



## First evidence of a neonate dentition in pareiasaurs from the Upper Permian of Russia

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**Finds of juvenile pareireptiles are rare in the fossil record. We describe partial upper dentition with large vacuities between bones belonging to a neonate pareiasaur (preserved skull fragment is 22.4 mm long). The specimen was collected within 5 m from a skeleton of an adult specimen of *Deltavjatia vjatkensis* (Hartmann-Weinberg, 1937) (Pareiasauridae) from red calcareous mudstones in the upper part of the Vanyushonkov Member of Ursulov Formation (Upper Permian, Upper Tatarian substage, Vishkil'skiy regional stage) of Kotel'nich locality, Vyatka River region, Russia. Referral to *Deltavjatia vjatkensis* is based on the presence of heterodont dentition: spatulate maxillary, triconodont vomerine and conical, palatine and pterygoid teeth located on well-developed palate ridges. This is the first positively identified record of the neonate pareiasaur dentition.**

The finds of juvenile pareiasaurs are rare in the fossil record, although of adult pareiasaurs are quite numerous in the Late Permian terrestrial assemblages. Up to now we only have information about a few juvenile specimens of pareiasaurs. Postcranial elements are known for *Elginia mirabilis* from the Cutties Hillock Sandstone Formation of Scotland and *Scutosaurus* sp. from the North Dvina bone beds (Spencer & Lee 2000). First cranial material of a juvenile pareiasaur *Deltavjatia vjatkensis* from the Urpalov Formation of the Vyatka River region of Russia has been announced in an abstract by Kordikova & Khlyupin (2000). This specimen, having well-preserved upper dentition, is described here in more detail. The specimen was collected by K. Grekhov from red clay/mudstone layers of the Vanyushonkov Member of Kotel'nich locality in 1999. The locality is known as one of the most productive pareiasaur localities in the world (Efremov & V'yushkov 1955). It is located 18 km south of the town Kotel'nich near the Vanyushonki village on the western bank of the Vyatka River, Kirov district, Russia (Fig. 1).

The detailed geology and stratigraphy of the locality was studied by Coffa (1997). He recognized the Urpalov Formation at the locality as consisting of four members (Fig. 2), the oldest of which – Vanyushonkov Member (arrow in Fig. 2) composed of red calcareous clays and mudstones yields remains of pareiasaurs. At present, the Vanyushonkov Member correlates to the middle of the Urpalov Formation, Kotel'nich Group, Vishkil'skiy Horizon, Upper Tatarian Stage of the Upper Permian (Coffa 1997). The old Severo-Dvinsky Horizon is no longer in usage due to nomenclature problems. Recently, a zonal scheme of the Upper Permian deposits has been proposed, based on tetrapod assemblages (Golubev 1998). This scheme introduces a provincial zone with *Deltavjatia vjatkensis* within the Upper Permian.

The Vanyushonkov Member also contains diverse therapsid fauna with *Suminia getmanovi*, *Emeroleter laevis*, *Viatkosuchus sumini*, *Viatkogorgon ivachnenkovi*, *Karenites ornamentatus*, *Perplexisaurus foveatus*, *Chlynovia serridentata*, *Scalopodon tenuifrons*, *Scalopodontes kotelnichi*, etc. (Ivakhnenko *et al.* 1997; Coffa 1997). Remains of the pareiasaur *Deltavjatia vjatkensis* are numerous in the site. They are generally represented by complete articulated skeletons, but up to now only subadult and adult specimens are known.

