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THE GENUS *ARENOBULIMINA* CUSHMAN FROM THE UPPER ALBIAN AND CENOMANIAN OF THE POLISH LOWLANDS

(Pl. V—VIII, 13 Figs.)

Rodzaj Arenobulimina Cushman z górnego albu i cenomanu Niżu Polski

(*Tabl. V—VIII, 13 fig.*)

Abstract: Seven species of the genus *Arenobulimina* Cushman, found in the Upper Albian and Cenomanian of the Polish Lowland, are described. Five of them, *Arenobulimina sabulosa* (Chapman), *A. chapmani* Cushman, *A. conoidea* (Perner), *A. frankei* Cushman and *A. advena* (Cushman) are very well known in the literature. The new species described are *Arenobulimina polonica* n. sp. and *A. varsoviensis* n. sp.

In the author's considerations of representatives of *Arenobulimina* Cushman (sensu lato), occurring in the Upper Albian and Cenomanian sediments of the Polish Lowlands, two factors arise: variability within genera and a relatively large number of individuals, as well as their state of preservation. The internal structure of the chambers of certain species is not reflected in morphology of the test exterior. Nor could it be seen in thin sections of tests, filled with recrystallized material. The state of preservation of representatives of the genus *Arenobulimina* was undoubtedly one of the factors preventing recognition of the internal structure of some species well known in the literature. The *Arenobulimina* assemblage in samples from Gorzów Wielkopolski bore-hole differs from those occurring in other borings, such as Łódź 4a and Ślazewo 5. They show greater differentation of species and a different state of preservation of tests.

The tests of species of *Arenobulimina* Cushman from the Gorzów Wielkopolski boring are not recrystallized and the interior is not filled with rock in most cases. In many specimens the walls of chambers of the last formed whorl are damaged and thus their internal structure is seen.

Certain species of this almost exclusively European and Cretaceous genus were described for the first time from N.W. Poland. These include

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Arenobulimina frankei Cushman and *Hagenowella advena* Cushman, described in 1936 by A. J. Cushman. The first of the species mentioned above comes from the Cenomanian sediments at Mierczany (formerly Hildesheim), about 8 km SSE from Rzepin (Fore-Sudetic Monocline). The Cretaceous is here in situ and is overlain by a comparatively thick cover (about 200 m) of Cenozoic sediments. Therefore J. A. Cushman's samples must have come from a bore-hole.

Hagenowella advena Cushman comes from the cretaceous rocks exposed at Zastań (formerly Zünz) in Pomorze.

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GENUS *ARENOBULIMINA* CUSHMAN 1927

The genus *Arenobulimina* was created by J. A. Cushman in 1927 for spiral forms with agglutinated tests. J. A. Cushman took *Bulimina preslii* Reuss 1845 as a typical species for the genus.

In the diagnosis of the genus *Arenobulimina*, J. A. Cushman does not give the number of chambers occurring in the last whorls. The initial part of the test is triserial. In 1937, Cushman mentions the occurrence of more than 3 chambers in the later whorls. According to P. Marie (1941), the particular species of this genus have a constant number of chambers in all whorls. Among a number of additional features assigned by P. Marie to the genus *Arenobulimina* Cushman, is the presence of pillar-like supports in the interior of the chambers (arcs-boutants). Also T. Barnard and F. T. Banner (1953) maintain that representatives of *Arenobulimina* contain in their chambers (with the exception of the chambers of the first whorl, loc. cit. p. 177) „strong radial vertical partitions project from the periphery back into the test and occupy the full height of the chambers"... They even hold that, in the case of some individuals, there exists a tendency to form a radial division in two tiers of the interior of the chamber, similar to that in representatives of *Pseudotextulariella* Barnard 1953. As it is clearly seen from the data given above, T. Barnard and F. T. Banner (1953) preserve the name *Arenobulimina* for forms with an internal division. Forms with an agglutinated, trochospiral test in the initial part and uncoiling in the final part, without internal structures in the chambers, they assign to *Ataxogyroidina* Marie. This genus is a younger synonym of the genus *Ataxophragmium* Reuss. As a species typical for the genus *Ataxogyroidina* Marie (1941) accepted *Bulimina variabilis* d'Orbigny, which is a typical species for the genus *Ataxophragmium* Reuss. W. T. Balakhmatowa and E. J. Rejtlinger (in: Osnowy Paleontologii, 1959) hold that both *Arenobulimina* genus and *Ataxophragmium* are characterized by simple and not divided interiors of the chambers.

According to J. Hofker (1957), *Arenobulimina* Cushman is synonymous to the genus *Ataxophragmium.* Test differing in internal structure and belonging, according to the authors, to various genera, are classified by Hofker as individuals of the microspheric generation of species of the genus *Ataxophragmium.* P. Marie (1941) already stated a similar supposition, that *Ataxogyroidina* is the megalospheric generation of *Arenobulimina.*

The author of the present account does not agree with the views given above for two reasons. In accepting P. Marie and J. Hofker's (1957) views it should be assumed that the representatives of the genus *Arenobulimina* in Albian sediments reproduced only sexually because representatives of the genus *Ataxophragmium* thus of generation *A,* appear only in the Cenomanian. Work carried out by the present author has shown the presence of individuals of generations *B* and *A* among the representatives of the genus *Arenobulimina,* occurring in Upper Albian sediments, which contradicts the opinions of P. Marie and J. Hofker.

J. A. Cushman (1933) created a new genus, *Hagenowella,* for agglutinated forms, with a trochospiral manner of coiling and with chambers divided by radial plates extending from the internal parts of the walls of the laterformed whorls and characterized by 3 chambers in the initial part of the test and 4 in the last-formed part. J. A. Cushman's genotype was *Valvulina gibbosa* d'Orbigny, from the Cenomanian of the Parisian Basin. According to Cushman (1933), the fundamental factor, differentiating the newly erected genus from the *Arenobulimina* was the presence of plates in the chambers as well as the absence of tendency for a bigger number of chambers to occũr in the last formed whorl.

J. A. Cushman's choice of a type species for the newly erected genus was critisized by P. Marie (1941). According to P. Marie, *Valvulina gibbosa* is represented in d'Orbigny's collection by 2 forms, the smaller of which is not characteristic and may belong to the genus *Ataxogyroidina (=Ataxophragmium)* or *Globigerina elevata* d'Orbigny 1840, whereas the larger form, with deformed last chamber, represents the genus *Arenobulimina.* D'Orbigny's drawing shows a compilation of all characteristics of these two examples. Furthermore, the specimens mentioned have neither any tooth in the aperture nor divided interiors of chambers. P. Marie's (1941) statement about the inapropriate choice of species, characteristic for the genus *Hagenowella,* brought about research on this subject by A. R. Loeblich and H. Tappan (1961). They examined the specimens designated *Hagenowella gibbosa* by Cushman, which are to be found in Cushman's collection and come from the Upper Cretaceous of Rugia. They came to the conclusion that the specimens do not belong to *Valvulina gibbosa* d'Orbigny, for the French species has simple interiors of chambers. In their opinion those specimens belong to *Valvulina quadribullata* Hagenow, because the interiors of the chambers contain lamellae.

A. R. Loeblich and H. Tappan (1964) include an illustration of a specimen, which they consider as topotype of *Valvulina quadribullata* Hagenow. This specimen had already been illustrated by J. A. Cush-m a n (1933; 1937) as Hagenowella gibbosa. Lamellae dividing the interiors of chambers are indeed clearly visible in the specimen illustrated.

In the history of development of ideas, as to the range of the genus *Arenobulimina* C u s h m a n, one fundamental problem is outstanding: the question whether representatives of *Arenobulimina* have simple or divided interiors of chambers. This problem arises mainly as the result of the lack of information about the internal structure of a large number of holotypes. Moreover, various authors differently estimate the systematic value of the internal lamellae (or, as authors name them, columns) which has caused chaos in the systematics of this group. In the opinion of J. H o f k e r (1957), this characteristic is not even of specific rank. J. A. C u s h m a n and also A. R. L o e b l i c h and H. T a p p a n consider it to be generic characteristic, while A. M. V o l o s h i n a (1965) describes it as subgeneric. The important factor, establishing the systematic value of this characteristic, is the occurrence of lamellar plates in chambers not only present in forms with the Arenobulimina type of coiling, but also in specimens with other types of coiling, as in the case of *Orbignyna, Ataxophragmiun, Voloshinovella,* as well as the remaining specimens, assigned by A. R. L o e b l i c h, H. T a p p a n (1964) to the sub-family *Ataxophragmiinae* S c h w a g e r. Therefore, the occurrence of lamellae can at the most have only specific significance. The genus *Arenobulimina* is rich in species; comprising various forms, among which A. M. V o l o s h i n a (1965) distinguished separate sub-genera on the basis of characteristic features or combinations of features. Among these features, A. M. V o l o s h i n a includes: the rapid expansion of whorls, their degree of convexity, the shape and number of chambers in the whorls, the shape of the aperture, the nature of the surface, the structure of the wall and finally the character of the interior of the chambers (simple or divided by lamellae). On the basis of combinations of the features mentioned above, A. M. V o l o s h i n a (1965) distinguishes several sub-genera, in addition to the typical forms of the genus *Arenobulimina* C u s h m a n, such as the sub-genus *Pasternakia,* with its typical species *Bulimina d'orbignyi* R e i s s, the sub-genus *Harena* with the typical species *Arenobulimina amanda* V o l o s h i n a, *Columnella* with the typical species *Arenobulimina labirynthica* V o l o s h i n a and the sub-genus *Novatrix* with the typical species *Globigerina elevata* d ' O r b i g n y. According to A. M. V o l o s h i n a, the sub-genera erected do not as yet include all the Upper Cretaceous *Arenobulimina.* However, A. M. V o l o s h i n a (1965) does not give any diagnosis for her proposed sub-genera. She refers only to typical forms. Thus, the danger of misunderstanding arises as to the limits of these sub-genera and their distinction from units formed earlier; for instance, the sub-genus *Columnella* V o l o s h i n a seems to correspond entirely to the genus *Hagenowina* L o e b l i c h and T a p p a n. However, A. M. V o l o s h i n a (1965) writes that it is not known whether the number of chambers in the genus *Hagenowina* is constant in all whorls or whether this varies in the adhering whorls; but there is a similar lack of certainty in the case of the sub-genus *Columnella.*

The present author, after examining the material from the Upper Albian and the Cenomanian from the Polish Lowlands, deduced that the number of chambers in the whorls is a specific characteristic. Species of the genus *Arenobulimina* may have a constant number of chambers in all whorls, with a smaller number in the initial whorls and a larger one in last-formed whorls, or vice versa. Within a particular species, even the number of chambers in the last-formed whorl varies within certain limits.

J. A. Cushman (1927), P. Marie (1941), W. T. Balakhmatova and E. A. Rejtlinger (in: Osnovy Paleontologii; 1959) and Neumann (1967) consider the presence of the tooth in the aperture to be one of the characteristic features for the genus *Arenobulimina*. Only A. R. Loeblich and H. Tappan (1964) are of the opinion that the aperture mentioned is without any tooth.

The specimens from the Polish Lowlands with *Arenobulimina* coiling of the test, both simple chambers and internally divided chambers, have no tooth in the aperture. The aperture in species examined by the author has a loopshaped or oval opening; it is situated in the middle of the apertural surface in a trough-like depression and is surrounded from the top of the test by a thin halfmoon-shaped lip of varying altitude. Among specimens, in which the depression of the apertural surface, where the aperture lies, is quite broad, one of the arms of the lip might be mistaken for a tooth.

SYSTEMATIC DESCRIPTION

Order Foraminiferida Eichwald, 1830
Suborder Textulariina Delage and Herouard, 1896
Superfamily Lituolacea de Blainville, 1825
Family Ataxophragmiidae Schwager, 1877
Subfamily Ataxophragmiinae, Schwager, 1877
Genus *Arenobulimina* Cushman, 1927
Type species: *Bulimina preslii* Reuss, 1846
(= *Hagenowella* Cushman, 1933 (type, *Valvulina gibbosa* d'Orbigny, 1840); *Hagenowina* Loeblich and Tappan, 1961 (type, *Valvulina quadribullata* von Hagenow, 1842)

Arenobulimina sabulosa (Chapman)

Pl. V, Fig. 3; Pl. VII, Fig. 3 a, b, Text-fig. 1, 2

1892 *Bulimina presli* Reuss var. *sabulosa* Chapman; Chapman F.: p. 755, Pl. XII, Fig. 5.
1934 *Arenobulimina sabulosa* (Chapman), Cushman J. A.; Parker F. L.: pp. 32—35, Pl. 6, Fig. 6a, b.
1937 *Arenobulimina sabulosa* (Chapman); Cushman J. A.: pp. 36—37, Pl. 3, Fig. 29, 30a, b.
1947 *Arenobulimina sabulosa* (Chapman); Grekoff N.: p. 499, Pl. 2, Fig. 3a, b.
1957 *Verneuilinoides borealis* Tappan; Tappan H.: p. 206, Pl. 66, Fig. 16 (non Fig. 10, 11, 12, 13, 14, 15, 17, 18).
1963 *Arenobulimina sabulosa* (Chapman); Kaptarenko-Chernousova O. K. et al.: p. 74, Pl. 14, Fig. 2a, b.

