



First record of the Early Carboniferous ammonoid genus *Goniatites* from the Greater Karatau (Kazakhstan palaeocontinent)

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Abstract

The Late Viséan ammonoid genus *Goniatites* had a near-global distribution within the tropical seas but was rarely reported from Central Asia. New investigations of the Early Carboniferous sedimentary succession in the Greater Karatau of Kazakhstan revealed a species-poor new assemblage with *Goniatites* and assists in the biostratigraphic subdivision of the section. The new species *Goniatites zhankurganensis* and *G. abaiensis* are described; these species have a morphological position at both ends of the morphological spectrum of the genus.

Keywords Ammonoidea · Goniatitidae · Carboniferous · Greater Karatau · Kazakhstan · Biogeography

Introduction

The genus *Goniatites* is the classic Early Carboniferous ammonoid genus and has a nearly worldwide distribution in the tropical zone (Korn et al. 2012). Its occurrences range from Alaska (Gordon Jr. 1957) across the American West (e.g. Korn and Titus 2011), the American Midcontinent (e.g. Gordon Jr. 1965; Drahovzal 1972), numerous localities in the North African, Western, North-Western and Central European parts of the North Variscan realm (e.g. Bisat 1934; Korn 1988, 1997b; Korn and Ebbighausen 2008; Korn 2017), the South Variscan Cantabrian Mountains (e.g. Kullmann

1961), the North Gondwanan localities in North-Western Africa (e.g. Klug et al. 2006; Korn et al. 2007), the North Urals (Skompski et al. 2001), the South Urals (e.g. Bogoslovskaya 1966) to Xinjiang in North China (Liang and Wang 1991) and possibly to Queensland of Australia (Campbell et al. 1983).

Here we report on new findings of ammonoid specimens belonging to *Goniatites* in southern Kazakhstan. With these, we add another region to the near-global occurrences of *Goniatites* within the tropical Early Carboniferous seas. The assemblage has been discovered in the Zhankurgan section of the Greater Karatau Mountains (Fig. 1) in a series of intercalated shales with proximal limestone turbidites (Zhaimina et al. 2014).

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Geological and stratigraphic background

The Greater Karatau Mountains is a part of the Kazakh-Kyrgyz terrane, one of the continental terranes assembled within the accretionary-orogenic system of the Tian Shan (Tien Shan) belt (e.g. Filippova et al. 2001; Worthington et al. 2017). During the Devonian-Carboniferous times, this terrane constituted an individual microcontinent called the Kazakh-Kyrgyz, Kazakhstania or the Kazakhstan palaeocontinent (e.g. Abrajevitch et al. 2008; Alexeiev et al. 2009; Biske and Seltmann 2010). Its southwestern passive margin was formed by a 4500-m-thick carbonate platform of the Greater Karatau (Alexeiev et al. 2017). The seaward margin and the

