ROCZNIK POLSKIEGO TOWARZYSTWA GEOLOGICZNEGO
ANNALES DE LA SOCIÉTÉ GÉOLOGIQUE DE POLOGNE

Tom (Volume) XXXIX — 1969 Zeszyt (Fascicule) 1—3 Kraków 1969

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TO THE REVISION OF MILIOLIDAE WITH QUINQUELOCULINE AND TRILOCULINE STRUCTURE OF TESTS

(5 Figs.)

А. К. БОГДАНОВИЧ

К ревизии милиолид *(Miliolidae)* с квинквелокулиновым и трилокулиновым строением раковин

Abstract: Studies of the internal structure of tests of Foraminifera of the *Quinqueloculina* and *Triloculina* genera proved, that some tests with three external chambers, assigned to the genus *Triloculina* have in reality a quinqueloculine--type structure. This type of structure is termed „cryptoquinqueloculine" by the author who regards it as a modification of the quinqueloculine structure proper, and proposes an appropriate modification of the diagnosis of the *Quinqueloculina* genus. A similar cryptoquinqueloculine structure has been found in other Miliolidae genera, among others in the genus *Miliolinella* Wiesner. As this feature relates it to the *Scutuloris* genus, the author proposes to unite these two genera, returning to the former Wiesner's description, and to supplement appropriately the diagnosis of the *Miliolinella* genus.

Miliolidae representatives with quinqueloculine and triloculine tests have been known since Trias and Jurassic, and are extremely interesting for the study of phylogenetic development of the family and stratification of deposits. These foraminifers are especially important for a detailed subdivision and correlation of Miocene deposits of Eastern Paratethys (Euxine-Caspian) that yielded about one hundred fifty species having a relatively narrow stratigraphic range (A. K. Bogdanovich 1947, 1952, 1960, 1965; O. I. Djanelidze, 1958, 1963, 1964; W.Y. Didkovskij, 1961; W. M. Pobedina and oth., 1956; M. Y. Serova, 1955, and oth.) Unfortunately the structure of the tests of the given group has not been studied thoroughly enough; this resulted in inaccuracy and even certain errors in generic diagnoses. This in its turn was responsible for difficulties in establishing the generic position of a great number of species and elucidation of their generic relations.

If we turn to the *Quinqueloculina* Orbigny and *Triloculina* Orbigny genera which served as a basis for distinguishing „quinqueloculine" and „triloculine" structural types of tests, we shall see that the diagnoses of the genera presented in summary works are so distinct that their distinguishing would not seem to present a problem (J. Cushman,

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1917, 1955; Galloway, 1928; M. Glaessner, 1944; A. Loeblich and H. Tappan, 1964; J. Sigal, 1952, and oth.). Thus *Quinqueloculina* is characterized by a structural type of chambers, when the latter, being successive in time of formation (I and II, II and III and so on — Fig. 2) [1] coil at an angle of 144° relative to each other, whereas the adjacent chambers (I and IV, IV and II, II and V and so on — Fig. 2) are arranged on five intercrossing planes at an angle of 72°. Owing to such regular arrangement of chambers, five of them are observed on the external part of quinqueloculine tests, including I, II, III and V on the multicamerate side, and I, II and IV — on the side with a small number of chambers (Fig. 1 A) [2]. Triloculine tests have quite different structure. Here, as a rule, in all megalospheric forms, as well as at the adult stage of development of microspheric tests, the chambers coil in three intercrossing planes at an angle of 120°; therefore only three chambers can be seen on the external part (Fig. 4) [3].