Dimensions in mm.	Largest specimen	Average	Smallest
height	1.030	0.900	0.420
width	0,650	0.684	0.310

Material. 60 well preserved specimens.

D e s c r i p t i o n. Test agglutinated, coarse-grained, very rough, cuneiform, somewhat rounded at the bottom, gradually widening to a considerable extent towards the top, built of 4 whorls. The most readily visible, last-formed whorl mainly constitutes $\frac{1}{2}$ of the length of the test. There are deep incisions in the outline of the test and the cross-section is round. The whorls, with the exception of the last one, consist of 4 chambers strongly convex, trapezoidal in the outline. The chambers in the 3 older whorls are of almost the same height and length, while they are somewhat elongated in the younger whorl. A distinct size selection of quartz grains is to be seen on the surface of the chambers. The largest grains are arranged in the spiral suture and inter-chamber sutures. The sutures between the chambers and the spiral suture are strongly depressed and run obliquely with respect to the horizontal axis of the test. The sutures in the first whorls, masked by large grains of quartz occur on the parts of the chambers close to the sutures. The last-formed whorl is built of 3 chambers; last chamber reniform, convex slightly rounded at the top, forms a kind of collar. The oval aperture situated in the middle of the apertural surface extends from the top of this to the interior edge and is rounded, with a thin, relatively high lip. Individual variability is displayed in an abrupt or gradual broadening of the test in the time of its growth, in the degree of convexity of chambers, in the degree of the depression of the sutures between the chambers and the spiral suture, as well as in the position of the aperture. The aperture becomes terminal in some specimens and does not reach the internal edge of the last chamber. In some forms, there is a tendency towards the uniserial arrangement of chambers revealed in the last-formed whorl, where 2 chambers may occur, the younger one spreading terminally. In the material from Poland, apart from large specimens, somewhat smaller, but very thick specimens are also encountered. However, they consist of 2 or 3, but not 4 whorls. At first they were considered to be forms of various generations of the species mentioned. The size and shape of the test in that case would be connected with different stages of ontogenetic development. After making thin sections, it was confirmed that the size of the initial chamber of the species considered is not connected with the size of the test and with the number of the whorls. The individuals of the microspheric generation B, in which the diameter of the initial chamber varies between 48.0 and 52.8 μ reach a size in the gerontic stage, similar to that of representatives of macrospheric generation A_1 and A_2, that is, they exceed 1 mm in length and 0.5 mm in width at the height of the last-formed whorl. Among the macrospheric forms, individuals of generations A_1 and A_2 may be distinguished. The size of the initial chamber in the individuals of generation A_1 varies within the limits 60.0 to 72.0 μ, while for individuals of generation A_2, the size in the initial chamber is also variable between 81.6 and 91.2 μ. Of the 16 individuals sectioned, of the species under consideration, 4 belong to generation B, 9 to generation A_1 and only 3 to generation A_2. It should be added that the specimens examined come from one population in boring Łódź 5a at a depth of 605.0 m.

The species described differs from *Arenobulimina chapmani* C u s h m a n in having a rougher test, made of larger grains of quartz, a more lobate outline of test, stronger convexity of chambers, a different outline of chambers, stronger depressed sutures, a smaller number of chambers in the last-formed whorl, higher location of the aperture and the lack of additional plates in the chambers of the last whorl.

D i s t r i b u t i o n. It occurs in Folkestone Gault (England), most abundantly in the upper-most Folkestone Beds. J. A. C u s h m a n (1937) holds that specimens from the marls, lying above the Gault-sediments, belong to a different species. It occurs in USSR in the Cenomanian of the Dniepr-Don Depression and the margins of the Donbas basin, as well as in the Albian and Cenomanian of the central Volga region. The species also occurs in the Jura Mts. in the Vraconne area, Switzerland, and in the northern part of Alaska, probably in the sediments of Grandstand formation (Upper Albian). In Poland, it was found in Upper Albian and Cenomanian sediments in the Łódź 4a, Łódź 5a, Ślazewo 5 and Pagórki IG-1 borings.

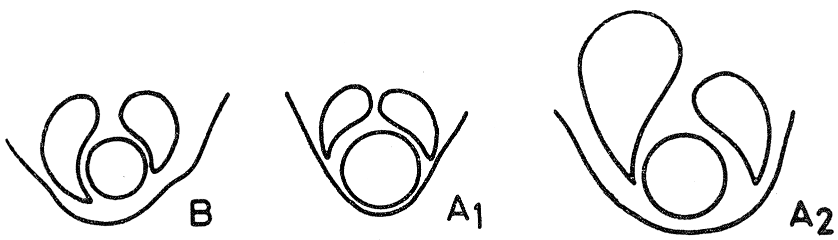

Fig. 1. *Arenobulimina sabulosa* (C h a p m a n). B — generation, diameter of the proloculus — 52,8 microns, length of the test — 1,044 mm, width — 0,558 mm, Łódź 5 a, depth 605 m; A_1 — generation, diameter of the proloculus — 67,2 microns, length of the test — 0,830 mm, width — 0,450 mm, Gorzów Wielkopolski, depth 711 m; A_2 — generation, diameter of the proloculus — 81,6 microns, length of the test — 0,648 mm, width — 0,378 mm, Łódź 5 a, depth 605 m

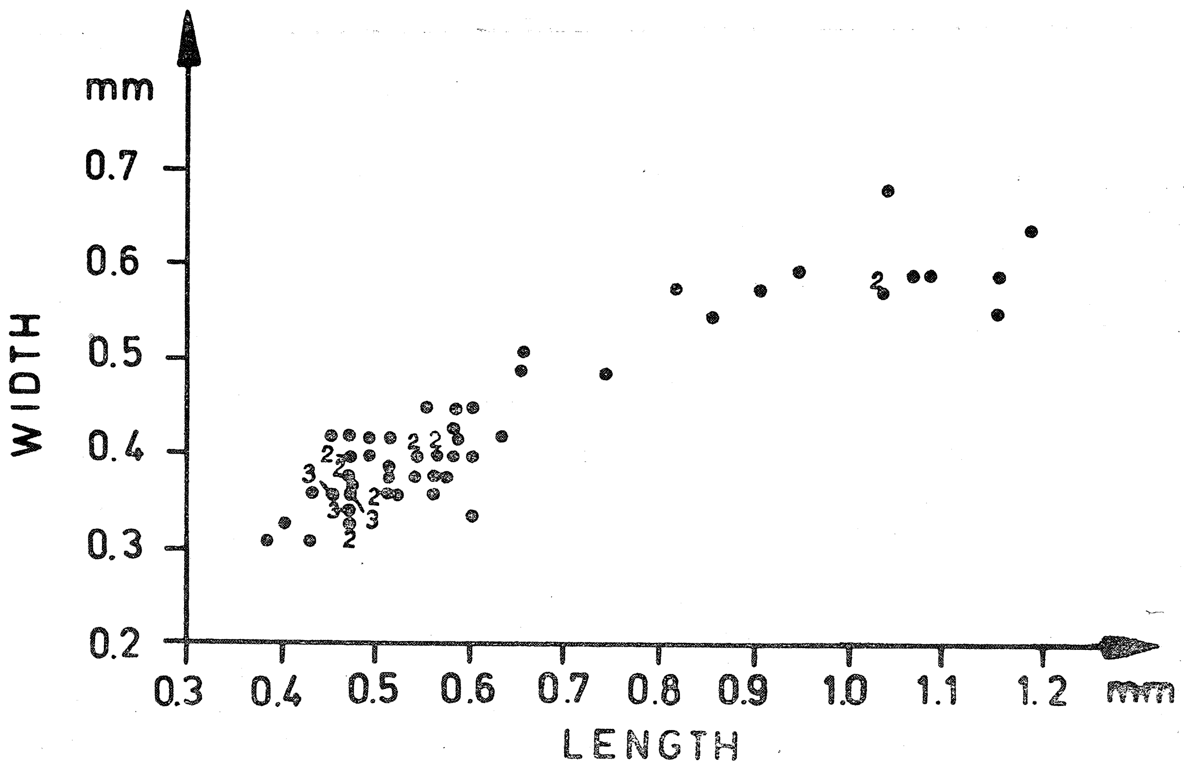

Fig. 2. Diagram for *Arenobulimina sabulosa* (C h a p m a n), Łódź 5 a, depth 605 m

Table 1

	Number of spe-cimens	Diameter of initial chamber /microns/	Length of test /MM/	Width of test /MM/
Generation B	1	48,0	1,026	0,630
	1	50,4	0,666	0,414
	2	52,8	1,044	0,558
			0,630	0,414
Generation A_1	4	60,0	0,594	0,394
			0,558	0,396
			1,080	0,594
			0,936	0,594
	1	67,2	0,830	0,450
	4	72,0	0,648	0,450
			1,044	0,558
			1,044	0,630
			0,828	0,450
Generation A_2	2	81,6	0,552	0,378
			0,648	0,378
	1	91,2	0,360	0,306

Arenobulimina conoidea (Perner)

Pl.V, Fig. 6a, b, Pl. VII, Fig. 4a, b, 5a, b

1892 *Bulimina conoidea* Perner; Perner J.: p. 55, Pl. 3, fig. 5a, b.
1934 *Arenobulimina conoidea* (Perner), Cushman J. A., Parker F. L.: p. 36, Pl. 6, Fig. 9a, b.
1937 *Arenobulimina conoidea* (Perner); Cushman A. J.: p. 38, Pl. 4, Fig. 1a, b, 2.
1947 *Arenobulimina conoidea* (Perner); Grekoff N.: p. 493, Pl. 1, Fig. 7.

Dimensions in mm.	Largest specimen	Average	Smallest
height	0.810	0.756	0.720
width	0.540	0.540	0.540

Material. 20 well preserved specimens.

Description. Test egg-shaped, short, broad, only slightly higher than wider, slightly rounded at the bottom, widening towards the top, widest at the level of the youngest whorl, made of 4 whorls with 4 chambers in each. Wall of test built of fine-grained quartz, cemented by large amount of calcareous cement. Surface of test slightly rough and glassy. Outline of test egg-shaped, slightly lobate. Cross-section round. The last-formed whorl making up about $\frac{1}{2} - \frac{2}{3}$ of the surface of test. Surface of chambers in all whorls is convex or almost flat. Outline of chambers trapezoidal. Surface of chambers in older whorls quite rough, almost smooth in last-formed whorl. Chambers in older whorls more or less of same length and width; in youngest whorl very strongly elongated, and their height is more than 3× bigger than the width. Sutures between the chambers and spiral suture poorly depressed, with the exception of sutures in the last-whorl, which can be depressed or flat, bright, glassy, and even thickened due to deposition of coarse grains of quartz on sutures.

Last-formed chamber is the biggest and somewhat more convex than previous chambers. Seen from dorsal side it hangs over the chambers of the previous whorl in the form of a collar and is reniform, as seen from the apertural side. The apertural surface of the last-formed chamber is flat, strongly indented at the aperture. The aperture a loop-shaped opening, situated at the centre of the apertural face in the depression and is perpendicular towards the internal edge of the last-formed chamber and rounded with a thin, fairly high lip. It is very difficult to make thin sections of individuals of this species. Out of 10 attempts, only one met with some success; the size of the initial chamber for the form sectioned is 53.4 μ.

I n d i v i d u a l v a r i a b i l i t y is exhibited in varying degrees of convexity of the chambers, in the degree of depression of sutures between chambers, and the spiral suture which can be depressed and even thickened, as well as in the variable width of the initial part of the test.

C o m p a r i s o n. Specimens, which come from the Upper Albian and Cenomanian beds of the Polish Lowlands correspond in all features with the Czechoslovakian form, described and illustrated by J. P e r n e r in 1892. The Polish forms are also in agreement in all characteristics with the descriptions and illustrations by J. A. C u s h m a n (1934, 1937), for the specimens from Czechoslovakia, which he received from P e r n e r. J. A. C u s h m a n had also the opportunity to compare the forms described by himself with J. P e r n e r's specimens in the National Museum in Prague.

