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Short communication

First pterosaur bone from the Lower Cretaceous of Siberia, Russia

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ABSTRACT

A distal fragment of the wing metacarpal from the Lower Cretaceous Ilek Formation at the Novochernorechensk locality in Krasnoyarsk Territory, West Siberia, Russia, is nearly identical to the wing metacarpal of the dsungaripterid pterosaur *Lonchognathosaurus acutirostris* from the Lower Cretaceous of North-West China. It is identified here as cf. *Lonchognathosaurus* sp. Both specimens share a ridge on the dorsal condyle not found in other pterodactyloids. In the Siberian wing metacarpal there is a faint groove flanked by ridges on the dorsal surface of the shaft apparently for the reduced metacarpal III. This structure corresponds to the rugosity present in *L. acutirostris* and *Dsungaripterus weii*. The Siberian wing metacarpal represents the first pterosaur postcranial bone for the Lower Cretaceous Ilek Formation of West Siberia and the first record of the Dsungaripteridae in Russia.

1. Introduction

The pterosaurs are among the rarest terrestrial vertebrates known from the Lower Cretaceous of Siberia. Previously they were known only by isolated teeth from the Hauterivian (?) Murtoi Formation and Aptian Khilok Formation of Transbaikalia and the Barremian (?) – Aptian Ilek Formation of West Siberia (Averianov et al., 2003; Leshchinskiy et al., 2003; Averianov, 2007, 2008; Averianov et al., 2015). These teeth were referred to Ornithocheiridae indet., Ctenochasmatidae (?) indet., and Istiodactylidae indet. The rarity and low diversity of pterosaurs in the Lower Cretaceous of Siberia is likely a sampling artifact because this was a time of maximum taxonomic richness of pterosaurs in their fossil record (Butler et al., 2013). Although the pterosaur teeth are abundant at some localities, no pterosaur bones were found previously in the Lower Cretaceous of Siberia. Here we report on the first pterosaur bone from the Lower Cretaceous of Siberia – a distal fragment of the wing metacarpal found in 2017 in the Ilek Formation at the Novochernorechensk locality in Krasnoyarsk Territory, Russia. Despite its incompleteness, this find can be confidently attributed to the pterosaurian clade Dsungaripteridae, which were widely distributed in the Lower Cretaceous of Central and East Asia. This find is even more surprising because it was made in one of the least rich localities. The Novochernorechensk locality, discovered in 2000 (Leshchinskiy and Fayngertz, 2001), so far produced few remains of terrestrial vertebrates, including a turtle dentary fragment and shell plates, crocodylomorph vertebrae, sauropod, theropod and ornithischian isolated teeth and bone fragments, and a mammalian edentulous dentary (Averianov et al., 2019; Lopatin et al., 2019).

1.1. Institutional abbreviation

LMCCE – Laboratory of Mesozoic and Cenozoic Continental Ecosystems, Tomsk State University, Tomsk, Russia.

2. Geological setting

The Novochernorechensk locality (Berezovaya Rechka locality in Leshchinskiy and Fayngertz, 2001) is situated on the right bank of the Berezovaya River valley, exposed by the series of quarries to the northeast from the settlement of Novochernorechenskiy, Kozulka District of Krasnoyarsk Territory (Fig. 1). The generalized section is composed of six outcrops. According to the geological map (Berzon et al., 2006), they represent the interval from the Middle–Upper

