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HALKYARDIA MAXIMA N. SP. (MIDDLE OLIGOCENE) AND *HALKYARDIA MINIMA* (L I E B U S) (MIDDLE EOCENE)

(Pl. LVII—LVIII, 1 fig.)

Halkyardia maxima n. sp. (srednji oligocen) in Halkyardia minima (L i e b u s) (srednji eocen)

(Tabl. LVII—LVIII, sl. 1)

A b s t r a c t: The species Halkyardia maxima n.sp. from Middle Oligocene (Gornji Grad Beds, Slovenia) and Halkyardia minima from the Middle Eocene of Dalmatia are described.

Middle Oligocene strata in the surroundings of Pojšica (fig. 1) (Slovenia, NW Yugoslavia) are known in the geological literature for more than a hundred years, and were described as Gornji Grad Beds [1]. The Lower Gornji Grad Beds are represented by conglomerates and sandstones. They are overlain by the littoral Upper Gornji Grad Beds comprising about 15 meters of alternating clays (more or less sandy) and calcareous sandstones with megafossils. The Gornji Grad Beds pass upwards into a marly clay containing a very rich Middle Oligocene foraminiferal fauna identical with the fauna of the Kiscell Clay in Hungary. Therefore, the marly clay in question was also at this locality described under this name (C i m e r m a n, 1967, p. 253).

We have investigated also the foraminiferal fauna from two samples of the Upper Gornji Grad Beds at Poljšica. The first sample (No. 1092) has been taken from a softer bed of the calcareous sandstone, and the other one (No. 1112) from the clay, about meter under the first one.

In the sample No. 1092 the following foraminiferal fauna occurs:

Spiroplectammina carinata (d ' O r b i g n y)
Virgulina schreibersiana C z j z e k
Reussella spinulosa (R e u s s)
Cibicides lobatulus (W a l k e r et J a c o b)
Halkyardia maxima n. sp.
Sphaerogypsina globulus (R e u s s)
Asterigerina bimammata (G ü m b e l)
Asterigerina rotula K a u f m a n n
Conorbina formosa (R e u s s)
Pararotalia lithothamnica (U h l i g)

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[1] Gornji Grad Beds were orignally described under the german name „Oberburger Schichten" at Gornji Grad (germ: Oberburg), 35 km NE from Ljubljana.

Nummulites intermedius d'Archiac
Nummulites chavannesi de la Harpe
Operculina ex gr. *alpina.*

In the sample No. 1112 the following fauna occurs:
Cibicides lobatulus (Walker et Jacob)
Halkyardia maxima n. sp.
Conorbina formosa (Reuss)

In both samples occurs a form of the genus *Halkyardia* which we originally designated as *Halkyardia* sp. (Cimerman, 1967, p. 252). This form is rather frequent in our samples, so it has been possible to study it more closely. We found that we have to deal with a new species and named it *Halkyardia maxima.*

Family: *Cymbaloporidae* Cushman 1927
Genus: *Halkyardia* Heron-Allen et Earland in Halkyard 1919

Halkyardia maxima n. sp.
(pl. LVII, figs. 1—11)

Holotypus: 1112/Hk-20.
Stratum typicum: Upper Gornji Grad Beds, Middle Oligocene.
Locus typicus: Poljšica.
Paratypi: 1112/Hk-7, 1112/Hk-18, 1112/Hk-19, 1092/Hk-1.
Derivatio nominis: by its larger size on the contrary to *Halkyardia minima* (Liebus).

Diagnosis: The test is lenticular, usually concavo-convex, more rarely planoconvex (especially the smaller tests), sometimes even somewhat biconvex. The dorsal side is always convex, changeable is only the ventral side. The embryonic chambers are very large.
Description: The dorsal side of the lenticular test is always more or less convex. The entire surface is perforated, although without ornamentation. On the dorsal side the chambers are not visible. They are observable only in transmited light on the periphery where the test is thinner.

The ventral side displays in its center the porous umbilical plug, and around it the radially arranged tubular chambers of the last ring. The umbilical plug is outwards usually concave, rarely flat and exceptionally convex. *Halkyardia* has no aperture. The chambers communicate with the surroundings only through the pores (pl. LVII, fig. 1).

We have measured the diameter of the tests and their heights. The height has been measured from the tangent on the ventral side to the top of the dorsal side.

diameter of the test: 0,33—1,34 mm; holotype: 0,76 mm
height of the test: 0,17—0,44 mm; holotype: 0,34 mm

The inner structure has been studied in oriented sections: in the axial section and in the horizontal sections through the embryonic apparatus, closely under the embryonic apparatus, and approximately in the equator plane.

a) Horizontal section through the embryonic apparatus

In this section the microspheric and megalospheric forms have been observed. The microspheric embryonic part consists of a small proloculus with up to six chambers arranged in a spire around it (pl. LVII, figs. 10, 11).

diameter of the proloculus: appr. 10 microns
diameter of the spire: appr. 80 microns.

