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Gastropods of the Family Aporrhaidae from the Lower Cretaceous of Ulyanovsk, Volga Region

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Abstract—Three new species of the genus *Trilemma* (family Aporrhaidae), *T. polivnense* Blagovetshenskiy, sp. nov., *T. kremenkense* Blagovetshenskiy, sp. nov., and *T. tenuicarinatum* Blagovetshenskiy, sp. nov., from the Lower Cretaceous of the Volga Region near Ulyanovsk are described. The data on the stratigraphic range of these species are provided.

Keywords: Gastropoda, Aporrhaidae, Lower Cretaceous, Upper Hauterivian, Barremian, Lower Aptian, Ulyanovsk Region.

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INTRODUCTION

In the Lower Cretaceous of the Volga Region near Ulyanovsk, the family Aporrhaidae is represented by only one genus, *Trilemma* Blagovetshenskiy et Shumilkin, 2006, and four species. The analysis of published data and recent original material shows that the total number of species included in this genus is 22 (see descriptions). Distinctions between the previously described species of the genus *Trilemma* are sometimes uncertain. This is caused by insufficient preservation of specimens, the absence of data on the protoconch structure of juvenile shells, and frequently poorly informative figures.

Species of the genus *Trilemma* have a spindle-shaped shell, with dicarinate (or tricarinate) whorls, three processes deviating from the palatal and palato-parietal margin of the aperture, and a rostrum. The protoconch is orthostrophic, smooth, with a poorly pronounced boundary with the teleoconch. Notwithstanding such a uniform structural pattern, species are reliably distinguished by a number of characters of the shell structure. Based on new original material and published data, we believe that the following characters are distinctive for species of the genus *Trilemma*:

(1) The number of carinae per whorl and the extent to which they are developed; some species have two carinae, others have three. This character is very reliable, but manifested completely only in adults. In addition, the third carina, which is located at the shell base, is only visible in the last whorl (in the present study, the carinae are numbered from above downwards).

(2) Features of the formation of carinae: the carinae on shell whorls are formed as a result of strengthening certain spiral ribs from whorl to whorl. These ribs are easy to count from the overlying suture. Species of the genus *Trilemma* from the Lower Cretaceous of the Ulyanovsk Volga Region form two upper carinae of the second and fourth spiral ribs (*T. polivnense* sp. nov., *T. kremenkense* sp. nov.), third and fifth (*T. russiense* Blagovetshenskiy et Shumilkin, 2006), and first and seventh (*T. tenuicarinatum* sp. nov.).

(3) The shape and length of processes and the angle at which they are inclined relative to the shell axis. The processes are completely developed only in adults and rarely preserved.

(4) The number of spiral ribs in the intercarinal space. This number usually depends on spiral ribs that form carinae (spiral ribs that are not strengthened and located in the intercarinal space). It is noteworthy that, in some species, this area acquires secondary riblets, which appear with the development of the teleoconch.

(5) The number of spiral ribs above the upper carina.

(6) The shape of cells formed by crosses of axial and spiral ribs, the extent and direction of elongation of cells. These characters depend on the number of axial and spiral ribs in whorls and the extent of curvature of axial ribs.

A revision of the genus *Trilemma*, taking into account the differentiating characters listed, improved species identification of forms from the Volga Region near Ulyanovsk and Saratov (Pchelintsev, 1926; Ivanova, 1959; Blagovetshenskiy and Shumilkin, 2006; Golovinova and Guzhov, 2009). The form which we previously determined as *T. striatocarinatum* (Sinzow, 1880) (Blagovetshenskiy and Shumilkin, 2006) is in fact a separate species, although it is close to the form described by Sinzow. In the present study, it is regarded as a new species, *T. polivnense* Blagovetshen-