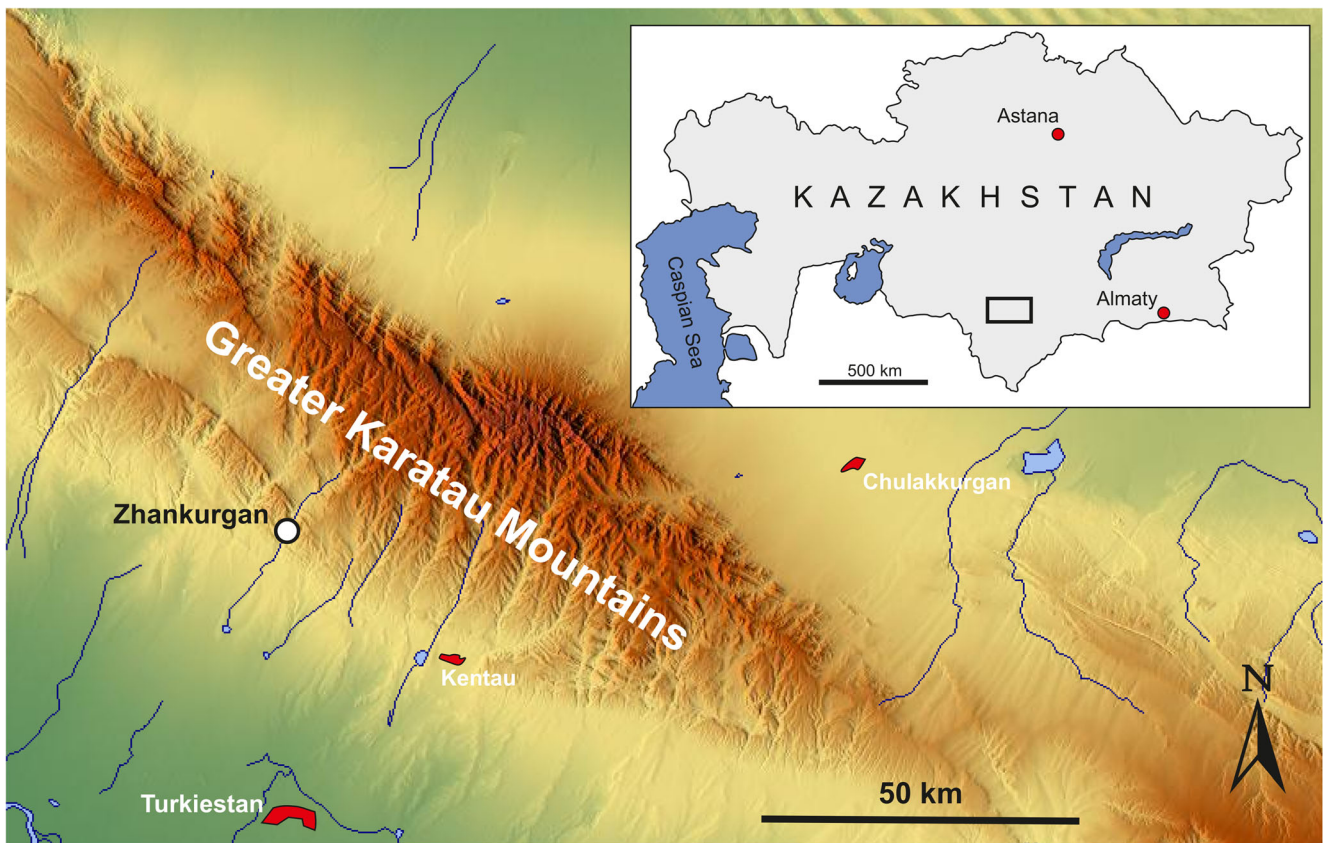


Fig. 1 Relief map of the Greater Karatau Mountains to show the location of the Zhankurgan section. Inset shows the location of the Greater Karatau in Kazakhstan

overall geometry of this platform were structurally controlled by rifted edges, thermal subsidence, local tectonics and relative sea-level fluctuations (Cook et al. 2002). In comparison to similar Palaeozoic depositional systems, the Greater Karatau carbonate platform was unique because numerous, large mud mounds developed on its seaward margin and on the upper slope, within six stratigraphic levels (Zempolich et al. 2002).

The Carboniferous sedimentary succession of the Greater Karatau comprises various carbonates deposited in basin-plain, slope, platform-margin and platform-interior settings (Cook et al. 2002). The investigated Viséan succession of the Zhankurgan section is several 100 m thick and composed of mudstones and shales intercalated with layers of allodapic limestones (grainstone and packstone in texture) and carbonate debris (Fig. 2). It belongs to the Baktysai Formation and represents deep-water facies sediments formed in a slope environment. The interbeds contain allochthonous bioclastic material derived predominantly from shallow-water areas of the carbonate platform (Zhaimina et al. 2014). In contrast, the mudstones are rich in radiolarians and sponge spicules.

