PeriTethys Programme

Report on Project 95-28

Biostratigraphic correlations and black shale deposition of the Upper Jurassic from the Russian Platform

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INTRODUCTION

The Russian Platform is a large cratonic area where the Jurassic strata are widely distributed, although relatively thin. The Upper Jurassic deposits are represented mainly by clays and black shales; sands and silts being subordinate facies. The objectives of this study are the followings:

- to precise the correlations between Russian Platform and West-European Upper Jurassic series and to precise the age of the black shales from the Russian Platform,
- to check their possible synchronity with the main organic-rich intervals from the North Sea area ,
- to characterise the organic matter using geochemical tools and to reconstruct the depositional environment of the black shales using both paleoecological and geochemical indicators.

To achieve these goals, six sections were examined in the Moscow basin and along the middle part of the Volga River, including the stratotype of the Volgian Stage. Numerous ammonites and rock samples were collected from Lower Oxfordian to Upper Volgian. This report exposes the first results of the study.

I. GEOLOGICAL FRAMEWORK

I.1 Geological and tectonic settings

The Russian Platform is a large cratonic unit with an area of 5.5 million km2. It generally consists of Precambrian crystalline basement and Phanerozoic cover. The Russian Platform was consolidated by the end of the early Proterozoic (1500 Ma). The accumulation of presently unmetamorphosed sediments began in the Late Proterozoic (Riphean) about 1400 Ma with the active formation of major aulacogens typical of the initial stages of platform development. In the Vendo-Cambrian (650-550 Ma) the aulacogen stage terminated and sediments began to accumulate on the relatively flat-lying surface. Subsequently, predominantly vertical tectonic movements occurred throughout the platform, resulting in differentiated structure of the sedimentary cover. In general it consists of large scale depressions and arches that themselves include smaller scale swells and troughs (Figure 1). During the Paleozoic, significant subsidence occurred throughout much of the platform resulting in the deposition of thick sedimentary units. In some areas, aulacogens were further developed, with inversion in many cases.

By early Mesozoic time, the central part of the platform was no longer tectonically active. This interpretation is supported by the uniformity and relatively thin nature of Mesozoic beds over great distances. For example, in the Oxfordian shale facies of the Ryazan region and Unzha river sections (located about 600 km apart), isopachs are similar even down to the ammonite zone discrimination. This is the situation for most of the Mesozoic section throughout the central part of the Russian Platform. Sandy units are less uniform because of the variations typical of shoreface facies, different rates of sediment supply, and local erosion. Throughout most of the Mesozoic, the elevation of the region was very close to sea level so that deposition occurred under shallow marine conditions. Waves and bottom currents (which often caused truncation of deposited sediments) and sparse sediment supply resulted in deposition of thin sedimentary units. Away from the central part of the Russian Platform, the thickness of the entire Mesozoic package increases Southeast toward the Povolzhie region and Caspian depression where significant subsidence occurred during deposition, possibly due to tectonic coupling of the Southeast margin of the Russian Platform to the Caspian Depression.

The presence of a great number of unconformable surfaces and depositional hiatuses in the Mesozoic section of the Russian Platform represents additional evidence of stability. Due to very flat hypsometry and the lack of subsidence, even minor sea-level falls may have caused submarine erosion or subaerial exposure, resulting in truncations and unconformities. In contrast, the more continuous deposition observed toward the Southeast indicates significant subsidence and deeper water.

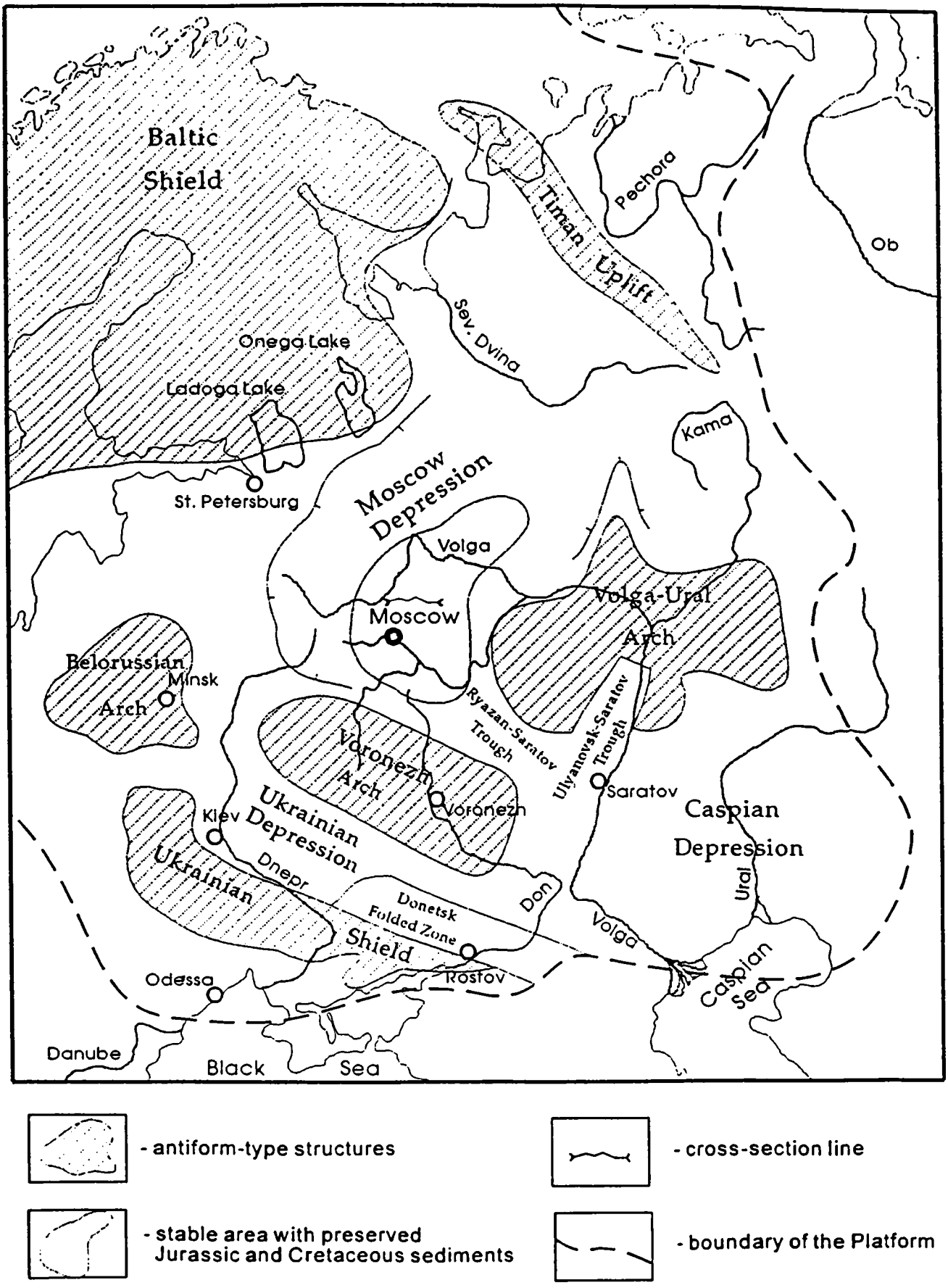


Fig. 1 Sketch map of major structures of the Russian Platform.

I.2 Lithostratigraphy

The Jurassic strata are widely distributed on the Russian Platform ranging in age from Dogger to Late Volgian. Many of the preserved strata are bounded both above and below by unconformities. The Jurassic deposits are represented by sands, silts, clays, and black shales. Various facies are indicators of various environments including lagoon, shoreface, offshore and deeper marine (tab. 1). The lithostratigraphy of the Moscow basin is as follow:

The Podosinovskaya of Late Callovian and Early Oxfordian age is composed of a basal marl with oolites overlain by light gray clay. Upper Callovian ammonites have been identified in the *marl (Peltoceras athletes, Quenstedtoceras lambert)* and clay *(Cardioceras cordatum, C. vertebrate).* No visible boundary exists between the Callovian and Oxfordian in well or outcrop sections (Unzha River near Makariev and Ryazan Province). The unconformably overlying Podmovskovnaya and Kolomenskaya Fms. (Middle to Upper Oxfordian) are represented by deep marine black shales and offshore marine silty clay with Cruziana ichnofacies (between fair weather and storm wave base). The unconformity between the Podosinovskaya and Podmovskovnaya Fms is widespread, extending across the entire Russian Platform. The Middle Oxfordian age of the Podosinovskaya is indicated by ammonites (C. *zenaidae., C. ilovaisky, C. alternoides*). The overlying Kolomenskaya Fm. of Late Oxfordian age includes *Anweboceras alternans*, A. *serrature* of the Ravni Zone. The overlying Yermolinskaya Fm. (17 m of black offshore chamosite clays) representative onset of the Upper Oxfordian-Kimmeridgian transgression. The lower Kimmeridgian age is indicated by ammonites *Prorasenia stephanoides* and *Ringsteadia pseudoyo* in the lower part and *Amoeboceras kitchini* and A. *kapfti* in the upper part of the formation. The lowermost part of the section is characterised by Upper Oxfordian ammonites of the *A. novosselkense* Zone (Olferiev, 1986). The Upper Kimmeridgian has not been investigated in as much detail as have other parts of the Jurassic section because it has been almost completely lost to erosion and is adequately preserved in only one small area of the Russian Platform (near Gorki village, Vladimir province). The Gorkinsakaya Fm. consists of offshore marine clays with spongeolites. The Upper Kimmeridgian age of the formation corresponds to the Aulacostephanus eudoxus Zone (Gerassimov, 1971). The Lower Volgian is absent throughout virtually all of the Moscow Synclise. The only occurrence is in the Kostroma province where calcareous silty clays (3.5 m) have been encountered in wells. The age of the clay is indicated by forams *(Pseudolamarckina polonica, Planularia polenovae, Marginulina gluschisaensis)* (Olferiev, 1986). The Middle Volgian overlies the prominent unconformity throughout the region. There is no paleontological evidence for the Lower Volgian including phosphorite nodules on the erosion surface. The Middle Volgian is widespread throughout the Moscow Synclise and is characterised by a vertically variable marine facies. This is the reason that there are four formations in the Middle Volgian substage. The Kostromskaya Fm. consists of deep marine black shales of the *Dorsoplanites panderi* Zone, and the Yegor'evskaya Fm. consists of shoreface sands with pebbles and phosphorite nodules of the *Virgatites virgatus* Zone unconformably overlying the Kostromskaya Fm. The offshore gray-black clayey sands and silts of the Philevskaya Fm. overlies the Yegor'evskaya Fm. with no sign of sedimentary interruption. The Philevskaya contains abundant fossils including ammonites *Virgatites rosanovi* and *Crendonites kunsevi.* The Lopatinskaya Fm. is represented by very homogenous gray-green fine quartz-chamosite shoreface sands, and overlies the Philevskaya with an erosional unconformity. The stratigraphic position of the Lopatinskaya Fm. occupies the interval from *the Epivirgatites nikitini* Zone of the Middle Volgian until the *Craspedites mosquensis* Subzone of the Upper Volgian. In the upper part of the formation, at the level of the *Craspedites subditus* there is a lithified phosphate layer which consists of filled *Buchia* shells and simple phosphate nodules. The top of the Jurassic section is observed in outcrop in the vicinity of Moscow, and consists of a thick section of white fine quartz-chamosite sands with phosphorite pebbles of the Kuntzevskaya Fm. (Gerassimov, 1969). The age of this section corresponds to the *Craspedites nodiger* Subzone (Upper Volgian).

The base of the lower Cretaceous Ryazanian horizon overlies the Jurassic with an erosional unconformity everywhere, but according to the biostratigraphic data there is no significant interruption in sedimentation between the Jurassic and Cretaceous that would be equivalent to an ammonite zone (Mesezhnikov, 1979; 1984)

stage	s/st	age (Ma)	formation;	thickness (m)	lithology; environment
Berriasian		145.6	Ryazanskaya	6.0	sands, phosphrite pebbles; shoreface
Volgian	U		Kuntsevskaya	15.5	Q-sands; shoreface
			Lopatinskaya	5.8	sands, chamosites; marine, shoreface
	M		Philevskaya	28.4	sands, silts; offshore
			Yegorievskaya	3.8	Glauconitic sands Phosphorite pebbles shoreface
			Kostromskaya	11.0	bituminous shales; deep marine
	L				stagnation?
Kimmeridgian	U	152.1	Gorkinskaya	11.0	clays, spongolites; deep marine
	L		Yermolinskaya	17.0	clays; deep marine
Oxfordian	U	154.7	Kolomenskaya	8.0	silts, clays; marine' offshore
	M		Podmoskovnaya	8.5	bituminous clays; deep marine
	L		Podosinkovskaya	13.0	clays; marine, offshore oolithic marls shoreface
Callovian	U	157.1	Velikodvorskaya	8.0	clays; marine, offshore
	M		Kriushskaya	8.0	oolithic sands; marine, shoreface
	L		Yelatminskaya	29.0	clays, silts, sands; offshore, marine
Bathonian	U	161.3	Moskvoretskaya	20.0	sands, silts swamps fluvial lacustrine
	M		Mokshinskaya	28.5	silts; clays lagoon
	L		Vyazhevskaya	2.0	Clays; marine, offshore oolithic sands shoreface
Bajocian	U	166.1			

Tab. 1 Jurassic stratigraphy of the Moscow Basin

I.2 Paleogeography

The area of preserved Mesozoic strata does not correlate with depositional area, but rather with stratigraphic position subject to modern erosion in an incoherent drainage system. Paleogeographic maps of the Russian Platform have been compiled [Vinogradov, 1968; Milanovsky, 1987; Keller, 1974; Naidin, 1959; 1986; Sazonov, 1967) but are generally based on outcrop and subsurface extent. However, it is clear that the extent of marine deposition was considerably greater than that of preservation because the preserved facies generally do not vary as the outcrop edge is approached. A set of paleogeographic map, covering the Upper Jurassic, is proposed in Fig. 2 to 8.

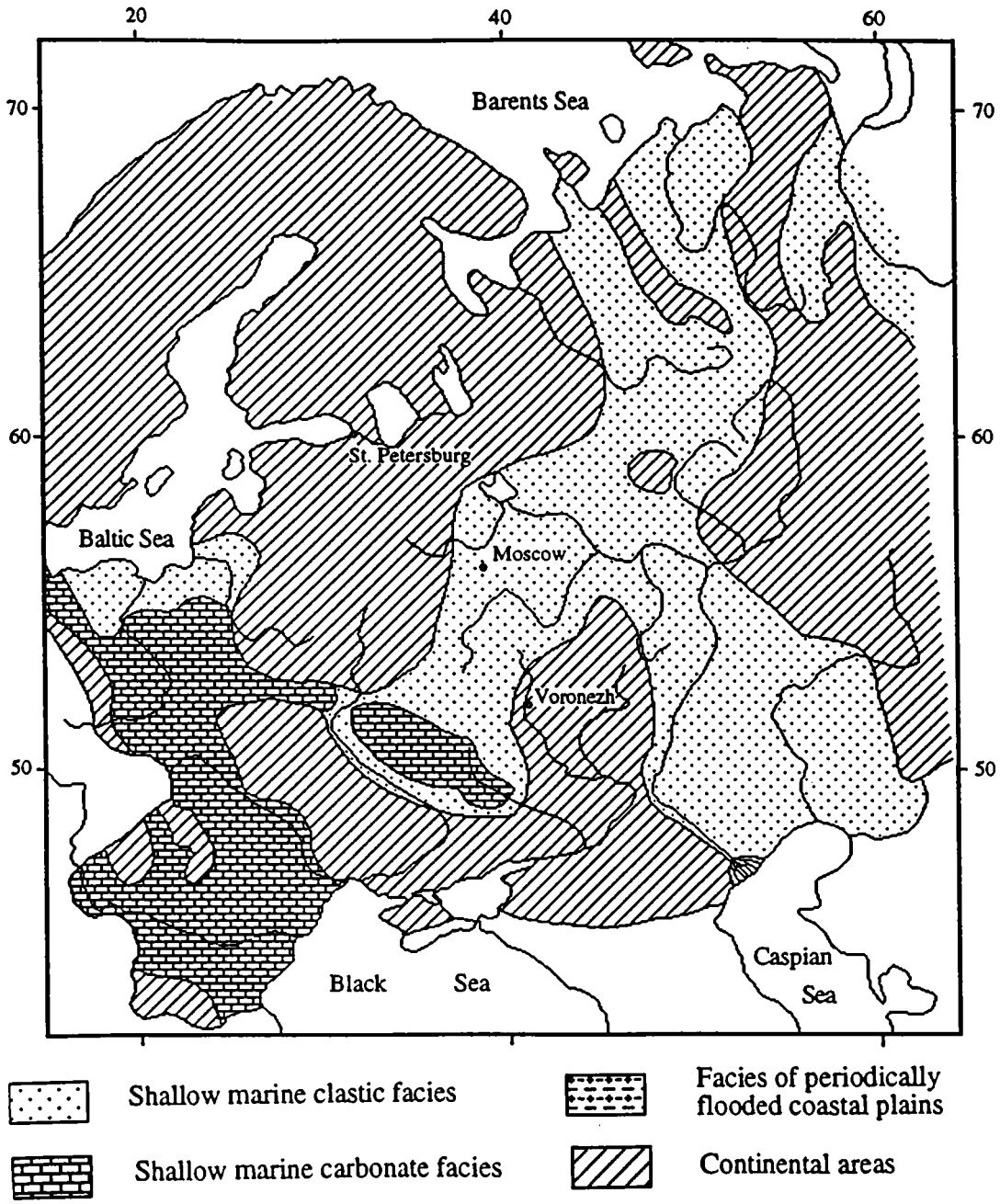


Fig. 2 Upper Oxfordian lithofacies and paleogeography of the Russian Platform (after Sazonov and Sazonova, 1967).

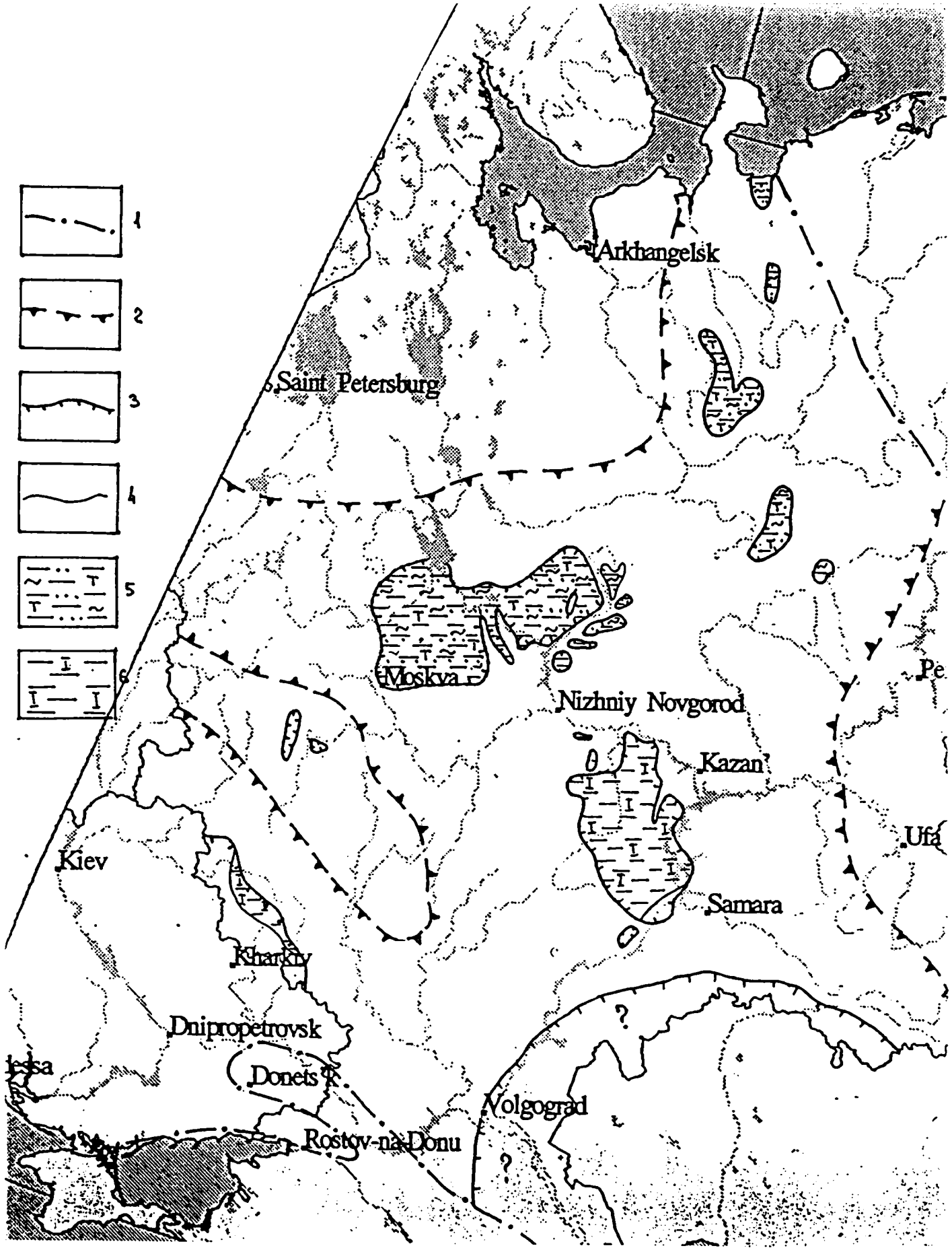


Fig. 3 Lower Kimmeridgian lithofacies and paleogeography of the Russian Platform (1. boundary of the Russian Platform, 2. possible position of shore line, 3. present distribution of Kimmeridgian deposits, 4. present distribution of Lower Kimmeridgian deposits, 5. dark-grey clays, sometimes with mudstones, sands and glauconite, 6. light-grey clays, enriched in carbonate, sometimes with interbedded marls and limestones).

