

# The Campanian–Maastrichtian Stage Boundary in the Aktulagai Section (North Caspian Depression)

D. P. Naidin<sup>a</sup> and V. N. Beniamovski<sup>b</sup>

<sup>a</sup> Moscow State University, Leninskie Gory, Moscow, Russia

<sup>b</sup> Geological Institute, Russian Academy of Sciences, Pyzhevskii per. 7, Moscow, 119017 Russia

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**Abstract**—Distribution of belemnites and benthic foraminifers in the Campanian–Maastrichtian boundary layers of the Aktulagai section, one of Upper Cretaceous reference sections in the east of the European paleobiogeographic region (EPR) is discussed. The base of *Lanceolata* Beds defined by A.D. Arkhangelsky in 1912 is well-substantiated biostratigraphic level corresponding to boundary between the Campanian and Maastrichtian stages. In spacious outcrops of Upper Cretaceous deposits in the Aktulagai Plateau (Aktyubinsk region, Kazakhstan Republic), “primitive *Belemnella* forms” (two rostra plates) appearing above that base distinctly replace the genus *Belemnitella* dominant in the Campanian.<sup>1</sup> Seven successive zonal assemblages of benthic foraminifers (one plate) are established in the boundary interval. The Aktulagai reference section of Upper Cretaceous sediments can be used to trace the Campanian–Maastrichtian boundary from the eastern EPR to Boreal regions of Russia based on abundant micro- and nanofossils.

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## INTRODUCTION

For several reasons, problems of Upper Cretaceous stratigraphy in different regions of the world (e.g., position of boundary between Campanian and Maastrichtian stages) attract attention of researchers in different aspects.

Our conceptual standpoint on boundaries between stages in the upper series of the Cretaceous System (Kopaevich et al., 1987; Naidin, 1996, 1998; 2002b) is as follows:

(1) Boundaries between stages reflecting empirical conclusions of many generations of geologists are to variable extent substantiated in terms of historical geology;

(2) Biostratigraphic criteria are principal ones for establishing the stage boundaries;

(3) Tracing of stage boundaries over the globe should result from successive interregional correlation. Stage boundaries in the reference (type) sections of different paleobiogeographic regions should be correlated with their standards in stratotype sections using all the correlation methods available;

(4) The stage boundaries are subjects of **agreement** between stratigraphers from different countries.

The base of the *Lanceolata* Beds (the Chalk) defined by A.D. Arkhangelsky in 1912 is accepted to be the boundary between Campanian and Maastrichtian stages, which is well substantiated in terms of biostratigraphy (Naidin, 1974, 1996; 2002b).

(5) The Aktulagai section in the east of the European paleobiogeographic region (EPR) is the reference one for boundary layers of the Upper Cretaceous terminal stages in the region. In this well exposed region, the lower boundary of the *Lanceolata* Chalk marks disappearance of the genus *Belemnitella* and appearance of abundant *Belemnella* forms.

(6) It is necessary to remember that at the Brussels meeting of 1995 devoted to stage boundaries of the Cretaceous System, Russian stratigraphers proposed the Aktulagai section for a candidate of the Campanian–Maastrichtian boundary stratotype, since it is perfectly exposed, contains diverse well-preserved macro- and microfossils, and may bridge the Tethyan and Boreal realms, being located in the northern periphery of the former.

(7) Owing to its geographic position in the eastern part of the EPR, the Aktulagai section is of significance for tracing the Campanian–Maastrichtian boundary to spacious Boreal regions of Russia. It is not a simple task, however, to extrapolate potential of this reference (standard) section to other region (Naidin, 1996). The main difficulty is proper selection of widespread fossil

<sup>1</sup> A.D. Arkhangelsky, who defined *Lanceolata* Beds in 1912 and subsequently, in 1926, referred them the Maastrichtian Stage, did not include “primitive *Belemnella* forms” unknown at that time into the beds.

groups having correlation potential independent of paleoclimatic and paleobiogeographic barriers.

(8) Intense drilling and geophysical works aimed at the study of deep structure of the Ural–Emba oil-bearing province required a high-resolution biostratigraphy of Upper Cretaceous formations principal ones in sedimentary succession of the region.

Fursenko (1937), Morozova (1939), Vasilenko and Myatlyuk (1947) who were first to study micropaleontology and stratigraphic distribution of foraminiferal assemblages in borehole sections recovered by drilling through Upper Cretaceous sediments of the region correlated their data with observations of natural exposures in the region, the Aktulagai section included, where distribution of macrofossils can be substantiated.

### SECTION DESCRIPTION

The section is located in the eastern part of the North Caspian Lowland, where the Upper Cretaceous sediments are exposed in the scarp of the Aktulagai Plateau armored by lower Eocene rocks.<sup>2</sup>

In the southwestern part of the Aktyubinsk region (350–370 km south-southwest of Aktyubinsk) near its boundary with the Gur'ev region of Kazakhstan, the plateau extends for tens kilometers approximately along the meridian 55° E southward of latitude 48° N. The plateau is located on the right side of the Emba River and, consequently, outcrops of the plateau characterize the Upper Cretaceous sedimentary succession in the extreme southeast of Europe (*Stratigraphy of the USSR...*, 1986, Fig. 16).

The integral succession (Fig. 1) is compiled based on materials of fieldworks carried out in 1995, 1978, and 1988 in the southwestern part of the plateau, 100–120 km to the south of the Sagiz railway station and the Gur'ev (Aterau)–Aktyubinsk (Aktyube) highway.

