Continental Triassic biostratigraphy of the Bolshaya Synya and Korotaikha depressions, North CisUrals, Russia : Tetrapod and palynological data

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Novikov IV & Ilyina NV 1995. Continental Triassic biostratigraphy of the Bolshaya Synya and Korotaikha depressions, North CisUrals, Russia : Tetrapod and palynological data. *Palaeobotanist* **44** : 128-138.

The study of rich palaeontological samples from the continental Triassic deposits of the Bolshaya Synya and Korotaikha depressions, North CisUrals, Russia, has provided a new evidence of age. Palynological and tetrapod data indicate substantial changes in the dating of the Lower and Middle Triassic units, and allow correlation with the standard stratigraphic scheme established in the East European Platform and South CisUrals.

Key-words—Continental Triassic, Biostratigraphy, Tetrapod fauna, Palynology, North CisUrals (Russia).

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साराँश

रूस में उत्तर सिसयूराल में कोरोतेखा एवं बोलशाया सिनया दबावों का महाद्वीपीय त्रिसंधी जैवस्तरविन्यास : टेट्रापोड एवं परागाणविक आँकड़े

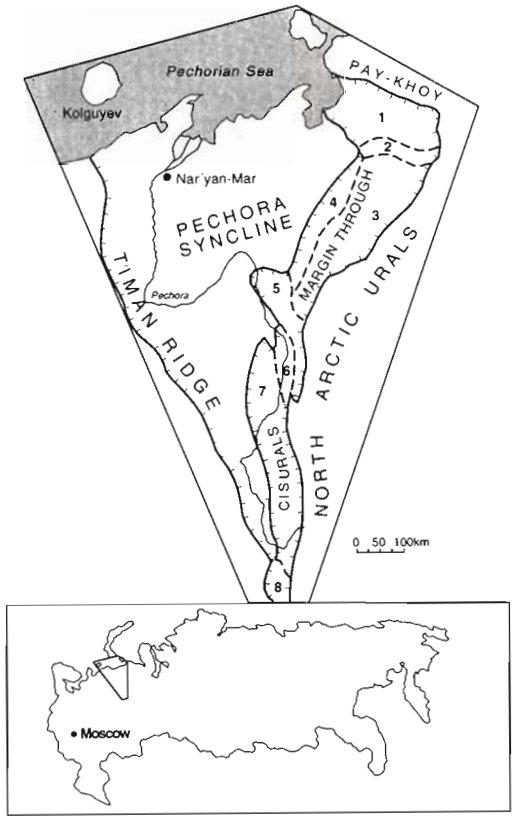
आई. वी. नोविकॉफ एवं नताली वी. इलिना

रुस में उत्तर सिसयूराल में कोरोतेखा एवं बोलशाया सिनया नामक दबावों के त्रिसंधी कालीन निक्षेपों के जैवस्तरविन्यास से आयु सम्बन्धी नये प्रमाण उपलब्ध हुए हैं। परागाणविक एवं टेट्रापोडी ऑकडों से अधिक एवं मध्य त्रिसंधी इकाईयों के कालनिर्धारण में महत्वपूर्ण परिवर्तन प्रेक्षित किये गये हैं। इसी के आधार पर पूर्व यूरोपीय प्लेटफॉर्म एवं दक्षिण सिसयूराल में मानक स्तरिक मॉडल से इसका सहसम्बन्धन भी सम्भव हुआ है।

TRIASSIC deposits of the Northern CisUrals Margin Trough are mainly represented by continental facies, and these occur in isolated structures, for each of which there is a separate stratigraphic scheme (Anonymous, 1980). The most complete Triassic sections, including all three parts, are defined in the Bolshaya Synya and Korotaikha depressions (Text-figure 1).

Palaeontologically, these are also the best defined and richest sequences. This, together with relatively good knowledge of the lithology, confirms the high significance of the Triassic sections in these depressions for the Northern CisUrals Margin Trough as a whole.

Triassic biostratigraphic schemes for the Bolshaya Synya and Korotaikha depressions have been based mostly on palynological data. Land tetrapod remains, which provide a reliable basis for the stratification of the continental Triassic in contiguous territories (South CisUrals, East European Platform), were poorly-known hitherto. During the last few years, rich diagnostic tetrapod material has been collected by I.V.N. from different Triassic stratigraphic levels in these depressions. In addition, revision of previously described palynological assemblages as well as the study of new material obtained by E.D. Morakhovskaya, I.Z. Kalantar and the authors from the stratotypical and reference Triassic sections in the Pechora, Maly Aranets, Bolshaya Synya (Bolshaya Synya Depression) and Khey-Yakha (Korotaikha Depression) River basins, has been carried out by N.V.I. All these investigations have made it possible to revise the stratigraphic schemes adopted for-



Text-figure 1 — Major structural elements of the North CisUrals, Russia. Abbreviations: **1**, Korotaikha Depression; **2**, Chernov Rise; **3**, Kosyu-Rogovaya Depression; **4**, Chernyshev Ridge; **5**, Bolshaya Synya Depression; **6**, Srednyaya Pechora Depression; **7**, Verkhnyaya Pechora Depression; **8**, Polyudovskoye Rise.

merly for the Bolshaya Synya and Korotaikha depressions.