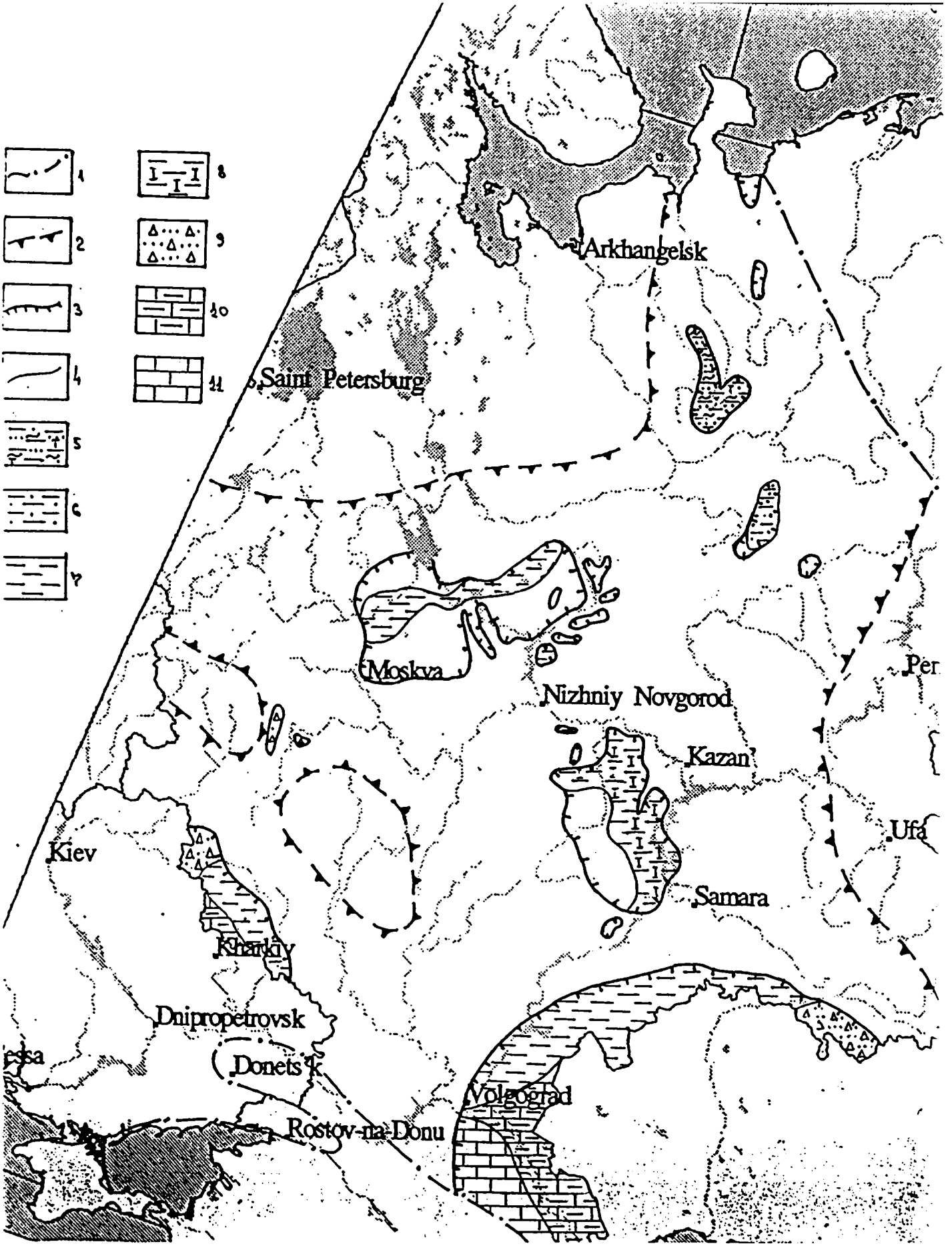


Fig. 4 Upper Kimmeridgian lithofacies and paleogeography of the Russian Platform (1. boundary of the Russian Platform, 2. possible position of shore line, 3. present distribution of Kimmeridgian deposits, 4. present distribution of Upper Kimmeridgian deposits, 5. dark-grey clays, interbedded with silty clays and glauconite, 6. dark-grey clays with sand lenses, 7. dark-grey silty clays, 8. light grey carbonate clays, 9. sands, sandstones and siltstones with terpel ciment, spongolites, 10. intercalation of limestone, marlstone and clays, 11. limestones).

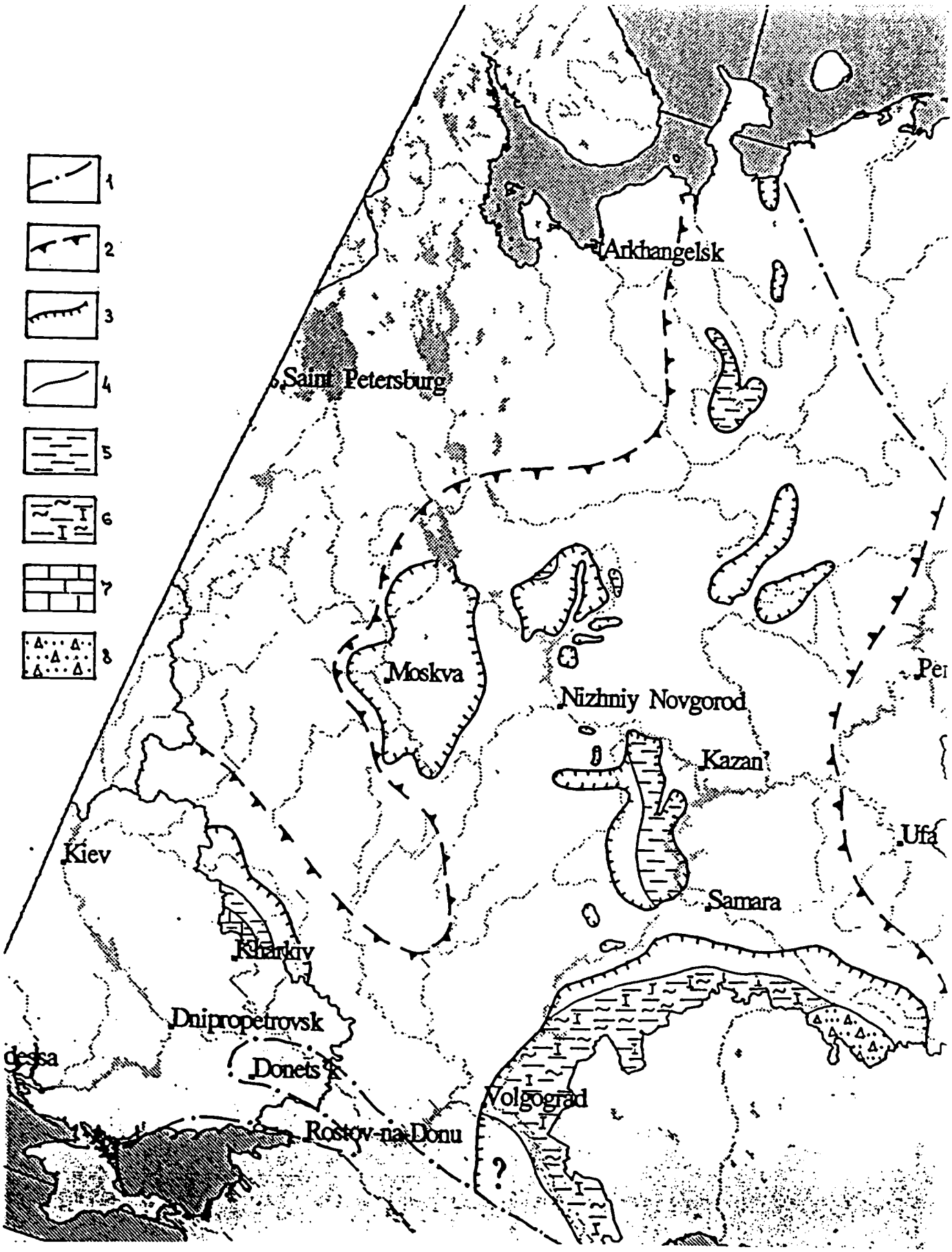


Fig. 5 Lower Volgian lithofacies and paleogeography of the Russian Platform (1. boundary of the Russian Platform, 2. possible position of shore line, 3. present distribution of Volgian deposits, 4. present distribution of Lower Volgian deposits, 5. dark-grey clays, 6. dark-grey clays interbedded with siltstones, marlstones and limestones, 7. alternation of clays and organic-rich limestones, 8. Opoke sandstones).

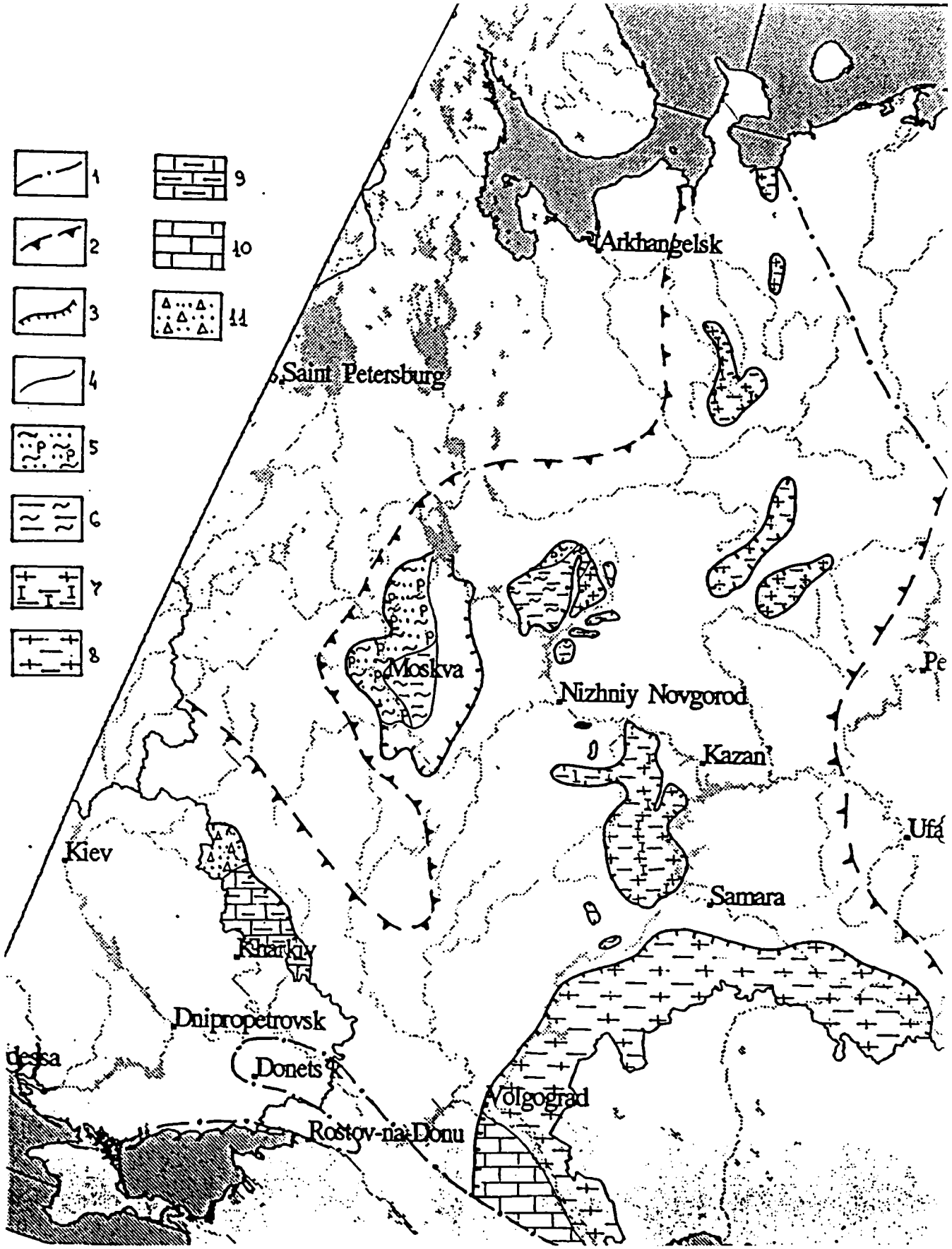


Fig. 6 Middle Volgian (Panderi Ammonite zone) lithofacies and paleogeography of the Russian Platform (1. boundary of the Russian Platform, 2. possible position of shore line, 3. present distribution of Volgian deposits, 4. present distribution of Panderi zone deposits, 5. Silts and sands with phosphorites nodules, 6. light-grey carbonate-rich clays overlapping by black shales and carbonated clays, 7. dark-grey silty clays, 8. grey and dark-grey clays with lenses of black shales, 9. alternation of clays, marlstone and limestones, 10. limestones, 11. Opoke siltstones and spongolites).

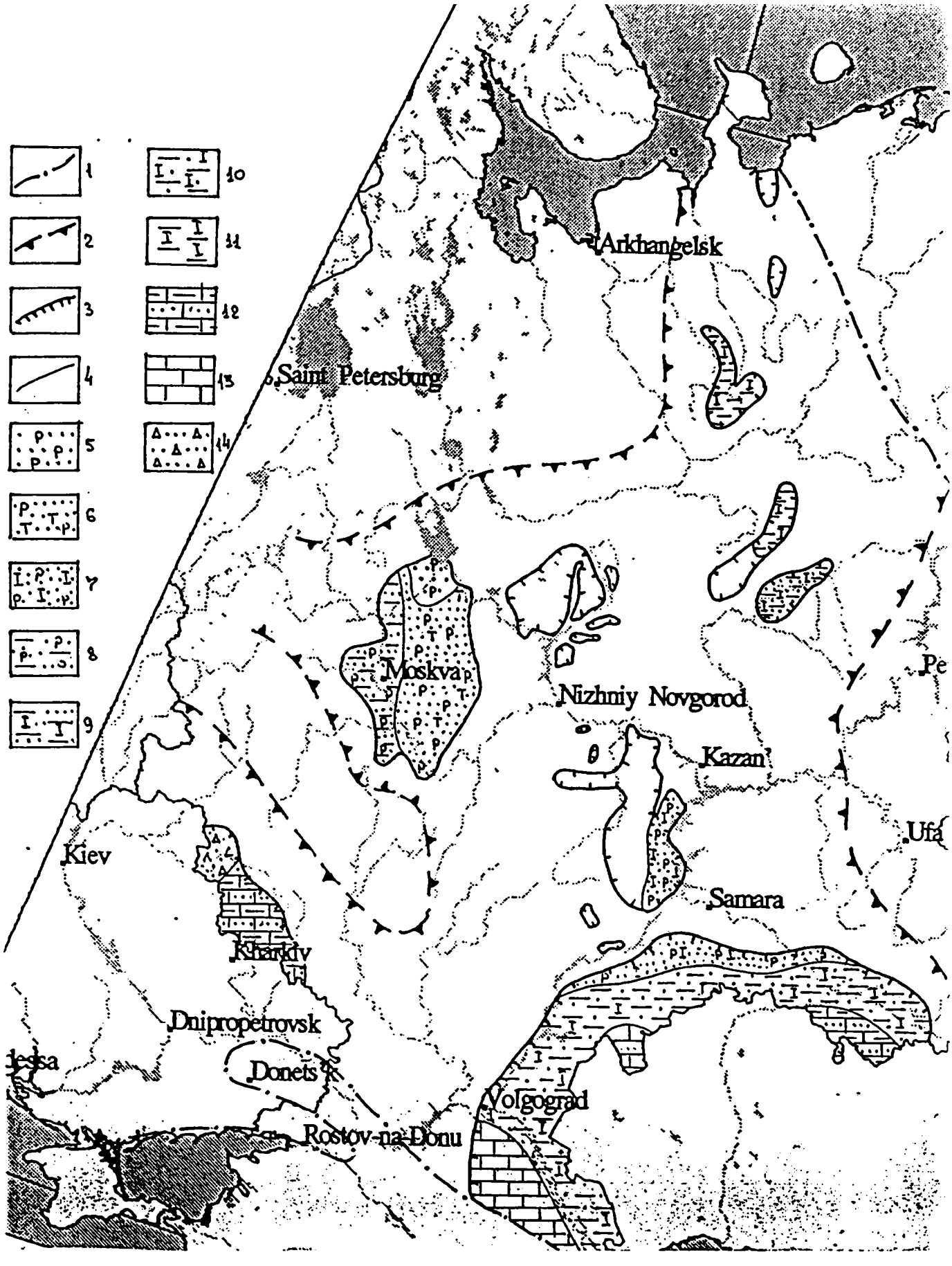


Fig. 7 Middle Volgian (Virgatus-Nikitini Ammonite zones) lithofacies and paleogeography of the Russian Platform (1. boundary of the Russian Platform, 2. possible position of shore line, 3. present distribution of Volgian deposits, 4. present distribution of Virgatus-Nikitini zones deposits, 5. Coarse-grained sandstones with phosphatic nodules, 6. fine-grained sandstones with phosphatic nodules, 7. fine-grained sands and sandstones with glauconite, quartzite, limestone and phosphatic nodules, 8. fine-grained silty and clayey sands with phosphatic nodules, 9. grey and dark-grey clays interbedded with sands and marls, 10. sandy clays interbedded with sands and limestones, 11. light-grey carbonate-rich clays, 12. limestones and sandstones with clay lenses, 13. limestones, 14 Opoke sandstones and siltstones, spongolites).

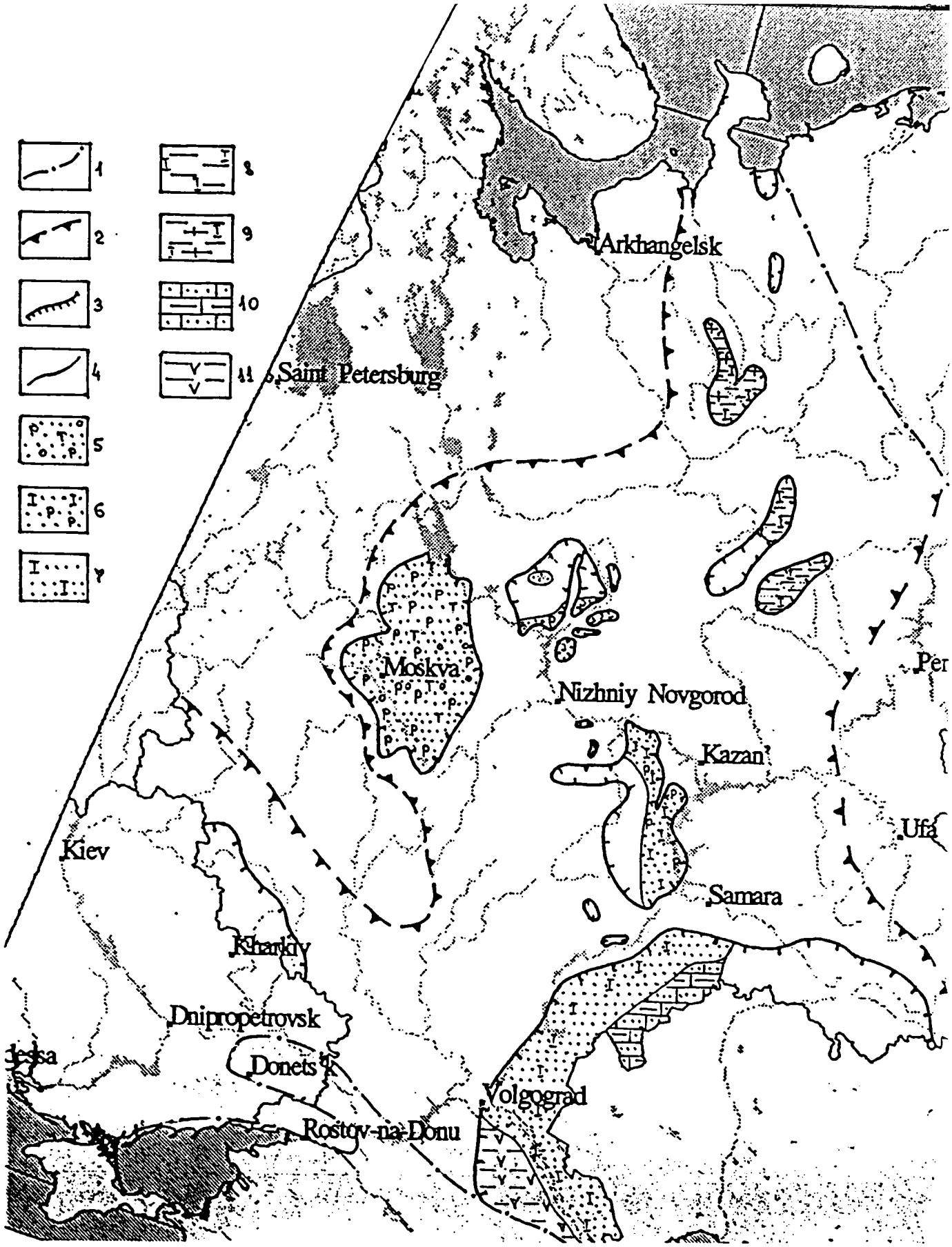


Fig. 8 Upper Volgian lithofacies and paleogeography of the Russian Platform (1. boundary of the Russian Platform, 2. possible position of shore line, 3. present distribution of Volgian deposits, 4. present distribution of Upper Volgian deposits, 5. quartz-glauconitic sands and sandstones with phosphatic nodules and oolites, 6. calcareous sands with phosphatic nodules, 7. calcareous sands, 8. green-grey calys with marl lenses, 9. light-grey calcareous, clays, marls with rare bed of black shales, 10. limestone, marly clayey sandstones, 11. halitic and anhydritic breccias overlapped by clays).

II LOCATION AND DESCRIPTION OF THE STUDIED SECTIONS

Six sections were studied in the Moscow basin and the Ulyanovsk-Saratov trough along the Volga River (Fig. 9) including the Volgian stratotype of Gorodishche. The precise location of section is done in Fig. 10.

