西伯利亚西部白垩纪孢粉的参照序列：演化阶段，相和对比①

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摘 要：研究西伯利亚西部白垩纪沉积层的孢粉可以建立孢粉组合的参照序列。本文运用采自海相剖面的材料与菊石化石带进行对比，建立了下白垩统和上白垩统一些层位中的孢粉化石带。这些新确立的孢粉组合层序反映了白垩纪孢粉植物群的演化阶段。由于生物相和古地理特征的变化，孢粉组合在横向上变化较大，很难依据孢粉资料进行地区间的精确对比。然而，有些孢粉组合演化发展的总体趋势能用于对比、定义部分地层层位。

关 键 词：孢粉地层学，孢粉组合，相，区域间对比，古植物分区，白垩纪，西伯利亚
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REFERENCE CRETACEOUS SPORE-POLLEN SUCCESSION OF WEST SIBERIA: EVOLUTIONARY STAGES, FACIES, AND CORRELATIONS

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Abstract Palynological studies of Cretaceous deposits in West Siberia allow the definition of a reference succession of spore-pollen assemblages. Materials from marine sections provide their calibration against ammonite scale and definition of spore-pollen zones at some levels in the Lower and Upper Cretaceous. Defined succession of spore-pollen assemblages reflects the evolutionary stages of Cretaceous palynofloras. Considerable lateral variations of spore-pollen assemblages related to facies and palaeogeographic features preclude accurate interregional correlations on spore-pollen based data, but some general tendencies in the evolutionary development of spore-pollen assemblages can be defined for some stratigraphic levels.

Key words palynostratigraphy, spore-pollen assemblages, facies, interregional correlation, palaeofloristic provinces, Cretaceous, West Siberia

1 Introduction

Palynological studies on the Cretaceous of Siberia began in the 40-50th of the last century, and their history was described in several reviews (Samoilovitch & Mchedlishvili, 1961; Fradkina, 1967; Chlonova, 1974; Ilyina et al., 1994; Pestchevitskaya, 2010). The results of comprehensive studies of Cretaceous palynological successions carried out by several palynological laboratories were included in Regional Stratigraphic Schemes of Mesozoic deposits of the West-Siberian plain (1991). They demonstrated the successions of spore-pollen assemblages in different regions of West Siberia defined on the basis of quantitative relations of certain palynomorph groups and occurrences of characteristic accessory taxa. The complex structure of Siberian palynostratigraphic schemes is related to several

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factors, including the complex composition of Cretaceous sediments represented by different facies, frequent changes of palaeoenvironments ranging from normal marine to continental, and climatic features. Therefore, the composition of spore-pollen assemblages is a result of sedimentation processes, hydrodynamic conditions, and vegetation peculiarities in different palaeofloristic provinces.

Different facies of Cretaceous deposits in West Siberia are caused by their complex formation during transgressive-regressive fluctuations. Being widespread over this territory, Cretaceous deposits are usually overlapped by Cenozoic sediments and exposed only in some outcrops in North Siberia (Yenisey mouth region, Khatanga depression) and the eastern slope of the Ural Mountains. These Cretaceous sections contain rich fauna providing the basis for the development of reference biostratigraphic scales based on ammonites, bivalves, and foraminifers for Boreal regions (Zakharov et al., 1997). The palynological study of reference sections are of special interest as it allows the calibration of spore-pollen zones against faunistic and dinocyst successions.

2 Neocomian

Neocomian deposits of West Siberia were formed during the gradual regression of the Siberian palaeobasin, which occupied almost all the territory in the Berriasian and Valanginian and was restricted by the central and north western regions in the Hauterivian (Golbert, 1987). The facies generally ranged from normal marine in central and northern regions to near shore and restricted marine in the south, replaced by alluvial and lacustrine facies in the Hauterivian (Golbert, 1987). Different climatic conditions caused the occurrence of two palaeofloristic provinces: the humid and temperate-warm Siberian-Canadian province in the north-east, and the subtropical and arid Indo- European province in the south and west (Vakhrameev, 1988). High facies heterogeneity and floristic peculiarities led to the formation of spore-pollen assemblages characterized by different composition and percentage relations. It was possibly the cause of the special emphasis given in the palynological studies of the last century to the definition of typical spore-pollen assemblages for certain regions characterized by a similar composition of dominant, subdominant, and subsidiary taxa in isochronous stratigraphic intervals (Markova, 1971; Golbert et al., 1972; Korzh, 1978, Golbert, 1981, and others). The stratigraphic position of spore-pollen assemblages was mostly determined by the changes in the relative percentages of dominant species and in the systematic composition of subsidiary ones. The results of these studies were included in Regional Stratigraphic Schemes of West Siberia (1991). Nevertheless, the reported spore-pollen assemblages were often of a large stratigraphic range up to stage or substage, as most of these palynological taxa are found continuously throughout the Lower Cretaceous, and sometimes occur in Jurassic or Upper Cretaceous strata.

Comparative analysis of percentage data based on a literature review and the author's material revealed an uneven distribution of spore-pollen assemblages over Siberia and a high variation of quantitative relations of their main components (Pestchevitskaya, 2007a, 2010). Taxonomic compositions of the stratigraphically important Lower Cretaceous groups appear to be a more reliable feature for detailed stratigraphic division, because they reflect evolutionary tendencies. Their distribution was studied in several marine sections from wells and outcrops in North Siberia given a detailed spore-pollen zonation of Berriasian, Valanginian, Hauterivian and Lower Barremian deposits (Figs. 1, 2). These sections are well dated by ammonites, bivalves and foraminifers, with the Nordvik and Anabar sections being of the most interest, as they are included in the Boreal zonal standard. It provides the calibration of spore-pollen zones against a standard boreal scale based on ammonites. An additional control on stratigraphic position of spore-pollen zones comes from dinocyst data obtained from the same sections (Pestchevitskaya, 2007b, 2010).

Comprising many taxa arose from the Jurassic, the Lower Cretaceous spore-pollen assemblages include characteristic species of Gleicheniaceae, Schizaeaceae and Hepaticae, which gradually become more diverse upward through the sections. Berriasian assemblages are of a transitional systematic composition including

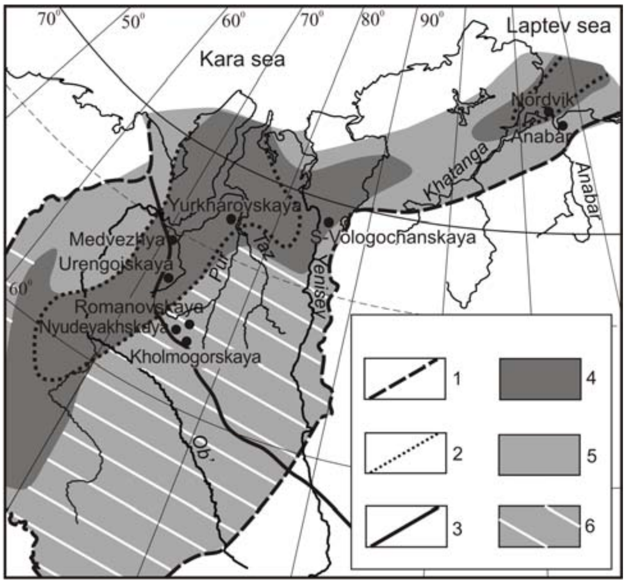

Fig. 1　The localities of some studied Necomian sections and palaeofacies (Zakharov & Yudovny, 1974; Golbert, 1987)

1. the boundary of Siberian palaeobasin in the Berriasian-Valanginian; 2. the boundary of Siberian palaeobasin in the Hauterivian; 3. the boundary between the Siberian-Canadian and Indo-European palaeofloristic provinces; 4-6. palaeofacies: 4. relatively deep-water, organic-reach bituminous facies; 5. shallow-water, terrigenous-glauconite facies; 6. shallow-water, terrigenous-calcareous- oligomicte facies

mostly Jurassic taxa. Nevertheless, a remarkable stratigraphic level is revealed in the middle of the Berriasian by the increased diversity of *Cicatricosisporites*, *Trilobosporites* and *Gleicheniidites* (Fig. 3). Spore-pollen assemblages with similar systematic compositions were reported from Berriasian sections of the Subarctic Urals and northern regions in East Siberia (Korotkevich, 1962; Lyubomirova & Kislyakov, 1985; Fedorova et al., 1993, and others). It should be noted that the percentages of main taxa considerably vary over the territory of Siberia. Striate and granular spores of Schizaeaceae are mostly rare (up to 3%) (Fedorova et al., 1993; Golbert, 1981, and others), reaching relatively high percentages (5%~9%) only in the north of East Siberia (Pavlov, 1969). Gleicheniaceous spores are abundant (up to 16%) and diverse in the Urals and some western and northern regions of West Siberia (Korzh, 1978, and others).

The taxonomic composition of spore-pollen assemblages is considerably changed at the base of the SPA2 Zone (Fig. 3). According to Bolkhovitina (1961), *Lygodium splendidum* Kara-Mursa and *Cicatricosisporites minutaestriatus* (Bolchovitina) Pocock are also present in the transitional Berriasian−Lower Valanginian assemblages, and the most ancient occurrences of *Cicatricosisporites pseudoauriferus* (Bolchovitina) Voronova are found in the Neocomian of the Caucasian region. Increased diversity and abundance of Schizaeaceae and Gleicheniaceae for the Lower Valanginian are often reported from different areas of Siberia (Markova, 1971; Korzh, 1978, and others). The percentages of these taxa are mainly 3%~5%, but locally they can be rather abundant: Schizaeaceae are of 10%~12% in central East Siberia and northern West Siberia, and Gleicheniaceae are 12%~16% in the Urals and central East Siberia, and 45%~60% in the northern West Siberia (Fradkina, 1967; Strepetilova et al., 1982, and others).

The base of the SPA3 Zone is well recognized by the occurrences of characteristic Valanginian species of striate schizaeaceous spores (Fig. 3). It is commonly marked by the appearance of 2~4 Valanginian species, but their diversity gradually increases within the Zone, and is a reliable indicator (Fig. 3). These species were often regarded as typical for the Valanginian, but the level of their inception was not accurately defined and calibrated against the ammonite succession, that precluded a detailed spore-pollen zonation (Markova, 1971; Korzh, 1978; Golbert, 1981, and others). The base of the SPA3 Zone is confirmed by the appearance of additional key taxa, such as *Foraminisporis asymmetricus* (Cookson & Dettmann) Dettmann, *Foraminisporis dailyi* (Cookson & Dettmann) Cookson & Dettmann, *Cooksonites variabilis* Pocock and some species of granular schizaeaceous spores (Fig. 3). Their occurrences in the middle of the Lower Valanginian were also reported from northern East Siberia and different regions of West Siberia (Sheiko, 1970; Chirva et al., 1979; Lyubomirova & Kislyakov, 1985, and others).

