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Churkites, a trans-Panthalassic Early Triassic ammonoid genus from South Primorye, Russian Far East

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Abstract. The taxonomy, biostratigraphy and paleobiogeographic origin of *Churkites*, an Early Triassic acute-ventered arctoceratid ammonoid genus, are reported based on carefully controlled bed-by-bed sampling of several sections in South Primorye, Russian Far East. *Churkites syaskoi* is herein regarded as a synonym of the type species, *C. egregius*, which was described from the upper Smithian (loewr Olenekian) *Anasibirites* Zone of Russia. *C. egregius* is relatively abundant in sandstone laminae in the laminated mudstone beds of distal turbidites, but rare in the sandstone beds of relatively proximal turbidites. In contrast, *Anasibirites* is abundant in the sandstone beds, but very rare in the mudstone beds. This disparity in occurrence makes a precise biostratigraphic correlation difficult for the upper Smithian *Anasibirites* Zone in the mudstone facies, but *C. egregius* makes it possible to correlate the zone in the mudstone facies. The different modes of occurrence among ammonoid taxa strongly suggest that they either were preserved by different taphonomic processes or had different habitats. *Churkites* most likely evolved from *Arctoceras tuberculatum* on the eastern side of the Panthalassa during the middle Smithian and then crossed the Panthalassa and gave rise to *C. egregius* on the western side of the Panthalassa during the late Smithian. This westward dispersal across the Panthalassa was likely aided by westward equatorial currents as well as by stepping stones provided by the shallow waters around reefs and island terranes.

Key words: ammonoid, *Churkites*, Panthalassa, Smithian, South Primorye, Triassic

Introduction

The Panthalassa was a vast global ocean surrounding the supercontinent Pangaea during the late Paleozoic and early Mesozoic, occupying two-thirds of the global surface area (Péron *et al*., 2005). In spite of the very long distance (20,000+ km) across this wide ocean, several nearly identical ammonoid taxa existed on both sides of the Panthalassa during the Early Triassic (Brayard *et al*., 2006, 2009; Jenks, 2007; Jenks *et al*., 2010; Monnet *et al*., 2013; Shigeta, 2014). *Churkites* Okuneva, 1990, a Smithian (early Olenekian) acute-ventered arctoceratid ammonoid genus, was one of these Early Triassic trans-Panthalassic ammonoids; two species were originally reported from the Far Eastern region of Russia and one species was later recorded from western USA.

Churkites egregius Zharnikova and Okuneva in Okuneva (1990), the type species of the genus, occurs in the upper Smithian (lower Olenekian) of South Primorye and southern Khabarovsk, Russian Far East, and *C. syaskoi* Zakharov and Shigeta, 2004 occurs in the upper Smithian of South Primorye (Zakharov *et al*., 2013). *C. noblei* Jenks, 2007 is known from the upper middle Smithian (middle lower Olenekian) of western USA. Although the American taxon's stratigraphic distribution and ontogenetic and intraspecific variation have been well documented (Jenks, 2007; Brayard *et al*., 2013), the taxonomic relationship between the two Russian *Churkites* species as well as their detailed stratigraphic distributions are still unclear.

In order to better understand the evolution of *Churkites*, we made a thorough geological survey of the Lower Triassic in South Primorye and also examined the type specimens reposited in the Far Eastern Geological Institute (DVGI, Vladivostok) and the Central Scientific-Research Geological-Prospecting Museum (TsNIGR Museum, St. Petersburg). In this paper, we describe the detailed stratigraphic distribution and intraspecific variation of the shell morphology of the Russian *Churkites* and discuss their taxonomic and biostratigraphic impli-

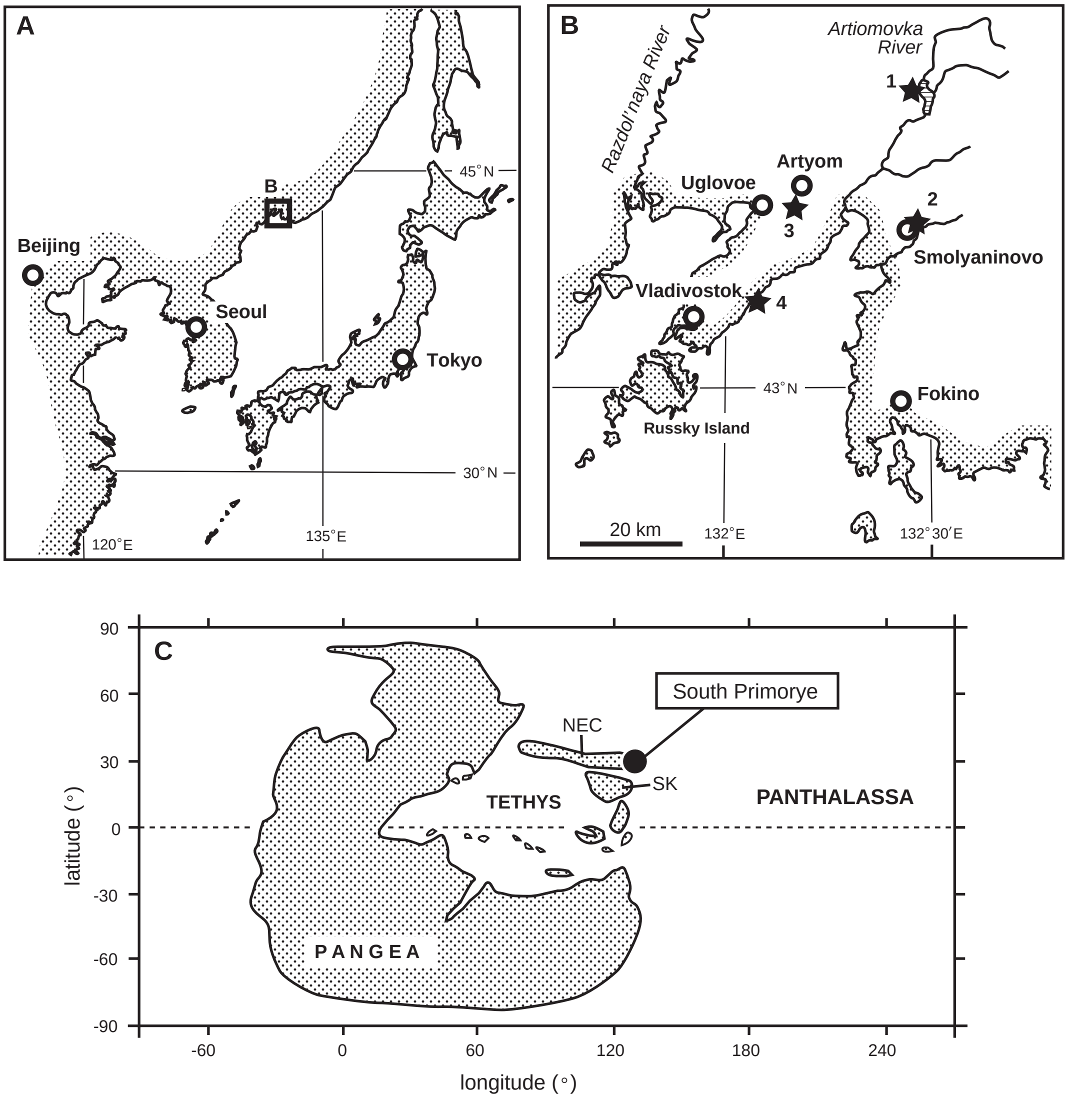

Figure 1. Generalized map (A) showing location (B) of South Primorye. Location (B) of sections from which specimens assigned to *Churkites* were collected by previous authors (indicated by stars). Location (C) of South Primorye during the Early Triassic.1, Artiomovka River section, type locality of *C. egregius*; 2, Smolyaninovo section, type locality of *C. syaskoi*; 3, Artyom section; 4, Tri Kamnya section. NEC, Northeast China Block; SK, Sino-Korea (North China) Craton. Paleomap modified after Péron *et al.* (2005), Brayard *et al.* (2006) and Shigeta *et al.* (2009).

cations, mode of occurrence and evolution with particular attention to the taxon's crossing of the Panthalassa.

