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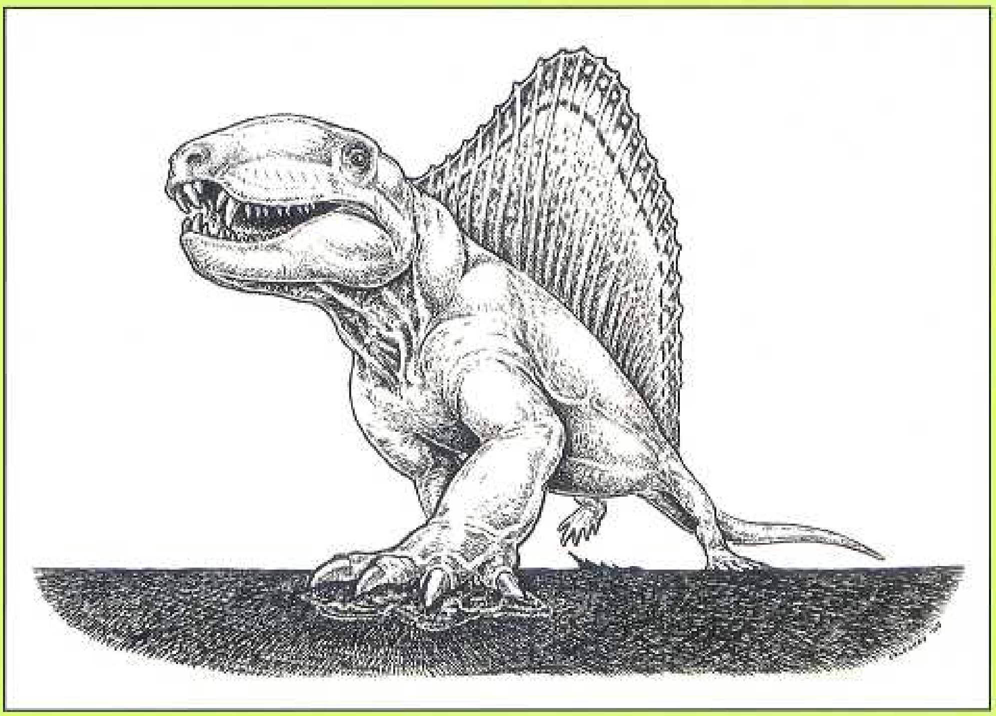
The Nonmarine Permian



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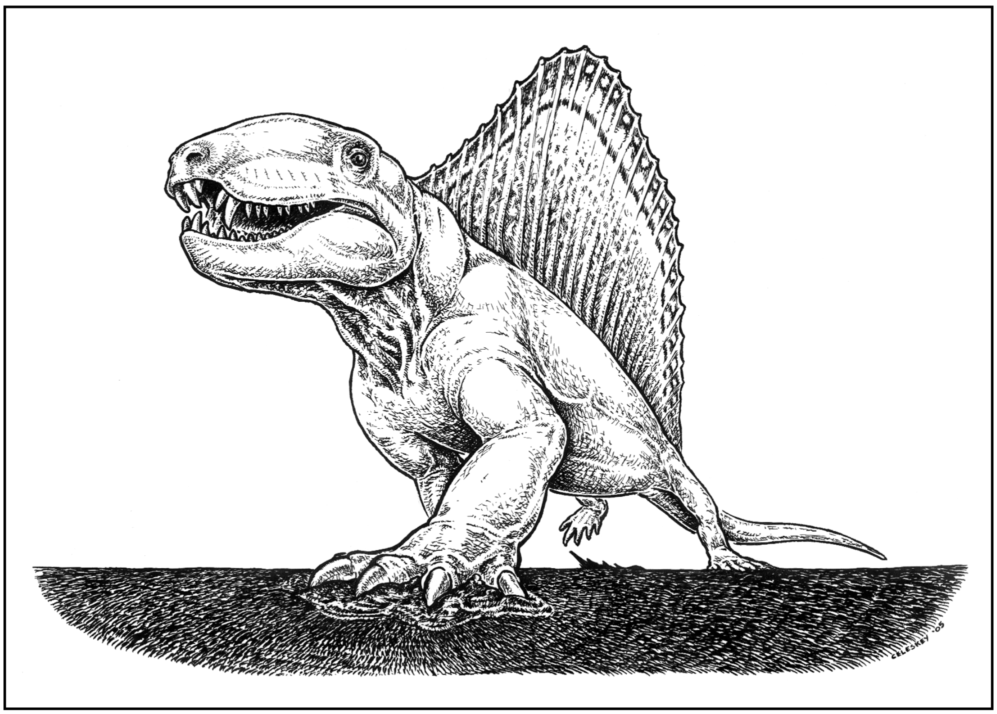

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PERMIAN TETRAPOD STRATIGRAPHY

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Tetrapod fossils from the Permian of European Russia were first described in 1838 by Stephan Kutorga. Since then, many dozens of localities have been investigated and several dozens of forms belonging to 57 families have been described (Fig. 1). The majority of basic groups were considered in detail in special monographs (Efremov, 1954; Orlov, 1958; Shishkin, 1973; Tatarinov, 1974, 1976; Tchudinov, 1983; Ivakhnenko, 1987, 2003; Gubin, 1991; Sennikov, 1995; Ivakhnenko et al., 1997; Golubev, 2000b; Bulanov, 2003). When the results of particular studies were generalized, an integral system of faunal assemblages replacing each other in time was reconstructed (Fig. 2).

