

Botany. — *Some remarks on Nummulites javanus Verb. and Nummulites perforatus de Montf.* By T.J. VAN ANDEL. (Communicated by Prof. PH. H. KUENEN.)

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A b s t r a c t.

Specimina of *Nummulites perforatus* de Montf. from Timor have been studied in order to solve the problem of the systematic position of *N. javanus* Verb. This species is found to belong to *N. perforatus*. The opinion of DOORNINK, who considers it to be partly *N. perforatus* and partly *N. gizehensis* Forsk., is rejected. Several other theories on this point are discussed and rejected. *N. perforatus* from Timor occurs in two varieties, 1 and 2, which are identical with γ and δ of Verbeek (var. 1) and β Verb. (var. 2). The existence of the name *N. javanus* Verb. is not justified.

The megalospheric form belonging to *N. perforatus* is *N. bagelensis* var. 1a Verb.

- 1808 *Eogon perforatus* Denys de Montfort: Conchyliologie systématique, t. I, p. 166—167.
- 1826 *Nummulina perforata* Montf. d'ORBIGNY: Tableau méthodique de la classe des Céphalopodes. Ann. des Sc. Nat. VII, p. 296. Forma A.
- 1840 *Nummulites obtusa* J. de C. SOWERBY: Systematic list of organic remains of Cutch. Transact. Geol. Soc. of London (2)V, p. 329. Forma B.
- 1853 *Nummulites perforatus* d'Orb. d'ARCHIAC et HAIME: p. 115—120.
- 1881 *Nummulites perforatus* d'Orb. DE LA HARPE: VIII, p. 130—140.
- 1896 *Nummulites javanus*, VERBEEK et FENNEMA: p. 1096 Forma B.
- 1896 *Nummulites bagelensis* 1a VERBEEK et FENNEMA: p. 1101, Forma A.
- 1912 *Nummulites laevigatus* pars, DOUVILLÉ: p. 261 Forma B.
- 1915 *Nummulites bagelensis* II, var. *megaspherica* RUTTEN: in WATER-SCHOOT VAN DER GRACHT: p. 53 Forma A.
- 1915 *Nummulites Vredenburgi* Prever pars. DOLLFUSS: p. 15.
- 1926 *Nummulites obtusus* Sowerby, NUTTALL: p. 138 Forma B.
- 1929 *Camerina obtusa* Sowerby GERTH: p. 592—593 Forma B.
- 1929 *Camerina gizehensis* Forsk GERTH: ibid Forma B.
- 1932 *Camerina perforata* de Montf. DOORNINK: p. 6 Forma B.
- 1932 *Camerina gizehensis* Forsk. DOORNINK: ibid Forma B.
- 1932 *Camerina bagelensis* 1a Verb. DOORNINK: ibid Forma B.
- 1934 *Camerina javana* Verb. CAUDRI: p. 63—64 Forma B.
- 1934 *Camerina perforata* de Montf. HENRICI: p. 21—25 Forma A. et B.

Other synonyms see BOUSSAC (1911)

Since in 1896 VERBEEK and FENNEMA based their description of *Nummulites javanus* (p. 1096) on javanese specimina, this species has been the subject of much discussion. Soon it appeared to be identical with previously described European species in so many respects, that its independance was

almost universally denied. Only CAUDRI in 1934 (p. 64) still maintained the name *Camerina javana* (Verb.). The question to which species it thus belonged led to a long and complicated discussion. GERTH (1929, p. 592) believes it to be partly *N. obtusus* Sowerby, partly *N. gizehensis* Forsk. DOUVILLÉ (1912, p. 261) believes one of VERBEEK's varieties can be identified as *N. laevigatus* Bruguière. DOLFUSS considers *N. javanus* as a transitional form between *N. Vredenburgi* Prever of the *laevigata*-group and the group of *perforata* de Montf. (1915, p. 15). DOORNINK spreads the varieties of *N. javanus* over *N. perforatus* de Montf. and *N. gizehensis* Forsk (1932, p. 6). And HENRICI rejects all these ideas and reckons *N. javanus* as a whole to be part of *N. perforatus* (1934, p. 25).

