

Appendix 1

Description of a new Bajocian (Middle Jurassic) ammonite species, *Cranocephalites tvaerdalensis* sp.nov., from Geographical Society Ø, North-East Greenland.

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A new *Cranocephalites* species, *C. tvaerdalensis* sp. nov., is described. Its type locality is a restricted outcrop of the Pelion Formation in Tværdal on Geographical Society Ø, North-East Greenland. It belongs to the *C. carlsbergensis* group and has its type horizon in the upper Bajocian (Middle Jurassic) Pompeckji Zone.

Keywords: ammonite, *Cranocephalites tvaerdalensis* sp. nov., Tværdal, Geographical Society Ø, North-East Greenland, Pompeckji Zone, faunal horizon Po-13, Pelion Formation.

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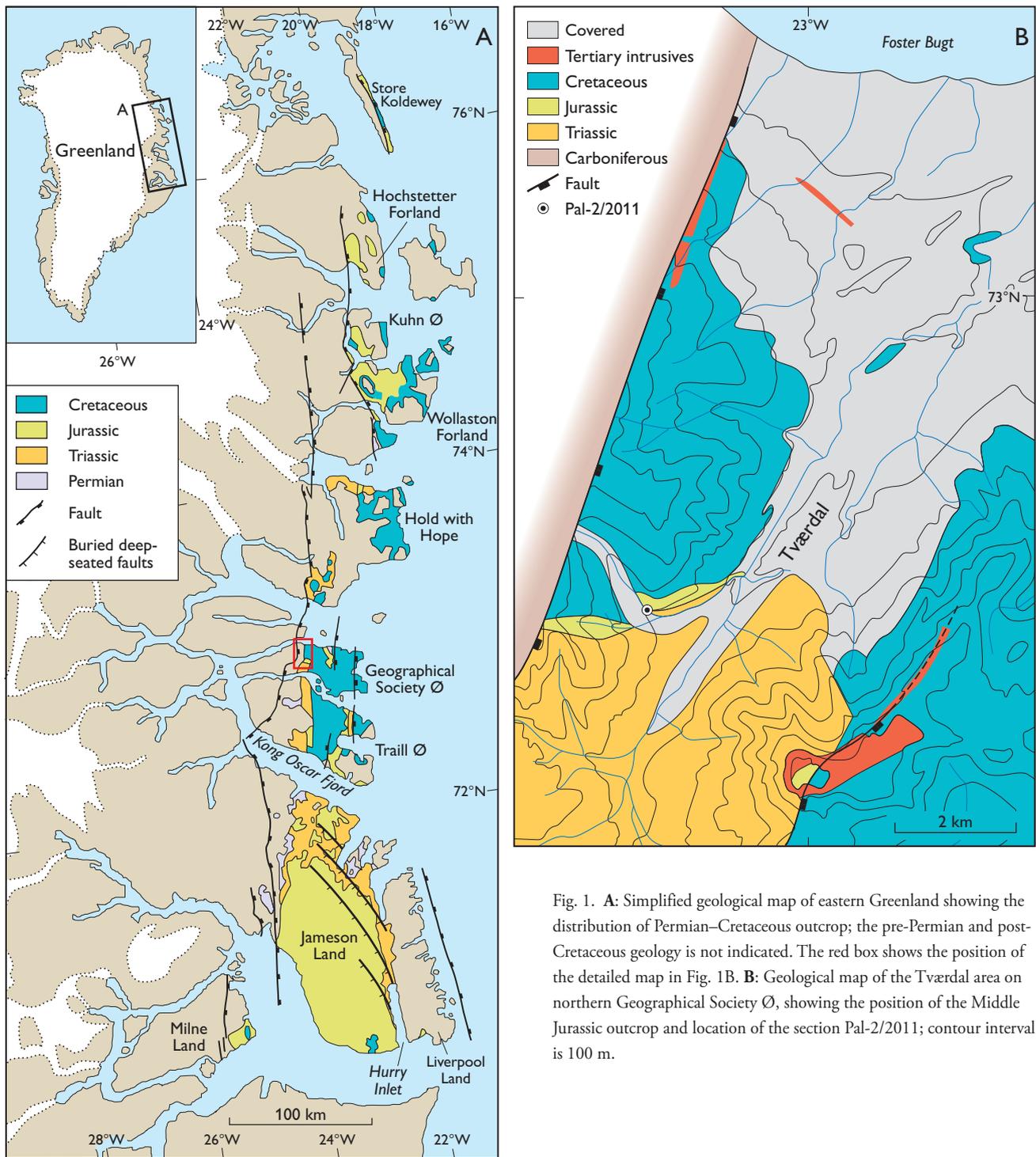


Fig. 1. A: Simplified geological map of eastern Greenland showing the distribution of Permian–Cretaceous outcrop; the pre-Permian and post-Cretaceous geology is not indicated. The red box shows the position of the detailed map in Fig. 1B. B: Geological map of the Tværdal area on northern Geographical Society Ø, showing the position of the Middle Jurassic outcrop and location of the section Pal-2/2011; contour interval is 100 m.

