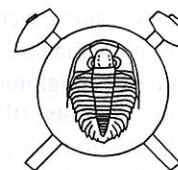


Cyathidium Steenstrup (Crinoidea) in the Upper Cretaceous of Bohemia (Czech Republic)



Cyathidium Steenstrup (Crinoidea) ve svrchní křídě Čech (Czech summary)

(3 text-figs., 2 plates)

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Two thecae from the upper Cenomanian and thirty seven ones from the lower Turonian nearshore sediments are herein described as *Cyathidium* aff. *depressum* Sieverts. Furthermore, several conspecific first primibrachials (IBr1) and first secundibrachials (IIBr1) closely resembling those of the Danian species *C. holopus* were found. Several specimens of *Cyathidium* aff. *depressum* show they lived cemented to the organic debris of the bottom. They frequently overgrew smaller cementing associates such as the bryozoans, corals and thecideans. Thecae were also encrusted both during the crinoids' life and postmortally. In the latter case they were mostly colonized by rapidly growing opportunists (agglutinated foraminifers, bryozoans). Some other taphonomic features of *Cyathidium* and their environmental context are also discussed.

Key words: Crinoidea, taxonomy, taphonomy, Upper Cretaceous

1. Introduction

First Bohemian finds of the cyrtocrinid *Cyathidium* Steenstrup were briefly described from several Upper Cretaceous localities by Zázvorka (1939). Thirteen thecae were at a disposal to this author in the collections of the National Museum, Prague, and this set was later completed by another 22 thecae. One of the museum specimens was studied by Rasmussen (1961) but since that time the material remained unnoticed. However, during the last few years two new localities of *Cyathidium* were discovered by me and by O. Nekvasilová (Geol. Institute ASCR, Prague), indicating a much wider geographical range of this crinoid in the Bohemian Upper Cretaceous than known before. These new specimens together with mentioned 35 ones of the National Museum are dealt with in this paper.

Acknowledgements: My thanks are due to John W. M. Jagt from the Natural Museum of Maastricht (The

Netherlands) for the demonstration of *Cyathidium vliexi*, and to J. Geys from the University of Antwerpen for making me possible the visit of Maastricht. I thank also Mrs. O. Nekvasilová from the Geological Institute, Academy of Sciences of the Czech Republic, Prague, for an assistance during the works and kind reading of the first draft of the manuscript.

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2. Geographical and geological settings

Localities of *Cyathidium* are dispersed along the southern margin of the Bohemian Cretaceous Basin (Text-fig. 1). All the occurrences are situated on the low landscape elevations, where the lydites (Předboj) or crystalline rocks (Kamajka, Kolín-Zálabí, Krakovany, Velim) of Proterozoic age crop out. In this bedrock the