Palaeogeographic position of the *Goniatites* assemblage in the Greater Karatau

Late Viséan to earliest Serpukhovian ammonoids are known from only a few regions in Central Asia:

Kazakhstan: Librovitich (1940) described Viséan ammonoid assemblages from four regions in Kazakhstan: (1) Qaraghandy Province (Karaganda Oblast' in the older literature)—specimens of *Beyrichoceras* and *Bollandoceras* from the Ashchi-Su basin. (2) Semey Province (Semipalatinsk Oblast' in the older literature)—a single occurrence of *Lusitanoceras orientale* from Ak-Dzhal. (3) Kokpekty Province (Kokpektinskaya Oblast' in the older literature)—*Lusitanoceras orientale* from Pokpekty Mountain. (4) Priirtysh region—*Lusitanoceras orientale* and *Lusitanoceras irtyshense* from the area of the Tarankul' Lake.

According to the ammonoid assemblages, two stratigraphic horizons are represented. The Qaraghandy assemblage may have an early Late Viséan age; the co-occurrence of *Beyrichoceras* and *Bollandoceras* is characteristic for the late Asbian of the British regional stratigraphy (Bisat 1934; Korn and Tilsley 2006). In the

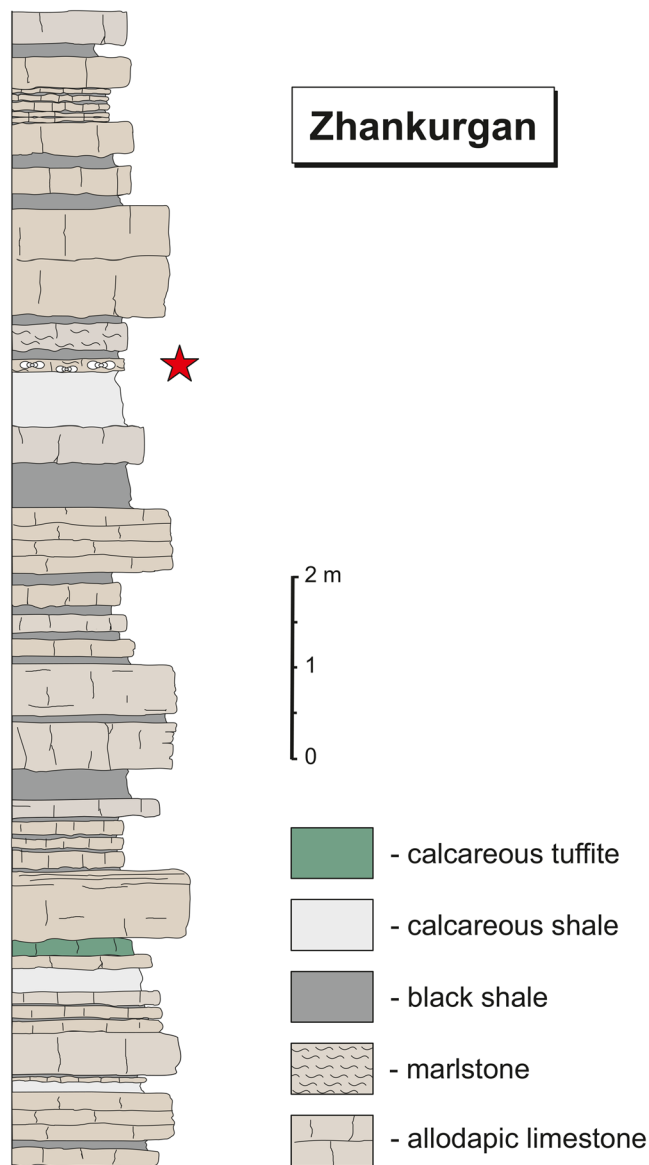


Fig. 2 Detailed lithological column of the middle part of the Viséan succession in the Zhankurgan section. The *Goniatites*-bearing layer is asterisked

European occurrences, however, ammonoid assemblages of this age regularly contain specimens of *Goniatites*.

