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Early Carboniferous Ammonoids from the Chatkal River Basin (Middle Tien Shan, Uzbekistan)

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Abstract—The Late Tournaisian ammonoids from the Kuilyuk Formation and the carbonate massifs of the Chatkal Group were studied in the lower reaches of the Chatkal River (Middle Tien Shan, Uzbekistan). Three successive ammonoid assemblages of the Late Tournaisian *Pericyclus–Progoniatites* and *Fascipericyclus–Ammonellipsites* Genozones were recognized. A new pericyclid genus, Parasiacyclus gen. nov., with the type species *Parasiacyclus chatcalicus* sp. nov., and the new species *Eurites kuilukensis* sp. nov., *Habadraites kulosiensis* sp. nov., and *Nodopericyclus asiaticus* sp. nov. are described. The genus *Muensteroceratoides* Popov, 1965, previously considered as a junior synonym of *Dzhaprakoceras* Popov, 1965 is reinstated and redescribed.

Keywords: ammonoids, Late Tournaisian, Kuilyuk Formation, Tien Shan

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INTRODUCTION

The Late Tournaisian and Early Viséan ammonoid fauna of Central Asia, from the Middle Tien Shan, is one of the most taxonomically diverse such faunas along with the well-known and systematically studied faunas of Western Europe and North Africa. However, in contrast to those faunas, it remains insufficiently studied. Ammonoids from the eastern regions of the Middle Tien Shan (Naryn River basin and Son-Kul Lake) are the best studied because of the work of L.S. Librovitch and A.V. Popov (Librovitch, 1927, 1941, 1947; Popov, 1965, 1968). These authors described a rich ammonoid fauna from the Dzhapryk Formation and mounds in the Akchetash Formation. At present, most workers refer this fauna to the *Fascipericyclus–Ammonellipsites* Genozone that characterized the terminal Tournaisian–Viséan deposits. The age of the ammonoids from Dzhapryk Formation remains debatable. Some authors suggest Late Tournaisian or transitional Tournaisian–Viséan (Riley, 1990, 1996; Korn et al., 2010; Ebbighausen et al., 2010), but this age is not supported by other fossil groups (Djenchuraeva et al., 2013). The latest monographic studies on these ammonoids were published more than half a century ago. Since then the taxonomy, stratigraphic assignments and data on geographic distributions of these taxa have significantly changed, and the previously described taxa require revision.

The data on the Tournaisian and Viséan ammonoids of the western and central regions of the Middle Tien Shan are very scarce. Ammonoid assemblages are briefly mentioned by Nigmadzhanov (1986, 1987a, 1987b), and a brief and not entirely precise description of some species is given in the Atlas of the fossil fauna and flora of the Phanerozoic of Uzbekistan (*Atlas* ..., 2007).

MATERIAL

This study is based on a medium-sized collection (100 specimens) of ammonoids from the Upper Tournaisian basin of the Chatkal River, Middle Tien Shan, housed in the Paleontological Institute, Russian Academy of Sciences. The ammonoids were collected over a number of field seasons in 1982, 1984, 1986, and 1991–1992 by I.M. Nigmadzhanov and O.I. Sergunkova (Stratigraphic Party, Geological Mapping Expedition, Uzbekistan State Geological Committee); two specimens were collected by V.I. Poletaev (Institute of Geological Sciences, Academy of Sciences, Ukraine) in 1990. All these materials were donated to the Paleontological Institute, Russia by I.M. Nigmadzhanov. I collected some specimens during a field trip in 2006 and have studied small additional material from the same region and housed in the Museum of Geology of Uzbekistan in Tashkent (coll. nos. 781, 709).

RESULTS AND DISCUSSION

The ammonoids studied come from a series of localities in the Bostanlyk District, Tashkent Region, approximately 100 km northeast of Tashkent in the lower reaches of the Chatkal River, on the banks of the Mazarsai, Kuilyuk, and Kulosya rivers (Fig. 1). In this region, deposits of the Late Tournaisian are recognized as the Sargardon Horizon of the Chatkal

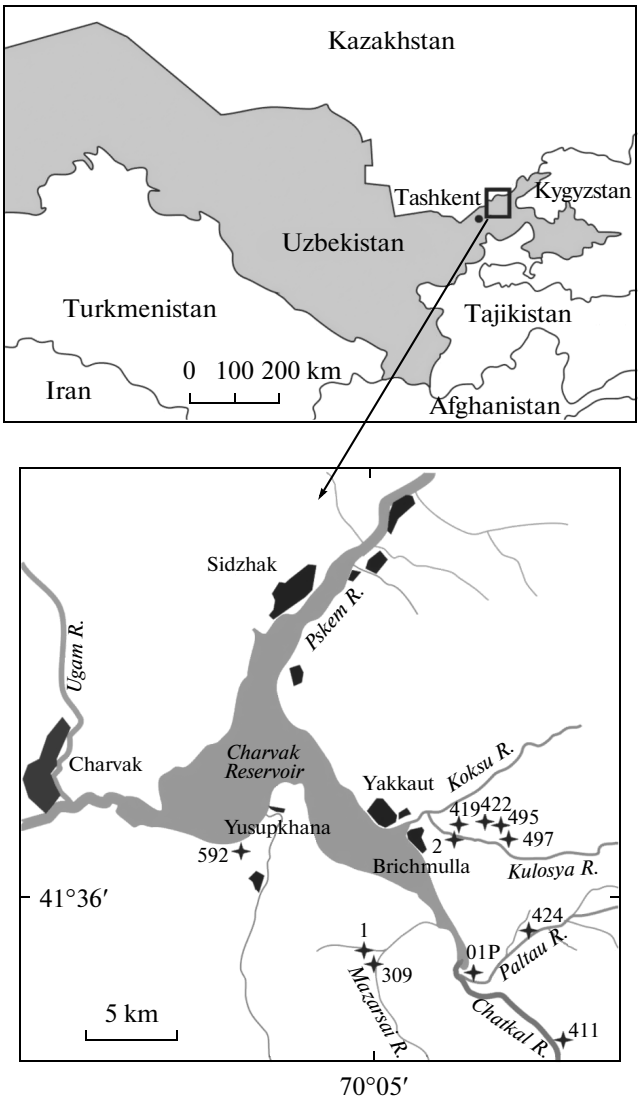


Fig. 1. Ammonoid localities (shown by asterisks). Explanations: (1) Kuilyuk section, (2) Brichmulla, other numbers are other localities.

Regional Stage, which includes two synchronous Sargardon and Kuilyuk formations replacing each other laterally. The Sargardon Formation is represented by thin- and medium-bedded bioclastic limestones, mostly characterized by benthic fossils. The Kuilyuk Formation is composed by cherty carbonates with interbeds of carbonate turbidites, which were formed on the outer slope of a carbonate platform bordering a deep depression. The transitional zone is characterized by the development of large Waulsortian-type mud mounds, recognized as the so-called Chatkal Group and also included in the Sargardon Horizon (*Atlas* ..., 2007). Some of these structures, prominent in the landscape, have been given names, such as the Kulosya Bioherm Range, Aurakhmat Mound, Paltau mounds, and bioherm mounds in the Chavata River basin. The range of the Kuilyuk Formation is determined as an interval between the base of the Upper conodont *Dollymae bouckaerti* of the *semiglaber* Zone to the base of the *texanus* conodont zone and includes the *anchoralis–pseudosemiglaber* Zone of the regional conodont scale (*Atlas* ..., 2007). The mud mounds on the Kulosya and Chavata rivers are dated by conodonts from the base of the conodont *D. bouckaerti* Zone to the *texanus* Zone, age of the Aurakhmat and Paltau buildups as the *D. bouckaerti* Subzone. Nigmadzhanov (1986, 1987a, 1987b, 1989) characterized the conodont assemblages, and described conodonts, stratotype and standard sections of the Kuilyuk Formation and carbonate massifs, and gave their correlation.

Most of the ammonoids studied come from the Kuilyuk Formation and are most widely represented in the "Kuilyuk" and "Brichmulla" sections (Figs. 2, 3). The Kuilyuk section is located 2 km away from the village of Yusupkhana, on the right bank of the Kuilyuk River, 150 m upstream of the mouth of the river and the Mazarsai water catchment station. The section contains the Kulosya, Kuilyuk, and Karatut Tournaisian and Early Viséan formations. The Kuilyuk Formation is composed of members of alternating (beds of 5–10 cm) dark-gray, greenish, and reddish micritic argillaceous and cherty limestones with traces of slumpy sliding of bedding surfaces and beds, lenses and nodules of chert, silicites, and mudstones 0.1-–0.5 thick. The section contains two levels with ammonoids.