A new species of the genus *Cranocephalites* is described from Tværdal on Geographical Society Ø in North-East Greenland (Figs 1, 2). Donovan (1955) was the first to report Middle Jurassic ammonites (*Arcticoceras* sp. indet.) from Tværdal. They were fragments reported to be found *in situ* near the top of a more than 500 m thick succession, which was referred to the ‘Yellow Series’ (Donovan 1955,

1957). Koch & Haller (1971) accordingly mapped a large area of Tværdal as Middle Jurassic. The majority of this area, however, is now considered Triassic and the Middle Jurassic is restricted to a thickness of only 50 m (Fig. 2). Price & Whitham (1997) recorded a slightly thicker Pelion Formation section (65 m), probably partly due to measurement from the top of the most markedly reddish beds, a com-



Fig. 2. The type locality of *Cranocephalites tvaerdalensis* sp. nov. in the valley of Tværdal, Geographical Society Ø. The approximate position of the Triassic–Jurassic boundary is indicated (dashed line). The level with *C. tvaerdalensis* sp. nov. is indicated with an arrow.

mon feature of Triassic deposits in eastern Greenland. It is, however, difficult to exactly locate the Jurassic–Cretaceous boundary in the field. Palynological analysis of mudstones within a 4 m thick interval overlying the redbeds has not revealed spores, pollen or dinoflagellates, reflecting a highly oxidising depositional environment. Such a lack of palynomorphs is atypical of Jurassic mudstones. Based on negative evidence, therefore, the mudstones are considered to be probably Triassic in age (S. Piasecki, personal communication 2012). A conglomeratic bed immediately above this interval is thus considered here to represent the base of the Pelion Formation. A visit to the locality in 1998 revealed the section to be rich in fossils, which are commonly well preserved, and include a succession of *Cranocephalites*–*Arctocephalites* ammonites that were collected bed-by-bed. This appendix focuses on the erection of only one new species, *Cranocephalites tvaerdalensis* sp. nov., and is based on the collection made in 1998 and another collected in 2011.

Family Cardioceratidae Siemiradzki 1891
Subfamily Arctocephalitinæ Meledina 1968
Genus *Cranocephalites* Spath 1932
 Type species *C. vulgaris*

***Cranocephalites tvaerdalensis* sp. nov.**
 Plates 1–5

2015 *Cranocephalites tvaerdalensis* Alsen – Callomon *et al.*, p. 74, plate 14, figs 1–4, fig. 41

Material. The type series comprises 52 specimens (Table 1). The macroconch/microconch (dimorphic) ratio strongly favours the macroconchs. 26 specimens are adult macroconchs. 25 others are probably also adult macroconchs, but are fragmented and incomplete. The holotype MGUH 31377 (ex GGU 522023a) is a complete adult macroconch with dimensions and sculpture close to the average for the type series (Plate 1, fig. 1a–c). The allotype, the only microconch found in the assemblage, is MGUH 31378 (ex GGU 444903; Plate 2, fig 5a, b). The remaining specimens of the type series are paratypes (MGUH 31379–31428); those

paratypes that best represent the intraspecific variation have been numbered paratypes I–XV (Table 1).

Repository. The type material is housed at the Geological Museum in Copenhagen.

Etymology. Named after the valley of Tværdal, where the type locality is situated (Fig. 1B). *Tvær* is Danish for transverse or transverse, and Donovan (1955, p. 6) translated Tværdal as ‘Transverse Valley’ referring to the valley that traverses the island along major N–S-oriented faults from the southern to the northern coasts. It separates the Triassic – mid-Cretaceous succession in the valley from the Devonian–Carboniferous to the west and the Upper Cretaceous to the east (Koch & Haller 1971).

Stratigraphical horizon/type horizon. The material comes from one, characteristic sandstone bed, which in section Pal-2/2011 is 1 m thick, at 16.5–17.5 m above the base of the Pelion Formation (Fig. 2). The thickness of the bed varies and is observed to decrease to 0.5 m when followed laterally some tens of metres to the west. The bed is rich in fossils, commonly fragmented, of ammonites, bivalves (including one specimen of the genus *Goniomya*), belemnite rostra, cylindroteuthid phragmocones and wood. The micaceous sandy matrix also contains angular or subangular quartz pebbles of 4–5 mm size. The bed is characteristically hardened with an early diagenetic carbonate cement that favoured preservation of shell material. In contrast, Middle Jurassic ammonites in the Pelion Formation in general are typically preserved as moulds/steinkerns or just as sediment-filled body chambers, and shell material is commonly absent.