Efremov (1937, 1939) was the first to subdivide the Upper Permian of Eastern Europe into four tetrapod assemblage zones: (1) Zone I (*Rhopalodon*), the upper part of the Kungurian Stage (currently the Ufimian Stage) and the lower part of the Lower Kazanian Substage; (2) Zone II (*Titanophoneus*), the upper part of the Lower Kazanian and the lower part of the Upper Kazanian Substages; (3) Zone III (pelycosaurian), the upper part of the Upper Kazanian Substage; and (4) Zone IV (pareiasaurian), the Tatarian Stage (currently the Urzhumian, Severodvinian, and Vyatkian Stages). Later, Efremov distinguished five Upper Permian faunal assemblages reflecting taphonomic differentiation of tetrapod localities (Efremov, 1952; Efremov and Vyushkov, 1955). The Fore-Ural Dinocephalian Assemblage characterizes the Lower Kazanian Substage and the lower part of the Upper Kazanian Substage (Zones I and II). The Isheevo Dinocephalian Assemblage existed later and was dated as upper part of the Upper Kazanian Substage (Zone IV). The Mezen-Belebey Cotylosaurian Assemblage (former pelycosaurian fauna) existed contemporarily with these assemblages. The Tatarian Stage (currently, only the Upper Tatarian Substage) is characterized by two assemblages of the same age (Zone IV), the Northern Dvina Pareiasaurian Assemblage and the Gorki City Batrachosaurian Assemblage. Zone III is distinguished only speculatively on the basis of great differences between the evolutionary levels of the faunas from zones II and IV. In actual fact, a transitional fauna has not been found; this is explained by the presence of a large gap in the Upper Permian deposits between zones II and IV. In addition to the listed zones, a new zone (Zone 0) characterizing the Lower Permian deposits was distinguished.

Subsequently, the scheme of faunal assemblages repeatedly was expanded and worked out in detail by Tchudinov, Ochev, Ivakhnenko and Golubev (Ivakhnenko et al., 1997; Golubev, 2000a). The concept distinguishing the following three main faunal superassemblages was developed by degree: (1) Eryopoidean Superassemblage, Early Permian; (2) Dinocephalian Superassemblage, Middle Permian; and (3) Theriodontian Superassemblage, Late Permian (Fig. 2). The superassemblages are sharply distinguished from each other by higher taxa (usually, higher than the family rank) of all blocks of the community of terrestrial vertebrates, i.e., dominant, subdominant, and aquatic blocks. (The dominant block in the Paleozoic tetrapod communities is formed by large phytophagous animals and carnivores that preyed upon them (Olson, 1966; Sennikov, 1995); the subdominant block is formed by the forms feeding on invertebrates; the aquatic block comprises the forms consuming aquatic plants, invertebrates, fish and tetrapods). A relatively large number of shared families in two successive superassemblages (coefficient of similarity) is, at most, 32%. Moreover, these families belong to the subdominant block and small members of the dominant block. The superassemblages separated from each other do not include shared families (Fig. 1). The transitions from one superassemblage to the other reflect large crisis stages in the development of the tetrapod fauna.

The superassemblages consist of assemblages. The assemblages are distinguished from each other mainly by the composition of large members of the dominant block, i.e., the largest animals of different assemblages are represented by different large taxonomic groups (of order rank or higher). The composition of the subdominant block and small members of the dominant block change at the family level and lower-rank taxonomic level. Only the pattern of the aquatic fauna remains invariable, i.e., the faunal changes involve the taxa of generic and specific rank. The coefficient of similarity between the assemblages of the same superassemblage is usually higher than 60%.

Some of assemblages consist of some subassemblages. The subassemblages are distinguished from each other by general changes in the composition of the entire fauna at the taxonomic level of genera and species. They reflect a gradual course of community evolution. The coefficient of similarity between subassemblages of the same assemblage is usually higher than 75%.

The Eryopoidean Superassemblage (Early Permian, Cisuralian) is characterized by widespread eryopoidean edopiform temnospondyls, embolomere and gephirostegid anthracosauromorphs and captorhinomorphs. The fauna is characterized by certain features inherited from the Carboniferous faunas of North America and Western Europe, being most similar to the first. This suggests that, in the Carboniferous, the Timan-Pechora Region contacted most closely with North America rather than with Western Europe. However, the absence of a number of dominant Early Permian members of both North American and West European faunas indicates that, in the Permian, the Eryopoidean Tetrapod Fauna was isolated from the faunas of both Eurasia and North America. The superassemblage includes the Inta Assemblage.