Forma A also shares in the nomenclatory confusion, although the question has drawn attention in a lesser degree. Mention of this form is very scarce. VERBEEK and FENNEMA described also a group of forms together under the name of *N. bagelensis*, divided in two groups, each with a megalospheric (Ia, IIc) and a microspheric (Ib, IId) form. Already the authors thought it possible that one of those types belongs to *N. javanus* as its A-form. RUTTEN (1914, p. 53—55) found *N. javanus* and *N. bagelensis* together in the same rock without any other Nummulitidae, but did not conclude that they belong together. And DOORNINK adds *N. bagelensis* (Ia) to that part of *N. javanus* that he reckons to be *N. gizehensis* (1932, p. 10). HENRICI, although rejecting the conclusion of DOORNINK concerning *N. gizehensis*, adds *N. bagelensis* Ia to *N. javanus*, under the name of *N. perforatus*.

With the help of extensive material collected by D. TAPPENBECK in the Mollo region on Dutch Timor and used stratigraphically in his thesis (1939) the present author has tried to solve the problem of the systematic place of *N. javanus* Verb., deciding in favour of the opinion of HENRICI (1934) in spite of later objections by CAUDRI (1934).

The material appeared on examination to consist of two closely related microspheric and one megalospheric form. Both microspheric types, being identical in all important characters, belong without doubt to the same species, forming two varieties (1 and 2) of it.

Description.

Forma B, var. 1 (fig. 1, 2)

Shape: disc lenticular or flat, often saddle-shaped or with undulating border. Edge sharp. One side often flatter than the other.

Surface: with strongly curved or meandriform raised lines, joining in one or more points. Often not very clear or lacking. Surface in that case smooth, some structure visible only after etching with HCl. Granulations visible on the border, after etching also on the whole shell, numerous, irregularly distributed.

Septal filaments visible after grinding down part of the shell, sometimes more or less meandriform, branching in the direction of the border, sometimes reticulate, branching and anastomosing in elongated and irregular meshes; nearer and more parallel to the median layer of the shell simply curved and furcated, radiating in whirling shapes from

