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GEOLOGY

Find of Early Planktonic Foraminifers in the Triassic of the Crimea

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The appearance of planktonic foraminifers is the most dramatic episode in the evolution of Protozoans and an important event in the development of the biosphere during the last 400 Ma. Data on initial stages of the development of planktonic foraminifers are far from being complete, which hampers reliable dating of their evolution [1, 3–5, 8, 9].

The keen attention that micropaleontologists pay to early planktonic foraminifers is explained by new finds of these microorganisms at progressively older stratigraphic levels. Moreover, study of this Protista group helps us to understand several issues, such as evolution of morphogenesis from early stages of taxa development to their mature state; dependence of test morphotypes on environmental parameters (including the water temperature of the World Ocean in different periods of geological history) closely correlated with paleoclimatic evolution; and dispersal of these organisms and widening of their domains from discrete occurrences during their origination in the Early Mesozoic to global expansion in the Late Jurassic and subsequent Cretaceous epoch. The find of planktonic foraminifers in the Triassic provokes an additional problem related to one of the greatest biotic crises at the Triassic–Jurassic boundary when mass extinction affected planktonic foraminifers and other groups of organisms that lost up to 50% of their taxa. This crisis was slightly predated by the most important event in foraminiferal evolution: a new group of organisms with an absolutely different skeleton, principally new mode of life, and tremendous evolutionary potential that originated in the terminal Triassic and rapidly occupied the entire World Ocean.

Therefore, the first find of a planktonic foraminifer assemblage in reliably dated Triassic rocks of the Crimea is of large significance. It should be noted that we could observe morphological peculiarities of planktonic foraminifers, because tests extracted from rocks were studied.

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Among the planktonic foraminifer assemblage of six genera and eight species found in the Triassic rocks, one genus and four species have been identified and described for the first time. This assemblage is marked by the presence of species with typical morphological features of early stages of taxa development and characteristic forms of mature evolutionary stages. Despite the high diversity of morphotypes, morphological features in some taxa are unstable. The existence of an advanced assemblage of planktonic foraminifers, which originated in pre-Rhaetian and Rhaetian times and successfully survived the greatest biotic crisis, specifies the crisis scenario and its impact on biota at different levels of water column in the World Ocean. The occurrence of forms with sinistral tests, which are typical of cold-water conditions, among planktonic foraminifers implies a presumably cold hydrosphere, similar to the present-day one, during the Triassic–Jurassic biotic crisis.

We also studied the Upper Triassic limestone block usually interpreted as an olistolith within the Lower Jurassic Eskiorda Formation [2]. This terrigenous formation has developed in the Lozovskaya zone of the mountainous part of Crimea and contains numerous bodies of different age (Carboniferous–Leiassic) limestones. The Triassic block is one of the largest structures (100 m across). It is located northeast of the Kichik-Saraman Plateau on the left bank of Izvestkovyi Creek 2.5 km upstream of its inflow into the Partizanskoe water reservoir (Fig. 1a). Previous researchers sampled Rhaetian brachiopods [6] and upper Norian–Rhaetian foraminifers from different parts of this olistolith [6, 7]. Since no bed-by-bed description of the block was performed, positions of these fossils remain unclear. Nevertheless, the normal block attitude (NW 310°, dip angle 20°) allows its subdivision into the following Late Triassic, *s.s.* Late Norian (Sevatian)–latest Rhaetian, lithostratigraphic units exposed in the creek thalweg (from the bottom to top):

(1) Light gray, massive algal–brachiopodal limestone. Apparent thickness 8 m.