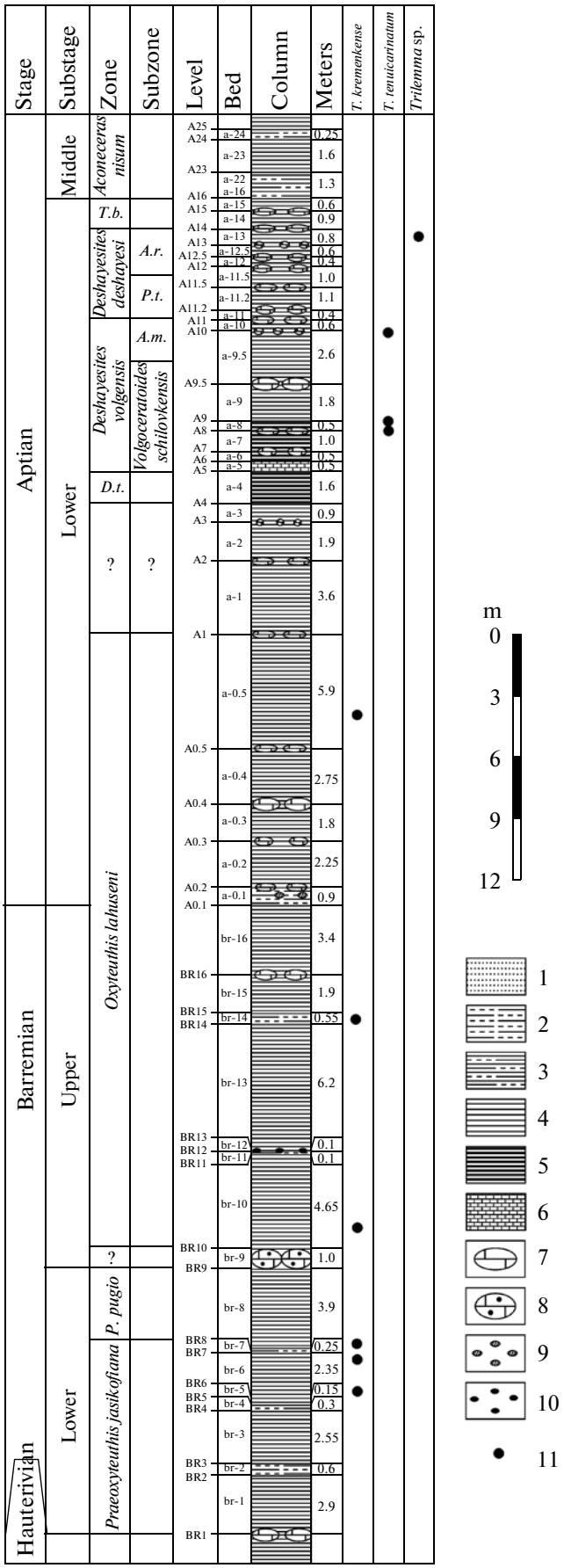


Fig. 1. Distribution of the mollusk genus *Trilemma* in the Barremian and Aptian of the Volga Region near Ulyanovsk. Designations: (1) sand, (2) silty clayey, (3) interbedding silt and clay, (4) clay, (5) shale clay, (6) clayey limestones (Aptian plate), (7) limestone concretions, (8) silty concretion, (9) sulfide concretions, (10) phosphorites, (11) gastropod records; zones and subzones: *tenuicostatus*, (*A.m.*) *Ancyloceras matheronianum*, (*A.r.*) *Audouliceras renauxianum*, (*D.t.*) *Deshayesites*, (*P.t.*) *Proaustraliceras tuberculatum*, and (*T.b.*) *Tropaeum bowerbanki* (zonation follows Baraboshkin and Mikhailova, 2002; Baraboshkin, 2004a, 2004b).

skiy, sp. nov. It differs from *T. striatocarinatum* in the thicker carinae and different number of spiral ribs in the intercarinal space and above the first carina. In addition, *T. polivnense* Blagovetshenskiy comes from the *Simbirskites decheni* Zone of the Upper Hauterivian and *T. striatocarinatum* (Sinzow, 1880) occurs in the Lower Aptian. Sinzow (1880) indicated that this species is confined to the Lower Cretaceous sand and clay beds of Sokolova Mountain of Saratov. Recent stratigraphic studies (Baraboshkin and Mikhailova, 2002, p. 87, text-fig. 2) have shown that the sands and underlying clays in the area of Sokolova Mountain are dated Lower Aptian, *Deshayesites tenuicostatus* Zone. The Aptian age of these beds is corroborated by paleomagnetic data (Grishanov, 1984). This species probably also occurs in the upper part of the Barremian Stage, which is supported by records accompanied by belemnites in the underlying clays (Sinzow, 1880). It is possible to exclude the Hauterivian age with confidence, because deposits of this stage in the vicinity of Saratov virtually lack macrofaunal remains (Baraboshkin, personal communication).

Thus, we agree with Golovinova and Guzhov (2009) that the form previously referred by us to *Trilemma striatocarinatum* is a different species; at the same time, we disagree with the statement of these authors that the form which they figured from the vicinity of the village of Doktorovka, Saratov Region (Golovinova and Guzhov, 2009, p. 32, pl. 2, fig. 8), is *T. striatocarinatum*. This form is subjuvenile, whereas Sinzow (1880, p. 6. pl. 3, fig. 1) figured an adult (the form shown in fig. 3 of the same plate Sinzow regarded as a young specimen of *T. striatocarinatum*, although it apparently does not belong to the family Aporrhaidae; Guzhov proposed that it is more similar to the family Mathildidae). It is evident that, in the course of ontogeny, the third carina and secondary ribs can appear, the carinae and other characters that are absent in young individuals are strengthened to a greater or lesser extent. In addition, it is probable that *T. striatocarinatum* is not the only species of this genus from the Aptian of Saratov. In particular, the Aptian beds of the Volga Region near Ulyanovsk have yielded two or three different forms of the genus *Trilemma*; in addition, the Barremian species *T. kremenkensis* sp. nov. enters the basal Lower Aptian (Fig. 1).

The idea of Golovinova and Guzhov that the form figured by them comes from the level at which this species (*T. striatocarinatum*) was originally described is questionable. As mentioned above, the specimens collected by Sinzow come from the Lower Aptian *Deshayesites tenuicostatus* Zone, while the form figured by Golovinova and Guzhov (2009) comes from the *Deshayesites deshayesi* Zone. This is corroborated by the data of Baraboshkin and Mikhailova (2002, p. 87, text-fig. 2.) that deposits of the Lower Aptian *Deshayesites deshayesi* Zone outcrop in the vicinity of Doktorovka. To establish with certainty the stratigraphic position of *T. striatocarinatum* and obtain more reliable data on its morphology and ontogeny, detailed systematic level-by-level collecting of all age stages of this species throughout the Barremian and Aptian in the Saratov area are required.

The Barremian and Aptian ("Albian") beds of the Saratov Region have yielded an aporrhaid which Pchelintsev (1926, p. 997, pl. 33, figs. 11, 12) and Ivanova (1959, p. 364, pl. 15, figs. 8, 9.) described as *T. ebrayi* (Loriol, 1882). This form essentially differs from the specimens figured by Loriol (1882, p. 25, pl. 3, figs. 16–20) in the presence of the third carina at the shell base and is probably analogous to *Trilemma kremenkense* sp. nov. from the Barremian of the Ulyanovsk Region described in the present study.

Below are descriptions of three new species of the genus *Trilemma* from the Hauterivian, Barremian, and Aptian of the Volga Region near Ulyanovsk. The description of the first species *T. polivnense* sp. nov. is as brief as possible, because the data on its morphology, stratigraphic range, and comparison with other species were provided in the previous study (Blagovetshenskiy and Shumilkin, 2006). At the same time, we provide figures of two specimens of *T. polivnense* sp. nov. with preserved processes of the apertural margin, which are important for species identification. One of these specimens is taken for the holotype of the species. In addition, a revised and improved species composition of the genus is provided. Figure 2 shows schematically adults and juveniles of species of the genus *Trilemma*, displaying difference between them. The stratigraphic range of *T. kremenkense* sp. nov. and *T. tenuicarinatum* sp. nov. is shown in Fig. 1. The zonation of the Aptian and Barremian beds investigated here follows modern stratigraphic studies (Baraboshkin and Mikhailova, 2002; Guzhikov, et al., 2003; Baraboshkin, 2004a, 2004b; Baraboshkin and Mutterlose, 2004).

The material examined in the present study is housed in the Natural Scientific Museum of Ulyanovsk State University (ENM UlGU, collection no. 220).

