

MYSTERIOUS KOTEL'NICH

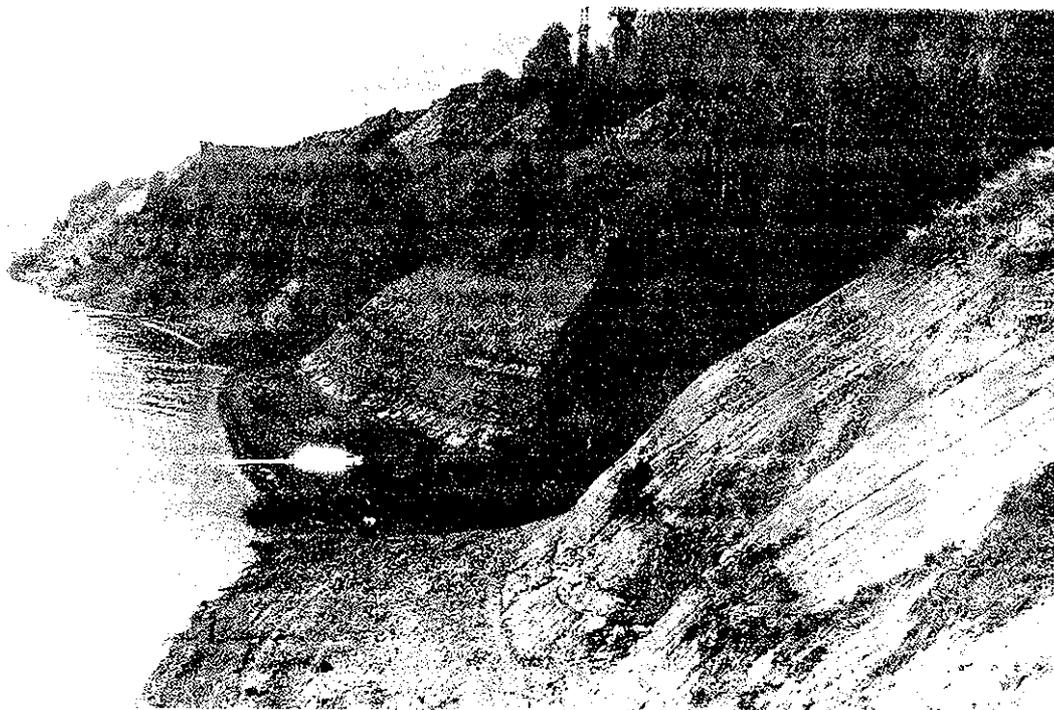
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TO THE SOUTH of the ancient Russian town of Kotel'nich, on the right bank of the Vyatka River, there is an almost continuous exposure of red-brown sediments, 30-40 m high, and marking the beginning of the end of the Late Permian epoch (the end of the Palaeozoic). In the sequence of the earth's crust, these deposits can be dated to the upper Tatarian Substage of the Tatarian Stage. From a distance, the sediments seem monotonous, but on closer examination it can be seen that they are multilayered. The top layer, not less than 10 m in thickness, is a combination of brown and brownish-red sandy mudstones, with layers of greenish- and brownish-grey non-uniformly granular sandstones. Below lie reddish or yellowish-orange fine-grained argillaceous, cross-bedded sandstones up to 15-18 m in thickness. They form a huge, kilometer-scale 'lens' which extends upstream along the riverbank between the villages of Mukha and Volkovo. Beyond, the upper brown clay lies directly on the rock, except at the lowest part of the exposed bank of the Vyatka and its towpath (vegetation does not cover a narrow strip of the bank located between the floodplain and the river's edge). This lower part of the section presents particular interest to us, and we will review it in more detail. It is composed of reddish-brown siltstone (containing small clastic grains of quartz, feldspar, mica, etc.), shell-bearing dense clay with pockets of bluish siltstone, which are sometimes concentrated in eight layers. There are layers of concretionary clay marl and clay layers of thinly-bedded, enriched, unsorted detrital sandy material. The apparent thickness of these rocks is more than 10 m above, they gradually pass into half-metre interbeds of bluish-green siltstone, and then interbeds over a metre thick of sandstones.

