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New Stratigraphic Scheme of the Lower Aptian in the Volga River Middle Courses

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Abstract—Aptian deposits in middle courses of the Volga River have been under investigation for more than a century. Although stratigraphy was elaborated in detail for that region, new data allowed revision and further development of available stratigraphic schemes. Previously, the age of lower Aptian deposits was traditionally established based on changing ammonite assemblages of the family Deshayesitidae. The studied diverse assemblage of heteromorphic Ancyloceratidae, the habitants of relatively deep basin parts, made it possible to propose a new scheme of ammonoid zonation in the lower Aptian epipelagic deposits of the Russian plate. Many of identified ancyloceratids were established here for the first time. The analysis of coexisting deshayesitids and heteromorphs enabled a correlation of stratigraphic schemes for the monomorphic Deshayesitidae and heteromorphic Ancyloceratidae. The described generic taxa and species are *Volgoceratoides* I. Michailova et Baraboshkin, gen. nov., *V. schilovkensis* I. Michailova et Baraboshkin, sp. nov., *Koeneniceras* I. Michailova et Baraboshkin, gen. nov., *K. tenuiplicatum* (von Koenen, 1902), *K. rareplicatum* I. Michailova et Baraboshkin, sp. nov.

Key words: lower Aptian, Russian plate, Volga River middle courses, Cretaceous, stratigraphy, ammonites.

In the Russian plate, the most complete sections of the Aptian Stage are exposed within the Ul'yanovsk–Saratov syneclise in the Volga River middle courses. The lower Aptian part of the interval is best characterized by fauna and hence studied best. Nevertheless, there are some debatable points concerning both the biostratigraphy of lower Aptian deposits and the structure of the section itself.

A unique section of Aptian deposits was studied in 1995–2000 in the vicinity of the city park Yunost' of Ul'yanovsk. The section appeared due to stripping on the Volga bank for the construction of a new bridge. Other sections of the lower Aptian and Barremian–Aptian boundary interval were studies in landslides on the Volga right bank near the Village of Kremenki, downstream of Novoul'yanovsk, and near Sengilei (Fig. 1). Aptian sections located near Khvalynsk, Vol'sk, and Saratov were studied in 1998–2000. Stratigraphic description of the sections was carried out by Baraboshkin (Moscow State University, MGU) and his colleagues from the Research Institute of Geology of Saratov State University (RIG SSU) and from the Geological Institute of the Russian Academy of Sciences (GIN RAS). Ammonoids and their distribution through the section, as well as distinguishable zonal assemblages, were studied by present authors.

The new biostratigraphic scheme elaborated for the lower Aptian in the Volga River middle courses is based on a layer-by-layer study of sections, new findings of ammonites, and on revision of available collections donated to us by geologists from other institutions. It was this problem that the present work is devoted to.

INVESTIGATION HISTORY

The study of lower Aptian deposits is associated with many researchers who visited the Volga region between Ul'yanovsk and Saratov over 150 years. Sintsov, Sazonova, and Glazunova undoubtedly made a great contribution to the knowledge of this substage. Having started his works in the Saratov and Simbirsk regions in 1866, Sintsov published a series of papers on the geological structure of the regions in the 1870s–1880s. In earlier papers (Sintsov, 1870, 1872a), he described two new species *Ammonites trautscholdi* and *Crioceras tuberculatum*. Moreover, he focused his attention on *Ammonites deshayesi* (Leym.) found near Simbirsk and pictured in the work by Trautschold (1865).

Papers by Sintsov were preceded by Yazykov's works, the *Brief Review of Cretaceous Deposits of the Simbirsk Province* (1832) included. As Sintsov (1872b) reported, Yazykov kept fossils collected by him at the Museum of the Mining Institute, and in 1845, for the first time for the Simbirsk province, he pointed to the presence of ammonites *Ancyloceras* and *Hamites* in the sections he studied. Thus, it was Yazykov who pointed first to presence of Aptian ammonites in the region.

Preliminary brief reports on geological investigations were published by Sintsov in 1873, 1875, 1887

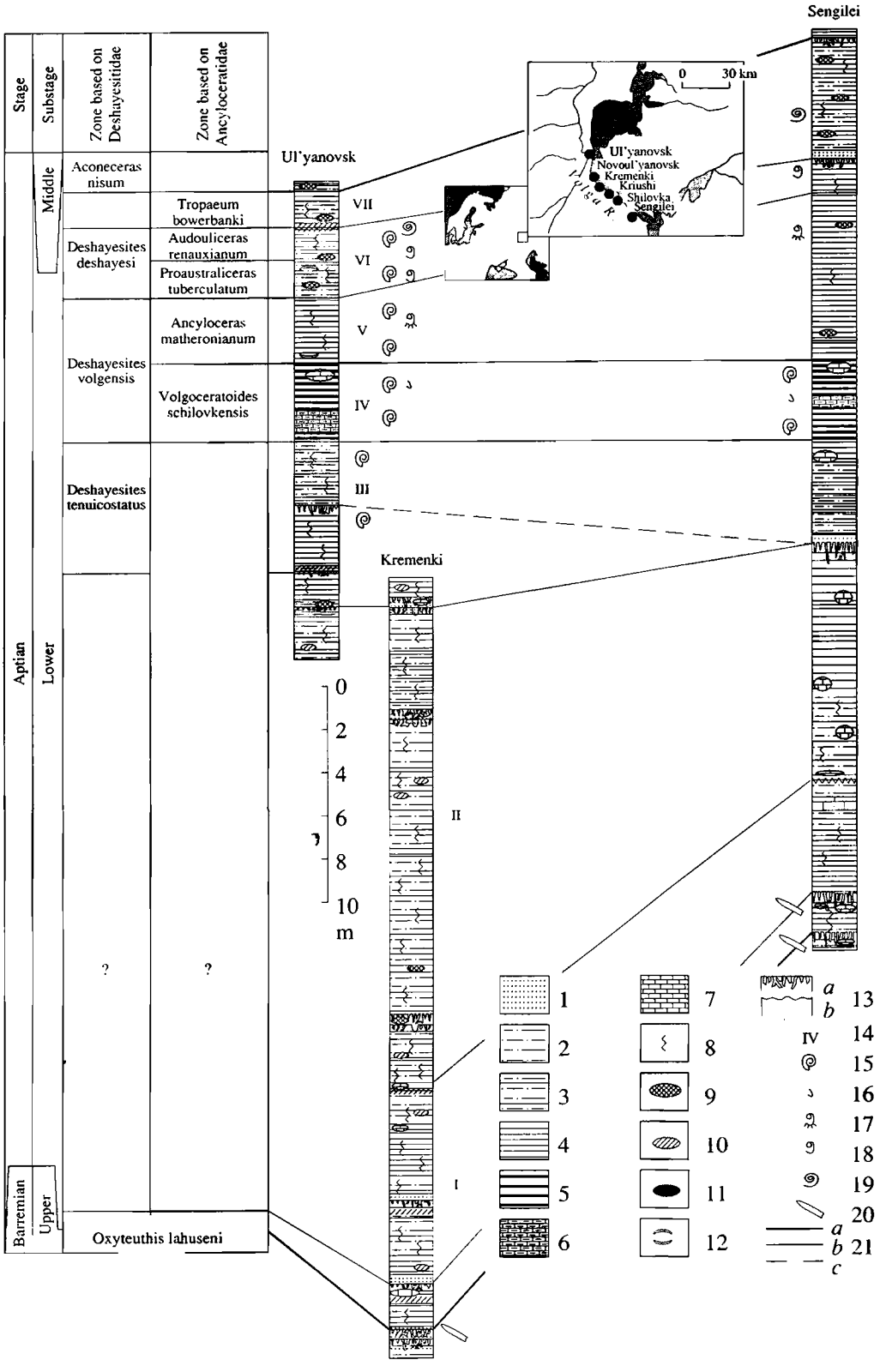


Fig. 1. Localities with ammonite fauna in the Ul'yanovsk region (inset map) and lithostratigraphy of the Ul'yanovsk (exposures near the new bridge), Kremenki, and Sengilei sections: (1) sand; (2) silt; (3) alternating sand and clay; (4) clay; (5) combustible shale; (6) clayey limestone; (7) limestone; (8) bioturbation; (9) siderite concretions; (10) sulfide concretions; (11) phosphorite; (12) shell detritus; (13) softground (*a*) and erosional (*b*) contacts; (14) member nos. after Baraboshkin, (1998); (15) *Deshayesites*, (16) *Volgoceratoides/Koeneniceras*, (17) *Ancyloceras/Lithancylus*, (18) *Audouliceras/Proaustraliceras*, (19) *Tropaeum*, and (20) *Oxyteuthis* faunas; (21) boundaries of stages and substages (*a*), members (*b*), and beds (*c*).

Table 1. Ammonite zonation in the lower Aptian Substage after Sazonova (1958) and Glazunova (1961)

Stage	Substage	Index	*Resheniya...*, 1955; Zonal subdivision for the Caucasus	I.G. Sazonova, 1958; Volga River basin	A.E. Glazunova, 1961; Ul'yanovsk region, Volga River basin
Aptian	lower	$Cr_1apt_1^4$	*Dufrenoya furcata*, *D. subfurcata*	Not dividable into zones	
		$Cr_1apt_1^3$	*Deshayesites dechyi*	*Deshayesites consobrinoides* (Sinz.), *D. deshayesi* (Leym.), *D. dechyi* (Papp), *Sinzovia trautscholdi* (Sinz.), *Corbula polita* Trautsch.	Horizon of uncoiled ammonites: *Ancyloceras gracilis* Sinz., *Ancyloceras* sp., *Deshayesites* sp., *Inoceramus* sp.;
					Deshayesites deshayesi Leym., *D. consobrinoides* Sinz., *Aconeceras trautscholdi* Sinz.
		$Cr_1apt_1^2$	*Deshayesites weissi*	*Deshayesites weissi* (Neum. et Uhl.), *Tropaeum bowerbanki* Sow., *Sinzovia trautscholdi* (Sinz.)	*Deshayesites weissi* Neum. et Uhl., *D. lavaschensis* Kas., *D. ssengillyensis* I. Sas., *Aconeceras trautscholdi* Sinz., *Tropaeum bowerbanki* Sow., *Ancyloceras* ex gr. *matheroni*
		$Cr_1apt_1^1$	*Tropaeum gillsi*, *Matheronites ridzewskyi*	In the south of the Volga River right bank area, south of Saratov; *Matheronites ridzewskyi* Kar.	

and other years. His valuable notes on Aptian ammonites were published a bit later (Sintsov, 1898, 1905). In 1898, he described in detail *Oppelia trautscholdi* Sinz. found near Simbirsk and Saratov, established two new species *Hoplites consobrinoides, H. subfissicostatus*, and reported about *H.* cf. *weissi* Neum. classified in the open nomenclature. Species *Ammonites deshayesi* (Leym.) pictured by Trautschold (1865, Plate III, nos. 16 a–b), as mentioned above, was suggested as a synonym of *H. consobrinoides*. Trautschold's collection is stored at the Timiryazev Agricultural Academy, however, we failed to find here the specimen in question. In 1905, Sintsov described heteromorphic ammonites from the Volga River basin: *Crioceras bowerbanki* J. de C. Sowerby, 1937, *Crioceras gracile* Sinzow, 1870, *Crioceras tuberculatum* Sinzow, 1870, *Crioceras tuberculatum* var. *graciloides* Sinzow, 1870, and *Hamites (?) eichwaldi* Jasykow. He also established a new species *Crioceras laticeps*.

In 1889, Nikitin correlated Aptian deposits of the Simbirsk area with analogous deposits of England and gave a brief characteristics to two ammonites: *Hoplites deshayesi* d'Orb. (Leym.) and *Amaltheus bicurvatus* Mich.

A purposeful study of lower Aptian deposits was resumed in the middle of the 20th century. Works by Sazonova (1954, 1956, 1957, 1958, 1961) and those in co-authorship with Sazonov (1967, 1991) lasted nearly 40 years. The work by Sazonova's *Lower Cretaceous Deposits of Central Areas of the Russian Platform* (1958) occupies an important place in this list that is far from being complete. This work contains description of particular sections in the Ul'yanovsk region (near Sengilei and Kremenki) and elucidates subdivision of these deposits and their correlation with coeval deposits of the Caucasus. Unfortunately, clays abundant in these sections caused numerous landslides that resulted in an erroneous interpretation of successive changes in ammonite assemblages. For instance, Sazonova (1958, p. 66) distinguished two ammonite zones in the Sengilei section and reported that *Deshayesites weissi* (Neum. et Uhl.), *Sinzovia trautscholdi* (Sinz.), *Tropaeum bowerbanki* Sow., *Ancyloceras* ex gr. *matheroni* (Orb.), and *D. ssengillyensis* I. Sason. are characteristic of the lower one, whereas various *Deshayesites* species and *Sinzovia trautscholdi* Sinz. were regarded as forms of the upper zone. Leaving aside some debatable identifications of the species, it is evident that the horizon with uncoiled ammonites occurs below the horizon, in which only monomorphic *Deshayesites* and *Sinzovia* were encountered. The lower assemblage was correlated with the *D. weissi* Zone and the upper one with the *D. dechyi* Zone (Table 1).

