

Ichthyofaunal correlation of the Triassic deposits from the northern Cis-Caspian and southern Cis-Urals regions

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ABSTRACT

All the known data on the Triassic ichthyofauna from south-east European Russia are summarized. The material studied comes from thirty-nine localities from the Lower and Middle Triassic reference and stratotype sections of the South Cis-Urals and northern Cis-Caspian regions. Data on terrestrial vertebrates, ostracodes, and charae are used as well as paleomagnetic sampling results. A certain stratigraphic importance of the Triassic gnathorhiza and ceratods is demonstrated relative to lungfish, the one of hybodontids relative to squaliforms and the one of saurichthiids among actinopterygians. Two super-ichthyocomplexes were revealed within the Triassic sections according to dipnoan distributions: those of gnathorhiza and ceratods. Their change in the region occurs in the middle of the Olenekian age and is associated with the rather short Akhtuba time in the Cis-Caspian and with the synchronous Fyodorovka time in the South Cis-Urals. Considering the data on other fish groups, three independent ichthyocomplexes are recognized in the Triassic ichthyofauna: the Vetlugian and Yarenian ones in the Early Triassic and another one in the Middle Triassic. The Yarenian ichthyocomplex comprises two clearly manifested groups of different ages (the Akhtuba and Bogdo ones in the Cis-Caspian and the Fyodorovka and Gamskaya ones in the South Cis-Urals). The Middle Triassic ichthyocomplex comprises the Donguz and Bukobaj fish groups. The regularities revealed in fish-taxa changes with time, are traced within the sections across the adjacent territories from the Cis-Urals to the Cis-Caspian. The Lower Triassic Akhtuba suite from the Cis-Caspian Bogdo section was correlated by fish with the lowermost part of the Petropavlovka suite, and the overlying Bogdo suite with the rest of the Petropavlovka section from the Orenburg region. The Middle Triassic Donguz and Bukobaj suites from the Cis-Urals are stratigraphically analogous to the Elton and Inder suites from the Middle Triassic

KEY WORDS

Ichthyofauna,
Triassic,
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southern Cis-Urals.

section in the northern Cis-Caspian. The succession revealed in the Triassic ichthyofauna development is maintained all over the territory of European Russia. It is traced in the adjacent regions and may serve as the basis for stratigraphic divisions and interregional correlations of different-facies marine and non-marine sections of the Triassic.

RÉSUMÉ

Toutes les données connues sur l'ichthyofaune triasique du SE de la Russie européenne sont compilées. Le matériel étudié provient de trente-neuf localités des coupes de références et stratotypiques du Trias inférieur et moyen du sud du Cis-Oural et du nord de la Cis-Caspienne. Les données sur les vertébrés terrestres, les ostracodes, les characées sont utilisées aussi bien que les résultats paléomagnétiques. Deux super-ichthyocomplexes sont mis en évidence dans les coupes du Trias. Leur changement dans la région se produit au milieu de l'Olenekien, il est rattaché à l'intervalle court de Akhtuba dans la région de la Cis-Caspienne et à l'intervalle synchrone de Fyodorovska dans la région du Sud du Cis-Oural. Considérant les données des autres groupes de poissons, trois ichthyocomplexes indépendants sont reconnus dans le Trias. Le Vetlugian et le Yarenien dans le Trias inférieur et un autre dans le Trias moyen. L'ichthyocomplexe Yarenien comprend deux groupes d'âge différents (l'Akhtuba et le Bogdo dans la Cis-Caspienne et le Fyodorovka et le Gamskaya dans le sud du Cis-Oural). L'ichthyocomplexe du Trias moyen comprend les groupes de poissons de Donguz et de Bukobaj. Les changements dans le temps de la faune de poissons sont reportés sur les coupes à travers les territoires depuis le Cis-Oural jusqu'à la Cis-Caspienne. La suite d'Akhtuba, du Trias inférieur, de la coupe de Bogdo (Cis-Caspienne) est corrélée par les poissons avec la partie basale de la suite de Petrovpavlovka, et la suite de Bogdo sus-jacente avec le reste de la suite de Petrovpavlovka dans la région d'Orenbourg. Les suites du Trias moyen de Donguz et Bukobaj (Cis-Oural) sont stratigraphiquement analogues aux suites de Elton et Inder de la coupe du Trias moyen du nord de la Cis-Caspienne. La succession dans le développement des ichthyofaunes du Trias est une constante sur tout le territoire de la Russie européenne, elle est tracée pour les territoires adjacents et peut servir de base pour des divisions stratigraphiques et des corrélations interrégionales des différents faciès marins et continentaux du Trias.

MOTS CLÉS

Ichthyofaune,
Trias,
nord Cis Caspienne,
sud Cis Oural.

INTRODUCTION

In the territory of European Russia, the Triassic deposits are developed in two disconnected extensive fields: the southern and northern ones. The present paper considers the ichthyofauna only from the southern Triassic field, embracing the territories of the northern Cis-Caspian (the Peri-Caspian Depression), the south of the Cis-Ural Marginal Deflection, the southern slope of the Volga-Ural Anticline (Obshchy Syrt) and, partially, the zone of the Don-Medveditsa dislo-

cations. The Triassic accumulation, as well as the aquatic paleobiota development in these regions, were directly or indirectly controlled by the Tethys paleo-ocean regime. The first paleontologically characterized Triassic deposits in Russia were established within the southern Triassic field, in the Bolshoye Bogdo Mountain, near the lake of Baskunchak in the northern Cis-Caspian. In the middle of the eighteenth century, Pallas (1788) discovered ammonites in the Bogdo limestones; later on, those were described by Bukh (1885) as *Ammonites bogdoanus* Buch.