(1) **Level 1—**the base of the Kuilyuk Formation. The bed of a micritic, argillaceous, indistinctly bedded, nodular dark gray limestone, 1.5 m thick contained the following ammonoids: *Imitoceras* sp., *Eurites kuilukensis* sp. nov., *Muensteroceratoides aksuensis* Popov, 1965, *Becanites* sp., *Pericyclus* sp. (specimen nos. 593/14, 594) (Fig. 2). The occurrence of *Muensteroceratoides aksuensis*, the type species of the genus, is particularly interesting. The genus *Muensteroceratoides* was established by Popov (1965) based on material from the Dzhapryk Formation developed in the region of Son-Kul Lake and Moldo-Too Range. The re-examination of the holotype of *M. aksuensis* and the study of new material allowed recognition of characters indicated as diagnostic of *Muensteroceratoides* and refinement of the diagnosis of this genus, which was for a long time considered as a junior synonym of *Dzhaprakoceras* (Kuzina, 1980; Work et al., 2000; Petersen et al., 2000; 2010).

The first appearance of ammonoids in the section coincides with the FAD of *D. bouckaerti*, the index species of the upper subzone of the *semiglaber* Zone (Nigmadzhanov, 1987b). The ammonoid assemblage is likely to be synchronous with that from the *Pericyclus – Progoniatites* Genozone proposed by Korn et al. (2007; 2010) in North Africa.

(2) **Level 2.** Approximately 50 m from the previous level the following ammonoids were found: *M. aksuensis* Popov, *Merocanites djaprakensis* Librovitch, *Helicocyclus tianshanicus* (Librovitch), *Dzhaprakoceras*

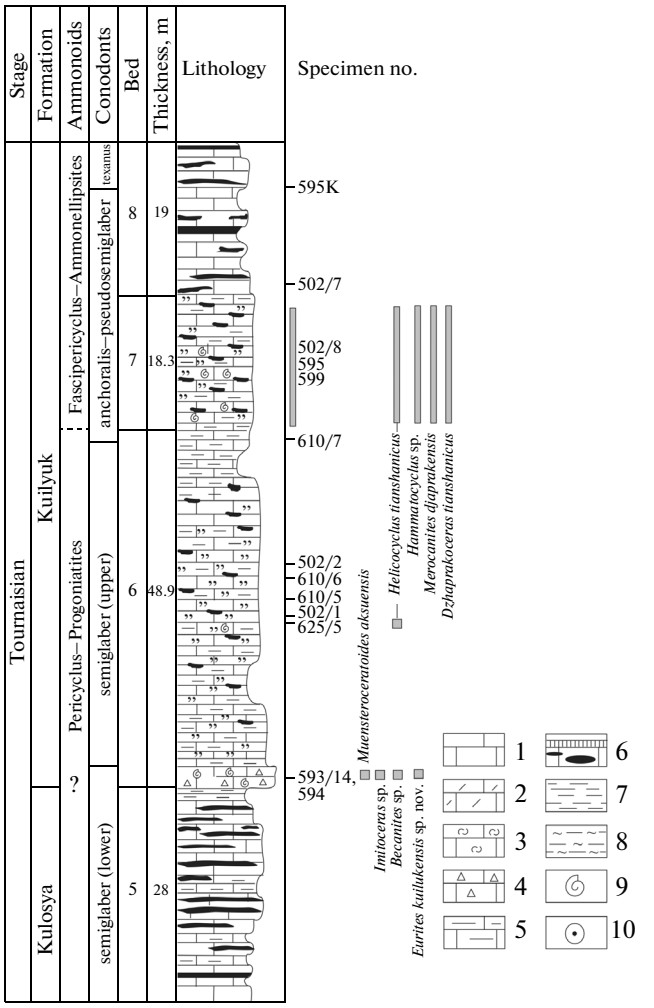


Fig. 2. Distribution of Late Tournaisian ammonoids in the Kuilyuk section. Explanations: (1–6) bedded limestone: (1) micritic and fine-grained, (2) finely bioclastic and microbioclastic, (3) detrital,(4) brecciated, (5) argillaceous, (6) siliceous with beds and lenses of compact chert, (7) mudstones, (8) argillaceous-cherty shale, (9) ammonoids; (10) crinoids. Based on I.M. Nigmadzhanov's data (1987, 2006 pers. comm.).

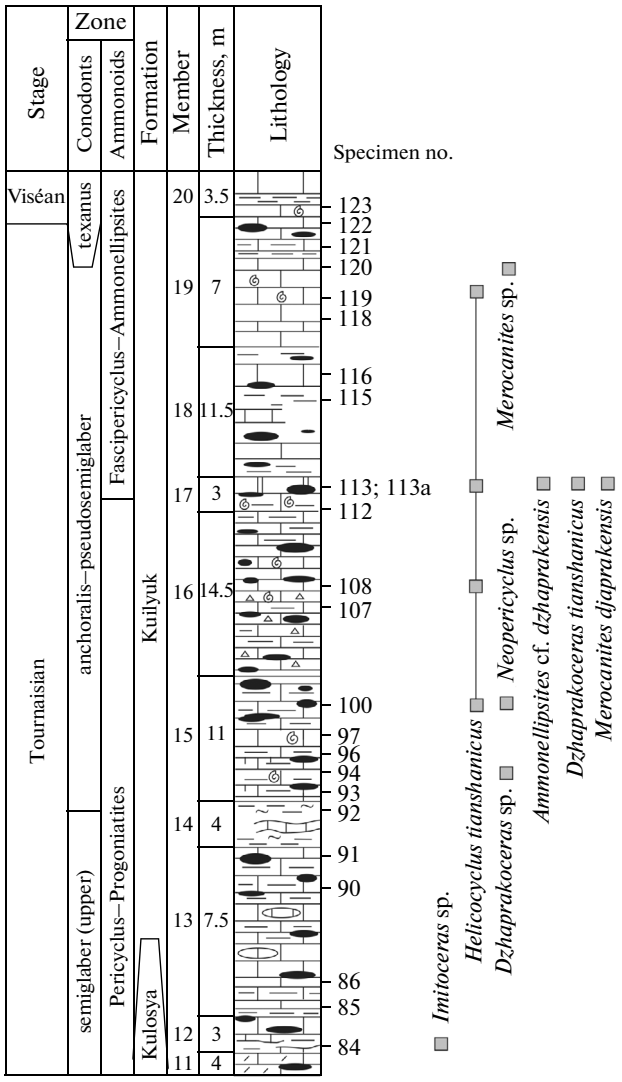


Fig. 3. The distribution of the Late Tournaisian ammonoids in the Brichmulla section. Explanations as in Fig. 2. Composed from I.M. Nigmadzhanov's data (1987, 2006, pers. comm).

tianshanicus Popov, *Hammatocyclus* sp. (Fig. 2). The taxonomic composition of the assemblage is characteristic of the *Fascipericyclus–Ammonellipsites Genozone*. The conodonts found in these beds are characteristic of the Central Asian regional conodont *anchoralis–pseudosemiglaber* zone (Nigmadzhanov, 1987a, 1987b; *Atlas*, 2007).

The Brichmulla section with good ammonoid occurrences is located on the right bank of the Chatkal River near the village of Brichmulla, 250 m north of the "Samorodok" hotel. The section contains the Tournaisian and Early Viséan beds: Koksu, Kulosya, Kuilyuk, and the lower part of the Karatut Formation. The Kuilyuk Formation is underlain by the dark-gray micritic limestone of the Kulosya Formation and conformably overlain by black thinly bedded argillaceous-cherty mudstones and argillites of the Viséan Karatut Formation. The transition between the formations is indistinct and reflects a gradual change in conditions related to a transgression, i.e., the transition of the slope facies to deep-water basinal low-energy deposits.

The distribution of ammonoids is shown in Fig. 3. The section contains two assemblages. The first contains *Imitoceras* sp. (specimen no. B-84), which is similar to *Imitoceras* sp. from the Kuilyuk section and apparently indicates the same level. The conodonts found in association with ammonoids are characteristic of the upper subzone of the *semiglaber* Zone (Nigmadzhanov, pers. comm.).