*Right bank of
the River
Vyatka -
location
Kotel'nich I.
Photo by D. L.
Sumin.*

In the above place, as in some other parts of the East European part of Russia (for instance, from the North Dvina), have been found the richest burials



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of ancient reptiles. Even at the end of the last [= nineteenth] century, the Russian geologist P. Krotov found the remains of reptiles. But the study of the Kotel' nich locality began with discoveries made in 1933 in hydrogeological investigations. Then a young assistant, and later professor of Kazan University, S. G. Kashtanov unearthed two skeletons of pareiasaurs near the village of Vanyushonki, approximately 18 km down the river from the city [1]. Three years later, he found another two or three skeletons, already destroyed by erosion, approximately 2 km upstream [2].

Materials collected and sent by Kashtanov to the Paleontological Institute of the Academy of Sciences of I. A. Efremov [= PIN, Moscow], were not in adequate condition for study [3]. However, his findings attracted the attention of palaeontologists. In 1935, an expedition from the Paleontological Laboratory of Moscow State University, headed by A. P. Hartmann-Weinberg unearthed two incomplete skeletons and two skulls of pareiasaurs down the river near the village of Volkov. They were assigned to new species of South African genera, as *Pareiasuchus vjatkensis* and *Anthodon rossicus* [4]. Revised recently, these materials have been attributed by M. F. Ivakhnenko, the first pareiasaur to the new genus *Deltavjatia* of the bradysaurid family, and the remains of the second were ascribed to young individuals of the same genus [5].

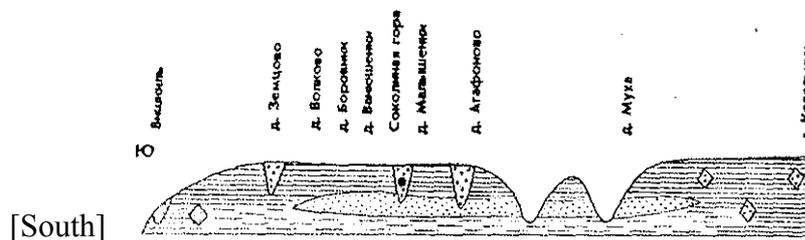
Excavations carried out by Hartmann-Weinberg showed that the red-brown mudstones exposed below Kotel' nich contain extensive remains of ancient reptiles. But the true scale of this location was only found after the fieldwork of Efremov's student V. P. V'yushkov [6]. In 1948, near the village of Boroviki, located some way downstream from the village of Vanyushonki, he discovered four skeletons of pareiasaurs (three of them had been destroyed by erosion). And in 1949, staff of the Paleontological Institute uncovered seven well preserved and six damaged skeletons at a 12 km long site (from the village Potraki to the pier Vishkil'). Two more of skeletons were reported in 1950 from the village of Boroviki by D. M. Vologzhanin (indicated by many previous findings), but could not extract it.

Annual bank caving caused by the spring melt floods, reveals new remains, which, according to V'yushkov, run to tens of thousands. This location probably has no equal for the number of remains of pareiasaurs and was registered in the site list of I. A. Efremov and B. P. V'yushkov as Kotel' nich [7].

As is a common experience in palaeontological research, the greater the accumulation of fossils of organisms, the more difficult it is to explain the origins and the more hypotheses there are. The Kotel' nich locality perfectly illustrates this. Kashtanov believed that all the remains of pareiasaurs lay in the topmost layers of the lower clay at the contact with the sandstones, and he came to think that the bulk of animal deaths had occurred as a result of changing physical and geographical conditions. However, in subsequent excavations, skeletons were found at various bone-bearing levels. V'yushkov was able to question one thing about the hypothesis of Kashtanov and offer his idea coming from Hartmann-Weinberg. According to these scholars, the death of the animals at Kotel' nich was not simultaneous and *en masse*, but occurred individually and randomly.

