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The genus *Discoceras* (Tarphyceratida, Cephalopoda; Ordovician) from Estonia and glacial erratics in north-central Europe

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Abstract. The cephalopod genus *Discoceras* Barrande, 1867 (family Trocholitidae Chapman, 1857; order Tarphyceratida Flower, 1950) is a characteristic component of the late Middle and Late Ordovician carbonates of Baltoscandia and its glacial erratics in north-central Europe. The genus consists of tens of species, most of which are, however, poorly constrained, partly due to the type material being inaccessible or lost. Consequently, a comprehensive revision of the genus is needed. Here, we describe 39 specimens from in-situ rocks in northern Estonia and Norway, and from boulders in Pleistocene glaciofluvial sediments in Germany and Poland. Six previously described species were identified: *Discoceras antiquissimum* (Eichwald, 1842), *D. saemanni* (Hyatt, 1894), *D. ievense* (Balashov, 1953), *D. damesii* (Schröder, 1891), *D. bandonis* Remelé, 1890 and *D. danckelmanni* (Remelé, 1880). Two species were left in open nomenclature: *D.* cf. *paopense* Kröger, 2025 and *D.* cf. *gubkovense* Balashov, 1953; seven species are newly described: *D. aseriense* sp. nov., *D. brandenburgense* sp. nov., *D. angustum* sp. nov., *D. circulare*. sp. nov., *D. sovaki* sp. nov., *D. alienum* sp. nov. and *D. polonicum* sp. nov. The single specimen and holotype of *Discoceras aseriense* (Aseri Regional Stage, Darriwilian, Middle Ordovician) is the stratigraphically earliest known representative of the genus from Baltica and possibly globally. *Lituites trapezoidalis* is herein synonymised under the type species, *Discoceras antiquissimum*. A neotype is proposed for the latter, stabilising the concept of the type species and the genus *Discoceras*. The study showed that the separation of *Discoceras* at the family level is not justified and the monogeneric family Discoceratidae Hyatt, 1894 is herein synonymised under the family Trocholitidae Chapman, 1857.

Keywords. Tarphyceratida, *Discoceras*, taxonomy, ontogeny, Ordovician.

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Introduction

In the late Middle Ordovician, the seas of the palaeocontinent Baltica witnessed the arrival of the first coiled cephalopods of the family Trocholitidae Chapman, 1857 (order Tarphyceratida Flower, 1950) – *Trocholites* Conrad, 1838 and *Curtoceras* Ulrich, Foerste, Miller & Furnish, 1942. These two were followed by a third genus, *Discoceras* Barrande, 1867, which subsequently diversified markedly and became one of the most distinctive elements of Late Ordovician cephalopod faunas of Baltica.

In the fossil record, the conchs of *Discoceras* are abundant and relatively easily recognised and have therefore been studied for a long time (see summary in Schröder 1891). The conchs are rather large (typically over 100 mm in diameter), discoidal, tightly coiled, planispiral, evolute and slowly expanding; in most species, the terminal body chamber is uncoiled from preceding whorls. The whorl profile is usually weakly depressed in earlier growth stages (WWI = 1.00–1.50) but changes to equidimensional or compressed (WWI = 0.50–1.00) later in growth; the whorl profile shape is variable (circular, oval, subrectangular, subquadrate, trapezoidal or heart-shaped) even within individual species. The siphuncle is subdorsal or dorsal. The shell surface is ornamented with frilled and imbricated elements.

The high intraspecific and ontogenetic variation in morphological characters of *Discoceras* led to the establishment of dozens of species (e.g., Remelé 1890; Schröder 1891; Strand 1933; Balashov 1953; Sweet 1958; Lai & Wang 1981). Some of these species have recently been examined in greater detail (e.g., Kröger *et al.* 2011; Kröger 2013a, 2025; Kröger & Aubrechtová 2018, 2019), while others have not been revised for decades, partly due to insufficiently documented, inaccessible, or lost type collections.

This study builds upon the previous comprehensive work on the trocholitid genera *Trocholites* and *Curtoceras* (Aubrechtová & Korn 2025) and presents a revision of the genus *Discoceras*. With this updated taxonomy, the Baltoscandian members of the family Trocholitidae can now be used to address broader palaeoclimatological and palaeoenvironmental questions, as previously explored by, e.g., Kröger (2013a, 2013b, 2025) and Kröger & Aubrechtová (2018, 2019).

Historical overview

The genus *Discoceras* was established by Barrande (1867) for coiled cephalopods characterised by a simple aperture, a short uncoiled ontogenetic interval, a subquadrate or subtrapezoidal whorl profile, an annulated or smooth shell surface and a dorsally shifted siphuncle (Barrande 1877). Based on the length of the uncoiled section and the shape of the aperture, Barrande (1867) distinguished *Discoceras* from other adaperturally uncoiled cephalopods, namely *Ophioceras* Barrande, 1865 (family Ophioceratidae Hyatt, 1894; order Tarphyceratida) and *Lituites* Bertrand, 1763 (family Lituitidae Phillips, 1848; order Lituitida Starobogatov, 1983).

Subsequently, Noetling (1883), Remelé (1886) and Schröder (1891) further differentiated *Discoceras* from estonioceratid cephalopods (family Estonioceratidae Hyatt, 1900; order Tarphyceratida).

Discoceras was later subdivided into several genera (*Schroederoceras* Hyatt, 1894, *Rectanguloceras* Stumbur, 1962 and *Sweetoceras* Stumbur, 1962) based on differences in shell ornamentation and whorl profile shape. However, these latter taxa are currently not widely accepted (Strand 1933; Ulrich *et al.* 1942; Sweet 1958; Kröger 2013a) and are instead interpreted as reflecting either the high morphological variability or possible sexual dimorphism within *Discoceras* (see Kröger 2025 for a detailed discussion and references).

Approximately thirty species of *Discoceras* are currently recognised from Middle and Late Ordovician strata across various regions, primarily Northern Europe and the St Petersburg region of Russia (e.g., Remelé 1890; Strand 1933; Balashov 1953; Sweet 1958; Rasmussen & Surlyk 2012; Kröger &

Aubrechtová 2019; Kröger 2025), but also North America (Flower 1968), Kazakhstan (Barskov 1972), India (Salter in Reed 1912), and China (Lai & Wang 1981; Gao *et al.* 1982; Lai 1982, 1987; Lai & Wang 1986).

During the Silurian, the diversity of *Discoceras* had declined significantly, with only six species known from the Llandovery and Wenlock of the Prague Basin (central Bohemia) (Manda & Turek 2018), the Wenlock of North America (Meek & Worthen 1870; Foerste 1925), Australia (Etheridge 1904), Inner Mongolia (Zou 1983) and the Swedish island of Gotland (Manda & Turek 2018).

Palaeogeographically, *Discoceras* was largely restricted to mid- or low-palaeolatitude regions during the Ordovician and Silurian periods (e.g., Manda & Turek 2018).

Material and methods

Studied material and preservation

This study examined 39 specimens assigned to *Discoceras*. The material was collected from Middle-Late Ordovician carbonate sedimentary rocks at localities in northern Estonia and Norway, as well as from erratic boulders within Pleistocene glaciofluvial sediments in northern Germany and Poland (Fig. 1; Table 1).

The stratigraphic age of the specimens from erratic boulders was initially determined based on the primary information provided on the museum labels and previously published literature (Hucke 1967; Neben & Krueger 1971, 1973). Since the stratigraphy of erratic boulders was historically based on the Swedish lithostratigraphic units, we used the most recent correlations (Ebbestad & Högström 2007; Nakrem & Rasmussen 2013; Nielsen *et al.* 2023) to determine the age of the specimens relative to the Scandinavian chronostratigraphic scale (Fig. 2). The correlation between the Baltic and Scandinavian regional stages and the global scale is provided by Nielsen *et al.* (2023).

The stratigraphic age of the specimens from in-situ carbonates in Estonia is adopted from the Estonian Geoscience Data Portal eMaapõu (https://geoloogia.info), where verified and updated information on localities, stratigraphy and references are accessible. Thus, the Baltic regional stages as correlated with the global chronostratigraphic scale (Meidla *et al.* 2014, 2023) were used (Fig. 2). The latter were applied also on specimens from erratic boulders, in which their stratigraphic age was primarily indicated using the Baltic units. In certain intervals, however, the initial correlation between the Baltic scale and the stratigraphic scheme for the erratics (e.g., Hucke 1967) was later shown to be inaccurate (Meidla *et al.* 2023; Nielsen *et al.* 2023); in these cases, the Scandinavian regional scale (Nielsen *et al.* 2023) was used instead (Fig. 2).

The stratigraphic age of the single specimen MB.C.11569 from Asker, Norway was determined using Strand (1933) and Nakrem & Rasmussen (2013); the Scandinavian regional scale was used (Nielsen *et al.* 2023).

The specimens are preserved as largely complete internal moulds of conchs in late or terminal growth stages, frequently retaining at least partially preserved shell walls and ornamentation. The adapertural portion of the body chamber and terminal aperture are typically missing. Approximately one quarter of specimens preserve at least part of the initial whorl of the phragmocone, with specimen MB.C.32315 (*D. saemanni*) showing the most complete preservation.

In specimen MB.C.32315, the first whorl likely represents the initial chamber, exhibiting tight coiling with exceptionally long phragmocone chambers (RCL ~0.60) that gradually shorten in later growth stages (RCL ~0.20–0.25). While some authors have interpreted such chamber length variation as

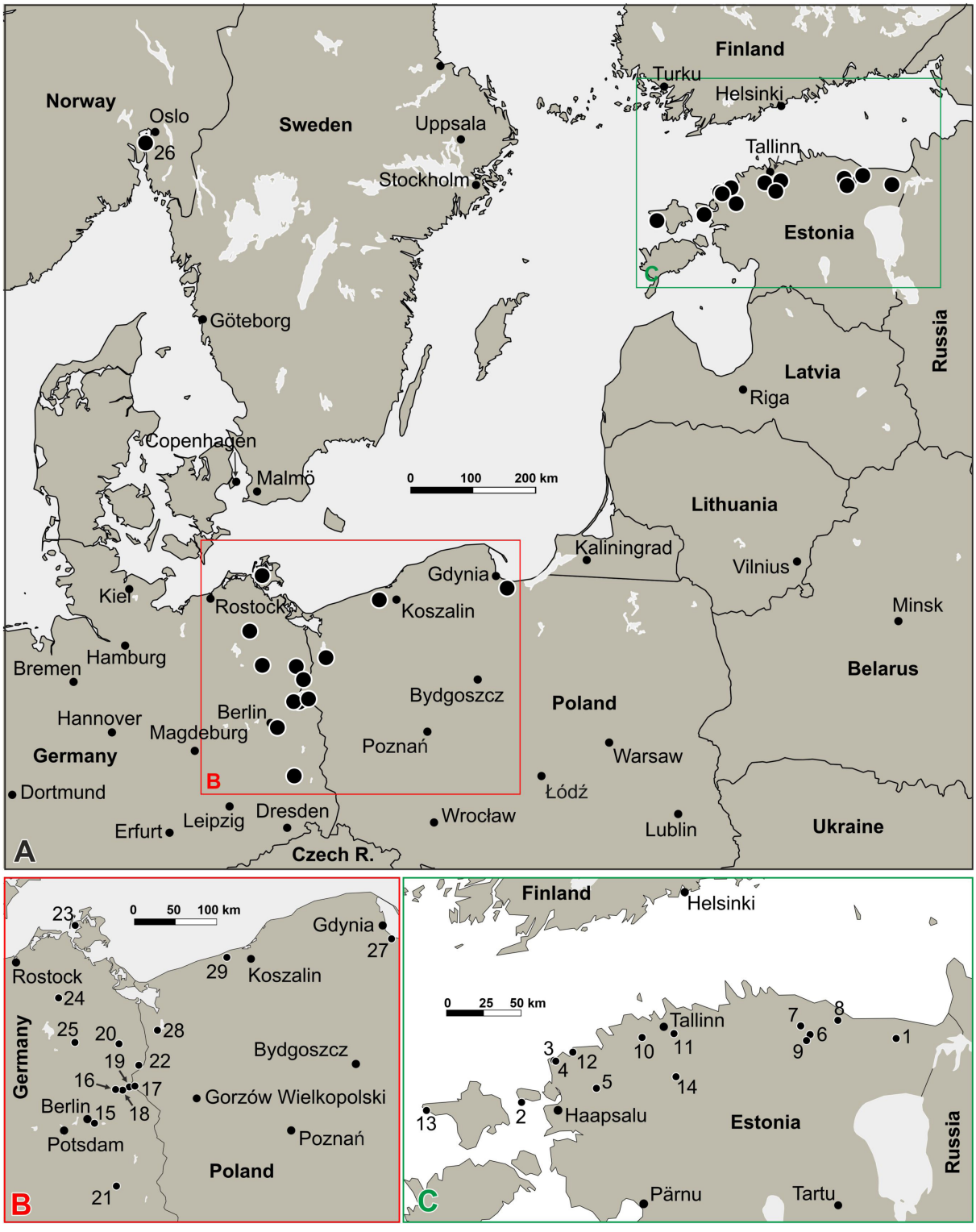

Fig. 1. A. Map showing the geographic position of the localities, at which the specimens of *Discoceras* Barrande, 1867 described herein were collected. **B**. Detailed map with localities in north-eastern Germany and western Poland. **C**. Detailed map with localities in Estonia. Map prepared using the QGIS software (QGIS Development Team 2024) (using the open-source World Map, OpenStreetMap and "WISE Large rivers and large lakes F1v1 geodatabase" of the European Environment Agency). Number coding of localities in Table 1.

Table 1. Number coding of the localities as used in Fig. 1.

Coding	Country	Region	Locality
1	Estonia	Ida-Viru County	Jõhvi-Paemurru quarry
2	Estonia	Lääne County	Hosholm (Vormsi Island)
3	Estonia	Lääne County	Põõsaspea cliff
4	Estonia	Lääne County	Põõsaspea cliff, outcrop of Kinnekulle bentonite
5	Estonia	Lääne County	Piirsalu old quarry
6	Estonia	Lääne-Viru County	Aluvere quarry
7	Estonia	Lääne-Viru County	Idavere
8	Estonia	Lääne-Viru County	Koila
9	Estonia	Lääne-Viru County	Rakvere
10	Estonia	Harju County	Peetri hillrock
11	Estonia	Harju County	Rae
12	Estonia	Harju County	Ristna cliff
13	Estonia	Hiiumaa Island	Ristna
14	Estonia	Rapla County	Härgla Quarry
15	Germany	Berlin	Britz
16	Germany	Brandenburg	Eberswalde
17	Germany	Brandenburg	Hohensaaten
18	Germany	Brandenburg	Niederfinow
19	Germany	Brandenburg	Oderberg
20	Germany	Brandenburg	Prenzlau
21	Germany	Brandenburg	Schlabendorf (near Calau)
22	Germany	Brandenburg	Schwedt
23	Germany	Mecklenburg-Vorpommern	Hiddensee
24	Germany	Mecklenburg-Vorpommern	Salem (near Malchin)
25	Germany	Mecklenburg-Vorpommern	Schlicht (near Neustrelitz)
26	Norway	Akershus County	Asker
27	Poland	Pomerania	Gdańsk
28	Poland	West Pomerania	Szczecin
29	Poland	West Pomerania	Ustronie Morskie (West Pomerania)

evidence of hatching in tarphyceratid cephalopods, subsequent research has challenged this interpretation (detailed discussion in Manda & Turek 2018).

No specimens display evidence of in vivo shell damage or growth anomalies. However, two specimens – MB.C.32316 (*D. saemanni*) and TUG 2-731 (*D. angustum*) – exhibit shallow longitudinal grooves or bands on their flanks. Similar structures have been previously documented in trocholitids by Manda & Turek (2018), Aubrechtová & Korn (2025) and Kröger (2025), though their origin and functional or taxonomic significance remain uncertain.

Morphological terminology

Morphological terms are used according to Flower (1964) and Furnish & Glenister (1964) and as refined by Pohle *et al.* (2022). The conch geometry is quantified using the parameters and ratios of Korn & Klug

Table 2. Parameters and ratios used for the description of the specimens of the genus *Discoceras* Barrande, 1867 studied herein.