The Aktulagai section s. l. represents a giant practically continuous exposure (Fig. 2) tens kilometers long. We consider below a single section along the Chilisai Ravine crossing the Aktulagai Plateau, where the following members are exposed at the scarp base:

(1) Upper Albian and Cenomanian sands and sandstones; the apparent thickness is 15–20 m.

(2) Lower Santonian sandy marls with scattered pebbles of brown phosphorites; rostra of belemnites *Gonio-camax lundgreni uilicus* (Kolt.) Naid., *Actinocamax verus fragilis* Arkh., shells of bivalves *Inoceramus* ex gr. *cardisoides* Goldf., and carapaces of echinoderms *Micraster rogalae* Now. are found in the rocks (thickness 1.5 m).

(3) Upper Campanian clayey marls, greenish gray with fragments of large inoceramid shells; thickness is 4.5–5.0 m.

<sup>2</sup> Site 52 in the isopach map of the Campanian and Maastrichtian sediments of the Ural–Emba salt-dome region (Koltypin, 1957, p. 32). Several photos of scarp areas (Koltypin, 1957, figs. 28–31, 35, 36) illustrate perfectly exposed Upper Cretaceous sections of the region.

Higher in the section, there is a succession (beds 4–9) of rhythmical upper Campanian–Maastrichtian marls (Fig. 1).

Rhythms of this carbonate succession (80–90 m thick) are composed of multiply repeated paired units: the lower sandy or clayey greenish gray to gray marls and the upper more compact light gray to almost white chalky marls (limestone, chalk). The marl-to-chalky marl transition is gradual, while the boundary between pairs is sharp, corresponding to hardground at the top of chalky marls. Beds of more compact chalky marls form cornices traceable for many kilometers along slope outcrops (Fig. 2). Some cornices correspond to small structural terraces.

Special structural observations of the rhythmical pairs have not been carried out, although it is noted that marls prevail substantially over chalky marls in beds 5 and 7 (0.8–1.0 m versus 0.1–0.2 m and 0.4–0.5 versus 0.1–0.2 m, respectively).

According to Koltypin (1957), rhythmical pairs in Campanian and Maastrichtian sections of the Caspian region are formed by greenish gray sandy or clayey marl and white chalk of approximately equal thickness in each pair.

As is shown (Naidin, 2004), changeable structure of pairs in the rhythmical Upper Cretaceous succession of the EPR reflects paleogeographic evolution of sedimentation basin. The rhythmical Campanian and Maastrichtian sediments perfectly exposed in the Caspian region represent suitable object to study structural changes in individual pairs and their successions through sections, i.e., through the geological time.

#### Upper Campanian

(4) Greenish gray marls and light gray to almost white chalky marls; thickness is 18–19 m.

(5) Gray marls and light gray to almost white chalky marls; a structural terrace is formed over the top of the upper chalky marl bed. The thickness is 5.0–5.5 m.

(6) Grayish white marls with well-developed fucoids; the upper part of the member is represented by a prominent bed of hard chalky marl. The thickness is 2–3 m.

#### Lower Maastrichtian

(7) Greenish gray marls (0.4–0.5 m) and more compact thick-platy grayish white chalky marls (0.1–0.2 m); thickness is 6.0–8.5 m.

(8) Greenish gray clayey marls and compact grayish white chalky marls forming a scarp at the slope; thickness is 19–20 m.

(9) Grayish white marls with yellowish tint, sandy, uniformly compact (in distinction from underlying member) and locally forming steep walls with reticular weathering pattern; thickness is 20–22 m.

#### Upper Maastrichtian

(10) Grayish white soft chalk crossed at the top by neptunian dikes of overlying marls; thickness is 17–20 m.