The Upper Lower and Upper Valanginian spore-pollen assemblages (SPA4-SPA5 Zones) are characterized by the common occurrences of *Aequitriradites* and diverse *Cicatricosisporites* as well as by the appearance of some granular schizaeaceous spores (Fig. 3). *Cicatricosisporites dorogensis* Potonie et Gelletich, *Cicatricosisporites cuneiformis* Pocock, *Trilobosporites verrucosus* (Delcourt & Sprumont) Voronova and *Trilobosporites purverulentus* (Verbitskaya) Bondarenko were also found in sediments with fauna typical of the

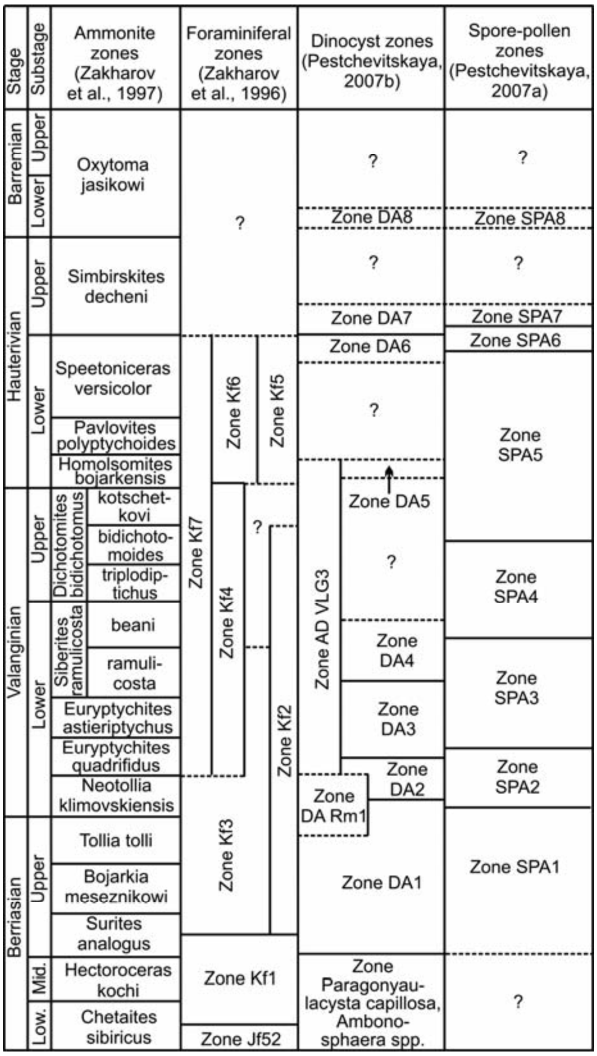

Fig. 2 Calibration of northern Siberian spore-pollen zones against ammonite, foraminiferal and dinocyst scales

(after Pestchevitskaya E B et al., 2012)

Siberites ramulicosta-Polyptychites beani Zones in the Lena-Anabar region of northern East Siberia (Lyubomirova & Kislyakov, 1985). Deposits characterized by ammonite fauna with *Polyptychites* spp. in the Khatanga River basin (N. Siberia) comprise relatively abundant Schizaeaceae, common *Trilobosporites valanjinensis* (Kara-Mursa) Doring and rare Polypodiaceae (Pavlov, 1969). Common *Aequitriradites spinulosus* (Cookson & Dettmann) Cookson & Dettmann and *Aequitriradites verrucosus* (Cookson & Dettmann) Cookson & & Dettmann were reported from the Upper Valanginian and Hauterivian of the Subarctic Urals, central West Siberia (up to 5%), and the Lena River region (northern East Siberia) (Bochkareva, 1970; Golbert et al., 1972; Kovalskaya, 1980). The assemblages from the latter region also comprise *Cooksonites variabilis* Pocock and diverse granular spores of Schizaeaceae (*Trilobosporites mirabilis* (Bolchovitina) Bondarenko, *T. crassiangularis* Doring, *T. cavernosum* (E. Ivanova) Voronova, and *Lygodium pseudogibberulum* Bolchovitina, etc.).

Hauterivian and Barremian levels can't be recognized from the published material, as the reported spore-pollen assemblages are of a wide stratigraphic range (Markova, 1971; Golbert et al., 1972; Korzh, 1978; Kovalskaya, 1980; Lyubomirova & Kislyakov, 1985, and others). Nevertheless, they confirm the tendency of common occurrences of *Cicatricosisporites* and *Trilobosporites* species characterized by a higher percentage since the Hauterivian: 1.5% *Cicatricosisporites tersus* (Bolchovitina) Pocock, 1.5%~3% *Cicatricosisporites dorogensis* Potonie & Gelletich, 1.5%~3% *Cicatricosisporites minutaestriatus* (Bolchovitina) Pocock, 4.5%~7% *Impadecispora gibberula* (Kara-Mursa) Venkatachala). Abundance of striate schizaeaceous spores is lower in the north (3%~10%), but higher in central West and East Siberia (10%~30%) (Markova, 1971; Golbert et al., 1972; Korzh, 1978, Lyubomirova & Kislyakov, 1985, and others). Spore-pollen assemblages from West Siberia often contain spinous spores of Schizaeaceae (1%~5%), which are rarely reported from East Siberia (Markova, 1971; Korzh, 1978, Lyubomirova & Kislyakov, 1985, and others). The level of their increased diversity can't be accurately inferred from the literature, but it is possibly confined to the base of the Upper Hauterivian, because no publications mention their diversity for the Lower Hauterivian (Bochkareva, 1970; Chirva et al., 1979; Kovalskaya, 1980; Markova, 1971). The abundance of gleicheniaceous spores is rather high (1%~20%), increasing in western West Siberia (15%~50%). The occurrences of *Clavifera* and *Ornamentifera* and inception of *Gleicheniidites toriconcavus* Krutzsch are reported for northern East Siberia (Golbert, 1981).

Thus, the analysis of the stratigraphic distribution of key taxa groups allows a more detailed Lower Cretaceous spore-pollen zonation in Siberia, than spore-pollen zonation proposed in the Regional Stratigraphic Schemes of West Siberia (1991). Percentage relations of spore-pollen assemblages, traditionally used in Siberian palynostratigraphy, turned out to be less informative, revealing high lateral variations related to a combination of factors. The distribution of terrestrial palynomorphs over West Siberia was influenced by paleoclimatic and paleoenvironmental parameters as well as by post-sedimentary processes, resulting in the variable composition of palynological associations, that was inferred from cluster analysis of Valanginian spore-pollen assemblages (Pestchevitskaya & Lebedeva, 2003). The lateral distribution of palynological associations with certain relationships of the main spore-pollen groups shows their general dependence on facies: the boundaries of large areas charaterized by the spore-pollen associations of first order almost repeat those of facies zones by Golbert (1987). The distribution of minor spore-pollen associations of second order is related to paleofloristic and palaeogeographic features providing more accurate definition of the boundary between the Siberian-Canadian and Indo-European palaeofloristic provinces (Fig. 3). Its configuration is indirectly supported by geophysical data, as it is extended in palaeolatitudinal direction according to the reconstructed location of the North Pole in the Early Valanginian (Pestchevitskaya & Lebedeva, 2003).

Considerable lateral variations in spore-pollen assemblages related to facies and palaeogeographic features preclude accurate long-distance correlations based on the spore-pollen data. Nevertheless, some general tendencies in the evolution of spore-pollen assemblages can be defined (Fig. 4). The uppermost Jurassic is often marked by the occurrences of the first shizaeaceous spores. The appearance of *Cicatricosisporites* is reported from the basal Tithonian of North America, Africa and West Europe, and the Upper Tithonian/Volgian of Australia, Antarctica, India, Siberia, and the Russian Platform (Fig. 4), although their rare specimens were found in the Uppermost Oxfordian and Kimmeridgian of West Europe and North Africa (Batten, 1996; Herngreen et al., 2000). A significant increase of *Cicatricosisporites* diversity is observed in the Upper Berriasian of West Europe and Russian Platform, but this palynological event is less pronounced in Siberia and North America. The first *Trilobosporites*/*Concavissimisporites* are reported from different levels: the Oxfordian of West Europe, Africa and Australia (Batten, 1996; Herngreen et al., 2000; Sajjadi & Playford, 2002; Schrank, 2010), the Upper Volgian of Siberia and Russian Platform, and the basal Berriasian of North America, Ukraine, Far East and Antarctica (Fig. 4). The Uppermost Tithonian−Lowermost Berriasian is also marked by the first occurrences of *Pilosisporites* in North and South America, West Europe, and Australia. In West Europe, rare specimens of *Pilosisporites* are defined in the Kimmeridgian, but their consistent occurrences are typical for the Tithonian-Berriasian (Batten, 1996; Herngreen et al., 2000). In Siberia, the inception of *Pilosisporites* is identified in the Valanginian, which is also observed in the Far East, North China, and the Ukraine (Fig. 4). *Aequitriradites* is also important taxon: its first occurrences are reported from the uppermost Kimmeridgian of Australia and Africa (Sajjadi & Playford, 2002; Schrank, 2010), and the inception of *Aequitriradites spinulosus* (Cookson & Dettmann) Cookson & Dettmann is defined in the Upper Volgian of Siberia, and Lower Berriasian of West Europe, India, Africa, and South America (Fig. 4). The appearance of *Appendicisporites* is typical of the Berriasian of Africa, North America, West Europe, the Ukraine, the Russian Platform and the Far East. In Siberia, its inception is identified in the Valanginian. The uppermost Berriasian−Lower Valanginian is marked by several palynological events: the appearance of *Coptospora* in North America, West Europe and Siberia; the appearance of *Aequitriradites verrucosus* (Cookson & Dettmann) Cookson & Dettmann in West Europe and Siberia; the appearance of *Foraminisporis asymmetricus* (Cookson & Dettmann) Dettmann in Siberia,