However, cases when on tests of many quinqueloculine species the number of chambers seen outside decreases to 4 and even 3 are quite common. This phenomenon described by A. K. Bogdanovich (1952, p. 8, Fig. 5) and later by V. A. Krasheninnikov (1959, p. 79), J. Hofker (1964, p. 25) and R. Prell-Müssig (1965, p. 233, Fig. 23) was caused by a rapid increase of thickness of chambers as the test grows, and thus by their larger involution. As a result, the last three chambers (I, II, III — Fig. 1 A, B, C) cover the earlier ones — the fifth (V — Fig. 1 B) and also not seldom the fourth chamber (IV — Fig. 1 C). In the last case only three chambers can be traced outside; in the outward appearance these tests are very much like real triloculines. But when compared, the median cross („axial") sections of the tests prove quite different.

Indeed, if the triloculine chambers grow at an angle of 120°, the chambers of quinqueloculines with three external chambers (I, II, III — Fig. 1 C and 3) form quite different angular distances: approximately 144° between chambers I and II, II and III, and about 72° between chambers III and I. As to chambers IV and V, they are completely involute and are, as though, hidden by three extreme ones. At the same time these two chambers occupy an obviously adjacent position relative to three external chambers, and form angles of 72° (i.e. angles between chambers IV and I, IV and II, V and II, V and III). Hence it may be easily concluded that all the five chambers (three external and two that are covered by them) coil in five planes under angles 72° and correspond to five external chambers of typical *Quinqueloculina*. In another paper the author suggested to name this structure as cryptoquinqueloculine and to regard it as a modification of a true quinqueloculine structure of Miliolidae (A. K. Bogdanovich, 1969).

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[1] Here and further in the text and on figures the chambers of the last cycle are counted from the final chamber.

[2] L. Rhumbler (1936, p. 201) uses the name „four- and three-chambered" for lateral sides of quinqueloculines, but it will be seen below that the number of outer chambers of this genus may be less than five. Therefore it would be better to name these sides „many- and few-chambered" (A. K. Bogdanovich, 1952, p. 15, Fig. 14).

[3] Earlier stages of development of microspherical tests of triloculines are known to be of a quinqueloculine structure.

Thus, it is concluded that the tests with three external chambers may have quite different inner structure. In one case these tests coil in a typically triloculine order and undoubtedly belong to genus *Triloculina*. The cryptoquinqueloculine structure is peculiar to them in the other case, and the species having the tests of this kind belong to genus *Quinqueloculina*.