Parameter [unit]	Abbrev.	Calculation
conch diameter [mm]	dm	–
whorl height [mm]	wh	–
whorl width [mm]	ww	–
umbilical width [mm]	uw	dm_1-wh_1-wh_2
apertural height [mm]	ah	dm_1-dm_2
imprint zone [mm]	iz	wh_1-ah
whorl expansion rate (outline)	WERdm	$(dm_1/dm_2)^2$
whorl expansion rate (apertural height)	WERah	$[dm_1/(dm_1\text{-ah})]^2$
imprint zone rate	IZR	iz/wh
umbilical width index	UWI	uw/dm
conch width index	CWI	ww/dm
whorl width index	WWI	ww/wh

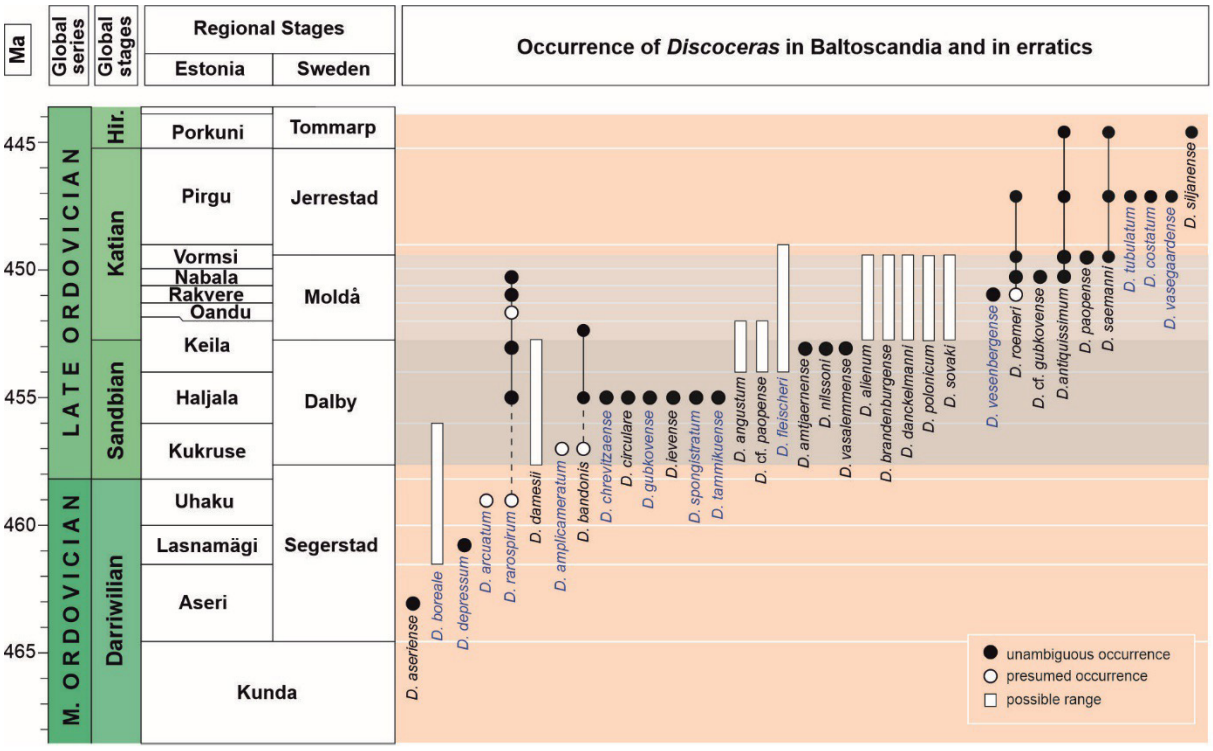

Fig. 2. Stratigraphic distribution of the trocholitid *Discoceras* Barrande, 1867 in the Ordovician strata of Baltoscandia and in erratics. Species not physically available for study here are marked in blue. Stratigraphic chart after Ebbestad & Högström (2007) and Meidla *et al.* (2014). Abbreviations: D. = *Discoceras*; Hir. = Hirnantian; M = Middle..

(2003), Korn (2010) and Klug *et al.* (2015). The terminology is shown in Fig. 3, Table 2 and commented on in the text below.

Length of the phragmocone chambers – expressed as the relative cameral length (RCL) (Pohle *et al.* 2022) and calculated as the ratio between cameral length (cl) and corresponding whorl height (wh):

$$RCL = cl/wh$$

Diameter of siphuncle – expressed as the relative septal foramen height (RSH) (Pohle *et al.* 2022) and calculated as the septal foramen height (fh) over the corresponding apertural height (ah):

$$RSH = fh/ah$$

Position of siphuncle – expressed as the relative septal foramen position (RSP) (Pohle *et al.* 2022) and calculated from the distance of the septal foramen from the ventral shell wall (sv), the apertural height (ah) and the septal foramen height (fh):

$$RSP = sv/(ah-fh)$$

In contrast to Pohle *et al.* (2022), Aubrechtová & Korn (2025) calculated the RSP using the apertural height (i.e., the distance between ventral sides two successive whorls or smallest dorso-ventral height of the whorl profile) instead of the whorl height (i.e., the greatest dorso-ventral height of the whorl profile). The reason for this was that the use of whorl height resulted in an apparently narrower (i.e., artificially lower RSH) and more central (i.e., artificially lower RSP) siphuncle in specimens with a dorsal imprint zone. The specimens of *Discoceras* do not have a significant imprint zone (i.e., ah ~ wh) but the above formula is still used with apertural height to maintain consistency and comparability with the other trocholitids studied by Aubrechtová & Korn (2025).

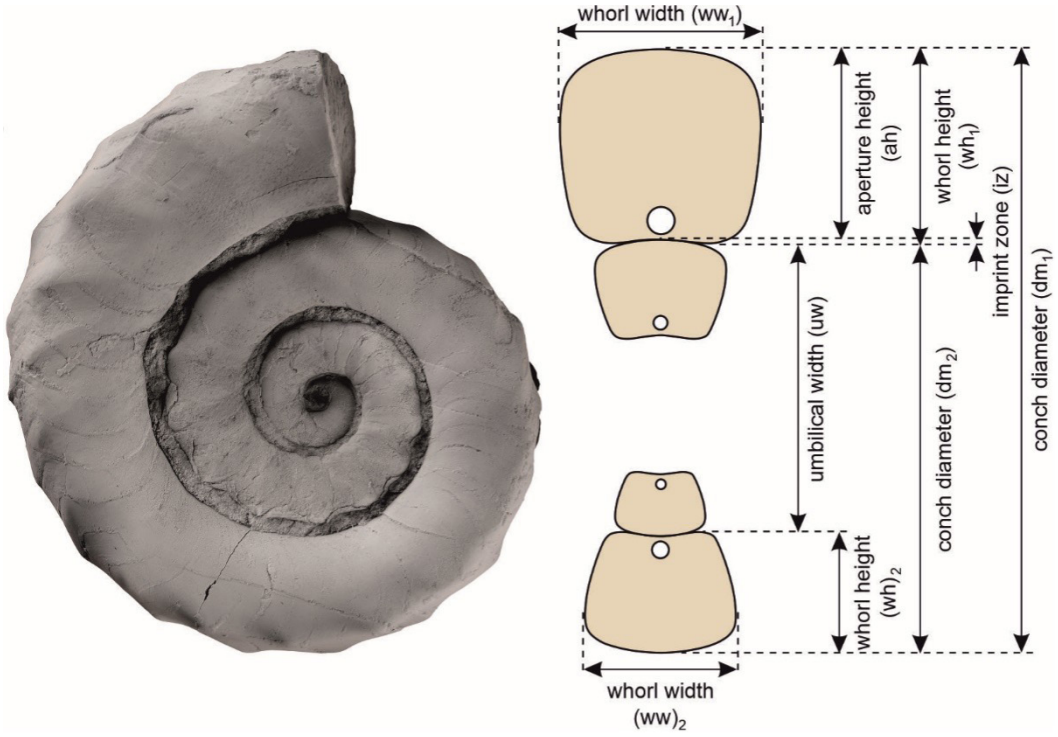

Fig. 3. Morphological terminology used here to describe the specimens of *Discoceras* Barrande, 1867 (based on MB.C.11569, *D. antiquissimum* (Eichwald, 1842)).

Throughout the text, we differentiate between the overall shape of the whorl profile (e.g., circular, square-shaped, rectangular, heart-shaped etc.) and its proportions expressed as the ww/wh ratio (i.e., compressed, equidimensional or depressed whorl profile).

The shell ornament terminology follows Kröger (2008), Klug *et al.* (2015) and Pohle *et al.* (2022). In the *Discoceras* specimens described in this work, the following ornament elements are present (from Aubrechtová & Korn 2025):

Growth lines – finest type of transverse ornament, formed by discontinuous shell secretion at the aperture (Klug *et al.* 2015).
Lirae – transverse raised growth lines with transverse profile either symmetric or asymmetric, may be narrowly undulated (frilled).
Ribs – coarse transverse elements, which are limited to a certain part of the conch circumference (typically flanks) and do not leave any traces on the internal mould.
Annuli – coarse transverse ornament elements, which are present around the whole circumference of the conch and are visible on the internal mould; where annuli-like structures are visible on the internal mould but not on the shell surface, or where the shell surface is not present, the terms annular ridges or annular impressions are used.
Spiral lines – longitudinal elements of ornament.

Repositories

The present study is based on specimens from palaeontological collections kept at the following institutions:

GIT = Tallinn University of Technology, Estonia
MB.C. = Museum für Naturkunde, Berlin, Germany
TAM = Estonian Museum of Natural History, Tallinn, Estonia
TUG = Museum of Natural History of the University of Tartu, Estonia

Results

Class Cephalopoda Cuvier, 1797
Subclass Multiceratoidea Mutvei, 2013

Order **Tarphyceratida** Flower, 1950

Diagnosis (from Aubrechtová & Korn 2025)

Multiceratoid cephalopods with coiled to gyroconic conchs of various whorl profile and simple transverse or slightly curved suture lines. Coiling planispiral, rarely torticonic; body chambers usually long, extending from a half to more than one complete whorl in length. Last whorl commonly slightly to greatly divergent from preceding coiled portions; terminal aperture commonly modified. Siphuncle varies in position; siphuncular segments tubular, nautilosiphonate, with orthochoanitic or loxochoanitic septal necks and thick connecting rings in stratigraphically earlier forms, and cyrtochoanitic septal necks and thin homogeneous rings in stratigraphically later forms. Muscle attachment scars ventromyarian or sometimes pleuromyarian. Thin cameral deposits present in some taxa. Shell surface smooth or ornamented with transverse lirae, ribs or annuli, or spiral ornament elements.

Families included

Barrandeoceratidae Foerste, 1925; Estonioceratidae Hyatt in Zittel, 1900; Ophioceratidae Hyatt, 1894; Plectoceratidae Hyatt in Zittel, 1900; Tarphyceratidae Hyatt, 1894; Trocholitidae Chapman, 1857.

Family **Trocholitidae** Chapman, 1857

Diagnosis (from Aubrechtová & Korn 2025)

Family of the order Tarphyceratida with subglobular to discoidal conchs consisting of three to five or more gradually expanding volutions; body chamber may uncoil from preceding volution. Terminal aperture of body chamber with flares in some taxa, aperture often modified with ventral sinus and lateral projections. Whorl profile usually with dorsal imprint zone; usually depressed except for the adult growth stage that may have an equidimensional or compressed whorl profile; flanks and venter broadly rounded or flattened. Shell ornament varies during ontogeny, usually consisting of imbricating and/or frilled lirae, ribs or annuli, but taxa with smooth shell surface exist; ornament elements form ventral sinus. Conch in some taxa with periodic constrictions. Phragmocone chambers short (on average six phragmocone chambers relative to whorl height). Suture line simple with shallow ventral lobe or rarely saddle. Siphuncle subcentral, subdorsal or marginodorsal in position, ventral to central in initial volution; siphuncle segments tubular, weakly convex or weakly concavo-convex, narrow in diameter (usually less than 0.25 of apertural height); septal necks short (less than 0.20 of segment length), orthochoanitic or loxochoanitic; connecting rings usually thick, layered, but becoming thin and homogeneous in some taxa.

Genera included

Arkoceras Ulrich, Foerste, Miller & Furnish, 1942; *Crenuloceras* Flower, 1968; *Curtoceras* Ulrich, Foerste, Miller & Furnish 1942; *Discoceras* Barrande, 1867; *Hardmanoceras* Teichert & Glenister, 1952; *Jasperoceras* Ulrich, Foerste, Miller & Furnish, 1942; *Litoceras* Hyatt, 1884; *Paradiscoceras* Barskov, 1972; *Plectolites* Flower, 1968; *Trocholites* Conrad, 1838; *Trocholitoceras* Hyatt, 1894; *Weberoceras* Barskov, 1972; *Wichitoceras* Ulrich, Foerste, Miller & Furnish, 1942; *Yushanoceras* Chen & Liu, 1976.

Remarks

Trocholitidae Schröder, 1891 is a junior homonym of Trocholitidae Chapman, 1857 and consequently, Chapman (1857) is the author of the family name.

Some authors have previously included *Discoceras* in the family Discoceratidae Dzik, 1984, which is, however, a junior homonym of Discoceratidae Hyatt, 1894. The latter originally included several early Palaeozoic genera (besides *Discoceras* also *Peismoceras* Hyatt, 1894, *Systrophoceras* Hyatt, 1894, *Trochoceras* Barrande, 1848, *Mitroceras* Hyatt, 1894 and *Plectoceras* Hyatt, 1884), which have later been shown to belong to various, unrelated lineages. For example, the Silurian lechritrochoceratids *Peismoceras* and *Systrophoceras* represent basal members of the order Nautilida Agassiz, 1847 (Dzik & Korn 1992; Manda & Turek 2019). When all the unrelated genera are excluded, the family Discoceratidae is left with just *Discoceras*, the name-bearing taxon. However, the separation of *Discoceras* at the family level is not justified – the conch geometry, internal conch structures and ornament in *Discoceras* all perfectly fall within the morphological variability observed among the representatives of the family Trocholitidae. Thus, the family Discoceratidae Hyatt, 1894 is synonymised here with the family Trocholitidae Chapman, 1857.

Genus ***Discoceras*** Barrande, 1867

Type species

Clymenia antiquissima Eichwald, 1842; by subsequent designation (Schröder 1891).

Diagnosis (after Kröger & Aubrechtová 2018; Manda & Turek 2018)

Genus of the family Trocholitidae with adult conch diameters between 40 and 150 mm or more; body chamber usually divergent from preceding whorl, aperture may be slightly constricted or ventrally flared;

whorl profile weakly depressed, equidimensional or weakly compressed; shape of whorl profile circular, elliptic, subquadrate, trapezoidal or heart-shaped; whorls weakly embracing or not embracing; caecum subcentral, shifted towards ventral side, siphuncle shifts dorsally in second and third chamber, final dorsal or subdorsal position is attained in third septum; thick, layered connecting rings; shell surface smooth or ornamented with frilled and imbricated to lamellar lirae, narrow to strong annuli or ribs present in some taxa; ornament forms ventral sinus.

Remarks

Among the Ordovician Baltoscandian trocholitids, the genera most similar to *Discoceras* are *Curtoceras* Ulrich, Foerste, Miller & Furnish 1942 and *Trocholites* Conrad, 1838 (see Aubrechtová & Korn 2025 for detailed discussions). The species of both genera are smaller in adult diameters (usually between 20 and 60 mm), and their shells are more finely ornamented; the ornamentation elements are neither frilled nor strongly imbricated. In *Curtoceras*, the whorl profile is equidimensional or nearly so, with convex or only slightly flattened ventral and lateral sides. In *Trocholites*, the conch is stouter, more tightly coiled, the whorls embrace each other and the whorl profile is much more depressed.

In *Discoceras*, the adult conch size usually exceeds 100 mm, and the shell is ornamented with frilled and imbricated elements. The terminal body chamber is typically uncoiled to varying degrees. The adult growth stages of *Discoceras* are extremely discoidal (CWI < 0.35), and the whorls usually have only a weak imprint zone or no imprint zone at all. The whorl profile in *Discoceras* is typically weakly depressed in earlier growth stages (WWI = 1.00–1.50), becoming equidimensional or compressed in later growth (WWI = 0.50–1.00). The shape of the whorl profile ranges from circular or oval to subrectangular, subquadrate, trapezoidal or heart-shaped. Both the whorl profile WWI and its shape are highly variable within species and during ontogeny (Kröger 2025).

Geographic and stratigraphic occurrence

North America, Baltoscandia and St Petersburg Region of Russia, Kazakhstan, India, China, Middle–Late Ordovician. Baltoscandia, Czech Republic, North America, China and Australia, Llandovery–Wenlock series, Silurian.

Species included

North America (Meek & Worthen 1870, 1873; Whiteaves 1897; Flower 1968): *Lituites Graftonensis* Meek & Worthen, 1870; *Lituites*? *Ortoni* Meek & Worthen, 1873; *Discoceras canadense* Whiteaves, 1897; *Discoceras perornatus* Flower, 1968.

Northern Europe and St Petersburg Region of Russia (Eichwald 1840; Saemann 1853; Lossen 1860; Remelé 1880, 1890; Schröder 1891; Hyatt 1894; Strand 1933; Balashov 1953; Sweet 1958; Kröger *et al.* 2011; Rasmussen & Surlyk 2012; Manda & Turek 2018; Kröger & Aubrechtová 2019; Kröger 2025): *Clymenia antiquissima* Eichwald, 1840; *Clymenia rarospira* Eichwald, 1840; *Lituites angulatus* Saemann, 1853; *Lituites arcuatus* Lossen, 1860; *Lituites danckelmanni* Remelé, 1880; *Discoceras bandonis* Remelé, 1890; *Trocholites Damesii* Schröder, 1891; *Schroederoceras saemanni* Hyatt, 1894; *Schroederoceras tubulatum* Hyatt, 1894; *Discoceras roemeri* Strand, 1933; *Discoceras spongistratum* Balashov, 1953; *Schroederoceras chrevitzaense* Balashov, 1953; *Schroederoceras gubkovense* Balashov, 1953; *Schroederoceras ievense* Balashov, 1953; *Schroederoceras tammikuense* Balashov, 1953; *Schroederoceras vasalemmense* Balashov, 1953; *Schroederoceras vesenbergense* Balashov, 1953 *Discoceras amplicameratum* Sweet, 1958; *Discoceras boreale* Sweet, 1958; *Discoceras depressum* Sweet, 1958; *Discoceras fleischeri* Sweet, 1958; *Discoceras siljanense* Kröger *et al*. 2011; *Discoceras costatum* Rasmussen & Surlyk, 2012; *Discoceras vasegaardense* Rasmussen & Surlyk, 2012; *Discoceras lindstroemi* Manda & Turek, 2018; *Discoceras stridsbergi* Manda & Turek, 2018;

Discoceras amtjaernense Kröger & Aubrechtová, 2019; *Discoceras nilssoni* Kröger & Aubrechtová, 2019; *Discoceras paopense* Kröger, 2025.

Bohemia (Barrande 1865): *Lituites* (*Ophioceras*) *amissus* Barrande, 1865.

Kazakhstan (Tarbagatay, East Kazakhstan) (Barskov 1972): *Discoceras kazakhstanense* Barskov, 1972; *Discoceras tshingizense* Barskov, 1972.

China (Xainza, Tibet) (Lai 1982): *Discoceras xainzaense* Lai, 1982.

