Stratigraphic correlation of the Upper Permian deposits from the south of the Cis-Ural marginal Trough and the adjacent areas of the Russian Plate

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ABSTRACT
Studied in detail were about 100 sections of the Upper Permian marine and continental deposits from the South Cis-Urals: from the south-eastern edge of the Russian Plate and the Cis-Ural Trough. Characteristic complexes of marine and non-marine ostracodes were distinguished. All the regional stratigraphic units of the Upper Permian were characterized in detail from micropaleontologic point of view. Associated organic remains were specified: tetrapods, bivalves, miospores. Brief lithologo-facies descriptions of the sections from various structural zones are presented. Detailed correlations of the Upper Permian sections from the South Cis-Urals were carried out.

KEY WORDS
Upper Permian, stratigraphy, correlation, South Cis-Urals, Cis-Ural Trough, Russian Plate.

RÉSUMÉ
Une centaine de coupes dans les dépôts marins et continentaux du Permien supérieur du Cis-Oural sont étudiées en détail : de l'extrémité sud orientale de la plate-forme jusqu'à la dépression du Cis-Oural. Des assemblages d'ostracodes marins et continentaux sont distingués. Toutes les unités stratigraphiques régionales sont caractérisées en détail du point de vue micropaléontologique. Les bio-restes associés sont spécifiés : tétrapodes, bivalves, miospores. De brèves descriptions des faciès et de la lithologie sont présentées pour les différentes zones structurales. Des corrélations détaillées pour les coupes du Permien supérieur sont conduites.

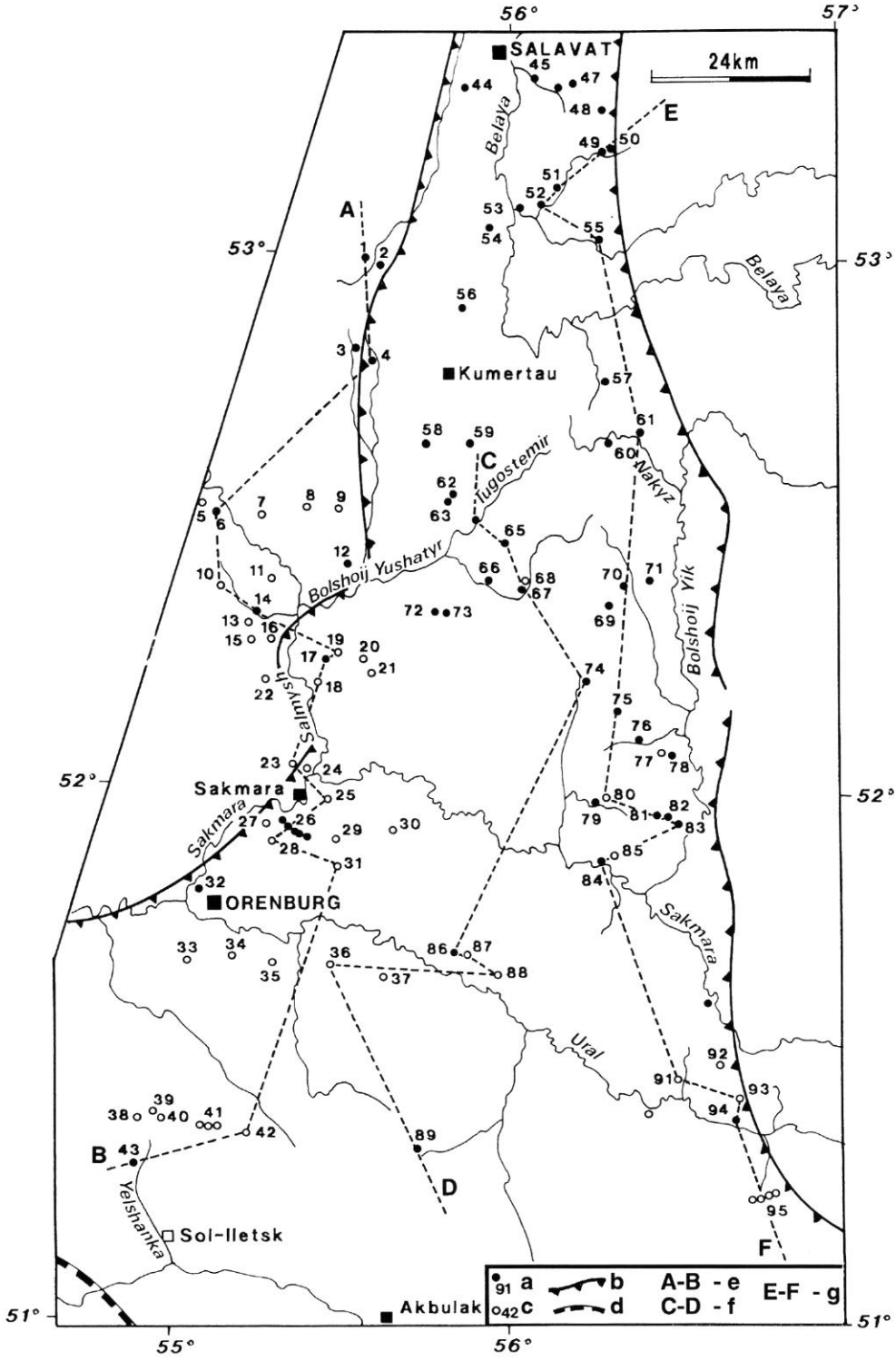
MOTS CLÉS
Permien supérieur, stratigraphie, corrélations, Sud Oural, Cis-Oural, plate-forme russe.

INTRODUCTION

The Permian system is distinguished for the wide-scale distribution of continental deposits in Gondwana and Laurasia. It is extremely difficult to divide or correlate these deposits due to their facial variations and scarcity of organic remains. The Upper Permian continental formations from the east of European Russia are exceptional in the respect, because diverse fossils have been found and studied there: ostracodes, bivalves, conchostracans, tetrapods, fishes, flora and miospores. Tetrapods and ostracodes are among those most studied. Due to their common occurrence and fast evolutionary variability, ostracodes have become the leading fauna in regional correlations. They may prove to be important for distant stratigraphic correlations as well.

The present paper deals with stratigraphic correlations and complex biostratigraphic description of the Upper Permian deposits from the southern Cis-Urals, one of the most complicated geologic regions embracing the junction zone of the south-east of the Russian Plate, Cis-Ural Marginal Trough and Peri-Caspian Depression. Special attention was paid to ostracodes, which formed the basis for section divisions and correlations. The research was founded on well and natural section descriptions made by the author in the process of geologic survey and thematic works, and on the materials presented in the papers by Kuleva (1975) and Kochetkova (1970). Ostracode studies were performed by the author. Besides the original material, definitions by Kochetkova & Spirina (*in* Kuleva 1975) were used, in some cases provided with new strati-