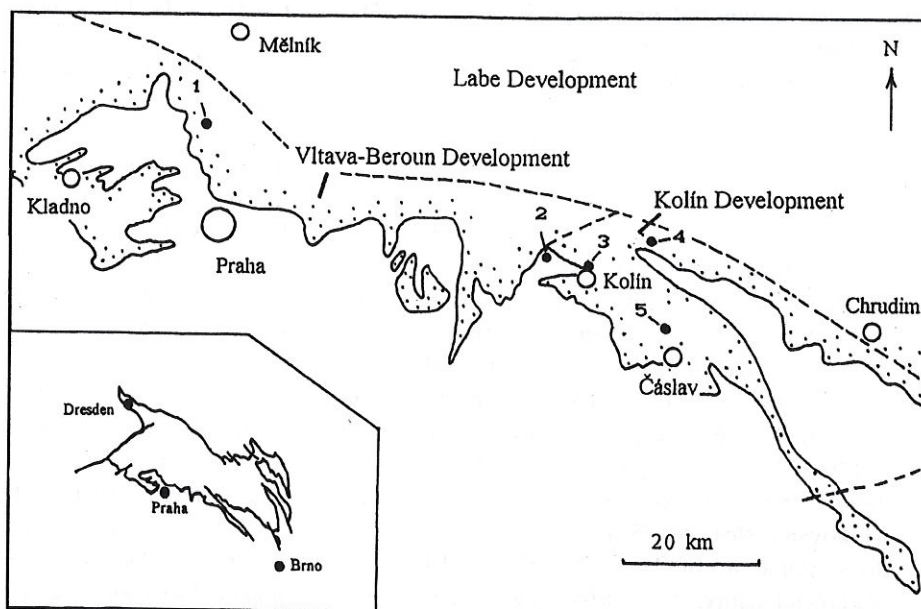


Fig. 1. Sketch-map of a part of the southern margin of the Bohemian Cretaceous Basin and the occurrences of *Cyathidium* 1 - Předboj; 2 - Velim; 3 - Kolín-Zálabí; 4 - Krakovany; 5 - Kamajka

depressions were formed by erosion activity of the Cenomanian sea. In their basal parts sedimented the coarse conglomerates locally overlain by the bioclastic deposits (the Kaňk Member of the Korycany Formation; Houša 1991). Above them the silty rocks of the Bílá Hora Formation sedimented, reflecting the gradual deepening of the sea. At the disappeared Krakovany locality probably only the last unit was present. The material of *Cyathidium* is derived mainly from the area of the Kolín lithofacial development and come from the Bílá Hora Formation of the lower Turonian age (Hercogová 1988, Svobodová 1990, Štemproková-Jírová 1991). Westernmost locality of *Cyathidium*, Předboj near Prague, belongs, however, to the upper Cenomanian of the Vltava-Beroun development and its fauna shows a pronounced similarity to some Saxonian localities. Two thecae from the now infilled Předboj quarry were recently found in old samples gathered in 60's by O. Nekvasilová. They probably come from the upper part of the Kaňk Member. Immediately above this horizon, the siltstones with rich *Actinocamax plenus* were observed by Zázvorka (1939).

3. Systematic part

Cyrtocrinida Sieverts - Doreck, 1952

Holopodina Arendt, 1974

Holopodidae Zittel, 1879

Cyathidium Steenstrup in Michaelis et Schenk, 1847

Type species: *Cyathidium holopus* Steenstrup, 1847.

Type horizon: Middle Danian, Fakse in Denmark.

Cyathidium aff. *depressum* Sieverts, 1932

Pls. I and II, Text-figs. 2, 3

?1932 *Cyathidium depressum* n. sp.; Sieverts, Pl. 12, figs. 1-3.

1939 *Cyathidium depressum* Sieverts, 1931; Zázvorka, p. 1-8, 2 figs.

1961 *Cyathidium depressum* Sieverts, 1931; Rasmussen, p. 239-241, Pl. 34, figs. 1-4.

non 1932 *Cyathidium depressum* n. sp.; Sieverts, Text-fig. 2 (holotype), Pl. 12, fig. 4 (holotype), figs. 5-13.

Horizon and locality: Upper Cenomanian, Předboj near Prague; lower Turonian, Krakovany, Kolín-Zálabí, Kamajka, Velim (Text-fig. 1).

Material: Collections of the National Museum, Prague: 19 thecae and one IIBr1 from Kolín-Zálabí (so called Hvězda's quarry), Nos. 26813 and 26179; 12 thecae from Kamajka, Nos. 25882, 26910, 9501, 227/68, 536/64; 2 thecae from Krakovany, Nos. 24575 and 26740; 1 theca from the surroundings of Čáslav, No. 533/64; 1 theca of unknown locality, No. 534/64. New material depo-

sited in the Geological Institute, Academy of Sciences of the Czech Republic, Prague: 1 fragment of theca and 3 brachials from Kamajka; 1 fragment of theca and 14 brachials from Velim; 2 thecae (one overgrowing the other) from Předboj.