Spore-pollen zones	Palynological features of zone bases	Characteristic spore-pollen assemblages
Foraminisporis wonthaggiensis, Trilobosporites valanjinensis, Cicatricosisporites ludbrookiae, C. subrotundus, SPA1	- appearance of Foraminisporis wonthaggiensis, Taxodiaceaepollenites; - increased diversity of granular shizeaeceous spores, appearance of Trilobosporites valanjinensis, T. bernissartensis, T. grossetuberculatus, Concavissimisporites multituberculatus, C. crassatus; - increased diversity of striate shizeaeceous spores, appearance of Cicatricosisporites ludbrookiae, C. perforatus, C. subrotundus, C. tricostata; increased diversity of Gleicheniaceae, appearance of Gleicheniidites laetus, G. rasilis	**Abundant**- Leiotriletes, Cyathidites, Coniferales, Piceapollenites; **Considerable** - Osmundacidites, Pinuspollenites, Alisporites, Ginkgocycadophytus; **Common**- Tripartina, Eboraciasporites, Concavisporites junctus, Hymenozonotriletes bicycla, Densoisporites velatus, Klukisporites, Duplexisporites, Todisporites minor, Lophotriletes, Classopollis; **Diverse** - Neoraistrickia, Lycopodiumsporites, Stereisporites, Podocarpidites; **Important**- consistent low percentage (0,3-1,5%, rare 3%) of Gleicheniidites senonicus, Cicatricosisporites, Lygodiumsporites subsimplex, Trilobosporites; rare- Impardecispora giberrula, I. apiverrucata, Lygodiumsporites japoniciformis, Lygodium granulatum, Concavissimisporites macrotuberculatus, C. crassatus, C. planotuberculatus, C. multituberculatus, Trilobosporites asper, T. valanjinensis, T. bernissartensis, T. grossetuberculatus, Cicatricosisporites tersus, C. brevilaesuratus, C. hallei, C. subrotundus, Plicatella exilioides, Anemia remissa, Aequitriradites spinulosus, Foraminisporis wonthaggiensis, Taxodiaceaepollenites
Rouseisporites spp., Pilosisporites spp., Ornamentifera granulata, SPA2	- appearance of Rouseisporites, Pilosisporites, Ornamentifera granulata, Clavifera; - appearance of Cicatricosisporites minutaestriatus, C. pseudoauriferus, C. hallei, C. brevilaesuratus; - consistent occurrences of low percentage (1-5%) of granular and striate spores of Schizaeaceae; - appearance of Lygodium splendidum, L. ornatum, Trilobosporites grandis; - increased percentage of Foraminisporis wonthaggiensis and Taxodiaceaepollenites spp. (up to 3%)	**Abundant**- Leiotriletes, Cyathidites, Osmundacidites, Coniferales, Piceapollenites; **Considerable** - Pinuspollenites, Alisporites, Ginkgocycadophytus; **Common**- Tripartina, Neoraistrickia, Eboraciasporites granulosa, E. microverrucosa, E. torosa, Concavisporites junctus, Hymenozonotriletes bicycla, Densoisporites velatus, Klukisporites, Duplexisporites, Todisporites minor, Leptolepidites verrucatus, Podocarpidites, Classopollis; **Diverse** - Lycopodiumsporites, Stereisporites; **Important** - low percentage (0,3-1,5%) of Cicatricosisporites ludbrookiae, Foraminisporis wonthaggiensis, Gleicheniidites (1-5%); rare - Cicatricosisporites minutaestriatus, Plicatella chetaensis, P. tripartita, Anemia cardioformis, Mohria limbata, Lygodium clarum, Concavissimisporites spasituberculatus, Pilosisporites parvispininosus, Rouseisporites, Aequitriradites spinulosus, A. verrucosus, Taxodiaceaepollenites, and species of striate and granular spores of Schizaeaceae from lower zone
Cicatricosisporites australiensis, C. dorogensis, Foraminisporis dailyi, SPA3	- appearance of Cicatricosisporites dorogensis, C. australiensis, C. mediostriatus, C. pseudotripartitus, C. mohrioides, C. imbricatus, C. stoveri, C. verbitskaja); - appearance of Foraminisporis dailyi, F. asymmetricus; - frequent occurrences of Aequitriradites; - appearance of Cooksonites variabilis, Rouseisporites reticulatus, Coptospora; - increased diversity of granular shizeaeceous spores, appearance of Lygodium pseudogibberulum, L. conforme, L. obsoletum, Concavissimisporites verrucosus; - increased percentage of Taxodiaceaepollenites (up to 6,5%); - appearance of Laevigatospoties ovatus	**Abundant**- Leiotriletes, Cyathidites, Osmundacidites, Coniferales, Piceapollenites; **Considerable** - Pinuspollenites, Alisporites, Ginkgocycadophytus; **Common**- Tripartina, Neoraistrickia, Eboraciasporites granulosa, E. microverrucosa, E. torosa, Concavisporites junctus, Hymenozonotriletes bicycla, Densoisporites velatus, Klukisporites, Todisporites minor, Leptolepidites verrucatus, Podocarpidites, Classopollis; **Diverse** - Lycopodiumsporites, Stereisporites; **Important** - low percentage (0,3-5%) of Cicatricosisporites; common Foraminisporis wonthaggiensis, F. dailyi, Cicatricosisporites australiensis, C. minutaestriatus, C. ludbrookiae, C. sibiricus, Gleicheniidites, Taxodiaceaepollenites; rare - Cicatricosisporites dorogensis, C. pseudotripartitus, C. mohrioides, C. stoveri, C. subrotundus, C. verbitskaja, C. imbricatus, C. mediostriatus, Lygodium pseudogibberulum, L. obsoletum, L. conforme, Concavissimisporites verrucosus, Pilosisporites, Aequitriradites, Rouseisporites reticulatus, Cooksonites variabilis, Foraminisporis asymmetricus, Ornamentifera, Clavifera, Laevigatospoties ovatus
Appendicisporites spp., Trilobosporites purverulentus, T. uralensis, SPA4	- appearance of Appendicisporites parviangulatus, A. problematicus; - appearance of Trilobosporites purverulentus, T. mirabilis, T. uralensis; - consistent occurrences of Trilobosporites bernissartensis, T. valanjinensis, Lygodium splendidum	**Abundant**- Leiotriletes, Cyathidites, Osmundacidites, Coniferales, Piceapollenites; **Considerable** - Pinuspollenites, Alisporites, Ginkgocycadophytus; **Common**- Tripartina, Neoraistrickia, Eboraciasporites granulosa, E. microverrucosa, E. torosa, Concavisporites junctus, Hymenozonotriletes bicycla, Densoisporites velatus, Todisporites minor, Leptolepidites verrucatus, Podocarpidites, Classopollis; **Diverse** - Lycopodiumsporites, Klukisporites, Stereisporites; **Important** - common Cicatricosisporites australiensis,C. ludbrookiae, C. minutaestriatus, Foraminisporis, Lygodiumsporites, Concavissimisporites multituberculatus,C. macrotuberculatus, Trilobosporites bernissartensis, T. asper, Lygodium splendidum, L. granulatum, F. wonthaggiensis, F. dailyi, Rouseisporites, Taxodiaceaepollenites; rare - Coptospora, Cooksonites, Rouseisporites reticulatus, R. laevigatus, Foraminisporis asymmetricus, Aequitriradites verrucosus, A. spinulosus, Ornamentifera, Clavifera, Appendicisporites parviangulatus, A. problematicus, Cicatricosisporites cuneiformis, C. exilis, C. myrtellii, Trilobosporites verrucosus, T. perverrucatus, T. mirabilis, T. uralensis, T. macrothelis, Lygodium enorme, L. rufescens, L. cretaceum, L. crispaeformis, L. triangulatum, L. concors, Laevigatospoties ovatus
Ruffordiaspora goepperti, Aequitriradites spp., Ornamentifera tuberculata, O. echinata, SPA5	- appearance of Ruffordiaspora goepperti, R. aralica; - consistent occurrences of Aequitriradites spinulosus, A. verrucosus; - appearance of Ornamentifera tuberculata, O. echinata, O. peregrina, Lygodium ornatum; - consistent occurrences of Cicatricosisporites subrotundus, Ornamentifera; - appearance of Lygodium ornatum, Trilobosporites marylandensis	**Abundant**- Leiotriletes, Cyathidites, Osmundacidites, Coniferales, Piceapollenites; **Considerable** - Pinuspollenites, Alisporites, Ginkgocycadophytus; **Common**- Tripartina, Neoraistrickia, Eboraciasporites granulosa, E. microverrucosa, E. torosa, Concavisporites junctus, Hymenozonotriletes bicycla, Densoisporites velatus, Todisporites minor, Leptolepidites verrucatus, Podocarpidites, Classopollis; **Diverse** - Lycopodiumsporites, Klukisporites, Stereisporites; **Important** - common Cicatricosisporites subrotundus, C. ludbrookiae, Aequitriradites verrucosus, A. spinulosus, Foraminisporis wonthaggiensis, Lygodium splendidum, Trilobosporites bernissartensis, T. microverrucosus (in the upper part), Taxodiaceaepollenites; rare - Ornamentifera tuberculata, O. echinata, O. peregrina, Lygodium ornatum, L. cotidianum, Concavissimisporites clarus, Pilosisporites parvispininosus, Ruffordiaspora goepperti, R. aralica, and species of liverworts and striate and granular spores of Schizaeaceae from lower zones

Spore-pollen zones	Palynological features of zone bases	Characteristic spore-pollen assemblages
Cicatricosisporites tersus, Foraminisporis spp., Taxodiaceaepollenites spp., SPA6	- increased percentage of Taxodiaceaepollenites (5-17%); - increased percentage and diversity of Cicatricosisporites	**Abundant**- Leiotriletes, Cyathidites, Coniferales; **Considerable** - Gleicheniidites, Pinuspollenites, Piceapollenites, Alisporites, Ginkgocycadophytus; **Common**- Osmundacidites, Lycopodiumsporites, Stereisporites, Eboraciasporites, Podocarpidites, Classopollis; **Diverse** - Cicatricosisporites, Trilobosporites, **Important** - common considerable percentages of Taxodiaceaepollenites; common - Gleicheniidites senonicus, Lygodium splendidum, Trilobosporites bernissartensis, Cicatricosisporites subrotundus, C. ludbrookiae, Aequitriradites; diverse - Foraminisporis; rare - Cicatricosisporites dorogensis, C. tersus ,C. ludbrookiae, Ornamentifera, and species of liverworts and striate and granular spores of Schizaeaceae from lower zones
Pilosisporites notensis, P. echinaceus, SPA 7	- appearance of Pilosisporites echinaceus, P. notensis, Gleicheniidites toriconcavus; - consistent occurrences of Cicatricosisporites dorogensis	**Abundant**- Leiotriletes, Cyathidites, Coniferales; **Considerable** - Gleicheniidites, Pinuspollenites, Alisporites, Piceapollenites, Ginkgocycadophytus; **Common**- Osmundacidites, Lycopodiumsporites, Stereisporites, Eboraciasporites, Podocarpidites, Gnetaceaepollenites, Classopollis; **Diverse** - Cicatricosisporites, Trilobosporites; **Important**- common considerable percentage of Taxodiaceaepollenites (5-19%); common Cicatricosisporites dorogensis, C. tersus, C. ludbrookiae, Foraminisporis, Gleicheniidites senonicus, Aequitriradites; diversity of Gleicheniidites, Cicatricosisporites, Trilobosporites; rare Pilosisporites echinaceus, P. notensis, Gleicheniidites toriconcavus, Rouseisporites
Lygodium longipilosum, Pilosisporites hirsutus, Rouseisporites laevigatus, R. radiatus, SPA8	- increased diversity of Pilosisporites, appearance of Pilosisporites hirsutus, Lygodium longipilosum, L. calvum; - consistent occurrences of Pilosisporites, Rouseisporites; - increased percentage of Taxodiaceacpollenites	**Abundant**- Leiotriletes, Cyathidites, Coniferales; **Considerable** - Gleicheniidites, Pinuspollenites, Alisporites, Piceapollenites, Ginkgocycadophytus; **Common**- Osmundacidites, Lycopodiumsporites, Stereisporites, Eboraciasporites, Podocarpidites, Classopollis; **Diverse** - Cicatricosisporites, Pilosisporites, Trilobosporites, Rouseisporites; **Important**- abundant Taxodiaceacpollenites spp. (6-22%); common considerable percentage of Gleicheniidites senonicus, Cicatricosisporites; common Cicatricosisporites dorogensis, C. ludbrookiae, C. tersus, Pilosisporites, Rouseisporites (R. reticulatus, R. laevigatus, R. simplex, R. radiatus), Aequitriradites; diversity of Gleicheniidites, Cicatricosisporites, Trilobosporites, Pilosisporites; rare Pilosisporites hirsutus, P. echinaceus, P. notensis, Lygodium longipilosum, L. calvum, and species of striate and granular spores of Schizaeaceae from lower zones

Fig. 3　Characteristic features of Neocomian spore-pollen zones (Abundant: more than 10%, considerable 2%～10%)

North China and the Ukraine; the appearance of *Foraminisporis dailyi* (Cookson & Dettmann) Cookson & Dettmann in West Europe and Siberia; the appearance of *Clavifera triplex* (Bolchovitina) Bolchovitina in Ukraine and Siberia; the inception of several Valanginian species of striate and granular spores of Schizaeaceae in North America, West Europe, Ukraine, Siberia and North China (Fig. 4). The first occurrences of *Trilobosporites marylandensis* Brenner and *Ruffordia aralica* Bolchovitina are observed in the Upper Valanginian in Siberia and Africa. In the Hauterivian, the correlative events are: the appearance of *Pilosisporites notensis* Cookson & Dettmann in the Ukraine, Siberia and Australia; the appearance of *Concavisporites dubia* (Bolchovitina) Voronova in the Ukraine and the Russian Platform; the appearance of *Trilobosporites microverrucosus* (Döring) Voronova in the Ukraine and Siberia; the appearance of Hauterivian forms of *Gleicheniidites toriconcavus* Krutzsch in the Russian Platform and Siberia (Fig. 4). The typical Barremian features are the diversity of *Pilosisporites* in the Ukraine and Siberia, and consistent occurrences of *Foraminisporis asymmetricus* (Cookson & Dettmann) Dettmann in the Far East, India and Australia. Angiosperms are revealed in the Barremian of Africa, North America, West Europe and North China (Fig. 4), and problematic specimens are sometimes reported from Siberia (Rybak, 1984).