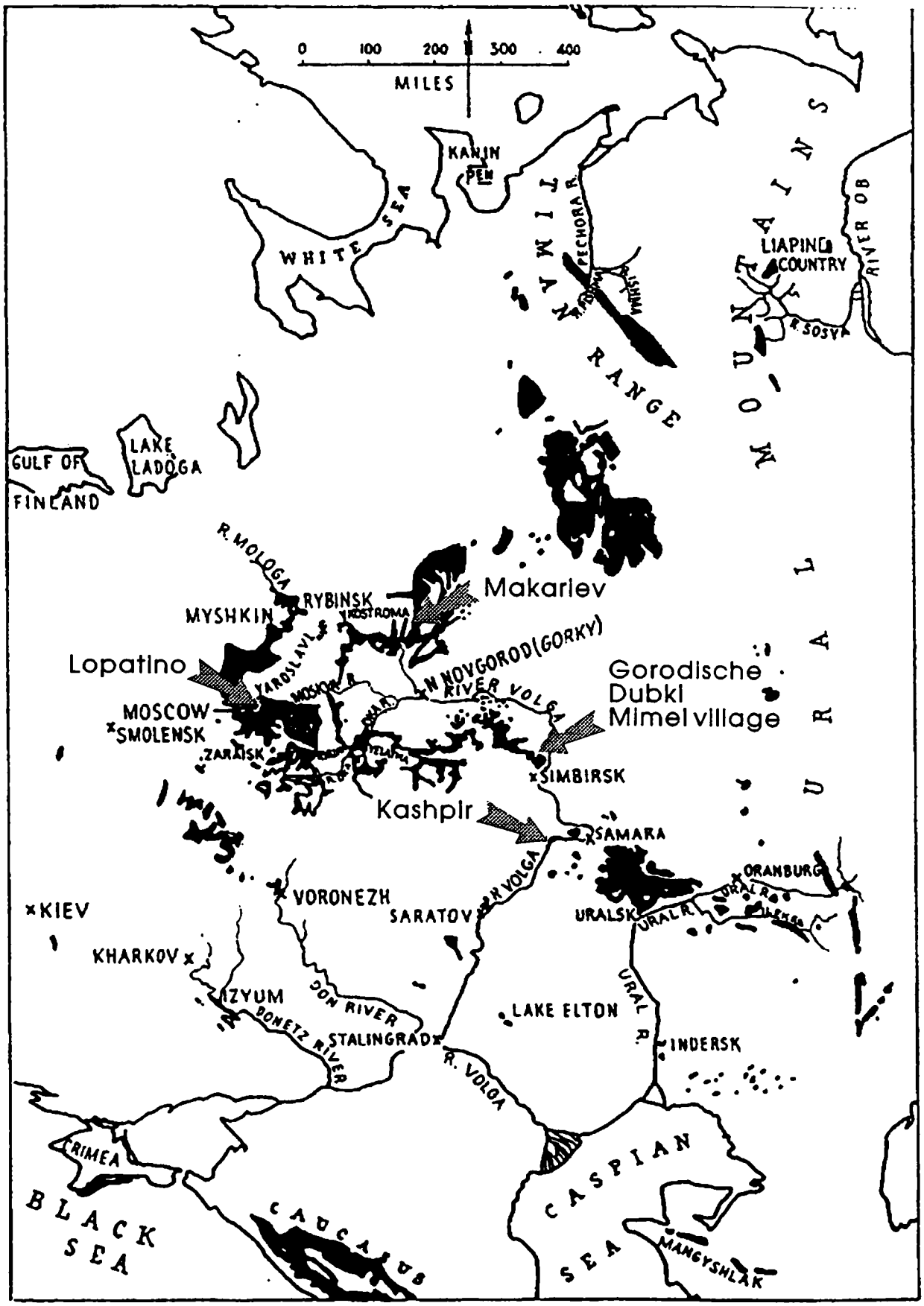


Fig. 9 Distribution of the Jurassic outcrops on the Russian Platform (after Arkell, 1956) and location of the studied section.

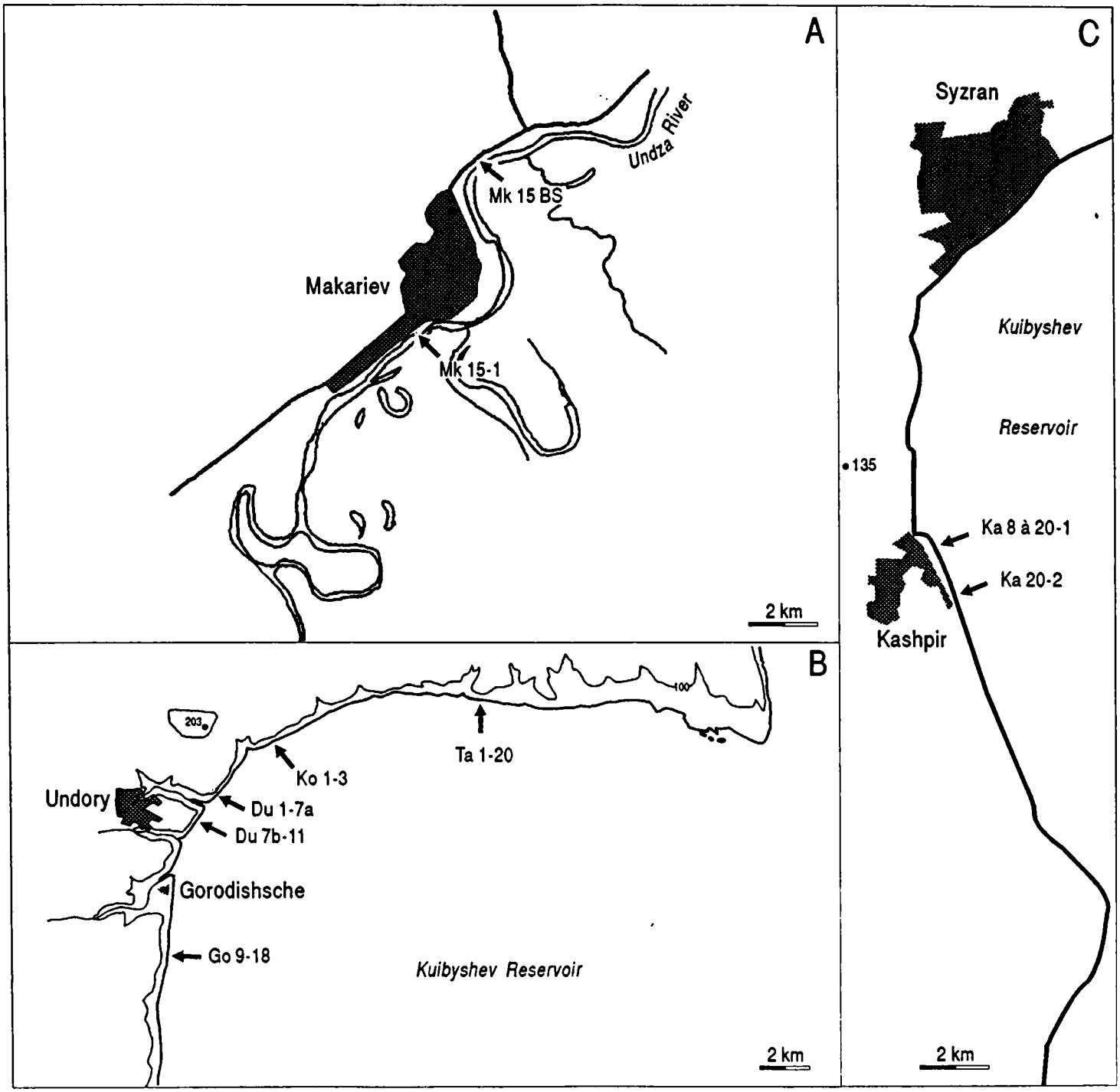


Fig. 10 A- Location map of the Makariev section

B- Location map of the Gorodishsche, Dubky, Kameni Ourag and Mimei village sections

C- Location map of the Kasphir section

II.1 Makariev (Mk, Fig. 11):
* [Thickness measured by A. Olferiev and faunas determined by Gerassimov and Antostchenko]
The ammonte fauna was also studied by Mesehznikov (1989), the list of which is given in appendix.

OXFORDIAN:

Mk 16 1.40 m [1.70 m] compact grey clays, intensely bioturbated, showing a 10 to 20 cm-thick bedding with planar surfaces. Centimetric phosphatic nodules are present, and large pieces of wood occur at 20 cm from the bottom. Ammonites, Belemnites, Gastropods (*Pleurotomaria, Dentalium*), Brachiopods (Rhynchonellids) and Bivalves (*Astarte, Nuculoma cordata, Entolium*).
[**+0.40 m / 12**: *Cardioceras vertebrale* SOW., *Perisphinctes* sp., *Oxytoma* sp.]
[**+1.30 m / 43**: *Cardioceras* sp.]

Mk 15 1.80 m [2.30 m] compact grey clays, intensely bioturbated, starting with a 10 to 15 cm-thick layer rich in glauconite and containing a lot of reworked and non-oriented Belemnites. The boundary with the previous unit is underlined by a thin level with crushed Ammonites. A lumachellic bed with Ammonites, Belemnites, Gasteropods (*Pleurotomaria*) and Bivalves (*Gryphaea dilatata*) occurs 40 cm below the top. The top of this unit is marked by a yellowish to greenish 10 cm-thick layer of argillaceous pyritic sand with Belemnites.
A thin (2 to 4 cm-thick) black shale occurs laterally and takes place 90 cm below the top.
[**+0.05 m / 11**: *Cardioceras zenaidae* ILOV., *C. cordatum* SOW., *C. tenuicostatum* NIK., *C. russiensis* SAS., *Grammatodon* sp.]
[**+0.30 m / 42**: *Cardioceras* cf. *cordatum* (SOW.)]
[**+0.55 m / 41**:*Cardioceras* sp., *C.* cf. *cordatum* (SOW.)]
[**+0.70 m / 30**: *Cardioceras* cf. *tenuicostatum* (NIK.); *C. tenuicostatum* (NIK.)]
[**+0.90 m / 29**: *Cardioceras cordatum* (SOW.)]
[**+1.35 m / 28**: *Cardioceras zenaidae* ILOV.; *Cardioceras* sp.]
[**+1.55 m / 27**: *Perisphinctes* sp. *ex. gr. plicatilis* SOW.; *Cardioceras percaelatum ?* PAV., *C. zenaidae* ILOV.]
[**+1.65 m / 26**: *Perisphinctes* sp. *ex. gr. plicatilis* SOW.]
[**+1.75m / 25**: *Perisphinctes* sp.]
[**+1.90 m / 24**: *Cardioceras* cf. *zenaidae* ILOV., *C. zenaidae* ILOV., *Miticardioceras* sp.]

Mk 14 0.12 m [0.10 m] finely laminated black shale, with some planar traces (trails ?) at the bottom. Ammonites, Gasteropods (*Aporrhais*), Bivalves and Fish-scales.
[5,6,7,: *Amoeboceras ilovaiskii* (SOK.), *Entolium* sp., *Dicroloma* sp.]

Mk 13 0.15 m black bioturbated (chondrites) clays with a thin level of crushed Ammonites, Bivalves and Gasteropods at 2 cm from the base. Rare pieces of crinoids at the top.
[**+0.05 m / 8**: *Amoeboceras ilovaiskii* SOK.]
[**+0.10 m / 9**: *Amoeboceras* sp.]

Mk 12 0.30 m [0.35 m] grey silty clays with debris of Ammonites.
[**+0.20 m / 10**: *Amoeboceras ilovaiskii* SOK.]

Mk 11d 0.30 m compact grey clays with Belemnites.
[**+0.10 m / 13**: *Cardioceras zenaidae* ILOV., *Amoeboceras alternans* BUCH., *A. ilovaiskii* SOK., *Pachyteuthis panderiana* d' ORB.]
[**+0.20 m / 14**: *Amoeboceras* cf. *alternans* BUCH., *A.* cf. *ilovaiskii* SOK., *Hibolites* sp., *Nucula* sp.]
[**+0.25 m / 15**: *Amoeboceras* cf. *ilovaiskii* SOK.]
[**+0.30 m / 16**: *Perisphinctes ex gr. plicatilis* (SOW.)]

Mk 11c 0.10 m greenish clays having a yellowish to rust-coloured alteration, containing pyritic and phosphatic nodules, glauconite and Belemnites.

Mk 11b 0.10 m compact grey clays.

Mk 11a 0.08 m greenish clays having a yellowish to rust-coloured alteration, containing Bivalves (*Buchia*) and Belemnites.

Mk 10b 0.20 m grey clays becoming glauconitic to the top with Belemnites and Bivalves (*Astarte cordata*). The upper surface is bioturbated and burrows fill in the glauconitic clays.

[**+0.15 m / 17** *Cardioceras zenaidae* ILOV., *Amoeboceras* cf. *ilovaiskii* SOK., *A. alternans* BUCH.]

Mk 10a 0.40 m grey clays with phophatic pebbles, becoming intensely bioturbated with reworked Belemnites to the top.
[**+0.3 0 m / 18**: *Cardioceras zenaidae* ILOV., *Amoeboceras* cf. *ilovaiskii* SOK., *A. alternans* BUCH.]
[**+0.35 m / 19**: *Cardioceras zenaidae* ILOV., *Cardioceras* sp., *Amoeboceras* sp.]

Mk 9b 0.40 m grey clays with Ammonites, Belemnites and some phosphatic concretions at the top.
[**+0.10 m / 31**: *Amoeboceras* sp. (cf. *kitchini* (SALF.), *Amoeboceras* sp. (cf. *alternans)* (BUCH)]
[**+0.25 m / 32**: *Amoeboceras* sp. (cf. *kitchini* (SALF.), *Amoeboceras* cf. *alternans* BUCH.]
[**+0.30 m / 33**: *Amoeboceras* sp.]

Mk 9a 0.05 m glauconitic clays with phosphatic concretions, Belemnites, Bivalves and Serpulids. Floating wood appears on the upper surface of this unit.

Mk 8d 0.50 m grey clays with Ammonites (*Ringstedia*) and Belemnites to the top.
[**+0.30 m / 34**: *Amoeboceras* sp., *Amoeboceras alternans* BUCH., *Amoeboceras tuberculatoalternans* NIK., *Inoceramus* sp.]
[**+0.40 m / 35**: *Amoeboceras* sp. (cf. *kitchini* (SALF.), *A. alternans* BUCH., *A. tuberculatoalternans* NIK.]
[**+ 0.50 m / 36**: *Prorasenia stephanoides* (OPP.), *Desmosphinctes* sp.]

KIMMERIDGIAN:

Mk 8c 0.05 m glauconitic and ferrugineous clays with phosphatic nodules, Ammonites (*Pictonia densicostata*), Belemnites and Bivalves.

Mk 8b 0.50 m grey clays with Ammonites (*Pictonia baylei*) appearing at 20 cm from the base.
[**+ 0.30 m / 37**: *Amoeboceras* sp., *A.* cf. *alternans* (BUCH.), *A.* cf. *kitchini* (SALF.), *Desmosphinctes* cf. *mniovnikensis* NIK.]

Mk 8a 0.05 m altered glauconitic clays with phosphatic nodules and small crystal of (secondary ?) gypsum.

Mk 7b 0.30 m dark laminated clays with Belemnites, Fish-scales and Bivalves (*Loripes*).
[**+0.05 m / ***: *Perisphinctes* sp. *juv.*]

Mk 7a 0.05 m glauconitic clays with nodules and large crushed Ammonites.

Mk 6c 0.20 m grey clays having a cubic cutting up.

Mk 6b 0.10 m dark laminated clays with Bivalves (*Loripes*).

Mk 6a 0.30 m grey clays with large shells of Ammonites (*Rasenia* cf. *uralensis* and *R.* aff. *cymodoce*).

Mk 5 0.20 m dark laminated clays.
[**+0.15 m / 38**: *Amoeboceras* sp.]

Mk 4 0.70 m grey clays having a cubic cutting up and containing large shells of Ammonites.
[**+0.25 m / 39**: *Amoeboceras* sp.]
[**+0.35 m / 40**: *Amoeboceras* sp.]

Mk 3 0.30 m dark laminated clays with Ammonites (*Rasenia* sp.).

Mk 2 1.10 m grey clays, deeply altered toward the top, with Belemnites at the base, rare Ammonites, Bivalves and phosphatic nodules to the top.

Mk 1c 1.80 m grey clays, bioturbated near the bottom, with numerous shelly debris (Ammonites, Bivalves) at the middle part. Centimetric limestone nodules appear 30 cm below the top.
[**+1.25 / 4**: *Amoeboceras* sp. (cf. *cricki* (SALF.)]
[**+1.15m / 3**: *Amoeboceras* sp. (cf. *cricki* (SALF.)]

Mk 1b 0.20 m grey micritic limestones with an rust-coloured alteration in the middle part containing Ammonites (*Rasenia* cf. *uralensis*) at the top.

Mk 1a 0.40 m clays, deeply altered by the proximity of soil.

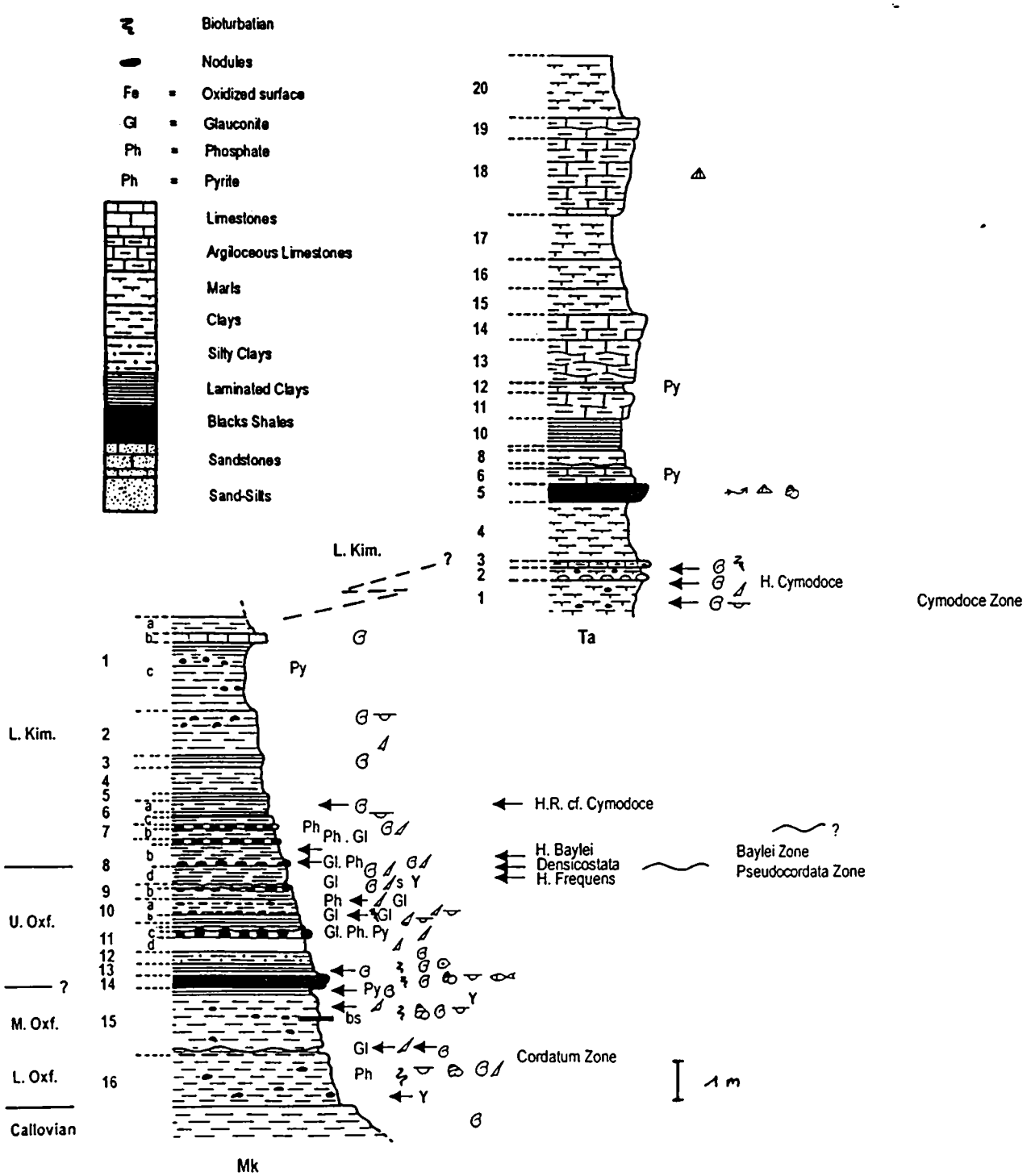


Fig. 11 Lithostratigraphic column of the Oxfordian and Lower Kimmeridgian deposits studied.

II.2 Mimel village (Tatarstan Ta, Fig. 11)

LOWER KIMMERIDGIAN:

Ta 1 2.00 m (visible) grey marls with phosphatic nodules. At the bottom, large debris of wood. Ammonites (*Rasenia* cf. *uralensis, Amoeboceras*), Bivalves (*Buchia concentrica, Malletia*). At the top Ammonites (*Rasenia* cf. *cymodoce*) and Belemnites.

Ta 2 0.30 m grey marls with phosphatic nodules and Ammonites (Perisphinctids). The base is marked by a more or less continuous level of whitish nodules.

Ta 3 0.20 m grey argillaceous limestones, intensely bioturbated.

Ta 4 1.60 m grey marls becoming darker to the top.

Ta 5 0.50 m brownish finely laminated black shales with planar traces (trails ?) and rare fauna of Brachiopods and Gasteropods (*Melleagrinella, Aporrhais* sp.).

Ta 6 0.45 m dark-grey platty argillaceous limestones with pyritic nodules.

Ta 7 0.03 to 0.14 m dark-grey laminated marls.

Ta 8 0.40 m light-grey marls.

Ta 9 0.10 m greyish to brownish laminated clays.

Ta 10 0.70 m dark-grey laminated clays.

Ta 11 0.75 m light-grey argillaceous limestones.

Ta 12 0.25 m marls more or less laminated.

Ta 13 1.10 m grey to beige argillaceous limestones.

Ta 14 0.70 m compact beige argillaceous limestones.

Ta 15 0.70 m grey to beige platty marls.

Ta 16 0.80 m grey marls.

Ta 17 1.10 m compact beige marls.

Ta 18 2.00 m light-beige argillaceous limestones containing rare Brachiopods (*Lingula* sp.).

Ta 19 0.50 m light-grey argillaceous limestones.