Description

Thecae: Monocrystalline, without traces of multielement composition. Diameter of theca mostly highly exceeds its height. Diameter of smallest specimen = 10.0 mm and its maximum height = 6.8 mm; respective dimensions of largest specimen equal to 15.8 and 10.5 mm. The majority of thecae are at least slightly narrowed above their bases. The diameter of base only rarely slightly exceeds that of the uppermost part of theca. All thecae but one are externally smooth. One of the Krakovany thecae is granulated over the whole outside surface. Several specimens bear on their sides possible increment lines, sometimes very densely arranged. They are developed only in the lower parts of thecae. Upper portions of thecae are mostly obliquely oriented as regards their attachment surfaces. From this follows also the relative inclination of the arm-apparatus relative to the substrate. Outline of radial ring is pentagonal to subcircular. Radial facets are of equal or slightly different size. They are very narrow and interradially separated by very low processes. Ligamentary and muscular parts of the articulation are sharply separated by distinct transverse ridge with short perpendicularly oriented crenulae. Ligament fossa is very narrow and shallow, ligament pit near the ridge is small but deep. Muscular part of facet dips to the centre of theca. Muscle fossae are large but relatively shallow (Pl. I, fig. 1). Ventral groove between them is shallow and rapidly disappears on the ventral cavity wall below the facet. Axial canal lying near the ligament pit on the opposite side of transverse ridge is small. Ventral cavity is wide and very deep, in low specimens approaching the base of theca. Between the radial facets, the granules or subvertically inclined wrinkles are present if preservation is good. Basal attachment surfaces are mostly subcircular.

Brachials: Arms probably divided at first primibrachial which is axillary but one non-axillary element of equal size was also found. Axillars are massive, low and dorsally swollen, smooth or granulated. Proximal facet of the axillary corresponds morphologically to the radial facet of the theca. Distal faces are small, asymmetrical, with partly reduced adaxial part. They are separated from each other by distinct process. Branching ventral groove is shallow. Lateral parts of axillars bear small irregularly crenulated faces for the interlocking with similar faces of neighbouring axillars. For morphology of the non-axillary primibrachial I refer to the Text-fig. 2 e, f. First secundibrachials are of a triangular, sometimes rather asymmetrical outline in dorsal and ventral views. Laterally, the crenulated faces are developed, similar in function to tho-

se of primibrachials. Proximal facet morphologically corresponds to the distal facet of the axillary element. A small facet of undistinct morphology for the articulation of a pinnule lies laterally in the lower part of the ossicle (Text-fig. 2 c). In the upper part, a small facet for a second secundibrachial is developed. This facet is hidden on the foot of a pointed, ventrally concave end of the ossicle.

Remarks and relations: Most extensive abroad sets of *Cyathidium* specimens belong to *C. holopus* Steenstrup from the Danian of Fakse (Denmark, several thousand thecae), *C. depressum* Sieverts from the upper Cenomanian of Rheinland - Westfalens (Germany, 318 thecae), and to *C. vlieksi* Jagt from the Maastrichtian of Limburg (Netherlands, 23 thecae). Here described Bohemian material (39 thecae) is the third as regards the number of specimens. German material of *C. depressum* includes several young specimens, which are, on the contrary, absent in our material. As a whole, the German set of specimens

seems to be taxonomically heterogenous. Based on Sieverts' descriptions and figures, 2 species may be present. The higher, more or less cylindrical or conical specimens are similar to the Bohemian ones. The shield-shaped thecae (the majority of specimens including the holotype) are different and should be regarded as true *C. depressum*. These specimens also seem to be more densely and completely granulated than the higher ones. The Zázvorka's (1939) and Rasmussen's (1961) conclusions on the taxonomic identity of German and Bohemian specimens were, therefore, probably premature. Nevertheless, no definite taxonomic solutions are possible without a revision of Sieverts' specimens.