The Dinocephalian Superassemblage (Middle Permian, Guadalupian) consists of widespread edopiform temnospondyls (archegosauroideans and dissorophoideans), various small parareptiles (discosauriscins and nycteroleterins), gephirostegid anthracosauromorphs, captorhinomorphs, pelycosaurs, and primitive therapsids (eotheriodonts, dinocephalians, and primitive anomodonts, such as venyukoviid dromasaurs). In addition, the earliest theriodonts (pristerognathid therocephalians) appear. The presence of certain groups known from the Carboniferous and Early Permian of Europe (archegosauroideans, discosauriscins, and ? pelycosaurs) and North America (dissorophoideans, captorhinomorphs, and pelycosaurs) is typical of this superassemblage. The presence of North American forms is probably explained by the Eryopoidean Superassemblage; however, dissorophids, rather common for the Early Dinocephalian Fauna and having a North American appearance (Golubev, 2000a), have not been found in the Eryopoidean Superassemblage. This is attributable to a poor understanding of the Eryopoidean Fauna rather than to the presence of a direct contact between East European and North American tetrapod faunas early in the Late Permian.

The Dinocephalian Superassemblage includes caseids and varanopids, i.e., the most primitive groups of pelycosaurs. The territory they immigrated from is not clear, since both groups probably existed in the time interval of the Carboniferous when Western Europe and North America formed a united continent (Kalandadze and Rautian, 1997). Consequently, East European pelycosaurs could originate in either Western Europe or North America. This group of theromorph reptiles is known from the Mezen Fauna only. Other North American elements have not been found in this fauna. At the same time, the latter