Arenobulimina conoidea (P e r n e r) resembles *Arenobulimina advena* (C u s h m a n) in shape of test, its dimensions, number of whorls, shape of chambers, and rough surface of the test. It differs, however, in the lack of additional plates in the interiors of chambers of the last-formed, as well as in the lack of darker and brighter bands on the surface of the test, in the greater convexity of the surface of chambers, particularly in the last-formed whorl and the development of the sutures, which may be somewhat thickened.

The species mentioned above is also similar to *Arenobulimina preslii* R e u s s; it differs, however, in the rounded, initial part of the test, as well as in the larger sizes.

D i s t r i b u t i o n: Described for the first time from the Cenomanian of Czechoslovakia. Found also in the Cenomanian of Switzerland in the area of Vraconne canton de Vaud (O. R e n z, H. L u t e r b a c h e r 1965). In Poland, it occurs in Upper Albian and the Cenomanian sediments in the Łódź 4a boring.

Arenobulimina chapmani C u s h m a n

Pl. V, Fig. 1a, b, Fig. 2, Pl. VII, Fig. 1a, b, Fig. 2, Text-fig. 3, 4

1893 *Bulimina preslii* R e u s s; C h a p m a n F.; p. 755, Pl. XII, Fig. 4.

1936 *Arenobulimina chapmani* Cushman; Cushman J. A.: p. 26, Pl. 4, Fig. 7a, b.
1937 *Arenobulimina chapmani* Cushman; Cushman J. A.: p. 36, Pl. 3 Fig. 27, 28.
1947 *Arenobulimina chapmani* Cushman; Grekoff N.: p. 493, Pl. I, Fig. 1a, b.
1950 *Arenobulimina chapmani* Cushman; Dam A. ten: p. 14—15.
1955 *Arenobulimina preslii* Reuss 1851 et aff. sp. sp., Bettenstaedt F.; Wicher C. A.: p. 503, Pl. IV, Fig. 29.
1962 *Arenobulimina preslii* Reuss, Bartenstein H., Bettenstaedt F.; p. 290, Pl. 41, Fig. 5, Pl. 18.
1965 *Arenobulimina chapmani* Cushman; Neagu T.; p. 10, Pl. 2, Fig. 9.

Dimensions in mm.	Largest specimen	Average	Smallest
height	0.900	0.648	0.400
width	0.520	0.414	0.310

Material. 80 well preserved specimens.

Description. Test elongated, uniform in shape, sharp at the bottom rapidly widening upwards, widest at level last-formed whorl, comprising 5 whorls. Longitudinal outline of test is triangular, lobate, and transverse cross-section round. Surface of test rough. Walls of test of medium thickness, made of medium-grained quartz fragments, cemented with large amount of calcareous cement. Largest quartz grains arranged on surface of chambers at sutures. Test in adult forms consists of 5 whorls with 4 chambers in each whorl, with the exception of the last, comprising 4—5 chambers. The last-formed whorl making up more than half length of test. Surface of chambers highly convex. Chambers in 4 older whorls are almost as long as broad; their outline trapezoidal and they are weakly coiled in relation to perpendicular axis of test; their size increases during growth of test. Size of chambers of last-formed whorl increases gradually though strongly in the first whorls. Length of chambers in last-formed whorl approximately 3 times greater than their width. They are strongly coiled with respect to perpendicular axis of test.

Sutures between chambers and spiral suture clearly visible, strongly depressed. Apertural surface of last-formed chamber very weakly convex and reniform. Aperture a loop-shaped opening situated in trough-like depression, runs perpendicularly from top of test to internal edge of last-formed chamber and is surrounded by a narrow lip.

The last chambers of forms of this species are divided internally by plates extending radially from the walls of the interior towards the centre. These plates are not visible in cross-sections of forms filled with recrystallized material. The internal structure of this species is not reflected in the morphology of the test exterior. So far no attention has been paid to internal structure. No dark and bright streaks, as seen for instance in representatives of the species *Arenobulimina advena* Cushman, nor any convexity or depressions, as in the case of *Arenobulimina varsoviensis* n. sp., were noticed on the surfaces of chambers.

The size of the initial chamber for particular forms indicates the probable occurrence of representatives of three generations of the species discussed in the Upper Albian and Cenomanian sediments of the Polish Lowlands. In forms of the microspheric generation B, this value varies between 48.0 and 57.0 μ, while the limits are 74.4—86.4 μ for forms of the macrospheric generation A_1 and 96.0—120 μ for forms of generation A_2. Out of 13 sectioned samples, 5 belong to generation B, 4 to generation A_1 and 4 to generation A_2. In representatives of generations B and A_1 the initial chamber is spherical, while in generation A_2, it is spherical, oval or reniform. No clear connection is seen between the size of the initial chamber and the size of the test in *A. chapmani* Cushman. It should be indicated, that the samples examined come from different borings.

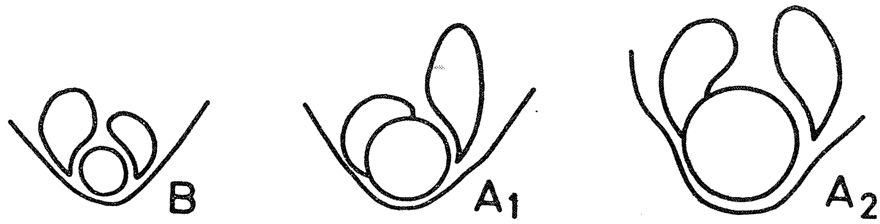

Fig. 3. *Arenobulimina chapmani* Cushman. B — generation, diameter of the proloculus — 48 microns, length of the test — 0,846 mm, width — 0,522 mm; A_1 — generation, diameter of the proloculus — 74,4 microns, length of the test — 0,648 mm, width — 0,450 mm, Pagórki IG 1, depth 925 m; A_2 — generation, diameter of the proloculus — 105 microns, length of the test — 0,540 mm, width — 0,414 mm, Gorzów Wielkopolski, depth 709,6 m

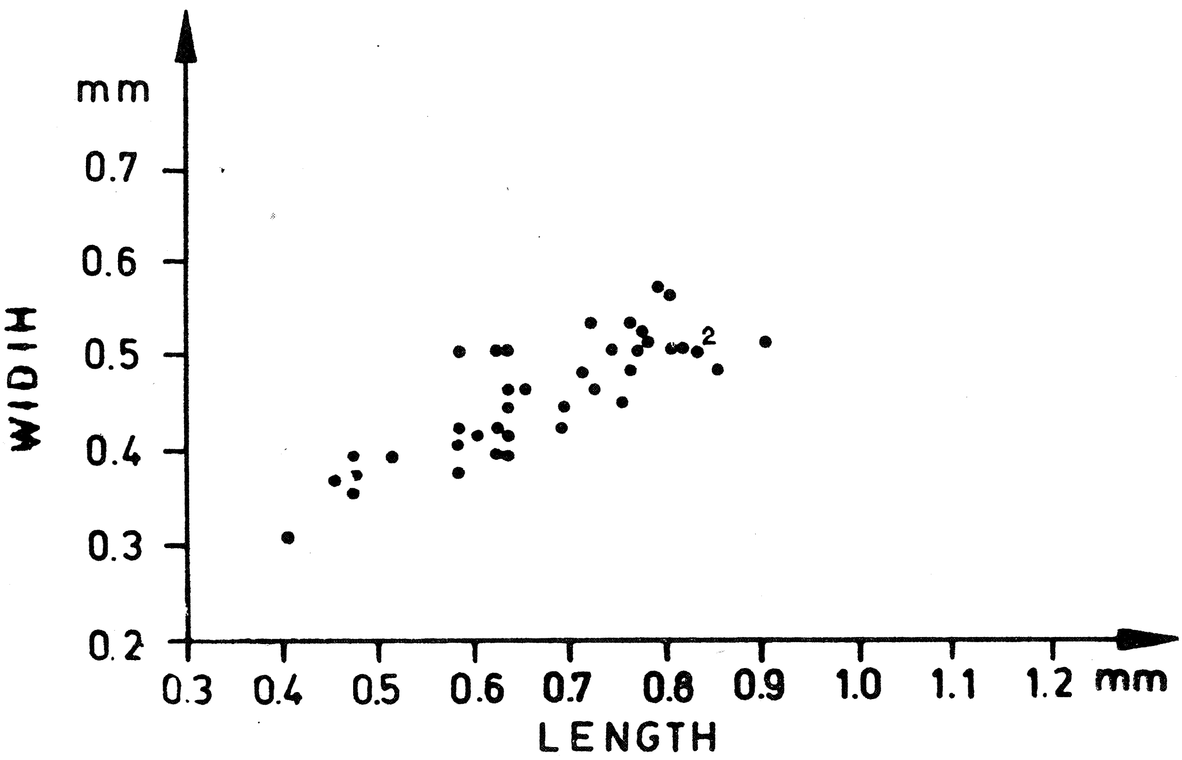

Fig. 4. Diagram for *Arenobulimina chapmani* Cushmani, Pagórki IG 1, depth 925 m

Individual variability is slight and is seen in different numbers of chambers in the last-formed whorl (4 or 5), in the convexity of the apertural surface of the last chamber and in the width of the last--formed whorl (which occupies $^1/_2$ or $^2/_3$ of the length of the test). Numerous young forms of this species, in various stages of ontogenetic development, occur in the material examined.

Comparison. The forms described from the Szczecin-Łódź trough and the Pre-Sudetic monocline correspond in almost all features with the holotype from Folkestone Gault (England). The morphological similarity is striking.

Table 2

	Number of specimens	Diameter of initial chamber /microns/	Length of test /MM/	Width of test /MM/
Generation B	2	48,0	0,846 0,540	0,522 0,360
	2	52,8	0,810 0,558	0,558 0,486
	1	57,6	0,540	0,360
Generation A_1	2	74,4	0,648 0,720	0,450 0,378
	1	84,0	0,774	0,504
	1	86,4	0,774	0,504
Generation A_2	1	96,0	0,450	0,324
	2	105,6	0,540 0,720	0,414 0,558
	1	120,0	0,450	0,324

The species under discussion is most closely comparable with *Arenobulimina macfadyeni* Cushman; it differs however in its more rapid widening of the test throughout its growth, in the lower spacing of whorls, in the greater convexity of chambers, in the considerably more strongly depressed sutures and in the greater number of chambers in the last-formed whorl.

Distribution. According to data of the authors of the synonyms cited above, this species occurs in the Upper Albian sediments in England and Holland; in the uppermost Lower and also Middle Albian of N.W. Germany, in the Upper Albian and Cenomanian of Switzerland in the Jura Mountains Canton de Vaud (O. Renz, H. Luterbacher, M. Reichel, H.J. Oertli, F. Stumm 1965) and in the Albian of the Rumanian Depression. In Poland, this species was found in Upper Albian beds in Łódź 4a bore-hole (from depths in the range 813.0—822.5 m), Łódź 5a (610.0—593.0 m), Ślazewo 5 (220.0—228.0 m), Gorzów Wielkopolski IG-I (709.0—711.0 m), Pagórki at a depth of 925 m.

Arenobulimina frankei Cushman

Pl. V, Fig. 4, Fig. 5, Pl. VII, Fig. 6, Fig. 7a, b, Fig. 8a, b, Text-fig. 5, 6

1936 *Arenobulimina frankei* Cushman; Cushman J. A.; p. 27, Pl. 4, Fig. 5a, b.
1937 *Arenobulimina frankei* Cushman; Cushman J. A.: pp. 37—38, Pl. 4, Fig. 21a, b.

1947 *Arenobulimina frankei* Cushman; Grekoff N.: p. 494, Pl. 1, Fig. 8a, b.
1957 *Arenobulimina frankei* Cushman; Mikhailova-Jovtheva P.: p. 103, Pl. 1, Fig. 14a, b.

Dimensions in mm.	Largest specimen	Average	Smallest
height	0,960	0,846	0,400
width	0,540	0,522	0,340

Material. 50 well preserved specimens.

Description. Wedge-shaped test, regularly triserial, gradually broadening upwards during growth, broadest at level of the 3 youngest chambers. Cross-section triangular, with strongly rounded corners. Surface of test quite rough, medium-grained, made up of calcareous as well as siliceous grains in a siliceous cement. In adult forms, each of the 3 perpendicular series consists mainly of 6 chambers. Chambers, with exception of 3 youngest, are almost hemispherical, quite strongly convex, closely adjoining, separated by depressed sutures. A slightly depressed, zigzag suture, where chambers of particular series make contact, is seen on each of the 3 sides of the test. The 3 last chambers trapezoidal in shape, convex surface and weakly coiled with respect to the perpendicular axis of the test. Apertural surface of last-formed chamber slightly convex. The aperture a loop-shaped opening, located on top of test in shallow depression; it sometimes extends to internal edge of last-formed chamber.