China (Xinjiang) (Lai & Wang 1981): *Discoceras aqalense* Lai & Wang, 1981; *Discoceras rareplicatum* Lai & Wang, 1981; *Discoceras robustum* Lai & Wang, 1981; *Discoceras semicirculare* Lai & Wang, 1981; *Discoceras ventrosellatum* Lai & Wang, 1981; *Discoceras yinganense* Lai & Wang, 1981.

China (Shaanxi, Gansu, Ningxia) (Gao *et al.* 1982): *Discoceras huanxianense* Gao, Lai & Wen, 1982.

China (Altun area, Xinjiang) (Lai & Wang 1986): *Discoceras altunense* Lai & Wang, 1986.

China (Mt Charchag, Xinjiang) (Lai 1987): *Discoceras xinjiangense* Lai, 1987.

India (Spiti, Himachal Pradesh) (Salter in Reed 1912): *Trocholites juliformis* Salter, 1912.

Discoceras antiquissimum (Eichwald, 1842)
Figs 4–6; Table 3

Clymenia antiquissima Eichwald, 1842: 33, pl. 3 figs 16–17.
Lituites trapezoidalis Lossen, 1860: 25, pl. 1 fig. 2.

Clymenia antiquissima – de Verneuil 1845: 361. — Eichwald 1860: 1301.
Lituites cornu arietites – Eichwald 1860: 1298.
? *Discoceras antiquissimum* – Rüdiger 1889: 55.
Lituites antiquissimus – Roemer 1861: 62, pl. 6 fig. 2f–g; 1885: 68(315), pl. 4(27) fig. 12.
Trocholites antiquissimus – Foord 1891: 51.
? *Discoceras antiquissimum* – Schröder 1891: (25)163.
Discoceras antiquissimum – Hyatt 1894: 500. — Foerste 1925: 17, 58, pl. 18 fig. 1. — Teichert 1930: 285. — Strand 1933: 33, pl. 2 figs 4, 11, pl. 4 figs 2–3, pl. 13 fig. 9. — Thorslund 1936: pl. 2 fig. 11 — Balashov 1953: 265, pl. 4 fig. 2, pl. 11 fig. 3, pl. 12 fig. 1; 1962: pl. 9 fig. 1; 1974: pl. 9 fig. 1. — Sweet 1958: 99, text-fig. 13Q. — Neben & Krueger 1973: pl. 77 figs 24–25. — Dzik 1984: 42, text-fig. 9c–d, 12.39, pl. 7 fig. 1. — Kröger 2013a: 72 fig. 31b; 2025: 129 figs 47c–d, 48a, 49a, 50a.
Discoceras cf. *antiquissimum* – Balashov 1964: 48, pl. 3 figs 3a–b.

non *Lituites antiquissimus* – Roemer 1861: pl. 6 fig. 2a–e.
non *Lituites antiquissimus* – Roemer 1885: 68, pl. 4 fig. 12.
non *Discoceras antiquissima* – Hucke 1967: 58, pl. 15 fig. 1.

Diagnosis (after Strand 1933; Kröger 2013a, 2025; emended)

Species of the genus *Discoceras* with adult sizes of up to about 150 mm, WER_{ah} ~1.90 (decreasing with ontogeny), whorl profile slightly depressed and becoming less depressed to equidimensional in maturity (WWI decreases from 1.50 to ~1.00 during ontogeny), broadly reniform in juvenile stages, rounded trapezoidal with venter wider than dorsum in later growth stages; suture line with ventral and lateral lobe and ventrolateral saddle; free adult body chamber with constriction near aperture; shell ornamented

with prominent annuli, one to two annuli per distance between two septa; siphuncle close to dorsal conch margin, diameter 0.15–0.17 of whorl height in late growth stages, septal necks orthochoanitic.

Type material

Neotype (designated here)
ESTONIA • Piirsalu old quarry (Lääne County); Pirgu Regional Stage, Katian Stage; illustrated in Fig. 4; TAM G432:72.

Other material examined

ESTONIA • 1 spec.; Hosholm (Vormsi Island, Lääne County); Pirgu Regional Stage (late Katian, Late Ordovician); 2007; Krueger leg.; MB.C.32314 • 1 spec.; Härgla Quarry (Rapla County); Porkuni Regional Stage, Hirnantian Stage; illustrated in Fig. 5A; TUG 1862-1.

NORWAY • 1 spec.; Asker (Akershus County); Jerestadian Regional Stage (late Katian, Late Ordovician); von Buch Coll.; illustrated in Fig. 5B; MB.C.11569.

Description

Neotype TAM G432:72 (Fig. 4) is an internal mould of a nearly complete conch in the adult growth stage, 151 mm in maximum diameter; the inner volutions are obscured by the rock. The body chamber is preserved in the length of ~55 degrees and it is uncoiled adaperturally. At the diameter of 145 mm, the conch is extremely discoidal (CWI = 0.21) with a whorl expansion rate (WER_{wh}) of ~1.62. The whorl

Fig. 4. *Discoceras antiquissimum* (Eichwald, 1842), neotype TAM G432:72 from Piirsalu (Lääne County, Estonia); lateral view. Scale bar units = 1 mm.

profile is roughly equidimensional (WWI ~ 1.00), weakly round laterally and slightly flattened ventrally. The ornament consists from prominent, widely spaced annuli (~ 16 mm apart in the last half whorl); their crests are rather sharp and adapically inclined. The annuli are oblique laterally and produce a deep and sharp sinus ventrally. The annuli are locally covered by fine transverse and longitudinal lirae. The suture lines are directly transverse and extend with a ventrolateral saddle and a lateral and ventral lobe. The relative cameral length (RCL) is ~ 0.25 in the last half volution.

Specimen TUG 1862-1 (Fig. 5A) is an internal mould of a conch in the subadult or adult growth stage, 109 mm in diameter, with locally preserved shell wall. One side of the conch is slightly worn resulting in the need to reconstruct whorl width, but otherwise, the specimen is not significantly deformed. A little over three, tightly coiled whorls are preserved, which are fully chambered; only the last ~ 24 degrees belong to the body chamber. At the maximum diameter, the conch is evolute (UWI = 0.50) and extremely discoidal (CWI ~ 0.29) with a whorl expansion rate (WER_{wh}) of ~ 1.90. The whorl profile is slightly depressed (WWI ~ 1.07) and very weakly imprinted dorsally, rounded laterally and slightly flattened ventrally. The shell is ornamented with sharp and widely spaced annuli (~ 13 mm apart at dm = 109 mm);

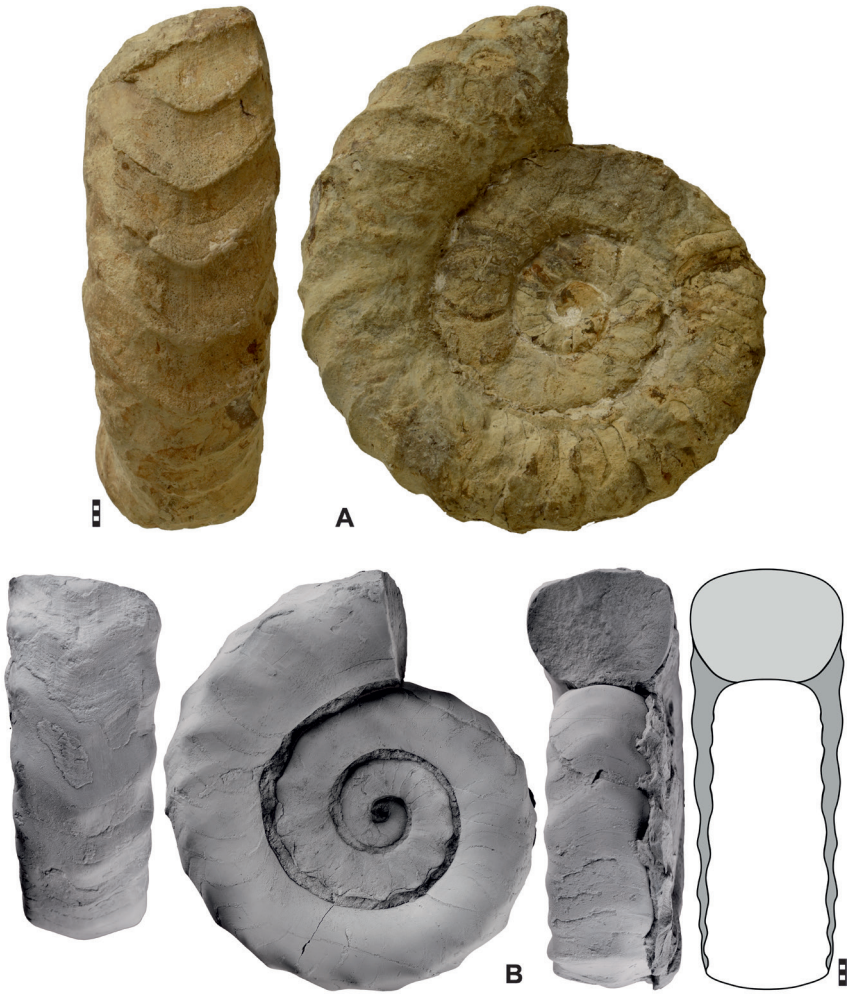

Fig. 5. *Discoceras antiquissimum* (Eichwald, 1842). **A**. Specimen TUG 1862-1 from Härgla Quarry (Rapla County, Estonia); ventral and lateral views. **B**. Specimen MB.C.11569 (von Buch Coll.) from Asker (Akershus County, Norway); ventral, lateral and dorsal views and dorsal reconstruction. Scale bar units = 1 mm.

Table 3. Conch measurements, ratios and rates of *Discoceras antiquissimum* (Eichwald, 1842).

specimen	dm	ww	wh	uw	ah	CWI	WWI	UWI	WER	IZR
TAM G432:72	145	31	31	–	31	0.21	1.00	v	1.62	–
TUG 1862-1	109	32	29.8	54.7	–	0.29	1.07	0.50	1.89	–
MB.C.32314	118.3	30.5	27.7	65.7	27.7	0.26	1.10	0.56	1.71	0.00
minus 180°	86.8	–	24.9	42.1	24.5	–	–	0.48	1.94	0.02
MB.C.11569	79.8	28.6	21.0	42.2	20.6	0.36	1.36	0.53	1.82	0.02
minus 90°	70.4	25.2	19.9	35.6	–	0.36	1.26	0.51	–	–
minus 180°	58.8	–	16.6	28.2	–	–	–	0.48	–	–

their crests are rather sharp and inclined towards the adapical part. The annuli run obliquely across the flanks and produce a sharp ventral sinus. Finer ornament elements are locally preserved, especially on the ventral side of the outer whorl. These fine elements are transverse lirae and very fine longitudinal lirae. The suture lines are directly transverse; they produce a ventrolateral saddle and a lateral and ventral lobe. The relative cameral length (RCL) is 0.18 at the dm = 104 mm).

Specimen MB.C.11569 is a conch in the subadult growth stage with a diameter of 81 mm and three preserved whorls (Fig. 5B). The conch is evolute (UWI = 0.53) and discoidal (CWI = 0.36) with moderate whorl expansion (WER_{ah} = 1.82). The last whorl is weakly depressed (WWI = 1.36) and very weakly embracing (IZR = 0.02); the whorl profile is rounded trapezoidal in shape, being narrowest dorsolaterally and widest ventrolaterally. A short part of the body chamber is preserved; it is very slightly uncoiled from the preceding whorl. The shell is ornamented with distinct, widely spaced annuli (~11 mm apart at dm = 81 mm) with rounded, symmetrical crests, along with coarse lirae (up to 1 mm apart); the annuli have low nodes mid-ventrally and at the ventrolateral shoulder. Extremely fine longitudinal ornament is discernible at the ventral side at the end of the last whorl. The septa are relatively crowded (RCL = 0.15 at dm = 60 mm).

Specimen MB.C.32314 is a large, nearly adult conch with a diameter of 119 mm; only the outer whorl is preserved. The conch is extremely discoidal (CWI = 0.26) and evolute (UWI = 0.56), expanding with

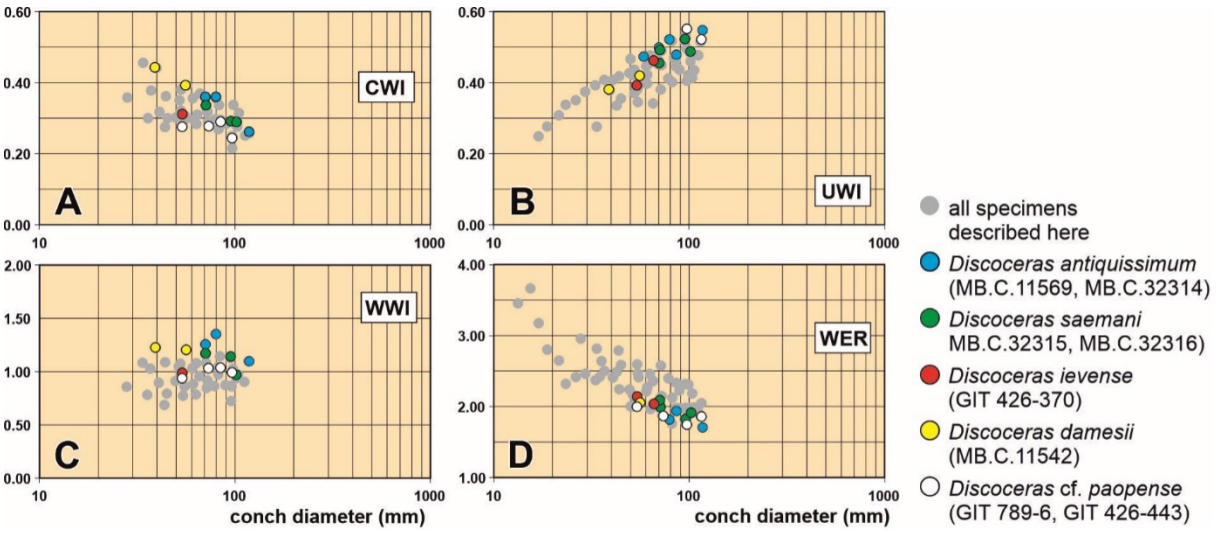

Fig. 6. Ontogenetic development of the conch width index (CWI), umbilical width index (UWI), whorl width index (WWI) and whorl expansion rate (WER) of various species of *Discoceras* Barrande, 1867.

a WER_{ah} of 1.71. The whorl profile at the maximum diameter of the conch is weakly depressed (WWI = 1.10) and trapezoidal in shape (widest ventrally); weakly imprinted dorsally or not imprinted (IZR = 0.02–0.00). The relative cameral length (RCL) is 0.22 (dm = 86 mm). The incomplete body chamber is preserved in the length of 100 degrees and uncoils from the preceding whorl at near its beginning. The siphuncle has a position close to the dorsal shell wall but its distance and the diameter cannot be precisely measured. The ornament consists of widely spaced annuli (~ 10 mm apart at dm = 87 mm) with rounded and symmetric crests.

Remarks

The holotype of *Discoceras antiquissimum* comes from the late Katian (Vormsi–Pirgu regional stages) of Kärdla (Island of Hiiumaa, Estonia). It was described by Eichwald (1840: 115), illustrated by Eichwald (1842: pl. 3 figs 16–17) and then re-illustrated by Foerste (1925: pl. 18 fig. 1) and Balashov (1953: pl. 12 fig. 1). The latter author stated the holotype was held at the "Prussian Geological Institute?" in Berlin. However, any attempts of the present authors to trace the current location and status of the specimen were unsuccessful and it is probable that the specimen was lost. For this reason, we designate TAM G432:72 (Fig. 4) from the Pirgu Regional Stage (Katian Stage) of west Estonia (Piirsalu old quarry, Lääne County) as the neotype. The specimen is roughly corresponds stratigraphically to the holotype and bears all the diagnostic features of the species, namely the coarse annulation on the shell surface. The specimen was previously described by Strand (1933: 34, pl. 2 fig. 11) and Kröger (2025: 132; under the obsolete collection number TAM G1:170), and is re-described and illustrated here for the purpose of neotype designation.

Specimen MB.C.11569 described above was originally used by Lossen (1860) to establish the species *Lituites trapezoidalis*. As already noted by Strand (1933: 36), the specimen corresponds in all aspects to the diagnosis of *D. antiquissimum* and is thus considered to represent an earlier growth stage attributable to the latter taxon.

Discoceras antiquissimum is similar to *D. saemanni* due to its weakly depressed, trapezoidal whorl profile, which is widest at the ventrolateral shoulder. However, it can be readily distinguished by the distinctly annulated shell surface; the annuli are clearly visible also on the internal mould. The thickness of the annuli varies between specimens, and the annuli are present in all growth stages except the earliest and latest growth stage (Kröger 2025).

Geographic and stratigraphic occurrence

Baltoscandia, north-eastern Russia, northern Germany and northern Poland; late Katian–early Hirnantian, Late Ordovician.

Discoceras saemanni (Hyatt, 1894)
Figs 6–8; Table 4

Schroederoceras Saemanni Hyatt, 1894: 462.
Lituites angulatus Saemann, 1853: 166, pl. 21 fig. 1c–d.
Trocholites undosus Foord, 1891: 45.
Discoceras hyatti Strand, 1933: 38, pl. 2 fig. 2, pl. 5 fig. 3a–b.

Discoceras sp. – Foerste 1930: 176, pl. 20 fig. 2a.
Discoceras saemanni – Strand 1933: 40, pl. 2 fig. 1a–b, pl. 4 fig. 1. — Sweet 1958: 102, text-fig. 13n. — Dzik 1984: 44, text-fig. 12.43. — Kröger 2025: 141, text-figs 48c, 49c, 50b, 51a, 53.
Discoceras hyatti – Sweet 1958: 102, text-fig. 13g.
Schroederoceras hyatti – Stumbur 1959: 26, text-fig. 1c; 1962: 137. — Dzik 1984: 44, text-fig. 12.44.

