THE PERMO-TRIASSIC OF THE NORTHERN PART OF THE RUSSIAN PLAIN AND ITS LABYRINTHODONT LOCALITIES

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The northeastern part of European Russia is characterized by the continental layers of the Upper Permian and Permo-Triassic. In the basin of the Suhona, Wetluga, Joug, Luza, and Viatka Rivers, there are layers of variegated strata almost without any organic remnants, whose stratigraphic position is the subject of debate as to whether it is Permian or Triassic. Quite a long time ago, the geologists Nikitin, Latugin, Thirmunsky, and others established in some outcrops of the variegated layers the presence of fossilized land vertebrates found as indefinite fragments of bones. Later Prof. Yakovlev (8 and 9) described remains of the amphibian *Rhinesuchus wolgo-dwinensis* and a vertebra of *Thecodontosaurus*, and on the basis of this inconclusive data classified the variegated series as Triassic.

We instigated a search for Tetrapoda in this layer in 1927, and found large accumulations of bones of labyrinthodonts along the Wetluga and Sharzhenge Rivers. Other localities were also investigated (1, 2, 3, and 4). On the basis of the material discovered, we established a new genus of labyrinthodont—*Benthosaurus* (10). Somewhat later, Prof. Riabinin described a new genus, *Wetlugasaurus* (7). Both genera are related and belong to the same family—Benthosauridae. Described by Lakovlev,

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Rhinesuchus wolgo-dwinensis obviously belongs to the family Benthosauridae. The same may be also said of *Trematosuchus* (?) *jakovlevi*, which was found by A. N. Riabinin (6) in the variegated series along the Kormitzi River, 3 km from the city of Ribinsk.

The distribution of labyrinthodonts, according to L. J. Latugin, spreads along the total course of the Luza River. The Academy of Science sent an expedition in 1930 under the direction of F. M. Kuzmin to verify this location of labyrinthodonts and to collect orientation materials. The expedition made a careful investigation of all the outcrops along the middle and upper parts of the Luza River. The starting point for this expedition was the easternmost point of occurrence of the labyrinthodonts Benthosauridae—Tschernii Bor, in the middle part of the Luza River, where the expedition of 1928 (Academy of Science) finished its easterly route. Due to the purely preliminary character of the investigation, no digging was done. In a few places the ends of the strata were exposed for prospecting. These investigations of 1930 showed twelve outcrops of the variegated series in the middle course of the Luza River, almost all of which are also the places where the discovery of land vertebrates was made.

The 1st outcrop—near Tschernii Bor, 5 km below the mouth of the Korzhi River. Due to lack of time and means the clearing up of the layers was not completed. From a small outcrop of a bone-bearing stratum there were collected only a few fragments of bones of labyrinthodonts.

The 2nd outcrop—higher along the course of the river. Four km above the town of Loima. Average height—13 meters. Thickness of bone-bearing stratum 0.40 meters.

The 3rd outcrop. Four km above the second. Corresponds with description of Latugin (5).

The 4th outcrop—near the mouth of the small Din-U River. Limited excavations produced some fragments of bones.

The 5th and 6th outcrops, on the left shore of the Luza above and below the village of Mishakovskaya, are covered with alluvium, and it was not possible to discover the bone-bearing stratum. At the foot of the 6th there were found two fragments of bones.

The 7th outcrop—at the mouth of the small Por-Yol River, there was found a typical stratum of bone-bearing sandy conglomerate, which was outcropping almost at the level of the river. But there were no bones found in it.

The 8th outcrop—above Por-Yol, was also covered with alluvium, but at a few places were small exposures of variegated marl with bone-bearing layers up to 0.25 meters in thickness.

The 9th outcrop—was very insignificant in size. Began at about 101 km below the beginning of the river. Its cross-section is as follows:

Top of variegated marls—4.5 m.
And gray sand to the level of river—2.5 m. In the gray sand is a bone-bearing sandy conglomerate, about 0.40 m thick.

The 10th outcrop—found a little above the Soksi-U River, is 6 m high and in cross-section is identical with the 11th.

The 11th outcrop—2 km above Miatezh. Height 8 m. Cross-section:

1. Soil layer (sand)—0.75 m.
2. Top roof of variegated marl—4.5 m.
3. Bone-bearing sandy conglomerate—0.5 m.
4. Bedding of variegated marls—2.25 m and goes beneath the level of the Luza.

The 12th outcrop—was found at Scoba, on the right shore of the Luza. Further along the Luza no more variegated series were found. In this outcrop was started an

excavation of 9 sq. meters that produced a considerable number of bones; unfortunately, however, in a fragmentary state. The cross-section under the soil:

1. Layer of sandy clay with many tree trunks—1.25 m.
2. Grey clay—1.5 m.
3. Dense gray sand, gradually changing into
4. Firm plate-like sand—3 m. This gradually changes into
5. Sandy conglomerate with numerous marl pebbles and bones of labyrinthodonts, also with numerous spots of calcite crystals—0.5 m.
6. Bluish-gray sand with small admixture of clay— 0.5 m.
7. Red-brown with bluish streaks of marl (0.25 m), which goes under the level of the Luza.

