



GEOLOGICAL STUDY OF THE GAS-MAIN EXCAVATIONS, PART VI. – BIVALVES *ANOMIA* LINNAEUS AND *PLICATULA* LAMARCK CEMENTED ON LYDITE BOULDERS (KOJETICE, BOHEMIAN CRETACEOUS BASIN)

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Abstract. Silicite (lydite) cobbles and boulders with a cemented epibiont community were studied in the excavations for the gas-main near Kojetice in central Bohemia (Upper Cenomanian?, Korycany Member). Two interesting bivalve species, i.e., *Anomia subtruncata* D'ORBIGNY and *Plicatula inflata* SOWERBY were determined. In the Bohemian Cretaceous Basin, these bivalves were hitherto known only on the basis of their isolated upper valves. Several articulated shells were identified on the studied clasts, which enabled the determination of even disarticulated cemented valves. Based on the settlement processes and taphonomy of epibiont remains, the fates of their clastic substrates, and the development of respective depositional environments can be estimated and better understood. The succession of processes, starting with the input of coarse clasts, their behaviour (including the different possibility of providing substrate for encrusters) in an area of sand sedimentation, and their final burial agree well with the local response to the gradually rising sea level in the basin.

■ Cementing bivalves, lydite clasts, palaeoenvironment, Upper Cenomanian (?), Bohemian Cretaceous Basin.

INTRODUCTION

An interesting oyster-like cemented bivalve was found at Černovičky within the study of the Late Cretaceous (Late Cenomanian) hard substrates and their encrusters in the Bohemian Cretaceous Basin (Žítt et al. 1999, Pl. 3, Fig. 3). Because of the lack of sufficient taxonomically important features, it was not determined to the species level and its affinity to rudists was tentatively considered. However, based on the more complete specimens recently found by one of the authors (J. Ž.), the species was determined as *Anomia subtruncata* D'ORBIGNY. Surprisingly, another interesting and very rare cementing bivalve was also found together with this species and preliminarily determined as *Plicatula inflata* SOWERBY. Both species are briefly characterized in this paper.

GEOGRAPHICAL AND GEOLOGICAL SETTING

In spring 2000, the excavations for the gas-main were realized north of Prague, central Bohemia (see Žítt et al. in press). In a part of the excavated furrow near the western foot of the so-called Kojetice High (see Žítt et al. 1999) south of the Kojetice village (Fig. 1), an interesting section in Late Cretaceous deposits (Upper Cenomanian?, Korycany Member,

Peruc-Korycany Formation) and locally even their Proterozoic basement was exposed (Fig. 2). The lowermost lithological unit is brownish to slightly yellowish clayey sandstone with resistant intercalations or lenses rich in small suboval lydite (i.e., Proterozoic silicite) clasts up to 10 mm in size. Streaks of granule-sized (clasts up to 5 mm in size) sandy conglomerate are locally present. In addition, oval to suboval and less often subangular lydite cobbles to boulders up to 40 cm in size are rarely present in the rock. These clasts are a substrate, besides other epibionts (see Žitt et al. in press), to the herein described bivalves. Sandstones with large clasts are overlain by massive sandy to calcareous conglomerate with prevailing suboval to oval lydite clasts up to 50 mm in size. In the western part of the section, this sediment directly overlies the Proterozoic basement. In the eastern part of the section, the above mentioned conglomerate is overlain by brownish to yellowish clayey sandstone to sandy claystone containing rare angular clasts of grey rock of shale appearance (most probably of Proterozoic age) but no abraded lydite gravel. These sandstones are overlain by a body of grey to brownish massive limestone with bioclasts and pebble-sized gravel (clasts up to 20 mm in size), markedly thickening to the west. Dark greenish glauconitic sandstone enormously rich in lydite gravel lies on the top of the section. The section is locally deeply disturbed by Quaternary cryoturbation. In these portions, sand and clay of purple to reddish colours occur together with Cretaceous sediments and chaotically embedded large lydite clasts. Nevertheless, the relics of adhered sandstone and preserved epibionts indicate that these clasts originated from the lowermost lithological unit. The variegated admixture may represent the weathering products of pre-Cretaceous age locally underlying the Cretaceous strata.