Observations made by palaeontological excavations allowed them to explain the reasons for the death of the reptiles in the area. The skeletons lie with their backs upwards, and in many cases the limbs of the animals go straight down (it is as if they are 'standing in the rock') - all of this, as well as the good preservation of the remains (including dermal ossifications of the back and the full set of small bones of the feet) indicates that the reptiles died stuck fast in muddy silt. Cases where the downward limbs were down only on one side of the body and the skeleton was 'rolled over' on its side, can be explained as the result of attempts by the animal to free itself. The corpses

of the reptiles could long remain exposed and attract scavengers (near one of the skeletons was discovered a fragment of a tooth from a small predator, possibly a theriodont) - this explains the post-mortem displacement of the skeleton in this one case. In two cases, the bones are bleached, apparently under the influence of the sun, which means that they lay a long time on the surface.



Section on the right bank of the River Vyatka in the part near Kotel'nich town – the Vishkil' Port (after B. P. V'yushkov).

[Horizontal bars]	Upper clays
[Fine stipple]	Fine-grained sandstones
[Dashes]	Bone-bearing clays (Kotel'nich I)
[Coarse stipple]	Grey, coarse-grained sandstones
[Black dot]	Kotel'nich II

Since at Kotel'nich the skeletons are mostly small, Hartmann-Weinberg, and V'yushkov came to the conclusion that it was mostly young or debilitated individuals that died there, sinking into the mud. Other animals apparently did not visit this area or were so small that they successfully avoided getting bogged down in the quagmire, so their remains are rare at this location. This hypothesis is based on established ideas about the ecology of pareiasaurs. Efremov characterizes them as massive animals with highly developed muscles, allowing them to wade through thickets in the marshy lowlands [8].

For a long time, such an explanation was acceptable to all. However, a prominent specialist in Permian terrestrial vertebrates, M. F. Ivakhnenko, challenged these views, believing that pareiasaurs were not land animals, but aquatic algophages (= feeders on algae), and compared them with modern dugongs (*Dugong dugong*). According to Ivakhnenko, pareiasaurs had a very broad and massive body and extremely short legs, so they could [not] move on land. On this basis, scientists have suggested that the death of pareiasaurs was associated with periodically drying lakes in which they lived.

But the matter did not end, and a member of the Paleontological Institute of the RAS, Yu. M. Gubin, rejecting both hypotheses, suggested a third [9]. It is based on study of the conditions of occurrence of six skeletons found by him while visiting the Kotel'nich-I locality. In his view, the animal skeletons showed postures inconsistent with the 'boggling-down hypothesis'. For example, in some of them the distal part of the downward legs was at one level, the other legs were stretched out to the side, the muzzle was lowered and the tail was directed vertically downward. Gubin rejected the hypothesis of Ivakhnenko on the grounds that the bone-bearing sediments show no obvious signs (in the form of characteristic cracks) of drying of the reservoir, but nevertheless agreed with the assumption that pareiasaurs were aquatic animals and lived in a relatively deep basin, whose bottom was covered by a thick layer of silt. After death, the corpses fell to the bottom, with their backs upwards. Under the influence of

their heavy weight, the carcasses sank to the bottom, were stuck in dense layers of mud and so could not rise under the influence of gases released during decomposition in the cavity of their bodies. Otherwise, they would have been reburied in the coastal shallows, belly-up.



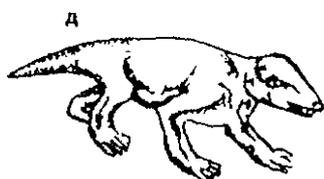
Pareiasaurs, different views of the lifestyle of these reptiles: on the left - the traditional view (Fig. K. K. Flerov), on the right – according to the new hypothesis of M. F. Ivakhnenko (Fig. Y. D. Kalganov).