Ta 20 1.50 m marls, deeply altered due to the proximity of soil.

II. 3 Dubky and Kamennyl Ourag (Du and Ko, Fig. 12)

UPPER KIMMERIDGIAN:

Ko 1 0.50 m grey argillaceous limestones with Ammonites (*Pararasenia hybridus, Aspidoceras caletanum*) and Belemnites.

Ko 2 0.40 m greyish to greenish silty clays with planar burrows (trails ?) with numerous Fish-scales and remains.

Ko 3 1.00 m grey marls.

Du 1 0.60 m light-grey argillaceous limestone containing some ferrugineous nodules with Belemnites and Ammonites (*Aulacostephanus eudoxus, Aspidoceras caletanum, A.* cf. *longispinum* and *Amoeboceras* sp.)

Du 2 0.50 m marls containing light-grey calcareous lenses and numerous limonitic Ammonites (*Aulacostephanus contejeani, Aspidoceras quercynum, Tolvericeras sevogodense*).

Du 3 0.50 m marls containing light-grey calcareous lenses and numerous limonitic Ammonites (*Aulacostephanus yo, Aspidoceras* gr. *quercynum*).

Du 4 4.00 m light-grey marls containing some calcareous nodules and small Belemnites. A 50 cm-thick more clayey interval lays 2 m from the base. Ammonites (*Aspidoceras* sp., *Aulacostephanus yo*) appear at 3 m and 4 m. The top of this unit is marked by a layer of calcareous nodules.

Du 5 4.00 m beige massive argillaceous limestones, with rare phosphatic nodules, becoming grey and marly within the uppermost 1 m. Aptychus (*Laevaptychus*), Belemnites, Brachiopods (Zeillerids), Bivalves (*Loripes*) and large pyritic disc containing Ammonites (*Aspidoceras* sp., *Aulacostephanus* cf. *yo*).

Du 6 5.00 m grey to beige bioturbated marls and argillaceous limestones with calcareous nodules containing Ammonites (*Tolvericeras* gr. *sevogodense*).

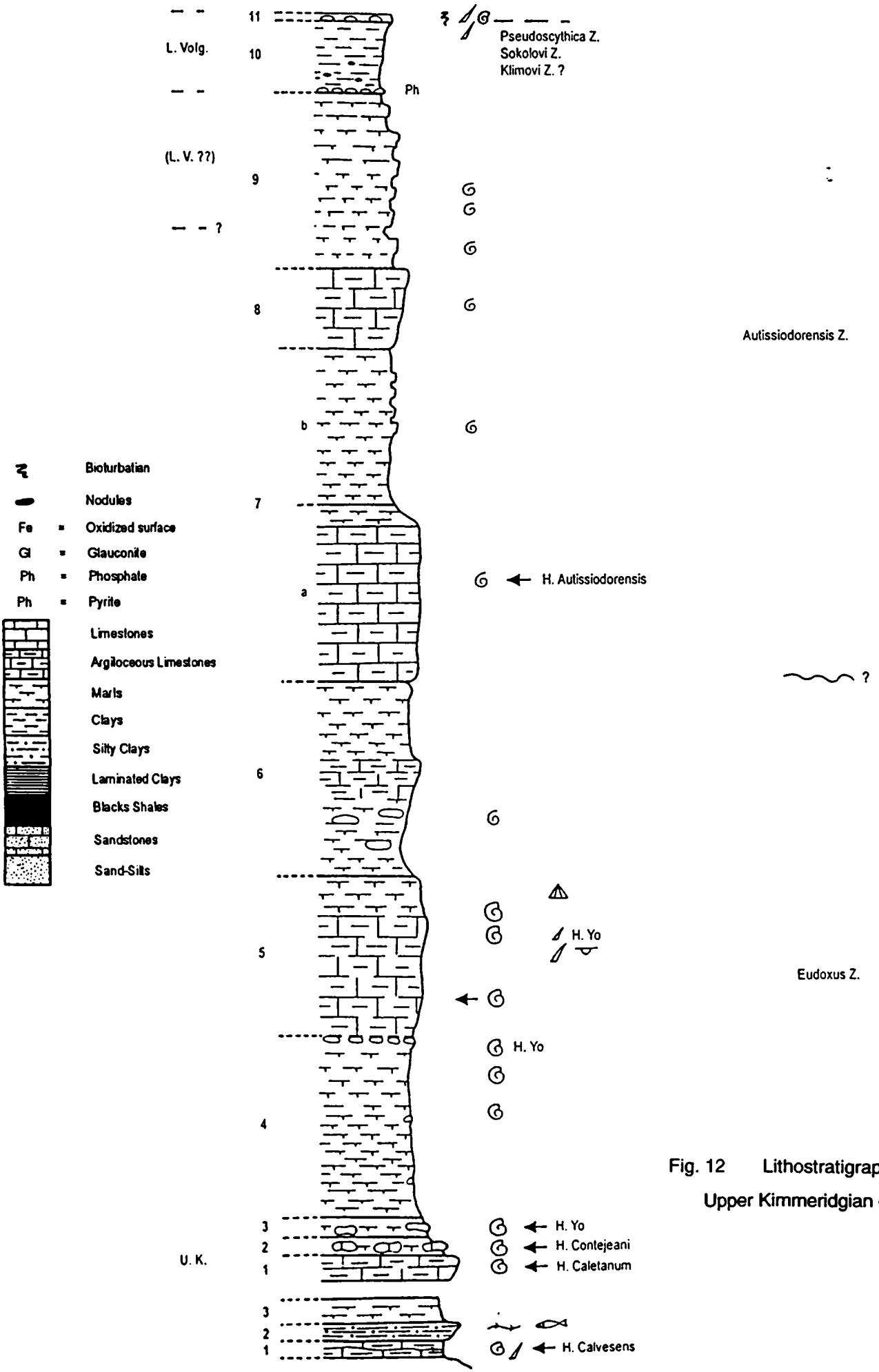


Fig. 12 Lithostratigraphic column of the Upper Kimmeridgian deposits studied.

Du 7a 4.50 m beige argillaceous limestones becoming marly in the topmost 50 cm. Ammonites (*Amoeboceras* sp., *Aulacostephanus autissiodorensis, A. kinghiensis, Virgataxioceras* sp.).

Du 7b1 2.00 m grey to grey greenish marls with phosphatic nodules and pyritic discs.

Du 7b2 2.00 m alternations of dark-grey to light-grey marls with Ammonites (*Aulacostephanus autissiodorensis, Virgataxioceras fallax*).

Du 8 2.20 m grey to light-beige calcareous limestones with Ammonites (*Aulacostephanus autissiodorensis, Virgataxioceras fallax*).

Du 9 4.50 m alternations of dark-grey to light-grey marls with Ammonites concentrated at the base of dark-grey beds (*Aulacostephanus autissiodorensis, Virgataxioceras fallax*, small *Aspidoceras* ?, *Sutneria* sp., *Perisphinctes* sp.).

LOWER VOLGIAN:

Du 10 1.80 m grey clays starting by a level with phosphatic nodules. Belemnites are concentrated at the top.

Du 11 0.20 m grey marls, intensely bioturbated (chondrites), with pyrite concretions. Perforated calcareous nodules occur at the base and Ammonites and Belemnites at the top (equivalent to bed Go 9a, see below).

II. 4 Gorodische (Go, Fig. 13)

MIDDLE VOLGIAN:

Go 9a 0.20 m grey marls, intensely bioturbated (chondrites), with pyrite concretions. Perforated calcareous nodules occur at the base and Ammonites and Belemnites at the top. (equivalent to bed Du 11, see above).

Go 9b 0.25 m dark-grey marls with Ammonites and Belemnites.

Go 9c 1.00 m grey marls, intensely bioturbated, with phosphatic nodules, Belemnites and Ammonites.

Go 10a 1.50 m grey marls, intensely bioturbated, with phosphatic nodules, Belemnites and Ammonites.

Go 10b 0.08 to 0.15 m nodular argillaceous limestones with Ammonites.

Go 10c 0.85 m bioturbated grey marls being dark-grey in the middle part with Ammonites, Belemnites and phosphatic nodules. Within the last 20 cm, a white argillaceous millstone level is visible.

Go 11 6.08 m showing alternations of black shales and dark-grey calcareous clays with Ammonites, Belemnites, rare Bivalves and pyritic nodules. Toward the top, the clays appear lighter in colour: grey to brownish with some yellowish level due to alteration of pyritic layer (jarosite ?). This unit is subdivide as follows:

Go 11a 0.20 m black shale + 0.50 m dark-grey calcareous clays,

Go 11b 0.07 m black shale + 0.15 m dark-grey calcareous clays,

Go 11c 0.20 m black shale + 0.30 m dark-grey calcareous clays,

Go 11d 0.15 m black shale + 0.40 m dark-grey calcareous clays,

Go 11e 0.20 m black shale + 0.50 m dark-grey calcareous clays,

Go 11f 0.05 m black shale + 0.07 m dark-grey calcareous clays,

Go 11g 0.04 m black shale + 0.09 m dark-grey calcareous clays,

Go 11h 0.10 m black shale + 0.80 m dark-grey calcareous clays,

Go 11i 0.12 m black shale + 0.08 m dark-grey calcareous clays,

Go 11j 0.20 m black shale + 0.35 m light-grey clays,

Go 11k 0.10 m black shale + 0.20 m light-grey clays,

Go 11l 0.13 m black shale + 0.35 m brownish-grey clays,

Go 11m 0.03 m black shale + 0.20 m brownish-grey clays with rust-colour spots,

Go 11m 0.20 m black shale + 0.30 m brownish-grey clays with rust-colour spots,

At a short distance from outcrop, the black shale layers from units Go 11f to Go 11h appears as a single black shale bed.

Go 12 0.09 to 0.12 m conglomerate of red to black phosphatic nodules and pebbles, Belemnites and Ammonites (*Virgatites virgatus*).

Go 13 0.50 m yellowish to greenish argillaceous silts with dispersed phophatic pebbles and Belemnites. 14 cm below the top, phosphatic pebbles, Belemnites and vertebrates remains (*Icthyosaurus, Pleisiosaurus*) are concentrated.

Go 14 0.06 to 0.10 m conglomerate of black phosphatic pebbles, Belemnites and Ammonites (*Virgatites virgatus*) in a sandy matrix. The top of this unit has an irregular surface.

Go 15 0.50 to 0.60 m yellowish to greenish argillaceous sands passing laterally to sandstones with Ammonites (*Paracraspedites* sp., *Epivirgatites nikitini*), Bivalves (*Buchia*) and concentration of Belemnites to the top. The upper limit is an undulated oxidised surface with a rust-colour.

UPPER VOLGIAN:

Go 16 0.06 to 0.08 m shell-rich sands with Bivalves, Belemnites and Ammonites (*Kachpurites fulgens*). The top of the unit is an oxidised surface.

Go 17 0.95 m brownish to greenish well-sorted and fine-grained sand with rust-coloured sandy nodules and lenses of grey calcareous sandstones. Fossils are concentrated: Ammonites (*Craspedites subditus*), broken Belemnites and Bivalves (*Buchia*).

Go 18 0.05 to 0.14 m glauconitic sands poorly-cemented with Ammonites (*Craspedites* sp.), Belemnites and Bivalves (*Buchia volgensis*). The top of this unit is eroded and overlain by Valanginian deposits.

II.5 Kashpir (Ka, Fig. 13)

MIDDLE VOLGIAN:

Ka 8 0.20 m Brown finely laminated black shales.

Ka 9 0.15 m dark-brown glauconitic sandstones with nodules of phosphorite and white marls. The lower boundary of this unit is wavy.

Ka 10 0.10 m greyish to greenish sandstones with Ammonites (*Epivirgatites* cf. *nikitini*).

Ka 11 0.10 m glauconitic silty sandstones with ferrugineous yields.

Ka 12 0.05 to 0.15 m greenish to grey sandstones with abundant Ammonites (*Epivirgatites nikitini, Lomonossovella* sp.) and Belemnites (*Acroteuthis mosquensis, A. russiensis*).

UPPER VOLGIAN:

Ka 13 0.50 m brownish to greyish clayey sandstones with calcareous seams with Ammonites (*Kashpurites fulgens, Garniericeras catenulatum*), Belemnites (*Acroteuthis mosquensis*) and Bivalves (*Buchia*). At the top of the unit occurs a thin level (2 cm) of strongly ferrugineous carbonate.

Ka 14a 0.25 m light-grey fine-grained glauconitic sandstones with Belemnites, Ammonites and Bivalves.

Ka 14b 0.60 m light-grey sands poorly cemented with calcareous patches. This unit is rich in Ammonites (*Craspedites okensis, C. subditus*), broken Belemnites and Bivalves (*Buchia*).

Ka 15 0.35 m light-grey fine-grained sandstones with calcareous cement containing Ammonites and Bivalves (*Buchia*).

Ka 16 0.30 m dark-grey bioturbated sandstones with numerous Ammonites and Bivalves.

Ka 17a 0.35 m light-grey fine-grained sandstones, strongly bioturbated, with dark-grey burrows. Ammonites (*Craspedites* ex. gr. *nodiger*) and Belemnites.

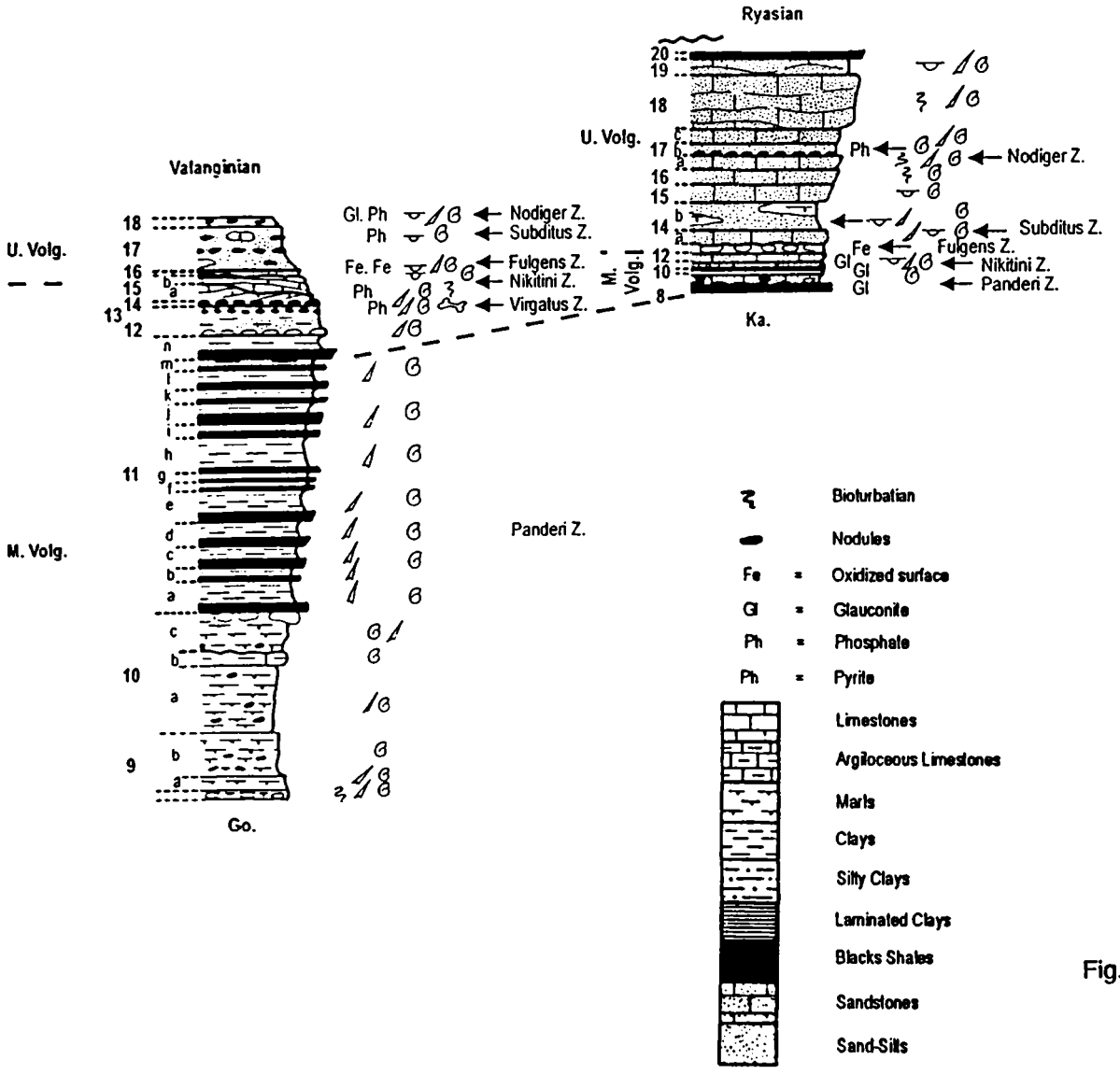
Ka 17b 0.20 m fine-grained calcareous sandstones starting by a level containing cm-long phosphatic pebbles and Ammonites.

Ka 17c 0.25 to 0.30 m light-grey calcareous sandstones with lumachellic lenses rich in Belemnites, Ammonites and Bivalves.

Ka 18 1.10 m massive light-grey fine-grained calcareous sandstones, strongly bioturbated, with numerous and non-oriented shells: Belemnites, Ammonites.

Ka 19 0.40 m light-grey to greenish-grey bioclastic sandstones having a nodular appearance. Numerous Ammonites (*Craspedites nodiger, C. parakashpuricus* and *Garniericeras subclypeiforme*).

Ka 20 0.06 to 0.15 m brown finely laminated black shales overlain by Ryazanian deposits.



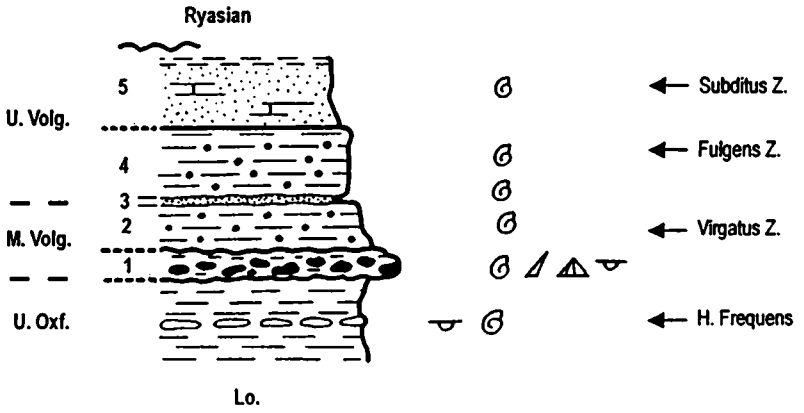


Fig. 13 Lithostratigraphic column of the Volgian deposits studied.

II.6 Egorevsk - Lopatino quarry nº 10 (Lo, Fig. 13)

The middle Volgian deposits rest upon Upper Oxfordian black laminated clays (1.00 m observed) with Ammonites (*Amoeboceras alternans, A. tubercolatoalternans, Ringsteadia* sp.) and Bivalves (*Retroceramus*).

MIDDLE VOLGIAN:

Lo 1 0.5 m poorly-cemented conglomerate with rounded phosphatic pebbles in a dark-grey sandy cement. The phosphatic pebbles contain reworked Ammonites (*Dorsoplanites panderi, Zaraiskites* sp., *Pavlovia* sp.), Belemnites, Brachiopods and Bivalves (*Buchia*). The topmost 10 cm are more argillaceous and contain younger Ammonites (*Virgatites palliasianus, V. gerassimovi*).

Lo 2 0.80 m black sandy clays with Ammonites (*Virgatites virgatus, Dorsoplanites serus*)

Lo 3 0.05 m Mixture of black to grey clayey sands with Ammonites (*Epivirgatites* sp.).

UPPER VOLGIAN:

Lo 4 1.20 m Clayey sands with Ammonites (*Kashpurites fulgens, Craspedites* sp.).

Lo 5 1.20 m micaceous sandstones and sands with clay seams being penetrated by phosphatic sandstones. Ammonites (*Craspedites subditus*). The uppermost centimeters of this unit are grey clays overlain by Ryazanian deposits.

III. BIOSTRATIGRAPHIC RESULTS

III.1. OXFORDIAN (after M.S. Mesezhnikov, 1988)

On the central part of the Russian Platform, the Oxfordian Stage consist of clay. In this area, Moscow district and Upper Volga Basin are of major stratigraphic significance (Nikitin, 1881, 1885; Lahusen,1883; Ilovaisky, 1903; Smorodina, 1926; Sasonov,1957). The Oxfordian is rather clearly divisible into two parts (Krymholts,1972). The lower part was traditionally assigned to the Lower Oxfordian (*Cordatum* Beds), and is made up of gray to dark gray clays (3-20 m, 1.40 m in Makariev section).

Higher **Lower Oxfordian** is characterised by diverse *Cardioceras*. Possibly, all standard Subzones of the Cordatum Zone can be distinguished. At any rate, the association of *Cardioceras* s.s., including *C. cordatum* (Sow.), together with *Pachycardioceras*, and of *Cardioceras* s.s. with *Scoticardioceras* higher up in the section, indicate the Percaelatum (=costicardia) and Cordatum Subzones. However, species ranges and some subzonal boundaries have to be determined more precisely.

The **Middle Oxfordian**, described by Nikitin (1884) on the Unzha River near the town of Makariev, present a more definite subdivision; The following biostratigraphic units are distinguished:

(1) *Cardioceras densiplicarum* Zone: (a) lower part with *C. (Subvertebriceras) densiplicatum* Boden, *C. (Vertebriceras)* sp. and abundant *C.(Plasmatoceras) popilanense* Boden (Popilanense Subzone); (b) upper part dominated by *C. densiplicatum* Boden, *C.(Plamatoceras) tenuicostatum* (Nik.), the first *Cawtoniceras* and *Maltoniceras* appear (Densiplicatum Subzone). (2) *Cardioceras tenuiserratum* Zone: (a) lower part characteristically with *C.(Subvertebriceras) zenaide* Ilov. and *C.(Plasmatoceras) tenuicostatum* (Nik.) (Zenaidae Subzone); (b) upper part dominated by *C.(Miticardioceras)* spp. including *C.(M.) tenuiserratum* (Opp.) (Tenuiseratum Subzone).