FIG. 1. — The Upper Permian sections from the South-East of the Russian Plate and Cis-Ural marginal deflection. **P_2u**, Ufimian; **P_2kz_1**, Lower Kazanian; **P_2kz_2**, Upper Kazanian; **P_2t_1**, Lower Tatarian; **$P_2t_2^{sd}$**, Upper Tatarian (North Dvina horizon); **$P_2t_2^{vt}$**, Upper Tatarian (Vyatka horizon); **T_1**, Lower Triassic.
1, Novo-Kandaurovka, the Chekushu - the Sukhalya River tributary (P_2u, P_2kz_1, P_2kz_2). **2**, Korneyevka, the Sukhalya River (P_2kz_2). **3**, Yumaty, the Sukhalya River (P_2kz_1, P_2kz_2). **3a**, Taimasovo, the Bol. Kuyurgara River (P_2kz_1, P_2kz_2). **4**, Yalchikayevo, the Shaitanka River (P_2u, P_2kz_1). **5**, Well 104, Byelozyorka, the Salmysh River (P_2u, P_2kz_1, P_2kz_2). **6**, Karmalka, the Salmysh River (P_2kz_1, P_2kz_2). **7**, Well 124, Petrovka (P_2u, P_2kz_1, P_2kz_2, P_2t_1). **8**, Well 122, Verkhni Gumbet (P_2u, P_2kz_1, P_2kz_2, P_2t_1). **9**, Well 123, Voskresenskoye (P_2u, P_2kz_1, P_2kz_2, P_2t_1). **10**, Well 13[sh], the Shestimir River (P_2kz_2, P_2t_1). **11**, Well 12[sh], the Shestimir River (P_2u, P_2kz_1, P_2kz_2). **12**, Nizhni Babalar (P_2kz_1). **13**, Well 388, Yangiz (P_2u, P_2kz_1, P_2kz_2, P_2t_1). **14**, the Shestimir River (P_2kz_2, P_2t_1). **15**, Well 152[k], Maryevka, the Salmysh River (P_2u, P_2kz_1, P_2kz_2, P_2t_1). **16**, Well 157[k], Maryevka (P_2u, P_2kz_1, P_2kz_2). **17**, Brody Spring (P_2kz_2, P_2t_1). **18**, Well 3, Brody (P_2u, P_2kz_1). **19**, Well 43[k], Tiryak-Lizyak (P_2u, P_2kz_1, P_2kz_2). **20**, Well 48[k], (State farm) Oktyabrskij (P_2kz_2, P_2t_1). **21**, Well 55, Budyonnovskij (P_2t_1, $P_2t_2^{sd}$). **22**, Well 52[k], Anatolyevka, the Salmysh River (P_2u, P_2kz_1, P_2kz_2). **23**, Well 2[k], Sakmara (P_2u, P_2kz_1, P_2kz_2, P_2t_1). **24**, Well 1[k], Sakmara (P_2kz_1, P_2kz_2). **25**, Well 31[k], Grebeni (P_2kz_1, P_2kz_2, P_2t_1). **26**, Krasny Gully, Grebeni (P_2u, P_2kz_1, P_2kz_2, P_2t_1). **27**, Well 5[k], Grebeni (P_2u, P_2kz_1, P_2kz_2). **28**, Well 7[k], Grebeni (P_2kz_1, P_2kz_2). **29**, Well 39[k], Grebeni (P_2kz_1, P_2kz_2, P_2t_1). **30**, Well 6[x], Chebenki (P_2kz_2, P_2t_1). **31**, Well 30, Nezhenka (P_2u, P_2kz_1, P_2kz_2, P_2t_1). **32**, Orenburg (P_2kz_1). **33**, Well 70[k], Bolshoj Sulak (P_2kz_1, P_2kz_2). **34**, Well 94[k], Bolshoj Sulak (P_2u, P_2kz_1, P_2kz_2, P_2t_1, $P_2t_2^{sd}$). **35**, Well 80, Dzhuan-Tyubinskaya (P_2kz_1, P_2kz_2, P_2t_1). **36**, Well 79[k], Dzhuan-Tyubinskaya (P_2u, P_2kz_1, P_2kz_2, P_2t_1, $P_2t_2^{sd}$, $P_2t_2^{vt}$). **37**, Well 98[k], Karavanny (P_1kz, T_1). **38**, Well 59[i], Boyevaya Mt. (P_2kz_2). **39**, Well 60[i], Boyevaya Mt. (P_2kz_1, P_2kz_2). **40**, Well 53[i], Boyevaya Mt. (P_2kz_2, P_2t_1). **41**, Wells 61[k]-67[k], Krasnoyarka (P_2kz_1, P_2kz_2, P_2t_1). **42**, Well 73[k], Kamennaya (P_2u, P_2kz_1, P_2kz_2, P_2t_1, $P_2t_2^{sd}$, $P_2t_2^{vt}$). **43**, Yelshanka ($P_2t_2^{vt}$, T_1). **44**, Korneyevka, the Yarykly River (P_2k_z). **45**, Yeldashevo, the Yurgashka River (P_2t_1). **46**, Skvorchikha, the Yergabusha River (P_2t_1). **47**, Osipovka, the Budenya (P_2kz_2). **48**, Karatalka, the Teiryuk River (P_2kz_2). **49**, Rodnikovsk, the Teiryuk River (P_2kz_2). **50**, Verkhotor, the Tor River (P_2kz_2). **51**, Voskresenskoye, the Tor River (P_2t_1). **52**, Vesyoly, the Nugush River (P_2t_1, $P_2t_2^{sd}$, $P_2t_2^{vt}$). **53**, Krasnogorka, the Nugush River ($P_2t_2^{vt}$). **54**, Lipovka (P_2t_2). **55**, Alexandrovka, the Nugush river (P_2kz_1, P_2kz_2, P_2t_1). **56**, Yumaguzino, the Meleuz ($P_2t_2^{sd}$, $P_2t_2^{vt}$). **57**, Kadyrovo, the Menyu River (P_2t_1). **58**, Malakanovo (P_2kz_1). **59**, Sergeyevskij, the Chukur - Bulyak River - the Bolshoj Yushatur tributary (P_2t_1). **60**, Chernigovskij ($P_2t_2^{sd}$). **61**, Bekechevo, the Nakuz River (P_2kz_1, P_2kz_2, P_2t_1). **62**, Savelyevskij ($P_2t_2^{vt}$). **63**, Sankinskij ($P_2t_2^{vt}$). **64**, Raznomoika, the Tugostemir River ($P_2t_2^{sd}$). **65**, Slavyanka (P_2kz_2, P_2t_1). **66**, Allaberdino (P_2kz_2). **67**, Davletkulovo, the Yaman-Yushatyr River (P_2kz_2, P_2t_1). **68**, Well 28 and well 43, Davletkulovo (P_2kz_1, P_2kz_2, P_2t_1). **69**, the Tashla River (P_2kz_2, P_2t_1). **70**, Alexandrovka, the Kuplya River ($P_2t_2^{sd}$). **71**, Urman-Tashla ($P_2t_2^{sd}$). **72**, Kasterinskij, the Bolshoi Yushatur River basin ($P_2t_2^{vt}$). **73**, Maslovskij, the Bolshoi Yushatur River basin ($P_2t_2^{vt}$). **74**, Smirnovka ($P_2t_2^{vt}$). **75**, Alebastrovaya ($P_2t_2^{vt}$). **76**, Cherepanovka, the Burunchar River ($P_2t_2^{vt}$). **77**, Well 41, Staroseika, the Bolshoi Ik River (P_2kz_1, P_2kz_2). **78**, Staroseika (P_2kz_2). **79**, Dmitriyevskij (P_2t_1, $P_2t_2^{sd}$). **80**, Well 4[i] and 5[i], Dmitriyevskij (P_2kz_2, P_2t_1, $P_2t_2^{sd}$). **81**, Stary Kazlair, the Chena River (P_2kz_2). **82**, Novosyolki, the Chena River (P_2t_1). **83**, Kholmogory, the Bolshoi Ik River (P_2t_1). **84**, Novokulchumovo, the Sakmara River ($P_2t_2^{sd}$, $P_2t_2^{vt}$). **85**, Well 121, Novokulchumovo (P_2kz_2, P_2t_1). **86**, Vyazovka, the Ural River ($P_2t_2^{sd}$, $P_2t_2^{vt}$). **87**, Well 102, Vyazovka, (P_2kz_2, P_2t_1). **88**, Well 19[x], Ostrovnoye, the Ural River (P_2kz_1, P_2kz_2, P_2t_1). **89**, Blumental Gully, the Burtya river ($P_2t_2^{vt}$, T_1). **90**, Zholtoye, the Sakmara River (P_2kz_2). **91**, Giryal, the Ural River ($P_2t_2^{vt}$, $P_2t_2^{sd}$). **92**, Well 73, Activny (P_2kz_2, P_2t_1). **93**, Well 44, Verkhneozernoye, the Ural River (P_2kz_1). **94**, Verkhneozernoye (P_2kz_2, P_2t_1). **95**, Wells profile 5-22, the Burly River (P_2t_1, $P_2t_2^{sd}$, $P_2t_2^{vt}$).
a, outcrop exposure. **b**, well. **c**, boundary of the Cis-Ural marginal deflection. **d**, boundary of Peri-Caspian Depression. **A-B**, the line of the sections studied in Fig. 2. **C-D**, the line of the sections studied in Fig. 3. **E-F**, the line of the sections studied in Fig. 4.