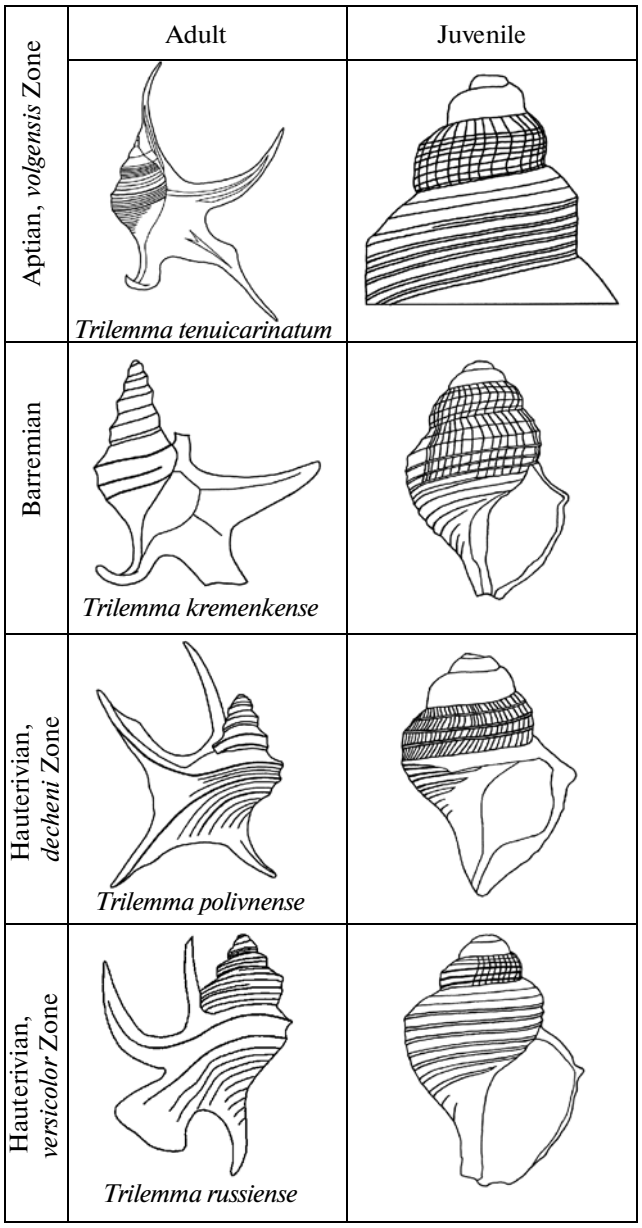


Fig. 2. Shell structure of adults (with elements of reconstruction) and juveniles of species of the genus *Trilemma* from the Lower Cretaceous deposits of the Volga Region near Ulyanovsk.

SYSTEMATIC PALEONTOLOGY

Order Alata Lamarck, 1809

Superfamily Stromboidea Rafinesque, 1815

Family Aporrhaidae Gray, 1850

Genus *Trilemma* Blagovetshenskiy et Shumilkin, 2006

Type species. *Aporrhais striatocarinata* Sinzow, 1880; Lower Cretaceous, Lower Aptian; Saratov Region.

Species composition. In addition to the type species, 21 species: *T. bicarinatum* (Deshayes,

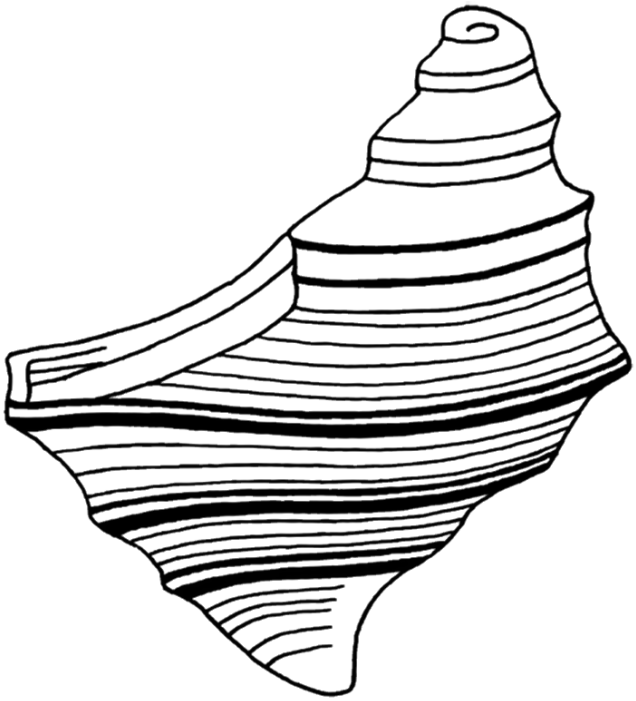


Fig. 3. Scheme of the shell structure of adult *Trilemma striatocarinatum* (after Sinzow, 1880).

1842) from the Albian of France; *T. densestriatum* (Kase, 1980) from the Barremian of Japan; *T. ebrayi* (Loriol, 1882) from the Albian of Switzerland; *T. fittoni* (Forbes, 1845) from the Lower Aptian of England; *T. giganteum* (Kase, 1984) from the Barremian of northeastern Japan; *T. kremenkense* Blagovetshenskiy, sp. nov.; *T. moreausianum* (d'Orbigny, 1842) from the Neocomian of France; *T. polivnense* Blagovetshenskiy, sp. nov.; *T. retusum* (Sowerby, 1836) from the Albian of England; *T. russiense* Blagovetshenskiy et Shumilkin, 2006 from the Upper Hauterivian (*versicolor* Zone) of Russia (Ulyanovsk Region); *T. tenuicarinatum* Blagovetshenskiy, sp. nov.; *?T. arrialoorense* (Stoliczka, 1867) from the Senonian of southern India; *?T. acutimarginatum* (Nagao, 1932) from the Senonian of Sakhalin and Hokkaido; *?T. ditropis* (Ryckholt, 1862) from the Cretaceous of Belgium; *?T. ebersini* (Plămădială, 1982) from the Lower Cenomanian of the eastern Caspian Depression (western Kazakhstan); *?T. histochila* (Gardner, 1875) from the Albian of England; *?T. japonicum* (Yabe et Nagao, 1928) from the Senonian of Hokkaido; *?T. oligoochila* (Gardner, 1875) from the Cenomanian of England; *?T. piettei* (Buvignier, 1852) from the Upper Jurassic of Denmark; *?T. pyriforme* (Kner, 1850) and *?T. trinale* (Murphy et Rodda, 1960) from the Upper Albian–Upper Cenomanian of California.