Description. The macroconchs are medium to large sized with maximum diameter close to 100 mm. They vary from fairly slender forms (e.g. Plate 3, figs 2, 3) to inflated ones, the most extreme example being shown in Plate 4, fig. 3. The umbilicus is narrow and deep as particularly well illustrated in cross-section (Plate 4, fig. 4) but opens when the uncoiling commences in the mature stage. Ribbing numbers 19–20 primaries and 45–50 secondaries per whorl throughout ontogeny. In inner whorls (juvenile stages) ribbing is strong and sharp and the secondaries are developed from bifurcation with addition of intercalatories. At the last septum, i.e. onset of the final body chamber, ribbing becomes more blunt, but still strong, and the primaries may become bullate. Ribbing commonly weakens on the venter in the mature stage but this feature is variable. The venter becomes smooth in some specimens, varying from a narrow band, for example as in the holotype (Plate 1, fig. 1b), to a broader

smooth band (e.g. Plate 4, fig. 2b). In other individuals, the ribbing weakens but is not interrupted or only partly interrupted (e.g. Plate 3, fig. 3). A few are not affected by ventral weakening of the ribs. The two largest specimens develop fine lirae on the final body chamber (Plate 2, figs 1b, 2b). The body chamber occupies *c.* 0.70 of the last whorl.

The allotype is incomplete, but the preserved part of the body chamber shows uncoiling, and thus maturity, allowing the maximum diameter to be estimated to 38–40 mm, i.e. *c.* 2¼ times smaller than the macroconchs (Plate 2, fig. 5a, b). The umbilicus is relatively open. It is strongly sculptured with sharp ribs. It has a similar number of primaries (19) as the macroconchs (Plate 1, figs 3a, b, 4a, b), but whereas the latter have common intercalatories between the secondaries (45–50 in total per whorl) the allotype only has bifurcating primaries and therefore is less densely, and more coarsely, ribbed with 35 secondaries on its last whorl.

Dimensions. Measurements on 52 specimens are listed in Table 1; for explanation of parameters, see Callomon *et al.* (2015, this volume, fig. 32). The dimensions of the holotype are close to the mean values measured for the adult macroconchs except that it displays a more closed umbilicus.

	D_{\max}	D_{ph}	h	w	u
MGUH 31377 (HT; Plate 1, fig. 1):	85	61	0.50	0.61	0.10
Mean values of adult macroconchs:					
$\langle D_{\max} \rangle$	85.5 ± 1.5	$\sigma = 6.6$ (7.7%)			$n = 19$
$\langle D_{\text{ph}} \rangle$	59.7 ± 1.1	$\sigma = 5.5$ (9.2%)			$n = 25$
$\langle h_{\text{ph}} \rangle$	0.50 ± 0.01	$\sigma = 0.027$ (5.3%)			$n = 25$
$\langle w_{\text{ph}} \rangle$	0.57 ± 0.02	$\sigma = 0.076$ (13.4%)			$n = 25$
$\langle u_{\text{ph}} \rangle$	0.14 ± 0.005	$\sigma = 0.018$ (12.9%)			$n = 16$

D_{\max}, D_{ph} in mm

Comparisons. The species differs with respect to its much stronger ribbing from the older species *C. carlsbergensis*. One specimen (Plate 3, fig. 4) is a relatively slender and finely ribbed variety which approaches the characteristics of the younger *C. gracilis*. The allotype is essentially identical to microconchs of *C. tvaerdalensis* found from Ugleelv in Jameson Land (Callomon *et al.* 2015, this volume, fig. 41).

Chronostratigraphy and distribution. The species has so far only been recorded in two areas: the type locality in Tværdal (this study), and in two adjacent sections in Ugleelv, Jameson Land (Callomon *et al.* 2015, this volume). In both areas, the beds carrying the species wedge out within short dis-

Table 1. Dimensions of the type series of *Cranocephalites tvaerdalensis* sp. nov.