3　Barremian−Cenomanian

The Barremian, Aptian and some horizons of the Albian and Cenomanian are mainly characterized by continental sedimentation that precludes the definition of reference spore-pollen assemblages. Until now, the Barremian has not been reliably confirmed by faunal fossils in West Siberia, so reference spore-pollen assemblage (SPA) can't be established. The Barremian age of Siberian deposits is mostly inferred from their position in the section and from the comparison of Siberian spore-pollen assemblages to those from the Russian Platform, the Caucasus and some other regions, where spore-pollen assemblages are calibrated against faunistic successions. Typical features of Barremian assemblages in Siberia are the abundance of Gleicheniaceae, *Osmundacidites* spp., diversity of *Appendicisporites*, *Cicatricosisporites*, *Lygodiumsporites*, and the occurrences of *Aequitriradites*, *Pilosisporites*, and *Stereisporites*. Certain Barremian intervals are marked by a high percentage of *Aequitriradites* and *Klukisporites* (Korzh, 1978). Gymnosperms include *Ginkgocycadophytus*, *Taxodiaceaepollenites*, *Classopollis*, ancient and young representatives of Pinaceae.

There are rather considerable percentage variations of main components in the spore-pollen assemblages. Markova (1971) defined six types of spore-pollen assemblages for the Hauterivian–Barremian in six regions of West Siberia, which are characterized by the different quantitative relations of the main groups of spores and pollen.

The marine fauna in the Aptian is very rare in West Siberia. The main diagnostic features of the Aptian spore-pollen assemblages are: the increased quantity of Taxodiaceae and young morphotypes of bisaccate pollen of conifers, changes in taxonomical composition of Gleicheniaceae and Schizaeaceae, the reduced percentage of *Classopollis*, and the occurrences of angiosperms (Figs. 5, 6). Aptian spore-pollen assemblages contain abundant Gleicheniaceae including consistent *Clavifera triplex* Bolchovitina and *Ornamentifera echinata* Bolchovitina. The genera *Appendicisporites* and *Cicatricosisporites* are the most diverse among the schizaeaceous, while the percentage of *Pilosisporites* is considerably reduced. There is a bloom of *Rouseisporites* (*R. tringularis* Pocock, *R. reticulatus* Pocock, *R. laevigatus* Pocock). The important accessory taxa are *Osmundacidites* spp., *Laevigatosporites ovatus* Wilson & Webster, *Foveosporites cenomanicus* (Chlonova) Schvetzova, and *Lophotriletes amabilis* Fradkina. The first angiosperms are represented by tricolpate and rarer colporate pollen. It should be noted sufficient lateral variations of the percentages of Gleicheniaceae, Schizaeaceae, Polypodiacea and Taxodiaceae, which are related to facies, climatic and some other parameters.

The Albian is represented in West Siberia by a complex sedimentary body of different facies, with alternation of continental and marine deposits. Albian spore-pollen assemblages are well studied, with the main attention being given to the palynological material from marine layers dated by fauna. Their main characteristic features are reported in several reviews (Markova, 1971; Chlonova, 1974; Korzh, 1978, and others). Albian spore-pollen assemblages are rather uniform having almost no lateral variations, which is shown in the Regional Stratigraphic Schemes (1991) (Figs. 5, 6). There are considerable taxonomic changes in comparison to Aptian spore-pollen assemblages: the increased diversity of Gleicheniaceae and angiosperms; consistent occurrences of Taxodiaceae, several species of *Rouseisporites*, Polypodiaceae, and Albian species of striate schizaeaceous spores; the common finds of *Ornamentifera echinata* Bolchovitina and *Foram-inisporis*; the occurrences of *Kuylisporites lunaris* Cookson & Dettmann, *Cooksonites variabilis* Pocock, *Klukisporites* sp. and others.

Two palaeofloristic provinces are defined on palaeobotanical data for the Aptian–Albian of West Siberia: the Siberian-Canadian province characterized by temperate-warm seasonal climate in the north, and the Indo-European one with warmer and more arid climate in the south (Vakhrameev, 1988). The boundary between these provinces based on palynologicaldata is located by Markova (1971) in more southern regions, than was proposed by Vakhrameev (1988) (Fig. 5). In the Aptian–Albian, the northern boundary of arid areas moved from south West Siberia to Southern Kazakhstan. It indicates the beginning of a transitional stage in the development of the Siberian flora, gradually changing from the Mesophytic to Cenophytic type (Vakhrameev, 1988). The uniform composition of spore-pollen assemblages described from different regions in West Siberia is possibly related to the almost ceased influence of arid zone and uniform continental regime occurred in West Siberia during almost the whole Aptian (Golbert, 1987). New marine trassgression began only in the latest Aptian–earliest Albian.

Typical features of Cenomanian spore-pollen assemblages are identified on the bases of detailed morphologic and palynostratigraphic investigations (Strepetilova, 1979a, 1979b, 1980, 1989; Chlonova, 1988; Ilyina et al., 1994, and others). Cenomanian spore-pollen assemblages are well differed from those of the Albian and Turonian and studied in different regions of West Siberia (Regional Stratigraphic Schemes, 1991) (Fig. 6). A specific feature of the Cenomanian spore-pollen assemblages is the cooccurrences of Early and Late Cretaceous species (Chlonova, 1974). The assemblages are dominated by gymnosperms with abundant Taxodiaceae and no ancient morphotypes. The percentage of angiosperms including frequent tricolpate and rarer triporate pollen increases up to 8%~10%. The composition of spores is changed in the reduced percentage of *Leiotriletes* spp. and Gleicheniaceae and increased abundance of *Stereisporites* spp. Important accessory taxa are consistent *Laevigatosporites ovatus* Wilson &

Stages	N America	West Europe	Caucasus	Ukraine	Russian Platform	Siberia	Far East	N China	India	Australia	Antarctica	S America	Africa
Barremian	Angiospermae *Pristinuspolleni-tes inchoatus; Impardecispora humilis*	Angiospermae	Dominated Schizaeaceae	Diversity of *Pilosisporites*		Diversity of *Pilosisporites* (↑*P. hirsutus, P. longipilosum, P. calvum*) and *Rouseisporiets*	Dominated *Cicatricosisporites* (↑*C. auriferus*), *Foraminisporis asymmetricus, Trilobosporites mirabilis*	Angiospermae	*Foraminisporis asymmetricus, Coptospora verrucosa*	*Foraminisporis asymmetricus; Cyclusporites hunghesi*		*Cyatheacidites tectifera*	Angiospermae
Hauterivian	*Appendicisporites crimensis*		*Pilosisporites*; dominated Gleicheniaceae; consistent abundance of Schizaeaceae	Abundance of *Cicatircosisporites; Trilobosporites marylandensis, T. microverrucosus; Pilosisporites notensis; Concavisporites dubius*	*Concavisporites dubius; Gleicheniidtes toriconcavus* (Hauterivian forms)	*Pilosisporites notensis, echinaceus; Gleicheniidtes toriconcavus* (Hauterivian forms) *Trilobosporites microverrucosus*	*Gleicheniidites dicarpoides, G. conflexa; Rouseisporiets laevigatus, R. reticulatus, R. triangularis; Lobatia involucrata*	Abundance of *Cicatricosisporites* (↑*C. tersus, C. pseudotripartitus*); *Concavissimisporites variverrucatus; Kyulisporites lunaris*		*Trilobosporites purverulentus; Pilosisporites notensis*			*Dicheiropollis etruscus*
Valanginian	*Cooksonites variabilis; Cicatircosisporites pseudotripartitus, C. mohrioides; Trilobosporites marylandensis, T. purverulentus; Coptospora reticulata*	*Concavissimisporites verrucosus; Foraminisporis dailyi; Coptospora dettmannae; Aequitriradites verrucosus*	Diversity of Gleicheniaceae, Schizaeaceae; dominated Taxodiaceae	Diversity of *Cicatircosisporites* (↑*C. pseudotripartitus, C. dorogensis, C. perforatus, C. mohrioides, C. minutaestriatus*); *Appendicisporites macrorhyzus, A. crimensis; Concavissimisporites verrucosus; Lygodium pseudogibberulum, L. cotidianum; Pilosisporites; Foraminisporis asymmetricus, F. wonthaggiensis; Ornamentifera; Clavifera triplex; Gleicheniidites radiatus*	Dominated *Gleicheniidites*; consistent *Ornamentifera*	*Trilobosporites marylandensis; Ruffordiaspora goepperti, R. aralica* Diversity of *Cicatircosisporites* (↑*C. pseudotripartitus, C. dorogensis, C. sibiricus, C. mohrioides*); *Appendicisporites; Concavissimisporites verrucosus; Foraminisporis asymmetricus, F. dailyi; Coptospora* *Cicatircosisporites minutaestriatus; Lygodium cotidianum, L. pseudogibberulum; Pilosisporites; Rouseisporites; Ornamentifera; Clavifera triplex*	Taxodiaceae; *Pilosisporites echinaceus, P. verus; Gleicheniidites carinatus*	Diversity of *Cicatricosisporites*, (↑*C. minutaestriatus, C. minor, C. ludbrookiaea*) *Trilobosporites asper; Pilosisporites; Foraminisporis wonthaggiensis, F. asymmetricus; Aequitriradites; Lygodium cotidianum*	Abundant *Cicatricosisporites; Foraminisporis wonthaggiensis; Januasporites spiniferus*	*Foraminisporis wonthaggiensis*; consistent *Balmeiopsis* (*limbatus, B. robusta*)	*Foraminisporis wonthaggiensis; Matonisporites agatonensis*	Consistent *Balmeiopsis limbatus; Interulobites; Cyclusphaera psilata; Trilobosporites trioreticulosus; Kyulisporites lunaris*	*Trilobosporites marylandensis; Ruffordiaspora aralica* *Cicatircosisporites sibiricus, C. sinuosus* *Rouseisporites*
Berriasain / Ryazanian	Diversity of *Cicatricosisporites* *Appendicisporites macrorhyzus; Pilosisporites trichopapillosus, P. verus, P. ericus; Foraminisporis wonthaggiensis*; diversity of *Trilobosporites* (↑*T. apiverrucatus*); *Rouseisporites*	*Concavissimisporites multituberculatus*; diversity of *Cicatricosisporites* (↑*C. exilioides, C. minutaestriatus*); *Gleicheniidites minor, G. latifolius, G. delcourti; Appendicisporites macrorhyzus, A. crimensis, A. parviangulatus; Rousiesporites* *Pilosisporites verus, P. ericus* *Cicatricosisporites perforatus; Aequitriradite spinulosus; Laevigatosporites ovatus* *Cicatricosisporites australiensis*; diversity of *Trilobosporites*		*Cicatricosisporites, Appendicisporites, Trilobosporites*	Abundance of *Gleicheniidites* (↑*G. radiatus*); *Appendicisporites parviangulatus*; diversity of *Cicatricosisporites* (↑*C. exilioides, C. perforatus*) *Cicatricosisporites ludbrookiaea*	*Aequitriradites verrucosus* Diversity of *Trilobosporites* (↑*T. bernissartensis, T. valanjinensis, T. asper*); *Concavissimisporites C. macroverrucosus, C. variverrucatus, C. multituberculatus; Cicatricosisporites ludbrookiaea*; Taxodiaceae; *Foraminisporis wonthaggiensis* *Cicatricosisporites exilioides*	Diversity of *Cicatricosisporites* (↑*C. exilioides, C. ludbrookiaea, C. perforatus, C. dorogensis, C. minutaestriatus*), *Appendicisporites tricostatus, Trilobosporites asper*		*Aequitriradites spinulosus*	*Cicatricosisporites hughesi; Pilosisporites; Balmeiopsis limbatus*	*Concavissimisporites crassatus*	Abaundant *Callialosporites* *Aequitriradites spinulosus; Balmeiopsis limbatus*	*Aequitriradites spinulosus; Balmeiopsis limbatus; Pilosisporites trichopapillosus; Cicatricosisporites australiensis, C. hughesi; Appendicisporites; Concavissimisporites variverrucatus*
Tithonian / Volgian	Consistent *Cicatricosisporites* (↑*C. australiensis*)	*Pilosisporites* (*P. trichopapillosus*) Consistent *Cicatricosisporites* and *Trilobosporites* (↑*T. apiverrucatus, T. valanjinensis*)			*Cicatricosisporites, Trilobosporites* Diversity of *Gleicheniidites* (↑*G. minor, G. delcourti*) *Ornamentifera*; diversity of *Gleicheniidites*	*Cicatricosisportes; Trilobosporites; Aequitriradite spinulosus* *Selaginella granata, S. utriculosa; Gleicheniidites senonicus*			*Cicatricosisporites australiensis, C. augustus, C. hughesi* *Foraminisporis dailyi*	*Cicatricosisporites australiensis; Nevesisporites undatus; Aequitriradites hispidus* *Foraminisporis dailyi*	*Cicatricosisporites australiensis, C. ludbrookiaea*	*Pilosisporites trichopapillosus*	*Cicatricosisporites*