Trilemma striatocarinatum (Sinzow, 1880)

Aporrhais striatocarinata: Sinzow, 1880, p. 6. pl. 3, fig. 1 (non pl. 3, figs. 2–4).

Lectotype. Figured by Sinzow (1880, pl. 3, fig. 1), depository is not known; Lower Aptian, *Deshayesites tenuicostatus* Zone, probably Upper Barremian Stage, *Oxyteuthis lahuseni* Zone of the Volga Region near Saratov.

Description (Fig. 3). The shell is medium-sized, up to 20 mm long, spindle-shaped, with a wing-shaped expansion of the palatal margin of the aperture, consists of seven dicarinate whorls. At the base of the last whorl of adults, under the second carina, there is the third carina, which is similar in shape and development to the carinae located above. The distances between carinae are almost equal. In addition to the carinae, the spiral sculpture is formed of weak spiral ribs. On the last whorl, there are five spiral ribs above the first carina; between the first and second carinae and between the second and third carinae, there are three spiral ribs. The axial sculpture is represented by thin axial riblets, which gradually decrease in size towards the shell base.

Comparison. The differences from the other new species of the genus are considered below, accompanying their descriptions.

Material. The new species is investigated based only on the figure of the lectotype (Sinzow, 1880, pl. 3, fig. 1).

Trilemma polivnense Blagovetshenskiy, sp. nov.

Plate 1, figs. 1 and 2

?Aporrhais (*Tessarolax*) *bicarinata*: Wollemann, 1912, p. 181, pl. 13, fig. 12.

Trilemma striatocarinatum: Blagovetshenskiy and Shumilkin, 2006, p. 40, pl. 6, figs. 2–6.

Etymology. From the village of Polivna.

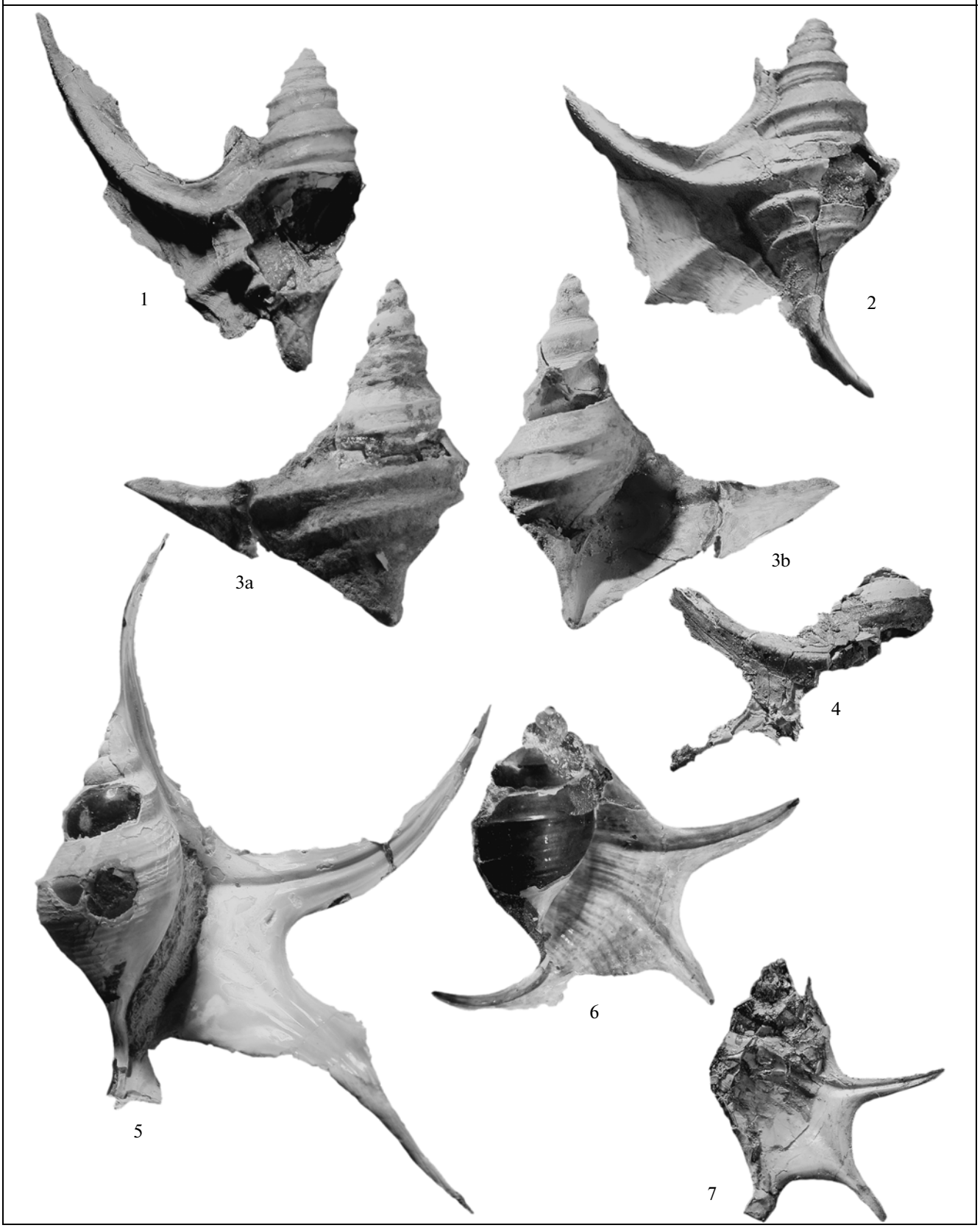
Explanation of Plate 1

Figs. 1 and 2. *Trilemma polivnense* Blagovetshenskiy, sp. nov.: (1) specimen ENM UlGU, no. 220/2, side opposite to aperture, ×4; village of Polivna, Upper Hauterivian *decheni* Zone, layer g-13; (2) holotype ENM UlGU, no. 220/3, side opposite to aperture, ×4; village of Polivna, Upper Hauterivian *decheni* Zone.

Figs. 3 and 4. *Trilemma kremenkense* Blagovetshenskiy, sp. nov.: (3) holotype ENM UlGU, no. 220/12, ×2.5: (3a) side opposite to aperture, (3b) apertural side; village of Kremenki, Upper Barremian, *lahuseni* Zone, Bed br-10; (4) specimen ENM UlGU, no. 220/20, side opposite to aperture, ×4; the same locality and age.

