record well above the *Hyphantoceras* Event and unequivocal records range only as high as the lowermost part of the Grau-Weiße Wechselfolge (lower *scupini* Zone) of northern Germany (WIESE & KRÖGER 1998). It occcurs in the Late Turonian of Westphalia and Lower Saxony. So far, no records are known outside these areas. Other records in the literature are uncertain, as it is not clear to which extent they may refer to *H. flexuosum* or even to *H. ernsti*, a new species, which is described below. The stratigraphic position of the lectotype figured by SCHLÜTER (1872) is given as "*Cuvieri* Pläner des Windmühlenberges bei Salzgitter in Hannover". This suggests an Early Coniacian age; the range must be, therefore, expanded into the Lower Coniacian.

Hyphantoceras ernsti sp. n.
(Pl. 1, Figs 1-11; Pl. 3, Figs 3, 9, 15; Text-fig. 3)

1968. *Hyphantoceras reussianum* (D'ORBIGNY); TRÖGER, p. 50, Pl. 1, Fig. 1, p. 48, Text-fig 2.
1982. *Anisoceras paderbornense* (SCHLÜTER); KAPLAN, p. 4, Figs 3a & b.
1988. *Hyphantoceras flexuosum* (SCHLÜTER); KAPLAN & SCHMID, p. 87, Pl. 13, Fig. 2.
1995. *Hyphantoceras reussianum* (D'ORBIGNY); TRÖGER & VOIGT, p. 266, Pl. 1, Fig. 3.
1997. *Neocrioceras* aff. *paderbornense* (SCHLÜTER); HORNA & WIESE, Pl. 1, Figs 6-7.
1998. *Neocrioceras* sp. aff. *paderbornense* (SCHLÜTER); WIESE & KRÖGER, Pl. 2, Fig. 7.

TYPE: The holotype is the specimen figured by TRÖGER (1968, p. 50, Pl. 1, Fig. 1; Text-fig. 2) as *Hyphantoceras reussianum*, here refigured on Pl. 1, Figs 1-3 and Text-fig. 3. It comes from the Dresden-Blasewitz borhole, Saxony, in south-eastern Germany (Strehlen Formation, Upper Turonian *Mytiloides scupini* Zone). It is housed in the collection of the Geological Institute of the TU Bergakademie Freiberg, without registration number.

DERIVATIO NOMINIS: *ernsti*: in honour of Prof. Dr. Gundolf ERNST.

MATERIAL: Beside the holotype, the following specimens were considered: MB.C.2805, MB.C.2813-MB.C.2819

DIAGNOSIS: *Hyphantoceras* with torticone earliest whorls, immediately followed by a fast expanding whorl with a very high apical angle, quadrituberculate main ribs and intercalatories that lack tubercles.

DESCRIPTION: The earliest growth stage of the new species can be seen on the holotype. No ammonitella is preserved, and the first documented stage is an orthocone shaft with a length of approximately 6 mm (Pl. 1, Figs 1-2). The shell is smooth and shows no ornamentation. It is followed by a torticone interval, approximately 9 mm in height, which consists of 2.5 (-3.5?) closely coiled, subrounded whorls that are in contact. At the begin of this stage, weak ornament starts to develop, consisting first of one row of ventral tubercles and incipient ribs that cross the venter obliquely (comp. Text-fig. 3). On the second torticone whorl, simple, slightly prorsiradiate main ribs develop that cross the venter. Each rib now bears two rows of tubercles. After approximately 2.5 to 3.5 whorls, the phragmocone grades into a wide open, crioceratoid to weakly helicoid spiral with an extremely high apical angle, resulting in a very wide umbilical opening. The ribs are now rectiradiate. Other than the pyritized and three-dimesionally preserved torticone juvenile whorls, the crioceratoid part of the type species is strongly compressed and almost flattened due to compaction. The same growth stage is also represented by the specimen figured in TRÖGER & VOIGT (1995, p. 266, Pl. 1, Fig. 3), which is also from the Dresden-Blasewitz corehole. Specimen MB.C.2814 (Pl. 1, Figs 4-5) from the Upper Turonian Pläner limestones of Groß-Flöthe (Lower Saxony) lacks the torticone juvenile whorls but shows, less compacted, the earliest parts of the almost crioceratoid interval, which expands in a wide, very weakly helicoid spiral and, thus, with a very high apical angle. The whorls show almost no overlap and do not touch. The whorl height increases approximately at 120% per half whorl. The whorl breadth cannot be measured due to compaction. Several fragments indicate the whorl section now to be subrounded to oval. Immediately following the torticone part, the primary ribs are regularly spaced, with very few (1-3) intercalationaries. Primaries now become stronger and bear 4 rows of umbilicolateral and ventrolateral spines that end in a spatula-like termination. The rib index of the main ribs is approx. 3 and comparatively constant. Later, ribbing becomes more irregular. 4 to a maximum of 7 weaker intercalatories, which themselves can develop secondaries, occur without tubercles. With increasing size, the umbilicolateral spines move to a midflank and later to an almost outer ventrolateral position. As most of the material has suffered compaction, the variation in roundness of the whorl cannot be estimated, but the highly oval whorl sections encountered in numerous specimens is considered to be due to compaction. On the subadult shell, the primaries become stronger, while the number and strength of the intercalationaries decreases (Pl. 1, Figs 7, 11). The largest fragments referred to this species (Pl. 1, Fig. 11) show an almost complete loss of intercalationaries and irregular, strong and collar-like main ribs that seem to crowd, suggesting maturity, occur. If this were the case, it appears that there was no J-shaped interval and both phragmocone and body chamber have the same coiling mode. Unfortunately, no complete specimens have been collected. Based on the numerous

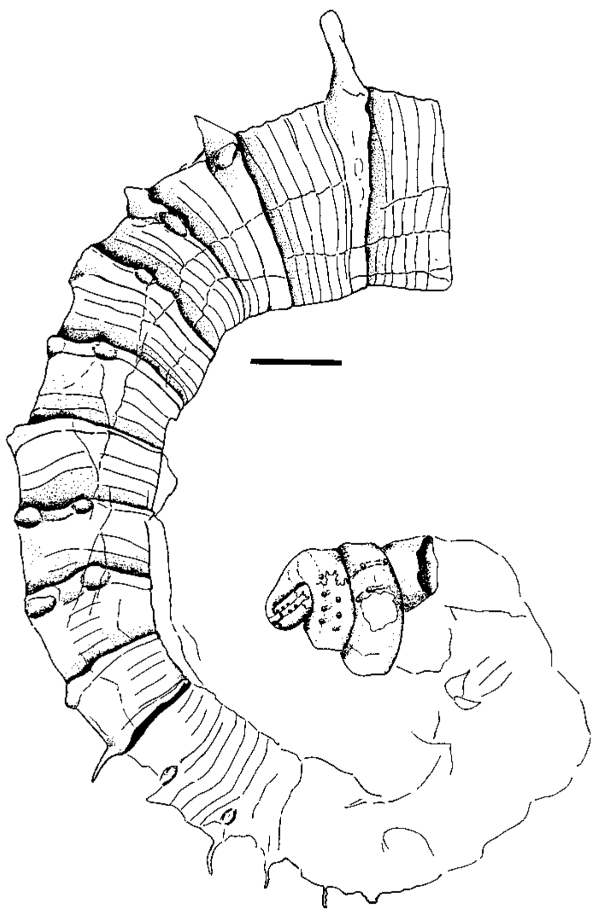

Fig. 3. Sketch of the holotype of *Hyphantoceras ernsti* sp. n.: modified after TRÖGER (1968). Scale bar: 5 mm