Unlike the body shape, the skeleton of arms seems to be of greater systematic value. Axillary primibrachials of the Bohemian specimens are more similar to those of *Cyathidium holopus* than to the German *C. depressum* (see Sieverts op. cit., Pl. 12, fig. 13). Important secundibrachial elements are, however, unk-

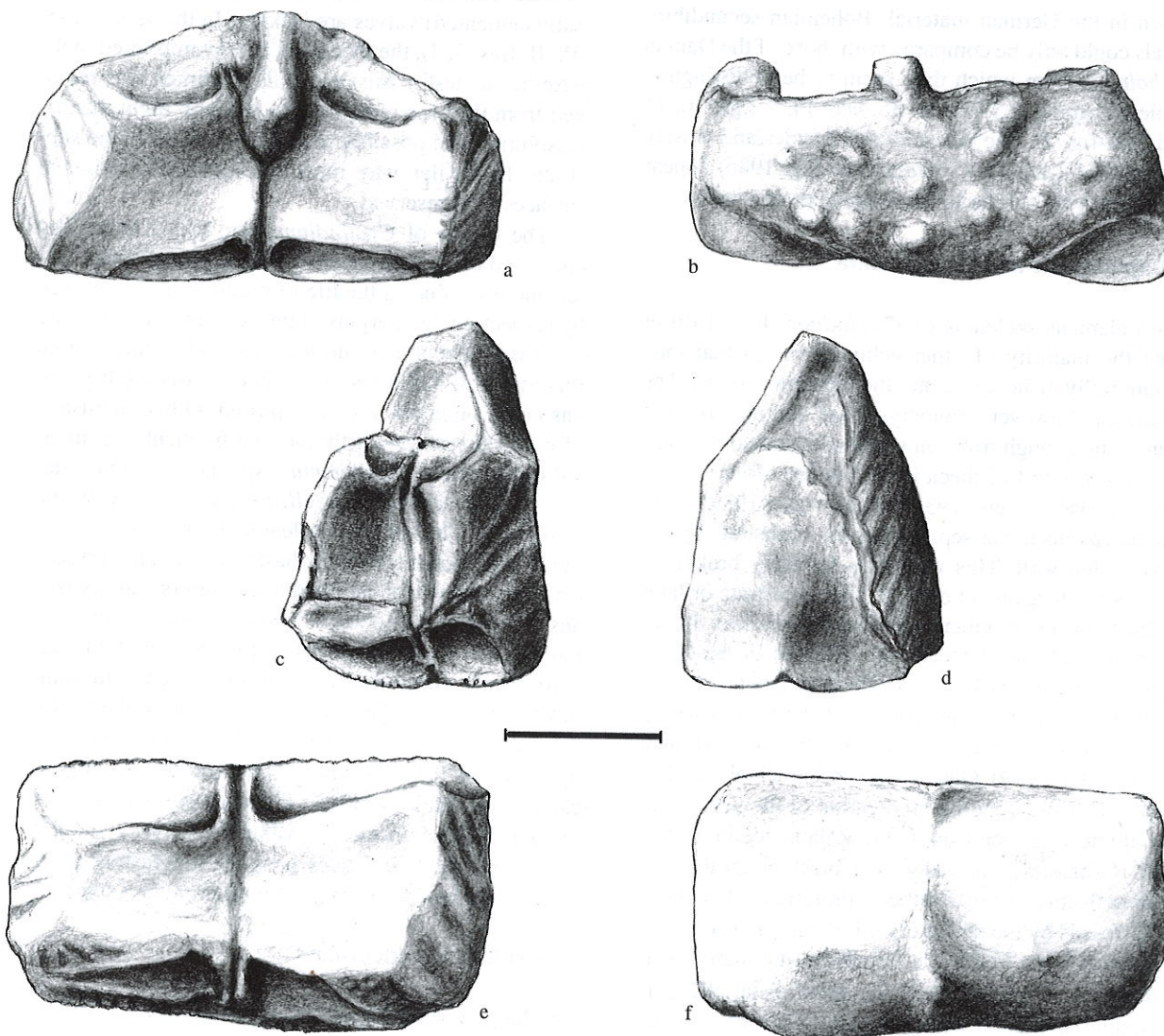


Fig. 2. Brachials of *Cyathidium* aff. *depressum* from Velim, all deposited in the Geol. Inst. ASCR
a, b - Ibr1 (axillary) in ventral and dorsal views; c, d - IIBr1 in ventrolateral and dorsolateral views; e, f - anomalous non-axillary Ibr1 in ventral and dorsal views (distal facet down); In fig. c note a small side pinnular facet (lower left). Scale bar = 1 mm for all figures. Orig. author