The second, younger assemblage, similar to Assemblage 2 in the Kuilyuk section is found 20 m above in the section in the interval between specimens

nos. B-100 and B-120. The assemblage contains *Helicocyclus tianshanicus* (Librovitch), *Dzhaprakoceras tianshanicus* Popov, *Merocanites djaprakensis* Librovitch, *Neopericyclus* sp., *Ammonellipsites* cf. *dzhaprakensis* (Librovitch), *Merocanites* sp., *Dzhaprakoceras* sp. These ammonoids are characteristic of the *Fascipericyclus–Ammonellipsites* Genozone and are found in the beds with conodonts of the *anchoralis–pseudosemiglaber* Zone (Nigmadzhanov, 1987a, 1987b).

An ammonoid assemblage similar in composition to the upper assemblage from the Kuilyuk and Brichmulla sections was found in a number of localities representing small outcrops of the Kuilyuk Formation (Outcrops 592, 429a, 305), in limestones of the upper part of the Kulosya mounds (Outcrop 464, Kulosya River) and the bioherm massif on the Chavata River (Outcrop 17). These localities contained *Helicocyclus tianshanicus* Librovitch, Dzhaprakoceras sp., *D.* cf. *tianshanicus* Popov, *Neopericyclus kokjarensis* Popov, *Merocanites djaprakensis* Librovitch. Conodonts found together with ammonoids also characterize the *anchoralis–pseudosemiglaber* Zone (Nigmadzhanov, 1987a).

A small, but taxonomically interesting ammonoid collection from the marginal parts of the mounds of the Chatkal Group: Paltau (Outcrop 424), Aurakhmat (Outcrop 01 – P) and in the lower part of the Kulosya mound range (Outcrop 495, 497, 419) was examined. The ammonoid assemblage contains *Nodopericyclus* asiaticus sp. nov., *Parasiacyclus chatkalicus* gen. et sp. nov., *Habadraites kulosiensis* sp. nov., and *Helicocyclus* sp. Locality 495 also contained a specimen identified in the Atlas of the fossil flora and fauna of Uzbekistan (*Atlas*, 2007, p. 357, pl. 65, figs. 3, 4) as *Neopericyclus kokjarensis* Popov. I re-examined this specimen, which has coarse, bifurcating ribs, forming a shallow ventral sinus and running rectiradiate on the flanks, and three constrictions per whorl, and which belongs to a different genus and species. The suture was not preserved. The suture figured in *Atlas*, 2007 (p. 354, text-fig. 8e) in association with this specimen, was in fact drawn from a different specimen. apparently, no. 6/709, from Outcrop 17 on the Chavata River, which belongs to *Neopericyclus kokjarensis* Popov. The deposits with ammonoids belong to the upper subzone of the *semiglaber* Zone of the regional conodont scale (Nigmadzhanov, 1987a, 1987b, 1989).

Outcrop 422 on the left bank of the Kulosya River, 150 from the mouth, the upper part of the Kuilyuk Formation at the boundary with the upper part of the mound massif contained *Bollandoceras* sp., *Neopericyclus moldotooensis* Popov, *Merocanites djaprakensis* Librovitch, *Dzhaprakoceras* aff. *sonkulica* (Librovitch), *Dzhaprakoceras* sp. the assemblage is in general characteristic of the *Fascipericyclus—Ammonellipsites* Genozone. Unfortunately the stratigraphic log is absent for this outcrop, so the precise position of the ammonoid occurrences in the section is unknown. The occurrence of *Bollandoceras* sp. (Fig. 4j, Figs. 5j, 5k) suggests the presence of younger Viséan beds with ammonoids in this region (of younger beds of *Fascipericyclus–Ammonellipsites* Genozone or even younger *Bollandites–Bollandoceras* Genozone).

The analysis of the taxonomic diversity of ammonoids allows recognition of the following ammonoid assemblages for this region.

Assemblage 1. The earliest assemblage comes from the basal horizons of the Kuilyuk Formation and includes: *Imitoceras* sp., *Muensteroceratoides aksuensis, Eurites kuilukensis* sp. nov., *Becanites* sp., and *Pericyclus* sp. (Figs. 4, 5). It is most completely represented in the Kuilyuk section (specimens nos. 594, 593/14) and is apparently present in the Brichmulla section, where sample B-84 contains *Imitoceras* sp. Specimens identified as *Imitoceras* sp. are similar to *I. rotatorium* (Konink) from the Calcaire de Calonne Formation of Belgium and resemble *I. dimidium* Korn, Bockwinkel et Ebbighausen, 2010 from the upper part of the Gres de Kahla beds of North Africa (Korn et al., 2010), which has a similar ontogeny. Faunas containing the genera *Imitoceras*, *Becanites, Eurites, Muensteroceras*, and *Pericyclus* characterize the beginning or middle part of the Late Tournaisian. A recent stratigraphic scheme (Atlas..., 2007) shows beds with this assemblage formally recognized as the *Pericyclus* Zone. Korn et al. (2007), based on the ammonoid succession in the sections of Morocco and Algeria, proposed a detailed zonal scale and recognized for this interval the *Pericyclus–Progoniatites* Genozone. Thus, this assemblage can also be assigned to the *Pericyclus–Progoniatites* Zone. In Western Europe, the closest equivalent is the ammonoid fauna of the Calcaire de Calonne Formation of Belgium (Korn et al., 2007, 2010).

Assemblage 2. This assemblage comes from the lower part of the limestones of the Kulosya mound range (Outcrops 419, 497, 495), Paltau Massif (Outcrop 424), and the small Aurakhmat mound. The ammonoid assemblage contains: *Habadraites kulosiensis* sp. nov., *Nodopericyclus asiaticus* sp. nov., *Parasiacyclus chatkalicus* gen. et sp. nov., and *Helicocyclus* sp. Representatives of *Habadraites* and *Nodopericyclus* were previously known only from North Africa (South Algeria, Mouydir area). Korn et al. (2010) indicated *Habadraites* from the upper part of the *Pericyclus–Progoniatites* Genozone. *Nodopericyclus* is typical of the higher *Helicocyclus–Ouauofilalites* assemblage, which these authors placed at the base of the *Fascipericyclus–Ammonellipsites* Genozone. In North Africa, this genus is found together with *Rotopericyclus*, *Ammonellipsites, Helicocyclus, Muensteroceras, Eurites, Dzhaprakoceras*, and the endemic *Ouaoufilalites*, *Moudiria, Kusinia, Follotites*, and *Antegoniatites* (Korn et al., 2010). The age of the Asian