fragments encountered it seems that the third growth stage had at least three whorls. A second whorl is indicated in the specimen figured by KAPLAN & SCHMID (1988, Pl. 13, Fig. 2). Based on its size, specimen MB.C.2819 (Pl. 1, Fig. 11) most likely represents the third whorl. The fragmentary material does not allow determination of size variations of the species. The largest fragment suggest a diameter of at least 103 mm at a whorl height of only 19 mm.

As no suture lines are preserved, the extent of the body chamber remains unclear. In the holotype, the suture lines are visible in the earliest growth stages only. They exhibit a typical quadrilobate nostoceratid suture.

DISCUSSION: Even though diverging significantly from other European species of *Hyphantoceras* in the extremely high apical angle, the taxon is referred to the genus on the basis of the very similar mode of ornamentation to that of *H. reussianum* and the identical mode of juvenile growth. At least three very distinct growth stages can be observed: an early orthocone stage is followed by a torticone part and is immediately succeeded by an open helicoid shell.

The overall very similar ornament but different mode of coiling amongst the different Turonian nostoceratids with affinity to *Hyphantoceras* was already recognized by GEINITZ (1843) who stated, somewhat resignedly, that the different morphotypes are virtually indistinguishable and belong most probably to one variable species, which he referred to as *Helicoceras armatus*: "*Diese Art ist theils in einer Ebene, als echter* Hamites*, am häufigsten entfernt spiralförmig als* Helicoceras*, ja sogar auch schneckenförmig als echter* Turrilites *gewunden, und man hat hier einen zweiten Übergang dieser drei wohl nicht zu trennenden Gattungen ineinander* (GEINITZ 1843, p. 8). In fact, *H. ernsti* shows, with respect to its ornamentation, large similarities with *H. reussianum* and *H. flexuosum*. GEINITZ, in his investigations on the Cretaceous of Saxony (south-eastern Germany), covered a comparatively broad stratigraphic interval, ranging at least from the Lower Turonian to the Middle Coniacian. Within a narrower stratigraphic context, however, and with more material, it appears possible to separate these three taxa. From *H. reussianum*, *H. ernsti* differs significantly by its very high apical angle. While the first has rather low values, giving the species its typical corkscrew-like morphology, the latter has an extremely high apical angle. Both taxa are morphologically clearly separated and no intermediate forms have been observed. *H. flexuosum* can also be very similar to *H. ernsti* in middle growth stages, especially if the material is badly preserved and distorted. However, the early whorls of *H. flexuosum* already show the lower apical angle (Pl. 2, Figs 4, 8-9), making the species distinguishable from *H. ernsti*. Additionally, intercalatories weaken with age, and main ribs become collar-like and irregular in the latter (Pl. 1, Figs 7, 11), while *H. flexuosum* still has intercalatories until adulthood (Pl. 2, Fig. 10). It seems also that *H. flexuosum* reaches a much larger whorl diameter than *H. ernsti* at a comparable size. As both taxa enter the stratigraphic record approximately at the same time, it may be argued that they both may reflect merely a dimorphic pair, well documented for some Nostoceratidae (KENNEDY 1986, KAPLAN & SCHMID 1988, DAVIS & *al.* 1996). This is unlikely because of the clear morphological differences already in early growth stages.

In none of the material investigated are the earliest whorls preserved. It is, therefore, impossible to decide whether or not the juvenile stage is charcterized not only by an orthocone shaft, but by ptychoceratoid whorls as shown for some *Eubostrychoceras* (TANABE & *al.* 1981, COBBAN 1987). However, based on data from the literature, it may be possible that the European stock of *Eubostrychoceras* and *Hyphantoceras* are characterized by the same growth pattern of the juvenile whorls (*E. saxonicum*: BREITKREUZ & METZDORF 1992, *H. reussianum*: PERVINQUIÈRE 1910, *H. ernsti*: this paper) and that they form, therefore, one cluster of Nostoceratidae that are presumably taxonomically very closely allied.

FRITSCH & SCHLOENBACH (1872, Pl. 14, Figs 14-18; Pl. 16, Fig. 9) figured specimens of what they called *Helicoceras armatus*, and they noted three distinct growth stages (orthocone shaft; torticone interval with 3.5 to 4.5 whorls; crioceratoid part), a diagnosis also very suggestive of *H. flexuosum* and/or *H. ernsti*. Most of the material derived from the so-called Priesener Schichten of Bohemia, a term first introduced by KREJČÍ (1869) (The latter subdivided the Priesener Beds into 7 lithological units. In context with a revision of the Bohemian Cretaceous successions, Bed 1-3 were separated from the Priesener Schichten and named Rohatce Member by ČECH & *al.* 1980. Bed 3 to 7 of the original Priesen Beds now belong to the Březno Formation and are Middle Coniacian in age). The specimens are also characterized by an initial straight vertical shaft, early torticone whorls, followed by first crioceratoid whorl. Based on this whorl development, it is very likely that the Bohemian material is closely allied to either *H. flexuosum* or *H. ernsti*.

The Lower Coniacian *Hyphantoceras yabei* COLLIGNON, 1965 (Pl. 420, Fig. 1738) from Madagascar is also very similar to *H. ernsti*. However, it differs from the latter species by its much coarser ribbing and its higher apical angle. In the original description of COLLIGNON (1965), three rows of tubercles were mentioned, which distinguishes it from *H. ernsti*.

Additionally, it is inferred to have a J-shaped body chamber, a feature not yet observed in *H. ernsti*. However, the species is badly documented, and more material is needed to clarify the relation to *H. ernsti*.

ZONOVA & YAZYKOVA (1999, Pl. 8, Fig. 2) figured a specimen from the Upper Turonian of the Penzhina Gulf Coast, far eastern Russia. It is, based of a similar mode of coiling with a very high apical angle, similar to that of *H. ernsti*. It lacks any tubercles, however.