SUBSTRATES AND COMMUNITY COMPOSITION

The colonized lydite clasts are 15 cm to ca. 40 cm in size (i.e., coarse cobbles to fine boulders *sensu* Blair – McPherson 1999), mostly abraded and more or less rounded. One of them was partly subangular, indicating fragmentation of a large boulder or the basement rock. The surfaces of clasts vary in quality; some parts are generally smooth, some are rugged. Small depressions of various shapes are occasionally developed (subcircular shallow holes, furrows). However, no sharp edges are visible in neither micro- nor macroscale (except for some parts of the above mentioned large rock fragment).

The most abundant epibionts belong to five oyster species of the genera *Amphidonte* (*Amphidonte*) and *Pycnodonte* (*Phygraea*), one species of *Spondylus*, two species of worms (genera *Pomatoceros* and *Glomerula*), several species of bryozoans (e.g., *Proboscina* and *Heteropora*), one unidentified octocoral species, and about two species of agglutinated foraminifers (genus *Acruliammina*) (for a complete list of all epibiont species see Žitt et al. in press; cf. also Žitt – Nekvasilová 1991). The below discussed bivalves represent a not too abundant but conspicuous community component, and were found on 4 of the 10 studied clasts.

Anomia subtruncata D'ORBIGNY

(Pls. I, II; Pl. III, Fig. a)

Material: 101 cemented more or less fragmentary right valves, 7 of them with fragments of left (upper) valves preserved *in situ*. The specimens were attached to clasts of the following sizes and weights: 1/ 40 cm and 24 kg; 2/ 32 cm and 18 kg; 3/ 38 cm and 14 kg; 4/ 26 cm and 7 kg. The second and fourth boulder and the studied fragments of the other boulders are deposited in the Institute of Geology, Academy of Sciences, Prague.

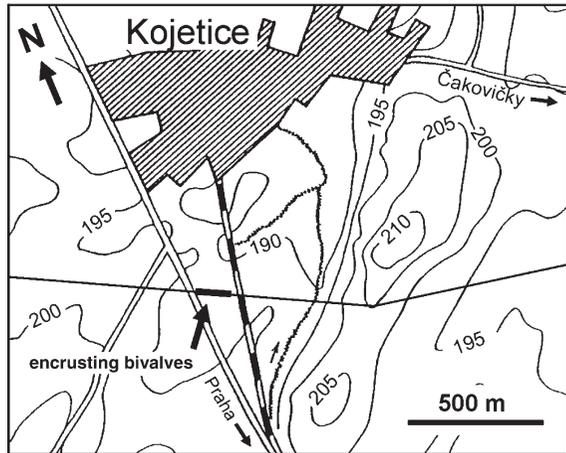


Fig. 1. A map with the course of the gas - main (solid line) and a section (arrow) shown in detail (see Fig. 2).

Measurements: The largest found specimen is incompletely preserved and is about 16.5 mm long, the smallest, well preserved specimen is 10.5 mm long.

Morphological characteristics: Right valves spirally coiled, attached with the whole surface (no free part is visible). External flange (high external margin) of valve is steep resembling the anterior flange of some oysters (e.g., *Amphidonte (A.) reticulatum* (REUSS)). Cemented shell part beyond this flange is relatively thin, mainly in the lateralmost part, where it is mostly broken off. The inner surface of the shell is ornamented with densely arranged more or less distinct striae curved parallel to the external shell margin. The attachment area is relatively large as seen in the extremely well preserved specimens (e.g., Pl. II, Fig. a). The left (upper) valves are known only in fragments, preserved inside the right valves and concentrated near their external margins (Pl. I, Figs. a, b). They are thin-walled and their outer surfaces bear regularly spaced concentric ribs curved parallel to the external margin of the right valve. These ribs are provided with small tubercles which become larger distally and form a type of low cylindrical pustules. The valve seems to get thinner towards its centre and the ribs get denser and lower in the same direction.