Schroederoceras saemanni – Stumbur 1962: 137.
Rectanguloceras sp. – Neben & Krueger 1973: pl. 76 figs 16–17.

non *Lituites angulatus* Saemann, 1853: pl. 21 fig. 1a–b.

Diagnosis (after Kröger 2025)

Species of the genus *Discoceras* with adult conch diameters of up to ca 125 mm; adult WER ~2.00; adult whorl profile with WWI ~1.10–1.20, subtrapezoidal with flattened venter, venter considerably wider than dorsum except at adult aperture and in juvenile growth stages; WER and WWI decrease with conch size; free adult body chamber with constriction near aperture; ornamented with crenulated costae and distinct growth lines that form U-shaped hyponomic sinus, low ribs can occur.

Material examined

GERMANY – **Brandenburg** • 1 spec.; Hohensaaten; Vormsi or Pirgu regional stages (late Katian Stage, Late Ordovician); Stober leg.; illustrated by Neben & Krueger (1973: pl. 76 figs 16–17), re-illustrated here in Fig. 7; MB.C.32315.

POLAND – **Pomerania** • 1 spec.; Gdańsk; probably Late Ordovician; Rühle von Lilienstern Coll.; illustrated in Fig. 8; MB.C.32316.

Fig. 7. *Discoceras saemanni* (Hyatt, 1894). Specimen MB.C.32315 (Stober Coll.) from Hohensaaten (Brandenburg, Germany); reconstructed cross section and lateral view. Scale bar units = 1 mm.

Description

Specimen MB.C.32315 is a conch of an adult individual, where a little less than one half is missing (Fig. 7). The maximum diameter is 102 mm; 3.25 whorls are preserved. The whorl width and profile had to be reconstructed due to the conch being embedded in rock on one side and the imprecise preparation of the specimen by a previous researcher. In the last half whorl, the conch is discoidal (CWI ~ 0.34) and increasingly evolute (UWI increases from 0.46 to 0.49); the coiling rate drops (WER decreases from 2.09 to 1.91), and the whorls are weakly embracing (IZR close to zero). The whorl profile is almost equidimensional (WWI = 0.96) and weakly trapezoidal in shape, with the widest point at the subangular ventrolateral shoulder. The sutures line has lateral and external lobes and a ventrolateral saddle. The body chamber is preserved over nearly 90 degrees of the whorl and is uncoiled from the preceding whorl. The end of the body chamber flares laterally, causing the whorl profile to change from trapezoidal to rectangular, with flattened dorsal and ventral sides. The relativa cameral length decreases during ontogeny, from RCL = 0.60 in the earliest whorl to 0.19 in the latest part of the phragmocone (dm = 72 mm). The initial chamber measures approximately 1.7 mm in length and 2.3 mm in width at the position of the first septum. The siphuncle is located close to the dorsal shell wall in the inner whorls and is nearly in contact with it in the outer whorl; the RSH is 0.20 at the largest preserved whorl height. The shell ornament in the earliest whorl is only very faintly preserved and appears to consist of widely and regularly spaced raised lirae or thin ribs. The second whorl has low, lamellar lirae and at the end of the body chamber, the raised lirae with symmetric crests are present.

Fig. 8. *Discoceras saemanni* (Hyatt, 1894). Specimen MB.C.32316 (Rühle von Lilienstern Coll.) from Gdańsk (Poland); ventral and lateral views. Scale bar units = 1 mm.

Table 4. Conch measurements, ratios and rates of *Discoceras saemanni* (Hyatt, 1894).

specimen	dm	ww	wh	uw	ah	CWI	WWI	UWI	WER	IZR
MB.C.32316	95.6	28.1	24.8	50.2	24.8	0.29	1.13	0.53	1.82	0.00
minus 180°	70.8	24.0	20.6	35.0	20.6	0.34	1.16	0.49	1.99	0.00
MB.C.32315	102.2	29.8	31.0	50.1	28.3	0.29	0.96	0.49	1.91	0.09
minus 180°	70.1	–	21.6	32.1	21.6	–	–	0.46	2.09	0.00

Specimen MB.C.32316 is a nearly complete adult conch, broken off on one side (Fig. 8). The conch measures 96 mm in diameter, with a reconstructed maximum size of 120 mm, and consists of 3.25 whorls. In the last half-whorl, the conch becomes increasingly discoidal (CWI decreases from 0.34 to 0.29) and more evolute (UWI increases from 0.49 to 0.53), while the coiling rate decreases (WER drops from 1.99 to 1.82). The imprint zone rate (IZR) is close to zero. The whorl profile is weakly depressed (WWI decreases from 1.16 to 1.13) and weakly trapezoidal in shape, with the widest point at the subangular ventrolateral shoulder and a convex umbilical wall. The suture line extends with external and ventral lobes as well as a ventrolateral saddle. The last whorl begins to uncoil at approximately the rear part of the terminal body chamber or slightly earlier. The body chamber is 110 degrees in length, with a laterally flared aperture forming a ventral sinus. The relatice cameral length (RCL) is 0.25 in the last whorl. In the latest part of the phragmocone, the siphuncle is subdorsal, with an RSH of approximately 0.19. The shell ornament in the first whorl transitions from sharp, widely and regularly spaced raised lirae or thin ribs to low, lamellar lirae. The outer whorl bears fine lirae, either with symmetrical crests or imbricated, while very flat ribs appear at the end of the body chamber. A pair of very low, narrow ridges is present on the ventral shell surface of the last whorl.

Remarks

According to the original museum label, the specimen MB.C.32316 comes from the "Orthoceratite Limestone", which would correspond to the Darriwilian Stage (Middle Ordovician). However, the lithology of the specimen indicates that the actual age is the Katian Stage (Late Ordovician). Additionally, no Darriwilian representatives of *Discoceras* exhibit a conch morphology similar to that of specimen MB.C.32316, suggesting that the stratigraphic information on the label is erroneous. Instead, specimen MB.C.32316 is almost identical to specimen MB.C.32315 and other late Katian–early Hirnantian representatives of *Discoceras* with a trapezoidal, ventrally flattened whorl profile. Its coiling parameters, ontogenetic trends and shell ornamentation perfectly align with the morphological variation recognised in *D. saemanni* by Kröger (2025); the two specimens are therefore assigned to that species.

Hyatt (1894) based *D. saemanni* on two specimens originally illustrated by Saemann (1853: pl. 21 fig. 1c–d). Both specimens come from the latest Katian of Herøya (near Porsgrund, Norway) and are now kept at the Museum of Comparative Zoology (Massachusetts, USA) under coll. no. MCZ:IP:109000 and MCZ:IP:109001. Neither of the syntypes were available for study in this work.

Discoceras saemanni is most similar to *D. antiquissimum* in terms of conch proportions, ratios and whorl profile, but its shell surface lacks annuli; instead, crenulated costae and, in some cases, low ribs are present. A weakly trapezoidal whorl profile is also present in specimens of the stratigraphically older (Sandbian) *D. spongistratum*, but the latter differs in shell ornamentation (narrow ribs or annuli), a more compressed whorl profile (WWI ~ 0.70) and a greater coiling rate (WER = 2.12) in the terminal growth stage.

Geographic and stratigraphic occurrence

Norway, Estonia, northern Germany and northern Poland; late Katian–Hirnantian Stage, Late Ordovician.

Discoceras ievense (Balashov, 1953)
Figs 6, 9; Table 5

Schroederoceras ievense Balashov, 1953: 259, pl. 9 fig. 1.

Discoceras ievesense – Sweet 1958: 112, pl. 12 figs 2–3, text-fig. 13h — Dzik 1984: 44.
Rectanguloceras ievense – Stumbur 1962: 137, 142.
Discoceras ievense – Kröger & Aubrechtová 2018: 809, 811; 2019: 966.

Diagnosis (after Balashov 1953; Sweet 1958; emended)

Species of the genus *Discoceras* with adult sizes of about 110 mm; up to four tightly coiled whorls; last whorl discoidal with CWI ~0.30 and WER_{ah} ~2.00. Whorl profile weakly imprinted dorsally, equidimensional (WWI ~1.00), convex in first two whorls but flattened laterally and ventrally (subquadrate) later in ontogeny. Suture line almost straight with broad and shallow ventral and lateral lobe. Shell ornamented with lirae on inner whorls, fine annuli are added on the last whorl, which are most pronounced on flanks. Siphuncle subdorsal with diameter ~0.20 of whorl height in late growth stages.

Material examined

ESTONIA • 1 spec.; Idavere; early Haljala Regional Stage (Sandbian Stage, Late Ordovician); Mark Coll; illustrated in Fig. 9; GIT 426-370.

Description

Specimen GIT 426-370 is a tightly coiled conch in the subadult growth stage, with a maximum diameter of 66 mm (Fig. 9); a little over one whorl is preserved (minimum diameter ~30 mm). At a conch diameter of 54 mm, it is subevolute (UWI = 0.39) and discoidal (CWI = 0.31), with a high coiling rate (WER_{ah} = 2.14). The conch is worn on one side, but it can be recognised that at smaller diameters, the whorl profile is very slightly compressed or equidimensional (WWI close to one), nearly square-shaped with flattened venter and flanks and very weakly embracing (IZR close to zero). In ontogenetically earlier stages of the conch, the flanks are more rounded, but the venter remains flattened; in the earliest visible whorl profile (at dm ~30 mm), the venter also appears rounded, with the whorl profile transitioning from nearly circular to nearly square-shaped during ontogeny. The shell ornament is preserved only in small remnants

Fig. 9. *Discoceras ievense* (Balashov, 1953). Specimen GIT 426-370 (Mark Coll.) from Idavere (Lääne-Viru County, Estonia); dorsal reconstruction, lateral view, and septal view. Scale bar units = 1 mm.

Table 5. Conch measurements, ratios and rates of *Discoceras ievense* (Balashov, 1953).

specimen	dm	ww	wh	uw	ah	CWI	WWI	UWI	WER	IZR
GIT 426-370	65.5	–	19.6	30.4	19.6	–	–	0.46	2.03	0.00
minus 90°	53.5	16.8	16.9	21.1	16.9	0.31	0.99	0.39	2.14	0.00

of the shell wall or as faint imprints on the internal mould of the outer whorl; it consists of irregularly thick lirae and/or low annuli. The siphuncle is positioned near the dorsal shell wall but is not in contact with it (subdorsal) and has a relative septal foramen height (RSH) of about 0.20. The septa are closely spaced with the RCL ranging between 0.15 and 0.20 in the outer whorl; the suture line is nearly straight, with only a very shallow lateral and external lobe.

Remarks

The holotype of *Discoceras ievense* was not accessible for study herein. It is the specimen illustrated by Balashov (1953: pl. 9 fig. 1), reportedly deposited under coll. no. 40 at the St. Petersburg State University. The holotype originates from the late Haljala Regional Stage (Sandbian Stage, Late Ordovician) of the Tallinn Region of Estonia.

Discoceras ievense is readily recognised from all other representatives of the genus by the square-shaped whorl profile with clearly flattened lateral and ventral sides in the outer two whorls and the relatively wide (RSH ~0.20), subdorsal siphuncle. The most similar species are *D. rarospirum* and *D. vesenbergense* from Estonia. In the late Darriwilian to Katian *D. rarospirum*, the whorl profile transitions from circular to trapezoidal (with wider dorsal side) and finally square-shaped, but the flanks of the conch remain rounded (Balashov 1953; Kröger & Aubrechtová 2018, 2019). In the Katian (Rakvere Regional Stage) *D. vesenbergense*, the whorl profile has a flattened venter and flanks, but it is depressed, with the WWI decreasing from 1.35 to 1.08 (Balashov 1953; Kröger & Aubrechtová 2018, 2019).

Geographic and stratigraphic occurrence

Northern Estonia and Norway (Oslo-Asker and Nes-Hamar districts); Sandbian Stage, Late Ordovician.

Discoceras damesii (Schröder, 1891)
Figs 6, 10; Table 6

Trocholites Damesii Schröder, 1891: 158, pl. 28(5) fig. 2.

Schroederoceras Damesi – Hyatt 1894: 469–470.
Discoceras damesi – Sweet 1958: text-fig. 13a.
Trocholites damesii – Neben & Krueger 1971: pl. 39 figs 13–15.

Diagnosis

Species of the genus *Discoceras* in which the shell ornament on inner whorls has sharp, regularly spaced (up to 1 mm apart) and weakly frilled annuli or raised lirae, with symmetric crests, accompanied by extremely fine spiral ornament; shell in later whorls ornamented with irregularly frilled and strongly imbricated transverse elements. Whorl profile rounded, weakly depressed (WWI ~1.20); siphuncle near dorsal shell wall in subadult stage.

Type material

Holotype

GERMANY – **Brandenburg** • Schwedt/Oder; Dalbyan Regional Stage (Sandbian Stage, Late Ordovician); illustrated by Schröder (1891: pl. 5(28) fig. 2) and Neben & Krueger (1971: pl. 39 figs 13–15), re-illustrated here in Fig. 10; MB.C.11542.

Table 6. Conch measurements, ratios and rates of *Discoceras damesii* (Schröder, 1891).

specimen	dm	ww	wh	uw	ah	CWI	WWI	UWI	WER	IZR
MB.C.11542	56.3	22.2	18.4	23.7	17.0	0.39	1.21	0.42	2.05	0.07
minus 180°	39.3	17.5	14.2	15.1	–	0.45	1.23	0.38	–	–

Description

Holotype MB.C.11542 is a phragmocone in the juvenile or early adult growth stage, with a diameter of 56 mm and 2.5 whorls preserved (Fig. 10). The conch is embedded in rock on one side and broken off on the other; therefore, some ratios are estimates. At its largest diameter, the conch is discoidal (CWI ~0.42) and subevolute (UWI = 0.42), with a WER_{ah} of 2.05. The whorl profile is elliptic and weakly depressed (WWI ~1.19). The imprint zone rate appears to increase in the last half-whorl (IZR from 0.00 to approximately 0.07). The siphuncle is positioned close to the dorsal shell wall (RSP ~0.12), with a relative septal foramen height (RSH) of 0.18. In the inner whorls, the shell is ornamented with rather sharp annuli or raised lirae, which are regularly and relatively widely spaced (up to 1 mm apart at dm = 24 mm), weakly frilled and not imbricated; the transverse elements are accompanied by an extremely fine spiral ornament. On the outer whorl, the transverse ornament becomes irregularly frilled and strongly imbricated, while spiral lines are no longer discernible.

Remarks

Discoceras damesii is a species of the genus in which the first 2.5 whorls are characterised by a weakly depressed, elliptic whorl profile and distinct shell ornament. The first at least 1.5 whorls show sharp annuli or raised lirae crossed by an extremely fine, flat spiral ornament. This transitions into irregularly thick, irregularly frilled, and strongly imbricated transverse elements, while spiral elements are no longer present.

The conch ratios and ornament of the holotype of *D. damesii* are rather similar to corresponding growth stages of the holotype of *D. vesenbergense* (Balashov 1953) and some representatives of *D. saemanni* (Kröger 2025: text-figs 50b, 53 and the specimen MB.C.32316 studied herein). However, it appears most similar to some specimens of *D. roemeri* (Kröger 2025), not only in whorl profile but particularly in the shell ornament, which transitions from thin, sharp ribs to frilled transverse elements. Further comparison

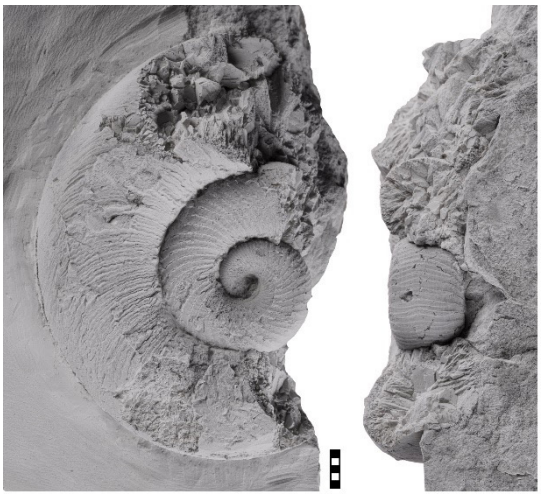

Fig. 10. *Discoceras damesii* (Schroeder, 1891). Holotype MB.C.11542 from Schwedt (Brandenburg, Germany); lateral and dorsal views. Scale bar units = 1 mm.

is hindered by the insufficient details provided by Balashov (1953) and the lack of knowledge on the late growth stages of the holotype of *D. damesii*. Additionally, the latter is stratigraphically much older (Sandbian vs Katian to Hirnantian stages) than the representatives of the other three species named above. *D. damesi* is thus kept separate until more completely preserved material is known.

Geographic and stratigraphic occurrence

Northern Germany; Sandbian Stage, Late Ordovician.

Discoceras cf. ***paopense*** Kröger, 2025
Figs 6, 11–12; Table 7

Material examined

ESTONIA • 1 spec.; Ristna cliff (Harju County); Keila Regional Stage (late Sandbian or early Katian Stage, Late Ordovician); Hints Coll.; illustrated in Fig. 11; GIT 789-6 • 1 spec.; Ristna (Hiiumaa Island); Keila Regional Stage (late Sandbian or early Katian Stage, Late Ordovician); illustrated in Fig. 12; GIT 426-443.