While making a layer-by-layer description of the same section, Auerbach (1871) found some remains of labyrinthodont, *Mastodonsaurus* (?) sp., and fish, *Hybodus plicatilis* Agassiz, *Acrodus dunkeri* Auerbach, *Sphaerodus minimus* Agassiz, *Saurichthys* sp. Those fauna-bearing layers are comparable with the Middle Triassic Muschelkalk from Germany. It was only when

Mojsisovich (1882) found ceratites in the ammonite fauna of Bolshoy Bogdo, late in the nineteenth century, that the section could be compared to the Campilian layers of the Alpine Lower Triassic. Later on, Khabakov (1932) described two lungfish tooth plates from the Bogdo limestones: *Ceratodus* ex gr. *kaupi* Agassiz, and *C. facetidens* Chabakov. It is worth mentioning

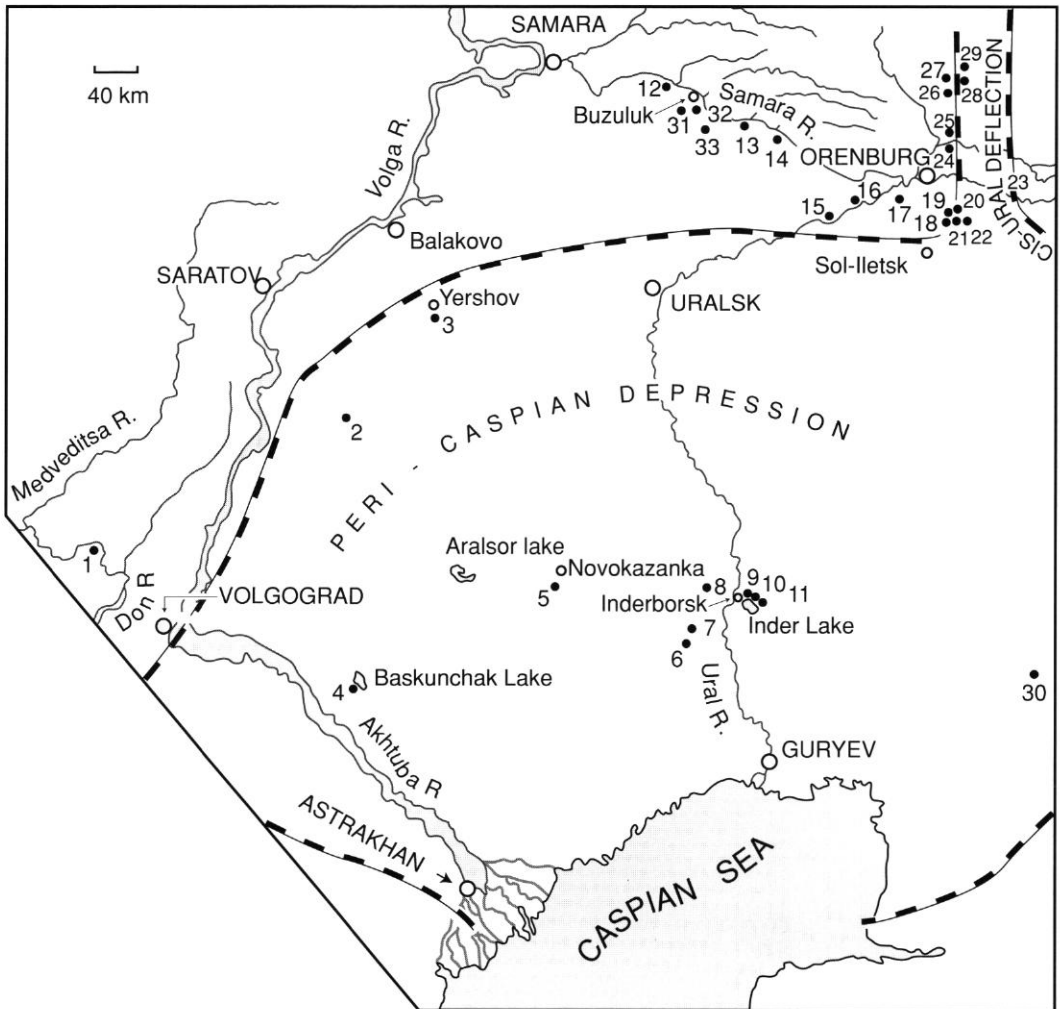


FIG. 1. — Principal ichthyofauna localities in the northern Cis-Caspian and southern Cis-Ural regions, main sections: 1, The Don Bend; 2, Gmelinka, well 5041-c (1521-1526 m int.); 3, Yuzhno-Yershovskaya, well 1 (931-934 m int.); 4, Bolshoj Bogdo Mountain; 5, Novokazanka, well k-6 (424.5-427 m int.); 6, Zhundykuduk, well 46 (depth 440 m); 7, Zhundykuduk, well 22 (487-491 m int.); 8, Barkhanny, well k-4 (358-365.5 m int.); 9, Azi-Molla-1, -2; 10, Kok-Tau; 11, Kara-Bala-Kantemir; 12, Mechet; 13, Markovka; 14, Mirol'yubovka; 15, Rossypnoye; 16, Nizhneoz'yornoye; 17, Chyornaya-1; 18, Donguz-1, -2, -12; 19, Berdyanka-2, -3; 20, Bukobaj-5; 21, Karagachka; 22, Kzyl-Saj-2; 23, Krasnogory-2; 24, Bekhteyev Gully; 25, Petropavlovka-1, -2; 26, Kaltayev-2, -3; 27, Yaslav; 28, Muraptalovo; 29, Yamangulovo; 30, Sankubaj, well G-1 (890.1-893.6 m int.); 31, Rozhykha; 32, Yelshanka-I; 33, Dolgy Yar.

that the first of the two forms was first described from the German Muschelkalk. Subsequently, lungfish remains were found within the Triassic beds from the Middle Don (the Don Bend locality), the South Cis-Urals (Donguz-1 and Kaltayevo-2 localities), and over vast areas of the northern Triassic field (Efremov & V'yushkov 1955).