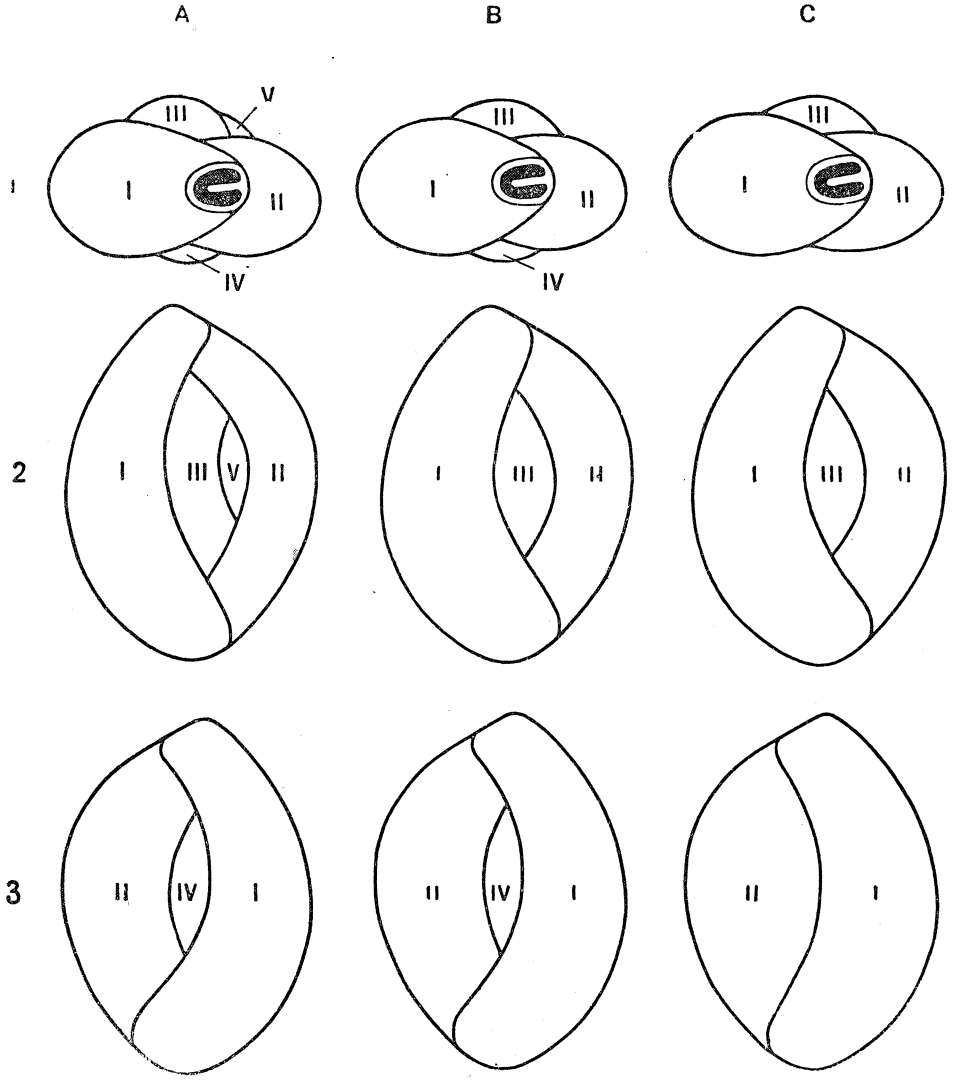

Fig. 1. External structure of tests with quinqueloculine and cryptoquinqueloculine arrangement of chambers. A, B — quinqueloculine tests with five and four external chambers; C — cryptoquinqueloculine test with three external chambers. 1 — apertural side; 2 — many-chambered side; 3 — few-chambered side; I, II, III, IV, V — external chambers counted from the final on

This conclusion points out to the necessity of checking out whether species with „three-chambered" tests described before were correctly attributed to *Triloculina*. Preliminary studies of the author showed that some of these species have a cryptoquinqueloculine structure of tests and should be included into genus *Quinqueloculina*. Among them are, for example, triloculines described before: *Quinqueloculina consobrina* (d'Orbigny), *Q. nitens* (Reuss), *Q. williamsoni* (Terquem), *Q. satanovi* (Didkowskij), *Q. rotunda* (d'Orbigny), *Q. laevigata* (d'Orbigny) etc. There are good reasons to believe that these quinqueloculine tests with three (as well as with four) external chambers led

the authors to a wrong conclusion about the existence of „transitions" between genera *Quinqueloculina* and *Triloculina* (A. Reuss, 1855, A. Hosius, 1895, and oth.); this made W. Williamson (1858) to unite them into a new genus which he called *Miliolina* [1].

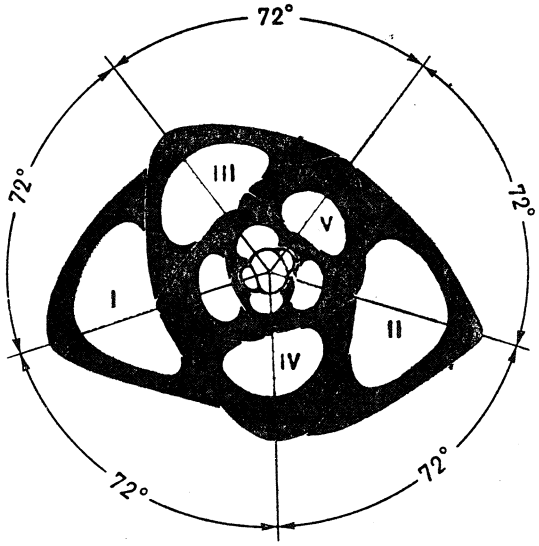

Fig. 2. Median cross section of *Quinqueloculina vulgaris* Orbigny test (after Schlumberger, 1893, with supplements of the author). Typical quinqueloculine arrangement of chambers