The *Matheronites ridzewskyi* Zone, shown in the Table below the two mentioned zones, is not substantiated by fauna from the Ul'yanovsk locality. As to the *Deshayesites weissi* Zone, it is most likely that it was distinguished near Ul'yanovsk in accord with presence of synonymous zone in the unified scheme elaborated for the Caucasus (*Resheniya...*, 1955).

The composition of ammonite assemblages of the *D. weissi* Zone and the overlying *D. dechyi* Zone engages attention. Along with representatives of genera *Sinzovia* and *Deshayesites*, ammonites in the lower of two mentioned zones are represented by heteromorphic *Ancyloceras* ex gr. *matheroni* (Orb.), *Crioceras* (?) *gracile* (Sinz.), *Tropaeum bowerbanki* (Sow.).

In the paleontological part of her work, Sazonova described several species of the *Deshayesites* genus (*D. deshayesi* Leym., *D. consobrinoides* Sinz., *D.* cf. *consobrinoides* Sinz., *D. volgensis* I. Sasonova, *D. weissi* Neum. et Uhl., *D. ssengillyensis* I. Sasonova, *D. evolvens* Lupov) and three species of the *Sinzovia* genus (*S. trautscholdi* Sinz., *S. luppovie* I. Sasonova, *S. saratoviensis* I. Sasonova). Among the described heteromorphic ammonites, there were only *Tropaeum bowerbanki* Sowerby (actually the spiral part of *Audouliceras*) and *Ancyloceras* cf. *matheroni* Orbigny (specimen no. 1 shown in her Plate XII does not belong to this genus and species). In their joint work (1991), Sazonova and Sazonov retained the zonal subdivision mentioned above.

Glazunova started her work in the Volga River middle courses in the 1960s (her works of 1961, 1967, 1968, and others). She collected fossils near Ul'yanovsk and village of Shilovka, i.e., northward from areas studied by Sazonova. "K.A. Kabanov from the Ul'yanovsk Regional Museum took part in some itineraries throughout the region" (Glazunova, 1973, p. 5). He granted some additional material for her study. Later, Kabanov's collection was purchased by the Paleontological Institute of the Russian Academy of Sciences (PIN RAS), and now it is stored here under no. 3390. Some specimens of the collection are exhibited in the Paleontological Museum.

Glazunova in her monograph *Paleontological Substantiation of Cretaceous Subdivisions in the Volga River Areas: The Lower Cretaceous* (1973) disagrees in many instances with inferences made by Sazonova. She calls into question two points. First, her idea of distinguishing the *Deshayesites weissi* Zone, since it is unlikely that the form pictured by Sazonova under this name represents the necessary species (Glazunova, 1973, p. 13). Second, the marker layer in the *D. deshayesi* Zone is known as the so-called Aptian plate, and ammonite assemblage of several *Deshayesites* and *Aconeceras* (= *Sinzovia* according to Sazonova) species is characteristic of the plate and beds below it. In contrast, ammonites found above the plate are of substantially different composition (as reported by Glazunova): in this assemblage, species of the *Deshayesites* genus coexist with abundant uncoiled ammonites. The term "horizon of uncoiled ammonites" was applied for this part of the section as early as in 1961.

Hence, the disagreement in stratigraphic position of the level with uncoiled ammonites is obvious: the level is below the *D. deshayesi* Zone according to Sazonova, whereas Glazunova placed it in the upper part of the *D. deshayesi* Zone above the Aptian plate. Thus, the succession of ammonite zones was inversely understood.

In 1961, Glazunova only noted that she failed to distinguish the *Deshayesites weissi* Zone of Sazonova in the section, but in 1973 she cast doubt on its existence. Glazunova (1973) described in detail a diverse assemblage of *Deshayesites* forms and established five new species of the genus: *D. variabilis, D. kabanovi, D. collevarus, D. lavaschensiformis*, and *D. imitator.* She also identified two new heteromorphic species of the *Australiceras* genus (*A. apticum, A. altum*) and additionally distinguished in Sintsov's collection three species and one variety: *Australiceras rossicus, A. solidum, A. jasykowi, A. simbirskense* var. *sitschevkensis.*

Though the Aptian stratigraphy for the Volga River region has been elaborated in detail, the latest data made it possible to reconsider and supplement the available stratigraphic schemes (Baraboshkin, 1998; Baraboshkin *et al.*, 1999; Mikhailova and Baraboshkin, 2001). Biostratigraphic schemes for this region, like for many other regions of the world (Casey, 1961; Casey *et al.*, 1998; Kemper, 1995, and others), have been worked out on the basis of ammonites of the family Deshayesitidae. In the last decade, lower Aptian arenaceous–argillaceous rocks of the Volga River region were found to contain a rich assemblage of heteromorphic ammonites of the family Ancyloceratidae poorly known before.

Numerous specimens found by Shumilkin, Uspenskii, Efimov, Krivosheev (Ul'yanovsk) and by us, as well as the restudy of specimens collected by K.A. Kabanov and G.K. Kabanov (PIN RAS) showed an extreme diversity of ancyloceratids from the Volga River region. Among them, we identified for the first time many genera, which were unknown in the study area. The revealed succession of heteromorphic genera and species in the section allowed us to propose a new biostratigraphic scheme for the lower Aptian (Mikhailova and Baraboshkin, 2001). Accordingly, we feel it necessary to present here brief information on the lower Aptian biostratigraphy in the Ul'yanovsk–Saratov area of the Volga River region.

The lower Aptian section traceable between the village of Kremenki and Ul'yanovsk is most complete, having the best paleontological characterization (Baraboshkin, 1998; Baraboshkin *et al.*, 1999). The section can be regarded as the reference one for the lower Aptian of the region.

STRUCTURE OF THE REFERENCE SECTION

The section begins near the village of Kremenki (Fig. 1); its lower member is composed of silty clays with interlayers of loose sandstones with siderite concretions. Clays are gray to brownish, bioturbated, containing rare casts and imprints of *Cymbula* aff. *nuda* (Keys.) and *Nucula* sp. An interlayer of bioturbated sandstones, 0.4 m thick, occurs at the top. At the base, the member is bounded by a horizon of giant (up to 1 × 5 m) carbonate concretions. The upper boundary is represented by the "softground" surface and pierced by fucoids of the *Scolithos* type, which are filled with overlying clays. Species *Oxyteuthis lahuseni* (Pavl.), *O. barremicus* Glas., *Oxyteuthis* sp., and fragments of *Cucullaea golowkinskii* (Sinz) were encountered at the

base of sandstones. As for rare belemnites found in the section, their rostra are highly weathered and replaced by gypsum. Species *Oxyteuthis lahuseni* (Pavl.), *O.* aff. *germanica* Stoll, *O.* sp. were found directly below landslides on the sloping beach. The member is 21.7 m thick. It crowns the section of Barremian deposits, the age of which is confirmed by the presence of the reverse magnetic polarity zone (an analog of Chron M0) and by appearance of Aptian dinoflagellate form *Pseudoceratium eisenackii* at the base of the overlying member (Baraboshkin *et al.*, 1999). The following units are distinguished above the latter:

Member I: rhythmic alternation of gray–brown, loose sandstone (0.03–0.1 m), dark gray, clayey silt (0.8–2.0 m), and black clay. Rocks are bioturbated. Clay encloses abundant weathered marcasite (pyrite) concretions. As a rule, sandstone interlayers bear carbonate concretions, and their roof usually corresponds to the "softground" surface. Upper parts of the rhythms are brown, colored with iron oxides. The member includes three rhythms, 10.2 m thick in total.

Member II: rhythmic alternation of dark gray, silty, bioturbated clay (2–5 m) and brown, loose, glauconite–quartz sandstone (0.2–0.5 m). Clays bear weathered marcasite (pyrite) concretions, whereas carbonate concretions are characteristic of sandstones. "Softground" surfaces are usually encountered in the roof of sandstone beds. The member includes four rhythms. The total thickness is 22–23 m. The ammonite species *Deshayesites* cf. *tenuicostatus* (von Koenen, 1902), as well as bivalves *Arctica* (?) sp. and *Cymbula nuda* (Keys.) were encountered in landslide from the upper part of the member.

Units described further are exposed near a new bridge in Ul'yanovsk and continue the section.

Member III: rhythmic alternation of green–brown loose glauconite–quartz sandstone (0.2–0.5 m), dark gray clay (0.2–3.0 m), gray banded bioturbated clay (1.5–2.0 m), and silty clay with siderite concretions. "Softground" surfaces occur at the base of each sand interlayer. The member includes three rhythms, the total thickness of which is 7.8 m. The roof of the upper rhythm is eroded. The ammonite species *Deshayesites* cf. *tenuicostatus* (von Koenen, 1902), bivalves *Cymbula nuda* (Keys.) and *Neocomiceramus volgensis* (Glas.), and abundant serpulids *Ditrupa notabile* (Eichw.) were encountered in the member.

Member IV: black combustible shale with large, closely spaced carbonate concretions near the base and with smaller concretions in the upper part; the member exhibits fine alternation of light and black laminae (1–5 mm thick). Large wood fragments, shell detritus, and small phosphate concretions occur at the member base. One or two erosion surfaces are distinguishable in the basal part. Abundant flattened ammonites, aptychi, and fish scales are confined to bedding planes. Some of the latter are almost completely covered with embryonic ammonite shells. These peculiarities, along with a high C_{org} content (up to 6–8%), are indicative of anoxic conditions during sedimentation. Ammonites encountered in the member represent taxa *Deshayesites gracilis* Casey, 1964, *D. volgensis* Sasonova, 1958, *D. forbesi* Casey, 1961, *D. consobrinoides* (Sinzow, 1898), *D. saxbyi* Casey, 1964, *D.* aff. *vectensis* Spath, 1930, *D.* sp., *Paradeshayesites imitator* (Glasunova, 1968), *Obsoleticeras levigatum* (Bogdanova, 1991), and *Sinzovia trautscholdi* (Sinzow, 1870). These forms associate with smaller heteromorphs *Volgoceratoides schilovkensis* I. Michailova et Baraboshkin, sp. nov., *Koeneniceras tenuiplicatum* (von Koenen, 1902), *K. rareplicatum* I. Michailova et Baraboshkin, sp. nov., and with bivalves *Cymbula* sp. and *Phacoides borealis*. It was this level from which Glazunova (1973) had reported findings of *Deshayesites deshayesi*. The member is 3.8–4 m thick.

Member V: homogeneous, dark gray clay with disseminated shell detritus at the base; collected ammonites are *Deshayesites multicostatus* Swinnerton, 1935, *D. consobrinoides* (Sinzow, 1898), *D.* sp., *Paradeshayesites ssengillyensis* (Sasonova, 1958), *P. callidiscus* (Casey, 1961), *P. topleyi* (Spath, 1930), *P. similis* (Bogdanova, 1991), *P. imitator* (Glasunova, 1968), heteromorphic ammonites: *Ancyloceras matheronianum* d'Orbigny, 1842, *Lithancylus* aff. *grandis* (J. de C. Sowerby, 1829), *L. glebi* I. Michailova et Baraboshkin, 2001, *L. grandis* (J. de C. Sowerby, 1829) *L. igori* I. Michailova et Baraboshkin, 2001, *L. russiensis* I. Michailova et Baraboshkin, *L. tirolensiformis* I. Michailova et Baraboshkin, 2001. The thickness is 3–3.2 m.