The recognition of *H. ernsti* also clarifies some stratigraphic problems. In northern Germany, *H. reussianum* occurs first in the upper Middle Turonian and has its acme occurrence in the so-called *Hyphantoceras* Event of the Upper Turonian (ERNST *& al.* 1983, KAPLAN & SCHMID 1988, METZDORF 1992). Above this event, true *H. reussianum* are apparently extremely rare. Even in Westphalia, where the heteromorph ammonite fauna is well-known within an exact stratigraphic framework (KAPLAN 1986, KAPLAN & SCHMID 1988, KAPLAN & KENNEDY 1996), only scattered *H. reussianum* are reported above the main *Hyphantoceras* event, up to the tuff layer T_F (see Text-fig. 2), which also marks the base of the *scupini* Zone. Instead, *H. ernsti* enters, as does the first well dated *H. flexuosum*, below T_F. Based on these data, only a small overlap with *H. reussianum* can be recognized. New collecting in the interval around T_F and the *Micraster* Event indicate that true *H. reussianum* has disappeared around the *Micraster* Event, or just above. Therefore, only a very short overlap of this species together with *H. flexuosum* and *H. ernsti* can be observed. Even amongst the ammonite fauna from Groß-Flöthe, where the interval around T_F is exposed on bedding planes, only one *H. reussianum* was found amongst numerous *H. flexuosum* and *H. ernsti*, and one doubtful fragment was collected ca. 1 m above the *Micraster* Event. Based on this, it is here suggested that *H. flexuosum* and *H. ernsti* only overlap with *H. reussianum* in the lower part of their ranges. Due to the almost identical ornamentation on the torticone interval of the very early whorls, as well as on the older stages investigated, a very close relationship between *H. reussianum* and *H. ernsti*/*H. flexuosum* appears obvious. Based on this and the partial stratigraphic separation, it is suggested here that *H. ernsti* may have developed from *H. reussianum*. It enters the stratigraphic record well above the *Hyphantoceras* Event in the uppermost *striatoconcentricus*/*labiatoidiformis* AZ, at an interval which equates with the *incertus* Event. A first peak-occurrence is located above the *Micraster* Event (Heteromorph Beds of WIESE & KRÖGER 1998; Text-fig. 2). The Heteromorph Beds are known from Lower Saxony, Saxony-Anhalt and possibly Saxony. Based on a comparison with Westphalia, this maximum is inferred to equate with a similar occurrence of heteromorph ammonites, where *Prionocyclus germari* enters (KAPLAN & KENNEDY 1996). Lithostratigraphically, this interval falls within the upper part of the Lower Limestone Unit (see Text-fig. 2). Scattered occurrences of the species are known from the lowermost part of the "Grau-Weiße Wechselfolge" in the *scupini* Zone, and it seems to be exclusively a late Late Turonian species.

OCCURRENCE: So far, *H. ernsti* is known from the Upper Turonian of Westphalia, Lower Saxony, Saxony-Anhalt and Saxony (all Germany). It is common in the lower part of the *Mytiloides scupini* Zone. One fragment has been collected from the *Didymotis* I Event (upper *scupini* Zone) of the Kahnstein section near Goslar. Possible fragments of this species are amongst Upper (uppermost?) Turonian material from the Mangyshlak area from Kazakhstan (at the moment investigated in detail by Prof. Dr. R. MARCINOWSKI, Institut of Geology of the Warszawa University, who kindly permitted access to the collection), referred to as *Neocrioceras* sp. by MARCINOWSKI *& al.* (1996). The relation of the species to the Middle Coniacian material from Bohemia requires further investigation.

Nostoceratid gen. et sp. indet (not figured)

1988. *Hyphantoceras flexuosum* SCHLÜTER; KAPLAN & SCHMID, Pl. 13, Fig. 3.

MATERIAL: 1 unregistered specimen from the Upper Turonian Heteromorph Beds (lowermost *scupini* Zone) of Hoppenstedt (Saxony-Anhalt), in the collection of the TU BA Freiberg; WMN 9556 from below the Rothenfelde Greensand, Foerth limestone quarry at Halle, Westphalia (lowermost *scupini* Zone).

DESCRIPTION: The specimens are only fragments preserved. The earliest preserved growth stage is represented by a gently curved part that grades into a crioceratoid interval, terminating in a J-shaped hook. As no suture lines are preserved it is not clear, whether or not the last-preserved growth stage is a body chamber. The ornament consists of straight and simple main ribs that seem to bear four rows of tubercles. Between the main ribs, two to three intercalationaries occur that are free from tubercles. With increasing size, the main ribs become stronger and the secondaries weaker.

DISCUSSION: The general mode of ribbing and tuberculation is very similar to that of *H. ernsti*, especially in early growth stages, and the taxonomic position and relationships to other Nostoceratidae is unclear. It may well be that it is a very small specimen (microconch ?) of *H. ernsti*, in which case the latter species has a *Schlueterella*-like terminal body chamber. On the other hand, it may well represent a distinct taxon. A similar specimen (TU BA Freiberg collections, unregistered) from an intervall well above the *Micraster* Event in the vicinity of Hoppenstedt (Text-fig. 1) shows also this ancyloceratoid growth. However, it appears that the phragmocone diameter increases very slowly, thus resulting in a shell characterized by only low whorl heights. In this respects, it differs from *P. ernsti*. This specimen is left in open nomenclature. Its identification as *Hyphantoceras flexuosum* by KAPLAN & SCHMID (1988) is not followed here, because there are significant differences to the latter species both in mode of coiling and mode of ribbing.

Family Diplomoceratidae WRIGHT & MATSUMOTO, 1954
Genus *Scalarites* WRIGHT & MATSUMOTO, 1954

TYPE SPECIES: *Helicoceras scalare* YABE, 1904 (Pl. 3, Figs 2-3) by original designation by WRIGHT & MATSUMOTO (1954, p. 115).