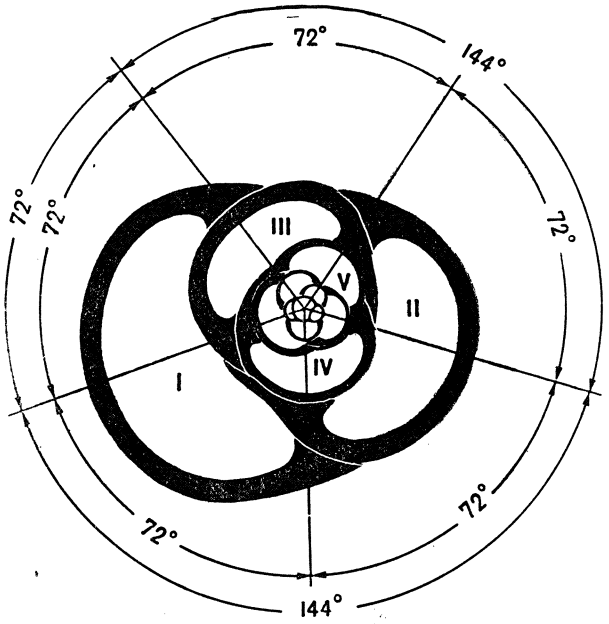

Fig. 3. Median cross section of *Quinqueloculina rotunda* (d'Orbigny) test (after Schlumberger, 1893, with supplements of the author). Cryptoquinqueloculine arrangement of chambers

[1] As Prell-Müssig (1965) points out, the name *Miliolina* in general cannot be considered valid, because when uniting two taxons, the name of the oldest should be retained according to the International Code of Zoological Nomenclature.

The distinguishing of a new feature, i.e. a cryptoquinqueloculine structure of tests should be naturally reflected in its generic characteristic. This feature was already mentioned by the author in „Osnovy Paleontologii", where he wrote while describing *Quinqueloculina*: „five-

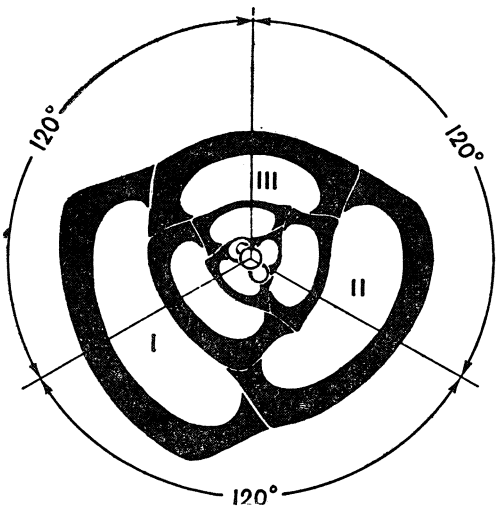

Fig. 4. Median cross section of megalospheritc *Triloculina marioni* Schlumberger test (after Schlumberger, 1893, with supplements of the author). Triloculine arrangement of chambers

-four, more seldom three chambers are seen on the external side of the test, the involution of the last two-three chambers being rather considerable" (A. K. Bogdanovich and N. A. Voloshinova, 1959, p. 239). The similar detalization of a generic characteristic coincides in many respects with the diagnosis of quinqueloculines that was later recommended by R. Prell-Müssig (1965). In the given paper the author suggests to supplement the diagnosis of the genera with the words: „the test of a quinqueloculine and cryptoquinqueloculine structure".