Paleogeographical and geological setting

The Lower Triassic Series in South Primorye consists mainly of clastic rocks of various depositional environments. The age distribution pattern of detrital monazites in the sandstone facies is very similar to that of the Khanka Block, which was part of a continent that was attached to the Northeast China Block (Khanchuk, 2001; Yokoyama *et al.*, 2009a, b). This evidence suggests that South Primorye was probably located along the eastern continental margin of the Khanka Block in the middle northern latitudes on the western side of the Panthalassa (Figure 1).

In the Russky Island-Vladivostok-Artyom area, shallow-marine facies of the Lower Triassic are prevalent in the southwestern part (Russky Island), while offshore facies are predominant in the northeastern part (Artyom). As indicated by Zakharov (1968, 1997) and Shigeta and Maeda (2009), an eastward-deepening setting is inferred.

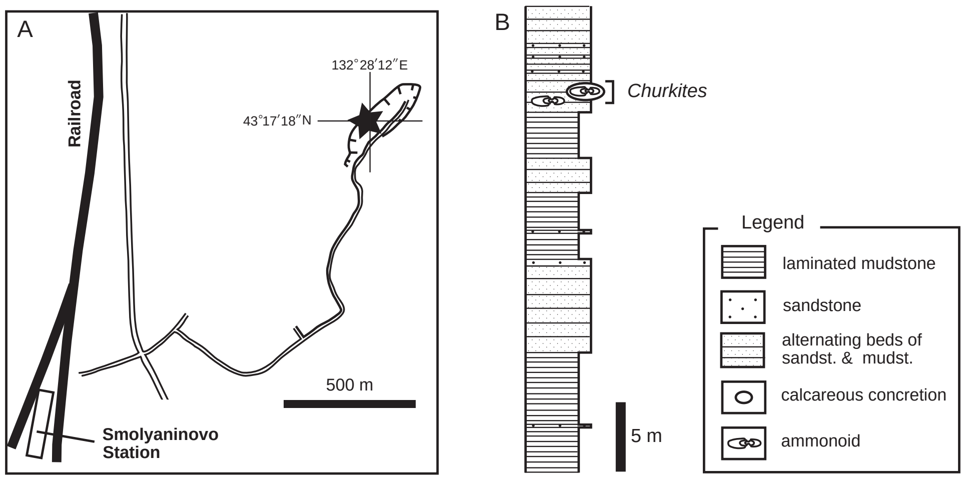

Figure 2. Locality (A) of the Smolyaninovo section and horizon (B) from which the holotype of *C. syaskoi* and other *Churkites* specimens were collected.

Marine Lower Triassic deposits in South Primorye yields numerous well preserved fossils from various horizons within a relatively complete biostratigraphic sequence that includes some biozones typified by species common to Boreal, Tethyan and Eastern Panthalassa realms (e.g. Kiparisova, 1961; Zakharov, 1968; Shigeta, 2009).

Churkites occurrences in South Primorye

Specimens assigned to *Churkites* in South Primorye have been reported from the following four sections: Artiomovka (= Maihe) River, Smolyaninovo, Artyom, and Tri Kamnya (Figure 1). The Artiomovka River section is the type locality of *C. egregius*, but it is now submerged under a reservoir created by a recently constructed dam.

Smolyaninovo section

The Smolyaninovo section, located about 50 km northeast of the center of Vladivostok in a quarry on the northeastern part of Smolyaninovo Village, consists of a well exposed 33-m thick continuous succession of the Zhitkov Formation (Figure 2). These strata strike N35°E–45°E and dip 30–40° eastward; dark gray, laminated mudstone beds (2–8 m thick) and alternating beds of sandstone and mudstone (2–3 m thick) are predominant.

In the upper part of the section, specimens assignable to *Churkites* are abundant in both calcareous concretions and the 1–2 m host rock interval. Zakharov and Shigeta (2004) collected the holotype of *C. syaskoi* from this interval. The section is probably correlated to the middle to upper Smithian (lower Olenekian), but the precise biostratigraphic position of the *Churkites*-bearing beds is unclear because co-occurring age-diagnostic ammonoids and conodonts have not been found in the section (Bondarenko *et al*., 2013; Zakharov *et al*., 2014).

Artyom section

The Artyom section, situated approximately 30 km northeast of the center of Vladivostok, is located in a quarry about 8 km south of Artyom City, in which a 138 m thick continuous succession of Lower Triassic is well exposed (Figure 3). These strata, which generally strike E–W and dip 25–40° southward, are divided into the Lazurnaya Bay and Zhitkov formations in ascending order.

The 11-m thick Lazurnaya Bay Formation consists only of unfossiliferous muddy sandstone, whereas the overlying 120-m thick Zhitkov Formation is comprised of dark grey- to black-colored laminated mudstone with intercalations of fine-grained sandstone in the lower part and sparsely bioturbated, dark grey- to black-colored mudstone in the middle and upper parts. A key, widely traceable, 30 cm thick white vitric tuff bed is intercalated in the upper part.

Ammonoids are abundant in the fine-grained sandstone beds in the lower part of the Zhitkov Formation. *Owenites* Hyatt and Smith, 1905, a middle Smithian index ammonoid is found in the middle part and the late Smithian index ammonoid *Anasibirites* Mojsisovics, 1896, occurs in the topmost part. The 50–60 cm thick *Anasibirites*-bearing beds are composed of sandstones and laminated mudstones (Figure 3C). *Anasibirites* is especially abundant in a 1–5 cm thick, fine-grained sandstone bed (Figure 4C) and *Xenoceltites* Spath, 1930 is common in a 5–10 cm thick overlying mudstone in the