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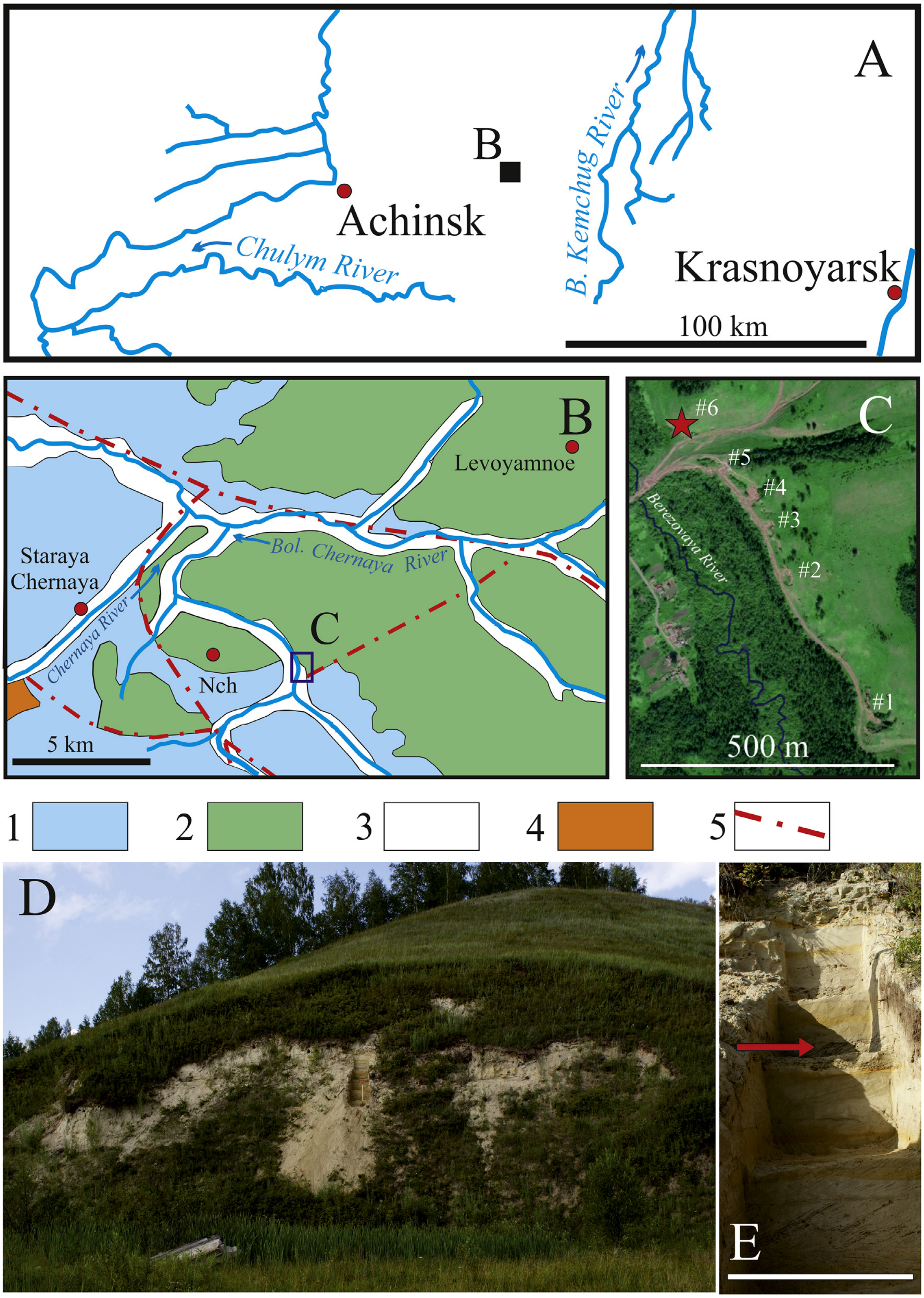


Fig. 1. Location map of the study area within southern part of Krasnoyarsk Territory. A, Map of southern Krasnoyarsk Territory showing position of Novochernorechenskiy settlement by inset B. B, Geological map of the vicinity of Novochernorechenskiy settlement (abbreviated as "Nch" on map) (modified from Berzon et al., 2006) with position of outcrops 1–5 indicated by inset C. C, Position of outcrops 1–6 on a landscape map, with the site producing vertebrate remains indicated by asterisk (56°16.388' N, 91°7.068' E; absolute altitude 258 m). D, Outcrop 6. E, A close up of the upper part of the section of outcrop 6, with the productive bone bed indicated by arrow. Legend for the geological map: 1, Jurassic continental deposits of Itat and Tyazhin formations unspecified; 2, Cretaceous continental deposits of the Ilek Formation; 3, Modern alluvial deposits unspecified; 4, intrusive massif; 5, faults. The scale bar for E equals 0.5 m.

