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# Upper Permian vertebrates and their sedimentological context in the South Urals, Russia

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**Abstract**

Fossil fishes and tetrapods (amphibians and reptiles) have been discovered at 81 localities in the Upper Permian of the Southern Urals area of European Russia. The first sites were found in the 1940s, and subsequent surveys have revealed many more. Broad-scale stratigraphic schemes have been published, but full documentation of the rich tetrapod faunas has not been presented before. The area of richest deposits covers some 900,000 km$^2$ of territory between Samara on the River Volga in the NW, and Orenburg and Sakmara in the SW. A continental succession, some 3 km thick, of mudstones, siltstones, and sandstones, deposited on mudflats and in small rivers flowing off the Ural Mountain chain, span the last two stages of the Permian (Kazanian, Tatarian). The succession is divided into seven successive units of Kazanian (Kalinovskaya, Osinovskaya, and Belebey svitas, in succession) and Tatarian age, which is further subdivided into the early Tatatian Urzhumian Gorizont (Bolshekinelskaya and Amanakskaya svitas, in succession), and the late Tatarian Severodvinian (Vyazovskaya and Malokinelskaya svitas, of equivalent age) and Vyatkian gorizonts (Kulchumovskaya and Kutulukskaya svitas, of equivalent age). This succession documents major climatic changes, with increasing aridity through the Late Permian. The climate changes are manifested in changing sedimentation and the spread of dryland plants, and peak aridity was achieved right at the Permo–Triassic (PTr) boundary, coincident with global warming. Uplift of the Urals and extinction of land plants led to stripping of soils and massive run-off from the mountains; these phenomena have been identified at the PTr boundary elsewhere (South Africa, Australia) and this may be a key part of the end-Permian mass extinction. The succession of Late Permian fish and tetrapod faunas in Russia documents their richness and diversity before the mass extinction. The terminal Permian Kulchomovskaya and Kutulukskaya svitas have yielded respectively some 6 and 13 species of fishes (sharks, bony fishes, lungfishes) and 11 and 14 species of tetrapods (aquatic amphibians, herbivorous and carnivorous reptiles of all sizes up to the hippo-sized pareiasaurs and sabre-toothed gorgonopsians). Immediately following

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the end-Permian environmental catastrophe, earliest Triassic faunas consisted only of a few fish taxa and small, aquatic tetrapods, in low-diversity, low-abundance assemblages.


*Keywords:* Permian; Triassic; Mass extinction; Tetrapod; Amphibian; Reptile; Russia; Urals; Stratigraphy

## 1. Introduction

The end-Permian crisis was the largest mass extinction ever, with estimates of the loss of as many as 80–90% of all species (Benton, 2003). The impact of the crisis on land is less well understood than in marine settings, partly because of dating and correlation problems, but partly also because there are few areas where extensive faunas and floras are known from both the Late Permian and Early Triassic. Indeed, there are only two regions in the world where tetrapod faunas may be tracked across the boundary: the Karoo Basin in South Africa, and the Russian Permo–Triassic successions, especially in the zone from the River Volga to the plain south of the Ural Mountains. Fossil amphibians and reptiles have been known from the Russian successions for more than 200 years, and many summaries have been published, in Russian and in other languages. However, the last comprehensive overview (Efremov and V'yushkov, 1955) lacked a modern stratigraphic and sedimentological context, and new finds have immeasurably expanded knowledge of the faunas. This paper presents the Late Permian tetrapod faunas of the S Urals and their context, and it is a companion to Tverdokhlebov et al. (2003), which covered the Early and Mid Triassic tetrapod faunas.

Upper Permian deposits are common throughout the whole of the E of European Russia, from the Barents Sea coast in the N, to the Pre-Caspian Depression in the S. The richest sites for fossil vertebrates lie in the S Urals region, around the town of Orenburg, extending W towards Samara and E to the Autonomous Republic of Bashkortostan (Fig. 1). The best exposures are seen close to the major rivers, along the valleys of the Ural, Sakmara, and Samara rivers and their tributaries, as well as along the left-bank (Eastern) tributaries of the Volga. The whole area lay some 30°N of the Permian palaeo-equator, and extensive red-bed sediments accumulated, comprising some 3 km of deposits predominantly from lakes and small rivers and deltas, with some marine and brackish units in the early Kazanian (Newell et al., 1999).

Bones of fossil reptiles were reported from the Copper Sandstones of Perm' Province and the Orenburg area in the late 18th century, and the first descriptions were published in the 1830s and 1840s. At first, these were thought to have been the bones of deceased miners, or at least of mammals. Studies by Russian, English, and German palaeontologists during the 19th century revealed a fauna of dinocephalian synapsids and temnospondyls that demonstrated links with the new discoveries from the Karoo of South Africa (Ochev and Surkov, 2000). Intensive collecting by Russian palaeontologists through the 20th century, revealed a succession of faunas of fishes, amphibians, and reptiles throughout the Late Permian from S to N of the Ural Mountain chain.

We focus here on the Southern Urals area. Late Permian tetrapods are known also from the Severnaya Dvina River, Inta, and the Pechora Basin in the far N, as well as from some locations around the towns of Kotlas, Kirov, Kazan', and Perm in the central area of European Russia. The Inta fauna, of possible Ufimian

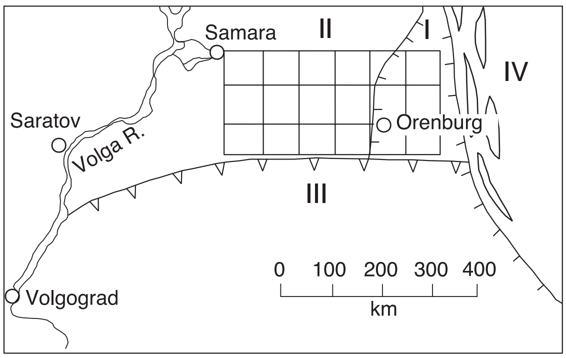


Fig. 1. Geographical setting of the South Urals region. Permian tetrapod-bearing localities are located in the grid area (shown in more detail in Fig. 23). For major zones: I, the Cis-Ural Trough; II, the southeastern slope of the Volga–Ural Anteclise; III, the Peri-Caspian Depression; IV, the Ural Mountain fold system.

age, consists of eryopoid temnospondyls, a captorhinid, and a bolosaurid. The Ezhovo (Ocher) fauna from Ezhovov, near Perm, of late Kazanian and possibly earliest Tatarian age, comprises various temnospondyls, estemmenosuchid dinocephalians, and biarmosuchians (Chudinov, 1983; Modesto and Rybczysnki, 2000). These faunas are not further discussed here.

The stratigraphic subdivision of the Russian continental Upper Permian has been difficult because of the general scarcity of fossils. As for the overlying Lower and Middle Triassic succession (Tverdokhlebov et al., 2003), most stratigraphic schemes have relied on the sporadically abundant vertebrate fossils and the long-term and substantial faunal changes. The earliest scheme for subdivision of the Upper Permian and Triassic of European Russia based on tetrapod remains was presented by Efremov (1937, 1950) and Efremov and V'yushkov (1955). This tetrapod biostratigraphy was confirmed and refined through the 1960s and 1970s, and more recently an attempt has been made to develop a biostratigraphy based on ostracod remains determined by Molostovskaya (1993, 1997, 1999, 2000).

In the 1950s, only a limited number of Permian tetrapod localities were known, and only from the Northern sections; only occasional finds had been reported from the SE of the Russian Plate. Extensive geological surveying in the 1960s and 1970s increased the number of tetrapods identified. About 80 new localities for tetrapod and fish remains were discovered in the S Cis-Urals and on the SE slope of the Volga–Ural Anteclise, and these were studied by a group of geologists and palaeontologists at the Geological Research Institute of the State University of Saratov (SGU).

A great deal of new material of fossil vertebrates from the Upper Permian has been collected and prepared in both the SGU and in the Palaeontological Institute in Moscow (PIN). Alla V. Minikh and Maxim G. Minikh have studied the ichthyofaunas in a series of publications (Minikh and Minikh, 1986, 1990, 1997, 1999; Minikh, 1992). The new tetrapods were described by Ochev (1976), Tverdokhlebova (1972, 1973, 1975, 1991), Ivakhnenko (1979, 1987, 1990a, 2001), Ochev et al. (1979, 1993, 1999), Ivakhnenko and Tverdokhlebova (1980, 1987), Chudinov and Ochev (1975), Chudinov (1983, 1987), Chudinov and Tverdokhlebova (1991), Gubin (1991), Golubev (1996, 1998, 1999, 2000), Ivakhnenko et al. (1997), and Bulanov (1999, 2000, 2002a,b).

The first attempt to synthesize the data on Permian and Triassic terrestrial vertebrates was made by Efremov and V'yushkov (1955). Information on the S Cis-Urals was supplemented by Garyainov and Ochev (1962), who were able to list only seven Upper Permian tetrapod localities. A later catalogue by Kalandadze et al. (1968) gave more localities. The most extensive overview was provided by Tverdokhlebova (1976), who was able to include all the new sites discovered by the geological surveying teams from the SGU. Her catalogue was reproduced by Ivakhnenko et al. (1997).

All the Upper Permian localities in the E of European Russia that have yielded tetrapod and fish remains are in Kazanian and Tatarian deposits (Tverdokhlebova et al., 1989). Here, we review current understanding of the stratigraphic divisions in the S Cis-Urals (the Cis-Ural Marginal Trough) and in the SE slope of the Volga–Ural Anteclise, and outline the geological structure and history of the region. A broad overview is given of the sedimentary and environmental history of the region, as well as of the evolution of vertebrate ecosystems. The key focus of the paper is the sites themselves, documenting for the first time the geographic location, sedimentology, fossil finds, and age of each site. This documentation is a crucial first step in attempting to use the extensive Russian data to document the effects of the end-Permian mass extinction, and to compare them with the Kazanian and Tatarian successions in the Karoo Basin of S Africa.

*A note on names*. We have attempted to transliterate all Russian place names and author names according to a standard Anglo–Russian scheme (Kielan-Jaworowska, 1995; Benton, 2000). Here and there, older 'Germanic' transliterations of author names survive by convention, for example in the names of authors of taxa—compare Ochev (Anglo–Russian transliteration) and Otschev (Germanic transliteration).

## 2. Stratigraphy

The SE of European Russia comprises two geostructural elements: the SE slope of the Volga–Ural Anteclise (the SE termination of the E-European

Platform) and the Cis-Ural Marginal Trough (S Cis-Urals). The latter zone is characterized by the widespread development of diapir structures, meridionally elongated, and parallel to the fold-belt of the Ural Mountains. Upper Permian deposits here lie in interdome blocks; their thicknesses are an order of magnitude greater than those of the coeval strata in the platform part of the area.

Across the whole of the Uralian Foreland Basin, sedimentation dynamics and formation cyclicity were mainly determined by the tectonic activity of the Urals, and these mountains were the principal source of clastic material and water masses (Newell et al., 1999; Tverdokhlebov et al., 2003). Despite the interlinked nature of controls on sedimentation in both zones, however, the character and composition of the deposits in the Trough and on the platform differ substantially, and independent local strata (Svitas) have been recognized in the two adjacent subregions.

The Upper Permian comprises deposits of all stages—the Ufimian, the Kazanian and the Tatarian—but tetrapods are known only from the last two in SE European Russia (Fig. 2). Fishes have been found recently in Ufimian rocks far to the N of the area under consideration. However, the Ufimian deposits are not considered here.

| Epoch | Stage | Substage | Gorizont | Svita: South-eastern slope of the Volga-Ural Anticlise | Svita: Cis-Ural Trough |
|---|---|---|---|---|---|
| UPPER PERMIAN | Tatarian | upper | Vyatkian | Kutulukskaya | Kulchumovskaya |
| | | | Severodvinian | Malokinelskaya | Vyazovskaya |
| | | lower | Urzhumian | Amanakskaya | Urzhumian |
| | | | | Bolshekinelskaya | |
| | Kazanian | upper | | Belebeyevskaya | Belebeyevskaya |
| | | lower | | Kalinovskaya | Osinovskaya |
| | Ufimian | | | | |

Fig. 2. Stratigraphic scheme of the Upper Permian of southeast European Russia.

### 2.1. Conventions in stratigraphy

There has been much confusion in the past over comparisons of Russian and international systems of stratigraphy. According to the Russian system, rock units, and geological time, are subdivided into svitas, gorizonts, and other subdivisions (e.g., podgorizont, supergorizont). Sometimes these units are anglicized, for example gorizont as horizon and svita as suite. Another solution has been to equate the Russian divisions with international units, for example, gorizont with horizon, and svita with formation. These approaches, however, mask the fundamental differences between the Russian and the international approaches to stratigraphy, and we prefer to retain transliterated versions of the Russian terms in order to avoid confusion.

According to the Russian Stratigraphic Code (Zhamoida, 1977), gorizonts are the main regional stratigraphic units, identified primarily from their palaeontological characteristics, and they do not pertain to lithostratigraphic units. The gorizont may unite several svitas, or parts of svitas, or deposits of different facies in various districts that are clearly contemporaneous on the basis of included fossils. Svitas, on the other hand, are largely lithostratigraphic units, given a locality name that is close to their characteristic exposure. The definition of a svita incorporates a mix of field lithological observations and biostratigraphic assumptions. Fuller details may be found in Zhamoida (1977) and Benton (2000).

There is often difficulty in rendering the names of gorizonts and svitas into English, whether to transliterate directly from the Russian, or to anglicize to some extent. For example, the highest svita of the Permian may be rendered as Kutulukskaya, Kutulukski, Kutulukskian, Kutulukskayan, and probably in many other ways. After discussion among the editors of Benton et al. (2000), the following convention was adopted: (1) to use an anglicized adjectival ending for Gorizont and Supergorizont terms; and (2) to use a transliterated adjectival form of the place name for svitas (except for those named from Tatar terms, such as Belebey). So, we refer to the Kutulukskaya Svita, which corresponds to the Vyatkian Gorizont. Further details are given by Benton (2000).

### 2.2. Sedimentology and the end-Permian event

The Permian succession of the S Urals documents a classic deep marine to continental foreland basin transition (Newell et al., 1999). The whole Permian sequence along the Sakmara River is some 3 km thick (Fig. 3), beginning with 1 km of deep-water turbidites of Artinskian age, which terminate abruptly and are followed by 500 m of Kungurian-age evaporites. This is followed by 200 m of fluvial sediments dated as Ufimian, then a further marine episode, represented by 200 m of Kazanian-age limestones, mudstones, and halites. The final phase is a succession of some 1 km of fluvial clastics, generally coarsening upwards, dated as Tatarian. All these units thin rapidly westwards on to the Moscow Plain (Fig. 3), the entire Permian succession thinning from 3 km around Orenburg, to 1 km at Yarensk and Kotelnich, and less than 500 m at Vologda, north of Moscow.

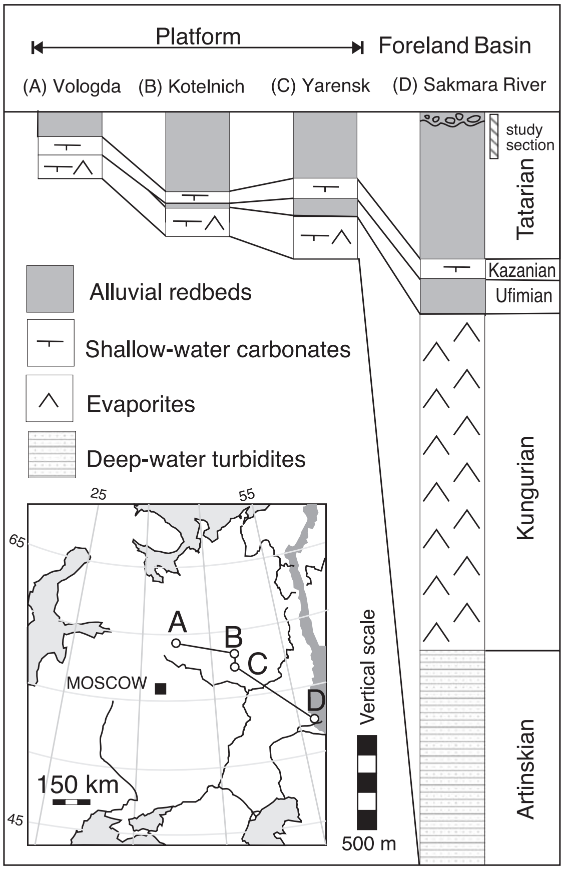


Fig. 3. Permian (Artinskian–Tatarian) stratigraphy of the Southern Uralian Foreland Basin and European Platform. (From Newell et al., 1999.)

The continental Tatarian of the S Urals consists of a variety of facies types: mudflat, sandy distributary, small gravelly channel, and large gravelly channel fluvial systems (Newell et al., 1999). Fluvial processes were dominant, with the size of channels and grain size increasing up-section. The mudflat and small gravelly channel associations represent deposits of a small prograding terminal fan (100–150 km long) characterized by downslope decreases in channel size caused by evaporation and infiltration.

The overlying large gravelly channel association, which begins at the base of the Triassic, represents a complete change in sedimentary style with a massive increase in discharge. The thick conglomerate units formed large-scale alluvial fans that were part of a much larger terminal fan, some 350 km long. The abrupt change in the size of the basin and the incoming of coarse-grained alluvial fans all along the Western margin of the Urals probably resulted from a change towards a more arid climate, with higher sediment yield and greater peak discharges in a drainage basin with reduced vegetation cover.

These massive changes in style of sedimentation at the Permo–Triassic (PTr) boundary, noted before by Tverdokhlebov (1971) and Newell et al. (1999), have been seen independently in the continental Karoo succession in South Africa (Ward et al., 2000) and Australia (Michaelsen, 2002). The changes have been linked to the end-Permian catastrophe, when the Siberian basalt eruptions appear to have caused dramatic global warming and acid rain. The acid rain perhaps killed off the vegetation on land, and soils were stripped from the landscape, and swept down rivers on to the plains, and eventually into the sea (Benton, 2003). In Russia, the main factor in triggering massive discharge of sediment from the Ural Mountains may have been tectonic: folding processes in the Urals reached a peak in the Late Permian, and there is evidence for glaciers high in the mountains and humid upland regions (Tverdokhlebov, 1971).

### 2.3. The Kazanian stage

The Kazanian stage is divided into two substages. The lithological-facies composition of the lower substage, and its fossils, change drastically over the area. In the platform area, in the Volga–Ural Anteclise and in the outer zone of the Cis-Ural Trough, the lower Kazanian substage is represented by marine beds termed the Kalinovskaya Svita. In the S Cis-Urals, the Osinovskaya Svita, its analogue in age, comprises alternating lagoonal, lagoonal-marine, and continental formations. The upper Kazanian substage, the Belebey Svita, is recognized throughout the area, and it is represented by continental, mostly terrigenous deposits.

### *2.3.1. Kalinovskaya Svita*

The Kalinovskaya Svita is represented by grey-coloured, carbonate-terrigenous beds of marine origin. Among vertebrate remains, fishes were identified, the janassid *Janassa* sp., as well as an abundant marine fauna of brachiopods, bivalves, corals, bryozoans, crinoids, foraminifers, and ostracods. The Kalinovskaya Svita is from 60 to 120 m thick.

### *2.3.2. Osinovskaya Svita*

The Osininovskaya Svita is a heterogeneous sequence of mainly red-bed terrigenous rocks with interlayers of grey marls and limestones (Fig. 4). A diversity of textures, structures, and fossils are seen throughout: laminations of current and oscillatory ripples, gutter casts from surge and reverse flows, pseudomorphs after halite crystals, desiccation cracks, brecciform structures (ablation breccias), root traces and grey-coloured interlayers enriched in plant remains, and limestone and marl interlayers containing remnants of freshwater or impoverished marine faunas.

These features indicate that sedimentation took place in frequently changing settings—coastal marine and diversely saline lagoonal conditions, periodically alternating with strictly continental, lacustrine-marsh or deltaic settings (deltas of intercontinental basins; Tverdokhlebov, 1987). Whatever the conditions were, sedimentation was influenced by the variable arid (pseudomorphs, desiccation) and humid (ripples, plant remains) climates.

Both marine and freshwater faunas indicate a Kazanian age for the polyfacies units within the Osinovskaya Svita, while miospore floras are non-ambiguous indices of an early Kazanian age. The total thickness of the Osinovskaya Svita in the S Cis-Urals may be as large as 300 m.

### *2.3.3. Belebey Svita*

Red clays (reddish-brown, brownish-yellow, brown) and siltstones dominate in this unit. The rocks are massive, occasionally with thin, wavey or subhorizontal laminations. Rounded carbonate nodules occur frequently; at some sites the rock is replaced by concretions of clayey limestone. Such formations are characteristic of arid-marsh subsoils. Clays and siltstones make layers 0.1–2.5 m thick, or

Fig. 4. Lagoonal and lacustrine deltaic facies of the Osinovskaya Svita at Spasskoe (locality 1), Orenburg Region, South Cis-Urals. Subhorizontal bedding and pinching out of a sand layer are clearly seen. (Photograph by V.P. Tverdokhlebov).

compose cyclic, thinly interstratified members with fine-grained clayey sandstone.

Interbeds of cross-laminated sandstone are observed in the section: from reddish-brown, fine-grained to grey, medium and coarse-grained, with thin conglomerate lenses, as well as rare interlayers (up to 0.1 m) of limestones—light grey, clayey or sandy. Sandstone layers and lenses may be up to 4.0 m thick, but they do not exceed 10% of the section.

A high general carbonate content and plentiful clayey-carbonate concretions are characteristic of all the rocks of the Belebey Svita. The character of bedding, the rock textures, and compositions indicate that the Belebey deposits accumulated in vast playa lakes (Fig. 5a, b), inherited from the early Kazanian lacustrine-lagoonal areas. Sedimentation was periodically interrupted by local, rarely ubiquitous, desiccations with the temporary establishment of an alluvial–deltaic regime. This is recorded in the section by the lenses of cross-bedded sandstone and conglomerate—products of channels (Fig. 6).