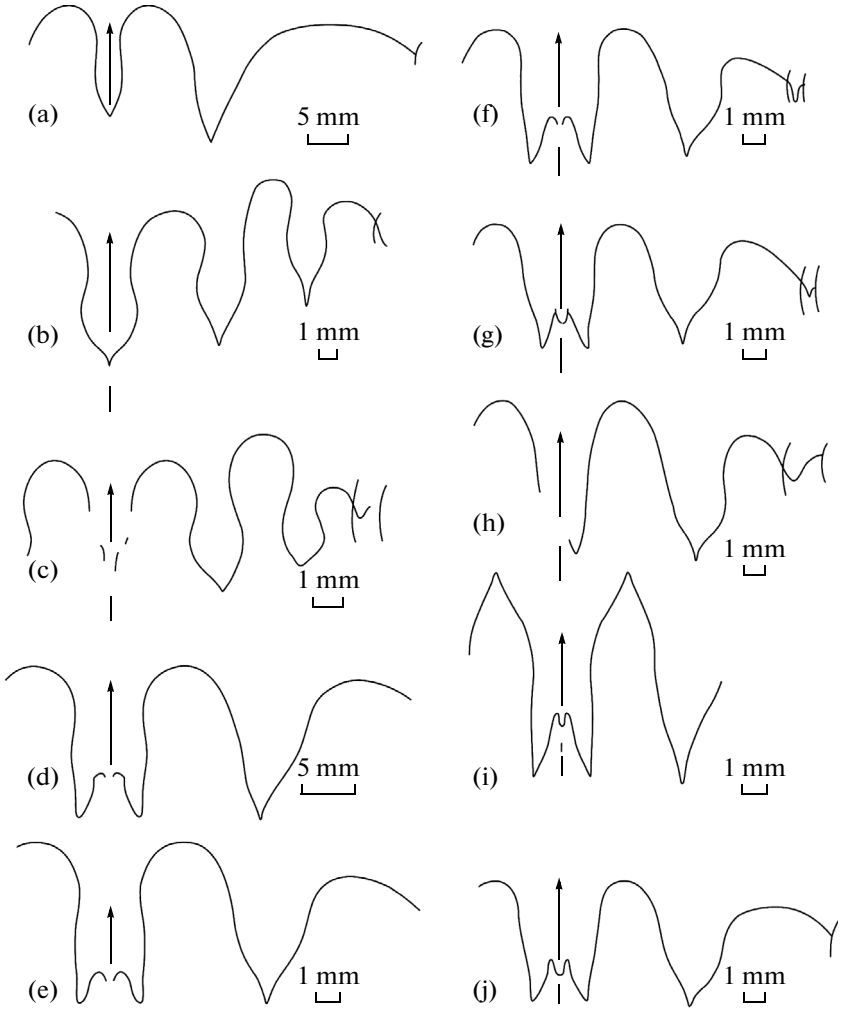


Fig. 4. Sutures of Late Tournaisian ammonoids: (a) *Imitoceras* sp., specimen no. 5020/1 at WH = 30.4 mm; Kuilyuk section, specimen no. 593/14; Kuilyuk Formation, *Pericyclus–Progoniatites* Genozone; (b) *Becanites* sp., specimen no. 5020/105 at WH = 12.5 mm; locality and age the same; (c) *Merocanites djaprakensis* (Librovitch), specimen no. 5020/16 at WH = 9.0 mm; Kuilyuk section, specimen no. 595; *Fascipericyclus–Ammonellipsites* Genozone; (d, e) *Dzhaprakoceras tianshanicus* (Librovitch): (d) specimen no. 5020/26 at WH = 28.3 mm; locality and age the same; (e) specimen no. 5020/11 at WH = 10.7 mm; Brichmulla section, specimen no. B – 100; the same age; (f) *Helicocyclus tianshanicus* (Librovitch), specimen no. 5020/23 at WH = 8.5 mm; Brichmulla section, specimen no. B-113; the same age; (g) *Neopericyclus* sp., specimen no. 5020/33 at WH = 9.4 mm; Brichmulla section, specimen no. B–100; the same age; (h) *Hammatocyclus* sp., specimen no. 5020/20 at WH = 7.2 mm; Kuilyuk section, specimen no. 599; the same age; (i) *Ammonellipsites* cf. *djaprakensis* (Librovitch), specimen no. 5020/36 at WH ~ 8.6 mm; Brichmulla section, specimen no. B-113; the same age; (k) *Bollandites* sp., specimen no. 5020/71 at WH = 12.7 mm, WW = 17.8 mm; Outcrop 422; Viséan.

assemblage is apparently similar to the North African assemblage with *Nodopericyclus*. *Helicocyclus* sp. is found in association with *Nodopericyclus*. The endemic genus *Parasiacyclus* gen. nov. is very similar to *Asiacyclus* Librovitch described by Librovitch (1940) from the Tournaisian of Kazakhstan. The fauna with *Asiacyclus* from the Terekty beds of northern Kazakhstan is considered to be synchronous with the *Pericyclus–Progoniatites* Genozone (Korn et al., 2003, 2007, 2010). The new genus differs from *Asiacyclus* in the more advanced suture with a higher median saddle and is probably a younger, evolutionary developed taxon, which agrees with my conclusion on a younger age of the assemblage.

Assemblage 3. The most taxonomically diverse ammonoid assemblage is found in the middle and upper parts of the Kuilyuk Formation (Kuilyuk and Brichmulla sections, Outcrops 429a, 592), in the synchronous limestone of the Kulosya mounds (Outcrop 422, 464) and the carbonate massif on the Chavata River (Outcrop 17). It is represented by the following species: *Merocanites djaprakensis* Librovitch, *Helicocyclus tianshanicus* (Librovitch), *Neopericyclus kokjarensis* Popov, *Neopericyclus* sp., *Ammonellipsites* cf.

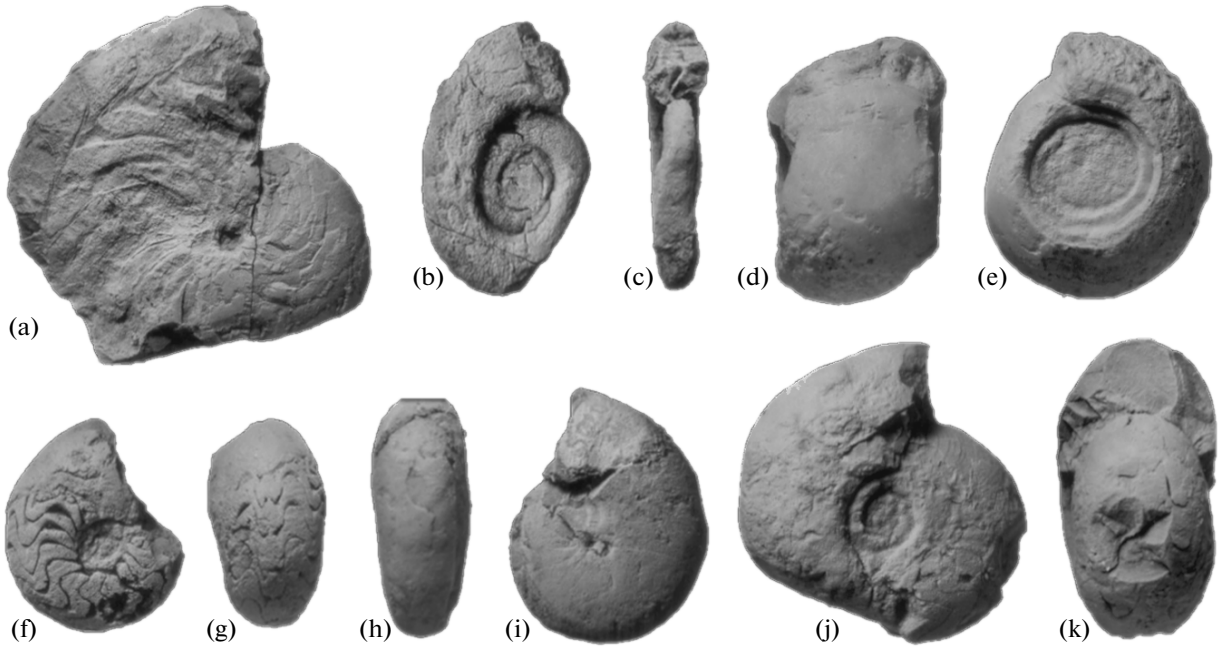


Fig. 5. Ammonoids from the Kuilyuk Formation: (a) *Imitoceras* sp., specimen no. 5020/1; Kuilyuk section, specimen no. 593/14; *Pericyclus–Progoniatites* Genozone; (b, c) *Merocanites djaprakensis* (Librovitch), specimen no. 5020/106; Brichmulla section, specimen no. 120; *Fascipericyclus–Ammonellipsites* Genozone; (d, e) *Hammatocyclus* sp., specimen no. 5020/20; Kuilyuk section, specimen no. 599; the same age; (f, g) *Neopericyclus* sp., specimen no. 5020/33; Brichmulla section, specimen no. B-100; the same age; (h, i) *Dzhaprakoceras tianshanicus* (Librovitch), specimen no. 5020/34; Brichmulla section, specimen no. B-107; the same age; (j, k) *Bollandoceras* sp. specimen no. 5020/71; Kulosya River, Outcrop 422; Viséan?, Kuilyuk Formation. All sizes are natural.

dzhaprakensis (Librovitch), *Dzhaprakoceras tianshanicus* (Librovitch), *Dzhaprakoceras* sp., *Muensteroceratoides aksuensis* Popov, *Hammatocyclus* sp. (Figs. 4, 5, Pl. 3, figs. 8, 9). The assemblage is typical of the *Fascipericyclus–Ammonellipsites* Genozone.

A very taxonomically similar ammonoid assemblage is described from the lower part of the Dzhapryk Formation and bioherm limestones of the Akchetash Formation near Son-Kul Lake Moldo-Too Range in Kyrgyzstan (Librovitch, 1927; Popov, 1965, 1968). Popov (1968) recognized successive local ammonoid assemblages from F2 to A4 in the Dzhapryk Formation. All assemblages described by Popov characterize the *Fascipericyclus–Ammonellipsites* Genozone. The ammonoid assemblage from the Kuilyuk Formation and mounds of the Chatkal Group is similar to the earliest assemblages from the Dzhapryk Formation (F2) and, apparently, F3. The similarity of the taxonomic composition of ammonoid assemblages is explained by the fact that in the Tournaisian and early Viséan, these regions represented a single marine basin. Nevertheless, the ammonoid fauna from the Kuilyuk Formation lacks typical representatives of *Ammonellipsites*, e.g., *Ammonellipsites nikitini* (Librovitch and *A. kochi* (Holzapfel) characteristic of the Dzhapryk fauna (Popov, 1968). A single poorly preserved specimen, which I tentatively assigned to *A.* cf. *dzhaprakensis* (Librovitch), has a narrow evolute shell, unlike typical members of the genus, and it is possible that this specimen should in fact be assigned to a different genus. The absence of typical *Ammonellipsites* in the assemblages of the Kuilyuk Formation may indicate a somewhat older geochronological age for this fauna compared to the Dzhapryk assemblage, which agrees with the conodont and foraminiferal data, dating the Dzhapryk Formation as Early Viséan (Djenchuraeva et al., 2013). On the other hand, slight differences in the composition of the assemblages can be explained by differences in the environment in the basins (Barskov et al., 2008).