Total height—7.5 m.

All enumerated outcrops, with the exception of 1, 5, and 6, are on the right bank at the Luza River. Cross-sections of all of them are built in the same fashion. In all of them, the bone-bearing layer is found in the gray sand, on the same stratigraphic horizon in the layer of variegated marls. The marls are principally red, but the presence of bluish-gray and greenish sand gives them a characteristic striped appearance and a spotty coloration. The cross-sections along the Sharzhenga and Wetluga Rivers are exactly identical with this cross-section (on the Luga). In the Zubowskoe or Wetluga localities and at Wahnevo on the Sharzhenga River, the tops of the spot colored variegated marl is washed off, and there is alluvial yellow sand on the eroded surface of the bone-bearing stratum. In some of the places on the Luza the spotted layer was also subject to erosion, everywhere on its surface is irregularly deposited sand, but the considerable part of the top (about 5 m) of the bone-bearing layer is preserved.

The bone-bearing stratum is always of the same type. It is porous quartz sand. The grains of sand have sharp edges and are not rounded off, and they are mixed with numerous pebbles of red-brown and gray sandy marl. Only a small percentage of the

pebbles are rounded; the majority have an irregular form and are collected into irregular groups. The cement is carbonate, and the cementation is irregular. Among the more porous intermediate layers are met fractions of considerable hardness. The thickness of the bone-bearing layer varies from 0.2 m to 3.0 m. With the increasing thickness the number of complete, non-rounded bones and skulls increases and the number of sharp-angled and rounded fragments diminishes.

The material collected by the expedition is very fragmentary, but comparison with the numerous similar fragments of previous collections permits us to state with certainty that is belongs to the family Benthosauridae. Its generic identification unfortunately cannot be given, as almost all fragments belong to the postcranial skeleton, which is almost indistinguishable in the case of *Benthosaurus* and *Wetlugasaurus*. By consideration of the fragment of the lower jaw, ribs, and the occipital part of the skull, it is possible to establish the presence in the Luza River fauna of the gigantic species similar to that found in Vahnvo and Bolshaye Sludka. Also in Tschernii Bor and #12, the expedition discovered vertebrae of reptiles, which according to A. P. Hartman-Weinberg belong to the group Araeoscelidae. Those examples were very much like those found by the expedition of 1928. From this fact it is clear that the locality at the Luza River belongs to the same complex to which belong the localities at the Wetluga and Sharzhenga Rivers. But the variegated series are probably much larger. According to the prominent Russian geologist E. M. Lutkevich, two places where the remnants of Benthosauridae were found belong to the same complex.

1st—on the left bank of the Unga River, 3 km below the mouth of the Uza River, in the terrace of the exposed greenish micaceous sands with the remains of

Benthosauridae, and 2nd—on the right bank of the Kundsh River in the same kinds of sand with very fragmentary remains of Benthosauridae. In the collections of Prof. A. N. Riabinin is an incomplete skull of *Benthosaurus* from the Kobra River, near the village of Teruhan. It is from the denudation of the variegated series. All of these locations belong to the same group, to which belongs the locality where the fragment of *Trematosuchus* was found by A. N. Riabinin.

There is no doubt that the laying down of the variegated series was progressing at the same time on the tremendous area (see fig. 2)—from the Unga River probably to the western edge of the Urals; later (Quaternary time) the whole area of development of the Permo-Triassic was broken by erosion; and only small portions of it were left here and there. There are no exact statements about how far to the south these portions are located, but according to Nikitin in the Costroma district, fragments of the bones of vertebrates were located in the identical variegated series. All this permits us to suppose that the area of the variegated series stretches much further toward the south. Its layers are in horizontal position without tectonic disturbance.

Only in the basin of the Luza River are slight dislocations noticeable. Most probably the thickness of the variegated series equals about 80-100 meters.

The petrographic composition and the character of the formation of different materials of the variegated series are quite similar to the delta lenses of the North Dvina. There is a possibility of the gradual change of the layer containing less into the variegated series.

It is remarkable that the location of labyrinthodonts is closely connected with the of horizon located within the variegated series. The top and the base of the bone-bearing

layer consists of the same materials with identical stratification. According to Efremov (3), the process of formation of the bone-bearing layer was going on in the past within great streams of water. The formation of the layer of variegated marl itself occurred during the stage of decreasing denudation, when a fine material washed over and over again and was easily carried on for long distances. Thus the formation of the thin, bone-bearing less-containing layers is closely connected with the break in the formation of marl, with the change of desert facies by conditions of erosion with a great amount of water. The broken-off form of the sand grains in the sand of the middle layer, the presence of mica and quartz crystals with very sharp edges, point to its burial while it was a fresh product of denudation.