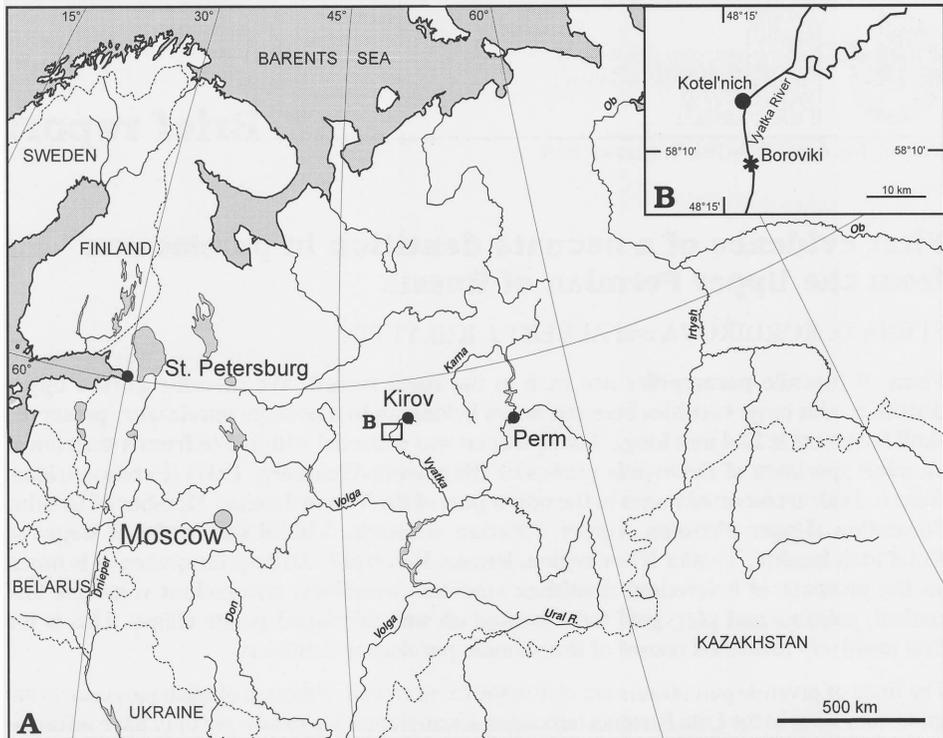


Fig. 1. Map of the Kotel'nich area, Russia.

**Institutional abbreviations.** — PIN, Paleontological Institute of the Russian Academy of Sciences, Moscow; KPM, Kotel'nich Paleontological Museum, Kotel'nich, Russia.

## Systematic paleontology

### Order Pareiasauria Olson, 1947

### Family Pareiasauridae Lydekker, 1889

### Genus *Deltavjatia* Lebedev, 1987

Type species: *Deltavjatia vjatkensis* (Hartmann-Weinberg, 1937).

### *Deltavjatia vjatkensis* (Hartmann-Weinberg, 1937)

Fig. 3.

*Pareiasuchus vjatkensis*; Hartmann-Weinberg 1937: p. 664 (partim); Efremov 1940a: p. 379 (partim); Efremov 1941: p. 101 (partim); 1944: p. 57 (partim); Huene 1956: p. 189 (partim).

*Anthodon rossicus*; Hartmann-Weinberg 1937: p. 676 (partim); Efremov 1940a: p. 379 (partim); Efremov 1941: p. 101 (partim); 1944: p. 57 (partim); Huene 1956: p. 189 (partim). Holotype PIN, N2212/2.

*Anthodon chlynoviensis*; Efremov 1937: p. 129 (partim); 1939: p. 278 (partim); 1940b: p. 82 (partim); Efremov 1940a: p. 379. PIN, N2212/4.

*Scutosaurus rossicus*; Ivakhnenko 1987: p. 86 (partim).

*Deltavjatia vjatkensis*; Ivakhnenko 1987: p. 76 (partim); Lee 1997: p. 254.

*Deltavjatia vjatkensis* (Hartmann-Weinberg, 1937); Kordikova & Khlyupin 2000: p. 52A.