MGUH	ex GGU	D_{max} (mm)	D_{ph} (mm)	D	H (mm)	W (mm)	U (mm)	h (H/D)†	w (W/D)	u (U/D)	
31377	522023a	85	61*		28	31	8	0.46	0.51	0.13	holotype
31378	443903		28*		13	13	7	0.46	0.46	0.25	allotype
31379	443911	85	57*		26	32.5	7	0.46	0.57	0.12	paratype I
31380	444797	99.5	67*		31	37		0.46	0.55		paratype II
31381	522023b	99.5	71		31	38	11	0.44	0.54	0.15	paratype III
31382	522023p		56		27	30.5	7	0.48	0.54	0.13	paratype IV
31383	444798	74.5	43.5*		20	24	7.5	0.46	0.55	0.17	paratype V
31384	522023f	81.5	55*		25	25		0.45	0.45		paratype VI
31385	522023i	81	57.5*		28.5	27		0.5	0.47		paratype VII
31386	522023h	87	64*		30	33.5	8.5	0.47	0.52	0.13	paratype VIII
31387	443908	89	60*		28	44.5		0.47	0.74		paratype IX
31388	443910	87	60		28.5	37.5	8	0.48	0.63	0.13	paratype X
31389	443901	85	60*		32	45.5		0.53	0.76		paratype XI
31390	443909	93	68*		33	40.5		0.49	0.6		paratype XII
31391	443912	79	57*		26.5	33.5	8	0.46	0.59	0.14	paratype XIII
31392	522023g	86	57*		30	36	9	0.51	0.63	0.16	paratype XIV
31393	522023j		59.5		28	31	9	0.47	0.52	0.15	paratype XV
31394	522023c	88.5	62*		27	33		0.44	0.53		
31395	522023e	85	58*		25	30		0.43	0.52		
31396	522023k		60		27	29.5	8.5	0.45	0.49	0.14	
31397	522023l		61.5		29	36.5		0.47	0.59		
31398	522023n		54		24	28	9.5	0.44	0.52	0.18	
31399	522023q	78	60*		27	31	9	0.45	0.52	0.15	
31400	522023r	79	54		26	28	8	0.48	0.52	0.15	
31401	443923		66.5		36	43	7.5	0.54	0.65	0.11	
31402	443902		62*		31	40	8	0.5	0.65	0.13	
31403	443924	82									
31404	522023m			57.5	26	31.5	9	0.45	0.55	0.16	
31405	522023o			50	23.5	27	7.5	0.47	0.54	0.15	
31406	522023s			53	27	29.5	7	0.51	0.56	0.13	
31407	522023t			56	27	30.5	8	0.48	0.54	0.14	
31408	522023u			51.5	23.5	31	9.5	0.46	0.6	0.18	
31409	522023v			57	27	32	7.5	0.47	0.56	0.13	
31410	522023w			34.5	16.5	17.5	5	0.48	0.51	0.15	
31411	522023z			64	30	36.5	9	0.49	0.57	0.14	
31412	522023aa			56.5	29	35	7	0.51	0.62	0.12	
31413	522023ab			52	25.5	36		0.49	0.69		
31414	522023ad			62	29	36.5	9	0.47	0.59	0.15	
31415	522023ae			57.5	27.5	32.5		0.48	0.57		
31416	522023af			32.5	14.5	17.5	6	0.45	0.54	0.18	
31417	522023ah			55	28.5	31.5		0.52	0.57		
31418	522023			17	8.5	10		0.5	0.59		
31419	522023			29	14	15	6	0.48	0.52	0.21	
31420	522023			38	18	22.5	6	0.47	0.59	0.16	
31421	522023			47	24	25	6	0.51	0.53	0.13	
31422	443913			57	27	34	8.5	0.47	0.6	0.15	
31423	443917			66	31	40	9	0.47	0.61	0.14	
31424	443907			63	31.5	33.5	8.5	0.5	0.53	0.13	
31425	443914			58	28	31	8.5	0.48	0.53	0.15	
31426	443921			47.5	23	24.5	7	0.48	0.52	0.15	
31427	443915			50.5	25.5	28	7.5	0.5	0.55	0.15	
31428	444799			39.5	17	20	4.5	0.43	0.51	0.11	

* D_{ph} estimated since the last whorl of the phragmocone is hidden by the body chamber† Calculation of h , w and u based on the diameter at the last septum (D_{ph}) on mature specimens (wherever possible) or at random diameter (D)

tances. In Jameson Land, *C. tvaerdalensis* defines the faunal horizon Po-13 in a succession of 23 (Po-1 – Po-23) horizons in the Pompeckji Zone (Callomon *et al.* 2015, this volume). In Tværdal, it is found immediately above beds with *C. carlsbergensis sensu stricto* Callomon 1975, trans β

and immediately below beds with *Cranocephalites* of the lower part of the *Gracilis* Subzone, i.e. between faunas Po-11 and Po-15/16, and its stratigraphic occurrence is thus compatible with the record in Jameson Land.

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Plate 1 *Cranocephalites tvaerdalensis* sp. nov.

All specimens from the type locality in Tværdal, Geographical Society Ø. All figures are shown at natural size (1:1). Arrow marks position of the last septum.

Fig. 1a–c: MGUH 31377 (ex GGU 522023a), holotype, a complete mature macroconch.

Fig. 2a–c: MGUH 31379 (ex GGU 443911), paratype I, a mature macroconch.

Fig. 3a, b: MGUH 31416 (ex GGU 522023af), nucleus with strong, dense and sharp ribbing.