The other three occurrences with *Lusitanoceras orientale*, which was attributed to the genus *Goniatites* by Librovitch (1940), are stratigraphically younger. *Lusitanoceras orientale* closely resembles the species *L. poststriatum* (Brüning 1923), *L. algarviense* (Pereira De Sousa 1923) and *L. zirari* Korn and Ebbighausen 2008 from Central and South-Western Europe as well as the Hercynian part of North Africa; most probably it indicates a Late Viséan to the earliest Serpukhovian age. In North-Western Ireland and in the Rhenish Mountains, *Lusitanoceras* species occur in beds at the base of the *Lochriea zieglerei* Zone (Barham et al. 2014; Wang et al. 2018).

China: Rich occurrences of Late Viséan and early Serpukhovian ammonoids were described by Liang and Wang (1991) from near the Kalajila village in northern Xinjiang. From the lowest of four successive horizons with ammonoids, three species of *Goniatites* were reported to co-occur with *Arcanoceras* and *Prolecanites*, followed by a horizon with *Hibernicoceras*, *Junggarites*, *Kalajilalites* and *Praedaraelites*, a third horizon with *Dombarites* and *Neogoniatites* and a fourth horizon with *Dombarites* and *Platygoniatites*. It is by far the best latest Viséan-early Serpukhovian ammonoid succession known from east of the Urals.

When compared with other regions, the lower two ammonoid occurrences have a Late Viséan age and the younger two belong in the early Serpukhovian. *Goniatites* and *Hibernicoceras* are typical genera of the Late Viséan succession in Ireland, the Rhenish Mountains, South Portugal and the Hercynian part of North Africa (Moore and Hodson 1958; Korn 1988, 1997a; Korn and Horn 1997; Korn and Ebbighausen 2008).

Dombarites, *Neogoniatites* and *Platygoniatites* are characteristic early Serpukhovian genera, which occur in the South Urals (Dombar Hills in north-western Kazakhstan and Verkhnyaya Kardailovka in South Russia) in beds belonging to the *Lochriea zieglerei* Zone (Nikolaeva et al. 2009; Nikolaeva 2013; Nikolaeva and Konovalova 2017).

This review shows that the new record of *Goniatites* in the Greater Karatau is almost a unique occurrence in the entire Central Asian region. A look at the composition of the assemblage makes clear that the Zhankurgan assemblage is species-poor with only two representatives of *Goniatites*. *Goniatites* is in other regions accompanied by other genera of the families Girtyoceratidae, Pericyclidae, Nomismoceratidae etc., all of which are missing in the newly found assemblage. It is interesting, however, that these two species represent the margins of the morphological range with respect to conch geometry. Whilst *G. zhankurganensis* has, even at a conch diameter of more than 40 mm, a nearly ball-shaped conch (width-diameter ratio of more than 0.90), *G. zhankurganensis* is much slenderer with a width-diameter ratio of only 0.50. Whilst the first is amongst the stoutest species of *Goniatites*, the latter is the slenderest. A wide range of morphospace has been found in an almost time equivalent assemblage in the Anti-Atlas of Morocco, but this assemblage contains *Goniatites* co-occurring with other ammonoids (Klug et al. 2016).

Material

The investigated section is located in the southwestern part of the Greater Karatau Mountains (43.6452° N; 68.2133° E). The material comes from the Baktysai Formation, which is underlain by Waulsortian bioherms and was dated using

foraminifera Early Viséan to Serpukhovian (Zhaimina et al. 2017, p. 49). The Baktysai Formation crops out along the Zhankurgan River, about 2.5 km north of the Abai village. In the middle part of the succession, exposed on the southern flank of the valley, one of the numerous marlstone layers contained numerous specimens of *Goniatites* (Fig. 3).

A total of 23 specimens have been studied, and 14 of these can be attributed to the new species. All of them are deformed to some degree. Most of the phragmocones are partly crushed and in all specimens, the body chamber is nearly completely squashed. The phragmocone chambers are usually filled with calcite. The material is stored in the fossil cephalopod collection of the Museum für Naturkunde Berlin under the catalogue numbers MB.C.29201 to MB.C.29203.