The **Upper Oxfordian** on the central Platform consists of black and gray clay (2 to 7 m; rarely 14 m) increasing in the Pechora Basin to as 25 to 30 m. At the Unzha River, the base of this member has characteristic horizon of bituminous shale (0.2 m). In the lower part of the section, *Amoeboceras alternoides* Nik. (neotype: Nikitin,1916, Pl.1, Fig. 1). The Alternoides Zone is strictly coeval to the Glosense Zone in the Boreal Standard scale of Sykes and Callomon (1979). It is clearly divisible into two units: Ilovaiskii Subzone below, dominated by *Amoeboceras ilovaiskii* (M.Sok.) known, for example, from the oil shale on the Unzha River; and the Alternoides Subzone, above. Resting on top are beds dominated by the *Amoeboceras (Prionodoceras)* of the *serratum* (Sow.) group. *Amoeboceras alternans* occurs in the upper subzone of the Alternoides Zone, and in the lower part of the Serratum Zone.

The subdivision of the higher Oxfordian is less definite, yielding *Amoeboceras leucum* Spath (=*C.* cf. *bauhini* Opp. of Ilovaisky, 1903, PL. 11, Fig. 2), *A. freboldi* Spath, *A. tuberculato-alternans* (Nik.), and *Ringsteadia cuneata* (Trd.). The species ranges in general correspond to the Regulare and Rosenkrantzi Standard Zones. In the extreme Northeast of the Russian platform, in Pechora Basin, the Serratum Zone is followed by the *Amoeboceras ravni* Zone (Mesezhnikov, 1967).

III.2. KIMMERIDGIAN (after M.S. Mesezhnikov, 1988)

The Kimmeridgian Stage is mostly made up of clay and carbonaceous clay, but sometimes, especially its upper substage, is represented only by a thin interbed phosphorite nodules (Gerassimov, 1978).

The Lower Kimmeridgian on the central Russian Platform consists of gray glauconitic strata, in place calcareous clays (20-25 m), but commonly it does not exceed 5 to 7 m. These beds are characterised by *Amoeboceras (Amoebites) kitchini* (SALF.), *A. (A.) cricki* (SALF.), *Prorasenia stephanoides* (OPP.), *Desmosphinctes praelarei* (FAVRE), and *Rasenia (Eurasenia) trimera* (OPP.). Subdivision and detailed correlations within the zonal standard are, as yet, impossible. The Upper Kimmeridgian is most fully developed on the eastern Russian Platform, where it consists of gray calcareous clay and clayey marls. Three biostratigraphic units are distinguished:

1. *Aspidoceras acanthicum* Zone. Pavlow (1886). With diverse *Aspidoceras*. Presently, exposures are below the water table of the Ul'yanovsk Reservoir.

2. *Aulacostephanus eudoxus* Zone. With *Aspidoceras* spp., *Orthaspidoceras liparum* (OPP.), *Aulacostephanus (Aulacostephanoceras) eudoxus* (d'ORB.), *A. (A.) volgensis* (VISCHN.), *A. (A.) jasonoides* (PAVL.), *Amoeboceras (Nannocardioceras) subtilicostatum* (PAVL.) and *Sutneria* sp.

3. *Aulacostephanus autissiodorensis* Zone. (a) Below, with *A. (Aulacostephanoceras) autissiodorensis* (COTTEAU), *A. (A.) volgensis* (VISCHN.), *A. (A.) kirghisensis* (D'ORB.), *Amoeboceras (Nannocardioceras) subtilicostatum* (PAVL.), and *Sutneria* cf. *eumela* (SCHNEIND)- *Sutneria subeumela* Subzone (Geyer, 1969). (b) Above, with *A. (A.) autissiodorensis* (COTTEAU), *A. (A.) kirghisensis* (D'ORB.), *A. (A.) undorae* (PAVL.), *Virgataxioceras fallax* (ILOV.), *Sutneria* sp., and *Glochiceras* spp.- *Virgataxioceras fallax* Subzone (Mikhailov, 1962).

NEW BIOSTRATIGRAPHICAL INTERPRETATIONS

The studied sections of Makariev and Gorodishche allow to observe a more accurate succession of ammonites horizons:

LOWER KIMMERIDGIAN

a) Baylei Zone, SALFELD, 1913: with two standard horizons: **Densicostata Horizon** (below): *Pictonia densicostata* (SALFELD), and the **Baylei Horizon** corresponding to a monospecific level exclusively characterise by *Pictonia baylei* (SALFELDG). This Baylei Zone is equivalent to the *Pictonia involuta* Zone of the western Siberia Plate define by Mesezhnikov. Consequently, the Oxfordian / Kimmeridgian boundary can be precisely localised between a Late Oxfordian level including *Ringsteadia frequens* (top of Pseudocordata Subzone) and the first Kimmeridgian horizon (Densicostata Horizon).

b) Cymodoce Zone, DOUVILLÉ, 1881: in upper part of Makariev section and north to Dubky cliff, the Kimmeridgian deposits contain any *Rasenia uralensis* (D'ORB.). A « Zonovia » uralensis Subzone correspond with the upper part of the standard Cymodoce Zone. The classic *Amoeboceras kitchnini* Beds of Russian Platform are probably the equivalent, or partial equivalent to Baylei and Cymodoce Zones of the west European standard biostratigraphical scale.

UPPER KIMMERIDGIAN

c) Mutabilis Zone, SALFELD, 1913: *Orthaspidoceras liparum* (OPP.), dimorphic form of *O. lallierianum* (D'ORB.), mentioned by Mesezhnikov below the water table of the Ul'yanosvsk Reservoir, characterise the **Lallierianum Horizon**, (Lallierianum Subzone, Hantzpergue, 1987)

d) Eudoxus Zone, NEUMAYR, 1873: three west European horizons of the Eudoxus Zone are present in the Dubky outcrop: (1) **Caletanum Horizon**, Caletanum Subzone (Hantzpergue, 1979), with *Aspidoceras caletanum* (OPP.), *Aspidoceras* gr. *longispinum* (SOW.), *Aulacostephanus eudoxus* (D'ORB.), *Pararasenia* cf. *hybridus* ZIEGLER and *Amoeboceras* sp. (2) **Contejeani Horizon**, Contejeani Subzone (Hantzpergue, 1979), with *Aspidoceras* gr. *quercynum* HANTZPERGUE, *Aulacostephanus contejeani* (THURMANN), *Tolvericeras sevogodense* (CONTINI § HANTZPERGUE), (3) **Yo Horizon** (Contejeani Subzone) with *Aulacostephanus yo* (D'ORB.), *Aspidoceras* gr. *quercynum* HANTZPERGUE, *Aspidoceras* sp. and *Tolvericeras* gr. *sevogodense* (CONTINI & HANTZPERGUE)

e) Autissiodorensis Zone, ZIEGLER, 1961, with below, typical macro- *(A. autissiodorensis* (COTT.) and microconques forms [*A. volgensis* (VISCHN.), *A. kirghisensis* (D'ORB.), *A. undorae* (PAVL.)], and in upper part, dominant *Virgataxioceras fallax* (ILOV.), *Aspidoceras* sp. and *Sutneria* sp. - Fallax Subzone (Mikhailov, 1962).

III.3. VOLGIAN

The deposits of the Volgian stage of the typical region (central part of the Russian Platform) are subdivided into three substage (Gerassimov, Michailov, 1966): Lower Volgian (D.N. Sokolov's, 1901, «Wetlianian" horizon's), Middle Volgian (S.N. Nikitin, 1881, "Lower Volgian stage"), and Upper Volgian (S.N. Nikitin, 1881, "Upper Volgian stage").

At the All-Russian Conference in Saint Petersburg (Leningrad, 1988) on the development of a unified stratigraphic scheme of the Mesozoic deposits of the Russian Platform, Volgian Stage is subdivided into following substages, zones and subzones: lower substage (Klimovi Zone, Sokolovi Zone, Pseudoscythica Zone), middle substage (Panderi Zone with Pavlovi and Zarajskensis Subzones, Virgatus Zone with Gerassimovi, Virgatus and Rosanovi Subzones, Nikitini Zone with Blakei and Nikitini Subzones, Oppressus Zone), and upper substage (Fulgens Zone, Subditus Zone, Nodiger Zone with Mosquensis and Nodiger Subzones).

Nowaday, the Volgian stage is subdivided as follow (Mitta, 1993; Gerassimov, Mitta, Kochanova, 1995):

LOWER VOLGIAN

(a) Klimovi Zone

=Sokolovi Zone (pars): Ilovaisky *in* Ilovaisky, Florensky,1941;
=Klimovi and *Gravesia* sp. Zone: Michailov, 1966.
Author: N.P.Michailov, 1964.
Index: *Ilowaiskya klimovi* ILOVAISKY.
Ammonoidea: *Ilowaiskya klimovi* ILOVAISKY, *Neochetoceras* sp., *Glochyceras* sp., *Gravesia* cf. *gigas* (D'ORBIGNY).
Type locality: Stratotypical section in the banks of the Berdjanka River (Orenburg Region). This Zone is represented there by yellowish-grey gaize-like sandstones (3,0m).

(b) Sokolovi Zone

Author: D.I.Ilovaisky *in* Ilovaisky, Florensky, 1941.
Index: *Ilowaiskya sokolovi* ILOVAISKY.
Ammonoidea: *Ilowaiskya sokolovi* ILOVAISKY, *I.pavida* ILOVAISKY
Type locality: Lectostratotypical section in the banks of the Sukhaja Peschanka River (Orenburg Region). This Zone is represented by grey and yellowish-grey gaize-like sandstones (3,0 m).

(c) Pseudoscythica Zone

Author: D.I. Ilovaisky *in* Ilovaisky, Florensky, 1941.
Index: *Ilowaiskya pseudoscythica* ILOVAISKY.
Ammonoidea: *Ilowaiskya schaschkovae* ILOVAISKY, *I.pseudoscythica* ILOVAISKY, *Pectinatites* aff. *pectinatus* (PHILLIPS), *P. ianschini* (ILOVAISKY), *P. tenuicostatus* MICHAILOV, *Weatleyites* aff. *aestlecottensis* (SALFELD), *W. arkelli* MICHAILOV, *W. spathi* MICHAILOV, *Physodoceras neuburgense* (OPPEL).
Type locality: Lectostratotypical section on the Wetlianka River (Orenburg Region). This Zone is represented by grey and yellowish-grey gaize-like sandstones (4,5 m).

MIDDLE VOLGIAN

(a) Panderi Zone

=Scythicus and Panderi Zone: Rosanov, 1906
=Dorsoplanus Zone: Pavlow, 1914
Author: A.N.Rosanov, 1906.
Index: *Dorsoplanites panderi* (D'ORBIGNY).
Ammonoidea: *Zaraiskites zarajskensis* (MICHALSKY), *Z.scythicus* (VISCHNIAKOFF), *Z. michalskii* MITTA, *Z. quenstedti* (ROUILLIER & FAHRENKOHL), *Z. tschernyschovi* (MICHALSKY), *Acuticostites acuticostatus* (MICHALSKY) *A. bitrifurcatus* MITTA, *Dorsoplanites dorsoplanus* (VISCHNIAKOFF), *Dorsoplanites panderi* (D'ORBIGNY), *Pavlovia pavlovi* (MICHALSKY).
Type locality: Typical sections on the Moscow River, Moscow. Neostratotypical sections on the Volga River (the village of Gorodishche, Ul'yanovsk Region). This Zone is represented by dark-grey

III.3. VOLGIAN

The deposits of the Volgian stage of the typical region (central part of the Russian Platform) are subdivided into three substage (Gerassimov, Michailov, 1966): Lower Volgian (D.N. Sokolov's, 1901, «Wetlianian" horizon's), Middle Volgian (S.N. Nikitin, 1881, "Lower Volgian stage"), and Upper Volgian (S.N. Nikitin, 1881, "Upper Volgian stage").

At the All-Russian Conference in Saint Petersburg (Leningrad, 1988) on the development of a unified stratigraphic scheme of the Mesozoic deposits of the Russian Platform, Volgian Stage is subdivided into following substages, zones and subzones: lower substage (Klimovi Zone, Sokolovi Zone, Pseudoscythica Zone), middle substage (Panderi Zone with Pavlovi and Zarajskensis Subzones, Virgatus Zone with Gerassimovi, Virgatus and Rosanovi Subzones, Nikitini Zone with Blakei and Nikitini Subzones, Oppressus Zone), and upper substage (Fulgens Zone, Subditus Zone, Nodiger Zone with Mosquensis and Nodiger Subzones).

Nowaday, the Volgian stage is subdivided as follow (Mitta, 1993; Gerassimov, Mitta, Kochanova, 1995):

LOWER VOLGIAN

(a) Klimovi Zone

=Sokolovi Zone (pars): Ilovaisky *in* Ilovaisky, Florensky,1941;
=Klimovi and *Gravesia* sp. Zone: Michailov, 1966.
Author: N.P.Michailov, 1964.
Index: *Ilowaiskya klimovi* ILOVAISKY.
Ammonoidea: *Ilowaiskya klimovi* ILOVAISKY, *Neochetoceras* sp., *Glochyceras* sp., *Gravesia* cf. *gigas* (D'ORBIGNY).
Type locality: Stratotypical section in the banks of the Berdjanka River (Orenburg Region). This Zone is represented there by yellowish-grey gaize-like sandstones (3,0m).

(b) Sokolovi Zone

Author: D.I.Ilovaisky *in* Ilovaisky, Florensky, 1941.
Index: *Ilowaiskya sokolovi* ILOVAISKY.
Ammonoidea: *Ilowaiskya sokolovi* ILOVAISKY, *I.pavida* ILOVAISKY
Type locality: Lectostratotypical section in the banks of the Sukhaja Peschanka River (Orenburg Region). This Zone is represented by grey and yellowish-grey gaize-like sandstones (3,0 m).

(c) Pseudoscythica Zone

Author: D.I. Ilovaisky *in* Ilovaisky, Florensky, 1941.
Index: *Ilowaiskya pseudoscythica* ILOVAISKY.
Ammonoidea: *Ilowaiskya schaschkovae* ILOVAISKY, *I.pseudoscythica* ILOVAISKY, *Pectinatites* aff. *pectinatus* (PHILLIPS), *P. ianschini* (ILOVAISKY), *P. tenuicostatus* MICHAILOV, *Weatleyites* aff. *aestlecottensis* (SALFELD), *W. arkelli* MICHAILOV, *W. spathi* MICHAILOV, *Physodoceras neuburgense* (OPPEL).
Type locality: Lectostratotypical section on the Wetlianka River (Orenburg Region). This Zone is represented by grey and yellowish-grey gaize-like sandstones (4,5 m).

MIDDLE VOLGIAN

(a) Panderi Zone

=Scythicus and Panderi Zone: Rosanov, 1906
=Dorsoplanus Zone: Pavlow, 1914
Author: A.N.Rosanov, 1906.
Index: *Dorsoplanites panderi* (D'ORBIGNY).
Ammonoidea: *Zaraiskites zarajskensis* (MICHALSKY), *Z.scythicus* (VISCHNIAKOFF), *Z. michalskii* MITTA, *Z. quenstedti* (ROUILLIER & FAHRENKOHL), *Z. tschernyschovi* (MICHALSKY), *Acuticostites acuticostatus* (MICHALSKY) *A. bitrifurcatus* MITTA, *Dorsoplanites dorsoplanus* (VISCHNIAKOFF), *Dorsoplanites panderi* (D'ORBIGNY), *Pavlovia pavlovi* (MICHALSKY).
Type locality: Typical sections on the Moscow River, Moscow. Neostratotypical sections on the Volga River (the village of Gorodishche, Ul'yanovsk Region). This Zone is represented by dark-grey

clay and bituminous shales with layers of light-grey compact marl in middle and lower parts (total thickness about 9.5 m)
Remarks: Subdivision of Panderi Zone into two Subzones is impossible. The same ammonite species are found in lower and upper parts of zone; there are not biostratigraphical or lithostratigraphical limits. N.P.Michailov (1962) who proposed subdivision Panderi Zone into two subzones, as D.I. Ilovaisky (Ilovaisky, Florensky, 1941) which proposed such subdivision, have based their suppositions on A.N. Rosanov's indications. However, Ilovaisky and Michailov did not taken in account that the greater part of Rosanov's "lower Subzone Panderi-Zone" was included into Lower Volgian "Wetlianian horizon" by previous workers.

(b) Virgatus Zone
Author: Ch.Rouillier, 1845 (as "stage of *Ammonites virgatus*"), *emend.* I.I. Lahusen, 1888 and A.N.Rosanov, 1906.
Index: *Virgatites virgatus* (BUCH).
Ammonoidea: *Virgatites virgatus* (BUCH), *V.sosia* (VISCHNIAKOFF), *V. sosia* (VISCHNIAKOFF), *V. pallasianus* (D'ORBIGNY), *V. larisae* MITTA, *V.gerassimovi* MITTA, *V. crassicostatus* MITTA, *Dorsoplanites serus* GERASSIMOV, *D.rosanovi* GERASSIMOV, *Serbarinovella serbarinovi* MITTA, *S. ringsteadiaeformis* (GERASSIMOV), *Lomonossovella lomonossovi* (VISCHNIAKOFF), *Craspedites ivanovi* GERASSIMOV, *C. pseudofragilis* GERASSIMOV.
Type locality: Neostratotypical section in the phosphorite quarry Lopatino (Moscow Region). This zone is represented by dark-grey aleuritic clay and dark-green aleuritic sand with bands of phosphorite concretions (1.2 m).
Subdivision: Three Subzones.
(i) Gerassimovi Subzone
Author: A.N.Rosanov, 1919; V.V. Mitta, 1988.
Index: *Virgatites gerassimovi* MITTA.
Ammonoidea: *Virgatites gerassimovi* MITTA, *V. pallasianus* (D'ORBIGNY), *V. sosia* (VISCHNIAKOFF), *Dorsoplanites serus, D. rosanovi* GERASSIMOV spp., *Lomonossovella lomonossovi* (VISCHNIAKOFF).
(ii) Virgatus Subzone
Author: A.N. Rosanov, 1906; emend. N.P. Michailov, 1957 and V.V.Mitta, 1988.
Index: *Virgatites virgatus* (BUCH).
Ammonoidea: *Virgatites virgatus* (BUCH), *V.pallasianus* (D'ORBIGNY), *V. sosia* VISCHNIAKOFF, *V. arisae, V. crassicostatus* MITTA spp., *Dorsoplanites serus, D. rosanovi* GERASSIMOV spp., *Lomonossovella lomonossovi* (VISCHNIAKOFF), *Serbarinovella serbarinovi* MITTA, *S. ringsteadiaeformis* (GERASSIMOV).
(iii) Rosanovi Subzone.
=Rosanovi Zone: Michailov, 1957
Author: A.N.Rosanov, 1913, 1919; N.P. Michailov, 1957; P.A. Gerassimov, 1971; N.S. Mesezhnikov *et al.*, 1982.
Index: *Virgatites rosanovi* MICHAILOV.
Ammonoidea: *Virgatites virgatus* (BUCH), *V. rosanovi* Mich., *Crenodites kunchevi* Mich., *Lomonossovella lomonossovi* (VISCHN.), *Laugeites stchurowskii*.
Remarks: V.V.Mitta supposes that *Virgatites "rosanovi"* Michailov was based on two fragments, which do not admit the exact definition (*nomen dubium*).

(c)Nikitini Zone
=Blakei Zone: Pavlow, 1890;
=Giganteus Zone: Pavlow, 1892;
=Triplicatus and Blaki Zone: Pavlow, 1892;
=Oxyoptycha Zone: Rosanov, 1913;
=Bipliciformis Zone: Rosanov, 1919.
Author: I.I.Lahusen, 1888.
Index: *Epivirgatites nikitini* (MICHALSKY).
Ammonoidea: *Epivirgatites nikitini* (MICHALSKY), *E. bipliciformis* (NIKITIN), *Laugeites stschurowskii* (NIKITIN), *L. aenivanovi* MITTA, *Lomonossovella lomonossovi* (VISCHNIAKOFF), *Craspedites ivanovi, Craspedites pseudofragilis* GERASSIMOV spp.

Type locality: Stratotypical section in the bank of the Volga River (the Kashpir villages, Samara Region), where it is represented by glauconite sands and sandstones (up to 1 m).Hypostratotypical Section on the bank of the Volga River (near Glebovo village, Jaroslavl Region), it is represented by greyish-brown, parts ferruginisations sands and sandstones (up to 6,0 m).
Remarks: The separation of the upper part of formerly Nikitini Zone as Oppressus Zone by R. Casey, M.S. Mesezhnikov (1986) can not be adopted. Nikitini Zone is the interval of distribution of species *Epivirgatites nikitini* (MICHALSKY), which is found in complete section of Zone in its formerly volume. The separation "the beds with *Paracraspedites oppressus*", as upper subzone of Nikitini Zone is also impossible. The presence of the West-European genus *Paracraspedites* is not confirmed in Middle Volgian.
The separation of the lower part Nikitini Zone into Blakei Subzone can not be adopted also. The name *Lomonossovella blakei* (PAVLOW) *emend.* Michailov is the younger synonym of the *L. lomonossovi* (VISCHNIAKOFF). There are no dates, which allow to distinguish the complexes of "Blakei and Nikitini Subzones". The differences shown by Casey and Mesezhnikov had geographical nature. They can not be adopted as evidence of more older age Nikitini Zone in near-Moscow and Upper Volga than age of the beds in Middle Volga.

UPPER VOLGIAN

(a) Fulgens Zone
Author: H. Trautschold, 1866.
Index: *Kachpurites fulgens* (TRAUTSCHOLD).
Ammonoidea: *Craspedites fragilis* (TRAUTSCHOLD), *C. okensis* (D'ORBIGNY), *C. nekrassovi* PRIGOROVSKY, *C. subditoides* (NIKITIN), *Garniericeras catenulatum* (FISCHER), *G. interjectum* (NIKITIN), *Kachpurites fulgens* (TRAUTSCHOLD), *K. subfulgens* (NIKITIN).
Type locality: Environs of the Moscow. Type section none designated. In the Moscow Region represented by dark aleuritic or glauconite sand with phosphorite concretions (1-2,5 m).