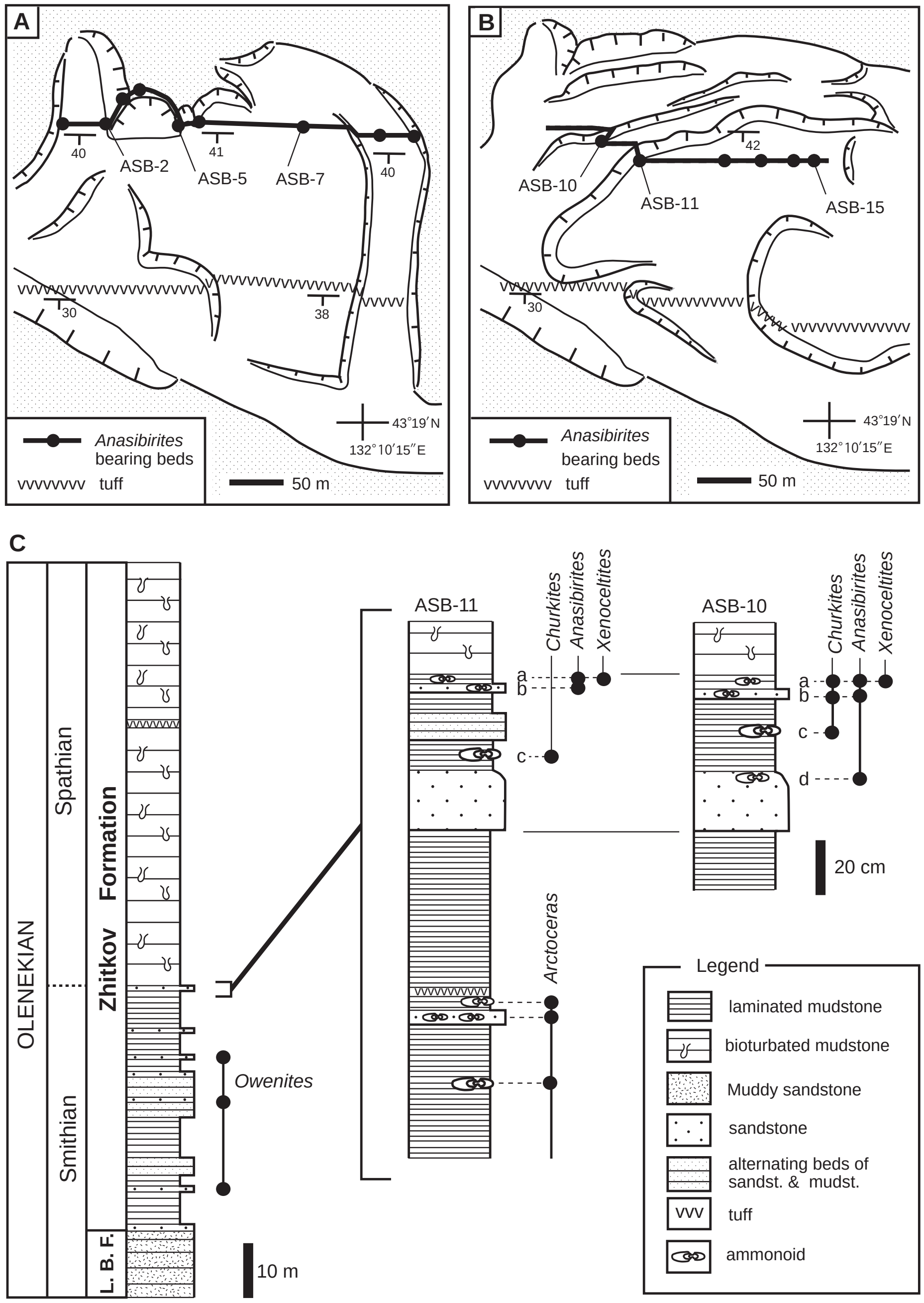

Figure 3. Localities (A, B) of the Artyom section and horizons (C) from which specimens of *Churkites* were collected. Sketch maps A and B of the quarry were made in 2005–2008 and 2011–2012 respectively. The 50–60 cm thick *Anasibirites*-bearing beds and the 30 cm thick white vitric tuff bed are widely traceable in the quarry. Specimens of *Churkites* were collected from ABS-2, 5, 7, 10a, b, c, 11c and 15. L.B.F., Lazurnaya Bay Formation.

uppermost part of the beds (Figure 4B). This sandstone bed probably represents the "calcareous marl lenses" described by Zakharov *et al*. (2013), who studied the same section. According to Zakharov *et al*. (2013), these "calcareous marl lenses" were recognized in three different horizons (basal part of member A, B, and C of the paper) and this apparently led them to assign a thickness of 32.5 m to the *Anasibirites*-bearing beds. However, the fifteen outcrops of *Anasibirites*-bearing beds that we studied in the Artyom section, which include all those

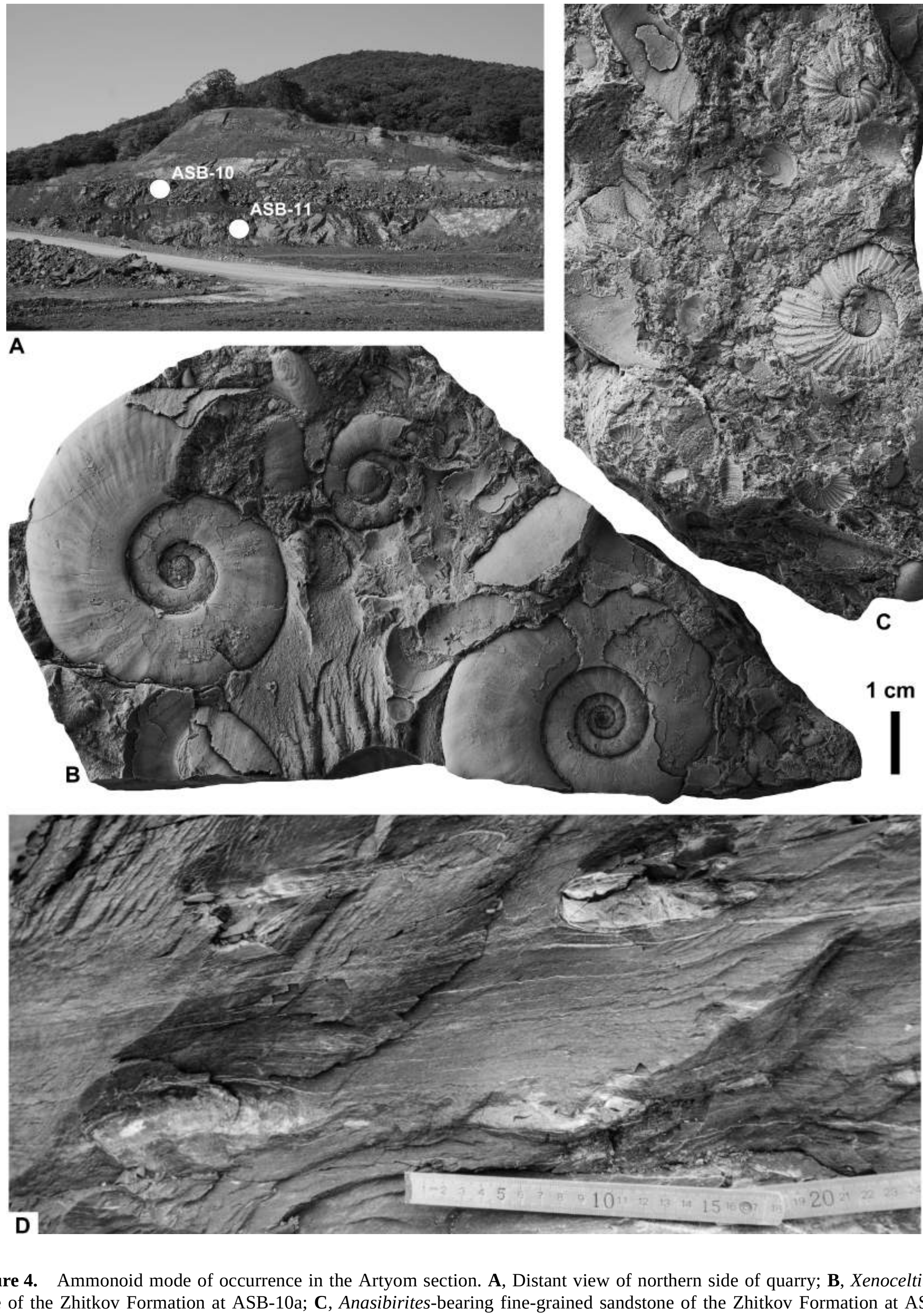

Figure 4. Ammonoid mode of occurrence in the Artyom section. **A**, Distant view of northern side of quarry; **B**, *Xenoceltites*-bearing mudstone of the Zhitkov Formation at ASB-10a; **C**, *Anasibirites*-bearing fine-grained sandstone of the Zhitkov Formation at ASB-10b; **D**, Large-sized *Arctoceras* of middle Smithian age in finely laminated mudstone; mode of occurrence is very similar to that of *Churkites* at ASB-10c. Although *Churkites* only occurs rarely with *Anasibirites* at ASB-10B, it is relatively abundant at ASB-10a and ASB-10c.