Assemblage 4. This ammonoid assemblage from Outcrop 422, is probably mixed. It contains elements of the Late Tournaisian fauna from the preceding assemblage, and also *Bollandoceras* sp. The latter is characteristic of younger Viséan beds. The presence of *Bollandoceras* indicates a younger ammonoid fauna (the level has not been identified) in the upper part of the Kuilyuk Formation or overlying Karatut Formation, of the Viséan *Bollandites–Bollandoceras* Genozone.

Thus, three successive ammonoid assemblages are recognized in the Late Tournaisian beds in the Chatkal River basin, indicating the presence of the *Pericyclus–Progoniatites* and *Fascipericyclus–Ammonellipsites* genozones. A younger ammonoid assemblage indicates the presence of the Viséan *Bollandites–Bollandoceras* Genozone.

The ammonoid fauna of the Chatkal River basin is in general older than that of the Dzhapryk Formation, as it contains two older assemblages, still unrecognized in the Chatkal-Talass marine basin. Librovitch (1947) mentioned ammonoids of this age in the vicinity of Son-Kul Lake, but did not describe or illustrate these records. The similarity of the youngest assemblage with *Helicocyclus* and *Ammonellipsites* and assemblages F2 and F3 from the Dzhapryk beds suggests that these faunas developed in a single marine basin. Ammonoids inhabited the outer shelf, bordered by large carbonate buildups (Nigmadzhnov, 1989). The presence of genera shared with the basins of North Africa suggests wide connections between these basins, and eastward migrations were likely.

The new and re-examined taxa are described below. The terminology follows Ruzhencev and Bogoslovskaya (1971). The collection is housed in the Paleontological Institute of the Russian Academy of Sciences (PIN), no. 5020. Photographs are by V.T. Antonova.

SYSTEMATIC PALEONTOLOGY

Superfamily Pericycloidea Hyatt, 1900

Family Muensteroceratidae Librovitch, 1957

Genus *Eurites* Kuzina, 1973

***Eurites kuilukensis* Konovalova, sp. nov.**

Plate 3, fig. 1

Etymology. From the Kuilyuk River.

Holotype. PIN, no. 5020/12; lower reaches of the Chatkal River, Kuilyuk section, specimen no. 593/14; Late Tournaisian, base of the Kuilyuk Formation; coll. by I.M. Nigmadzhanov in 1990.

Description. Shell shape. The shell is large. Adult whorls are pachyconic; the early whorls are subspheroconic, with involute whorls. The venter is relatively wide and rounded. The ventral shoulder not developed. The flanks are wide and weakly convex. The umbilical shoulder is distinct and rounded-angular. The umbilical wall is narrow and steep. The umbilicus is moderately narrow.

Dimensions in mm and ratios:

	Specimen no.	Dm	WH	WW	UW	WW/Dm	WW/Dm	UW/Dm
Holotype	no. 5020/12	86.9	~34.4	57.4	19.5	0.40	0.66	0.23
	—	40.0	16.6	26.5	9.3	0.41	0.66	0.23

Ornamentation. The ornamentation is not preserved. The mold at Dm = 40 mm possesses three narrow constructions, forming a shallow ventral sinus.

Suture. (Fig. 6). The ventral lobe is narrow (LW/LH = 0.3), with straight parallel sides, subdivided by a low median saddle (SH/LH = 0.19). The first lateral saddle is widely rounded, considerably wider than the ventral lobe. The lateral lobe symmetrical, bell-shaped, with a small attenuated termination, slightly deeper than the ventral. The second lateral saddle is low and, wide.

Comparison. The shell shape is the most similar to *E. ellipsoidalis* (Crick, 1899) and *E. corpulentus* (Crick, 1899). It differs from *E. ellipsoidalis* in the slightly wider shell (WW/Dm = 0.66 against 0.60 at Dm = 40.0 and 47.0 mm respectively) and in the presence of constrictions. It is distinguished by *E. corpulentus* by the considerably narrower umbilicus (WW/Dm = 0.23 against 0.35 at Dm = 40.0 mm and 37.0 mm, respectively), and also by the presence of constrictions. This species differs from all other species by the narrower shell.

Remarks. I assign this species to the genus *Eurites* with some hesitation. It is distinguished by the typical representatives of the genus by the narrower shell; being intermediate between the position between *Eurites* (average WW/Dm = 0. 70–0.78) and *Muensteroceras* (average WW/Dm = 0.39–0.47). The most similar species of *Eurites*, with a narrow shell, such as *E. ellipsoidalis, E. corpulentus,* ?*E. browni* (M'Coy, 1844), need to be re-examined.

Recently Korn et al. (2010) reviewed the diagnosis of *Eurites*. These authors consider one of the main generic rank characters for *Eurites* to be the pattern of their ontogenetic changes. In their opinion, shells of representatives of the genus *Eurites* show an increase in WW/Dm in ontogeny at the late stages. The specimen described has a reasonably large shell (D = 86.9 mm), but no such changes have been recorded. However, in my opinion, this character cannot be considered as defining for *Eurites*. The type species of the

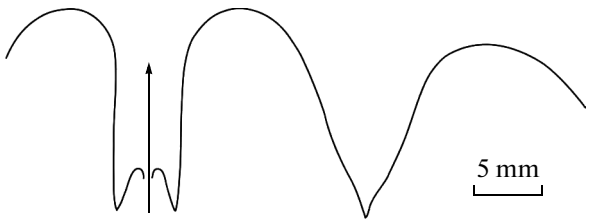
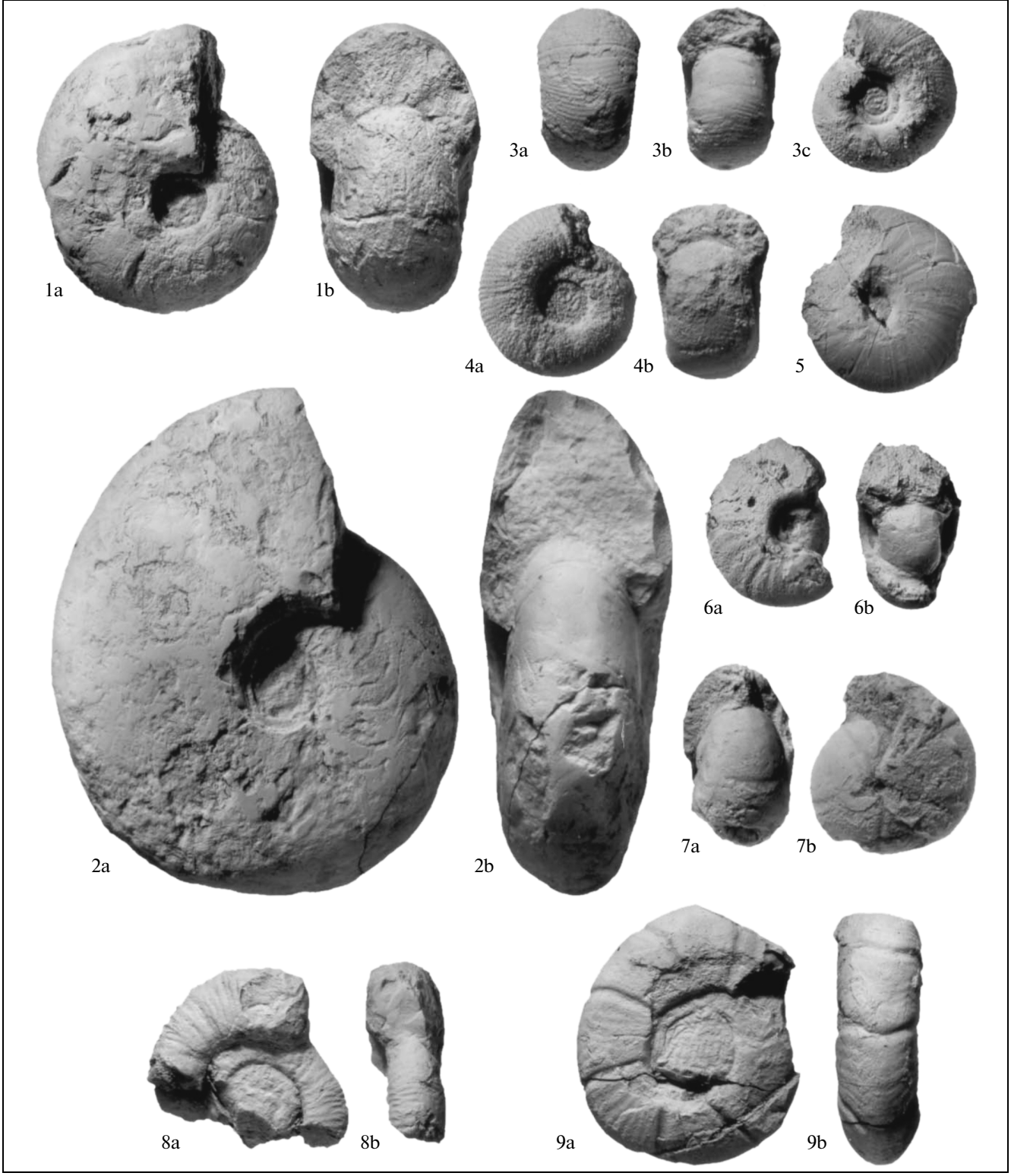


