Paleontological Journal, Vol. 38, No. 5, 2004, pp. 469–478. Translated from Paleontologicheskii Zhurnal, No. 5, 2004, pp. 3–11.

On "Paleocene" Nummulites from Mangyshlak

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Received September 30, 2002

Abstract—An assemblage of Lower Eocene nummulitids is established here for the first time from the Sullukapian Formation, which has been referred to the Upper Paleocene. A new species, *Nummulites akorpensis* sp. nov., which was previously identified as *Nummulites fraasi* Harpe, is described. The new species differs from *N. fraasi* by the more uniformly and rapidly untwisting spire and more curved septa. Brief characterization of the associated species *Nummulites panteleevi* Nemkov is given.

Key words: Nummulites, Paleogene, Mangyshlak.

INTRODUCTION

Paleocene nummulites of Mangyshlak were first reported by Barkhatova and Nemkov (1964). They identified *Nummulites fraasi* Harpe and *Discocyclina* ex gr. *D. archiaci* (Schlumb.) from the Sullukapian Formation of the Baisarly (eastern Mangyshlak) and Chakyrgan (central Mangyshlak, southern Aqtau) areas. The same authors provided a full description of *N. fraasi* from the same sections in their monograph (Barkhatova and Nemkov, 1965) on Mangyshlak and the northern Aral region. This description was cited by Il'ina in the paper that mainly dealt with mollusks and echinoids from the Late Paleocene of Mangyshlak (Il'ina and Shmidt, 1969). A specimen of *N. fraasi* from the Baisarly area was also figured in a monograph on the nummulitids of the Soviet Union (Nemkov, 1967).

In two papers dedicated to the nummulites of Georgia and Spain, the Mangyshlak members of *N. fraasi* were included in the synonymy of this species (Mrevlishvili, 1978; Tosquella and Serra-Kiel, 1998). However, the most extensive monograph on the nummulites of the Tethys (Schaub, 1981) made no mention of the Mangyshlak forms of *N. fraasi.*

MATERIAL

The material under study includes larger foraminifers (about 90 tests) from the working collection of G.I. Nemkov (Fig. 1): outcrop 12, specimens nos. 312–328, Baisarly area (collected by E.K. Shutskaya, 1965); specimens from borehole 147, vicinity of Amankizilit; boreholes 137 and 138, eastern Mangyshlak (collected by A.I. Sharapov); specimens from the Ushkuyu ravine and Chakyrgan area (collected by N.N. Barkhatova, 1961). The topotypes of *N. fraasi* (Egypt) from the collection of L. Hottinger, topotypes of *N. panteleevi* from the northern Aral region (collected by A.L. Yanshin, 1938), *N. oppenheimi* from the Spilezzo section in Northern Italy, and *N. panteleevi* from the Crimea (collected by the author, 1984 and 2000) are used for comparison. Collection no. VI-232 is currently housed in the Vernadsky State Geological Museum (VSGM).

The values of structural characters of tests from different localities are listed in tables to provide better characterization of specific variation. The abbreviations of these structural characters are as follows: (*D*), diameter; (*T*), thickness; (*R*) test radius; (*N*) number of whorls; (*Nc*), number of septa (per whorl, from the second whorl onward in megaforms; and per quarter-whorl, from the third whorl onward in microforms); (*Tc*) maximum thickness of the spiral wall; (*h*) height of chambers; (*l*) length of chambers in the last whorl; (*d'*) diameter of the protoconch; and (*d''*) maximum size of the nucleoconch in the equatorial plane.

STRATIGRAPHIC POSITION OF THE SULLUKAPIAN FORMATION

The Sullukapian Formation (Kuznetsova, 1952) is usually assigned to the Thanetian Stage based on either assemblages of mollusks, echinoids, or brachiopods (in shallow sandy facies) or smaller foraminifers (in deeper carbonaceous clayey equivalents) (Bykova, 1975). The Sullukapian Formation is composed of glauconitic quartzy sands and sandstones with phosphatic nodules and oyster beds in the type section in the Sullu-Kapy area and in other sections of central Mangyshlak (Chakypgan area, Chat well, and Ushkuyu ravine), in the Uzen' Depression, and in some sections of the northern Aqtau (Kuma-Kapy area). Its stratigraphic position is mainly determined by the assemblage of the Thanetian oysters *Pycnodonta nomada* (Vial.), *P. sinzovi* (Netsch.), *P. antiqua* (Schwetz.), *Liostrea reussi* Netsch., and others (Il'ina, 1963; Panteleev, 1974; Nai-

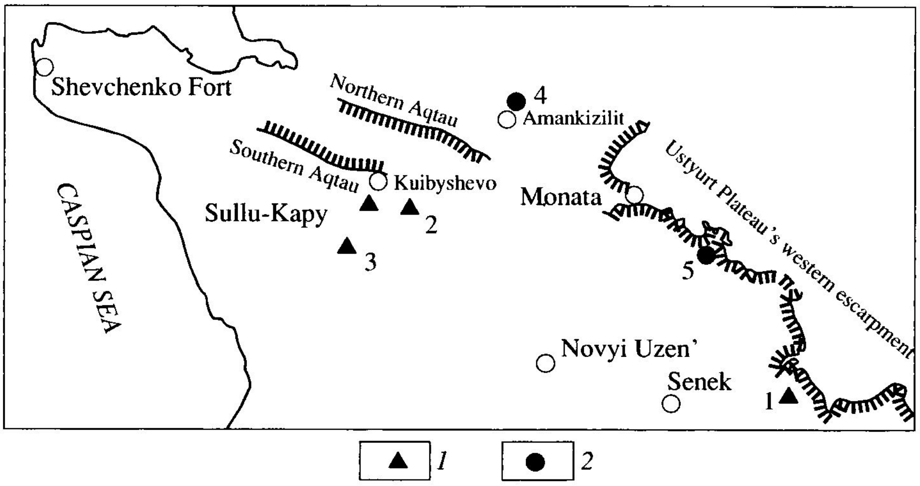


Fig. 1. Sections with *Nummulites akorpensis* sp. nov. in the Paleogene of Mangyshlak. Designations: (*1*) outcrops; (*2*) boreholes; sections of (1) Baisarly area; (2) Chakyrgan area; (3) Ushkuyu ravine; (4) borehole 147; (5) boreholes 137 and 138.