**Material.** — KPM N11/99, a fragment of skull belonging to a neonate.

Stage	Substage	Regional stage	Group	Formation	Member	Paleomgn.	Paleomagn. zone	
Tatarian	Upper	Vyatskiy	Vyatka	Nefedov			Illawara	
				Bykov	Sokolovogora Sokolovogora	N <sub>1</sub> P		
		Vishkil'skiy	Kotel'nich	Ulov	Shestakov Chizhov Borovikov Vanyushkov clays from core			
				U				
				Slobod				N <sub>2</sub> P
	Lower	Urzhumskiy	Urzhum	Syrian			N <sub>r</sub> P	
	Kazanian							Kiama

Fig. 2. Generalised stratigraphic scheme of the Paleozoic in Vyatka River region (after Coffa 1997). The arrow denotes fossiliferous horizon in the Vanyushonkov Member yielding pareiasaurs.

**Locality, horizon, and age.** — Kotel'nich locality, Vyatka River region, Russia; Vanyushonkov Member, zone of Deltavjatia vjatkensis, Urpalov Fm.; Upper Permian.

**Description.** — KPM N11/99 (Fig. 3A) is a fragment of the palate region of the skull missing the premaxilla and all bones posterior to pterygoid. It includes a part of the maxilla with bases of tooth crowns, the vomer, palatine and pterygoid. The preserved part of the dentition is 22.4 mm long and 23 mm wide (the maximal skull length in adults is up to 260 mm). The ventral part of the skull is elongated. It is strongly widened and flattened during ontogeny because of unproportional expansion of cheek and temporal area in adult pareiasaurs. The specimen has heterodont dentition as in subadults and adults. Teeth are present on the maxilla, vomer, palatine and pterygoid.

The maxilla is narrow and rather thin. It contacts the palatine with a narrow bony strip bordering a maxillo-palatine vacuity. A sutural contact between the maxilla and palatine forms during morphogenesis. In subadult specimens the maxillo-palatine vacuity is closed and only a small opening – foramen palatinum posterius – is preserved (Fig. 3B). On the right side the maxilla bears 6 broken tooth bases of crowns and 4 or 5 spatulate teeth lying horizontally 1–3 mm from their bases. There are usually 10–12 maxillary teeth in Deltavjatia vjatkensis. A single tooth is preserved on the left side. Maxillary teeth in the neonate are well-developed, large and flattened with expanded crowns. They are labiolingually compressed. The bases of crowns are oval. Maxillary teeth have big roots and are thecodont. Maxillary teeth were replaced during ontogeny. At least two tooth generations appear to be present in the observed specimen. One of

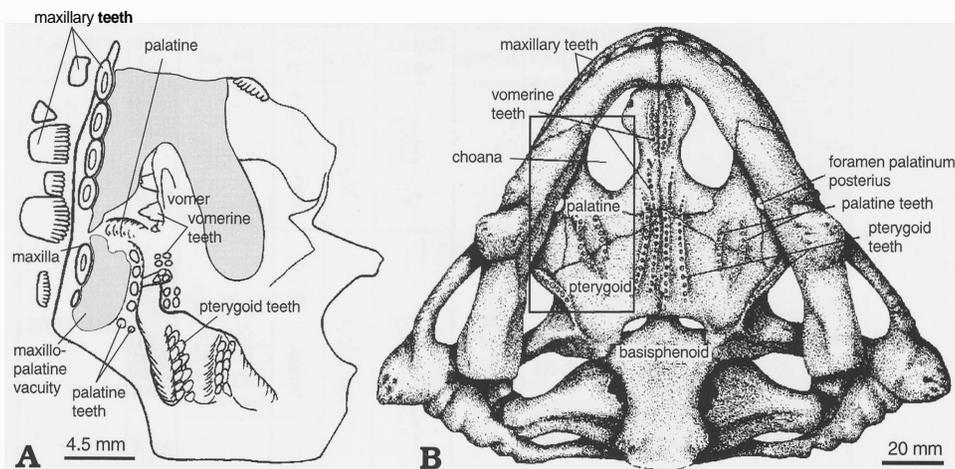


Fig. 3. *Deltavjatia vjatkensis* (Hartmann-Weinberg, 1937); Vanyushonkov Member of the Urpalov Formation, Kotel'nich locality, Vyatka River region. A. Fragment of the upper dentition of a neonate, KPM N11-99, ventral view. B. Skull and lower jaw of adult specimen, PIN N2212/1, ventral view (modified from Ivakhnenko 1987). The portion of the palate region compared with the preserved portion of the neonate pareiasaur is shown in box.