The authors began to study fossil fish from the Triassic of Russia in the mid-sixties. An ample material from over 150 localities was collected, representing Early and Middle Triassic squaliforms, lungfish and actinopterygii from Eastern Europe. The Late Triassic fishes from the region are still unknown. There are over forty localities of the Triassic ichthyofauna in the south of the East European Platform and in the South Cis-Urals (Fig. 1). It was largely this material that provided the basis for revealing the stratigraphic importance of lungfish (Vorobyova & Minikh 1968; Minikh M. G. 1969, 1977), squaliforms and actinopterygii remains (Minikh A. V. 1975, 1985, 1992). Frequent joint finds of fish and tetrapod remains proved to be of much use. The study of both (Ochev *et al.* 1979), combined with informations on other fossils and the data from lithologic (Tverdokhlebov 1966, 1970; Lipatova *et al.* 1965; Lipatova 1967, etc.) and paleomagnetic research (Molostovsky 1983), made it possible to develop unified stratigraphic division schemes for the Triassic of European Russia (Anonymous 1982).

STRATIGRAPHIC ICHTHYOCOMPLEXES

Notwithstanding considerable taxonomic diversity of certain Triassic fish groups, a number of regularities are observed in their evolution, which may be used for stratigraphic purposes. Dipnoans served as the basis for recognition of two major stages, or superichthyocomplexes, changes in the Triassic from the East European Platform and the Cis-Ural deflection: the gnathorhizian and ceratodian ones. The first one has a worldwide distribution from the Late Carboniferous to the Early Triassic. The second one appears in the Early Triassic and exists up to now. It is in the Lower Triassic that their change

occur, which is clearly demonstrated by our materials. At the boundary of the Vetlugian and Yarenian, in the Olenekian age, everywhere over the Russian Plate, ceratods appear in the dipnoan fauna, with gnathorhiza still existing. They co-exist during the rather short Fyodorovka time, after which the gnathorhiza vanish. This phenomenon is clearly evident in the Cis-Caspian, within the Bolshoye Bogdo section, as well as in a number of localities from the Moscow and Mezen synclises. The revealed changes in fossil-fish compositions with time in this region were used for distinguishing the ichthyocomplexes there: two in the Lower (the Vetlugian and Yarenian) and one in the Middle Triassic.

1. The Vetlugian ichthyocomplex is represented by gnathorhiza - *Gnathorhiza triassica triassica* Minich, *Gn. lozovskii* Minich, and hybodus - *Hybodus spasskiensis* A. Minich. The dominant form here is *Gn. triassica triassica* Minich, which does not occur in any younger deposits. This ichthyocomplex is more complete in the northern Triassic field; a number of stratigraphic groups are recognized within it.

2. The Yarenian ichthyocomplex is subdivided into two groups: the early, the Akhtuba one (with dipnoans: *Gnathorhiza bogdensis* Minich, *Gn. otschevi* Minich, *Gn. triassica baskunchakensis* Minich, *Ceratodus multicristatus* Vorobyova, *C. jechartiensis* Minich, *C. gracilis* Vorobyova; and squaliforms: *Hybodus spasskiensis* A. Minich, *Hybodus maximi* A. Minich) and the later, the Bogdo one (with ceratods: *Ceratodus recticristatus* Vorobyva, *C. donensis* Vorobyva *et* Minich, *C. multicristatus* Vorobyva, *C. multicristatus lipovensis* Minich, *C. jechartiensis* Minich, *C. kaupi* Agassiz, *C. facetidens* Chabakov; squaliforms: *Hybodus maximi* A. Minich, *H. plicatilis* Agassiz, *Acrodus dunkeri* Auerbach, *Lissodus angulatus* Stensio; and actinopterygii: *Sphaerodus minimus* Agassiz, *Colobodus varius* Giebel).

3. The Middle Triassic ichthyocomplex is also subdivided into two groups of various ages. In the earlier group, the Donguz one, fishes are represented by *Ceratodus gracilis* Vorobyva, *C. bucobaensis* Minich, *C. orenburgensis* Minich,

C. recticristatus Vorobyva, *C. donensis* Vorobyva et Minich, *C. jechartiensis* Minich, *Saurichthys dongusensis* A. Minich, *Hybodus otschevi* A. Minich, *Hybodus karagatshkaensis* A. Minich. *Ceratodus recticristatus* Vorobyva, *Hybodus otschevi* A. Minich and *Saurichthys dongusensis* A. Minich are characteristic of the considered group. In the younger, the Bukobaj group, fishes are represented by *Ceratodus bucobaensis* Minich, *C. gracilis* Vorobyva, *C. orenburgensis* Minich, *Saurichthys ultimus* A. Minich, *Hybodus karagatshkaensis* A. Minich, *Ceratodus bucobaensis* Minich and *Saurichthys ultimus* A. Minich. General information on all the known ichthyofauna localities, within the southern Triassic field, is presented below and its correlative possibilities are revealed.

REVIEW AND CORRELATION OF ICHTHYOFAUNAL LOCALITIES

THE VETLUGIAN ICHTHYOCOMPLEX

Within the Vetlugian series of the Lower Triassic from the South Cis-Urals and the adjacent from the west regions of Obshchy Syrt, fish remains were encountered in several bone-bearing sites. The most ancient of those is Yelshanka-I, a locality 9 km to the south of the town of Buzuluk in Orenburg region. Tooth plate remains belonging to *Gnathorhiza lozovskii* Minich, typical of the Vetlugian ichthyocomplex, were found there in an interlayer of red brown aleurolites within a sand sequence of the Kopanskaya suite. The soundness of this gnathorhiza being assigned to the Kopan level is confirmed by the discoveries of *Tupilakosaurus* sp. vertebra, typically representative of the tupilakosaur group of the vetlugosaur terrestrial vertebrate fauna (Ochev 1992). Another locality, Nizhneozornoye, is situated in the left wall of a gully, falling into the Ural River near Nizhneozornoye village, Krasnokholmsk district, Orenburg region. The Early Triassic hybodont shark remains, *Hybodus spasskiensis* A. Minich, were found there in an abandoned-channel suite, represented by a sequence of brown cross-bedded sands with clay and sandstone interlayers with apparent thickness up to 5 m. Chyornaya-I locality is associated with the upper