56°
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SALAVAT
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Belaya
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Nakyz
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Bolshoij Yik
Salmysh
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ORENBURG
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Sol-Iletsk
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A
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C-D - f
E-F - g

graphic interpretations.
Bivalve complexes were studied by Kuleva (1975), fish by Minikh & Minikh (*in* Ochev *et al.* 1979), conchostracans by Lopato (*in* Kuleva 1975), miospores by Shatkinskaya (Efremov & Shatkinskaya 1972). Tetrapod definitions belong to Tverdokhlebova, Chudinov & Ochev (*in* Ochev *et al.* 1979). The data on marine macrofauna was taken from the works by Kochetkova (1979) and Romanov (1972).
The wells were drilled by the Orenburg Territorial Geologic Service from 1960 to 1985.

UPPER PERMIAN DEPOSITS

The upper section of the Permian system in the south of the Cis-Ural marginal bend and the adjacent region of the Russian plate is represented by the Ufimian, Kazanian and Tatarian stages. The Kazanian and Tatarian stages are each represented by two substages: the lower and the upper ones. The lower substage of the Tatarian consists of the Urzhum horizon, the upper one of the North Dvina and Vyatka horizons.
According to the features of the Late Permian sedimentogenesis, this territory is divided (Fig. 1) into three structural-facial zones: the western (Novo, Kandaurovka, Grebeni and Yelshanka settlements), the axial (Raznomoika, Vyazovka, Blumental) and the eastern (Tor, Kholmogory, Burly). The principal stratigraphic units from each zone possess lithologic compositions, thicknesses and mineral complexes that differ to various extents (Figs 1-4).

The Ufimian stage

The Ufimian stage from the western zone is studied in exposures and cores from numerous mapping and pioneer wells (Fig. 1, Kandaurovka, Shestimir, Yangiz, Urnyak, Brody, Sakmara, Grebeni, etc.).
The stage is composed predominantly of red terrigenous rocks that are replaced by halogenic Kungurian structures downwards along the section. The boundary between the Ufimian and Kungurian beds is conventionally drawn over the roof of the last more or less thick interlayer of chemogenic rocks. Clays, aleurolites, sandstones dominate in the section, marl, limestone and dolomite interlayers are rare. Rock gypsification is characteristically observed, significant in the lower portion (Fig. 2). The thickness varies from 75 to 190 m. Diverse organic remains occur: ostracodes, bivalves, conchostracans, miospores.
Ostracodes. *Paleodarwinula abunda* (Mandelstam), *P. angusta* (Mandelstam), *P. parphenovae* (Belousova), *P. procera* (Mandelstam), *P. lancetiformis* (Kashevarova), *P. trita* (Palant), *P. burjevoensis* (Palant), *P. lubimovae* (Kashevarova), *Garjainovula lija* (Spirina *et* Molostovskaya), *G. kulevae* (Spirina *et* Molostovskaya), *G. gracilis* (Spirina *et* Molostovskaya), *Prasuchonella stelmarta* (Kashevarova), *Pr. kargalensis* (Kotshetkova), *Pr. kamyschencaensis* (Palant), *Darwinuloides djurtjuliensis* Palant, *Sinusuella pergraphica* Mandelstam.
Bivalves. *Palaeomutela attenuata* Gusev, *P. ovataeformis* Gusev, *P. sintasensis* Gusev.
Conchostracans. *Hemicyeloleaia baentschiana* (Beyrich), *Limnadia* (*Paleolimnadia*) *rossica* Molin.
Miospores. They are represented by two complexes: the early (Miospores H1) and the late ones (Miospores H2) (Efremov & Shatkinskaja 1972). Within the H1 miospore complex dominate *Zonotriletes*, significantly *Disaccites*, associated *Vittatina*, characteristic *Lycospora variabilis* (Jansonius), *Cirratriradites procumbens* (Luber), *Striatopodocarpites tojmensis* Sedova, *Striatoidiplopinites elongaus* (Luber), *Vittatina striata* Luber, *Granisporites osmundae* (Samoilovich), *Granulatisporites resistens* (Luber), *Cirratriradites procumbens* (Luber), *Platysaccus alatus* (Luber), *Striatohaplopinites perfectus* (Naumova).
The Ufimian beds are poorly studied in the central zone due to little outcropping and the lack of core materials. A 180 m thick sequence of red gypsified clays, marls, sandstones with gypsum interlayers, situated a bit to the north of the area concerned, near the village of Yar-Bishkadak (Kotschetkova 1970), has been assigned to the Ufimian. The confirmed Ufimian beds to the south, were penetrated by well 79 in the left-bank region of the Ural River. They are represented by red clays, aleurolites and sandstones.