Figs. 5–7. *Trilemma tenuicarinatum* Blagovetshenskiy, sp. nov.: (5) holotype ENM UlGU, no. 220/24, apertural side, ×4; Ulyanovsk Region, Lower Aptian, *volgensis* Zone, level A8; (6) specimen ENM UlGU, no. 220/33, apertural side, ×4; village of Panskaya Sloboda, Lower Aptian, *volgensis* Zone, level A8; (7) specimen ENM UlGU, no. 220/28, apertural side, ×4;. Novoulyanovsk, clay quarry, Lower Aptian, *volgensis* Zone, layer a-8.

Plate 1



H o l o t y p e. ENM UlGU, no. 220/3; Ulyanovsk Region, village of Polivna; Upper Hauterivian, *decheni* Zone.

D e s c r i p t i o n (Fig. 2). The shell is medium-sized, up to 25 mm high, spindle-shaped, with a wing-shaped expansion of the palatal margin of the aperture, consists of seven or eight dicarinate whorls. At the base of the last whorl of adults, under the second carina, there is a somewhat smaller third carina.

The protoconch is smooth, consists of 3.5 whorls; then, spiral ribs gradually appear and, somewhat later, axial ribs are developed. On the fourth whorl of the spire, four spiral ribs are distinct; the second uppermost rib is slightly larger than others; in the fifth whorl, it becomes the first carina. In the fifth or sixth whorl, as a result of strengthening of the fourth (or, less frequently, fifth) uppermost spiral rib, the second carina is formed. In the last whorl of adults, because of strengthened sixth or seventh uppermost rib, the weakest third carina is developed.

Between the carinae, above and below them, unstrengthened spiral ribs are retained. Above the first carina of young individuals (having five whorls), there is one spiral rib (in adults, three spiral ribs, two of which are secondary). Between the first and second carinae (in the fifth or sixth whorl), a weak spiral rib is retained. In later whorls, additional (secondary) ribs (up to two in number) appear here. In the last whorl (seventh or eighth), between the second and third carinae, one or two weak spiral ribs are distinct; under the third carina, there are seven spiral ribs. The axial sculpture of the fourth whorl is composed of opisthocyrt ribs. It remains the same to the fifth whorl inclusive and, then, becomes almost indiscernible. One whorl retains from 48 to 54 axial ribs. When crossing the axial and spiral ribs, cells in the shape narrow parallelograms, extending along the shell axis are formed.

The aperture is elongated elliptical. The upper palatoparietal margin of the aperture passes into the posterior process; in adults, it extends above the initial whorls of the shell (terminology is considered in the study of Blagovetshenskiy and Shumilkin, 2006). The palatal margin of the aperture is expanded wing-shaped and has two saber-shaped carinate processes. The posterior lateral process, which continues the first carina, is directed horizontally posteriorly and to the right at an angle of 17°–37° (end of the process) to the whorl axis; in some individuals, it rises above the initial whorls. The anterior lateral process, which continues the second carina is directed anteriorly and to the right. The anterior process is elongated, sometimes posteriorly curved. On the inner side, the processes have grooves, which correspond to the carinae on the opposite side.

Specimen VDChO, no.	H	L	NW
220/1	15.9	17.7	5
220/2	16.6	15.6	4.5
220/3 (holotype)	18.4	15.9	5.5

Note: Specimen no. 220/2 retains the posterior lateral process and, partially, anterior and posterior processes; specimen no. 220/3 retains the posterior lateral and anterior processes and, partially, the anterior lateral and posterior processes; and specimen no. 220/1 partially retains the anterior lateral and posterior lateral processes; (H) shell height, (L) shell length, and (NW) number of whorls.

V a r i a b i l i t y is manifested in the extent of development of carinae on the lateral processes (from slightly carinate to sharply carinate) and respective grooves on the opposite side. The angle between the posterior lateral process and the shell axis also varies; in this connection, this process sometimes rises above the initial whorls or terminates short of reaching them. The size of processes relative to the shell vary.

C o m p a r i s o n. The new species differs from the very close species *T. striatocarinatum* in the thicker carinae and the presence of three spiral ribs above the first carina (versus five ribs in *T. striatocarinatum*). From a form that Golovinova and Guzhov (2009, p. 35, pl. 2, fig. 8) referred to as *T. striatocarinatum*, specimens of *T. polivnense* of the same age differ in the more strongly developed first carina compared to the second (in *T. striatocarinatum*, these carinae are approximately equally developed), the considerably narrower spiral ribs, and in the greater number of axial ribs (approximately 50 versus 30 per whorl).

The differences from *T. kremenkense* sp. nov. and *T. tenuicarinatum* sp. nov. are considered below, accompanying descriptions of these species. The differences from other related species were considered in the previous study (Blagovetshenskiy and Shumilkin, 2006).

O c c u r r e n c e. Upper Hauterivian, *decheni* Zone; Volga Region near Ulyanovsk.

M a t e r i a l. Thirty well and satisfactory preserved specimens from slightly sandy clay.

Trilemma kremenkense Blagovetshenskiy, sp. nov.

Plate 1, figs. 3 and 4; Plate 2, figs. 1–4

?Aporrhais (*Tessarolax*) *ebrayi*: Pchelintsev, 1926, p. 997, pl. 33, figs. 11 and 12.