Member VI: dark gray, bioturbated, silty clay with rare extended lenticular interlayers rich in glauconite–quartz sandy material; organic remains are abundant separated valves *Arctica anglica* (Woods), *Cymbula gardneri* (J. Nikit.), *Modiolus* sp., *Thetironia* sp., *Panopea neocomiensis* (Leym.), *Corbula* sp., *Neocomiceramus volgensis* (Glas.), and *N. borealis* (Glas.). Two horizons of carbonate concretions and disseminated phosphorite are recorded. Ammonite taxa encountered in clay and concretions are *Deshayesites* aff. *rarecostatus* Bogdanova, Kvantaliani, and Scharikadze, 1979, *D.* sp., *Paradeshayesites ssengillyensis* (Sasonova, 1958), *Cheloniceras* ex gr. *cornuelianum* (d'Orbigny, 1841), and nautiluses *Cymatoceras* aff. *bifurcatum* (Ooster, 1858), *C. karakaschi* Shimansky, 1975, *C.* cf. *karakaschi* Shimansky, 1975. Heteromorphic ammonites are characteristic of two levels. The lower one yields species *Proaustraliceras tuberculatum* (Sinzow, 1870), *P. rossicum* (Glasunova, 1973), *P. laticeps* (Sinzow, 1905), *P.* sp., *Pseudoaustraliceras pavlowi* (Vassilevsky, 1908), and *Toxoceratoides* sp. Forms identified at the upper level are *Audouliceras renauxianum* (d'Orbigny, 1842), *Toxoceratoides royerianus* (d'Orbigny, 1842), *T.* ex gr. *royerianus* (d'Orbigny, 1842), and *T.* sp. This member is known as the "horizon of uncoiled ammonites." Its thickness is 4 m.

Member VII: rhythmic alternation of gray clayey silt (0.2 m) and dark gray glauconite-bearing clay (0.2–0.3 m) with shell detritus and fragments of *Cymbula nuda* (Keys.) and *Neocomiceramus borealis* (Glas.). At the base, there are large flat siderite concretions with large ammonites *Tropaeum (Tropaeum) bowerbanki* (J. de C. Sow.) up to 80 cm in diameter and with clasts of inocerams *Neocomiceramus* cf. *borealis* (Glas.). A "softground" surface is developed at the member roof. The thickness is 1.6–1.8 m.

Member VIII begins the middle Aptian sequence. It is represented by dark gray bioturbated clay with shell detritus and several horizons of carbonate and marcasite concretions, septaria included. At the base, there is a thin silt interlayer, and the erosion surface marks the member top. Ammonites collected from the unit are *Tonohamites* sp., *Aconeceras nisum* (d'Orb.), *Nuculana lineata* (Sow.), *N.* sp., *Cymbula gardneri* (J. Nikit.), *Modiolus* cf. *subsimplex* (d'Orb.), *M. reversus* (J. Sow.), *Neocomicermus* cf. *borealis* (Glas.) *Arctica sedgwicki sedgwicki* (Walker), *Venilicardia (V.) protensa* (Woods), *V. (V.)* sp., *Panopea neocomiensis* (Leym.), and *Dentalium?* sp. The thickness is 7 m.

A similar section near Sengilei (Fig. 1) is supplemented with data of I.A. Shumilkin. It is analogous to that located near Ul'yanovsk being less complete in its lower part and, by contrast, more complete in the uppermost lower Aptian interval. We traced the described deposits along the Volga River right bank far to Saratov (Fig. 2).

LOWER APTIAN AMMONITE ASSEMBLAGES FROM THE UL'YANOVSK–SARATOV AREA

Ammonites have not been found in Member I, and its stratigraphic position is established on the basis of dinocyst assemblage and paleomagnetic data (Baraboshkin *et al.*, 1999). First rare ammonites, identified previously as *Deshayesites forbesi* Casey (Baraboshkin, 1998), appear in the upper part of Member II. Revising them together with T.N. Bogdanova, we came to the conclusion that they should be referred to as *Deshayesites* cf. *tenuicostatus* (von Koenen, 1902). As is shown by Bogdanova and Mikhailova (1999), the species are affiliated to the *Deshayesites* but not to *Prodeshayesites* genus (according to Casey, 1960–1980, 1961) that complies with opinion of Kemper (1995) as well. The assemblage from this stratigraphic level is more diverse near Saratov, where the arenaceous facies yield such forms as *Deshayesites tenuicostatus* (von Koenen, 1902, Plate I, fig. 3), *D.* ex gr. *tenuicostatus* (von Koenen, 1902), *D. bodei* (von Koenen, 1902), and *D.* aff. *bodei* (von Koenen, 1902, Plate I, fig. 2), and *D.* sp. (Fig. 3).

In Member III of the Ul'yanovsk section, a single specimen of *Deshayesites* cf. *tenuicostatus* was encountered (von Koenen, 1902). The upper part of the member is eroded in the Ul'yanovsk area, while in the more complete sections near Khvalynsk, we encountered *Deshayesites volgensis* Sasonova, 1958 and *D.* sp. directly below combustible shales of Member IV.

Member IV of combustible shales (the "Aptian plate" level) yields abundant ammonites *Deshayesites gracilis* (Casey, 1964), Plate II, fig. 3; *D. volgensis* (Sasonova, 1958), Plate III, fig. 1; *D. forbesi* (Casey, 1961), Plate III, fig. 2; *D. consobrinoides* (Sinzow, 1898), *D. saxbyi*, (Casey,1964), Plate IV, fig. 2; *D.* aff. *vectensis* (Spath, 1930); *D.* sp., *Paradeshayesites imitator* (Glasunova, 1968); *Obsoleticeras levigatum* (Bogdanova, 1991), Plate II, fig. 1; and *Sinzovia trautscholdi* (Sinzow, 1870), Plate V, fig. 4. Among forms appearing here for the first time, there are small heteromorphic ammonites *Volgoceratoides schilovkensis* I. Michailova et Baraboshkin, sp. nov., Plate VI, figs. 8–11; *Koeneniceras tenuiplicatum* (von Koenen, 1902), Plate VI, figs. 2–5; and *K. rareplicatum* I. Michailova et Baraboshkin, sp. nov., Plate VI, fig. 12.

Forms identified in Member V are *Deshayesites multicostatus* Swinnerton, 1935; *D. consobrinoides* (Sinzow, 1898); *D.* sp. and *Paradeshayesites ssengillyensis* (Sasonova, 1958); *P. callidiscus* (Casey, 1961), Plate I, fig. 1; *P. topleyi* (Spath, 1930); *P. similis* (Bogdanova, 1991), Plate IV, fig. 1; *P. imitator* (Glasunova, 1968), Plate III, fig. 3; and abundant heteromorphic ammonites: *Ancyloceras matheronianum* d'Orbigny, 1842, Plate VI, fig. 7; *Lithancylus* aff. *grandis* (J. de C. Sowerby, 1829); *L. glebi* I. Michailova et Baraboshkin, 2001; *L. grandis* (J. de C. Sowerby, 1829); *L. igori* I. Michailova et Baraboshkin, 2001; *L. russiensis* I. Michailova et Baraboshkin, 2001, Plate V, fig. 2; *L. tirolensiformis* I. Michailova et Baraboshkin, 2001. These forms were found mainly in the upper part of the member. It was believed previously (Baraboshkin *et al.*, 1999) that a stratigraphic hiatus corresponds to this interval in the Ul'yanovsk section. The *Ancyloceras matheronianum* species, found recently by Shumilkin and Uspenskii, confirms presence of the interval with *Ancyloceras* in this section, although it is half as thick as the Sengilei section.

Member VI yields both the monomorphic deshayesitids and heteromorphic ancyloceratids. The Deshayesitidae assemblage is homogeneous for the whole member and includes *Deshayesites* aff. *rarecostatus* Bogdanova, Kvantaliani, and Scharikadze, 1979, *D.* sp., and *Paradeshayesites ssengillyensis* (Sasonova, 1958). In addition, among the encountered forms there were *Cheloniceras* ex gr. *cornuelianum* (d'Orbigny, 1841), Plate IV, fig. 3; *Cymatoceras* aff. *bifurcatum* (Ooster, 1858), Plate II, fig. 2; *C. karakaschi* Shimansky, 1975; and *C.* cf. *karakaschi* Shimansky, 1975.

Representatives of the family Ancyloceratidae constitute two assemblages. The lower consists of *Proaustraliceras tuberculatum* (Sinzow, 1870), Plate V, fig. 1 (= *Ancyloceras simbirskensis* Jasykow sensu Laguzen, 1974, p. 70, Plate VIII, fig. 2 = *Australiceras simbirskense*, Sinzow, 1872, sensu Glazunova, 1973, Bara-

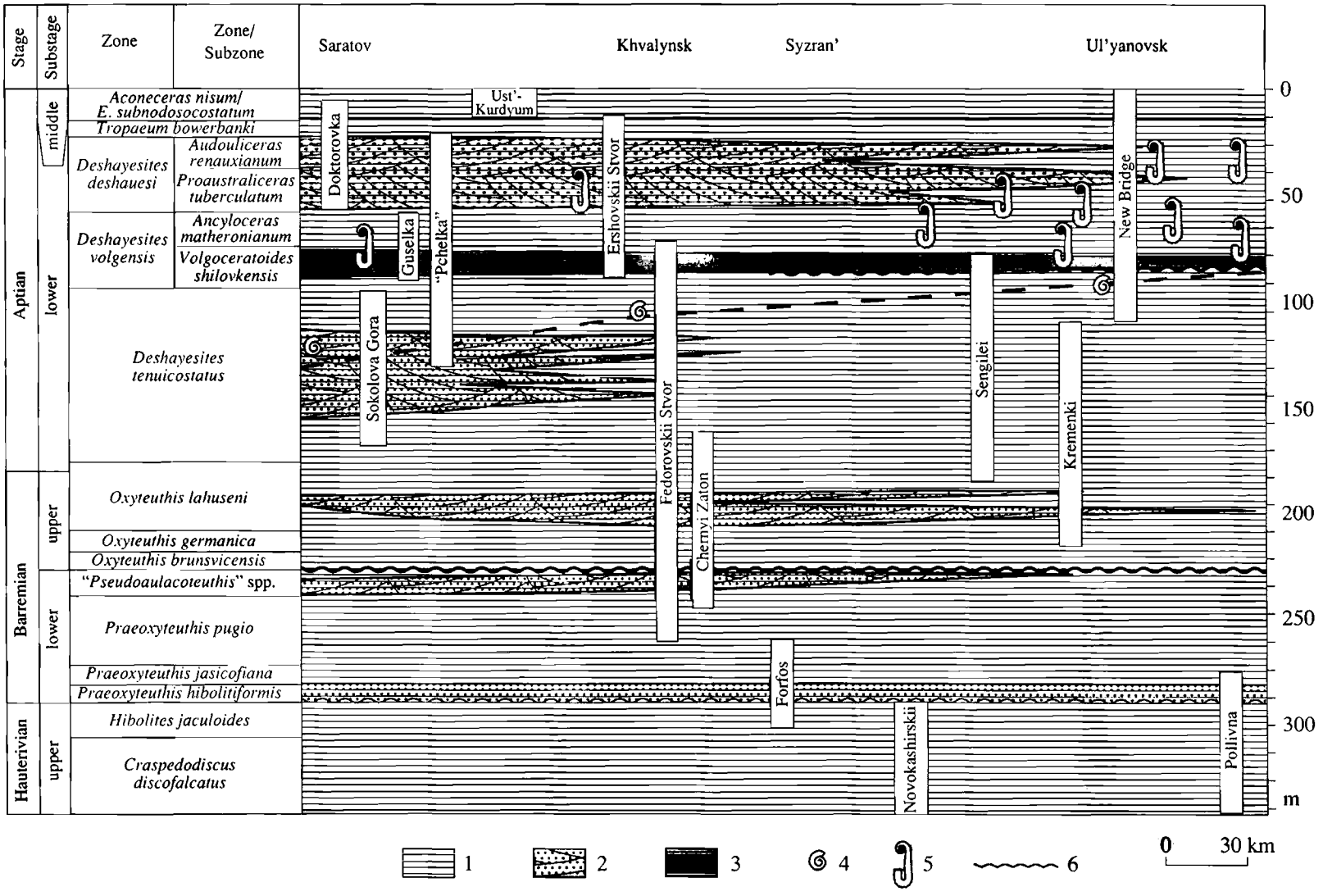


Fig. 2. Facies relationships and localities of lower Aptian sections along the Volga River right bank between Ul'yanovsk to Saratov: (1) clay; (2) obliquely laminated sand; (3) combustible shale; (4) findings of *Deshayesites tenuicostatus*; (5) findings of heteromorphic ammonites; (6) most significant stratigraphic hiatuses.