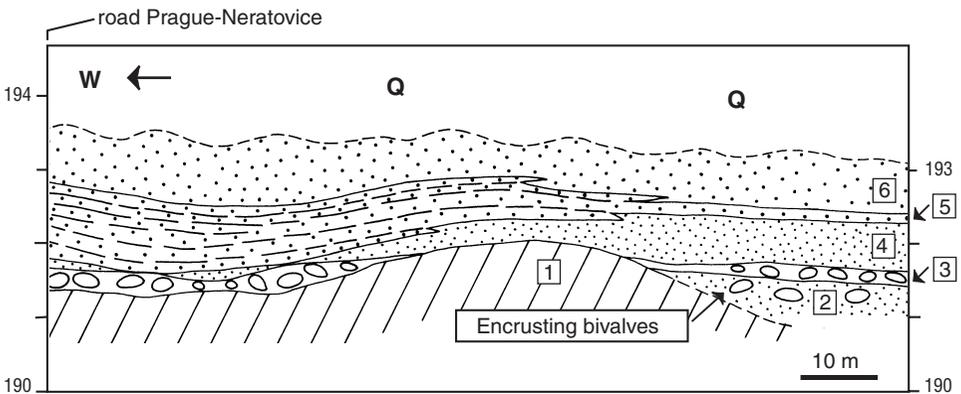


Fig. 2. Geological section east of the road Praha - Neratovice, south of Kojetice (see Fig. 1). Altitude in metres above sea level marked on sides of section. 1 – Proterozoic basement, 2 – sandstone with clasts colonized by epibionts, 3 – matrix-supported, granule-sized conglomerate with pebble-sized clasts, 4 - clayey sandstone, 5 – gravelly sandy limestone, 6 – gravelly sandstone. Q – Quaternary elluvia with redeposited Cretaceous sediments, and loamy sands.

Growth and distribution on substrates: Not all specimens of *Anomia* could be identified and counted on the two largest boulders as their surfaces are partly covered in firm sandstone and/or the bivalve remains are strongly damaged. The counted numbers of *Anomia* must be therefore considered as minimum ones: 65 specimens on the 24 kg boulder and 30 specimens on the 18 kg boulder. On the other hand, the fragmented boulder (14 kg) possessed certainly not more than 3 specimens as well as one of medium-sized clasts (7 kg). *Anomia* was completely absent from 6 clasts (12, 5, 4, 3, 2 and 1 kg).

The individuals were growing both solitarily and in clumps of several specimens (Pl. III, Fig. a). Solitary individuals sometimes grew across small substrate elevations, and were therefore strongly deformed. On the other hand, some other specimens were found in small deep depressions. Their cemented valves completely coated steep hole walls, thus being extremely deformed in the opposite manner than those growing on the elevations. Generally flat areas were seemingly colonized most frequently; it should be taken into account, however, that this type of surfaces highly prevails on the clasts. As regards the quality parameters of clast surfaces, all areas could be, therefore, successfully colonized.

Remarks: Several species of *Anomia* were described from the Bohemian Cretaceous Basin (BCB). The species *Anomia subtruncata* was mentioned from the Lower-Upper Turonian strata (Malnice, Schillinge near Bílina, Louny, Chřibská) by Reuss (1846). This species is also included in the d'Orbigny's (1850) list of the Bohemian Cenomanian bivalve species. It was described by Geinitz (1873) from the Middle-Upper Turonian of Saxony and the Upper Turonian of the BCB (Chřibská). This species was also found in the Korycany, Bílá hora, Jizera, Teplice and Březno formations of the Late Cenomanian to Coniacian age by Frič (1879, 1885, 1894, 1898, 1911). The pertinence of the presently described lower valves to this species could be identified due to the *in situ* preservation of the upper valve.

