

AEOLIAN DEPOSITS OF THE TATARIAN STAGE IN THE VYATKA RIVER BASIN

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Aeolian sands occur in Upper Permian deposits in almost continuous sections extending up to 20 km, in segments along the banks of the river Vyatka, below the city of Kotel'nich. They are deposited in middle parts of the steep cliffs at a height of 40-80 m on the slope in the form of lens-like beds up to 15 m thick and up to 10 km in length, deposited between double siltstone-mudstone packets.

In the USSR, ancient aeolian deposits were first discovered by V. P. Tverdokhlebov [1], but then described in detail by N. D. Shminke [2] in the Lower Triassic in the basin of the River Samara around the town of Buzuluk.

We now report even more ancient aeolian deposits assigned now to the Upper Tatarian Substage. They are represented by sands, in which the grain size of 0.5-0.05 mm constitutes 90% of the sample, which in general is very typical for aeolian formations, and of this the absolutely most dominant fraction is in the range 0.1-0.05 mm, and 8.5% clay (about 0.01 mm), based on 8 samples.

Usually, the most widely developed aeolian sediment (in the classification of A. V. Sidorenko [3]) is dominated by the sand fraction, 0.25 -0.1 mm, and mudstone does not exceed 3-4%. It is possible that we are dealing here with another group of aeolian formations - displaced (winnowed) sands.

In favour of an aeolian origin is the very high coefficient of sorting of the sand, on average 1.32, while, as in "the original" (obviously fluvial origin) sands in this section it varies from 4.29 to 8.31. The clearest separation between them is seen in the mineralogical composition of the light fraction (Fig. 1). In the aeolian sands, the quartz content increases more than 3 times (on average, from 21% to 69%), there is a 5-fold reduced amount of debris (consisting mainly of clay-siliceous aggregates), a 20 times reduced content of aggregates of clay and carbonate-clay, and a slight increase in the number of grains of feldspar).

Because of the small grain size, the predominant form is of subrounded, rarely rounded, and even rarer hemispheres. The surface of the grains (mostly quartz) is uneven, finely marked with grooves, holes, and a brilliant thin film of iron hydroxide, which imparts a characteristic light brown sand colour. In the original rocks, weathered grains are extremely rare, and often they are spherically subrounded with an uneven but smooth surface, a film of iron hydroxide (if any), are pretty rough, and uneven in thickness and colour intensity.

Underlain by the aeolian sands, are silt-clay sediments of temporary ponds, drainage basins, takyrs (flat proluvium [4]). At different levels there appear illuvial horizons of arid wetland soil and subsoil, expressed in lightness and colour spots, an abundance of clay and calcareous concretions, nodules. This packet, apparently up to 12 m thick in total, is associated with the major locality for tetrapod remains, "Kotel'nich" (a group of locations that can be traced for 10 km), which is dominated by full-skeletal burials of pareiasaurs [5].

* Original reference: Tverdokhlebov, V. P. & Shminke, L. N. 1990. Aeolian deposits of the Tatarian Stage in the Vyatka River Basin. *Doklady Akademii Nauk SSSR*, 315 (4), 934-936. Translated by Michael J. Benton, 2011.

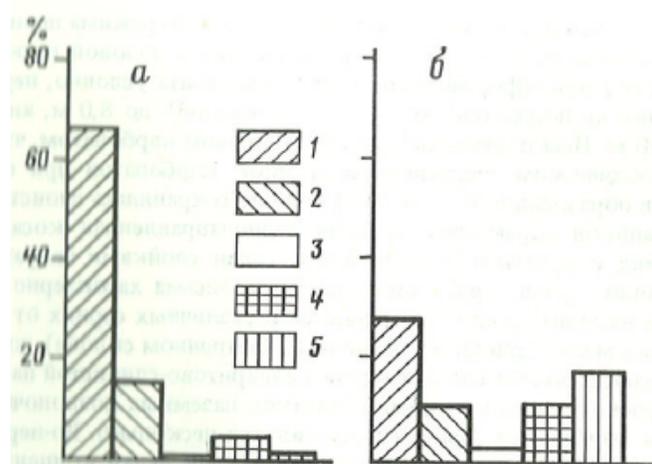


Figure 1. Histograms of mean composition of the light fraction of the sands: a - aeolian (8 samples) from India), b – fluvial (4 samples). 1 - quartz, 2 - feldspars, 3 - muscovite-chlorite, 4 – rock fragments, 5 – aggregated clay, carbonate-clay

The deposits of aeolian sands on the silt-clay formations are close to those, that show mixed composition, inasmuch as that substrate could not serve as the source material for their essential composition.