Fig. 6. Suture *Eurites kuilukensis* sp. nov.: holotype no. 5020/12 at WH = 27 mm; Kuilyuk section, specimen no. 593/14; Upper Tournaisian, Kuilyuk Formation, *Pericyclus–Progoniatites* Genozone.

Plate 3



genus, *Eurites latus* Kuzina, 1973 was described based on a single large (Dm = 48.3 mm) shell which does not show this character (Kuzina, 1973).

M a t e r i a l. Holotype.

Genus *Muensteroceratoides* Popov, 1965

Muensteroceratoides: Popov, 1965, p. 39 (pars).

T y p e s p e c i e s. *M. aksuensis* Popov, 1965; Middle Tien Shan; Tournaisian.

Diagnosis. Shell large, pachyconic or subdiscoconic, with involute whorls at all growth stages. Umbilicus narrow. Umbilical shoulder is angular and distinct. WW/Dm ratio gradually increasing in ontogeny. Ornamentation of transverse growth lines and constrictions forming a ventral sinus and a ventrolateral projection. Ventral lobe narrow, its sides weakly convex in lower part and distinctly converging at top. Base of ventral lobe wider than top part. First lateral saddle widely rounded. Lateral lobe wedge-shaped.

Species composition. Type species.

Comparison. This genus is distinguished from the morphologically similar genus *Muensteroceras* Hyatt, 1884 by the shape of the ventral lobe, the lateral sides of which are weakly convex and are noticeably converging in the upper part, whereas in *Muensteroceras* they are parallel throughout. It differs from *Dzhaprakoceras* Popov, 1965 in the wider, scalate umbilicus, and the sides of the ventral love converging at the top. If differs from *Eurites* Kuzina, 1973 in the narrower shell and the suture outline. It is distinguished from other genera in the sutural outline.

Muensteroceratoides aksuensis Popov, 1965

Muensteroceratoides aksuensis: Popov, 1965, p. 37, pl. 3, figs. 1, 2; 1968, p. 85, pl. 2, figs. 3, text-figs. 15a, 16e.

Holotype. KP SPbGU, no. 2730/86; Tien Shan, south slope of the Moldo-Too Range, Kok-Dzhar River; Viséan, Dzhapryk Formation, *Fascipericyclus–Ammonellipsites* Genozone.

Description. Shell shape. (Fig. 7f). The shell is large, reaching 100 mm or more in diameter, subdiscoconic, with involute whorls at all growth stages. The venter is rounded. The ventral shoulder is not developed. The flanks are wide, flattened, slightly divergent towards the umbilical shoulder, and becoming parallel with age. The umbilical shoulder is distinct, subangular. The umbilical wall is narrow and steep. The umbilicus in young shells is narrow, in adults becoming moderately narrow and scalate. The WW/Dm ratio gradually increases in ontogeny.

Dimensions in mm and ratios:

Specimen no.	Dm	WH	WW	UW	UW/Dm	WW/Dm	UW/Dm
5020/9	50.0	25.5	21.3	7.0	0.51	0.43	0.14
5020/3	92.0	41.0	34.8	17.0	0.45	0.38	0.18
5020/13	110.0	47.0	40.0	26.0	0.43	0.36	0.24

Ornamentation. Large specimens (Dm = 90 mm and over) show weak constrictions on the mold, one or two per whorl, forming a shallow ventral sinus and a low ventrolateral projection. Molds of smaller individuals (Dm = 70–50 mm) are smooth. The holotype studied at Dm = 55 mm has no constrictions.

Suture. (Figs. 7a–7e). The ventral lobe is narrow in young shells, with age becoming slightly wider (LW/LH = 0.31 at WH = 14.2 mm and 0.44 at WH = 25.6 mm), subdivided by a low median saddle (SH/LH = 0.16 at WH = 14.2 mm and 0.2 at WH = 25.5 mm). The lateral sides of the ventral lobe in young individuals are almost straight, slightly converging upwards; in adult specimens the sides of the ventral lobe are weakly convex in the middle, while noticeably converging at the top. The base of the ventral lobe is always wider than its upper part, which is particularly distinctly visible in large specimens. The first lateral saddle is widely rounded, symmetrical. The lateral lobe is wedge-shaped, with a small mammilate termination, slightly deeper than the ventral. The second lateral saddle is wide. The small angular umbilical lobe lies on the umbilical wall.

Remarks. Popov (1965) assigned *M. aksuensis* to a separate genus and indicated among the main distinguishing characters the shape of the ventral lobe, the sides of which converge upward. Popov (1965, 1968), in papers containing descriptions of this genus and species, figured sutures of three specimens, two of which (specimen nos. 782/84, 2771/324) have a ventral lobe with a vertical lyre-shaped sides and were probably drawn from representatives of the genus *Dzhaprakoceras* Popov, 1965. In the figured suture of the holotype (Popov, 1968, p. 83, text-fig. 16f) the sides of the ventral lobe are almost straight and slightly convergent in the upper part. Based on these figures, Kuzina (1980) assigned *M. aksuensis* to the genus

Explanation of Plate 3

All sizes are natural, unless specifically stated.

Fig. 1. *Eurites kuilukensis* sp. nov., holotype PIN, no. 5020/12; Kuilyuk section, specimen no. 593/14; Kuilyuk Formation, *Pericyclus–Progoniatites* Genozone.

Figs. 2. *Muensteroceratoides aksuensis* Popov, 1965, specimen no. PIN, no. 5020/3; same locality and age.

Figs. 3 and 4. *Nodopericyclus asiaticus* sp. nov.: (3) specimen PIN, no. 5020/84, ×2; Kulosya River, Kulosya Mound, Outcrop 495; Late Tournaisian, *Fascipericyclus – Ammonellipsites* Genozone; (4) holotype PIN, no. 5020/93, ×1.5; Kulosya River, Kulosya Mound, Outcrop 497; the same age.

Figs. 5 and 6. *Parasiacyclus chatkalicu* gen. et sp. nov.: (5) specimen PIN, no. 5020/96; Chatkal River, Aurakhmat Mound, Outcrop 01-P; the same age; (6) holotype PIN, no. 5020/95; same locality and age.

Figs. 7. *Habadraites kulosiensi* sp. nov., holotype PIN, no. 5020/82, ×2; Kulosya River, Kulosya Mound, Outcrop 497; the same age.

Figs. 8 and 9. *Helicocyclus tianshanicu* (Librovitch, 1927): (8) specimen PIN, no. 5020/17; Kuilyuk section, specimen no. 502/8; the same age; (9) specimen PIN, no. 5020/21; Brichmulla section, specimen no. B-113; the same age.