The Belebey Svita beds are not rich in organic remains; a few localities produce rare fossils of fishes, tetrapods, ostracods, bivalves, conchostracans, miospore floras, and macromeric fauna. Late Kazanian ostracods are known from deposits of the Cis-Ural Trough and SE termination of the E-European Platform. The ostracod fauna is represented by *Paleo-*

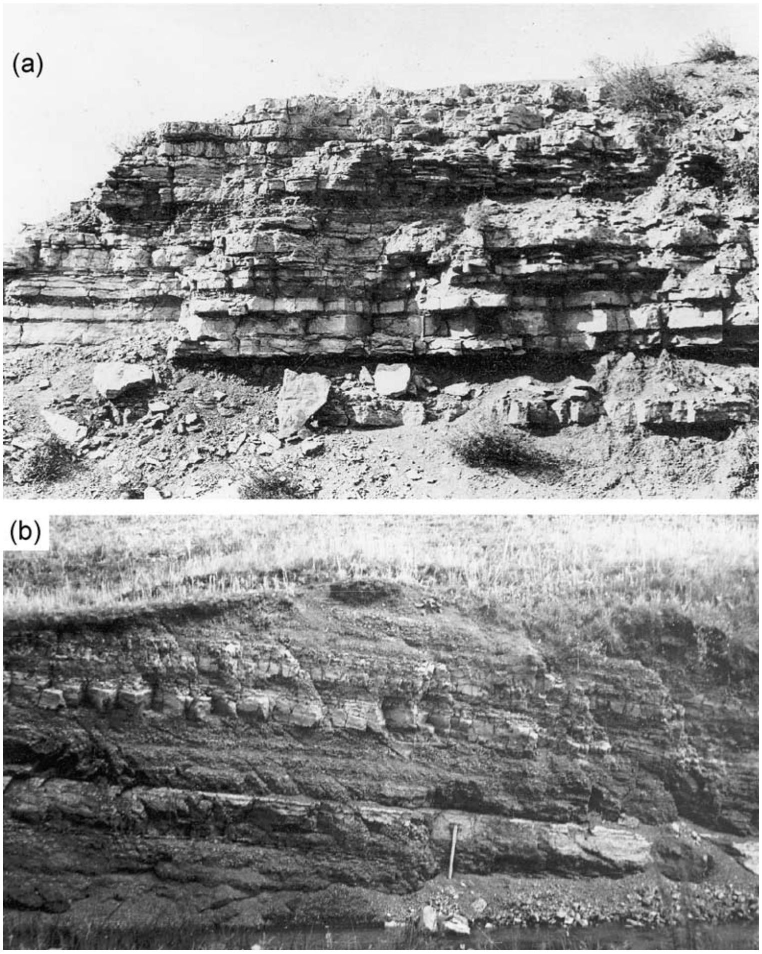


Fig. 5. Lacustrine-marshy facies of the Belebey Svita, Orenburg Region, South Cis-Urals. (a) Fine-rhythmic, subhorizontal bedding in lacustrine deposits at Yaman–Yushatyr (locality 3). (b) Lacustrine-marshy facies with distinctive small clayey-carbonate concretions looking like many small light spots. (Photographs by V.P. Tverdokhlebov).

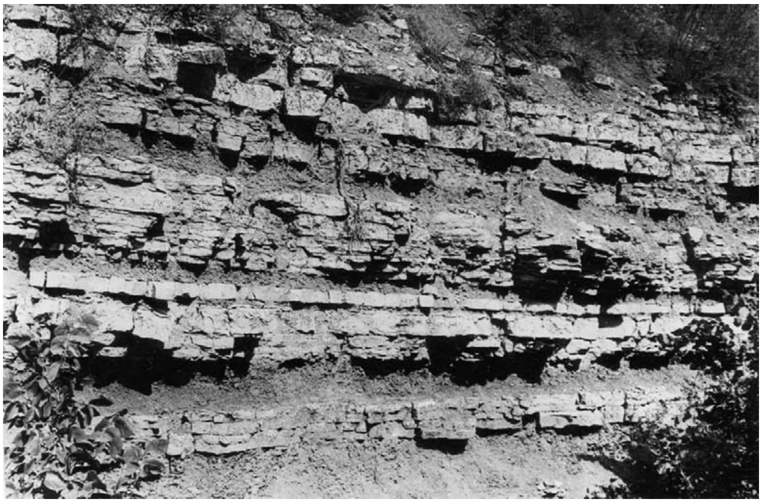

Fig. 6. Near-shore lacustrine facies of the Belebey Svita at Dobrinka (locality 6), Orenburg Region, South Cis-Urals. Small-scale rhythmic horizontal bedding. (Photograph by V.P. Tverdokhlebov).

*darwinula inornatina*, *Paleodarwinula fanae*, *Paleodarwinula elegantella*, *Paleodarwinula chramevella*, *Paleodarwinula belousovae*, *Prasuchonella tichvinskaja*, *Prasuchonella onega*, *Prasuchonella belebeica*, and *Darwinuloides sentjakensis* (Molostovskaya, 1990, 1993, 1997, 2000).

The fish assemblage is represented by the typical Kazanian genus *Kazanichthys*, the deep-bodied platysomids *Platysomus bashkirus*, *Platysomus soloduchi*, and *Kargalichthys pritokensis*, as well as the eurynotoid *Eurynotoides* and the varialepidid *Varialepis*.

The tetrapod assemblage is characterized by the specialized archegosaurid *Platyoposaurus*, the amphibious parareptile *Tokosaurus*, and the terrestrial captorhinomorphs *Belebey* and *Davletkulia.* Therapsids are a small component of this assemblage, represented only by the genus *Estemmenosuchus.*

The ostracod and miospore assemblages are most informative for age determination, and they indicate a late Kazanian age for the Belebey Svita. The unit ranges from 200 to 270 m thick in the platform zone and up to 700 m thick in the Cis-Ural Trough.

## 2.4. The Tatarian stage

Tatarian deposits are more extensive than those of Kazanian age, and hence the number of locations yielding tetrapod remains of this age are correspondingly higher than in older units. The Tatarian stage is subdivided into two units: the regional Urzhumian Gorizont (lower Tatarian) followed by the Severodvinian and the Vyatkian gorizonts (upper Tatarian).

### 2.4.1. Urzhumian Gorizont

In the Cis-Ural Trough, the Urzhumian Gorizont has homogeneous lithological composition and uniform palaeontological characteristics, and is therefore not divided into smaller units.

There is a clearly manifested erosional contact between the sediments ascribed to the Urzhumian Gorizont and the Belebey Svita. Cross-bedded Urzhumian sandstones with conglomeratic lenses lie on the eroded surface of the upper Kazanian clays or siltstones. The whole of the section shows cyclicity. Typical cycles consist of 5–25 m thick poorly sorted sandstones with conglomeratic lenses at the base, fining up to alternating fine-grained sandstones, siltstones, and clays. Rare limestone and marl interlayers up to 0.3 m thick occur.

The Urzhumian sandstone is reddish- and brownish-grey, grey and brown, from fine-grained to coarse-grained, massive and cross-bedded. In the basal layers of cycles, are thick units of low-angle, cross-bedded conglomerates and sandstones up to 1.5 m thick. Higher in the cycles are units with wavey, flaser, and rarely, subhorizontal lamination. Medium-scale pebble conglomerates are seen, with clasts of sandstone, siltstone, and marl, as well as many clay balls and carbonate nodules. Many units are carbonate-cemented.

Siltstones vary in colour from brown to light grey, and they may be clayey, massive and subhorizontally laminated. The light grey varieties are dense, with carbonate-clayey cement and small, current-ripple cross lamination. The siltstone interlayers are up to 15 m thick.

Clays are coloured in diverse shades of brown, often with reddish, lilac or violet hues; they have montmorillonite–hydromica compositions/admixtures of sandy and siltstone materials are often recorded, as well as a high general carbonate content. Ostracod shell accumulations, small carbonate nodules, traces of deposit-feeders and plant roots, and desiccation fractures occur in the clays. The clay interlayers are up to 5 m thick.

Most of the layers and lenses of poorly sorted, cross-bedded sandstone represent deposits from channels. River-channel deposits occur probably just at the very base of the most laterally persistently sandstone strata. Finer-grained rocks—clayey sandstone, siltstone, clays—were deposited in delta flood-plain or shallow-water lacustrine basins in semi-arid conditions.

The age of the deposits of the Urzhumian Gorizont is based on the abundant ostracods: *Paleodarwinula elongata*, *Paleodarwinula fragiliformis*, *Paleodarwinula chramovi*, *Paleodarwinula defluxa*, *Paleodarwinula faba*, *Paleodarwinula pavlovskaja*, *Paleodarwinula arida*, *Paleodarwinula obvia*, and *Prasuchonella nasalis* (Molostovskaya, 1990, 1993, 1997, 2000).

Tetrapod and fish remains characterize the whole Urzhumian Gorizont, but without indicating finer subdivisions. Typical species in the Urzhumian ichthyofauna are *Platysomus biarmicus* and *Kargalichthys efremovi*. Besides these, the genera *Varialepis*, *Samarichthys*, *Lapkosubia*, *Kichkassia*, and *Discordichthys* also occur. Amphibians include the melosaurids *Konzhukovia*, *Uralosuchus*, and *Tryphosuchus*, while reptiles are a minor component, being represented by the aquatic lanthanosuchid *Chalcosaurus* and probably some nycteroleterids. Therapsids form the main terrestrial component, represented predominantly by the large forms *Titanophoneus*, *Deuterosaurus*, and *Ulemosaurus*, and the medium-sized *Ulemica*.

The thickness of the Urzhumian Gorizont in the Cis-Ural Trough varies from 200 to 500 m. In the platform part of the area, on the SE slope of the Volga–Ural Anteclise, the Urzhumian Gorizont is subdivided into two Svitas: the Bolshekinelskaya and Amanakskaya.

*2.4.1.1. Bolshekinelskaya Svita.* The Bolshekinelskaya Svita was formed at the beginning of the major early Tatarian sedimentation cycle. At the base of the section are up to 10 m of poorly sorted, cross-bedded sandstone, products of river channels and delta branches (Fig. 7). Lenses of coarse sandstone occur higher in the section, among subhorizontally interbedded clays, siltstones, fine-grained clayey sandstone, and rarer limestone and marl, all deposits of

Fig. 7. Facies of the deltaic flood-plain and a deltaic channel of the Bolshekinelskaya Svita at Borisov (locality 51), Orenburg Region, South Cis-Urals. Tetrapod remains are found in clays of the flood plain. (Photograph by V.P. Tverdokhlebov).

delta flood-plains, lakes, and marshes. The rocks are of red-brown and red-brownish-yellow colours.

The clays contain an early Urzhumian fauna of ostracods: *Paleodarwinula fragiliformis*, *Paleodarwinula fragilis, Paleodarwinula angusta*, *Paleodarwinula multa*, *Paleodarwinula defluxa*, *Prasuchonella nasalis*, and some uncommon forms which were abundant in the Belebey ostracod fauna: *Paleodarwinula inornatinaeformis*, *Paleodarwinula alexandrinae*, *Paleodarwinula belousovae,* and *Garjainovula lija* (Molostovskaya, 1990, 1993, 1997, 2000). The Bolshekinelskaya Svita is up to 100 m thick.

*2.4.1.2. Amanakskaya Svita.* The Amanakskaya Svita closes the early Tatarian erosion–sedimentation cycle. It is composed mainly of lacustrine and lacustrine-deltaic clays, siltstones, marls, limestones with channel lenses of cross-bedded poorly sorted sandstones (Fig. 8). The Amanakskaya Svita overlies the Bolshekinelskaya, mainly concordantly. At some sites at the base of the Amanakskaya Svita, there are cross-bedded sandstone lenses and erosion at the base (Fig. 9).

Late Urzhumian ostracods occur in clays, siltstone and marl. This fauna is represented by *Paleodarwinula elongata*, *Paleodarwinula chramovi*, *Paleodarwinula arida*, *Paleodarwinula faba*, *Paleodarwinula torensis* and *Prasuchonella nasalis*. Rocks in the Amanakskaya Svita are from 40 to 130 m thick.

### 2.4.2. Severodvinian Gorizont

Severodvinian Gorizont-age sediments in the S Cis-Urals differ substantially in composition from

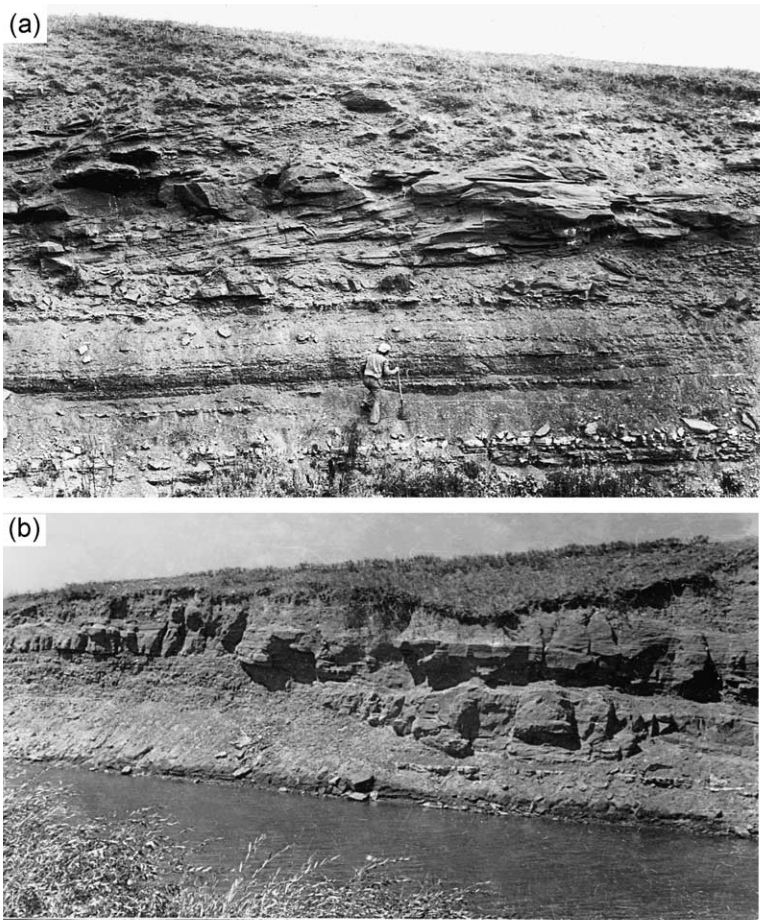


Fig. 8. Facies of deltaic channels from the Amanakskaya Svita enclosed in flood-plain deposits, Orenburg Region, South Cis-Urals, at (a) Kantserovka-1 (locality 34) and (b) Malyi Uran (locality 43) (Photograph by V. Tverdokhlebov).

Fig. 9. Stream-flow facies in the Amanakskaya Svita, at Tatischevo-2 (locality 25), Orenburg Region, South Cis-Urals, represented by large lenses of cross-bedded, fine- to medium-grained sandstone with small lenses of conglomerates. (Photograph by V.P. Tverdokhlebov).

those in the SE of the Volga–Ural Anteclise. These are recognized as different svitas: the Vyazovskaya in the Cis-Ural Trough and the Malokinelskaya in the platform part of the area.

A rich vertebrate fauna has been discovered mainly in localities of the Malokinelskaya Svita. The ichthyoassemblege is characterized by the genera *Toyemia*, *Geryonichthys, Strelnia, Sludalepis*, and *Isadia*. The genera *Lapkosubia*, *Kichkassia*, *Kargalichthys*, and *Varialepis* are known only from the lowermost part of the Severodvinian Gorizont.

The tetrapod assemblage is composed mainly of amphibious taxa (Ivakhnenko, 2001). Amphibians are represented by the dvinosaurid *Dvinosaurus* and the kotlassiid *Microphon.* Parareptiles are the most diverse, and represented by the genera *Karpinskiosaurus* and *Proelginia.* Remains of the chroniosuchid *Chroniosaurus* are the most common. Therapsids are represented by gorgonopsids and the small venyukovioid *Suminia*. Tetrapod remains have not been discovered in the Vyazovskaya Svita, except for imprints of tracks in flood-plain deposits (Tverdokhlebov et al., 1997).

*2.4.2.1. Vyazovskaya Svita.* There is an erosional contact between the Vyazovskaya Svita and the underlying rocks. The unit has a cyclic structure, with fining-up cycles from 10–15 to 75 m thick. Cycles begin with a cross-laminated, poorly sorted sandstone containing fragments of local red, terrigenous-carbonate rocks and small pebbles of quartz and flints carried along from the Urals. On the whole, the Vyazovskaya Svita is composed of red, mainly terrigenous rocks: clays, siltstones, fine-grained clayey sandstones with interlayers and lenses of fine- and medium-grained, cross-bedded sandstones and conglomerates. Carbonate rocks are represented by rare, thin (from 0.1 to 0.4 m) interlayers of marls or limestones—grey, lilac-grey, sandy, and concretionary.

The cycles are, as a rule, crowned with evaporite limestones or caliche, and sometimes pseudomorphs after halite crystals occur in carbonate-clayey interlayers. The Vyazovskaya Svita is dominated by flood-plain deposits, formed in rainy seasons by temporary currents in numerous land-locked depressions and dry basins (Tverdokhlebov, 1989).

The Vyazovskaya Svita contains a rich ostracod fauna throughout the section, which characterizes the Severodvinian Gorizont: *Suchonellina daedala*, *Suchonellina cultella*, *Suchonellina undulata*, *Suchonellina futschiki*, *Suchonellina spizharsky*, *Suchonellina inornata*, *Paleodarwinula fragiliformis*, and *Prasuchonella nasalis* (Molostovskaya, 1990, 1993, 1997, 2000). The thickness of the Vyazovskaya Svita ranges from 240 m in the near-marginal part of the Cis-Ural Trough, to 500 m in its axial zone.

*2.4.2.2. Malokinelskaya Svita.* The boundary between the Malokinelskaya Svita and the lower Tatarian deposits is drawn at the sole of sand channel units starting a new cycle and indicating clear erosion. The sedimentology of the Malokinelskaya Svita is complicated. Subhorizontally bedded, brown, brownish-yellow, reddish-brownish-yellow clays, siltstones, fine-grained clayey sandstones with rare interlayers (up to 0.1 m) of grey, lilac-grey limestone and marls represent deposits from shallow lakes and delta flood-plains (Fig. 10a). A large number of thick (up to 10 m) lenses of cross-bedded sandstone occur, the products of distributary channels (Fig. 10b).

The Malokinelskaya Svita is well characterized by vertebrate and invertebrate faunas. The ostracod fauna is represented by *Suchonellina parallela*, *Suchonellina inornata*, *Suchonellina futschiki*, *Suchonellina spizharskii*, *Suchonellina undulata*, *Suchonellina daedala*, *Prasuchonella stelmachovi*, *Paleodarwinula fragiliformis*, and *Prasuchonella nasalis* (Molostovskaya, 1990, 1993, 1997, 2000) from the lower part of the Malokinelskaya Svita. The thickness of the Malokinelskaya Svita ranges from 70 m in the NW, to 180 m in the SE of the platform part of the area.

### 2.4.3. Vyatkian Gorizont

Deposits of the Vyatkian Gorizont are termed the Kulchumovskaya Svita in the S Cis-Urals, and the Kutulukskaya Svita in the Volga–Ural Anteclise.

The ichthyoassemblage is characterized by the typical species *Toyemia blumentalis* and *Isadia aristoviensis*, as well as the first appearance of the lepidosirenid *Gnathorhiza* and probably the saurichthyid *Saurichthys*. The genera *Xenosynechodus*, *Geryonichthys*, *Boreolepis*, *Strelnia*, and *Mutovinia* comprise the rest of this assemblage. The tetrapod assemblage is represented by the amphibian *Dvino-*

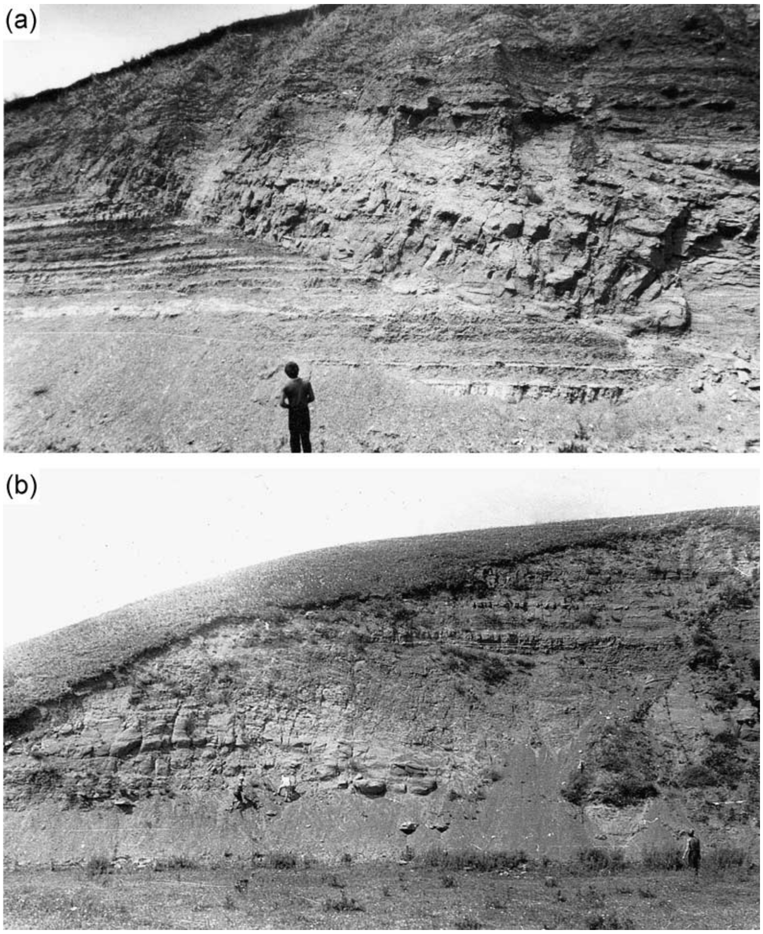

Fig. 10. Facies of channels and the deltaic flood-plain in the Malokinelskaya Svita, Orenburg Region, South Cis-Urals. (a) Sandstone lens cut by a stream flow into subhorizontally interbedded clay, siltstone, and sandstone of deltaic flood-plain deposits at Rychkovka-2 (locality 61). (b) Sand lenses in finer-grained flood-plain deposits at Borovka (locality 74). (Photographs by V.P. Tverdokhlebov).

*saurus*, the amphibious parareptiles *Karpinskiosaurus*, *Kotlassia*, *Microphon*, *Scutosaurus*, and *Proelginia*, and the dominant anthracosaurs *Uralerpeton*, *Chroniosuchus* and *Jarilinus*. The mainly terrestrial component of the tetrapod fauna is composed of the herbivorous *Dicynodon* and the carnivorous therapsids *Scylacosuchus*, *Inostrancevia*, *Annatherapsidus*, and *Chthonosaurus*.

*2.4.3.1. Kulchumovskaya Svita.* The Kulchumovskaya Svita closes the Upper Permian section; there is an erosional boundary with the Vyazovskaya Svita. The sedimentology is similar to that of the Vyazovskaya Svita, with dominance by flood-plain deposits of temporary flows and ephemeral lakes (Fig. 11). The principal sedimentation was of a seasonal, avalanche character. Local water-catchment areas served as the chief suppliers of terrigenous material. The ephemeral lakes of such periods tended to become key landscape features. Later on, during the longer-lasting dry seasons, lake degradation took place, making the landscape look like dry savannah (Tverdokhlebov et al., 1989).