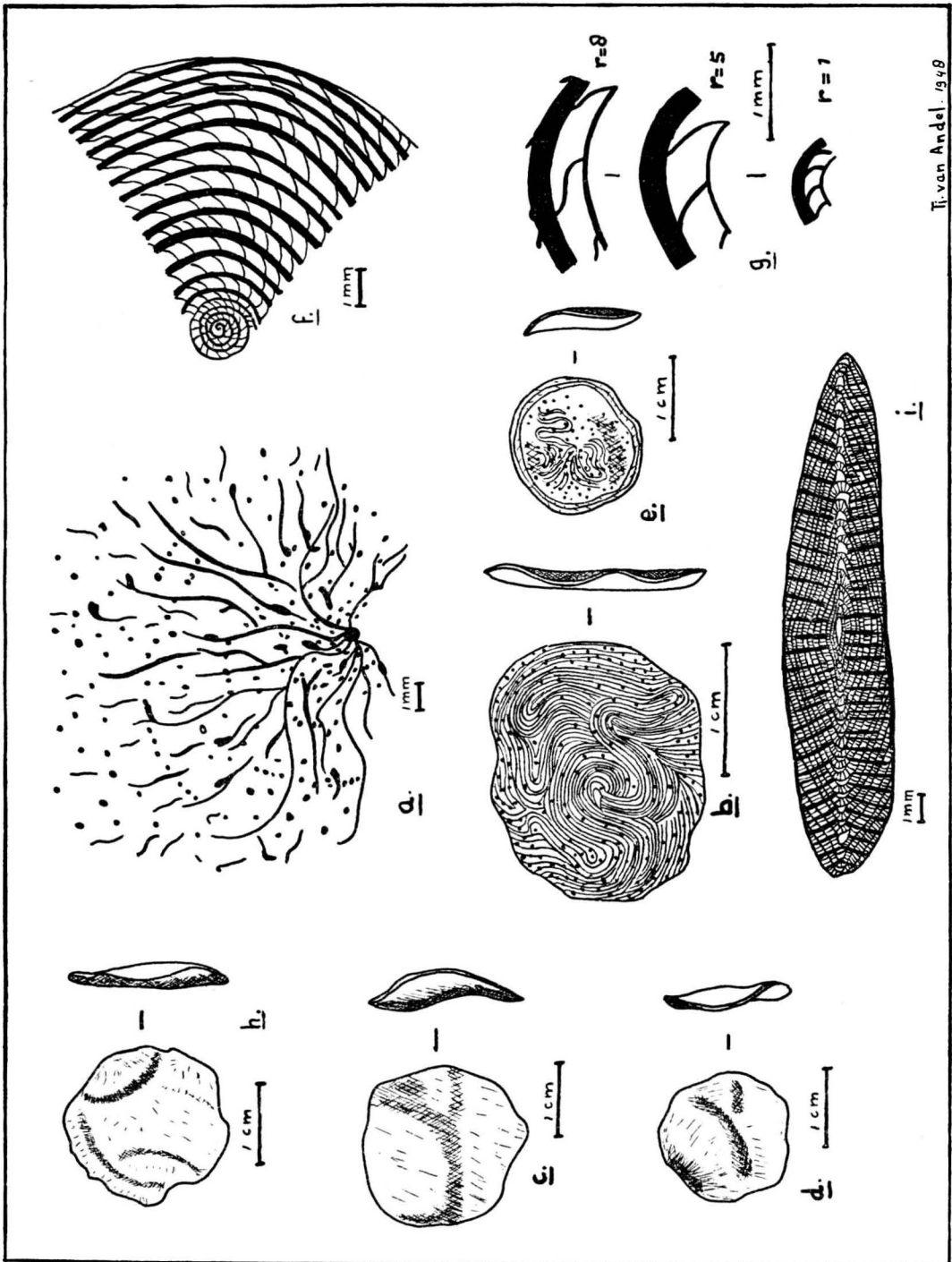


Fig. 1. *Nummulites perforatus* de Montf. Forma B, var. 1.