Jurassic Tyazhin Formation to the Lower Cretaceous Ilek Formation, gently dipping to the north.

Outcrop 1 represents the succession of light-yellow and greyish lenticular bodies of silicic conglomerates that are replaced upwards by channel sandstones with mudstone intraclacts and coalified trunks associated with bedding surfaces. Some intraclasts contain plant imprints preliminarily determined as *Sphenobaiera* sp.

Outcrops 2 to 5 depict the development of the facies evolution with prevailing sandstones. Up to 1-m-thick layers of mudstone pebbles and boulders may reflect proluvial events of variable intensities. In the upper half of the outcrop 5, we noted the interbedding of fine-grained yellowish grey sandstones and dark-green and brownish mudstones with abundant phyllopod remains. The outcrops 1 and 2 contain the rare indeterminable rib fragments of dinosaurs. Sampling of the coarse-grained cross-bedded layers for vertebrate remains had given no results.

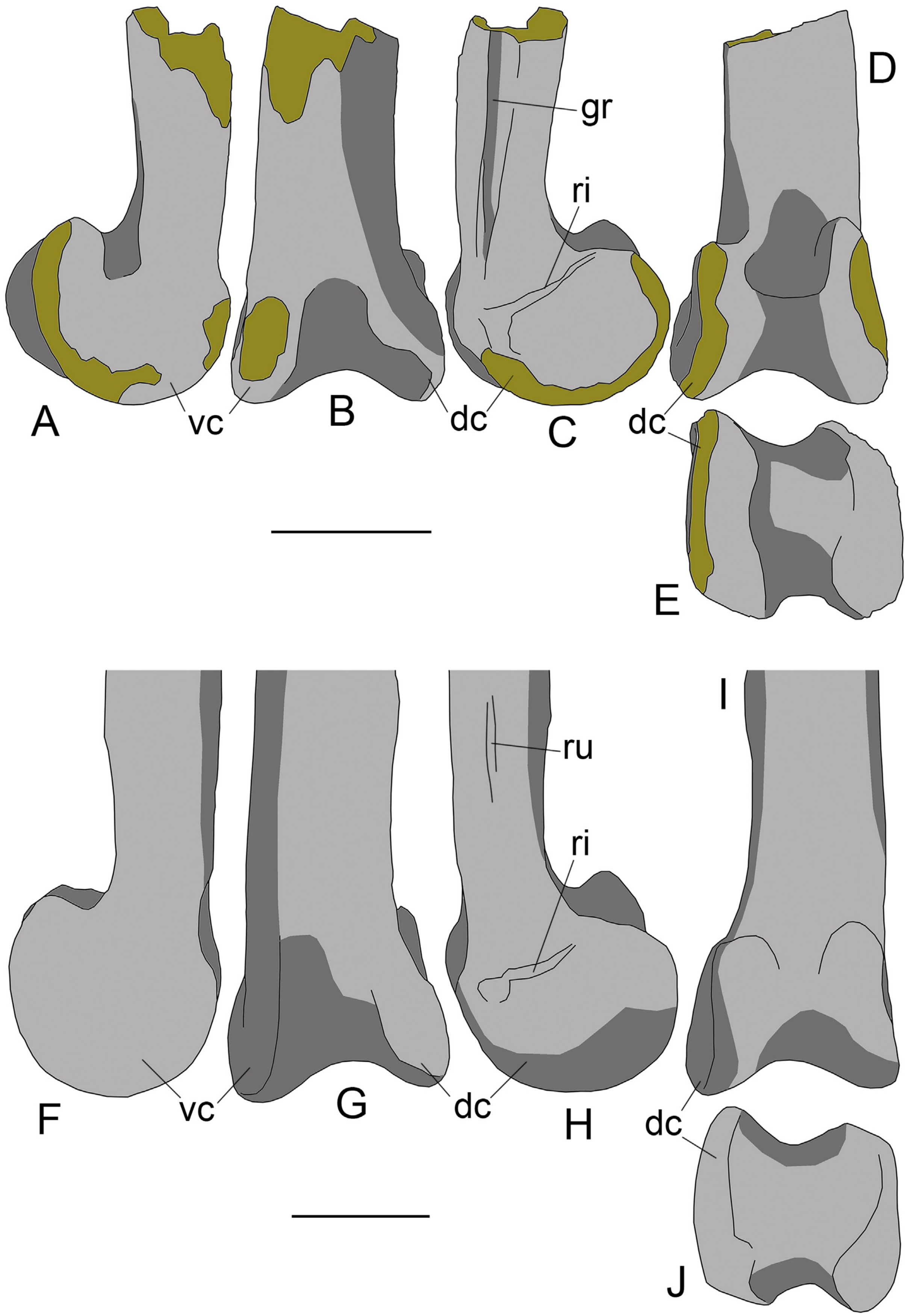
At present, most part of the outcrop 6 (56°16.388' N 91°7.068' E; absolute altitude 258 m) is covered with talus. The uppermost interval of its section comprises the layers or lenticular bodies of cross-bedded poorly lithified medium to coarse-grained sandstones with intraclasts of mudstone pebbles which yielded vertebrate remains. The assemblage of the remains from Novochernorechensk locality is close to the assemblage of the Ilek Formation with minor specific features.