Contrary to the underlying deposits, practically all the cycles in the Kulchumovskaya Svita are terminated by caliches of varying thickness (up to 2 m). Moreover,

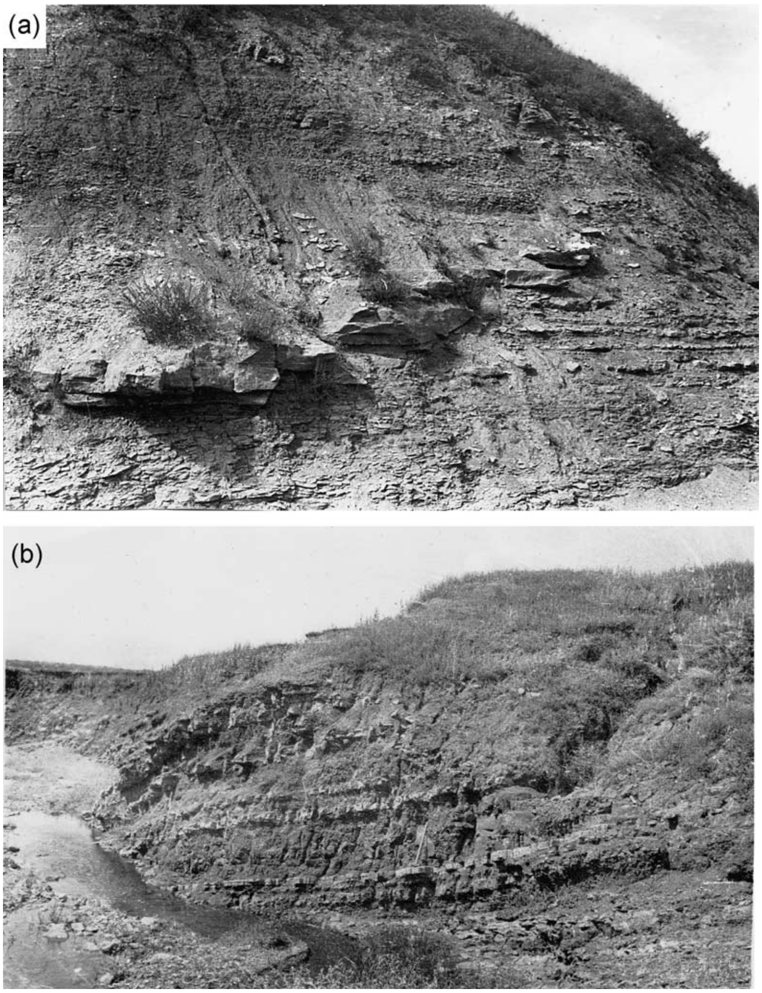


Fig. 11. Flood-plain facies of the Kulchumovskaya Svita represented by subhorizontally bedded sand–silt-clayey deposits, Orenburg Region, South Cis-Urals. (a) Lens of cross-bedded sandstone; the lens contains tetrapod remains, at Vyazovka-1 (locality 54); (b) Rhythmic deposits reflect seasonal sedimentation, at Vyazovka-3 (locality 56). (Photograph by V.P. Tverdokhlebov).

throughout the S Cis-Urals, in the uppermost part of the svita, about 40 m below the top, there is a cross-bedded sand-conglomerate member, from 1.0 to 12 m thick. This resulted from short, intensive movements of the folded Urals and rapid erosion into the Cis-Ural Trough. The sandstone contains large amounts of clastic material mainly of local origin: pebbles of Ural rocks dominate in the conglomerates. Abundant remains of leaves, tree trunk fragments, remains of fishes, and tetrapod bones are associated with this member.

The ostracod fauna is represented by the species *Suchonellina trapezoida*, *Suchonellina compacta*, *Suchonellina inornata*, *Suchonellina parallela*, *Suchonellina futschiki*, and *Wjatkellina fragilina* (Molostovskaya, 1990, 1993, 1997, 2000). The thickness of the Kulchumovskaya Svita along the Trough periphery is about 200–250 m, reaching 400 m in the central zone.

*2.4.3.2. Kutulukskaya Svita.* The Kutulukskaya Svita corresponds to the Vyatkian Gorizont in the SE slope of the Volga–Ural Anteclise. The rocks of the closing Upper Permian cycle lie with erosional unconformity over the underlying Malokinelskaya Svita deposits of the Severodvinian Gorizont. The section is dominated by subhorizontal interbedded red-brownish-yellow clays, siltstones, and fine-grained clayey sandstones—products of lakes and flood plains (Fig. 12). As in the laterally equivalent Kulchumovskaya Svita, lenses of grey, brownish-yellow sandstone occur, deposits from distributary channels (Fig. 13); but their number and thicknesses are substantially smaller than in the Malokinelskaya Svita.

Abundant ostracods have been found in the siltstones and clays: *Suchonella blomi*, *Paleodarwinula stelmachovi*, *Suchonellina anjigensis*, *Suchonellina inornata*, *Suchonellina undulata*, and *Suchonellina anjigensis* (Molostovskaya, 1990, 1993, 1997, 2000). The thickness of the Kutulukskaya Svita ranges from 40 to 110 m.

### 2.4.4. The end-Permian 'gap'

The Upper Permian continental sedimentary sequence ends with a marked, and regionally extensive, erosional level which is overlain by a massive conglomerate unit up to 15 m thick. There are two unresolved issues here: is the conglomerate part of the Upper Permian or Lower Triassic, and does the erosive level mark a modest or a substantial gap in time?

Russian stratigraphers have tended to mark the base of the Triassic in the region by the base of the conglomerate unit (Tverdokhlebov, 1971; Lozovskii, 1998; Tverdokhlebov et al., 2003), assigning the underlying sediments to the Vyatkian Gorizont of the Tatarian stage (Permian) and the conglomerate and overlying sediments to the Vokhmian Gorizont of the Induan stage (Triassic). Newell et al. (1999), on the

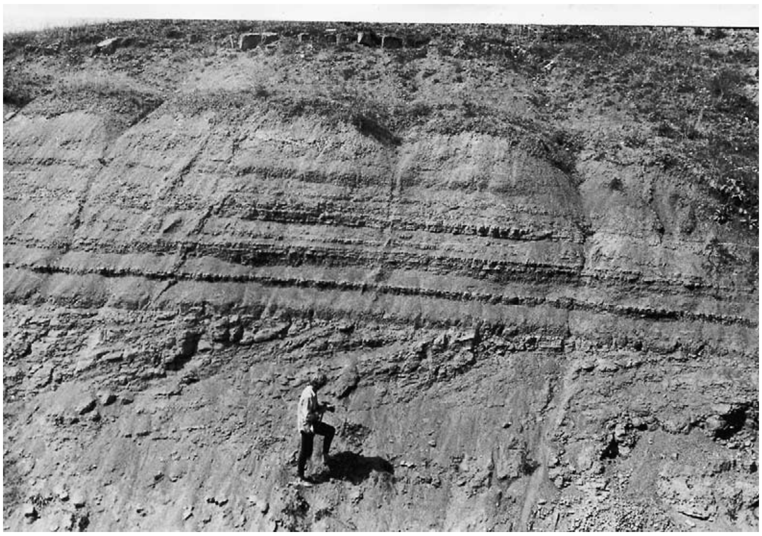

Fig. 12. Shallow-lake facies, showing subhorizontal bedding, and front-of-delta facies, showing oblique synsedimentary deposition, of the Kutulukskaya Svita, at Vozdvizhenka (locality 76), Orenburg Region, South Cis-Urals. (Photograph by V.P. Tverdokhlebov).

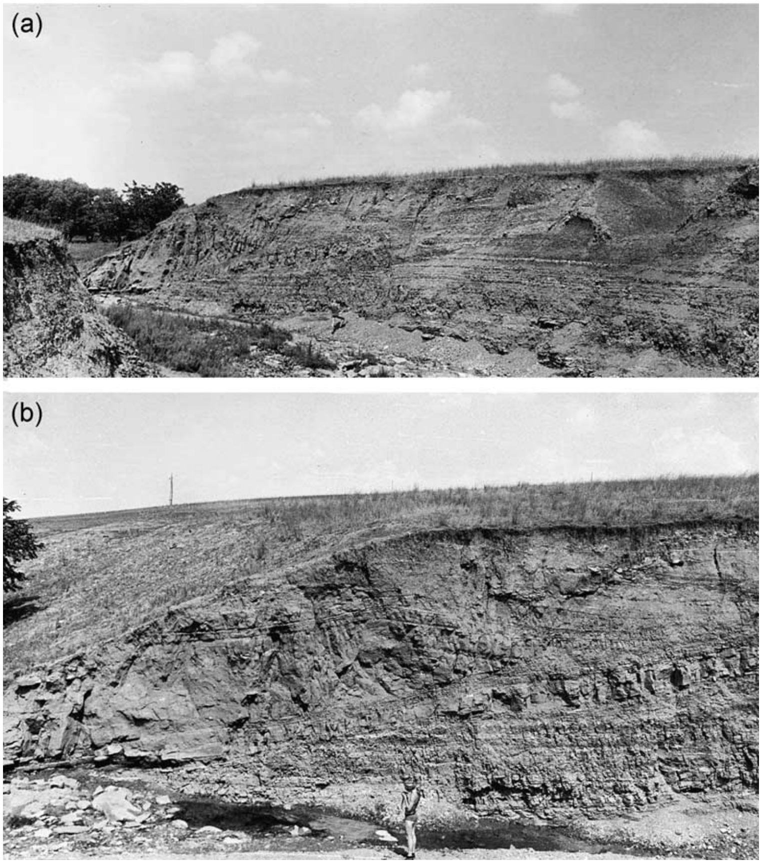


Fig. 13. Facies of channels cut into lacustrine deposits in the Kutulukskaya Svita. (a) General view; tetrapod remains were found in the upper, thinning part of the stream-flow lens; (b) Close-up view of the lens. (Photographs by V.P. Tverdokhlebov).

other hand, included the conglomerate as the last manifestation of the Permian because the unit lies below a structural unconformity with the Triassic, and the conglomerate is more closely related to the underlying upper Tatarian in terms of sediment provenance (intraorogen) and transport direction (westwards). Lower Triassic sediments in the basin also comprise fluvial-channel sandstone and overbank mudstone. However, they were deposited by S-flowing rivers in a N–S extensional basin which formed during a phase of regional crustal tension in the Southern Urals (Puchkov, 1997).

The analagous change from a meandering to a braided system in the Karoo was dated initially (Ward et al., 2000) as lying precisely at the PTr boundary. New studies (Retallack et al., 2003) indicate that the PTr boundary, lies 1–2 m below the sedimentary transition, based on vertebrate biostratigraphy (onset of the *Lystrosaurus* Zone), the dearth of vertebrate fossils, and the first of several major negative carbon isotope excursions. Carbon isotopes also place the PTr boundary 1.5 m below the sedimentary shift in the Northern Bowen Basin, Australia (Michaelsen, 2002). Many other continental PTr successions, including those in Russia, lack such fine dating control, and hence the onset of massive conglomerates/braided systems cannot yet be placed precisely.

The size of the pre-Triassic gap in the Russian successions has not been determined. The sediments below and above the conglomerate unit are confidently dated as late Tatarian and Induan, respectively on the basis of fossil vertebrates and microfossils (Anfimov et al., 1993; Tverdokhlebov et al., 1997, 2003). The duration of the gap was clearly large enough for complete reconstruction of the sedimentary systems, but far shorter than the gorizont. Russian authors have often assumed that the gap was large, and that much of the thickness of Vyatkian sediments had been eroded, and it was unclear whether some basal Triassic might also be missing (Lozovskii, 1998). More recent work (Tverdokhlebov, 1987, 1989; Tverdokhlebov et al., 1989), however, suggests that the Vyatkian section is nearly complete, judging from ostracods and section thicknesses. It is not clear yet, however, whether the gap represents a geological instant or a million years. More precise determination awaits closer palaeontological, isotopic and magnetostratigraphic studies.

The commencement of the Triassic differs in different regions of the S Urals basin. The basal Triassic may appear as massive conglomerates containing great boulders of rocks from high in the Urals and deposited within alluvial fans near the foothills, for example at Kulchomovo. At other sites, the Permian is overlain by bedded Triassic sediments consisting of sandstones with pebbles and gravel, for example at Vyazovka. Further west, in blind drainage areas, the sediments came from the local hills, and the basal Triassic is represented by flood-plain sediments of redeposited Permian sediments, for example in the Buzuluk section. Since the redeposited material is local, the basal Triassic sediments look like the Permian. The basal Triassic is not synchronous throughout the S Urals region, and hence the PTr gap may vary from almost nothing in some places to something more substantial elsewhere.

## 3. Climate change in the Late Permian of the SE of European Russia

The Late Permian and earliest Triassic were times of global warming and increasing aridity, from the rather humid Early Permian to the arid Early Triassic (Veevers et al., 1994; Chumakov and Zharkov, 2003; Kidder and Worsley, 2004). These climatic changes are manifested worldwide by the disappearance of coals, linked to the disappearance of tropical and subtropical forests in equatorial latitudes, and by the deglaciation of Gondwana (Veevers et al., 1994; Retallack and Krull, 1999; Retallack et al., 2003). The rate of global warming peaked at the PTr boundary, and this is associated with the most profound biotic crisis in the history of the Earth, with major environmental changes and the extinction of up to 95% of species of plants and animals (Benton, 2003).

The red-bed sequences of the Upper Permian and Lower Triassic of European Russia represent carbonate-rich formations of arid type, and aridity increased through the Late Permian, after the early Kazanian marine transgression, from semi-arid to severely arid. This was most clearly manifested in changes in the palaeolandscape: major intracontinental lake basins of marine type were gradually substituted by lacustrine, lacustrine-deltaic, and lakes/flood plains, with constant reduction of lacustrine sedimentation (Fig. 14).

The most vivid transformations of landscape-climatic conditions happened in the late Tatarian. During the Severodvinian, the dominant depositional regime shifted from lacustrine to deltaic. Deposits from distributary channels and flood-plains filled substantial volumes of lake basins. Due to increased aridity in Vyatkian time, most lake plains ran dry periodically and were transformed into flood plains. A particular deposit complex was being formed here, with a close paragenesis of lacustrine beds proper, flood-plain units, and distributary channels. Vast areas appeared with dry-steppe and semi-desert regimes; these were not flooded with water for thousands of years. Intensive accumulation of palaeosol carbonates, caliches, took place.

These major changes in sedimentation were broadly influenced by the tectonic and climatic regimes of the source region, the Ural Mountains. The elimination of large lake basins, which have substantial heat inertia and act as powerful thermoregulators, made all formation processes dependent on temperature oscillations, and on the seasonal climate.

Against a general background of increasing aridity, all landscape transformations were of a moderate, gradual character. The evolution of faunas and floras must also have been influenced by the arid climates and the degree of seasonality. During the Late Permian of European Russia, plants that were well adapted to arid conditions became more dominant. Cordaite forests that were common along the lake and marsh banks in the Kazanian and Urzhumian, retreated far to the E, to the foothills of the Urals, in the Severodvinian. A low-shrub Tatarian flora dominated over the rest of the area (Goman'kov and Meyen, 1986; Tverdokhlebov et al., 1989), made up mainly from near-shore brushwood around water

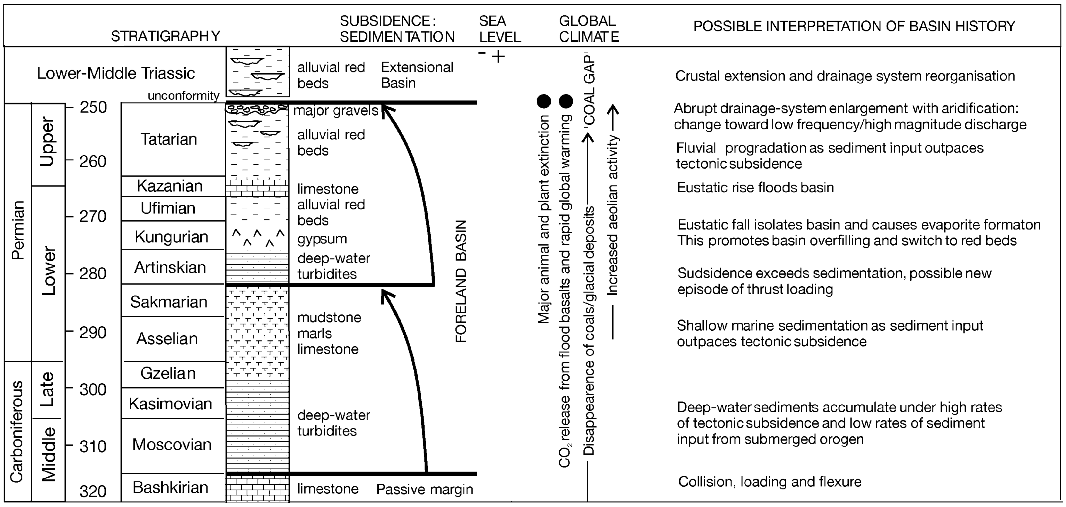


Fig. 14. Diagram summarizing the stratigraphy of the Southern Uralian Foreland Basin, the development of major depositional cycles, the sea-level curve for the Euramerican platform area (from Veevers et al., 1994) and major global events (based on Newell et al., 1999).

bodies. In some areas, herbaceous lycopods and horsetails dominated, and elsewhere, conifers.

These gradual changes in sedimentation and in vegetation cover were broken at the end of Vyatkian time. The sharp tectonic rise of the Urals was followed by a powerful ejection of debris flows on to the lake/flood plain of the S Cis-Urals. The landscape was completely transformed as the debris flows built out vast alluvial fans, many tens of kilometres across, over the plain. The sharp, brief rise of the Urals was accompanied by a similarly sharp increase in aridity. Dry-steppe, nearly semi-desert conditions were established over the vast areas of the delta plain that used to be characterized by a stable water supply. Enormous areas of lake/flood plain were moistened rather more episodically than before. Aeolian formations accumulated side-by-side with flood-plain deposits; aeolian units become widespread at the beginning of the Triassic (Tverdokhlebov, 1971; Tverdokhlebov et al., 2003). In the cyclical units from the upper part of the Vyatkian section, abundant horizons of arid soils and caliche mark the increasing aridity. In spite of gradual climate aridization through the whole of the Late Permian, however, there were no severe arid-desert conditions over the area of European Russia.

Peak aridity fell in the pre-Triassic break, and maximum aridity is recorded in deposits and fossils at the very beginning of the Early Triassic (Tverdokhlebov et al., 2003). The coincident dramatic outflow of massive alluvial fans over the Uralian Foreland Basin, represented by the PTr boundary conglomerate, was explained (Newell et al., 1999) as a consequence of uplift of the Urals and changes in precipitation pattern and stripping of the vegetation by intense global warming and aridification. Reduction in vegetation cover would have had two important effects: first, sediment yield from soils and debris held in place by plant roots would have been released as the roots rotted and came free, and, second, the rate of surface runoff would increase. This is a positive feedback process in which initial erosion removes soils and bound sediment and cuts rills and channels, and these in turn increase the efficiency of subsequent erosion and runoff. What is suggested is a small number of rather rare, but intense/high magnitude, events that cleared the upland areas of plant debris, soils, and loose sediment, and washed huge volumes rapidly over the lower-lying areas, building up massive conglomerate beds in perhaps one or two events over a short time.

The same sedimentological shift was identified independently by Ward et al. (2000) at the PTr boundary in the Karoo Basin of S Africa. They noted a rapid and apparently basin-wide change from meandering to braided river systems, and linked this to a rapid and major die-off of rooted plant life in the basin. These authors proposed that a catastrophic terrestrial die-off of vegetation was a global event, producing a marked increase in sediment yield as well as contributing to the global $\delta^{13}C$ excursion across the PTr boundary. Michaelsen (2002) noted the same thing in the Northern Bowen Basin, a major coal-bearing sedimentary basin in Eastern Australia. Here, a long-lived (ca. 9 Myr) cold-climate peat mire ecosystem collapsed at the PTr boundary when 95% of peat-producing plants became extinct. This abrupt environmental change matches a change in landscape attributes and fluvial style from large-scale (up to 1 km wide), sandstone-dominated, low-sinuosity, relatively static trunk river channel deposits to highly mobile braided sandy systems, dominated by flash-floods.

The hypothesis that plants and soils were stripped from the land at the PTr boundary, and that this is seen in changes in fluvial regimes and soil types, may give clues to the nature of the end-Permian mass extinction. The events on land and in the sea apparently coincided, and there is evidence for the washing-off of terrestrial plant debris into the oceans (Ward et al., 2000; Twitchett et al., 2001; Sephton et al., 2002). Finer stratigraphic resolution of continental sections from a range of locations around the world may help resolve the model.

## 4. Late Permian vertebrate faunas in the SE of European Russia

### *4.1. List of vertebrate stratigraphic distributions*

Most specimens of fossil amphibians and reptiles are located in the collections of the Palaeontological Institute, Russian Academy of Sciences, Moscow (PIN); Saratov State University, Saratov (SGU); Museum of Sankt Peterburg University (SPGU); Centralny Nauchno-Issledovatelskii Geologo-Razvedochny Muzei [Gorny Institut/Institute of Mines], Sankt Peterburg (CNIGR), and Moscow State University (MGU). The classification of fishes follows work by A.V. Minikh and M.G. Minikh, while the classification of tetrapods follows Shishkin et al. (2000) on batrachomorph amphibians, Novikov et al. (2000) on reptiliomorph amphibians (anthracosaurs and seymouriamorphs), Lee (2000) on pareiasaurs, Spencer and Benton (2000) on procolophonoids, and Battail and Surkov (2000) on therapsids.

### *4.2. Lower Kazanian*

#### *4.2.1. Kalinovskaya Svita*

**Fishes**

Chondrichthyes, Elasmobranchii, Subterbranchialia

Family Janassidae Jaekel, 1898: *Janassa* sp.

#### *4.2.2. Osinovskaya Svita*

**Batrachomorpha**

Family Archegosauridae Meyer, 1858: *Platyoposaurus* sp.

### *4.3. Upper Kazanian*

#### *4.3.1. Belebey Svita*

**Fishes**

Osteichthyes, Actinopterygii

Order Eurynotoidiiformes

Family Eurynotoidiidae Minikh and Minikh, 1990: *Eurynotoides nanus* (Von Eichwald, 1861).

Order Platysomiformes

Family Platysomidae Young, 1866: *Platysomus bashkirus* Minikh, 1992 (holotype, SGU 104-B/1145, part of the skull and scales from Saray Gir locality, Orenburg region; description: Minikh, 1992, pp. 141–143), *Platysomus soloduchi* Minikh, 1992; *Platysomus* sp.; *Kargalichthys pritokensis* Minikh, 1992 (holotype, SGU 104-B/2052, several scales from Dobrinka locality, Orenburg region; description: Minikh, 1992, pp. 143–144), *Kargalichthys* sp.

Order Elonichthyiformes

Family Varialepididae A. Minikh, 1990: *Varialepis*(?) sp.

Family Acrolepididae Aldinger, 1937 *Kazanichthys*(?) *golyushermensis* Esin, 1995, *Kazanichthys* sp.

**Parareptilia/Anapsida**

Family Tokosauridae Tverdokhlebova and Ivakhnenko, 1984: *Tokosaurus perforatus* Tverdokhlebova and Ivakhnenko, 1984 (holotype SGU 104B/2004, skull from Krymsky locality, Orenburg region; description: Tverdokhlebova and Ivakhnenko, 1984, pp. 105–107); Tokosauridae gen. indet.

Nycteroleteridae gen. indet.

Family Bolosauridae Cope, 1878: *Belebey vegrandis* Ivakhnenko, 1973 (lectotype, SGU 104B/2020-2022, skeleton from Krymsky locality, Orenburg region; description: Ivakhnenko and Tverdokhlebova, 1987, p. 101); *Belebey maximi* Tverdokhlebova, 1987 (holotype, SGU 104B/2027, dentary from Saray Gir locality, Bashkortostan Republic; description: Ivakhnenko and Tverdokhlebova, 1987, p. 104); *Davletkulia gigantea* Ivakhnenko, 1990a (holotype, PIN 4311/1, tooth from Yaman Yushatyr locality, Orenburg region; description: Ivakhnenko, 1990b, p. 109; *nomen dubium*, Reisz et al., 2002).

**Therapsida**

Family Estemmenosuchidae Chudinov, 1960: *Estemmenosuchus* sp.

### *4.4. Lower Tatarian*

#### *4.4.1. Bolshekinelskaya Svita (Urzhumian Gorizont)*

**Fishes**

Chondrichthyes, Elasmobranchii

Order Xenacanthiformes

Family Xenosynechodontidae Gluckman, 1980: *Xenosynechodus egloni* Gluckman, 1980.