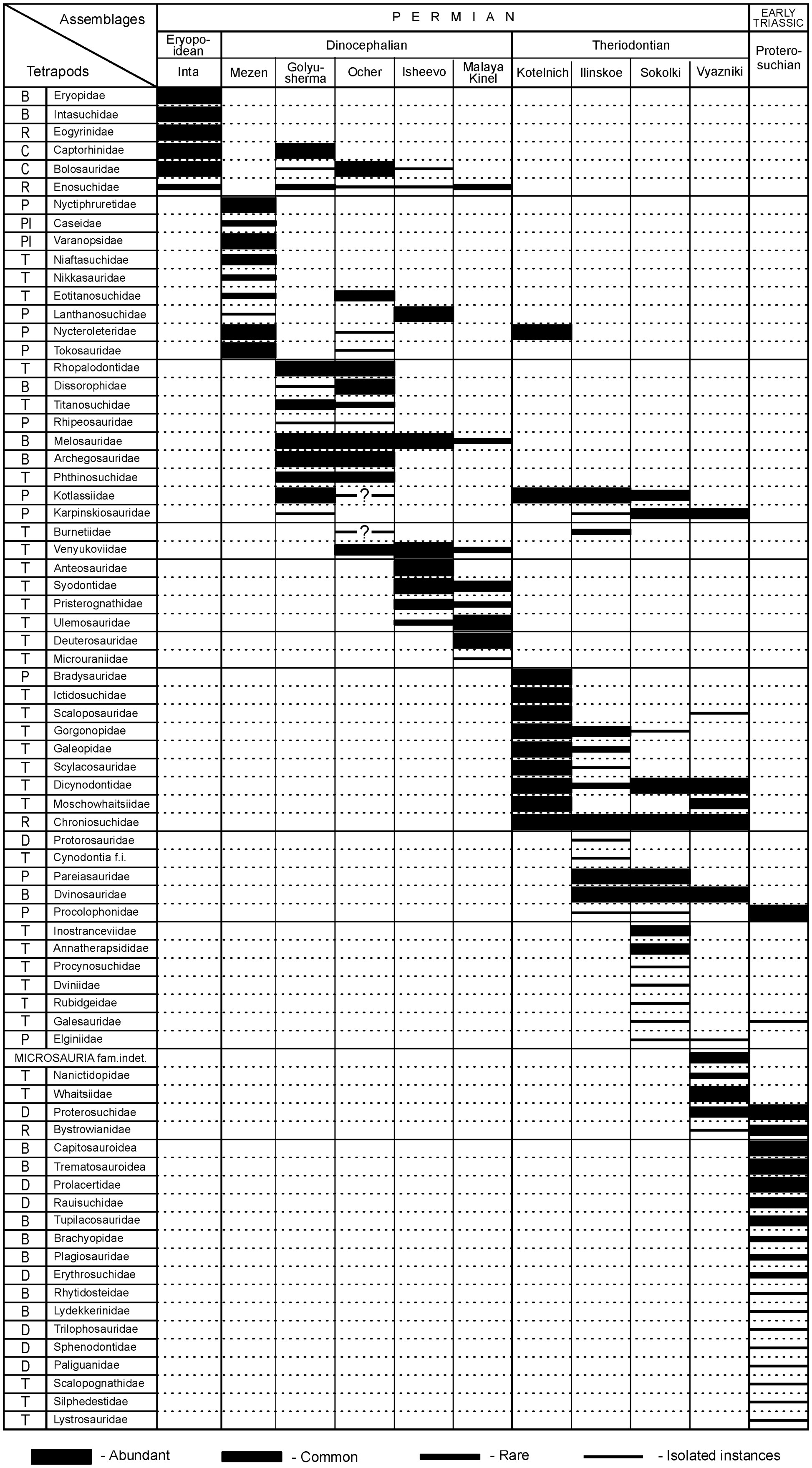

FIGURE 1. Occurrence of tetrapod families in Permian and Early Triassic faunal assemblages of Eastern Europe. Designations: (B) Temnospondyli, (C) Captorhinomorpha, (D) Diapsida, (P) Parareptilia, (PI) Pelycosauria, (R) Reptiliomorpha, and (T) Therapsida.

includes various parareptiles of undoubted Eurasian origin. This allows one to propose that pelycosaurs from the Mezen Fauna are also of European origin.

The occurrence of therapsids, similar to those from South Africa, in the Dinocephalian Fauna, is evidence of certain faunal exchange with Gondwana (Golubev, 2000a; Kalandadze and Rautian, 1997). The dominant blocks of the Dinocephalian Fauna are formed mainly by taxa of Gondwanan origin (except for the Mezen Assemblage, including local elements, namely, pelycosaurs). Tetrapods of the aquatic blocks are of West European origin. The subdominant blocks are most diverse; they include both local, Gondwanan, and West European groups. The presence of West European and Gondwanan elements is a paramount feature distinguishing the Dinocephalian Fauna from the Eryopoidean Fauna. Thus, by the end of the Ufimian Age, the territory of Eastern Europe adjoining the Ural Mountains and Timan had faunal contacts with both Western Europe and Gondwana. However, the time sequence of these events is not clear. In any case, after the Ufimian, Eastern Europe becomes a zoogeographic province of Eurasia.

The Dinocephalian Superassemblage includes three Assemblages: Mezen Assemblage (Kazanian and the Urzhumian), Ocher Assemblage (Sheshmian-early Urzhumian), and Isheevo Assemblage (late Urzhumian—Early Severodvinian). The Mezen Fauna is the most primitive fauna of all East European dinocephalian faunas; this is evidenced by the presence of pelycosaurs, a wide variety of parareptiles, and the absence of dinocephalians. However, it existed at the same time as the Ocher and Isheevo assemblages (Fig. 2). The localities containing the Mezen Fauna are isolated geographically from the localities of other dinocephalian faunas and concentrated in the regions adjoining the Baltic Shield from the south-east. Paleogeographically, this corresponds to the western coast of the Kazanian and Early Tatarian lake-marine basin. All known localities containing the Mezen Fauna are of the same taphonomic pattern; therefore, they only slightly differ from each other in the composition of the oryctocenoses; the forms belonging to the subdominant block are numerous and relatively diverse, members of the dominant block are extremely scarce, and the aquatic block is not represented at all. A peculiar pattern of the Mezen Fauna indicates it was isolated from the Kazanian and Early Tatarian tetrapod faunas inhabiting the regions adjoining the Ural Mountains.

The Ocher Assemblage includes the Golyusherma Subassemblage (Sheshmian-Kazanian) and Ocher Subassemblage (early Urzhumian) that sequentially replaced each other. The Isheevo Assemblage includes Isheevo and the Malaya Kinel subassemblages. These subassemblages are characterized by diametrically opposite faunal composition, i.e., the forms widespread in one subassemblage are rare or completely absent in the other (Fig. 1). This feature is possibly attributable to the fact that the subassemblages are ecologically different parts of the same fauna and do not reflect the stages of evolution of the Permian tetrapod community. The hypothesis of a contemporary existence of the Isheevo and Malaya Kinel subassemblages offers a suitable explanation for numerous difficulties and contradictions concerned with the determination of the relative age of these subassemblages.