these generations has larger teeth, 2.3 to 2.8 mm long, with 8–10 serrations as in adult specimens. The length of the maxillary teeth in the other generation is about 1.5 mm, with 5–6 serrations.

The palate region in the young specimen has well-developed and closely spaced dental ridges which are weakly developed in subadults and adults. In *Deltavjatia* there are usually several such ridges: one paired medial arcade on the vomer, two paired medial arcades going along the posterior part of the vomer and medially along the anterior part of the pterygoid, two paired oblique ridges going posteriorly and medially from the palatine to the centre of the pterygoid and one paired arcade going posterior, along the lateral pterygoid flanges (Fig. 3B).

The vomer in the neonate is narrow and widened posteriorly, while in adult specimens it is strongly widened at the level of the anterior part of the choanae, so its posterior part is relatively narrow (Fig. 3B). It is separated from the maxilla by a wide vacuity, diminishing during ontogeny. The vomer contacts the palatine and pterygoid. In adult specimens it has unpaired anterior and paired posterior ridges bearing heterodont teeth. The anterior ridge in the described specimen is high. It carries at least two or perhaps three large triangular teeth. The anterior tooth has two apical cones while the posterior have two lateral and one apical cones. Their diameter is 0.5 and 0.6 mm, respectively. Each of the posterior ridges bears at least 4 small conical teeth which slightly smaller than the anterior ones, with diameter of up to 0.3 mm. In subadult and adult pareiasaurs the anterior vomerine teeth are also triconodont and larger than the posterior vomerine, pterygoid and palatine teeth, but their diameter (e.g., in PIN N2212-11) is about 3.5–4 mm while the transverse diameter of the other conical teeth is about 2 mm.

The palatine in the neonate is separated from the maxilla by a wide opening (the foramen palatinum posterius), the form and size of which change during ontogeny. Juveniles and subadults of *Deltavjatia vjatkensis* have a joint between the pterygoid and basisphenoid. Later, during morphogenesis the pterygoid and basisphenoid form a suture in adult specimens. Similar opening is on the left side of the skull of the specimen. The palatine has a high parasagittal ridge which bears at least 6 small symmetrical and conical teeth. Their diameter is about 1 mm. In *Deltavjatia* there are usually two paired parasagittal ridges on the palatine

which continue onto the pterygoid. Each of these ridges bears at least 16 teeth. The length of the arcade is about 31 mm.

The pterygoid also bears teeth. It has two paired well-developed ridges which are very close in the described specimen relative to subadult and adult specimens. These ridges bear at least 5–7 uniform teeth each. The pterygoid teeth are symmetrical, small and conical. Their diameter ranges from 0.3 to 0.5 mm. The pterygoid in subadults and adults has two paired lower medial ridges, each of which bear at least 18 teeth. The diameter of these teeth is about 2.4 mm. Lateral pterygoid flank ridges in subadult and adult specimens are better developed relative to other ones. They usually bear at least 6 teeth.

All palate teeth in investigated specimen are thecodont: they are surrounded by bony ridges (i.e., implanted in sockets).

**Conclusions.** — The pareiasaur neonate has heterodont, thecodont marginal dentition represented by replaced maxillary teeth as well as heterodont, thecodont palatal teeth attached to the well-developed vomerine, palatine and pterygoid ridges. The investigated specimen retains large maxillo-palatine and vomero-maxillary vacuities between bones. The estimated total length of the skull is about 45 mm. The different morphology of the palate region in young and adult specimens suggests different diets.

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