part of the Vetlugian series, the Kzylsaj suite; it is situated along the right bank of the Chyornaya River, 5 km to the south of Krasny Kholm village, Orenburg region. A typical Early Triassic gnathorhiza form, *Gnathorhiza otschevi* Minich, was found there in red-brown sands (10 m). There is another known locality, the one of Muraptalovo-I, on the right bank of the Bolshoy Ynshatyr River near Muraptalovo village, Kyurgazy district in the south of Bashkiria. The section is represented by a sequence of red brown cross-bedded sandstones (over 25 m). In one of the lenticular interlayers was found a fin spine of a squaliform, *Hybodus spasskiensis* A. Minich, typical of the Early Triassic deposits. *Hybodus spasskiensis* A. Minich fin spines were also encountered higher in the section, near Yakutovo village, in similar sandstones containing remains of the Vetlugian tetrapod fauna (*Wetlugasaurus* sp., *Benthosuchus bashkiricus* Otchev). Two other bone-bearing sites from the Kzylsaj suite of the Vetlugian series, containing a typical Vetlugian ichthyocomplex, are known from Buzuluk district, Orenburg region. One of them is Dolgiy Yar locality in the same-named gully falling into the Pogromnaya River (the Samara left tributary), from the left 2.3 km north-west of Logachyovka village. Several well-preserved lungfish tooth plates were found in an interlayer of brown clayey aleurolites within a sequence of cross-bedded sandstones. They belonged to *Gnathorhiza triassica bereznikiensis* Minich, typical of the uppermost layers of the Vetlugian series of the more northerly regions of the East European Platform. The second site, Rozhikha locality, is situated in the mouth of Rozhikha Gully, falling into the Grachyovka River (the Buzuluk left tributary) 1.4 km north of Grachyovka village, Buzuluk district. In the similar rocks of the Kzylsaj suite there, a large tooth plate of *Gnathorhiza otschevi* Minich was found, typically representative of the Vetlugian ichthyocomplex. The Vetlugian level of the Triassic section from the Peri-Caspian Depression is penetrated by a substantial number of wells, but with incomplete core selection, lung fish remains (*Gnathorhiza triassica triassica* Minich) were found only in well No. G-1 (Sankubaj), within the 890.1-893.6 m depth interval. These dip-

noan forms are extremely common in Verlugian deposits, included the area of the northern Triassic field, and may serve as good correlatives of the host beds.

THE YARENIAN ICHTHYOCOMPLEX

Formations of the Yarenian age are widely distributed over the considered regions of the South Cis-Urals and northern Cis-Caspian. Bone remains of terrestrial vertebrates and fishes occur there rather frequently. Taken together, they constitute the basis for determination of the relative geologic ages of the deposits. Within the Peri-Caspian Depression, the Yarenian ichthyocomplex was studied in the Triassic section from the Bolshoye Bogdo Mountain, on the southwestern bank of Baskunchak brine lake (Minikh 1972, 1977). Diverse fish remains from both groups of the Yarenian ichthyocomplex were found there at various levels, in the Akhtubia and Bogdo suites (Fig. 2). Numerous gnathorhiza and ceratod remains were found in the red-bed clayey aleurolites of the Akhtubia suite (bone-bearing site A): *Gnathorhiza triassica baskunchakensis* Minich, *Gn. bogdensis* Minich, *Gn. otschevi* Minich, *Gn. sp.*, *Ceratodus multicristatus multicristatus* Vorobyova. Combinations of gnathorhiza and ceratod remains within the Lower Triassic sections are characteristic of the Akhtubia group from the Yarenian ichthyocomplex of the Cis-Caspian. Saurichthian remains (*Saurichthys* sp.) occur within the Akhtubia suite from Bolshoye Bogdo alongside with dipnoans. A typical form of the Akhtubia group, *Gnathorhiza triassica baskunchakensis* Minich, was also encountered at the depth of 553 m in a core from K-6 well (Barkhannaya), drilled between the Ural and the Volga. This part of the Triassic section was assigned to the upper half of the Olenekian stage, according to the ostracode (*Gerdalia triassiana* (Belousova), *G. wetlugensis* Belousova) and charofite (*Porochara triassica* (Saidakovsky), *Auerbachichara achtubensis* Kisilevsky) complexes. The lungfish from this section indicates an Akhtubian age of deposition. In the South Cis-Urals, the early Yarenian (Fyodorovka) group of the Lower Triassic ichthyofauna is only represented in Kyzyl-Say-2 locality (Garyainov & Ochev 1962). In the

Burtya River basin (a left tributary of the Ural) near Andreyevka village (Burtinskij district, Orenburg region), in the sand-conglomerate sequence of the Petropavlovskaya suite, representatives *Gnathorhiza* and *Ceratodus* occur, characteristic of the early Yarenian group (*Gnathorhiza triassica baskunchakensis* Minich and *Ceratodus multicristatus multicristatus* Vorobyova). In the suite section they are associated with hybodont sharks remains, *Hybodus spasskiensis* A. Minich. Thus, the presence of Gnathorhizids and Ceratodids in the Lower Triassic sections makes it possible to correlate the Akhtubia suite of the Peri-Caspian Depression with the lowermost part of the Petropavlovka suite of the South Cis-Urals in the reference section along the Kyzyl-Say Gully. Two explanations may be offered for the lack of representativeness of this fish-group in the suite stratotype section near Petropavlovka village. The first one seems to be optimistic: the discoveries are waiting ahead. The second one runs as follows: either this part of the section is absent from the stratotype or the conditions for fish burial were unfavourable near Petropavlovka at that time.