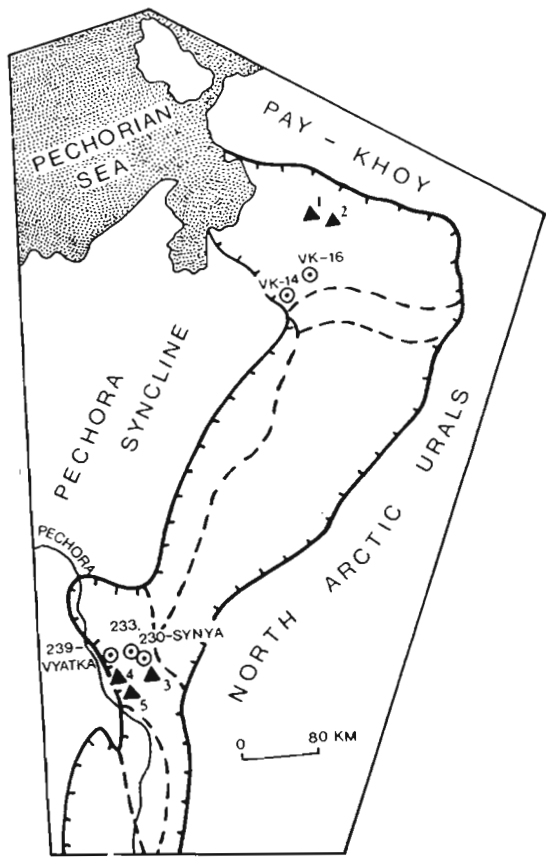
LITHOLOGY AND PALAEONTOLOGY

Bolshaya Synya Depression

At present, in the Bolshaya Synya Depression, Triassic sediments are subdivided into the following members (in ascending order): the Ust-Berezovka Formation, the Byzovaya Formation, the Krasny Kamen Formation, the Keryamayol Formation and the Synya Formation (Anonymous, 1980).

Ust-Berezovka Formation — The Ust-Bere-zovka Formation is represented mainly by greenish-grey sandstones and reddish-brown clays in alternation. A basal large-pebble conglomerate ranges from 5 m thick (Bolshaya Synya River) to 20 m thick (Berezovka River). The thickness of the formation as a whole is up to 300 m.

Palynological data characterize only the lower part of the formation section in the Bolshay Synya River Basin (Text-figure 2). Three restudied samples have been obtained from the interlayer of dark-grey clays (outcrop 66, layer 2, here and hereinafter the outcrop numeration is given according to Chalyshev Varyukhina, 1966). The palynospectra indicate a palynocomplex where the spores prevail. Among them, representatives of *Aratrisporiles* (*A. robustus* Yaroshenko & Golubeva and *Aratrisporites* with fine ornamentation), various species of *Verrucosisporites* and *Nevesisporites* (*N. limatulus* Playford, *N. fossulatus* Balme, *N.* sp.) are dominant. The content of *Punctatisporites* (*P. fungosus* Balme, *P. triassicus* Schulz, *P.* sp.), *Dictyophyllum vulgaris* (Mal.)



Text-figure 2—The principal Triassic vertebrate and palynological localities in the Bolshaya Synya and Korotaikha depressions, North CisUrals, Russia. Abbreviations: **1**, Khey-Yakha; **2**, Nyadeitayu; **3**, Bolshaya Synya; **4**, Byzovaya; **5** Maly Aranets. The other numbered sites are bore-holes mentioned in the text.

Kruchinina and *D.* sp. spores is fairly abundant. *Kraeuselisporites cuspidus* Balme, *K.* sp., *Lundbladispora willmottii* Balme, *Densoisporites* sp., *Retusotriletes radiatus* (Kara-Murza) Warzuchina, *Cyclogranisporites* sp., *Camptotriletes warchianus* Balme, *C. verrniformis* Romanovskaya and *C. cerebriformis* Naumova are present in reduced numbers. The presence of forms, mainly distributed elsewhere in the Middle and Upper Triassic- *Todisporites major* Couper, *T.* sp., *Duplexisporites* sp. and *Carnisporites* sp. is significant. The pollen of *Ginkgocycadophytus* predominates in the pollen part of the complex. *Taeniaesporites* is represented by single pollen grain. This palynoassociation is practically identical to the late Olenekian *Aratrisporites robustus* - *Verrucosisporites pseudomorulae* palynocomplex of the Kharaley Formation in the Pechora Syncline (Yaroshenko & Golubeva, 1989). A similar complex was described by N.A. Koloda from the speckled clay and sandstone horizon of the Mezen Syncline, correlated with the Late Olenekian Yarenskian Horizon of the Moscow Syncline (Budanov *et al.*, 1972). Thus, the miospore complex from the lower part of the Ust-Berezovka Formation in the Bolshaya Synya River basins is of Late Olenekian age.

Byzovaya Formation — This formation is formed by greenish-grey and yellowish-grey cross-bedded sandstones with rare lenses of red clays and siltstones. The occurrence of sandy-carbonate concretions and heavy ore-mineral grains is typical for the sandstones. The upper part of the formation (approximately 20 to 30 m) in the south-eastern part of the Bolshaya Synya Depression (Bolshaya Synya River Basin) is represented by violet boulder-pebble conglomerates with single interlayer of violet-red sandstones. The thickness of the formation is up to 520 m.

The land tetrapod remains have key significance for the dating of the formation. Its lower part (stratotypical outcrop near Byzovaya Village; Text-figure 2) is characterized by the following tetrapod assemblage : *Wetlugasaurus* sp., *Tichvinskia* sp., *Tsylmosuchus* sp., *Microcnemus* sp., *Chasmatosuchus* (?) sp. and Thoosuchinae gen. indet. (*Angusaurus ?*). On the basis of association of the first three forms mentioned above, this complex is correlatable with the Early Olenekian *Wetlugasaurus* grouping of the Neorhachitome Fauna, which typifies the Sludkian Horizon and its analogues in the Lower Triassic of the East European platform and South CisUrals (Ochev & Shishkin, 1989). The procolophonid *Tichvinskia* (?) was also found in the lowermost part of the formation section (outcrop 70) in the Bolshaya Synya River Basin (Novikov *et al.*, 1992).