Fig. 4　Interregional correlation of some stratigraphically important spore-pollen events for the Neocomian of Siberia and other regions

North America by Dorhofer, 1979; Burden & Hills, 1989, and others; West Europe by Dorhofer, 1979; Batten, 1996; Herngreen et al., 2000, and others; Caucasus by Yaroshenko, 1970, and others; Ukraine by Voronova, 1971, and others; Russian Platform and Siberia by author's material; Far East by Markevich, 1995, and others; N China by Wan Chuan-biao et al., 2002; Wu Bing-wei & Lei An-gui, 2007, and others; India by Vijaya & Bhattacharji, 2002; Tripathi, 2008, and others; Australia by Helby et al., 1987; Burger, 1996; Sajjadi & Playford, 2002; Antarctica by Mohr, 1990; Duane, 1996; South America by Quattrocchio et al., 2003, 2006, and others; Africa by Kaska,1989; Schrank & Mahmoud, 1998; Schrank, 2010, and others

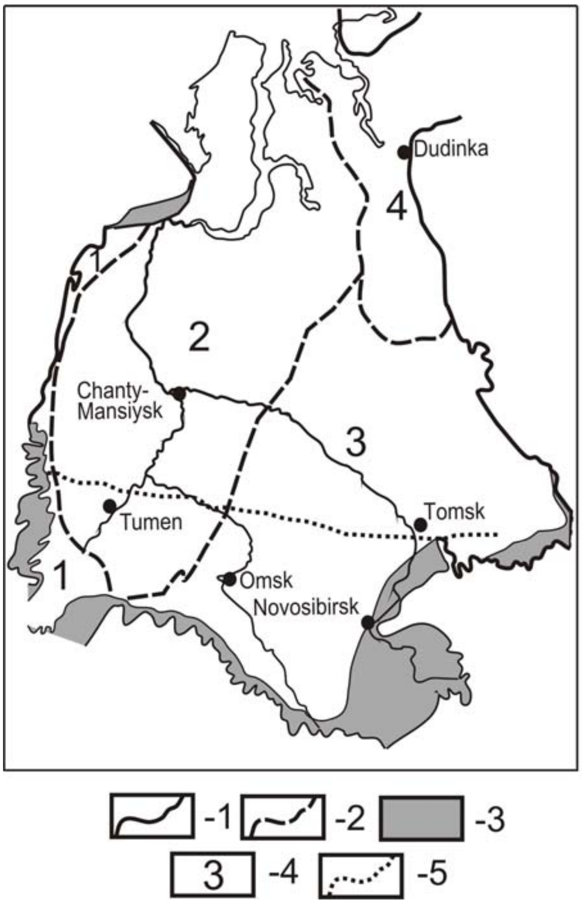

Fig. 5 Regions of the distribution of Aptian−Cenomanian palynological assemblages

1. the boundary of West Siberia; 2. the boundary of the regions; 3. areas, where Aptian-Cenomanian deposits are absent; 4. the regions: 1-West region, 2-Central region, 3-South-East region, 4-North-East region; 5-the boundary of paleofloristic provinces

Webster, *Foveosporites cenomanicus* (Chlonova) Schvetzova, *Rouseisporites reticulatus* Pocock, *R. laevigatus* Pocock, *Foraminisporis asymmetricus* (Cookson & Dettmann) Dettmann, *Camarozonosporites insignis* Norris, and *Ruminatisporites.* The latter having a wide lateral distribution is regarded as a key Cenomanian taxon (Strepetilova, 1979a, 1979b). The zone of *Ruminatisporites delicatus* is defined in the Yenisey mouth region (the Lower Agapa River) in marine deposits dated by *Inoceramus pictus* in its upper part, and so corresponds to the Upper Cenomanian (Ilyina et al., 1994). It is characterized by a high diversity of mosses and ferns. The key taxa are *Ruminatisporites delicates* Strepetilova, *Foraminisporis asymmetricus* (Cookson & Dettmann) Dettmann, *Baculatisporites comaumensis* (Cookson) Potonie, *Lobatia involucrata* (Chlonova) Chlonova, *Lycopodiumsporites marginatus* Singh, *L. cerniidites* (Ross) Delcourt & Sprumont, *Foveosporites cenomanicus* (Chlonova) Schvetzova, and *Klukisporites* sp. Angiosperms are represented by *Tricolpites* spp., *Retitricolpites* spp., and by *Polyporites clarus* N. Mtchedlishvili in the uppermost part of the zone.

4 Upper Cretaceous

The Late Cenomanian–Early Turonian transgression caused the formation of a wide epicontinental paleobasin occurring in West Siberia up to the end of the Late Cretaceous. The differentiation of Late Cretaceous palynofloras, demonstrated by the percentage relations of certain palynological taxa of ferns and gymnosperm as well as by different composition of angiosperms, was rather pronounced, as West Siberria was influenced by two paleofloristic provinces: the Siberian-Canadian (Aquilapollenites) and the Indo-European (Normapolles) (Herngreen & Chlonova, 1981) (Fig. 7). Their boundary extended in meridional direction and had a large ecotone zone, that is related to the intensity and direction of transportation of terrigenous material carried away from the coastal areas occupied by floras of different types.

Turonian spore-pollen assemblages from the deposits dated by inoceramids and foraminifers are studied in different regions of West Siberia (Strepetilova, 1979a, 1979b, 1989; Chlonova, 1974, and others), the Yenisey mouth region (Bondarenko, 1958, 1967; Ilyina et al., 1994), and the Khatanga depression in North Siberia (Bondarenko, 1958, 1967; Samoylovitch, 1980). The characteristic features of Turonian spore-pollen assemblages are the extinction of *Ruminatisporites* and reduced quantity of other Cenomanian taxa. Important spore species are *Osmunda granulata* (Malajvkina) Chlonova, *Taurocusporites reduncus* (Bolchovitina) Stover, *Stenozonotriletes radiatus* Chlonova, consistent *Gleicheniidites* sp., *Aequitriradites verrucosus* (Cookson & Dettmann) Cookson & Dettmann, *A. spinulosus* (Cookson & Dettmann) Cookson & Dettmann, *Rouseisporites reticulatus* Pocock, *Cicatricosisporites* sp., and *Appendicisporites* sp. The abundance and diversity of angiosperms are increased. The first occurrences of *Wodehouseia jacutensis* (Samoilovitch) Samoilovitch and *Kuprianipollis* spp. are defined in the Upper Turonian. The pollen of the stemma Normapolles appeared in southern regions.

Series	Stage	Substage	Boreal Standart	Local zones	Spore-pollen assemblages			
					West region 1	Central region 2	South-East region 3	North-East region 4
Upper Cretaceous	Cenomanian	Upper Middle Lower	Upper: Inoceramus pictus Middle: Turrilites costatus Lower: Shloenbachia varians; Mantelliceras mantelli	Borissiakoceras orbiculatum; Inoceramus pictus	SPA VII/I/. **Dominant:** Gleicheniidites spp. **Subdominant:** Cedripites /C. pachyderma, C. parvisaccatus, C. media, C. laxireticulata, C. radiostriata /, Podocarpidites, Pinaceae, Taxodiaceae. **Common:** Stereisporites spp., Anemia spp., Cicatricosisporites spp., Lygodiumsporites spp., Laevigatosporites ovatus, Foveosporites cenomanicus, Tricolpopollenites spp., Tricolporopollenites spp. **Rare:** Ruminatisporites sp.,Tricolpites spp.	SPA VII/2/. **Dominant:** Taxodiaceae. **Subdominant:** Stereisporites spp., Cicatricosisporites spp., Gleicheniidites spp., Pinaceae. **Common:** Lygodiumsporites spp., L. trioreticuosus, Ruminatisporites delicatus, R. latirugatus, Foveosporites cenomanicus, Anemia insignis, A. trichacantha diseota, Dacrydiumites sp., Cedripites sp., Tricolpopollenltes spp., Tricolpites spp.	SPA VII/3/. **Dominant:** Pinaceae. **Subdominant:** Gleicheniidites spp., Taxodiaceae, Cedrus spp., Tricolporopollenites sp. **Common:** Stereisporites spp., Foveosporites cenomanicus, Cicatricosisporites, Coptospora paradoxa, Balmeisporites glanelgensis, Ruminatisporltes sp., Triporoletes singularis, Lobatia involucrata, Ephedripites costatus, Retitricolpites sp., Polyporites clarus.	PA VII/4/. **Subdominant:** Taxodiaceae, Stereisporites spp., Gleicheniidites spp., Taurocusporites reduncus. Dacrydiumites sp., Pinaceae, Cedripites spp. **Common:** Foveosporites cenomanicus, Anemia macrorhyza, Lygodiumsporites cavernosum, Tricolpopollonites spp. **Rare:** Polyporites clarus, Ruminatisporites delicatus.
Lower Cretaceous	Albian	Upper Middle Lower	Upper: Neogastroplites americanus; N. cornutum; N. muelleri; N. selwyni; Paragastroplites liardense; Gastroplites canadensis Middle: Gastroplites subquadratus; Grycia sablei Lower: Anadesmoceras strangulatum; Arcthoplites (S.) belli; Arcthoplites (A.) jachromensis; Freboldiceras singulare	Inoceramus anglicus; Pseudopulchellia sp. ind.; Arcthoplites sp. ind., "Cleoniceras" cf. bicurvatoides	SPA VI/I/ **Dominant:** Taxodiaceae. **Subdominant:** Gleicheniaceae, Stereisporites spp., Pinaceae /Pinuspollenites spp., Piceapollenites spp., Cedripites spp./, Schizaeaceae / Anemia spp., Cicatricosisporites spp., Lygodiumsporites spp./. **Common:** Leiotriletes spp., Laevigatosporites ovatus, Ginkgoaceae, Osmundacidites spp., Angiospermae. **Rare:** Lycopodiumsporites spp., Selaginella spp.	SPA VI/2/. **Dominant:** Pinaceae, Taxodiaceae, Leiotriletes spp. **Subdominant:** Gleicheniaceae /Clavifera triplex, Ornamentifera echinata, O. tuberculata /, Stereisporites spp., Schizaeaceae /Anemia spp., A. dorsostriata, A. trichacantha, Lygodiumsporites spp., L. cavernosum, L. bellum, L. trioreticuosum. **Common:** Laevigatosporites ovatus, Rouseisporites spp., Taxodiaceae, Ginkgoaceae. **Rare:** Angiospermae, Selaginella aculeata, S. rara, S. klemensis, Foveosporites cenomanicus, Lophotriletes amabilis, Chomotriletes fibriatus, Cooksonites sp.	SPA VI/3/. **Dominant:** Taxodiaceae. Schizaeaceae /Anemia spp., Cicatricosisporites spp., Lygodiumsporites spp. **Subdominant:** Leiotriletes spp., Pinaceae /Pinuspollenites spp., Piceapollenites spp./, Gleicheniaceae. **Common:** Laevigatosporites ovatus, Stereisporites spp., Selaginella spp., Ginkgoaceae. **Rare:** Lycopodiaceae, Angiospermae.	SPA VI/4/. **Dominant:** Gleicheniaceae, Pinaceae. **Subdominant:** Stereisporites spp., Foveosporites cenomanicus, Pelletierla spp., Laevigatosporites ovatus, Leiotriletes spp., Taxodiaceae. **Common:** Angiospermae.
	Aptian	Upper Middle	Upper: Leconteites deansi; ? Middle: Tropaeum arcticum; Aconeceras nisum	?Pseudosaynella sp. ind.	SPA V/I/. **Dominant:** Gleicheniaceae. **Subdominant:** Stereisporites spp., Pinaceae. **Common:** Taxodiaceae, Osmundacidites spp., Rouseisporites spp., Ginkgoaceae, Classopollis spp., Laevigatosporites ovatus. **Rare:** Lycopodiumsporites spp., Angiospermae.	SPA V/2/. **Dominant:** Gleicheniaceae, Pinaceae, Leiotriletes spp. **Subdominate:** Stereisporites spp., Schizaeaceae, Taxodiaceae. **Common:** Osmundacidites spp., Rouseisporites spp., Laevigatosporites ovatus, Foveosporites cenomanicus, Ginkgoaceae. **Rare:** Angiospermae, Classopollis spp.	SPA V/3/. **Dominant:** Schizaeaceae /Anemia spp., Cicatricosisporites spp., Lygodiumsporites spp./. **Subdominant:** Gleicheniaceae, Leiotriletes spp., Pinaceae. **Common:** Taxodiaceae, Osmundacidites spp., Ginkgoaceae, Classopollis , Stereisporites spp. **Rare:** Lycopodiumsporites spp., Rouseisporites spp., Laevigatosporites ovatus, Angiospermae.	SPA V/4/. **Dominant:** Pinaceae /Pinuspollenites spp., Piceapollenites spp./. **Subdominant:** Gleicheniaceae, Leiotriletes spp. **Common:** Stereisporites spp., Laevigatosporites ovatus, Ginkgoaceae, Schizaeaceae /Anemia spp., Lygodiumsporites spp./. **Rare:** Lycopodiumsporites spp., Selaginella spp., Osmundacidites spp., Cedripites spp.