(2) Pink, pelitomorphic, massive, biomicritic limestone alternating with brachiopod coquina layers. Sam-

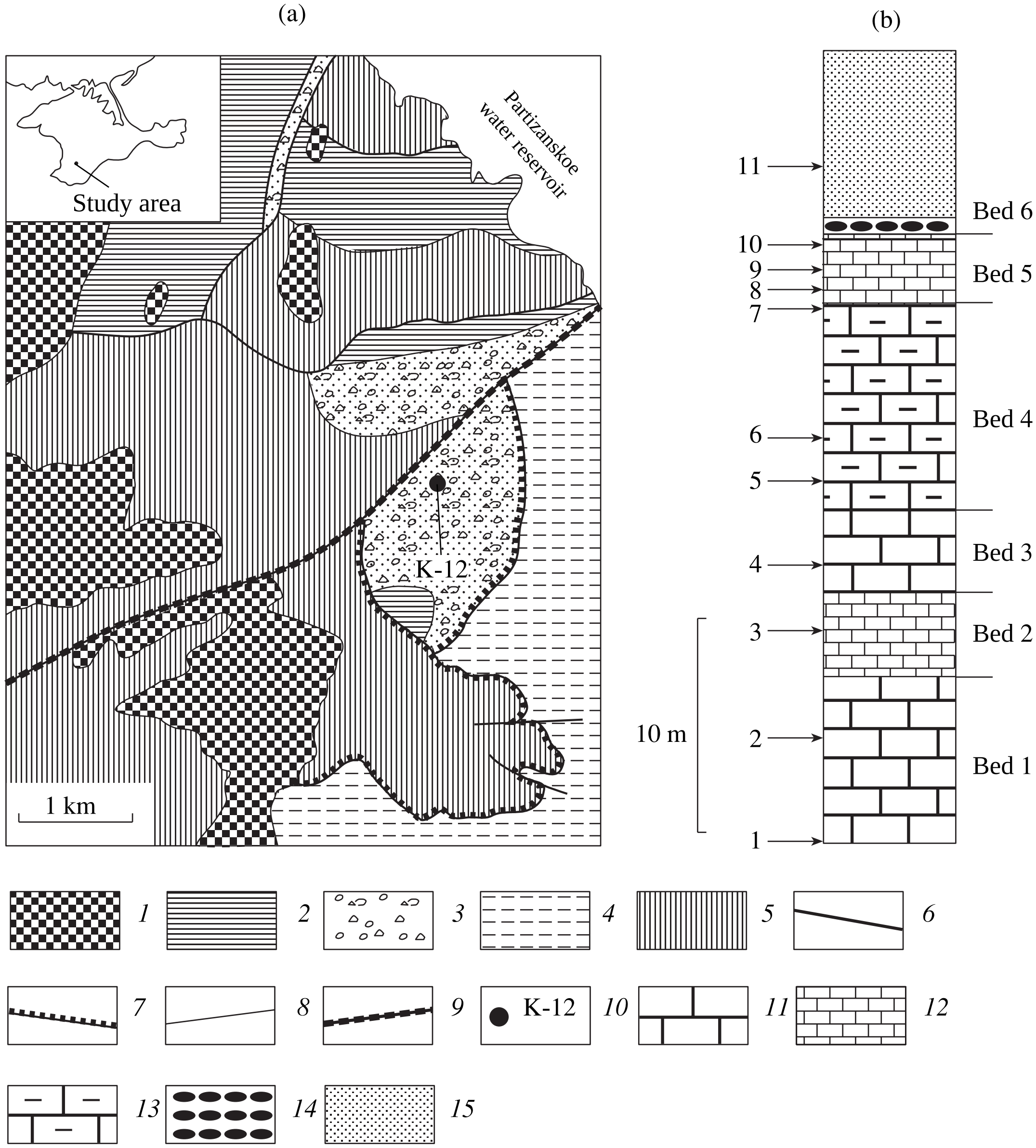

Fig. 1. Position and structure of the Upper Triassic limestone block on the northern slope of the Kichik-Saraman Plateau (Crimean Mountains). (a) Geological structure of the Alma and Bodrak interfluve [2]; (b) section of the Triassic limestone olistolith (observation point K-12); sampling levels (numbers on the left side of the column) and bed numbers (right side of the column) correspond to those in the description. (*1*) Lower Cretaceous rocks; (*2*) Dzhidair Formation (Toarcian–Aalenian); (*3*) Eskiorda Formation (Lower Jurassic); (*4*) Upper Tavriya Formation (Lower Jurassic); (*5*) Kurtsov and Salgir formations (Middle–Upper Triassic); (*6*) steep faults; (*7*) low-angle overthrust; (*8*) stratigraphic boundaries; (*9*) Bodrak polygenic fault; (*10*) olistolith of Upper Triassic limestones; (*11*) massive biohermal limestone; (*12*) micritic limestone; (*13*) organogenic-detrital crinoid–brachiopodal limestone; (*14*) limy conglomerate; (*15*) sandstone and gritstone.

ple 3 yielded foraminifers *Galeanella panticae* Zanninetti and Bronnimann and conodonts *Neogondolellla* cf. *steinbergensis* (Mosher) of the Late Norian (Seavatian) age. Thickness 4 m.

(3) Light gray, massive, algal–brachiopodal limestone. Thickness 4 m.

(4) Pink, crinoid, massive (obscure-bedded in the upper part) limestone. Thickness 10 m.

(5) Pink, lumpy, obscure-bedded, biomicritic limestone with brachiopods and microfossils. Samples 8–10 from this bed contain a diverse foraminiferal assemblage of Rhaetian age including benthic *Gaudryinella kotlensis* Trifonova, *G. elegantissima* Kristan-Tollmann, *Gaudryina* sp., *Ammobaculites* cf. *rhaeticus* Kristan-Tollmann, *Variostoma coniforme* Kristan-Tollmann, *Galeanella panticae* Zanninetti and Bronnimann, *Triasina* sp., *Involutina* cf. *turgida* Kristan-Toll-