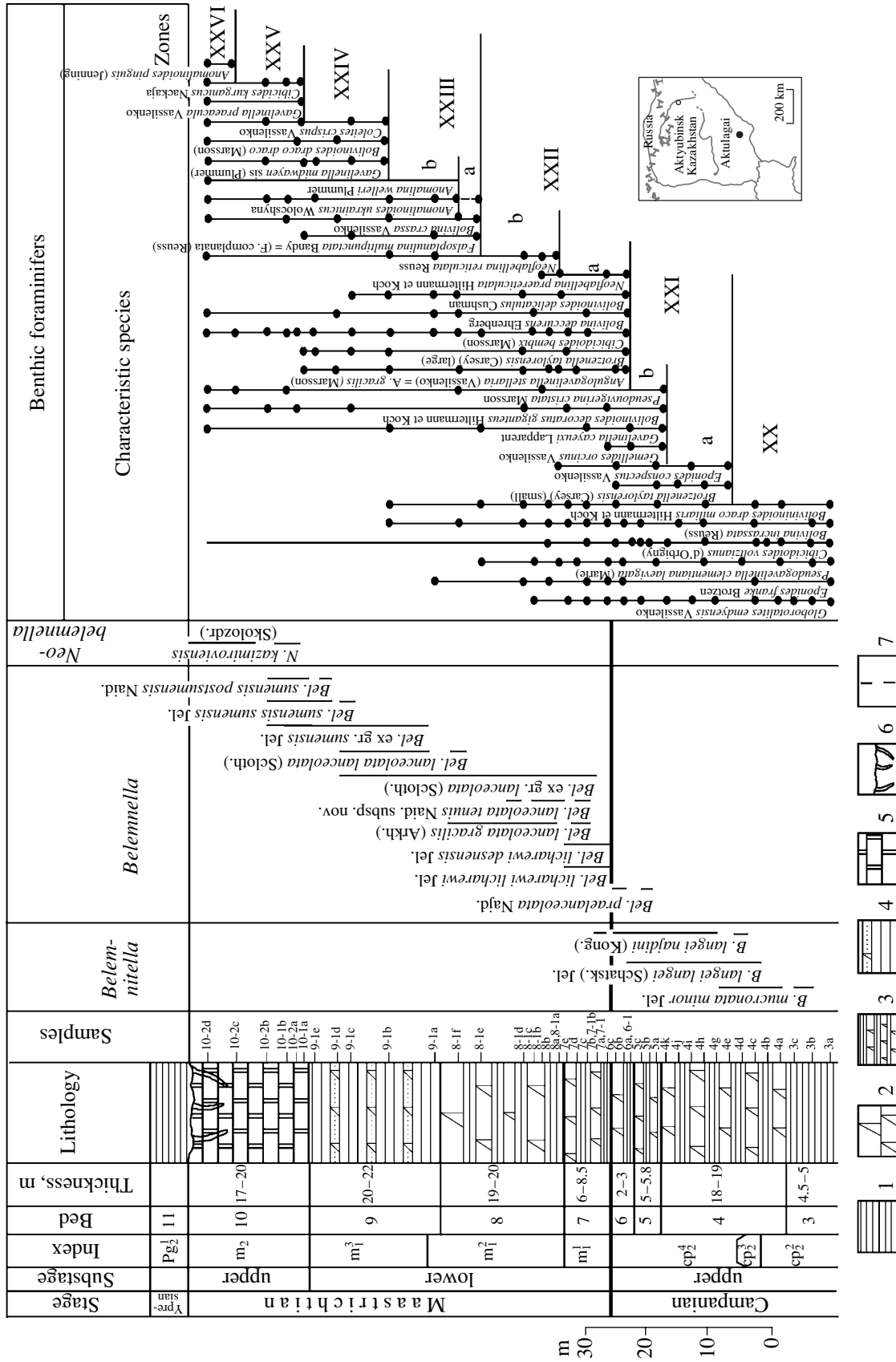


Fig. 1. Distribution of belemnites and foraminifers through the Campanian–Maastrichtian boundary interval in the Aktulagai section (indices are after Naidin et al., 1984, Table 1; brief lithological characteristic is given in the text; lines below names of belemnite species show their stratigraphic ranges: (1) unspecified and (2) chalky marls; (3) alternating marls and chalky marls; (4) sandy marls (Bed 9); (5) neptunian dikes; (6) single belemnite rostra.



**Fig. 2.** Differentiated relief of the Aktulagai Plateau southwestern margin (Chilisai Ravine), western view with the North Caspian depression at background; gentle bend after almost vertical slope visible in the photo lower part corresponds to terrace at the top surface of Bed 5; 2 m above the bend, there is interface of beds 6 and 7 corresponding to Campanian–Maastrichtian boundary.

(11) Lower Eocene: grayish white marls with yellowish tint and interbeds of grayish brown clays; thickness is 5–10 m.

The Cretaceous upper boundary at the top of Bed 10 corresponds to a typical hardground (Gekker, 1960). Stratigraphic hiatus associated with the hardground comprises in the Aktulagai section an upper part of the Maastrichtian *Neobelemnella kazimiroviensis* Zone together with the Paleocene and lower Eocene.

Carbonate sediments of the Aktulagai section are bioturbated. Fucoids (in particular, abundant *Chondrites*) are characteristic of the lower interval in rhythmical pairs. Macrofossils abundant in some intervals of the section are represented by unidentified echinoderms, corals, brachiopods, and bivalves (oysters, inoceramids, pectinids, and others). In addition to belemnite rostra, cephalopods are represented by rare nautiloid casts and by scarce ammonoid casts and impressions classed with baculites and scaphites *Haploscaphites* ex gr. *constrictus* (Sow.) and *Acanthoscaphites* ex gr. *tridens* (Kner).

As is shown in some publications of last decades (Naidin, 1974, 1996; Akimets et al., 1983; Naidin et al., 1984; Kopaevich et al., 1987), the Campanian–Maastrichtian boundary in the EPR sections should be placed at the base of the *Lanceolata* Chalk defined by Arkhangel'sky (1912).

In this understanding, the boundary is very distinct in lithologically different sections of the spacious East European platform from the Atlantic coast on the west to the Sea of Aral on the east. In many sections, abun-

dant *Belemnitella* rostra are suddenly replaced above this boundary by numerous *Belemnella* forms.