Scalarites turoniense (SCHLÜTER, 1872)
(Pl. 3, Figs 1-2, 4-8, 10-11)

1872. *Toxoceras turoniense* SCHLÜTER, p. 103, Pl. 31, Figs 4-5.
1872. *Hamites verus* FRITSCH; FRITSCH & SCHLOENBACH, Pl. 13, Figs 13, 18, 20, 26; Pl. 16, Fig. 15.
? 1872. *Hamites strangulatus* D'ORBIGNY; FRITSCH & SCHLOENBACH, Pl. 13, Fig. 22.
1872-1875. *Hamites* an *Helicoceras* SCHLÜTER, p. 197.
1872-1875. *Crioceras* an *Helicoceras* SCHLÜTER, Pl. 37, Fig. 2; p. 199 .
1891. *Hamites rotundus* (SOWERBY); LANGENHAN & GRUNDEY, Pl. 2, Fig. 3.
1893. *Hamites bohemicus* FRITSCH; FRITSCH, p.78, Text-figs 58 a.
1893. *Crioceras* (?) *membranaceum* FRISTCH; FRITSCH, p. 79, Fig. 61.
1897. *Hamites bohemicus* FRITSCH; FRITSCH, Text-fig. 21.
1934. *Hamites bohemicus* FRITSCH; ANDERT, Pl. 19, Figs 1a-b.
1963. *Toxoceras turoniense* SCHLÜTER; HALLER, Pl. 1, Fig. 3.
1994. *Scalarites turoniense* (SCHLÜTER); KAPLAN & KENNEDY, Pl. 37, Figs 1, 5, 6; Pl. 39, Figs 1-2, 4, 9.

TYPE: Lectotype, by the subsequent designation of KAPLAN & KENNEDY (1994, p. 58) is the original of SCHLÜTER (1872, Pl. 31, Fig. 4; PIB SCHLÜTER-original 69b). Paralectotype is the original of SCHLÜTER (1872, Pl. 32, Fig. 5; PIB SCHLÜTER-Original 69a). Both come from the *Cuvieri* Pläner of Rothenfelde of an Early Coniacian age.

MATERIAL: Geowissenschaftliche Sammlung 194/97, TU BA Freiberg; MB.C.2797-MB.C.2804

DIAGNOSIS: Coiling criocone, cross-section oval. Ornament consists of simple ribs that weaken dorsally. Earliest growth stages show only slightly prorsiradiate ribs that become increasingly prorsiradiate through ontogeny. Fragments with maximum whorl height 18 mm, represent latest growth stages known and bear rare, strong, collar-like ribs associated with shallow constrictions. Rib index varies between 3 and 5.

DISCUSSION: The material from Lower Saxony is identical to *S. turoniense*, as figured by KAPLAN & KENNEDY (1994), and there is no doubt that the material described here belongs to this species. This is also the case for the Bohemian material figured by FRITSCH & SCHLOENBACH (1872, Pl. 13, Figs 13, 18, 20, 26; Pl. 16, Fig. 15) as *Hamites verus* and FRITSCH (1893, p. 78, Text-figs 58 a-e; Text-fig. 59) as *Hamites bohemicus*. *Crioceras membranaceum* FRITSCH, 1893 is inferred to be merely a juvenile specimen of *S. turoniense* that has the ammonitella, the protoconch and the quadrilobate primary suture preserved. The ammonitella is followed by an only weakly curved, suborthocone shaft that is ornamented by faint, prorsiradiate ribs. Later, the typical, extremely wide open, crioceratoid spiral of *Scalarites* develops. Compared with the Japanese representatives of *Scalarites*, e. g. *S. scalaris* (YABE, 1904) and *S. mihoensis* WRIGHT & MATSUMOTO, 1954, *S. turoniense* seems to lack the well developed prorsiradiate constrictions in the early growth stages as observed in the first two species (TANABE *& al.* 1981). In addition, the suborthocone part, well developed in the Japanese material, is significantly reduced in *S. turoniense*, if not absent.

The specimen figured by GEINITZ (1872-1875, Pl. 37, Fig. 1) as *Crioceras* an *Helicoceras* is probably a pathological specimen (as recognized already by GEINITZ himself) of *S. turoniense*.

OCCURRENCE: The material investigated suggests that *S. turoniense* first appears in the Lower Coniacian *deformis erectus* Zone and extends into the *crassus/deformis* Zone. In Germany, it is known from Westphalia, Lower Saxony and Saxony. There are records from Bohemia in the Czech Republic. *S.*

turoniensis is also recorded from a hardground that represents condensed Upper Turonian and Coniacian in the Besakty section (Mangyshlak, Kazakhstan).

Genus *Neocrioceras* SPATH, 1921

TYPE SPECIES: *Neocrioceras spinigerum* (JIMBO, 1894) (Pl. 8, Fig. 1) by the subsequent designation of DIENER (1925, p. 192).

Neocrioceras paderbornense (SCHLÜTER, 1872)
(Pl. 3, Fig. 12)

1872. *Ancyloceras paderbornese* SCHLÜTER, p. 97, Pl. 30, Figs. 1-2.
1893. *Helicoceras reussianum* GEINITZ; FRITSCH; p. 79, Fig. 62.
1982. *Anisoceras paderbornense* (SCHLÜTER); KAPLAN, p. 4, Figs 3a-b.
1994. *Neocrioceras paderbornense* (SCHLÜTER); KAPLAN & KENNEDY, p. 146, Pl. 39, Figs 3, 5-8.

TYPE: Lectotype, by the subsequent designation of KAPLAN & KENNEDY (1994, p. 146), is the original of SCHLÜTER (1872, p. 97, Pl. 30, Figs 1-2; PIB Schlüter Original 55), refigured by KAPLAN & KENNEDY (1994, p. 146, Pl. 39, Fig. 8). It comes from the "*Cuvieri* Pläner von Paderborn", that is from the Lower Coniacian.

MATERIAL: 1 specimen (MB.C.2806), collected loosely from the uppermost Grauweiße Wechselfolge of Groß-Flöthe (Lower Coniacian *crassus*/*deformis* Zone?).

DESCRIPTION: Coiling criocone. Whorls slowly expanding, ornament consists of periodic, slightly rectiradiate, quatrituberculate ribs. Tubercles are dorsolateral and midflank in position either on one or on pairs of ribs. In the latter case, the ribs are looped between the tubercles. Nontuberculate ribs vary in number between two and four betweeen successive tuberculate ribs. KAPLAN & KENNEDY (1994) gave full description of the species, and nothing new can be added from the poorly preserved material from Lower Saxony.

DISCUSSION: The fragment figured here fits well *N. paderbornese*, as figured by KAPLAN & KENNEDY (1994). The latter authors included *Neocrioceras* into the Nostoceratidae. Here, the classification of WRIGHT *& al.* (1996) is followed, who include the genus into the Diplomoceratidae.

Neocrioceras SPATH, 1921 has previously been a receptacle for any kind of Turonian to Maastrichtian heteromorph ammonite with an open, more or less planispiral or slightly helicoid or crioceratoid whorl with four rows of tubercles. WIEDMANN (1962), therefore, suspected that the genus was polyphyletic, and MATSUMOTO *& al.* (1986) noted that most of the above mentioned heteromorphs were erected on incomplete material. In fact, in most of the material, the early and earliest whorls are virtually unknown and the suture lines are rarely documented. This makes a generic identification and a coherent systematic treatment of this heterogenous group often difficult, if not impossible, and it explains the uncertainties in its taxonomy.