mann, *Reophax rudis* Kristan-Tollmann, *Diplosphaerella ramose* Kristan-Tollmann, and planktonic forms *Schmidita hedbergelloides* Fuchs, *Oberhauserella quadrilobata* Fuchs, *O. prarhaetica* Fuchs, *Globuligerina almensis* O. Korchagin and K. Kuznetsova, sp. n., *Sphaerogerina crimica* O. Korchagin and K. Kuznetsova, gen. et sp. n., *S. tuberculata* O. Korchagin and K. Kuznetsova, gen. et sp. n., *Praegubkinellla turgescens* Fuchs, *Wernliella explanata* O. Korchagin and K. Kuznetsova sp. n. Thickness 3 m.

(6) Polymictic gritstone and coarse-grained sandstone with dispersed pebbles. The basal part is composed of limy conglomerate. Apparent thickness 7 m.

The data suggest the following conclusions: (1) the first appearance of true planktonic foraminifers is related to the Triassic (Rhaetian) rocks (the oldest stratigraphic level at the moment); (2) the planktonic microbiota was characterized by a diverse composition and unstable morphological features at the initial stages of evolution; (3) based on peculiarities of test morphotypes, habitat of this fauna corresponded to a cold hydrosphere during evolutionary innovations; and (4) the appearance of a new ecological type of fauna predated the mass extinction of biota (biotic crisis) at the Triassic–Jurassic boundary (in our case).

Order GLOBIGERINIDA LANKASTER, 1885

Family GLOBIGERINIDAE LOEBLICH AND TAPPAN, 1984

Genus *Globuligerina* Bignot and Guydader, 1971

Globuligerina almensis O. Korchagin and K. Kuznetsova, sp. n.

Fig. 2, *1–3*

Etymology. After find locality in the Alma River basin, the Crimean Mountains.

Holotype. No. 4776/10 stored at the Geological Institute; the Crimea, northeastern slope of the Kichik-Saraman Plateau, section K-12, Bed 5; Upper Triassic, Rhaetian Stage.