The late Yarenian (Gamskaya) group of the Early Triassic ichthyofauna is reasonably completely represented in the South Cis-Urals and in the adjacent western region of the East European Platform. First of all, let us mention the availability of a purely ceratod dipnoan association in the Petropavlovka suite stratotype (Tverdokhlebov 1967a). This is situated on the bank of the Sakmara (Fig. 1), in the vicinity of Petropavlovka village, Sakmara district, Orenburg region. It is mainly built (Fig. 2) of greyish brown sandstones with aleurolite and clay interlayers of a total thickness up to 250 m. Dipnoan remains (*Ceratodus multicristatus lipovensis* Minich and *C. jechartiensis* Minich) were found there at various levels (Petropavlovka-1 and -2 localities). These fish widely occur in the late Yarenian deposits of the East European Platform. *Ceratodus multicristatus lipovensis* Minich tooth plates were also encountered (Fig. 3) in the Petropavlovka suite-developed along the Donguz River (Donguz-9 locality) near Mescheryakovka village, Sol-Iletsk district, Orenburg region, in Bekhteyev Gully within the

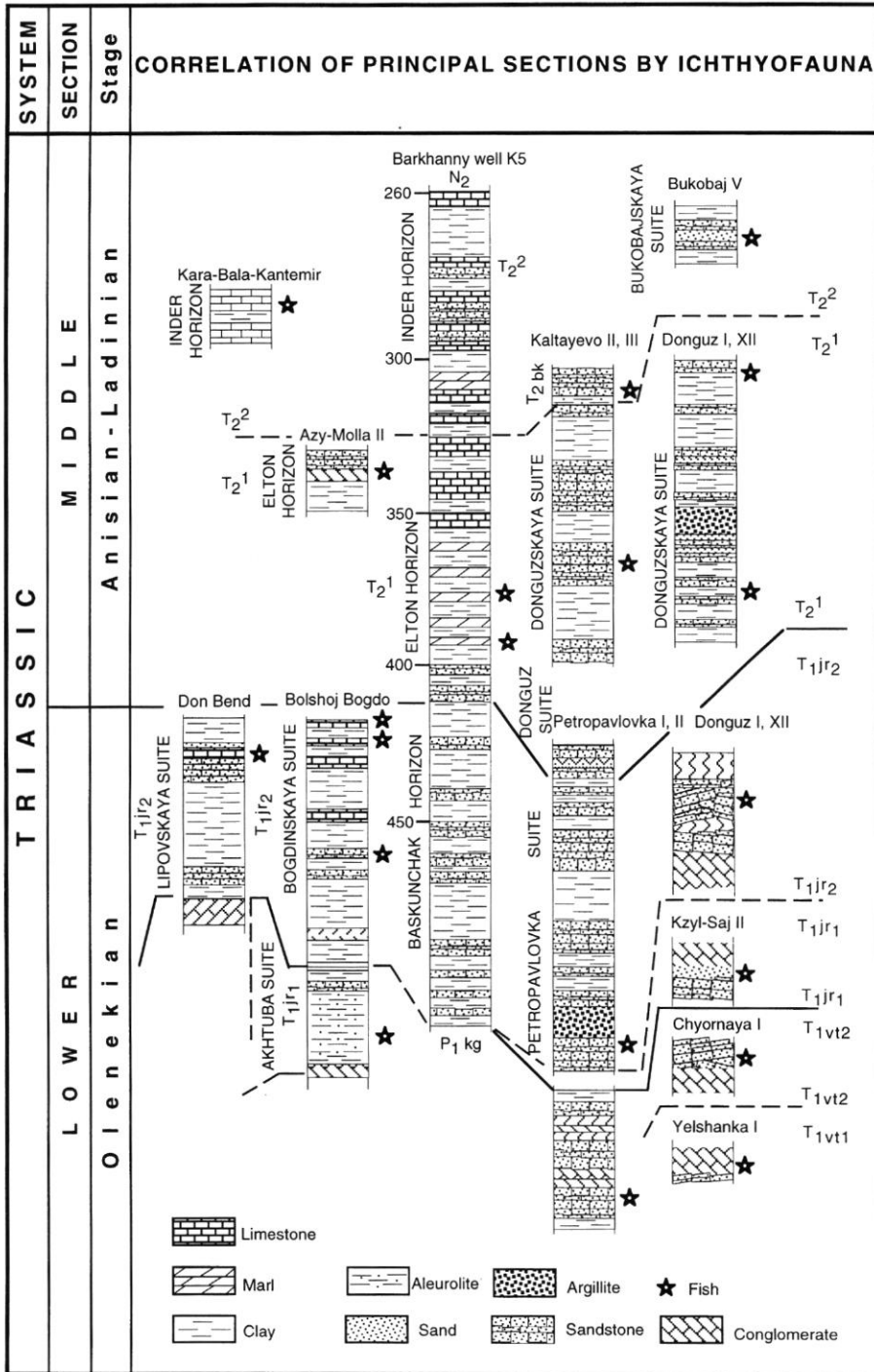


FIG. 2. — Correlation of the Triassic sections from the northern Cis-Caspian and southern Cis-Urals regions according to ichthyofauna.

Ural-Sakmara watershed, and in the vicinity of Yazlav Farm, Kyurgazy district, Bashkiria. There is a major Triassic vertebrates locality, Rossypnoye, to the west of the Cis-Ural deflection, in the territory of Obshchiy Syrt (Efremov & V'yushkov 1955). It is located in the right slope of Mayachnaya Gully, opened from the right into the Ural valley 1.0 km to the north-east of Rossypnoye village, Ilekiskij district, Orenburg region. Ceratod tooth plates *Ceratodus recticristatus* Minich (Fig. 3) occur here alongside with parotosuchian fauna tetrapod remains, in red clays.