Inside chambers of last-formed whorl, there are radial plates, spreading from walls of chambers. Internal division of chambers not visible on surface of test. Size of initial chamber in forms of species examined in range 52.8—74.4 μ. Out of 14 sectioned samples, only one was diameter of this chamber 52,8 μ, in two 62,4 μ, in one 67,2 μ, in seven 69,6 μ, in two 72,0 μ and in one 74,0 μ. It should be presumed that the specimen with diameter of initial chamber 52,8 μ represents microspheric generation B while the remaining forms represent macrospheric generation A_1, A_2. The individuals with diameter of initial chamber 62,4 may be considered to be representatives of generation A_1 and those forms with diameter in the range 67,3—74,4 μ should be considered to be representatives of generation A_2. Initial chamber round in outline for samples of each generation. Generations do not differ in morphological features. Samples examined come from single population from borehole Gorzów Wielkopolski IG-1 at depth 685.0 m.

Individual variability. Is seen mainly in the location and the shape of the aperture. Forms included in this species show a tendency for the aperture to occur at the top. The aperture in these forms is not associated with the internal edge of the last-formed chamber and has a comma-like shape. Variability is also seen in the degree of depression of sutures between chambers. In the material examined occur many young forms in various stages of ontogenetic development, with the exception of the youngest. The most frequently encountered are specimens containing 3 or 4 chambers in each of the perpendicular series.

Comparison. The forms described correspond in all features to the description and illustration of the holotype which comes from the Cenomanian at Mierczany (Hildesheim), Zielona Góra district, Poland.

Distribution. Described first by J. A. Cushman (1936) from the Cenomanian of Hildesheim, now called Mierczany (Poland). Further-

Table 3

	Number of specimens	Diameter of initial chamber /microns/	Length of test /MM/	Width of test /MM/
Generation B	1	52,8	0,684	0,450
Generation A_1	2	62,4	0,774	0,432
			1,044	0,540
Generation A_2	1	67,2	0,940	0,594
	7	69,6	0,648	0,450
			0,522	0,342
			1,152	0,648
			0,720	0,414
			0,576	0,414
			0,630	0,396
			0,900	0,594
	2	72,0	0,720	0,450
			0,576	0,396
	1	74,0	0,826	0,558

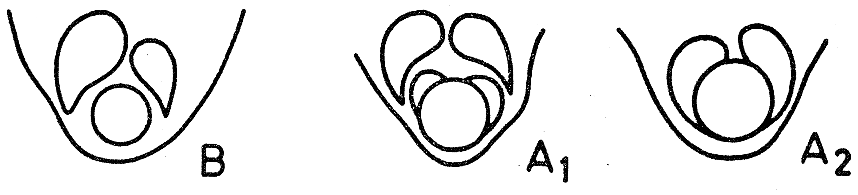

Fig. 5. *Arenobulimina frankei* Cushman, B — generation diameter of the proloculus 52,8 microns, length of the test — 0,684 mm, width — 0,450 mm, Gorzów Wielkopolski, depth 685 m; A_1 — generation, diameter of the proloculus — 62,4 microns, length of the test — 0,774 mm, width — 0,432 mm, Lusowo 1, depth 358,2 m; A_2 — generation, diameter of the proloculus — 74,4 microns, length of the test — 0,826 mm, width — 0,558 mm, Gorzów Wielkopolski, depth 685 m

more, it occurs in the Upper Albian and Cenomanian sediments in borings Gorzów Wielkopolski IG-1, Ślazewo 5, and Lusowo I. It was noted by Mikhailova-Jovtheva P. (1957) as occurring in the Maestrichtian of Bulgaria.

Arenobulimina advena (Cushman)

Pl. VIII, Fig. 1—4, Text-fig. 7, 8

1936 *Hagenowella advena* Cushman; Cushman J. A.; p. 43, Pl. 6, Fig. 21a, b
1937 *Hagenowella advena* Cushman; Cushman J. A.; p. 174, Pl. 21, Fig. 3 a, b, 4.

1945 *Hagenowella advena* Cushman; Brotzen F.; pp. 44—45, Pl. 1, Fig. 3.
1961 *Hagenowella chapmani* (Cushman); Vassilenko V. P.; pp. 22—23, Pl. III, Fig. 3a, b, Pl. IV, Fig. 1, (non Pl. IV, Fig. 2a, b, w, Fig. 3).

Dimensions in mm	Largest specimen	Average	Smallest
height	1,010	0,834	0,470
width	0,610	0,540	0,360

Material. 80 well preserved specimens.

Description. Test oval, egg-shaped, smooth or poorly lobate in outline, rounded at the bottom, widening slightly upwards, consisting

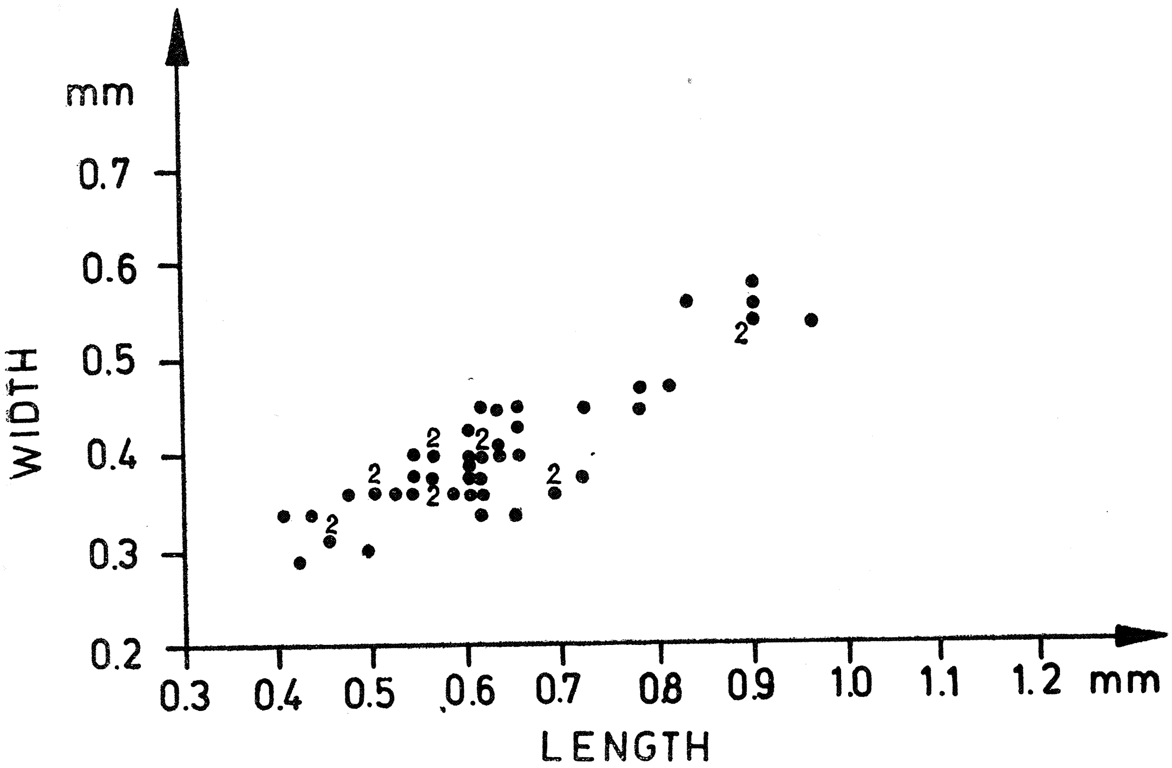

Fig. 6. Diagram for *Arenobulimina frankei* Cushman, Gorzów Wielkopolski, depth 685 m

of 3 whorls. Two older whorls low and with 4 chambers each. Last-formed whorl makes up $\frac{2}{3}$ or even $\frac{3}{4}$ of length of test and most frequently consists of 3, more rarely of 4 chambers. Wall of tests agglutinated, fine-grained almost smooth, built of fine quartz grains, cemented with a great deal of calcareous cement. Chambers in older whorls barely visible, trapezoidal in outline, very poorly convex or almost flat. Chambers of last-formed whorl strongly elongated and in the order of 4 times longer than wide; their surface poorly convex. Light and dark bands running normal to sutures, seen in majority of samples on surface of chambers of last-formed whorls. These bands correspond to the radial plates and open spaces occurring in chambers and thus correspond to cavities of secondary chambers. Dark bands correspond to plates, light ones to open spaces.

Sutures between chambers and spiral suture very poorly depressed. They are virtually flat and marked by slight convexity of progressively growing chambers.

Last-formed chamber very large, reniform; in some specimens, it makes up $\frac{1}{2}$ surface of last-formed whorl. Apertural surface of last-formed chamber is convex; in some specimens slightly depressed around aperture. Aperture a loop-shaped opening, rounded from the top of the test by a thin lip and is elongated towards internal edge of last-formed chamber. In population examined coming from bore-hole Gorzów Wielkopolski IG-1, the size variability of the initial chamber in individuals of the species described recognition of particular generations difficult. The outline of initial chambers is also variable; it can be round, slightly oval or elliptical. Without doubt in the material examined there are individuals of microspheric generation B as well as those of the macrospheric generation A. For 11 sectioned samples, the size of the initial chamber in two was 52,8 μ and they were taken to represent generation B. In the 9 remaining samples, the size of the initial chamber ranged from 62,4 to 120 μ.

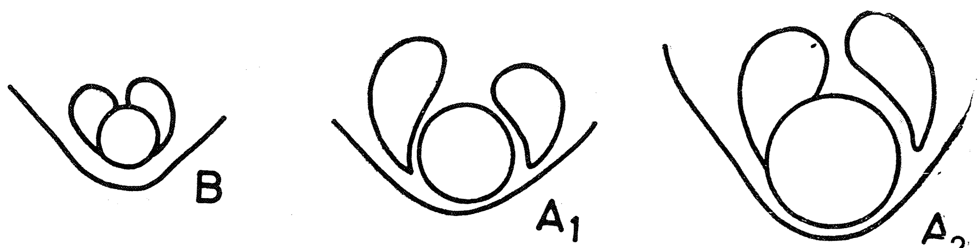

Fig. 7. *Arenobulimina advena* (Cushman), B — generation, diameter of the proloculus — 52,8 microns, length of the test — 0,810 mm, width — 0,558 mm; A_1 — generation, diameter of the proloculus — 84 microns, length of the test — 0,468 mm, width — 0,360 mm; A_2 — generation, diameter of the proloculus 120 microns, length of the test — 0,990 mm, width — 0,684 mm, Gorzów Wielkopolski, depth 685 m

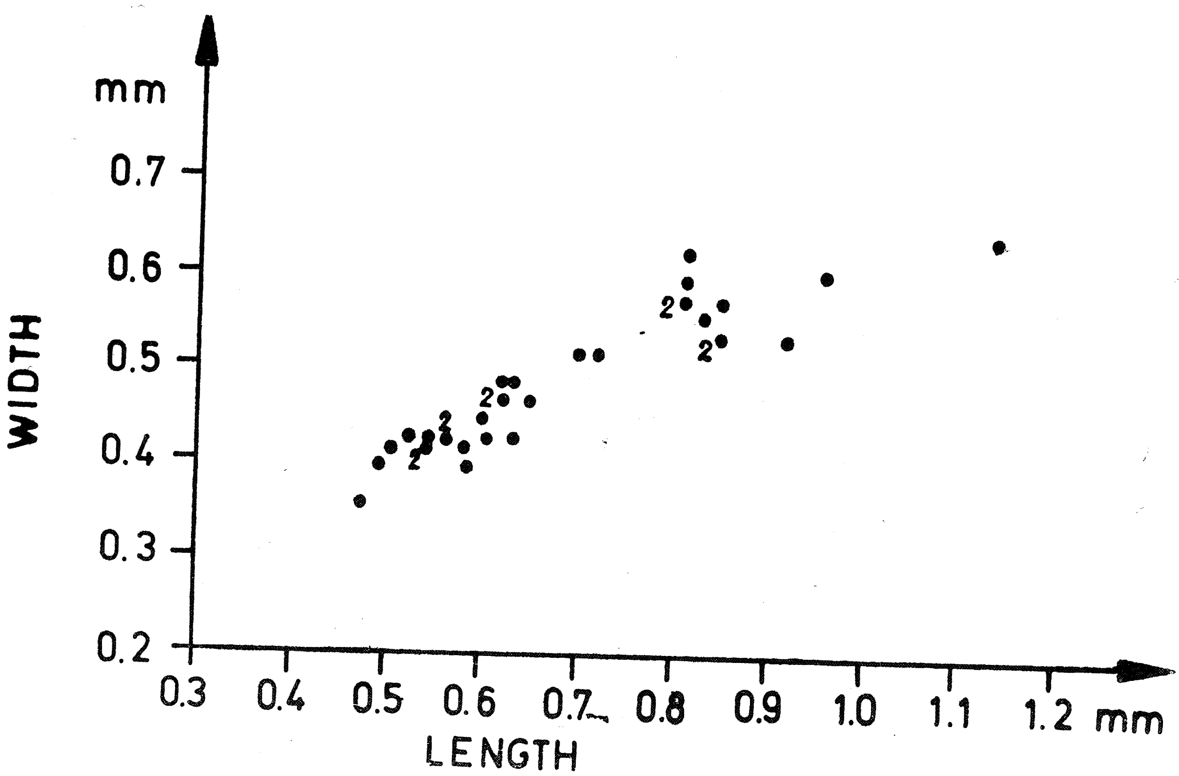

Fig. 8. Diagram for *Arenobulimina advena* (Cushman), Gorzów Wielkopolski, depth 685 m