Osteichthyes, Actinopterygii

Order Platysomiformes

Family Platysomidae Young, 1866: *P. biarmicus* Von Eichwald, 1861 (Fig. 15a); *Platysomus* sp.; *Kargalichthys* sp.

Family Palaeoniscidae gen. indet.

Order Elonichthyiformes

Family Acrolepididae Aldinger, 1937: *Kazanichthys* sp.

Family Varialepididae A. Minikh, 1990: *Varialepis orientalis* Esin, 1995; *Varialepis bergi* A. Minikh, 1986; *Varialepis* sp.

Order Eurynotoidiiformes

Family Eurynotoidiidae Minikh and Minikh, 1990: *Kichkassia furcae* Minick, 1986 (Fig. 15b); Dipnoi indet.

**Batrachomorpha**

Family Melosauridae Fritsch, 1885: *Konzhukovia vetusta* (Konzhukova, 1955); *Tryphosuchus* sp; Melosauridae gen. indet.

**Seymouriamorpha**

Family Leptorophidae(?) gen. indet.

**Parareptilia/Anapsida**

Family Lanthanosuchidae Efremov, 1946: *Chalcosaurus lukjanovae* (Ivakhnenko, 1980) (holotype, PIN 2793/2, skull from Novo-Nikolskoe-2 locality, Orenburg region; description: Ivakhnenko, 1987, pp. 68–70); Lanthanosuchidae gen. indet.

**Therapsida**

Family Phthinosuchidae gen. indet.

Family Anteosauridae Boonstra, 1954: *Titanophoneus* sp.; *Deuterosaurus jubilaei* (Von Nopcsa, 1928).

Family Tapinocephalidae Gregory, 1926: *Ulemosaurus* cf. *gigas*.

Dinocephalia incertae sedis: *Rhopalodon*(?) sp.

Family Venyukoviidae Efremov, 1940: *Ulemica efremovi* Ivakhnenko (holotype, PIN 2793/1, skull from Novo-Nikolskoe-2 locality, Orenburg region; description: Ivakhnenko, 1996, p. 82).

#### *4.4.2. Amanakskaya Svita (Urzhumian Gorizont)*

**Fishes**

Chondrichthyes, Elasmobranchii

Order Hybodontiformes Gluckman, 1964

Family Sphenacanthidae Maisey, 1982: *Wodnika* sp.

Order Xenacanthiformes

Family Xenosynechodontidae Gluckman, 1980: *X. egloni* Gluckman, 1980; *Xenosynechodus* sp.

Osteichthyes, Actinopterygii

Order Platysomiformes

Family Platysomidae Young, 1866: *P. biarmicus* Von Eichwald, 1861 (holotype, CNIGR 97/107 (3855), fish from Kargalinskie rudniki locality; description: Von Eichwald, 1861, p. 486); *K. efremovi* Minikh, 1986 (holotype, SGU 104-B/P-20, nearly complete fish skeleton with head from Kichkass locality, Orenburg region, description: Minikh, 1986a,b, pp. 17–25); *Platysomus* sp.

Order Elonichthyiformes

Family Varialepididae A. Minikh, 1990: *V. bergi* A. Minikh, 1986 (holotype, SGU 104-B/P-1, fish from Kichkass locality, Orenburg region; description: Minikh, 1986, pp. 4–13; Fig. 16 here); *V. orientalis* (Von Eichwald, 1861) (holotype, CNIGR 99/107 anterior part of the body without pectoral fin from Kargalinskie rudniki locality; description: Esin, 1995, pp. 86–89).

Family Acrolepididae Aldinger, 1937: *Kazanichthys* sp.

Order Cheirolepiformes

Family Karaunguriidae Kazan'tseva, 1977: *Samarichthys luxus* A. Minikh, 1990 (holotype, SGU 104-B/P-96, nearly complete fish skeleton from

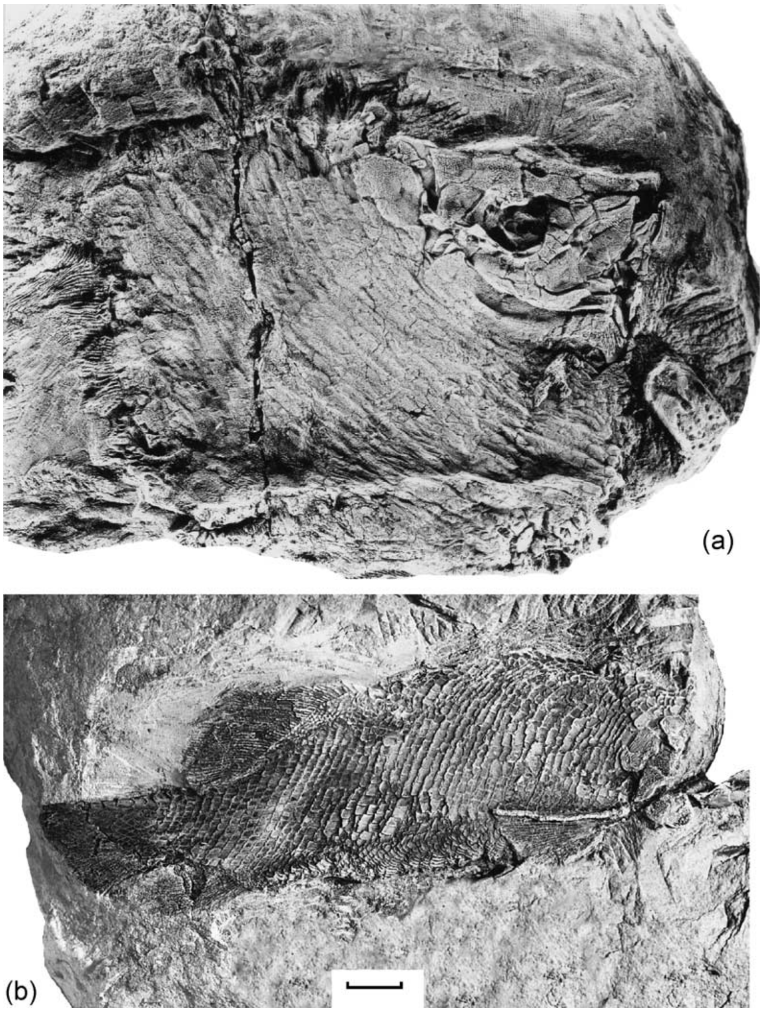


Fig. 15. Actinopterygian fishes from the Bolshekinelskaya Svita (Urzhumian Gorizont, lower Tatarian, Upper Permian) of the South Cis-Urals. (a) *Platysomus biarmicus*, specimen SGU 104-B/p-279, fish without tail, ×0.75. (b) *Kichkassia furcae*, specimen SGU104-B/p-36, nearly complete fish, scale bar: 10 mm. (Photographs by A.V. Minikh).

Kichkass locality, Orenburg region; description: Minikh and Minikh, 1990, pp. 100–101).

Family Boreolepedidae gen. indet.

Order Eurynotoidiiformes Minikh and Minikh, 1990

Family Eurynotoidiidae Minikh and Minikh, 1990: *Lapkosubia uranensis* A. Minikh, 1986 (holotype, SGU 104-B/P-4, anterior part of a fish from Kichkass locality, Orenburg region; description: Minikh and Minikh, 1986, pp. 5–11); *Lapkosubia barbalepis* A. Minikh (holotype, SGU 104-B/P-45, fish from Kichkass locality, Orenburg region; description: Minikh and Minikh, 1990, pp. 91–92); *K. furcae* Minikh, 1986 (holotype, SGU 104-B/P-5, whole fish from Kichkass locality, Orenburg region; description: Minikh and Minikh, 1986, pp.13–17); *E. nanus* (Von Eichwald, 1861), (holotype, SPGU 1/2860, fish without head and tail from Kargalinskie rudniki locality; description: Von Eichwald, 1861, p. 484).

Order Discordichthyiformes A. Minikh, 1998

Family Discordichthyidae A. Minikh, 1998: *Discordichthys spinifer* A. Minikh (holotype, SGU 104-B/

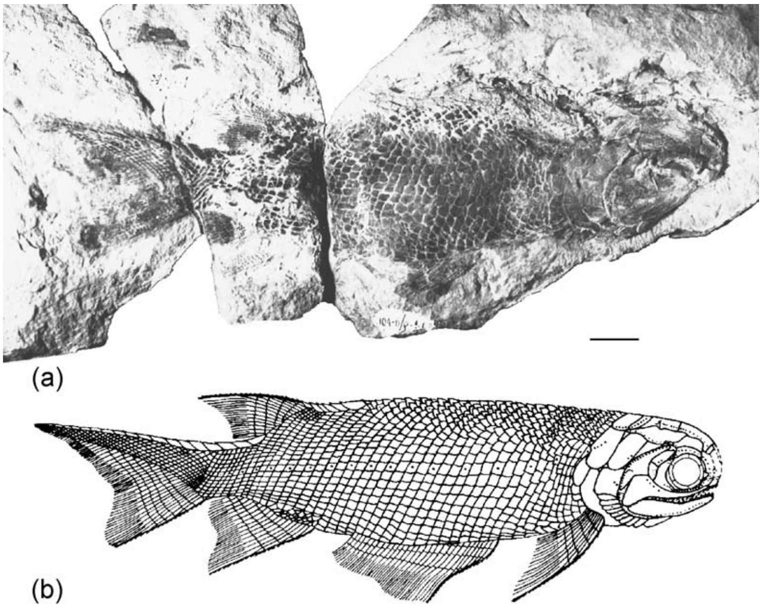

Fig. 16. Actinopterygian fish from the Bolshekinelskaya Svita (Urzhumian Gorizont, lower Tatarian, Upper Permian) of the South Cis-Urals, *Varialepis bergi*, whole fish from the Kichkass locality. (a) holotype SGU 104-B/P-1; (b) reconstruction of the specimen. Scale bar: 20 mm. (Photo and reconstruction by A.V. Minikh).

B-1, incomplete fish skeleton from Kichkass locality, Orenburg region; description: Minikh, 1998, pp. 54–56).

**Batrachomorpha**

Family Melosauridae Fritsch, 1885: *K. vetusta* (Konzhukova, 1955) (holotype, PIN 520/1, skull from Malyi Uran locality, Orenburg region; description: Gubin, 1991, pp. 23–26); *Uralosuchus tverdochlebovae* Gubin, 1993 (holotype, PIN 4405/1, lower jaw from Podgorodnaya Pokrovka–2 locality, Orenburg region; description: Gubin, 1993, pp. 101–103); *Tryphosuchus kinelensis* (V'yushkov, 1955) (holotype, PIN 272/52, pelvis fragment from Malaya Kinel locality, Orenburg region; description: V'yushkov, 1955, pp. 177–179; Gubin, 1989, pp. 118–119).

Family Archegosauridae Meyer, 1858: *Platyoposaurus rickardi* (Twelvetrees, 1880) (holotype, PIN unnumbered, skull from Kargalinskie rudniki, Orenburg region; description: Gubin, 1991, p. 15); *Platyoposaurus vjuschkovi* Gubin, 1989 (holotype, PIN 272/57, right femur from Malaya Kinel locality, Orenburg region; description: Gubin, 1989, pp. 117–118); *Platyoposaurus* sp.

**Seymouriamorpha**

Family Enosuchidae Konzhukova, 1955: *Enosuchus* cf. *breviceps* (Konzhukova, 1955).

**Parareptilia/Anapsida**

Family Lanthanosuchidae Efremov, 1946: *C.* cf. *lukjanovae* Ivakhnenko, 1980; *Chalcosaurus* sp.

Family Nycteroleteridae gen. indet.

**Therapsida**

Family Phthinosuchidae gen. indet.

Family Biarmosuchidae Olson, 1962: *Biarmosuchoides romanovi* Tverdochlebova and Ivakhnenko, 1994 (holotype, SGU 104B/2051; fragment of the lower jaw from Dubovka-1 locality, Orenburg region; description: Tverdokhlebova and Ivakhnenko, 1994, pp. 126).

Family Anteosauridae Boonstra, 1954: *Syodon* sp.; *Titanophoneus adamanteus* (Orlov, 1958) (holotype, PIN 520/3, skull from Malyi Uran locality, Orenburg region; description: Orlov, 1958, p. 105); *Titanophoneus* sp.; *D. jubilaei* (Von Nopcsa, 1928) (holotype, PIN 1954/2, skull from Kargalinskie rudniki locality, Orenburg region; description: Efremov, 1954, pp. 193–195); *Deuterosaurus* sp.

Family Tapinocephalidae Gregory, 1926: *U.* cf. *gigas*.

Family Microuraniidae Ivakhnenko, 1995: *Microurania minima* Ivakhnenko, 1995 (holotype, PIN 4337/1, incomplete skull from Kichkass locality, Orenburg region; description: Ivakhnenko, 1995, pp. 116–117).

Family Venyukoviidae Efremov, 1940: *Ulemica* sp.

Family Pristerognathidae Broom, 1908: *Porosteognathus*(?) sp.

### 4.5. Upper Tatarian

#### 4.5.1. Vyazovskaya Svita (Severodvinian Gorizont)

**Fishes**

Osteichthyes, Actinopterygii

Order Discordichthyiformes A. Minikh, 1998

Family Discordichthyidae A. Minikh, 1998: *Geryonichthys*(?) *longus* A. Minikh, 1998.

Order Eurynotoidiiformes Minikh and Minikh, 1990

Family Eurynotoidiidae Minikh and Minikh, 1990: *I. aristoviensis* A. Minikh; *Isadia* sp.

**Tetrapoda**

No tetrapod remains have been found in deposits of the Vyazovskaya Svita, except for imprints of tetrapod traces.

#### 4.5.2. Malokinelskaya Svita (Severodvinian Gorizont)

**Fishes**

Osteichthyes, Actinopterygii

Order Elonichthyiformes

Family Gonatodidae Gardiner, 1967: *Toyemia tverdochlebovi* Minikh, 1990, holotype, SGU 104-B/988 a,b,v, fish from Babentsevo locality, Orenburg region; description: Minikh and Minikh, 1990, pp. 98–99); *T. blumentalis* A. Minikh, 1995; *Toyemia* sp.

Family Varialepididae A. Minikh, 1990: *Varialepis* sp.

Order Discordichthyiformes A. Minikh, 1998

Family Discordichthyidae A. Minikh, 1998: *Geryonichthys burchardi* A. Minikh, 1998 (holotype, SGU 104-B/1320-4, spike fragment of the dorsal fin from Babentzevo locality, Orenburg region; description: Minikh, 1998, p. 53), *G. longus* A. Minikh (holotype, SGU 104-B/898, spike of the pectoral fin; description: Minikh, 1998, pp. 51–52); *Geryonichthys* sp.

Order Elonichthyiformes

Family Eigillidae Kazan'tseva, 1981: *Sludalepis spinosa* A. Minikh, 2001, *Strelnia* sp.

Order Eurynotoidiiformes Minikh and Minikh, 1990

Family Eurynotoidiidae Minikh and Minikh, 1990: *Lapkosubia tokense* A. Minikh, 1995 (holotype, SGU 104-B/I-54, scale from Pleshanovo locality, Orenburg region; *L. uranensis* A. Minikh, 1986; *Lapkosubia* sp. description: Minikh and Minikh, 1995, pp. 10–11); *I. aristoviensis*(?) A. Minikh, 1990; *Isadia suchonensis* A. Minikh 1986; *Isadia* sp.

Order Platysomiformes

Family Platysomidae Young, 1866: *Kargalichthys*(?) *efremovi* Minikh 1986; *Kargalichthys* sp.; *P. biarmicus* Von Eichwald, 1861; *Platysomus* sp.

Family Palaeoniscidae: *Palaeoniscus* sp.

Chondrichthyes, Elasmobranchii, Order Xenacanthiformes

Family Xenosynechodontidae Gluckman, 1980: *Xenosynechodus* sp.

**Batrachomorpha**

Family Dvinosauridae Amalitskii, 1921a: *Dvinosaurus primus* Amalitskii, 1921a; *Dvinosaurus* sp.

**Seymouriamorpha**

Family Karpinskiosauridae Sushkin, 1925: *Karpinskiosaurus ultimus* (Chudinov and V'yushkov, 1956; Bulanov, 2002a).

Family Kotlassiidae Romer, 1934: *Microphon exiguus* Ivakhnenko, 1983 (holotype, 3585/31, maxilla from Donguz-6 locality, Orenburg region; description: Bulanov, 2000, pp. 83–88, 2002b); *Microphon* sp.

Family Chroniosuchidae V'yushkov, 1957: *Chroniosaurus dongusensis* Tverdokhlebova, 1972 (holotype, SGU 104B/198, skull from Donguz–6 locality, Orenburg region, dermal bones; description: Tverdokhlebova, 1972, pp. 56–103; Golubev, 2000, pp. 52–53; Fig. 17 here); *Chroniosaurus levis* Golubev, 1998.

**Parareptilia/Anapsida**

Family Pareiasauridae Seeley, 1888: *Proelginia permiana* Hartmann-Weinberg, 1937; *P.* cf. *permiana* Ivakhnenko, 1987; Pareiasauridae gen. indet.

**Therapsida**

Gorgonopsia fam. indet.

Dicynodontia fam. indet.

Venyukovioidea: *Suminia* cf. *getmanovi* Ivakhnenko, 1994 (Rybczynski, 2000).

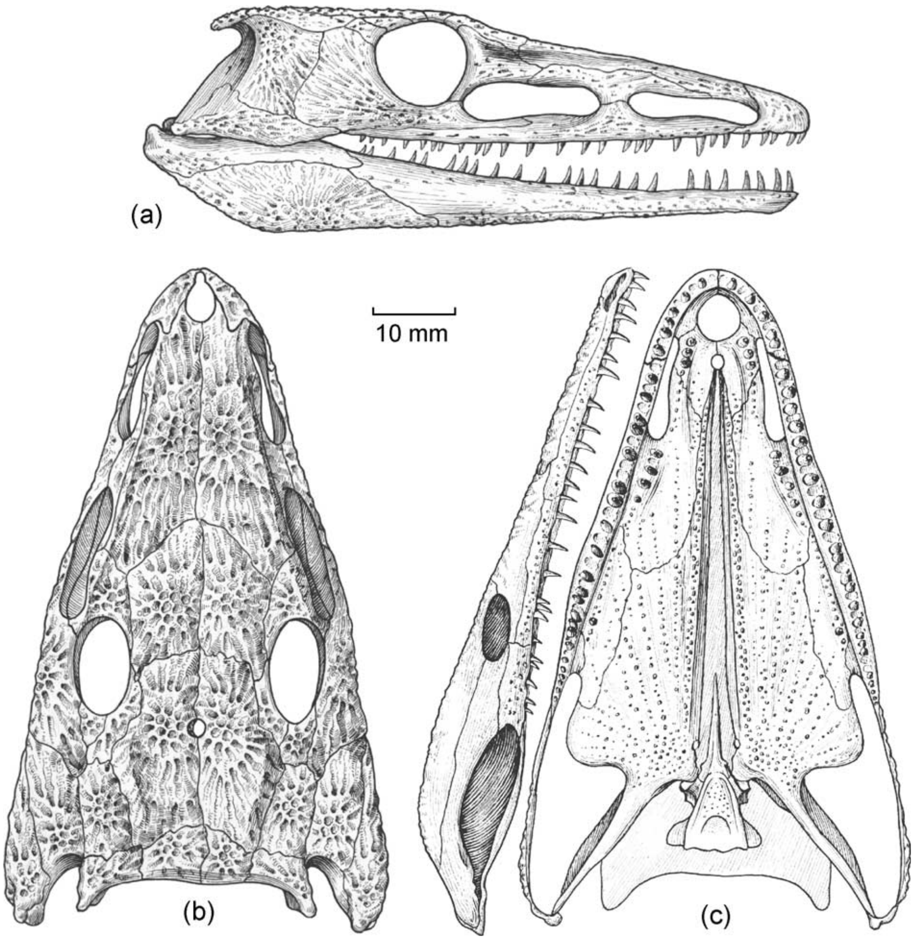


Fig. 17. The chroniosuchian reptiliomorph *Chroniosaurus dongusensis* (Tverdokhlebova, 1972) from the Malokinelskaya Svita (Severodvinian Gorizont, upper Tatarian, Upper Permian). The holotype skull (SGU 104B/198) from the Donguz-6 locality, Orenburg Region, South Cis-Urals, in lateral (a), dorsal (b), and ventral (c) views, with medial view of the lower jaw (c). (Based on drawings in Tverdokhlebova, 1972).

*4.5.3. Kulchumovskaya Svita (Vyatkian Gorizont)*

**Fishes**

Osteichthyes, Actinopterygi

Order Elonichthyiformes

Family Gonatodidae Gardiner, 1967: *T. blumentalis* A. Minikh, 1995 (holotype, SGU 104-B/1681-1, scale from Blyumental' locality, Orenburg region; description: Minikh, 1995, pp. 10–16).

Family Varialepididae A. Minikh, 1990: *Varialepis* sp.; Varialepididae gen. indet.

Order Eurynotoidiiformes Minikh and Minikh, 1990

Family Eurynotoidiidae Minikh and Minikh, 1990: *I. aristoviensis* A. Minikh, 1990 (holotype, SGU 104-B/P-87, fragments of a fish body with dorsal and anal fins from Vyazovka–2 locality, Orenburg region; description: Minikh and Minikh, 1990, pp. 96–97).

Order Discordichthyiformes A. Minikh, 1998

Family Discordichthyidae A. Minikh, 1998: *M. stella* Minikh, 1992.

Order Saurichthyiformes

Family Saurichthyidae Goodrich, 1904: *Saurichthys* sp.

Sarcopterygii, Dipnoi, Order Ceratodontiformes

Family Lepidosirenidae Bonaparte, 1841: *Gnathoriza* sp.

**Batrachomorpha**

Family Dvinosauridae Amalitskii, 1921a: *Dvinosaurus* sp.

**Seymouriamorpha**

Family Karpinskiosauridae Sushkin, 1925: *Karpinskiosaurus* cf. *secundus* Ivakhnenko, 1987; *K. ultimus* (Chudinov and V'yushkov, 1956); Karpinskiosauridae gen. indet.

Family Chroniosuchidae V'yushkov, 1957: *Chroniosuchus paradoxus* V'yushkov, 1957 (Fig. 18); *C.* cf. *paradoxus* V'yushkov, 1957; *U. tverdochlebovae* Golubev, 1998.

**Parareptilia/Anapsida**

Family Pareiasauridae Seeley, 1888: *Scutosaurus* sp.; Pareiasauridae gen. indet.

**Therapsida**

Family Inostranceviidae Huene, 1948: *Inostrancevia uralensis* Tatarinov, 1974 (holotype, PIN 2896/1, braincase from Blyumental' locality, Orenburg region; description: Tatarinov, 1974, pp. 96–99); Theriodontia fam. indet.

Family Dicynodontidae Owen, 1859: *Dicynodon* sp.

Family Scylacosauridae Broom, 1903: *Scylacosuchus orenburgensis Tatarinov (holotype, PIN 2628/1, nearly complete skeleton from Vyazovka–3 locality, Orenburg region; description: Tatarinov, 1974,* pp. 110–117).