In order to advance the taxonomy of this cluster of species, WIEDMANN (1962) split *Neocrioceras* into the subgenera *Neocrioceras* (*Schlueterella*) (with *Ancyloceras pseudoarmatum* SCHLÜTER, 1872, from the Campanian of northern Germany as the type species) from *Neocrioceras* (*Neocrioceras*). The two main differences between these subgenera are the mode of coiling and the tuberculation: *N.* (*Schlueterella*) WIEDMANN is charaterized by an open, ancyloceratoid whorl with tubercles on the main ribs and no tubercles on the intercalationaries, while *N.* (*Neocrioceras*) SPATH shows a narrow crioceratoid whorl with simple prorsiradiate ribs (a discussion of *Neocrioceras* and a detailed differential diagnosis is given im MATSUMOTO *& al.* 1986). Following MATSUMOTO *& al.* (1986), *Schlueterella* and *Neocrioceras* are treated as separate genera here.

The type species of *Neocrioceras* is *Crioceras spinigerum* JIMBO, 1894 (Pl. 8, Fig. 1). SPATH (1921, p. 51, Pl. 7, Fig. 6) gave *N.* cf. *spinigerum* (JIMBO, 1894) from the Santonian in Pondoland as type species, the original of this figure is actually *Schlueterella compressa* KLINGER, 1976 (KLINGER 1976, IMMEL *& al.* 1982, MATSUMOTO 1986). Where well dated, e. g. numerous finds of *N. spinigerum* from Japan, it seems to be restricted almost exclusively to the Santonian. One doubtful *Neocrioceras*, *Neocrioceras* (?) *undulosum* MATSUMOTO, 1977 was recorded from the (Middle?) Turonian of Japan. As MATSUMOTO (1977) pointed out, this species, erected on one specimen only, combines characters of *Hyphantoceras* and *Madagascarites*, and its true taxonomic position remains unclear. Even though MATSUMOTO (1967, 1977) suggested that *Neocrioceras sensu stricto* enters the stratigraphic record in the Turonian, there are no unequivocal records of the genus until the Lower Coniacian. From the Western Interior of the United States, KENNEDY & COBBAN (1991) report *Neocrioceras maximum* KENNEDY & COBBAN from the Middle Coniacian, and IMMEL *& al.* (1977) record *Neocrioceras maderi* IMMEL, KLINGER & WIEDMANN, 1982 from the Lower Santonian of the Northern Calcareous Alps (Austria). Unfortunately, as with *N. paderbornense* (see below), taxa such as *N.*

maderi and *N. maximum* are based on incomplete material, and the juvenile whorls are also not preseverd.

Comparing *Neocrioceras paderbornense* with the type species of *Neocrioceras*, *N. spinigerum*, some differential diagnosises can be discussed.

Early whorls: N. spinigerum has a subhelical ammonitella, immediately followed by a crioceratoid whorl (TANABE *& al.* 1981, MATSUMOTO 1985, MATSUMOTO *& al.* 1986). The north German material has no juvenile whorls preserved. Therefore, no statements are possible.

Mode of coiling: N. paderbornense is characterized by a wide open spiral, while *Neocrioceras* has a tightly coiled planar to slightly helicoid whorl.

Whorl section: In *N. paderbornense* more compressed and subrounded to oval. *N. spinigerum* has well developed, and, in some specimens, almost subangular umbilical shoulders, a flat venter and an almost depressed whorl section.

Ribbing and tuberculation: *N. paderbornense* has simple, straight main ribs that bear four rows of tubercles. In some cases, the tubercles sit on pairs of ribs. Secondaries outnumber primaries, the first being less pronounced. *N. spinigerum* is comparatively densicostate and characterized by simple, prorsiradiate ribs of an almost equal strenght. The tubercles sit on one or pairs of ribs (see SHIMIZU 1933, Pl. 2, Figs 4-5, 8).

It appears that, comparing the type species of *Neocrioceras* with *N. paderbornense*, there are more differences than similarities, and the only feature identical in both taxa is the crioceratoid shell. On the other hand, the mode of ornamentation of *H. ernsti* and *N. paderbornense* is very similar, at least in earlier whorls (compare KAPLAN & KENNEDY 1994, Pl. 39, Fig. 8; this work Pl. 1, Fig. 4). It is, therefore, very tempting to conclude that *N. paderbornense* might have had developed from *H. ernsti* during latest Turonian times. Ideally, both taxa should then be characterized by comparable juvenile growth stages, which are, unfortunately, so far unknown from *N. paderbornense*. If this, however, were the case, *N. paderbornese* should be excluded from *Neocrioceras*.

A comparison of *N. paderbornense* with *Schlueterella* remains difficult, because the type specimen of the type species of the latter taxon is incomplete. However, the J-shaped body chamber distinguishes *Schlueterella* from *Neocrioceras*. The relation of *Neocrioceras* to Upper Turonian to Santonian representatives of *Schlueterella* remains unclear. *Schlueterella compressa* KLINGER, 1976 from the Santonian of Zululand (KLINGER 1976) and the Gosau (IMMEL *& al.* 1982), *Neocrioceras* (*Schlueterella*) sp. indet. (SUMMESBERGER & KENNEDY 1996) from the Gosau and *Neocrioceras* (*Schlueterella*) ex gr. *kossmati* (SIMIONESCU, 1899) described by IMMEL *& al.* (1981) from the Northern Calcareous Alps are incomplete and their ontogenetic development as well as their phylogenetic origin is unknown.

OCCURRENCE: The FAD of *N. paderbornense* is located around the Turonian/Coniacian boundary interval (KAPLAN & KENNEDY 1996). So far, records are known only from the Early Coniacian of Westphalia and Lower Saxony (*deformis erectus* to *crassus*/*deformis* Zone).

DISCUSSION

In the Upper Turonian and Lower Coniacian, a distinct sequence of heteromorph ammonites can be recognized that show some stratigraphic separation (Text-fig. 2). In the lower Upper Turonian, the interval around the *Hyphantoceras* Event is characterized by a *Hyphantoceras reussianum-Eubostrychoceras-Allocrioceras* fauna (for details see KAPLAN 1992, KAPLAN & KENNEDY 1996). Additionally, scaphitids and baculitids occur, together with collignoniceratids. The terminal part of the *Inoceramus costellatus costellatus*/*I. striatoconcentricus*/*Mytiloides labiatoidiformis* assemblage Zone and wide parts of the *scupini* Zone, especially the interval above the *Micraster* Event yielded a *H. flexuosum*/*H. ernsti* Assemblage together with *E. saxonicum* (rare) and scaphitids. Presumably in the lower parts of the Lower Coniacian, an association of *N. paderbornense* together with *S. turoniense* occurs. As can be seen from the ammonite distribution in the interval investigated, *Scaphites* and *Sciponoceras* are ubiquituos (WIESE & KRÖGER 1998) and are not, therefore, ecologically significant. The nostoceratids/diplomoceratids, however, seem to occur in numbers invariably in the context of shallowing events (Text-Fig. 2), thus suggesting that these forms favoured near-swell environments. This is also indicated by their in part abundant occurrences in intervals with hardgrounds, inferred to reflect increased winnowing. This observation deviates from ideas synthesized by WESTERMANN (1996, p. 668, Text-fig. 14) who interpreted these forms as inhabiting an epipelagic setting or water depth around 150 m, respectively (WESTERMANN 1996, p. 660, Text-fig. 12).