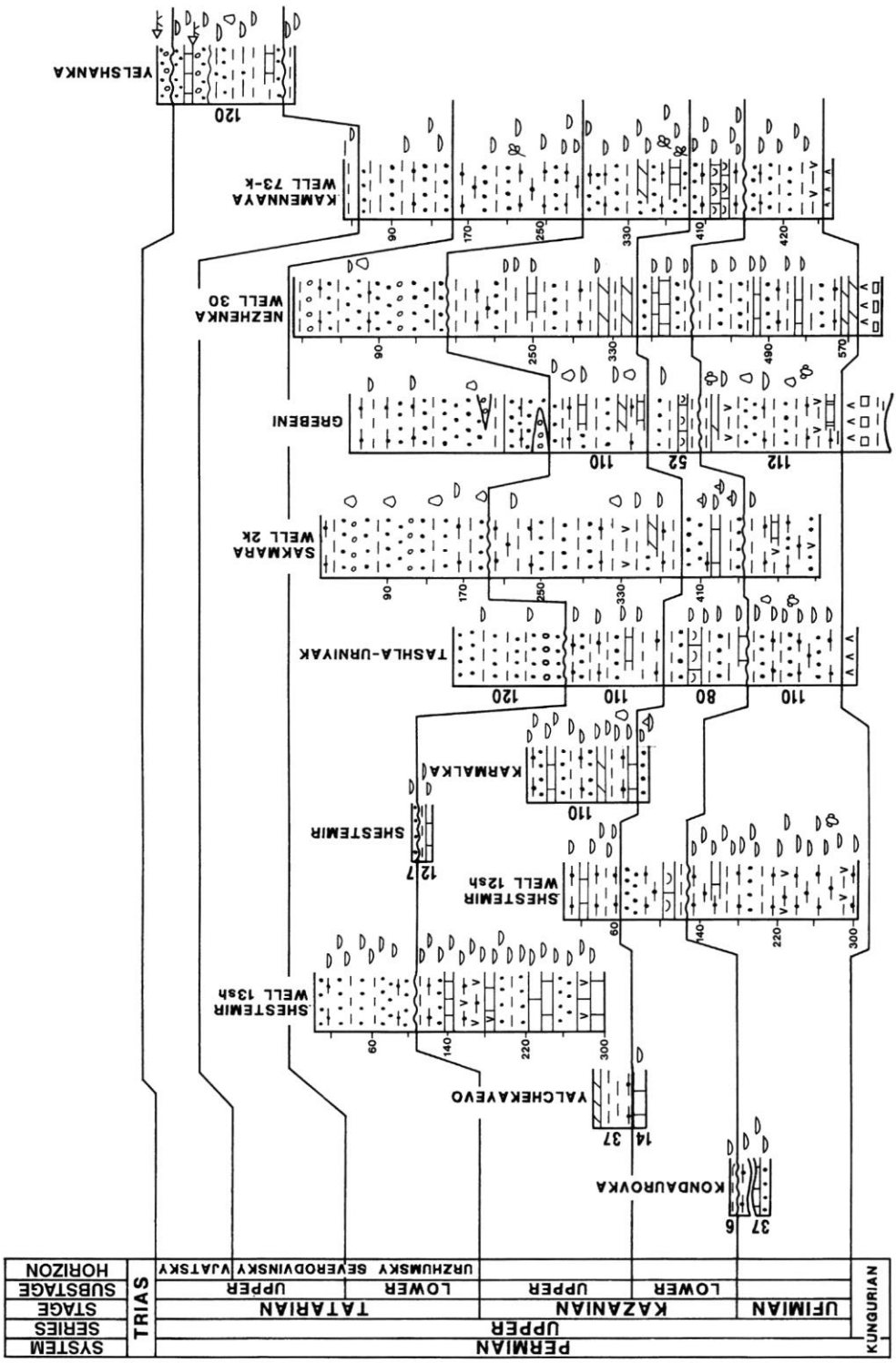

FIG. 2. — Correlations of the sections of the Upper Permian deposits in western part of the Cis-Ural marginal deflection (legend in figure 3).

Wells show the Ufimian beds to be up to 360 m thick. In the eastern zone, the Ufimian deposits occur along the Nugushu River (Vishnevskaya and Alexandrovka villages). They are represented by a thick (about 700 m) sequence of red conglomerates with flint pebbles, sandstones, aleurolites and marls with rare thin limestone interlayers. Coarse clastics are characteristic of the middle portion. Along the Nakyz river near the Ryazansky Farm and the basins of the Bolshoj Ik and Bolshoj Syuren Rivers, the Ufimian deposits are represented by thick pebble conglomerates often changed by boulder ones. These conglomerates consist of coarse pebbles of diverse metamorphosed and igneous rocks, limestones with Carboniferous faunal remains, quartz and flint. Sandstone lenses occur among conglomerates, and very seldom interlayers of marls and sulfur silicified limestone (Kotchetkova 1970).

In the vicinity of Zalair-Ilyinskoye and Starosejka villages, the Ufimian deposits are represented by 68 m thick reddish-brown argillites with interlayers of brownish-grey sandstones and grey limestones. The age of the sequence is established according to ostracode complex: the zonal guide fossil *Paleodarwinula abunda* (Mandelstam) and *P. angusta* Mandelstam, *P. lancetiformis* Kashevarova, etc.

The Kazanian stage

The Kazanian stage according to its lithologic-facial features is divided into two substages: the lower and the upper ones.

The lower Kazanian stage

The lower Kazanian stage has a complicated structure within the area considered. In the west, it is represented by marine facies substituted by lagoonal-continental ones farther eastward, mainly in the axial zone; this reflects the transgressive-regressive cycle of the Kazanian sea (Fig. 1, Urnyak, Brody, Sakmara, Grebeni, Nezhenka, etc.).

Within the western zone, the lower Kazanian substage is composed of grey sandstones, aleurolites, clays and limestones. Clays and aleurolites dominate in the lowermost of the section; the middle part is represented mainly by limestones, marls and clays.

The upper third of the sequence is built of clays, aleurolites and sandstones, the latter ones often constituting up to 50-70% of its volume. The substage thickness varies from 60 to 200 m.

Diverse organic remains occur within the lower Kazanian deposits: ostracodes, corals, bryozoans, crinoids.

Ostracodes. Ostracodes are represented by the marine species: the guide fossil *Amphissites tscherdynzevi* Posner and *Pseudoparaparchites formidabilis* Schneider, *Aecuminella bella* Khivintseva, *Cornigella valosa* Khivintseva, *Kirkbya rara* Khivintseva, *Moorea facilis* Schneider, *Cavellina grandis* Schneider, *Cavellina unica* Kotschetkova, *Healdia postcornuta* Schneider, *H. oblonga* Kotschetkova, *Healdia simplex* Roundy, *H. pseudisimplex* Kotschetkova, *H. subtriangula* Kotschetkova, *H. reniformis* Schneider, *Healdianella vulgata* Kotschetkova, *Cribroconcha urschakensis* Kotschetkova, *Bairdia beedei* Ulrich *et* Bassler, *B. garrisonensis* Upson, *B. pompilioides* Harlton, *Acratia baschkirica* Kotschetkova, *Fabalicypris crepidalis* Kotschetkova, *Actuaria diffusa* Schneider, *A. secunda* Kotschetkova, *Monoceratina fastigiata* Kotschetkova, *M. faveolata* Kotschetkova, *M. parvula* Kotschetkova, *M. exilis* Schneider, *Fascianella notabilis* Schneider.

Foraminifers. *Glomospira* sp., *Ammodiscus* cf. *bradynus* Pandel, *Verneuilinoides kasanica* Ucharskaya, *Cornuspira megasphaerica* Gerke, *C. microsphaerica* K. M. Maclay, *Calcivertella kasanica* K. M. Maclay, *Nodosaria cushmani* Paalzov, *N. forcimeniformis* K. M. Maclay, *N. hexagona* (Tscherdynzev), *N.* aff. *noinskyi* Tscherdynzev, *N. krotovi* Tscherdynzev, *Pseudonodosaria lata* K. M. Maclay, *Frondicularia longissima* (K. M. Maclay), *Fr. geinitzinaeformis* (K. M. Maclay), *Geinitzina spandeli* Tscherdynzev, *Tetrataxis* sp., *Tristis permiana* Gerke, etc.

Brachiopods. *Cleiothyridina pectinifera* Sowerby, *Cl. semiconcava* Waagen, *Cl. reyssiana* Keyserling, *Stepanoviella hemisphaerium* Kutorga, *Pr.* (*Cancrinella*) *cancrini* Verneuil, *Pr. koninckianus* Keyserling, *Licharewia rugulatia* Kutorga, *L. curvirostris* Verneuil, *Dielasma elongata* Schlotheim, *D. elliptica* Netschajev, *D. angusta* Netschajev, *Lingula orientalis* Golowkinsky, *Aulosteges horrescens* Verneuil.