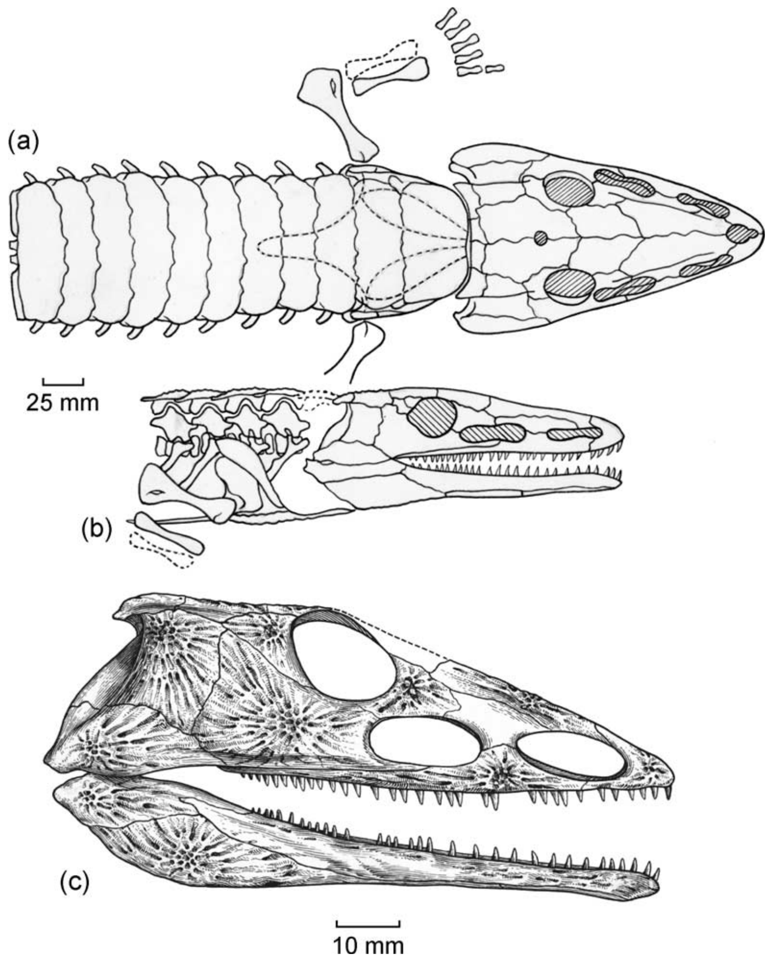


Fig. 18. The chroniosuchian reptiliomorph *Chroniosuchus paradoxus* V'yushkov, 1957 from the Kulchomovskaya and Kutulukskaya svitas (Vyatkian Gorizont, upper Tatarian, Upper Permian). Restorations, based on the holotype (PIN 521/6, part of the vertebral column from Pronkino locality, Orenburg Region, South Cis-Urals) and skull remains, showing the anterior part of the animal, in (a) dorsal and (b) lateral vies, and (c) lateral view of the skull. (Based on drawings in Tverdokhlebova, 1972).

Family Moschorhinidae Brink, 1959: *Annatherapsidus* cf. *petri* (Amalitskii, 1922).

Family Procynosuchidae Broom, 1937: *U. tverdochlebovae* Tatarinov, 1987 (holotype, SGU 104B/308, dentary from Blyumental' locality, Orenburg region; description: Tatarinov, 1987, pp. 111–113).

*4.5.4. Kutulukskaya Svita (Vyatkian Gorizont)*

**Fishes**

Chondrichthyes, Elasmobranchii, Order Xenacanthiformes

Family Xenosynechodontidae Gluckman, 1980: *Xenosynechodus*(?) sp.

Osteichthyes. Actinopterygii

Order Elonichthyiformes

Family Gonatodidae Gardiner, 1967: *T. tverdochlebovi* Minikh, 1990; *T. blumentalis* A. Minikh, 1995; *Toyemia* sp.

Family Eigillidae Kazan'tseva, 1981: *Strelnia* sp.

Order Eurynotoidiiformes Minikh and Minikh, 1990

Family Eurynotoidiidae Minikh and Minikh, 1990: *I. aristoviensis* A. Minikh 1990; *Isadia* sp.

Order Discordichthyiformes A. Minikh, 1998

Family Discordichthyidae Minikh, 1998: *M. stella* Minikh, 1992; *G. burchardi* A. Minikh, 1998; *Geryonichthys* sp.

Order Cheirolepiformes

Family Boreolepedidae Aldinger, 1937: *Boreolepis tataricus* Esin, 1996 (holotype, MGU PR203/1-2, scale from Pronkino locality, Orenburg region; description: Esin and Mashin, 1996, p. 282).

Bradiodontiformes gen. indet.

Sarcopterygii, Dipnoi, Order Ceratodontiformes

Family Lepidosirenidae Bonaparte, 1841: *Gnathorhiza tatarica* Minikh, 1989 (holotype, SGU 104-B/968, tooth plate from Novogorodetskoe locality, Orenburg region; description: Minikh, 1989, pp. 122–123), *Gnathorhiza* sp.

**Batrachomorpha**

Family Dvinosauridae Amalitskii, 1921a: *D. primus* Amalitskii, 1921a; *Dvinosaurus* sp.

**Seymouriamorpha**

Order Seymouriamorpha Watson, 1917.

Family Karpinskiosauridae Sushkin, 1925: *K. ultimus* (Chudinov and V'yushkov, 1956) (holotype, PIN 521/104, dentary from Pronkino locality, Orenburg region; description: Ivakhnenko, 1987, pp. 41–42); *K.* cf. *ultimus* Ivakhnenko; *Karpinskiosaurus*(?) sp.; *Buzulukia butsuri* V'yushkov, 1957 (holotype, PIN 521/2; sacral vertebrae from Pronkino locality, Orenburg region; description: V'yushkov, 1957, pp. 90–98).

Family Kotlassiidae Romer, 1934: *Kotlassia* cf. *prima* Amalitskii, 1921b; *M. exiguus* Ivakhnenko, 1983.

Family Chroniosuchidae V'yushkov, 1957: *C. paradoxus* V'yushkov, 1957 (holotype, PIN 521/6, part of the vertebral column from Pronkino locality, Orenburg region; description: Golubev, 2000, p. 51; Fig. 18); *Chroniosuchus* sp.; *Jarilinus mirabilis* (V'yushkov, 1957).

**Parareptilia/Anapsida**

Family Tokosauridae gen. indet.

Pareiasauridae gen. indet.

**Therapsida**

Family Dicynodontidae Owen 1859: *Dicynodon* sp.

Family Moschorhinidae Brink, 1959: *Chthonosaurus velocidens* V'yushkov, 1955 (holotype, PIN 521/1, skull from Pronkino locality, Orenburg region; description: Tatarinov, 1974, pp. 158–166); *Chthonosaurus* sp.

*4.6. Evolution of ecosystems*

The early Kazanian vertebrate faunas (Kalinovskaya and Osinovskaya svitas) are so meagre that nothing useful may be said about their ecology. The late Kazanian Belebey Community (Belebey Svita; Fig. 19), on the other hand, is more extensive, consisting of various species of fishes, especially palaeonisciforms, that fed on water plants and insects. These were preyed upon by batrachomorphs amphibians (identity uncertain). Anapsid reptiles, such as unnamed nycteroleterids, *Belebey*, *Davletkulia*, and *Tokosaurus* lived mainly on dry land, but fed on aquatic plants and insects. There may have been some carnivorous eotheriodonts that fed on smaller tetrapods. The largest animal is the herbivorous dinocephalian *Estemmenosuchus*, which seems to have been free of predation.

Much of the Kazanian ecosystem structure survived in the early Tatarian vertebrate faunas, the Urzhumian Community, seen in the Bolshekinelskaya and Amanakskaya svitas (Fig. 20). In the ponds and rivers, palaeonisciform, and other, fishes

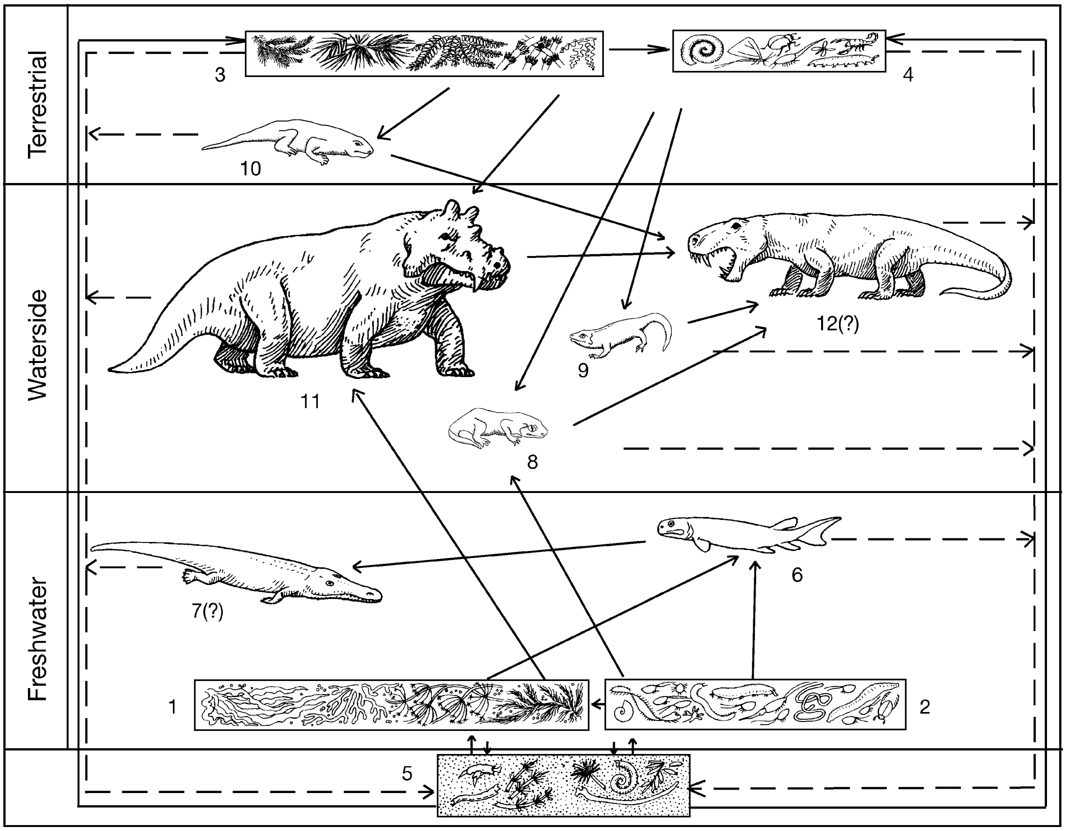


Fig. 19. Reconstructed food web for the terrestrial and aquatic components of the Belebey Community (Belebey Svita; Late Kazanian) of the SE of European Russia. Lines with arrows indicate the movement of energy through the community: solid lines show feeding pathways, and dashed lines show decay pathways. Aquatic components: (1) aquatic plants, (2) invertebrates, taxa whose role in terrestrial food chains is insignificant. Amphibious components: taxa which play a significant role in both aquatic and terrestrial food chains. Terrestrial components: (3) plants, (4) invertebrates, taxa which play a role in terrestrial food chains; (5) plant and animal detritus; (6) palaeonisciform, (7) probable batrachomorphs, (8) nycteroleretids, (9) *Tokosaurus*, (10) *Belebey*, *Davletkulia*, (11) *Estemmenosuchus*, (12) probable carnivorous eotheriodonts.

fed on aquatic plants and insects. But a wider community of batrachomorph amphibians, such as *Konzhukovia*, *Uralosuchus*, and *Tryphosuchus*, and reptiliomorphs, such as *Chalcosaurus* and unnamed leptorophids, preyed on the fishes, as well as on tetrapod larvae. On land, nycteroleterids and the batrachomorph *Enosuchus* also fed on aquatic plants and animals. The therapsid component of the fauna is much more extensive, with medium-sized herbivores such as the venyukoviid anomodont *Ulemica* and the dinocephalians *Rhopalodon* and *Microurania* feeding on waterside and terrestrial plants. These were preyed on by the anteosaurid dinocephalian *Syodon*, the therocephalian *Porosteognathus* and unnamed phthinosuchids. The largest herbivores are the dinocephalians *Ulemosaurus* and *Deuterosaurus*, and these were preyed on by the large anteosaurid dinocephalian *Titanophoneus*, a new top-level predator.

By the late Tatarian, the ecosystem had further matured. Vertebrate faunas from the Malokinelskaya and Vyazovskaya svitas, the Severodvinian Community (Fig. 21), show the usual palaeonisciform, and other, fishes and tetrapod larvae feeding on aquatic plants and insects, and they in turn being preyed on by the batrachomorph *Dvinosaurus* and the reptiliomorphs *Microphon*, *Karpinskiosaurus* and *Chroniosaurus*. Terrestrial herbivores include the basal anomodont *Suminia*, medium-sized dicynodonts, and the giant pareiasaur *Proelginia*. The top predators were

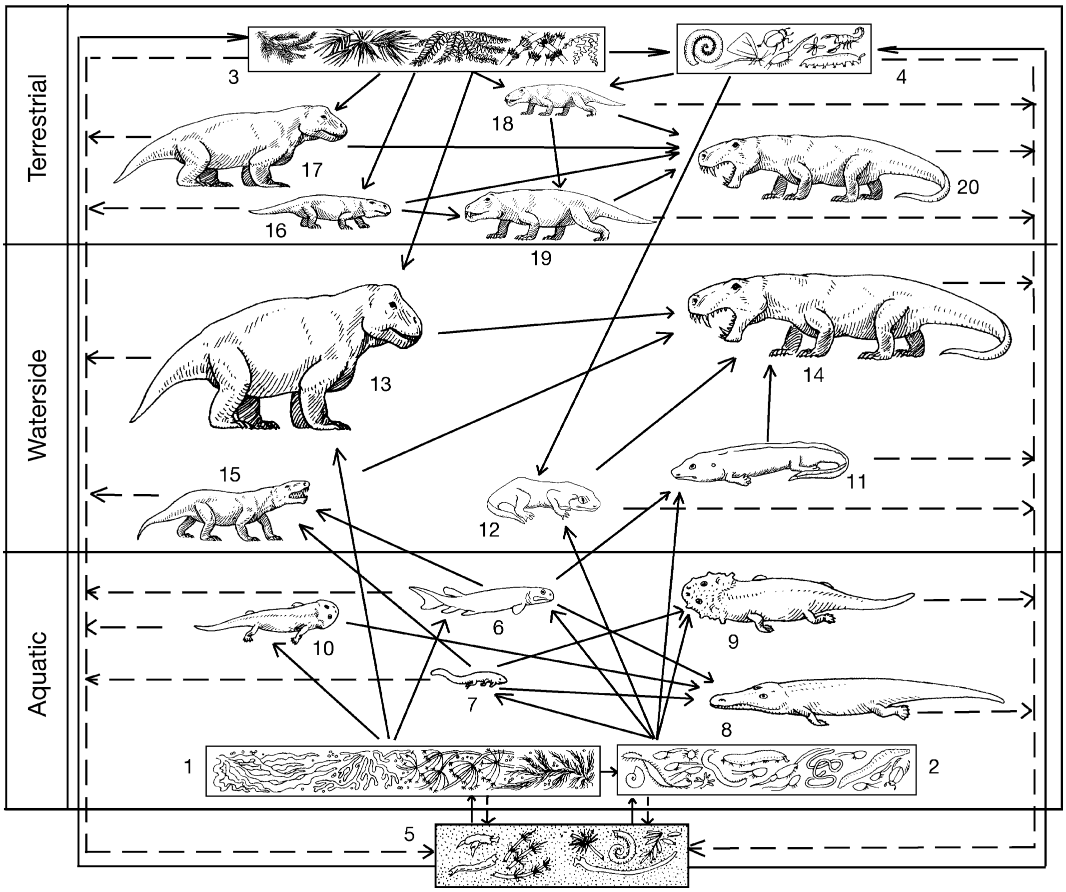


Fig. 20. Reconstructed food web for the terrestrial and aquatic components of the Urzhumian Community (Bolshekinelskaya and Amanakskaya svitas; Early Tatarian) of the SE of European Russia. Lines with arrows indicate the movement of energy through the community: solid lines show feeding pathways, and dashed lines show decay pathways. Aquatic components: (1) aquatic plants, (2) invertebrates, taxa whose role in terrestrial food chains is insignificant. Amphibious components: taxa which play a significant role in both aquatic and terrestrial food chains. Terrestrial components: (3) plants, (4) invertebrates, taxa which play main role in terrestrial food chains; (5) plant and animal detritus; (6) palaeonisciform, (7) larva of amphibians, (8) batrachomorphs: *Konzhukovia*, *Uralosuchus*, *Tryphosuchus*, *Platyoposaurus,* (9) *Chalcosaurus*, (10) leptorophids, (11) *Enosuchus*, (12) nycteroleterids, (13) dinocephalians *Ulemosaurus*, *Deuterosaurus*, (14) *Titanophoneus*, (15) *Syodon*, (16) *Ulemica*, (17) herbivorous *Rhopalodon* and *Biarmosuchoides*, (18) *Microurania*, (19) *Porosteognathus*, (20) phthinosuchids.

gorgonopsians, which could presumably have killed a large, thick-skinned pareiasaur with their sabre teeth.

The latest Tatarian Vyatkian Community (Kutulukskaya and Kulchumovskaya svitas; Fig. 22) continued at a similar level of complexity. The aquatic component is comparable to previous examples; the fishes and larval tetrapods were fed on by the reptiliomorphs *Microphon*, *Dvinosaurus*, *Karpinskiosaurus*, and the chroniosuchids *Chroniosuchus*, *Jarilinus*, and *Uralerpeton*. Small herbivores on land include unnamed tokosaurids. Larger herbivores are the dicynodont *Dicynodon* and the pareiasaur *Scutosaurus*. Terrestrial carnivores include the reptiliomorph *Chthonosaurus*, the therocephalians *Annatherapsidus* and *Scylacosuchus*, and the procynosuchid cynodont *Uralocynodon*. The top carnivore, capable of preying on the largest of contemporary herbivores was the gorgonopsian *Inostrancevia*.

Immediately following the end-Permian environmental catastrophe, earliest Triassic faunas consisted only of a few fish taxa and small, aquatic tetrapods, in low-diversity, low-abundance assemblages. These

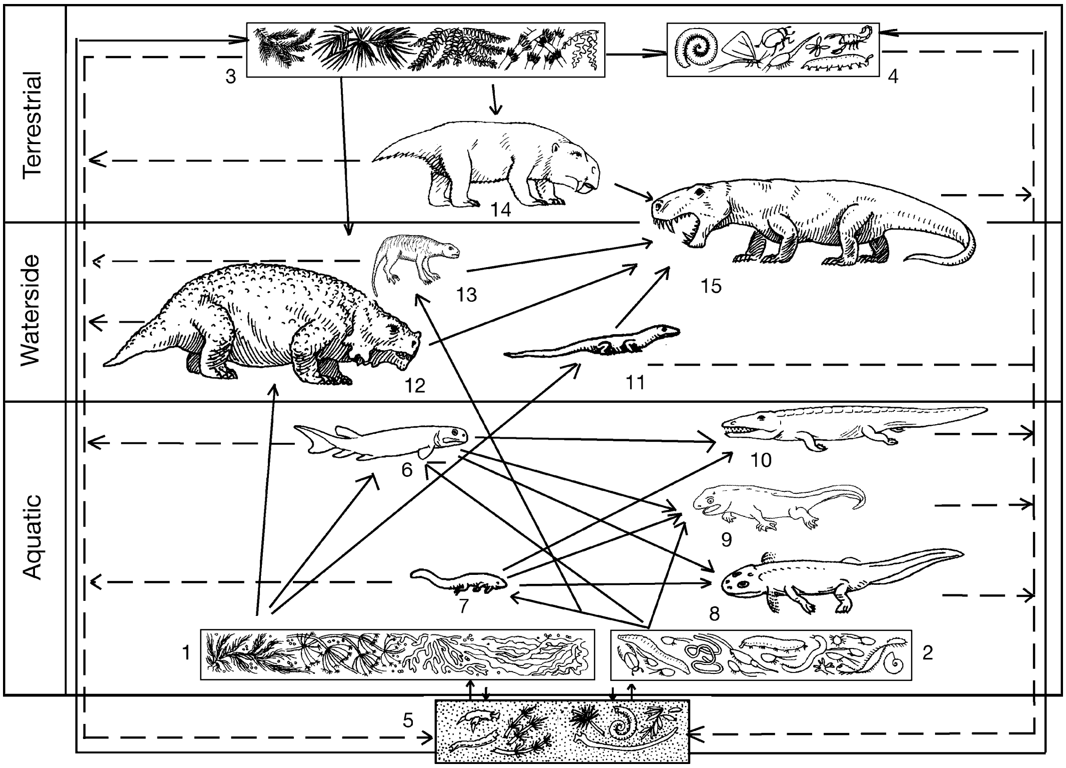


Fig. 21. Reconstructed food web for the terrestrial and aquatic components of the Severodvinian Community (Malokinelskaya and Vyasovskaya svitas; Late Tatarian) of the SE of European Russia. Lines with arrows indicate the movement of energy through the community: solid lines show feeding pathways, and dashed lines show decay pathways. Aquatic components: (1) aquatic plants, (2) invertebrates, taxa whose role in terrestrial food chains is insignificant. Amphibious components: taxa which play a significant role in both aquatic and terrestrial food chains. Terrestrial components: (3) plants, (4) invertebrates, taxa which play a role in terrestrial food chains; (5) plant and animal detritus; (6) palaeonisciform, (7) larva of amphibians, (8) *Dvinosaurus*, (9) *Karpinskiosaurus*, (10) *Chroniosaurus*, (11) kotlassiid *Microphon*, (12) pareiasaur *Proelginia*, (13) *Suminia*, (14) dicynodonts, (15) gorgonopsians.

faunas, from the S Urals region, are detailed in Tverdokhlebov et al. (2003).

## 5. List of tetrapod localities

The localities are numbered 1 to 81, according to a long-standing catalogue held at the Geological Institute in Saratov. Their distribution is indicated in Fig. 23.

1. SPASSKOE (STAROSEIKA) (Fig. 4)
*Geographic location:* Orenburg region, 5 km NNW of Spasskoe village, left bank of Staroseika stream, a right tributary of Bolshoi Ik River, Ural drainage basin (Tverdokhlebova, 1976; Ivakhnenko et al., 1997).
*Host rocks:* Grey-green, medium-grained sandstone with vegetation imprints.
*Faunal assemblage:* Archegosauridae: palate fragment of *Platyoposaurus* sp.
*Stratigraphic level:* Osinovskaya Svita, lower Kazanian substage, Upper Permian.
*Burial conditions:* Near-shore marine deposits.
*Storage:* Institute of Palaeontology, Moscow.

2. BOLSHIYE GREBENI
*Geographic location:* Orenburg region, 18 km NE of Orenburg city, beside Grebeni power station, on left bank of Sakmara River (Minikh and Minikh, 1997).
*Host rocks:* Light–grey, thin, horizontally bedded sand and limestone. Thickness 3.5 m.
*Faunal assemblage:* Fishes: tooth plate of *Janassa* sp.
*Stratigraphic level:* Kalinovskaya Svita, lower Kazanian substage, Upper Permian.