Table 4

	Number of specimens	Diameter of initial chamber /microns/	Length of test /MM/	Width of test /MM/
Generation B	2	52,8	0,810 0,522	0,558 0,396
Generation A	1	62,4	0,828	0,552
	3	74,4	0,900 0,684 0,630	0,630 0,450 0,486
	1	81,0	0,504	0,432
	1	84,0	0,468	0,360
	1	96,0	0,620	0,414
	2	120,0	0,990 0,936	0,684 0,620

Most difficult is the classification of individuals with 62,4 μ and 96,0 μ in the diameter of the initial chamber; specimens with the initial chamber 74,4—84,0 μ in diameter could represent generation A_1 and those with initial chamber of diameter 120 μ generation A_2. The difficulties encountered in sectioning samples of the species mentioned did not permit a larger number of cross-sections to be made for a careful study of the variability of generations. The specimens examined were not filled with sediment and broke easily, when sectioned, despite boiling in Canadian balsam.

Individual variability is not great and is seen in different numbers of whorls within the test (2 to 4), in different numbers of chambers, 3 in the last-formed whorl rarely 4, in the varying convexity of chambers, in the shape of the test (typically egg or wedge-shaped) as well as in the size of the tests.

Comparison. The forms described above differ from the holotype only in the finer-grained test wall, the presence of dark and light bands on the chambers of the last-formed whorl and the absence of a tooth in the aperture.

Some of the forms described by V. P. Vassilenko (1961; see Plate III, Fig. 3a, b, Plate IV, Fig. 1) under the name *Hagenowella chapmani* (Cushman) probably belong to the species „*advena*". These forms differ from the holotype of *Arenobulimina chapmani* Cushman in the more rounded and broader initial part of the test, in the finer-grained wall of the test, in the smaller number of chambers in the last whorl, as well as in the lower degree of convexity of these. V. P. Vassilenko (1961) assigns specimens of two different species to „*chapmani*". The forms illustrated in Pl. IV, Fig. 2a, b, w, 3, with a rough surface of the test, clearly convex chambers, covered with depressions and convexities, corresponding to the internal structure of chambers, probably belong to *Arenobulimina varsoviensis* n. sp. The description of those forms by V. P. Vassilenko (1961) is a summary description, bringing together characteristics of two different species. Therefore, it is not known, neither whether the forms shown on Pl. III, Fig. 2a, b, Pl. IV, Fig. 1 have the interiors of chambers in the last whorl divided by plates or not, nor to what extent this is reflected at the surface of the test. These additional data are necessary for a correct classification of the forms mentioned. It is also not known to which species belongs the form called *Hagenowella chapmani* (Cushman) by O. K. Kaptarenko-Chernousova (1967, p. 25, Pl. I, Fig. 5). Not giving any description, she only refers to remarks relating to that species by V. P. Vassilenko (1961).

Distribution. Occurs in Upper Cenomanian sediments of Zastań (formerly Zünz) and Rachów, Poland, Kamień Pomorski region. Representatives of this species also occur in Poland in the Cenomanian sediments in the boring Gorzów Wielkopolski IG-1 and Łódź 4a. J. A. Cushman (1936) gives as „type locality" of *Hagenowella advena*, Junz near Kamień Pomorski, where the Upper Senonian occurs. F. Brotzen claims to have found a mistake in the name of the locality; he calls it Zünz, presently Zastań, where Upper Cenomanian sediments occur. The species mentioned probably occurs also in Cenomanian sediments and perhaps in the Lower Turon on the Mangyshlak Peninsula. It has also been found in the Cenomanian of the borings Höllviken I and II (Sweden).

Arenobulimina polonica n. sp.

Pl. VI, Fig. 3 a, b, c, Pl. VIII, Fig. 5 a, b, Fig. 6, 7, 8, Text-fig. 9, 10

Holotype: specimen shown on Pl. VI, Fig. 3 a, b, c, Pl. VIII, Fig. 5 a, b.
Stratum typicum: Cenomanian.
Locus typicus: Gorzów Wielkopolski IG-1.

Dimensions in mm	Largest specimen Holotypus	Average Paratypus	Smallest Paratypus
height	0,936	0,930	0,666
width	0,468	0,404	0,378

Material. 80 well preserved or partly damaged specimens.

Diagnosis. Test agglutinated, with siliceous grains and cement, smooth, glossy surface, trochospiral, wedge-shaped, slightly widening upwards, cross-section quadrilateral with rounded angles, built of 4—5 whorls, each of which consists of 4 chambers arranged in 4 perpendicular rows. Interior of last chambers of whorl divided by additional plates.

Description. Test strongly elongated, wedge-shaped, poorly rounded at botton, fairly broad, gradually widening slightly upwards almost same width throughout the whole length, widest at level of youngest whorl. Outline of test very poorly depressed, almost smooth, cross-section quadrilateral, with sides slightly concave and somewhat rounded angles. Wall of test agglutinated, medium-grained, slightly rough, glossy. Test in mature forms comprises 4—5 whorls. There are 4 chambers in each whorl. Chambers arranged in 4 rows running along test. Last whorl makes up approximately $\frac{1}{3}$ of length of test. All 4 chambers of each of 4 older whorls lie at almost same level and are not coiled in relation to perpendicular axis of test. Only chambers of last whorl are fairly tightly coiled. On each of 4 walls of test can be seen 2 perpendicular series of chambers, separated by zigzag, slightly indented suture. Surface of chambers slightly convex giving rise to rounded angles of the quadrilateral. Length of chambers somewhat greater than their height. Sutures between chambers somewhat oblique, slightly depressed.

Three oldest chambers of last whorl markedly elongated, about 3 times longer than wide and strongly coiled with respect to perpendicular axis of test. Youngest chamber of last whorl is reniform. Surface of this chamber somewhat more convex than those remaining. Apertural surface of last chamber flat. Aperture a loop-shaped opening, situated in middle of apertural surface, in a fairly deep depression with triangular or oval shape in contact with the internal edge of last chamber. Opening rounded with a thin lip.

Table 5

	Number of specimens	Diameter of initial chamber /microns/	Length of test /MM/	Width of test /MM/
Generation A_1	2	62,4	0,630	0,360
			0,594	0,396
	9	64,8	0,576	0,396
			0,720	0,468
			0,504	0,360
			0,774	0,360
			0,756	0,486
			0,756	0,360
			0,630	0,360
			0,900	0,360
			0,900	0,486
Generation A_2	2	76,8	0,972	0,540
			1,008	0,558

Inside chambers of last-formed whorl there are additional plates running radially from walls of chambers. Thickness of additional plates somewhat greater than thickness of wall. Internal structure of species discussed is not reflected in surface of test. In examined material individuals probably occur of 2 generations of this species, which do not differ in morphological features. It is possible that these are individuals of macrospheric generations A_1 and A_2. Size of initial chamber in 9 out of 13 sectioned specimens is 64,8 μ, in 2 samples 62,4 μ and in 2 samples, 76,8 μ. Individuals with diameter of initial chamber between 62,4 and

64,8 μ undoubtedly represent same generation, most probably A_1 while forms with diameter 76,8 μ represent generation A_2. Shape of initial chamber for all specimens examined round. Specimens come from borings Gorzów Wielkopolski IG-1 and Lusowo IG-1.

Individual variation is shown in the size of the last-formed whorl which may constitute $\frac{1}{3} - \frac{1}{2}$ of the length of the test, as well as in the degree of convexity of chambers in that whorl. In some specimens, they are markedly more strongly convex than in older whorls; in others, the degree of convexity of all chambers in the test is almost the same.

Comparison. The newly described species differs from the species *Arenobulimina advena* (Cushman) in the markedly elongated shape of the test, almost constant width of the test, throughout the entire length, in the quadrilateral cross-section of the initial part of the test, as well as in the distribution of chambers within the test.

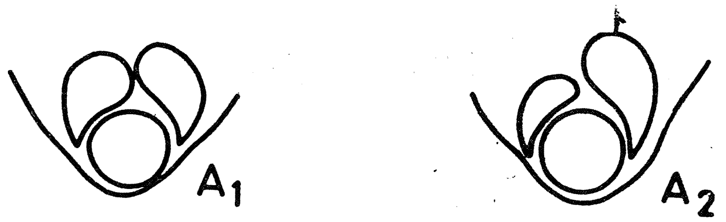

Fig. 9. *Arenobulimina polonica* n. sp., A_1 — generation, diameter of the proloculus — 64,8 microns, length of the test — 0,756 mm, width — 0,486 mm; A_2 — generation, diameter of the proloculus — 76,8 microns, length of the test — 1,008 mm, width — 0,558 mm, Gorzów Wielkopolski, depth 685 mm

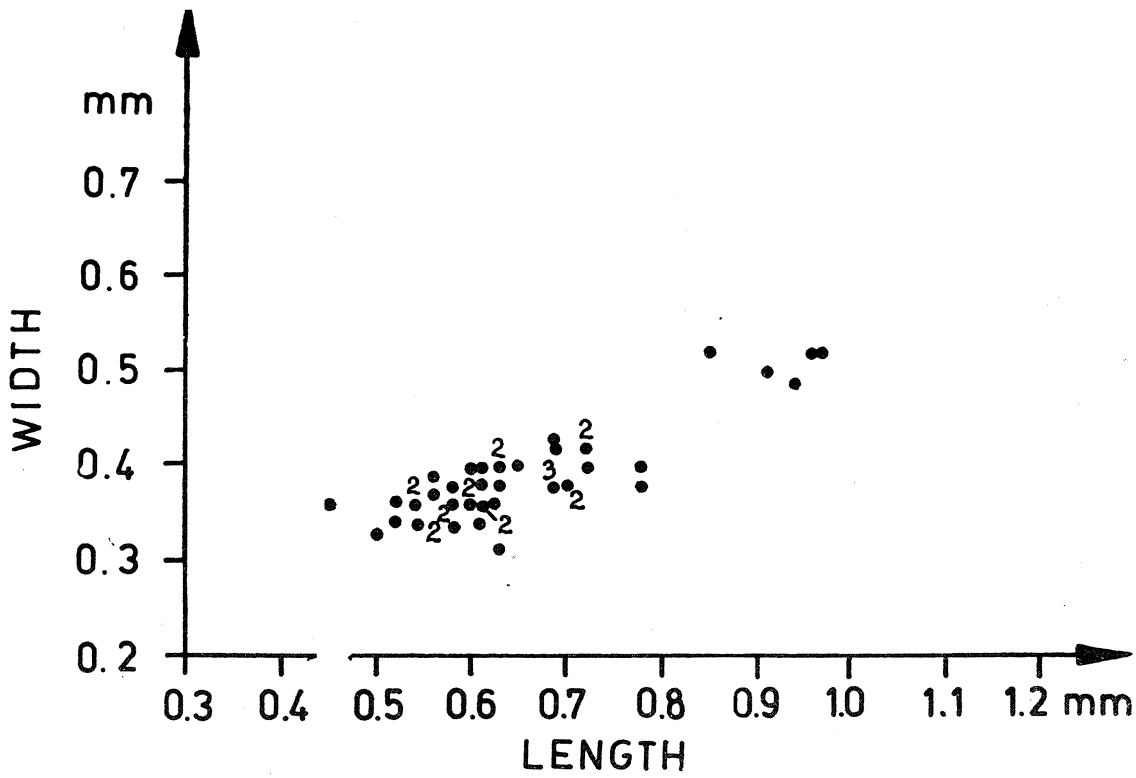

Fig. 10. Diagram for *Arenobulimina polonica* n. sp., Gorzów Wielkopolski, depth 685 m

Arenobulimina polonica n. sp., with its elongated shape of test and narrow width of last-formed whorl, resembles most closely *Arenobulimina macfadyeni* Cushman. It differs from this in the quadrilateral cross-section in the initial part of the test, in slightly concave sides, in the almost constant width of the test throughout the whole length, in the finer-grained wall and in the occurrence of radial plates in chambers of the last-formed whorl. The coiling of the test seen in *Arenobulimina polonica* n. sp. separates this species from forms classified as sub-genus Columnella Voloshina and, on the other hand, brings it closer to the sub-genus Harena Voloshina.