Bivalves. *Leibea hausmanni* Goldfuss, *Allorisma*

elegans King, *Pseudobakewellia sulcata* (Geinitz), *Ps. ceratophragaeformis* Noinski, *S. tutchburia tschernyschevi* Licharev.

In the central and eastern zones, the lower Kazanian comprises a sequence of grey-colored sandstones, aleurolites, clays, marls, limestones and dolomites of lagoonal-deltaic and littoral-marine genesis (Figs 1, 2, 3, Davletkulovo, Bekeshevo, Starosejka, Ostrovnoye, Verkhneozernoye). The sequence contains the Kazanian complex of non-marine ostracodes: guide zonal fossil *Paleodarwinula fainae* (Belousova) and *P. cuneata* (Kotschetkova), *P. irinae* (Belousova), *Prasuchonella belebeica* (Belousova), *Darwinuloides* cf. *sentjakensis* (Sharapova).

Non-marine bivalves. *Paleomutela sintasensis* Gusev, *P. ovataeformis* Gusev, characteristic of the Ufimian and Lower Kazanian deposits.

Flora. *Pecopteris anthriscifolia* Meyen, *Sphenophyllum*, *Asterodiscus*.

Pollen of cordaites: *Cordaitina uralensis* (Luber) Samoilovich, *C. cubrotata* (Luber) Samoilovich.

Ginkgos: *Ginkgocycadophytus erosus* (Luber) Samoilovich.

Conifers: *Protodiploxypinus elongatus* Samoilovich, *Protopodocarpus alatus* Samoilovich.

Some pollen of obscure systematic affiliation: *Azonalites* (*Rugosina*) *tenuis* Luber, *A.* (*Tenuella*) *levis* Luber.

Fern-like spores: *Azonotriletes* cf. *resistens* Luber, *A. osmundes* Samoilovich (Kuleva 1975).

The upper Kazanian substage

The upper Kazanian substage in the western zone is represented by lagoonal-continental formations: red, less frequently grey clays, aleurolites, sandstones, and, to a smaller extent, by limestones, marls, dolomites (Yalchekayevo, the Shestemir River, Shestemir, the Karmalka Spring, Tashla-Urnyak, Sakmara, Grebeni, Nezhenka, etc.). The lower boundary of the late Kazanian deposits is clear, drawn over the roof of marine sandstones, overlain by clays with the zonal guide fossil *Paleodarwinula fainae* (Belousova). Its thickness varies from 110 to 140 m.

Within the axial zone (Davletkulovo, Slavyanka, Islayevka, Ostrovnoye), the upper Kazanian substage is composed of non-marine interlaid clays, aleurolites and sandstones with rare interlayers of limestones and marls. Within the section near Davletkulovo village, scattered small flint and marl pebbles occur as well as small lenses of fine-pebble conglomerates. The substage is up to 600 m thick there. The section near Ostrovnoye village is distinguished for thiner rocks; it is 250 m thick.

The upper Kazanian substage has a somewhat uneven structure in the eastern zone. At the Tor River (Kotchetkova 1970), this is represented by a thick (556 m) carbonate-terrigenous sequence composed of interlaid brown, lilac and grey clays, aleurolites, marls, limestones, sandstones. The Kazanian is not divided into substages within the section along the Nugush River. Assigned to it is a thick (over 700 m) sequence of brown, lilac, grey marls and aleurolites with sandstone interlayers; this sequence overlies a sand-conglomerate one, that is conventionally considered to belong to the Ufimian stage. Coarse clastics are rather significant near Zhyoltoye village: sandstones, gravelstones and conglomerates. The section near Novokulchimovo is represented by a rather monotonous interlayers of concretionary and bedded brown limestones. Diverse organic remains occur within the upper Kazanian deposits over the whole of the territory: ostracodes, bivalves, conchostracans, tetrapods, flora and miospores.

Ostracodes. Ostracodes are represented by the following species: *Paleodarwinula fainae* (Belousova), *P. alexandrinae* (Belousova), *P. irenae* (Belousova), *P. cuneata* (Kotschetkova), *P. tichonovichi* (Belousova), *P. tuimazensis* (Kotschetkova), *P. varsanofievae* (Belousova), *P. inornatinaeformis* (Belousova), *P. chramovella* (Belousova), *P. aronovae* (Belousova), *P. persimplex* Kotschetkova, *P. procurva* (Kotschetkova), *Garjainowula lija* (Spirina *et* Molostovskaja), *G.* ex gr. *gracilis* (Spirina *et* Molostovskaja), *Prasuchonella tichwinskaja* (Belousova), *P. belebeica* (Belousova), *Darwinuloides sentjakensis* (Scharapova), *Placidea* ex gr. *lutkevichi* (Spizharskyi). *Schneideria kazanica* Kotschetkova occurs only in the lower part of the section.

Bivalves. Bivalves are represented by the Belebej complex : *Palaeanodonta rhomboidea* (Netschaev), *Palaemutela celebrata* Gusev, *P. quadrata* Kuleva, *P. novalis* Netschaev, *P. umbonata*