An entirely different palaeogeographic pattern of formation of the bone-bearing clays at Kotel'nich has recently been proposed by V. P. Tverdokhlebov (Research Institute of Geology, Saratov State University) [10]. Without deciding on the most probable mechanism of formation at this location, it is only necessary to link the environment at the time when there was accumulation of the cross-bedded sands overlying the bone-bearing mudstone. These sands, which are usually mistaken for those of a lake or river, [11] the author considers to be aeolian in origin, and containing the remains of pareiasaur clay – bedding from water bodies, drainage basins, takyrs [= periodically drying-up lake; *transl.*]. In the sediments at different levels there are visible illuvial horizons of arid wetland soils and subsoils, expressed by their lightness and spot colour, the abundance of clay-calcareous concretions and loesses.

Schematic poses, in which the skeletons at the locality of Kotel'nich-I lie (a - side view, others - top view: pareiasaurs (a, b), dromasaurs (r), theriodonts (e)).



Thus, the palaeogeographic situation at Kotel'nich is interpreted by different authors in different ways: as a deep lake basin, then as a waterlogged plain, then as temporary reservoirs in drainage basins. Pareiasaurs are treated as either terrestrial, or exclusively aquatic, dugong-like animals. It would be wrong to assume that the value of all these differences is confined to the question about the genesis of this single, albeit wonderful, location. From the interpretation of the conditions of formation of several similar locations of terrestrial strata of all ages (in this case, from Preural deposits), this depends largely on the findings of palaeogeography and palaeoclimate throughout this vast region. So what happened in the past in this area of the upper Vyatka?



Theriodont

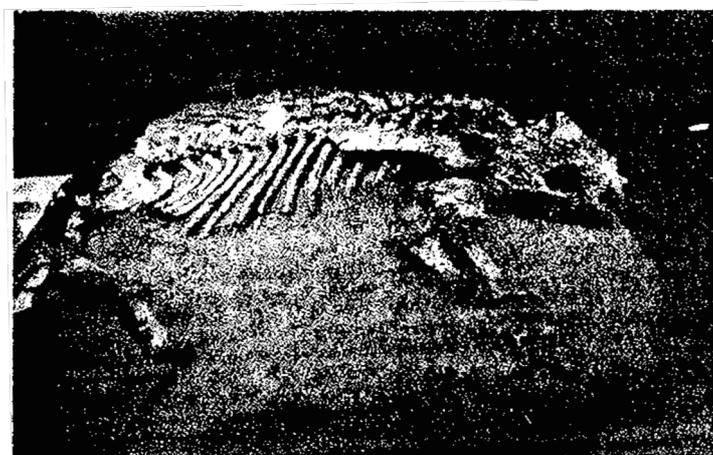
Systematic excavations at Kotel'nich had not been conducted until in 1990 this location attracted the attention of palaeontologists from the cooperative 'Kamenniy Tsvetok' (= 'Stone Flower') (D. L. Sumin, S. I. Getmanova, A. Y. Khlyupin, etc.). As a result of their three-year (1990-1992) work on the mysterious Kotel'nich, we learnt many new things, and to 32 discoveries of pareiasaurs found by previous researchers, they added 40 more. Most of them were found near the village of Boroviki, and partly at the village of Mukha. It was important to check how the skeletons are distributed along the section in the bone-bearing layer, whether they are confined to some strictly defined levels or, conversely, occur randomly. Accounting for the substantial new material confirmed that, although the findings are scattered throughout the thickness of the enclosing clays, most of the skeletons are concentrated at levels that are located in bone-bearing deposits, from 3 to 4 m below the overlying sands. In addition to numerous individual skeletons of varying degrees of preservation, at Kotel'nich were also found several clusters of isolated bones of several individuals, among which sometimes co-exist relatively large remains of pareiasaurs and smaller animals, Therapsida. It is possible that some of these clusters occurring in the laminated rock were formed by the movement of bone flows.

Unfortunately, not all new discoveries have been subjected to careful analysis; however, it was found that in 23 cases pareiasaurs were preserved in the form of fully articulated skeletal remains, and in nine cases in the form of clusters of scattered bones, each of which belonged to a single individual. Between whole skeletons and such clusters exist a range of transition states. Although most of the skeletons remained in good condition, there is even partial damage to them: some were missing one or both hands, feet, legs, the front part of the skull or lower jaw, etc. Apparently, the dead animals found themselves in different conditions: some were even quickly buried intact under sediment, while others, remaining for some time exposed, had time to decompose, and their skeletons were destroyed. Sometimes the nature of the damage makes it clear that scavengers participated in the destruction of the bodies of the pareiasaurs.