The megalospheric embryonic apparatus consists of a protoconch, a somewhat larger deuteroconch, two symmetrically disposed primary auxiliary chambers, and about seven secondary auxiliary chambers. The primary auxiliary chambers touch with their base the protoconch and the deuteroconch, the secondary ones touch either the protoconch or the deuteroconch.

The tubular chambers having in the horizontal section the form of irregular polygons, are disposed around the embryonic apparatus in annular series. There are no whorls. The chambers of a ring do not always touch each other, especially in the younger part of the test. Therefore the rings are difficult to follow in the horizontal section. The horizontal section through the embryonic apparatus never shows all the rings of the tubular chambers, the dorsal side being convex and the embryonic apparatus lying closely under the top. In the slides at most five rings could have been counted.

On the megalospheric embryonic apparatus we have measured the minimal diameter (D min) and the maximal diameter (D max) of the protoconch and deuteroconch. The minimal diameter is perpendicular to the septum between both chambers, and the maximal diameter is parallel to it. The minimal diameter is at the same time the height of the chamber.

protoconch	D min:	27—86 microns
	D max:	35—108 microns
deuteroconch	D min:	32—75 microns
	D max:	40—124 microns

The dorsal wall consists of several layers of a porous matter, seen in the horizontal section as a ring on the periphery of the section. If the test is more convex, the ring is narrower, and vice versa (pl. LVII, figs. 5, 6, 7).

b) Axial section

No axial sections trough a microspheric form were available. The axial section through the megalospheric test in the direction of the smallest diameter of the first two chambers shows a hemispherical protoconch and a somewhat larger deuteroconch. On left and on right they are touched by two secondary auxiliary pyriform chambers ending downwards in a point. These two chambers are followed towards the ventral side of the section by continually larger tubular chambers.

The dorsal wall of the test is thickest over the embryonic chambers. The structure of the wall is layered parallel to the convexity. As a new ring of radially disposed tubular chambers grows around the umbilicus, the entire test is covered with a new layer. Only during the growth of the youngest rings the top of the test can remain uncovered. Therefore on the dorsal side of some tests concentric circles can be seen.

The conical cavity under the embryonic apparatus is filled by the porous umbilical plug. In the axial section, this filling has the form of an isosceles triangle. The angle at the top of the umbilical plug, varies from 76°—84° (six measurements). The umbilical plug grew similar as the dorsal wall. The older layers are horizontal, whereas the younger ones are concave, and very rarely convex. It depends of the umbilical plug, whether the test is concavo-convex, planconvex, or even biconvex. The pores in the plug are always perpendicular to the layers (pl. LVII,

figs. 2, 3, 4).

c) Horizontal section closely under the embryonic apparatus

In the horizontal section closely under the embryonic apparatus only the radially disposed auxiliary chambers can be seen, around of them follow tubular chambers and on the perifery there is a broad belt of the porous dorsal wall (pl. LVII, fig. 6).

d) Equatorial section

The equatorial section shows in the center the porous umbilical plug, a broad ring of tubular chambers towards the periphery (pl. LVII, fig. 9).

Halkyardia minima (L i e b u s)

(pl. LVIII, figs. 1—6)

1911 *Cymbalopora radiata* H a g. var. *minima* nov. — L i e b u s, p. 952, pl. 3, fig. 7.
1919 *Halkyardia minima* (L i e b u s) — H e r o n - A l l e n et E a r l a n d in H a l k y a r d, p. 110, pl. 6, figs. 7, 8.
1959 *Halkyardia minima* (L i e b u s) — H o f k e r, p. 116, text figs. 21—27.
1967 *Halkyardia minima* (L i e b u s) — H a g n, p. 229, pl. 4, fig. 5 .

D e s c r i p t i o n: In the literature the species *Halkyardia minima* (L i e b u s) is often mentioned. However, the descriptions and illustrations are controversial (e.g. H a l k y a r d, 1919; B u r s c h, 1947). They differ also from L i e b u s' original description that, unfortunately, gives only the external shape, of the test, but not its internal structure. Therefore we studied topotypes of the species *Halkyardia minima* (L i e b u s) from Middle Eocene flysch from Smoković (fig. 1), ENE of Zadar (Dalmatia).