The upper main part of the formation is characterized by the find in the Bolshaya Synya River Basin (outcrop 70; Text-figure 2) of a skull fragment of a large thecodontian, assigned to the family Erythrosuchidae? (or Rauisuchidae ?) and estimated to be not earlier than Yarenskian (Late Olenekian) in age (Novikov *et al.*, 1992).

A Late Olenekian miospore complex has been identified by L.P. Golubeva in well 230-Synia at a depth of 1032. 0 m. This complex, comparable to the Ust-Berezovka, has some more forms characterizing the Middle Triassic : *Concentricisporites, Raistrickia* and *Lygodiumsporites* (cf. *Converrucosisporites*). Pollen grains include *Volziaceaesporites heteromorpha* Klaus, *Taeniaesporites, Chordasporites, Platysaccus, Alisporites, Sulcatisporites, Protohaploxypinus* and *Ginkgocycadophytus.*

Krasny Kamen Formation — The Krasny Kamen Formation is represented by reddish-brown clays, greenish-grey sandstones and siltstones. The lower part of the formation section in the Bolshaya Synya River Basin is formed by yellow conglomerates and sandstones with interlayers of raspberry-red and snuff-green clays and sandstones. The thickness of the formation is up to 250 m.

The stratotypical section of the Krasny Kamen Formation (Bolshaya Synya River Basin) is characterized by a palynocomplex which is defined both at the bottom of the formation section (a bed of yellow conglomerate) and in upper stratigraphic levels (a bed of intercalated sandstones and clays). Spores prevail over pollen in this palynocomplex. The presence of such forms as *Concentricisporites, Duplexisporites* (*D. gyratus* Playford & Dettmann, *D.* sp.), *Lygodiumsporites* (*L.* cf. *Converrucosisporites* de Jersey), *Dictyotriletes macroreticulatus* Rovnina, *Comptotriletes cerebriformis* Naumova and *Aratrisporites fischeri* (Klaus) Playford & Dettmann among spores is an index of the Middle Triassic age of the assemblage. Forms which are characteristic of Early Triassic palynocomplexes are fairly abundant. These include species

of the genera *Verrucosisporites* (*V. morulae* Klaus, *V. thuringiacus* Madler, *V.krempii* Madler, *V.* sp.) and *Punctatisporites* (*P. fungosus Balme, P. triassicus* Schulz). *Kraeuselisporites septatus* Balme, *Lundbladispora, Densoisporites, Aratrisporites robustus* Yaroshenko & Golubeva, *A. scabratus* Klaus are rare. The spores of *Nevesisporites limatulus* Playford, *N. macrogranulatus* Romanovskaya, *Carnisporites hercynicus* Mädler and *Dictyophyllum*, as well as similar to them in morphology. *Todisporites* sp., *Osmundacidites senectus* Balme, representatives of the families Calamitaceae and Matoniaceae are represented by different quantities. The appearance of single spore of *Stereisporites radiatus* Schulz and *Uvaesporites argentaeformis* (Bolch.) Schulz, characterizing the Late Triassic, should be noted. The pollen of *Platysaccus queenslandi* de Jersey, *P. leschikii* Hart, *Alisporites grauvogelii* Klaus, *A. cf. parvus* de Jersey make the main share of the nonstriate pollen component. *Voltziaceaesporites heteromorpha* Klaus, *Falcisporites stabilis* Balme, *Chasmatosporites* sp., *Klausipollenites schaubergeri* (Potonié & Klaus) Jansonius and *Heliosaccus* sp. persist in reduced numbers. The bisaccate striate forms are represented by *Taeniaesporites noviaulensis* Leschik, *T. novimundi* Jansonius, *T. pellucidus* (Goubin) Balme, *T.* sp., *Chordasporites singulichorda* Klaus and by a single grain of *Protohaploxypinus samoilovichii* (Jansonius) Hart and *Striatopodocarpites* sp.

On the whole, on the basis of the presence of characteristic Middle Triassic forms and the abundance of nonstriate pollen and Early Triassic elements among spores, the palynocomplex of the Krasny Kamen Formation is close to the palynoassociation of the Middle Triassic Eltonskian Horizon of the CisCaspian Depression and to the palynoassociation from the Anisian (*Paraceratites trinodosus* ammonite zone) of Romania (Antonescu, 1970).

An Anisian palynoassemblage has also been identified by O.P. Yaroshenko from the Krasny Kamen Formation in well 239-Vyatka (depth 1200 m), and by L.P. Golubeva, N.V. Ilyina and I.S. Makarova in well 233-Synya (at depths of 621-821 m) as well as in the Maly Aranets River Basin (outcrop 151; Text-figure 2), from where the find of a new plagiosaur genus *Aranetsia (A. improvisa* Novikov & Shishkin) has been reported (Novikov & Shishkin, 1992). Taking into consideration, on the one hand, that this plagiosaur temnospondyl is close to the Ladinian *Plagiosternum* and, on the other hand, that there have been no reliable finds of plagiosaurs in the Early Anisian *Heptasaurus-Eocyclotosaurus* fauna of Central Europe, we tend to attribute *Aranetsia* to the Late Asinian (Novikov & Shishkin, 1992). The fact *Aranetsia* found in an extremely impoverished Maly Aranets locality, also argues in favour of its Middle Triassic dating, because Plagiosterninae became widespread only after this time (Shishkin, 1987).

Keryamayol Formation — The Keryamayol Formation is composed of mottled (violet-brown, red, greenish- and yellowish-grey) clays with subordinate interlayers of yellowish-grey sandstones, siltstones and clays. Carbon-bearing bands occur sometimes in the sandstones, and siderite and phosphate concretions have been noted in the clays and siltstones. The thickness of the formation is 150-230 m.