din *et al.*, 1996). The complete type sections of the formation feature poor paleontological characterization of the thicker upper part and its gradual transition to the overlying sands and sandstones of the *Nummulites planulatus* Zone (equivalent of the Gvimrovskaya Formation) of the Lower Eocene. Thus, in the Sullu-Kapy area, Thanetian oysters occur in the lowermost 4-m-thick sand layer, and only rare fragments of macrofauna occur in the upper 25-m-thick part (Liverovskaya, 1960; Naidin *et al.*, 1996). In the Chakyrgan area, the oyster bed composed of *Pycnodonta nomada* shells is overlain by a 20-m-thick member of barren sands (Barkhatova and Nemkov, 1965). It is not surprising, then, that the age of the formation was originally determined by its position in the section. Kuznetsova (1952) assigned the sandy beds that underlie the Danian and overlie the Lower Eocene deposits (the lower nummulitid subformation or equivalents of the Gvimrovskaya Formation) to the Sullukapian Formation. Liverovskaya (1960) already divided the Sullukapian Formation into the lower member with Thanetian oysters and the Upper Paleocene–Lower Eocene member of barren sands. She drew the Paleocene–Eocene boundary in the Sullu-Kapy area through the middle part of the "barren" member along the horizon of sandstone concretions with isolated small nummulites. Later, the Paleocene species *Nummulites fraasi* was defined from a similar sandstone horizon of the Chakyrgan area that lies in the middle part of "barren" sands and from the upper part of the Sullukapian Formation of Baisarly area (Barkhatova and Nemkov, 1964, 1965); thus, the entire formation has been assigned to the Thanetian. The *N. fraasi* Zone belongs to the Upper Thanetian or the Lower Ilerd (northern and southern Mediterranean) and correlates with the *Discoaster multiradiatus* Zone (NP9) according to the current stratigraphic scale. Before the 1960s, the assignment of the upper part of "barren" sands (which is about 10 m thick in the Sullu-Kapy and Chakyrgan areas) to the Paleocene was also substantiated by their position under the sandstones of the *N. planulatus* Zone, at the base of which the lower boundary of the Lower Eocene was then drawn. However, in the 1960s–1970s three new Lower Ypresian zones (Middle and Upper Ilerd) that underlie the *N. planulatus* Zone in the Mediterranean area were distinguished by nummulites and alveolinids. These zones correlate with the *Operculina semiinvoluta* and *Nummulites crimensis* zones of the Bakhchisarai section of the Crimea. In Mangyshlak the stratigraphic interval corresponding to these zones in Mangyshlak must either be located in the uppermost part of the Sullukapian Formation or absent. The first convincing evidence that the uppermost part of the Sullukapian Formation is of Lower Eocene age was provided by Shutskaya (1970). She identified foraminifers of the *Globorotalia aequa* Zone (transitional zone between the Paleocene and Eocene) in the upper part of the formation in the Baisarly area and found the Lower Eocene *Asterigerina bartoniana* Dam in association with smaller nummulites in the overlying beds. Based on these finds the upper part of the Sullukapian Formation was assigned by Shutskaya to the Lower Eocene *Globorotalia subbotinae* Zone. These conclusions went unnoticed, and the Sullukapian Formation was included in the Thanetian in the official Paleogene scale of Mangyshlak. Naidin *et al.* (1996) also showed a broader understanding of the age of this formation, by including part of the Lower Ypresian in the Sullukapian Formation in their figure of the Usak section of western Mangyshlak. Unfortunately, they make no comment in the text to support this position.

The sandy limestone and marly members of the *Acarinina subsphaerica* (P4) and *A. acarinata* (P5) zones, which, as in the shallow-water facies of southern

Aqtau, gradually develop into the Lower Eocene, are usually correlated with the Sullukapian Formation in the deeper water facies of the Paleogene of northern Mangyshlak. In recent papers dealing with the Paleocene–Eocene boundary in the northeastern Tethys (Pardo *et al.*, 1999; Bolle *et al.*, 2000), this boundary was drawn between Subzones P5a and P5b of Zone P5 (*Morozovella velascoensis*). This position of the boundary is based both on biotic (global appearance of the short-existing species *Acarinina sibaiyensis* and *A. africana*, appearance of the foraminifers in the central Tethys) and geochemical, mineralogical, and lithological changes (sharp decrease in isotope ^{13}C, increase in organic carbon, etc.) that occurred at this boundary and suggest that the global climate became warmer and wetter (Upper Paleocene terminal maximum) and beginning of the transgression. A thin clay parting containing fish debris (Subzone P5b) is present in this interval in the section described as a type section of northern Mangyshlak (Kaurta-Kapy area). A small washout is observed at the base of the parting. However, an equally important event (cooling), which is reflected in the sharp expansion of cold-water subbotinids and in the decrease of organic carbon and increase in ^{13}C isotope, occurred at the boundary between Zones P5 (*M. velascoensis*) and P6 (*M. subbotinae*). It seems likely that the authors of these articles have not yet answered the question whether the Paleocene–Eocene boundary should be drawn at the beginning or end of the Paleogene terminal maximum. This boundary is drawn either at the base of Subzone P5b along the base of the clay parting in the Kaurta-Kapy section (Pardo *et al.*, 1999) or along the roof of Subzone P5b in the same section (Bolle *et al.*, 2000). According to the first variant, the lowermost Eocene is included in the Sullukapian Formation, in which Zone P5 is completely contained.