The Theriodontian Superassemblage (Late Permian, Lopingian) is characterized by widespread colosteiform temnospondyls, large (pareiasaurs) and relatively small (discosauriscine) parareptiles, chroniosuchian anthracosauromorphs, various anomodonts (galeopid dromasaurs and dicynodonts), and theriodonts (gorgonopians, therocephalians, and cynodonts). The groups characteristic of the Early Permian are completely absent; however, the following taxa surviving till the Triassic appear: bystrowianid chroniosuchians, prolacertid and thecodont diapsids, dicynodonts, cynodonts, and procolophonid parareptiles. The taxonomic composition of the Theriodontian Fauna is distinguished from that of the Dinocephalian Fauna by the high-rank taxa (higher than family rank). Only four common families have been revealed: Burnetiidae, Kotlassiidae, Nycteroleteridae, and Karpinskiosauridae. However, each (except for the Kotlassiidae) is widespread in one Superassemblage and scarce in the other; the family Kotlassiidae is represented in the Theriodontian Fauna by the other subfamily (Kotlassiinae). In addition, in the Dinocephalian Fauna, these families are observed in the Ocher Assemblage only, whereas in the Isheevo Assemblage, they have not been found. As a result, the latter contrasts even more with the Kotelnich Fauna.

The Early Theriodontian Fauna includes many elements widespread in the Gondwanan Fauna but not registered in the Dinocephalian Fauna of Eurasia: pareiasaurs, most theriodonts, galeopids, and dicynodonts. Throughout the entire Late Tatarian, the degree of provincialism of the Theriodontian Fauna increased until the onset of the Triassic when the faunal composition changed abruptly. This probably indicates the presence of a short-term contact between the tetrapod faunas of Gondwana and Eurasia just before the time of the Kotelnich Fauna (Kalandadze and Rautian, 1997; Golubev, 2000a). In the Theriodontian Fauna, the Gondwanan elements form the dominant block (pareiasaurs, anomodonts, gorgonopians, and therocephalians) and a large part of the subdominant block (therocephalians and cynodonts). The forms of the aquatic fauna are probably local, i.e., originate from Eurasia (colosteiform temnospondyls, chroniosuchians, and discosauriscins).

The Superassemblage is divided into two parts, the Sokolki (Late Severodvinian and the first, larger part of the Vyatkian) and Vyazniki (terminal part of the Late Vyatkian) assemblages. The Sokolki Assemblage is divided into three parts, Kotelnich (early Late Severodvinian), Ilinskoe (late Late Severodvinian – early Vyatkian), and Sokolki (middle Vyatkian) subassemblages that sequentially replaced each other.

The Early Triassic Proterosuchian Fauna of Eastern Europe is characterized (Fig. 1) by widespread temnospondyls, including colosteiforms, zatracheiforms, and trematosaurian edopiforms; procolophonid parareptiles; bystrowianid chroniosuchian anthracosauromorphs; and various diapsids, including eolacertids, rhynchocephalids, prolacertids, and thecodonts. Therapsids are extremely scarce; only isolated finds of lystrosaurid dicynodonts, scaloposaurian and scalopocynodont therocephalians, and galesaurid cynodonts occur. The Proterosuchian Fauna usually lacks a distinct dominant block (Golubev, 2000a; Sennikov, 1995). Only the Spasskoe Assemblage (*Tupilakosaurus* Fauna) probably includes small members of this block of evidently Eurasian origin, dicynodonts (Lystrosauridae) and thecodonts (Proterosuchidae). In other Proterosuchian assemblages, only large thecodonts (proterosuchids, rauisuchids, and erythrosuchids) can be tentatively referred to as the dominant block; they were probably the consumers of the higher orders in the terrestrial and aquatic blocks of the community. Similar to the dominant block, the subdominant block of the Proterosuchian Fauna is formed by Eurasian groups, including bystrowianids, procolophonids, diapsids, therocephalians, and cynodonts. Only the aquatic community includes Gondwanan elements, i.e., trematosaurian (capitosauroideans, trematosauroideans, and lydekkerinids) and rhytidosteid batrachomorphs.

The Inta Assemblage, Golyusherma Subassemblage, Ocher Subassemblage, Isheevo Assemblage, Kotelnich Subassemblage, Ilinskoe Subassemblage, Sokolki Subassemblage, Vyazniki Assemblage, and Proterosuchian Superassemblage reflected certain stages of the Late Permian history of the tetrapod fauna. They consecutively replaced each other. A new tetrapod biozonation of the Eastern Europe Permian based on the succession of tetrapod faunas was proposed in 1997 by Golubev (Ivakhnenko et al., 1997; Golubev, 2000b). The biostratigraphic scale consists of eight Assemblage Zones (Fig. 3):

Clamorosaurus nocturnus Assemblage Zone. The zone is characterised by the presence of tetrapod of Inta Assemblage, Eryopoidea, Eogyrinidae, *Nyctiboetus*, Bolosauridae, Captorhinidae. Lower boundary is characterised by the first appearance Inta Assemblage tetrapods. Age: from the Sakmarian to lower Ufimian (the Solikamskian). The Zone is correlated with larger part of the Cisuralian Series.