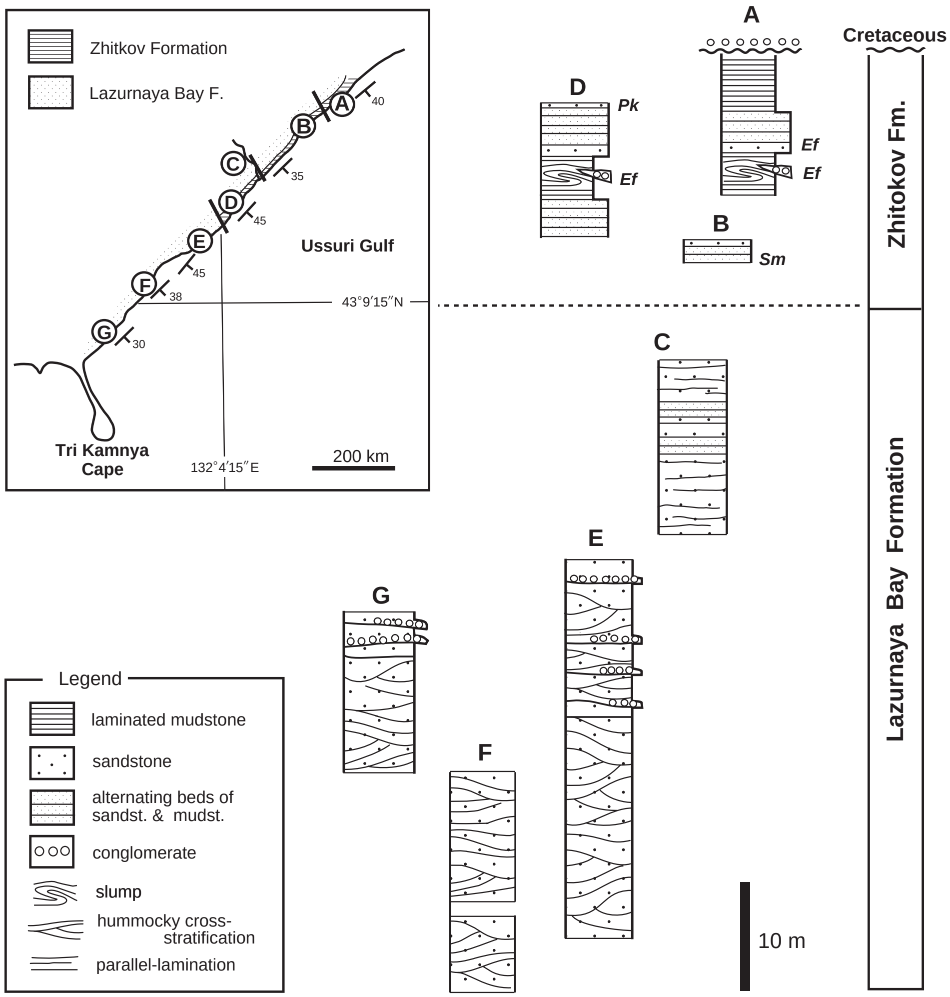

Figure 5. Columnar sections of the Lower Triassic in the Tri Kamnya section. Ef, *Euflemingites prynadai*; Pk, *Palaeokazakhstanites ussuriensis*; Sm, *Shamaraites schamarensis*.

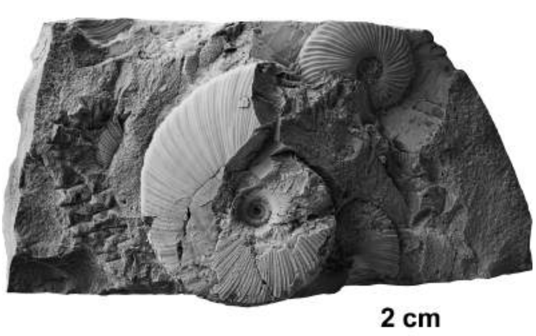

Figure 6. A fragment of calcareous concretion containing *Anasibirites* that was collected as float along the beach on the north side of Tri Kamnya Cape on the western coast of the Ussuri Gulf. It probably came from a pebble in the basal conglomerate of the Lower Cretaceous Ussuri Formation, which unconformably overlies the lower Smithian Zhitkov Formation.

studied by Zakharov *et al*. (2013), suggest that the "calcareous marl lenses" occur in only a single horizon and therefore, the *Anasibirites*-bearing beds are actually only 50–60 cm thick. When considering the orientation of the beds, the *Anasibirites*-bearing outcrops indeed moved southward as the quarry was excavated downward over a period of several years. This may have caused Zakharov *et al*. (2013) to overestimate the thickness of these beds. The middle and upper parts of the Zhitkov Formation are composed of nearly unfossiliferous, barely bioturbated mudstone. Spathian ammonoids occur very rarely in the middle and upper parts.

Specimens assignable to *Churkites* are found only in the *Anasibirites*-bearing beds. While *Churkites* occurs rarely with *Anasibirites* in the fine-grained sandstone at ASB-10b, it is relatively abundant and usually occurs solitarily in the laminated mudstone at ASB-2, 5, 7, 10a, 10c, 11c, and 15 (Figure 3A, B). Although middle Smithian ammonoids are abundant in the lower part of the Zhitkov Formation, *Churkites* has never been found in this interval.

Tri Kamnya section

Located about 16 km east-northeast of Vladivostok, the ~80-m thick Tri Kamnya section is well exposed along the shore northeast of Tri Kamnya Cape on the western coast of the Ussuri Gulf (Figure 5). These strata generally strike NE–SW and dip 30–45° southward. The section mainly consists of +60 m thick wave- and storm-influenced shallow-marine sandstones of the Lazurnaya Bay Formation and dark grey laminated mudstone intercalated with fine-grained sandstone of the overlying 20-m thick Zhitkov Formation, which is unconformably overlain by basal conglomerate of the Lower Cretaceous Ussuri Formation (Zakharov *et al*., 2004).

Various invertebrate fossils such as ammonoids, gastropods, lingulid brachiopods and bivalves are abundant in the Lazurnaya Bay Formation, but a detailed biostratigraphic position for the ammonoids is unclear because they have not yet been well studied. However, the ammonoid-bearing interval can probably be assigned to the lower to middle lower Smithian because the Induan (Griesbachian and Dienerian) index ammonoid *Gyronites subdharmus* Kiparisova, 1961 has never been found in the section and the overlying Zhitkov Formation contains typical late early Smithian ammonoids, such as *Shamaraites schamarensis* (Zakharov, 1968), *Euflemingites prynadai* (Kiparisova, 1947) and *Palaeokazakhstanites ussuriensis* (Zakharov, 1968).

Recently, Zakharov *et al*. (2014) reported *Churkites*-like and *Anasibirites*-like specimens from float blocks found on the beach in the northern area of the Tri Kamnya Cape between sections E and F in Figure 5. Zakharov *et al*. (2014) assumed that they came from the nearest outcrop and correlated them with the upper Smithian *Anasibirites nevolini* Zone. However, the lithology of the nearest outcrop clearly suggests that it belongs to the Lazurnaya Bay Formation, whose youngest age is early to middle early Smithian.

In the Tri Kamnya section, the lower Smithian Zhitkov Formation is unconformably overlain by the Lower Cretaceous Ussuri Formation, which includes a conglomerate at its base with pebbles that actually consist of calcareous concretion fragments that contain *Anasibirites* (Figure 6). For this reason, *Anasibirites* and associated fossils can be collected from float rocks along the beach, and the *Churkites*-like specimens reported by Zakharov *et al*. (2014, pl. 1, figs. 3–6) presumably came from these pebbles. Furthermore, the assignment of these specimens to *Churkites* by Zakharov *et al*. (2014) is questionable, because their fragmental nature precludes a generic assignment. The exact nature of the occurrence of *Churkites* in the Tri Kamnya section must await further work that will focus on taxonomic studies of well preserved specimens as well as their mode of occurrence.

Paleontological description

Systematic descriptions basically follow the classification established by Tozer (1981, 1994) and Brayard and Bucher (2008). Morphological terms are those used in the *Treatise on Invertebrate Paleontology* (Moore, 1957). Quantifiers used to describe the size and shape of the ammonoid shell replicate those proposed by Matsumoto (1954, p. 246) and modified by Haggart (1989, table 8.1).