Systematic descriptions (DK and ZB)

Superfamily Goniatitoidea de Haan, 1825

Family Goniatitidae de Haan, 1825

Genus *Goniatites* de Haan, 1825

Goniatites zhankurganensis n. sp.
(Figs. 4a–c, 5a)

Etymology: Named after the type locality at the Zhankurgan River.

Holotype: Specimen MB.C.29201.1, illustrated in Fig. 4a.

Type locality and horizon: Zhankurgan River bank, 2.5 km north of the Abai village (Greater Karatau, Kazakhstan); Baktysai Formation (Late Viséan).

Material: Ten specimens (MB.C.29201.1–10).

Diagnosis: Species of *Goniatites* with spindle-shaped conch in the early juvenile stage and globular conch between 15 and 40 mm diameter ($w/dm = 0.95–1.00$). Umbilicus moderate in early ontogeny ($uw/dm = 0.20–0.30$) and very narrow in all stages larger than 4 mm diameter (uw/dm around 0.10). Umbilical wall slightly incurved in late growth stages. Aperture very low ($WER = 1.45$) at 40 mm diameter. Suture line at 36 mm conch diameter with very narrow or narrow external lobe (0.60 of the external lobe depth; 1.25 of the



Fig. 3 Looking southeast at the middle part of the Viséan succession in the Zhankurgan section. The *Goniatites*-bearing layer is asterisked, person for scale