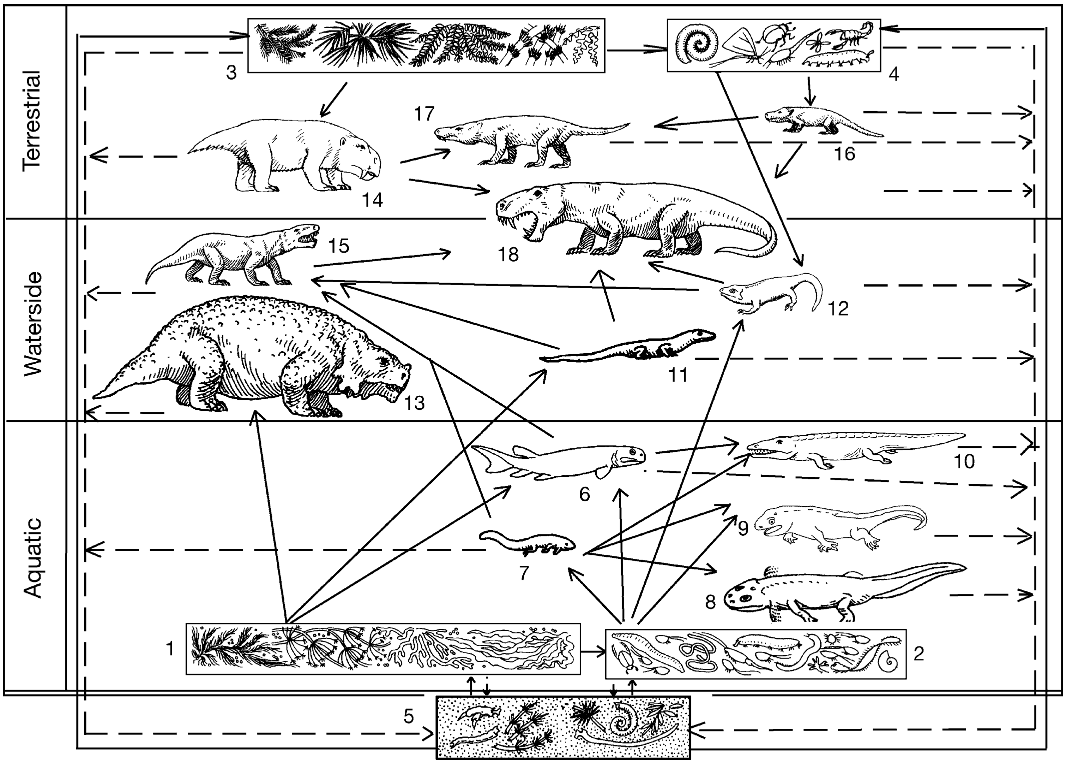


Fig. 22. Reconstructed food web for the terrestrial and aquatic components of the Vyatkian Community (Kutulukskaya and Kulchumovskaya svitas; Late Tatarian) of the SE of European Russia. Lines with arrows indicate the movement of energy through the community: solid lines show feeding pathways, and dashed lines show decay pathways. Aquatic components: (1) aquatic plants, (2) invertebrates, taxa whose role in terrestrial food chains is insignificant. Amphibious components: taxa which play a significant role in both aquatic and terrestrial food chains. Terrestrial components: (3) plants, (4) invertebrates, taxa which play a role in terrestrial food chains; (5) plant and animal detritus; (6) palaeonisciform, (7) larva of amphibians, (8) *Dvinosaurus*, (9) *Karpinskiosaurus*, (10) chroniosuchids: *Chroniosuchus*, *Jarilinus* and *Uralerpeton*, (11) kotlassiid *Microphon*, (12) tokosaurids, (13) pareiasaur *Scutosaurus*, (14) *Dicynodon*, (15) therocephalians *Chthonosaurus* and *Annatherapsidus*, (16) procynosuchid *Uralocynodon*, (17) therocephalian *Scylacosuchus*, (18) gorgonopsian *Inostrancevia*.

*Burial conditions:* Marine deposits.
*Storage:* Saratov State University.

3. YAMAN–YUSHATYR (Fig. 5)
*Geographic location:* Orenburg region, right bank of Yaman Yushatyr River, opposite Davletkulovo village, Ural drainage basin (Tverdokhlebova, 1976; Ivakhnenko et al., 1997; Minikh and Minikh, 1997).
*Host rocks:* From top to bottom, (1) brown silt with interlayers of buff and yellow coarse-grained sandstone (thickness 3.5 m); (2) lens of greenish-grey fossiliferous conglomerate with interlayers of siltstone and silt (maximum thickness of the lens is about 0.3–0.4 m, and the length exceeds 10 m).
*Faunal assemblage:* Fishes: skull bones of *Kazanichthys* sp.; Bolosauridae: isolated bones of postcranial skeleton; Estemmenosuchidae: *Estemmenosuchus* sp.
*Stratigraphic level:* Belebey Svita, upper Kazanian substage, Upper Permian.
*Burial conditions: Deltaic deposits.*
*Storage:* Institute of Palaeontology, Moscow.

4. KURLAEVSKY-1
*Geographic location:* Orenburg region, 8 km E of Kurlaevsky village, Mokrinka stream, a left tributary of Bitkul River, Samara drainage basin (Minikh and Minikh, 1997).
*Host rocks:* Alternation of buff clays, violet-buff siltstones, buff-grey sandstones, and grey limestones with fish remains.

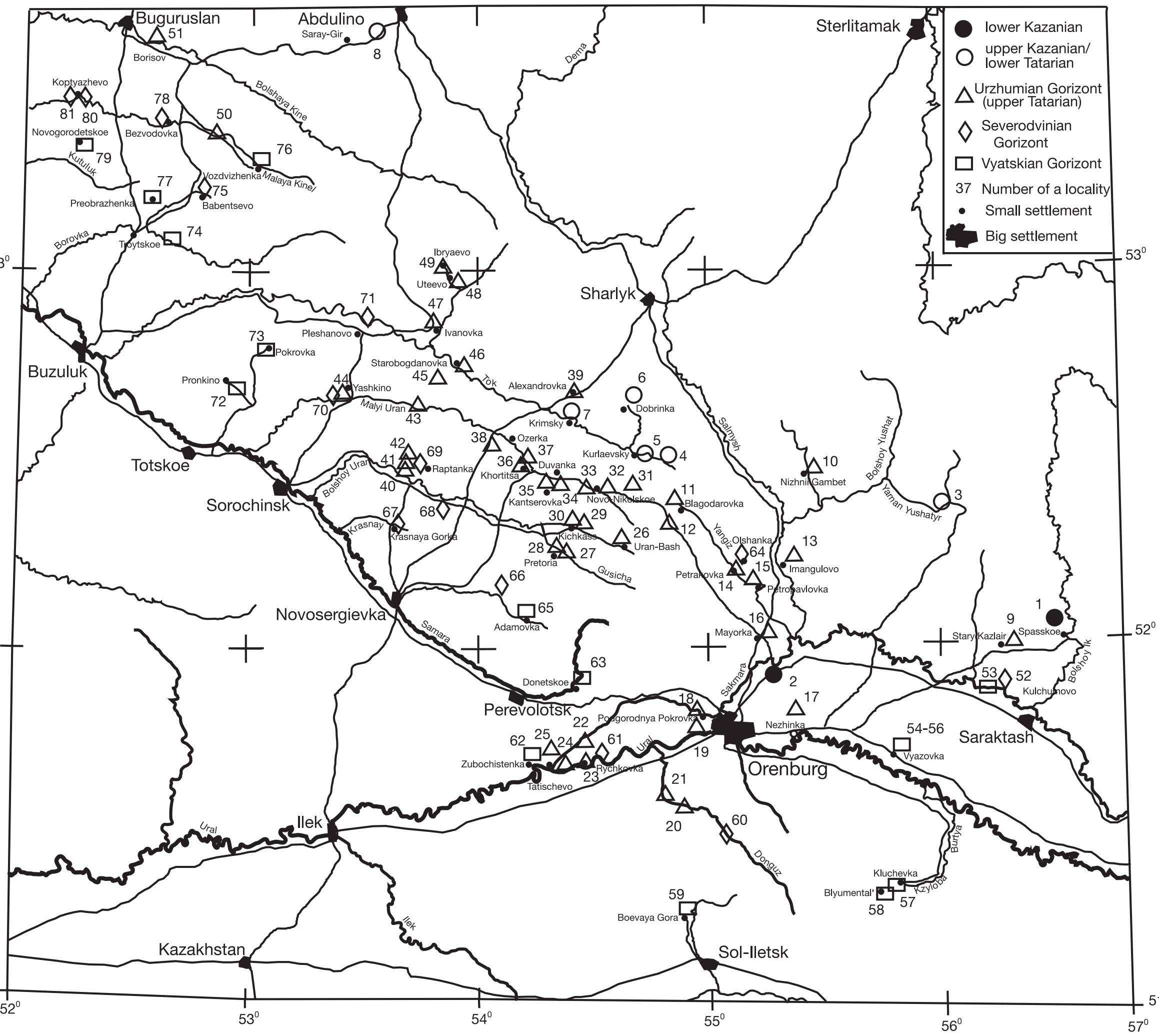


Fig. 23. Map showing the vertebrate-bearing localities of the southeastern part of European Russia.

*Faunal assemblage:* Fishes: dermal bones of Eurynotoididae gen. indet.; scales of Palaeoniscidae gen. indet., *Varialepis*(?) sp., *Platysomus* sp.
*Stratigraphic level:* Belebey Svita, upper part of upper Kazanian substage, Upper Permian.
*Burial conditions:* Near-shore lacustrine deposits.
*Storage:* Saratov State University.

5. KURLAEVSKY-2
*Geographic location:* Orenburg region, 1.9 km upstream from Kurlaevsky village, on right bank of Tok River, Samara drainage basin (Tverdokhlebova, 1976).
*Host rocks:* Horizontal alternation of buff, brown clays, brown thin layer siltstone with tetrapod remains and grey-buff, fine-grained sandstone. Thickness 2 m.
*Faunal assemblage:* Lower jaw of Nycteroleteridae gen. indet.
*Stratigraphic level:* Belebey Svita, upper Kazanian substage, Upper Permian.
*Burial conditions:* Near-shore lacustrine deposits.
*Storage:* Saratov State University.

6. DOBRINKA (KORMYASHKA STREAM) (Fig. 6)
*Geographic location:* Orenburg region, 5 km NE of Dobrinka village, 2.7 km upstream of the Kor-

myashka stream, Samara drainage basin (Tverdokhlebova, 1976; Minikh and Minikh, 1997).
*Host rocks:* Alternation of pink-buff clay containing tetrapod and fish remains, siltstone, light-grey limestone and sandstone.
*Faunal assemblage:* Fishes: scales of *Kargalichthys pritokensis* (Minikh, 1992), *Platysomus* sp. Lower jaw fragment of Nycteroleteridae gen. indet.
*Stratigraphic level:* Belebey Svita, upper part of upper Kazanian substage, Upper Permian.
*Burial conditions:* Near-shore lacustrine deposits.
*Storage:* Saratov State University.

7. KRYMSKII
*Geographic location:* Orenburg region, 1.2 km NE of Krymskii village, right bank of Molochai stream, Samara drainage basin (Tverdokhlebova, 1976; Ivakhnenko et al., 1997; Minikh and Minikh, 1997).
*Host rocks:* Grey, buff-grey carbonate mudstone with spotted colouring and breccial structure, characteristic of marshy soils. Thickness 4.3 m.
*Faunal assemblage:* Fishes: scales of *Kargalichthys pritokensis*(?). Bolosauridae: some whole skeletons with skull and numerous fragments of postcranial skeleton of *Belebey vegrandis* (Ivakhnenko, 1973); Tokosauridae: skull of *Tokosaurus perforatus* (Tverdokhlebova and Ivakhnenko, 1984).
*Stratigraphic level:* Belebey Svita, upper Kazanian substage, Upper Permian.
*Burial conditions:* Parched basin.
*Storage:* Institute of Palaeontology, Moscow.

8. SARAY GIR
*Geographic location:* Orenburg region, left bank of Saray Gir stream, 1 km upstream of Kluchevka village from where it empties into Zhilaya River, a left tributary of Ik River, Ural drainage basin (Ivakhnenko et al., 1997; Minikh and Minikh, 1997).
*Host rocks:* Light, yellow-grey limestone and grey thin layer siltstone containing abundant debris of plants.
*Faunal assemblage:* Fishes: fragment of scale covering and skull bones of *Platysomus bashkirus* (Minikh, 1992); scales of *Kazanichthys*(?) *golyushermensis*, *Platysomus soloduchi* (Minikh, 1992), *Platysomus* sp., *Kargalichthys pritokensis*, *Kargalichthys* sp., *Eurynotoides nanus*; Bolosauridae: lower jaw fragments of *Belebey maximi* (Ivakhnenko and Tverdokhlebova, 1987).
*Stratigraphic level:* Belebey Svita, upper Kazanian substage, Upper Permian.
*Burial conditions:* Near-shore lacustrine deposits.
*Storage:* Institute of Palaeontology, Moscow; Saratov State University.

9. STARII KAZLAIR
*Geographic location:* Orenburg region, 2 km E of Starii Kazlair village, ravine on right bank of Samara River (Minikh and Minikh, 1997).
*Host rocks:* Brownish-red mudstone containing fish remains and plant detritus with interlayer of buff-grey fine-grained sandstone. Thickness 2.5 m.
*Faunal assemblage:* Fishes: scales of *Kargalichthys* sp., *Kazanichthys* sp.
*Stratigraphic level:* Bolshekinelskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Flood-plain deposits of delta area.
*Storage:* Saratov State University.

10. NIZHNII GUMBET (TATYANOVKA)
*Geographic location:* Orenburg region, 1.4 km E of Nizhnii Gumbet village, left tributary of Bolshoi Gumbet River, Samara drainage basin (Tverdokhlebova, 1976).
*Host rocks:* Lilac-buff, yellow-buff, yellow, fine- to medium-grained, cross-bedded sandstone with conglomeratic lenses. Thickness 15 m.
*Faunal assemblage:* Dinocephalia fam. indet. tibia, fragment of scapulocoracoid.
*Stratigraphic level:* Bolshekinelskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Saratov State University.

11. BLAGODAROVKA
*Geographic location:* Orenburg region, left bank of Yangiz River, 2.7 km upstream of Blagodarovka village (Tverdokhlebova, 1976; Gubin, 1991).
*Host rocks:* Buff, buff–yellow, lilac-buff, cross-bedded sandstone with siltstone lenses and buff, yellow-buff lenses of conglomerate in the lower part of the layer.
*Faunal assemblage:* Fragment of lower jaw of Archegosauroidea fam. indet.
*Stratigraphic level:* Bolshekinelskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.

*Burial conditions:* Deltaic deposits.
*Storage:* Institute of Palaeontology, Moscow.

12. KARGALINSKIE RUDNIKI
*Geographic location:* Orenburg region, 6.5 km N of Gorny village. This name refers to the group of old mines in the basin of the Kargalka River (Efremov and V'yushkov, 1955; Ivakhnenko et al., 1997).
*Host rocks:* No description of the section is available. Bones match lenses of grey, greenish-grey copper-ferrous sandstones and conglomerates of clay pebbles. Conglomerates contain remains of fossil wood and plant detritus.
*Faunal assemblage:* Melosauridae: *Platyoposaurus rickardi* (Rozhdestvensky Mine; Gubin, 1991); Anteosauridae: skull of *Deuterosaurus jubilaei* (Staro-Myasnikovsky Mine; Efremov, 1954). Fishes: *Eurynotoides nanus*, *Platysomus biarmicus* (Von Eichwald, 1861), *Varialepis orientalis* (Esin, 1995).
*Stratigraphic level:* Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Channel deposits of delta area.
*Storage:* Institute of Palaeontology, Moscow.

13. IMANGULOVO
*Geographic location:* Orenburg region, 5 km NE of Imangulovo village, Bolshoi Opasovskii ravine, a left tributary of the Salmysh River, Samara drainage basin (Tverdokhlebova, 1976).
*Host rocks:* Grey, grey-buff, yellow-buff, fine-grained, cross-bedded sandstone with lenses of conglomerate, siltstone and silt. Thickness 2.5 m.
*Faunal assemblage:* Scapulo-coracoid and femur of Temnospondyli fam. indet.
*Stratigraphic level:* Bolshekinelskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Flood-plain deposits of delta area.
*Storage:* Saratov State University.

14. PETRAKOVKA
*Geographic location:* Orenburg region, 17 km W of Petrakovka village, Ordynsky ravine, right tributary of Kargalka River, Ural drainage basin (Minikh and Minikh, 1997).
*Host rocks:* Buff, yellow, fine-grained, cross-bedded sandstone with lenses of conglomerate. Buff-brown clay with fish remains and siltstone.
*Faunal assemblage:* Fishes: scales of *Platysomus biarmicus*.
*Stratigraphic level:* Bolshekinelskaya Svita, lower part of Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Flood-plain deposits of a delta area.
*Storage:* Saratov State University.

15. PETROPAVLOVKA (NOVO-ORLOVKA)
*Geographic location:* Orenburg region, 1 km N of centre of Petropavlovka village, right slope of Volchii ravine, Ural drainage basin (Tverdokhlebova, 1976; Gubin, 1991).
*Host rocks:* Buff, fine-grained sandstone with conglomeratic interlayers. Thickness 5 m.
*Faunal assemblage:* Archegosauroidea fam. indet.: dermal bone fragment.
*Stratigraphic level:* Bolshekinelskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Palaeontology Institute, Moscow.

16. MAYORSKOE
*Geographic location:* Orenburg region, 2.2 km NE of Mayorskoe village, left bank of Kargalka River, Ural drainage basin (Tverdokhlebova, 1976; Ivakhnenko et al., 1997).
*Host rocks:* Yellow, reddish, lilac, poorly sorted, cross-bedded sandstone with small lenses of conglomerate. Thickness 10 m.
*Faunal assemblage:* Anteosauridae: palate, vertebrae of *Titanophoneus* sp.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Distributary channel.
*Storage:* Institute of Palaeontology, Moscow.

17. NEZHINKA
*Geographic location:* Orenburg region, 6.5 km N of Nezhinka village, right tributary of Nezhinka stream, Ural drainage basin (Tverdokhlebova, 1976; Ivakhnenko et al., 1997; Minikh and Minikh, 1997).
*Host rocks:* Lens of buff-yellow, medium-grain sandstone in the section of cross-bedded sandstone with lenses of conglomerate and clay. Thickness 50 m.
*Faunal assemblage:* Fishes: scales of *Platysomus* sp.; Anteosauridae: skull of *Deuterosaurus jubilaei*.

*Stratigraphic level:* Bolshekinelskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Institute of Palaeontology, Moscow.

18. PODGORODNAYA POKROVKA-1
*Geographic location:* Orenburg region, 2.3 km NE of Podgorodnaya Pokrovka village, left slope of ravine, a right tributary of Ural River (Garyainov and Ochev, 1962; Tverdokhlebova, 1976; Ivakhnenko et al., 1997).
*Host rocks:* Grey, buff-lilac-yellow poorly sorted, cross-bedded sandstone with lenses of siltstone. Thickness 20 m.
*Faunal assemblage:* Lanthanosuchidae: *Chalcosaurus* cf. *lukjanovae*; Anteosauridae: *Syodon* sp.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Institute of Palaeontology, Moscow.

19. PODGORODNAYA POKROVKA-2
*Geographic location:* Orenburg region, 3 km downstream of Podgorodnaya Pokrovka village, mouth of ravine on right bank of Ural River (Garyainov and Ochev, 1962; Tverdokhlebova, 1976; Gubin, 1991; Ivakhnenko et al., 1997; Minikh and Minikh, 1997).
*Host rocks:* Buff-grey, fine- to medium-grained, cross-bedded mottled sandstone with conglomeratic lenses. Thickness 8 m.
*Faunal assemblage:* Fishes: a few fin spines of *Wodnika*(?) sp.; Melosauridae: lower jaw of *Uralosuchus tverdochlebovae* (Gubin, 1993).
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Institute of Palaeontology, Moscow.

20. DONGUZ-4
*Geographic location:* Orenburg region, right bank of Donguz River, opposite Dolmatovskii village, Ilek drainage basin (Garyainov and Ochev, 1962; Tverdokhlebova, 1976; Ivakhnenko et al., 1997).
*Host rocks:* Red-buff, cross-bedded sandstone with lenses of conglomerate. Thickness 18 m.
*Faunal assemblage:* Anteosauridae: fragment of lower jaw of *Titanophoneus* sp.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Institute of Palaeontology, Moscow.

21. DONGUZ-5
*Geographic location:* Orenburg region, right bank of the Donguz River, 2.5 km downstream of railway bridge, Ilek drainage basin (Garyainov and Ochev, 1962; Tverdokhlebova, 1976).
*Host rocks:* Grey, yellowish-grey, cross-bedded, fine- to medium-grained sandstone. Thickness 25 m.
*Faunal assemblage:* Anteosauridae: fragment of lower jaw of *Syodon* sp.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, Upper Permian.
*Burial conditions: Deltaic deposits.*
*Storage:* Saratov State University.

22. RYCHKOVKA-1
*Geographic location:* Orenburg region, 1 km NNE of Rychkovka village, limestone quarry on right bank of Ural River.
*Host rocks:* Pale-blue, white limestone.
*Faunal assemblage:* Fishes: large scales of *Platysomus biarmicus*.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Saratov State University.

23. RYCHKOVKA-3
*Geographic location:* Orenburg region, right bank of Ural River, 0.2 km downstream of Rychkovka village (Garyainov and Ochev, 1962; Tverdokhlebova, 1976; Gubin, 1991; Ivakhnenko et al., 1997; Minikh and Minikh, 1997).
*Host rocks:* Buff, poorly sorted, cross-bedded sandstone with lenses of clay and conglomerate. Conglomeratic lenses are fossiliferous. Thickness 7 m.
*Faunal assemblage:* Fishes: scale covering of *Kazanichthys* sp.; Archegosauridae: *Platyoposaurus* sp.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Distributary channel.
*Storage:* Institute of Palaeontology, Moscow; Saratov State University.

24. TATISCHEVO-1 (VERKHNE–PODGORNOE)
*Geographic location:* Orenburg region, 3.5 km E of Tatischevo village, Verkhne–Podgornoe lake shore (Tverdokhlebova, 1976).
*Host rocks:* Buff-grey, small-pebbled conglomerate.
*Faunal assemblage:* Maxilla fragment of Temnospondyli fam. indet.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Saratov State University.

25. TATISCHEVO-2 (Fig. 9).
*Geographic location:* Orenburg region, 3.2 km NE of Tatischevo village, right slope of ravine on right bank of Ural River (Tverdokhlebova, 1976).
*Host rocks:* Buff, grey-brown, fine-grained, cross-bedded sandstone with lenticular interlayers of conglomerate. Thickness 8 m.
*Faunal assemblage:* Dermal bone of Archegosauroidea(?) fam. indet.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Saratov State University.

26. URAN–BASH (OCHUN GULLY)
*Geographic location:* Orenburg region, 4.4 km N of Uran-Bash village, upper reaches of Ochun gully, a right tributary of Bolshoi Uran River, Samara drainage basin (Tverdokhlebova, 1976).
*Host rocks:* Buff, green-yellow, lilac, poorly sorted, cross-bedded sandstone with lenticular conglomeratic interlayers. Thickness 15 m.
*Faunal assemblage:* Fishes: scales of Platysomidae gen. indet. Skull fragment of Nycteroleteridae(?) gen. indet.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Saratov State University.

27. PRETORIA-1 (GUSIKHA)
*Geographic location:* Orenburg region, 3 km NE of Pretoria village, right bank of Gusikha River, Samara drainage basin (Tverdokhlebova, 1976).
*Host rocks:* Yellow-buff, buff, raspberry-coloured, pale-grey cross-bedded sandstone with conglomeratic lenses. Thickness 6 m.
*Faunal assemblage:* Bone fragments of Dinocephalia fam. indet.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Saratov State University.

