Gradual opening of the siphonal tube in an orthoconic cephalopod from the Silurian of Central Bohemia (Czech Republic)

Postupné otvírání sifonální trubice u ortokonnního hlavonožce ze siluru středních Čech (Czech summary)

(2 text figs, 2 plates)

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A specimen of an orthoconic cephalopod from the Silurian (Ludlow, Ludfordian), Kopanina Formation of Central Bohemia, described by Barrande (1870) as Orthoceras obelus, has been studied in detail. New information was obtained on the morphology of the siphon-cameral structures; the gradual opening of the siphonal tube, enabling the tissue to enter the gas chambers during the ontogeny, has been found out. The specimen was established the holotype of a new species Nucleoceras hollandi sp. n., and was, based on the proved presence of the cameral mantle, attributed to the Family Lamellorhiceratidae Teichert, 1961, Order Pallioceratidae Marek, 1998.

Key words: Mollusca, Cephalopoda, Pallioceratida, functional morphology, internal structures, new taxon, Silurian, Barrandian Area, Bohemia.

Introduction

Joachim Barrande was the first who recognized the organic origin of the siphonal and cameral deposits (1855, 1859, 1877). In the last century, also some other palaeontologists, e.g. Schröder (1888) came to a similar conclusion. Later Teichert (1933) and Flower (1939, 1941, etc.) published the theory about a tissue (cameral mantle) originally present in the gas chambers of some orthocones. This has been supported by many authors – a detailed history of the development of opinions published e.g. Zhuravleva in Shmianskiy and Zhuravleva (1961) and, partly, Kolebaba (in print), who also demonstrated dorsally open connecting rings (toughs) enabling the immediate connection of the siphonal and cameral tissues in two Silurian orthoconic species.

The purpose of the cameral deposits – to ballance the shell into the horizontal position with venter down – seems now to be generally accepted. However, up to now, many questions remain, one of them being in which way the animal controlled the precipitation of the deposits. For a good effect, the animal had to place the deposits into the distal portion of its shell; while the gas chambers lying in the proximity of the living chamber served for the buoyancy changes and had, therefore, to be free of the deposits.

It has been observed for many times that there are e.g. twenty five gas chambers free of deposits behind the living chamber and, that in the next few chambers (traced adapically), the cameral deposits rapidly increase to their maximum thickness. The study of Nucleoceras hollandi enabled following explanation of this change of the gas chambers morphology and strikingly quick formation of the deposits.

Material, methods and terms

One of Barrande’s syntypes of O. obelus (Pl. 366, fig. 15), represented by the phragmocone with 32 gas chambers, was a subject of the study. Its adial third was sectioned longitudinally as well as transversally (Fig. 1). Serial cross-sections (Fig. 2) and two thin sections have been made; the specimens were embedded into an epoxide resin before being ground. Internal structures in the more adapical portion of the phragmocone are favourably preserved. The outer layer of the shell wall is, up to tiny remainders, unpreserved.

The term “connecting trough” is used herein for the dorsally open connecting ring (see also Kolebaba, in print).

Fig. 1. Schematic drawing of the holotype showing the individual separated parts (A–F) and positions of the figures illustrated in Plates I, II: 1 – Pl. I, fig. 1; 2 – Pl. I, fig. 2; 3 – Pl. I, fig. 3; 4 – Pl. I, figs 4, 5; 5 – Pl. II, fig. 7; 6 – Pl. I, fig. 7; Pl. II, figs 1–6; 7 – Pl. I, fig. 6; Pl. II, fig. 8.
Morphology

In the chambers containing the cameral deposits, the cross-sections revealed the contours of spaces in which the cameral mantle had been originally present (Pl. II, figs 1–8). The cameral mantle was of the lamellar type with the conspicuous gap (G) running dorsally from the central area and dividing the cameral mantle into two lateral lobes (L).

When traced adapically from the 19th chamber (Pl. I, fig. 2), siphonal structures show following development: The 19th to 21st chambers contain remains of the connecting rings which was probably destructed by the crystals of the secondary calcite. The 22nd chamber contains almost complete tubular connecting ring. Going on, the first change can be observed: the structures homologous to the connecting ring are dorsally open in two consecutive chambers and form troughs. In the chamber No. 25 (the adoral one in Pl. I, fig. 4) we can again see a tubular, closed connecting ring. The second point of change occurs at the 26th chamber; there the connecting structure is again fully open on its dorsal side to form a trough. The same pattern is also in all remaining chambers (see also the sequential sections of the 31st chamber in Pl. II, figs 1–6 and polished sections of the 32nd chamber in Pl. II, figs 7, 8.)

The cross-sections figured on Pl. I, figs 6, 7 show walls of the connecting troughs; their ventral, rounded part consists of two parallel curves, the distance between them being about 0.02 mm (the arrow PM in Pl. I, fig. 7). They continue to the right, into the area of the dark cameral deposits. These originally parallel curves are here disjoined from one another (the arrow DM) and the outer of them is broken. Their length approximately equals to the missing part of the circular double curve which represents a cross sectioned wall of an originally closed, tubular connecting ring. The identical case can be seen in the polished section of the neighbouring gas chamber figured on Pl. I, fig. 6 where the missing part of the originally tubular connecting ring is indicated by a dotted curve.