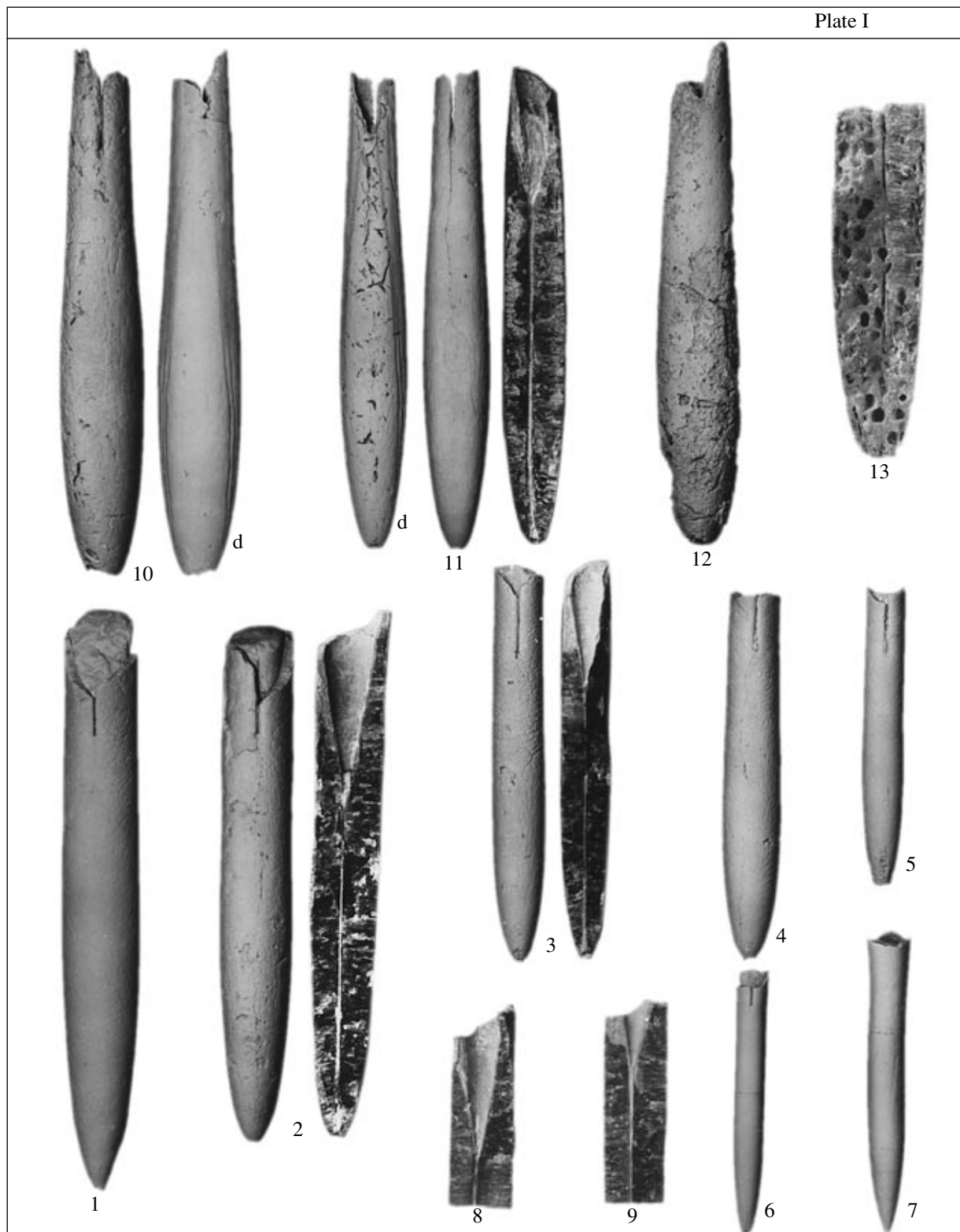
#### BELEMNITES FROM THE CAMPANIAN–MAASTRICHTIAN BOUNDARY LAYERS

First researchers of geology in the Caspian region noted that belemnite rostra are particularly abundant among Upper Cretaceous macrofossils. Species *Belemnitella mucronata* and *Belemnitella lanceolata* are most characteristic here of the lower and upper Senonian, respectively.

The progressing studies of the region called for a higher biostratigraphic resolution. Koltypin accomplished the first (and the only) monographic study of Upper Cretaceous belemnites in the Caspian region soon after the World War II. Using the specially elaborated method, he studied the internal structure of rostra (the first visible rostrum, alveolus plate) and defined 10 new species and *embiensis*, *temirensis*, *tulagensis*, and other subspecies. Their descriptions and images are available only in the unpublished VNIGRI report of 1949.

The aforementioned specific features of the Campanian–Maastrichtian boundary layers are particularly well manifested in the Aktulagai section. The section subdivision based on belemnites and benthic foraminifers has been proposed by Akimets et al. (1983).