Further studies showed that cryptoquinqueloculine type of coiling of chambers is peculiar to a number of other Miliolidae representatives as well, including the genus *Miliolinella* Wiesner. Under this name H. Wiesner (1931) united the species having a lamellar structure of a tooth and various types of structure of tests, namely quinqueloculine, triloculine and even biloculine. Later A. Loeblich and H. Tappan (1953) attributed to *Miliolinella* only species with triloculine tests; quinqueloculine forms, were assigned to a newly established genus — *Scutuloris*. The study of the inner structure of *Miliolinella* and *Scutuloris* tests led the author to a conclusion that the first do not have a triloculine arrangement of chambers, but are of a cryptoquinqueloculine structure; among the second ones a quinqueloculine structure prevails, and only a small number of tests have 3—4 chambers on its external part.

The median cross section (polished section) of the species *Miliolinella* aff. *valvularis* (Reuss) from the Lower Oligocene (North Caucasian) shows the inner structure of a *Miliolinella* test (Fig. 5 d). This test was drawn before polishing and is of a real triloculine habitus (Fig. 5 a—c). Its section, however, convinces us that the chambers coil here on five, (but not on three) planes, chambers I, II and III being arranged on the external part and IV and V — on the internal one. Thus, we deal with

the cryptoquinqueloculine structure of tests, i.e. with the arrangement of chambers presented on Fig. 3 [1].

It should be noticed, however, that the above discussion of the structure of *Miliolinella* tests contradicts the picture of *Miliolinella subrotunda* (M o n t a g u) thin section presented in „Treatise on Invertebrate