An even richer locality of Early Triassic vertebrates, the Don Bend (Rykov & Ochev 1966), is known from the south-eastern slope of the Voronezh antecline dislocations. It is situated (Fig. 1) in a large bend of the Don, north of Sirotinskaya village, in Lipovskij Gully (a Don right tributary). Diverse fish remains occur there in the upper, sand-conglomerate portion of the Lipovskaya suite, together with the parotosuchian tetrapod fauna remains. Among fish, dipnoans are found there: *Ceratodus multicristatus lipovens* Minich, *C. jechartiensis* Minich and *C. donensis* Vorobyova et Minich; sharks *Hybodus maximi* A. Minich, *Lissodus angulatus* Stensio, actinopterygii *Saurichthys* sp., and other, forms of squaliform and actinopterygian fish that are not described yet. On the whole, according to the composition of fossils encountered there, the Don Bend locality belongs to the Late Yarenian (Lipovskaya) group of the Early Triassic ichthyofauna, and may be correlated by fish with most of the Petropavlovka suite from Obshchiy Syrt and from the Cis-Ural Deflection; through these, it may also be correlated with the Gamskaya suite from Safonovsky Deflection of Mezen syncline. It is interesting to compare *Ceratodus donensis* Vorobyova et Minich, very common in the Lipovskaya suite and described by the Don Bend material, with the Triassic ceratodes known from all over the world. Among the European forms, *C. priscus* Fraas from the Lower Triassic of Schwarzwald (medium mottled sandstones) seems to be the most similar one. This allows us to correlate, in a first approximation, the Lower Triassic dipnoan bearing beds from the East European and West European Platforms.

Within the Peri-Caspian Depression, the Late Yarenian (Bogdo) group of the Early Triassic ichthyofauna is most clearly seen in the Bogdo suite section (Fig. 2), from the Bolshoye Bogdo Mountain (bone-bearing site B). Fish remains are represented there by dipnoans (*Ceratodus multicristatus lipovens* Minich, *Ceratodus facetidens* Chabakov and *Ceratodus* ex. gr. *kaupi* Agassiz) and squaliforms (*Hybodus plicatilis* Agassiz and *Acroodus dunkeri* Auerbach). Actinopterygii are represented by perleidids (*Colobodus varius* Giebel and *Sphaerodus minimus* Agassiz) and saurichthiids (*Saurichthys apicalis* Agassiz and *Saurichthys* sp.). Evolutionary levels identities, and similarities in a number of lungfish, squaliforms and actinopterygians from the single late Yarenian group of the Early Triassic ichthyofauna within the Cis-Caspian Bogdo section and those from the Triassic section of the Don Bend (*Ceratodus multicristatus lipovens* Minich, *Lissodus* sp. and *Saurichthys* sp.), make it possible to correlate with certainty the Bogdo suite with the Lipovskaya suite of the Middle Don, the Petropavlovka suite of the south-eastern slope of the Volga-Ural antecline and the south of the Cis-Ural deflection. The presence in the Bogdo group of ceratods, *Ceratodus kaupi* Agassiz, very common in the Middle Triassic Muschelkalk of the German basin implies, in its turn, probable paleogeographic and ichthyofaunal connections between the Bogdo and German marine sedimentation basins towards the end of the Early Triassic. Such a connection between the Peri-Caspian and North German Depressions might be accomplished through the Cis-Caucasian marginal deflection, the system of the Dnieper-Donets depressions, Pripyat Deflection and Polish-Lithuanian syncline. At the end of the Early Triassic, a lot of interconnected freshened semi-marine basins existed all over that region, which might provide the exchange of brackish faunas.

THE MIDDLE TRIASSIC ICHTHYOCOMPLEX

In the territory of European Russia, the Middle Triassic ichthyofauna was first discovered and described from the South Cis-Urals (Vorobyova & Minikh 1968). It comes from the Donguz and Bukobaj suites (Tverdokhlebov 1967b) and is

known from the faunas of a number of localities, where it is often encountered together with the remains of eriosuchian and mastodontosaurian terrestrial vertebrate faunas (Ochev 1992). The principal localities of the Middle Triassic ichthyofauna are associated with type and reference sections of both suites. The Donguz suite strato-type is located along the Donguz River (left tributary of the Ural) near Perovka village, Sol-Iletsk district, Orenburg region. The section is generally composed of variegated aleuro-clayey and arenaceous rocks up to 150 m thick. In the middle part of the suite, in the conglomerate-like interlayers among variegated aleurolites and clays of the Donguz-I locality (Figs 1-3), lung fish tooth plates were discovered (*Ceratodus gracilis* Vorobyova, *C. recticristatus* Vorobyova, *C. orenburgensis* Minich and *C. jechartiensis* Minich). The latter forms, although quite common in the upper layers of the Lower Triassic, are rather rare in the Middle Triassic. About 75 m higher in the section of the Donguz suite, in the Donguz-12 locality in a lens of unsorted sandy-aleurite rocks together with bones of tetrapod eriosuchian fauna and tooth plates of ceratods (*Ceratodus gracilis* Vorobyova, *C. recticristatus* Vorobyova, *C. orenburgensis* Minich and *C. bucobaensis* Minich), some other fossils were found: hybodontid fin and head spines (*Hybodus otchevi* A. Minich), teeth of *Lissodus angulatus* Stensio, teeth of new squaliform genera and species (their descriptions are being prepared for publication) and actinopterygian jaws (*Saurichthys dongusensis* A. Minich). Almost the same set of taxa occurs among the lungfish and squaliform remains, from a number of other vertebrate localities, at various levels of the Donguz suite of the South Cis-Urals. These are Berdyanka-2, Berdyanka-3, Karagachka, Kaltayevo-2 localities (Figs 1-3). Fin pines of yet another *Hybodus* species were found in the latter two ones: *Hybodus karagatschkaensis* A. Minich, typical of the whole of the Middle Triassic ichthyocomplex.

Thus, the Donguz group of the Middle Triassic ichthyofauna clearly stands apart from the above considered Early Triassic ones, because of the new dipnoan species appearing within the sections (*Ceratodus gracilis* Vorobyova, *C. bucobaensis* Minich), new squaliforms (*Hybodus*

karagatschkaensis A. Minich, *H. otchevi* A. Minich) and actinopterygians (*Saurichthys dongusensis* A. Minich). All these forms may be regarded as typical of the Middle Triassic ichthyocomplex on the whole. The combination of these forms with those known from the Early Triassic deposits (*Ceratodus recticristatus* Vorobyova and *C. jechartiensis* Minich) makes it possible to separate the Donguz group both from the earlier and from the younger groups of the Triassic ichthyofauna.