Fig. 4a, b: MGUH 31426 (ex GGU 443921), nucleus with strong, dense and sharp ribbing.

Fig. 5a, b: MGUH 31410 (ex GGU 522023w), inner whorls.

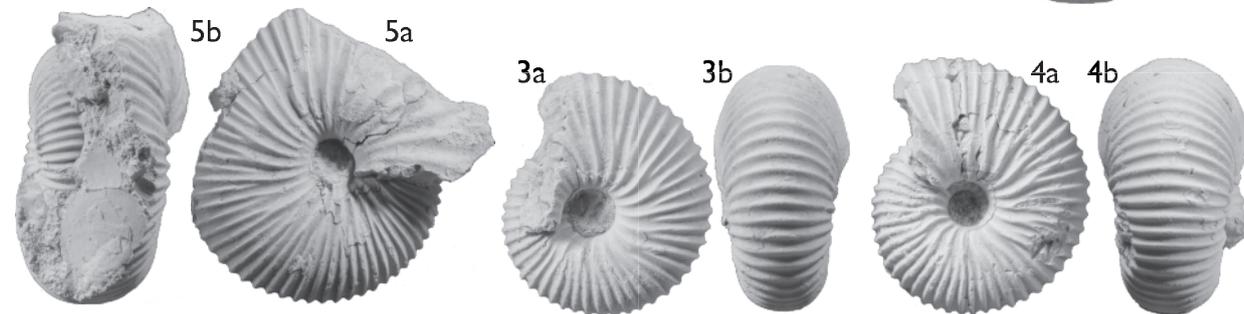
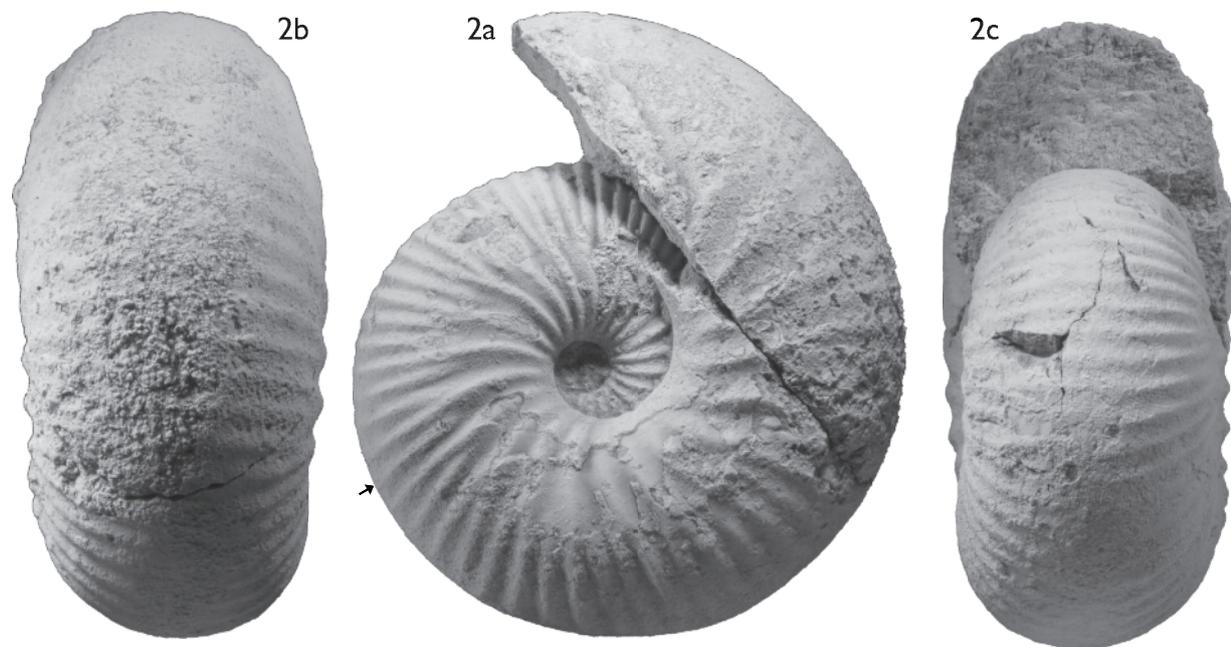
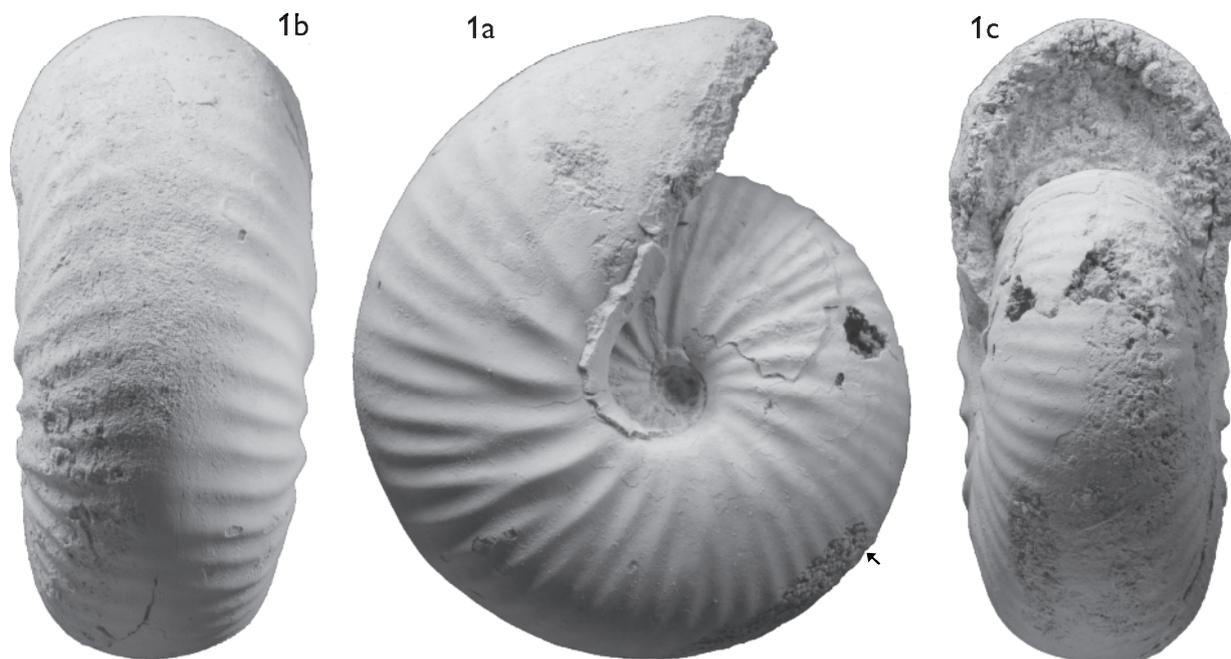