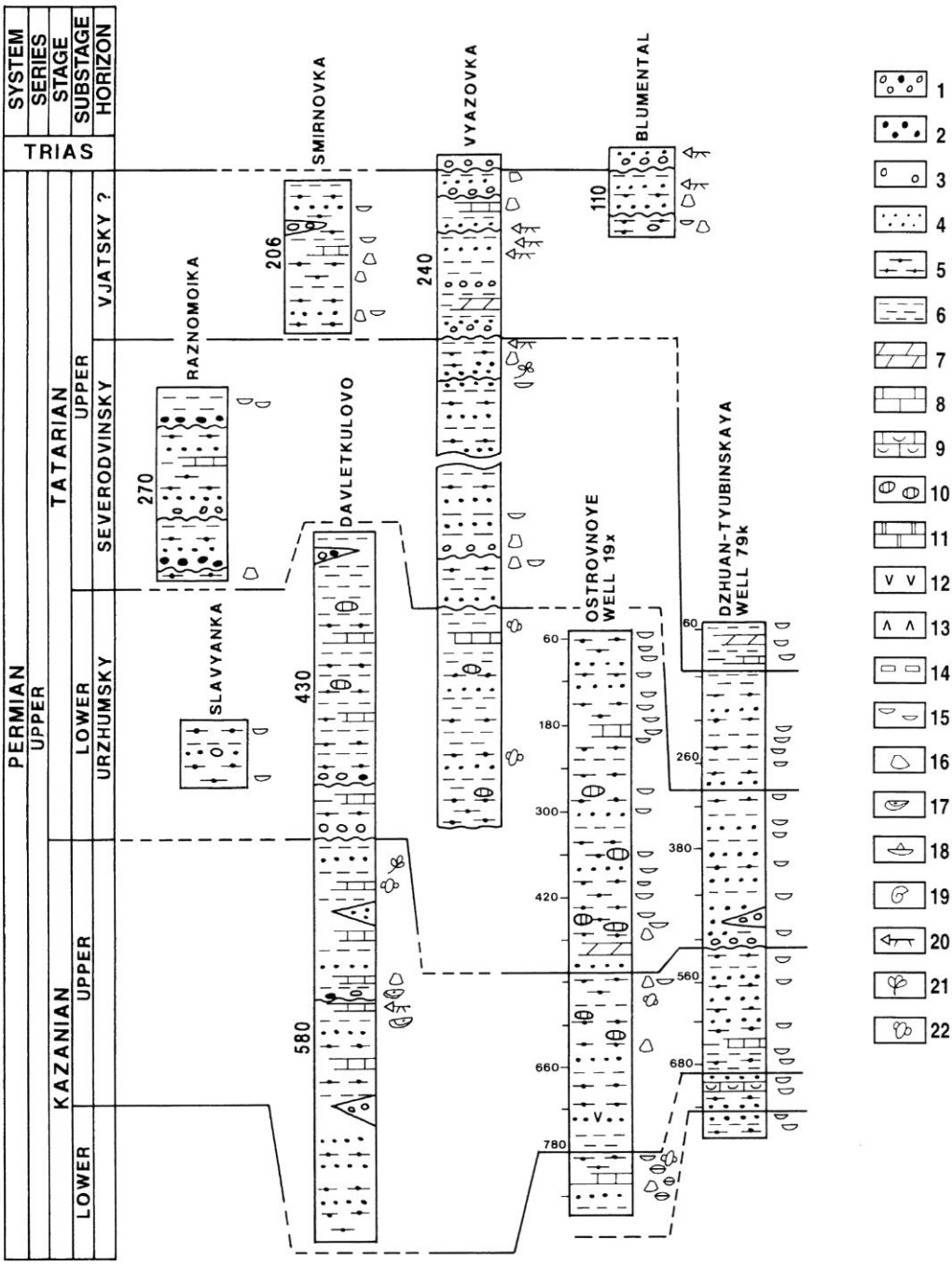

FIG. 3. — Correlations of the sections of the Upper Permian deposits in central part of Cis-Ural marginal deflection. **1**, conglomerates. **2**, Ural rocks pebbles. **3**, local rocks pebbles. **4**, sandstones. **5**, aleurolites (siltstones). **6**, clays. **7**, marls. **8**, limestones. **9**, organogenic-clastic limestones. **10**, nodular limestones. **11**, dolomites. **12**, gypsum. **13**, anhydrites. **14**, salts. **15**, ostracodes. **16**, bivalves. **17**, conchostraceans. **18**, brachiopods. **19**, foraminifers. **20**, gasteropods. **21**, tetrapods. **22**, fishes. **23**, flora. **24**, miospores.

(Fischer), *P. krotovi* Netschaev, *P. olgae* Gusev, *P. doratiformis* Gusev.

Conchostracans. *Palaeolimnadiopsis eichwaldi* (Netschaev), *Clyptoasmussia exiqua* (Eichwald), *Cyclotungusites kazanensis* Molin, *Ulugkemia borisi* Novojilov, *U. orengurgiana* Molin, *U. petri* Novojilov, *Sphaerestheria ikensis* Molin, *Pseudestheria kaslanica* Molin.

Tetrapods. *Platyaps* sp., *Deuterosaurus* sp., *Tapinocephalidae*, similar in dimensions to *Deuterosaurus gigas* Efremov.

Miospores. Characteristic *Cordaitina*, *Limitisporites leschikii* Klaus, *Gigantosporites hallstathensis* Klaus, *Striatites marginalis* Klaus, *Striatohaplopinites latissimus* (Luber), *Striatopiceites suchinensis* Sedova, *Vittatina striata* Luber, associated *Cyclogranisporites*, *Acanthotriletes*, *Azonaletes*.

Flora. *Carpolithes* sp., *Phyllododerma* sp., *Noeggerathiopsis* sp., *Lepeophyllum* sp., *Samaropsis* sp., *Paracalamites* sp., *Odontopteris* sp., *Equisetina* sp., *Rufloria* sp., *Taeniopteris* sp., *Recopteris* sp., *Voltzia mamadyschensis* Zalessky, *Samaropsis irregularis* Neuburg, *Psygmophylum expansum* Brongniart, *Odontopteris* cf. *rossica* Zalessky, *Ullmannia biarmica* Eichwald.

The Tatarian stage

The Urzhum horizon

The lower Tatarian substage (Urzhumsky in figures 2-4) in the western zone discontinuously overlies the Kazanian beds and is characterized by binary structure (Shestemir, Sakmara, Grebeni, Nezhenka, Boyevaya Mt.). Its lower part is composed of obliquely layered red sandstones, aleurolites, clays and fine-pebble conglomerates of local-rock pebbles. The upper half is built of red aleurolites, clays, fine and more seldom coarse-grained sandstones. The horizon is up to 200 m thick.

This division in two parts becomes progressively less vivid eastwards (Kamennaya, Dzhuan-Tyubinskaya).

The axial zone of the Urzhum horizon is distinguished for high thicknesses, aleurolite-clayey composition, conglomerate-lens occurrence and widely spread nodular limestones. The number of conglomerate interlayers reduces southwards (Fig. 3), the number of nodular limestones increases. The section near Davletkulovo village is composed of red interlaid clays and aleurolites, sandstone, limestone and marl interlayers, thin lenticular interlayers of fine-pebble conglomerates and gravelstones with their clastics consisting mainly of flints. Unevenly scattered flint pebbles and gravels occur in some aleurolite interlayers. A thick (6 m) interlayer of coarse-pebble conglomerate lies in the base of the section. The boundary between the Kazanian and Tatarian deposits is drawn over its rugged lower surface. The apparent thickness - 430 m. The Urzhum horizon section near the villages of Ostrovnoye and Vyazovka looks more monotonous and consists of finer rocks. It is over 550 m thick. The Urzhum horizon is unevenly structured within the eastern zone (Fig. 4). It is characterized by binary structure in the north of the zone, in the sections along the Tor, Yergabusha and Yurgashi rivers. Its lower half consists of a conglomerate-sandstone sequence with rare interlayers of red-brown clays and marls. The upper one is represented by a marl-clay-sandstone sequence with interlayers of grey clayey limestones and aleurolites. The horizon is 780 m thick.

Southwards, near the villages of Bekechevo, Dmitriyevo, Kholmogory, the Urzhum horizon is dominated by interlaid clays, aleurolites, interlayers of fine-grained sandstones and brown concretionary limestones. Fine and coarse-pebble and even boulder conglomerates are also important. Their clastic material is poorly sorted. The pebble sizes vary from 1 to 10 cm, the boulders are up to 20-25 across. Large pebbles and boulders are represented by the Lower Permian and Middle Carboniferous limestones and sandstones; fine pebbles by flints. Conglomerates are usually found within the bases of sedimentation rhythms which are closed by clays with nodular limestones. Conglomerate members in the lower part of the section are up to 8-10 m thick. Upwards along the section, conglomerate members become thinner and the sizes of clastic materials decrease (Kuleva 1975).

Farther south, towards the Peri-Caspian Depression (Burly), and to the west of the Urals forefolds (Novokulchumovo), the sizes of clastic material and the share of coarse-clastic rocks in the section decrease. The principal position in its

structure is occupied by clays, aleurolites and fine-grained sandstones. The following features are characteristic of these sections: rather monotonous brown color of the rocks, scattered limestone nodules, aleurolite predominance within the lower part of the section and that of clays in its upper part. The apparent thickness of the Urzhum horizon section at Burly constitutes 960 m.

Ostracodes. The paleontologic description of the Urzhum horizon is complete and involves large variety of forms. Ostracodes are represented by a rich complex consisting of the following species: zonal guide fossil *Paleodarwinula fragiliformis* (Kashevarova) and *P. elongata* (Lunjak), *P. fragilis* var. *angusta* (Schneider), *P. inornatinae* (Lunjak), *P. chramovi* (Glebovskaya), *P. torensis* (Kotschetkova), *P. faba* (Mischina), *P. impostor* (Mischina), *P. defluxa* (Mischina), *P. arida* (Molostovskaya), *P. obvia* (Molostovskaya), *P. gariainovi* (Molostovskaya), *Prasuchonella nasalis* (Sharapova), *Darwinuloides buguruslanicus* Kashevarova, *Sinusuella ignota* Spizharskyi, *Placidea lutkevichi* (Spizharskyi).