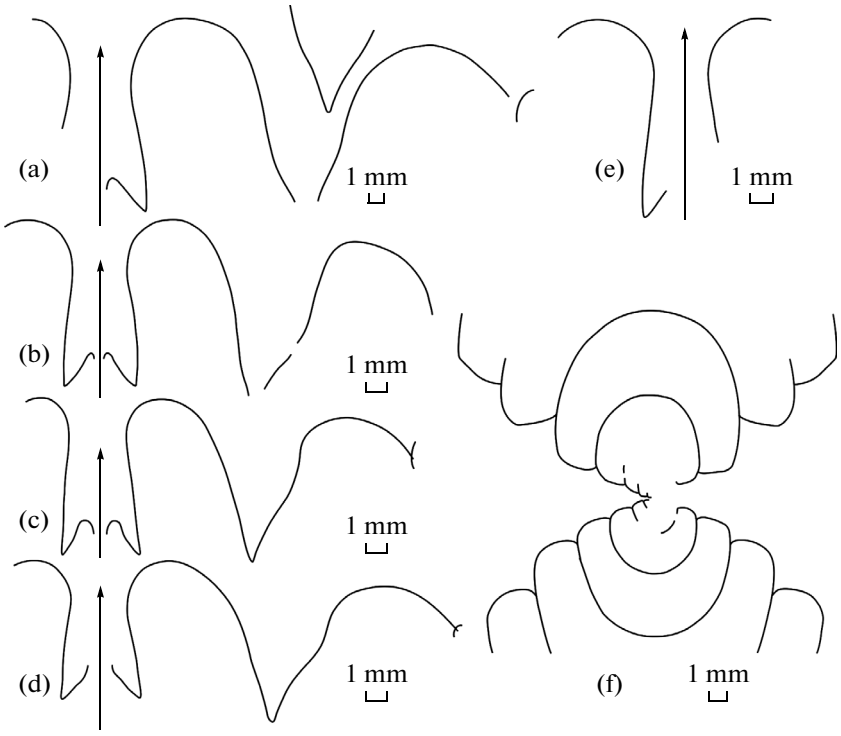


Fig. 7. Sutures (a–e) and cross-section (f) of *Muensteroceratoides aksuensis* Popov: (a) specimen no. 5020/3 at WH = 23.5 mm; Kuilyuk section, specimen no. 593/14; Kuilyuk Formation, *Pericyclus–Progoniatites* Genozone; (b) specimen no. 5020/9 at WH = 16.2 mm; same locality and age; (c) specimen no. 5020/110 at WH = 13.3 mm; Mazarsai River, Outcrop 305; Kuilyuk Formation, *Fascipericyclus–Ammonellipsites* Genozone; (d) holotype SPbGU no. 2730/86 at WH = 14.0 mm; southern slope of the Moldo-Too Range, Kok-Dzhar River; Viséan, Dzhapryk Formation; (e) specimen no. 5020/9 at WH = 17.0 mm; Kuilyuk section, specimen no. 593/14; Kuilyuk Formation, *Pericyclus–Progoniatites* Genozone; (f) specimen no. 5020/5; same locality and age.

Dzhaprakoceras, thereby making *Muensteroceratoides* a junior synonym. This opinion was supported by some authors (Korn et al., 1999; Petersen et al., 2000; Work et al., 2000; Korn et al., 2010, Ebbighausen et al., 2010). The re-examination of the suture and the study of the available material show that these specimens have characters indicated by Popov when he established the genus. The shell shape of *M. aksuensis* is similar to that of *Muensteroceras*, such as *M. parallelum* (Hall, 1860), *M. complanatum* (Koninck, 1880), and *M. rotella* (Koninck, 1880), but the ventral lobe with slightly convex sides convergent upwards is not characteristic of *Muensteroceras*, in which the sides of the ventral lobe are always straight. The shape of the ventral lobe is similar to that of *Dzhaprakoceras*, however in the latter the sides of the ventral lobe are parallel. In addition, in *Dzhaprakoceras*, the umbilicus is usually has a blurred umbilical shoulder, and the shell ontogeny does not show a trend towards the increase in WW/Dm, as in Muensteroceratoides.

O c c u r r e n c e. Middle Tien Shan, Chatkal River basin, south Son-Kul region; Upper Tournaisian–Lower Viséan, *Pericyclus–Progoniatites* Genozone, *Fascipericyclus–Ammonellipsites* Genozone.

M a t e r i a l. Nine moderately well preserved specimens from the Kuilyuk Formation, Kuilyuk section (specimen nos. 593/14, 594, 595), Brichmulla section (specimen no. 107), Mazarsai Creek (PT 309); coll. by I.M. Nigmadzhnov, 1990, 2006.

Family Pericyclidae Hyatt, 1900

Subfamily Pericyclinae Hyatt, 1900

Genus *Nodopericyclus* Korn, Bockwinkel and Ebbighausen, 2010

***Nodopericyclus asiaticus* Konovalova, sp. nov.**

Plate 3, figs. 3, 4

E t y m o l o g y. After the continent of Asia.

H o l o t y p e. PIN, no. 5020/93; Chatkal River basin, Kulosya, Kulosya organic mound, Outcrop 497; Upper Tournaisian, *Fascipericyclus–Ammonellipsites* Genozone.

S h e l l s h a p e. (Fig. 8a). The shell is small, pachyconic, at the first three whorls, it is evolute, with a wide umbilicus, and later involute. The venter is broadly rounded forming with the inflated flanks a single curved surface. The umbilical shoulder is distinct. The umbilical wall is narrow and steep. The umbilicus is medium-sized, scalate.

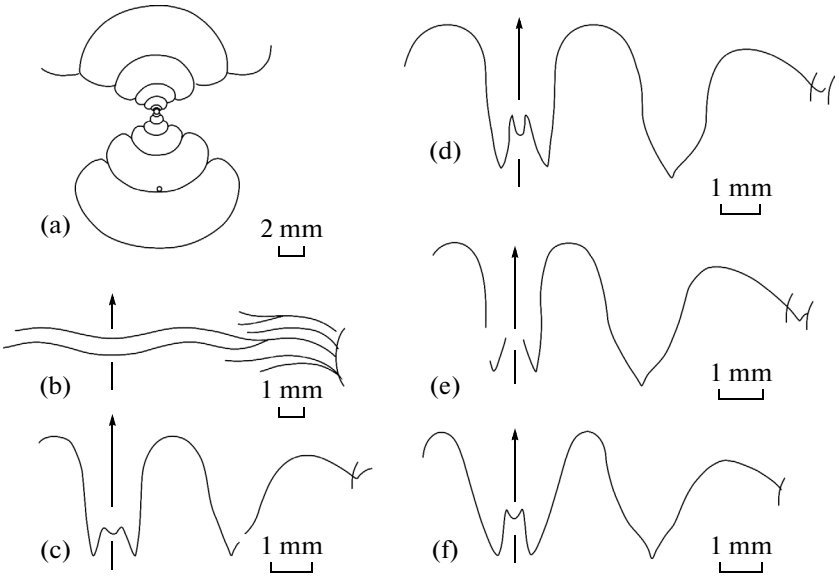


Fig. 8. A cross-section (à), ornamentation (b), and sutures (c–f) of ammonoids from the Tournaisian mound of the Chatkal Group: (a–c) *Nodopericyclus asiaticus* sp. nov.: (a) specimen no. 5020/80; Paltau Mound, Outcrop 424; (b) specimen no. 5020/84 at WH = 6.2 mm; Kulosya River, Outcrop 495; (c) holotype no. 5020/93 at WH = 4.1 mm; Kulosya River, Outcrop 497; (d–e) *Parasiacyclus chatkalicu* gen. et sp. nov.: (d) specimen no. 5020/70 at WH = 6.8 mm; Kulosya River, Outcrop 419; (e) holotype no. 5020/95 at WH = 5.0 mm; Aurakhmat Mound, Outcrop 01-P; (f) *Habadraites kulosiensi* sp. nov., holotype no. 5020/82 at WH = 6 mm; Kulosya River, Outcrop 497.

Dimensions in mm and ratios:

	Specimen no.	Dm	WH	WW	UW	UW/Dm	WW/Dm	UW/Dm
Holotype	no. 5020 /93	19.3	7.0	13.1	7.3	0.36	0.68	0.38
	no. 5020/84	15.5	5.6	10.3	5.2	0.36	0.66	0.34

Ornamentation. (Fig. 8b). The shell is covered by thin transverse ribs, often bifurcating and rarely intercalating on the flanks. In the umbilical zone, ribs increase and form fine umbilical folds. At Dm = 19.3 mm 1–12 ribs are counted in 1 cm of the ventral side surface. The ribs form a low ventral sinus and a weak ventrolateral projection. The umbilical wall is smooth. The mold shows constrictions (three per whorl), following the course of the ribs.