Fig. 6　Calibration of Aptian-Cenomanian spore-pollen assemblages against Boreal standard and local zones

(Regional stratigraphic schemes of Mesozoic deposits of West-Siberian plain, 1991)

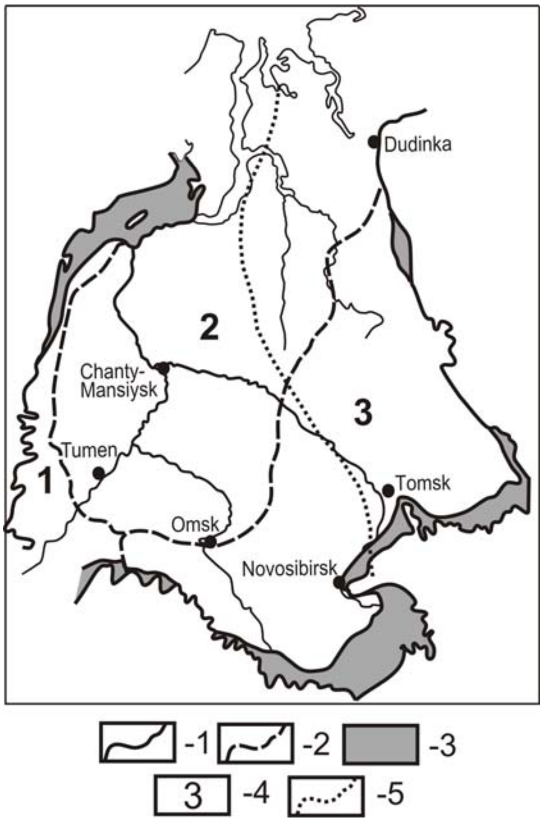

Fig. 7 Regions of the distribution of Upper Cretaceouspalynological assemblages

1. the boundary of West Siberia; 2. the boundary of the regions; 3. areas, where Upper Cretaceous deposits are absent; 4. the regions: 1-West region, 2-Central region, 3-South-East region; 5-the boundary of paleofloristic provinces

Coniacian spore-pollen assemblages are characterized by considerable changes in their taxonomic composition (Fig. 8). The diversity of ferns and mosses decreases, the dominant taxa are *Gleicheniidites* spp., *Camarozonosporites insignis* Norris, *Osmundacidites wellmanii* Couper, *Adiantum mirum* Chlonova, Polypodiaceae, and *Cyathidites minor* Couper. Angiosperms become more diverse, including first *Ocellipollis munitus* Chlonova, *Orbiculapollis lucidus* Chlonova, *Fibulapollis* sp., *Aquilapollenites* sp., and several new genera of the stemma *Normapolles* in southern regions. The further decrease of spore abundance and growth of angiosperm percentages are observed in the Santonian and Campanian. Angiosperm pollen of the *Aquilapollenite* paleofloristic province is represented by *Aquilapollenites*, *Mancicorpus*, *Wodehouseia*, *Kuprianipollis*, and *Azonia*. The characteristic features are the occurrences of *Tricerapollis minimus* Chlonova and *Chlonovaia sibirica* (Chlonova) Elsik. The latter is regarded as a key Santonian−Campanian species for central and southeastern regions in West Siberia (Chlonova, 1974). *Trudopollis*, *Oculopollis*, *Vacuopollis* and others are typical for spore-pollen assemblages in southwestern and southwestern regions.

The regression of the West Siberian palaeobasin began in the Maastrichtian. The deposits are represented by marine and continental facies with rich spore-pollen assemblages well studied and dated by foraminifers in most of the regions. It allows the correlation of widespread continental deposits in the eastern regions of West Siberia against near-shore and marine deposits of the central regions. There are no changes in the taxonomic composition of spore assemblages, but angiosperms provide several marker characters (Chlonova, 1974): the increased abundance and diversity of *Aquilapollenites*, *Mancicorpus*, *Integricorpus*, *Wodehouseia* and *Orbiculapollis*; the reduced percentage of *Kuprianipollis*; no occurrences of *Kuprianipollis*; no occurrences of *Chlonovaia sibirica* (Chlonova) Elsik and *Tricerapollis minimus* Chlonova; the inception of *Expressipollis*.

5 Conclusion

Palynological studies of Cretaceous deposits in West Siberia allow the definition of reference succession of spore-pollen assemblages. Materials from marine sections provide their calibration against the ammonite scale and definition of spore-pollen zones at some levels in the Lower and Upper Cretaceous. A defined succession of spore-pollen assemblages reflects the evolutionary stages of Cretaceous palynofloras. The main levels of considerable taxonomic changes are identified: 1) near the Volgian-Berriasian boundary, characterized by first occurrences of *Aequitriradites* and striate and granular spores of Schizaeaceae; 2) in the middle of the Berriasian defined by increased diversity of Schizaeaceae and appearance of Taxodiaceae; 3) in the Lower Valanginian characterized by the appearance of Valanginian species of schizaeaceous ferns and some liverworts as well as consistent occurrences of Taxodiaceae; 4) near the base of the Upper Hauterivian determined by in-creased diversity and abundance of Schizaeaceae and the inceptions of new taxa; 5) in the Lower Barremian, defined by increased diversity and abundance of *Pilosisporites* and *Rouseisporites* as well as high percentage of Taxodiaceae; 6) in the Lower Aptian, determined by