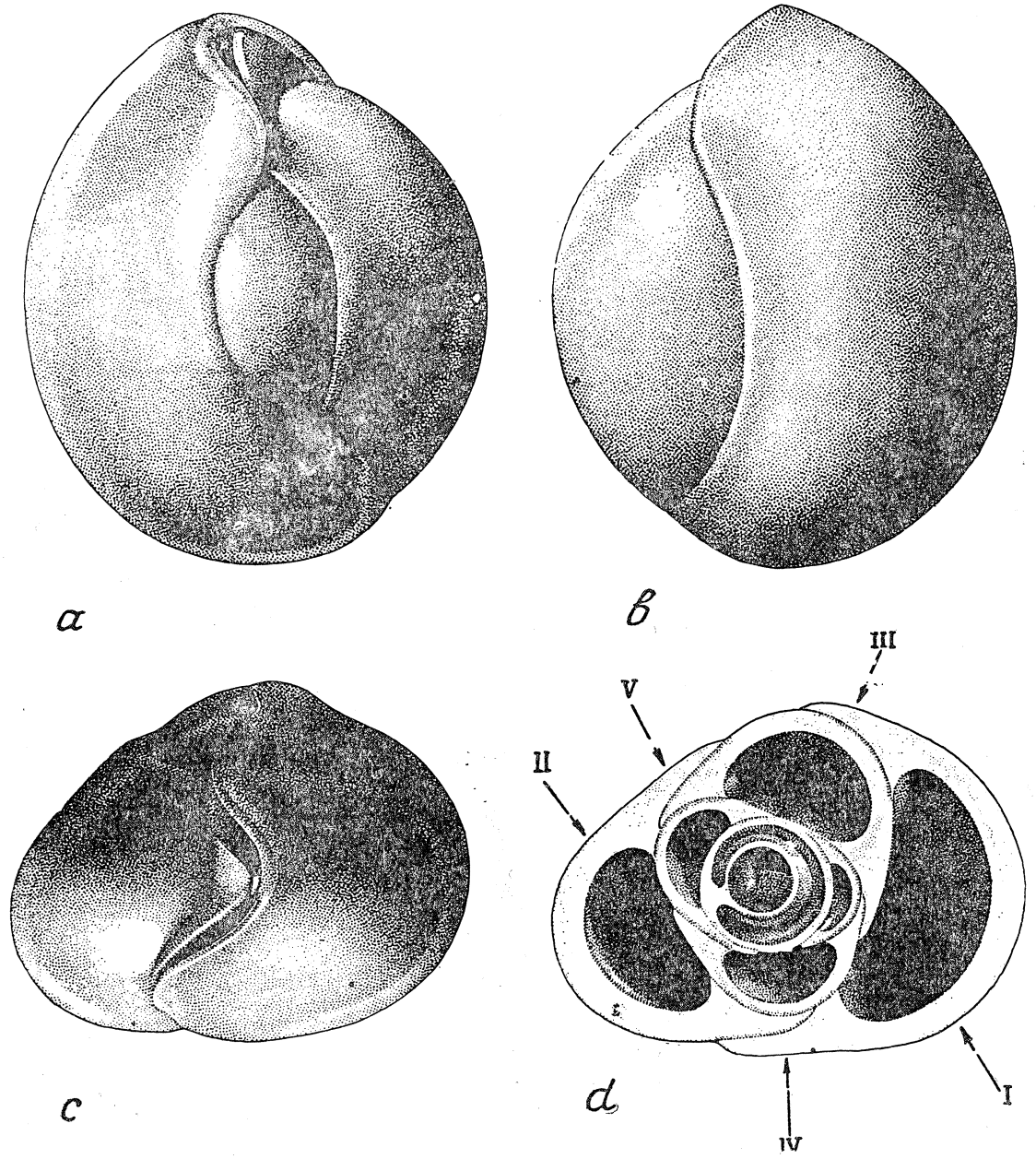

Fig. 5. *Miliolinella* aff. *valvularis* (R e u s s) ×120. Original sample No. 528/56 in the collection of NIGRI (Leningrad). Peschanokopsk region (North Caucasus). Lower Oligocene (*Spiroplectammina carinata oligocenica* beds) (a — many-chambered side; b — few-chambered side; c — apertural side; d — median cross section (polished section); I—V — chambers counted from the final on

[1] The polished section presented differs from Fig. 3 in a lesser number of chambers (7 altogether) and in an abrupt displacement (90°) of a coiling plane of the earliest (larval) part of the test; as a result a spiral thin-tubular chamber that follows proloculus, is dissected not in a cross („axial"), but in a longitudinal („equilateral") direction.

Paleontology Part C, Protista 2" by A. Loeblich and H. Tappan (1964, Fig. 355, 2) and showing three (!) external chambers with angular distances approaching 120°. However, a careful examination of this picture convinced the present author that the section of the test is not a median cross section according to which the types of arrangement of chambers of glomerately coiled Miliolidae can be determined, but a median longitudinal one. Besides, the thin section has been prepared from a test having a „flintina-like" structure (the name of the genus — *Flintina* Cushman) — a specific anomaly peculiar to certain Miliolidae and characterized by the presence of three (but not two, as usual) chambers in one whorl (see, for instance the paper by A. K. Bogdanovich (1958, plate 1, Fig. 6). Thus, the above-mentioned section of the *Miliolinella* test does not prove that it belongs to a triloculine type. If *Miliolinella* have a cryptoquinqueloculine type of structure, their close relation with „*Scutuloris*" with a quinqueloculine arrangement of chambers is beyond any doubt, and there seems to be no reasons for independent distinguishing of these genera. The author believes that it would be most expedient to reestablish the *Miliolinella* genus according to the original description by H. Wiesner; however, the diagnosis suggested by this author for the genus should be supplemented: instead of the „milioline" [1] structure of the tests presented by H. Wiesner, it should be pointed out that the tests grow here in a quinqueloculine and cryptoquinqueloculine order.