Suture. (Fig. 8c). The ventral lobe is narrow (LW/LH = 0.5). The lateral sides of the ventral lobe are subparallel, slightly divergent at the top. The ventral prongs are parallel. The median saddle is low (SH/LH = 0.20 at WH = 4.2 mm). The first lateral saddle is widely rounded, almost as wide as the ventral lobe. The ventral lobe width to the first lateral saddle ratio is 0.81. The lateral lobe is as wide as the ventral lobe, asymmetrical, with a weakly convex ventral side and S-shaped dorsal side, pointed, and as deep as the ventral lobe. The second lateral saddle is wide and low. The small angular umbilical lobe lies on the umbilical wall.

Comparison. In shell shape and ornamentation, this species is similar to *N. deficerus* Korn, Bockwinkel et Ebbighausen, 2010, differing in the wider whorls (WW/Dm = 0.66 instead of 0.57 at Dm= 15.5 and 14.6 mm, respectively) and in the sutural outline: the higher median saddle (SH/LH = 0.20 instead of 0.12 at WH = 4.1 and 4.7 mm, respectively), the narrower, deep, and symmetrical lateral lobe. In *N. deficerus* the ventral lobe width to the lateral lobe width ratio is 0.77, and is 1 in the new species. The new species is distinguished from *N. circumnodosus* Korn, Bockwinkel et Ebbighausen, 2010 by the finer ornamentation, the weak umbilical folds, and in the wider ventral lobe (LW/LH = 0.5 instead of 0.40 at WH = 4.2 and 6.2 mm, respectively). In addition, in the new species, the lateral digits of the ventral lobe are parallel, whereas in *N. circumnodosus* they are slightly curved dorsally.

Remarks. *N. circumnodosus* and *N. asiaticus* sp. nov. are very similar, and the existing differences could probably be attributed to intraspecific variations. However, our collections do not have sufficient material to make a positive conclusion, and therefore, taking into account the existing differences, I describe *N. asiaticus* sp. nov. as a new species.

Occurrence. Middle Tien Shan, Chatkal River basin; Upper Tournaisian, Sargardon Horizon, *Fascipericyclus–Ammonellipsites* Genozone, lower part.

Material. Apart from the holotype, two well-preserved specimens from the localities nos. 495, 497, 424; Middle Tien Shan, Chatkal River basin; coll. by I.M. Nigmadzhnov in 1982.

Genus *Parasiacyclus* Konovalova, gen. nov.

Etymology. From the Latin *para* (similar) and the genus *Asiacyclus* Librovitch, 1962.

Type species. *Parasiacyclus chatkalicus* sp. nov.

Diagnosis. Shell small, pachyconic, with involute whorls at all growth stages. Umbilicus narrow to moderately narrow. Shell shape more or less consistent in ontogeny. Ornamentation consisting of weak, thin transverse ribs, more strongly pronounced on flanks and weakening on venter, forming shallow ventral sinus and small ventrolateral projection. Ribs can dichotomize and intercalate. Ventral lobe narrow, with weakly convex, parallel sides. Median saddle relatively high, about 1/3 of lobe depth. First lateral saddle widely rounded. Lateral lobe narrow, as deep as ventral, or slightly deeper.

Species composition. Type species.

Comparison. The new genus is distinguished from the similar genus *Asiacyclus* by the weakly curved sides of the ventral lobe and higher median saddle (SH/LH = 0.28 instead of 0. 11–0.16). It differs from other genera in the family in the weak ornamentation.

Parasiacyclus chatkalicus Konovalova, sp. nov.

Plate 3, figs. 5, 6

Etymology. From the Chatkal River.

Holotype. PIN, no. 5020/95; Middle Tien Shan, Chatkal River basin, right bank of the Kulosya River, Outcrop 495; Upper Tournaisian, Sargardon Horizon, *Fascipericyclus–Ammonellipsites* Genozone.

Description. Shell shape. The shell is pachyconic, with very involute whorls at all growth stages. The venter is rounded, gently joins the weakly convex flanks. The ventral shoulder is rounded, at later stages subangular. The umbilical wall is narrow, flat, and steep. The umbilicus is from very narrow to narrow.

Dimensions in mm and ratios:

	Specimen no.	Dm	WH	WW	UW	WH /Dm	WW/Dm	UW/Dm
	5020/70	14.6	6.4	9.7	2.4	0.44	0.66	0.16
Holotype	5020/95	32.0	13.7	19.6	6.9	0.43	0.61	0.22
	5020/96	32.8	15.2	22.3	6.5	0.46	0.68	0.19

Ornamentation. The ornamentation is represented by low, thin ribs, rarely dichotomizing and intercalating, forming a shallow ventral sinus and a low ventrolateral projection. The ribs are more pronounced on the flanks and weaken on the venter. At Dm = 32 mm, there are five to seven ribs per 1 cm of the ventral surface. In young specimens in the umbilical zone, the ribs become stronger and form small umbilical folds. The umbilical wall is smooth. The mold shows distinct constrictions, 3–4 per whorl, the direction of which follows the course of the ribs.

Suture. (Figs. 8d, 8e). The ventral lobe is narrow, with parallel, weakly curved sides in the lower third (LW/LH = 0.48 at WH = 6.8 mm), subdivided by a relatively high median saddle (SH/LH = 0.29 at WH = 6.8 mm). The first lateral saddle is wide, widely rounded at the top. The lateral lobe is as wide as the ventral or slightly wider, bell-shaped, with S-curved lateral sides and a small mammilate termination. It is deeper than the ventral lobe. The second lateral saddle is wide and high. The small subacute umbilical lobe lies on the umbilical wall.

Occurrence. Middle Tien Shan, Chatkal River basin; Late Tournaisian, *Fascipericyclus–Ammonellipsites* Genozone, Sargardon Horizon.

Material. Apart from the holotype, 2 specimens from the Aurakhmat mound, Outcrop 01-P; coll. by I.M. Nigmadzhanov in 1984 and V.I. Poletaev in 1990.

Family Goniatitidae de Haan, 1825

Subfamily Habadraitinae Korn, Bockwinkel et Ebbighausen, 2010

Genus *Habadraites* Korn, Bockwinkel et Ebbighausen, 2010

Habadraites kulosiensis Konovalova, sp. nov.

Plate 3, fig. 7

Etymology. From the Kulosya River.

Holotype. PIN, no. 5020/82; Middle Tien Shan, Chatkal River basin, Kulosya; Tournaisian, Sargardon Horizon, *Fascipericyclus–Ammonellipsites* Genozone.

Shell shape. The shell is pachyconic, strongly involute, with a low cross-section. The venter

rounded, gradually joins the flattened flanks. The umbilical shoulder is distinct, slightly rounded. The umbilical wall is narrow. The umbilicus is very narrow, almost closed.

Dimensions in mm and ratios:

	Specimen no.	Dm	WH	WW	UW	WH /Dm	WW/Dm	UW/Dm
Holotype	5020/82	17.4	8.3	10.3	0.5	0.48	0.59	0.02

Ornamentation. The ornamentation is preserved incompletely. Weak growth striae are visible in places on the venter and flanks. The mold has radial constrictions, five per whorl.

Suture. (Fig. 8f). The ventral lobe is narrow for the genus (LW/LH = 0.67 at WH = 6.1 mm), with strongly divergent sides, slightly convex in the middle, subdivided by a relatively high median saddle (SH/LH = 0.36 at WH = 6.1 mm). The lateral digits of the central lobe are pointed. The first lateral saddle is saddle almost symmetrical, narrowly rounded at the top. The lateral lobe is asymmetrical, with a small mammilate termination. The second lateral saddle is low, widely rounded.

Comparison. In the shell shape and sutural outline, the new species is most similar to *H. weyeri* Korn, Bockwinkel et Ebbighausen, 2010 differing in the narrower, almost closed umbilicus. WW/Dm = 0.02 against 0.14 at Dm = 17.4 and 18.8 mm respectively, larger number of constrictions per whorl (5 against 3 per one whorl at comparable diameters) and in the shape of the lateral lobe. In our species, at WH = 6.1 mm, the lateral lobe is asymmetrical, with the S-shaped curved sides, whereas in *H. weyeri* it is symmetrical, with almost straight sides. It is distinguished from *H. supralatus* Korn, Bockwinkel et Ebbighausen, 2010 by a narrower ventral lobe (LW/LH = 0.67 instead of 0.79).

Material. Holotype; coll. by I.M. Nigmadzhanov in 1982.

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