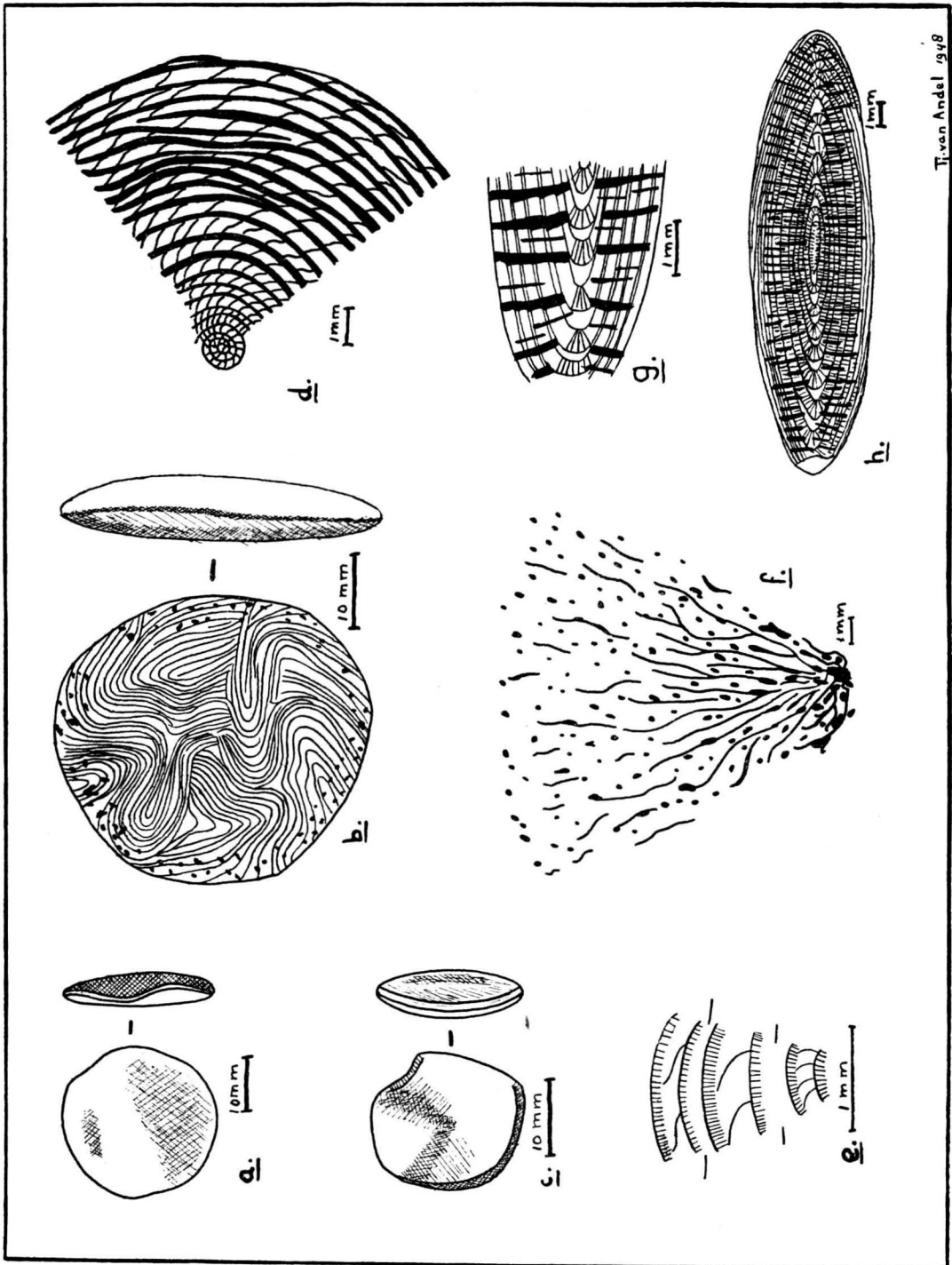


Fig. 2. *Nummulites perforatus* de Montf. Forma B, var. 2.

a central point. Sections near the median layer always show this type, even when mean-driform near the surface.

Pillars numerous, irregular, mostly flattened, concentrated in the centre, mainly placed between the septal filaments but also for some part upon them. Mostly placed on the outside of each whorl.

Whorls in the centre evenly and narrowly wound. Gradually widening. Sometimes on the periphery narrower again. Regularly increasing chamberheight or a constant height from a certain distance from the centre are also often found. Whorls on the outer part of the spiral irregular, no longer circular. The undulation of the whorls, sometimes described, is caused by sectioning an undulating median layer. Sometimes extra whorls between the normal ones occur, mostly shorter than one winding. Distance between two whorls very variable; even in one whorl. Number of whorls $1\frac{1}{2} - 2 \times$ mm radius.

Septa thin and strongly curved, falcate or S-shaped; in the central part mostly perpendicular to the preceding whorl, more oblique up to 45° in the outer part; meeting the next whorl under 45° . Always widely spaced.

Chambers near the centre higher than long or as high as long, on the periphery always two or more times as long as high (height measured parallel to the radius of the shell, length measured tangentially. Central chamber invisible. Chamberform very characteristic, falcate with sharp corners.

Spiral wall with variable thickness, always less than the chamberheight. In an *axial section* spiral walls very thick; touching each other everywhere, except in the median layer. Pillars numerous, number increasing in the direction of the median layer, often reaching the surface even in the central part of the shell, cylindrically, generally placed on the outer side of each whorl.