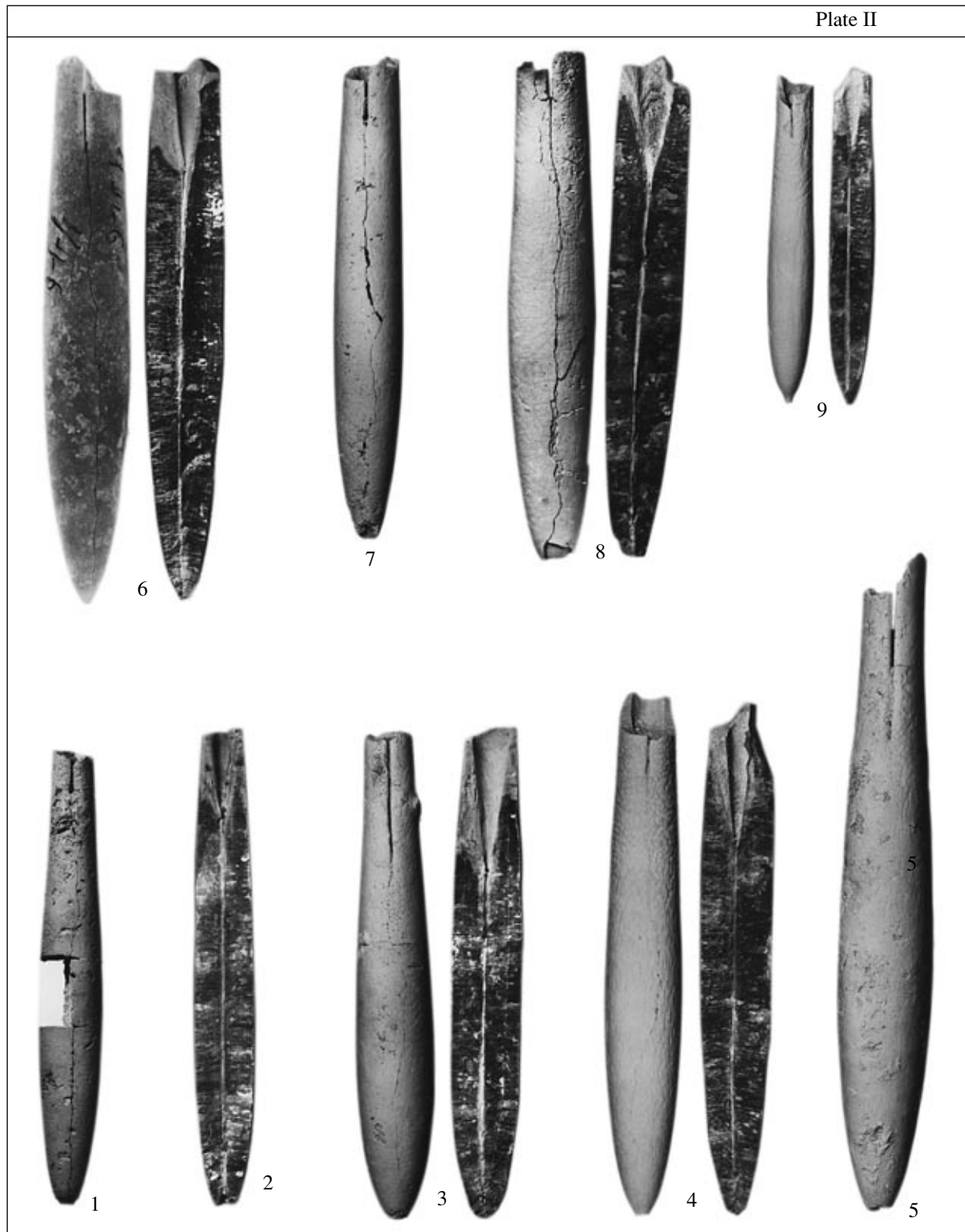
Beds 4–6, which are 25 to 28 m thick in total, are dominated by representatives of the genus *Belemnitella*



**Plate I.** *Belemnitella* and “primitive *Belemnella*” species.

Rostra (ventral views and dorsal–ventral sections) are figured in their natural size; (d) dorsal view (Plate I, figs. 10, 11). Numerator designates bed number with letter corresponding to the level of sampling for microfauna analysis and denominator corresponds to the rostrum number in collection of D.P. Naidin.

Beds 4–6, (1, 2) *Belemnitella mucronata minor* Jel.: (1) 4-1a/1, (2) 4-1/1; (3–6) *Belemnitella langei najdini* Kong.: (3) 4-1/17, (4) 5c/1, (5) 6-1/14; (7) *Belemnitella* gr. *langei*, rostrum lacking ventral alveolus, 6a/25; (8, 9) structure of ventral alveoli in different *B. langei* rostra: (8) 4/1, (9) 4/7; (10–12) *Belemnella licharewi licharewi* Jel.: (10) 7-1a/1, (11) 7-1b/1, (12) 7/9; (13) *Belemnella* rostrum with boring traces of *Cliona*, 7/12.



**Plate II.** *Belemnella* and *Neobelelemnella* rostra.

Beds 7, 9, (1, 2) *Belemnella lanceolata tenuis* Naid. subsp. nov.: (1) 7/7, (2) 7b-c/2; (3) *Belemnella lanceolata lanceolata* (Schloth.), 9-1d/14; (4) *Belemnella lanceolata gracilis* (Arkh.), 7/1; (5) *Belemnella lanceolata lanceolata* (Schloth.), 9-1d/3; Beds 3, 9, 10, (6) *Belemnella sumensis* Jel., 9-1d/1; (7) *Belemnella sumensis praearkhangelskii* Naid., 10-1/2; (8) *Belemnella praelanceolata* Najd., roof of Bed 3, 5429-3/1 (Naidin, 1964b, p. 93, Plate 2, fig. 3); (9) *Noebuliminella kazimiroviensis* (Skořozdr.), 10-1/2.

(110 rostra, sampling results of 1978); in beds 7 and 8 of comparable total thickness, 20 *Belemnella* rostra have been found.

Bed 3 and lower part of Bed 4 (Fig. 1) with rostra of *Belemnitella mucronata minor* Jel. are referred to  $K_2cp_2^2$ .<sup>3</sup> In the eastern part of the EPR, middle and upper parts of Bed 4 correspond along with beds 5 and 6 to the *Belemnitella langei* s.l. Zone of the terminal Campanian, which is considered as characterizing a lineage of subspecies *B. langei langei* (Schatsk.) Jel. and *B. langei najdini* Kong.