Description. Test is moderately trochospiral with convex chambers loosely arranged in two whorls; cambers of the early whorl are distinctly raised over those in the last whorl; spiral side is evolute and strongly convex; umbilical side is involute and slightly concave; the last whorl consists of 3.0 to 3.5 almost uniform spherical chambers; chambers on umbilical side are flattened-convex with near-umbilicus deeps; septal sutures on spiral side are slightly depressed, straight radial in the early whorl, and slightly curved in the last whorl; sutures on umbilical side are depressed and straight; umbilical area is of medium size and occupies one-third of test diameter; test contour is strongly lobulate; periphery is widely rounded; aperture is not observed; and test surface after etching is even and smooth. Sinistral tests are prevalent.

Dimensions (mm). Holotype no. 4776/10: $D = 0.2$, $H = 0.13$.

Comparison. The species differs from *Globuligerina oxfordiana* (Grigelis) in less convex chambers and highly elevated early whorl of the test and from *Globuligerina frequens* Fuchs in wider and open umbilicus and strongly elevated early whorl of the test.

Distribution and age. The Crimea, Rhaetian limestones.

Material. Five specimens of moderate preservation.

Genus *Sphaerogerina* O. Korchagin and K. Kuznetsova, sp. n.

Etymology. From Latin *sphaero* (spherical) indicating spherical shape of the test.

Type species. Sphaerogerina tuberculata O. Korchagin and K. Kuznetsova, gen. and sp. n. The Crimea, northeastern slope of the Kichik-Saraman Plateau, section K-12, Bed 5; Upper Triassic, Rhaetian Stage.

Diagnosis. Test spherical, compactly coiled, moderately trochoidal, involute, consists of two whorls. The last whorl includes 3–5 spherical inflated tightly arranged chambers. Test contour is almost regular, rounded, and slightly lobulate. Septal sutures are straight, slightly depressed. Umbilicus is poorly expressed, because internal margins of chambers are tightly attached to each other and cover aperture. Aperture is intraumbilical, basal, low- to high-arcuate, and sometimes rimmed by narrow lip. Test surface after etching is hummocky or coarsely rough. Wall is irregularly porous.

Species composition. Rhaetian rocks of the Crimea enclose, in addition to type, species *Sphaerogerina tuberculata, S. crimica* O. Korchagin and K. Kuznetsova gen. and sp. n.

Comparison. The new genus differs from *Compactogerina* Simmons *et al.*, 1997 in lower number of chambers in the last whorl, absence of widely arcuate aperture characteristic of *Compactogerina* genus, and irregularly porous and hummocky test surface. It differs from *Favusella* genus in hummocky, rather than reticular, test surface.

Distribution and age. The Crimea, Upper Triassic, Rhaetian Stage.

Sphaerogerina tuberculata O. Korchagin and K. Kuznetsova, gen. and sp. n.

Fig. 2, *7–9*

Etymology. From Latin *tuberculatus* (hummocky).

Holotype. No. 4776/14 stored at Geological Institute; the Crimea, northeastern slope of the Kichik-Saraman Plateau, section K-12, Bed 5; Upper Triassic, Rhaetian Stage.

Description. Test is moderately trochospiral, spherical, with 2.5 spiral whorls; the last whorl consists of 3–4 spherical, closely arranged chambers gradually increasing in size; septal sutures are straight, radial, slightly depressed or flat on spiral side and flat