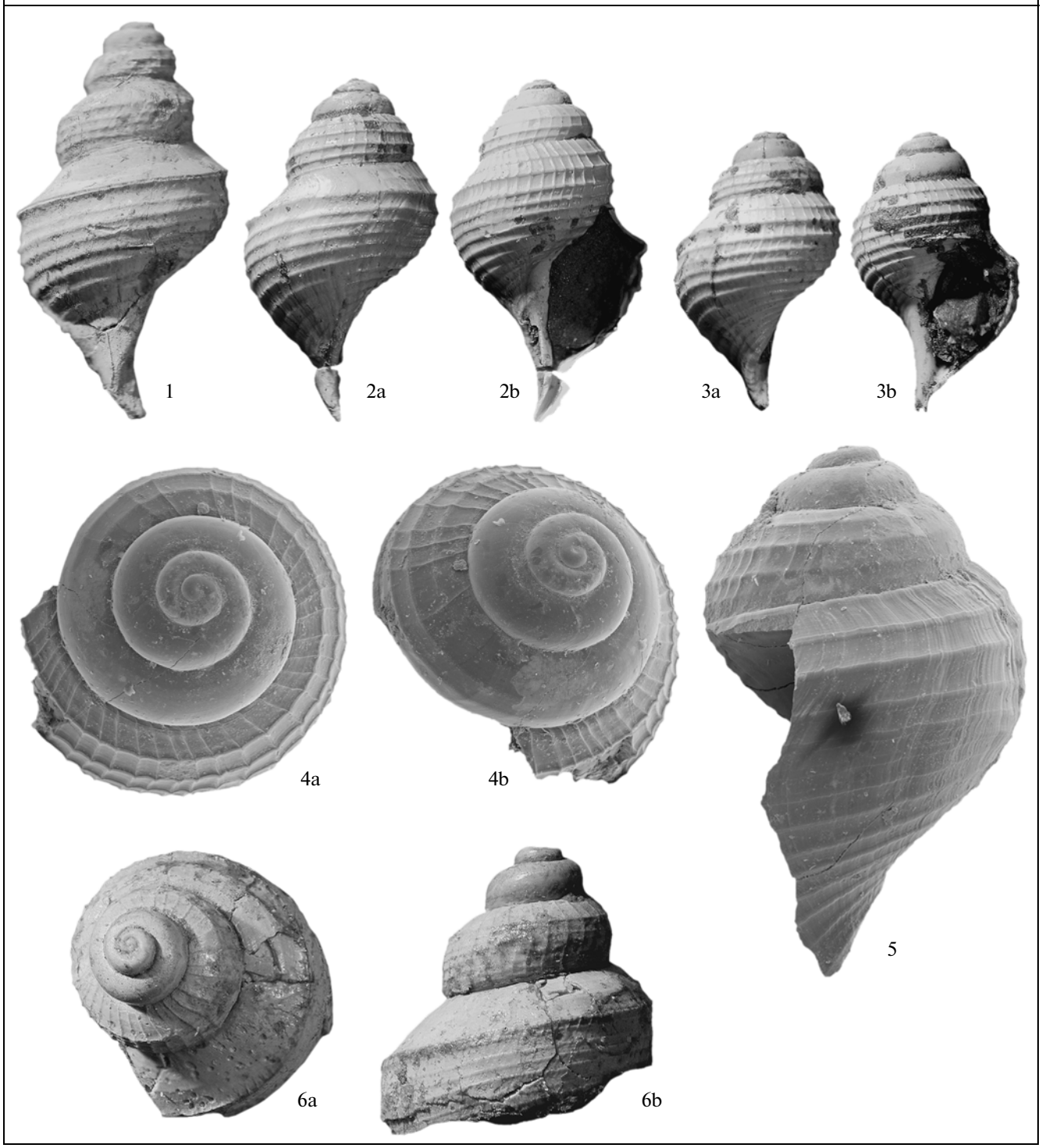
Aporrhais (*Tessarolax*) *ebrayi*: Ivanova, 1959, p. 364, pl. 15, figs. 8 and 9.

E t y m o l o g y. From the village of Kremenki.

H o l o t y p e. ENM UlGU, no. 220/12, Ulyanovsk Region, the village of Kremenki; Upper Barremian, *Oxyteuthis lahuseni* Zone.

D e s c r i p t i o n (Fig. 2). The shell is large, up to 40–45 mm high, spindle-shaped, with a wing-shaped

Plate 2



Explanation of Plate 2

Figs. 1–5. *Trilemma kremenkense* Blagovetshenskiy, sp. nov.: specimen ENM UlGU, no. 220/14, young individual, side opposite to aperture, ×8; village of Kremenki; Upper Barremian, *lahuseni* Zone, Bed br-10; (2) specimen ENM UlGU, no. 220/9, young individual with protoconch, ×12: (2a) side opposite to aperture, (2b) apertural side; Ulyanovsk, Lower Barremian, *jasikofiana* Zone, Bed br-6; (3) specimen ENM UlGU, no. 220/8, young individual with protoconch, ×12: (3a) side opposite to aperture, (3b) apertural side; the same locality and age; (4) specimen ENM UlGU, no. 220/4, protoconch, ×40: (4a) top view, (4b) oblique top view; the same locality and age; (5) specimen ENM UlGU, no. 220/5, young individual with protoconch, ×40; the same locality and age.

Fig. 6. *Trilemma tenuicarinatum* Blagovetshenskiy, sp. nov.: specimen ENM UlGU, no. 220/29, young individual with protoconch, ×15: (6a) oblique top view, (6b) lateral view; clay quarry, Lower Aptian, *volgensis* Zone, Bed a-8, Novoulyanovsk.

expansion of the palatal margin of the aperture, formed of eight or nine dicarinate whorls. The first carina is located in the middle of the whorl of the spire. The second carina is located just above the underlying suture. At the base of the last whorl, under the second carina, the weaker third carina becomes distinct. The distances between the carinae are almost equal; the third carina is slightly shifted towards the overlying carina. The surface between the carinae is concave; above the upper carina, it is slightly concave, almost flat. The apical angle is 107°, the pleural angle is 47°–51°. The tangential line is almost straight.

The protoconch is smooth, consists of 3.2–3.3 whorls; its boundary with the teleoconch is tentatively determined by the appearance of sculptural elements; beginning from whorls 3.25, spiral ribs appear and, in 0.1 whorls, opisthocyrt axial ribs are observed. On whorls of the spire, four spiral ribs appear; the fifth spiral rib is differentiated below, which is partially covered by succeeding whorls. Beginning from the fifth whorl, the second uppermost rib is strengthened and becomes the first carina and, through a whorl, the fourth uppermost rib becomes the second carina. The sixth uppermost rib gives rise to the third carina, which is only observed on the last whorl of adults. Between the carinae, unstrengthened spiral ribs are retained; one is located between the first and second carinae and one is between the second and third carinae. Secondary ribs between carinae are not formed. Available specimens lack a rib above the first carina. The axial sculpture is composed of thin opisthocyrt ribs, which are about 33 per whorl. The axial ribs are approximately half as wide as spiral ribs; when crossing, they form cells in the shape of squares and rectangles or parallelograms slightly extended along the shell axis. The axial sculpture disappears after 4.3–4.8 whorls; in this place, rather distinct commissures are formed; subsequently, axial elements are only represented by growth lines.