Series	Stage	Substage	Boreal Standart	Local zones	Dinocyst assemblages (Lebedeva, 2006)	Spore-pollen assemblages: West region	Spore-pollen assemblages: Central region	Spore-pollen assemblages: South-East region
Upper Cretaceous	Maastrichtian	Upper	Neobelemnella kazimiroviensis	?	Cerodinium speciosum, Areoligera coronata, Palynodinium spp.; Cerodinium diebelii, Achomosphaera spp., Palaeocystodinium spp., Areoligera spp.	SPA XI/1/. Subdominant: Pinaceae, Taxodiaceae, Trudopollis spp., Extratriporopolienites medianus. Common: Gleicheniidites spp., Anacolosidites spp., Aquilapollenites spp., A.quadrilobus, Simplocacites sp.	SPA XI/2/. Dominant:Aquilapollenites spp., Mancicorpus spp., Integricorpus compositus. Subdominant: Stereisporites spp., Laevigatosporites ovatus, Gleicheniaceae. Common: Taxodiaceae, Wodehousea spp., Proteacidites spp., Expressipollis spp.	SPA XI/3/. Dominant: Aquilapollenites spp., Mancicorpus sp. Subdominant: Orbiculapollis globosus, Pinaceae, Taxodiaceae. Common: Proteacidites spp., Symplocaceae, Rhamnaceae, Onagraceae, Kuprianipollis sp., Expressopollis borealis. On south part W Siberia: Subdominate: Myricaceae, Tricolpites spp., Ulmoideipites sp.
		Lower	Acanthoscaphites tridens: Belemnella sumensis; Belemnella lanceolata; Belemnella licharewi	Belemnella lanceolata	Cerodinium diebelii, Fibrocysta axialis, Operculodinium centrocarpum, Chatangiella ditissima, Fromea chytra			
	Cpmpanian	Upper	Belemnitella langei; Belemnitella mucronata	?	Chatangiella niiga, C. manumii, C. spinata, Dinogymnium spp., Laciniadinium arcticum, L. williamsii, L. rhombiforme, Fibrocysta sp.,	SPA X/1/. Subdominant: Gleicheniidites spp., Cedrus spp., Taxodiaceae, Trudopollites spp., Oculopollis fossulotrudens, Vacuopollis concavus. Common: Polypodiisporites flexus, Laevigatosporites ovatus, Kuprianipollis sp. Rare: Extratriporopollenites medianua, Bassaopollis, Anacolosidites sp.	SPA X/2/. Subdominant: Laevigatosporites ovatus, Pinaceae, Taxodiaceae, Myricaceae, Aquilapollenites spp., A. magnus, A. reticulatus, A.despositus Mancicorpus spp., Common: Gnetaceaepollenites, Proteacidites spp., Sentalimidites cainozoicus, Orbiculapollis globosus, Normapolles.	SPA X/3/. Subdominant: Pinaceae, Taxodiaceae, Myricaceae. Tricolpites sp., Aquilapollenites spp. Common: Stereisporites spp., Laevigatosporites ovatus, Kuprianipollis sp. Rare: Proteacidites sp., Parviprojectus sp., Normapolles, Orbiculapollis globosus.
		Lower	Gonioteuthis quadrata gracilis; Gonioteuthis quadrata guadrata	Scaphites hippocrepis-Baculites obtusus; Sphenoceramus patootensiformis	Chatangiella verrucosa, Isabelidinium spp. (I. cooksoniae, I. microarmum, I. belfastense, I. bakerii), Chatangiella vnigrii, C.microcantha, C. manumii, Laciniadinium arcticum			
	Santonian	Upper	Actinocamax laevigatus; Gonioteuthis granulata	Sphenoceramus patootensis	Spinidinium echinoideum, Alterbidinium, A. "daveyi", A.acutulum, Chatangiella madura, Microdinium ornatum	SPA IX/1/. Subdominant: Gleicheniidites spp.,Pinuspollenites aralica, Cedripites parvisaccatus, Taxodiaceae, Vacuopollis pyramis, V. concavus., Trudopollis spp., Triporopollenites plicoides Common: Kuprianipollis sp., Oculopollis praedicatus, Vacuopolites triangulatus	SPA IX/2/. Dominant: Pinaceae, Taxodiaceae. Subdominant: Gnetaceaepollenites sp., Myricaceae, Kuprianipollis spp. Common: Laevigatosporites ovatus, Triceraopollis minimus, Chlonovia sibirica, Trudopollis spp., Vacuopollis spp., Azonia fabacea, Wodehousea sp. Aquilapollenites spp., Plicapollis certa.	SPA IX/3/. Dominant: Pinaceae, Taxodiaceae. Subdominant: Gleicheniidites spp., Kuprianipollis sp., Myricaceae, Tricolpites sp., Aquilapollenites sp. Common: Laevigatosporites ovatus, Anemia sp., Lygodiumsporites sp., Triceraopollis minimus, Mancicorpus spp., Borealipollis bratzevae, Chlonovia sibirica, Orbiculapollis globosus
		Lower	Sphenoceramus cardissoides	Sphenoceramus cardissoides	Dominant: Chatangiella chetiensis, C. tanamaensis, C. cassidea, Trithyrodinium suspectum, Spinidinium uncinatum, Isabelidinium rectangulatum			
	Coniacian	Upper	Volviceramus involutus	Inoceramus (Heanleinia) russiensis	Canningia macroreticulata, Alterbidinium minus, Senoniasphaera protrusa, Subtilisphaera pirnaensis.			
		Middle						
		Lower	Inoceramus schloenbachi	Inoceramus (I.) schulginae jangodaensis; Volviceramus subinvolutus	Dominant: Spinidinium: S. sverdrupianum., S. balmei, S. ornatum	PA VIII/1/. Dominate: Gleicheniidites spp. Subdominate: Laevigatosporites ovatus, Cedripites spp., Pinaceae, Taxodiaceae, Tricolpopollenites sp. Common: Lycopodiumsporites cerniidites, Cicatricosisporites spp., Rouseisporites reticulatus. Rare: Kuprianipollis sp., Normapolles.		
	Turonian	Upper	Inoceramus costellatus	Inoceramus lamarcki (s.l.): Voliceramus inaequivalvis	Chatangiella bondarenkoi, C.serratula, Pierceites.; Chatangiella spectabilis,		PA VIII/2/. Subdominate: Stereisporites spp., Gleicheniidites spp., Pinaceae, Taxodiaceae, Tricolpites sp. Common: Schizaeaceae, Taurocusporites reduncus, Stenozonotriletes radiatus, S. exuperans, Osmunda granulata, Menispermum turonicum. Rare: Selaginella diuturna, S. kemensis.	PA VIII/3/. Dominate: Pinaceae. Subdominate: Taxodiaceae, Cedripites spp., Tricolpopollenites sp. Common: Taurocusporites reduncus, Stenozonotriletes radiatus, Anemia phyllitidiformis, A. insignis, Lygodiumsporites cretaceum, Tricolpites sp., Menispermum turonicum, Kuprianipollis sp.
		Middle	Inoceramus lamarcki	Inoceramus lamarcki (s.l.): Inoceramus (I.) cuvieri	Chatangiella victoriensis; Dominant: Chlamydophorella nyei, Chlonoviella agapica, Microdinium? glabrum, Maghrebinia membraniphora,			
		Lower	Mytiloides labiatus	Inoceramus (Mytiloides) labiatus	Eurydinium saxoniense, Isabelidinium magna, Ginginodinium evittii			

Fig. 8　Calibration of Upper Cretaceous spore-pollen assemblages against Boreal standard and local zones

(Regional stratigraphic schemes of Mesozoic deposits of West-Siberian plane, 1991) the first occurrences of angiosperms; 7) near the Cenomanian-Turonian boundary, characterized by considerable changes in the composition of some mosses and ferns; 8) near the Turonian-Coniacian boundary defined by the inceptions of new angiosperm species; 9) near the Coniacian-Santonian boundary, characterized by a considerably increased percentage of angiosperms, inceptions of new species and a reduced diversity of spores of mosses and ferns; 10) near the Santonian-Maastrichtian boundary, characterized by a further increase of angiosperm diversity and inceptions of several new genera. Considerable lateral variations of spore-pollen assemblages related to facies and paleogeographic features preclude accurate interregional correlations on spore-pollen data, but some general tendencies in the evolution of the palynoflora can be defined for some stratigraphic levels.

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Explanation of plates

Plate Ⅰ

Fig.1. *Cicatricosisporites ludbrookiae* Dettmann
Nordvik section, North Siberia, Upper Berriasian, spore-pollen Zone SPA1, ×500

Fig.2. *Aequitriradites spinulosus* (Cookson & Dettmann) Cookson & Dettmann
Nordvik section, North Siberia, Upper Berriasian, spore-pollen Zone SPA1, ×500

Fig.3. *Foraminisporis wonthaggiensis* (Cookson & Dettmann) Dettmann
Severo-Vologachanskaya well, Yenisey mouth region, Lower Valanginian, spore-pollen Zone SPA2, ×500

Fig.4. *Rouseisporites radiatus* Dettmann
Medvezhya well, West Siberia, Lower Valanginian, spore-pollen Zone SPA3, ×500

Fig.5. *Cicatricosisporites australiensis* (Cookson) Potonie
Medvezhya well, West Siberia, Lower Valanginian, spore-pollen Zone SPA3, ×500

Fig.6. *Gnetaceaepollenites* sp.
Medvezhya well, West Siberia, Lower Valanginian, spore-pollen Zone SPA3, ×500

Fig.7. *Pilosisporites parvispinosus* Dettmann
Severo-Vologachanskaya well, Yenisey mouth region, Lower Valanginian, spore-pollen Zone SPA2, ×400

Fig.8. *Cicatricosisporites dorogensis* Potonie & Gelletich
Nordvik section, North Siberia, Lower Valanginian, spore-pollen Zone SPA3, ×400

Fig.9. *Lygodium granulatum* E. Ivanova
Nordvik section, North Siberia, Upper Berriasian, spore-pollen Zone SPA1, ×400

Fig.10. *Cicatricosisporites minutaestriatus* (Bolchovitina) Pocock
Medvezhya well, West Siberia, Lower Valanginian, spore-pollen Zone SPA3, ×500

Fig.11. *Aequitriradites verrucosus* (Cookson & Dettmann) Cookson & Dettmann
Severo-Vologachanskaya well, Yenisey mouth region, Lower Hauterivian, spore-pollen Zone SPA5, ×400

Fig.12. *Concavissimisporites verrucosus* Delcourt & Sprumont
Nordvik section, North Siberia, Lower Valanginian, spore-pollen Zone SPA3, ×400

Fig.13. *Concavissimisporites multituberculatus* (Bolchovitina) Döring
Nordvik section, North Siberia, Lower Valanginian, spore-pollen Zone SPA4, ×400

Fig.14. *Trilobosporites mirabilis* (Bolchovitina) Bondarenko
Yurkharovskaya well, West Siberia, Lower Valanginian, spore-pollen Zone SPA4, ×600

Fig.15. *Lygodium cotidianum* (Bolchovitina) Bolchovitina
Anabar section, North Siberia, Lower Valanginian, spore-pollen Zone SPA4, ×400

Fig.16. *Impardecispora gibberula* (Kara-Mursa) Venkatachala
Nordvik section, North Siberia, Upper Berriasian, spore-pollen Zone SPA1, ×500

Fig.17. *Trilobosporites valanjinensis* (Kara-Mursa) Döring
Severo-Vologachanskaya well, Yenisey mouth region, Lower Hauterivian, spore-pollen Zone SPA5, ×500

Fig.18. *Plicatella chetaensis* (Kara-Mursa) Bondarenko
Vostochno-Messoyakhskaya-73 well, Yenisey mouth region, Lower Valanginian, spore-pollen Zone SPA3, ×500

Fig.19. *Concavissimisporites macrotuberculatus* **(**Kara-Mursa) Bondarenko
Nordvik section, North Siberia, Lower Valanginian, spore-pollen Zone SPA3, ×400

Fig.20. *Concavissimisporites variverrucatus* (Couper) Brenner
Severo-Vologachanskaya well, Yenisey mouth region, Lower Hauterivian, spore-pollen Zone SPA5, ×500

Fig.21. *Gleicheniidites toriconcavus* Krutzsch
Gorodische section, Russian Platform, River Volga region, Lower Hauterivian, ammonite Zone Speetoniceras versicolor, ×800

Fig.22. *Klukisporites variegatus* Couper
Nordvik section, North Siberia, Lower Valanginian, spore-pollen Zone SPA3, ×500

Fig.23. *Trilobosporites uralensis* (Bolchovitina) Bondarenko
Yurkharovskaya well, West Siberia, Lower Valanginian, spore-pollen Zone SPA4, ×600

Fig.24. *Mohria multicostata* Verbitskaya
Vostochno-Messoyakhskaya-132 well, Yenisey mouth region, Lower Hauterivian, spore-pollen Zone SPA5, ×500

Fig.25. *Cicatricosisporites tricostatus* (Bolchovitina) Voronova
Nordvik section, North Siberia, Upper Berriasian, spore-pollen Zone SPA1, ×500

Fig.26. *Cicatricosisporites minor* (Bolchovitina) Pocock
Vostochno-Messoyakhskaya-127 well, Yenisey mouth region, Albian, ×500

Fig.27. *Laevigatosporites ovatus* Wilson & Webster
Vostochno-Messoyakhskaya-127 well, Yenisey mouth region, Albian, ×500

Fig.28. *Rouseisporites simplex* (Cookson &Dettmann) Dettmann
Vostochno-Messoyakhskaya-32 well, Yenisey mouth region, lower Valanginian, spore-pollen Zone SPA4, ×500

Fig.29. *Cicatricosisporites pseudoauriferus* (Bolchovitina) Voronova
Medvezhya well, West Siberia, Lower Valanginian, spore-pollen Zone SPA3, ×500

Fig.30. *Taxodiacaeapollenites* sp.
Vostochno-Messoyakhskaya-132 well, Yenisey mouth region, Barremian, ×1000

Fig.31. *Cicatricosisporites sibiricus* (Kara-Mursa) Chlonova
Vostochno-Messoyakhskaya-73 well, Yenisey mouth region, Lower Valanginian, spore-pollen Zone SPA3, ×500

Plate Ⅱ

(Palynomorphs are from Upper Cretaceous deposits of South-East region of West Siberia)