Description

Specimen GIT 789-6 represents a subadult growth stage of a conch with a diameter of 98 mm with 1.5 volutions preserved (Fig. 11). The specimen is slightly worn on one side, and the inner whorls are damaged and compacted. In the last whorl, the conch is discoidal (CWI decreasing from 0.28 to 0.25) and evolute (UWI = 0.55). The coiling rate (WER_{ah} = WER_{wh} in this case) decreases from 2.01 to 1.75. The whorl profile is weakly imprinted dorsally (IZR close to zero) and transitions from compressed to

Fig. 11. *Discoceras* cf. *paopense* Kröger, 2025. Specimen GIT 789-6 (Hints Coll.) from Ristna cliff (Harju County, Estonia); lateral view and whorl profiles. Scale bar units = 1 mm.

equidimensional (WWI increases from 0.94 to 1.00), with convex flanks and a flattened venter. The penultimate whorl profile (dm = 53 mm) appears to be weakly trapezoidal, with a wider ventral side, though this may result from an oblique natural cut of the specimen. The relative cameral length (RCL) is approximately 0.20 of the corresponding whorl height in the last preserved whorl. The suture line extends with a lateral lobe, an external lobe and a ventrolateral saddle. At a diameter of 53 mm, the siphuncle is subdorsal (RSP = 0.32) with a relative septal foramen height (RSH) of 0.19.

Specimen GIT 426-443 is a conch in the subadult or adult growth stage, measuring 116 mm in diameter, with approximately three outer volutions preserved (Fig. 12). The specimen is broken off adaperturally and strongly compacted from one side. The innermost whorls cannot be measured, and the width and shape of the outer volutions can only be estimated from the unaffected flank. At the beginning of the last whorl, the conch is discoidal (CWI ~ 0.29 at dm ~ 85 mm) with an equidimensional whorl profile (WWI ~ 1.04 at dm ~ 85 mm), which appears convex laterally and either convex or very weakly flattened ventrally. In the last whorl, the coiling rate (WER_{wh}) slightly increases from ~ 1.93 to 2.07 between a conch diameter of ~ 85–101 mm) before decreasing again from ~ 2.07 to 1.89 between a conch diameter of ~ 101–116 mm. At its greatest diameter, the conch is evolute (UWI ~ 0.52). The whorl profile in the last two whorls appears only very weakly imprinted dorsally or not imprinted (IZR close to zero). The relative cameral length (RCL) is approximately 0.20 of the whorl height in the last 1.5 whorls. The suture lines feature a lateral lobe, a ventral lobe, and a ventrolateral saddle. The siphuncle cannot be precisely measured, but it appears to be subdorsal, at least in the inner whorls. The shell ornament is best preserved on the compacted lateral side of the specimen. It consists of slightly irregularly spaced, oblique ribs or annuli, which appear rounded on top, with weaker transverse elements present between them.

Fig. 12. *Discoceras* cf. *paopense* Kröger, 2025. Specimen GIT 426-443 from Ristna (Hiiumaa Island, Estonia); lateral view. Scale bar units = 1 mm.

Table 7. Conch measurements, ratios and rates of *Discoceras* cf. *paopense* Kröger, 2025.

specimen	dm	ww	wh	uw	ah	CWI	WWI	UWI	WER	IZR
GIT 789-6	97.1	23.9	23.9	53.6	23.8	0.25	1.00	0.55	1.75	0.01
minus 180°	73.4	20.5	19.8	–	19.8	0.28	1.04	–	1.87	0.00
minus 360°	53.4	14.8	15.7	–	15.7	0.28	0.94	–	2.01	0.00
GIT 426-443	115.6	–	31.6	60.3	31.0	–	–	0.52	1.87	0.02
minus 180°	84.6	24.7	23.7	–	–	0.29	1.04	–	–	–

On the inner whorls, the ornament appears much finer, though this may be a result of the specimen's preservation.

Remarks

The minor differences in whorl expansion rate between the two specimens are interpreted here as being due to inaccuracies in the measurements of the compacted specimen GIT 426-443 and differences in adult size. The conch geometry and ornament in both specimens are most similar to those seen in representatives of *Discoceras paopense*. However, both specimens are kept in open nomenclature due to incomplete preservation and compaction. Additionally, there is a stratigraphic gap between the specimens studied here (Keila Regional Stage) and representatives of *D. paopense* (Vormsi Regional Stage).

Geographic and stratigraphic occurrence

Western Estonia; Keila Regional Stage, late Sandbian or early Katian Stage, Late Ordovician.

Discoceras cf. ***gubkovense*** Balashov, 1953

Figs 13–14; Table 8

Material examined

GERMANY – **Brandenburg** • 1 spec.; Schwedt; Nabala Regional Stage (Katian Stage, Late Ordovician); illustrated in Fig. 13; MB.C.32317.

Description

Specimen MB.C.32317 is a conch in the subadult or adult growth stage, measuring 100 mm in diameter (Fig. 13). In the final half whorl, the conch becomes increasingly discoidal (CWI decreasing from 0.32 to 0.21), more widely umbilicate (UWI increasing from 0.46 to 0.51), and less expanded (WER decreasing from 2.16 to 1.76). The whorl profile transitions from equidimensional to weakly compressed (WWI decreasing from 1.00 to 0.86) and from convex to flattened ventrally and laterally. The final whorl is not uncoiled, but the conch is distorted adaperturally, and it is unclear whether the aperture is preserved. The ornament consists of strongly imbricated lirae, which are irregularly raised to form narrow, transverse ribs.

Remarks

The conch geometry and ornament of specimen MB.C.32317 are similar to those of specimens of *D. paopense* from the Vormsi Regional Stage of Estonia. However, in MB.C.32317, the whorl profile transitions from equidimensional to weakly compressed and from convex to flattened ventrally and laterally, and the body chamber does not appear to uncoil.

Table 8. Conch measurements, ratios and rates of *Discoceras* cf. *gubkovense* Balashov, 1953.

specimen	dm	ww	wh	uw	ah	CWI	WWI	UWI	WER	IZR
MB.C.32317	98.6	25.9	25.0	53.2	25.0	0.26	1.04	0.54	1.79	0.00
minus 90°	83.6	23.8	22.0	40.3	22.0	0.28	1.08	0.48	1.84	0.00
minus 180°	73.6	25.0	20.4	35.1	20.4	0.34	1.23	0.48	1.91	0.00
minus 270°	62.7	22.1	21.9	27.9	21.9	0.35	1.01	0.45	2.36	0.00
minus 360°	53.2	20.7	18.1	23.7	18.1	0.39	1.14	0.45	2.30	0.00

Specimen MB.C.32317 more closely resembles the type specimens of *D. gubkovense* from the Sandbian Stage of the St. Petersburg Region of Russia as described by Balashov (1953). The similarities include an adult conch size of approximately 100 mm, an extremely discoidal conch shape, very slowly expanding and compressed whorls and shell ornamentation consisting of lirae and low ribs that form a ventral sinus. However, the type material of *D. gubkovense* described by Balashov (1953) is rather incompletely preserved and originates from a stratigraphically older interval (Sandbian vs Katian Stage). Additionally, internal features cannot be examined in MB.C.32317. As a result, the latter specimen is tentatively assigned to *D. gubkovense* with a question mark, pending further study.

Geographic and stratigraphic occurrence

Northern Germany; Nabala Regional Stage, Katian Stage, Late Ordovician.

Fig. 13. *Discoceras* cf. *gubkovense* Balashov, 1953. Specimen MB.C.32317 from Schwedt (Brandenburg, Germany); ventral and lateral views, dorsal reconstruction. Scale bar units = 1 mm.

Discoceras bandonis Remelé, 1890
Figs 14–17; Table 9

Discoceras bandonis Remelé, 1890: 105, pl. 3 fig. 4.

Discoceras Bandonis – Schröder 1891: 24–25(162–163).
Discoceras bandonis – Sweet 1958: 102, 106, text-fig. 13m. — Neben & Krueger 1971: pl. 39 fig. 11.
Sweetoceras bandonis – Stumbur 1962: 137, 143.
Schroederoceras bandonis – Dzik 1984: 42, 44, text-fig. 12.42.

non *Trocholites damesii* – Neben & Krueger 1971: pl. 39 figs 13–15.

Diagnosis

Species of the genus *Discoceras* with adult conch diameter of ~115 mm; conch extremely discoidal (CWI < 0.35) and evolute (UWI ~0.43); whorls weakly imprinted dorsally or not imprinted (IZR close to zero); whorl profile in the last whorl elliptic and weakly compressed (WWI ~0.90); whorl expansion rate decreases in ontogeny (WER = 2.6–2); relative cameral length (RCL) of ~0.17 in the last whorl; body chamber uncoiled, tubular or only slowly expanding, and short (up to 180 degrees in length); siphuncle position (RSP) of 0.23, relative septal foramen height (RSH) of ~0.20; shell ornament of fine, weakly frilled or flat and lamellar transverse lirae; flat, indistinct ribs may be present in late growth stages.

Type material

Holotype

GERMANY – **Brandenburg** • Oderberg; Dalbyan Regional Stage (Sandbian Stage, Late Ordovician); 1881; Remelé Coll.; illustrated by Remelé (1890: pl. 3 fig. 4) and Neben & Krueger (1971: pl. 39 fig. 11), re-illustrated here in Fig. 15; MB.C.11602.

Additional material

ESTONIA • 1 spec.; unknown locality; late Haljala Regional Stage (Sandbian Stage, Late Ordovician); Mägi Coll.; GIT 426-128 • 1 spec.; Aluvere quarry (Lääne-Viru County); late Haljala Regional Stage

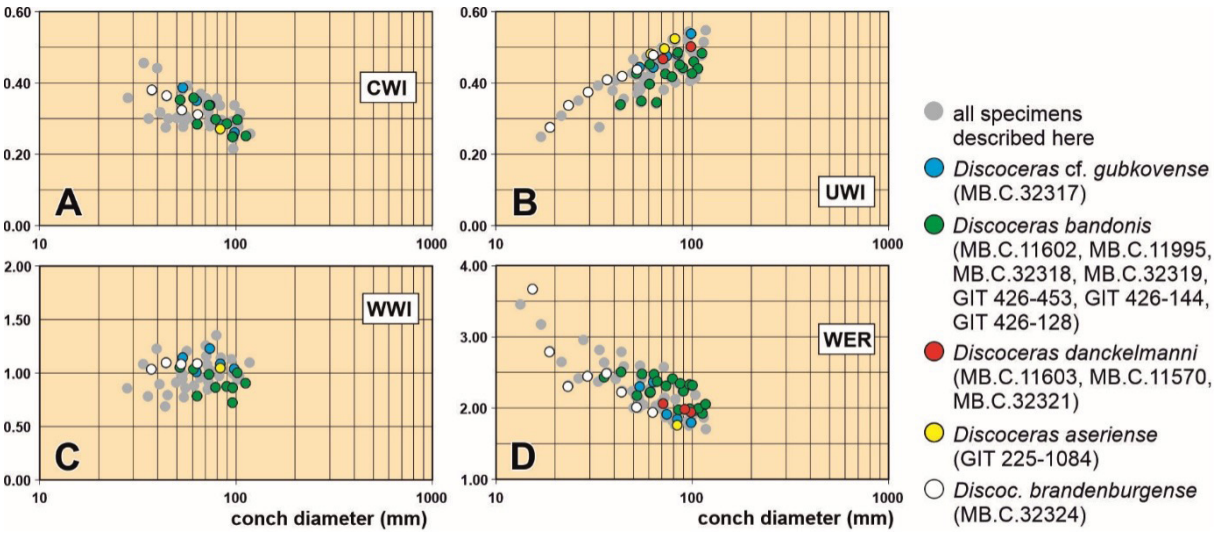

Fig. 14. Ontogenetic development of the conch width index (CWI), umbilical width index (UWI), whorl width index (WWI) and whorl expansion rate (WER) of various species of *Discoceras* Barrande, 1867.

(Sandbian Stage, Late Ordovician); GIT 426-144 • 1 spec.; Jõhvi-Paemurru quarry (Ida-Viru County); late Haljala Regional Stage (Sandbian Stage, Late Ordovician); Hermaküla Coll.; illustrated in Fig. 17; GIT 426-453.

GERMANY – **Mecklenburg-Vorpommern** • 1 spec.; Salem (near Malchin); Moldåan Regional Stage (early Katian Stage, Late Ordovician); Krueger leg.; MB.C.32318 • 1 spec.; Schlicht (near Neustrelitz); Moldåan Regional Stage (early Katian Stage, Late Ordovician); Müller-Friedmann Coll.; MB.C.32319.

POLAND – **West Pomerania** • 1 spec.; "Stettin" (now Szczecin); Moldåan Regional Stage (early Katian Stage, Late Ordovician); illustrated in Fig. 16; MB.C.11995.

Description

Holotype MB.C.11602 is a tightly coiled phragmocone with a diameter of 102 mm, consisting of about three volutions, distorted from one side (Fig. 15). The conch is extremely discoidal (CWI = 0.32 at dm = 72 mm). In the last whorl, the umbilicus widens (UWI increases from 0.40 to 0.47) and the coiling rate (WER) decreases from 2.28 to 1.99). In the last half whorl, the whorl profile is elliptic and compressed (WWI increases from 0.85 to 0.94). The relative septal foramen height (RSH) is 0.17, and its position (RSP) is 0.23. The relative cameral length (RCL) is 0.20 at the maximum conch diameter. The shell is ornamented with relatively fine, weakly frilled, and generally regularly spaced transverse lirae that are not imbricated and form a ventral sinus.

Specimen MB.C.11995 is a conch of an adult individual with a diameter of 114 mm and 2.5 whorls preserved (Fig. 16). At a diameter of 100 mm, the conch is extremely discoidal (CWI = 0.29) and

Fig. 15. *Discoceras bandonis* Remelé, 1890. Holotype MB.C.11602 (Remelé Coll.) from Oderberg (Brandenburg, Germany); lateral and dorsal views, dorsal reconstruction. Scale bar units = 1 mm.

subevolute (UWI ~0.44) with a high coiling rate (WER = 2.11). The whorls are very weakly embracing (IZR close to zero). The whorl profile, at the maximum conch diameter, is weakly compressed (WWI = 0.93) and elliptic in shape. The body chamber is preserved over a length of 172 degrees and is uncoiled from the previous whorl; its profile is weakly compressed (WWI = 0.89) and elliptic, with a slight flattening on the dorsal side. The relative cameral length (RCL) in the last whorl is 0.18. The shell ornament is relatively fine and consists of increasingly frilled and lamellar lirae, irregular in thickness. The inner whorls of the conch appear to be out of the coiling plane, but this is only a result of preparation and gluing of the specimen by previous researchers.

Specimen MB.C.32318 is an adorally incomplete conch in the adult growth stage with a diameter of 115 mm; three whorls are preserved. The conch is subevolute (UWI ~0.42) with a high coiling rate (WER = 2.18). The imprint zone rate is close to zero. The whorl width cannot be accurately measured because one side of the specimen is distorted, but the whorl profile is apparently compressed and elliptic. The body chamber is preserved over a length of 120 degrees and is uncoiled from the previous whorl. The relative cameral length (RCL) in the last whorl is 0.14. The shell ornament is preserved only in a small area on the inner whorls; it consists of flat, strongly imbricated to lamellar lirae. The surface of the body chamber has faint impressions of flat, transverse rib-like elements.

Specimen MB.C.32319 is an incomplete coiled phragmocone in the subadult growth stage. The conch has a diameter of 87 mm; it is subevolute (UWI ~0.45) with a high coiling rate (WER = 2.00). The relative

Fig. 16. *Discoceras bandonis* Remelé, 1890. Specimen MB.C.11995 from "Stettin" (now Szczecin, West Pomerania, Poland); dorsal reconstruction, dorsal and lateral views. Scale bar units = 1 mm.

cameral length (RCL) is 0.18 at a diameter of 62 mm. The ornament consists of rather irregular lirae, increasingly frilled adaperturally; indistinct flat ribs are visible on the internal mould of the body chamber.

Specimen GIT 426-453 is a coiled phragmocone with a maximum measurable diameter of 117 mm (Fig. 17). The innermost whorls are covered by rock matrix, and the outermost whorl is adaperturally incomplete (only a short basal part of the body chamber is preserved). One side of the specimen is worn and slightly compacted, but the other side is mostly unaffected, which allows for the reconstruction of the whorl profile and some measurements. At a diameter of 96 mm, the conch is extremely discoidal (CWI = 0.25) and has a high coiling rate (WER = 2.00). The whorls are only slightly imprinted dorsally or not imprinted. The whorl profile is elliptic and compressed (WWI = 0.86 at dm = 96 mm). The siphuncle is relatively wide (RSH = 0.25) and has some distance from the dorsal shell wall (RSP = 0.25). The relative cameral length (RCL) in the last whorl decreases from 0.16 to 0.12; the suture line is nearly straight with only a shallow lateral lobe. The shell wall is not preserved, but imprints of oblique, irregularly raised ribs or annuli are visible in the last half a whorl.

Specimen GIT 426-144 is an incompletely preserved phragmocone with a diameter of 110 mm. The last half whorl is laterally compacted and worn, and thus, the conch geometry had to be reconstructed. Between a diameter of 63 and 96 mm, the conch is extremely discoidal (CWI ~0.25) and expands rapidly (WER decreases from 2.47 to 2.33). The whorls are either slightly dorsally imprinted dorsally or not imprinted. The whorl profile appears to be elliptic and compressed (WWI decreases from ~0.78 to 0.72). The relative cameral length (RCL) is approximately 0.15, and the suture line is straight with only

Fig. 17. *Discoceras bandonis* Remelé, 1890. Specimen GIT 426-453 (Hermaküla Coll.) from the Jõhvi-Paemurru quarry (Ida-Viru County, Estonia); lateral view and whorl profile. Scale bar units = 1 mm.