We attribute the middle part of Bed 4, where rostra of *Belemnitella mucronata minor* Jel. occur in association with first *B. langei langei* (Schatsk.) Jel., to  $K_2cp_2^3$ . In our opinion, the upper part of Bed 4 and beds 5 and 6, which yield *Belemnitella langei langei* (Schatsk.) Jel. and *B. langei najdini* Kong., should be correlated with  $K_2cp_2^4$ .

The mentioned subspecies differ in the rostra size. The postalveolar length of rostra (distance from the base of the ventral alveolus to the apex) ranges from 78 to 93 mm in five specimens of *Belemnitella mucronata minor* (basal part of Bed 4), averages 60 mm in 15 rostra of *B. langei langei* from Bed 4, and is 50–52 mm in 10 and 15 rostra of *B. langei najdini* from beds 4 and 6, respectively.

It is established that *Belemnitella* forms become replaced by *Belemnella* species above the boundary between beds 6 and 7. Scarce *Belemnitella* rostra appear however higher in the section, while rare representatives of the genus *Belemnella* (*B. praelanceolata* Najd.) occur below this boundary (Fig. 1).

*Belemnella licharewi licharewi* Jel. and *B. licharewi desnensis* Jel., which appear at the base of Bed 7 should be mentioned among representatives of the genus. One–two meters higher, they occur in association with *Belemnella lanceolata gracilis* (Arkh.), *B. ex gr. lanceolata* (Schloth.), and *B. lanceolata* subsp. nov.

*Belemnella licharewi licharewi* and *B. licharewi desnensis* are the so called primitive *Belemnella* forms (Jeletzky, 1941, 1949, 1951, 1958) having the *Actinocamax*-like, variably expressed termination of the anterior (alveolar) end of the rostrum. The alveolar conotheca is usually destroyed to expose a layer between the alveole walls (Plate I, fig. 11); the dorsal edge of the alveole is cut by a relatively deep incision (Plate II, fig. 11).

Schultz (1979) believed that *Actinocamax*-like features are simply a result of weathering. The available factual materials suggest different interpretation. It appears that these features are characteristic of rostra with their anterior (alveolar) part composed of arago-

nite and/or organic chitin, which can be readily destroyed during fossilization.

The supreme taxonomic significance of the *Actinocamax* features in *Belemnella* representatives is undoubted. It should be noted that classification of the genus *Actinocamax* is based on the structure of pseudoalveole and alveolar bend, which are observable due to destruction of the anterior edge of a rostrum (Naidin, 1964). The *Actinocamax* features in the alveole structure are also noted in *Belemnella praelanceolata* Najd. occasionally occurring in the Aktulagai section (Plate II, fig. 8).

Bed 7 yields rostra of *Belemnella lanceolata* subsp. nov.<sup>4</sup> Rostrum of this subspecies has significantly narrowed alveolar end and preserved conotheca of the alveolar wall. It is likely that Jeletzky referred specimens of this type to “primitive *Belemnella*.” Some rostra figured in works by Mozgovoï (1969, p. 153, Plate 52, fig 4) and Naidin (1974, p. 178, Plate 78, fig. 1) and identified as *Belemnella licharewi desnensis* Jel. or *Belemnitella lanceolata* (Sinz.) (Nikitin, 1958, Plate 23, fig. 6) belong to a new subspecies.

Many rostra of genera *Belemnitella* and, particularly, *Belemnella* sampled from the Aktulagai section bear signs of rock borers life activity. These traces are produced mostly by cirripeds and *Cliona* sponges (Plate I, fig. 13). Such rostra are abundant in the basal Maastrichtian Bed 7.

#### FORAMINIFERAL SUBDIVISIONS

A succession of seven zonal assemblages of benthic foraminifers is established in the Aktulagai section (Fig. 1). Elaborating the foraminiferal zonation, we used materials of V.I. Gladkova, a senior paleontologist of the West Caspian Territorial Geological Survey (Aktyubinsk) who studied foraminifers from the Aktulagai section, and published data (Akimets et al., 1983).