The sand lenses (loesses?) of the famous *Pareiasaurus* layers of the North Dvina are by their type of development very similar to the locations of the variegated series. Only the interval in the layer of marl was somewhat longer, and the sandy thin layer is much thicker. The erosive facies of V. P. Amalitsky corresponds to the sandy interval of the variegated series.

The Tartaric stratum was the indicator of the end of the great cycle of formation of continental sediments that was connected with the energetic denudation of the Ural Mountains from the Upper Carboniferous to the end of the Permian.

Weakened denudations could feed themselves only with already-formed materials developing thin layers of marl in conditions unfavorable for organic life. These conditions were the same for the whole continental plain in the northeastern part of the Russian platform. Probably because of the small movements in the layers of marl there

were two intervals. It was the result of the fast and large streams that originated the North Dvina fauna and Benthosauridae.

The first interval (rupture) was the longest, and the tetrapod fauna, which up to that time was hidden in the small area favorable for life (probably at the foot of the Ural Mountains), quickly occupied the plain, reproducing in great numbers in a very short time. Then the next phase of marl formation made a new interval (rupture) in organic life. This is a good explanation for the scarcity of forms of the North Dvina fauna in comparison with the Karoo fauna of South Africa. Thus the migration of the Permian forms of Tetrapoda to the north was not very easy. The conditions of the Russian Upper Permian gave only one movement favorable for the development of those forms which existed at that time.

The second erosional interval, which opened the way to the desolate plain of the variegated massif to the vertebrates, found even fewer forms of Tetrapoda. Only one group of labyrinthodonts—Benthosauridae—and a very limited number of reptiles of the type Araeoscelidae were able to continue their existence on the Permo-Triassic plain. It is interesting to note that both genera of labyrinthodonts—*Benthosaurus* and *Wetlugasaurus*—seem to mutually exclude one another. In the Wetluga River localities nearly every specimen belongs to *Wetlugasaurus*, and in the Sharzhenge River locality exclusively *Benthosaurus*. This fact indicates the adaptive radiation that began during the migration onto the Permo-Triassic plain. But it did not go far ahead because of the brevity of conditions favorable for life. In all of the localities there are disorderly mixtures of the remains of labyrinthodonts. These consist of entirely different sizes, and therefore the ages differ from the larval form, with a skull not more than 20 mm in

length, and ending with fragments of enormous skulls (up to 70-80 cm in length). These latter ones are always found in small fragments and probably represent the remains of gigantic individuals that died of old age. The reason for the poor preservation of their remains is that before burial in the ground, the bones underwent the actions of different reagents. The rest of the bones are the product of the mass death of forms during the coming of the new marl facies, quickly buried in the sand that was formed at the end of the erosional stage.

The group Benthosauridae is represented by entirely new genera and therefore cannot serve in the determination of the exact stratigraphic location of the variegated series. This is a type (species) of change between Rachitomi and Stereospondyli. The last Rachitomi disappears at the end of the Permian, the first Stereospondyli appears in the "Lower Triassic". The destruction of the Benthosauridae fauna in the variegated series occurred just at the time of the change of Rachitomi and Stereospondyli, that is at the time of change between the Permian and Triassic Periods. The remains of reptiles are very fragmentary, but close to the Permian group Araeoscelidae, differentiating only in that the skeleton went farther in the evolutionary way. Therefore, we may conclude that the variegated series was formed in the extreme upper part of the Permian, belonging to the type of middle layer of the continental strata. Basing on these arguments, we may suppose that the name "Permo-Triassic" should be kept for the variegated series.

Reference of the variegated series to the Triassic by analogy with the variegated marl of the middle cut of the city of Bogdo, Astrachan district, at the present time cannot be considered correct. The *Ceratites dorycranites* flora from the upper lime-clay formation of Bogdo was usually considered as belonging to the Triassic. The last

explorations of M. B. Bajarunas in Mangishlak discovered a flora that was very close to the Bogdo flora in the lowest part of the Triassic. The same similarity is noticeable in the lower part of the Caucasian Triassic.

Probably after more fieldwork in the stratigraphy at Bogdo, the age of the upper lime layer that covers the straits will be lowered.

Then the variegated series of Bogdo shall automatically be included in the Permo-Triassic, thus once more proving the common conditions between Permian and Triassic, when the end of the denudation occurred and the continental facies was formed.

For the exact study of the cut of the Permo-Triassic, further exploration to the east of the Luza River up to the first ridges of the North Urals is necessary. The disturbances in this region are probably connected with epeirogenic movements of the Urals. These disturbances will help to clear our knowledge about the upper and lower edges of the Permo-Triassic and the genesis of its composition. The nearness to the migratory ways of the old Tetrapoda permits us to expect the discovery of ancestral forms of the Permo-Triassic fauna in the North Ural region, and probably the faunas of their predecessors in the lower continental facies.