28. PRETORIA-2 (SUVOROVKA)
*Geographic location:* Orenburg region, 2.8 km N of Pretoria village, on the slope of the hill ridge (Tverdokhlebova, 1976; Gubin, 1991).
*Host rocks:* Pink-buff, yellow, reddish-buff, fine-grained, cross-bedded clayey sandstone with conglomeratic lenses. Thickness 15 m.
*Faunal assemblage:* Archegosauridae: skull fragment of *Platyoposaurus* sp.; scapula of Dinocephalia fam. indet.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Distributary channel deposits.
*Storage:* Institute of Palaeontology, Moscow.

29. KICHKASS-2 (RODNICHNOE)
*Geographic location:* Orenburg region, 4.1 km NE of Kichkass village (Tverdokhlebova, 1976; Gubin, 1991).
*Host rocks:* Yellow-buff, yellow, lilac-grey, medium- to coarse-grained, cross-bedded sandstone with conglomeratic lenses. Thickness 10 m.
*Faunal assemblage:* Skull fragments of Archegosauroidea fam. indet. Venyukoviidae: tooth of *Ulemica* sp.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Distributary channel deposits.
*Storage:* Institute of Palaeontology, Moscow.

30. KICHKASS-1
*Geographic location:* Orenburg region, old copper mine 2.4 km N of Kichkass village (Efremov and V'yushkov, 1955; Minikh and Minikh, 1997).
*Host rocks:* Interstratified grey clayey limestone, pale grey clays and shell limestone.
*Faunal assemblage:* Fishes: numerous whole specimens of *Kargalichthys efremovi* Minikh, 1986, *Platysomus biarmicus*, *Varialepis bergi* Minikh, 1986, *Samarichthys luxus* (Minikh and Minikh, 1990), *Lapkosubia uranensis* (Minikh and Minikh, 1986), *Lapkosubia barbalepis* (Minikh and Minikh, 1990), *Kichkassia furcae* (Minikh and Minikh, 1986);

*Discordichthys spinifer* (Minikh, 1998); Anthracosauromorpha fam. indet.; Enosuchidae: *Enosuchus* cf. *breviceps*; Microuraniidae: incomplete skull of *Microurania minima* (Ivakhnenko, 1995); Anteosauridae: *Deuterosaurus* sp.; Tapinocephalidae: *Ulemosaurus* cf. *gigas*; Venyukoviidae: *Ulemica* sp.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, Upper Permian.
*Burial conditions:* Coastal deposits.
*Storage:* Institute of Palaeontology, Moscow; Saratov State University.

31. MILOVANSKY
*Geographic location:* Orenburg region, 2.3 km SE of Milovansky village, old copper mine (Tverdokhlebova, 1976; Gubin, 1991; Minikh and Minikh, 1997).
*Host rocks:* A deposit of grey, fine-grained sandstone and violet-pink-grey marl covered by malachite.
*Faunal assemblage:* Fishes: headless body of *Varialepis*(?) *bergi*; lower jaw of Archegosauroidea fam. indet.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Institute of Palaeontology, Moscow; Saratov State University.

32. NOVO-NIKOLSKOE-1 (SUKHOI URAN)
*Geographic location:* Orenburg region, 4 km E of Novo-Nikolskoe village, right bank of Sukhoi gully, Samara drainage basin (Tverdokhlebova, 1976).
*Host rocks:* Yellow, buff, violet, fine-grained, cross-bedded sandstone with interlayers of conglomerate. Thickness 25 m.
*Faunal assemblage:* Fragment of dermal bone of Archegosauroidea fam. indet.; limb bone of Therapsida(?) indet.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Saratov State University.

33. NOVO-NIKOLSKOE-2
*Geographic location:* Orenburg region, right bank of Malyi Uran River, 2 km downstream of Novo-Nikolskoe village, Samara drainage basin (Tverdokhlebova, 1976; Gubin, 1991; Ivakhnenko et al., 1997).
*Host rocks:* Poorly sorted, cross-bedded, speckled sandstone. Thickness 20 m.
*Faunal assemblage:* Melosauridae: skulls of *Konzhukovia vetusta*; Lanthanosuchidae: skull of *Chalcosaurus lukjanovae* (Ivakhnenko, 1987); Anteosauridae: postcranial remains of *Titanophoneus* sp.; Venyukoviidae: skull of *Ulemica efremovi* (Ivakhnenko, 1996).
*Stratigraphic level:* Bolshekinelskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Institute of Palaeontology, Moscow.

34. KANTSEROVKA-1 (Fig. 8a)
*Geographic location:* Orenburg region, 3.4 km NE of Kantserovka village, Matka gully, a left tributary of Malyi Uran River, Samara drainage basin (Tverdokhlebova, 1976; Minikh and Minikh, 1997).
*Host rocks:* Poorly sorted, cross-bedded speckled sandstone with lenses of conglomerate and gritstone. Thickness 10 m.
*Faunal assemblage:* Fishes: fragment of scale covering of Boreolepedidae gen. indet.; fragments of dermal bone and ribs of Temnospondyli fam. indet.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Saratov State University.

35. KANTSEROVKA-2
*Geographic location:* Orenburg region, 2.2 km N of Kantserovka, Matka gully, a left tributary of Malyi Uran River, Samara drainage basin (Tverdokhlebova, 1976).
*Host rocks:* Poorly sorted, cross-bedded, speckled sandstone with lenses of conglomerate. Thickness 4.5 m.
*Faunal assemblage:* Lower jaw fragment of Temnospondyli fam. indet.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Saratov State University.

36. KHORTITSA (KALMYK–KOCHERGAN-4)
*Geographic location:* Orenburg region, 3 km N of Khortitsa village, Kalmyk–Kochergan stream, Samara drainage basin (Tverdokhlebova, 1976).

*Host rocks:* Buff, yellow-buff, yellow, fine-grained, cross-bedded sandstone with lenses of conglomerate and a layer of pebbles. Thickness 5.5 m.
*Faunal assemblage:* Pterygoid fragment of Archegosauroidea(?) fam. indet; fragment of lower jaw of Dinocephalia fam. indet.; limb bone of Nycteroleteridae(?) gen. indet.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Saratov State University.

37. DUVANKA
*Geographic location:* Orenburg region, right bank of Malyi Uran River, 0.2 km upstream of Duvanka village (Tverdokhlebova, 1976).
*Host rocks:* Alternation of brown-buff clays, siltstone and sandstone containing two horizontal layers of small-pebble conglomerate with tetrapod remains. Thickness 12 m.
*Faunal assemblage:* Fragment of neural arch, ilium of Archegosauroidea(?) fam. indet.
*Stratigraphic level:* Bolshekinelskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Near-shore deposits.
*Storage:* Saratov State University.

38. OZERKA (RUCHEY KOSHKA)
*Geographic location:* Orenburg region, 5 km WSW of Ozerka village, 2.8 km upstream from mouth of Koshka stream, a left tributary of Malyi Uran River (Tverdokhlebova, 1976; Ivakhnenko et al., 1997).
*Host rocks:* Alternation of buff-brown sandstone, clay and siltstone. Thickness 6 m.
*Faunal assemblage:* Tapinocephalidae: postcranial fragments of *Ulemosaurus* cf. *gigas*.
*Stratigraphic level:* Bolshekinelskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Near-shore deposits.
*Storage:* Institute of Palaeontology, Moscow.

39. ALEXANDROVKA
*Geographic location:* Orenburg region, 1 km NE of Alexandrovka village, right slope of Sukhaya Loschina gully, a tributary of Tok River, Ural drainage basin (Minikh and Minikh, 1997).
*Host rocks:* Alternation of red, buff-brown clay, siltstone, and limestone.
*Faunal assemblage:* Fishes: scales and tooth of *Varialepis orientalis*; tooth of Leptorophidae(?) gen. indet.;
*Stratigraphic level:* Bolshekinelskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Saratov State University.

40. DUBOVKA-3 (Kluchevka-1)
*Geographic location:* Orenburg region, 6 km N of Nesterovka village, mouth of Dubovka stream, a right tributary of Bolshoi Uran River, Samara drainage basin (Tverdokhlebova, 1976).
*Host rocks:* Yellow-buff, fine-grained, cross-bedded sandstone with lenticular interlayers of small-pebble conglomerate, containing tetrapod remains.
*Faunal assemblage:* Imprint of skull fragment and fragment of limb and rib of Dinocephalia fam. indet.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Saratov State University.

41. DUBOVKA-2
*Geographic location:* Orenburg region, 7 km N of Nesterovka village, right bank of Dubovka stream, a right tributary of Bolshoi Uran River, Samara drainage basin (Tverdokhlebova, 1976).
*Host rocks:* From the bottom: 1. Buff siltstone, violet clay, buff-yellow sandstone (thickness 4.5 m); 2. Yellow, small-pebble conglomerate erosively overlying the previous layer; conglomerate contains tetrapod remains and fossil wood (thickness 3 m); 3. Grey limestone (thickness 0.05 m).
*Faunal assemblage:* Large ribs and tooth fragments of Dinocephalia fam. indet.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Flood plain deposits of delta area.
*Storage:* Saratov State University.

42. DUBOVKA-1
*Geographic location:* Orenburg region, 10 km N of Nesterovka village, left bank of Dubovka stream, a right tributary of Bolshoi Uran River, Samara drain-

age basin (Tverdokhlebova, 1976; Ivakhnenko et al., 1997).
*Host rocks:* From the bottom: (1) Alternation of buff, reddish-buff siltstone, sandstone and clay (thickness 3 m); (2) Buff, buff-yellow fine-grained cross-bedded sandstone with lenses of conglomerate containing tetrapod remains (thickness 4 m); (3) Alternation of clay, siltstone, sandstone and marl (thickness 4 m).
*Faunal assemblage:* Burnetiidae(?): fragment of lower jaw of *Biarmosuchoides romanovi* (Tverdokhlebova and Ivakhnenko, 1994).
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Flood-plain deposits of delta area.
*Storage:* Institute of Palaeontology, Moscow.

43. MALYI URAN (Fig. 8b)
*Geographic location:* Orenburg region, right bank of Malyi Uran River, 4.5 km upstream from Sverdlovski village (Efremov and V'yushkov, 1955; Chudinov, 1983; Gubin, 1991; Ivakhnenko et al., 1997).
*Host rocks:* Large lense of buff-red, fine grained cross-bedded sandstone.
*Faunal assemblage:* Melosauridae: *Konzhukovia vetusta* (Gubin, 1991); Lanthanosuchidae: *Chalcosaurus* sp.; Anteosauridae: *Syodon* sp.; Antheosauridae: *Titanophoneus adamanteus* (Orlov, 1958); Pristerognathidae: *Porosteognathus*(?) sp.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Institute of Palaeontology, Moscow.

44. YASHKINO-1
*Geographic location:* Orenburg region, right bank of Malyi Uran River, 2.5 km W of Yashkino village (Minikh and Minikh, 1997).
*Host rocks:* Red-brown clay with interlayers of pale-brown siltstone, greenish-gray limestone and thin, blue, fossiliferous siltstone. Thickness 5.6 m.
*Faunal assemblage:* Fishes: teeth of *Xenosynechodus*(?) *egloni*, *Xenosynechodus* sp., scales of *Varialepis bergi*, *Lapkosubia uranensis*, *Platysomus biarmicus*, *Platysomus* sp., *Kichkassia furcae*, *Kargalichthys efremovi*.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Near-shore deposits.
*Storage:* Saratov State University.

45. ALATAY
*Geographic location:* Orenburg region, 5 km S of Pushkinsky village, right slope of unnamed gully, a left tributary of Tok River, Samara drainage basin (Minikh and Minikh, 1997).
*Host rocks:* Red-buff siltstone, buff and brown marls.
*Faunal assemblage:* Fishes: scales *Varialepis bergi*, *Lapkosubia uranensis*, *Kargalichthys efremovi*, *Kichkassia furcae*. Teeth of Temnospondyli gen. indet.;
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Near-shore deposits.
*Storage:* Saratov State University.

46. STAROBOGDANOVKA
*Geographic location:* Orenburg region, 3 km NW of Starobogdanovka village, Ryabinovii gully, Samara drainage basin (Ivakhnenko et al., 1997; Minikh and Minikh, 1997).
*Host rocks:* Pale–grey lenticular conglomerate layer in the section of yellow-green, light-grey siltstone and sandstone.
*Faunal assemblage:* Fishes: scales, teeth, skull bones of *Kichkassia furcae*, *Platysomus* sp., *Varialepis bergi*, teeth of *Xenosynechodus*(?) cf. *egloni*. Amphibia: Melosauridae gen. indet.
*Stratigraphic level:* Bolshekinelskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Institute of Palaeontology, Moscow; Saratov State University.

47. IVANOVKA
*Geographic location:* Orenburg region, 1.2 km NW of Ivanovka village, right slope of unnamed gully running into Turganik River, a right tributary of Tok River, Samara drainage basin (Minikh and Minikh, 1997).
*Host rocks:* Red-brown siltstone, with lenses of buff-grey gritstone containing fishes remains.
*Faunal assemblage:* Fishes: scales of Palaeoniscidae gen. indet.
*Stratigraphic level:* Bolshekinelskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.

*Burial conditions:* Flood-plain deposits of delta area.
*Storage:* Saratov State University.

48. UTEEVO
*Geographic location:* Orenburg region, 1.25 km W of Uteevo village, quarry on right bank of Turganik River, a right tributary of Tok River, Samara drainage basin (Minikh and Minikh, 1997).
*Host rocks:* Lilac and violet thin-bedded siltstone with interlayers of dolomite. Siltstone contains fish remains.
*Faunal assemblage:* Fishes: scales of *Platysomus biarmicus*, teeth of *Xenosynechodus egloni*; vertebra fragments of Lanthanosuchidae gen. indet.;
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Near-shore deposits.
*Storage:* Saratov State University.

49. IBRYAEVO
*Geographic location:* Orenburg region, gravel quarry 0.3 km E of Ibryaevo village (Ivakhnenko et al., 1997, Minikh and Minikh, 1997).
*Host rocks:* Conglomerate.
*Faunal assemblage:* Fishes: scales, teeth and cleithrum of *Platysomus* sp., *Varialepis* sp., tooth of Dipnoi indet.; Melosauridae: maxilla fragment of *Tryphosuchus* sp.; Phthinosuchidae gen. indet.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Institute of Palaeontology, Moscow; Saratov State University.

50. MALAYA KINEL
*Geographic location:* Orenburg region, 0.2 km E of Troitskoe village, right bank of Malaya Kinel River, Samara drainage basin (Efremov and V'yushkov, 1955; Chudinov, 1983; Ivakhnenko et al., 1997; Minikh and Minikh, 1997).
*Host rocks:* Greenish-grey, clayey sandstone with abundant plant detritus in the section of grey marl. Thickness 2 m.
*Faunal assemblage:* Fishes: scales of *Platysomus biarmicus,* Palaeoniscidae gen. indet.; Archegosauridae: *Platyoposaurus vjuschkovi* (Gubin, 1993); Melosauridae: *Tryphosuchus kinelensis* (Gubin, 1989); Enosuchidae: *Enosuchus* cf. *breviceps*; Anteosauridae: *Syodon* sp.; Anteosauridae: *Deuterosaurus* sp.; Pristerognathidae: *Porosteognathus*(?) sp.
*Stratigraphic level:* Amanakskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial conditions:* Near-shore deposits.
*Storage:* Institute of Palaeontology, Moscow; Saratov State University.

51. BORISOV (Fig. 7)
*Geographic location:* Orenburg region, right bank of Bolshaya Kinel River, opposite eastern outskirts of Borisov village, Samara drainage basin (Tverdokhlebova, 1976; Ivakhnenko et al., 1997).
*Host rocks:* Lens of grey, yellow-grey, fine-grained cross-bedded sandstone in a section of interlayered clay, sandstone, and limestone. Thickness 1 m, length 30 m.
*Faunal assemblage:* Rhopalodontidae: lower jaw of *Rhopalodon*(?) sp.
*Stratigraphic level:* Bolshekinelskaya Svita, Urzhumian Gorizont, lower Tatarian substage, Upper Permian.
*Burial condition:* Near-shore deposits.
*Storage:* Institute of Palaeontology, Moscow.

52. KULCHUMOVO
*Geographic location:* Orenburg region, 5 km NW of Kulchumovo village, left slope of unnamed gully, a right tributary of Sakmara River (Minikh and Minikh, 1997).
*Host rocks:* From top to bottom: 1. Grey-coloured section of horizontally interstratified marl, clay limestone, carbonate clays, sandstone, with fish remains (thickness 5m); 2. Grey, fine- to medium-grained sandstone with ripple marks, erosively overlies layers below (thickness 0.5 m).
*Faunal assemblage:* Fishes: scales and fin remains of *Isadia aristoviensis*, scales and teeth of *Isadia* sp., skull bones of *Geryonichthys*(?) *longus*.
*Stratigraphic level:* Vyazovskaya Svita, Severodvinian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Lacustrine deposits.
*Storage:* Saratov State University.

53. SAMBULLAK
*Geographic location:* Orenburg region, 5 km W of Kulchumovo village, right bank of Sakmara River,

foot of Sambullak hill (Tverdokhlebova, 1976; Ivakhnenko et al., 1997).
*Host rocks:* Alteration of clay, siltstone, limestone and sandstone. Thickness 12 m.
*Faunal assemblage:* Karpinskiosauridae: incomplete skull and postcranial fragments of *Karpinskiosaurus ultimus*; Chroniosuchidae: skull fragments, dermal bones, and vertebrae of *Uralerpeton tverdochlebovae*; Theriodontia fam. indet.
*Stratigraphic level:* Kulchumovskaya Svita, Vyatkian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Flood-plain deposits.
*Storage:* Institute of Palaeontology, Moscow.

54. VYAZOVKA-1 (Fig. 11a)
*Geographic location:* Orenburg region, 0.4 km N of Vyazovka village, right slope of Vyazovka gully, Ural drainage basin (Tverdokhlebova, 1976; Ivakhnenko et al., 1997; Minikh and Minikh, 1997).
*Host rocks:* Grey, greenish-grey clay and siltstone with lenses of buff-grey small-pebble conglomerate.
*Faunal assemblage:* Fishes: teeth of *Isadia aristoviensis*, scales and skull bones of *Toyemia blumentalis*. Karpinskiosauridae gen.indet.; Chroniosuchidae: dermal bones, vertebrae, intercentra of *Chroniosuchus paradoxus;* teeth and dermal bones of Pareiasauridae gen. indet.; limb bones of Theriodontia fam. indet.
*Stratigraphic level:* Kulchumovskaya Svita, Vyatkian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Deposits of temporary streams.
*Storage:* Institute of Palaeontology, Moscow; Saratov State University.

55. VYAZOVKA-2
*Geographic location:* Orenburg region, 0.6 km N of Vyazovka village, right slope of right tributary of Vyazovka gully, Ural drainage basin (Tverdokhlebova, 1976; Minikh and Minikh, 1997).
*Host rocks:* There are three fossiliferous levels, from the bottom: 1. Red argillite with much carbonaceous detritus; 2. Grey, buff or greenish-grey, fine-grained sandstone with much carbonaceous detritus and root traces; 3. Yellow, fine– to coarse-grained sandstone with lenses of conglomerate. Thickness 5 m.
*Faunal assemblage:* Lower fossiliferous level. Fishes: scales of *Isadia aristoviensis* (Minikh and Minikh, 1990); Dicynodontidae: postcranial skeleton of *Dicynodon* sp. (Surkov, 1996); Theriodontia fam. indet. Middle and upper fossiliferous levels: fragments of skeleton of Theriodontia fam. indet.;
*Stratigraphic level:* Kulchumovskaya Svita, Vyatkian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Flood-plain deposits.
*Storage:* Palaeontology Institute, Moscow; Saratov State University.

56. VYAZOVKA-3 (Fig. 11b)
*Geographic location:* Orenburg region, 0.6 km N to Vyazovka village, left tributary of Vyazovka gully, Ural drainage basin (Ivakhnenko et al., 1997; Minikh and Minikh, 1997).
*Host rocks:* Brown sandy argillite with interlayers of grey siltstone.
*Faunal assemblage:* Fishes: scales of *Isadia aristoviensis* and *Varialepis* sp.; Scylacosauridae: nearly complete skeleton of *Scylacosuchus orenburgensis* (Tatarinov, 1974).
*Stratigraphic level:* Kulchumovskaya Svita, Vyatkian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Flood-plain deposits.
*Storage:* Institute of Palaeontology, Moscow; Saratov State University.

57. KLUCHEVKA
*Geographic location:* Orenburg region, 1.2 km S of Kluchevka village, in waste pile of old copper mine (Garyainov and Ochev, 1962; Ivakhnenko et al., 1997).
*Host rocks:* Greenish-grey sandy-conglomeratic deposits.
*Faunal assemblage:* Fishes: scales of *Isadia aristoviensis*; Chroniosuchidae: *Chroniosuchus* cf. *paradoxus*; Dicynodontidae: skull of *Dicynodon* sp. (Surkov and Benton, 2004).
*Stratigraphic level:* Kulchumovskaya Svita, Vyatkian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Flood-plain deposits.
*Storage:* Institute of Palaeontology, Moscow.

58. BLYUMENTAL′
*Geographic location:* Orenburg region, 3 km E of Blyumental' village, right slope of Blyumental' gully, Ural drainage basin (Tverdokhlebova, 1976; Ivakhnenko et al., 1997; Minikh and Minikh, 1997).
*Host rocks:* Grey, pale yellow, fine-grained sandstone with thin layer of conglomerate containing abundant

fragments of carbonaceous detritus and fragments of stems. Thickness 3 m.

*Faunal assemblage:* Fishes: scales of *Isadia aristoviensis*, *Toyemia blumentalis* (Minikh and Minikh, 1995), anterior part of body with head and scale covering of pectoral and ventral region of Varialepididae gen. indet.; Dvinosauridae: *Dvinosaurus* sp.; Karpinskiosauridae: vertebrae of *Karpinskiosaurus* cf. *secundus*; dermal bones of Pareiasauria fam. indet.; Chroniosuchidae: fragments of skull, lower jaw, fragment of premaxillae with nares, numerous vertebrae, intercentra, dermal bones, shoulder girdle, pelvis and limb bones of *Chroniosuchus paradoxus*; Inostranceviidae: neurocranium of *Inostrancevia uralensis* (Tatarinov, 1974); Moschorhinidae: clavicle, scapula, tooth, phalange of *Annatherapsidus* cf. *petri*; Procynosuchidae: *Uralocynodon tverdochlebovae* (Tatarinov, 1987).

*Stratigraphic level:* Kulchumovskaya Svita, Vyatkian Gorizont, upper Tatarian substage, Upper Permian.

*Burial conditions:* Shore-deltaic deposits.

*Storage:* Institute of Palaeontology Moscow, Saratov State University.

59. BOEVAYA GORA (BOEVOII)

*Geographic location:* Orenburg region, 0.4 km SW of Korolki village, left tributary of Elshanka River, Ilek drainage basin (Tverdokhlebova, 1976; Ivakhnenko et al., 1997; Minikh and Minikh, 1997).

*Host rocks:* Lens of reddish-buff, small-pebble conglomerate in the section of interstratified silt, siltstone and sandstone. Thickness 4.5 m.