The lower part of the Keryamayol Formation in well 233-Synya (at depths of 590-601 m) is characterized by a palynocomplex that is close to one from the Krasny Kamen Formation, on the basis of its taxonomic composition. Their principal distinctions are in the abundance of pollen grains of *Angusticulcites, Sulcatisporites, Microcachryidites*, and spores of *Duplexisporites* in the former. However, these distinctions make it possible to correlate the assemblage from the lower part of the Keryamayol Formation with one from the base of the Donguz Formation of the South CisUrals, which in its lower part is of Late Anisian age (Novikov *et al.*, 1992).

The second palynocomplex of the Keryamayol Formation was established from the stratotype (Bolshaya Synya River Basin, outcrop 71) which corresponds, probably, to the upper part of the formation (Text-figure 2). This complex has its own well defined character. The genera *Concentricisporites, Lygodiumsporites, Camptotriletes, Raistrickia, Leschikisporites* and *Perotriletes* are commonly present. The significant specific diversity and abundance of spores of the genus *Duplexisporites* (*D. gyratus* Playford & Dettmann, *D. scanicus* (Nilsson) Playford & Dettmann, *D. problematicus* (Couper) Playford & Dettmann, *D.* sp.) is characteristic of this assemblage. Representatives of the genera *Aratrisporites, Nevesisporites, Todisporites, Carnisporites, Apiculatisporites* and *Dictyophyllum* are abundant.

The quantity of Early Triassic elements such as *Densoisporites, Lundbladispora, Kraeuselisporites, Punctatisporites* and *Verrucosisporites* is markedly reduced. Most important for this palynoassociation is the presence of forms characterizing different stratigraphic levels of theUpper Triassic of Western Europe (*Camerozonosporites rudis* (Leschik) Klaus, *Anapiculatisporites telephorus* (Pautch) Jansonius, *Lycopodiacidites, Uvaesporites, Camerosporites pseudoverrucatus* Scheuring, *Pseudensonalasporites summus* Scheuring, *Taurocusporites* sp.) and the Middle-Upper Triassic of Australia (*Punctatosporites walkomi* de Jersey, *Polypodiisporites ipsviciensis* (de Jersey) Playford & Dettmann, *Polycingulatisporites dentatus* de Jersey, *P. crenulatus* Playford & Dettmann) (Klaus, 1960; Morbey, 1975; Playford & Dettmann, 1965; Scheuring, 1970). The Middle-Upper Triassic species of the genera *Florinites* (*F. pseudostriatus* Kopytova, *F. walchius* Kopytova), *Platysaccus* (*P. leschikii* Hart, *P. queenslandi* de Jersey), *Alisporites* (*A. australis* de Jersey, *A. landianus* Balme, *A. plicatus* Kar, Kieser & Jain, *A. grauvogelli* Klaus), *Voltziaceaesporites* (V. *heteromorpha* Klaus, *V. globosus* Fisher & Dunay), *Chordasporites* (*C. singulichorda* Klaus, *C. minutus* Kar, Kieser & Jain), *Microcachryidites* (*M. doubingeri* Klaus, *M. sittleri* Klaus), *Minutosaccus* (*M. potoniei* Madler, *M. schizeatus* Madler) as well as *Sulcatisporites, Chasmatosporites, Podosporites amicus* Scheuring, *Ovalipollis ovalis* (Krutzsch) Scheuring and *Podocarpites* are abundant in the palynoassemblage. Pollen genera *Classopollis, Triadispora, Parillinites* and *Heliosaccus* are rare.

The palynocomplex from the upper part of the Keryamayol Formation is similar to one obtained from the Inderskian and Masteksayskian horizons of the CisCaspian Depression, which are of Ladinian age (Anonymous, 1982; Ochev & Shishkin, 1989). Moreover, it can be compared with the palynoassociation of the Bukobay Formation of the South CisUrals, characterized by the Late Ladinian *Mastodonsaurus* fauna (Ochev & Shishkin, 1989). Thus, the second palynocomplex of the Keryamayol Formation is Ladinian in age.

The stratotype of the Keryamayol Formation is also characterized by its vertebrate fauna. The capitosauroid temnospondyl *Bukobaja*(?), a new genus of anthracosaur of the family Bystrowianidae, the sauropterygian *Pistosaurus*(?), the prolacertiform *Malutinisuchus*, the rauisuchid *Energosuchus*(?), an undetermined dicynodont and cyclotosaurid temnospondyl, as well as the dipnoans *Ceratodus orenburgensis* Minich and *C.* cf. *jechartiensis* Minich, the actinopterygian *Saurichthys ultimus* A. Minich, the elasmobranch *Hybodus* and the coelacanth *Wimania (?) multistriata* Stensiö are also found (Chalyshev & Varyukhina, 1966; Novikov *et al.*, 1992). This assemblage is comparable to the Late Ladinian *Mastodonsaurus* fauna (Bukobay Formation) of South CisUrals on the basis of the presence of some elements such as *Malutinisuchus, Energosuchus* and the cyclotosaurid temnospondyl.

Synya Formation —- The Synya Formation is subdivided into two members : the Lower Synya Formation and the Upper Synya Formation. The Lower Synya Formation is represented by sandstones intercalated with siltstones and grey clays, with thin interlayers of coal and coal clays, siderite and pyrite concretions and numerous plant remains. The thickness of the formation is up to 550 m.

The Upper Synya Formation ranging in thickness up to 400 m, is formed from grey clays, siltstones and sandstones with siderite and phosphorite concretions and numerous intercalations of coal clays and coal.