Attention is drawn to the fact of a complete coincidence of the boundaries of the bone-bearing rock of the location "Kotel' nich" and the aeolian sands overlying them. Outside this location (above and below on the River Vyatka), the sands wedge out completely, and the siltstone-mudstone packets above and below merge into a single column. Such a coincidence is explained by assuming the total confinement of their accumulation in the central, hypsometrically lowest, parts of the drainage basins.

Initially, during the accumulation of the lower packets, with alternation of the seasons (and episodes) of rains and droughts, in the heart of depression it took a very long time to form a "cemetery" of terrestrial vertebrates. Here we are not concerned with possible options for its formation associated with droughts or floods. There is no doubt that the initial concentration of remains of animals of a certain adaptation is necessary for such a vast burial ground, related to the reservoir, located in the central basin, and the loss of their place in the habitat.

With increasing aridity of climate, and lengthening of dry periods, the wind began to move fine sandy material, left over earlier from flows along the periphery of drainage basins. Perhaps the initial flow of aeolian material occurred on a damp or water-covered surface, and then, after final drying, the accumulation of aeolian material only occurred. The build-up of wind is interrupted by periodic wetting, accompanied by a complete or partial leveling of palaeodunes and argillization aligned surface. The thickness of clay interlayers or slush in some areas reaches 0.2-0.4 m, and their shared aeolian sands 1.0-2.5 m.

These impermeable surfaces are clearly visible in the outcrops and can be traced over long distances as dark wet strips located at a considerable distance apart and subparallel, then approaching or even close. In the whole 10-kilometre outcrop of aeolian strata, can be observed from two to four mudstone-bearing interlayers marking a shift to periods of moisture within the aeolian regime. Only one site (below the village Vanyushonki) in a packet of aeolian dunes preserved a large fragment of dune (the form of aeolian relief is taken arbitrarily, an initial diagnosis of the type can not be made) of thickness (high) up to 8.0 m, and an apparent length of 150 m. The sands here are poorly cemented by carbonate that might be due to their episodic

wetting and deposition of carbonates at drainage. For the same reason, the sandstone bedding is well preserved.

For the sandstones a characteristic is large-scale multidirectional cross bedding. In the related series of steep and gentle beds, the oblique direction of their dip is usually the exact opposite, which is very typical of aeolian deposits. Angles of beds vary in different series from 33° (angle of repose of fine sand on the leeward slope) to 0°.

The overlap of aeolian sands with the upper siltstone-mudstone packet is similar in composition and structure to the bottom, but it does not directly contain the remnants of terrestrial vertebrates. There are a few reasons for this. First, in the most arid period the original centre of concentration of the animals was eliminated - the central part of the drainage basins was reformed by aeolian sands and completely levelled. Second, the overall arid climate at this time could lead to a sharp, unrecoverable reduction in this population. Third, the similarity of composition and structure of the upper and lower siltstone-mudstone packets is rather conditional, because of the enormous differences in paleogeomorphology of this site during their accumulation. For the lower rock packets, all the features characteristic of sedimentation in a final receiving basin, and the traces of transitory streams, are observed only at a distance from the location of the pareiasaurs. But at the top of a packet, there are large beds formed by temporary downcutting streams and deltaic branches, captured in some cases, and the underlying aeolian sands. As an example here, along with the local sedimentation in a particularly severe flood, was the transit of clastic material. These beds (their bases) are associated with scattered remnants of tetrapod bones of different composition.

The entire section on the River Vyatka, below the town of Kotel' nich, including the yellow sands, and the underlying and overlying sediments, are assigned [6] to the Yurpalovsky Svita (middle part of the Severodvinian Gorizont). The tetrapod fauna here is quite definite in clearly showing the Late Tatarian age of the deposits.

From the lower silt-clay packets with skeletal graves, have been identified the remains of the pareiasaurs *Deltavjatia vjatkensis* (Hartmann-Weinberg) and *Scutosaurus rossicus* (Hartmann-Weinberg). In the sand lens, cutting the top and, in part, aeolian packets are also found the remains of tetrapods – the theriodont *Proburnetia vjatkensis* Tatarinov, the labyrinthodont *Dvinosaurus primus* Amalitskii. In the mudstone and siltstone beds in one of these lenses at the village Zemtsi, have been found the remains of ostracods, characteristic, according to I. I. Molostovskaya, of the the upper Vyatkian Gorizont of the Upper Tatarian Substage: *Suchonellina* ex gr. *Parallela* Spizh., *S.* ex gr. *Undulata* Misch., *S. anjugensis* Misch., *S.* sp., *Suchonella* sp., *Tatariella* sp.

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