Unfortunately, the poor material, especially in the Turonian/Coniacian boundary interval, does not yet permit the recognition of the exact stratigraphic limitations of the assemblages. The known ranges, presented in Text-fig. 2, are, therefore, still tentative. The distribution of *P. paderbornense* and *S. turoniense* in Westphalia (KAPLAN & KENNEDY 1996) suggests, however, that the *paderbornense*/*turoniense* assemblage can probably be used alternatively for defining the base of the *petrocoriense* Zone. However, if the ecologic assumptions given above are correct, this zonation must be treated with care, because it is merely an eco-stratigraphic assemblage zone.

As repeatedly mentioned above, the similarities between *H. reussianum*, *H. flexuosum*, *H. ernsti* and the indetermined nostoceratid in certain growth stages demand further, well labelled stratigraphically collecting in order to elaborate and better understand the intraspecific variation of each taxon.

The taxa treated here are typical representatives of an Eurasian fauna with a Boreal character that can be traced from England, northern Germany and Poland over Bohemia to Kazakhstan.

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PLATE 1

Hyphantoceras ernsti sp. n.

1-3 – Holotype, unreg. specimen from the Blasewitz borehole (near Dresden, Saxony), *Mytiloides scupini* Zone, Upper Turonian Strehlen Formation; 1-2 – Pyritized, juvenile whorls, exhibiting the orthocone shaft and 3 whorls of the torticone part; 3 – Holotype (compare Text-fig. 3); after the juvenile part, the beginning of the crioceratoid interval is not preserved; the following whorl segments show the crioceratoid whorl with the well developed intercalatories and the main ribs with the spines; 1 × 6.5; 2: × 5; 3 – nat. size
4-5 – MB.C.2814 from the Heteromorph Beds of Groß-Flöthe, immediately above the *Micraster* Event (lowermost *scupini* Zone, Upper Turonian); both parts belong togehter; 5 is counterpart of 4
6 – MB.C.2815 from the lower *scupini* Zone of Nettlingen; the fragment represents the weakly or regularily ornamented morphotype
7 – MB.C.2816 from the lower *scupini* Zone of Hoppenstedt; this fragment shows the reduction of the intercalatories and the irregular main ribs with increasing size
8 – MB.C.2817 from bed 9c of the Salzgitter-Salder quarry, Upper Turonian *scupini* Zone.
9-10 – MB.C.2818 from the lower *scupini* Zone of Nettlingen; decrease of ornament as in 7 can be seen
11 – MB.C.2819 from the lower *scupini* Zone (Upper Turonian) of Nettlingen.

All specimen are figured in natural size, if not other stated

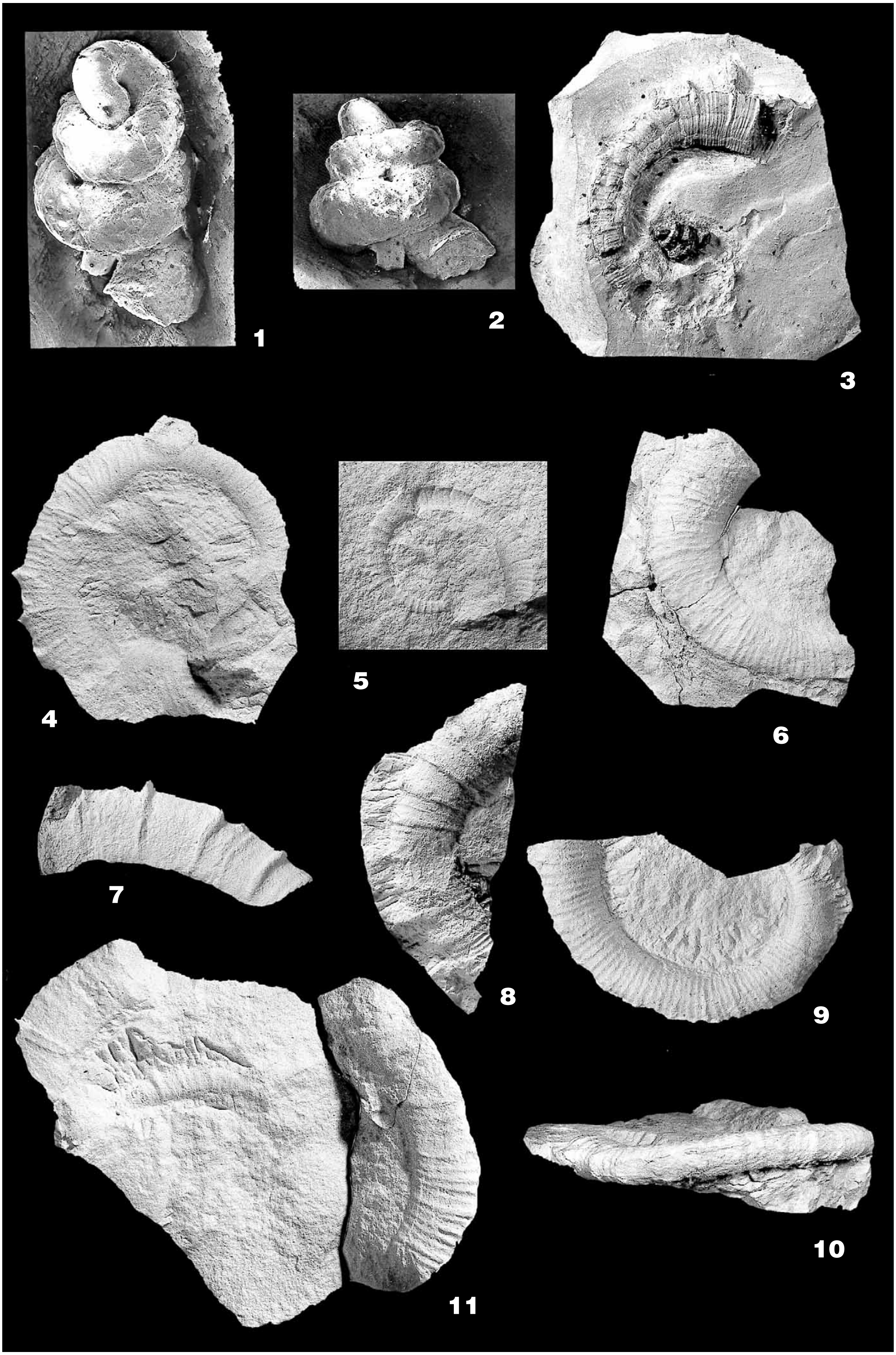
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PLATE 2