(b) Subditus Zone
Author: S.N. Nikitin, 1890.
Index: *Craspedites subditus* (TRAUTSCHOLD).
Ammonoidea: *Craspedites okensis* (D'ORBIGNY), *C. nekrassovi* PRIGOROVSKY, *C. jugensis* PRIGOROVSKY, *C. subditus* (TRAUTSCHOLD), *C. subditoides* (NIKITIN), *Garniericeras catenulatum* (FISCHER), *G. interjectum* (NIKITIN).
Type locality: Environs of the Moscow. Type section none designated. In the Moscow Region represented by dark-green glauconitic and phosphoritic sandstone (up to 10 m).

(c) Nodiger Zone
Index: *Craspedites nodiger* (EICHWALD).
Ammonoidea: *Craspedites nodiger* (EICHWALD), *C. triptychus* (NIKITIN), *C. kashpuricus* (TRAUTSCHOLD), *C. parakaschpuricus* GERASSIMOV, *C. milkovensis* STREMOOUKHOV, *C. kuznetzovi* (SOKOLOV), *C. mosquensis* GERASSIMOV, *Garniericeras subclypeiforme* (MILASCHEVITSCH).
Type locality: Environs of the Moscow. Type section none designated. In the Moscow Region represented by dark-green glauconitic and phosphatic or white quartz sands and sandstone (up to 33 m).
Subdivision. The Nodiger Zone subdivides two parts: Subzone of *Craspedites mosquensis* (lower) and Subzone of *Craspedites nodiger* (upper). This subzones differences with distribution of species *Craspedites mosquensis* GERASSIMOV and *C. triptychus* (NIKITIN) in the lower part (subzone) of Nodiger Zone.

III.4 PROPOSITION OF BIOSTRATIGRAPHIC CORRELATIONS

OXFORDIAN

Concerning the Lower Oxfordian, the Mariae and Cordatum Zones of Russian Platform are fundamentally characterised by Boreal Cardioceratides. They are equivalent to the subdivisions of the West-European Lower Oxfordian (tab. 2a). But, this two zones can be subdivided according to a comparable precision that the West-European or the Siberian horizons scale.

During the Middle and Upper Oxfordian, the bioprovincialism is more pronounced. Only, the zonal indices *C. tenuiserratum* (Middle Oxfordian) and *A. serratum* (base of Upper Oxfordian) are common elements between Russian Platform and stratotype series of the Oxfordian Stage. The occurrence of *Ringsteadia frequens* in upper part of the Ravni Zone allows to strictly situated the Oxfordian-Kimmeridgian boundary between this Frequens Horizon and the Densicostata Horizon (Baylei Zone) of the Standard Scale (tab.2b; after Cariou *et al.*,1996).

KIMMERIDGIAN

The better biostratigraphical correlations between the Russian Platform and Western Europe are effected to the Kimmeridgian Stage (tab.3; after Hantzpergue *et al.*,1996). Seven ammonites horizons are common between the two area*: P. densicostata, P. baylei, O. lallierianum, A. caletanum, A. contejeani, A. yo* and *A. autissiodorensis*. However, the levels with R. uralensis can be probably subdivided with various *Rasenia* species. In the same way, the « Acanthicum Zone » show many suboreal Aulacostephanids and a more precise biostratigraphical scheme can be obtain.

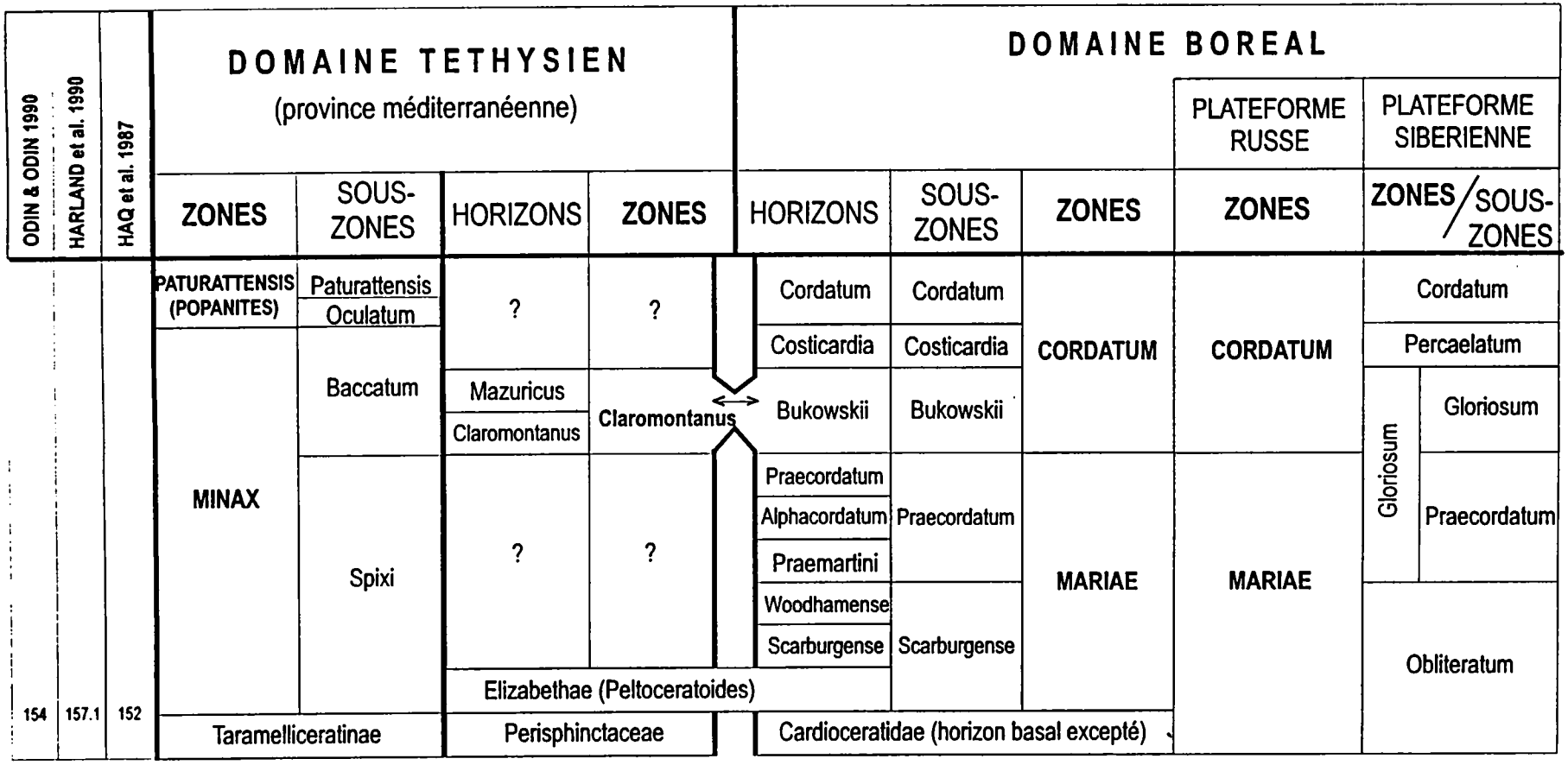
VOLGIAN.

The most perspective for correlation are the next levels: (tab. 4; after Geyssant, 1996)

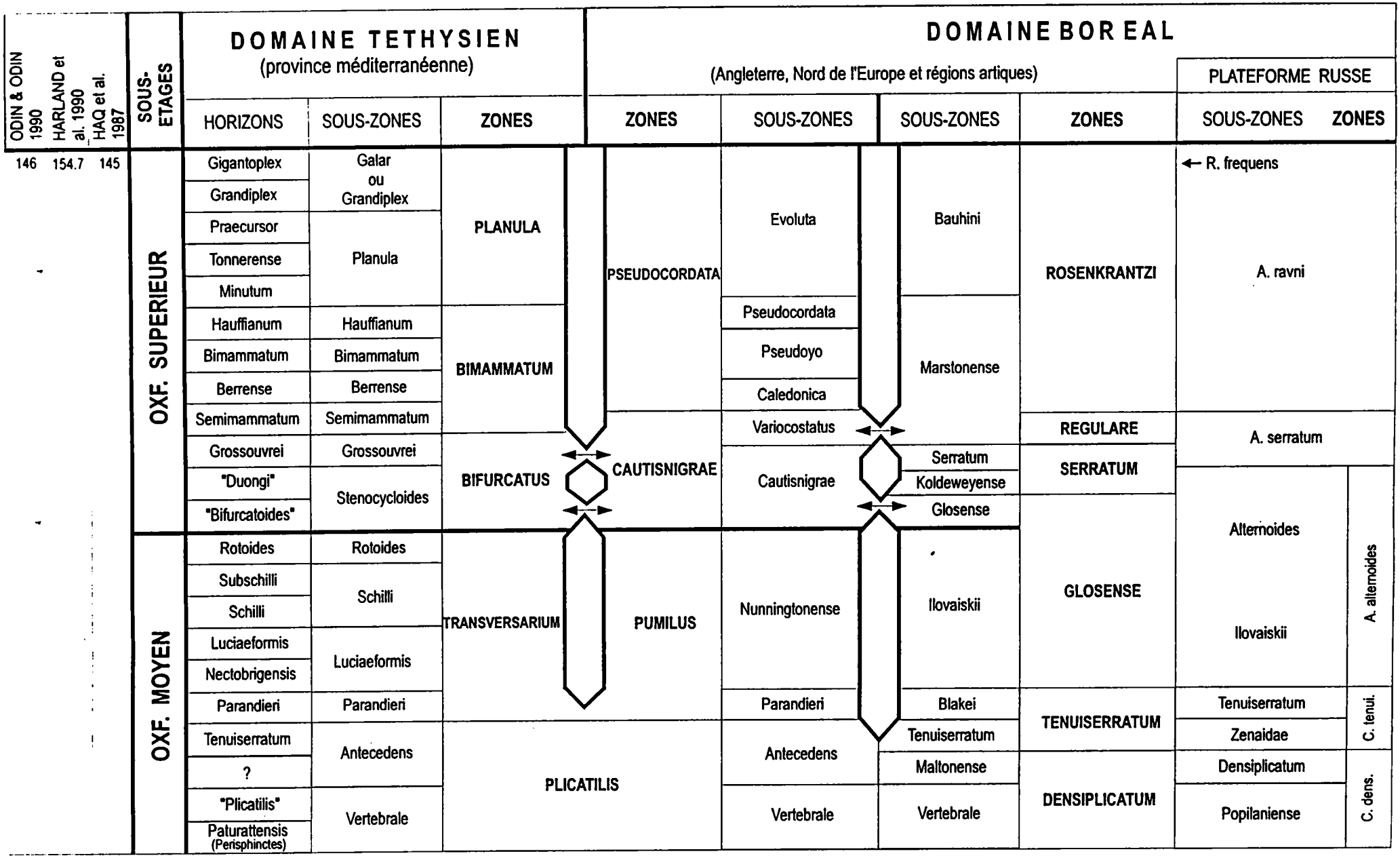
- With the Portlandian *s.a.*: the zone of Epivirgatites nikitini.

Applied formerly to West European genera *Crendonites*, *Behemoth*, *Paracraspedites* the Middle Volgian forms from Central Russia belong to various species *Virgatites*, *Lomonossovella*, *Epivirgatites* (Mitta, 1993). However both the Middle Volgian and the « Portlandian » ammonites were studied with the autonomic researchers. The ammonites are compared usually on illustrations. It is necessary to pay special attention to study of the relations of the genera *Lomonossovella* and *Kerberites*, *Epivirgatites* and *Paracraspedites*.

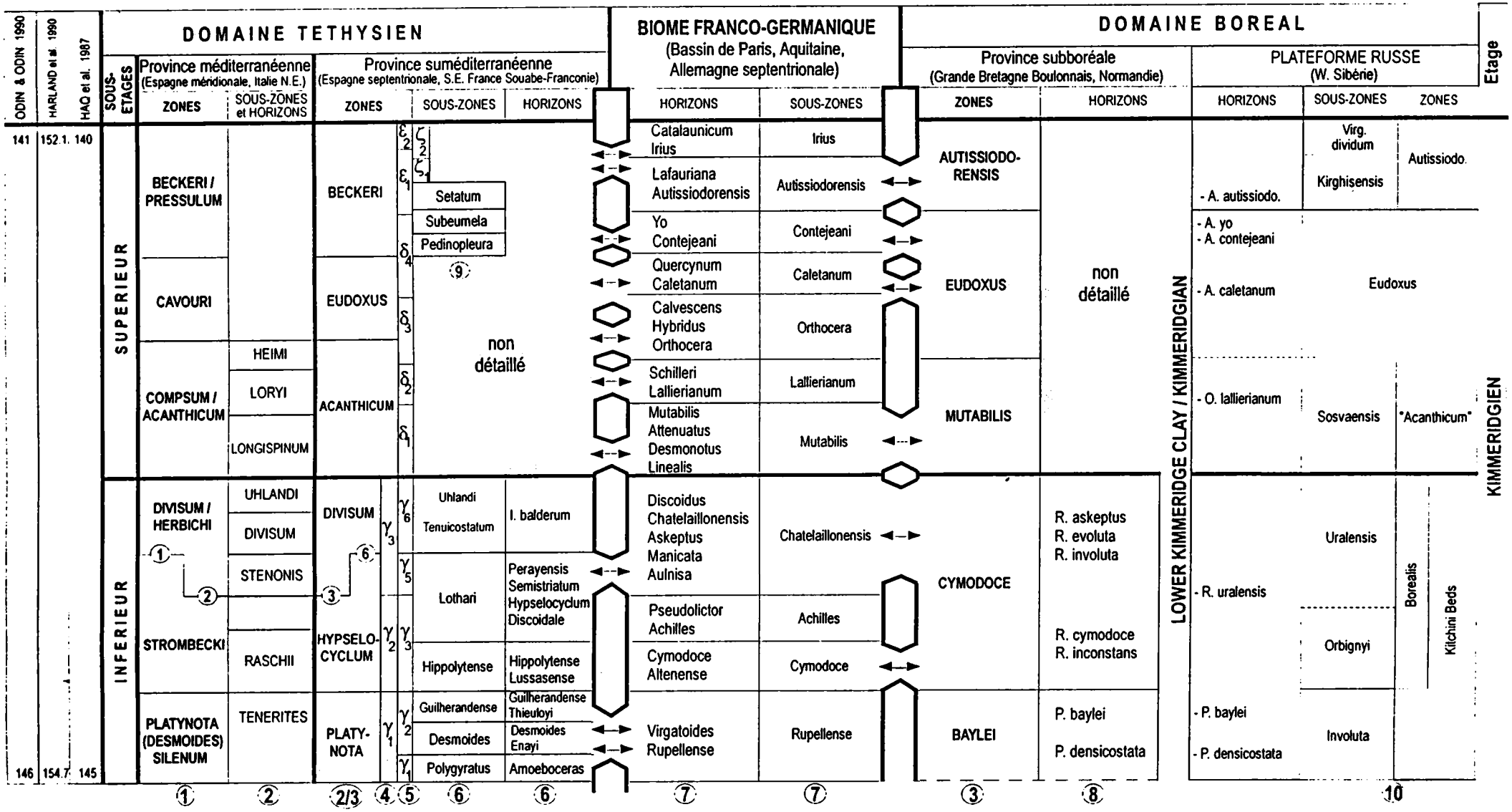
- With the Tithonian: basal part of the Volgian (from the Klimovi Zone to the Panderi Zone). The correlation accepted at present of the Volgian base with Hybonotum Zone of Tithonian on the grounds of ammonites founds of the genera *Gravesia*, *Neochetoceras*, *Glochyceras* (Gerassimov, Michailov, 1966; *etc.*) in Gorodishche section is not substantiate by the description and the illustration of this ammonites. It seems that the main interest is the study of the stratigraphical and geographical distribution of the ammonites genera *Physodoceras* and *Gravesia*. There are the unpublished ammonites belonging to these genera of the Volgian stage the collections of N.P.Michailov (Orenburg Region) and authors (Chuvashia Region).



Tab. 2a **Ammonites : zonation de l'Oxfordien inférieur**

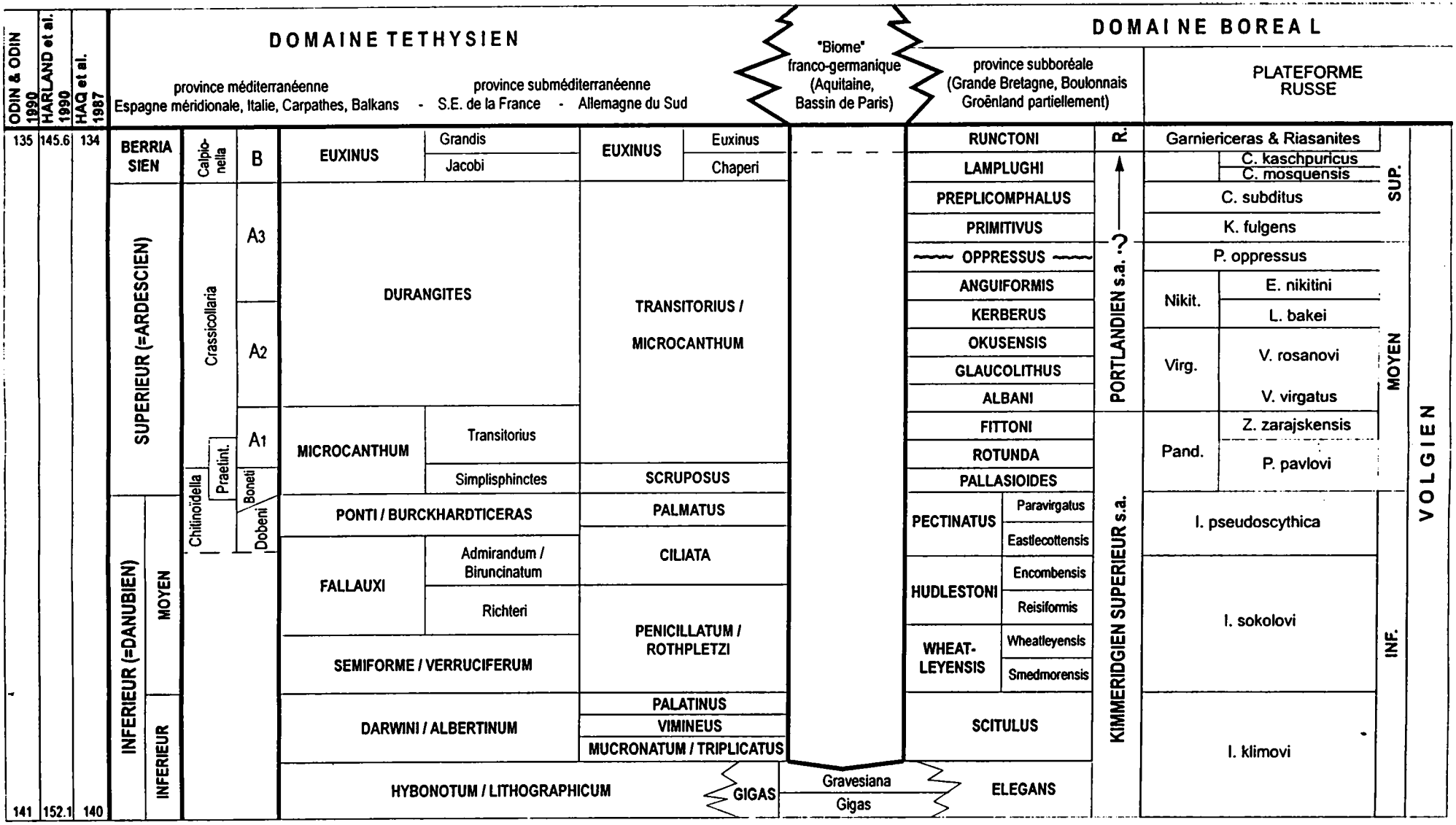


Tab. 2 - Ammonites : zonation de l'Oxfordien moyen et supérieur



Tab. 3 - Ammonites : zonation du Kimméridgien

(1) Oloriz, 1978 ; (2) Pavia et *al.*, 1987 ; Sarti, 1993 ; (3) Enay et *al.*, 1971 ; (4) Souabe Geyer, 1961 ;(5) Franconie, Adlinger, 1945 ; (6) Atrops, 1982 ; (7) Hantzpergue, 1979, 1987, 1989 ; (8) Birkelund et *al.*, 1983 ; (9) Schweigert, 1993 ; (10) Mesezhnikov, 1988.



Tab. 4 - Ammonites : zonation du Tithonien

IV FORAMS ANALYSIS RESULTS (by Boris Nikitenko, Institute of Geology, Novosibirsk)

Two samples were collected in the Panderi zone deposits of the Gorodishche section in order to analyse their forams assemblages. The first sample provides from marly claystone of level Go 10 and the second sample provides from the base of black shales of level Go 11.

The secretional calcareous forams are sharply dominated in the marly claystone. The wall of the shell is thick, the latter being big. The size of the grain of the agglutinate forms is big. The abundance of small (juvenile) forms postulates for an autochthonous taphocenosis. The ostracods are numerous ; the majority of specimens are big in the size and they have a smooth shell surface. On the contrary, the agglutinate forams - *Ammobaculites* sp. - are dominated in the bottom microcommunity (Fig. 14) of the black shales layers. It is opportunistic species. The agglutinate forms are slightly dominant over the secretional one. The wall of the secretional shells is thin. The wall of the agglutinate forms is fine-grain. A lot of juvenile forms have been founded in the black shales. There is no ostracods in the microbenthonic communities.