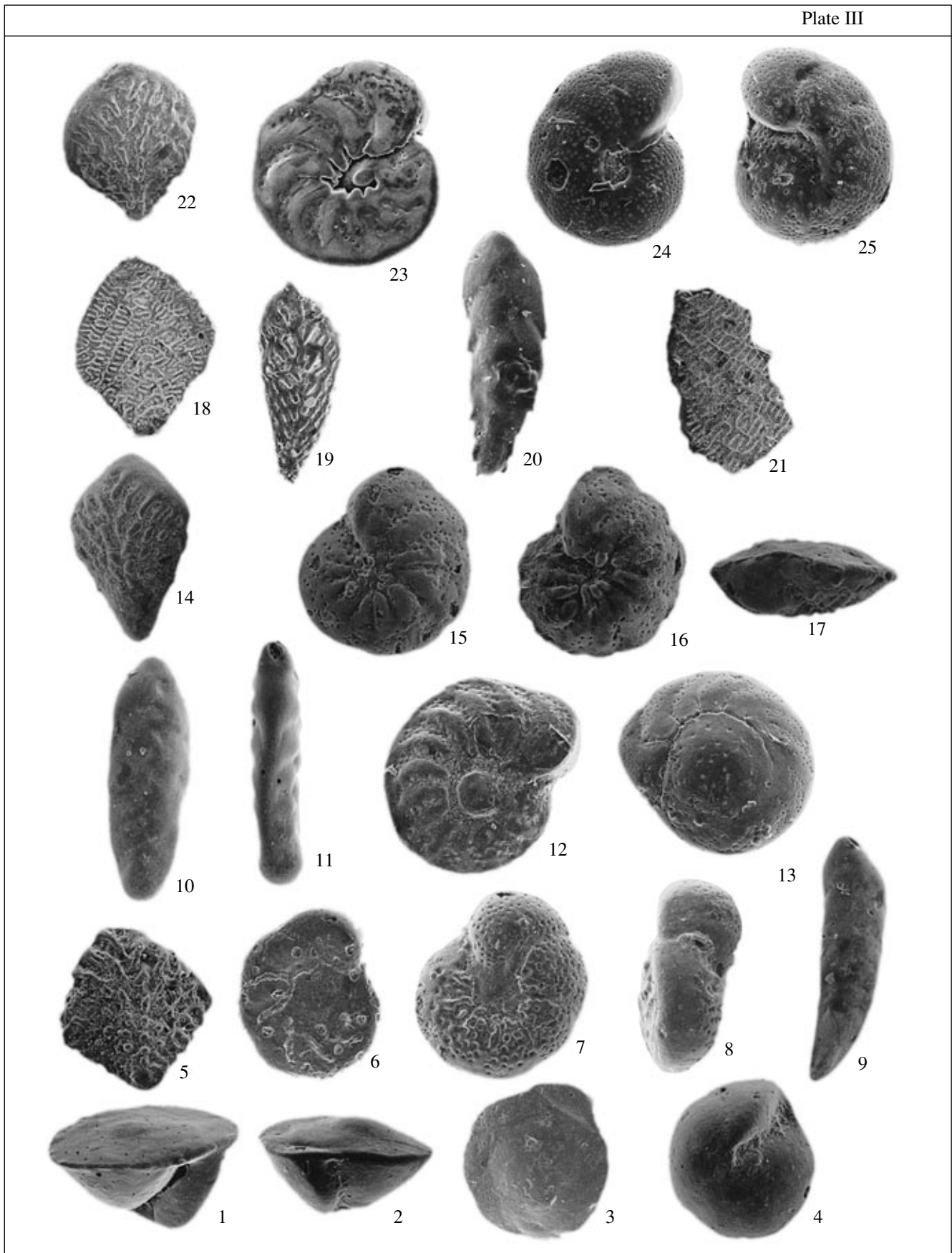
Morozova (1939) was first to publish the list of Campanian–Maastrichtian foraminifers from the North Caspian region and simultaneous bed-by-bed registration of belemnite finds.

Later on, Vasilenko and Myatlyuk (1947) studied the Upper Cretaceous assemblages of the South Emba region. Description and images of new species, *Angulogavelinella stellaria* (Vassilenko) = *A. gracilis* (Marsson) included, have been presented by Vasilenko in the same work.

Subsequently, exactly data on distribution of planktonic and benthic foraminifers substantiated stratigraphic subdivision of sections recovered by structural and survey drilling in areas of widespread Upper Cretaceous sediment. Remains of calcareous nannoplankton

<sup>3</sup> In earlier works (Naidin and Kopaeovich, 1997, Plates 1, 2; Naidin et al., 1984, Plate 1), this subspecies was erroneously named as *Belemnitella langei minor* Jel.

<sup>4</sup> In this work, the new subspecies of *Belemnella lanceolata* (Schloth.) is classed with *Belemnella lanceolata tenuis* Naid. subsp. nov.





**Plate III.** Benthic foraminifers.

Bed 3, (1–4) *Globorotaloides emdyensis* Vassilenko: (1) side view, 3-3a/1 (×90), (2) side view, 3-3a/2 (×80), (3) dorsal view, 3-3a/3 (×80), (4) ventral view, 3-3a/4 (×90); (5) *Bolivinoidea draco miliaris* Hiltermann et Koch, 3-3a/5 (×95); (6–8) *Pseudogavelinella clementiana laevigata* (Marie): (6) dorsal view, 3-3a/6 (×60), (7) ventral view, 3-3a/7 (×70), (8) side view, 3-3a/2 (×65); (9–11) *Bolivina incrassata* (Reuss): (9) microspherical specimen, 3-3a/9 (×160), (10) macrospherical specimen, 3-3a/10 (×65), (11) macrospherical specimen, apertural surface, 3-3a/11 (×70); (12) *Brotzenella taylorensis* (Carsey) (small), ventral view, 4-4d/1 (×80). Bed 5. (13) *Gemellides orcinus* Vassilenko, ventral view, 5-5a/1 (×60); (14) *Bolivinoidea decoratus giganteus* Hiltermann et Koch, 5-5a/2 (×80). Bed 6. (15–17) *Angulogavelinella srellaria* (Vassilenko) = *A. gracilis* (Marsson): (15) ventral view, 6-6a/1 (×95), (16) ventral view, 6-6a/2 (×120), (17) side view, 6-6a/3 (×100); (18) *Neoflabellina traereticulata* Hiltermann et Koch, 6-6a/4 (×115); (19) *Bolivinoidea delicatulus* Cushman, 6-6a/4 (×85); (20) *Bolivina decurrens* Ehrenberg, 6-6a/5 (×115); Bed 8. (21) *Neoflabellina reticulata* (Reuss), 8-8a/1 (×60); (22) *Bolivinoidea draco miliaris* Hiltermann et Koch transitional to *B. draco draco* (Marsson), 8-8-1b/1 (×80); (23) *Falsoplanulina multipunctata* (Bandy) = *Brotzenella complanata* (Reuss), ventral view, 8-8-1e/1 (×95); (24) *Anomalina welleri* Plummer, ventral view, 8-8-1f/1 (×120). Bed 10. (25) *Anomalinoidea pinguis* (Jenning), dorsal view, 10-10-2e/1 (×120).

represent substantial components of sediments under consideration. In Campanian and Maastrichtian sediments of the Aktulagai section, Dmitrenko (1985) defined several stratigraphic assemblages of nannofossils, each comprising tens species.