***Plicatula inflata* SOWERBY**

(Pl. I, Fig. a; Pl. III, Fig. b; Pl. IV)

Material: 25 more or less fragmentary cemented right valves; three of them with parts of its left (upper) valves preserved *in situ*. The species occurs together with *Anomia* only on the largest clasts (18 kg, 24 kg, 14 kg; for clast dimensions see the preceding section on *Anomia*). The first clast and fragments of the last two clasts are deposited in the Institute of Geology, Academy of Sciences, Prague.

Measurements: The largest specimen found was attached to more or less flat surface and isolated from other epibionts. It was 16.5 mm long and 15.5 mm wide. The other specimen, slightly deformed laterally due to the presence of neighbouring epibionts was 11.5 mm long and 12.5 mm wide. Probable juvenile specimen (see Pl. IV, Fig. c) was 3.8 mm long and 3.8 mm wide.

Morphological characteristics: Right valves almost as wide as long, attached with their entire surfaces. The valve is very thin in umbonal and central parts, margins are thicker and higher. Inner surface bears more or less well developed low radial ribs or linear-arranged tubercles. These structures are sometimes restricted to younger valve parts. Left (upper) valve is probably thin (thickness and inner surface not visible due to the adherence to the lower valve), with about 26 distinct radial ribs in the best preserved specimen, reaching up to the valve margin (Pl. I, Fig. a; Pl. III, Fig. b). Low, densely arranged pustules to spines, grooved on their undersides, are developed on the ribs.

Growth and distribution on substrates: The numbers of specimens on individual clasts (18 kg – 14 specimens, 24 kg – 6 specimens, 14 kg – 5 specimens) are on-

ly approximate due to presence of a sandstone cover and /or poor preservation (see section on *Anomia*) but this species was found to be distinctly more rare than *Anomia*. The specimens grew mostly solitarily. No preferred orientations are visible. Growth irregularities on uneven substrates (growth in holes or on small high elevations) are identical with those of *Anomia*.

R e m a r k s: The species was described from the Cenomanian of the Cambridge area by Sowerby (1825). Several species of *Plicatula* were described from the Bohemian Cretaceous Basin. Isolated valves of *P. inflata* were mentioned from the Teplice and Březno formations of the Late Turonian to Coniacian age (Frič 1889, 1898, Reuss 1846). Undetermined rare specimens of *Plicatula* were found cemented on a gneiss boulder in the quarry at Mezholezy near Kutná Hora (Korycany Member) by Klein (1962).

DISCUSSION

The colonization pattern of the studied boulders is often hardly legible and understandable. On many places of their surfaces, a very complicated tangle of variously damaged, fragmented and abraded remains indicates a multi-phase colonization. Encrustation of some clast surfaces is very rare or completely missing, indicating their inaccessibility possibly due to their burial in sand. Some parts of boulders bear only minute abraded relics of epibionts.

Only the largest clasts, highly elevated above the sandy sea bottom, were colonized by *Anomia* and *Plicatula*. However, the individuals occur together with other epibionts (oysters, worms etc.) on all encrusted surfaces. The range of shell size in *Anomia* is very narrow and the shells mostly seem to belong to adult or subadult individuals. It is interesting that all *Anomia* specimens, irrespective of their positions (solitary, aggregated specimens), attained comparable sizes (cf. Jackson 1993). In contrast to oysters, no important mutual overgrowths were observed in the aggregations of their shells. However, *Anomia* and *Plicatula* often overgrew variously preserved remains of older epibiont settlement phases (mostly juvenile oysters), but their cemented valves themselves are only rarely overgrown by other epibionts (only the foraminifer *Acruliammina longa* is present).