Table 9. Conch measurements, ratios and rates of *Discoceras bandonis* Remelé, 1890.

specimen	dm	ww	wh	uw	ah	CWI	WWI	UWI	WER	IZR
MB.C.11602	102.1	30.3	30.3	46.9	29.2	0.30	1.00	0.46	1.96	0.03
minus 90°	84.7	–	24.4	41.1	24.4	–	–	0.49	1.97	0.00
minus 180°	72.9	24.6	24.9	31.0	24.9	0.34	0.99	0.42	2.31	0.00
minus 270°	60.3	–	19.8	23.9	19.8	–	–	0.40	2.21	0.00
MB.C.11995	112.8	28.4	31.4	54.5	31.4	0.25	0.90	0.48	1.92	0.00
minus 90°	90.0	25.7	29.4	39.8	29.4	0.29	0.87	0.44	2.24	0.00
minus 180°	78.8	23.5	27.2	32.9	27.2	0.30	0.86	0.42	2.41	0.00
minus 270°	60.6	21.7	21.0	27.4	21.0	0.36	1.03	0.45	2.22	0.00
minus 360°	51.6	18.2	17.3	22.0	17.3	0.35	1.05	0.43	2.17	0.00
MB.C.32318	107.4	–	31.3	47.3	31.3	–	–	0.44	1.99	0.00
MB.C.32319	86.5	–	30.0	39.0	30.0	–	–	0.45	2.34	0.00
GIT 426-453	116.9	–	35.3	–	35.3	–	–	–	2.05	0.00
minus 90°	96.8	24.2	28.1	–	28.1	0.25	0.86	–	1.99	0.00
GIT 426-144	96.5	24.0	33.2	–	33.2	0.25	0.72	–	2.33	0.00
minus 180°	63.2	18.0	23.0	–	23.0	0.28	0.78	–	2.47	0.00
GIT 426-128	100.0	–	34.3	42.7	34.3	–	–	0.43	2.32	0.00
minus 180°	65.7	–	23.0	22.7	23.0	–	–	0.35	2.37	0.00
minus 270°	54.9	–	20.0	19.2	20.0	–	–	0.35	2.48	0.00
minus 360°	42.7	–	15.7	14.5	15.7	–	–	0.34	2.50	0.00
minus 450°	34.9	–	12.5	–	12.5	–	–	–	2.43	0.00

a shallow lateral lobe. The shell wall is preserved in patches where fine, straight or weakly frilled lirae are visible; faint imprints of oblique, irregularly raised ribs or annuli can be discerned on the surface of the internal mould.

Remarks

Holotype MB.C.11602 was originally illustrated by Remelé (1890: pl. 3 fig. 4), but this illustration is rather inaccurate. It depicts the whorl profile as nearly circular in shape, whereas it is, in fact, compressed, with a whorl width index (WWI) of 0.85–0.94 in the last half whorl. Additionally, the ornament is not as well-preserved as the illustration suggests.

Discoceras bandonis is distinguished from other representatives of the genus primarily by its large, discoidal, evolute conch with a weakly compressed and elliptic whorl profile in the late growth stage, as well as by the rather fine, evenly developed lirae on the shell surface. Additionally, the body chamber appears to be relatively short, not exceeding 180 degrees in length.

The conch geometry, whorl profile, relative diameter and position of the siphuncle, shell ornament, and suture distance in the three Estonian specimens (GIT 426-128, GIT 426-144, GIT 426-453) closely match those of the specimens classified above as *D. bandonis*. Some differences in the coiling rate (WER) and whorl width index (WWI) are likely attributable to lateral compaction, partial distortion and the larger adult size of these specimens. In terms of adult size, the three specimens correspond to the holotype of *D. tammikuense*, which comes from stratigraphically coeval strata at Tammiku (near Jõhvi) in Estonia (Balashov 1953). The holotype of *D. tammikuense* differs from the three described specimens, as well as from all specimens of *D. bandonis*, in having a rectangular whorl profile with flattened lateral and ventral sides in the late growth stage (the earlier growth stages have an elliptic whorl profile; Balashov 1953),

and a relatively narrower and more subdorsal siphuncle. However, it should be noted that the holotype of *D. tammikuense* was not available for this study; it cannot be ruled out that a physical examination would reveal that its conch geometry falls within the variation of *D. bandonis*. Furthermore, Balashov (1953) described *Discoceras tammikuense* var. *chrevitzaense* (Haljala Regional Stage, St Petersburg Region), which, according to him, differs only in having an elliptic whorl profile. This further supports the possibility that the three mentioned taxa may be synonymous.

In addition to the apparently closely similar *D. tammikuense*, the specimens of *D. bandonis* resemble representatives of *D. circulare* sp. nov.; however, in the latter, the whorl profile is circular in all growth stages, including the inner whorls.

Representatives of *D. danckelmanni* are also similar to those of *D. bandonis*, but the former species has a lower coiling rate (WER = 2.00 or less) with a more compressed whorl profile (WWI ~ 0.70 in the late growth stage); the body chamber appears to uncoil earlier in growth. However, the comparison of the two species is complicated by the poor preservation (compaction) of the types of *D. danckelmanni*.

Representatives of the two species from the Sandbian of the St Petersburg Region of Russia (*D. gubkovense* and *D. spongistratum*) are more discoidal (CWI ~ 0.20), more compressed (WWI ~ 0.70 vs > 0.90 in late growth stages) and have a whorl profile that is weakly flattened ventrally and laterally. Their terminal body chambers do not uncoil, and the shell ornament is much coarser (narrow ribs or annuli) compared to the fine lirae of *D. bandonis*. Additionally, in *D. spongistratum*, the whorl profile is wider on the ventral side than on the dorsal side (i.e., weakly trapezoidal). The holotype of *D. gubkovense* appears to have a much lower expansion rate, although this cannot be measured precisely based on the data provided by Balashov (1953).

Geographic and stratigraphic occurrence

Northern Germany, northern Poland, north-east Estonia; Sandbian–early Katian Stage, Late Ordovician.

Discoceras danckelmanni (Remelé, 1880)
Figs 14, 18–19; Table 10

Lituites Danckelmanni Remelé, 1880: 241, pl. 1 figs 7–8.

? *Lituites* (*Trocholites*) *cornuarietis* – Schmidt 1861: 199.
? *Discoceras danckelmanni* – Rüdiger 1889: 56. — Sweet 1958: 102, text-fig. 13f.
Discoceras (*Lituites*) *Danckelmanni* – Remelé 1890: 32, pl. 1 figs 7–8.
Discoceras Danckelmanni – Schröder 1891: 25(163). — Hyatt 1894: 469.
Schroederoceras danckelmanni – Balashov 1953: 261, pl. 9 fig. 2.
Discoceras danckelmanni – Sweet 1958: 102, text-fig. 13f.
Rectanguloceras danckelmanni – Stumbur 1962: 137, 142.
? *Schroederoceras danckelmani* (sic) – Saladžius 1966: 36, pl.1 fig. 2.
Rectanguloceras (*Discoceras*) – Neben & Krueger 1973: pl. 76 fig. 18.

non *Discoceras danckelmanni* – Hucke 1967: pl. 15 fig. 2.
non *Rectanguloceras* (*Discoceras*) *danckelmanni* – Neben & Krueger 1973: pl. 65 figs 3–4.

Diagnosis

Species of the genus *Discoceras* with adult conch diameters of ~ 100 mm; adult conch evolute (UWI = 0.50–0.60), moderately expanding (WER ~ 2.00); whorl profile elliptic and compressed (WWI ~ 0.70 in late growth stage); body chamber uncoiled from preceding whorl for most of its length, nearly tubular in

shape, only weakly curved and slightly flared ventrally in its apertural part; shell ornament with regularly spaced, weakly frilled lirae with symmetric crests, and irregularly spaced, low ribs on the body chamber.

Type material

Lectotype (designated herein)
GERMANY – **Brandenburg** • Eberswalde; Moldåan Regional Stage (early Katian Stage, Late Ordovician); Remelé Coll.; illustrated by Remelé (1880: pl. 1 fig. 7; 1890: pl. 1 fig. 7), re-illustrated here in Fig. 18; MB.C.11603.

Paralectotype (designated herein)
GERMANY – **Brandenburg** • 1 spec.; same data as for lectotype; illustrated by Remelé (1880: pl. 1 fig. 8) and Remelé (1890: pl. 1 fig. 8); MB.C.11570.

Other material examined

GERMANY – **Brandenburg** • 1 spec.; Hohensaaten; Moldåan Regional Stage (early Katian Stage, Late Ordovician); Neben and Krueger Coll.; illustrated by Neben & Krueger (1973: pl. 65, figs 3–4),

Fig. 18. *Discoceras danckelmanni* Remelé, 1880. Lectotype MB.C.11603 (Remelé Coll.) from Eberswalde (Brandenburg, Germany); lateral view. Scale bar units = 1 mm.

re-illustrated here in Fig. 19; MB.C.32321. – **Mecklenburg-Vorpommern** • 1 spec.; Salem (Malchin); Moldåan Regional Stage (early Katian Stage, Late Ordovician); MB.C.32320.

Description

Lectotype MB.C.11603 is a conch in the adult growth stage with an uncoiled body chamber (Fig. 18). The specimen is strongly secondarily compressed, but some measurements can still be obtained. The diameter of the conch is around 100 mm in total, and it is evolute (UWI ~ 0.50). The whorls were probably weakly compressed, elliptic, and weakly imprinted dorsally or not imprinted. The coiling rate decreases in the last whorl from 2.10 to 1.94. The body chamber is tubular, about 104 degrees in length, and its departure from the previous whorl starts shortly after the last septum; the uncoiled part is weakly curved. The shell ornament is not preserved; only indistinct traces of some irregularly thick, flat transverse ornament elements are visible on the internal mould of the body chamber.

The ornament is much better preserved in paralectotype MB.C.11570 (Fig. 19). It consists of regularly spaced lirae, which are weakly frilled and have symmetric crests; in addition, low, rounded ribs are indicated ventrolaterally. The whorl profile in the paralectotype is not as strongly distorted as in the lectotype; it appears to be compressed (WWI = 0.70) and elliptic in shape.

Fig. 19. *Discoceras danckelmanni* Remelé, 1880. Specimen MB.C.32321 (Remelé Coll.) from Eberswalde (Brandenburg, Germany); lateral view. Scale bar units = 1 mm.

Table 10. Conch measurements, ratios and rates of *Discoceras danckelmanni* (Remelé, 1880).

specimen	dm	ww	wh	uw	ah	CWI	WWI	UWI	WER	IZR
MB.C.11603	98.1	–	27.7	49.2	–	–	–	0.50	1.94	–
minus 180°	70.4	–	21.2	32.9	–	–	–	0.47	2.06	–
MB.C.32321	91.2	–	26.4	55.9	26.4	–	–	0.61	1.98	0.00

Specimen MB.C.32320 is a compacted, fragmentary conch in the adult growth stage. The specimen shows the uncoiled body chamber, about 85 degrees in length, with a slightly flared ventral side.

Specimen MB.C.32321 is a nearly complete conch, consisting of over three whorls and with a maximum diameter of 93 mm. At this diameter, the conch is evolute (UWI = 0.61) and moderately expanding (WER = 1.98). The conch is embedded in rock from one lateral side, hence the whorl width cannot be measured. The shell wall is preserved only locally and bears fine, relatively regularly spaced transverse lirae. The relative cameral length (RCL) is about 0.20 in the last whorl; suture lines appear to be nearly straight or only with a shallow lateral and ventral sinus. The last 100 degrees of the conch are occupied by the body chamber, which is uncoiled from about the last septum and is nearly tubular in shape; the uncoiled part is weakly curved and almost straight.

Remarks

Discoceras danckelmanni was described by Remelé (1880) based on two distorted (compacted) specimens. Additionally, the type specimens are not accurately illustrated by Remelé (1880, 1890); the ornamentation is only faintly preserved, and the specimens do not show the siphuncle or septa. Since the specimens are compacted, the whorl profile is not as strongly compressed as indicated by Remelé (1880, 1890) and Sweet (1958: text-fig. 13f).

Despite the poor preservation of the type material, some measurements and descriptions could still be made, and two other specimens, MB.C.32320 and MB.C.32321 from the herein studied collection, were assigned to the species.

Discoceras danckelmanni can be distinguished from other species of the genus by its large, discoidal conch. The body chamber is probably rather short, with a low expansion rate, and remains nearly tubular except for a slight ventral flaring in its apertural region. The whorls are also relatively slowly expanding and have an elliptic and weakly compressed profile. Most similar to *D. danckelmanni* is *D. bandonis*, in which the whorl profile is less compressed (WWI ~0.90 vs 0.70) and which has a higher coiling rate (WER of 2.00 in late growth stage); its body chamber uncoils from the previous whorl at about mid-length or later.

The holotypes of three species from the Haljala Regional Stage (Sandbian) of Estonia and the St Petersburg Region of Russia (*D. tammikuense*, *D. gubkovense*, and *D. spongistratum*) are also similar to the specimens of *D. danckelmanni*. All three of these species have rather large (95–145 mm), discoidal and slowly expanding conchs (WER ~2.00) with weakly subrectangular, subtrapezoidal, or elliptic, compressed whorl profiles (WWI = 0.70–0.80), and their shells are ornamented with lirae and/or low ribs. In contrast to the specimens of *D. danckelmanni*, only the adapertural end of the body chamber is uncoiled in *D. tammikuense*, while in *D. gubkovense* and *D. spongistratum*, the body chamber is not uncoiled at all.

The specimens of *D. paopense* are larger in adult size (120 mm vs 100 mm) than *D. danckelmanni*, and the whorl profile appears less compressed (WWI 0.80–0.90 vs ~0.70) with a flattened venter; the body chamber uncoils later in ontogeny.

Geographic and stratigraphic occurrence

Northern Germany and northern Estonia; early Katian Stage, Late Ordovician.

Discoceras aseriense sp. nov.
urn:lsid:zoobank.org:act:7E00DA96-8FBD-4160-996E-B0EA30BECF3E
Figs 14, 20; Table 11

Diagnosis

Species of the genus *Discoceras* with an adult conch diameter of about 90 mm, terminal body chamber uncoiled. Conch in the last half whorl thinly discoidal (CWI ~0.30) and evolute (UWI ~0.50) with WER of ~1.75 in late growth stage. Whorl profile not imprinted dorsally , weakly depressed (WWI ~1.10) with rounded or slightly flattened venter and flanks. Phragmocone chambers with RCL ~0.25 in last whorl. Suture line straight on the venter or with a shallow ventral and lateral lobes. Shell on inner whorls ornamented with fine lirae, and in the last whorl with regularly spaced, narrow, rounded ribs or flat annuli.

Etymology

From 'Aseri', referring to the type horizon.

Type material

Holotype

ESTONIA • Koila (Lääne-Viru County); Aseri Regional Stage (Darriwilian Stage, Middle Ordovician); Schmidt Coll.; illustrated in Fig. 20; GIT 225-1084.

Fig. 20. *Discoceras aseriense* sp. nov. Holotype GIT 225-1084 (Schmidt Coll.) from Koila (Lääne-Viru County, Estonia); lateral view. Scale bar units = 1 mm.

Table 11. Conch measurements, ratios and rates of *Discoceras aseriense* sp. nov.

specimen	dm	ww	wh	uw	ah	CWI	WWI	UWI	WER	IZR
GIT 225-1084	82.2	22.2	21.2	43.1	20.2	0.27	1.05	0.52	1.76	0.05
minus 90°	72.7	–	21.0	36.1	–	–	–	0.50	–	–
minus 180°	62.1	–	18.0	29.9	–	–	–	0.48	–	–

Description

Holotype GIT 225-1084 is an adaperturally uncoiled phragmocone in the adult growth stage, with a total diameter of approximately 90 mm; the last 2.5 whorls are preserved (Fig. 20). The body chamber is preserved over a length of about 120 degrees and becomes uncoiled from the phragmocone after about 100 degrees (at a coiled diameter of ~82 mm). In the last half whorl, the conch is discoidal (CWI = 0.27) and evolute (UWI increases from 0.48 to 0.52), with a coiling rate (WER) of 1.76 at dm = 82 mm. The whorls are not imprinted dorsally; the whorl profile is weakly depressed to equidimensional (WWI = 1.05), appearing slightly flattened on the ventral side. The relative cameral length (RCL) is 0.25 in the last whorl, with the final phragmocone chambers shortened. The suture line exhibits shallow ventral and lateral lobes. The shell ornament is preserved on the inner whorls, where it consists of fine lirae, and locally on the body chamber, where it comprises rather regularly spaced, narrow, rounded ribs or annuli.

Remarks

With its occurrence in the Aseri Regional Stage, the holotype of *Discoceras aseriense* sp. nov. represents the stratigraphically oldest known representative of *Discoceras* from Baltica, predating the Lasnamägian *D. depressum* of Norway and the Uhakuan *D. rarospirum* of Estonia, if not globally.

Among other species, the holotype of *D. aseriense* sp. nov. appears to be most similar in conch geometry and shell ornamentation to a late Darriwilian or early Sandbian specimen from Norway, which Sweet (1958: pl. 8 fig. 7) assigned to "*Discoceras arcuatum*?". However, it is difficult to compare the two based on the available information and the limited data on the internal whorls and siphuncle. Moreover, the validity of *D. arcuatum* has been questioned (Rasmussen & Surlyk 2012), as both type specimens were likely lost during World War II. Therefore, this matter remains unresolved until more complete specimens are available to allow proper taxonomic assignments.

The other Darriwilian representatives of *Discoceras* differ from the holotype of *D. aseriense* sp. nov. more significantly. The holotype of *D. depressum* has a depressed whorl profile even in the late ontogenetic stage (WWI ~1.35). The representatives of *D. rarospirum* do not uncoil adaperturally. The specimens of *D. boreale* have shorter phragmocone chambers (RCL 0.14–0.20 vs 0.25), and the whorl profile becomes slightly compressed in later growth stages (WWI = 0.90).

The other Darriwilian representatives of *Discoceras* differ from the holotype of *D. aseriense* sp. nov. more significantly. The holotype of *D. depressum* has a depressed whorl profile even in late ontogenetic stages (WWI ~1.35). The representatives of *D. rarospirum* do not uncoil adaperturally. The specimens of *D. boreale* have shorter phragmocone chambers (RCL 0.14–0.20 vs 0.25) and the whorl profile is becomes slightly compressed in growth (WWI = 0.90 in late ontogeny).