We interpret outcrops 1–5, as representing exceptional deposits of the Ilek Formation. The presence of fluvial conglomerates reflects the tectonic event, which caused an uplift of the folded areas in the south and southeast, producing the coarser clastic material at the beginning of the sedimentation cycle. According to this hypothesis, outcrop 6 represents the lowermost level of the Ilek Formation.

During the geological mapping in the given area, Berzon with colleagues (2006) distinguished the lower member of the Ilek Formation, according to its position in the section and the clear lithological difference, without any paleontological data, supporting the relative age.

In the adjacent Nazarovo Depression, approximately 100 km to the southwest from the given section, the lower part of the Ilek Formation is dated as Barremian by the presence of bivalves *Unio porrectus*, *U. urjupensis*, gastropods *Micromelania elegantoides*, and ostracods *Cypridea consulta*, *Darwinula barabinskiensis*, and

Fig. 2. Cf. *Lonchognathosaurus* sp., LMCCE 008/1, distal fragment of a left wing metacarpal, in ventral (A), anterior (B), dorsal (C), proximal (D, cross-section at the broken proximal end), posterior (E), and distal (F) views. Berezovaya Rechka, Krasnoyarsk Territory, Russia; Ilek Formation (Lower Cretaceous). Scale bar equals 10 mm.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D. contracta (Dolgov et al., 1972). Due to the relative synchrony of the accumulation in the Western Siberia southeast, we presume a most probable Barremian age for the Novochernorechensk locality.

3. Systematic palaeontology

Order Pterosauria Kaup, 1834
Suborder Pterodactyloidea Plieninger, 1901
Family Dsungaripteridae Young, 1964

Genus *Lonchognathosaurus* Maisch, Matzke and Sun (2004)

cf. ***Lonchognathosaurus*** sp.
(Figs 2, 3A–E)