Plate 2 *Cranocephalites tvaerdalensis* sp. nov.

All specimens from the type locality in Tvaerdal, Geographical Society Ø. All figures are shown at natural size (1:1). Arrow marks position of the last septum.

Fig. 1a, b: MGUH 31380 (ex GGU 444797), paratype II, large variety of a mature macroconch.

Fig. 2a, b: MGUH 31381 (ex GGU 522023b), paratype III, large variety of a mature macroconch.

Fig. 3a, b: MGUH 31382 (ex GGU 522023p), paratype IV, a mature macroconch with part (~half) of the final body chamber preserved.

Fig. 4a, b: MGUH 31408 (ex GGU 522023u), fragment of inner, septate, whorl.

Fig. 5a, b: MGUH 31378 (ex GGU 443903), allotype, the only microconch of the collection. The last septum is marked with an arrow, the outer part of the final body chamber is missing, but uncoiling is clearly seen.

Plate 2

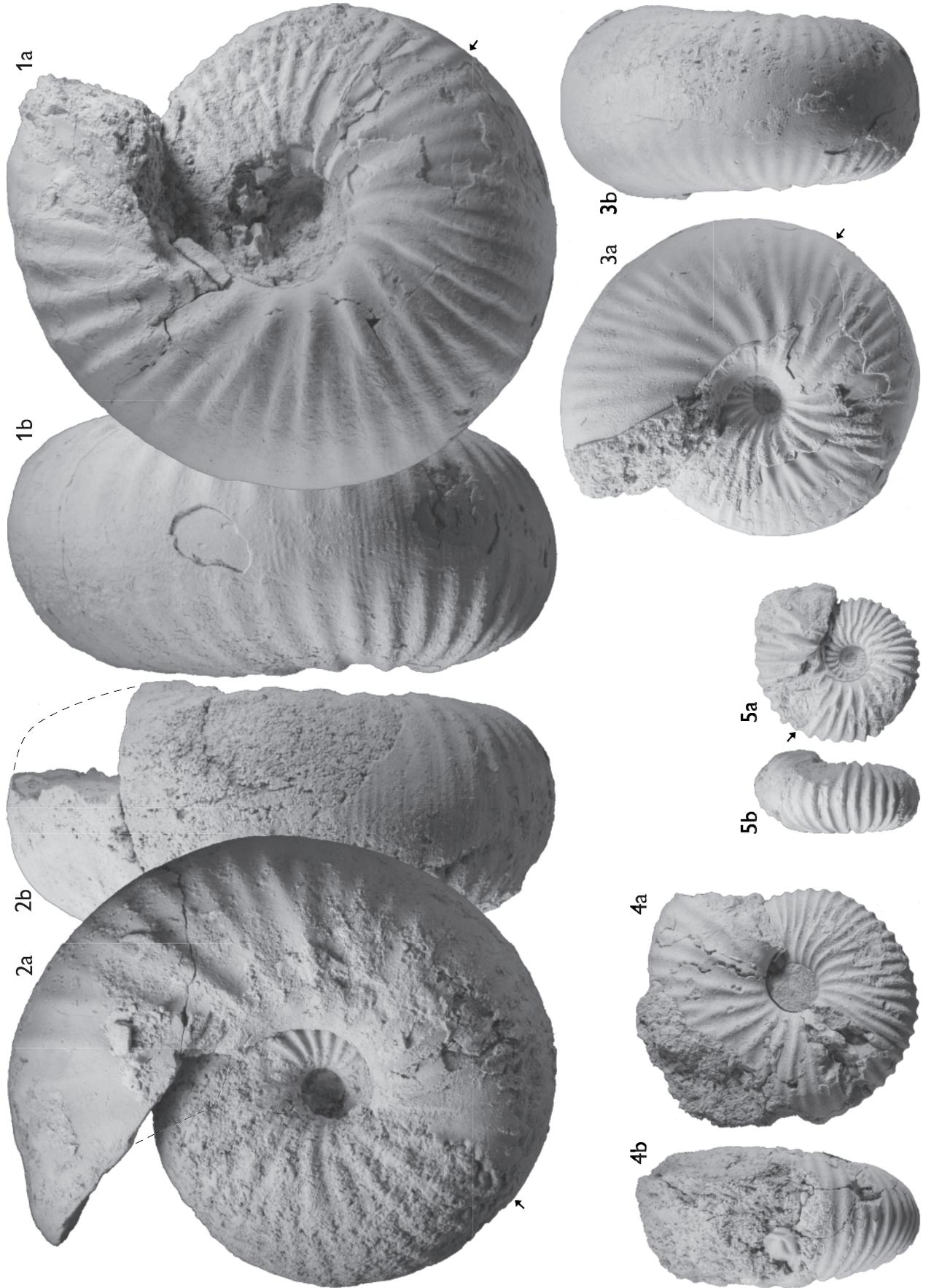


Plate 3 *Cranocephalites tvaerdalensis* sp. nov.

All specimens from the type locality in Tværdal, Geographical Society Ø. All figures are shown at natural size (1:1). Arrow marks position of the last septum.

Fig. 1a, b: MGUH 31385 (ex GGU 522023i), paratype VII, average-sized but slender variety, mature macroconch.