Abbreviations for shell dimensions.—D = shell diameter; U = umbilical diameter; H = whorl height; W = whorl width.

Institution abbreviations.—CGM = Central Scientific-Research Geological-Prospecting Museum (TsNIGR Museum), St. Petersburg; DVGI = Far Eastern Geological Institute, Vladivostok; NMNS = National Museum of Nature and Science, Tsukuba.

Order Ceratitida Hyatt, 1884
Superfamily Meekoceratoidea Waagen, 1895
Family Arctoceratidae Arthaber, 1911
Genus ***Churkites*** Okuneva, 1990

Type species.—*Churkites egregius* Zharnikova and Okuneva in Okuneva, 1990.

Churkites egregius Zharnikova and Okuneva in Okuneva, 1990

Figures 7–12

Metotoceras? sp. Okuneva, 1976, p. 33, pl. 33, pl. 1, fig. 16.
Churkites egregius Zharnikova and Okuneva in Okuneva, 1990, p. 134, pl. 14, figs. 1–3, text-fig. 6; Jenks, 2007, text-figs. 5, 10A–D.
Churkites syaskoi Zakharov and Shigeta, 2004, p. 223, pl. 1, text-fig. 66; Jenks, 2007, text-figs. 6, 10E–F; Zakharov *et al*., 2013, fig. 5-1; Zakharov *et al*., 2014, pl. 1, figs. 1–2.
? *Churkites* cf. *syaskoi* Zakharov and Shigeta. Zakharov *et al*., 2014, pl. 1, figs. 3–6.

Holotype.—CGM 1/10379 (Figure 7), designated but not figured by Zharnikova and Okuneva in Okuneva (1990), from the Lower Triassic (upper Smithian?) deposits in the Artiomovka River area, South Primorye, Russia. Consists of a fragment (part of a body chamber and its inner whorl) of a large-sized shell, probably mature.

Materials examined.—Five specimens, NMNS PM35000–35004, from 1–2 m interval in the upper part of the Zhitkov Formation in the Smolyaninovo section

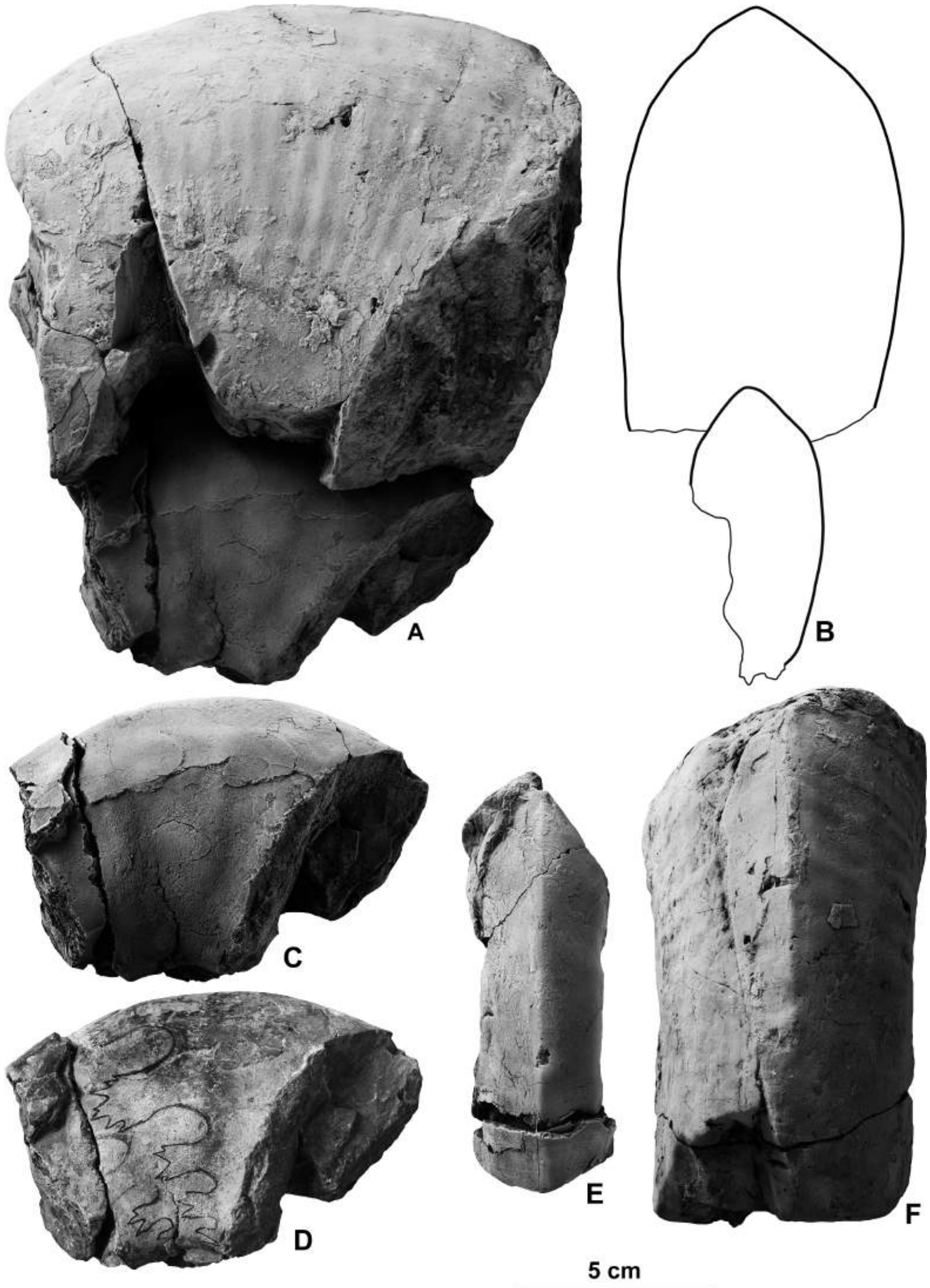

Figure 7. Holotype of *Churkites egregius* Zharnikova and Okuneva in Okuneva (1990), from the Lower Triassic (upper Smithian?) in the Artiomovka River section. **A**, **C**, **E**, **F**, plaster cast of the holotype, NMNS PM35014; A, left lateral view; C, left lateral view of the inner whorl of A; E, ventral view of C; F, ventral view of A; **B**, whorl cross section; **D**, left lateral view of the inner whorl of the holotype, CGM 1/10379.

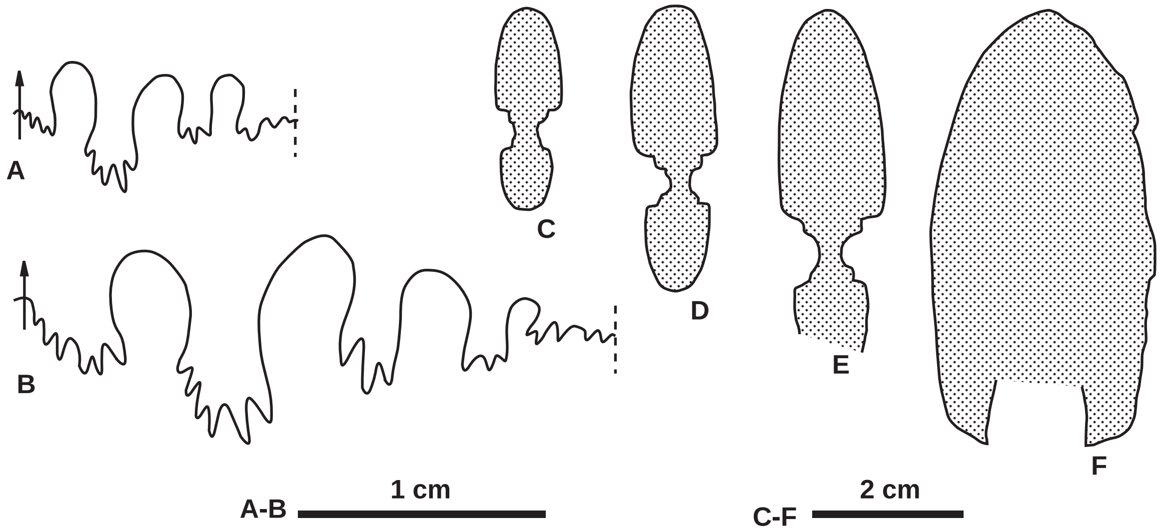

Figure 8. Suture lines (A, at H = 10 mm; B, at H = 27 mm) and whorl cross sections (C–F) of *Churkites egregius* Zharnikova and Okuneva in Okuneva (1990), NMNS PM35000, from the Smolyaninovo section. Solid and broken lines indicate position of the siphuncle and umbilical seam.