*Faunal assemblage:* Fishes: scales and skull bones of *Isadia aristoviensis*, *Toyemia blumentalis*, *Mutovinia stella*; tooth of *Saurichthys* sp., tooth plate of Gnathoriza sp. Pareiasauridae: caudal dermal bones of *Scutosaurus* sp.; vertebrae and humerus of Karpinskiosauridae gen. indet.; Chroniosuchidae: vertebrae, dermal bones, intercentrum, pectoral girdle, pelvis and limb bones of *Chroniosuchus paradoxus*; phalange of Theriodontia fam. indet.;

*Stratigraphic level:* Kulchumovskaya Svita, Vyatkian Gorizont, upper Tatarian substage, Upper Permian.

*Burial conditions:* Flood-plain deposits.

*Storage:* Institute of Palaeontology, Moscow, Saratov State University.

60. DONGUZ-6

*Geographic location:* Orenburg region, 3 km SE of Donguz village, right bank of Donguz River, Ilek drainage basin (Garyainov and Ochev, 1962; Tverdokhlebova, 1976; Ivakhnenko et al., 1997; Minikh and Minikh, 1997).

*Host rocks:* Reddish-brown clay and pale-grey limestone. The maximum concentration of fossils (about 200 bones and fragments per cubic decimetre) has been registered along the base of the contact layer between the limestone and clay. Thickness 0.6 m.

*Faunal assemblage:* Fishes: numerous remains of *Toyemia tverdochlebovi*, rare specimens of *Toyemia blumentalis* and *Isadia suchonensis*; Kotlassiidae: maxilla and skull fragments of *Microphon exiguus* (Bulanov, 2000, 2002b); Pareiasauridae gen.indet.; Chroniosuchidae: numerous skulls, skull and postcranial fragments of *Chroniosaurus dongusensis* (Tverdokhlebova, 1972; Golubev, 2000); Gorgonopsia fam. indet.; tooth of Theriodontia fam. indet.

*Stratigraphic level:* Malokinelskaya Svita, Severodvinian Gorizont, upper Tatarian substage, Upper Permian.

*Burial conditions:* Parched basin.

*Storage:* Institute of Palaeontology, Moscow; Saratov State University.

61. RYCHKOVKA-2 (Fig. 10a)

*Geographic location:* Orenburg region, 3.3 km NE of Rychkovka village, left tributary of Elshanka River, Ural drainage basin (Tverdokhlebova, 1976; Minikh and Minikh, 1997).

*Host rocks:* Lens of grey–buff, cross-bedded sandstone in section of interstratified thin layers of siltstone, sandstone, and clay. Thickness 20 m.

*Faunal assemblage:* Fishes: scales of *Toyemia tverdochlebovi*, *Toyemia* sp.(?), *Strelnia* sp.

*Stratigraphic level:* Malokinelskaya Svita, Severodvinian Gorizont, upper Tatarian substage, Upper Permian.

*Burial conditions:* Distributary channel deposits.

*Storage:* Saratov State University.

62. ZUBOCHISTENKA

*Geographic location:* Orenburg region, 2.9 km NE of Zubochistenka village, left slope of unnamed gully, Ural drainage basin (Tverdokhlebova, 1976; Ivakhnenko et al., 1997; Minikh and Minikh, 1997).

*Host rocks:* Buff, yellow, grey cross-bedded sandstone with lenses of conglomerate. Thickness 4 m.
*Faunal assemblage:* Fishes: large scales and postcleithrum of *Toyemia* sp., dermal bone of *Geryonichthys burchardi*; humerus of Karpinskiosauridae gen. indet.; Chroniosuchidae: dermal bones, vertebrae and clavicles of *Jarilinus mirabilis*; Moschorhinidae: fragment of maxillae of *Chthonosaurus*(?) sp.
*Stratigraphic level:* Kutulukskaya Svita, Vyatkian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Institute of Palaeontology, Moscow; Saratov State University.

63. DONETSKOE
*Geographic location:* Orenburg region, 4.2 km NE of Donetskoe village, right slope of unnamed gully, a left tributary of Samara River (Tverdokhlebova, 1976).
*Host rocks:* Red-brown clay with interlayers of pink gravel containing tetrapod remains.
*Faunal assemblage:* Dicynodontia: fragments of ulna and femur of *Dicynodon* sp.
*Stratigraphic level:* Kutulukskaya Svita, Vyatkian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Deposits of temporary streams.
*Storage:* Saratov State University.

64. OLSHANKA-1
*Geographic location:* Orenburg region, 2.5 km N of Olshanka village, in old copper mine (Tverdokhlebova, 1976).
*Host rocks:* Grey, fine-grained, coppery sandstone with interlayer of conglomerate.
*Faunal assemblage:* Dvinosauridae: lower jaw of *Dvinosaurus* sp.
*Stratigraphic level:* Malokinelskaya Svita, Severodvinian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Saratov State University.

65. ADAMOVKA
*Geographic location:* Orenburg region, 1.5 km E of Adamovka village, right tributary of Adamovka stream, upper reaches of Samara River drainage basin (Tverdokhlebova, 1976; Ivakhnenko et al., 1997; Golubev, 2000; Minikh and Minikh, 1997).
*Host rocks:* Two lenses of grey and yellow fine-grained sandstone with layers of conglomerate separated by reddish-buff clay. Maximum thickness 0.3–0.4 m.
*Faunal assemblage:* Fishes: skull fragments and scales of *Toyemia blumentalis*, *Isadia aristoviensis*; Karpinskiosauridae: lower jaws, fragments of pterygoid, palatine and ilium of *Karpinskiosaurus ultimus*; Chroniosuchidae: skull fragments, vertebrae, intercentra, lower jaws, dermal bones, pectoral girdle, pelvis, bones of limbs of *Chroniosuchus paradoxus*; dermal bones of Pareiasauridae gen. indet.
*Stratigraphic level:* Kutulukskaya Svita, Vyatkian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Institute of Palaeontology, Moscow, Saratov State University.

66. KUVAII
*Geographic location:* Orenburg region, 11.6 km NW of Adamovka village, right bank of Kuvaii River, Samara drainage basin (Minikh and Minikh, 1997).
*Host rocks:* Alternation of grey, grey-yellow fine- to medium-grained, cross-bedded sandstone, clay, siltstone and blue-grey limestone, with fish remains.
*Faunal assemblage:* Fishes: scales of *Toyemia blumentalis*.
*Stratigraphic level:* (?) Malokinelskaya Svita, Severodvinian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Near-shore deposits.
*Storage:* Saratov State University.

67. KRASNAYA GORKA
*Geographic location:* Orenburg region, 2 km NW of Krasnaya Gorka village, right bank of Krasnaya River, Samara drainage basin (Tverdokhlebova, 1976; Minikh and Minikh, 1997).
*Host rocks:* Alternation of red-buff horizontally bedded clay, siltstone and sandstone. There are two lenses of grey-yellow sandstone with conglomeratic interlayers containing tetrapod and fish remains. Thickness 15 m.
*Faunal assemblage:* Fishes: scales of *Toyemia* sp.; Chroniosuchia(?) fam. indet.
*Stratigraphic level:* Malokinelskaya Svita, Severodvinian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Distributary channel deposits.
*Storage:* Saratov State University.

68. BALEIKA
*Geographic location:* Orenburg region, 3.1 km upstream of BaleIka village on left bank of Baleika River, a left tributary of Bolshoi Uran River, Samara drainage basin (Minikh and Minikh, 1997).
*Host rocks:* Alternation of red-buff clay, brown-buff siltstone and grey, blue-grey fine-grained sandstone. Clay contains fish remains.
*Faunal assemblage:* Fishes: scales of *Sludalepis spinosa*, skull bones of Discordichthyidae gen. indet., fin spines of *Geryonichthys longus*, scales of *Toyemia* sp.
*Stratigraphic level:* Malokinelskaya Svita, Severodvinian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Flood-plain deposits of delta area.
*Storage:* Saratov State University.

69. RAPTANKA
*Geographic location:* Orenburg region, 1.3 km SW of Raptanka village, right bank of Raptanka River, a right tributary of Bolshoi Uran River, Samara drainage basin (Tverdokhlebova, 1976; Ivakhnenko et al., 1997; Minikh and Minikh, 1997).
*Host rocks:* Red-buff conglomerates.
*Faunal assemblage:* Fishes: scales and skull bones of *Kargalichthys*(?) *efremovi*, *Platysomus* sp., Platysomidae gen. indet.; bone fragments of Chroniosuchidae gen. indet.
*Stratigraphic level:* Malokinelskaya Svita, Severodvinian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Institute of Palaeontology, Moscow; Saratov State University.

70. YASHKINO-2 (Fig. 24)
*Geographic location:* Orenburg region, limestone quarry 4.5 km W of Yashkino village, right bank of Malyi Uran River, Samara drainage basin (Minikh and Minikh, 1997).
*Host rocks:* Grey, buff-grey marl in a section of interstratified red clay, sandstone, marl, and limestone.
*Faunal assemblage:* Fishes: scales of *Toyemia tverdochlebovi*; bones of indeterminate tetrapods.
*Stratigraphic level:* Malokinelskaya Svita, Severodvinian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Flood plains of delta area.
*Storage:* Saratov State University.

71. PLESHANOVO
*Geographic location:* Orenburg region, right bank of Tok River, opposite Pleshanovo village, Samara drainage basin (Minikh and Minikh, 1997).
*Host rocks:* Brown silt clay with interlayer of limestone with fish remains.
*Faunal assemblage:* Fishes: numerous scales and teeth of *Isadia* sp., *Lapkosubia* sp., fin spines of *Xenosynechodus* sp., scales of *Palaeoniscus* sp., *Toyemia* sp., *Lapkosubia tokense* (Minikh and Minikh, 1995), Discordichthyidae gen.indet., *Varialepis* sp.
*Stratigraphic level:* Malokinelskaya Svita, Severodvinian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Near-shore deposits.
*Storage:* Saratov State University.

72. PRONKINO
*Geographic location:* Orenburg region, 1 km SW of Pronkino village, left bank of Borovka River, Samara

Fig. 24. Perspective view of the Yashkino-2 locality, showing fine-grained marls, red clays, and sandstones of the Malokinelskaya Svita (Severodvinian Gorizont, upper Tatarian substage, Upper Permian). (Photograph by A.V. Minikh).

drainage basin (Efremov and V'yushkov, 1955; Ivakhnenko et al., 1997, Minikh and Minikh, 1997).
*Host rocks:* Light-grey, greenish-red fine-grained sandstone and siltstone.
*Faunal assemblage:* Fishes: scales of *Boreolepis tataricus* (Esin and Mashin, 1996), tooth plate of *Gnathorhiza* sp.; Dvinosauridae: *Dvinosaurus primus*; Karpinskiosauridae: *Karpinskiosaurus ultimus* (Ivakhnenko, 1987), *Karpinskiosaurus*(?) sp.; sacral vertebrae of *Buzulukia butsuri* (V'yushkov, 1957); Kotlassiidae: *Kotlassia* cf. *prima*, *Microphon exiguus*; Tokosauridae gen. indet.; Chroniosuchidae: *Chroniosuchus paradoxus* (Golubev, 2000); Moschorhinidae: *Chthonosaurus velocidens* (V'yushkov, 1955; Tatarinov, 1974).
*Stratigraphic level:* Kutulukskaya Svita, Vyatkian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Near-shore deposits.
*Storage:* Institute of Palaeontology, Moscow; Saratov State University.

73. POKROVKA
*Geographic location:* Orenburg region, quarry on SW outskirts of Pokrovka village on right bank of Chesnokovka River, Samara drainage basin (Ivakhnenko et al., 1997, Minikh and Minikh, 1997).
*Host rocks:* Conglomerates.
*Faunal assemblage:* Fishes: scales of *Toyemia tverdochlebovi*; Dvinosauridae: vomer of *Dvinosaurus* sp., dermal bones of Karpinskiosauridae gen. indet.; tooth, phalanx and fragment of dermal bone of Pareiasauridae gen. indet.; Chroniosuchidae: fragment of dermal bone of *Chroniosuchus* sp.
*Stratigraphic level:* Kutulukskaya Svita, Vyatkian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Distributary channel deposits.
*Storage:* Institute of Palaeontology, Moscow; Saratov State University.

74. BOROVKA (Fig. 10b)
*Geographic location:* Orenburg region, 1.5 km downstream of Bolimovka village, right bank of Borovka River, Samara drainage basin (Tverdokhlebova, 1976).
*Host rocks:* Horizontal alternation of buff-grey clay, siltstone, sandstone, and limestone. Fossils have been found in a lens of red-coloured conglomerate in the section of greyish, brown–yellow, poorly sorted cross-bedded sandstone. Thickness 18 m.
*Faunal assemblage:* Tooth of Pareiasauria fam. indet.; tusk of Dicynodontia fam. indet.; ilium of Chroniosuchidae(?) gen. indet.
*Stratigraphic level:* Malokinelskaya Svita, Severodvinian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic lens in lake deposits.
*Storage:* Institute of Palaeontology, Moscow.

75. BABENTZEVO
*Geographic location:* Orenburg region, 3.8 km NE of Babentzevo village, right slope of nameless gully, a right tributary of Konduzla River, Samara drainage basin (Ivakhnenko et al., 1997; Minikh and Minikh, 1997; Golubev, 2000).
*Host rocks:* Lower fossiliferous level composed of yellow-grey cross-bedded sandstone. Thickness 3 m. Upper fossiliferous level represented by interstratified red and buff sandstone, siltstone, and clay. Thickness varies from 0.4 to 2.5 m.
*Faunal assemblage:* Lower fossiliferous level contains Pareiasauridae: fragments of vertebral column of *Proelginia* cf. *permiana*. Upper fossiliferous level contains: Fishes: numerous scales of *Toyemia blumentalis*, *Toyemia tverdochlebovi*, scales and teeth of *Isadia aristoviensis*(?), skull bones and single scale of *Geryonichthys burchardi* (Minikh, 1998), *Geryonichthys* sp. Dvinosauridae: *Dvinosaurus primus*; Karpinskiosauidae: fragments of lower jaw of *Kaspinskiosaurus ultimus*; Kotlassiidae: fragments of lower jaw of *Microphon exiguus*; Chroniosuchidae: vertebrae, skull fragments, dermal bones, fragments of lower jaw of *Chroniosaurus dongusensis*; Venyukovioidea: *Suminia* cf. *getmanovi*.
*Stratigraphic level:* (?) Malokinelskaya Svita, Severodvinian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Lower fossiliferous level: distributary channel deposits. Upper fossiliferous level: deltaic flat deposits.
*Storage:* Institute of Palaeontology, Moscow; Saratov State University.

76. VOZDVIZHENKA (Fig. 12)
*Geographic location:* Orenburg region, right bank of the Malaya Kinel River, 1 km downstream from Vozdvizhenka village, Samara drainage basin (Tverdokhlebova, 1976; Ivakhnenko et al., 1997; Minikh and Minikh, 1997).

*Host rocks:* Two large lenses of cross-bedded sandstone in a section of interstratified clay, siltstone, and sandstone. Thickness varies from 1 to 6 m.
*Faunal assemblage:* Fish: *Isadia* sp.; Kotlassiidae: ilium of *Microphon exiguus*; tooth and fragment of neural arch of Pareiasauridae gen. indet.
*Stratigraphic level:* Kutulukskaya Svita, Vyatkian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Deltaic deposits.
*Storage:* Institute of Palaeontology, Moscow; Saratov State University.

77. PREOBRAZHENKA
*Geographic location:* Orenburg region, 2.8 km NE of Preobrazhenka village, Vyazovii stream, a right tributary of Konduzla River, Samara drainage basin (Ivakhnenko et al., 1997; Minikh and Minikh, 1997).
*Host rocks:* Graded beddings of clay, siltstone, and poorly sorted sandstone. The whole thickness 40 m. The basic cycle comprises buff-grey fine- to medium-grained, cross-bedded sandstone with conglomeratic lenses containing vertebrate remains. This gradually changes above into a subhorizontal alternation of red-buff siltstone, limestone, and fine-grained clayey sandstone. The cycle thickness is 8 m.
*Faunal assemblage:* Fishes: lower jaw and scales of *Toyemia blumentalis*(?), scales of *Toyemia tverdochlebovi*, *Toyemia* sp., *Strelnia*(?) sp., and *Mutovinia stella*, jaws and teeth of *Isadia aristoviensis*, lower jaw of *Isadia* sp., infraorbital of *Geryonichthys* sp., tooth plates of Bradyodontiformes, teeth of Eurynotoidiidae gen. indet.; Dvinosauridae: hypocentra and fragment of neural arches of *Dvinosaurus* sp.; Kotlassiidae: lower jaw of *Microphon exiguus*; Pareiasauridae: *Proelginia* cf. *permiana*; Chroniosuchidae: fragments of skull, dermal bones of *Chroniosaurus levis*.
*Stratigraphic level:* Malokinelskaya Svita, Severodvinian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Distributary channel deposits.
*Storage:* Institute of Palaeontology, Moscow; Saratov State University.

78. BEZVODOVKA
*Geographic location:* Orenburg region, 1 km NE of Bezvodovka village, large limestone quarry, right bank of Malaya Kinel River (Minikh and Minikh, 1997).
*Host rocks:* Reddish–brown silt, spotted coloured siltstone containing fish remains overlies limestone. Thickness 0.4 m.
*Faunal assemblage:* Fishes: dermal bones of *Geryonichthys*(?) *longus*, anterior part of skeleton with head and scale covering as well as isolated scales of *Platysomus biarmicus*, *Platysomus* sp., fragments of scale covering of *Lapkosubia uranensis*, isolated scales of *Kargalichthys*(?) *efremovi*, *Kargalichthys* sp., scales of *Toyemia* sp., Eurynotoidiidae gen. indet., Discordichthyidae gen.indet.
*Stratigraphic level:* Malokinelskaya Svita, Severodvinian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Near-shore lacustrine deposits.
*Storage:* Saratov State University.

79. NOVOGORODETSKOE
*Geographic location:* Orenburg region, 0.5 km SE of Novogorodetskoe village in unnamed gully, a left tributary of Malaya Kinel River, Samara drainage basin (Minikh and Minikh, 1997).
*Host rocks:* Large lens of speckled cross-bedded sandstone with interlayers of conglomerate containing a high concentration of tetrapod remains. The lens occurs in the alternation of clay, siltstone, and sandstone. Thickness varies from 0 to 12 m.
*Faunal assemblage:* Fishes: tooth plate of *Gnathorhiza tatarica* (Minikh, 1989), scales of *Toyemia tverdochlebovi*, *Toyemia blumentalis*, *Strelnia* sp., tooth and scales of *Isadia* sp., tooth of *Xenosynechodus*(?) sp.; Chroniosuchidae: numerous postcranial bones of *Chroniosuchus paradoxus*, Pareiasauria fam indet.: dermal bones and skull spikes.
*Stratigraphic level:* Kutulukskaya Svita, Vyatkian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Distributary channel deposits.
*Storage:* Institute of Palaeontology, Moscow; Saratov State University.

80. KOPTYAZHEVO1 (Fig. 25)
*Geographic location:* Orenburg region, limestone quarry on SW slope of hill near eastern outskirts of Koptyazhevo village, right bank of Malaya Kinel River, Samara drainage basin (Ivakhnenko et al., 1997; Minikh and Minikh, 1997).


Fig. 25. Perspective view of the Koptyazhevo-1 and Koptyazhevo-2 localities (numbered 1, 2), where fish and tetrapod remains have been found in grey marls in a section of red-brown mudstone and clay of the Malokinelskaya Svita (Severodvinian Gorizont, upper Tatarian substage, Upper Permian). (Photograph by A.V. Minikh).

*Host rocks:* Small lenses of blue-grey marl in a section of red-brown clay.
*Faunal assemblage:* Fishes: lower jaw and scales of *Lapkosubia tokense*, skull bones and scales of *Toyemia tverdochlebovi*; Kotlassiidae: *Microphon* sp. Venyukovioidea: *Suminia* sp.
*Stratigraphic level:* Malokinelskaya Svita, Severodvinian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Flood-plain deposits of delta area.
*Storage:* Institute of Palaeontology, Moscow; Saratov State University.

81. KOPTYAZHEVO-2 (Fig. 25)
*Geographic location:* Orenburg region, 500 m downstream on Malaya Kinel River from Koptyazhevo village, in limestone quarry (Minikh and Minikh, 1997).
*Host rocks:* Pale grey marl in a section of red-brown mudstone and clay.
*Faunal assemblage:* Fishes: cleithrum and scales of *Toyemia tverdochlebovi*.
*Stratigraphic level:* Malokinelskaya Svita, Severodvinian Gorizont, upper Tatarian substage, Upper Permian.
*Burial conditions:* Near-shore lacustrine deposits.
*Storage:* Saratov State University.

## 6. List of tetrapod localities, organised by Svita

### *6.1. Osinovskaya Svita*

(1) Spasskoe (Staroseika).

### *6.2. Kalinovskaya Svita*

(2) Bolshiye Grebeni.

### *6.3. Belebey Svita*

(3) Yaman–Yushatyr; (4) Kurlaevsky-1; (5) Kurlaevsky-2; (6) Dobrinka (Kormyashka Stream); (7) Krymskii; (8) Saray Gir.

### *6.4. Bolshekinelskaya Svita*

(9) Starii Kazlair; (10) Nizhnii Gumbet (Tatyanovka); (11) Blagodarovka; (12) Kargalinskie Rudniki; (13) Imangulovo; (14) Petrakovka; (15) Petropavlovka (Novo-Orlovka); (17) Nezhinka; (33) Novo-Nikolskoe-2; (37) Duvanka; (38) Ozerka (Ruchey Koshka); (39) Alexandrovka; (46) Starobogdanovka; (47) Ivanovka; (51) Borisov.

### *6.5. Amanakskaya Svita*

(16) Mayorskoe; (18) Podgorodnaya Pokrovka-1; (19) Podgoronaya Pokrovka-2; (20) Donguz-4; (21) Donguz-5; (22) Rychkovka-1; (23) Rychkovka–3; (24) Tatischevo-1 (Verkhne–Podgornoe); (25) Tatischevo-2; (26) Uran-Bash (Ochun Gully); (27) Pretoria-1 (Gusikha); (28) Pretoria-2 (Suvorovka); (29) Kichkass–2 (Rodnichnoe); (30) Kichkass-1; (31) Milovansky; (32) Novo-Nikolskoe–1 (Sukhoy Uran); (34) Kantserovka-1; (35) Kantserovka-2; (36) Khortitsa (Kalmyk–Kochergan-4); (40)

Dubovka-3 (Kluchevka-1); (41) Dubovka-2; (42) Dubovka-1; (43) Malyi Uran; (44) Yashkino-1; (45) Alatay; (48) Uteevo; (49) Ibryaevo; (50) Malaya Kinel.

*6.6. Vazovskaya Svita*

(52) Kulchomovo.

*6.7. Kulchumovskaya Svita*

(53) Sambullak; (54) Vyazovka-1; (55) Vyazovka-2; (56) Vyazovka-3; (57) Kluchevka; (58) Blyumental'; (59) Boevaya Gora (Boevoy).

*6.8. Malokinelskaya Svita*

(60) Donguz-6; (61) Rychkovka–2; (64) Olshanka-1; (66) Kuvaii; (67) Krasnaya Gorka; (68) Baleyka; (69) Raptanka; (70) Yashkino-2; (71) Pleshanovo; (74) Borovka; (75) Babentzevo; (77) Peobrazhenka; (78) Bezvodovka; (80) Koptyazhevo-1; (81) Koptyazhevo-2.

*6.9. Kutulukskaya Svita*

(62) Zubochistenka; (63) Donetskoe; (65) Adamovka; (72) Pronkino; (73) Pokrovka; (76) Vozdvizhenka; (79) Novogorodetskoe.

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