Fig. 2a, b: MGUH 31384 (ex GGU 522023f), paratype VI, slender variety.

Fig. 3a, b: MGUH 31386 (ex GGU 522023h), paratype VIII, mature macroconch.

Fig. 4a, b: MGUH 31383 (ex GGU 444798), paratype V, finely-ribbed, almost *C. gracilis*-like, variety.

Plate 3

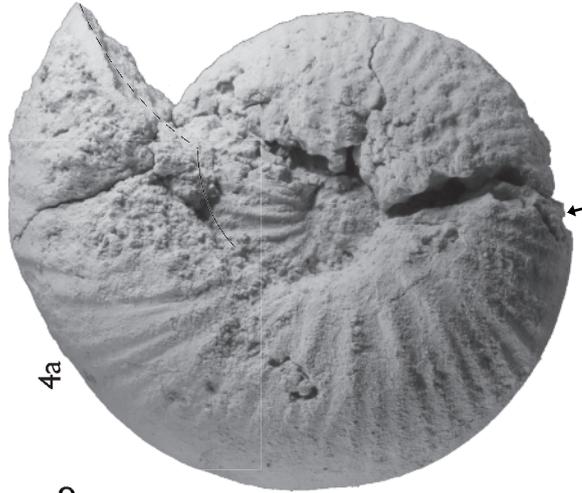


Plate 4 *Cranocephalites tvaerdalensis* sp. nov.

All specimens from the type locality in Tvaerdal, Geographical Society Ø. All figures are shown at natural size (1:1). Arrow marks position of the last septum.

Fig. 1a, b: MGUH 31387 (ex GGU 443908), paratype IX, large, inflated variety.

Fig. 2a, b: MGUH 31388 (ex GGU 443910), paratype X, fairly inflated variety with very smooth venter.

The outer part of the body chamber is missing.

Fig. 3a, b: MGUH 31389 (ex GGU 443901), paratype XI, the most extremely inflated variety (compared to its diameter), somewhat crushed giving a slightly oval appearance.

Fig. 4a, b: MGUH 31422 (ex GGU 443913), inner whorls of the phragmocone of a mature macroconch of an inflated variety. The cross-section shows the ontogenetic stages from the protoconch to the last septum.