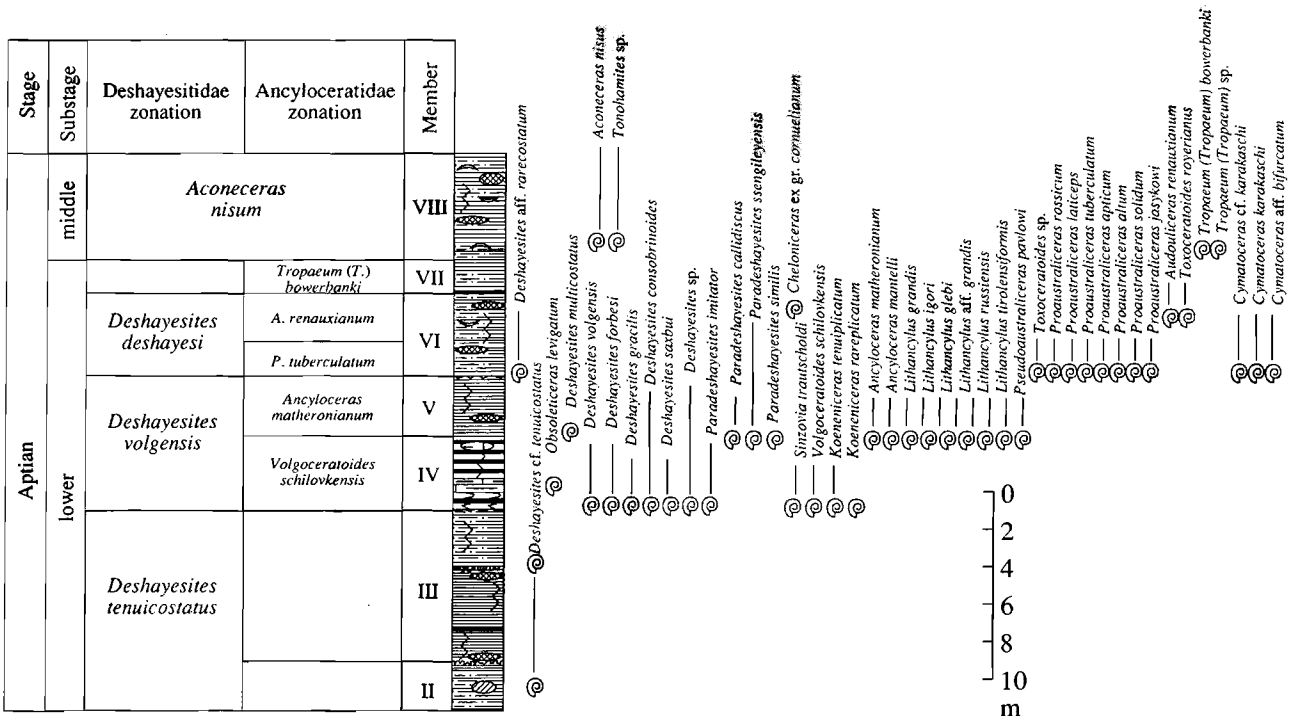


Fig. 3. Stratigraphic ranges of cephalopod mollusks in the lower Aptian section, the Ul'yanovsk region (symbols as in Fig. 1).

boshkin, 1998); *"A." rossicum* (Sasonova, non Casey; = *"Crioceras gracile,"* Sintsov, 1905); *"A."* sp., *Proaustraliceras laticeps* (Sinzow, 1905); *Pseudoaustraliceras pavlowi* (Vassilevsky, 1908), Plate V, fig. 3; and *Toxoceratoides* sp.

The upper assemblage is less diverse, consisting of *Audouliceras renauxianum* (d'Orbigny, 1842), Plate VI, fig. 1; *Toxoceratoides royerianus* (d'Orbigny, 1842), Plate VI, fig. 6; *T.* ex gr. *royerianus* (d'Orbigny, 1842); and *T.* sp.

It is quite likely that *"Australiceras" apticum* and *"A." altum*, which were identified by Glazunova (1973), and *"A." rossicum*, *"A." solidum*, and *"A." jasykowi* and listed based on data by Sintsov (1905) and which should be attributed to the genus *Proaustraliceras*, can characterize the lower part of Member VI. This inference needs however a further verification.

Member VI is more sandy southward, and in the Saratov area it is represented by obliquely laminated sand and sandstone beds, which yield only rare and large *Deshayesites* forms indicative of a strict facies control over the assemblage compositions (Fig. 2).

Member VII crowning the lower Aptian sequence bears rare giant ammonites *Tropaeum (Tropaeum) bowerbanki* J. de C. Sowerby, 1837, Plate III, fig. 4, and *T.* sp. It is also more sandy in southern sections.

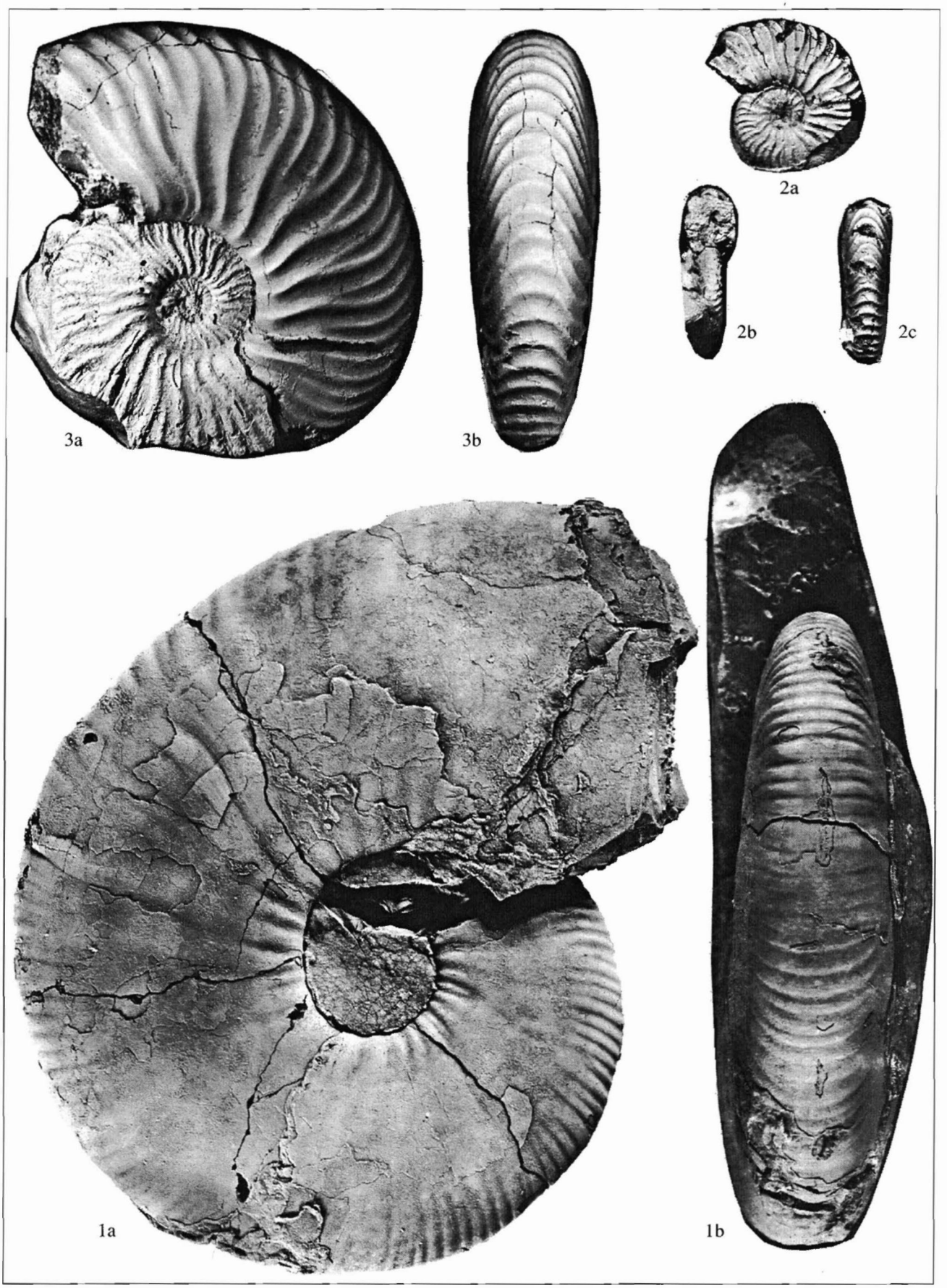
BIOSTRATIGRAPHIC SCHEME FOR THE LOWER APTIAN IN THE VOLGA RIVER MIDDLE COURSES

Owing to new comprehensive data on the distribution of ammonites in sections of the Volga River middle courses, we got a possibility to elaborate two parallel biostratigraphic schemes based on the phylogenetic evolution of representatives from families Deshayesitidae and Ancyloceratidae. For some reasons, such schemes are more preferential compared to synthetic schemes commonly used to subdivide the lower Aptian (Casey, 1960–1980, 1961; Casey *et al.*, 1998; Kemper, 1967, 1995, and others).

Various ammonite groups lived in different ecological (and bathymetric) environments (Westermann, 1990; Bengtson and Kakabadze, 1999, and others) that

PLATES I–VI. Zonal and characteristic cephalopod species from lower Aptian deposits of the Volga River middle courses (natural dimensions if otherwise not specified).

Plate I. (1) *Paradeshayesites callidiscus* (Casey, 1961), sp. 24/96 MPG MGU, side (a) and aperture (b) views, Ul'yanovsk region, the village of Shilovka. lower Aptian, the *Deshayesites volgensis/Ancyloceras matheronianum* Zone (collected by V.M. Efimov). (2) *Deshayesites* aff. *bodei* (von Koenen, 1902), sp. 21/96 MPG MGU, side (a), aperture (b), and ventral (c) views, Saratov, Sokolova Gora, lower Aptian, the *Deshayesites tenuicostatus* Zone (collected by Baraboshkin). (3) *Deshayesites tenuicostatus* (von Koenen, 1902), sp. 22/96 MPG MGU, side (a) and ventral (b) views, the same locality and stratigraphic range (collected by Baraboshkin).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determined their strict facies confinement (in particular, Kakabadze, 1981). This is readily apparent from comparison of ammonite assemblages characterizing the deep-sea sections of the Ul'yanovsk region, which are rich in representatives of Ancyloceratidae, and shallow-water sections of the Saratov area, where heteromorphic ammonites are extremely rare.

The abundance of Deshayesitidae and Ancyloceratidae was controlled by the water temperature as well: *Deshayesites, Proaustraliceras, Ancyloceras, Volgoceratoides*, and *Koeneniceras* forms populated only the northern hemisphere, whereas *Audouliceras, Tropaeum*, and *Lithancylus* taxa were found in both hemispheres (Day, 1969; Klinger and Kennedy, 1977; Kakabadze, 1981; Bengtson and Kakabadze, 1999), where they populated two separate areas (Fig. 4).

The aforesaid means that spatial and time ranges of different phylogenetic ammonite groups were different. This determines the provincial nature of biostratigraphic zones, and, consequently, we cannot avoid the overlapping or gaps between adjacent zones in a unified biostratigraphic scheme based on ecologically different zonal forms.

Taking this into consideration, we suggest two interrelated biostratigraphic schemes for the Volga River middle courses: the first one based on evolution of Deshayesitidae characteristic of shallow-water deposits and the second scheme based on distribution of Ancyloceratidae characterizing deep-water pelagic sequences.

We regard the Deshayesitidae zonation as follows (Table 2):

(1) The *Deshayesites tenuicostatus* Zone (Member II and the lower part of Member III) bears the ammonite assemblage similar to that from the *tenuicostatus* and *bodei* zones of northern Germany (Kemper, 1967, 1995), but we failed to subdivide it into two subunits. The zone can be also correlated with the *fissicostatus* Zone of England (Casey, 1960–1980, 1961), but its correlation with zonal schemes of Turkmenistan and Northern Caucasus (Bogdanova and Mikhailova, 1999), and with that of southeastern France (Delanoy, 1995) is impossible, because the analogous index species are unknown.

(2) The *Deshayesites volgensis* Zone (the upper part of Member III–Member V), the index species of which is very similar to and has been previously identified with *Deshayesites forbesi* Casey, 1961, from England (Baraboshkin, 1998; Baraboshkin *et al.*, 1999); it is not inconceivable that being further studied the last species could be included into the synonymy of the *volgensis* form described by Sazonova in 1958.

(3) The *Deshayesites deshayesi* Zone (Member VI) is distinguished based on its ammonite assemblage, though the corresponding index species has not been encountered in the studied sections. Accordingly, nomenclature can be likely changed in the future. The zone is correlative with synonymous zones of Turkmenistan, Northern Caucasus (Bogdanova and Mikhailova, 1999), England (Casey, 1960–1980, 1961; Casey *et al.*, 1998), Germany (Kemper, 1995), and France (Delanoy, 1995).

Characterization of Ancyloceratidae zonation is as follows (Table 2):

(1) The *Volgoceratoides schilovkensis* Zone (Member IV); representatives of the *Volgoceratoides* and *Koeneniceras* genera are known from the *weissi* Zone of Germany (Koenen, 1902) that corresponds to the *forbesi* Zone of England.