Description. The specimen LMCCE 008/1, discovered in the upper part of section 6, represents distal fragment of the left wing metacarpal (Figs. 2, 3A–E). The bone shaft is oval in cross-section at the broken end (Fig. 2D), with the long axis dorsoventral (8.1 mm at the broken end). The posterior part of this cross-section is nearly symmetrical, while its anterior part is asymmetrical, with the most prominent point closer to the ventral side (Fig. 2D). The shaft is hollow, with relatively thick walls (the maximum thickness is 1.4 mm). The distal part of the shaft, adjacent to the distal epiphysis, is slightly bent dorsally in the dorsoventral plane and posteriorly in the anteroposterior plane (Fig. 2). In dorsal or ventral view, the shaft is slightly constricted near the distal epiphysis (Fig. 2A, C). In anterior or posterior view, the shaft slightly expands towards the distal epiphysis. Along the dorsal margin of the shaft there are two subparallel ridges that converge distally into a short, more prominent ridge, which connects to the proximal end of anterior lip of the dorsal condyle. A faint groove between these ridges is likely a contact area for the rudimentary metacarpal III. There are no pneumatic foramina on either side of the shaft near the distal epiphysis.

The distal epiphysis is pulley-shaped, with the dorsal and ventral condyles being separated by the intercondylar groove. The dorsoventral height of the distal epiphysis is 12.9 mm, the antero-posterior diameter is 12.6 mm. The dorsal condyle is oval in dorsal view, with an antero-posterior long-axis. The proximal end of the posterior lip of the dorsal condyle is wider dorsoventrally than the remaining lip. On the dorsal side, the proximal ends of the anterior and posterior lips are connected by a distinct oblique ridge (Figs. 2C, 3C). There is a round depression on the dorsal condyle adjacent to this ridge. The ventral condyle is larger, round in ventral view, with the proximal end of the posterior lip extending more proximally compared with the proximal end of the posterior lip of the dorsal condyle. In anterior view, the proximal end of the anterior lip of the ventral condyle also extends more proximally compared with that of the dorsal condyle. The anterior lips of the dorsal and ventral condyles continues on the shaft into short and weak ridges delimiting a shallow depression between them. In distal view, both condyles have a similar anteroposterior diameter (the margin of the ventral condyle is eroded; Fig. 2F). In distal view, both condyles are parallel and perpendicular to the line connecting their anterior ends. The intercondylar groove is only slightly wider than the condyles in distal view. In this view, the intercondylar groove is nearly symmetrical, with the narrowest point set at the midline between the condyles. In posterior view, there is a short dorsoventral ridge within the intercondylar groove, which delimits distally a shallow depression between the proximal ends of the condyles. This depression extends for a short distance on the shaft.

Comparison. LMCCE 008/1 is nearly identical to the distal end of the wing metacarpal of the dsungaripterid *Lonchognathosaurus acutirostris* from the Lower Cretaceous Lianmuxin Formation of the southern Junggar Basin, China (Augustin et al., 2021: fig. 4) (Fig. 3F–J). Both specimens share a unique feature not found in other pterodactyloids: a short ridge on the dorsal side connecting the proximal ends of the anterior and posterior lips of the dorsal condyle (Fig. 3C, H). Attribution of LMCCE 008/1 to Dsungaripteridae is also supported by the thick bony walls of LMCCE 008/1, a character considered a synapomorphy for Dsungaripteroidea (Unwin, 2003). The rugosity on the dorsal side of the wing metacarpal shaft close to the distal epiphysis in *L. acutirostris* (Fig. 3I) (Augustin et al., 2021: fig. 4D) corresponds to the ridges and groove on the dorsal side of LMCCE 008/1 for attachment of the rudimentary metacarpal III (Fig. 3C). This rugosity is much more pronounced on the wing metacarpal of *Dsungaripterus weii* (Young, 1964: fig. 4C). In LMCCE 008/1, *L. acutirostris* (Augustin et al., 2021), the Tatal dsungaripterid (Lü et al., 2009: fig. 4d; Martill et al., 2013: fig. 10), and the dsungaripterid from the Lower Cretaceous Hutubei Formation at Haojiagou gorge in Junggar Basin, northwestern China (Augustin et al., 2022b: fig. 5) the dorsal condyle extends more distally compared with the ventral condyle, while in *D. weii* the ventral condyle protrudes more distally (Young, 1964: fig. 4C; Lü et al., 2009: fig. 4c). Based on the discussed similarities, LMCCE 008/1 can be confidently attributed to the Dsungaripteridae and identified as cf. *Lonchognathosaurus* sp.