Unfortunately, the postures of the skeletons were detected in detail in only 14 cases, but this revealed much of interest. It was found, for example, that eight skeletons were buried back-upwards (one of them, of course facing down, and a second, stretched to the sides), and four were lying on their sides. In many skeletons the vertebral column was arched – it was this feature that was accepted at the time by Hartmann-Weinberg as 'the pose of swimming', but such bending of the body is also characteristic of terrestrial reptiles. Among the finds no corpse was belly-up, which would indicate floating - all the animals were buried on the spot where they died.

However, the biggest success of the palaeontologists can be regarded as the discovery at the Kotel'nich locality of numerous skeletons of carnivorous Therapsida, of which V'yushov at one time found only a fragment of a tooth. In total there were 42 therapsid skeletons and accumulations of bones, which is about 37% of the total number of finds of reptiles from this locality. However, the actual number of remains of these small animals, which are hard to find and are quickly destroyed, was undoubtedly greater. In the view of Ivakhnenko (personal communication), there exists a previously unknown genus of dromosaur (small herbivorous animal), named *Suminia* after D. L. Sumin. In addition, the researchers found four kinds of land predators - theriodonts (cynodonts) of small and medium size. At least two of the discovered skeletons (*Suminias* and theriodonts) were almost intact. The death of the *Suminias* took place in

their life positions – with their backs looped by bending the body. The theriodont died, fell on his side and stiffened, with the backbone straightening, the legs and tail outstretched, and with the head slightly bent down. These poses quite definitely indicate a place of death near the burial spot.



Skeleton of a pareiasaur from Kotel'nich (Museum of the Faculty of Zoology, Cambridge University, Great Britain). Photo M. A. Shishkin.

Summing up all the accumulated facts, we can now try to assess the various viewpoints on the genesis of this huge 'graveyard'. Perhaps the least likely idea is that the burial of pareiasaurs at Kotel'nich happened in a fairly deep pool. First, this is contrary to the features of the sediments surrounding the skeletons, as noted by Tverdokhlebov and, moreover, the bleached nature of some skeletons already mentioned by V'yushkov suggests that the corpses were exposed for a long time on the surface. Secondly, it is unlikely that the lack of buried belly-upwards floated corpses can be explained by the fact that the dead carcasses stuck on the bottom under the action of gravity in a viscous sludge. They were not so big and not so heavy, especially in the aquatic environment (this applies even more so to the recently discovered small Therapsida). In the muddy sediments of the Permian and Triassic of the Preurals, many cases of burial of corpses and of much larger animals turn up. The Kotel'nich pareiasaurs did not float up, obviously, because of the fact that they died either on land, or rather they were not allowed to float in shallow waters. Thirdly, the skeletons of pareiasaurs are not always fully preserved. Such damage could be associated with the activity of terrestrial predators or scavengers, as already suggested by V'yushkov, and now fully confirmed by the findings here of theriodonts.

Representations of the burial of pareiasaurs at Kotel'nich in extremely shallow water or on dry surfaces do not seem to contradict the hypothesis about their death in periodically shrinking pools. The hypothesis is not explicitly excluded by either the pose of the skeletons, or the likelihood of damage of not yet buried dead terrestrial predators during the dry period. However, this hypothesis suggests other reasons. Here it is not only a matter of the already mentioned absence of traces of surface desiccation, which might be destroyed by the onset of the next period of moisture and rain. Drying of the whole basin could lead to mass death of aquatic animals. In this case, we would be dealing with discrete events recorded in sections of the host deposits in the form of a number of levels, enriched with skeletons. However, animal bones are scattered at various levels, which rather corresponds to the irregular burial of individuals that had perished from a variety of causes. Finally, it is difficult to imagine that with regular full

drying, sufficiently large lake basin populations of aquatic animals could completely replace themselves.