The tests are usually very small, and biconvex. Usually the dorsal side is more convex, and in some cases the ventral one. The dorsal side is not ornamented; the surface is sprinkled with small pores, which are especially well visible after coloring the tests with methylene blue. The ventral side shows on the periphery a ring of radially disposed tubular chambers, and in the center there is the always convex porous umbilical plug.

diameter of the test: 0,25—0,43 mm
height of the test: 0,14—0,21 mm

a) Horizontal section

The horizontal section through the embryonic part shows the hemispherical protoconch, the somewhat larger deuteroconch and two primary auxiliary chambers. Other chambers are in the section less visible (pl. LVIII, figs. 5, 6).

protoconch — D min: 19—43 microns
D max: 24—49 microns
deuteroconch — D min: 16—40 microns
D max: 27—59 microns

b) Axial section

The axial section shows the dorsal wall of the test, thinning from the top towards the periphery. This wall is of similar structure as in *H. maxima* n. sp. The pores pass through the dorsal wall always perpendicularly to the surface. On each side of the embryonic part there are about five tubular chambers. The limits between the chambers are in the slides not well observable. The conical cavity under the embryonic apparatus is filled by the porous umbilical plug. The pores pass through

the plug divergently towards the ventral side. The layers of the umbilical plug are always convex towards the ventral side, so that the pores pierce them at right angle. The angle at the top of the plug varies from 55° to 64° (four measurements). (pl. LVIII, figs. 2, 3, 4).

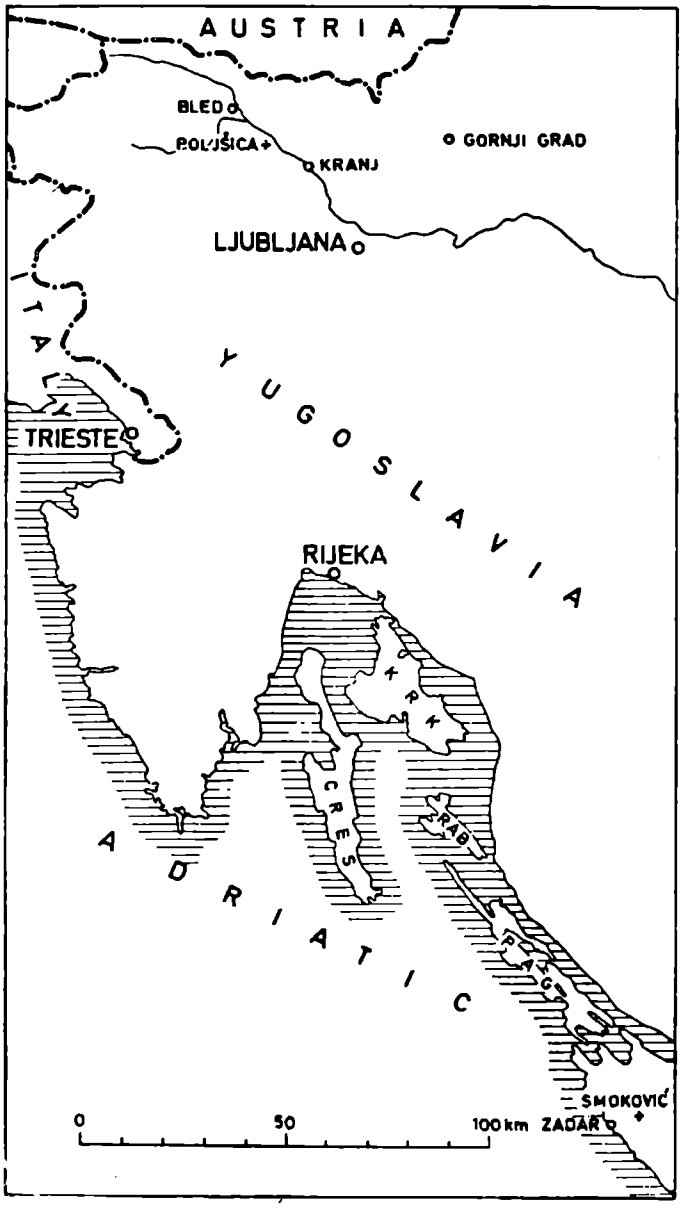

Fig. 1. Locality map

Comparison and discussion

We compared the species *Halkyardia maxima* n.sp. with some species of the genus *Halkyardia* already described: with the forms which Bursch (Bursch, 1947, p. 29) described as *Halkyardia minima* (Liebus) from the Upper Eocene of the Moluccas, and with the species *Halkyardia bikinensis* Cole (Cole, 1954), from the Lower Oligocene of the Bikini Atol.

Bursch's form of *Halkyardia* resembles surprisingly to *Halkyardia maxima* n.sp. Both correspond completely in the external shape

and in the dimensions of the test. The same holds for the arrangement of the chambers in the axial and horizontal sections. They differ only in the dimensions of the chambers of the embryonic apparatus. In Bursch's form these chambers are approximately half as large as the corresponding chambers of *Halkyardia maxima* n.sp., although the upper values of Bursch's form still fall into the variation range of *H. maxima* n. sp. We are convinced that both forms are identical.