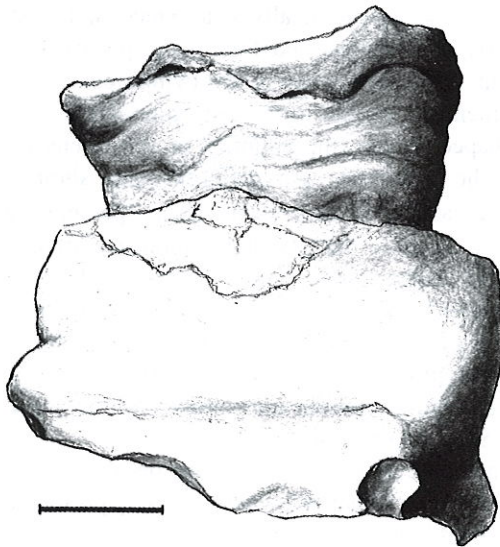


Fig. 3. *Cyathidium* aff. *depressum* growing in the ventral cavity of its dead conspecific. Specimen deposited in the Geol. Institute ASCR, Předboj locality. Scale bar = 3.0 mm. Orig. author

known in the German material. Bohemian secundibrachials could only be compared with those of the Danian *C. holopus* from which they seem to be undistinguishable (Rasmussen 1961, Pl. 35; here Pl. I, figs. 10, 11 and Text-fig. 2). The thecae of this species and closely related Maastrichtian *C. vlieksi* (see Jagt 1986) appear to be also very similar to the Bohemian specimens.

4. Taphonomic and ecologic data

Multi-element skeletons of *Cyathidium* do not differ from the majority of other echinoderms in that they postmortally disintegrate into the separate ossicles. The thecae are, however, monocrystalline and massive and seem to be enough resistant to the mechanical stresses. The weakest part of theca is the bottom of ventral cavity (see also Sieverts 1932 and Zázvorka 1939), as in low specimens it was separated from a substrate by only very thin wall. This wall may be likely broken as early as by detachment of theca from substrate or later on due to the environmental mechanical stresses. In our material c. 20 % of thecae are affected in this way. However, there exist several abraded (rounded) low specimens with very thin bottom of the ventral cavity imperforated. Isolated arm ossicles were not mentioned by Zázvorka (1939). One first secundibrachial was, however, recently found by preparation of the ventral cavity of one specimen from Kolín-Zálabí (see Pl. I, figs. 10-11). Therefore, the absence of brachials in the museum collection reflects rather a preferred selection of larger fossils by the collectors. In washings of unsorted bioclastics from Velim the brachials first signalize if *Cyathidium* is present. Only the small distal elements (including pinnulars) were not identified, probably due to the diagenetic dissolution of their morphologic details. This damage frequently occurs in a part of ossicles of other associated echinoderms (echinoids, asteroids, crinoids).

Bohemian specimens of *Cyathidium* are mostly low and widely attached. This indicates enough space in areas of attachment and growing, i.e., a rather low density of specimens in an original community. The thecae of only 4 specimens (c. 11 %) overgrew some higher objects upon which they touched by their lateral parts (Pl. I, figs. 4, 9, 15). The great majority of attachment surfaces bear imprints of unidentifiable small-scale substrate irregularities (Pl. I, figs. 5, 7). In several specimens there were, however, found interesting imprints indicating the substrate quality more precisely. Latex casts (Pl. II, figs. 1, 4) of basal surfaces show not only imprints of the overgrown fragmented bioclasts, but also a record of organisms (corals, thecideans, bryozoans) in living position. Coral skeletons belong most probably to juvenile specimens but thecideans were rather subadult to adult. The thecideans *Praelacazella lacazelliformis* show 2 different modes of preservation. In the first case (Pl. II, figs. 1, 2) they are completely preserved within a calcite of the crinoid base. Only small basal parts of their ventral (originally cemented) valves are lacking. In the second case (Pl. II, figs. 3, 4), the thecidean is only imprinted in the base but its test is missing. This specimen was removed from the base rather due to its small height than by dissolution and possibly remained adhered to the substrate. In similar way most epibionts of attachment surfaces are preserved.