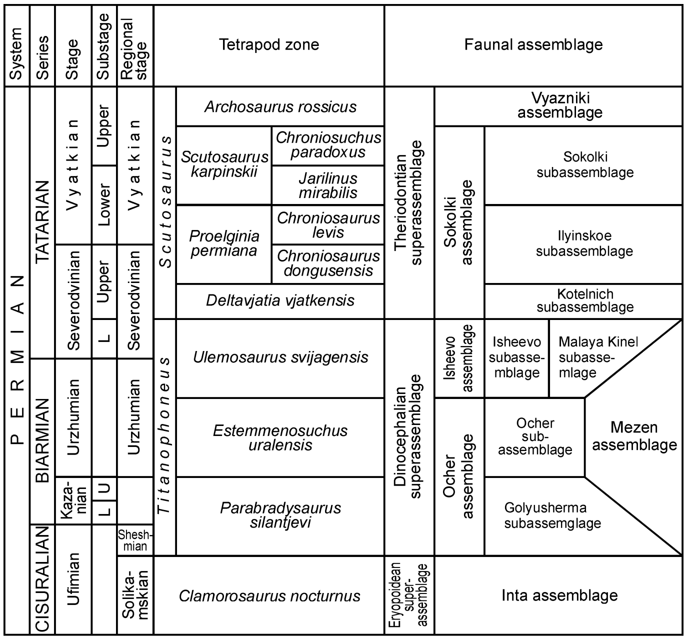

FIGURE 2. The scheme of tetrapod assemblages and biostratigraphic zonation of the East European Permian.

Parabradysaurus silantjevi Assemblage Zone. The Zone is characterized by the presence of tetrapods of theGolyusherma Subassemblage: Melosaurinae, *Platyoposaurus watsoni* (Efremov), Captorhinidae, Leptorophidae, *Parabradysaurus*, Phthinosuchidae and *Microsyodon*. The lower boundary is characterized by the first appearance of therapsids. Age: upper Ufimian (the Sheshmian) and Kazanian. The first appearance of therapsids is caused by the formation of the first Permian terrestrial link of Cis-Ural with Gondwana. This event is synchronous with a Kungurian-Roadian global regression. Thus the lower boundary of the zone may be correlated to a horizon within uppermost part of the Kungurian of the International Stratigraphic Chart. The Zone is correlated approximately to the Roadian.

Estemmenosuchus uralensis Assemblage Zone. The Zone is characterized by the presence of tetrapods of the Ocher Subassemblage: Tryphosuchinae, *Platyoposaurus stuckenbergi* (Trautschold), Dissorophidae, Bolosauridae, *Estemmenosuchus*, *Phthinosaurus*, *Biarmosuchus*, Phthinosuchidae, *Archaeosyodon*, and Venyukoviinae. Age: lower part of the Urzhumian. The Zone is correlated approximately to lower Wordian.

Ulemosaurus svijagensis Assemblage Zone. The Zone is characterized by the presence of tetrapods of the Isheevo Assemblage: Tryphosuchinae, Lanthanosuchidae, *Ulemosaurus*, *Titanophoneus*, *Deuterosaurus*, *Syodon*, Pristerognathidae, Ulemicinae. Age: upper part of the Urzhumian and the Lower Severodvinian. The Zone is correlated approximately to upper Wordian and Capitanian.

Deltavjatia vjatkensis Assemblage Zone. The Zone is characterized by the presence of tetrapods of the Kotelnich Subassemblage: *Deltavjatia*, *Suchonica*, *Microphon*, Nycteroleteridae, Moschowhaitsiidae, Scaloposauria, Gorgonopia, *Suminia*, Dicynodontia. The lower boundary is characterized by the first appearance various Gondwanan tetrapods, such as pareiasaurians, dicynodonts, galeopids, gorgonopids, and various therocrpalians. Age: lower part of the Upper Severodvinian. The event of the invasion of Gondwana tetrapod fauna is caused by the formation of the second Permian terrestrial link of Cis-Ural with Gondwana. This event is synchronous with a Capitanian-Wuchiapingian global regression and ecological crisis in marine communities. Thus, the lower boundary of the Zone may be correlated to the lower boundary of the Lopingian series and to the lower boundary of the *Pristerognathus* Assemblage Zone in South Africa. The Zone is