Comparing Bursch's very exact description of *Halkyardia* from the Moluccas with topotypes from Smoković (Dalmatia), we conclude that Bursch's form is not identical with *Halkyardia minima* (Liebus), but with *Halkyardia maxima* n.sp.

We mention here also the subspecies *Halkyardia minima indica* Tewari from the Middle Eocene of India. Obviously the point of departure to Tewari was Bursch's *Halkyardia* from Moluccas, and not Liebus's *Halkyardia minima* from the Eocene of Dalmatia. But judging upon the dimensions and the figures given by Tewari (Tewari, 1956, p. 174) the indian form is not related to *H. maxima* n. sp., but to *Halkyardia minima* (Liebus).

From the type locality, of the Gornji Grad Beds at Gornji Grad also Hemleben (Hemleben, 1964) mentions the species *Halkyardia minima* (Liebus), however in his paper there are neither a description nor pictures of this species. As the foraminiferal fauna of the Gornji Grad Beds at Poljšica resembles much the corresponding fauna of Gornji Grad, it is highly probable that also at Gornji Grad the species *Halkyardia maxima* n.sp. occurs.

Lühr (Lühr, 1962, p. 153) mentions the species *Halkyardia minima* (Liebus) from the Lower Oligocene of Häring in Tyrol. He refers to Bursch's exhaustive description and concludes his species to be identical, with Bursch's one. Therefore we suppose that also in this case the species *Halkyardia maxima* n. sp. is concerned.

By the external shape and dimensions also the *Halkyardia bikinensis* Cole (Cole, 1954, p. 584) resembles to our new form. However, there are differences in the internal structure and in dimensions of the chambers. Above all, its embryonic chambers are smaller. When Cole compared the species *Halkyardia bikinensis* with Bursch's form he noticed that Bursch's form has larger embryonic chambers. *Halkyardia maxima* n.sp. has still larger embryonic chambers as Bursch's form. In the axial section *Halkyardia bikinensis* differs from *Halkyardia maxima* n.sp. in a lower and broader umbilical plug. The angle at the top of the *Halkyardia bikinensis* is about 100° (measured on the picture). Therefore the younger tubular chambers are not so much longer of the older ones, as in *Halkyardia maxima* n.sp. The horizontal section shows a small embryonic apparatus, from which small polygonal chambers in almost straight rows are disposed radially towards the periphery. On the contrary in *H. maxima* n. sp. the chambers are not arranged in regular radial rows.

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POVZETEK

V dveh vzorcih srednjeoligocenskih gornjegrajskih skladov pri Poljšici smo našli predstavnike rodu *Halkyardia*, ki smo jih prvotno označili kot *Halkyardia* sp. Ko smo jih natančneje preučili, smo ugotovili, da gre za novo vrsto.

Družina: Cymbaloporidae Cushman 1927.
Rod: *Halkyardia* Heron-Allen et Earland v. Halkyard 1919

Halkyardia maxima n. sp.
(tabl. LVII, sl. 1—11)

Holotypus: 1112/Hk-20.
Stratum typicum: zgornji gornjegrajski skladi, srednji oligocen.
Locus typicus: Poljšica.

Paratypi: 1112/Hk-7, 1112/Hk-18, 1112/Hk-19, 1092/Hk-1.
Derivatio nominis: zaradi svoje velikosti v nasprotju z vrsto *Halkyardia minima* (Liebus).
Diagnoza: Lečasta hišica je navadno konkavno-konveksna, redkeje plankonveksna (posebno manjše hišice), včasih celo rahlo bikonveksna. Dorzalna stran je vedno konveksna, spreminja se samo ventralna stran. Embrionalne kamre so večje, kot pri drugih znanih vrstah.
Opis vrste:

Dorzalna stran lečaste hišice je vedno bolj ali manj izbočena in posuta s porami.

Ventralna stran kaže na sredi porozen umbilikalni čep, okrog njega pa so radialno razvrščene cevaste kamre zadnjega venca. Umbilikalni čep je na zunaj navadno konkaven, redkeje je raven, izjemoma konveksen.

Pravega ustja *Halkyardia* nima. Kamre komunicirajo z okoljem samo skozi pore (tab. LVII, sl. 1).

Pri hišicah smo merili premer hišice in njeno višino. Višino smo merili od tangente na ventralno stran do vrha dorzalne strani.

premer hišice: 0,33—1,34 mm, holotip: 0,76 mm
višina hišice: 0,17—0,44 mm, holotip: 0,34 mm

Notranjo zgradbo smo preučevali v orientiranih presekih: v osnem preseku in v horizontalnih presekih skozi embrionalni aparat, tik pod ebrionalnim aparatom, in približno v višini ekvatorja.

a) Horizontalni presek skozi embrionalni aparat

V tem preseku smo opazovali mikrosferične in megalosferične oblike. Mikrosferični embrionalni del sestoji iz majhnega prolokula, okoli njega pa je v spiralni razvrščenih do šest kamer (tab. LVII, sl. 10, 11)

premer prolokula: ca 10 mikronov,
premer spirale: ca 80 mikronov.