Forma B, var. 2 (fig. 3, 4)

Only small difference with the above described specimina. The differences are as follows. Disc flat or lenticular, often rather globular. Thickness much greater, as compared to the diameter, than in var. 1. Edge obtuse or rounded. Granulations even after etching only on the border part. Number of whorls slightly greater, number of chambers per whorl less. Average diameter greater, whorls more irregular, loose extra whorls often occurring, chamberheight very variable. In an axial section spiral walls mostly not touching, pillars in the central part not reaching the surface. Further particularities in the figures.

Both types are thus very similar, especially concerning the important features of septa and shape of the chambers. The most important and constant difference lies in the shape of the shell. Other differences in diameter, number of whorls and chambers are only statistically discernable.

In the table below some important numerical data are given.

A comparison of the specimina described with older descriptions shows the great resemblance to *Nummulites javanus* Verb. (VERBEEK and FEN-NEMA 1896, p. 1096) Dimensions, shape, surface structure, septal filaments, distribution of pillars, form, and number of chambers and whorls are completely identical with their description and figures (Pl. III 45—47, IV 56—68, V 69—73, VII 94). VERBEEK distinguishes four varieties, two, α and β , with obtuse edge and great thickness in relation to their diameter, the others thin and with sharp edge. Our var. I contains specimina of Verbeeks γ and δ together with many transitions. We were not able to find any useful limit between those two varieties. Var. I from Timor is thus identical with γ and δ Verbeek.

TABLE I.

	Var. I			Var. II		
	Number of specim.	Aver.	Min. max.	Number of specim.	Aver.	Min. max.
Diameter	22	18 mm	9-25	14	20,3	15-30
Thickness	21	4	2,5-7	11	6,6	5-9
Number of whorls	21	14	7-20	13	19	11-31
Whorls at $r = 5$ mm	14	10	6-13	7	11	9-12
$r = 10$ mm	9	15-16	12-20	7	18	15-20
Whorls from centr. —1 mm	13	5	4-6	6	5	5-6
1-3 mm	13	4-5	3-9	7	4	3-5
3-10 mm	7	8	6-17	5	9	6-11
Septa per 1/4 whorl $r = 5$	13	11-12	8-13	7	11	5-14
$r = 8$	10	15	12-16	5	12	8-16
Chamberheight \times length $r = 1$	13	$0,25 \times 0,25$	$0,15-0,5 \times 0,15-0,3$	7	$0,28 \times 0,21$	$0,2-0,35 \times 0,15-0,38$
$r = 5$	13	$0,45 \times 0,60$	$0,30-0,5 \times 0,50-0,8$	7	$0,46 \times 0,64$	$0,35-0,55 \times 0,45-0,85$
$r = 8$	10	$0,40 \times 0,90$	$0,30-0,6 \times 0,50-1,2$	6	$0,57 \times 1,00$	$0,50-0,75 \times 0,80-1,15$
Thickness spiralblade	13	0,35	0,10-0,30	7	0,30	0,15-0,50

Var. 2 from Timor shows a resemblance to var. β Verb. in some points (number of whorls, shape, edge, dimensions). A few specimina however possess the greater dimensions of var. α Verb. (33 mm). Pure specimina of this variety are not found, so I cannot decide upon the problem of its autonomy. DOORNINK (1932, p. 5) too noticed the vagueness of VERBEEK's varieties.

The following table contains a comparison between VERBEEK's data and the dimensions of the Timor Nummulitidae. It is clear that even the largest specimina of var. 2 differ still much with var. α Verb.

TABLE II.