(Figure 2), nine specimens, NMNS PM35005–35013, from the *Anasibirites*-bearing beds (50–60 cm thick) in the Zhitkov Formation in the Artyom section (Figure 3): NMNS PM35005, from ASB-2, NMNS PM35006, from ASB-5, NMNS PM35007, from ASB-7, NMNS PM35008, from ASB-10a, NMNS PM35009, from ASB-10b, NMNS PM35010, from ASB-10c, NMNS PM35011–35012, from ASB-11c, NMNS PM35013, from ASB-15.

Description.—Early whorls (up to 10 cm in diameter, Figures 8, 9): Fairly involute, fairly compressed shell with elliptical whorl section, arched venter, indistinctive ventral shoulders, and slightly convex flanks with maximum whorl width at mid-flank. Umbilicus narrow with moderately high, vertical wall and abruptly rounded or subangular shoulders. Ornamentation consists of fine sinuous prorsiradiate growth lines. Suture ceratitic. First lateral saddle lower and narrower than second saddle, and third saddle lower than second saddle. First lateral lobe deep, wide with many denticulations at base, and second lateral lobe half to two-thirds depth of first lobe.

Middle whorls (10–20 cm in diameter, Figures 10, 12): As size increases, venter becomes distinctively acute with ventral shoulders ranging from barely perceptible to distinctive. Maximum whorl width occurs at mid-flank. Umbilical width tends to become wider, with a more inclined umbilical wall. Ornamentation consists of weak to strong tuberculation on umbilical shoulders and distant, radial, slightly sinuous, fold-like ribs arising either from or near tubercles on umbilical shoulder, becoming strongly projected forward at ventral shoulders, and then rapidly fading away before reaching ventral carina.

Later whorls (over 20 cm in diameter, Figure 11): As shell grows larger, whorl section becomes more compressed and ventral carina more acute. Ribs become denser. Mature shell size unknown; body chamber length unknown, but at least 1/2 whorl.

Measurements.—See Table 1.

Remarks.—*Churkites egregius* was described based on specimens found in both the Artiomovka River section, South Primorye and the Bolshie Churki Range, southern Khabarovsk. Although the paratype and related specimens, which were collected from southern Khabarovsk were illustrated and described, the holotype collected from South Primorye was never figured until now. The holotype, CGM 1/10379, consists of a large body chamber fragment and part of its inner whorl (Figure 7), and had the complete shell been preserved, its diameter would be very large (~30 cm). The shell, characterized by a ventral carina and rounded ventral shoulder, is ornamented with distant, radial, slightly sinuous, fold-like ribs on the inner whorl and denser ribs on the body chamber, which arise at the umbilical shoulder, project strongly forward at the ventral shoulders, and rapidly fade away before reaching the ventral carina. These features match well with not only the specimens from the Smolyaninovo and Artyom sections described herein, but also the holotype of *Churkites syaskoi*, described by Zakharov and Shigeta (2004) from the Smolyaninovo section. Zakharov and Shigeta (2004) stated that the

Figure 9. *Churkites egregius* Zharnikova and Okuneva in Okuneva (1990), NMNS PM35000, from the Smolyaninovo section. **A–I**, inner whorls of J and K; A, H, E, left lateral views; B, F, apertural views; C, I, ventral views; D, G, right lateral views; **J**, ventral view; **K**, left lateral view.

suture lines in the early whorls of *C. syaskoi* are somewhat different than *C. egregius* in that the lobes are more denticulated. However, ongoing work has shown that this difference is not necessarily diagnostic and instead can be a function of preservation, preparation, shape of the whorl and size of the specimens (Kummel and Steele,

Figure 10. *Churkites egregius* Zharnikova and Okuneva in Okuneva (1990) from the Smolyaninovo section. **A–C**, NMNS PM35001; A, apertural view; B, right lateral view; C, ventral view; **D–F**, NMNS PM35002; D, apertural view; E, right lateral view; F, ventral view. Arrow indicates position of last septum.

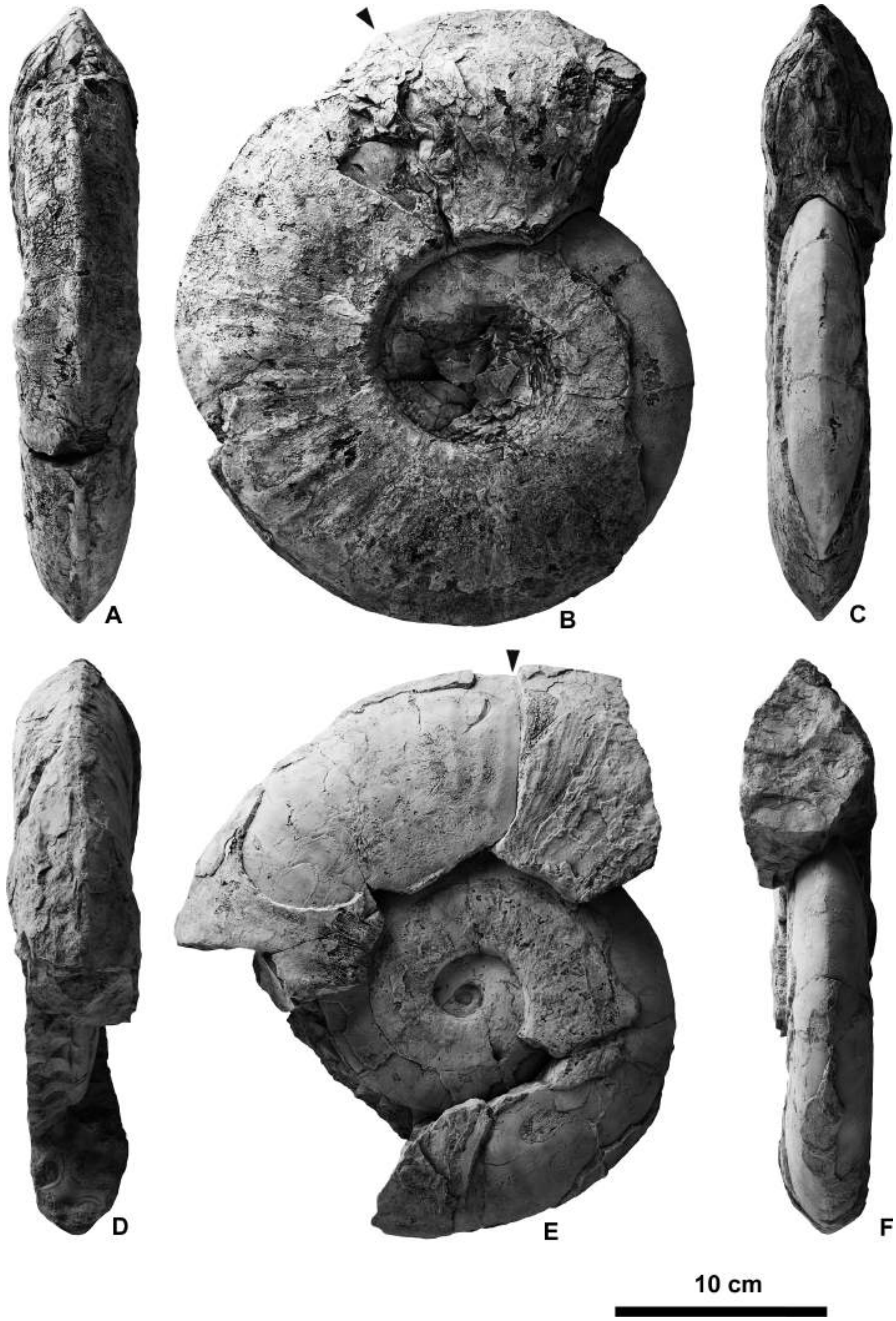

Figure 11. *Churkites egregius* Zharnikova and Okuneva in Okuneva (1990) from the Smolyaninovo section. **A–C**, NMNS PM35004; A, ventral view; B, left lateral view; C, apertural view; **D–F**, NMNS PM35003; D, ventral view; E, left lateral view; F, apertural view. Arrow indicates position of last septum.