In the dorsoventral thin section (Pl. I, fig. 5) similar double curves can be seen running from the septal fora-

Description: Phragmococone with probably 32 gas chambers (sutures in dorsal part are obscure), overall length 147 mm. Adapical portion of the phragmococone, 58 mm long, has been separated, divided into five parts and sectioned. The shell wall is poorly preserved; surface probably smooth. Shell is compressed with the dorsal-ventral diameter by 20% greater than the lateral one. Apical angle is almost constant at 4.5°. Septal foramina are intracentroventral, shifted ventrally by 29% of the distance between the centre and ventral margin. The average height of gas chambers is 36% of the relevant dorso-ventral diameter.

Discussion: Nucleoceras hollandi sp. n. differs from the type species, N. obelus (Barr.) in another shape of the cameral mantle (i.e., the space free of the cameral deposits in that part of the phragmococone containing the deposits). The large dorso-ventral gap dividing the mantle into two lateral lobes is the main identification feature.

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References


Postupné otevírání sífonální trubice u ortokónnního hlavonožce ze siluru středních Čech

Podrobným studiem jediného z Barrandových syntypů Orthoceras obelus (1870, Pl. 366, fig. 15) bylo zjištěno zvláštní uspořádání sífon-kameralních struktur. V adoralní části fragmokonu, kde se kameralní uloženiny nevytvářejí, byly pozorovány spojovací prstence obvyklého trubcovitého tvaru. Naproti tomu v adaptikálních plynových komorách, obsahujících kameralní uloženiny, je dorzální strana sífonální trubice široce rozvezena a její vnitřní prostor je bezprostředně propojen s prostorom plynové komory. V daném případě tato zmena proběhla ve dvou fázích (při siedování adaptikálním směrem); po prvních dvou plynových komorách s otevřeným prstencem následuje jistá jedna komora s normálně vyvinutými, trapkovitými spojovacími prsteny, dale adaptikálně již všechny komory obsahují otevřené spojovací prstence. Současné a pravidelné uspořádání vnitřního prostoru těchto komor svědčí o přítomnosti kameralního plátě. Morfologické vnitřních struktur studovaného hlavonožce poskytuje pravděpodobné vysvětlení známé skutečnosti, že u mnoha nautilioidů s ortocerakónním schránkou následuje za řadí nejčastěji 23–25 plynových komor bez kameralních uložení tři až pět komor, v nichž se kameralní uloženiny poprvé objevují a nabývají maximální mohutnosti. Zde soudí, že sífonální trubice v adaptikálních komorách byla hlavonožce postupně otevírána jako reakce na potřebu zvýšit začlenění adaptikální části schránky a zajištět tak její horizontální polohu. Po otevření spojovacího prstence plynové komory nejvíce vzádávají od obvyklé komory a dosud neobsahující kameralní uloženiny sífonační tkáň vstoupila do prostoru komory a začala intenzivní proces sekréce kameralních uložení.

Studovaný Barrandov syntyp byl stanoven jako holotyp nového druhu Nucleoceras hollandi sp. n. (Lamellorthoceratidae Teichert, 1961; Pallicocerasida Marek, 1998).
Plate I
1. Adoral part (A) of the holotype showing Brandy's original indication of the locality; lateral view, venter right; photograph by R. Horný; x1.5.
2. Dorsalventral polished section of the part B; a complete connecting ring is seen in the chamber No. 22, venter right; x5.6.
3. The same part B, a detail of the cross-section showing an open connecting ring = a connecting trough in the chamber No. 23; x36.
4. Dorsalventral thin section of the part D; the chamber No. 25 contains again a closed connecting ring, all consecutive chambers (adapically) have fully open connecting troughs and well developed deposits; venter left; x5.6.
5. Detail of the fig. 4; the parallel curves – sectioned membranes (PM) of the open walls of the connecting rings – are shown running from the septal neck dorsally into both neighbouring chambers. Venter left; x36.
6. Detail of the polished cross-section shown on Pl. II, fig. 8 (part F); the arrow DM indicates the disjoined membranes which originally formed the missing part of the circular (in cross-section) connecting ring (dotted curve); a view from the adapical side; x43.
7. Detail of the thin section on Pl. II, fig. 6 (part E), the similar pattern as in fig. 6. Two cross-sectioned parallel membranes (PM) forming the unbroken wall of the connecting trough, and disjoined membranes (DM) originally closing the connecting ring are shown; a view from the adapical side; x50.

Plate II
1.–7. Sequential cross-sections of the adapical portion of the gas chamber (part E); for the positions of the sections see Text-fig. 2. 1.–6. – views from the adapical side, 7. – a view from the adoral side. 1.–5. Polished sections; x9. 6. Thin section; G – dorsoventral gap; L – lobes; x9.
7. Polished cross-section; x9.
8. Polished cross-section of the neighbouring chamber (part F), situated near the centre of its height, a view from the adapical side; x9.
I. Kolebaba: Gradual opening of the siphonal tube in an orthoconic cephalopod from the Silurian of Central Bohemia (Pl. I)

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I. Koleba: Gradual opening of the siphonal tube in an orthoconic cephalopod from the Silurian of Central Bohemia (Pl. II)