	Nummulites javanus Verb.				Spec. from Timor			
	α	β	γ	δ	1		2	
					a	b	a	c
Border	obtuse	obtuse	sharp	sharp	sharp	sharp	obtuse	obtuse
Diameter	22	21	21	16.5	18	16	20	30
Thickness	7	7-9	4-5	4.5	4	4	6.5	9
Whorls at $r = 5$ mm	14-15	11	12-13	10-12	10	11	11	31
$r = 10$ mm	25-28	21	21-22	—	15-16	—	18	19
Septa to 1/4 whorl $r = 5$ mm	12-16	14-15	9-10	10-12	11	11	11	14
$r = 10$ mm	30-36	25	16-20	—	17	—	14	18

Column *a* of the Timor specimina contains the average values, column *c* the largest values, column *b* the smallest individuals. The conclusion seems

justified that the Timor Nummulitidae are identical with *N. javanus* Verb. Furthermore we can distinguish two varieties 1 (= γ and δ Verbeek) and 2 (= β Verbeek). The position of α Verb. remains obscure.

We have to consider now the theory of DOORNINK (1932, p. 6) who wants to spread *N. javanus* over *N. perforatus* de Montf. and *N. gizehensis* Forsk. Close inspection of his arguments shows this view to be untenable as appears already from the strong resemblance between the two varieties. This opinion is also expressed by HENRICI (1934, p. 25).

Descriptions of both species by DE LA HARPE (1880—1881, VIII, p. 115, 1883, p. 32—49); BOUSSAC (1911 p. 74) and ROZLOZNIK (1926 p. 170, 220, 1929, p. 43, 47) show many points of resemblance. Both possess a sharp or obtuse edge, dimensions are quite identical. DOORNINK (1932, p. 6) considers the possession of one flat and one convex side to be characteristic for *N. gizehensis*, but *N. perforatus* also often shows this feature. The septal filaments of *N. gizehensis* are mostly more meandri-form, but this is also found sometimes with *N. perforatus*. Both the specimina illustrated by VERBEEK (1896, Pl. III, 49, 51, 54; Pl. IV 58, 63; Pl. V 71) and those from Timor are within the range of variation of *N. perforatus*. Granulations in both *perforatus* and *gizehensis* lie mainly between and not (as DOORNINK (p. 6) mentions for *gizehensis*) upon the filaments. Studying the figures of BOUSSAC, DE LA HARPE and ROZLOZNIK there can be no doubt on this point. DOORNINK himself gives no figures of the septal filaments of his specimina.

The most important difference between both species is the shape of the chambers, a feature not considered by DOORNINK. In the chambers of *N. gizehensis* the height is always more than the length, at best they are equal. Septa are straight or only slightly curved and approximatively perpendicular to the spiral wall. The chambers thus show a typical arcade form (DE LA HARPE 1880—1881, p. 115, 1883, p. 32). Septa always close together. *N. perforatus* on the other hand has chambers many times as long as high, and strongly curved or falcate septa, which meet the spiral wall at an angle of about 45°. Chambers thus low and falcate. Both the Timor material and the figures of VERBEEK (pl. III, IV, V) and DOORNINK (pl. II) show this perforata chambertype. This important characteristic (BOUSSAC 1911, p. 8) enables us to join without any doubt our specimina, together with DOORNINK's and VERBEEK's material, to *N. perforatus*.

BOUSSAC records the occurrence of two main types of *N. perforatus*, corresponding with our varieties 1 and 2. Considering this complete resemblance to an European species the maintaining of *N. javanus* as a species of its own, as CAUDRI (1934, p. 64) does, loses its importance. In India specimina of *N. perforatus* are found (NUTTALL 1926) under the name *Camerina obtusa* de Sow, a synonymy for the microspheric form of *N. perforatus*, which bridge the gap between Europe and the East-Indian Archipelago. Remains the opinion of DOUVILLÉ, who combines part of *N. javanus* with *N. laevigatus* Bruguière, basing his opinion upon the

occurrence of pillars on the septal filaments (1912, p. 261). This opinion lacks other arguments and the fine and regular meshes of the filamental net of *laevigata* with all pillars on the points of junction, compared with the coarse net of *perforata*, strongly opposes it. The idea of DOLFUSS (1915, p. 15) that *N. javanus* would form a transition between *N. perforatus* and *N. laevigatus*, must be rejected on the same arguments.