Although Tverdokhlebov did not resolve the question of the mechanism of origin of the Kotel'nich graveyard, his hypothesis for the formation of the bone-bearing mudstones in temporary ponds, drainage basins, and takyrs does not allow that pareiasaurs were aquatic dugong-like algophages. Apparently, there really were no true water bodies inhabited by fishes and amphibians. However, none of the authors can convincingly explain how the sand lenses were formed among the mudstones - obviously, this requires further investigation.

Apparently, closest to the truth is the old view of Hartmann-Weinberg and V'yushkov. Perceptions of frequently flooded marshy lowlands are most consistent both with traces of the subaerial environment in rocks and bones, and with a random distribution of skeletons, and the probable ecology of pareiasaurs which, judging from the nature of the burial of the animals, were terrestrial, or at least amphibious. V'yushkov's reason for the lack of plant remains and fishes looks as if it is completely the correct explanation: regional floods, leading to frequent flooding during the year, prevented the development of lush vegetation and resulted in the absence of stratification. We note that soft aquatic vegetation, which is the food of pareiasaurs, simply is not preserved. Fishes that could get here only in times of floods, after drying ponds remained on the surface, were devoured or rotted without trace.

This very realistic old hypothesis only requires slight updating. According to V'yushkov's ideas, the burials were predominantly as standing skeletons in the rock from animals stuck in the quagmire. It is now clear that the poses are much more diverse, which indicates that these are natural deaths of animals permanently living here as a large population, rather than mass deaths of pareiasaurs while crossing the muddy plains, which served as a trap for the young and weak animals. Instances of individuals being bogged down in the quagmire is highly likely, but origins of skeletons preserved as if standing in the rock can be explained differently. They could have been killed by any cause, such as animals entombed in the mud during hibernation in the dry season, like modern crocodiles in India.

Existing ideas about the presence at the Kotel'nich locality of mostly juvenile pareiasaurs really suggest some kind of selective death. However, such views have arisen as a result of comparisons of the relatively small Kotel'nich reptiles with other known Upper Permian faunas, on the North Dvina, opened already at the end of the last [= nineteenth] century by the palaeontologist V. P. Amalitskii. Characteristic representatives of this fauna were larger species of *Scutosaurus*, the figuratively named sabre-toothed theriodont *Inostrancevia*, as well as other not so large animals. But be aware that the North Dvina fauna is geologically more recent than the Kotel'nich fauna. This is already apparent, because the remains of some representatives of the North Dvina (the labyrinthodont *Dvinosaurus* and the theriodont *Proburnetia*) were detected at Kotel'nich higher in the section than the described bone-rich layer. They are found in a sand lens embedded in the upper clay lying beneath cross-bedded sandstones. This lens is located above the village of Boroviki in the tract of Sokolya-gora. This location is usually called Kotel'nich II. The very assemblage of Kotel'nich reptiles, according to Ivakhnenko, looks older. There could even be as large pareiasaurs and theriodonts. The reptiles buried here probably were a community inhabiting this kind of terrain.

This last conclusion allows us to understand that the value of the Kotel'nich locality arises not only from its huge scale, but also from the fact that the land animals are buried here directly in their life habitat. For pre-Quaternary times this is an extremely unusual occurrence. As a rule, burial by intense accumulation of sediments is

not characteristic of terrestrial habitats, but on the contrary, erosion and the dumping of the waste products into neighbouring water bodies (rivers, lakes, etc.) is prevalent. Sediments with land animals are either completely destroyed or even destroyed in bodies of water, in sediments in which they are usually found. It is surprising also, that the locality Kotel'nich I was formed in remarkably balanced conditions: they combined marginal shallow water, which allowed terrestrial animals to exist, and adequate rates of sedimentation for their burial on the spot live and dead. This suggests that reptiles buried here very fully reflect the composition of their living community, and this offers a rare opportunity to analyze the structure of the latter.

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