Distribution. Numerous specimens were found in the boring Gorzów Wielkopolski IG-1 in the Lower Cenomanian beds at a depth of 685.0 m and somewhat less numerous in the boring Ślazewo 5 at 128.0 m and in Lusowo IG-1 at 358.0 m.

Arenobulimina varsoviensis n. sp.

Pl. VI, Fig. 1 a, b, Fig. 2, Pl. VIII, Fig. 9 a, b, Fig. 10 a, b, Fig. 11, Fig. 12; Fig. 13 a, b, Text-fig. 11, 12

1961 *Hagenowella chapmani* (Cushman); Vassilenko V. P.: pp. 22—23, Pl. IV, Fig. 2 a, b, w, 3 (non Pl. III, Fig. 3 a, b, Pl. IV, Fig. 1.

Stratum typicum: Cenomanian
Locus typicus: Gorzów Wielkopolski IG-1

Dimensions in mm	Largest specimen Paratypus	Average Holotypus	Smallest Paratypus
height	0,864	0,648	0,450
width	0,576	0,504	0,396

Material. 120 well preserved or partly damaged specimens.

Diagnosis. Agglutinated test with siliceous grains and cement, very rough surface, trochospiral, egg-shaped, short, oval, composed of 3—4 whorls. Initial whorls consist of 4 chambers; 3 chambers form the last whorl. On surface of chambers in last whorls, sac-like convexities and depressions occur. The interiors of these chambers are divided by additional plates. In the wall of the test, there are channels arising out of the union of the sac-like convexities with the wall of the test.

Description. Test oval, egg-shaped, short of markedly lobate outline, rounded at the bottom, wide rapidly widening at level of last whorl, where it reaches greatest width. Test most frequently made up of 3 whorls, more sporadically 4. Initial whorls not clearly visible and probably consisting of 4 poorly convex chambers. Last-formed whorl constitutes $\frac{2}{3}$ and, in only a few forms, $\frac{1}{2}$ of the surface of the test; consists of 3 markedly convex chambers. Last chamber largest, reniform; covers almost half surface of last-formed whorl. Chambers of last and sometimes penultimate whorl, are ornamented with wide, sac-like swelling occurring on surface of chambers, hanging over the spiral suture and dividing them, narrow and deep concavities, running normal to spiral suture. Sutures between chambers of last whorl and spiral suture markedly depressed. Surface ornamentation of chambers reflects internal structure. Chambers in this species, in last and penultimate whorl divided by additional septa, running radially from internal wall of chambers.

These septa correspond to depressions on surface of test and empty spaces to sac-like convexities.

An interesting phenomenon was noted — the inclusion of open spaces of sac-like convexities within the test wall and separation of them from the interior of the chamber. Namely, an additional septum is formed, parallel to the wall of the test and separating the sac-like convexity from the inside of the chamber. The wall of the chambers with included spaces from the sac-like convexities is twice as thick as in chambers divided by radial plates in which this phenomenon is not seen. In these walls, where additional parallel internal lamellae were formed, perpendicularly running channels reaching 0,036 mm in diameter of light, are thus present. The interiors of chambers, in the walls of which perpendicular channels exist, is partly divided by radial plates.

The wall of the test is made of quartz grains, medium in size, cemented with a large amount of siliceous cement. The surface of the test is markedly rough, with the exception of the apertural surface in the last chamber, which is smooth and convex. The oval aperture is surrounded from the top of the test by a thin lip and situated in a round, fairly deep depression, lying in the majority of forms, in the centre of the apertural surface and not making contact with the internal edge of the last chamber.

Table 6

	Number of specimens	Diameter of initial chamber /microns/	Length of test /MM/	Width of test /MM/
Generation B	3	72,0	1,260	0,720
			0,810	0,558
			0,522	0,468
Generation A_1	4	84,4	0,558	0,432
			0,450	0,396
			0,522	0,432
			0,810	0,684
	1	86,4	0,630	0,414
Generation A_2	1	96,0	0,486	0,314
	1	105,6	0,540	0,450
	3	108,6	1,080	0,720
			0,468	0,396
			0,468	0,414

In the material examined, individuals of 3 generations of this species probably occur. Specimens with the initial chamber 72,0 μ in diameter should be taken to be individuals of microspheric generation B, forms with a diameter of 84,0—86,4 μ probably belong to the macrospheric generation A_1, while specimens with a diameter of 96,0—108,0 μ belong to generation A_2. 13 forms of this species were sectioned. The shape of the initial chamber, in all forms except one, is round. In one specimen, belonging to the generation A_1, the shape is oval. Some of the forms examined come from the type locality for *Arenobulimina varsoviensis* n. sp., that is, from the boring Gorzów Wielkopolski IG-1 at a depth of 685,0 m, while some come from the Lusowo boring IG-1 at 358.0 m. Individual variability not great, seen mainly in the location of the aperture. This may lie in the centre of the apertural surface, without touching the base of the last chamber or in rare cases touching the base. The variability is also shown in different degrees of height in the sac-like convexities on the surface of the chambers, as well as in the various extents to which older chambers are seen.

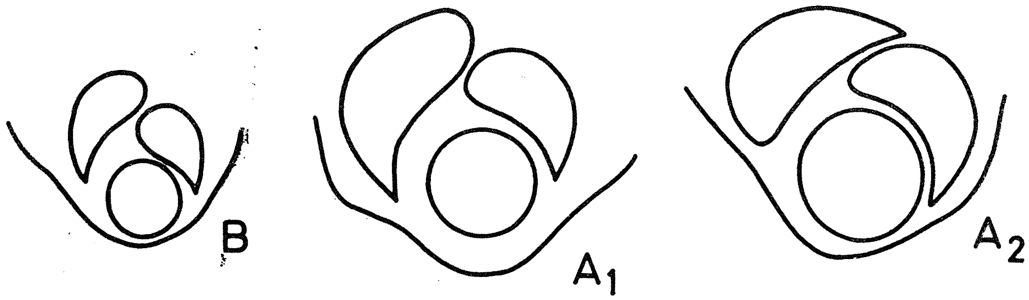

Fig. 11. *Arenobulimina varsoviensis* n. sp. B — generation, diameter of the proloculus — 72 microns, length of the test — 1,260 mm, width — 0,720 mm, Lusowo 1, depth 358,2 m; A_1 — generatoin, diameter of the proloculus — 84 microns, length of the test — 0,810 mm, width — 0,684 mm; A_2 — generation, diameter of the proloculus — 108 microns, length of the test — 0,468 mm, width — 0,414 mm Gorzów Wielkopolski, depth 685 m

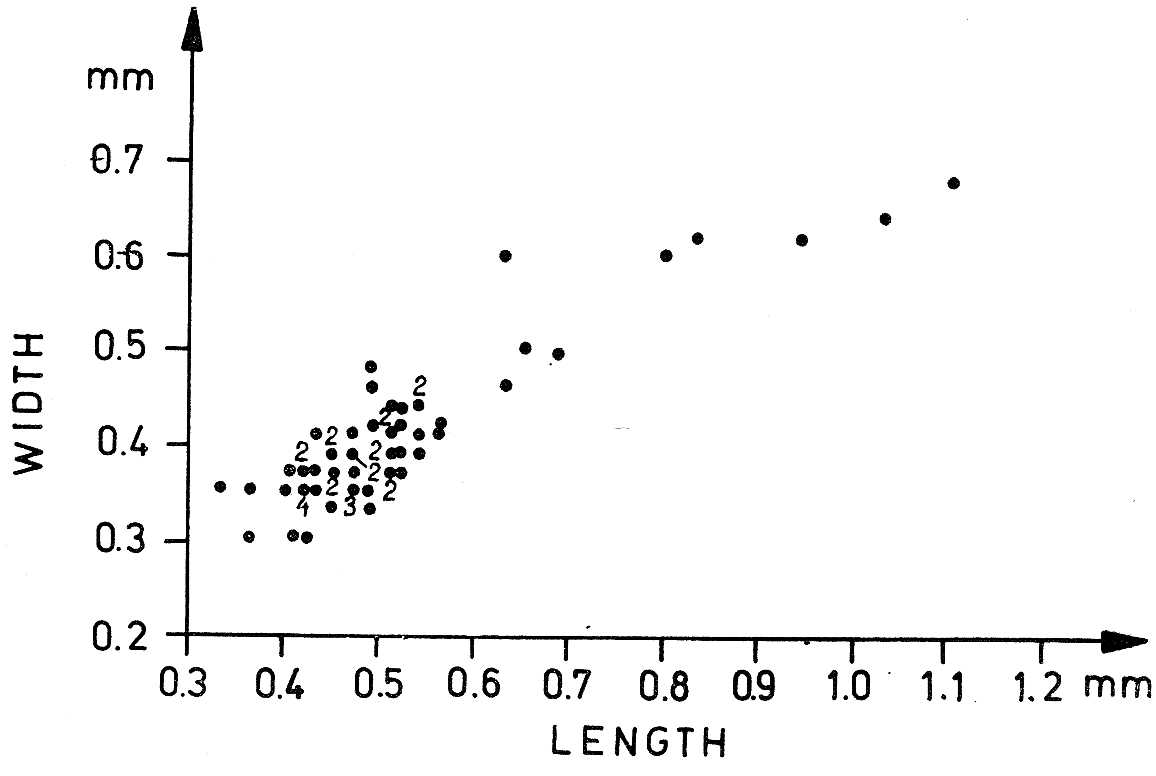

Fig. 12. Diagram for *Arenobulimina varsoviensis n. sp.*, Gorzów Wielkopolski, depth 685 m