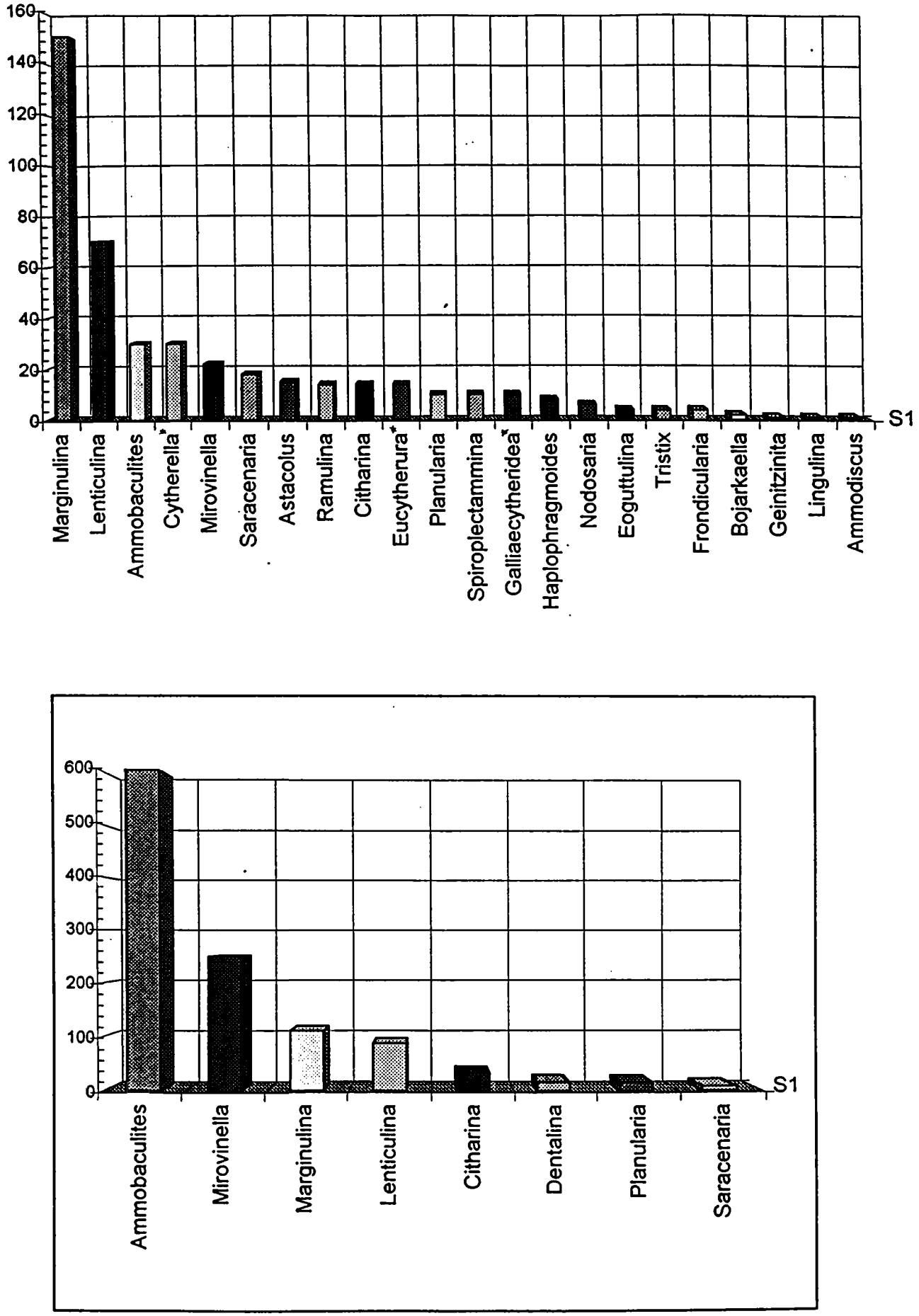


Fig. 14 Forams and ostracods of grey clay (top) and black shale (base) level of the Panderi zone deposits from Gorodishche section.

V. ORGANIC GEOCHEMISTRY RESULTS

The Upper Jurassic sediments from the Russian Platform are known to contain relatively thick horizons of black shales. The objectives of this study are the followings:
1- To precise the age of the black shales from the Russian Platform,
2- to check their possible synchronity with the main organic-rich intervals from the North Sea area (Kimmeridge Clay),
3- to characterise the organic matter using geochemical tools,
4- to reconstruct the depositional environment of the black shales.
To achieve these goals, 175 samples were collected along the six sections described above.

V.1 Methods

All the samples were open air-dried and crushed in a metallic mortar to obtain a fine (2 μm) powder. Calcium carbonate content (% $CaCO_3$) was measured using a calcimetric bomb. The total carbon content (% Ctot) was measured using a LECO apparatus. The organic carbon content (% Corg.) is estimated as the difference between total carbon and mineral carbon assuming that all the mineral carbon is as carbonate. Rock-eval pyrolysis was accomplished on a OSA (Oil Show Analysor) on samples with Corg content higher than 4 %.

V.2 Stratigraphic distribution of black shales from the Russian Platform

Six intervals show black shales layers with high TOC (>10%) and good petroleum. They are by stratigraphic order (Fig. 15):

- Close to the Middle-Upper Oxfordian boundary (Alternoides zone) with a 12-cm thick horizon, visible in the Makariev section (Mk 14). Its organic content varies from 10.7 à 18.7% TOC. This level is overlain by 15 cm of dark claystones with chondrites, containing up to 6.6% TOC.
- This first black shale horizon of the Upper Jurassic is well known in subsurface all over the Russian Platform. One sample, providing from a well situated 75 km North to Moscow, has been analysed. Its organic richness is only 3.% TOC.
- A discontinuous, cm-thick black shales level exists locally below this first horizon. This level has been found for the first time in the Makariev region along the Unzha river (Mk 15 BS, Fig. 10). Its thickness fluctuates from 2 to 4 cm and its organic richness reach 11.8% TOC.
- For the first time, we display a black shale horizon in the Lower Kimmeridgian (Cymodoce zone) from the Mimei village section. Up to now, this area was not intensely investigated and the Kimmeridgian deposits were supposed to be eroded or preserved only by place on the Russian Platform. This level is 50 cm thick (Ta 5) and its organic richness is 14.7% TOC. If the same level has been drilled before, it has probably been attributed to the Upper Oxfordian horizon. It is presently impossible to draw the geographic extension of this new black shale level.
- The most famous black shales have a Middle Volgian age and more precisely a Panderi zone dating. They are the thickest and widespread distributed on the Russian Platform. They were investigated along the Gorodishche section where their thickness reaches 6 m. They are made by alternation of black shales and dark claystones. The organic richness of black shales varies from 2.3 to 44.5% TOC with a 16.5% mean value. The dark claystones contain between 0.5 and 5.4%.
- The next horizon belongs to the same substage but has a Virgatus zone dating. This horizon was not recognised along the Gorodishche section nor in the Lopatino Quarry because of the predominance of sandy facies.
- The fifth horizon, from the base of Upper Volgian (Fulgens zone), was not recognised along the Gorodishche or Kashpir sections nor in the Lopatino Quarry because of the predominance of sandy and calcareous-sandy facies.
- The last horizon belongs to the uppermost Volgian (Nodiger zone), equivalent to the Lower Berriasian. This level has been studied in the Kashpir section. Its thickness ranges between 6 to 15 cm and its organic richness fluctuates from 22 to 33% TOC.

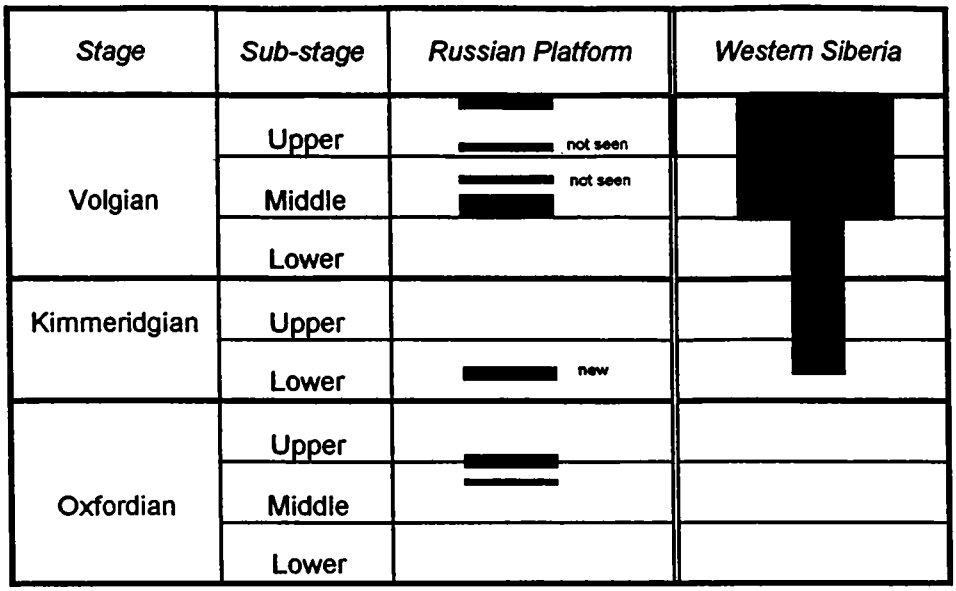


Fig. 15 Stratigraphical distribution of the black shale deposits on the Russian platform compared with those from the Western Siberia

By comparison with organic-rich intervals from the North Sea area (Kimmeridge Clay and its equivalents), its seems that there is no synchronity with the Russian Platform black shales. The main organic-rich intervals in the Kimmeridge Clay are distributed in the Upper Kimmeridgian and Lower Tithonian (Cox & Gallois, 1981; Herbin & Geyssant, 1993):
- the first (sometimes double) in the Mutabilis zone (Baudin, 1992; Saint-Germès *et al.*, in press),
- the second in the middle part of the Eudoxus zone,
- the third in the uppermost part of the Eudoxus zone and the lower part of the Autissiodorensis zone,
- the fourth in the upper part of the Autissiodorensis zone and the Elegans zone,
- the fifth at the boundary between Wheatleyensis and Hudlestoni zones,
- the last at the boundary between Hudlestoni et Pectinatus zones.

It should be noted that the Upper Kimmeridgian deposits was not completely investigated during our field work and the Mutabilis zone was not recognised. Most of the Russian literature considers the Kimmeridgian as absent (eroded) on the major part of the Russian Platform. The only « true » black shales horizon from the Upper Kimmeridgian is known in the Eudoxus zone in Subpolar Ural (Mezhenikov, 1983). The Lower Volgian, that corresponds partly to basal Tithonian, the black shales are absent. The deposits of this age are dark clays but their organic richness are negligible compared to the black shales described above.

V.3 Geochemical characterisation of the black shales from the Russian Platform

V.3.1 carbonate content (Tab. 5, Fig. 16)

The carbonate content of claystones and black shales is low and fluctuates 20 et 40%. Some levels show lower values (< 10%). The rare calcareous beds and carbonated nodules 80%. The sandy level from Upper Volgian are devoid of carbonate (0 à 6% CaCO3).

V.3.2 organic carbon content (Tab. 5, Fig. 16)

Most of the analysed samples show a high organic content (>1%). This is clearly linked with the argilaceous-dominated facies that favourished the preservation of organic matter. Levels rich in wood-fragments are of course organic-rich (16 to 34% Corg.). The black shales show exceptional organic content (up to 50 %) with a mean value of 19%. The sands and sandstones contain less than 1% Corg.

V.3.3 Rock-eval analysis

57 samples were analysed. The Tmax parameter indicates a low thermal maturation (415 C in average), that is in accordance with the low subsidence of the Mesozoic deposits on the Russian Platform. The TOC values are very similar, although a little bit lower, than those measured with LECO. Some differences are not clearly understood in the Oxfordian and Lower Kimmeridgian claystones (Fig. 17). Petroleum potentials of the black shales are very good with an average of 95 kg HC/t de rock and some exceptional potentials ranging from 200 to 300 kg/t (Go11 f, Go 11 g et Ka 20-2). The hydrogen index values are good with a mean value around 490 mg HC/g TOC and a maximum of 700 (Fig. 18).
The other clayey samples show HI-values corresponding to an altered type II organic (200<HI<300) or a type III (100<HI<200). The organic-poor samples contain a dispersed type III or a type IV organic matter (100<HI).

Tab. 5 Bulk geochemical data of the Upper Jurassic deposits from the Russian Platform (Peri-Tethys Programme)

N° Ech.	Coupe	Age	Cote	% CaCO3	% Ctot	% Corg.	% COT	Tmax	S1	S2	IH	IO
Mk 16-4	Makariev	Oxfordien inférieur	0,10	40	5,93	1,10						
Mk 16 bois	Makariev	Oxfordien inférieur	0,15	0	16,89	16,89	7,46	364	0,15	0,23	3	
Mk 16-3	Makariev	Oxfordien inférieur	0,60	40	5,73	0,95						
Mk 16-2	Makariev	Oxfordien inférieur	0,90	36	5,61	1,32						
Mk 16-1	Makariev	Oxfordien inférieur	1,30	40	5,80	1,05						
Mk 15-7	Makariev	Oxfordien moyen	1,60	41	6,71	1,81						
Mk 15-6	Makariev	Oxfordien moyen	1,80	45	6,22	0,80						
Mk 15-5	Makariev	Oxfordien moyen	2,05	47	6,77	1,16						
Mk 15 black shale	Makariev Nord	Oxfordien moyen ?	2,30	15	15,92	14,12	11,75	417	0,75	49,35	420	
Mk 15-4	Makariev	Oxfordien moyen	2,35	46	6,41	0,93						
Mk 15-3	Makariev	Oxfordien moyen	2,65	44	6,29	0,99						
Mk 15-2	Makariev	Oxfordien moyen	2,95	45	6,62	1,20						
Mk 15-1	Makariev	Oxfordien moyen	3,15	0	7,54	7,54	0,86	409	0,09	0,19	22	
Mk 14-3	Makariev	Oxfordien moyen	3,22	20	14,15	11,71	10,67	421	0,73	46,25	433	
Mk 14-2	Makariev	Oxfordien moyen	3,27	28	21,72	18,30	18,64	413	1,98	94,05	504	
Mk 14-1	Makariev	Oxfordien moyen	3,31	24	17,77	14,92	14,65	418	0,87	58,13	396	
Mk 13	Makariev	Oxfordien supérieur	3,40	30	10,89	7,29	6,60	421	0,19	16,19	245	
Mk 12	Makariev	Oxfordien supérieur	3,60	33	7,77	3,79	2,94	428	0,07	2,16	73	
Mk 11 d	Makariev	Oxfordien supérieur	3,80	52	6,77	0,50						
Mk 11 c	Makariev	Oxfordien supérieur	4,05	36	5,19	0,88						
Mk 11 b	Makariev	Oxfordien supérieur	4,15	32	4,85	1,02						
Mk 11 a	Makariev	Oxfordien supérieur	4,25	36	5,04	0,75						
Mk 10 b	Makariev	Oxfordien supérieur	4,35	36	5,27	0,89						
Mk 10 a	Makariev	Oxfordien supérieur	4,60	39	6,15	1,51						
Mk 9 b	Makariev	Oxfordien supérieur	5,00	40	5,98	1,12						
Mk 9 a	Makariev	Oxfordien supérieur	5,20	0	4,14	4,14	0,11	418	0,04	0,02	18	
Mk 9 a bois	Makariev	Oxfordien supérieur	5,25	0	32,88	32,88	28,83	392	0,79	9,04	31	
Mk 8 d2	Makariev	Oxfordien supérieur	5,40	30	5,18	1,56						
Mk 8 d1	Makariev	Oxfordien supérieur	5,65	42	6,43	1,40						
Mk 8c	Makariev	Kimméridgien inférieur	5,80	35	6,34	2,19						
Mk 8 b2	Makariev	Kimméridgien inférieur	5,90	29	5,19	1,74						
Mk 8 b1	Makariev	Kimméridgien inférieur	6,20	29	5,09	1,62						
Mk 7 b2	Makariev	Kimméridgien inférieur	6,30	8	4,03	2,39						
Mk 7 b1	Makariev	Kimméridgien inférieur	6,45	15	3,30	2,23						
Mk 7 a	Makariev	Kimméridgien inférieur	6,50	0	4,92	4,92						
Mk 6 c	Makariev	Kimméridgien inférieur	6,70	25	4,48	1,44						
Mk 6 b	Makariev	Kimméridgien inférieur	6,80	22	4,61	1,99						
Mk 6 a	Makariev	Kimméridgien inférieur	6,95	27	4,88	1,68						
Mk 5	Makariev	Kimméridgien inférieur	7,20	36	5,22	0,88						
Mk 4	Makariev	Kimméridgien inférieur	7,70	38	5,37	0,79						
Mk 3	Makariev	Kimméridgien inférieur	8,20	15	3,97	2,14						
Mk 2-3	Makariev	Kimméridgien inférieur	8,40	26	4,62	1,49						
Mk 2-2	Makariev	Kimméridgien inférieur	8,80	28	4,85	1,45						
Mk 2-1	Makariev	Kimméridgien inférieur	9,10	28	4,42	1,00						
Mk 1-6	Makariev	Kimméridgien inférieur	9,45	39	5,61	0,97						

Tab. 5 Bulk geochemical data of the Upper Jurassic deposits from the Russian Platform (Peri-Tethys Programme)

N° Ech.	Coupe	Age	Cote	% CaCO3	% Ctot	% Corg.	% COT	Tmax	S1	S2	IH	IO
Mk 1-5	Makariev	Kimméridgien inférieur	10,00	36	5,54	1,16						
Mk 1-4	Makariev	Kimméridgien inférieur	10,50	30	4,91	1,29						
Mk 1-3 galets	Makariev	Kimméridgien inférieur	10,90	16	3,26	1,32						
Mk 1-2	Makariev	Kimméridgien inférieur	11,10	21	3,93	1,41						
Mk 1-1	Makariev	Kimméridgien inférieur	11,25	78	10,12	0,76						
Mk 0	Makariev	Kimméridgien inférieur ?	12,00	28	4,57	1,15						
Ta1 base	Mimei village	Kimméridgien inférieur	0,15	29	4,17	0,64						
Ta1 bois	Mimei village	Kimméridgien inférieur	0,10	3	33,88	33,52	29,37	398	0,33	2,47	8	
Ta1 sommet	Mimei village	Kimméridgien inférieur	1,80	21	3,44	0,96						
Ta2	Mimei village	Kimméridgien inférieur	2,15	19	2,92	0,68						
Ta3	Mimei village	Kimméridgien inférieur	2,35	46	6,38	0,80						
Ta4 base	Mimei village	Kimméridgien inférieur	2,65	19	3,30	1,04						
Ta4 sommet	Mimei village	Kimméridgien inférieur	3,95	7	2,50	1,64						
Ta5	Mimei village	Kimméridgien inférieur	4,30	9	18,13	17,02	14,67	408	2,61	80,74	550	
Ta6	Mimei village	Kimméridgien inférieur	4,70	0	1,35	1,35						
Ta8	Mimei village	Kimméridgien inférieur	5,35	6	4,70	3,96	0,60	404	0,04	0,14	23	
Ta10	Mimei village	Kimméridgien inférieur	5,95	9	3,32	2,28						
Ta12	Mimei village	Kimméridgien inférieur	7,15	11	2,87	1,49						
Ta14	Mimei village	Kimméridgien inférieur	8,70	41	5,38	0,45						
Ta16	Mimei village	Kimméridgien inférieur	10,30	29	4,11	0,59						
Ko lentille	Kamennyi Ourag	Kimméridgien supérieur		41	8,79	3,86	3,07	414	0,50	12,69	413	
Du 1	Dubki	Kimméridgien supérieur	0,50	42	5,99	1,00						
Du 2	Dubki	Kimméridgien supérieur	0,70	42	5,73	0,70						
Du 3	Dubki	Kimméridgien supérieur	1,25	33	4,98	1,02						
Du 4 base	Dubki	Kimméridgien supérieur	1,60	25	4,25	1,26						
Du 4 +1m	Dubki	Kimméridgien supérieur	2,50	25	3,80	0,83						
Du 4 +2m	Dubki	Kimméridgien supérieur	3,50	28	4,33	0,94						
Du 4 +3m	Dubki	Kimméridgien supérieur	4,50	23	3,51	0,74						
Du 4 +4m	Dubki	Kimméridgien supérieur	5,50	36	4,85	0,58						
Du 5 base	Dubki	Kimméridgien supérieur	6,10	29	4,39	0,93						
Du 5 +1m	Dubki	Kimméridgien supérieur	7,00	30	4,47	0,88						
Du 5 +2 m	Dubki	Kimméridgien supérieur	8,00	29	4,76	1,30						
Du 5 +3m	Dubki	Kimméridgien supérieur	9,00	34	4,95	0,86						
Du 5 +4m	Dubki	Kimméridgien supérieur	10,00	26	4,48	1,41						
Du 6 base	Dubki	Kimméridgien supérieur	10,10	48	6,86	1,05						
Du 6 +0.5m	Dubki	Kimméridgien supérieur	10,50	26	4,52	1,42						
Du 6 +1m	Dubki	Kimméridgien supérieur	11,00	51	6,79	0,66						
Du 6 +2m	Dubki	Kimméridgien supérieur	12,00	44	6,35	1,07						
Du 6 +3m	Dubki	Kimméridgien supérieur	13,00	49	6,57	0,70						
Du 6 +4m	Dubki	Kimméridgien supérieur	14,00	35	5,05	0,85						
Du 7a base	Dubki	Kimméridgien supérieur	15,00	48	6,56	0,85						
Du 7a +2m	Dubki	Kimméridgien supérieur	17,00	50	6,95	0,89						
Du 7a +3m	Dubki	Kimméridgien supérieur	18,00	53	7,31	0,97						
Du 7a +4m	Dubki	Kimméridgien supérieur	19,00	34	4,91	0,77						
Du 7b base	Dubki	Kimméridgien supérieur	19,50	37	7,23	2,76						

Tab. 5 Bulk geochemical data of the Upper Jurassic deposits from the Russian Platform (Peri-Tethys Programme)