4. Discussion

Dsungaripterid pterosaurs are known predominantly from the Lower Cretaceous of Asia (Young, 1964, 1973; Bakhurina, 1982; Buffetaut, 1996; Unwin et al., 1996; Unwin and Bakhurina, 2000; Maisch et al., 2004; Andres and Norell, 2005; Lü et al., 2009; Li and Ji, 2010; Hone et al., 2018; Chen et al., 2020; Ji, 2020; Augustin et al., 2021, 2022a, b). A partial skeleton including presacral and sacral vertebrae, pelvis, and femur from the Kimmeridgian Süntel Formation of Langenberg Quarry, Germany, was attributed to the Dsungaripteridae and considered the geologically oldest dsungaripterid by Fastnacht (2005). This attribution was done mostly because of the thick walls of the long bones of this specimen. However, this character is the synapomorphy of Dsungaripteroidea, the clade including Germanodactylidae and Dsungaripteridae, not just Dsungaripteridae (Unwin, 2003). Moreover, the ilium from Langenberg Quarry with the long, raised, and tapering postacetabular process is more similar to the ilium of *Germanodactylus* than to the ilium of *Dsungaripterus*, which has a short and distally expanded postacetabular process (Fastnacht, 2005: fig. 8). It seems more likely that this specimen belongs to the contemporaneous *Germanodactylus* rather than to a dsungaripterid. This specimen was referred to the Dsungaripteroidea rather than Dsungaripteridae in a review of the pterosaur pelvis (Hyder et al., 2014). The fragmentary pterosaur remains from the Berriasian–Valanginian Lower Bauxite Formation at Cornet, Romania, attributed to the Dsungaripteridae by Dyke et al. (2011), more likely belong to the Azhdarchoidea (Averianov, 2014). The poorly known *Domeykodactylus ceciliae*

Fig. 3. Distal parts of the wing metacarpal in cf. *Lonchognathosaurus* sp. (LMCCE 008/1, A-E) and *Lonchognathosaurus acutirostris* (F-J, modified after Augustin et al., 2021: fig. 4), in ventral (A, F), anterior (B, G), dorsal (C, H), posterior (D, I), and distal (E, J) views. Abbreviations: dc, dorsal condyle; gr, groove for rudimentary metacarpal III; ri, ridge; ru, rugosity; vc, ventral condyle. The yellow shading in A-E indicates the broken or eroded area. Scale bars equal 10 mm. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

from the Lower Cretaceous of Chile (Martill et al., 2000) is the only dsungaripterid known outside Asia.

Discovery of a dsungaripterid cf. *Lonchognathosaurus* sp. in West Siberia considerably extends the known range of the group to the North and West. This is the first record of Dsungaripteridae in the Lower Cretaceous of Siberia. This finding increases the pterosaur diversity in the Ilek Formation. The pterosaurs from this stratigraphic unit were known previously only from isolated teeth referred to Ornithocheiridae indet., Ctenochasmatidae (?) indet., and Istiodactylidae indet (Averianov et al., 2003; Leshchinskiy et al., 2003; Averianov, 2007, 2008; Averianov et al., 2015).

5. Concluding remarks

A distal fragment of the wing metacarpal from the Lower Cretaceous Ilek Formation at Novochernorechensk locality in Krasnoyarsk Territory, West Siberia, Russia, is similar with the wing metacarpal of the dsungaripterid pterosaur *Lonchognathosaurus acutirostris* from the Lower Cretaceous of North-West China, especially in having a ridge on the dorsal condyle, which can be an autapomorphy of *Lonchognathosaurus*. This allows identification of the fossil as cf. *Lonchognathosaurus* sp. This is the first record of the Dsungaripteridae in Ilek Formation and in general in Russia, which extends the known range of the group to the north and west. This is also the first pterosaurian bone fossil from the Ilek Formation, where pterosaurs were known previously only by isolated teeth.

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