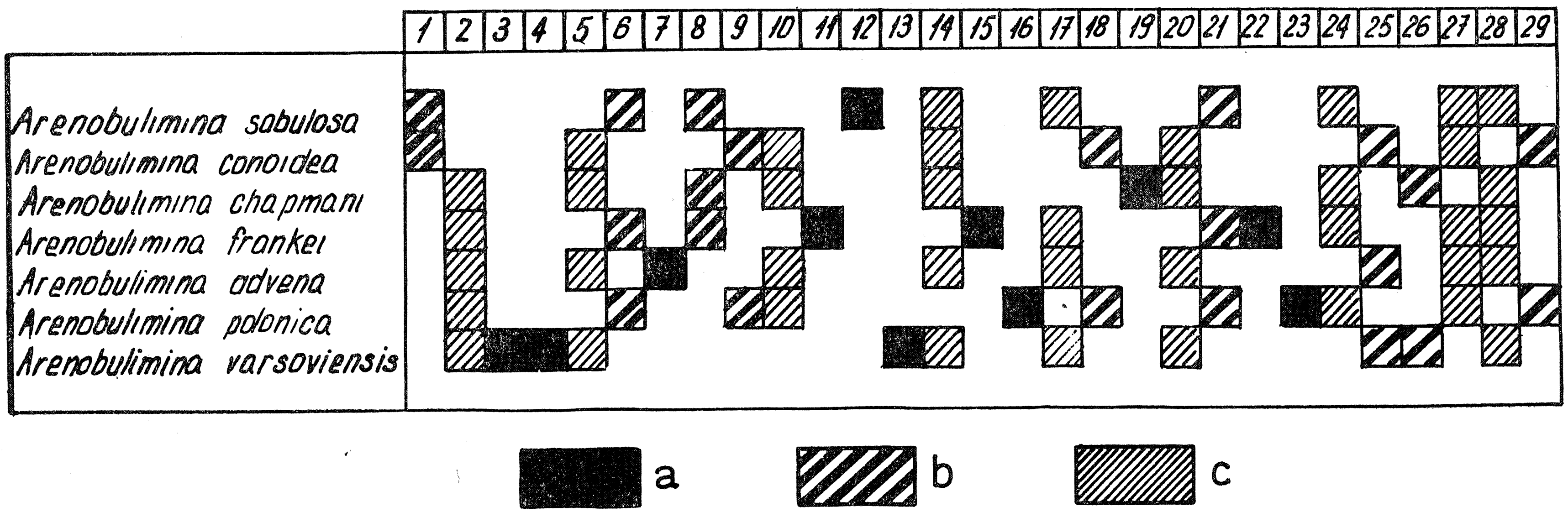

Fig. 13. Diagnostic features for species of the genus *Arenobulimina*. 1 — Chambers not divided internally by radial plates; 2 — Chambers of penultimate and last whorl divided by additional plates. 3 — Strongly convex chambers with sac-like swelling of surface. 4 — In walls of chambers of last whorl, canals formed through closing of sac-like swellings. 5 — Chambers of last whorl, strongly twisted in relation to vertical axis of test. 6 — Chambers of last whorl, weakly twisted in relation to vertical axis of test. 7 — Chambers in penultimate and last whorls covered by dark and light bands. 8 — Chambers strongly convex without ornamentation. 9 — Chambers weakly convex, without ornamentation. 10 — Aperture loop-shaped, making contact with internal edge of last chamber. 11 — Aperture lopp--shaped, located at top. 12 — Aperture oval, makes contact with inner edge of last chamber or located at top. 13 — Aperture oval, located at top. 14 — Transverse section through test circular. 15 — Transverse section through test triangular. 16 — Transverse section through test square. 17 — Last whorl of 3 chambers. 18 — Last whorl of 4 chambers. 19 — Last whorl of 4—5 chambers. 20 — Last whorl makes up more than half test. 21 — Last whorl makes up half test or less. 22 — Test triserial. 23 — Test quadriserial. 24 — Test elongate, wedge-shaped. 25 — Test oval, egg-shaped. 26 — Test widening markedly towards top. 27 — Test widening gradually towards top. 28 — Apertural surface of last chamber convex. 29 — Apertural surface of last chamber flat, truncated
a — features characteristic for 1 species. b — features characteristic for 2—3 species. c — features characteristic for 4—7 species

C o m p a r i s o n. The species described above with features very characteristic for it, differs entirely from all previously known species, classifies either in the genus *Arenobulimina* or the genus *Hagenowella* (*Hagenowina*). It is even difficult to state to which of the previous known species this one is similar.

It seems that forms described by V. P. V a s s i l e n k o (1961), under the name of *Hagenowella chapmani* (Pl. IV, Fig. 2 a, b, w., 3, non. Pl. III, Fig. 3 a, b, Pl. IV, Fig. 1) belong to the newly described *Arenobulimina varsoviensis* n. sp.

D i s t r i b u t i o n. In Poland it occurs abundantly in the Gorzów Wielkopolski boring IG-1. in Cenomanian sediments at a depth of 685.0 m and in the Lusowo boring IG-1, at 358.0 m. Most probably, it also occurs in the Lower Cenomanian sediments of the Mangyshlak Peninsula.

Geological Survey
Warszawa

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STRESZCZENIE

W osadach górnego albu i cenomanu Niżu Polski występuje dość duża ilość przedstawicieli rodzaju *Arenobulimina* Cushman (sensu lato). Mają one dużą wartość stratygraficzną, gdyż charakteryzuje je wąski zasięg rozprzestrzenienia. W sumie stwierdzono dotychczas na badanym obszarze 7 gatunków tego rodzaju, wśród nich 2 nowe. Do gatunków znanych już w literaturze należą: *Arenobulimina sabulosa* (Chapman), *A. chapmani* Cushman, *A. conoidea* (Perner), *A. frankei* Cushman i *A. advena* (Cushman). Jako nowe gatunki uznano formy opisane pod nazwą *Arenobulimina polonica* n. sp. i *A. varsoviensis* n. sp. Należy zaznaczyć, że holotypy dwóch gatunków opisanych w 1936 r. przez A. J. Cushmana, tj. holotyp *A. frankei* i *A. advena* pochodzą również z obszaru Polski. Holotyp pierwszego z wymienionych gatunków pochodzi z miejscowości Mierczany (dawniej Hildesheim) z ziemi lubuskiej, drugi z miejscowości Zastań (dawniej Zünz) z okolic Kamienia Pomorskiego. Nowe gatunki opisane w niniejszej pracy pochodzą z otworu Gorzów Wielkopolski IG-I z warstw dolnego cenomanu, z tym że *Arenobulimina varsoviensis* n. sp. stwierdzono dotychczas w otworze Gorzów Wielkopolski IG-I na głębokości 685,0 m i w miejscowości Lusowo IG-I na głębokości 358,0 m, natomiast *A. polonica* n. sp. poza Gorzowem Wielkopolskim, gdzie występuje także na głębokości 685,0 znaleziona została w otworze Ślazewo 5 na głębokości 128,0 m i Lusowo IG-I na głębokości 358,0 m.

Diagnoza gatunku *Arenobulimina polonica* n. sp.

Skorupka zlepieńcowata o ziarnach i lepiszczu krzemionkowym, o gładkiej błyszczącej powierzchni, trochospiralna, kształtu klinowatego, słabo rozszerzająca się ku górze, o przekroju poprzecznym czworokątnym z zaokrąglonymi kątami, zbudowana z 4—5 skrętów, z których każdy składa się z 4 komór układających się w 4 pionowe szeregi. Wnętrze komór ostatniego skrętu podzielone przez dodatkowe przegródki odchodzące od wewnętrznych ścianek komór.

Diagnoza gatunku *Arenobulimina varsoviensis* n. sp.

Skorupka zlepieńcowata o ziarnach i lepiszczu krzemionkowym, silnie chropowatej powierzchni, trochospiralna, kształtu jajowatego, krótka, szeroka, zbudowana z 3—4 skrętów. Początkowe skręty złożone z 4 komór, w skład ostatniego skrętu wchodzą 3 komory. Na powierzchni komór ostatniego skrętu występują woreczkowate wypukłości i zagłębienia. Wnętrza komór dwóch ostatnich skrętów podzielone przez dodatkowe przegródki. W ściance skorupki znajdują się kanaliki powstałe przez włączenie części światła woreczkowatych wypukłości do ścianki skorupki.

Wykonano ponad 90 cienkich płytek z przedstawicieli poszczególnych gatunków w celu udowodnienia przemiany pokoleń. Przytoczono także poglądy różnych autorów na zakres rodzaju *Arenobulimina* Cushman i na wartość systematyczną blaszek występujących w komorach.

EXPLANATION OF PLATES

Plate V

Fig. 1—2. *Arenobulimina chapmani* Cushman, Ślazewo 5, depth 228 m; Upper Albian. Fig. 1 a — ventral side; Fig. 1 b — dorsal side; Fig. 2 — internal plates in the chambers of the last whorl

Fig. 3. *Arenobulimina sabulosa* (Chapman), Łódź 4a, depth 814,5 m; Upper Albian, ventral side

Fig. 4. *Arenobulimina frankei* Cushman, Gorzów Wielkopolski IG 1, depth 711,6 m; Upper Albian, ventral side

Fig. 5. *Arenobulimina frankei* Cushman, Gorzów Wielkopolski IG 1, depth 685 m; Cenomanian, internal plates in the chambers of the last whorl

Fig. 6. *Arenobulimina conoidea* (Perner), Łódź 4 a, depth 813,5 m; Upper Albian; Fig. 6 a — dorsal side; Fig. 6 b — apertural view

Plate VI

Fig. 1—2. *Arenobulimina varsoviensis* n. sp., Gorzów Wielkopolski IG 1, depth 685 m, Cenomanian. Fig. 1 — holotype; Fig. 1 a — ventral side; Fig. 1 b — dorsal side; Fig. 2 a — pores in the wall of the chambers of the last whorl; 2 b — plates in the chambers of the last whorl

Fig. 3. *Arenobulimina polonica* n. sp. — holotype, Gorzów Wielkopolski IG 1, depth 685 m; Cenomanian. Fig. 3 a — ventral side; Fig. 3 b — dorsal side; Fig. 3 c — apertural view

Plate VII

Fig. 1—2. *Arenobulimina chapmani* Cushman, Ślazewo 5, depth 228 m. Upper Albian. Fig. 1 a — ventral side; Fig. 1 b — dorsal side, Fig. 2 — internal plates in the chambers of the last whorl

Fig. 3. *Arenobulimina sabulosa* (Chapman), Łódź 4 a, depth 813,5 m; Upper Albian. Fig. 3 a — ventral side; Fig. 3 b — dorsal side

Fig. 4. *Arenobulimina conoidea* (Perner), Łódź 4 a, depth 822,5 m; Upper Albian. Fig. 4 a — ventral side; Fig. 4 b — dorsal side

Fig. 5. *Arenobulimina conoidea* (Perner), Łódź 4 a, depth 811,2 m; Upper Albian. Fig. 5 a — ventral side; Fig. 5 b — dorsal side

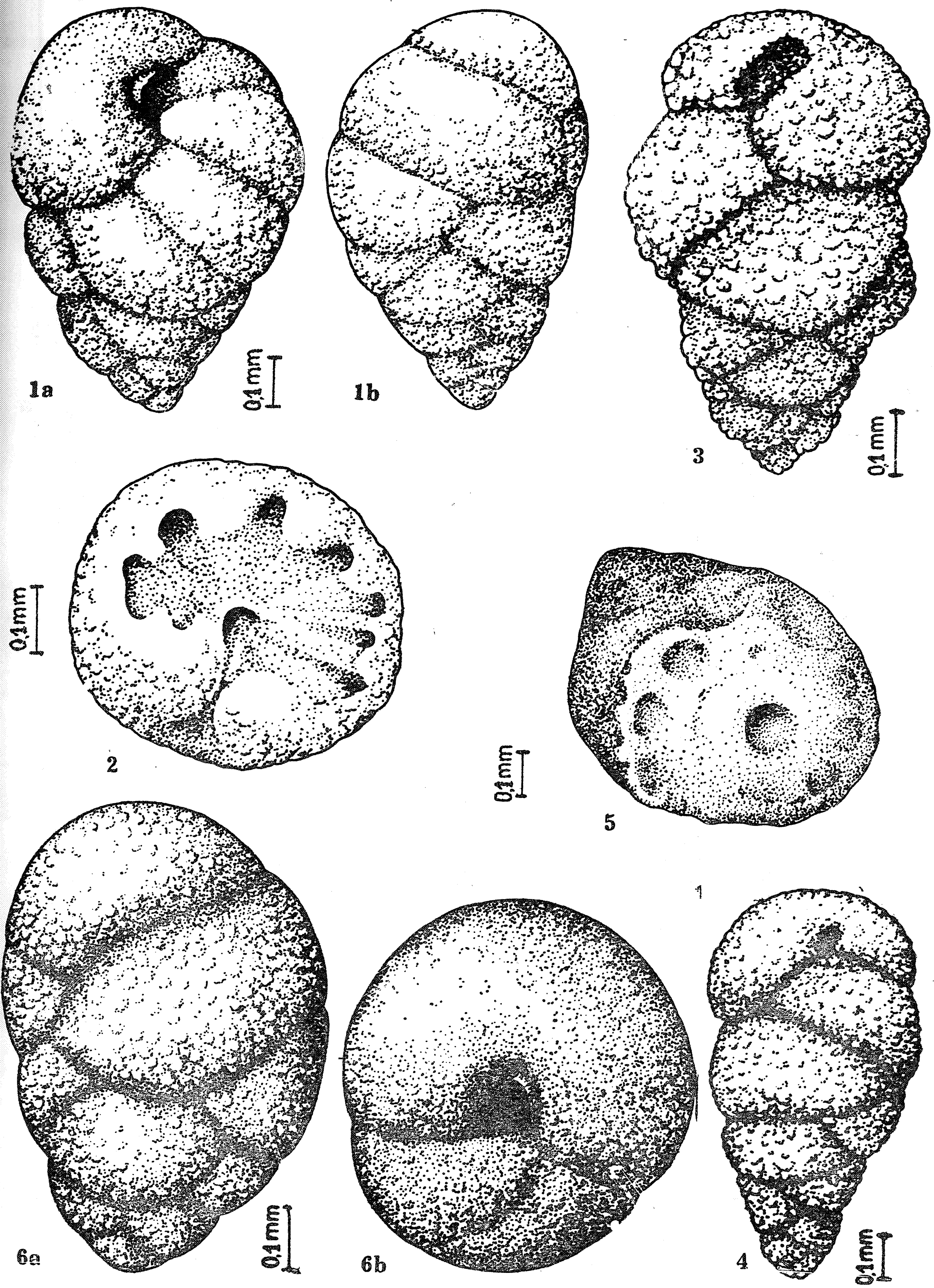
Fig. 6—8. *Arenobulimina frankei* Cushman, Gorzów Wielkopolski IG 1, depth 685 m, Cenomanian, a — ventral side; b — dorsal side