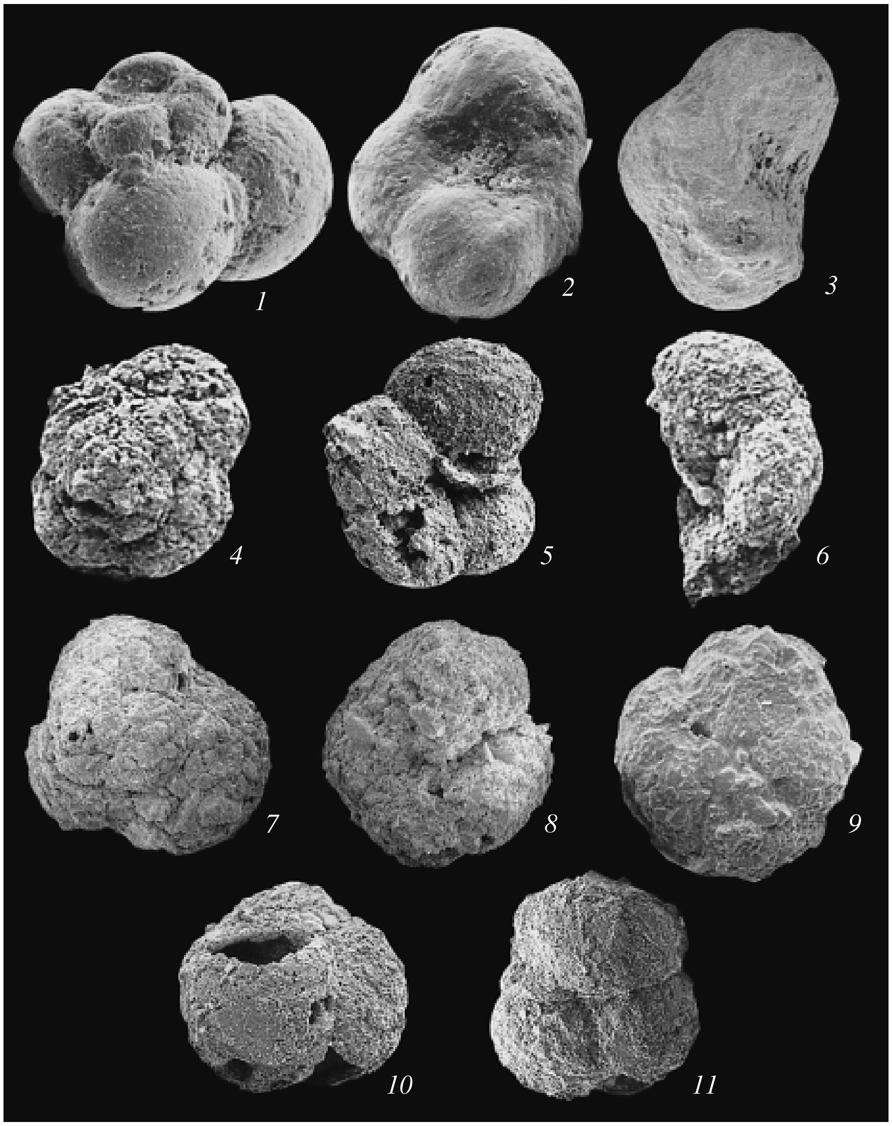

Fig. 2. Planktonic foraminifers from Rhaetian rocks of the Crimea. All specimens are taken from the Upper Triassic (Rhaetian Stage) section K-12 (Bed 5) exposed on the northeastern slope of the Kichik-Saraman Plateau and are stored at the Geological Institute under corresponding numbers. *Globuligerina almensis* O. Korchagin and K. Kuznetsova, sp. n.: (*1*) holotype no. 4776/10, side view, sinistral test, ×220, (*2*) paratype no. 4776/11, umbilical view, ×220, (*3*) paratype, no 4776/12, peripheral view, ×220; *Wernliella explanata* O. Korchagin and K. Kuznetsova, sp. n.: (*4*) holotype no. 4776/1, spiral side, dextral test, ×170, (*5*) paratype no. 4776/2, umbilical view, sinistral test, ×210, (*6*) paratype no. 4776/3, peripheral view, ×125; *Sphaerogerina tuberculata* O. Korchagin and K. Kuznetsova, gen. and sp. n.: (*7*) holotype no. 4776/14, spiral side, dextral test, ×144, (*8*) paratype no. 4776/15, side view, ×144, (*9*) paratype no. 4776/16, umbilical view, ×144; *Spherogerina crimica* O. Korchagin and K. Kuznetsova, gen. and sp. n.: (*10*) holotype no. 4776/18, side view, dextral test, ×140, (*11*) paratype no. 4776/19, umbilical view, ×160.