It should be mentioned that, in these and some earlier works, the Sullukapian Formation of northern Mangyshlak is regarded not only as a local lithostratigraphic unit, but also as a horizon that is characterized by smaller foraminifers in more detail and more comprehensively than in the stratotypical area; thus, the range the horizon does not coincide with the range of the Sullukapian Formation. As previously mentioned, the latter includes, in addition to the Thanetian, the lower part of the Ypresian; this is supported by the data on nummulitids given below.

The most diverse nummulitid assemblage is observed in the Baisarly section (Fig. 2). Although the layer of carbonaceous, clayey sands and loose sandstones with smaller nummulites is thin (about 2.5 m, according to E.K. Shutskaya), the species composition of nummulitids varies up the section, thus allowing recognition of three stratigraphic levels based on this group.

The lower part of the bed (sample no. 328) contains *Nummulites panteleevi* Nemk., *N. akkuurdanensis* Nemk., *Discocyclina archiaci bakhchisaraiensis* Less, and *Orbitoclypeus schopeni neumannae* (Toumar.). The first species in the type locality (northern Aral Region, Aq-Kuurdan ravine) is confined to the *Nummulites planulatus* Zone (Barkhatova and Nemkov, 1965) of the Lower Cuisian. In the Crimean sections, which are more complete and more abundant in nummulitids, this species occurs in older deposits of the local *Operculina semiinvoluta* and *Nummulites crimensis* zones of the Bakhchisarai Formation (*Discoaster binodosus* Zone, NP11), which correspond to the Middle Ilered in the Mediterranean stratigraphical scale, up to the formation roof (up to the upper part of the Lower Cuisian). To date the species *N. akkuurdanensis* has only been known from deposits of the *Nummulites planulatus* Zone of the northern Aral Region and Mangyshlak. The subspecies *Discocyclina archiaci bakhchisaraiensis* was originally distinguished in deposits of the *Operculina semiinvoluta* Zone and lower part of the *Nummulites crimensis* Zone of the Crimea, which belong to the Middle Ilered. This subspecies also occurs in some older localities (Pakistan). The subspecies *Orbitoclypeus schopeni neumannae* is only known from the Middle Ilered of France and Italy (Less, 1987).

The middle part of the bed (horizon with *Nummulites akorpensis* sp. nov., samples 322 and 323) is characterized by the presence of *Nummulites panteleevi* Nemk., *N.* aff. *N. bombitus* Hott., and *Orbitoclypeus schopeni suvlukayensis* Less. As previously mentioned, *Nummulites panteleevi* occurs from the Middle Ilered to the roof of the Lower Cuisian. *Nummulites* aff. *N. bombitus* is a transitional (ancestral) form to the Middle Cuisian *N. bombitus*. This form has been reported from the base of the Lower Cuisian in the Pyrenees (Tosquella and Serra-Kiel, 1998). The Mangyshlak forms differ from the Pyrenean ones in the slightly more tightly coiled whorls and smaller diameter of the nucleoconch (Pl. 1, fig. 17), which testify to their older age. In the Crimea the asterocyclinid subspecies *Orbitoclypeus schopeni suvlukayensis* occurs in the upper part of the local *Nummulites crimensis* Zone of the Bakhchisarai Formation, which correlates with the Upper Ilered (Less, 1987).

In the upper part of the bed with smaller nummulites (sample no. 320), they show a sharp decrease in abundance. Also this part is dominated by *Nummulites panteleevi*, but there are also isolated tests of *N. bombitus*. The latter species allows assignment of the host rocks to the very base of the Lower Cuisian. The numbers and diversity of nummulitids sharply increase in the overlying calcareous sandstones and sandy limestones (sample no. 312). They are represented by a typical Lower Cuisian assemblage of forms equivalent to those of the Gvimrovskaya Formation.

Obviously, the bed of the Sullukapian Formation with smaller nummulites in the Baisarly section should be assigned to the lower part of the Lower Ypresian: the