All the species listed above are rather widely distributed within the Urzhum horizon rocks over the whole of the Russian Platform (Molostovsky & Molostovskaya 1967; Molostovskaya 1974, 1993). Besides, the upper part of the Urzhum horizon in the territory considered is characterized by isolated localities of endemic cytherides: *Tscherdynzeviana squamosa* Kotschetkova, *Wetluginella* (?) *tatarica* Molostovskaya in press, *Kaschevaroviana delicata* Molostovskaya in press, *K. pectunata* Molostovskaya in press.

Bivalves. *Abiella subovata* (Jones), *Microdantella microdonta* (Khalfin), *M. plotnikovskiensis* (Fedotov), *Palaemutela doratiformis* Gusev, *P. parallelogramma* Kuleva, *P. gusevi* Kileva, *Anthraconaia verneuili* (Amalizky), *A. aktubensis* Gusev, *Anthraconauta* (*Prokopievskia*) *pseudophillipsi* Fedotov.

Conchostracans. *Pseudostheria angulata* (Lutkevich), *Sphaerestheria belorussica* Novojilov, *Triedrolophus tverdochlebovi* Molin, *Pseudostheria otchevi* Molin, *Megasitum jaroslavlense* Novojilov.

Tetrapods. *Mnemeiosaurus jubilaevi* Novikov, *Melosaurus* sp., *Deuterosaurus* sp., *Platyops* sp., *Notosyodon* sp.

Miospores. Characteristic *Lebachiacites pulcherrimus* (Sauer), *Striatoleachites*, *Jugasporites*, *Faunipollenites*, *Jaeniasporites albertal* Jansonis, *Vittatina striata* Luber; associated *Platysaccus* sp., *Alisporites striatohaplopinites*.

The North Dvina horizon

The North Dvina horizon (Severodvinsky in Figs 2-4) in the western zone is represented by interlaid red clays, aleurolites, sandstones, rare lenses of fine-pebble conglomerates of mostly local rocks and isolated interlayers of brown clayey limestones (Budyonovsky, Ostrovnoye, Kamenny).

As in the western zone, the North Dvina horizon section in the south of the central zone is characterized by rather fine terrigenous composition and red rock-color (well 73^{k} Dzhuan-Tyubinskaya, Vyazovka).

The North Dvina horizon is ununiform in its structure in the north of the central zone and in the eastern zone. It is variegated and characterized by carbonate-clayey composition, being formed of redrown, lilac, grey clays, aleurolites, sandstones, limestones and marls. The interlayers of grey rocks generally contain large amounts of charred plant detritus (Gumaguzino, Vesyoly, Raznomoika, Chernigovsky, Alexandrovka on the Kuplya River, Uman-Tashla, Dmitrovsky, Novokulchumovo, Giryal, Burly). In some sections (Chernigovsky, Raznomoika, Dmitriyevsky), coarse clastics (sandstones and conglomerates) are rather significant in the horizon structure. They are generally associated with the lower half of the section, sometimes forming a sequence up to 300 m thick there (Chernigovsky). The amount of coarse terrigenous material within the North Dvina horizon decreases westwards and southwards from the Urals to the Peri-Caspian Depression. The number of grey-rock interlayers decreases in the same direction.

The thickness of the North Dvina horizon varies from 100 m (Ostrovnoye) to 670 m (Burly).

The rock ages within the North Dvina horizon are determined by numerous and multiform organic remains.

Ostracodes. Ostracodes are represented by rich and diverse associations. The following species are ubiquitous: zonal guide fossil *Suchonellina futschiki* (Kashevarova) and *S. inornata* Spizhar-

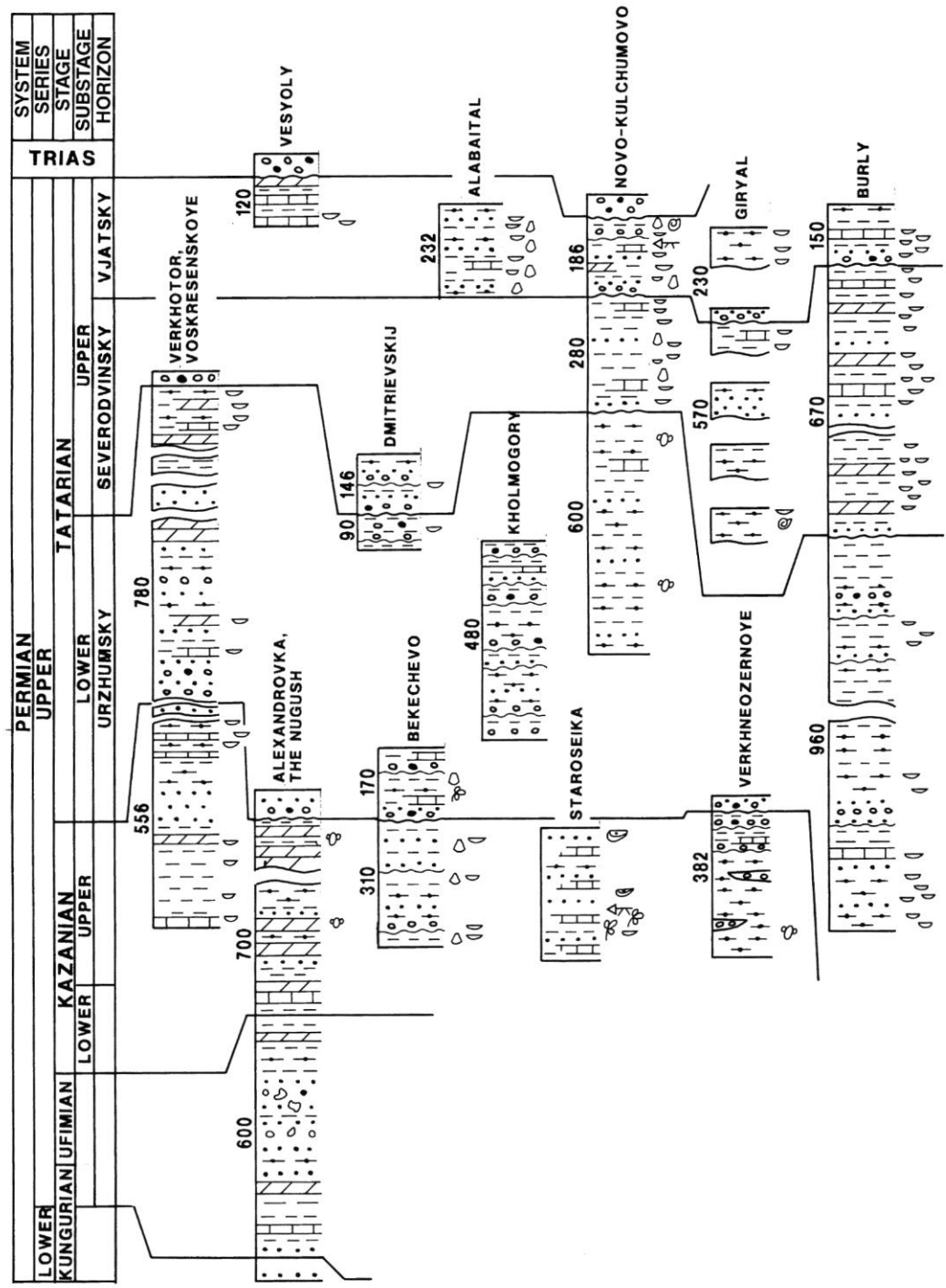

FIG. 4. — Correlations of the sections of the Upper Permian deposits in eastern part of Cis-Ural marginal deflection (legend, see figure 3).

skyi, *S. parallela* Spizharskyi, *S. undulata* (Mishina), *S. daedala* (Mishina), *S. cultella* (Mishina), *S. degitalis* (Mishina), *S. spizharskyi* (Pozner), *Prasuchonella stelmachovi* (Spizharskyi), *P. sulacensis* (Starozhilova), *Darwinuloides buguruslanicus* Kashevarova, *Permiana elongata* Posner, *P. oblonga* Posner, *Tscherdynzeviana pylchra* Belousova, *T. buzulukensis* Kashevarova.