(2) The *Ancyloceras matheronianum* Zone (Member V) bearing ammonite analogous to *Lithancylus grandis* known from the *Deshayesites deshayesi* Zone of England (Casey, 1960–1980). According to the latest data, *Lithancylus* cf. *grandis* and *Ancyloceras* cf. *matheronianum* are known from the *Deshayesites annelidus* Subzone of the *forbesi* Zone of England (Casey *et al.*, 1998), and *Ancyloceras matheronianum* is found in the *weissi* Zone of southeastern France (Delanoy, 1995). These data confirm that mentioned ammonite taxa occur near the boundary between the *forbesi* and *deshayesi* zones.

(3) The *Proaustraliceras tuberculatum* Zone (the lower part of Member VII); representatives of the genus *Proaustraliceras* are known from the upper part of the *Deshayesites grandis* Subzone (the *deshayesi* Zone) of England and from the lower part of the *Tropaeum bowerbanki* Zone (Casey *et al.*, 1998). They are characteristic of lower Aptian deposits in other regions as well (Kakabadze, 1981).

(4) The *Audouliceras renauxianum* Zone (the upper part of Member VII); the index taxon is known from lower Aptian deposits of southeastern France (Thomel, 1964; Delanoy, 1995) and the Caucasus (Kakabadze, 1981), though without the exact zonal position.

(5) The *Tropaeum* (*Tropaeum*) *bowerbanki* Zone (Member VIII); its index species characterizes the *bowerbanki* Zone of England (Casey, 1960–1980, 1961; Casey *et al.*, 1998).

As it is evident, the Ancyloceratidae zonation in relatively deep-water facies of the Ul'yanovsk area of the

Plate II. (1) *Obsoleticeras levigatum* (Bogdanova, 1991), sp. 20/96 MPG MGU, side (a) and ventral (b) views, Ul'yanovsk region, the village of Kriushi, Lower Aptian, the *Deshayesites volgensis/Volgoceratoides schilovkensis* Zone (collected by Uspenskii and Shumilkin). (2) *Cymatoceras* aff. *bifurcatum* (Ooster, 1858), sp. 28/96 MPG MGU, side view, Ul'yanovsk region, Sengilei, lower Aptian, the *Deshayesites deshayesi/Audouliceras renauxianum* Zone (collected by Uspenskii and Shumilkin). (3) *Deshayesites gracilis* Casey, 1964, sp. 25/96 MPG MGU, side (a) and ventral (b) views, Ul'yanovsk region, the village of Shilovka, lower Aptian, the *Deshayesites volgensis/Volgoceratoides schilovkensis* Zone (collected by Efimov).

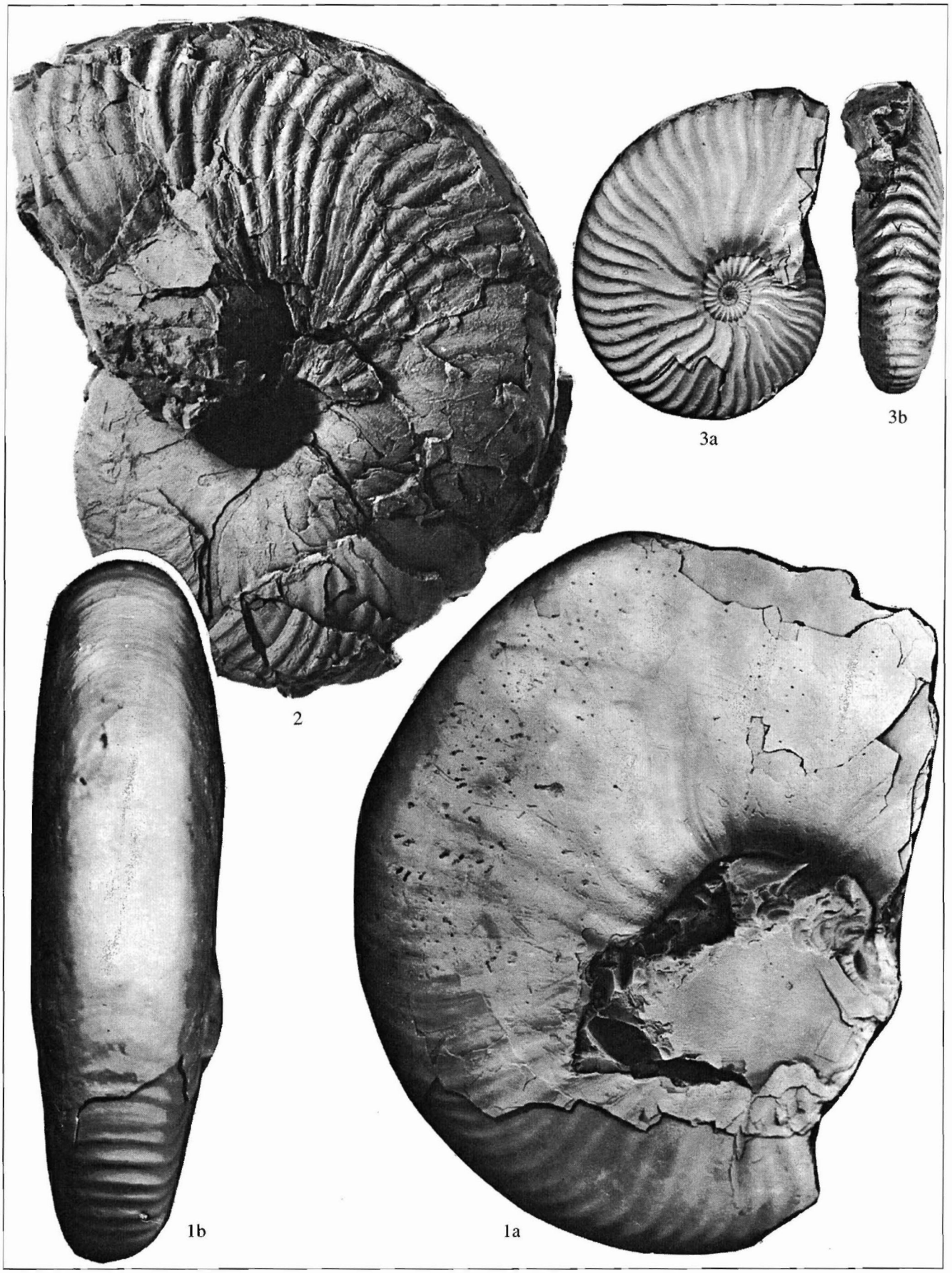
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Plate III. (1) *Deshayesites volgensis* Sasonova, 1958, sp. 30/96 MPG MGU, side (a) and ventral (b) views, Ul'yanovsk region, the village of Shilovka, lower Aptian, the *Deshayesites volgensis/Volgoceratoides schilovkensis* Zone (collected by G.K. Kabanov). (2) *Deshayesites forbesi* Casey, 1961, sp. 2291/3390 PIN RAS, side (a) and aperture (b) views, the same locality and stratigraphic range (collected by K.A. Kabanov). (3) *Paradeshayesites imitator* (Glasunova, 1968), sp. 29/96 MPG MGU, side (a) and aperture (b) views, the same locality, lower Aptian, the *Deshayesites volgensis/Ancyloceras matheronianum* Zone (collected by Efimov). (4) *Tropaeum* (*Tropaeum*) *bowerbanki* J. de C. Sowerby, 1837, sp. 13/96 MPG MGU, side view, magnification ×0.39, Ul'yanovsk, lower Aptian, the *Tropaeum bowerbanki* Zone (collected by Baraboshkin).

Volga River basin is more detailed and more easily recognizable than that of Deshayesitidae.

In conclusion, we present description of new generic and species ammonite taxa. Specimens are stored at the Museum of Physical Geography, Moscow State University (MPG MGU, Collection no. 96), and at the Paleontological Museum, Paleontological Institute, Russian Academy of Sciences (PM PIN RAS, Collection no. 3390). Size parameters of ammonoids and their symbols are shown in Fig. 5. Tables of measurement results also include data on angles between ribs and the trunk line (α_1) and between rib branches (α_3). When describing lobe lines, we used nomenclature of lobes suggested by Ruzhentsev: (V) ventral; (L) lateral; (U) umbilical; (I) internal lateral; (D) dorsal.

Family Ancyloceratidae Gill, 1971

Genus *Volgoceratoides* I. Michailova et Baraboshkin, gen. nov.[1]

Ancyloceras (pars): Koenen, 1902, p. 331.

Toxoceratoides (pars): Klinger and Kennedy, p. 305.

Toxoceratoides (pars): Aguirre Urreta, 1986, p. 295.

Type species: *Volgoceratoides schilovkensis* I. Michailova et Baraboshkin, sp. nov., lower Aptian, the *Deshayesites volgensis/Volgoceratoides schilovkensis* Zone, the Volga River right bank, the Ul'yanovsk region, the village of Shilovka.

Diagnosis. Small hamulicones with arched shells (widely uncoiled spiral) at the early stage and with a trunk and hamulus at the middle and late stages, respectively. Their first whorl and initial chamber are unknown. The section height is less than 1 mm at the beginning of the arch of two specimens. Hence, it is logic to assume that the arching began almost immediately after the first whorl. The living chamber spans half of the trunk and the hamulus. Trunk is sculptured with simple ribs having two rows of tubercles (the lateral and ventral rows); on the hamulus ribs are bifid and intercalating.

The lobe line (Fig. 6) is simple due to small dimensions of *Volgoceratoides* shells. The bifid ventral lobe is complicated by two lateral scallops. The remaining three lobes—umbilical (U), internal (I), and dorsal (D)—are trifid and almost symmetrical. The umbilical lobe is the largest (wide and deep) one, whereas the internal lobe is the smallest. Saddles are bifid, the external saddle (V/U) is asymmetrical.

Composition. *Volgoceratoides schilovkensis* I. Michailova et Baraboshkin, sp. nov., *V. biplicatum* (von Koenen, 1902).

Comparison. The genus differs from *Toxoceratoides* and analogous *Helicancylus* genera in the absence of thickened three-tubercle ribs and in presence of bifid ribs on the hamulus.

When compared with other smaller hamulicones, the genus is the most similar to the upper Barremian genus *Hamulinites*, especially to the group *"Eoleptoceras* (*Tzankoviceras*) *tzankovi* Manolov, 1962" (= *Hamulinites parvulus* according to Vasicek and Wiedmann, 1994). In distinction from mentioned taxa, its smaller hamuli have a peculiar ramification of ribs on their bends, and two rows of tubercles are distinguishable on ribs at the end of spiral and on the trunk. The last of mentioned features is characteristic of the genus *Karstenites*, shells of which are convolute at early stages but lack hamuli.

The genus *Hamiticeras* (especially its species *H. pilsbryi* Anderson) is also similar to the genus in question, but it shows alternation of thick tubercular and thin non-tubercular ribs on the trunk.

The *Volgoceratoides* forms occurring in sections of the Volga River basin (the Ul'yanovsk region) and Germany elucidate origin of the genus: representatives of upper Barremian *Parancyloceras*, the endemics of Northern Europe, are similar in morphology to them.

Distribution, lower Aptian, the *Deshayesites volgensis/Volgoceratoides schilovkensis* Zone of the Russian plate (the Volga River middle courses), the *Deshayesites weissi* Zone of Germany.