The unquestionable relation between *N. laevigatus* and *N. perforatus* leads BOUSSAC to the idea, that the latter is the result of further evolution of *N. laevigatus* (1911, p. 75). Because of its different chamberform lies *N. gizehensis* outside this group. ABRARD (1928, p. 89) supposes *perforatus* to originate from *gizehensis* in the same way as this is the case with *N. Brogniarti* and *N. laevigatus*. But the only argument, the very slight resemblance between *gizehensis* and *Brogniarti*, is of very little value.

Less complicated is the case of the related megalospheric form, also found in great quantities in the Timor material. Except these A. and the above described B. forms only very few Nummulitidae are found so the relation seems fairly well established.

Description (fig. 3)

Shape globular to thick lenticular or double conical, edge sharp.

Surface smooth. *Septal filaments* visible after some grinding, S-shaped, sometimes branching and curved as forma B, sometimes relatively straight and radial, in centre joining in a whirl.

Pillars irregular, not numerous, concentrated in the central part, mostly on the outside of the spiral wall, and placed between the septal filaments.

Whorls very regular, chamber height only slightly increasing from centre to border. Chamberlength regularly increasing, chambers higher than long.

Central chamber egg-shaped and fairly large. *Septa* thin, falcate, perpendicular to the preceding spiral wall. In an axial section a few cylindrical pillars are visible, mostly in

TABLE III.

	Timor			<i>N. gizeh.</i> Forma A. after DOORNINK		
	number	aver.	max. and min.	number	aver.	max. and min.
Diameter	15	4.2	3—6.8	4	4.3	3.7—4.5
Thickness	14	2.2	1.7—2.8	2	2.1	2.0—2.3
Whorls	13	5	4—6	4	5	4—6
Chambers i/th 1st whorl	15	3	3	2	3	3
3rd whorl	7	7	6—8	2	7	7
5th whorl	5	10	9—10	1	9	9
Chamberheight			0.35—0.15 X			0.15—0.24 X
X length 1st whorl	5	0.28 X 0.30	0.35—0.55	2	0.20 X 0.33	0.3—0
Chamberheight			0.25—0.38 X			
X length 3rd whorl	6	0.32 X 0.45	0.35—0.52	2	0.40 X 0.40	0.38—0.45
5th whorl	7	0.25 X 0.60	0.22—0.30 X	1	0.30—0.53	
			0.50—0.75			—
Central chamber	12	0.70 X 0.60	0.55—0.90 X	3	0.65 X 0.60	0.60—0.75 X
			0.50—0.85			0.60