1-3 – BGR × 5687a: Lectotype of *Hyphantoceras flexuosum* (SCHLÜTER, 1872) from the *Cuvieri* Pläner of the Salzgitter area; presumably Lower Coniacian; the phragmocone shows a dextral mode of coiling

4 – BGR × 5687b: Paralectotype of *Hyphantoceras flexuosum* (SCHLÜTER, 1872); it derives from the rock fragments associated with the lectotype; it cannot be decided whether or not this fragment belongs to the lectotype or whether it represents a second specimen

5 – MB.C.2810: *Hyphantoceras flexuosum* (SCHLÜTER, 1872) from the interval around T_F at Groß-Flöthe (*scupini* Zone, Upper Turonian)

6-7 – MB.C.2811: *Hyphantoceras flexuosum* (SCHLÜTER, 1872) from the *scupini* Zone of Groß-Flöthe, upper part of the Lower Limestone Unit; the phragmocone shows a dextral mode of coiling

8-9 – MB.C.2808: *Hyphantoceras flexuosum* (SCHLÜTER, 1872), around T_F (lower *scupini* Zone, Upper Turonian) from Groß-Flöthe

10 – MB.C.2812: Large fragment of *Hyphantoceras flexuosum* (SCHLÜTER, 1872), from the basal "Grau-Weiße Wechselfolge", lower *scupini* Zone (Upper Turonian) of Groß-Flöthe, which may represent the adult stage of the species

11 – MB.C.2809: *Hyphantoceras reussianum* (D'ORBIGNY, 1850), cast of a mould from the lower *scupini* Zone (Upper Turonian) of Groß-Flöthe

All specimen are figured in natural size, if not other stated

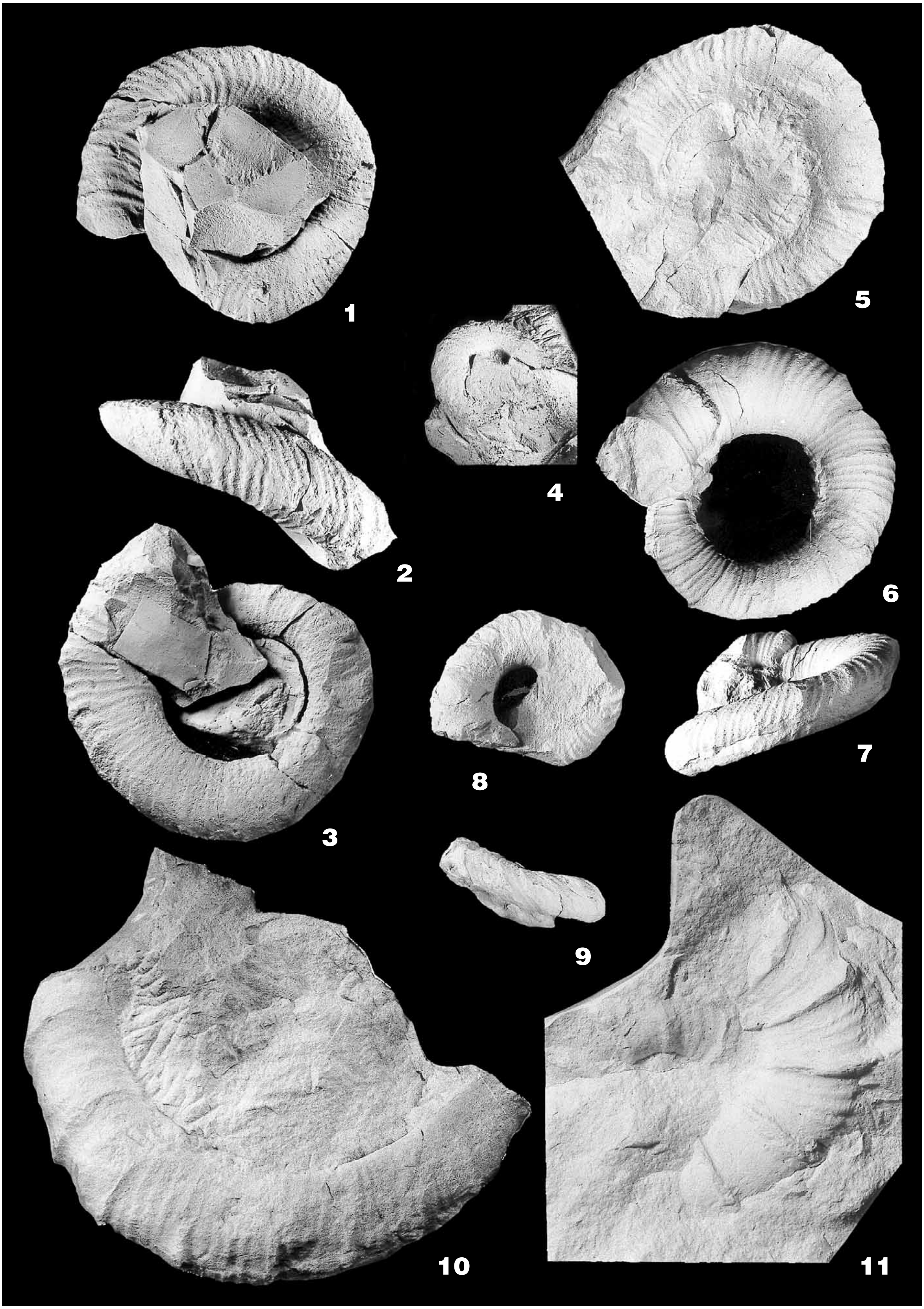
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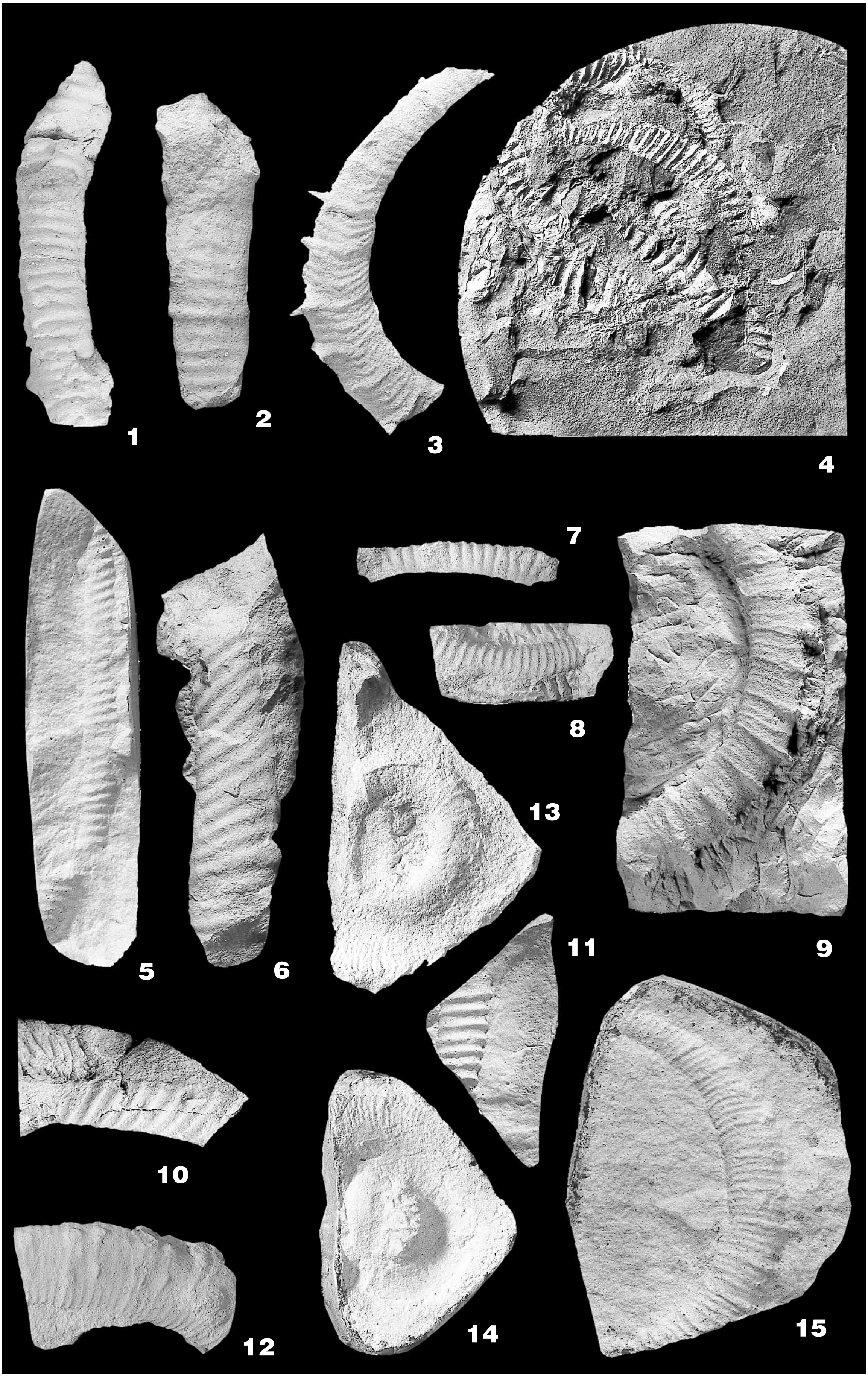
PLATE 3