The Synya Formation is characterized by two palynocomplexes. The first one comes from the Lower Synya Formation. It is identical to that of the Keryamayol Formation and may also be dated as Ladinian. The second complex was obtained from the Upper Synya Formation in the Well 202-Mishayag (at depths of 151-485 m; L.P. Golubeva, 1979). It differs sharply from the palynoassociation of the Lower Synya Formation in specific composition; there is a change in predominant forms. The smooth triangular forms of *Dictyophyllum* and *Matonisporites* are the predominant spores. Representatives of *Duplexisporites, Osmundacidites*, Calamitaceae and Marattiaceae are abundant. The spores of *Aratrisporites* and *Nevesisporites*, widespread in the Lower and Middle Triassic, are represented by rare specimens. Typical Upper Triassic forms appear and are widespread on this stratigraphic level. These are *Zebrasporites, Heliosporites, Rubinella, Ricciisporites tuberculatus* Lundblad, *Camerozonosporites rudis* Klaus, *Cingulizonales*

rhaeticus Schulz, *Limposporites lundbladii* Schulz, *Uvaesporites, Stereisporites* and *Annulispora*. The pollen component is dominated by *Pinuspollenites* and *Caytonipollenites*, accompanied by *Podozamites, Microcachryidites, Florinites, Chasmatosporites* and *Ginkgocycadophytus*. This palynocomplex seems to be Rhaetian in age (Golubeva, 1979).

Undetermined vertebrate remains obtained from the Lower Synya Formation in the Bolshaya Synya River Basin (Chalyshev & Veryukhina, 1966) unfortunately can not be helpful for dating.

Korotaikha Depression

Triassic deposits of the Korotaikha Depression are subdivided into the Lower Lestanshor, the Upper Lestanshor and Nyadeita formations (Anonymous, 1980).

Lower Lestanshor Formation — The Lower Lestanshor Formation (up to 1000 m) in the stratotypical outcrop (Kheya-Yakha River), characterizing the northeastern slope of the depression, is represented by a bed of greenish-grey sandstones, reddish-brown argillites and siltstones. Two basaltic lava horizons occur at the bottom of the formation in the southern part of the depression (Well VK-14).

The land tetrapod remains and palynocomplexes are the most important for dating of the formation. Two tetrapod assemblages are defined here. The first occurs in the middle part of the formation and is found at two localities : Khey-Yakha (Khey-Yakha River), and Nyadeitayu (Nyadeitaya River), Text-figure 2. The procolophonids *Orenburgia bruma* Ivachnenko and *Lestanshoria massiva* Novikov, the temnospondyls *Wetlugasaurus* (?) sp. and Thoosuchinae gen. indet. (*Angusaurus* ?) and the prolacertiform *Microcnemus* are known from the former and *Orenburgia* and Angusaurus come from the latter. This tetrapod assemblage is compared with Early Olenekian *Wetlugasaurus* grouping of the Sludkian Horizon and its analogues of the East European Platform and South CisUrals (Ochev & Shishkin, 1989). Moreover, the presence of procolophonid *Orenburgia* permits us to consider this tetrapod complex as an analogue of the Early Olenekian "Tsylmenskian" Assemblage, identified by I.V. Novikov in the uppermost part of the Charkabozhskaya Formation of the Pechora Syncline (Novikov, 1993).

The second tetrapod assemblage originates in the upper part of the formation in the Khey-Yakha River Basin. The assemblage includes the temnospondyls *Parotosuchus* cf. *komiensis* Novikov, *Inflectosaurus* (?), *Batrachosuchoides*, the procolophonid *Tichvinskia* (?) and undetermined remains of prolacertiforms and rauisuchids. It corresponds to the Late Olenekian *Parotosuchus* Fauna (Yarenskian Horizon and its analogues of the East-European Platform and South CisUrals) based on the occurrence of the temnospondyls mentioned above. The presence of the genus *Parotosuchus* makes it possible to compare this assemblage with the tetrapod association from the Middle Buntsandstein of Central Europe. The other elements of the second assemblage (in spite of uncertain types due to poor preservation) also rather definitely support younger than Early Olenekian age of the host rocks. Specifically, the cervical vertebra of the Khey-Yakha prolacertiform is very similar to an undescribed one from the Lower Triassic of the CisDonetsk Trough (A.G. Sennikov, pers. comm.), found together with a typical association of the Late Olenekian *Parotosuchus* Fauna. Morphological features of the Khey-Yakha prolacertiform resemble those of the vertebrae of *Tanystropheus antiquus* Huene from the Upper Buntsandstein and the Lower Muschelkalk of the German Basin.

The Lower Lestanshor Formation is characterized by three palynocomplexes. The first is determined at the bottom of the formation in well VK-14 at a depth of 844.5m. The spores prevail over pollen in this complex, the main taxa being three-ray cavate spores such as *Pechorosporites, Kraeuselisporites* and *Lundbladispora. Aratrisporites wollariensis* Helby, *A. paraspinosus* Klaus and *A. strigosus* Playford are fairly abundant. Less abundant are spores of the genera *Densoisporites* and *Punctatisporites* accompanied by *Anaplanisporites stipulatus* Jansonius, *Proprisporites pocockii* Jansonius, *Osmundacidites senectus* Balme, *Naumovaspora* sp., *Baculatisporites* sp. and *Nevesisporites* sp. The occurrence of *Tschernyscheviisporites* and *Seidisporites* spores, which are widespread in the Korotaikha Depression at this stratigraphical level, is typical of the palynocomplex. The pollen part is dominated by *Taeniaesporites* (*T. noviaulensis* Leschik, *T. novimundi* Jansonius, *T.*

pellucidus (Goubin) Balme, *T. transversundatus* Jansonius) and *Ginkgocycadophytus.*

The first palynocomplex of the Lower Lestanshor Formation is correlated with the *Pechorosporites disertus* palynocomplex, presumably Induan in age, and found in the lowermost part of the Charkabozhskaya Formation of the Pechora Syncline (Yaroshenko & Golubeva, 1981, 1989). Its main distinction is the lack of *Rewanispora foveolata* de Jersey, *Retusotrisporites radiatus* (Kara-Murza) Warjuchina and *Leptolepidites jonkeri* Jansonius in the former. Accordingly one comes from the Vokhmian Horizon of the Moscow to specific composition, the first Lower Lestanshor palynocomplex appw Syncline (Yaroshenko & Golubeva, 1981), which was dated on the basis of the tetrapod fauna as Induan (Ochev & Shishkin, 1989). Other analogues of the palynocomplex are known from *Lundbladispora obsoleta-Protohaploxypinus pantii* palynozone of the Poland - Lithua Syncline (Orlowska-Zwolinska, 1984) and from *Otoceras* ammonite zone of the Toad-Grayling Formation of western Canada (Jansonius, 1962). Moreover, it is close to the *Protohaploxypinus* and *Taeniaesporites* palynozone associations from the Griesbachian Stage of Eastern Greenland, characterized by the ammonites *Otoceras woodwardi* and *Glyptophiceras (Hypophiceras) triviale* and by the bivalve *Claraia* (Balme, 1979).