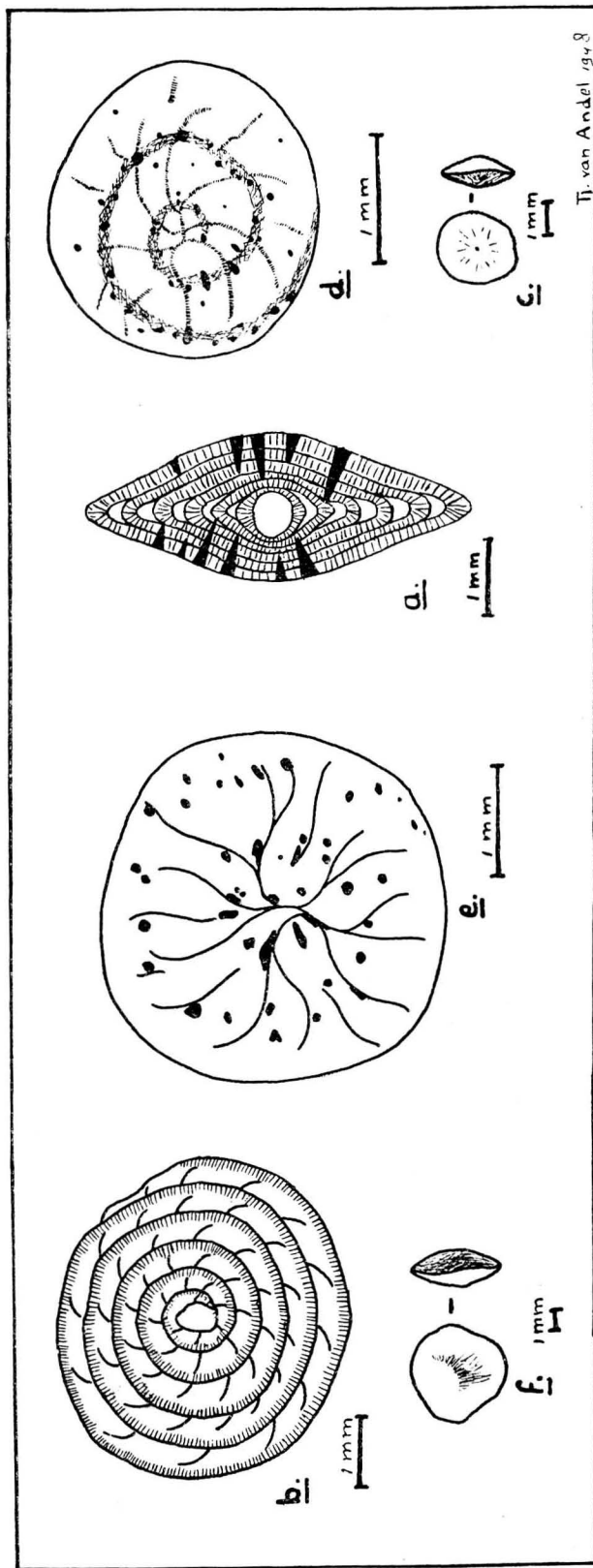


Fig. 3. *Nummulites perforatus* de Montf. Forma A.

the central part and reaching the surface. Spiral walls thick, touching each other, structure therefore compact. No central column.

The shape of chambers and septal filaments is completely identical with forma B. of *N. perforatus*. This and the occurring together of both forms is in favour of combining the two. I consider it logical to give both forms of one species the same name. The name *N. obtusus* Sowerby, given to the B. form, is the youngest and must be rejected in favour of *N. perforatus*, originally given to the A. form, for both.

If we compare this forma A. from Timor with *N. bagelensis* VERB. (VERBEEK 1896, p. 110) the resemblance to *N. bagelensis* Ia in form and dimensions of chambers and septal filaments is very clear. They are without doubt identical. HENRICI too describes the same form from Timor and declares it to be *N. bagelensis* Verb. Ia and the A. form of *N. perforatus*. On Celebes RUTTEN (1914, p. 54) found a variety of *N. bagelensis* together with *N. javanus* var. γ . He describes it as a variety apart, called *megasferica*, part of *N. bagelensis* II Verb. because of its dimensions (2,5—3,5 mm). The difference with the normal *N. bagelensis* IIc is a smaller number of whorls (3—4 against 4—6 for IIc), no central column and a central chamber with the same dimensions as var. Ia Verb. (0,50—0,80 mm against IIc 0,10—0,30 mm). All those differences however bring it to var. Ia Verb., so the A-form RUTTEN found to *N. javanus* γ is the same as the one found at Timor.

Only in the work of DOORNINK we find any further observations concerning this A-form. By the courtesy of Prof. H. A. BROUWER, director of the Amsterdam Geological Institute I was able to study the original thin sections made by DOORNINK. This and the figures in his book (Pl. II, 1—2) leads to the conclusion, that this form cannot belong to *N. gizehensis* owing to the great difference in chamberform, which is of the *perforatus* type. The A-form of *N. gizehensis* (*N. curvispirus*, cf. also ROZLOZNIK 1929, p. 220, and DE LA HARPE 1883, p. 32) shows the arcade form, as is definitely stated by the authors. In other features (form, dimensions, number of whorls) the two species resemble each other much, thus explaining the incorrect determination.

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