N° Ech.	Coupe	Age	Cote	% CaCO3	% Ctot	% Corg.	% COT	Tmax	S1	S2	IH	IO
Du 7b +1.5m	Dubki	Kimméridgien supérieur	21,00	29	5,44	1,98						
Du 7b +2.5m	Dubki	Kimméridgien supérieur	22,00	37	5,47	1,05						
Du 7b +3.5m	Dubki	Kimméridgien supérieur	23,00	6	4,54	3,84						
Du 7b top	Dubki	Kimméridgien supérieur	23,40	26	4,23	1,10						
Du 8 base	Dubki	Kimméridgien supérieur	23,60	41	6,07	1,16						
Du 8 +1m	Dubki	Kimméridgien supérieur	24,50	29	6,68	3,18						
Du 8 +2m	Dubki	Kimméridgien supérieur	25,50	45	6,72	1,29						
Du 9 base	Dubki	Kimméridgien supérieur	25,50	43	6,89	1,67						
Du 9 +0.75	Dubki	Volgien inférieur ?	26,25	12	3,49	2,04						
Du 9 +1.20	Dubki	Volgien inférieur ?	26,70	0	4,03	4,03						
Du 10a 0.50	Dubki	Volgien inférieur	26,70	20	3,90	1,52						
Du 10b 0.50	Dubki	Volgien inférieur	27,70	5	2,92	2,36						
Du 10b 1.00	Dubki	Volgien inférieur	28,20	22	3,87	1,26						
Du 10b 1.60	Dubki	Volgien inférieur	28,80	9	2,79	1,71						
Du 10b 1.90	Dubki	Volgien inférieur	29,10	23	4,05	1,25						
Du 10c nodules	Dubki	Volgien inférieur	30,20	10	2,99	1,80						
Du 10c 0.20	Dubki	Volgien inférieur	30,40	8	2,75	1,78						
Go 8-0.05	Gorodishche	Volgien inférieur	30,85	17	3,14	1,14						
Go 8 nodules	Gorodishche	Volgien inférieur	30,90	14	2,96	1,28						
Du 10c 0.80	Dubki	Volgien inférieur	31,00	0	1,93	1,93						
Go 8-0.25	Gorodishche	Volgien inférieur	31,05	21	3,48	0,97						
Du 10c 1.00	Dubki	Volgien inférieur	31,20	21	3,79	1,25						
Go 8-0.80	Gorodishche	Volgien inférieur	31,60	25	4,04	1,02						
Go 8-1.10	Gorodishche	Volgien inférieur	31,90	32	7,99	4,14						
Du 10c top	Dubki	Volgien inférieur	32,00	23	12,01	9,27						
Go 9 a	Gorodishche	Volgien moyen	32,20	29	4,60	1,13						
Go 9 b	Gorodishche	Volgien moyen	32,35	10	2,74	1,51						
Go 9 c base	Gorodishche	Volgien moyen	32,60	23	3,76	1,04						
Go 10 a middle	Gorodishche	Volgien moyen	34,50	41	6,16	1,19						
Go 10 b	Gorodishche	Volgien moyen	35,00	70	9,01	0,58						
Go 10 c middle	Gorodishche	Volgien moyen	35,40	16	3,50	1,60						
Go 10 c top	Gorodishche	Volgien moyen	36,00	47	6,43	0,82						
Go 10 c nodule	Gorodishche	Volgien moyen	36,20	82	10,42	0,52						
Go 11 a 0.08	Gorodishche	Volgien moyen	36,28	43	6,02	0,86	0,71	411	0,01	0,19	26	
Go 11 a BS base	Gorodishche	Volgien moyen	36,32	10	4,05	2,81	2,32	420	0,11	4,08	175	
Go 11 a BS middle	Gorodishche	Volgien moyen	36,36	2	8,86	8,61	7,51	417	0,81	38,92	518	
Go 11 a BS top	Gorodishche	Volgien moyen	36,40	34	18,33	14,26	12,04	416	1,60	63,27	525	
Go 11 a 0.30m	Gorodishche	Volgien moyen	36,50	32	9,99	6,13	5,37	422	0,34	21,44	399	
Go 11 a top	Gorodishche	Volgien moyen	36,70	25	5,03	2,02	1,48	423	0,04	0,79	53	
Go 11 b base	Gorodishche	Volgien moyen	36,95	10	9,72	8,52	7,57	413	0,71	36,23	478	
Go 11 b top	Gorodishche	Volgien moyen	37,05	27	6,89	3,64	3,17	423	0,16	7,61	240	
Go 11 c base	Gorodishche	Volgien moyen	37,30	35	19,04	14,78	14,60	411	2,78	82,55	565	
Go 11 c top	Gorodishche	Volgien moyen	37,60	30	5,76	2,11	1,81	425	0,08	2,17	119	
Go 11d base	Gorodishche	Volgien moyen	37,75	29	6,28	2,83	2,43	424	0,09	3,27	134	
Go 11 d top	Gorodishche	Volgien moyen	38,15	17	10,50	8,44	7,40	420	0,68	33,50	452	

Tab. 5 Bulk geochemical data of the Upper Jurassic deposits from the Russian Platform (Peri-Tethys Programme)

N° Ech.	Coupe	Age	Cote	% CaCO3	% Ctot	% Corg.	% COT	Tmax	S1	S2	IH	IO
Go 11 e base	Gorodishche	Volgien moyen	38,30	32	8,47	4,67	4,09	420	0,20	10,55	257	
Go 11 e base de top	Gorodishche	Volgien moyen	38,50	44	6,82	1,59	1,46	417	0,03	0,61	41	
Go 11 e top	Gorodishche	Volgien moyen	38,80	40	6,61	1,82	1,43	418	0,02	0,55	38	
Go 11 f base	Gorodishche	Volgien moyen	38,95	2	49,70	49,50	42,97	396	15,40	285,13	663	
Go 11 f top	Gorodishche	Volgien moyen	39,00	2	51,76	51,51	44,51	396	21,30	311,21	699	
Go 11 g base	Gorodishche	Volgien moyen	39,05	4	35,26	34,77	30,73	402	12,10	198,50	645	
Go 11 g top	Gorodishche	Volgien moyen	39,10	18	23,81	21,63	20,25	407	4,22	115,57	570	
Go 11 h base	Gorodishche	Volgien moyen	39,25	12	12,62	11,14	10,50	412	0,88	49,76	473	
Go 11 h top	Gorodishche	Volgien moyen	39,80	25	6,18	3,15	2,85	425	0,09	3,30	115	
Go 11 i base	Gorodishche	Volgien moyen	40,10	17	21,88	19,86	18,31	408	4,10	112,38	613	
Go 11 i top	Gorodishche	Volgien moyen	40,17	24	19,11	16,26	15,39	411	2,53	88,35	574	
Go 11 j base	Gorodishche	Volgien moyen	40,30	18	25,58	23,39	23,27	403	8,16	138,80	596	
Go 11 j top	Gorodishche	Volgien moyen	40,60	33	5,09	1,12	0,59	428	0,02	0,19	32	
Go 11 k base	Gorodishche	Volgien moyen	40,80	9	26,01	24,92	22,30	410	5,80	126,66	567	
Go 11 l base	Gorodishche	Volgien moyen	41,10	9	15,47	14,37	13,23	418	2,50	57,57	435	
Go 11 l middle	Gorodishche	Volgien moyen	41,30	0	22,23	22,23	20,18	420	4,01	80,21	397	
Go 11 l top	Gorodishche	Volgien moyen	41,45	7	1,79	0,92	0,51	427	0,02	0,18	35	
Go 11 m base	Gorodishche	Volgien moyen	41,55	13	4,73	3,14	2,46	430	0,15	2,86	116	
Go 11 m top	Gorodishche	Volgien moyen	41,65	8	1,76	0,78	0,74	427	0,04	0,23	31	
Go 11 n base	Gorodishche	Volgien moyen	41,90	0	17,18	17,18	14,75	425	1,29	32,67	221	
Go 11 n top	Gorodishche	Volgien moyen	42,10	0	1,65	1,65	1,18	430	0,06	0,55	46	
Go 12	Gorodishche	Volgien moyen	42,50	7	1,97	1,08						
Go 13 base	Gorodishche	Volgien moyen	42,70	0	0,27	0,27						
Go 13 conglomérat	Gorodishche	Volgien moyen	43,00	32	4,45	0,58						
Go 14 conglomérat	Gorodishche	Volgien moyen	43,20	26	4,00	0,88						
Go 15 grès	Gorodishche	Volgien supérieur	43,50	51	6,53	0,43						
Go 17 middle	Gorodishche	Volgien supérieur	44,50	0	0,85	0,85						
Go 17 nodule	Gorodishche	Volgien supérieur	44,70	52	7,86	1,57						
Go 18	Gorodishche	Volgien supérieur	45,00	0	2,24	2,24						
Ka 20-1	Kashpir	Volgien supérieur		0	24,70	24,70	21,92	410	4,94	119,18	543	
Ka 20-2	Kashpir	Volgien supérieur		0	36,20	36,20	32,93	407	9,64	212,63	645	
LO -1	Lopatino	Oxfordien	0,00	11	4,40	3,08	2,67	418	0,39	0,29	11	66
LO 0	Lopatino	Oxfordien	0,95	9	4,55	3,47	2,98	417	0,24	0,42	14	58
LO 1	Lopatino	Volgien supérieur	1,10	4	1,17	0,69	0,61	427	0,31	0,27	44	86
LO 2	Lopatino	Volgien supérieur	1,70	6	1,07	0,35	0,25	429	0,28	0,20	80	216
LO 3	Lopatino	Volgien supérieur	2,50	3	0,57	0,21	0,30	430	0,3	0,20	66	826
LO 4	Lopatino	Volgien supérieur	3,40	4	3,29	2,81	0,43	423	0,44	0,12	27	113
LO 5	Lopatino	Volgien supérieur	4,80	3	1,65	1,29	0,70	418	0,47	0,19	27	191
LO 6	Lopatino	Volgien supérieur	5,20	4	2,33	1,85	0,70	414	0,25	0,20	28	304

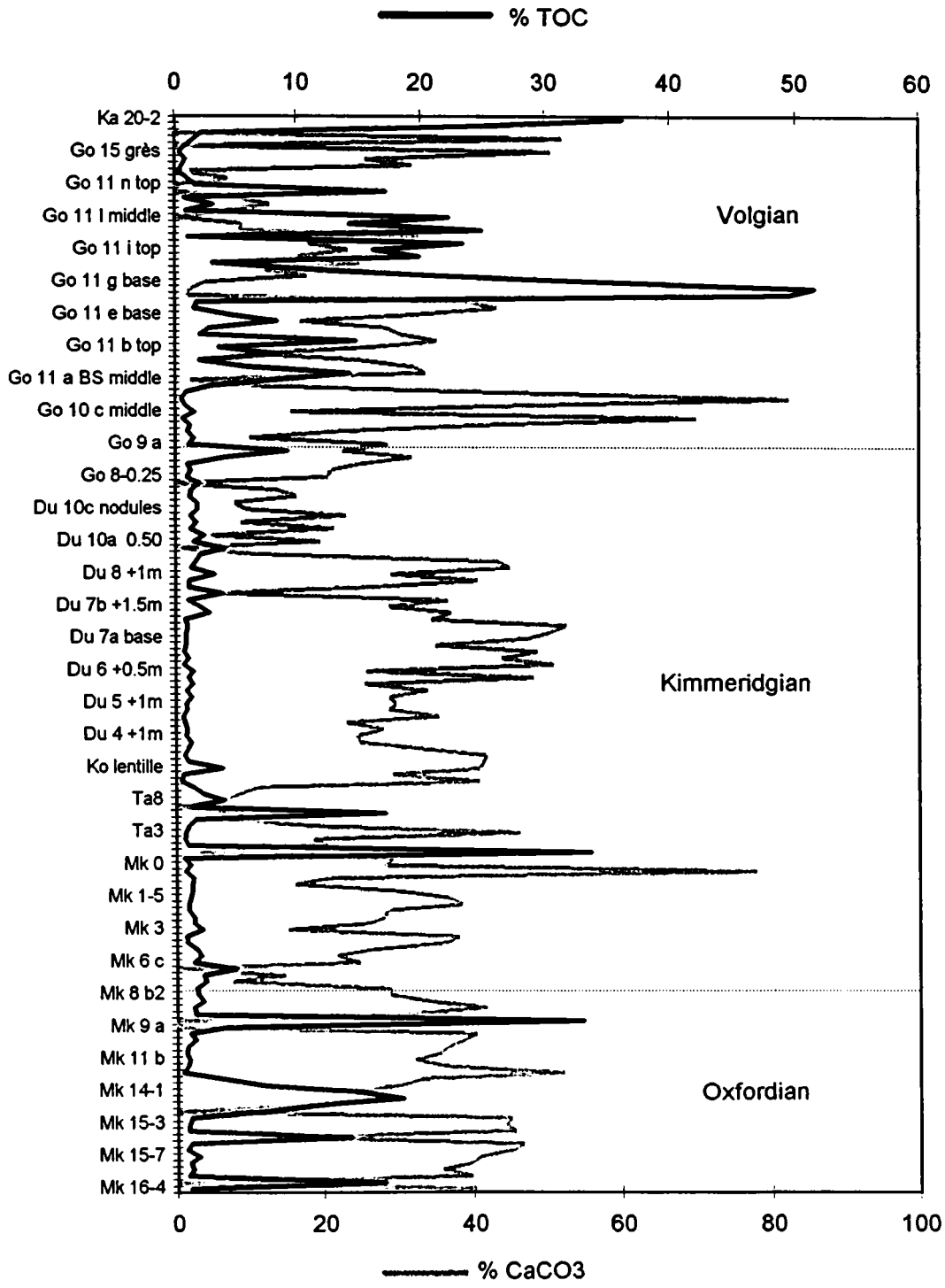


Fig. 16 Composite bulk geochemical log ($CaCO_3$, TOC) of the Upper Jurassic deposits from Russian Platform.

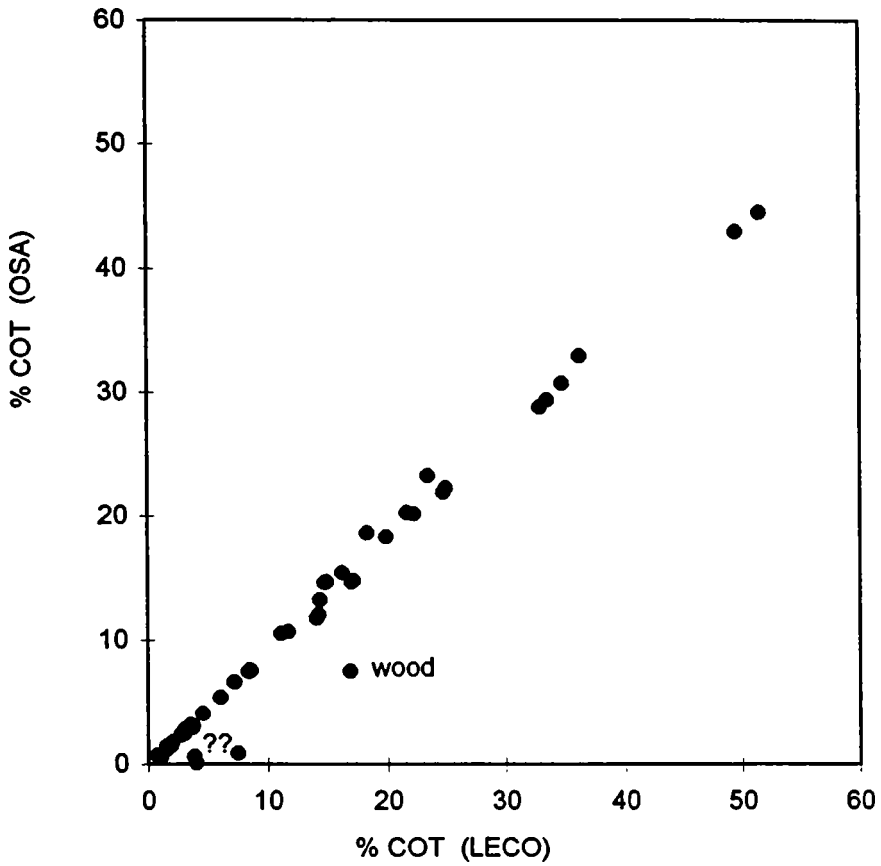


Fig. 17 Comparison of the organic content measured by LECO and Rock-eval

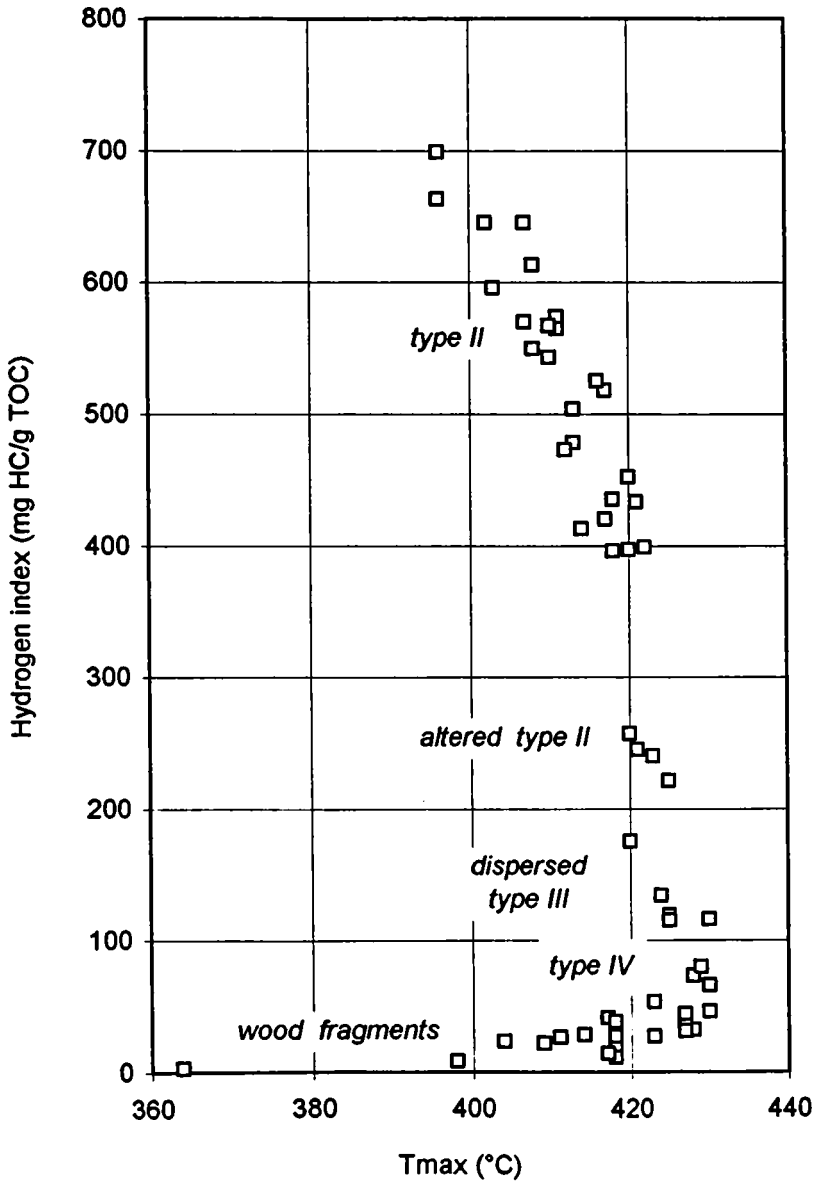


Fig. 18 Hydrogen index vs. Tmax diagram of selected samples from the Upper Jurassic of Russian Platform

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APPENDIX

Faunas determined by Mesezhnikov (1989) in the Makariev section.

Mk 15	0.30 m	*Cardioceras* cf. *densiplicatum* Boden
	0.3-1.1 m	*Cardioceras densiplicatum* Boden
		Cardioceras aff. *tenuistriatmun* Bor.
		Cardioceras popilaniense Boden
		Cardioceras cf. *mauntjoi* Freb.
	1.1-1.8 m	*Cardioceras densiplicatum* Boden
		Cardioceras zenaidae Ilov.
		Cardioceras tenuicostatum (Nik.)
		Cardioceras tenuistriatum Bor.
		Cardioceras kokeni Boden
	1.8-2.3 m	*Cardioceras zanaidae* Ilov.
		Cardioceras tenuiserratum (Opp.)
Mk 14	0-0.10 m	*Amoeboceras ilovaiskii* (Sok.)
		Amoeboceras alternoides (Nik.)
		Perisphinctidae
Mk 13	0-0.15 m	*Amoeboceras ilovaiskii* (Sok.)
		Amoeboceras alternoides (Nik.)
		Perisphinctidae
Mk 12	0-0.35 m	*Amoeboceras alternoides* (Nik.)
		Amoeboceras transitorium Spath
		Amoeboceras cf. *glosense* (Bigot et Brasil)
		Amoeboceras ilovaiskii (Sok.)
Mk 11d	0-0.25 m	*Amoeboceras alternoides* (Nik.)
		Amoeboceras cf. *damoni* Spath
		Amoeboceras cf. *koldeweyense* Sykes et Callomon
		Amoeboceras ilovaiskii (Sok.)
Mk 1l c	0-0.10 m	*Amoeboceras* cf. *koldeweyense* Sykes et Callomon
		Amoeboceras ex gr. *serratum* (Sow.)
		Amoeboceras cf. *talbejense* Kal. et Mesezhn.
Mk11 b	0-0.10 m	*Amoeboceras* cf. *ovale* (Quenst.)
		Amoeboceras cf. *tuberculatoalternans* (Nik.)
		Amoeboceras ex gr. *serratum* (Sow.)
Mk 10b	0-0.15 m	*Amoeboceras* cf. *ovale* (Quenst.)
		Amoeboceras ex gr. *serratum* (Sow.)
Mk 10a	0-0.10 m	*Amoeboceras* cf. *ovale* (Quenst.)
		Amoeboceras cf. *tuberculatoalternans* (Nik.)
		Amoeboceras cf. *lineatum* (Salf.)
		Amoeboceras ex gr. *serratum* (Sow.)
	0. 1-0.2 m	*Amoeboceras gerassimovi* Kal. et Mesezhn.
		Amoeboceras ex gr. *serratum* (Sow.)
	0.2-0.4 m	*Amoeboceras tuberculatoalternans* (Nik.)
		Amoeboceras gerassimovi Kal. et Mesezhn.
		Amoeboceras cf. *freboldi* Spath
		Amoeboceras leucum Spath
Mk 9b	0-0.15 m	*Amoeboceras* cf. *lineatum* (Salf)
Mk 8d	0-0.20 m	*Amoeboceras* cf. *lineatum* (Salf)