1962; Jenks, 2007). Therefore, *C. syaskoi* is herein regarded as a synonym of *C. egregius*.

Recently, Zakharov *et al*. (2014) reported several specimens that they assigned to *Churkites* cf. *syaskoi* from float blocks found on the beach in the northern area of the Tri Kamnya Cape. However, their assignment to

Figure 12. *Churkites egregius* Zharnikova and Okuneva in Okuneva (1990) from the upper Smithian *Anasibirites* beds at ASB-11c in the Artyom section. **A–D**, NMNS PM35011; A, left lateral view; B, apertural view; C, right lateral view; D, ventral view; **E–G**, NMNS PM35012; E, ventral view; F, left lateral view; G, apertural view.

Churkites is questionable, because the fragmental nature of the specimens precludes a generic assignment.

Occurrence.—The precise stratigraphic position from which the holotype of *Churkites egregius* was collected in the Artiomovka (= Maihe) River section is unknown, but the *Mesohedenstromia bosphorensis* and *Anasibirites nevolini* zones are both present in the section (Zakharov, 1968, 1978). According to Okuneva (1990), the paratype

Table 1. Measurements (in mm) of herein described specimens of *Churkites egregius* Zharnikova and Okuneva in Okuneva (1990) from the Smolyaninovo and Artyom sections, South Primorye.

Specimen no.	*D*	*U*	*H*	*W*	*U*/*D*	*W*/*H*
NMNS PM35000	27.3	5.4	13.5	9.3	0.20	0.69
ditto	45.5	7.7	25.0	12.9	0.17	0.52
ditto	59.0	8.7	31.3	15.5	0.15	0.50
ditto	—	—	58.0	31.0	—	0.53
NMNS PM35001	171.2	55.3	67.2	45.6	0.32	0.68
NMNS PM35002	190.2	63.1	72.8	48.4	0.33	0.66
NMNS PM35003	269.0	93.0	100.0	61.0	0.35	0.61
NMNS PM35004	280.0	89.6	106.2	59.2	0.32	0.56
NMNS PM35005	—	—	74.0	40.0	—	0.54
NMNS PM35006	—	—	82.0	41.5	—	0.51
NMNS PM35007	155.7	45.0	60.4	—	0.29	—
NMNS PM35009	175.0	49.1	71.1	43.0	0.28	0.60
NMNS PM35010	—	—	49.6	27.7	—	0.56
NMNS PM35011	117.0	26.2	52.3	31.2	0.22	0.60
ditto	99.0	18.9	46.3	27.1	0.19	0.59
NMNS PM35012	206.0	60.3	79.8	44.6	0.29	0.56
NMNS PM35013	—	—	63.8	38.6	—	0.61

and other related specimens were collected from a 50 cm thick conglomerate bed in the middle of a 5-m thickness of alternating beds of sandstones and mudstones together with the ammonoids *Owenites nevolini* (Burij and Zharnikova, 1972), *Dieneroceras chaoi* Kiparisova, 1961, *Koninckites lingyunensis* Chao, 1959, *Arctoceras septentrionale* (Diener, 1895), *A. simile* (Kiparisova, 1961), since reassigned to *A. subhydaspis* (Kiparisova, 1961), and *Prosphingites ovalis* Kiparisova, 1961 in a quarry located 5.5 km southwest of Ungun Village, southern Khabarovsk. The overlying sandstone contains the ammonoid *Anasibirites* and the conodont *Scythogondolella milleri* (Müller, 1956) (Zakharov *et al*., 2014). Judging from the lithology, the conglomerates probably represent debris flow deposits, which are common in the Zhitkov Formation in the Artyom and Tri Kamnya sections; these conglomerates sometimes contain pebbles coming from several underlying horizons. Although there is an 80 cm thick barren interval in the Artyom section (Figure 3C), *Churkites egregius* has never been found together with *Arctoceras* Hyatt, 1900, which is abundant in the middle Smithian. In South Primorye, *Arctoceras subhydaspis* is restricted to the latest middle Smithian and *Owenites* occurs in the middle middle Smithian, but they have not been found together in the same horizon. This evidence suggests that the conglomerate containing *Churkites egregius* includes ammonoids from several horizons. Therefore, the precise stratigraphic position of *C. egregius* in southern Khabarovsk is undeterminable.

Churkites egregius has been found in the Artiomovka River, Smolyaninovo and Artyom sections, but only in the Artyom section has it been found together with the age-diagnostic ammonoid genus *Anasibirites*, which indicates a late Smithian age.

Discussion

Biostratigraphic implications

Based on carefully controlled bed-by-bed sampling, the precise stratigraphic range of *Churkites egregius*, whose occurrence is restricted to the *Anasibirites*-bearing beds, is recognized only in the Artyom section (Figure 3C). *Anasibirites* occurs abundantly in the sandstone beds, but is very rare or absent in the laminated mudstone beds. In contrast, *C. egregius* is relatively abundant in the laminated mudstone beds, but is very rare in the sandstone beds. This inconsistency in the occurrence of *Anasibirites* makes a precise biostratigraphic correlation problematic for the upper Smithian *Anasibirites* Zone in the mudstone facies, but the occurrence of *C. egregius* in the mudstone facies facilitates a correlation with the *Anasibirites* Zone.

Anasibirites has not been found in the Smolyaninovo section, which is composed of alternating beds of sandstone and mudstone, but the occurrence of *Churkites egregius* strongly suggests that the upper part of the section can be correlated with the upper Smithian *Anasibirites* Zone.

Mode of occurrences of *Churkites* and *Anasibirites*

The *Anasibirites* beds in the Artyom section are comprised of alternating beds of sandstones and laminated mudstones (Figure 3C). The sandstone beds consist of very fine- to medium-grained, well sorted sandstone exhibiting a fining upward grading, and the basal part, characterized by erosional basal surfaces, contains angular rip-up clasts of laminated mudstones. These features are typical characteristics of turbidites (Bouma, 1962; Lowe, 1982; Mulder and Alexander, 2001). The laminated mudstone beds are intercalated with 1–5 mm-thick very fine grained sandy laminae, which probably represent relatively distal turbidites. Their non-bioturbated lithology suggests a lack or near lack of benthic organisms.