The most important feature of the studied bivalves is the preservation of several still articulated shells. They are dispersed irregularly over the practically whole colonized surfaces of two largest clasts (24 and 18 kg). Within the bivalve component of cemented community, the articulated shells were with no doubt the only individuals living during, or killed very shortly before, the burial of the clast (or its part).

CONCLUSION

Bivalves *Anomia subtruncata* D'ORBIGNY and *Plicatula inflata* SOWERBY played an important role in the cemented (and therefore preserved *in situ*) component of the epifaunal community living on lydite boulders and coarse cobbles of the Late Cenomanian(?) deposits (Korycany Member, Peruc-Korycany Formation) near Kojetice, Bohemian Cretaceous Basin. Unidentifiable remains of cemented valves of *Anomia* were previously found only in the Late Cenomanian deposits of the Černovičky locality (about 20 km SW of Kojetice); rare undetermined cemented valves of *Plicatula* were mentioned from the Mezholezy quarry near Kutná Hora (Upper Cenomanian). The studied specimens are unique in that a part of their shells is still articulated. This enabled the specific determinations of cemented lower valves which, by themselves, lack sufficient taxonomic characters.

The bottom with encrusted clasts may be characterized as a part of a relatively flat sandy plain, lying near the foot of a prominent lydite elevation, which at this time was most prob-

ably still emerged, forming an island. The studied lydite clasts could well be derived from the littoral zone of this elevated structure and occasionally transported to their present position by extreme high-energy events (storms). In this environment, the clasts, particularly the largest ones, were possibly the only suitable substrates for settling epifaunas dominated by oysters and worms. These clasts, scattered over the bottom, were most probably exposed to the episodic stronger activity of currents and migrating sand which, from time to time, could have caused not only the death and abrasion of epibionts, but also the burials, reburials and changes of the clast positions. On the repeatedly exposed surfaces, a rather complicated succession of encrusters was established, characterized by variously damaged generations. Finally, the scattered clasts were buried by sand and all possibilities of new epibiont settlements ceased. This process involved rising level of the sea, flooding of the nearby island and a corresponding change in regional depositional environment.

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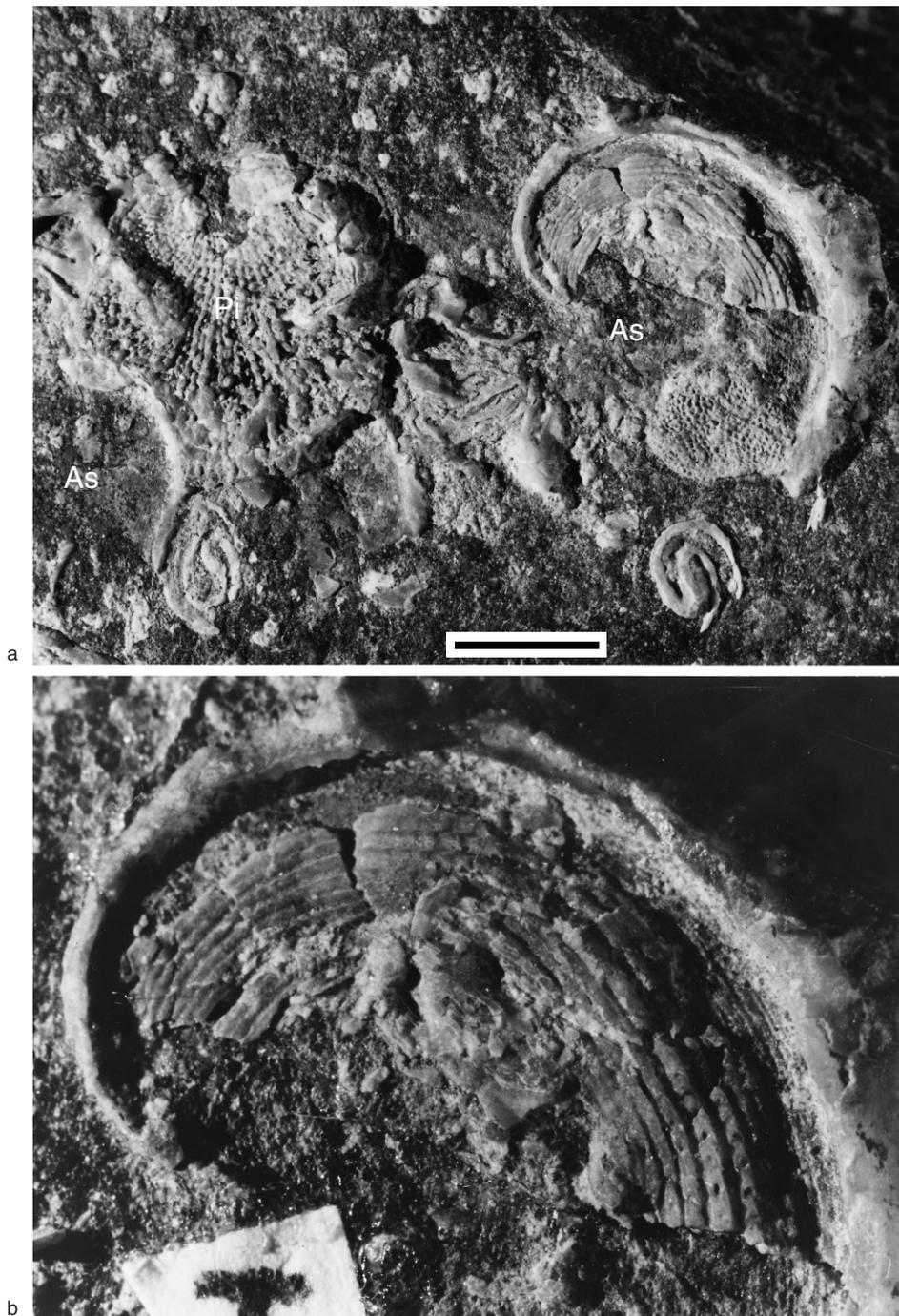