Along with fish remains in the Donguz suite of the South Cis-Urals, the remains of eriosuchian fauna terrestrial vertebrates occur, which correlate with the Ladinian tetrapod association from the uppermost Muschelkalk and lower Keuper of Germany, according to common plagiosaur genera (*Plagiosternum* and *Plagioscutum*).

The Donguz suite correlates with the Elton suite established in the northern Cis-Caspian, according to the ichthyofauna. The section of the Middle Triassic and its ichthyofauna were studied there (Fig. 4) from the cores of several reference and parametric wells and from the natural outcrops on the north-eastern shore of Inder Lake. The lake is situated in the left-bank region of the Ural, south-east of Inderborsky settlement, Gurjev region, Kazakhstan. A rather complete section of the Triassic, typical of the central parts of the Peri-Caspian Depression, is known there on the slopes of the Kok-Tau Range and along the lake shores. The Early Triassic Cis-Caspian series are represented in the Inder section by the basal red-bed clayey sequence (over 200 m). The Middle Triassic is represented by the Elton (a red-bed arenaceous-conglomerate sequence, up to 110 m and an arenaceous-clayey one up to 60 m) and Inder suites (grey-coloured limestone-clayey sequences about 250 m). The Late Triassic variegated sandstone sequence lies above them (up to 100 m), the Masteksaj horizon (Anonymous 1982).

The Lower/Middle Triassic boundary was previously drawn (Ochev & Smagin 1974) within the Elton suite, between the basal sandy-conglomerate and the red-bed sandy-clayey sequences. Our point of view regarding this problem was determined after the discovery of typical Middle Triassic ichthyofauna remains in the

sand-conglomerate sequence of the Elton suite. Lungfish tooth plates (*Ceratodus gracilis* Vorobyova) and undefinable tetrapod bone fragments were found there in the Kok-Tau and Azi-Molla-1 locations. This ceratod species is known as a component of the Middle Triassic (Donguz) ichthyocomplex from the South Cis-Urals. In the northern Cis-Caspian, this species is also found in some cores from the wells penetrating the Middle Triassic sections (the age was determined from ostracodes and charophytes). These are the sections of the Yuzhno-Yershovskaya-1 well (931.0-934.0 m interval), Barkhanny K-5 well (379.0-385.9 m and 385.9-392.9 m intervals) and Zhundykuduk-46 well (490 m depth). Besides ceratods, some sections contain the remains of hybodont sharks typical of the Donguz fish-group (*Hybodus otschevi* A. Minich; Gmelinka 5041-C well, 1521-1526 m interval) and new species of the shark genus *Lissodus* (Barkhanny K-4 well; 361.5-365.5 m interval).

The presented data on ichthyofauna distributions within the Middle Triassic deposits, confirm that *Ceratodus gracilis* Vorobyova belongs to the Middle Triassic ichthyofauna of the Donguz group; its taxonomic composition is rather stable within the whole of the southern field of the Triassic development in European Russia. On the basis of these lungfish discoveries, the age of the basal sandy-conglomerate sequence of the Elton suite, from the Inder Triassic section, may be defined as the Middle Triassic.

The younger, Bukobaj group of the Middle Triassic ichthyofauna, from the South Cis-Urals, is known from the stratotype section of the Bukobaj suite in Bukobaj-5 locality. It is situated in Bukobaj Gully falling in the Berdyanka river (left tributary of the Ural) from the right, upstream Belyayevka village, Sol-Iletsk district, Orenburg region. Within the light-grey sands and sandstones of this area, lungfish tooth plates were discovered (*Ceratodus gracilis* Vorobyova and *C. bucobaensis* Minich), as well as the remains of saurichthiid *Saurichthys ultimus* A. Minich, typical of the Bukobaj fish group. Some mastodonsaur tetrapod fauna remains were also found there. The Bukobaj suite comprised also the deposits, outcropping along the right

bank of the Bolshoj Yushatyr river near Starokaltayevo village (Efremov & V'yushkov 1955). In the Kaltayevo-3 location there, within the grey sandstones, besides tetrapods *Mastodonsaurus torvus* Konzhukova and others, squaliforms were found, *Hybodus karagatskensis* A. Minich, which occurs as early as at the Donguz level, and the latest of the saurichthiids known from the region, *Saurichthys ultimus* A. Minich, similar in their morphologic features to saurichthys from the Ladinian stage of Turkey (Minikh A. V. 1992).

In the northern Cis-Caspian, the Inder suite is correlated to the Bukobaj suite from the South Cis-Urals by tetrapod and fish faunas. A vertebrate locality, Kara-Bala-Kantemir, was discovered in the suite stratotype in the vicinity of Inder Lake (Ochev & Smagin 1974). This is situated on the north-eastern shore of Inder Lake on the hill top, 200 m to the south of Kara-Bala-Kantemir graves (masars). There, in the greyish-green clays of the Inder suite, along with the bones of mastodonsaur fauna tetrapods, ostracodes and charae (Lipatova *et al.* 1969), the remains were found that are typically representatives of the Middle Triassic Bukobaj ichthyofaunal group: ceratodontid tooth plates (*Ceratodus orenburgensis* Minich) and a cartilaginous ganoid (*Saurichthys ultimus* A. Minich).

CONCLUSION

The wide distribution of ichthyofaunas, similar in composition, in the south-east of the Russian Plate and in the northern Cis-Caspian, as well as the general succession in its change with time, indicate the unity of depositional basins in the Triassic, all over the considered territory. Such fishes as hybodonts, ceratods and saurichthiids prove to be very cosmopolitan. They are widespread and common in the Triassic deposits from practically all the continents of the globe (Minikh 1977; Minikh A. V. 1982). This may be used for solving the important problems of distant inter-regional and intercontinental correlations of marine, semi-marine and continental Triassic deposits.