Among the specimens studied herein, the holotype of *D. aseriense* sp. nov. is most similar to specimen MB.C.32328 (*D.* sp. indet.). However, at a diameter of 70 mm, the whorl profile in MB.C.32328 is weakly subquadrate with a convex venter and slightly flattened flanks. The shell ornamentation in the outer whorl of the holotype appears more distinctly and regularly developed. The two specimens are difficult to compare, however, due to the incomplete preservation of MB.C.32328 and the lack of

information on the whorl profile and siphuncle in the holotype of *D. aseriense*. Additionally, the two specimens are significantly separated stratigraphically (Aseri vs Haljala Regional Stages), which is a further argument for keeping them separate until better-preserved material is available.

Geographic and stratigraphic occurrence

Northern Estonia; Aseri Regional Stage, Darriwilian Stage, Middle Ordovician.

Discoceras brandenburgense sp. nov.
urn:lsid:zoobank.org:act:26674E19-CF3F-4E2C-B25C-A42F123EE5BF
Figs 14, 21; Table 12

Rectanguloceras cf. *roemeri* – Neben & Krueger 1973: pl. 65 figs 1–2.
Discoceras roemeri – Kröger 2013a: 73.

Diagnosis

Species of the genus *Discoceras* with an adult conch diameter of about 80 mm. Conch tightly coiled up to diameter of about 64 mm; body chamber and adapertural part of phragmocone widely uncoiled. Conch increasingly discoidal (CWI decreases from 0.40 to 0.30 in last three quarters of a whorl) with decreasing coiling rate (WER_{wh} decreasing from 2.50 to 2.00). Whorl profile subcircular, equidimensional to weakly depressed (WWI ~ 1.05) in last whorl but equidimensional and slightly ventrally flattened in body chamber. Phragmocone chambers short (RCL = 0.18 in last whorl), suture line with broad lateral lobe, straight across venter.

Etymology

From Brandenburg (Germany), the region of the type locality.

Type material

Holotype

GERMANY – **Brandenburg** • Niederfinow; Moldåan Regional Stage (early Katian Stage, Late Ordovician); Neben Coll.; illustrated in Fig. 21; MB.C.32324.

Description

Holotype MB.C.32324 is a conch with a maximum diameter of 82 mm; approximately 3.25 whorls are preserved, with the last ~100 degrees of the outer whorl being uncoiled (Fig. 21). The coiled portion has a diameter of about 64 mm. In the last three-quarters of a whorl, the conch becomes increasingly discoidal (CWI decreases from 0.38 to 0.31) and increasingly evolute (UWI increases from 0.41 to 0.48), while the coiling rate (WER) decreases from 2.51 to 1.97. The whorl profile is nearly circular, transitioning from equidimensional to slightly depressed (WWI increases to 1.03 to 1.08) throughout the last whorl, before becoming equidimensional again at the end of the body chamber, with a slightly flattened venter. The body chamber is preserved over a length of approximately 90 degrees; it is tubular in shape, with only a slightly flared venter. The phragmocone chamber length (RCL) is 0.18 in the last whorl. The shell ornament is preserved only in a small area on the venter at the end of the last whorl, where it consists of fine lirae.

Remarks

Holotype MB.C.32324 is unique among the species of *Discoceras* due to its comparatively small adult conch diameter of 82 mm. It is widely uncoiled, slowly expanding last volution, has an equidimensional or slightly depressed whorl profile that is ventrally slightly flattened, and shows the presence of short phragmocone chambers.

Table 12. Conch measurements, ratios and rates of *Discoceras brandenburgense* sp. nov.

specimen	dm	ww	wh	uw	ah	CWI	WWI	UWI	WER	IZR
MB.C.32324	63.7	19.8	18.3	30.7	18.3	0.31	1.08	0.48	1.97	0.00
minus 90°	52.6	17.0	15.8	23.2	15.8	0.32	1.08	0.44	2.04	0.00
minus 180°	44.0	16.0	14.7	18.6	14.7	0.36	1.09	0.42	2.25	0.00
minus 270°	36.8	14.0	13.6	15.2	13.6	0.38	1.03	0.41	2.51	0.00
minus 360°	29.3	–	10.7	11.1	10.7	–	–	0.38	2.47	0.00
minus 450°	23.2	–	8.0	7.9	8.0	–	–	0.34	2.33	0.00
minus 540°	18.6	–	7.5	5.2	7.5	–	–	0.28	2.82	0.00
minus 630°	15.2	–	7.3	–	7.3	–	–	–	3.70	0.00
minus 720°	11.1	–	5.9	–	5.9	–	–	–	4.54	0.00
minus 810°	7.9	–	5.6	–	5.6	–	–	–	–	0.00

Neben & Krueger (1973) classified holotype MB.C.32324 as "*Rectanguloceras (Discoceras)* cf. *roemeri*" (see also Kröger 2013a). However, the terminal conch of *D. roemeri* is much larger (up to 150 mm in diameter) with an elliptic, depressed to quadrangular whorl profile. In *D. roemeri*, the last whorl uncoils from the preceding whorl only at the very end of the body chamber, whereas it is much more widely uncoiled in holotype MB.C.32324. Additionally, the phragmocone chambers are longer in *D. roemeri* (RCL ~0.25 vs ~0.18 in the last whorl).

Holotype MB.C.32324 is similar in umbilical width, conch width and expansion rate to the holotype of *D. polonicum* sp. nov. (MB.C.11992); the latter also has an uncoiled outer whorl. However, the whorl profile in MB.C.11992 is compressed (WWI ~0.90 in the last volution) and ventrally rounded. Additionally, the last 90 degrees of the conch expand more rapidly in MB.C.11992 (WER = 2.27–2.15 vs 2.04–1.97 in MB.C.32324).

Fig. 21. *Discoceras brandenburgense* sp. nov. Holotype MB.C.32324 (Neben Coll.) from Niederfinow (Brandenburg, Germany); dorsal, lateral and ventral views. Scale bar units = 1 mm.

Geographic and stratigraphic occurrence

Northern Germany; early Katian Stage, Late Ordovician.

Discoceras angustum sp. nov.
urn:lsid:zoobank.org:act:A67ACC33-C790-4987-A16C-FBE9797AC8EE
Fig. 22

Diagnosis

Species of the genus *Discoceras* with adult conch diameter of 70 mm or more; conch extremely discoidal (CWI ~0.30) and evolute (UWI ~0.45); whorls weakly imprinted dorsally or not imprinted (IZR close to zero); whorl profile changes from nearly equidimensional (WWI ~1) to weakly depressed (WWI ~1.10) with convex flanks and slightly flattened venter; whorl expansion rate increases up to WER ~2.3 at ~50 mm conch diameter; relative cameral length (RCL) of 0.14 in the last whorl; shell ornament with low and irregularly thick transverse ribs; fine spiral elements in early growth stage.

Etymology

From the Latin 'angustum' (adj., neut.) = 'narrow', referring to the remarkably short phragmocone chambers.

Type material

Holotype

ESTONIA • Rakvere (Lääne-Viru County); Keila Regional Stage (late Sandbian or early Katian Stage, Late Ordovician); illustrated in Fig. 22; TUG 2-731.

Description

Holotype TUG 2-731 is an internal mould of a conch in the subadult or adult growth stage, embedded in the rock matrix on one side (Fig. 22). Internal structures are almost entirely destroyed, but some whorl

Fig. 22. *Discoceras angustum* sp. nov. Holotype TUG 2-731 from Rakvere (Lääne-Viru County, Estonia); reconstructed cross section and lateral view. Scale bar units = 1 mm.

profiles can be partially reconstructed. The conch has a diameter of 70 mm, with two outer volutions visible. In the last 1.5 whorls, the whorl profile transitions from nearly equidimensional (WWI = 0.97 at whorl height of 9 mm) to weakly depressed (WWI = 1.12 at a whorl height of 21 mm), subquadrate in shape, with convex flanks and an apparently slightly flattened venter. The coiling rate (WER) increases from 1.87 to 2.28, while the conch width index (CWI) increases from 0.27 to 0.33. At its maximum diameter, the conch is evolute (UWI = 0.45). At a whorl width of 9 mm, the siphuncle is positioned close to the dorsal shell wall and has a relative septal foramen height (RSH) of 0.18. The phragmocone chambers are markedly short, with a relative cameral length (RCL) of about 0.14 of the respective whorl height in the last whorl. The suture lines form shallow lateral and ventral lobes. The internal mould shows traces of strongly oblique, low, and irregularly thick transverse ornament elements. Additionally, fine spiral elements are discernible on the flank of the innermost preserved whorl.

Remarks

The flanks of the outer volution of the conch in specimen TUG 2-731 have a shallow impression with a series of thin grooves, measuring up to 6 mm in total width. Similar structures have been described in coiled cephalopods before and interpreted as evidence of conch damage during earlier ontogeny (Manda & Turek 2018; Aubrechtová & Korn 2025), as a colour band (Kröger & Aubrechtová 2019), or as a type of ornament produced by the elevation of costae (Kröger 2025). However, the shell wall is not preserved in specimen TUG 2-731, and it is unclear how this lateral band manifests on the shell surface. Therefore, further interpretation is avoided here.

It appears that the ontogenetic trajectories of several characters in TUG 2-731 are rather unique. The whorl profile becomes more depressed, and the expansion rate increases during growth. The latter may indicate that the specimen does not yet represent the adult growth stage.

Specimen TUG 2-731 differs from all other representatives of *Discoceras* with subquadrate or weakly depressed whorl profiles, such as *D. vesenbergense* and *D. roemeri*, in possessing very short phragmocone chambers and fine spiral ornamentation in the early growth stage.

Geographic and stratigraphic occurrence

Northern Estonia; Keila Regional Stage, late Sandbian or early Katian Stage, Late Ordovician.

Discoceras circulare sp. nov.
urn:lsid:zoobank.org:act:E909E2E3-131A-4015-8856-5F94EAB67E91
Figs 23–24; Table 13

Diagnosis

Species of the genus *Discoceras* with adult conch diameter of over 100 mm; conch extremely discoidal (CWI ~0.30) and subevolute (UWI ~0.40); whorls weakly imprinted dorsally or not imprinted (IZR close to zero); whorl profile remains nearly equidimensional (WWI ~1.00) with convex flanks and venter; whorl expansion rate decreases in ontogeny up to WER ~2.10; relative cameral length (RCL) of 0.25 in the last whorl; body chamber slightly uncoiled adaperturally and slightly flared; siphuncle subdorsal with a relative septal foramen height (RSH) of ~0.20 in the last whorl; shell ornament of fine, regularly spaced lirae which are not frilled or weakly frilled and weakly imbricated.

Etymology

From the Latin ‘circulare’ (adj., neut.) = ‘circular’, referring to the shape of the whorl profile.

Type material

Holotype

ESTONIA • Aluvere quarry (Lääne-Viru County); late Haljala Regional Stage (Sandbian Stage, Late Ordovician); illustrated in Fig. 24; GIT 426-145.

Paratype

GERMANY – **Brandenburg** • Schlabendorf (near Calau); early Haljala regional Stage (Sandbian, Late Ordovician); Krueger Coll.; MB.C.32325.

Description

Holotype GIT 426-145 is a conch of a nearly adult or adult individual with a maximum diameter of 102 mm (Fig. 24). The last 2.25 whorls are preserved; the conch is adaperturally incomplete, with at least 90 degrees of the outermost volution missing and indicated only by remains on the outer surface of the penultimate whorl. During growth, the conch is discoidal (CWI decreases from 0.46 to 0.34) and moderately evolute (UWI increases from 0.28 to 0.41). The coiling rate (WER) decreases from 2.83 at a diameter of 34 mm to 2.13 at a diameter of 83 mm. The whorl profile is weakly imprinted dorsally, subcircular, and equidimensional (WWI ~ 1.00). The siphuncle has a subdorsal position and a relative septal foramen height (RSH) of about 0.19. The shell ornament consists of well-developed transverse lirae, which are regularly spaced and not frilled or only weakly frilled. In the last half whorl, the lirae are irregularly thickened, with very fine lines present between thicker lines, and low, rounded annuli are indicated.

Paratype MB.C.32325 is a conch in the adult growth stage with a diameter of 105 mm with the last 2.5 volutions preserved. The conch is extremely discoidal (CWI = 0.31) and subevolute (UWI = 0.43) with a high coiling rate (WER = 2.19). At its largest diameter, the whorl profile is subcircular and nearly equidimensional (WWI = 0.97). The body chamber is preserved over 95 degrees and becomes uncoiled after about 70 degrees. It appears to be adaperturally slightly flared on its ventral and lateral sides, with a slight indication of a ventral sinus. However, it is not clearly visible whether the aperture is preserved. The relative cameral length (RCL) is 0.25 at dm = 70.9 mm. The ornament consists of regularly spaced lirae, which are not frilled or only weakly frilled and slightly imbricated.

Remarks

The holotype and paratype of *Discoceras circulare* sp. nov. are most similar to specimens assigned to *Discoceras bandonis*, but they differ in having a more circular whorl profile (WWI ~ 1.00 vs 0.93 at the corresponding conch diameter).

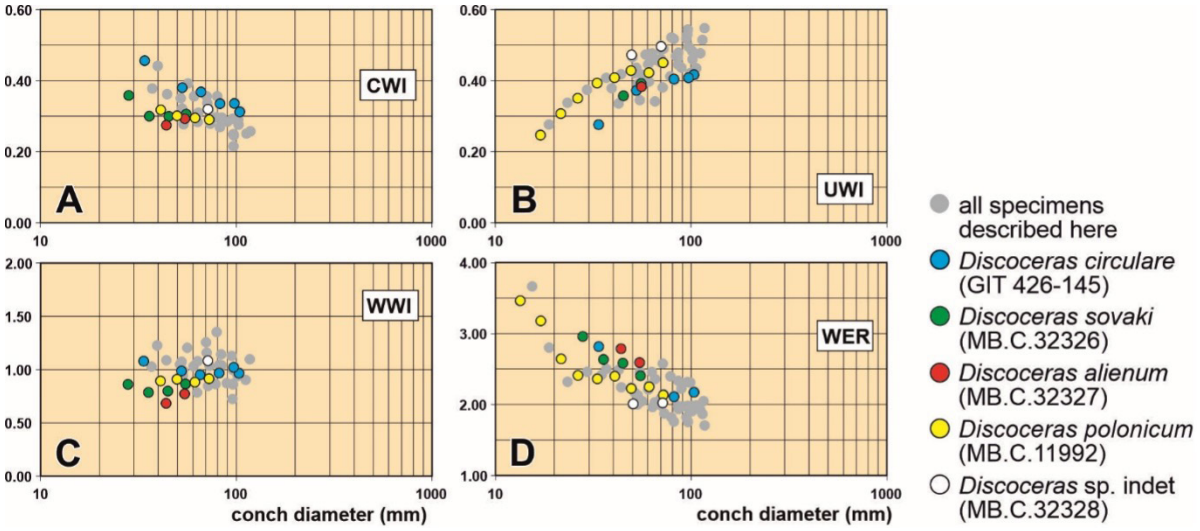

Fig. 23. Ontogenetic development of the conch width index (CWI), umbilical width index (UWI), whorl width index (WWI) and whorl expansion rate (WER) of various species of *Discoceras* Barrande, 1867.

Table 13. Conch measurements, ratios and rates of *Discoceras circulare* sp. nov.

specimen	dm	ww	wh	uw	ah	CWI	WWI	UWI	WER	IZR
MB.C.32325	104.8	33.1	34.0	43.9	34.0	0.32	0.97	0.42	2.19	0.00
GIT 426-145	98.3	33.3	32.4	40.3		0.34	1.03	0.41	–	–
minus 90°	82.6	28.0	28.7	33.6	26.0	0.34	0.97	0.41	2.13	0.10
minus 180°	65.9	24.5	25.6	–	–	0.37	0.96	–	–	–
minus 270°	52.7	20.2	20.3	19.7	–	0.38	1.00	0.37	–	–
minus 450°	33.6	15.4	14.2	9.4	13.6	0.46	1.09	0.28	2.83	0.04

The conch geometry in the representatives of *Discoceras circulare* sp. nov. falls within the variability described for the late Katian to early Hirnantian *D. roemeri* (Kröger 2025). However, *D. roemeri* differs in having a greater adult size (140 mm), a subquadratic whorl profile in subadult growth stages, and a stronger ornamentation consisting of imbricated lamellae, irregularly spaced costae, and shallow ribs.

Geographic and stratigraphic occurrence

Northern Germany, Estonia; Haljala Regional Stage, Sandbian Stage, Late Ordovician.

Fig. 24. *Discoceras circulare* sp. nov. Holotype GIT 426-145 from Aluvere quarry (Lääne-Viru County, Estonia); lateral view, broken cross section surface and reconstructed cross section. Scale bar units = 1 mm.

Discoceras sovaki sp. nov.
urn:lsid:zoobank.org:act:4A540D1B-F7B7-4638-827F-336D8CD3EAB0
Figs 23, 25; Table 14

Rectanguloceras (*Discoceras*) *danckelmanni* – Neben & Krueger 1973: pl. 65 figs 3–4.

Diagnosis

Species of the genus *Discoceras* with adult conch size of ~70 mm, of which the coiled part is ~55 mm in diameter; body chamber uncoils from about half of its length onward; whorl profile in external volution weakly compressed (WWI between 0.78 and 0.86), barely imprinted dorsally (IZR close to zero or zero), and elliptic in shape, slightly ventrally flattened from the base of the body chamber; shell ornament of sharp, raised lirae or thin annuli, evenly spaced, slightly imbricated with fine lirae or growth lines in between them.

Etymology

In honour of the late Jan Sovák (1953–2025), Czech painter renowned for vivid reconstructions of prehistoric life, including early Palaeozoic cephalopods.

Type material

Holotype

GERMANY – **Brandenburg** • Prenzlau; Moldåan Regional Stage (early Katian Stage, Late Ordovician); Neben Coll.; illustrated in Fig. 25; MB.C.32326.