on umbilical side; chambers on umbilical side are very tightly attached to each other; therefore, umbilicus is poorly expressed; periphery is widely rounded; test contour is oval, rounded, or slightly lobulate; aperture is intermarginal, basal, rounded, arcuate, sometimes rimmed by lip; test surface after etching in acids is rough and hummocky.

Dimensions (mm). Holotype no. 4776/14: $D = 0.28$, $d = 0.21$, $H = 0.27$.

Distribution and age. New species occurs in Rhaetian rocks of the Crimea.

Material. Approximately 15 specimens of moderate preservation.

Sphaerogerina crimica O. Korchagin and K. Kuznetsova, gen. and sp. n.

Fig. 2, *10–11*

Etymology. After locality of find (the Crimea).

Holotype. No. 4776/18 stored at Geological Institute; the Crimea, northeastern slope of the Kichik-Saraman Plateau, section K-12, Bed 5; Upper Triassic, Rhaetian Stage.

Description. Test is spherical, with slightly elevated cone-shaped chambers in early whorl, tightly coiled, moderately trochoid, consisting of two spiral whorls; last whorl includes three spherical inflated chambers; septal sutures are radial, flat or slightly depressed on spiral side and straight, radial, flat or slightly depressed on umbilical side; chambers on umbilical side of last whorl are very tightly arranged so that umbilicus is missing; periphery is widely rounded; test contour is rounded, even, or slightly lobulate; aperture is unobservable; test surface after etching by acids is even, smooth, or slightly rough.

Dimensions (mm). Holotype no. 4776/18: $D = 0.18$, $H = 0.19$.

Distribution and age. Species occurs in Rhaetian rocks of the Crimea.

Material. Six specimens of moderate preservation.

Family OBERHAUSERELLIDAE FUCHS, 1970

Genus *Wernliella* K. Kuznetsova, sp. n.

Wernliella explanata O. Korchagin and K. Kuznetsova, sp. n.

Fig. 2, *4–6*

Etymology. From Latin *explanatus* (flattened).

Holotype. No. 4776/1 stored at the Geological Institute; the Crimea, northeastern slope of the Kichik-Saraman Plateau, section K-12, Bed 5; Upper Triassic, Rhaetian Stage.

Description. Test is small, low- to medium-trochospiral, patelliform, with slightly convex spiral and slightly concave umbilical sides; test consists of 2.0–2.5 whorls; last whorl comprises 4–4.5 chambers; chambers of initial whorl are slightly elevated above last whorl; test contour is oval-quadrangular and slightly lobulate; chambers on spiral side are crescent-shaped or trapezoid, flattened-convex, gradually increasing in size; septal sutures are oblique and depressed; chambers are flattened-convex on umbilical side; last chamber is shifted to the umbilical side and partly overlaps umbilicus occupying sometimes one-third of test diameter; septal sutures are straight, radial, and depressed; umbilicus is small, shallow, and partly closed by the lower termination of the last chamber; periphery is slightly tapered and rounded; aperture is umbilical (slitlike or low-arcuate exrtaumbilical), partly covered by triangular plate or flap; test surface is spiny or hummocky on spiral side and smoother on umbilical side; wall is fine-grained. Dextral tests are prevalent .

Dimensions (mm). Holotype no. 4776/1: $D = 0.25$, $H = 0.14$.

Comparison. The species differs from *Wernliella toracensis* K. Kuznetsova in more lobulate test outlines and looser arrangement of chambers in last whorl.

Distribution and age. Species occurs in Rhaetian rocks of the Crimea.

Material. Twenty specimens of moderate preservation.

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