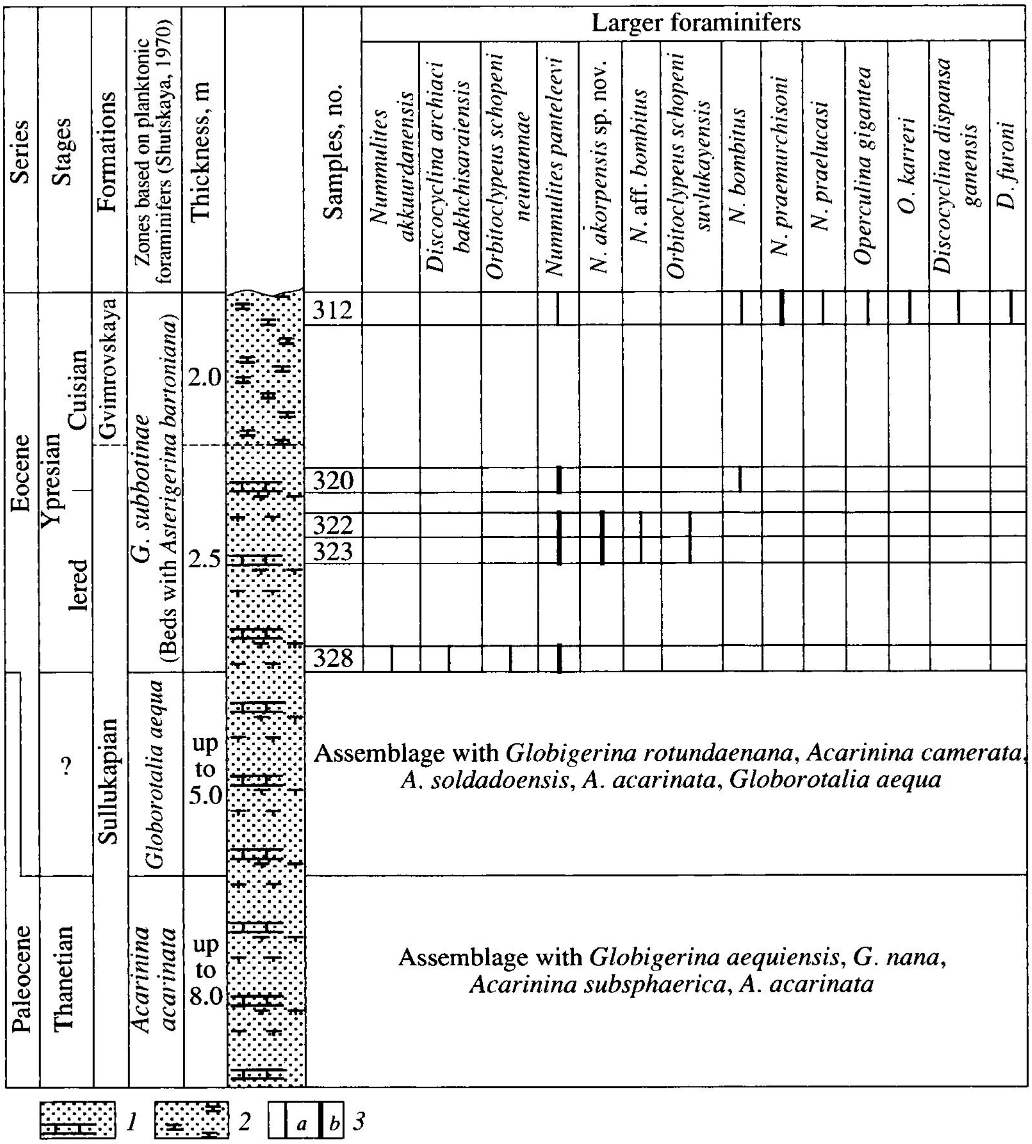


Fig. 2. Distribution of larger foraminifers in the Sullukapian Formation and at the base of the Gvimrovskaya Formation of the Baisarly area. Designations: (*1*) clayey and carbonaceous sands with partings of carbonaceous sandstones and sandy marls; (*2*) carbonaceous sands; (*3*) number of specimens of the species in the sample: (*a*) less than 10, (*b*) more than 10 (lithological characteristics of the section, assemblages, and zones based on planktonic foraminifers are shown after Shutskaya, 1970).

lowermost part of the bed, to the uppermost part of the Middle Ilered; its middle part (horizon with *N. akorpensis* sp. nov.), to the Upper Ilered; and the upper part of the bed, to the base of the Lower Cuisian.

The only sample from the Chakyrgan area that includes nummulitids contains only *N. akorpensis* sp. nov. and unidentifiable *Discocyclina* forms and, thus, may be tentatively assigned to the Upper Ilered. The Paleocene–Eocene boundary in the Sullu-Kapy and Chakyrgan sections should be drawn through the sandstone horizon with smaller nummulites in the middle part of the Sullukapian Formation, as was proposed by Liverovskaya (1960).

Thus, the Sullukapian Formation includes both the Upper Paleocene and lowermost part of the Lower Eocene, near the boundary of which, in the shallow-water facies of the stratotype area and in the transitional facies of eastern Mangyshlak, the carbonate content of sediments increases and larger foraminifers appear. The episode of a wide distribution of benthic foraminifers, which is one of the criteria of the Paleocene–Eocene boundary (Bolle *et al.*, 2000), occurred in the Lower Ilered (*Nummulites fraasi* Zone) in Mediterranean regions of the Tethys (Spain and Egypt) and in the Middle Ilered in the northeastern Paratethys (Crimea, Mangyshlak); thus, it cannot serve here as a criterion for the position of this boundary.

SYSTEMATIC PALEONTOLOGY

Family Nummulitidae de Blainville, 1827

Genus *Nummulites* Lamarck, 1801

***Nummulites akorpensis* Zakrevskaya, sp. nov.**

Plate 1, figs. 1–10

Nummulites fraasi: Barkhatova and Nemkov, 1964, p. 50, pl. in the text, figs. 1–5, 7–11, non fig. 6; 1965, pp. 30–33, text-figs. 9a and 9b, pl. 1, figs. 1–4, 6–9, non fig. 5; Nemkov, 1967, p. 120, pl. 2, figs. 4, 5, 7–9, non fig. 6; Il'ina and Shmidt, 1969, p. 88, pl. 8, figs. 7–13, 15, and 16, non fig. 14.

E t y m o l o g y. From the Akorpa well.

H o l o t y p e. VSGM, no. VI-232/1 (generation B); Eastern Mangyshlak (Kazakhstan), Baisarly area, Akorpa well; Paleogene, Lower Eocene, Sullukapian Formation, Lower Ypresian Substage.

D e s c r i p t i o n (Figs. 3a, 3b).

Megalospherical generation (A) (Fig. 3b; Pl. 1, figs. 2, 4–7, 10).

External characters. The test is very thin, uniformly flattened, and lacking granules and a well-defined septal line. The edge is rounded and slightly pointed.

Internal structure. The coiling is loose and regular, grows uniformly and rapidly, and includes three whorls in the adults. The spiral zone is thin. The septa are curved in the first two whorls and straight and curved only in their upper parts in the last whorl. The chambers are crescent-shaped, high, and almost rectangular in the last whorl. The chambers in the last whorl are two to three times as high as long. The number of septa in the first, second, and third whorls is 8, 14–19, and 19–26, respectively. The test is completely involute in the first two whorls and semi-involute in the last whorl. The nucleoconch is of *Isolepidina*-like type.