Plate 4

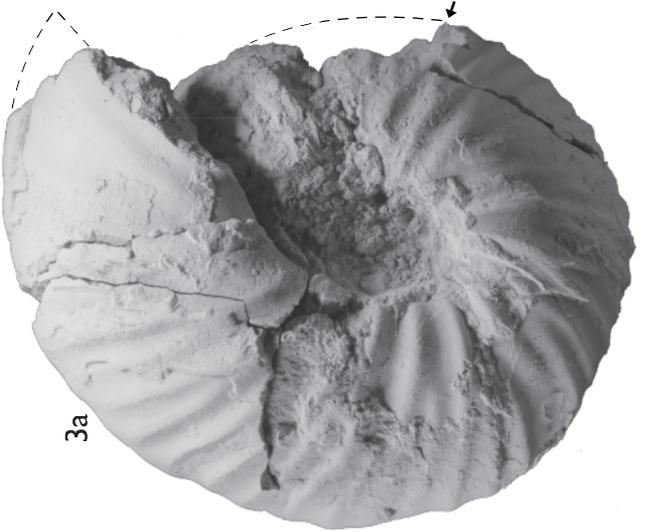
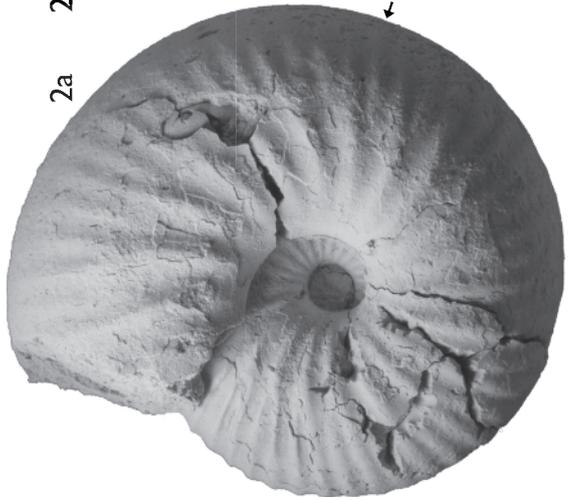
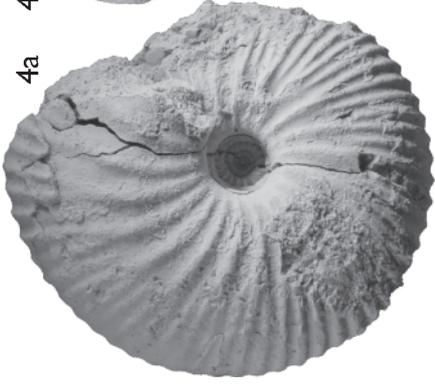
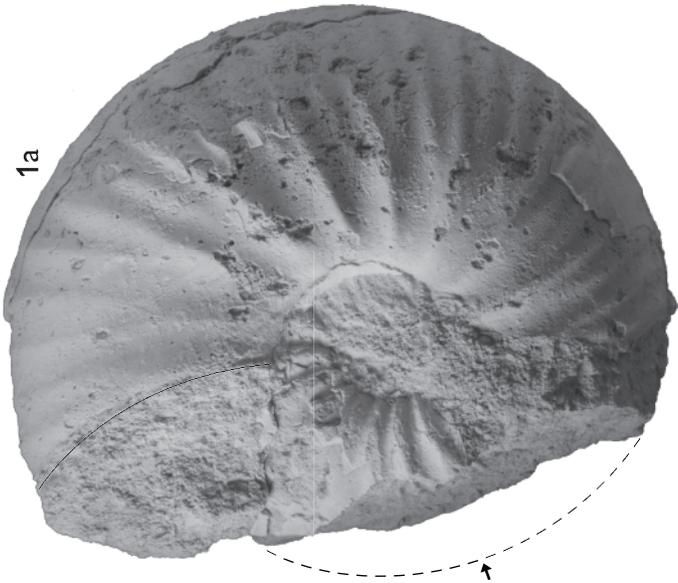


Plate 5 *Cranocephalites tvaerdalensis* sp. nov.

All specimens from the type locality in Tvaerdal, Geographical Society Ø. All figures are shown at natural size (1:1). Arrow marks position of the last septum.

Fig. 1a, b: MGUH 31390 (ex GGU 443909), paratype XII, a large, fairly inflated variety.

Fig. 2a, b: MGUH 31391 (ex GGU 443912), paratype XIII, an average specimen.

Fig. 3a, b: MGUH 31392 (ex GGU 522023g), paratype XIV, a slightly inflated variety.

Fig. 4a, b: MGUH 31393 (ex GGU 522023j), paratype XV. A mature macroconch with only the beginning of the body chamber preserved showing dense, relatively strong ribbing on inner whorls changing almost exactly at the last septum to more distant and blunt ribbing on the final body chamber.

Plate 5