The second palynocomplex of the Lower Lestanshor Formation was determined also in Well VK-14 at depths of 801.5-807.5 m. Species of *Aratrisporites,* viz., *(A. paenulatus* Playford & Dettmann, *A. tenuispinosus* Playford, *A. strigosus* Playford, *A. granulatus* (Klaus) Playford & Dettmann, *A. tschalyshevii* Warjuchina, *A. fimbriatus* Klaus, *A. parvispinosus* (Leschik) Playford are dominant. Spores of *Densoisporites, Lundbladispora, Pechorosporites, Punctatisporites, Retusotriletes radiatus* (Kara-Murza) Warjuchina, *Leptolepidites verrucatus* Couper, *Anaplanisporites stipulatus* Jansonius, *Leiotriletes* and *Osmundacidites senectus* Balme are present in reduced numbers. The genera *Cyclogranisporites* and *Dictyophyllum* appear. The pollen of *Ginkgocycadophytus* is the main component of this palynocomplex followed by the pollen of *Taeniaesporites* and *Alisporites.*

The second palynocomplex may be compared with the Early Olenekian *Densoisporites nejburgii - Lundbladispora variabilis* palynoassociation from the upper part of the Charkabozhskaya Formation of Pechora Syncline (Yaroshenko & Golubeva, 1989). The miospore complex from the Early Olenekian Rybinsk Formation of the Moscow Syncline is also a comparable palynoassociation (Yaroshenko & Golubeva, 1981). The second palynocomplex shows some similarity with the palynoassociations of *Densoisporites nejburgii* palynozone (Middle Buntsandstein) in the Poland-Lithua Syncline (Orlowska-Zwolinska, 1984), the lower part of the Locker Formation in the Camarvon Basin (Western Australia) Doldy & Balme, 1976) and of the Mittiwali and, probably, Narmia members in West Pakistan (Balme, 1970).

The third palynocomplex originates in the upper part of the Lower Lestanshor Formation. It is determined from a few tetrapod localities in the basin of the Khey-Yakha River, where a typical element of the Late Olenekian *Parotosuchus* Fauna *(Batrachosuchoides),* together with undetermined remains of capitosaurids, were found. Its composition is analogous to one of the palynoassociations described above for the Ust-Berezovka and Byzovaya formations, and it may also be dated as Late Olenekian.

Upper Lestanshor Formation— This formation at the base has a thick bed of grey sandstone with equisetalean remains, lens-shaped interlayers of coal argillite and sandy-carbonate concretions followed toward to the top by rhythmically interstratified sandstones, siltstones and argillites. The thickness of formation is 160 to 530 m.

The formation is characterized at the bottom by the presence in the Khey-Yakha River Basin of a plagiosaur temnospondyl (*Plagiosternum* ?), which indicates a Middle Triassic age of the host rocks (M.A. Shishkin, pers. comm.).

The palynocomplex of the Upper Lestanshor Formation has been determined by L.P. Golubeva from the Khey-Yakha River Basin (outcrop 190, layer 8). It is very close to that from the Krasny Kamen Formation and may be dated as Anisian (see above).

Nyadeita Formation — The Nyadeita Formation is subdivided into two members : the Lower Nyadeita and the Upper Nyadeita.

The Lower Nyadeita Formation is represented by cyclic alternation of mottled and grey argillites, silt-

stones and sandstones with siderite concretions and plant detritus. The thickness of the formation is from 220 to 700 m. The Upper Nyadeita Formation is known only on the basis of drilling data (wells VK-14 and VK-16). It consists of cyclically alternating grey sandstones, siltstones, argillites with iron-carbonate, phosphorite concretions, abundant plant remains and coals. The thickness of the formtion is up to 1,300 m.

The Nyadeita Formation contains tetrapod remains (*Komatosuchus chalyshevi* Novikov & Shishkin) only in its lower part, which permit correlation of this part of the section with the Anisian Stage, presumably with its lower part (Novikov & Shishkin, 1992).

Two Middle Triassic palynocomplexes have been determined from the rocks of the formation. The first is presumably Anisian in age and occurs in the Lower Nyadeita Formation. According to its taxonomic composition, this palynocomplex is quite analogous with the palynoassociation from the Upper Lestanshor Formation (see above). But the proportions of some palynomorph groups differ higher in the section, within the limits of the complex: the quantity of Early Triassic forms is sharply reduced; the spores of the genus *Kraeuselisporites* are absent. Quantitatively, the spores of *Verrucosisporites, Cyclotriletes, Cyclogranisporites, Cycloverrutriletes presselensis* Schulz and the pollen *Taeniaesporites* are reduced. On the other hand, the quantity of Middle Triassic elements (spores of *Logodiumsporites, Raistrickia, Duplexisporites, Concentricisporites, Leschickisporites, Dictyotriletes macroreticulatus* Rovnina, *Polypodites cladophleboides* Brick, *Phlebopteris*, and pollen *Florinites*) is increased.