The aperture is elongated elliptical. The upper palatoparietal margin of the aperture passes into the posterior process. The last is fused with the surface of the last whorl up to the first carina. The palatal margin of the aperture is expanded wing-shaped and has two narrow triangular processes. The posterior lateral process, which continues the first carina, is positioned almost horizontally or curved slightly posteriorly. The anterior lateral process, which continues the second carina, is directed anteriorly and to the right. The anterior process is well developed, curved posteriorly or almost straight. On the apertural side, processes have distinct grooves corresponding to the carinae on the opposite side.

Specimen VDChO, no.	H	L	NW
220/8	4.0	2.5	4.5
220/9	4.9	2.8	5.3
220/14	8.5	4.4	4.5
220/12 (holotype)	26.3	26.0	6

Note: Specimens nos. 220/8, 220/9, 220/14 are young individuals, their processes are undeveloped; specimen no. 220/12 is adult, with a preserved posterior lateral process

Comparison. The new species differs from *T. polivnense* sp. nov. in an almost right angle between the posterior lateral process and the shell axis (in *T. polivnense*, this angle is sharp), the presence in the intercarinal space of adults of one spiral rib (versus three in *T. polivnense*), the less strongly developed first carina compared to the second in young individuals, the fewer axial ribs on whorls, and, hence, the different shape of cells formed by crossing axial and spiral ribs (in *T. kremenkense* sp. nov., the cells are square, rhombic, or slightly extended parallelogram; in *T. polivnense*, these are parallelograms extending along the shell axis). It differs from *T. striatocarinatum* in the thicker carinae and one spiral rib in the intercarinal space of adults (in *T. striatocarinataum*, there are three ribs).

The new species differs from *T. russiense* (Blagovetshenskiy and Shumilkin, 2006, p. 38, pl. 5, figs. 1–9) in the thicker carinae, the development of two upper carinae formed of the second and fourth uppermost spiral ribs (in *T. russiense*, they are formed of the third and fifth ribs), the smaller pleural angle (50°–53° versus 65°–68°), and the more elongated shell (in the last two cases, young individuals of approximately the same age were compared).

It differs from the form referred by Golovinova and Guzhov (2009, p. 35, pl. 2, fig. 8) to *T. striatocarinatum* of the same age (Pl. 2, fig. 1) and younger individuals (Pl. 2, figs. 2, 3) in the considerably narrower spiral ribs.

It differs from *T. bicarinatum* (Leymerie, 1842, pp. 14, 31, pl. 17, fig. 14), *T. ebrayi* (Loriol, 1882, p. 25, pl. 3, figs. 16–20), *T. fittoni* (Gardner, 1875b, p. 293, pl. 7, fig. 4), and *T. retusum* (Gardner, 1875a, p. 52, pl. 3, figs. 1–6) in the presence of the third carina. It differs from *T. moreausianum* (d'Orbigny, 1842–1843, p. 301, pl. 211, figs. 1, 2) in the posterior process fused only with the last whorl (in *T. moreausianum*, the posterior process is fused with all overlying whorls), the gradually narrowing anterior lateral and posterior lateral processes (in *T. moreausianum*, they are sharply narrowed), and in the presence of one spiral rib in the intercarinal space (versus two in *T. moreausianum*).

Remarks. Specimen UPM, no. 519 (Blagovetshenskiy and Shumilkin, 2006, pl. VI, fig. 1.), which we originally determined as *T. striatocarinatum*, is

probably *T. kremenkense* sp. nov., because its posterior lateral process is directed almost perpendicular to the shell axis, which is characteristic of the last species, and probably comes from the Barremian of the Volga Region near Ulyanovsk. Doubts arising concerning the geological age are also caused by the absence of primary geographical and stratigraphical data on specimen UPM, no. 519 (they were reconstructed a posteriori based on indirect data).

Material. Forty well and satisfactory preserved specimens from silty clays of the Barremian and basal Lower Aptian, *jasikofiana* Zone: specimens ENM UlGU, nos. 220/4, 220/5, 220/6, 220/7, 220/8, 220/9; Bed br-6, Ulyanovsk (K_1br_1j); *pugio* Zone: specimens ENM UlGU, nos. 220/10, 220/11; Bed br-8, Ulyanovsk (K_1br_2l); *lahuseni* Zone: holotype ENM UlGU, no. 220/12, specimens ENM UlGU, nos. 220/13, 220/14, 220/15, 220/16, 220/17, 220/18, 220/19, 220/20, 220/21; Bed br-10, village of Kremenki (K_1br_2l); specimen ENM UlGU, no. 220/22; Bed br-14, village of Kremenki (K_1br_2l); basal Lower Aptian, Bed a-0.5, 1 km south of the village of Kriushi (K_1a_1): specimen ENM UlGU, no. 220/23.

Trilemma tenuicarinatum Blagovetshenskiy, sp. nov.

Plate 1, figs. 5–7; Plate 2, fig. 6

Etymology. From the Latin *tenuis* (thin) and *carina* (keel).

Holotype. ENM UlGU, no. 220/24, Ulyanovsk Region, Lower Aptian, *Deshayesites volgensis* Zone, *Volgoceratoides schilovkensis* Subzone.

Description (Fig. 2). The shell is relatively large, up to 35 mm high, spindle-shaped, with an expanded wing-shaped palatal margin of the aperture, formed by 7–9 dicarinate whorls. The carinae are relatively weakly developed; in whorls of the spire, the second carina is usually indiscernible, because it is covered by succeeding whorls. The surface of whorls is weakly convex between the carinae and under the lower carina and flat above the upper carina. The apical angle is 93°–94° and the pleural angle is 41°. The tangential line is weakly convex.

The protoconch consists of 3.2–3.5 whorls, the boundary between the protoconch and teleoconch is not sharp and determined based on the appearance of sculptural elements. The first 3.2–3.3 whorls are smooth; then, thin axial opisthocyrt ribs appear and, simultaneously, a shoulder in the upper part of the whorl is formed. Beginning from the 3.4–3.5 whorls, a rib is formed on the shoulder (later, it becomes stronger and passes into the first carina); below it, six additional spiral ribs are formed (the lower of which is also strengthened in succeeding whorls to form the second carina). Both carinae are distinct in the last whorl. Other elements of the spiral sculpture are represented by secondary and unstrengthened primary ribs. Above the first carina, spiral elements are formed beginning from 4.5 whorls in the shape of two and, then, three very weak ribs, which are retained on the last whorl. They should be regarded as secondary ribs, because they appear somewhat later than other spiral ribs. Between the carinae, five (or, less often, four) unstrengthened primary spiral ribs are retained. In the last whorl, nine or ten spiral ribs are seen below the second carina. The axial sculpture is represented by thin opisthocyrt ribs, which are gradually smoothed, beginning from the 4.5 whorls, and disappear on the last whorl of adults. One whorl has on average 40 ribs. The crossing axial and spiral ribs form cells in the shape of parallelograms extending across the shell axis and, less often, squares or rhombuses.