The thecae of *Cyathidium* were found to be also encrusted by cementing epibionts. A part of them settled and grew during the life of crinoids, as it is proved by respecting the margins of inaccessible sites like are the basal attachment surfaces and radial facets. Into this group of epibionts only some encrusting bryozoans could be unambiguously placed. Other encrusters of external surfaces of thecae like frequent agglutinated foraminifers *Acruliammina* sp. and scarce thecidean *Praelacazella lacazelliformis* may well be postmortal. The encrusters clearly colonizing dead crinoids are frequent on their basal attachment surfaces (in addition to the mentioned foraminifers and bryozoans, one small pycnodonte oyster and one specimen of *Exogyra* sp. were found), while they are rare on radial margins and facets of thecae and completely missing in ventral cavities. The latter case may be explained by the current-invoked overturning of the detached thecae upside down the sediment, i.e., into the hydrodynamically more stable position. The extraordinary find of theca cemented inside the ventral cavity of another one (Text-fig. 3) indicates possible longlasting postmortal attachment of a part of thecae on the substrate.

5. Results and conclusions

(a) Thirty nine thecae of *Cyathidium* coming from the upper Cenomanian-lower Turonian nearshore facies of the Bohemian Cretaceous Basin (Kaňk Member of the Korycany Formation and the Bílá Hora Formation) form a more or less morphologically uniform set be-

longing to one species. The Zázvorka's (1939) and Rasmussen's (1961) unambiguous determinations of this species as *C. depressum* Sieverts seem to be, however, doubtful due mainly to the badly known variation of thecae and construction of arms of German specimens. A tentative assignment as *C. aff. depressum* is preferred here though the similarities of brachials to other species (*C. holopus*, *C. vlieksi*) are striking.

(b) Studied specimens could probably settle on various types of solid substrates but together with other benthos they also colonized surfaces of sufficiently stable temporal bioclastic deposits. *Cyathidium* could here overgrow small associated cemented organisms such as corals, bryozoans and thecideans which were consequently incorporated into or imprinted in the calcite of basal attachment surfaces. Some of these species frequently encrusted also the thecae of living crinoids.

(c) Skeletons of *Cyathidium* postmortally disarticulated and, in the majority of sedimentary areas, the isolated ossicles were not sorted in size and shape. The thecae are massive and probably resistant to fragmentation even in their weakest part - the base of ventral cavity. The postmortal detachment from substrate could sometimes be rather postponed as indicated by the case of colonization of vacant ventral cavity by identically oriented crinoid specimen. Encrustation of postmortally detached thecae was frequent but preferentially by small rapidly growing opportunistic forms (bryozoans, agglutinated foraminifers). All taphonomic features of thecae indicate that relatively long intervals (measured in time units necessary for settlement and growing of crinoids) of undisturbed environment alternated with more agitated conditions of

increased sediment (i.e., substrate of crinoids) mobility, possibilities of abrasion and encrustation of just died specimens and recycled bioclasts and, on suitable places, their new burial.

Determinable brachials of *Cyathidium* are represented by axillars (IBr1) and first secundibrachials (IIBr1). The latter ones are adapted to the defense of more distal arm parts. The find of the only specimen of the non-axillary primibrachial shows rather an anomalous than current arm condition.