The cryptoquinqueloculine structure of the tests of Miliolidae described above is not always invariable for different species or groups. In some cases this feature pronounced relatively weakly, is obviously unstable and usually related to a later stage of ontogenesis (within the last five chambers). As an example serve numerous representatives of *Quinqueloculina* (group *Q. akneriana* d'Orbigny, *Q. errmanni* Bornemann, *Q. seminulum* (Linné), *Q. boueana* d'Orbigny etc.), and also some *Miliolinella* (*M. reussi* (Bogdanowicz); *M. lamellidens* (Reuss) etc.); within one and the same species with a well pronounced quinqueloculine structure of tests only sporadic cryptoquinqueloculine forms can be traced with three external chambers. It is worth attention that in certain populations of such species as *Quinqueloculina consobrina* (d'Orbigny), *Miliolinella selene* (Karrer) and others, an appreciable increase of a number of cryptoquinqueloculine tests may be observed. However, a decrease of the number of external chambers is present only in adult, well developed specimens whereas the younger (neanic) development stages are characterized mostly by five external chambers.

Especially interesting are the cases of a rather stable cryptoquinqueloculine structure of tests, this feature appearing in early ontogenesis. For instance, *Quinqueloculina angustioris* (Bogdanowicz), *Miliolinella enoplostoma* (Reuss) and others for which typical quinqueloculine tests are not known at all or are a rare exception.

Thus, a „cryptoquinqueloculine" characteristic either does not overstep the limits of intraspecific variability, or is well pronounced in certain species or groups of similar species: it is characterized by stability and acquires at least an importance of a species.

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[1] „Milioline" is derived from genus *Miliolina* Williamson which unites genera *Quinqueloculina* d'Orbigny and *Triloculina* d'Orbigny.

All above said enables to conclude that the present-day concepts on a composition and volume of genera of a quinqueloculine and triloculine structure of tests requires a critical revision. A thourough study of the inner structure of tests of this Miliolidae group is necessary so that we could establish exactly the type of arrangement of chambers and a degree of their involution, which results in a change of a number of external tests. The main task appears to be a revision of a heterogenous group of species with „triloculine" chambers in outward appearance, since this group is least studied and is a cause for many errors in the systematics of Miliolidae.

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РЕЗЮМЕ

Изучение квинквелокулин и трилокулин (Miliolidae) привело автора к выводу, что раковины с тремя наружными камерами могут иметь неодинаковое внутреннее строение. В одном случае раковины эти навиваются в типично трикулиновом порядке и относятся бесспорно к роду *Triloculina* d'Orbigny (фиг. 4), в другом случае им присуще квинквелокулиновое расположение камер и они входят уже в состав рода *Quinqueloculina* d'Orbigny (фиг. 3).

У квинквелокулин с тремя наружными камерами (I, II, III на фиг. 1 C и фиг. 3) последние образуют друг с другом угловые расстояния по 144° между камерами I и II, II и III и около 72° между камерами III и I. Камеры IV и V полностью объемлемы и как бы скрыты тремя наружными, занимают относительно трех наружных камер явно смежное положение и образуют с ними углы в 72°. Этим способом все пять камер последнего цикла навиваются в пяти плоскостях под углами в 72° и соответствуют пяти наружным камерам типичных *Quinqueloculina*. Подобное строение раковин автор предложил в другой работе назвать „криптоквинквелокулиновым" и рассматривать как модификацию истинного квинквело-

кулинового строения милиолид (А. К. Богданович, 1969). В связи с этим автор предлагает дополнить диагноз рода *Quinqueloculina* указанием: „раковина с квинквелокулиновым и криптоквинквелокулиновым строением".

Дальнейшие исследования показали, что криптоквинквелокулиновое навивание камер свойственно и ряду других представителей милиолид, в том числе роду *Miliolinella* Wiesner. Поскольку милиолинеллы с тремя наружными камерами построены по криптоквинквелокулиновому типу, то тесная связь их с родом *Scutuloris* Loeblich et Tappan, обладающим квинквелокулиновым расположением камер, не вызывает сомнения. Поэтому автор предлагает восстановить *Miliolinella* в рамках первоначального описания Визнера (H. Wiesner, 1931) и уточнить диагноз этого рода.