Plate VIII

Fig. 1—4. *Arenobulimina advena* (Cushman), Gorzów Wielkopolski IG 1, depth 685,5 m, Cenomanian. Fig. 4 — plates in the chambers of the last whorl

Fig. 5—8. *Arenobulimina polonica* n. sp. Gorzów Wielkopolski IG 1, depth 685 m, Cenomanian. Fig. 5 — holotypus; a — ventral side; b — dorsal side; Fig. 6 — paratypus, ventral side; Fig. 7 — paratypus, plates in the chambers of the last whorl; Fig. 8 — paratypus, juvenal forms

Fig. 9—13. *Arenobulimina varsoviensis,* n. sp. Gorzów Wielkopolski IG 1, depth 685 m, Cenomanian. Fig. 11 — holotype; Fig. 9, 10, 12, 13 — paratypes; a — ventral side; b — dorsal side; Fig. 12 — internal plates in the chambers of the last whorl



E. Gawor-Biedowa

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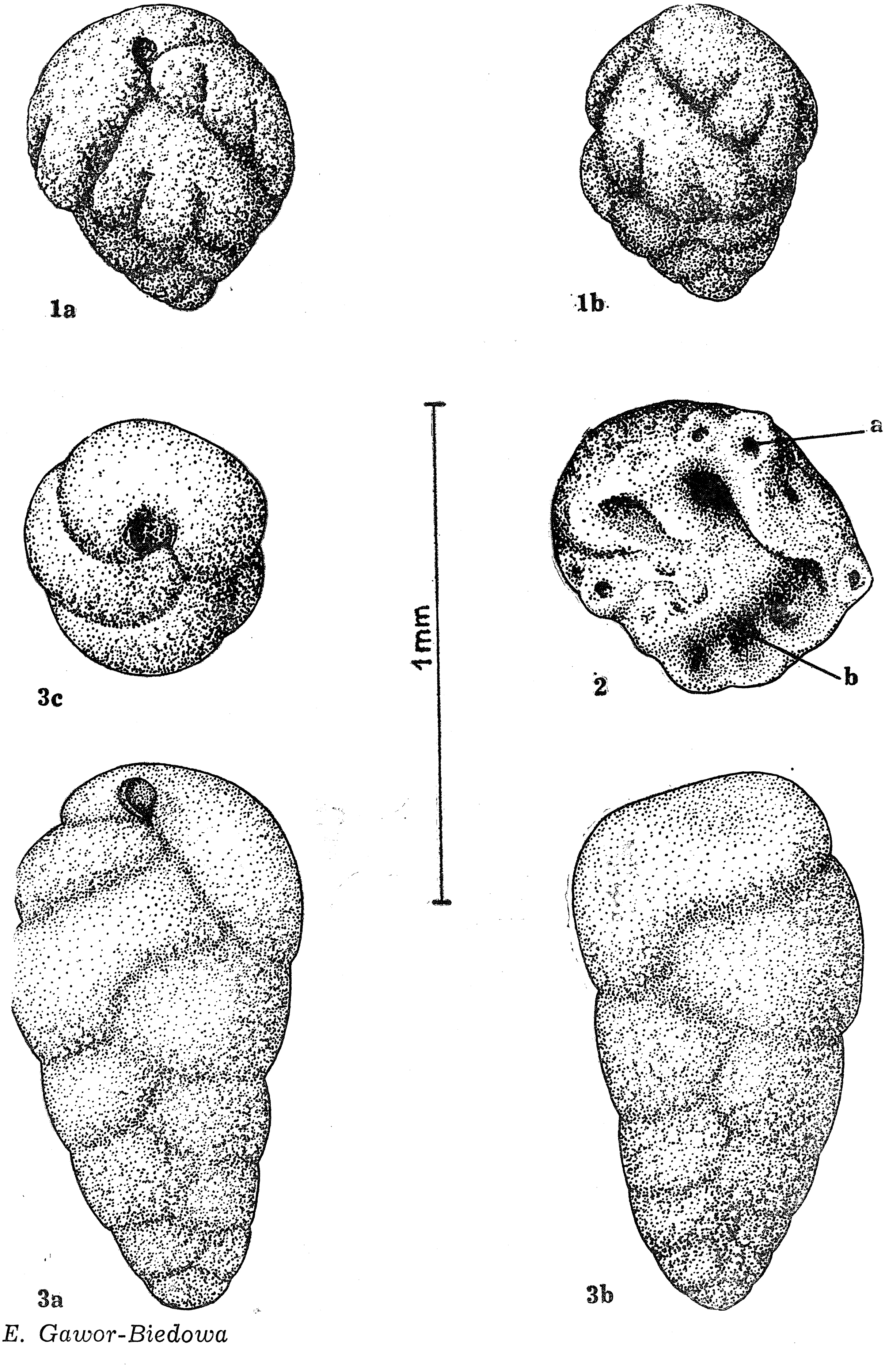

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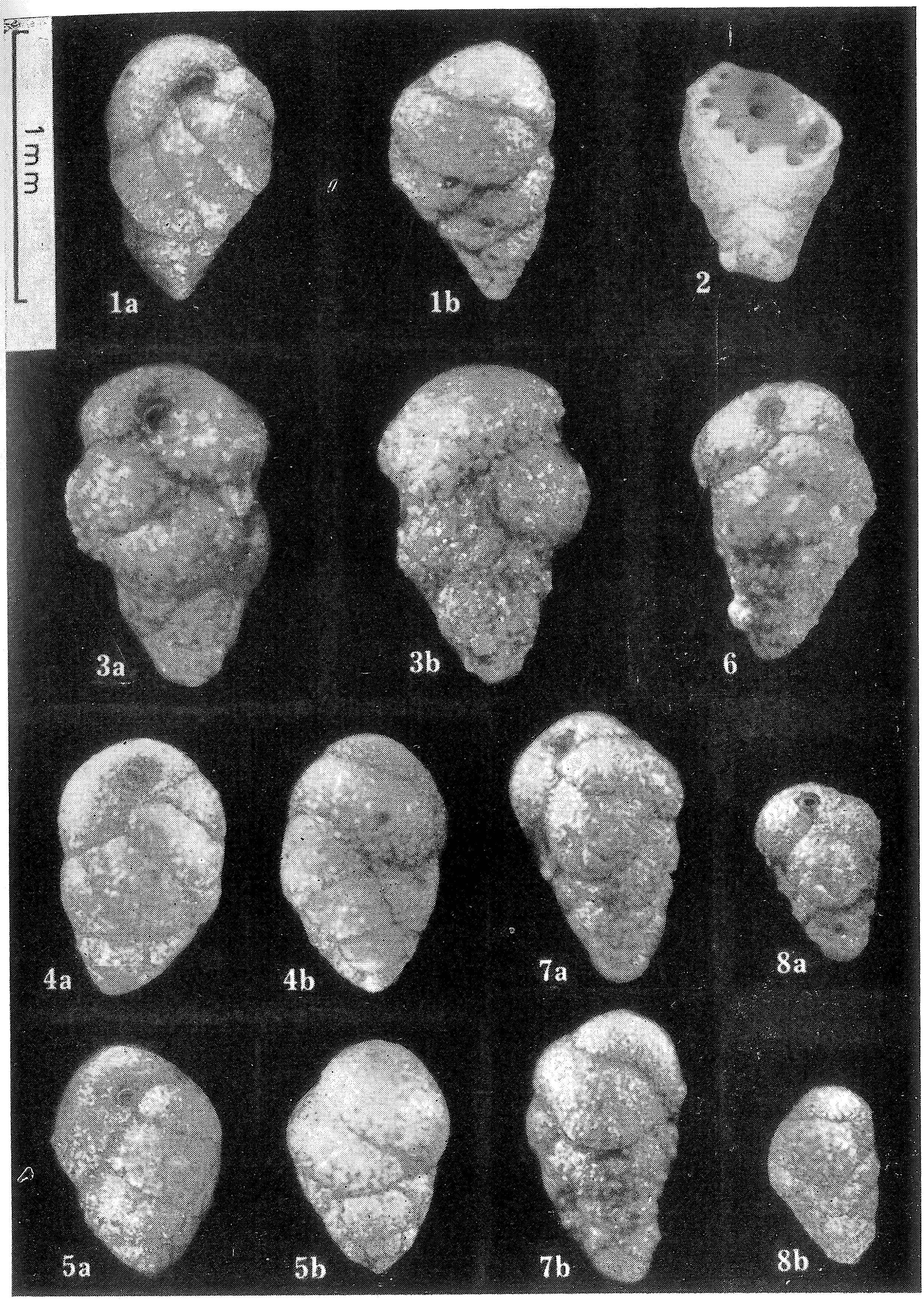

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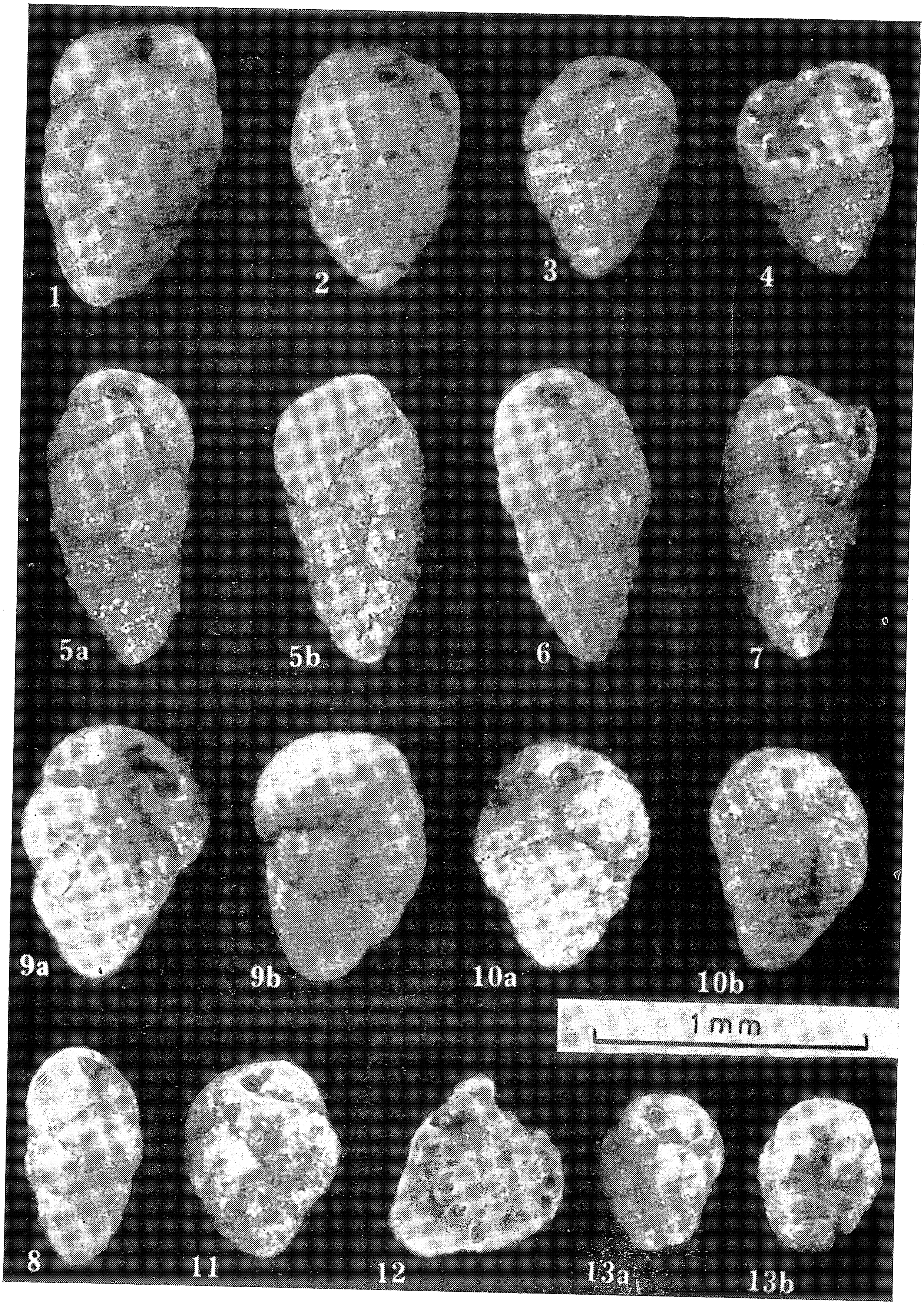

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