Plate I. a – Articulated shells of *Anomia subtruncata* D'ORBIGNY (As) and *Plicatula inflata* SOWERBY (Pi) attached to the surface of a lydite clast along with the remains of other epibionts (worms, oysters, a.o.). b – a close-up view of *Anomia subtruncata* from fig. a with partly preserved upper valve. Scale bars = 5 mm (a) and 1 mm (b). Photograph J. Brožek, Inst. Geol. AS CR, Prague.



a

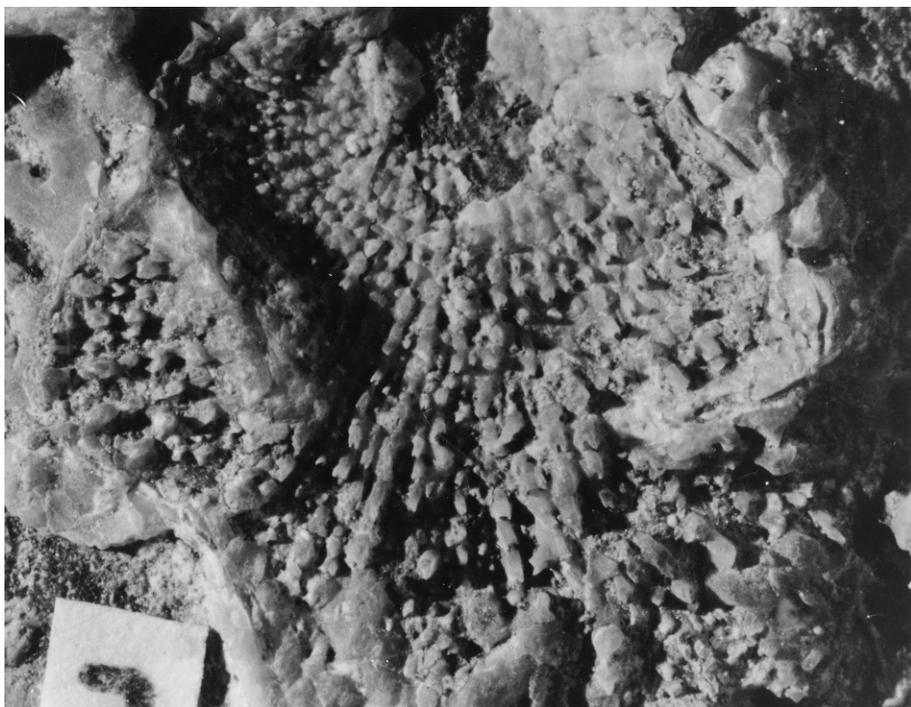


b

Plate II. a – Clast surface with cemented shell of *Anomia subtruncata* D'ORBIGNY with small remains of the upper valve preserved. Some remains of other epibionts are also visible. b – *A. subtruncata*, one complete (with attached foraminifer *Acruliammina longa* TAPPAN in the centre) and two fragmentary cemented valves. Scale bars = 2 mm. Photograph J. Brožek.

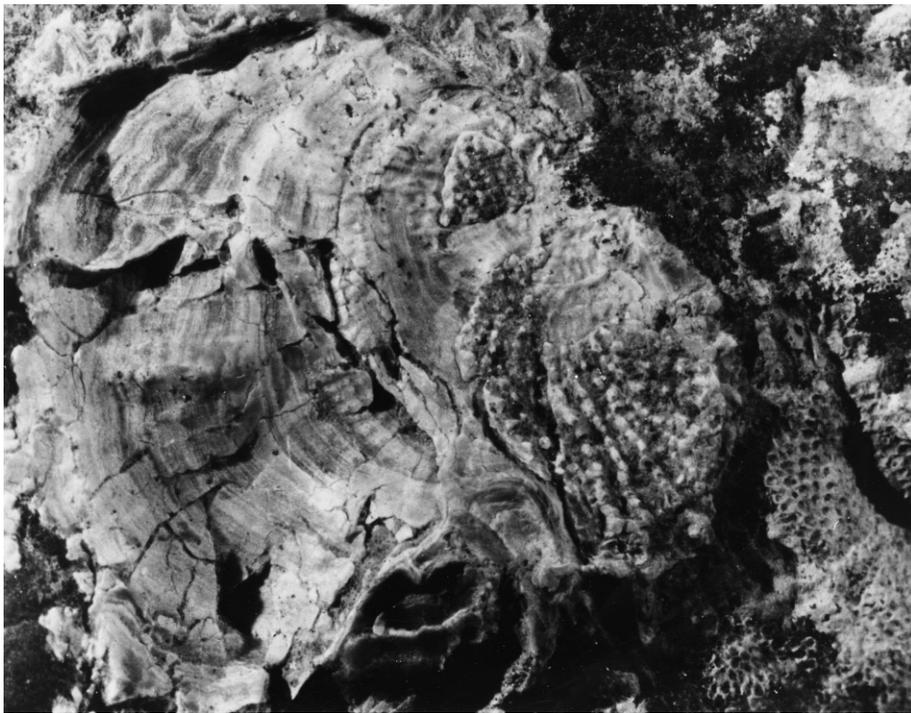


a



b

Plate III. a – A part of clast surface with remains of cemented valves of *Anomia subtruncata* D'ORBIGNY and other epibionts, showing the most common type of epibiont preservation. b – A close-up view of cemented valve of *Plicatula inflata* SOWERBY with preserved upper valve (see Pl. I, fig. a). Scale bars = 2 mm. Photograph J. Brožek.



a



b



c

Plate IV. a – *Plicatula inflata* SOWERBY, cemented lower valve with remains of upper valve. b – *P. inflata*, cemented valve. c – a probable juvenile specimen of the same species. Scale bars = 2 mm (a, c) and 5 mm (b). Photographs a and c – J. Brožek, b – J. Žítt.