The second palynocomplex was determined from the Upper Nyadeita Formation. The quantity of spores of *Verrucosisporites* diminished to single specimen in this complex. The content of spores of *Nevesisporites* and *Aratisporites* is also reduced. On other hand, the content of spores of *Aratrisporites* (cf. *Converrucosisporites*) increases. The pollen component is dominated by *Florinites*. The content of pollen of *Cedripites* and *Alisporites* is estimated to be considerable. The pollen of *Chasmatosporites* and *Caytonipollenites* and *Ginkgocycadophytus* are present.

The second palynocomplex of the Nyadeita Formtion is much less specially diverse than the Ladinian palynoassociation from the upper part of the Keryamayol Formation (see above.) It is difficult to make correlation of these palynocomplexes, but this may be done on the basis of a few taxa. This fact and the indicated difference from the first palynocomplex, permit us to consider the second to be characteristic of a higher stratigraphic level than Anisian (presumably Ludinian).

DISCUSSION AND CONCLUSION

New tetrapod and palynological data have permitted more precise (and in some cases changed) dating of the Triassic formations in the Bolshaya Synya and Korotaikha depressions and, in particular, correction of the extent of all three parts of the Triassic developed there.

The Ust-Berezovka and formations of the Bolshaya Synya Depression and the upper predominant part of the Lower Lestanshor Formation of Korotaikha Depression were previously dated as Induan (Anonymous, 1980). However, this paper has presented compelling evidence that tetrapods and palynoassemblages of Olenekian age are contained in these units. An Early Olenekian tetrapod fauna is determined from the lower part of the Byzovaya Formation and the middle part of the Lower Lestanshor Formation. The latter also contains Early Olenekian palynomorphs. Late Olenekian tetrapods and palynoassemblages have been discovered in the upper parts of the Byzovaya and the Lower Lestanshor formations. Indirect evidence of the presence of Upper Olenekian Substage analogue in the Byzovaya Formation shows the occurrence of Yarenskian (Upper Olenekian) temnospondyl of superfamily Trematosauroideae in the sandstone member of the Sharyu River Basin (Chernyshev Ridge) which can be correlated with the Byzovaya Formation lithologically (Anonymous, 1980). The Ust-Berezovka Formation is not characterized by tetrapod remains and contains the Late Olenekian palynomorphs in the Bolshaya Synya River Basin. Thus, only the lowermost part of the Lower Lestanshor Formation, characterising by the palynocomplex close to presumably Induan *Pechorosporites disertus* assemblage, may more or less certainly be correlated with the Induan Stage.

Analogously, the Krasny Kamen Formation of the Bolshaya Synya Depression and the Upper Lestanshor Formation of the Korotaikha Depression previously cor-

related with the Olenekian Stage (Anonymous, 1980) are found to be characterized by Middle Triassic palynomorphs and tetrapods. The Krasny Kamen Formation contains an Anisian palynocomplex and presumably Late Anisian tetrapods (the temnospondyl *Aranetsia*). Based up on this, and taking into consideration the Late Anisian age of the lower part of the Keryamayol Formation which directly overlies the Krasny Kamen Formation, the latter may be correlated with the larger part of the Anisian Stage. The Upper Lestanshor Formation is characterized by the remains of the Middle Triassic plagiosaur *Plagiosternum* ?, recovered from its lower part in the Khey-Yakha River Basin and by an Anisian palynocomplex. The upper age limit of the Upper Lestanshor Formation is defined on the basis of the Early Anisian temnospondyl *Komatosuchus* in the lowermost part of the overlying Nyadeita Formation. Therefore, the Upper Lestanshor Formation is of Early Anisian age. Thus, the lower boundary of the Middle Triassic in the Bolshaya Synya and Korotaikha depresssions has been corrected, and is determined in the base of the Krasny Kamen (for the Bolshaya Synya depression) and the Upper Lestanshor (for the Korotaikha Depression) formations.