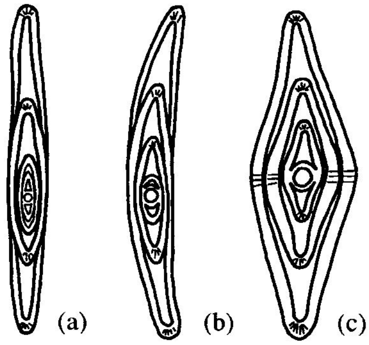


Fig. 3. Axial sections of *Nummulites akorpensis* sp. nov.: (a) microspherical generation, specimen VSGM, no. VI-232/23, ×10; (b) megalospherical generation, specimen VSGM, no. VI-232/20, ×20; (c) axial section of *N. panteleevi* Nemkov, megalospherical generation, specimen VSGM, no. VI-232/21, ×20. Baisarly area; Sullukapian Formation, Lower Ypresian Substage.

M e a s u r e m e n t s, mm. Test diameter, 1.8–3.0; thickness, 0.2–0.35; three whorls correspond to a radius of 1.0–1.5; protoconch diameter, 0.07–0.1; nucleoconch size, 0.1–0.17; and spiral zone thickness, 0.025–0.05.

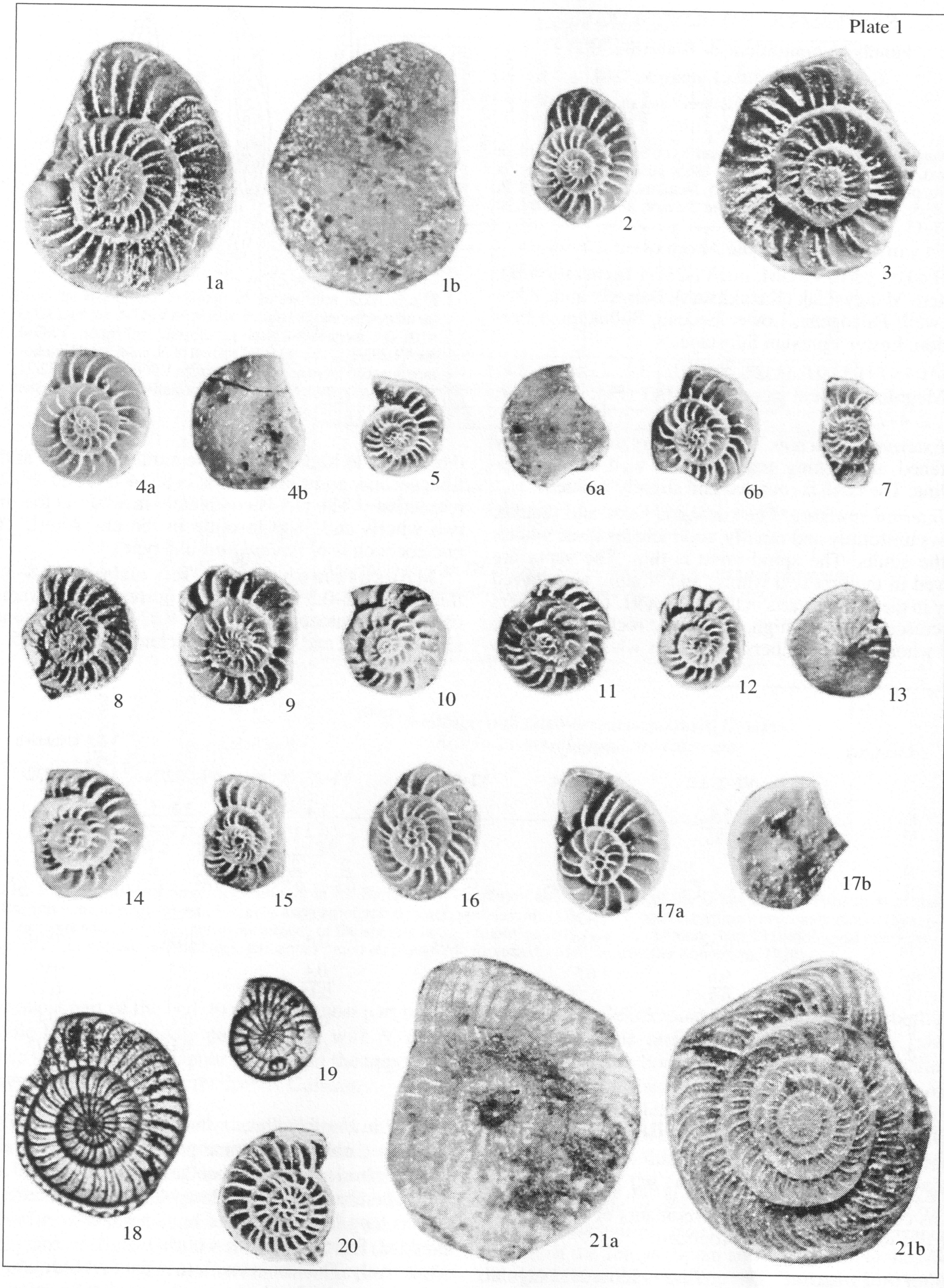
Character	Locality					
		Baisarly		Borehole no.		Ushkuyu
	VI–232/2	VI–232/4	VI–232/6a	VI–232/8	VI–232/11	VI–232/7
D/T	2.5/0.35	2.5/0.3	2.1/0.3	1.4/0.2	2.2/0.3	2.0/0.3
N/R	2/0.75 3/1.5	2/0.75 3/1.35	2/0.65 3/1.1	2/0.5 2.5/0.75	2/0.65 3/1.2	2/0.65 3/1.1
Nc	19.26	15.20	15.20	14.20	15.20	17.25
Tc	0.05	0.05	0.04	0.025	0.04	0.04
h/l	0.6/0.2	0.5/0.25	0.4/0.2	0.4/0.15	0.5/0.25	0.5/0.17
d'	0.1	0.1	0.075	0.075	0.1	0.1
d"	0.17	0.15	0.12	0.11	0.15	0.15

Microspherical generation (B) (Fig. 3a; Pl. 1, figs. 1, 3, 8, 9)

External characters. The test is flat, slightly inflated in its center, sometimes with remnants of the septa in the last whorl. The edge is rounded.