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Cyathidium Steenstrup (Crinoidea) ve svrchní křídě Čech

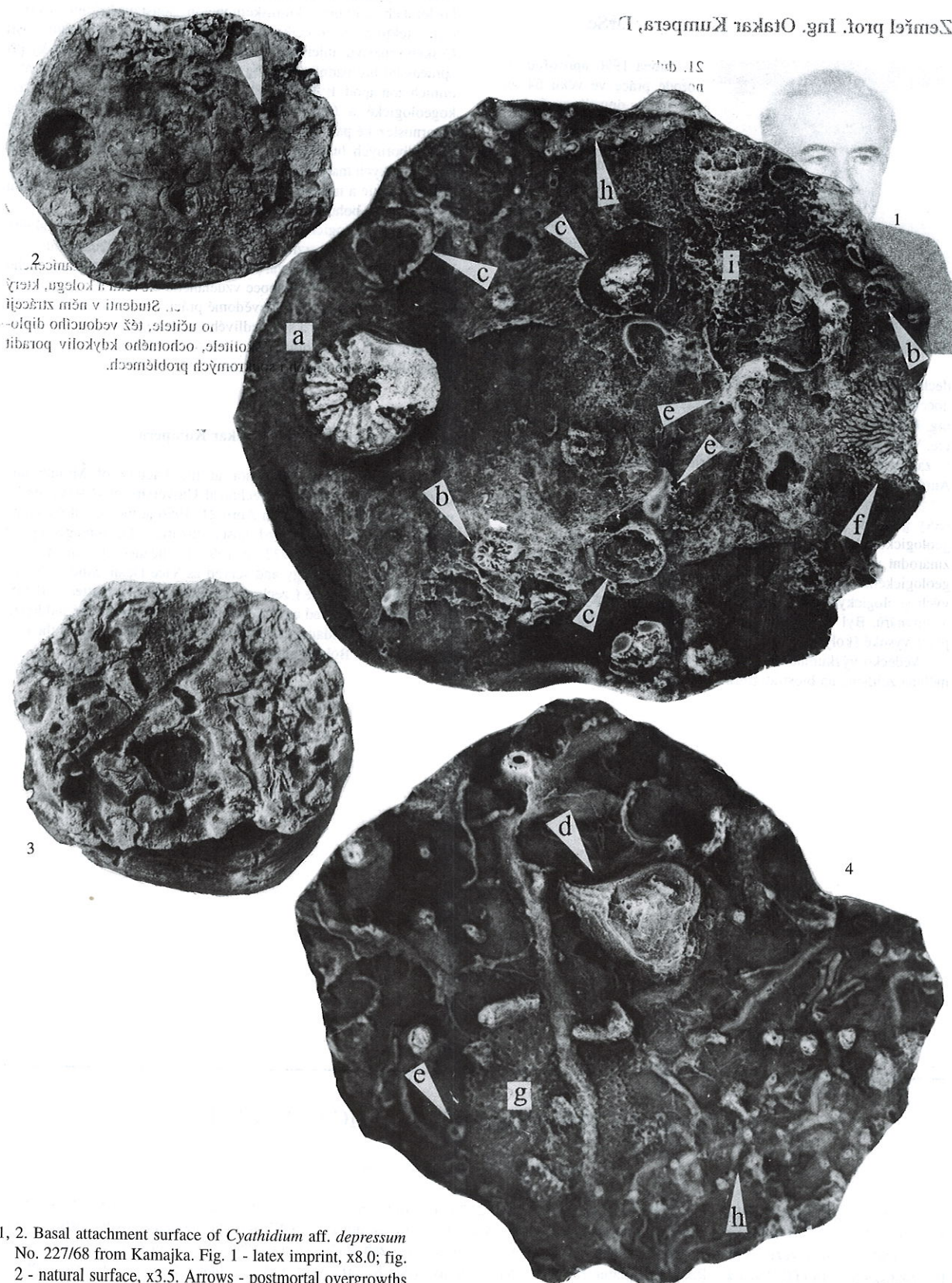
Taxonomická revize materiálu cytokrinidní lijice, determinované Zázvorkou (1939) jako *Cyathidium depressum* Sieverts, ukázala, že patrně jde o odlišný, i když příbuzný druh, prozatím označený jako *C. aff. depressum*. Jeho přesnější systematické postavení může být vyjasněno až po revizi typového materiálu z německého svrchního cenomanu. Řadou znaků je však český druh blízký i druhům *C. vlieksi* Jagt a *C. holopus* Steenstrup z vyšší svrchní křídly a danu západní Evropy. *C. aff. depressum* bylo relativně vzácnou součástí benthických společenstev, obývajících přibřežní zónu českého svrchnocenomanského a spodnoturonského moře. Otisky substrátu v bazálních přisedacích povrchích ukazují na to, že tato lijice kolonizovala dočasná bioklastická depozita a patrně i jiné pevnější povrchy, na nichž často přerůstala menší, zde rovněž žijící přitmělené organismy, např. thecidie, korály, mechovky aj. Těky lijič byly za živa i postmortálně poměrně řídky kolonizovány drobnými oportunisty, hlavně foraminiferami. Další tafonomické znaky jsou podrobně diskutovány.