Fig.1. *Gleicheniidites carinatus* (Bolhovitina) Bolchovitina. Albian, ×550

Fig.2. *Gleicheniidites umbonatus* (Bolchovitina) Bolchovitina. Albian, ×550

Fig.3. *Gleicheniidites senonicus* Ross. Albian, ×550

Fig.4. *Plicifera delicata* (Bolchovitina) Bolchovitina. Albian, ×550

Fig.5. *Ornamentifera echinata* (Bolchovitina) Bolchovitina. Albian, ×550

Fig.6. *Ornamentifera granulata* (Bolchovitina) Bolchovitina. Albian, ×550

Fig.7. *Cyathidites minor* Couper. Albian. ×550

Fig.8. Polypodiaceae. Maastrichtian, ×550

Fig.9. *Laevigatosporites ovatus* Wilson & Webster. Maastrichtian, ×550

Fig.10. *Trilobosporites purverulentus* (Vervitskaya) Bondarenko. Cenomanian, ×550

Fig.11. *Impardecispora apiverrucata* (Couper) Venkatachala, Kar & Raza. Cenomanian, ×550

Fig.12. *Trilobosporites trioreticulosus* Cookson & Dettmann. Cenomanian, ×550

Fig.13. *Concavissimisporites punctatus* (Delcourt & Sprumont) Brenner. Cenomanian, ×550

Fig.14. *Stenozonotriletes radiatus* Chlonova. Turonian, ×550

Fig.15. *Densoisporites microrugulatus* Brenner. Cenomanian, ×550

Fig.16. *Rouseisporites reticulatus* Pocock. Cenomanian, ×550

Fig.17. *Rouseisporites triangularis* Pocock. Cenomanian, ×550

Fig.18. *Taurocusporites redunctus* (Bolchovitina) Stover. Cenomanian, ×550

Fig.19. *Crybelosporites punctatus* Dettmann. Albian, ×550

Fig.20. *Ginkgocycadophytus* sp. Campanian, ×550

Fig.21. *Gnetaceapollenites* sp. Maastrichtian, ×550

Fig.22. *Orbiculapollis globosus* (Chlonova) Chlonova. Maastrichtian, ×900

Fig.23-24. *Fibulapollis mirificus* Chlonova. Maastrichtian; ×900

Fig.25. *Cranwellia striata* (Couper) Srivastava. Maastrichtian; ×900

Fig.26. *Tricolporopollenites* sp. Maastrichtian; ×900

Fig.27. *Proteacidites mollis* Samoilovitch. Maastrichtian; ×550

Fig.28. *Proteacidites tumidiporis* Samoilovitch. Maastrichtian; ×550

Fig.29. *Kurtzipites* sp. Maastrichtian; ×900

Fig.30, 31. *Triorites harrisii* Couper. Maastrichtian; 30-×900, 31-×550

Fig.32. *Tricolporopollenites* sp. Campanian, ×550

Fig.33. *Beaupreaidites elegansiformis* Cookson. Maastrichtian; ×900

Fig.34. *Fraxinoipollenites* sp. . Cenomanian, ×900

Fig.35. *Nyssapollenites* sp. Santonian, ×900

Fig.36. *Tricolpites* sp. Campanian, ×900

Fig.37. *Pseudovacuopollis* sp. Campanian, ×550

Fig.38. *Kuprianipollis* sp. Santonian, ×550

Fig.39. *Menispermum turonicum* N. Mtchedlishvili. Turonian, ×550

Fig.40. *Cupaniedites* sp. Santonian, ×550

Fig.41. *Trudopollis protrudens* Pflug. Maastrichtian; ×550

Fig.42. *Trudopollis* sp. Maastrichtian; ×550

Fig.43. *Ocullopollis* sp. Maastrichtian; ×550

Fig.44. *Mancicorpus senonicum* N. Mtchedlishvili. Maastrichtian; ×900

Fig.45. *Aquilapollenites dispositus* (N. Mtchedlishvili) Srivastava & Rouse. Maastrichtian; ×550

Fig.46. *Aquilapollenites unicus* Chlonova. Maastrichtian; ×550

Fig.47. *Aquilapollenites quadrilobus* Rouse. Maastrichtian; ×550

Fig.48. *Mancicorpus anchoriforme* N. Mtchedlishvili. Maastrichtian; ×550

Fig.49. *Rhoipites* sp. Maastrichtian; ×900

Plate I

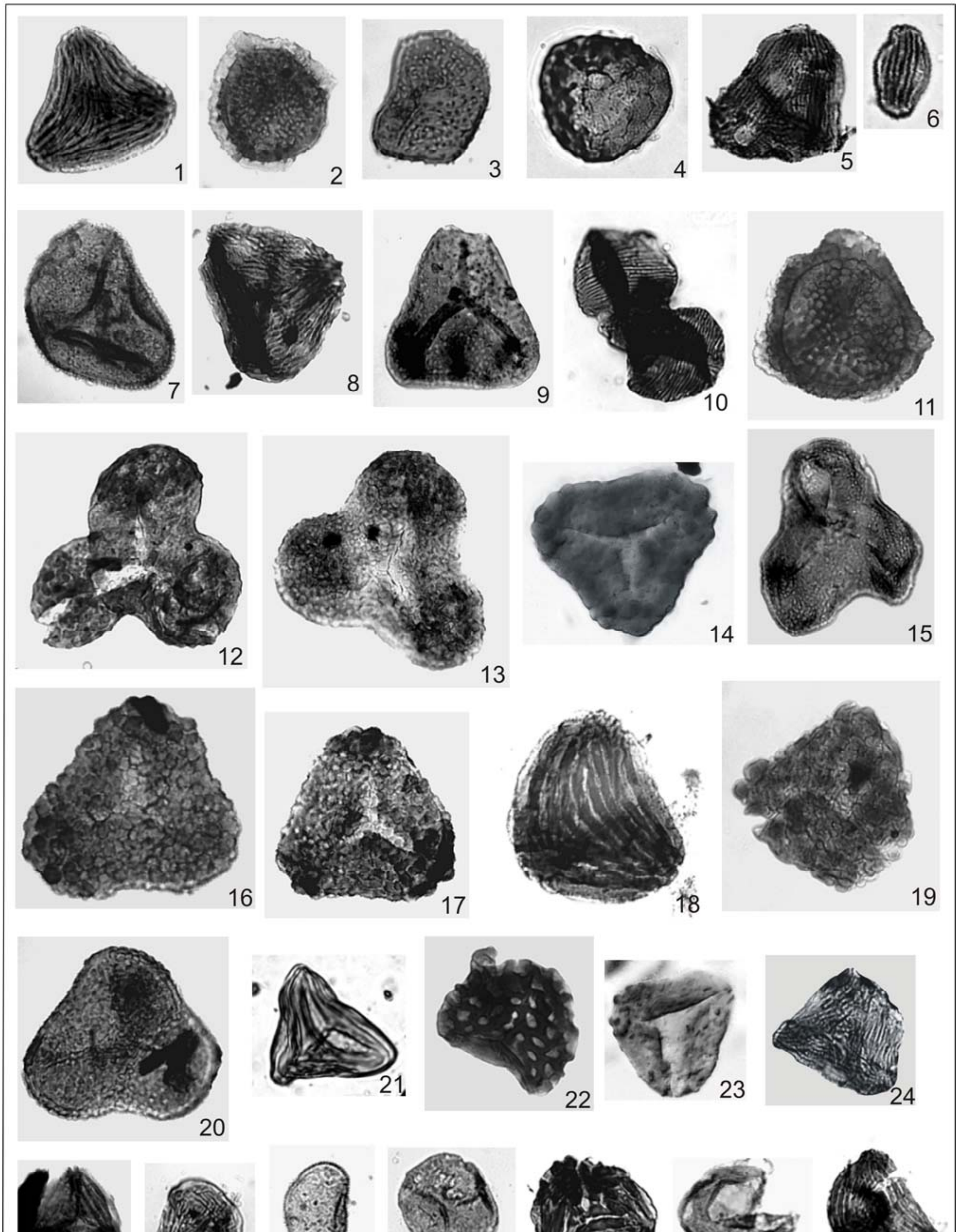
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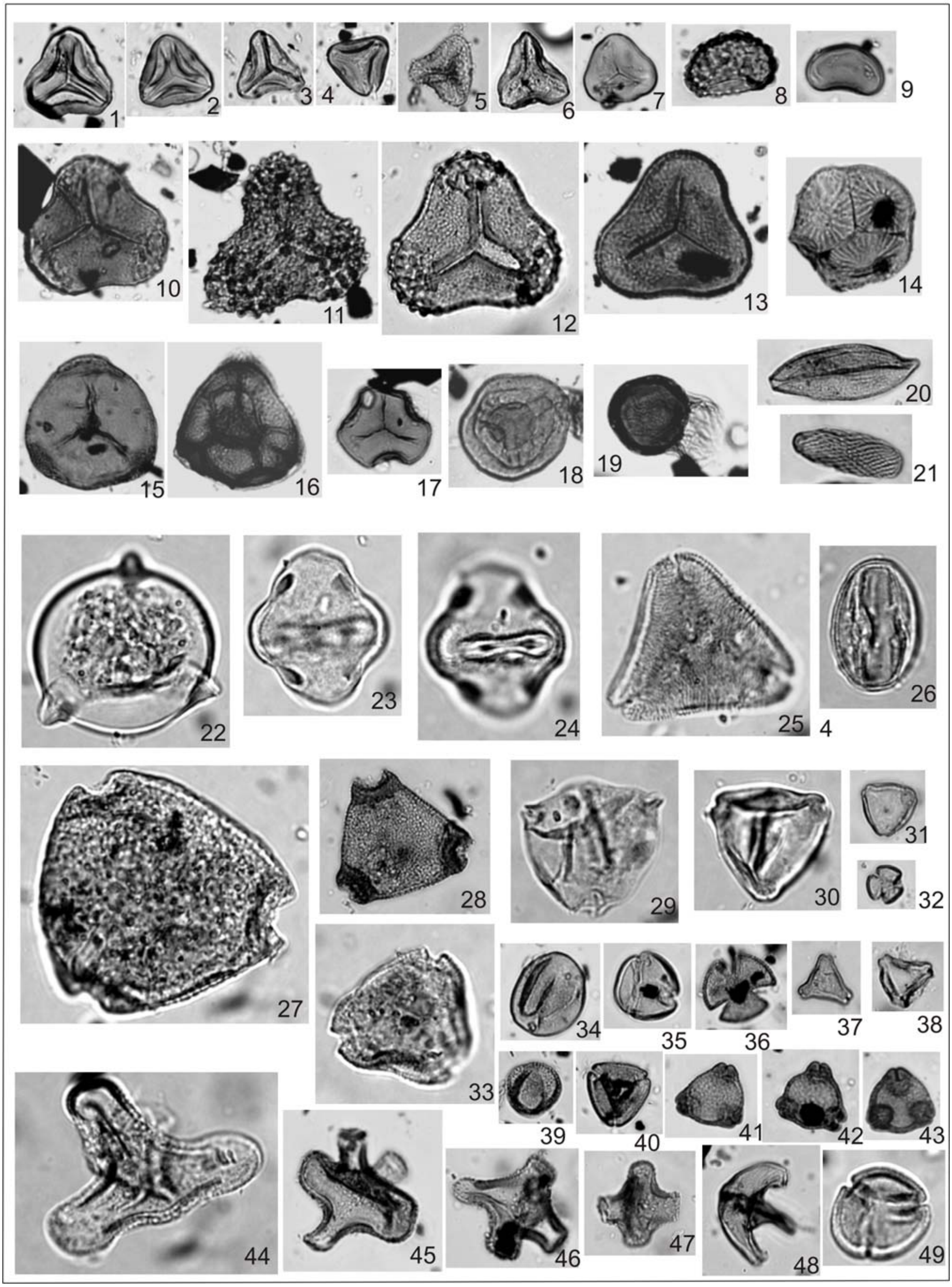
Plate II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