The aperture is elongated elliptic. The upper palatoparietal margin of the aperture passes into saber-shaped posterior process. In adults, it is fused with all overlying whorls (young specimens have one or two whorls) and continues above the shell apex. The palatal margin of the aperture is expanded wing-shaped and has two processes. The posterior lateral process, which continues the first carina, is saber-shaped, directed initially horizontally to the right and, then, curves posteriorly at an angle of 17° to the whorl axis. Its end is at the level of the shell apex. The anterior lateral process, which continues the second carina, is directed to the right and anteriorly. On the apertural side, both processes have grooves corresponding to the carina on the opposite side. The anterior process (rostrum) is saber-shaped, curves sharply posteriorly.

Specimen VDChO, no.	H	L	NW
220/29	–	3.0	4.7
220/28	12.3	11.1	5
220/25	13.8	13.5	4
220/33	14.4	15.2	5
220/24 (holotype)	27.0	21.5	6

Note: Specimen no. 220/29 is a young individual, with undeveloped processes; 3.2 of 4.7 whorls fit into the protoconch; in specimen no. 220/28, the anterior lateral and posterior lateral processes are preserved, the anterior and posterior processes are partially preserved; in specimen no. 220/25, the anterior, anterior lateral, and posterior lateral processes are preserved and the posterior lateral process is partially preserved; in specimen no. 220/33, the anterior, anterior lateral, and posterior lateral processes are preserved; in specimen no. 220/24, the anterior lateral, posterior lateral, and posterior processes are preserved.

Variability is manifested in the number of spiral ribs between carinae; five are usually present, although there are sometimes four (because of "flattening" of one rib) or six, if a secondary rib appears. The processes develop beginning from a certain age (6–7 whorls); the processes are initially short and almost straight; then, they become longer relative to the shell and curved to a greater extent. The axial sculpture becomes smoother with age.

Comparison. The new species differs from congeners from the Lower Cretaceous of the Volga

Region near Ulyanovsk, including *T. russiense* (Blagovetshenskiy and Shumilkin, 2006, p. 40, pl. V, figs. 2–6), *T. polivnense* sp. nov., and *T. kremenkense* sp. nov. and from *T. striatocarinatum* from the Lower Cretaceous of the Volga Region near Saratov, in the very weakly developed carinae, the absence of the third carina, the presence in the intercarinal space of five (four) spiral ribs (versus one–three in other species), and in the fusion of the posterior process with all whorls (in the species compared, the posterior process is only fused with one or two overlying whorls). The shell of young individuals of the species described differs from that of the above-mentioned species of the Volga Region near Ulyanovsk in the development of the carinae of the first and seventh spiral ribs below the overlying suture (in *T. russiense*, of the third and fifth ribs; in *T. polivnense* sp. nov. and *T. kremenkense* sp. nov., of the second and fourth), in the weaker developed axial and spiral sculpture, and in the shape of cells formed by crossing axial and spiral ribs (parallelogram-shaped, extending across the shell axis in the species described and square, rectangular, and parallelogram-shaped, extending along the shell axis in the species compared). In addition, it differs from *T. russiense* in the smaller pleural angle (55° versus 65°–68°).

It differs from *T. moreausianum* (d'Orbigny, 1842–1843, p. 301, pl. 211, figs. 1, 2), in which the posterior process is also fused with all whorls, in the absence of the third carina and the presence of five ribs in the intercarinal space (versus two in *T. moreausianum*).

It differs from *T. bicarinatum* (Leymerie, 1842, pp. 14, 31, pl. 17, fig. 14), *T. ebrayi* (Loriol, 1882, p. 25, pl. 3, figs. 16–20)), *T. fittoni* (Gardner, 1875b, p. 293, pl. 7, fig. 4), and *T. retusum* (Gardner, 1875a, p. 52, pl. 3, figs. 1–6), which also lack the third carina, in the weaker carinae and abundant spiral ribs in the intercarinal space (five versus one–three).

It differs from *T. retusum* (Kiel, 2006, pp. 466, 467, text-figs. 6.1–6.3) in the weaker carinae, the presence of five spiral ribs in the intercarinal space (*T. retusum* has three), the smaller number of spiral ribs above the first carina (three versus four or five), and in the considerably more convex whorls of the protoconch at the level where sculptural elements appear.

It differs from *T. densestriatum* (Kase and Maeda, 1980, p. 314, text-fig. 10, pl. 36, figs. 1–3) in the weaker carinae, the fusion of the posterior process with all whorls, and the cells extending across the shell axis (in *T. densestriatum*, the cells are square or rhombic).

M a t e r i a l. Fifty well and satisfactory preserved specimens from dark gray clays and carbonate concretions of the Lower Aptian, *volgensis* Zone, *schilovkensis* Subzone: holotype ENM UlGU, no. 220/24; level A8 (carbonate concretion), Volga Region near Ulyanovsk (K_1a_1v); specimen ENM UlGU, no. 220/25; A8 (carbonate concretion), Volga Region near Ulyanovsk (K_1a_1v); specimen ENM UlGU, no. 220/26; level A8 (carbonate concretion), village of Kriushi (K_1a_1v); specimen ENM UlGU, no. 220/27; Bed a-8, 1 km south of the village of Kriushi (K_1a_1v); specimens ENM UlGU, nos. 220/28, 220/29, 220/30, 220/31, 220/32; Bed a-8, Novoulyanovsk, quarry (K_1a_1v); specimen ENM UlGU, no. 220/33; level A8 (carbonate concretion), vicinity of the village of Panskaya Sloboda (K_1a_1v); *matheronianum* Subzone: specimen ENM UlGU, no. 220/34; level A10 (carbonate concretion), Volga Region near Ulyanovsk (K_1a_1v).

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