1 – MB.C.2797: *Scalarites turoniense* (SCHLÜTER, 1872) from the upper Limestone Unit of Salzgitter-Salder, Bed 75 (*Isomicraster* Event), *crassus inconstans* Zone (Lower Coniacian)
2 – MB.C.2798: *Scalarites turoniense* (SCHLÜTER, 1872) from the Upper Limestone Unit of Salzgitter-Salder, Bed 75 (*Isomicraster* Event), *crassus inconstans* Zone (Lower Coniacian)
3 – MB.C.2805: *Hyphantoceras ernsti* sp. n., 3 m above the *Micraster* Event, uppermost Lower Limestone Unit (*scupini* Zone, Upper Turonian) of the Hoppenstedt limestone quarry; the specimen shows strong distorsion
4 – TU Bergakademie Freiberg, Stratigraphische Hilfssammlung 194/97: *Scalarites turoniense* (SCHLÜTER, 1872), Borhole Bonnewitz, Kernmarsch 50, 8-51, 4 m, Lower Coniacian of the Strehlen Formation (× 1.5); presumably *deformis erectus* Zone
5 – MB.C.2799: *Scalarites turoniense* (SCHLÜTER, 1872) from the Upper Limestone Unit of Salzgitter-Salder, loose below beds 83-87, upper *crassus inconstans* Zone or *crassus/deformis* Zone respectively (Lower Coniacian). Cast from a mould
6 – MB.C.2802: *Scalarites turoniense* (SCHLÜTER, 1872) from the Upper Limestone Unit of Salzgitter-Salder, Bed 68, *waltersdorfensis hannovrensis* Zone (Lower Coniacian)
7 – MB.C.2800: *Scalarites turoniense* (SCHLÜTER, 1872); Upper Limestone Unit, abandoned limestone quarry between Söhlde and Barbecke (Lower Coniacian)
8 – MB.C.2801: *Scalarites turoniense* (SCHLÜTER, 1872); Upper Limestone Unit of Salzgitter-Salder, Bed 75 (*Isomicraster* Event), *crassus inconstans* Zone (Lower Coniacian)
9 – MB.C.2813: *Hyphantoceras ernsti* sp. n.; immediately below T_F (Lower Limestone Unit) from Groß-Flöthe, *scupini* Zone (Upper Turonian)
10 – MB.C.2803: *Scalarites turoniense* (SCHLÜTER, 1872); Upper Limestone Unit of Salzgitter-Salder, *crassus/deformis* Zone (Lower Coniacian)
11 – MB.C.2804: *Scalarites turoniense* (SCHLÜTER, 1872); Upper Limestone Unit of Salzgitter-Salder, Bed 75 (*Isomicraster* Event), *crassus inconstans* Zone (Lower Coniacian) (cast)
12 – MB.C.2806: *Neocrioceras paderbornense* (SCHLÜTER, 1872), loose from the Upper Limestone Unit of Groß-Flöthe (Lower Coniacian)
13-14 – MB.C.2820: *Hyphantoceras flexuosum* (SCHLÜTER, 1872), whorl fragment (Fig. 13) and cast of the counterpart (Fig. 14); loose around T_F, *scupini* Zone Upper Turonian) of Groß-Flöthe
15 – MB.C.2807: mould of *Hyphantoceras ernsti* sp. n., 1 m above the *Micraster* Event of Groß-Flöthe, upper Lower Limestone Unit (*scupini* Zone, Upper Turonian)

All specimen are figured in natural size, if not other stated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