An oldest foraminiferal assemblage is established in the interval spanning the Bed 3 and an upper part of Bed 4; it consists of *Globorotalites emdyensis*, *Pseudogavelinella clementiana laevigata*, *Cibicidoides voltzianus*, *Eponides frankei*, *Bolivinoidea draco miliaris*, and *Bolivina incrassata*. Sediments hosting the assemblage correspond to the *Bolivinoidea draco miliaris* Zone BF 5 of the EPR, which is designated as Zone XX in the Upper Cretaceous zonation of benthic foraminifers authorized for the East European paleobiogeographic region (Naidin et al., 1984; Beniamovski and Kopaeovich, 2001).

The next *Brotzenella taylorensis* assemblage (Zone XXI) is characteristic of beds 4, 5, and a lower part of Bed 6. Bed 4 is marked by the appearance and development of small *Brotzenella taylorensis* and *Eponides conspectus* (XXIa). Bed 5 yields first specimens of *Gemellides orcinus*, *Gavelinella caeyuxi*, *Bolivinoidea giganteus*, *Pseudovigerina cristata*, and *Neoflabellina permutata* (XXIb).

Overlying sediments of beds 6, 7, and 8 (without the uppermost part) are characterized by the *Angulogavelinella gracilis* assemblage (Zone XXII). The lower part of this zone contains newcomers *Angulogavelinella gracilis*, *Neoflabellina praereticulata*, *Brotzenella taylorensis* (large), *Cibicidoides bembix*, *Bolivina decurrens*, *Bolivinoidea peterssoni*, and scarce *B. delicatulus* (XXIIa). The assemblage from Bed 8 includes also *Neoflabellina reticulata*, an evolutionary descendant of *N. praereticulata*, that appears at this level and develops above it. Subzone XXIIb is determined above the appearance level of *N. reticulata* and forms transitional between *Bolivinoidea draco miliaris* and *B. draco draco*. In addition, the genus *Globorotalites* widespread in Campanian sediments disappears at this level.

The assemblage of *Falsoplanulina multipunctata* Zone (XXIII) is detected in the uppermost part of Bed

8 and in the lower half of Bed 9.<sup>5</sup> This zone characterizes appearance of genera *Falsoplanulina* (*F. multipunctata*) and *Anomalinoidea* (single *A. ukrainicus*), while the Campanian genus *Pseudogavelinella* disappears within it. The zone is subdivided in two the lower (XXIIIa) and upper (XXIIIb) subzones distinguished above the appearance levels of *Anomalina welleri* and abundant *A. ukrainicus*, respectively.

The upper part of Bed 9 hosts the assemblage of the *Bolivinoidea draco draco* Zone (XXIV); in this interval, zonal index species is associated with *Gavelinella midwayensis* and *Coleites crispus* appearing at this level. Bed 10 is characterized by appearance of species, which are characteristic of the next *Brotzenella praeacuta* Zone (XXV); indicative taxa are the index species and *Cibicides kurganicus*.

The uppermost member of Bed 10 yields *Anomalinoidea pinguis* whose appearance is indicative of the *Falsoplanulina ekbomi* Zone (XXVI).

## CONCLUSIONS

(1) In the Aktulagai reference section, distribution of belemnites and benthic foraminifers is studied in detail, and foraminiferal zonation of a high resolution is correlated with appearance levels of characteristic belemnite species. As is established, for example, the appearance levels of *Belemnella lanceolata* and *Neoflabellina reticulata* are diachronous. The latter species appears above the first occurrence level of the former, although in stratigraphic schemes of the European paleobiogeographic region, northwestern Germany, and East European platform, these events are postulated to be synchronous (Koch, 1977; Beniamovski and Kopaeovich, 2001; Olfer'ev and Alekseev, 2003).

(2) The modern knowledge of the Aktulagai section is inadequate, not satisfying the reference section requirements. Special works on sampling and study of stratigraphically important macrofossil groups (ammonites, inocerams, brachiopods, echinoderms) are needed.

<sup>5</sup> In the Russian paleontological literature, index species of this zone is termed *Brotzenella complanata* (Reuss).

According to our data, the Aktulagai succession of carbonate rocks and comparable sections of the North-eastern Caspian region contain (frequently in small abundances) remains of three main groups of widespread fossils, the calcareous foraminifers and nannoplankton, the siliceous diatoms, silicoflagellates, and radiolarians, and the organic-walled phytoplankton (dinoflagellate cysts). Representatives of the last two groups are characteristic of different sedimentary facies in northerly regions, where they are successfully used in stratigraphic correlation of Upper Cretaceous sections (Strel'nikova, 1974; Zakharov et al., 1986, 2002; Khlonova and Lebedeva, 1988; Sharafutdinova, 1992; Il'ina et al., 1994; Vishnevskaya, 1999, 2001; Amon, 2000; Beniamovski et al., 2002, 2003; Aleksandrova and Olfer'ev, 2005).

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