Internal structure. The coiling is loose and regular and grows uniformly and rapidly from the second or third whorl onward. The septa are curved and slightly inclined in the first three whorls. The septa are direct and curved only in the upper part of the spiral canal in the last whorls. The chambers are crescent-shaped and high. The chambers in the last whorl is 3–3.5 times as high as long. The number of septa per quarter-whorl in the third, fourth, and fifth whorls is 5, 6–7, and 8–10, respectively. The test is involute in the first four whorls, and the last whorl only covers the marginal cord of the previous whorl.

Plate 1


1a
1b
2
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4a
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7
8
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12
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16
17a
17b
18
19
20
21a
21b

Measurements, mm. Test diameter, 2.5–4.5; test thickness, 0.4–0.5; three, four, and five whorls correspond to radii of 0.5–0.6, 1.0–1.5, and 1.7–2.4, respectively; and spiral zone thickness, 0.08–0.12.

Character	Locality			
	Baisarly		Boreholes 137 and 138	
	VI–232/1 holotype	VI–232/3	VI–232/10	VI–232/9
D/T	4.5/0.5	4.0/0.5	2.5/0.5	2.4/0.5
N/R	3/0.6, 4/1.4, 5/2.4	3/0.6, 4/1.5, 5/2.25	3/0.45, 4/1.0, 5/1.7	3/0.5, 4/1.0, 5/1.7
Nc	5, 7, 10	5, 7, 9	5, 6, 8	6, 6, 9
Tc	0.12	0.12	0.1	0.09
h/l	1.25/0.4	0.9/0.25	0.7/0.25	0.65/0.2

Variations. During growth the step of spire, the thickness of the spiral wall, and the height of chambers increase slightly, and the septa become flatter. The form and frequency of septa and the shape and height of the chambers in the last whorl of this species display the widest variation. So, two morphotypes may be distinguished by these features in the samples from the Baisarly area: the former has flat septa and rectangular chambers (Pl. 1, figs. 1, 2) and the latter has septa that are more inclined and curved (Pl. 1, figs. 3, 4). The latter morphotype is more similar to *Nummulites panteleevi.* The spire is more tightly coiled in the forms from boreholes 147, 137, and 138, which belong to a higher stratigraphic level (Lower Cuisian). The size of protoconch and the shape of nucleoconch show the smallest variations. The thinner test walls and general test flattening, which is due to the semi-involute last whorl, are observed in the forms from the Chakyrgan area. These variations may be explained by the fact that the Chakyrgan forms come from a different environment, thus being allocated to another ecophenotype. Study of fossil nummulitids has shown that flattening and thinning of the test is in direct proportion to the depth of the basin (Nemkov, 1962). Research on modern nummulitid species has generally confirmed this conclusion (Reiss and Hottinger, 1984). This is not the case for the nummulitids under study; in contrast, tests from terrigenous rocks of the Chakyrgan area (which are very low in carbonate and apparently formed in shallower water) are thinner than tests from clayey carbonaceous sandy rocks of the Baisarly area (which obviously formed in deeper waters). Probably, the thinning of tests and their walls is connected with an increased water turbidity, which resulted from the transportation of fine sandy suspended material (with a grain diameter of 0.1–0.3 mm) along the basin bottom under conditions of increased hydrodynamics of the aquatic environment and from a decrease in salinity.

Explanation of Plate 1

For all specimens, ×10.

Figs. 1–10. *Nummulites akorpensis* sp. nov. (1, 3, 8, and 9 microspherical generation; 2, 4–7, and 10 megalospherical generation). (1) holotype, no. VI-232/1 (field no. 323): (1a) equatorial section, (1b) surface; (2) specimen, no. VI-232/2 (field no. 323), equatorial section; (3) specimen, no. VI-232/3 (field no. 322), equatorial section; (4) specimen, no. VI-232/4 (field no. 323): (4a) equatorial section, (4b) surface; (5) specimen, no. VI-232/5 (field no. 322), equatorial section; (6) specimen, no. VI-232/6 (field no. 322): (6a) surface, (6b) equatorial section; (7) specimen, no. VI-232/7, equatorial section; (8) specimen, no. VI-232/9 (field no. 137/105), equatorial section; (9) specimen, no. VI-232/10 (field no. 138/101), equatorial section; (10) specimen, no. VI-232/11 (field no. 138/101), equatorial section. (1)–(6) Eastern Mangyshlak, Baisarly area, Akorpa well; (7) Central Mangyshlak, Ushkuyu ravine; (8)–(10) Eastern Mangyshlak: (8) borehole no. 137; (9) and (10) borehole no. 138.

Figs. 11–16. *Nummulites panteleevi* Nemkov, megalospherical generation: (11) specimen, no. VI-232/12 (field no. 322), equatorial section; (12) specimen, no. VI-232/13 (field no. 322), surface; (13) specimen, no. VI-232/14 (field no. 323), equatorial section; (14) specimen, no. VI-232/15 (field no. 322), equatorial section; (15) specimen, no. VI-232/16 (field no. 323), equatorial section; (16) specimen, no. VI-232/17 (field no. 322), equatorial section. Eastern Mangyshlak, Baisarly area, Akorpa well.