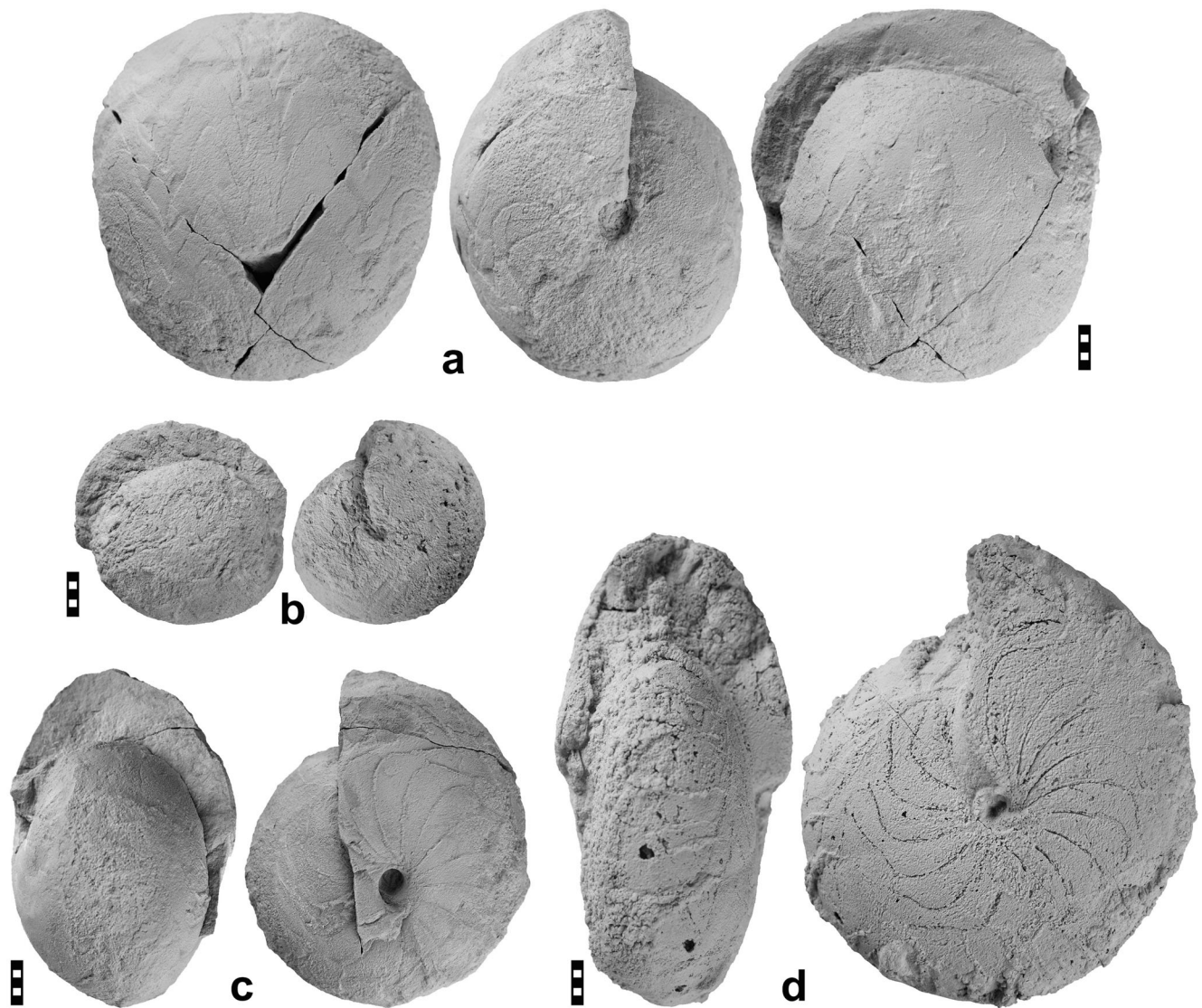


Fig. 4 Ammonoids from the Zhankurgan section, Greater Karatau, Kazakhstan. **a** *Goniatites zhankurganensis* n. sp., holotype MB.C.29201.1. **b** *Goniatites zhankurganensis* n. sp., paratype

MB.C.29201.2. **c** *Goniatites zhankurganensis* n. sp., paratype MB.C.29201.3. **d** *Goniatites abaiensis* n. sp., holotype MB.C.29202.1. Scale bar units, 1 mm

ventrolateral saddle width), and low median saddle (0.40 of the external lobe depth). External lobe V-shaped with weakly sinuous flanks and very narrow, V-shaped prongs, ventrolateral saddle bluntly acute.

Description: Holotype MB.C.29201.1 has, at 42 mm conch diameter, nearly the shape of a ball ($ww/dm = 0.93$). It is slightly deformed, but this did not affect the ww/dm ratio (Fig. 4a). The fully septate specimen is involute ($ww/dm = 0.07$) with a rounded umbilical wall, a broadly rounded venter and a very low aperture ($WER = 1.45$). It shows two shallow and wide steinkern constrictions, which extend nearly linearly across flanks and venter. Shell remains are not preserved.

The suture line of the holotype has a V-shaped external lobe with sinuous flanks, very narrow prongs and a median

saddle that has 0.40 the height of the E lobe depth (Fig. 5b). The ventrolateral saddle is weakly asymmetric and subacute, and the adventive lobe is weakly asymmetric with convexly curved flanks, of which the dorsal flank is slightly more convex.

The smaller paratype MB.C.29201.2 (23 mm dm) is poorly preserved and only allows the study of the conch geometry (Fig. 4b). It is also globular and involute ($ww/dm = 1.05$; $uw/dm = 0.05$) with a low coiling rate ($WER = 1.55$) (Tables 1 and 2). Paratype MB.C.29201.3 (Fig. 4c) with 42 mm conch diameter is laterally deformed (and thus appears to be more compressed).

The sectioned paratype MB.C.29201.4 is deformed and partly crushed but allows an insight in the conch ontogeny