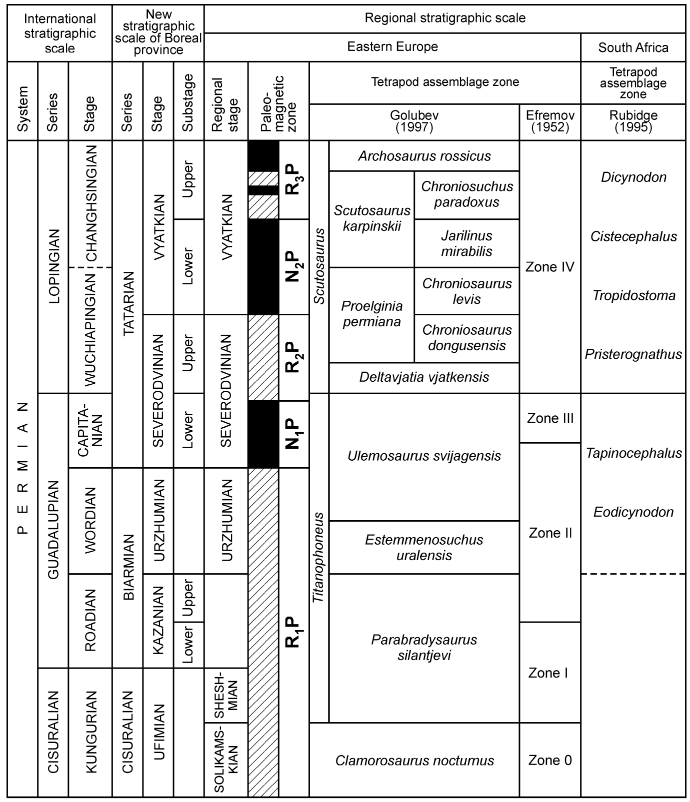

FIGURE 3. Correlation of East European, South African and global marine Permian stratigraphic scales.

correlated approximately to lower Wuchiapingian.

Proelginia permiana Assemblage Zone. The Zone is characterized by the presence of tetrapods of the Ilinskoe subassemblage: *Proelginia*, *Microphon*, *Chroniosaurus*, *Dvinosaurus ex gr. primus* Amalitzky, *Suminia*, Burnetiidae, Gorgonopidae and Dicynodontia. Age: upper part of the Lower Severodvinian and lower part of the Lower Vyatkian. The Zone is correlated approximately to upper Wuchiapingian. The Zone consist of two subzones based on chroniosuchid anthracosauromorphs, subzone *Chroniosaurus dongusensis* and subzone *Chroniosaurus levis*.

Scutosaurus karpinskii Assemblage Zone. The Zone is characterized by the presence of tetrapods of the Sokolki subassemblage: *Scutosaurus*, *Jarilinus*, *Chroniosuchus*, Karpinskiosauridae, Inostranceviidae, Annatherapsididae, *Dvinosaurus ex gr. primus* Amalitzky, Cynodontia and Dicynodontia. Age: middle part of the Vyatkian. The Zone is correlated approximately to lower Changhsingian. The Zone consist of two subzones based on chroniosuchid anthracosauromorphs, subzone *Jarilinus mirabilis* and subzone *Chroniosuchus paradoxus*.

Archosaurus rossicus Assemblage Zone. The Zone is characterized by the presence of the tetrapods of the Vyazniki Assemblage, *Archosaurus*, *Uralerpeton*, *Dvinosaurus egregius* Shishkin, Whaitsiidae, Dicynodontia, Karpinskiosauridae, Moschowhaitsiidae. Age: uppermost part of the Vyatkian. The Zone is correlated approximately to upper Changhsingian.

The *Parabradysaurus silantjevi*, *Estemmenosuchus uralensis* and *Ulemosaurus svijagensis* zones are combined into a *Titanophoneus* Superzone. This Superzone is correlated to the Guadalupian series and the South African Assemblages Zones *Eodicynodon* and *Tapinocephalus*. *Deltavjatia vjatkensis*, *Proelginia permiana*, *Scutosaurus karpinskii* and *Archosaurus rossicus* zones are combined into a *Scutosaurus* Superzone, which is correlated to the Lopingian series and the South African Assemblages Zones *Pristerognathus,* *Tropidostoma, Cistecephalus,* and *Dicynodon* (Fig. 3).

Zone 0 distinguished by Efremov (Efremov and Vyushkov, 1955) corresponds to the *Clamorosaurus nocturnus* Zone. Zone I after Efremov corresponds to the lower part of the *Parabradysaurus silantjevi* Zone. Zone II after Efremov corresponds to the upper part of the *Parabradysaurus silantjevi* Zone, *Estemmenosuchus uralensis* Zone, and lower part of the *Ulemosaurus svijagensis* Zone. Zone III after Efremov corresponds to the upper part of the *Ulemosaurus svijagensis* Zone. Zone IV after Efremov corresponds to the *Scutosaurus* Superzone (Fig. 3).

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REFERENCES

Bulanov, V.V., 2003. Evolution and systematics of Seymouriamorph Parareptiles. *Paleontological Journal,* vol. 37, suppl. 1, Pp. 1-105.