Description

Holotype MB.C.32326 is a conch of an adult individual with an adorally incomplete, uncoiled body chamber (Fig. 25). The maximum diameter of the conch is 70 mm, with the coiled part accounting for up to 55 mm. In the last 0.75 whorls, the conch is discoidal (CWI decreases from 0.36 to 0.31) and subevolute (UWI increases up to 0.39). The coiling rate (WER_{wh}) decreases from 2.98 to 2.42. The whorl profile is weakly compressed (WWI between 0.78 and 0.86), very weakly imprinted dorsally or

Fig. 25. *Discoceras sovaki* sp. nov. Holotype MB.C.32326 (Neben Coll.) from Prenzlau (Brandenburg, Germany); ventral, lateral and dorsal views. Scale bar units = 1 mm.

Table 14. Conch measurements, ratios and rates of *Discoceras sovaki* sp. nov.

specimen	dm	ww	wh	uw	ah	CWI	WWI	UWI	WER	IZR
MB.C.32326	54.3	16.0	20.7	20.9	20.7	0.29	0.77	0.38	2.61	0.00
minus 90°	43.5	12.0	17.5	–	17.5	0.28	0.68	–	2.81	0.00
minus 180°	35.5	10.7	13.7	–	13.7	0.30	0.78	–	2.65	0.00
minus 270°	27.8	10.0	11.7	–	11.7	0.36	0.86	–	2.98	0.00

not imprinted (IZR close to zero or zero) and elliptic in shape. From the rear part of the body chamber, the profile is slightly flattened ventrally. The suture line has a low lateral lobe and an external saddle. The body chamber is preserved over 115 degrees and becomes uncoiled from the previous whorl after ~70 degrees, with no indication of proximity to the aperture. In the outer volution, the relative cameral length (RCL) is 0.14. The shell ornament consists of sharp, raised lirae or thin annuli, which are also visible on the internal mould. The ornament elements are evenly spaced, slightly imbricated, and have fine lirae or growth lines between them.

Remarks

Discoceras sovaki sp. nov. is distinguished from other species of the genus by its comparatively small, extremely discoidal, adaperturally uncoiled, and sharply ornamented conch.

The holotype of *D. sovaki* sp. nov. is most similar to the holotype of *D. alienum* sp. nov., but differs in its larger adult size (70 mm vs 50 mm) and in having a body chamber that is much more strongly uncoiled from the previous whorls. Additionally, *D. sovaki* has a lower coiling rate (WER_{wh} = 2.42 vs 2.61 at a diameter of 55 mm), a less compressed whorl profile (WWI = 0.86 vs 0.77 at dm = 55 mm), and a coarser shell ornamentation (sharp lirae or thin annuli vs fine lirae).

The conch ratios of *D. sovaki* sp. nov. are also similar to those of the late Sandbian *D. vasalemmense* from Estonia. However, in late growth stages, the latter species exhibits a heart-shaped whorl profile (where the conch narrows ventrally) and an even coarser ornamentation with strongly crenulated and irregularly spaced transverse elements (Kröger & Aubrechtová 2018).

Geographic and stratigraphic occurrence

Northern Germany; early Katian Stage, Late Ordovician.

Discoceras alienum sp. nov.
urn:lsid:zoobank.org:act:6E931B16-8922-43E2-9558-DD1F36CE8A40
Figs 23, 26; Table 15

Diagnosis

Species of the genus *Discoceras* with adult conch size of 55 mm; adapertural half of the body chamber slightly uncoiled; whorl profile in external volution weakly compressed (WWI = 0.77), barely imprinted dorsally (IZR close to zero or zero), and elliptic in shape; aperture extended with a ventral sinus; shell ornament of raised lirae, slightly unevenly spaced, slightly imbricated with fine lirae or growth lines in between.

Etymology

From the Latin ‘alienum’ (adj., neut.) = ‘foreign’, referring to the origin of the holotype from erratic boulders.

Table 15. Conch measurements, ratios and rates of *Discoceras alienum* sp. nov.

specimen	dm	ww	wh	uw	ah	CWI	WWI	UWI	WER	IZR
MB.C.32327	54.3	16.0	20.7	20.9	20.7	0.29	0.77	0.38	2.61	0.00
minus 90°	43.5	12.0	17.5	–	17.5	0.28	0.68	–	2.81	0.00

Type material

Holotype

GERMANY – **Brandenburg** • Oderberg; Moldåan Regional Stage (early Katian Stage, Late Ordovician); Neben Coll.; illustrated in Fig. 26; MB.C.32327.

Description

Holotype MB.C.32327 is an adult conch, 55 mm in diameter, with a partly uncoiled body chamber (Fig. 26). The conch is discoidal (CWI = 0.29) and subevolute (UWI = 0.38). In the last 90 degrees of the conch, the coiling rate (WER_{wh}) decreases from 2.81 to 2.61, and the whorl profile becomes less compressed (WWI increases from 0.68 to 0.77); it is elliptic in shape. The whorls are weakly imprinted dorsally or not imprinted (IZR close to zero). The body chamber is preserved over 148 degrees, with its adapertural half uncoiled from the preceding whorl; the aperture extends into a small ventral sinus. The relative cameral length (RCL) in the last half whorl is 0.20. The shell surface has raised lirae (also visible on the internal mould), which are slightly unevenly spaced and slightly imbricated; fine lirae or growth lines are present between the coarser elements.

Remarks

Discoceras alienum sp. nov. differs from other species of the genus by its comparatively small, adaperturally only weakly uncoiled, and extremely discoidal conch with a compressed, elliptic whorl profile.

Discoceras alienum sp. nov. closely resembles *D. sovaki* sp. nov., but the former is smaller (55 mm vs 70 mm) and has a less strongly uncoiled body chamber. Additionally, *D. alienum* has a higher expansion rate (WER_{wh} = 2.61 vs 2.42 at dm = 55 mm), a more compressed whorl profile (WWI = 0.77 vs 0.86 at dm = 55 mm), and a finer shell ornamentation (raised lirae vs regularly spaced sharp lirae or thin annuli).

Fig. 26. *Discoceras alienum* sp. nov. Holotype MB.C.32327 (Neben Coll.) from Oderberg (Brandenburg, Germany); dorsal reconstruction, dorsal, lateral and ventral views. Scale bar units = 1 mm.

Discoceras vasalemmense differs from *D. alienum* sp. nov. in having a heart-shaped whorl profile and a coarser shell ornamentation, which consists of strongly crenulated and irregularly spaced transverse elements (Kröger & Aubrechtová 2018).

Geographic and stratigraphic occurrence

Northern Germany; early Katian Stage, Late Ordovician.

Discoceras polonicum sp. nov.
urn:lsid:zoobank.org:act:ADC2FF6A-2F7C-48AD-9147-99C6A6D76B02
Figs 23, 27; Table 16

Diagnosis

Species of the genus *Discoceras* with adult conch diameter of ~100 mm where the last 50 degrees are uncoiled (diameter of coiled part ~70 mm); conch extremely discoidal (CWI ~0.30) and evolute (UWI up to 0.45); whorls not imprinted dorsally (IZR close to zero); whorl profile in the last whorl elliptic and weakly compressed (WWI ~0.90); whorl expansion rate decreases to WER ~2.20); shell ornament of imbricated lirae and evenly distributed thin ribs.

Etymology

From the Latin 'polonicum' (adj., neut.) = 'polish', referring to the origin of the holotype.

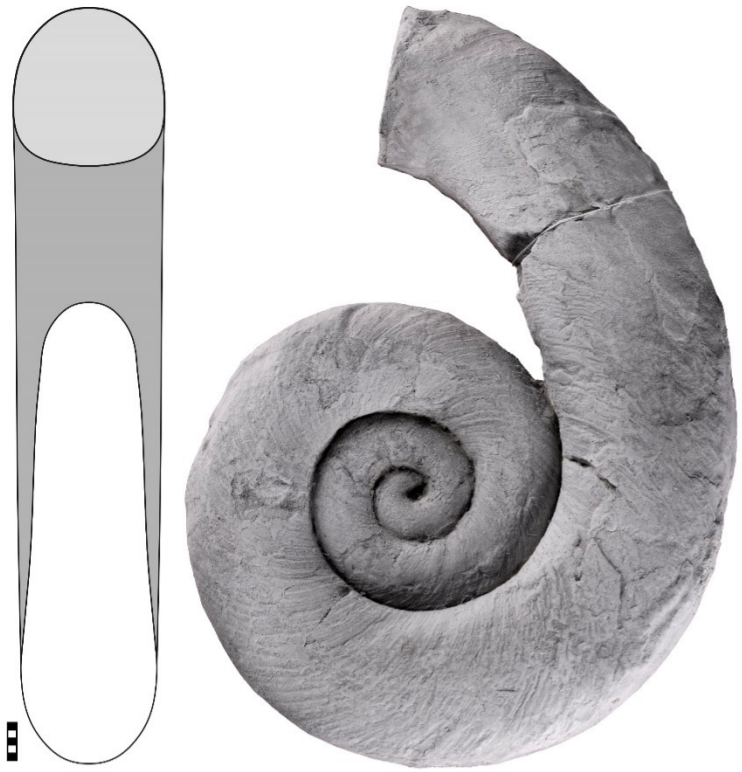

Fig. 27. *Discoceras polonicum* sp. nov. Holotype MB.C.11992 (Neben Coll.) from Ustronie Morskie (West Pomerania, Poland); dorsal reconstruction and lateral view. Scale bar units = 1 mm.

Table 16. Conch measurements, ratios and rates of *Discoceras polonicum* sp. nov.

specimen	dm	ww	wh	uw	ah	CWI	WWI	UWI	WER	IZR
MB.C.11992	72.7	21.2	23.1	33.1	23.1	0.29	0.92	0.45	2.15	0.00
minus 90°	61.3	18.2	20.6	26.2	20.6	0.30	0.88	0.43	2.27	0.00
minus 180°	49.5	15.0	16.5	21.4	16.5	0.30	0.91	0.43	2.24	0.00
minus 270°	40.7	13.0	14.5	16.8	14.5	0.32	0.89	0.41	2.42	0.00
minus 360°	33.1	–	11.6	13.1	11.6	–	–	0.40	2.38	0.00
minus 450°	26.2	–	9.4	9.3	9.4	–	–	0.35	2.43	0.00
minus 540°	21.4	–	8.3	6.7	8.3	–	–	0.31	2.66	0.00
minus 630°	16.8	–	7.4	4.2	7.4	–	–	0.25	3.20	0.00
minus 720°	13.1	–	6.1	–	6.1	–	–	–	3.48	0.00
minus 810°	9.4	–	5.2	–	5.2	–	–	–	4.97	0.00

Type material

Holotype

POLAND – **West Pomerania** • Ustronie Morskie; Moldåan Regional Stage (early Katian Stage, Late Ordovician); Müldner Coll.; illustrated in Fig. 27; MB.C.11992.

Description

Holotype MB.C.11992 is a plaster cast of a nearly complete conch in the adult growth stage. The conch has a maximum diameter of 100 mm and consists of 3.25 volutions (Fig. 27). The last 50 degrees of the external volution are widely uncoiled (diameter of the coiled part is 73 mm). In the last 0.75 whorl, the conch is extremely discoidal (CWI decreases from 0.32 to 0.29), more evolute (UWI increases from 0.41 to 0.45), and less expanded (WER decreases from 2.42 to 2.15). The whorl profile is weakly compressed (WWI around 0.90), elliptic, and barely imprinted dorsally (IZR close to zero). The shell ornament consists of imbricated lirae and evenly distributed thin ribs.

Remarks

The discoidal, compressed and adaperturally uncoiled conch of the holotype of *Discoceras polonicum* sp. nov. is similar to the holotypes of *D. sovaki* sp. nov. and *D. alienum* sp. nov. However, both *D. sovaki* and *D. alienum* are smaller in the adult stage (100 mm vs 70 mm and 55 mm, respectively), less compressed (WWI = 0.92 vs 0.86 and 0.77, respectively, at maximum conch diameter), and more expanded (WER_{wh} = 2.15 vs 2.42 and 2.61, respectively, at maximum conch diameter). Additionally, *D. alienum* has a finer shell ornamentation than *D. polonicum*, and the body chamber does not uncoil as strongly in the former.

The holotype of *D. polonicum* sp. nov. (MB.C.11992) is also somewhat similar to the holotype of *D. brandenburgense* sp. nov. (MB.C.32324). The similarities include umbilical width, conch width, expansion rate, and the wide uncoiling of the last volution. However, the whorl profile in MB.C.32324 is not compressed but equidimensional or weakly depressed (WWI = 1.03–1.09), and the last 90 degrees of the conch expand much less rapidly (WER = 2.04–1.97 vs 2.27–2.15 in *D. polonicum*).

Geographic and stratigraphic occurrence

Northern Poland; early Katian Stage, Late Ordovician.

Discoceras sp. indet.
Figs 23, 28

Material examined

GERMANY • 1 spec.; Britz (Berlin); Haljala Regional Stage (Sandbian Stage); Neben Coll.; illustrated in Fig. 28; MB.C.32328.

Description

Specimen MB.C.32328 is a coiled phragmocone with a diameter of 72 mm; it consists of two and a half whorls (Fig. 28). At its largest diameter, the conch is thinly discoidal (CWI = 0.32) and evolute (UWI = 0.50) with a high coiling rate (WER = 2.02). The whorls are not imprinted dorsally; the whorl profile is weakly depressed (WWI = 1.08) and weakly subquadratic with rounded venter and slightly flattened flanks. The phragmocone chamber length (RCL) is 0.24 in the last half whorl. The suture line has a shallow lateral lobe and it is straight on the venter. The siphuncle is very close to or in contact with the dorsal shell wall; its diameter cannot be measured exactly, but it appears to be about 0.25 of the corresponding whorl height. The shell ornament consists of fairly regularly spaced, flat annuli accompanied by fine lirae, which extend in a rather deep ventral sinus; on the internal mould, the annuli are rounded. The inner whorls of the conch cannot be measured and appear to be asymmetrically coiled but this is probably the result of inaccurate preparation or gluing by previous researchers.

Remarks

Specimen MB.C.32328 has an incomplete aperture and it is not possible to determine the size of the adult conch or whether the last whorl and body chamber were uncoiled. Its geometry is rather similar to that in the holotype of *Discoceras aseriense* sp. nov. (GIT 225-1084). The latter differs from specimen N21 in the whorl profile at dm = 70 mm; it is more flattened from the ventral side and has convex flanks (vs weakly subquadrate with rounded venter and slightly flattened flanks in MB.C.32328). Despite the similarities, specimen MB.C.32328 is kept in open nomenclature, since it is rather incompletely preserved and also significantly younger stratigraphically (Haljala vs Aseri regional stages).

Fig. 28. *Discoceras* sp. indet. Specimen MB.C.32328 (Neben Coll.) from Britz (Berlin, Germany); ventral, lateral and dorsal views. Scale bar units = 1 mm.

Discussion

The present study concludes the revision of the Baltoscandian members of the cephalopod family Trocholitidae (order Tarphyceratida) (Aubrechtová & Korn 2025) by addressing the genus *Discoceras*. A total of 39 specimens from the Ordovician limestones of northern Estonia and erratics in Germany and Poland were studied. The material stratigraphically corresponds to the Sandbian or Katian Stage (Late Ordovician). Only a single specimen (GIT 225-1084, *Discoceras aseriense* sp. nov.) comes from the stratigraphically older Aseri Regional Stage (Darriwilian Stage, Middle Ordovician) strata and is the earliest representative of the genus in Baltoscandia and possibly globally.

The taxonomic revision is based on both historical and more recently gathered material from palaeontological collections in Estonia and Germany. The type and published specimens of Lossen (1860), Remelé (1880, 1890), Schröder (1891) and Neben & Krueger (1973) were also available for the study.

Where the preservation was sufficient, ontogenetic changes, trajectories and variation of morphological characters were implemented in the descriptions. This facilitated a proper re-definition of the individual species, as well as of the whole genus *Discoceras*. This showed that the separation of the latter genus at the family level by some previous authors (e.g., Hyatt 1894; Dzik 1984) is not substantiated and the monogeneric family Discoceratidae Hyatt, 1894 is therefore synonymised under the family Trocholitidae Chapman, 1857. *Discoceras* is now clearly differentiated from the other Baltoscandian trocholitid genera, *Trocholites* and *Curtoceras*, mainly based on its adult conch size, conch geometry and surface ornament.

Seventeen species of *Discoceras* were identified herein, six of which had already been described before (*D. antiquissimum*, *D. saemanni*, *D. ievense*, *D. damesii*, *D. bandonis*, *D. danckelmanni*), two remained in open nomenclature (*D.* cf. *paopense*, *D.* cf. *gubkovense*) and seven are newly established (*D. aseriense* sp. nov., *D. brandenburgense* sp. nov., *D. angustum* sp. nov., *D. circulare* sp. nov., *D. sovaki* sp. nov., *D. alienum* sp. nov. and *D. polonicum* sp. nov.). The holotype and single specimen of *Lituites trapezoidalis* is interpreted as a sub-adult growth stage of *Discoceras antiquissimum* and the two species are thus synonymized. In addition, a neotype (TAM G432:72) is proposed for *D. antiquissimum*, thus stabilising the concept of the species and the genus *Discoceras*.

In the studied collection, most species are represented by only one to three specimens. Only the representatives of *Discoceras bandonis* (seven specimens) and *D. danckelmanni* (six specimens) are more frequent. Unfortunately, the specimens of the latter species are strongly compacted, which prevents studying its intraspecific variation. In *D. bandonis*, this was, however, possible. The variation mainly concerned the coiling rate (WER) and whorl width index (WWI), although the differences might be at least partly due to secondary compaction of the specimens and a different adult conch size. The range of intraspecific variation in *D. bandonis* indicates that the species might be synonymous to the stratigraphically coeval *D. tammikuense* and *D. chrevitzaense;* however, the type material of the two latter species was not available for study herein.

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