Volgoceratoides schilovkensis I. Michailova et Baraboshkin, sp. nov.[2]

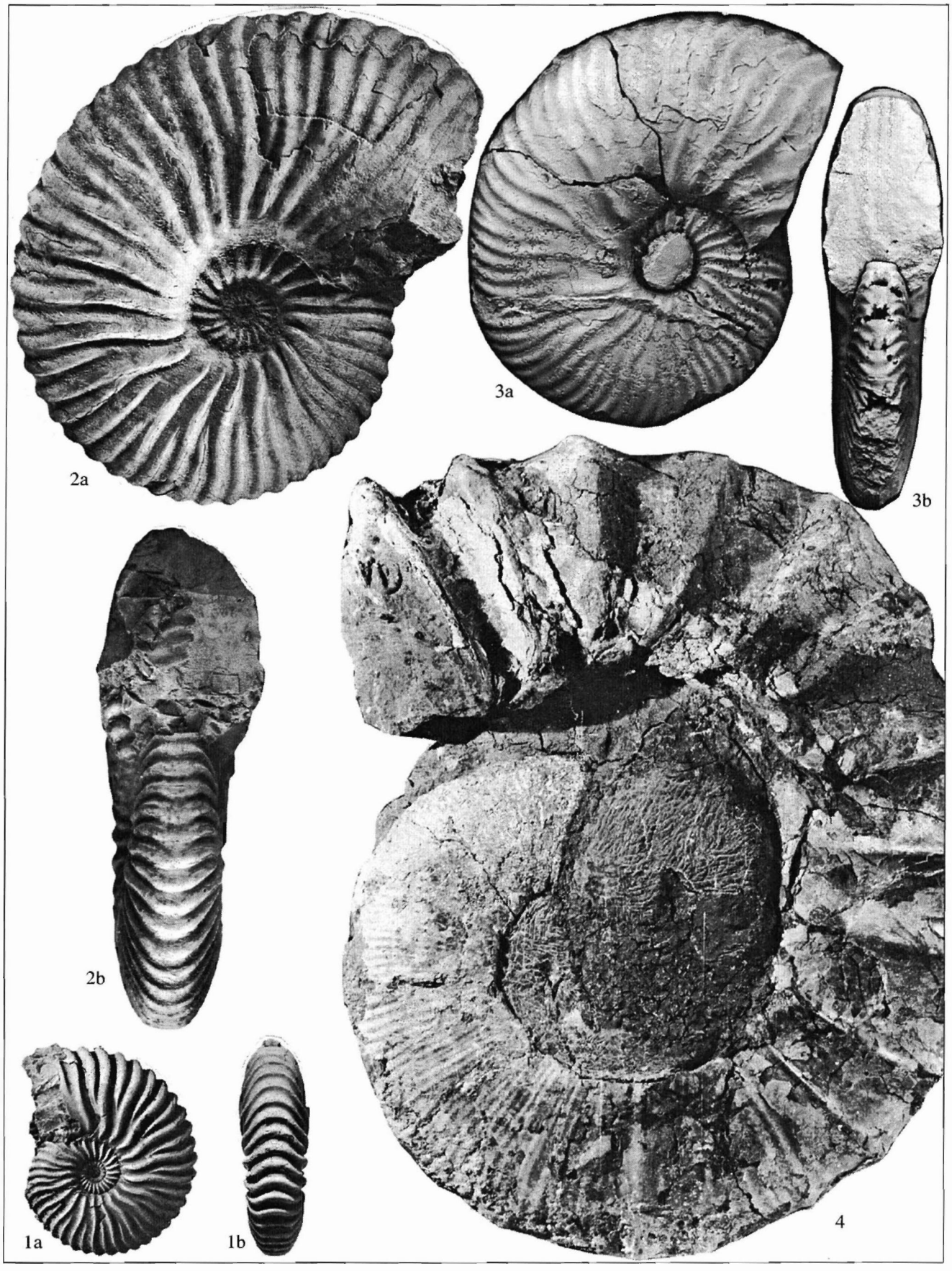
Plate VI, figs. 8–11

Holotype: 2478/3390, PIN RAS, the Volga River right bank, the Ul'yanovsk region near the village of Shilovka; lower Aptian, the *Deshayesites volgensis/Volgoceratoides schilovkensis* Zone.

Material: seven almost whole specimens, one specimen without hamulus, one imprint and several fragments.

[1] The genus name means the eponymous region Volga and Latin terms keras (horn) and oides (species, form).

[2] The species name is after the eponymous village of Shilovka, the Ul'yanovsk region.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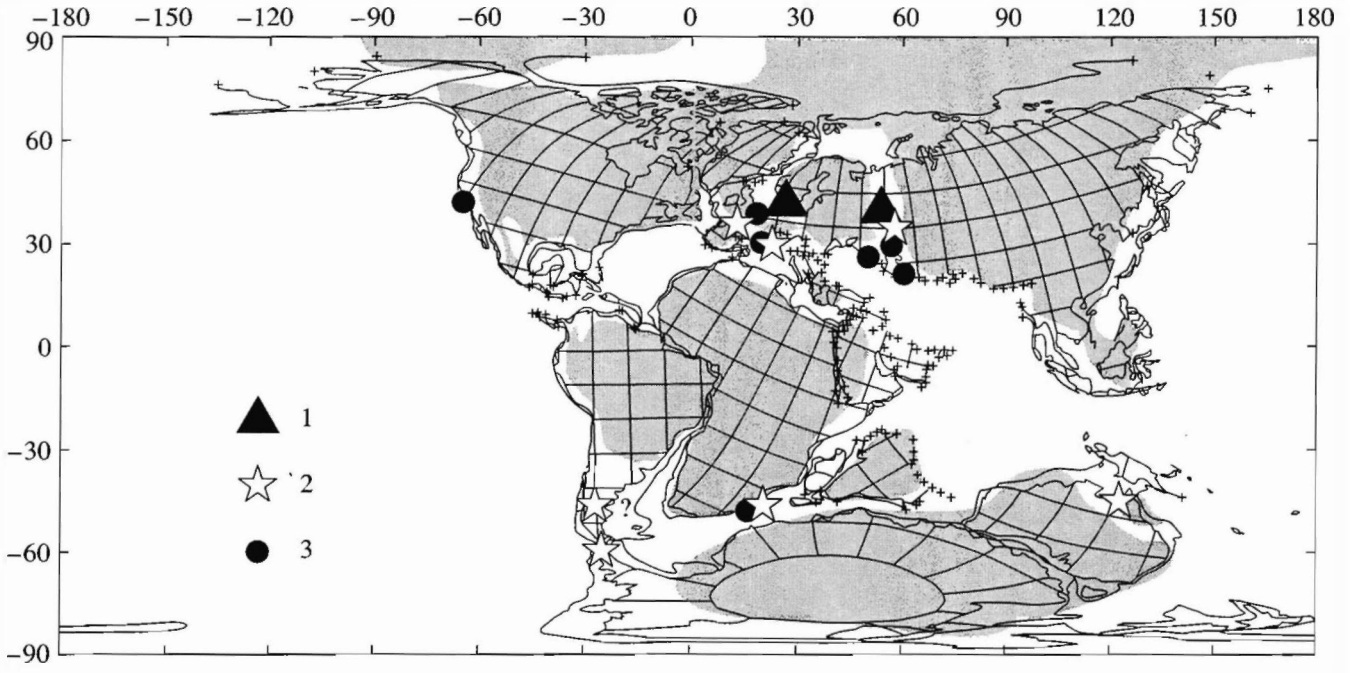

Fig. 4. Geographic distribution of genera *Volgoceratoides* and *Koeneniceras* (1), *Lithancylus* (2), and *Audouliceras* (3). Mercator projection and position of continents after Smith *et al.*, (1981); configuration of continents after Smith *et al.*, 1994 and authors' data.

Description. Shell is small (about 300 mm high), symmetrical, arched, terminated by hamulus, and characterizing three morphogenetic stages. The early stage corresponds to the arched shell 10–15 mm high (wide uncoiled spiral); short trunk appears at the middle stage and hamulus at the late stage. The living chamber occupies the middle part of the trunk and the hamulus. The cross-section is rounded–hexagonal with the maximum flattening on ventral side. We did not observe protoconchs and first whorls.

Sculpturing is clear, when trunk is more than 2 mm high. On the uncoiled spiral part, there are vague, widely spaced, single ribs. From the point of appearance and through the entire trunk, shells have frequent single ribs with two, ventral and lateral rows of small tubercles. Ribs are weakened between tubercles on the ventral side, but they do not disappear. Only near the hamulus bend, ribs ramify in two branches. The ramification point is located, as a rule, in the center of the lateral side or, less frequently, on the bend from the dorsal to lateral side. On the dorsal side, ribs slightly bending backward become lower and disappear at the beginning of the trunk.

Size (mm) and angle (degree) parameters (see Fig. 5 for explanations).

Specimen no.	H	ht*	ht	wt	hb	wb	hh	wh	α_1	α_3	δ
1/96	28	2	4.5		5.5		6		15	12	70
2/96			5.2	5.1	6	7	6.5	6.6	15	13	70
2478/3390 Holotype	<23	2	4.3		5		5.5		15	12	65
2480/3390			4.5	4	5.3		6		13	12	70
3/96			4.3		5				15	12	70
4/96					5	6			15	13	

The lobe line is characterized in the genus description.

Comparison. Similar specimens are pictured in work by Koenen under the name *Ancyloceras biplicatum* (Koenen, 1902: p. 379; Plate XLI, figs. 2a–b, 8a–b). Klinger and Kennedy (1977) attributed the *biplicatum* form to the genus *Toxoceratoides*. Aguirre Urreta (1986) arbitrarily assigned it to the same genus, particularly emphasizing this fact (p. 296). Unfortunately, samples collected by Koenen have not been preserved.

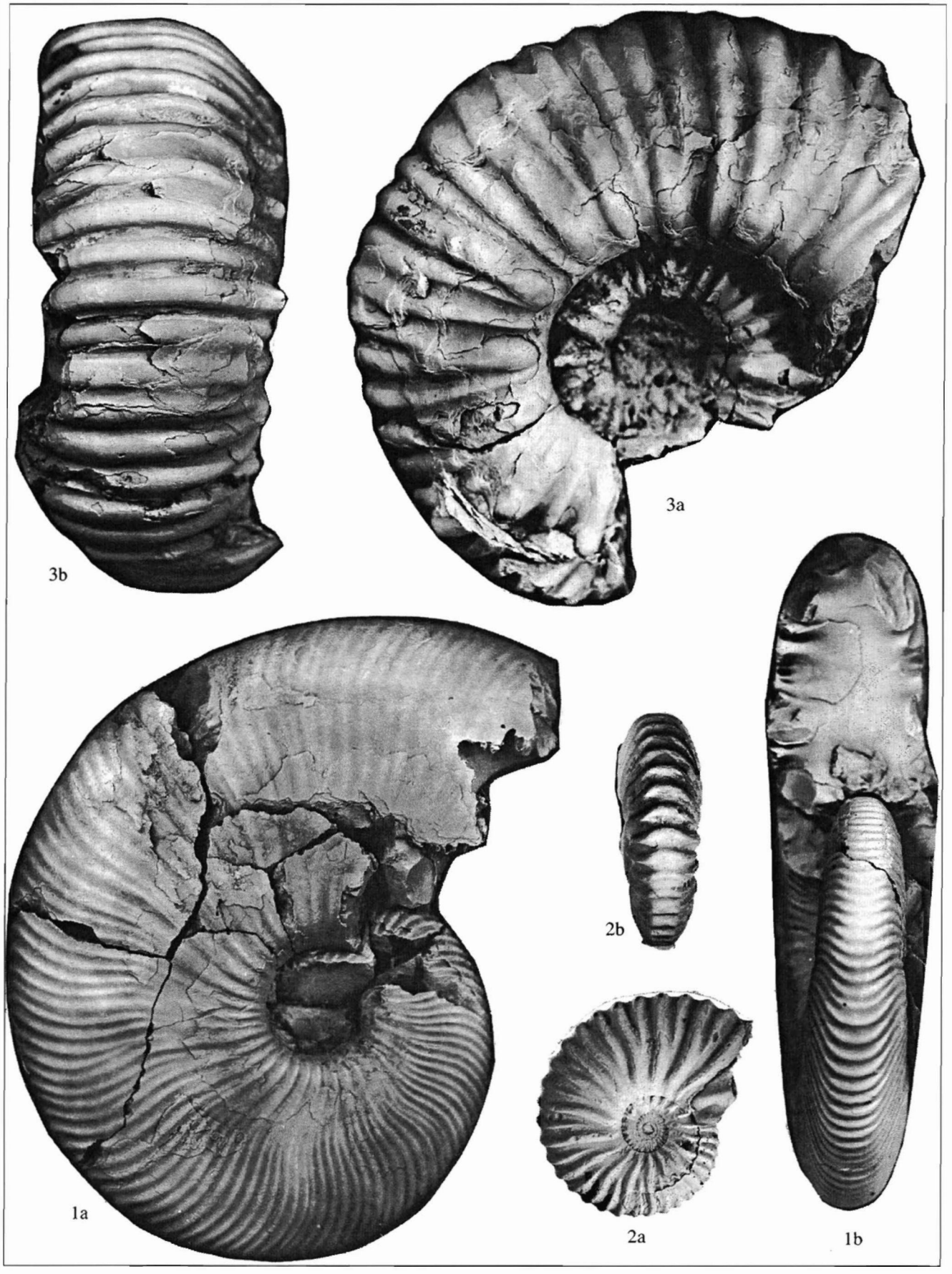
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Plate IV. (1) *Paradeshayesites similis* (Bogdanova, 1991), sp. 23/96 MPG MGU, side (a) and aperture (b) views, Ul'yanovsk region, Sengilei, lower Aptian, the *Deshayesites volgensis/Ancyloceras matheronianum* Zone (collected by Uspenskii and Shumilkin). (2) *Deshayesites saxbyi* Casey, 1964, sp. A/3390 PIN RAS, side (a) and ventral (b) views, Ul'yanovsk region, the village of Shilovka, lower Aptian, the *Deshayesites volgensis/Volgoceratoides schilovkensis* Zone (collected by K.A. Kabanov). (3) *Cheloniceras* ex. gr. *cornuelianum* (d'Orbigny, 1841), sp. 27/96 MPG MGU, side (a) and ventral (b) views, Ul'yanovsk region, Sengilei, lower Aptian, the *Deshayesites deshayesi/Audouliceras renauxianum* Zone (collected by Uspenskii and Shumilkin).