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REFERENCES

- Anonymous 1982. — Decisions of the interdepartment stratigraphic Conference on the Triassic of the East European Platform (Saratov, 1979). With regional stratigraphic schemes. *VSEGEI*, Leningrad, 66 p. [in Russian].
- Auerbakh I. B. 1871. — Bogdo Mountain. *Transactions of Russian Geographic Society*, volume 4, 82 p. [in Russian].
- Buch L. von 1885. — Explication de trois planches d'Ammonites. *Gesammelte Schriften*, volume IV, part. 1, 94 p.
- Efremov I. A. & V'yushkov B. P. 1955. — Catalogue localities of the Permian and Triassic terrestrial vertebrates in the USSR territory. *USSR AS Paleontological Institute Transactions*, volume 46, 185 p. [in Russian].
- Garyainov V. A. & Ochev V. G. 1962. — *Catalogue of vertebrate localities within the Permian and Triassic deposits from the Orenburg Cis-Urals and the south of Obshchy Syrt*. Saratov University Publication, 63 p. [in Russian].
- Khabakov A. V. 1932. — On lungfish (*Ceratodontida* fam.) remains from the Lower Triassic of Bogdo mountain. *USSR AS Paleozoological Institute Transactions*, volume 1: 45-55 [in Russian].
- Lipatova V. V. 1967. — On the German type of the Triassic from the Peri-Caspian Depression. *USSR AS Transactions*, geological serie, No. 1: 58-67 [in Russian].
- Lipatova V. V., Rykov S. P., Starozhilova N. N., Lopato A. Yu. & Makarova I. S. 1965. — New data on the Triassic deposits from the Peri-Caspian Depression: 282-287 [in Russian], in *Regional geologic-geophysic research in the border zone of the Peri-Caspian Depression*. Saratov.
- Lipatova V. V., Sajdakovsky L. Ya. & Starozhilova N. N. 1969. — Paleontologic grounding for recognition of the Middle Triassic within the Peri-Caspian Depression. *USSR AS Transactions*, geological serie, No. 3: 77-87 [in Russian].
- Minikh A. V. 1975. — Ichthyodorulites and their importance for stratigraphy of the Tatarian and Kasanian deposits from the east of European USSR, in *Stratigraphy and paleontology problems*, Saratov University Publication 1: 29-32 [in Russian].
- 1982. — *Saurichthiids and hybodontids from the Triassic of the east of the European USSR and their stratigraphic importance. An abstract of the Candidate of Geology Thesis*. Saratov University publication, 22 p. [in Russian].
- 1985. — New representatives of *Hybodus* genus squaliforms from the Triassic of the USSR European east. *Paleontological journal*, No. 3: 66-70 [in Russian].
- 1992. — Saurichthyid (*Saurichthyiformes* order) from the Middle Triassic of the South Cis-Urals: 146-151 [in Russian], in *Paleontology problems*, Saint-Petersburg University Publication, volume 10.
- Minikh M. G. 1969. — The Importance of Dipnoan Remains for Stratigraphy of the Triassic beds from the east of the USSR European Part, in *Geology Problems of the South Urals and Volga Region*, Saratov University Publication 6: 137-145 [in Russian].
- 1972. — *Fish, Stratotype section of the Lower Triassic Baskunchak series from Bolshoye Bogdo Mountain*. Saratov. Saratov University Publication: 48-50 [in Russian].
- 1977. — *Triassic lungfish from the east of European USSR*. Saratov University Publication, 96 p. [in Russian].
- Mojsisovich E. 1882. — Die Cephalopoden der Mediterranen Triasprovinz. *Abhandlungen d.k.-K. Geol. R.-A.*, vol. X.
- Molostovsky E. A. 1983. — *Paleomagnetic stratigraphy of the Upper Permian and Triassic from the east of the European USSR*. Saratov University Publication, 168 p. [in Russian].
- Ochev V. G. 1992. — To the history of the Triassic vertebrates from the Cis-Urals. *MOIP Bulletin, geological department*, volume 67, No. 4: 30-43 [in Russian].
- Ochev V. G. & Smagin B. N. 1974. — On the Triassic vertebrates localities near Inder Lake. *MOIP Bulletin, geological department*, volume 49, No. 3: 74-81 [in Russian].
- Ochev V. G., Tverdokhlebova G. I., Minikh M. G. & Minikh A. V. 1979. — *Stratigraphic and paleogeographic importance of the Upper Permian and Triassic vertebrates from the East European Platform and Cis-Urals*. Saratov University Publication, 160 p. [in Russian].
- Pallas L. von 1788. — *Travel over various Provinces of Russia*, Part 3. Saint-Petersburg [in Russian].
- Rykov S. P. & Ochev V. G. 1966. — On the Triassic vertebrates localities in the Don Bend, in *Geology problems of the South Urals and Volga region*, Saratov University Publication, issue 3: 58-62 [in Russian].
- Tverdokhlebov V. P. 1966. — New data on stratigraphy of the Lower and Middle Triassic deposits from the Cis-Ural Deflection within the Orenburg and Bashkiria Cis-Urals, in *Geology problems of the South Urals and Volga region, The Mesozoic*, Saratov University Publication, issue 3, part 2: 3-24 [in Russian].

- 1967a. — New data on the stratigraphy of the Lower Triassic deposits from the Orenburg and Bashkiria Cis-Urals, in *Geology problems of the South Urals and Volga region*, Saratov University Publication, issue 4, part 1: 45-77 [in Russian].
- 1967b. — Stratigraphy of the Middle and Upper Triassic from the South Cis-Urals, in *Geology problems of the South Urals and Volga region*, Saratov University Publication, issue 4, part 1: 78-91 [in Russian].
- 1970. — The Baskunchak deposits from the left-bank region of the Samara River and Obshchy Syrt (Orenburg and Bashkiria Cis-Urals), in *Geology problems of the South Urals and Volga region, The Paleozoic and Mesozoic*, Saratov University Publication, issue 7, part 1: 96-101 [in Russian].
- Vorobyova E. I. & Minikh M. G. 1968. — An experience of biometry application to ceratodontid tooth-plates study. *Paleontological journal*, No. 2: 77-87 [in Russian].

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