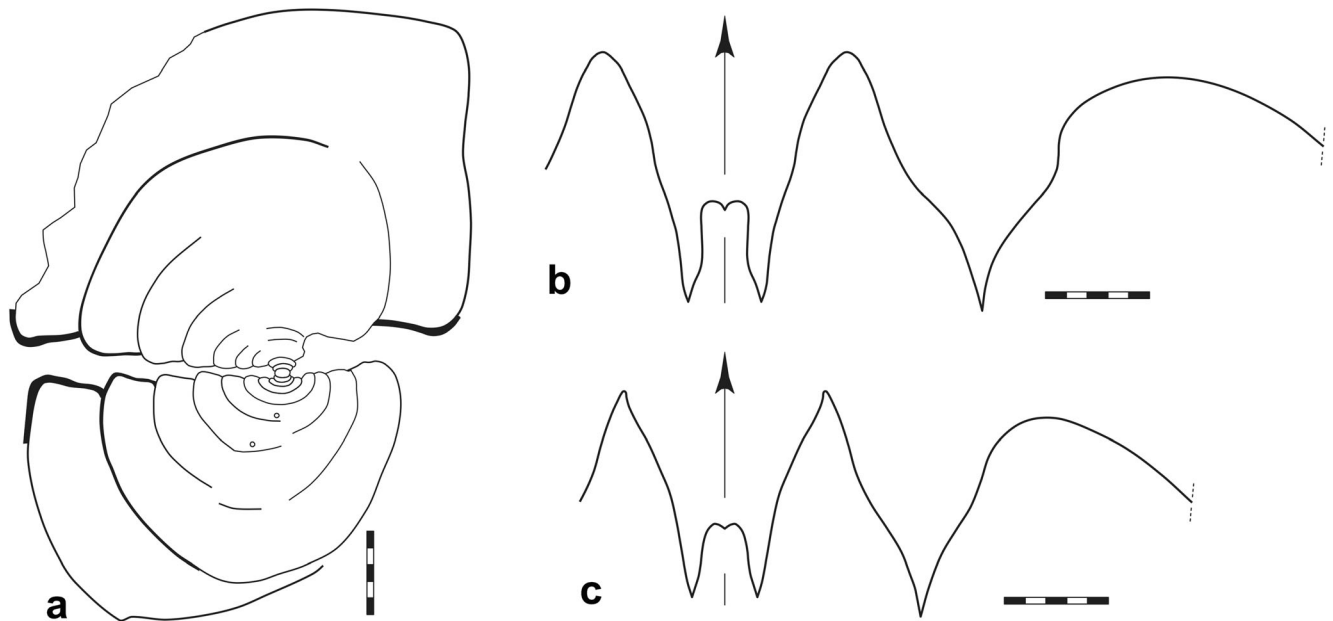


Fig. 5 Ammonoids from the Zhankurgan section, Greater Karatau, Kazakhstan. **a** *Goniatites zhankurganensis* n. sp., cross section of paratype MB.C.29201.4. **b** *Goniatites zhankurganensis* n. sp., sutures

line of holotype MB.C.29201.1, at 36.0 mm dm, 35.3 mm ww, 18.6 mm wh. **c** *Goniatites abaiensis* n. sp., sutures line of holotype MB.C.29202.1, at 20.9 mm ww, 20.2 mm wh. Scale bar units, 1 mm

(Fig. 5a). It had about 40 mm conch diameter and had a globular form. The initial stage is still quite intact and shows two weakly embracing, subevolute volutions with crescent-shaped whorl profile. The conch is spindle-shaped (ww/dm ca. 1.20) at about 2 mm diameter and becomes slenderer during ontogeny. It can be estimated that, at 15 mm dm, it is nearly perfectly ball-shaped. Although partly crushed, the cross section shows the shape of the umbilical margin and the umbilical wall. Above a conch diameter of about 8 mm, the umbilical margin tends to become pronounced and the umbilical wall gets a sinuous, slightly incurved section.

Discussion: *Goniatites zhankurganensis* is a species that has a marginal morphological position within the genus *Goniatites*

because of its very stout conch. Most of the other species of the genus are much slenderer at a comparative diameter. Whilst the stoutest conchs seen in the European species *G. sphaericus*, for instance, range between 0.70 and 0.75 (at 40 mm diameter), *G. zhankurganensis* is much stouter with a ww/dm ratio of 0.95. The same is true for the North American species *G. americanus* (see Korn and Titus 2011) and the North African species *G. rodioni* and *G. tympanus* (see Klug et al. 2006; Korn et al. 2007), which reach a ww/dm ratio of only 0.75–0.80 at 40 mm conch diameter. In its conch dimension, *G. zhankurganensis* has the appearance of a neotenic species that maintains the stout juvenile conch morphology in the larger growth stage.