Anasibirites is abundant in the sandstone beds of tur-

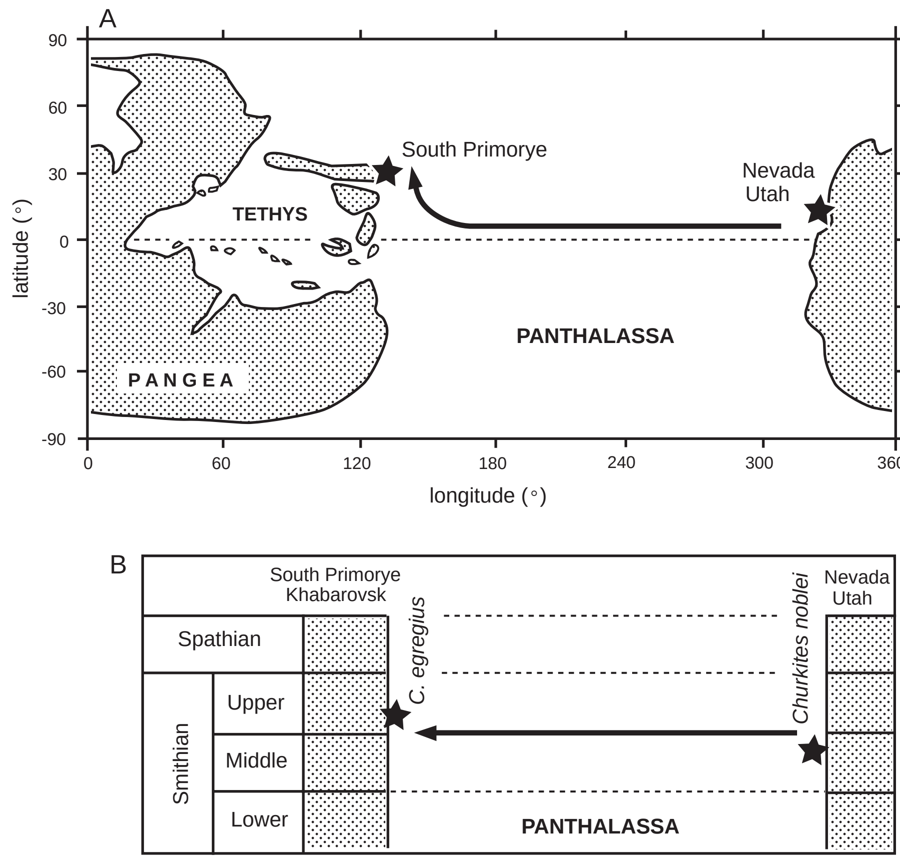

Figure 13. Paleogeographical (A) and stratigraphical position (B) of *Churkites*. *Churkites* most likely originated from *Arctoceras tuberculatum* on the eastern side of the Panthalassa during the middle Smithian, crossed the Panthalassa and gave rise to *C. egregius* on the western side of the Panthalassa during the late Smithian. Paleomap modified after Péron *et al*. (2005), Brayard *et al*. (2006) and Shigeta *et al*. (2009).

bidites, and *Churkites egregius* is relatively abundant in the sandstone laminae in the laminated mudstone beds of distal turbidites. As already suggested by Maeda and Shigeta (2009), most of the ammonoids preserved in the Zhitkov Formation probably lived at shallower depths above the storm wave base, and after death their empty shells were transported from their biotope to the basin-floor by sediment gravity flow. This difference in the mode of occurrence strongly suggests that they were preserved by different taphonomic processes, which may be attributable to hydrodynamic sorting during deposition of the turbidites. The other possibility that must be considered in that they had different habitats; *Anasibirites* likely lived in a sandy environment and *Churkites* may have lived in a muddy environment. Further detailed taphonomic and quantitative paleoecological studies of these ammonoids hopefully will provide an important key for understanding this difference in the mode of occurrence.

Evolution of *Churkites*

Three species of *Churkites* have been described up to now. As discussed above, *C. syaskoi* is herein regarded as a synonym of *C. egregius*, which occurs in the upper Smithian in South Primorye and probably in the upper Smithian in southern Khabarovsk. The most recent species reported is *C. noblei*, which was described by Jenks (2007) from the *Meekoceras gracilitatis* Zone (uppermost middle Smithian, middle lower Olenekian) at Crittenden Springs, Nevada, western USA. The taxon also occurs in the *Owenites* beds (middle Smithian, middle lower Olenekian) in Utah, western USA (Brayard *et al*. (2013). According to Jenks (2007), the morphology, ornamentation and suture line of *C. noblei* are closer to *Arctoceras tuberculatum* (Smith, 1932) than to *C. egregius*. This evidence suggests that *Churkites* most likely evolved from *A. tuberculatum* on the eastern side of the Panthalassa during the middle Smithian, crossed the Panthalassa and gave rise to *C. egregius* on the western side of the Panthalassa during the late Smithian (Figure 13).

It is well known that many ammonoid taxa (e.g. *Owenites*, *Parussuria* Spath, 1930, *Aspenites* Hyatt and Smith, 1905, *Pseudaspidites* Spath, 1934, *Guodunites* and *Galfettites* Brayard and Bucher, 2008, and *Globacrochordiceras* Monnet *et al*., 2013, among others) were distributed on both sides of the Panthalassa during the Early Triassic (Brayard *et al*., 2006, 2007, 2009; Jenks, 2007; Jenks *et al*., 2010; Monnet *et al*., 2013; Shigeta, 2014). Although the timing and direction of the dispersal across the Panthalassa have not well been studied, the geographical and stratigraphical distribution of *Churkites* suggests a westward dispersal across the Panthalassa.

As discussed by Maeda and Shigeta (2009), ammonoids, which had a nectobenthic mode of life similar to recent *Nautilus* (e.g. Scott, 1940; Tanabe, 1979; Cecca, 1992; Westermann, 1996), lived only in the shallower environment above the storm wave base due to the anoxic conditions thought to be so prevalent in deeper waters during the Early Triassic Epoch. Their migration between shallower environments may have been severely restricted by the surrounding oxygen-poor deeper waters (e.g. Wignall and Hallam, 1992; Twitchett and Wignall, 1996; Hallam and Wignall, 1997; Isozaki, 1997; Twitchett, 1999; Wignall and Twitchett, 2002). If the newly hatched juveniles of each *Churkites* species had a long planktic life, they likely would have shown a cosmopolitan distribution, because the duration of the planktic stage of newly hatched juveniles is a very important factor controlling the extent of the geographic distribution for many benthic gastropods and bivalves and probably ammonoids as well (Jablonski and Lutz, 1980, 1983; Scheltema, 1971). Following this line of reasoning, the endemic distribution of each *Churkites* species likely indicates that their newly hatched juveniles had a relatively short planktic stage. Dispersal across the Panthalassa was probably aided by westward equatorial currents, but it may have been difficult for ammonoids having a short planktic juvenile stage to cross this wide ocean. The Lower Triassic exotic limestone blocks found in Japan today were located in low paleolatitudinal regions of the Panthalassa during the Early Triassic and may well have served as stepping stones for ammonoid dispersal (Kummel and Sakagami, 1960; Kambe, 1963; Bando, 1964; Tozer, 1982).

Conclusions

1. *Churkites syaskoi* is herein regarded as a synonym of the type species, *C. egregius*, which occurs in the upper Smithian *Anasibirites* Zone in the Far Eastern region of Russia.
2. *Anasibirites* is abundant in the sandstone beds of South Primorye, but is very rare or absent in the laminated mudstone beds. This disparity in the occurrence of *Anasibirites* makes it difficult to precisely correlate the biostratigraphy of the upper Smithian *Anasibirites* Zone in the mudstone facies, but the occurrence of *C. egregius* in both the laminated mudstone beds and sandstone beds makes it possible to correlate the *Anasibirites* Zone in the mudstone facies.
3. *Anasibirites* occurs abundantly in the sandstone beds of turbidites, but *Churkites egregius* is relatively abundant in the sandstone laminae in the laminated mudstone beds of distal turbidites. This difference in the mode of occurrence strongly suggests that they either had different habitats or were preserved by different taphonomic processes.
4. *Churkites* most likely originated from *Arctoceras tuberculatum* on the eastern side of the Panthalassa during the middle Smithian, crossed the Panthalassa and gave rise to *C. egregius* on the western side of the Panthalassa during the late Smithian.
5. The dispersal of *Churkites* across the Panthalassa may have been aided by westward equatorial currents and stepping stones provided by the shallow waters of reefs and island terranes.

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