Megalosferični embrionalni aparat sestoji iz polkroglastega protokonha, nekoliko večjega devterokonha, dveh simetrično postavljenih primarnih auksiliarnih kamer in iz okoli sedem sekundarnih auksiliarnih kamer. Primarni auksiliarni kamri sta tisti dve, ki se dotikata s svojo bazo protokonha in devterokonha obenem, sekundarne pa se dotikajo ali protokonha ali devterokonha.

Cevaste kamre, ki imajo v horizontalnem preseku obliko nepravilnih mnogokotnikov, so razvrščene okoli embrionalnega aparata v vencih. Sosednje kamre enega venca se zlasti v mlajšem delu hišice med seboj ne dotikajo vedno. Zato je vence v horizontalnem preseku težko zasledovati. Horizontalni presek skozi embrionalni aparat nikoli ne kaže vseh vencev cevastih kamer. V zbruskih, ki smo jih naredili, smo lahko našteli največ pet vencev cevastih kamer.

Pri megalosferičnem embrionalnem aparatu smo merili najmanjši premer (D min) in največji premer (D max) protokonha in deveterokonha. Najmanjši premer je obenem tudi višina kamre.

Protokonh — D min: 27— 86 mikronov
D max: 35—108 mikronov
Devterokonh — D min: 32— 75 mikronov
D max: 40—124 mikronov

Dorzalno steno sestavlja več plasti porozne substance, ki jo v horizontalnem preseku vidimo kot kolobar na periferiji preseka (tab. LVII, sl. 5, 6, 7).

b) Osni presek

Nobeden od osnih presekov ni pokazal mikrosferične oblike. Presek skozi megalosferično hišico v smeri najmanjših premerov prvih dveh kamer kaže polkrožni protokonh in nekoliko večji devterokonh. Na levi in desni se ju dotikata dve sekundarni auksiliarni kamri hruškaste oblike, ki se navzdol koničasto končujeta. Tema dvema sledijo proti ventralni strani preseka vedno daljše cevaste kamre.

Dorzalna stena hišice je v aksialnem preseku najdebelejša nad embrionalnimi kamrami. Struktura stene je plastovita in to vzporedno s konvenksnostjo. Ko je zrasel nov venec cevastih kamer, se je cela hišica obdala z eno plastjo. Le pri najmlajših vencih je vrh hišice ostal gol. Zato vidimo na nekaterih hišicah na dorzalni strani koncentrične kroge.

Stožčast votel prostor pod embrionalnim aparatom je zapolnjen s poroznim umbilikalnim čepom. V aksialnem preseku ima ta zapolnitev obliko enakokrakega trikotnika. Kót pri vrhu umbilikalnega čepa je 76°—84°. Umbilikalni čep je nastajal vzporedno z dorzalno steno in je podobno zgrajen. Starejše plasti so horizontalne, mlajše pa so navadno konkavne, redko konveksne. Pore potekajo skozi čep vedno pravokotno na plastovitost (tab. LVII, sl. 2, 3, 4).

Halkyardia minima (L i e b u s)

(tab. LVIII, sl. 1—6)

V literaturi najdemo večkrat navedeno vrsto *Halkyardia minima* (L i e b u s), vendar si opisi in upodobitve med seboj nasprotujejo (n. pr. H a l k y a r d 1919, B u r s c h 1947). Razločujejo se tudi od originalnega Liebusovega opisa, kjer žal, ni opisana tudi notranja zgradba. Zaradi primerjave smo preučili topotipe vrste *Halkyardia minima* (L i e b u s) iz Smokovića pri Zadru.

Hišice so navadno zelo majhne in bikonveksne. Dorzalna stran je posejana z drobnimi porami. Ventralna stran kaže na periferiji venec radialno potekajočih cevastih kamer, na sredi pa vselej konveksno izbočen porozen umbilikalni čep. Horizontalni presek skozi embrionalni del kaže polkroglast protokonh, ki se ga drži nekoliko večji devetorokonh in dve primarni auksiliarni kamri. Ostale kamre se v preseku slabo vidijo, ker zbruski niso jasni. Osni presek kaže neenakomerno debelo dorzalno steno, ki se od sredine proti periferiji tanjša. Na vsako stran embrionalnega dela sledi okoli pet cevastih kamer. Stožčast prostor pod embrionalnim delom zapolnjuje porozen umbilikalni čep. Pore potekajo skozi čep divergentno proti ventralni strani. Plasti čepa so konveksne, tako da jih pore prebijajo pod pravim kotom. Kot pri vrhu čepa je 55°—64°.