Table 1 Conch proportions of *Goniatites zhankurganensis* n. sp.

dm	Conch shape	Whorl cross section shape	Whorl expansion
25 mm	Globular; involute (ww/dm ~ 1.05; uw/dm ~ 0.05)	Strongly depressed; very strongly embracing (ww/wh ~ 1.95; IZR ~ 0.65)	Low (WER ~ 1.55)
40 mm	Globular; involute (ww/dm ~ 0.95; uw/dm ~ 0.07)	Strongly depressed; very strongly embracing (ww/wh ~ 1.75; IZR ~ 0.65)	Very low (WER ~ 1.45)

Table 2 Conch measurements of *Goniatites zhankurganensis* n. sp.

	dm	ww	wh	uw	ah	ww/dm	ww/wh	uw/dm	WER	IZR
MB.C.29201.1	42.1	39.4	22.3	2.8	7.2	0.93	1.76	0.07	1.45	0.68
MB.C.29201.2	22.9	23.9	12.4	1.0	4.5	1.05	1.93	0.05	1.55	0.63
MB.C.29201.4	2.18	2.60	0.98	0.51	0.43	1.19	2.67	0.23	1.55	0.56

Table 3 Conch proportions of *Goniatites abaiensis* n. sp.

dm	Conch shape	Whorl cross section shape	Whorl expansion
50 mm	Thickly discoidal; involute (ww/dm ~ 0.50; uw/dm ~ 0.05)	Weakly depressed; very strongly embracing (ww/wh ~ 0.90; IZR ~ 0.60)	Low (WER ~ 1.65)

Table 4 Conch measurements of *Goniatites abaiensis* n. sp.

	dm	ww	wh	uw	ah	ww/ dm	ww/ wh	uw/ dm	WER	IZR
MB.C.29202.1	53.2	26.8	29.5	2.9	11.5	0.50	0.91	0.05	1.63	0.61

Goniatites abaiensis n. sp.
(Figs. 4d, 5c)

Etymology: Named after the type locality north of the Abai village.

Holotype: Specimen MB.C.29202.1, illustrated in Fig. 4d.

Type locality and horizon: Zhankurgan River bank, 2.5 km north of the Abai village (Greater Karatau, Kazakhstan); Baktysai Formation (Late Viséan).

Material: Four specimens (MB.C.29202.1–4).

Diagnosis: Species of *Goniatites* with thickly discoidal conch at 50 mm diameter (ww/dm = 0.50), umbilicus very narrow (uw/dm = 0.05). Aperture low (WER = 1.60) at 50 mm diameter. Suture line at 36 mm conch diameter with very narrow or narrow external lobe (0.55 of the external lobe depth; 1.25 of the ventrolateral saddle width), and low median saddle (0.33 of the external lobe depth). External lobe weakly Y-shaped with very narrow, V-shaped prongs, ventrolateral saddle acute.

Description: Holotype MB.C.29202.1 is a fully septate specimen of 53 mm phragmocone diameter (Fig. 4d). It is thickly discoidal and involute (ww/dm = 0.50; ww/dm = 0.05) with low coiling rate (WER = 1.63). The whorl profile is the widest at the rounded umbilical margin, from where the flanks converge towards the continuously rounded venter.

The suture line of the holotype is typical for *Goniatites* (Fig. 5c). The external lobe is V-shaped with weakly concave flanks, the prongs of this lobe are narrowly V-shaped, and the median saddle has 0.33 the height of the E lobe depth. The ventrolateral saddle is acute, and the adventive lobe is nearly symmetric with weakly convex flanks.

Discussion: *Goniatites abaiensis* is characterised by the very slender conch (ww/dm ~ 0.50 at 50 mm dm) and in this character, it is different from all other species of the genus. A species with comparatively slender conch and a similar suture line is *G. crenistria*, but even in this species, the ww/dm ratio is 0.60–0.65 at 50 mm conch diameter (Tables 3 and 4).

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

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