Fig. 17. *Nummulites* aff. *N. bombitus* Hottinger, specimen, no. VI-232/18 (field no. 322), megalospherical generation: (17a) equatorial section, (17b) surface. Eastern Mangyshlak, Baisarly area, Akorpa well.

Figs. 18–21. *Nummulites fraasi* Harpe; (18) and (21) microspherical generation and (19) and (20) megalospherical generation: (18) specimen, no. VI-232/25; (19) specimen, no. VI-232/26, equatorial section; (20) specimen, no. C28677/1 (Natural History Museum, Basel), equatorial section (from Schaub, 1981, Pl. 1, fig. 70a); (21) neotype, no. C7750/1 (Natural History Museum, Basel): (21a) surface, (21b) equatorial section (from Schaub, 1981, Pl. 1, fig. 59). Egypt, Farafra Oasis.

C o m p a r i s o n. The species *Nummulites akorpensis* sp. nov. resembles *N. fraasi* Harpe, *N. panteleevi* Nemk., and *N. oppenheimi* Rozlozsnik.

This species differs from *N. fraasi* by the more uniformly and rapidly untwisting spire (particularly in form B), more curved septa, and the absence of a tubercle and umbo at the test center. These differences are well shown in the photograph (Pl. 1, fig. 21) of the neotype of *N. fraasi* (after Schaub, 1981). However, some forms of *N. fraasi* (Pl. 1, fig. 18) from the type locality in Egypt are virtually identical in the spire shape to *N. akorpensis*. The new species differs from *N. panteleevi* by the flatter septa, smaller dimensions of the nucleoconch, and absence of a tubercle and remnants of septa. *N. akorpensis* is similar to the Middle Ilered species *N. oppenheimi* in the high, narrow chambers and small nucleoconch. However, the latter species generally has a more tightly coiled spire, inflated test and, in our opinion, should be assigned to the *N. praelucasi* group.

R e m a r k s. The position of the species in question in the nummulitid phylogenetic scheme remains uncertain. Having defined it as *N. fraasi*, Barkhatova and Nemkov (1965) placed this species in the *N. murchisoni* group (*N. irregularis* in more recent schemes). Later, it was shown (Schaub, 1981) that the phylogenetic lineage of *N. fraasi* has an evolutionary trend towards a decrease in the spire step and a rapid increase in nucleoconch size. At the Upper Ilered stratigraphic level, the species of the *N. fraasi*–*N. planulatus* line have a considerably larger test and nucleoconch and more tightly coiled spire in the first whorls (*N. involutus* Schaub). At the same time, the species of the *N. irregularis* group are also represented by larger forms of two phylogenetic lineages: *N. spirectypus* (*N. spirectypus* Donc., Middle Ilered–*N. bombitus* Hott., Lower Cuisian) and *N. irregularis* (*N. panteleevi* Nemk., Middle Ilered–Lower Cuisian–*N. praemurchisoni* Nemk. et Barkh., Lower Cuisian–*N. irregularis* Desh., Middle Cuisian) at this stratigraphical level. Thus, the species has no place in this phylogenetic lineage, and its descendants are unknown. Probably, it belongs to the mixed group of the "operculinoid" nummulites, being an intermediate form between *N. panteleevi* and *N.* aff. *N. bombitus*. This is supported by the presence of morphotypes with septa that are curved like those in *N. panteleevi*, and straighter like those in *N.* aff. *N. bombitus*.

O c c u r r e n c e. Upper part of the Sullukapian Formation, eastern and central Mangyshlak; lower part of the equivalent of the Gvimrovskaya Formation, northern and eastern Mangyshlak (boreholes 147, 138, and 137) and southern part of central Mangyshlak (Ushkuyu ravine). Lowermost part of the Lower Ypresian (lowermost part of the *Marthasterites tribrachiatus* Zone) in the global stratigraphic scale; Upper Ilered–lowermost part of the Lower Cuisian in the Mediterranean stratigraphical scale.

M a t e r i a l. About 30 tests of moderate and good preservation.

***Nummulites panteleevi* Nemkov, 1965**

Plate 1, figs. 11–16

Nummulites panteleevi: Barkhatova and Nemkov, 1965, p. 34, pl. 1, figs. 10–16 (A and B); Nemkov, 1967, p. 121, pl. 2, figs. 11–15 (A and B); Barkhatova and Razmyslova, 1974, pp. 53–54, pl. 1, fig. 1 (A); Barkhatova *et al.*, 1980, p. 127, pl. 2, figs. 1–2 (A).

Nummulites fraasi: Barkhatova and Nemkov, 1964, pl. in the text, fig. 6 (A); 1965, pl. 1, fig. 5 (A); Nemkov, 1967, pl. 2, fig. 6 (A);'Il'ina and Shmidt, 1969, pl. 8, fig. 14 (A).

H o l o t y p e. VSGM, no. VI-129/6; northern Aral region (Kazakhstan), Aq-Kuurdan ravine; strata of quartz glauconitic sands, Lower Eocene, *Nummulites planulatus* Zone.

D e s c r i p t i o n (Fig. 3c). Microspherical forms have not been found in the Baisarly section.

Megalospherical generation (A) (Fig. 3c; Pl. 1, figs. 11–16).

The test is small, flattened or lens-shaped, with radial and slightly curved septal lines. The spire is loose, regular or irregular. The septa are closely spaced and curved. The chambers are high and crescent-shaped. The height of chambers in the last whorl is twice or three times as large as their length. The number of septa in the first, second, and third whorls is 7–8, 17–20, and 23–26, respectively. The test is completely involute or semi-involute in the last whorl. The nucleoconch is small and of the *Isolepidina*-like type.

M e a s u r e m e n t s, in mm. Test diameter, 2.0–2.5; thickness, 0.5–1.0; two and three whorls correspond to a radius of 0.75–1.2 and 1.2–1.6, respectively; spiral zone thickness, 0.05–0.1; protoconch diameter, 0.1–0.15; and maximum size of the nucleoconch, 0.20–0.25.