On images, they exemplify only the hamulus fragments, thus giving only a rough idea about the *Volgoceratoides biplicatum* morphology. It is evident from description that the latter has only one row of tubercles. From comparison with our, more complete specimens, it becomes clear that lateral tubercles of the *Volgoceratoides schilovkensis* disappear long before the beginning of the hamulus. Moreover, specimens studied by von Koenen have frontal branches of bifid ribs, which are markedly curved forward on the hamulus.

Distribution: lower Aptian, the *Deshayesites volgensis/Volgoceratoides schilovkensis* Zone of the Volga River middle courses, found in sections near Ul'yanovsk and the village of Shilovka.

Genus *Koeneniceras* I. Michailova et Baraboshkin, gen. nov.[3]

Ancyloceras (pars), Koenen A. von 1902, p. 331.

Type species: *Ancyloceras tenuiplicatum*: von Koenen, 1902; lower Aptian, the *Deshayesites weissi* Zone, northern Germany, Kastendamm.

Diagnosis. Small criocones which had a planospiral, slightly asymmetrical shell with non-joint (macroconchs) or joint (microconchs) whorls at the middle stages. The cross section varies from rounded–hexagonal to nearly round. First whorl and initial chamber are unknown, though it is conceivable that the chamber could form immediately after the first whorl, as one can judge from a small (less than 0.5 mm) section height of the initial part of the spiral. The living chamber corresponds to about a half of the whorl. Sculpture is represented by simple and rarer bifid ribs, and by rare pinches. Ribs have two rows of tubercles: the ventral tubercles are well developed, whereas the lower lateral tubercles decorate only the early whorls. Bifid ribs ramify near the umbilical bend. Ribs do not disappear on the ventral side.

The lobe line (Fig. 6) has trifid lobes, except for the ventral ones. The ventral lobe (V) is shallow, slightly asymmetrical; the deepest umbilical lobe (U) is asymmetrical, with non-equivalent lateral denticles; the internal lobe (I) is small; the dorsal (D) lobe is narrow and elongated. Saddles are bifid, the external saddle (V/U) has unequal sides.

Composition: *Koeneniceras tenuiplicatum* (von Koenen, 1902, *K. rareplicatum* sp. nov.

[3] The genus is named honor of A. von Koenen, the German paleontologist.

Comparison and remarks. As we know, nobody has ever referred so far to the species *tenuiplicatum* von Koenen, 1902. Judging from fragments pictured by von Koenen and from specimens of better preservation found in the Volga River basin area, this genus may be thought of as differing from all known genera.

The most similar is the Hauterivian genus *Aegocrioceras*, the endemic form of northern Europe, which has larger dimensions and shows a lesser rate of the whorl height increase, more rarely arranged ribs, and presence of ventrolateral tubercles only and their earlier disappearance. It is likely that representatives of the *Aegocrioceras* genus could be ancestral forms for the genus *Koeneniceras*.

The genus *Hemihoplites* also slightly resembles the described taxon, but it exhibits a faster linkage of whorls.

Distribution: lower Aptian, the *Deshayesites volgensis/Volgoceratoides schilovkensis* Zone of the Russian plate (the Volga River middle courses), the *Deshayesites weissi* Zone of Germany.

Koeneniceras tenuiplicatum (von Koenen, 1902)

Plate VI, figs. 2–5

Ancyloceras ? cf. *brevispina*: von Koenen, 1902, p. 365, Plate XL, fig. 4

Ancyloceras tenuiplicatum: von Koenen, 1902, p. 377, Plate XLV, fig. 11; Plate LIII, fig. 5

Lectotype: specimen pictured in Plate VIII, fig. 5 (Koenen, 1902), lower Aptian, the *Deshayesites weissi* Zone, northern Germany, Kastendamm.

Material: eight almost whole specimens of good preservation and one large imprint.

Description. Shells are small, slightly asymmetrical, of the crioceratid morphology (up to 40–50 mm in diameter). The cross section is rounded–hexagonal, slightly elongated in height and flattened at the venter. Ribs are frequent, undivided or rarely (up to 1–5 per whorl) bifid, crossing the ventral side with some lowering. At the early whorls, there are two pairs of flattened tubercles: the ventrolateral disappearing by ageing and ventral. Pinches are rare. Micro- and macroconchs are distinguishable.

Macroconchs of the largest dimensions are dominant and abundant. Whorls are out of contact, and sculpture appears relatively late. Tubercles are less prominent than on microconchs. One specimen (10/96) has no tubercles at late stages.

Table 2. Ammonoid zonations and correlation between lower Aptian deposits of the Ul'yanovsk region (the Volga River basin), England, and Germany

Stage	Substage	Casey, 1961; Casey *et al.*, 1998 England		Kemper, 1995 Germany	Baraboshkin, 1998, Baraboshkin *et al.*, 1999 Ul'yanovsk	This work Ul'yanovsk region	
		Zone	Subzone	Zone	Zone	Zone	
						Deshayesitidae	Ancyloceratidae
Aptian	Middle (part)	*Cheloniceras martinoides* (part)	*Epicheloniceras debile*	*Tropaeum drewi* + *Tropaeum tenuinodosum*	*Aconeceras nisum*	*Aconeceras nisum*	
	Lower	*Tropaeum (Tropaeum) bowerbanki*	*Cheloniceras meyendorffi*	*Tropaeum bowerbanki* + *Dufrenoyia furcata*	*Tropaeum bowerbanki*		*Tropaeum bowerbanki*
			Dufrenoyia transitoria				
		Deshayesites deshayesi	*Deshayesites grandis*	*Deshayesites deshayesi* ?	***Deshayesites grandis***	*Deshayesites deshayesi*	*Audouliceras renauxianum*
			Cheloniceras parinodum				*Proaustraliceras tuberculatum*
		Deshayesites forbei	*Deshayesites annelidus*		Beds with *Deshayesites consobrinoides*	***Deshayesites volgensis***	*Ancyloceras matheronianum*
			Deshayesites callidiscus				
			Deshayesites kiliani				
			Deshayesites fittoni		*Deshayesites deshayesi*		*Volgoceratoides schiloivkensis*
		Prodeshayesites fissicostatus	*Prodeshayesites obsoletus*	*Deshayesites tenuicostatus*	*Deshayesites forbesi*	*Deshayesites tenuicostatus*	
			Prodeshayesites bodei	*Deshayesites bodei*	?	?	
Barremian	Upper	Veld		*Parancyloceras bidentatum*	*Oxyteuthis lahuseni*	*Oxyteuthis lahuseni*	

Microconchs exhibit a shortened stage with the poorly developed sculpture. Whorls stop to get into contact when D = 20 mm. Ribs are coarser and have tubercles more developed than those of macroconchs.

Dimensions (mm) and angles (degree)

Specimen no.	D	Ud	H	sbw	W	α_1	α_3
2474/3390	29	12.7	11.4	1	12	–10	5
2297/3390	35	14	12	1.5		–5	
5/96	31	13	11.5	1	8	–10	–5
6/96	~19	9	6		~6	–15	
7/96	13	8	4.4		4	–5	
8/96	20	9	9		8.5	–10	–5
9/96	20.5	8	7		8	–15	
11/96	24.5	11.5	9		7	–5	5
10/96	27.7	11	10.5	2	8	–10	–5

The lobe line is characterized in the genus description.

Comparison. In distinction from *Koeneniceras rareplicatum* sp. nov., ribbing of the described species is more frequent.

Remarks. Among specimens of *"Ancyloceras tenuiplicatum,"* pictured by Koenen (1902, p. 377, Plate XLV, fig. 11; Plate LIII, fig. 5), specimen no. 5 in Plate LIII is proposed to be the lectotype because specimen fig. 11 in Plate XLV likely had some defect in growth. Unfortunately, we failed to find type material of von Koenen in the collection of the Goettingen University Museum.

Distribution is similar to that of the genus *Koeneniceras.*

Koeneniceras rareplicatum I. Michailova et Baraboshkin, sp. nov.[4]

Plate VI, fig. 12

Ancyloceras cf. *tenuiplicatum*: von Koenen, 1902, p. 379, Plate LIII, fig. 4.

Holotype: 33/96 MPG MGU, the Volga River right bank, the Ul'yanovsk region, the village of Shilovka; lower Aptian, the *Deshayesites volgensis/Volgoceratoides schilovkensis* Zone.

Material: one whole well-preserved specimen (microconch).

Description. Shell is small, evolute, and slightly asymmetrical. The cross section is rounded–hexagonal. Ribs are single, embossed, and widely spaced; a bifid rib may occur on the whorl. All ribs intersect the ventral side with a noticeable lowering. Two pairs of small tubercles (ventrolateral and ventral) are present on the early whorls and disappear by ageing.

[4] Name is from Latin rarus (rare) and plicatilis (folded).

By analogy with the type species, the specimen from our collection should be attributed to microconchs: its whorls are in contact and ribbing is rough.

Dimensions (mm) and angles (degree).

Specimen no.	D	Ud	h	w	α_1	α_3
33/96 Holotype	16	7	5.5	6	–10	5

Comparison. Main points are above when describing the species *K. tenuiplicatum* von Koenen. In distinction from new *tenuiplicatum* form, species *"Ancyloceras"* cf. *tenuiplicatum* (Koenen, 1902, Plate LIII, no. 4) has whorls slowly increasing in height and rare ribs. By analogy with the type species, it can be regarded as macroconch of the new species.

Distribution is similar to that of the genus *Koeneniceras.*

CONCLUSION

Sections of lower Aptian deposits in the Volga River middle courses are unique in their completeness and paleontological characteristics. The comprehensive study of these deposits and layer-by-layer collection of ammonites made it possible to elaborate the new biostratigraphic scheme for lower Aptian deposits in the Russian plate. The scheme is as detailed as its analogs elaborated in Turkmenistan, Great Britain, and Germany. In contrast to the last regions, the scheme proposed for the Volga River middle courses is based on evolutionary trends of two parallel ammonite groups: monomorphic neritic Deshayesitidae and heteromorphic subplanktonic, probably benthopelagic *Ancyloceratidae.* This allows correlation between stratigraphic scales of shallow-water and relatively deep, epipelagic sediments accumulated in the basin.

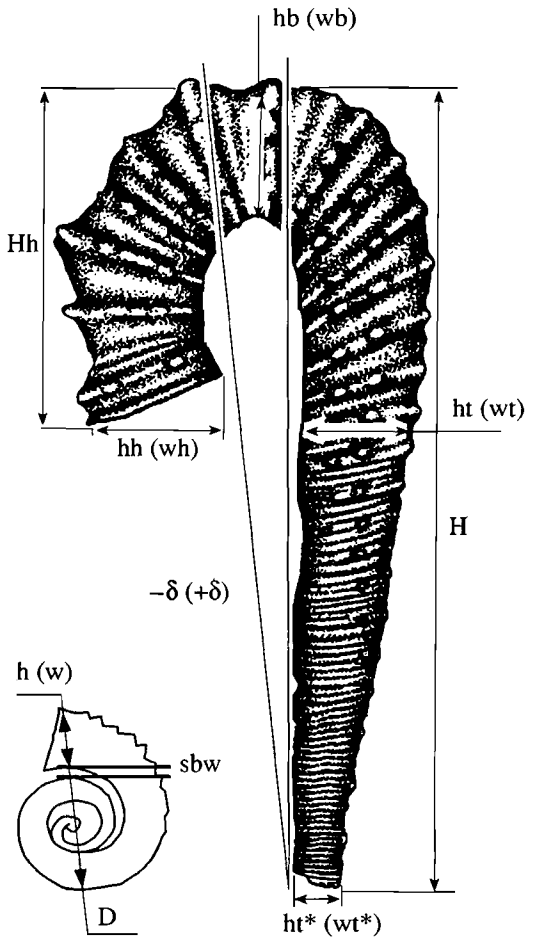


Fig. 5. Morphometric parameters of ammonites: (H) shell height; (Hh) hamulus height; (ht) height of the trunk cross section; (wt) width of the trunk cross section; (ht*) height of cross section at the beginning of trunk; (wt*)width of cross section at the beginning of the trunk; (hb) height of cross section at the bend of hamulus; (wb) width of cross section at the bend of hamulus; (hh) heights of cross section at the end of hamulus; (wh) width of cross section at the end of hamulus; (δ) angle of hamulus bending outward (+) or toward (–) the trunk; (D) diameter of the spiral part; (Ud) umbilicus diameter; (h) height of whorl at the end of spiral; (w) width of whorl at the end of spiral; (sbw) spacing between whorls at the end of spiral.