Efremov, I.A., 1937. On the stratigraphic division of the continental Permian and Triassic of the USSR based on the fauna of terrestrial vertebrates. *Doklady Akademii Nauk SSSR, Ser. Geol. (Moscow),* vol. 16, no. 2, pp. 125-132. [in Russian]

Efremov, I.A., 1939. On the development of the Permian tetrapod fauna of the USSR and division of the continental Permian into stratigraphic zones. *Izvestia Akademii Nauk SSSR, Ser. Biol. (Moscow),* no. 2, pp. 272-289. [in Russian]

Efremov, I.A., 1952. On the stratigraphy of Permian red beds of the USSR based on terrestrial vertebrates. *Izvestia Akademii Nauk USSR, Ser. Geol. (Moscow),* no. 6, pp. 49-75. [in Russia]

Efremov, I.A., 1954. The terrestrial vertebrate fauna from the Permian Copper Sandstones of the western Fore-Urals. *Trudy Paleontologicheskogo Instituta Akademii Nauk SSSR (Moscow)*, vol. 54, pp. 1-416. [in Russian]

Efremov, I.A. and Vyushkov, B.P, 1955. Catalogue of Permian and Triassic localities of terrestrial vertebrates from the territory of the USSR. *Trudy Paleontologicheskogo Instituta Akademii Nauk SSSR (Moscow),* vol. 46, pp. 1-185. [in Russian]

Golubev V.K., 2000a. The faunal assemblages of Permian terrestrial vertebrates from Eastern Europe. *Paleontological Journal*, vol. 34, suppl. 2, pp. 211-224.

Golubev, V.K., 2000b. The Permian and Triassic Chroniosuchians and the biostratigraphy of Upper Tatarian deposits of Eastern Europe based of tetrapods. *Trudy Paleontologicheskogo Instituta Rossiyskoy Akademii Nauk (Moscow)*, vol. 276, pp. 1-174. [in Russian]

Gubin, Yu.M., 1991. Permian archegosauroid amphibians from the USSR. *Trudy Paleontologicheskogo Instituta Akademii Nauk SSSR (Moscow)*, vol. 249, pp. 1-140. [in Russian]

Ivakhnenko, M.F., 1987. Permian Parareptiles of the USSR. *Trudy Paleontologicheskogo Instituta Akademii Nauk SSSR (Moscow)*, vol. 223, pp. 1-159. [in Russian]

Ivakhnenko, M.F., 2003. Eotherapsids from the East European Placket (Late Permian). *Paleontological Journal,* vol. 37, suppl. 4, pp. 339-465.

Ivakhnenko, M.F., Golubev, V.K., Gubin, Yu.M., Kalandadze, N.N., Novikov, I.V., Sennikov, A.G. and Rautian, A.S., 1997. Permian and Triassic tetrapods of Eastern Europe. (*Trudy Paleontologicheskogo Instituta Rossiyskoy Akademii Nauk (Moscow),* vol. 268) Moscow, GEOS, 216 pp. [in Russian]

Kalandadze, N.N., Rautian, A.S., 1997. Historical zoogeography of terrestrial tetrapods and a new method of global paleogeographical reconstructions. *Records of the Queen Victoria Museum and Art Gallery*, no. 104. Evolution of the Biosphere. Launceston, pp. 95-98.

Kutorga, S.S., 1838. Beitrag zur Kenntnis der organischen Über-reste des Kupfersandsteins am Westlischen Abhänge des Urals. St.-Petersb., 38 S.

Olson, E.C., 1966. Community Evolution and the Origin of Mammals, *Ecology*, vol. 47, no. 2, pp. 291-302.

Orlov, Yu.A., 1958. Predatory Deinocephalians from the Isheevo fauna (Titanosuchians). *Trudy Paleontologicheskogo Instituta Akademii Nauk SSSR (Moscow)*, vol. 72, pp. I-114. [in Russian]

Rubidge, B.S. Ed., 1995. Biostratigraphy of the Beaufort Group (Karoo Supergroup). *South African Committee for Stratigraphy. Biostratigraphic Series*, no. 1, pp. 1-46.

Sennikov, A.G., 1995. Early Thecodonts of Eastern Europe. *Trudy Paleontologicheskogo Instituta Akademii Nauk SSSR (Moscow)*, vol. 263, pp. 1-140. [in Russian]

Shishkin, M.A., 1973. The morphology of early amphibians and the problem of evolution of the lower tetrapods. *Trudy Paleontologicheskogo Instituta Akademii Nauk SSSR (Moscow)*, vol. 137, pp. 1-257. [in Russian]

Tatarinov, L.P., 1974. Theriodonts of the USSR. *Trudy Paleontologicheskogo Instituta Akademii Nauk SSSR (Moscow)*, vol. 143, pp. 1-240. [in Russian]

Tatarinov, L.P., 1976. *Morfologicheskaya evolyutsiya teriodontov i obshchie voprosy filogenefiki* {Morphological evolution of Theriodonts and general questions of the phylogeny). Moscow: Nauka, 258 pp. [in Russian]

Tchudinov, P.K., 1983. Early Therapsids. *Trudy Paleontologicheskogo Instituta Akademii Nauk SSSR (Moscow)*, vol. 202, pp. 1-230. [in Russian]