V a r i a t i o n s. Age variations include an increase in the chamber height during the middle stage (second whorl) and a decrease in the last (third) whorl. The rate of coiling varies in the populations from the Middle–Upper Ilered of Baisarly area, which are represented by megaforms alone (samples 328, 323, and 322). At a higher stratigraphic level (Lower Cuisian, samples 320 and 312), the spire becomes irregular, the septa become more widely spaced, the thickness of the spiral wall increases, and flat tests appear in addition to the lens-shaped tests. Comparison with the topotypical forms from the Lower Cuisian of the Aq-Kuurdan ravine (northern Aral region) has shown that the last whorls usually have an irregular spire, often flattened tests, and flatter septa. Similar phylogenetic variations have been observed in the Crimea: isolated specimens of *Nummulites panteleevi* of the Ilered level have only lens-shaped tests and are similar to the forms from the Baisarly area, Lower Cuisian forms are more flattened and pass through all stages of the transformation into *N. praemurchisoni*. The forms of *Nummulites panteleevi* from the Suzakskie Beds of the Tajik Depression (Barkhatova *et al.*, 1980) are indistinguishable morphologically from the types, but their measurements, including the sizes of the test and nucleoconch and the spire step, are reduced to half, which is characteristic of other nummulites from this area and is presumably linked to specific features of the paleoenvironment.

C o m p a r i s o n. *N. panteleevi* is similar to *N. praemurchisoni*, *N. fraasi*, and *N. akorpensis*. It differs from *N. praemurchisoni* by the smaller size of the test and nucleoconch, smaller test height, and more regular spire. It differs from *N. fraasi* by the more inclined and curved septa and the looser and more uniformly coiling spire; from *N. akorpensis*, it differs by the curved septa and larger size of the nucleoconch. In addition, the Ilered forms of *N. panteleevi* differ from *N. akorpensis* by the more involute and convex test (Fig. 3c); and the Cuisian forms, by the more irregular spire.

R e m a r k s. The forms from the Paleocene of the Tajik Depression (Ashurov and Nemkov, 1978) have not been included in the synonymy because of the lack of good illustrations and unclear generic status. Except for this work, all previous descriptions of the *N. panteleevi* from different regions of the eastern Paratethys (from the Crimea to Tajikistan) defined its stratigraphical range as the Lower Eocene or the *N. planulatus* Zone. In the current stratigraphical scale, this zone corresponds either to the upper part of the Lower Ypresian or to the Lower Cuisian. *N. panteleevi* is the immediate ancestor of the Lower Cuisian *N. praemurchisoni*. This was supported by Barkhatova and Nemkov (1965) on the basis of morphological characteristics of these species. In this case their stratigraphic positions, as well as the positions of the other two assumed descendants of *N. panteleevi*, i.e., *N. bolcensis* Munier-Chalmas and *N. spileccensis* Munier-Chalmas, are absolutely identical in the Caspian area: they belong to the Lower Cuisian. Since the latter species are confined in Italy to the Middle Ilered, Blondeau (1972) was forced to assign without proof the *N. panteleevi* biozone to the Lower Ilered or the Upper Thanetian, and Schaub (1981) did not include this species in the phylogenetic tree probably because of its unclear status. The finds of *N. panteleevi* in the lower part of the Lower Ypresian (or in the Middle and Upper Ilered) of eastern Mangyshlak and the Crimea verify its biozone and the phylogeny of the *N. irregularis* group. According to Schaub (1981) all the species of "operculinoid nummulites" with a loose spire share a common Lower Ilered ancestor, *N. pontis* Schaub, which was originally assigned by him to *N.* aff. *N. fraasi* (Kapellos and Schaub, 1973), and species of two phylogenetic lineages, *N. spirectypus* and *N. irregularis*, began to diverge from the Early Cuisian onward. The considerable differences between the Lower Cuisian operculinoid nummulites indicate that they most likely separated in Middle Ilered time. It is not inconceivable that species of the *N. irregularis* line are phylogenetically related to *N. fraasi* through *N. panteleevi* and not with *N. pontis*. This fact is confirmed by the presence of forms that are very similar to *N. panteleevi* among various morphotypes of *N. fraasi* (Schaub, 1981, pl. I, fig. 71).

O c c u r r e n c e. Upper part of the Lower Ypresian; northern Aral region, northern Caspian region and the Tajik Depression. Lower Ypresian; Mangyshlak and Crimea.

M a t e r i a l. About 40 tests in good condition.

CONCLUSION

The revision of nummulitids from the Baisarly area of eastern Mangyshlak resulted in the discovery of a Middle–Upper Ilered assemblage including nummulitids (*N. panteleevi*, *N. akkuurdanensis*, and *N.* aff. *N. bombitus*) and orthofragminid (*Discocyclina archiaci bakhchisaraiensis*, *Orbitoclypeus schopeni neumannae*, and *O. schopeni suvlukayensis*) species that have not been known in this section and a new species, *N. akorpensis*. The members of the morphotype with a flattened test, loose operculinoid spire, and high chambers clearly dominate the nummulitids. The low diversity and thin, small tests of nummulites and orthofragminids indicate that they lived under comparatively cold-water conditions at the beginning of the Ypresian in this area. The warming and, probably, shallowing of the basin are readily apparent from the increase in the taxonomic diversity and test size in larger foraminifers during the middle Lower Ypresian (beginning of the Cuisian). Lithological variations consisted of an increase in the carbonate and sand contents of the rocks.

ACKNOWLEDGMENTS

The author is grateful to L. Hottinger for providing specimens and to A.S. Nemkova, thanks to whom the entire collection of G.I. Nemkov has been preserved.

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