P r i m e r j a v a i n d i s k u s i j a

Vrsto *Halkyardia maxima* n. sp. smo primerjali z nekaterimi že opisanimi vrstami rodu *Halkyardia*. Ugotovili smo, da je oblika, ki jo Bursch opisuje kot *Halkyardia minima*, identična z vrsto *Halkyardia maxima* n. sp., ne pa z Liebusovo vrsto iz dalmatiskega eocena.

Za podvrsto *Halkyardia minima indica* T e w a r i (T e w a r i 1956) ugotavljamo, da gre za podvrsto Liebusove vrste *Halkyardia minima*, čeprav je Tewariju očividno služil za izhodišče Burschov opis.

Iz klasičnega nahajališča gornjegrajskih skladov pri Gornjem gradu citira H e m l e b e n (1964) vrsto *Halkyardia minima* (L i e b u s). Ker je

foraminiferna favna gornjegrajskih skladov pri Poljšici zelo podobna ustrezni favni pri Gornjem gradu, je zelo verjetno, da gre tudi za vrsto *H. maxima* n. sp.

Ker se tudi L ü h r (1962) sklicuje na izčrpen Burschov opis vrste *Halkyardia minima,* menimo, da gre v Lührovem primeru za vrsto *Halkyardia maxima* n. sp.

EXPLANATION OF PLATES

Plate LVII

Halkyardia maxima n. sp. (Middle Oligocen)

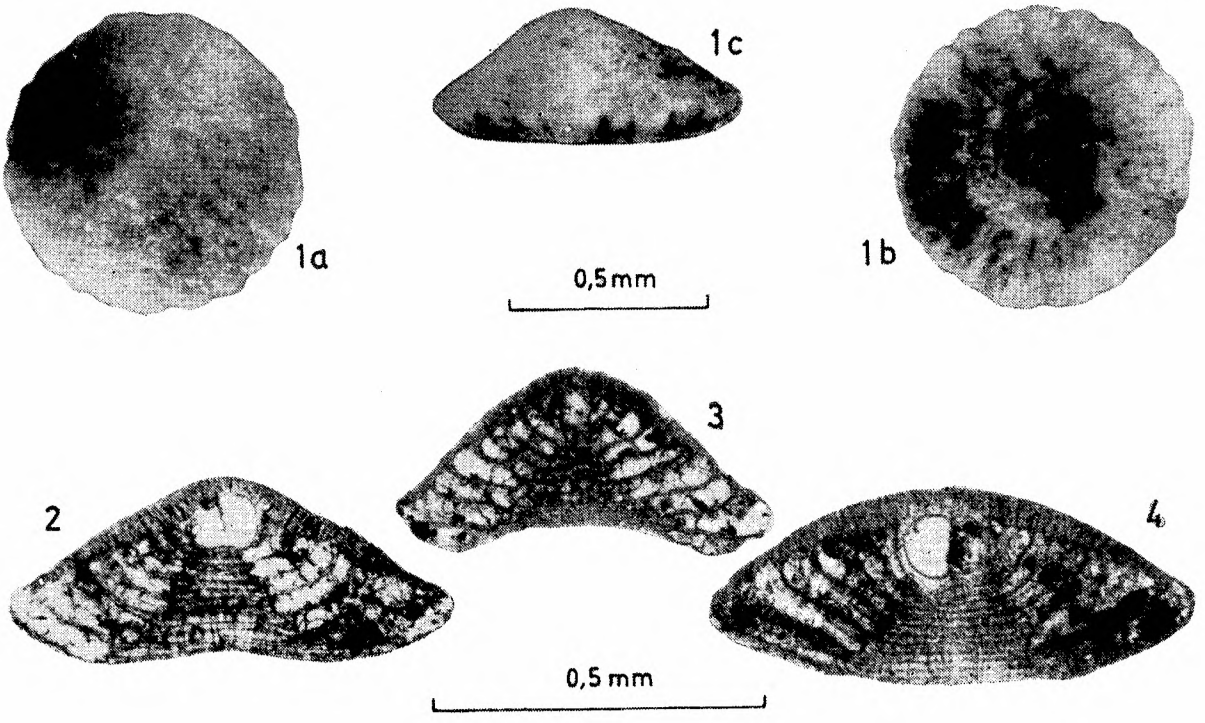
Fig. 1. Holotype, Poljšica 1112/Hk-20. a dorsal side; b — ventral side; c — side view
Fig. 2. Axial section, megalospheric form, Poljšica 1112/Hk-7
Fig. 3. Axial section, megalospheric form, Poljšica 1112/Hk-8
Fig. 4. Axial section, megalospheric form, Poljšica 1112/Hk-2
Fig. 5. Horizontal section through the embryonic apparatus, megalospheric form, Poljšica 1112/Hk-1
Fig. 6. Horizontal section closely under the embryonic apparatus, Poljšica 1112/Hk-3
Fig. 7. Horizontal section through the embryonic apparatus, megalospheric form, Poljšica 1112/Hk-18
Fig. 8. Horizontal section through the embryonic apparatus, megalospheric form, Poljšica 1112/Hk-10
Fig. 9. Equatorial section. Poljšica 1112/Hk-19
Fig. 10. Horizontal section through the embryonic apparatus, microspheric form, Poljšica 1092/Hk-1
Fig. 11. Horizontal section through the embryonic apparatus, microspheric form, Poljšica 1112/Hk-4