Fig. 11:11: (Cyathidium Steenstrup (Crinoidea) in the Upper Cretaceous of Bohemia (Czech Republic) Plate II



All figured specimens are deposited in the collections of the National museum, Prague. Photographed by J. Žitt.

1. Theca of *Cyathidium* aff. *depressum* in ventral view, Kolín-Zálabí locality. No. 26813/1. x8.3.
- 2-5. The same specimen in ventral, two lateral, and dorsal views. Fig. 2 - x3.2, fig. 3 - x2.9, fig. 4 - x3.0, fig. 5 - x3.2.
- 6-8. Specimen No. 26813/2 from Kolín-Zálabí in ventral, dorsal and lateral views. Arrow - a bryozoan overgrowing both the theca base and external surface. Fig. 6 - x2.8, fig. 7 - x3.1, fig. 8 - x2.9.
9. Specimen No. 26813/4 from Kolín-Zálabí in lateral view. x3.7.
- 10, 11. IIBr1 found during preparations of the ventral cavity of theca No. 26813/6 (see fig. 15 of this plate). Fig. 10 - ventral view, fig. 11 - dorsal-lateral view. x5.8.
12. Specimen No. 24575 from Krakovany in lateral view. Within the base of this specimen a part of *Argyrotheca* sp. (Brachiopoda) is incorporated by overgrowing (not figured). x3.0.
- 13, 14. Specimen No. 26813/5 from Kolín-Zálabí in ventral and lateral views. Fig. 13 - x2.9, fig. 14 - x3.1.
15. Specimen No. 26813/6 from Kolín Zálabí in lateral view. x5.6

J. Žítt: *Cyathidium* Steenstrup (Crinoidea) in the Upper Cretaceous of Bohemia (Czech Republic) Plate II

1, 2. Basal attachment surface of *Cyathidium* aff. *depressum* No. 227/68 from Kamajka. Fig. 1 - latex imprint, x8.0; fig. 2 - natural surface, x3.5. Arrows - postmortal overgrowths by *Acruliammina* sp.

3, 4. Ditto of specimen No. 26813/3 from Kolín-Zálabí. Fig. 3 - natural surface, x4.2; fig. 4 - latex imprint, x6.9.

Overgrown bottom fauna and bioclasts: a - probable juvenile of the hexacoral *Synhelia gibbosa* (Goldfuss), b - indetermined hexacoral, c, d - thecideid brachiopods *Praelaacazella lacazelliformis* (Elliot), e - indetermined serpulid worms, f - bryozoan *Berenicea* sp., g - bryozoan *Plagioecia* sp., h - indetermined bryozoans, i - fragment of a pycnodonte oyster with a vesiculate shell structure. Only the specimens marked as c are still incorporated into a calcite of the crinoid base.