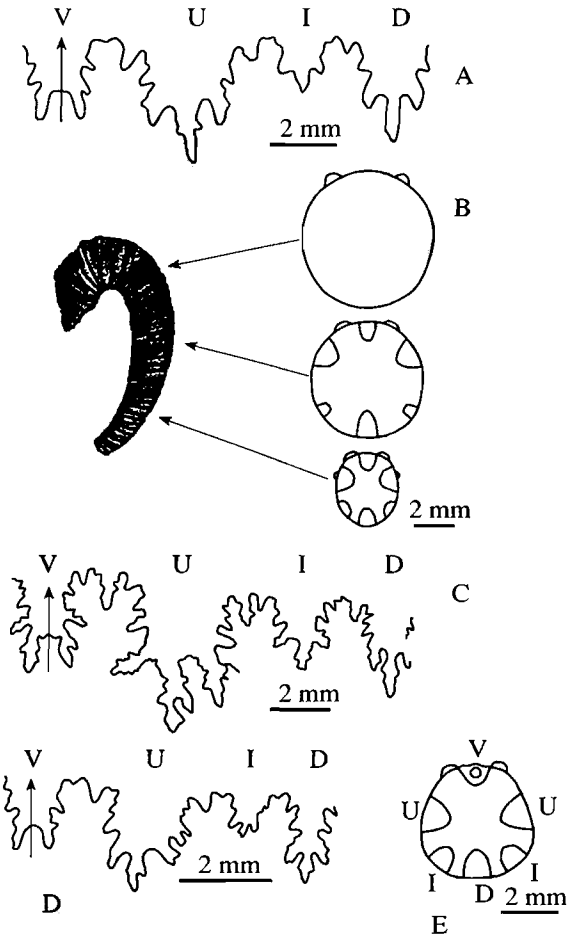


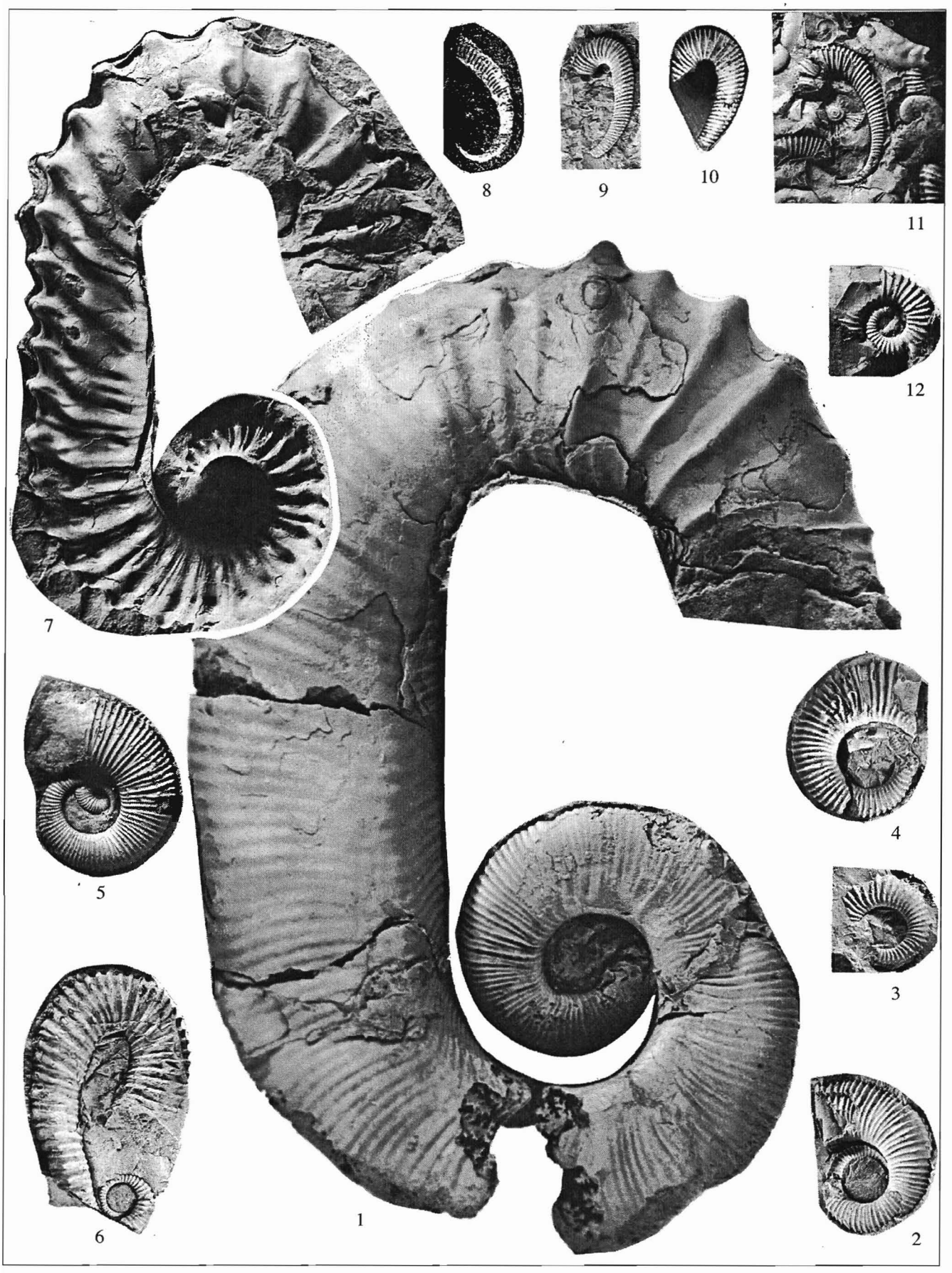
Fig. 6. Lobe lines and cross section configuration of studied ammonites. (A, B) *Volgoceratoides schilovkensis* I. Michailova et Baraboshkin, sp. nov., specimen 2/96 MPG MGU, lower Aptian, the *Deshayesites forbesi/Volgoceratoides schilovkensis* Zone, Ul'yanovsk region, the village of Shilovka: (A) lobe line when h = 4.7 mm and w = 4.4 mm, (B) changes of cross section shape when h = 3.1, h = 4.9, and h = 5.7 mm respectively; (C–E) *Koeneniceras tenuiplicatum* (von Koenen, 1902), the same locality and age: (C) specimen 2474/3390 PIN RAS, lobe line when h = 7.5 mm, (D) specimen 6/96 MPG MGU, lobe line when h = 3.9 mm and w = 3.6 mm, (E) the same specimen, cross section when h = 3.8 mm and w = 3.3 mm.

The *Deshayesites tenuicostatus* Zone was distinguished for the first time in the study region. Its ammonite assemblage is similar to that from the synonymous zone of northern Germany that radically changes our understanding of the sea transgression direction that caused fauna migration at the beginning of the Aptian.

The lower Aptian deposits of the study region were previously attributed to the *Deshayesites deshayesi*

Plate V. (1) *Proaustraliceras tuberculatum* (Sinzow, 1872), sp. 2563/3390 PIN RAS, side view, magnification ×0.7, Ul'yanovsk, lower Aptian, the *Deshayesites deshayesi/Proaustraliceras tuberculatum* Zone (collected by K.A. Kabanov). (2) *Lithancylus russiensis* I. Michailova et Baraboshkin, 2001, sp. 15/96 MPG MGU, holotype, side view, magnification ×0.7, Ul'yanovsk region, Sengilei, lower Aptian, the *Deshayesites volgensis/Ancyloceras matheronianum* Zone (collected by Uspenskii and Shumilkin). (3) *Pseudoaustraliceras pavlovi* (Wassiliewski, 1908), sp. 2506/3390 PIN RAS, ventral (a) and side (b) views, Ul'yanovsk, Solov'ev Ovrag, lower Aptian, the *Deshayesites volgensis/Ancyloceras matheronianum* (collected by K.A. Kabanov). (4) *Sinzovia trautscholdi* (Sinzow, 1870), sp. 1665/3390 PIN RAS, side (a) and aperture (b) views, Ul'yanovsk region, the village of Shilovka, lower Aptian, the *Deshayesites volgensis/Volgoceratoides schilovkensis* Zone (collected by K.A. Kabanov).


4b
4a
3b
1
3a
2


8
9
10
11
12
7
5
4
3
6
1
2

Zone, but we may state at present that the greater part of the section, the shale horizon included, yields the diverse ammonite assemblage of the *Deshayesites volgensis* Zone. The species composition of deshayesitids from this zone is similar in many respects to the ammonite assemblage from the *Deshayesites forbesi* Zone of Great Britain. Moreover, the index *forbesi* species from Great Britain is very similar to the *volgensis* species. If the identity of these forms can be proved in the future, then the *forbesi* form will be transferred to the category of a younger synonym of *Deshayesites volgensis*.

The revised Cephalopoda assemblages highly augmented our understanding of generic and species diversity of ammonoids in the lower Aptian deposits of the Russian plate. Previously, only *Ancyloceras, Tropaeum*, and *Australiceras* genera were known in this territory among heteromorphic ammonites. At present, the list also includes representatives of genera *Volgoceratoides, Koeneniceras, Ancyloceras, Lithancylus, Pseudoaustraliceras, Proaustraliceras, Audouliceras, Toxoceratoides, Tropaeum*, and a series of new forms investigation of which is now in progress.

The list of forms representing Deshayesitidae and genera *Deshayesites, Paradeshayesites*, and *Obsoleticeras* is also substantially extended. The extremely rare *Cheloniceras* forms from the Ul'yanovsk region are pictured for the first time. Nautiloids of the genus *Cymatoceras* found in the region are unique, because none of them have been previously encountered in the Russian plate. Their findings indicate that the early Aptian basin had maximum depth in the period of the *Audouliceras renauxianum* Zone.

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Plate VI. (1) *Audouliceras renauxianum* (d'Orbigny, 1842), sp. 31/96 MPG MGU, side view, Ul'yanovsk region, Sengilei, lower Aptian, the *Deshayesites deshayesi/Audouliceras renauxianum* Zone (collected by Uspenskii and Shumilkin). (2–5) *Koeneniceras tenuiplicatum* (v. Koenen, 1902): (2) sp. 5/96 MPG MGU, side view, Ul'yanovsk region, the village of Shilovka, lower Aptian, the *Deshayesites volgensis/Volgoceratoides schilovkensis* Zone (collected by G.K. Kabanov); (3) sp. 6/96 MPG MGU, side view, the same locality and stratigraphic range (collected by Efimov); (4) sp. 2474/3390 PIN RAS, side view, the same locality and stratigraphic range (collected by K.A. Kabanov); (5) sp. 37/96 MPG MGU, side view, the same locality and stratigraphic range (collected by Uspenskii and Shumilkin). (6) *Toxoceratoides royerianus* (d'Orbigny, 1842), sp. 2510/3390 PIN RAS, side view, Ul'yanovsk region, Sengilei, lower Aptian, the *Deshayesites deshayesi/Audouliceras renauxianum* Zone (collected by K.A. Kabanov). (7) *Ancyloceras matheronianum* d'Orbigny, 1842, sp. 12/96 MPG MGU, side view, Ul'yanovsk region, Novoul'yanovsk, lower Aptian, the *Deshayesites volgensis/Ancyloceras matheronianum* Zone (collected by Krivosheev). (8–11) *Volgoceratoides schilovkensis* I. Michailova et Baraboshkin, sp. nov.: (8) sp. 2481/3390 PIN RAS, side view, Ul'yanovsk region, the village of Shilovka, lower Aptian, the *Deshayesites volgensis/Volgoceratoides schilovkensis* Zone (collected by K.A. Kabanov); (9) sp. 2478/3390 PIN RAS, holotype, side view, the same locality and stratigraphic range (collected by K.A. Kabanov); (10) sp. 2/96 MPG MGU, side view, the same locality and stratigraphic range (collected by Efimov); (11) sp. 1/96 MPG MGU, side view, the same locality and stratigraphic range (collected by Uspenskii and Shumilkin). (12) *Koeneniceras rareplicatum* I. Michailova et Baraboshkin, sp. nov., sp. 33/96 MPG MGU, side view, Ul'yanovsk region, the village of Shilovka, lower Aptian, the *Deshayesites volgensis/Volgoceratoides schilovkensis* Zone (collected by Efimov).

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