Plate LVIII

Halkyardia minima (L i e b u s) (Middle Eocene)

Fig. 1. Smoković 1128/Hk-18. a — dorsal side; b — ventral side; c — side view
Fig. 2. Axial section, megalospheric form, Smoković 1128/Hk-14
Fig. 3. Axial section, megalospheric form, Smoković 1128/Hk-12
Fig. 4. Axial section, megalospheric form, Smoković 1128/Hk-13
Fig. 5. Horizontal section through the embryonic apparatus, megalospheric form, Smoković 1128/Hk-3
Fig. 6. Horizontal section through the embryonic apparatus, megalospheric form, Smoković 1128/Hk-2

Photographs were made by the author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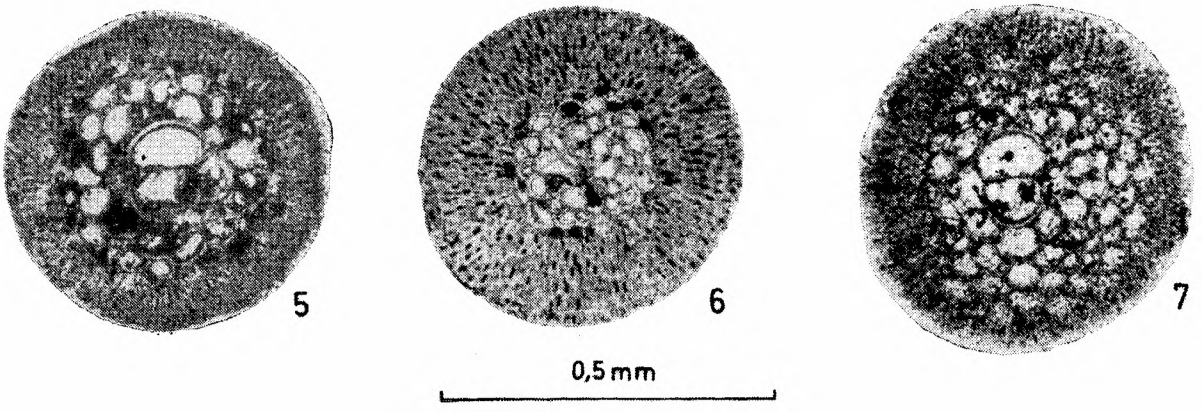
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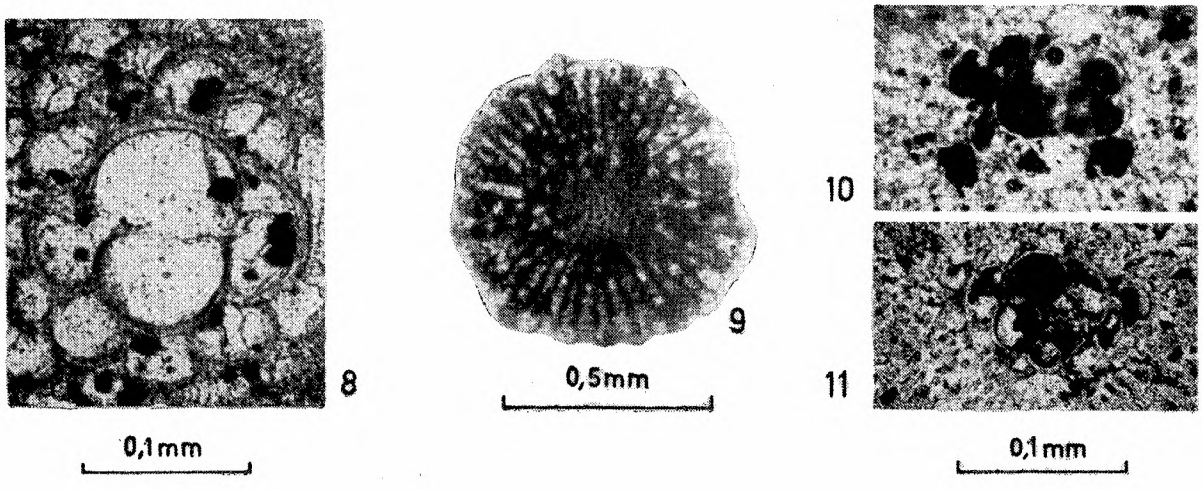
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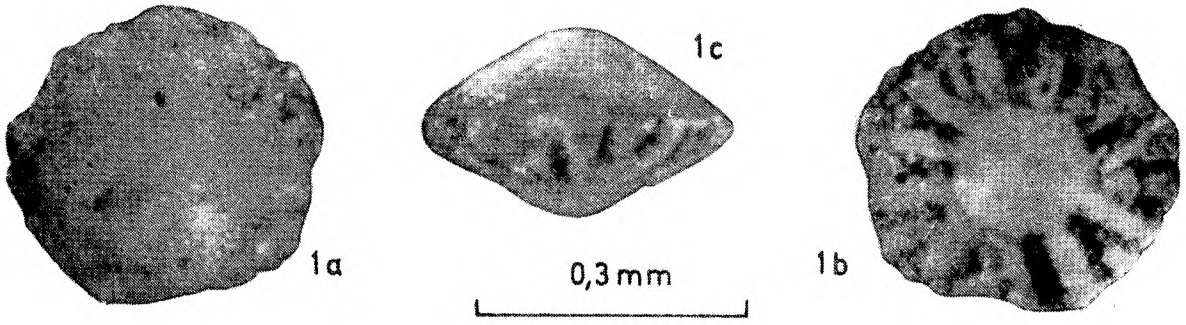
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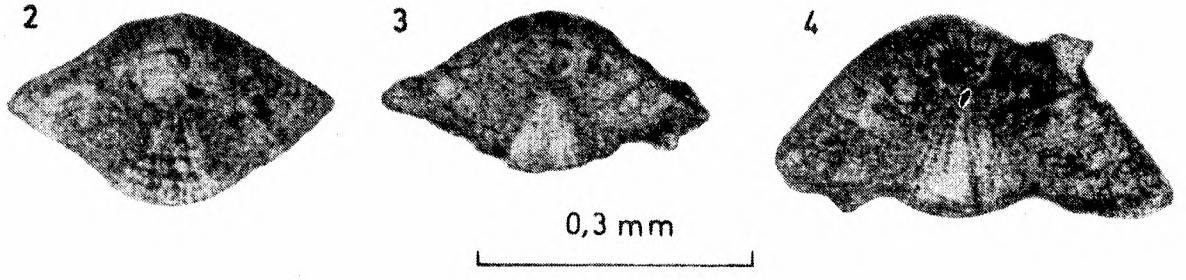
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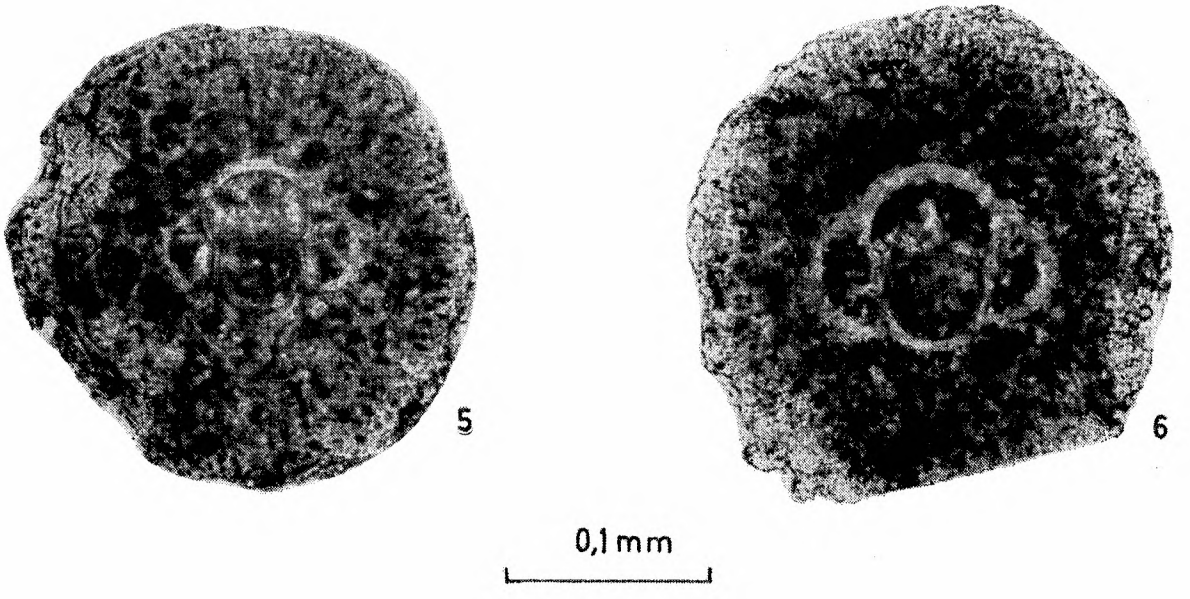
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