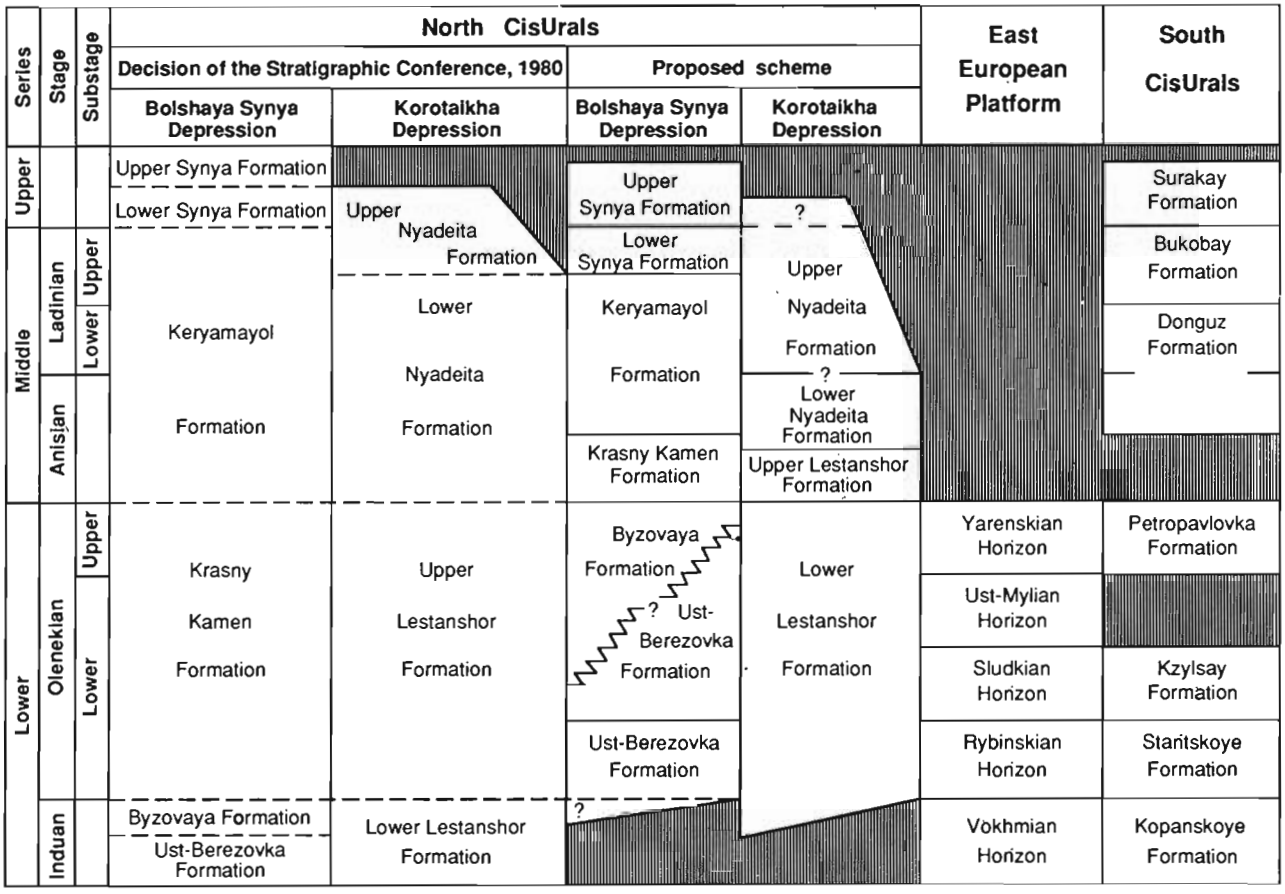
As for the upper boundary of the Middle Triassic, this has also been considerably changed. This boundary was formerly determined in the Bolshaya Synya Depression at the bottom of the Synya Formation and in the lower part of the Upper Nyadeita Formation in the Korotaikha Depression (Anonymous, 1980). However, new miospore data permit the lower member of the Synya Formation (the Lower Synya Formation) and the Nyadeita Formation to be included entirely in the Middle Triassic also. The basis for such a conclusion is the Ladinian palynocomplex characterising both units.

Several complications still exist in the Triassic stratigraphy of the areas considered. The first concern the dating of Ust-Berezovka Formation. The latter is characterized by a Late Olenekian palynoassemblage which has been determined in the lower part of the formation in the Bolshaya Synya River Basin. However, this conclusion is hard to match with the dating of the succeeding Byzovaya Formation, which is undoubtedly Early Olenekian in its lower part on the basis of tetrapod data. It is, therefore, possible that the Ust-Berezovka and Byzovaya formations are at least, in part, lateral equivalents. On the other hand, the outcrop of the Ust-Berezovka Formation in the Bolshaya Synya River Basin is located within the Nitchemyu-Synya Rampart, where the lowermost part of the formation could have been partly or completely eroded (I.Z. Kalantar, pers. comm.). Therefore, for the definition of the lower age limit of the Ust-Berezovka Formation, the data on the lower part of the Charkabozhskaya Formation of the Pechora Syncline correlated with the Ust-Berezovka Formation on the basis of the lithological criteria (Kalantar, 1980) have been used (Anonymous, 1980; Kalantar, 1980; Novikov *et al.*, 1992). The Induan *Pechorosporites disertus* palynocomplex was determined from the lower part of theCharkabozhskaya Formation in a number of wells (Yaroshenko & Golubeva, 1989). These grounds have been assumed for the correlation of the lower part of the Ust-Berezovka Formation with the Induan Stage (Kalantar, 1980; Novikov *et al.*, 1992).

The other question connects with the presence of the Upper Triassic in the Korotaikha Depression. It is quite possible that it is represented in Well VK-16. The palynoassemblage determined here at depth 107.12 m is dominated by spores of *Dictyotriletes macroreticulatus* Rovnina, described first from the Upper Triassic of Western Siberia. Based upon the above observations, a new version of theTriassic stratigraphic schemes for the Bolshaya Synya and Korotaikha depressions (Text-figure 3) has been suggested. It is worth noting that data on other groups (macroflora, phyllopods, gastropods and bivalves) found in the majority of the formations do not contradict our datings (Dobruskina, 1982; Novikov *et al.*, 1992).

ACKNOWLEDGEMENTS

This study could not have taken place without the assistance and invaluable advice of M.A. Shishkin, Palaeontological Institute, Moscow, and P. Golubeva, Timan-Pechora Branch of the All-Russian Petroleum Exploration Institute, Ukhta. We wish to thank I.Z. Kalantar, Timan-Pechora Branch of the All-Russian Petroleum Exploration Institute, Ukhta, E.D. Morakhovskaya and N.K. Kulikova, All-Russian Petroleum Exploration Institute, St.- Petersburg, for the loan of palynological material, V.R. Lozovsky, Moscow Geological Prospecting Institute, V.A. Molin and G.P. Kanev, Institute of Geology, Syktyvkar, for discussions, A.G. Sennikov, Palaeontological Institute, Moscow, for assistance in identification of reptile remains and P.



Text-figure 3 — Correlation of the Triassic deposits of the North and South CisUrals and East European Platform.

Baldaro, University of Bristol, for drawings. We also thank M.J. Benton, University of Bristol and G. Warrington, British Geological Survey, for their constructive criticism of the manuscript. This research was supported by the Palaeontological Institute, Moscow; Institute of Geology, Syktyvkar and Russian Foundation for Basic Research (Project No. 93-04-20024). The paper was completed during the tenure of a Royal Society Postdoctoral Fellowship held by I.V. Novikov at the University of Bristol. This forms Contribution XX of the Moscow-Bristol Joint Palaeontological Research Programme.

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