Besides the ostracode listed above, some peculiar sculptured endemic cytherides occur in the eastern zone : *Tscherdynzeviana busulucensis* Kashevarova, *T. pennata* Kotschetkova, *T. abscondita* Kotschetkova, *Netschajewiana costata* Kotschetkova, *Nuguschia sinizyni* Kotschetkova, *Kaschevaroviana delicata* Molostovskaya in press, *K. pectunata* Molostovskaya in press, *Jungumulus mirus* Molostovskaya in press, *Permianella inilaterata* Molostovskaya in press, *Pamilio primaris* Molostovskaya in press. They are clearly different from those common for the Russian Platform in their morphologic features, being close to marine and semimarine cytherides of the Triassic from the Peri-Caspian Depression.

Bivalves. Bivalves are represented by *Palaeomutela inostranzevi* Amalizky, *P. keyserlingi* Amalizky, *Palaenodonta fischeri* Amalizky, *Opokiella ignatjevi* Gusev.

Conchostracans. *Siberioleaia oblonga* (Mitschell), *Hemicycloleaia intermediata* (Mitschell), *Pseudostheria cicatricosa* (Novojilov).

Tetrapods. *Chroniosaurus dongusensis* Tverdochlebova, *Rophanodon tverdochlebovae* Ivachnenko, *Microphon exiquus* Ivachnenko.

Fishes. *Isadia aristoviensis* A. Minich, *I. suchonensis* A. Minich, *Toyemia tverdochlebovi* Minich.

Flora. *Pursongia amalitzkii* Zalessky, *Cordaites clercii* Zalessky.

Miospores. *Limitisporites* sp., *Jugasporites* sp., *Lueckisporites virkkiae* Potonie *et* Kremp, *Taeniaesporites albertae* Jansonius.

The Vyatka horizon

The Vyatka horizon (Vyatsky in Figs 2-4) in the western and central zones, like the North Dvina one, is composed of terrigenous and mostly red rocks: clays, aleurolites and, to a smaller extent, sandstones. Rare thin conglomerate interlayers or lenses occur, with their clastic material represented by local-rock pebbles, more seldom by flints and quartz (Savelyevka, Sankinsky, Kasterinsky, Maslovsky, Ostrovnoye, Dzhuan-Tyubinskaya, Kamennaya, Yelshanka, Vyazovka, Blumental). Grey and greenish-grey conglomerates and sandstones in Blumental Gully are associated with copperore manifestations. All the rock there are characterized by large amounts of charred plant remains: equisetite stem fragments, pieces of silicified wood.

The Vyatka horizon sections in the eastern zones are dominated by brown and, more seldom, grey clays, aleurolites, sandstones. Grey, lilac, brown limestones and marls are also important. Some conglomerates occur, forming rather large lenses and interlayers. Their clastic material is represented by flints, quartz, limestones, effusive rocks and more seldom, local red rock (Vesyoly, Krasnogorka, Yumaguzino, Smirnovka, Alebastrovaya, Cherepanovka, Novokulchu-movo, Giryal, Burly). The thickness of the Vyatka horizon comprise 245 m near Novokulchumovo, 465 m near Vyazovka.

The rocks from the Vyatka horizon contain diverse organic remains.

Ostracodes. Ostracodes are represented by the following species: guide fossil *Suchonellina trapezoidea* (Sharapova) and *S. parallela* Spizharskyi, *S. undulata* (Mishina), *Wjatkellina fragilina* (Belousova), *W. fragilis* (Schneider), *W. vladimirina* (Belousova), *Dvinella* ex gr. *cyrta* (Zekina), *Suchonella typica* Spizharskyi, *Tatariella angulata* Mishina, *Placidea lutkevichi* (Spizharskyi), *Tscherdynzeviana pulchra* (Belousova).

Besides them, the sections from the eastern zone bear endemic sculptured cytherides, conveyed from the North Dvina horizon *Tscherdynzeviana pennata* Kotschetkova, *Netschajewiana costata* Kotschetkova, *Kashevaroviana delicata* Molostovskaya in press, *Pamilio primaris* Molostovskaya in press.

Bivalves. *Palaeomutela inostranzevi* Amalizky, *P. orthodonta* Amalizky, *P. ovalis* Amalizky, *P. plana* Amalizky, *Palaeanodonta fisheri* Amalizky, *P. okensis* Amalizky, *Opokiella tschernyschevi* Plotnikov.

Conchostracans. *Limnadia angulidorsa* Novojilov, *L. maitschatica* Novojilov, *L.* (*Falsisca*) *furaica* Novojilov, *Megasitum kaljugense* Novojilov, *M. vanum* Novojilov.

Tetrapods. *Chroniosuchus uralensis* Tverdoch-

lebova, *Kotlassia* sp., *Raphanodon* sp., *Scutosaurus* sp., *Inostrancevia uralensis* Tatarinov, *Scylacosuchus orenburgensis* Tatarinov, *Dicynodon* cf. *amalitzkii* Suschkin.

Fishes. *Isadia aristoviensis* A. Minich, *Wodnika invicta* A. Minich.

SUMMARY

All the Upper Permian stratigraphic units from the southern Cis-Urals are at present provided with reasonably complete paleontologic description. Their detailed division was carried out according to ostracode fauna. The red beds of the Ufimian stage are characterized by a non-marine ostracode complex dominated by representatives of *Paleodarwinula* genus. Within the sections with the Kazanian marine and continental deposits, the marine-rock sequences are characterized by rich marine-ostracode complexes of *Healdia*, *Bairdia*, *Amphissites,* etc., genera. The non-marine Kazanian deposits contain a single complex of non-marine ostracodes, mainly of *Paleodarwinula* and *Darwinuloides* genera.

The most detailed stage division by ostracodes was carried out for the Tatarian, with the Urzhum, North Dvina and Vyatka horizons clearly distinguished by the ratios of certain species and genera. The Urzhum horizon is defined by the combination of *Paleodarwinula* species and abundant *Prasuchonella*; the North Dvina one by domination of *Suchonellina* and *Prasuchanella*, the Vyatkian horizon by origination of new genera: *Wjatkellina*, *Dvinella* and *Suchonella*.

The peculiarities of ostracode complex distributions revealed in the Cis-Ural Deflection, are sustained all over the Russian Plate (Molostovskaya 1993) for detailed correlations within vast territories from the boreal regions to the northern fringes of the Tethys.

The presence of peculiar endemic cytherid complex in the south-east of Cis-Ural Marginal Deflection may point to a possible link between this territory and the Tethys marine plain in the Tatarian age.

Thorough search for ostracodes in other regions should be considered a primary task aimed to distant correlations.

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