Stratigraphy and Geological Correlation, Vol. 10, No. 2, 2002, pp. 163–175. Translated from Stratigrafiya. Geologicheskaya Korrelyatsiya, Vol. 10, No. 2, 2002, pp. 67–79.

Late Albian Flora from the Vicinity of the Prokhladnoe Village (the Crimea)

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Received February 28, 2000

Abstract—Paleobotanical and palynological data on the same units seemingly lead to a controversial interpretation of the late Albian flora and vegetation. For instance, an upper part of the upper Albian *Hysteroceras orbignyi* Zone (the Prokhladnoe Village, the Crimea) reveals abundant impressions of Taxodiaceae shoots (genus *Geinitzia*) and ferns of the *Gleichenia* genus, which associate with rare representatives of Schizaeaceae and Dicksoniaceae. At the same time, bisaccate pollen of the Pinaceae, Podocarpaceae, and other families and that of the Schizaeaceae, Dicksoniaceae, Gleicheniaceae ferns dominate in the palynological spectrum of the same unit. So data, similar for ferns, are quite different for conifers: the prevalence of Taxodiaceae among imprints is not reflected in the palynological spectrum, where their pollen is found as single specimens. In turn, the dominance and diversity of bisaccate pollen in the palynological spectrum does not correspond to abundance of these plants imprints, as we found only two of them. The combination of data and the analyzed reasons of their inconsistency make it possible however to reconstruct reliably the late Albian vegetation. As is established, the seacoast in the studied area was covered with various ferns, among which Gleicheniaceae and Schizaeaceae representatives dominated. Abundant *Geinitzia* shoots found in the area suggest that the coastal band with ferns was not wide, and that coniferous microphyllous forests closely approached the sea. Palynological data indicate a proximity of hill slopes thickly populated by conifers producing the abundant bisaccate pollen. Taken together, these data imply that the relief was rugged and variable, and the climate was warm and humid.

Key words: Late Albian, the *Hysteroceras orbignyi* Zone, Crimea, fossil plants, palynological spectrum, palynological assemblage, flora, vegetation.

INTRODUCTION

The Albian was a specific period in the history of higher terrestrial plants because the angiosperms radiation started at that time. Unfortunately, there are only few corresponding floras reliably dated within the European part of the northern coast of the Tethys. More than a century ago, Albian floras were discovered in Portugal (Saporta, 1894), in the vicinity of Kanev, and in the Podolia region (Radkevich, 1895). The middle Albian flora has been recently found near Simferopol' in the Crimea (Stanislavskii and Kiselevich, 1986), while the late Albian flora was revealed near Kanev (Pimenova, 1939; Doludenko *et al.*, 1987, 1988, 1992), and near the Prokhladnoe Village in the Bakhchisarai region of the Crimea (Krasilov, 1984; Doludenko *et al.*, 1999). Krasilov found Cenomanian plant remains there as well. The late Albian floras from the Kanev and Prokhladnoe sites were investigated using modern techniques: the epidermal–cuticular analysis, observations under scanning microscope, and anatomic study of leaves and wood.

Since findings of late Albian plants are rare, we recollected samples from the Exposure A_4 studied by Krasilov (deposits of the *Hysteroceras orbignyi* Zone). Plant imprints are discovered in silty clays, and palynological spectrum is macerated from these rocks. This work is a result of the combined paleobotanical and palynological study aimed to get a deeper insight into the Albian flora and vegetation of the study region, since both methods supplement and verify each other.

Samples collected by Doludenko in 1988 are deposited at the Geological Institute RAS (Moscow), collection no. 4857. Plant impressions are pictured by A.I. Nazarov and M.G. Moiseeva who also prepared drawings of *Gleichenia zippei*.

DESCRIPTION OF THE SECTION

Near the Prokhladnoe Village, the upper Albian deposits fill in the deep Mangush depression. The synonymous sequence is represented by different terrigenous facies: from coarse unsorted conglomerates to fine silty clay. Because of a complicated structure, the Mangush sequence was studied time and again using geophysical, petrographic, paleontological methods, and purposeful drilling. Palynological assemblages and clay mineralogy were analyzed to reveal the formation

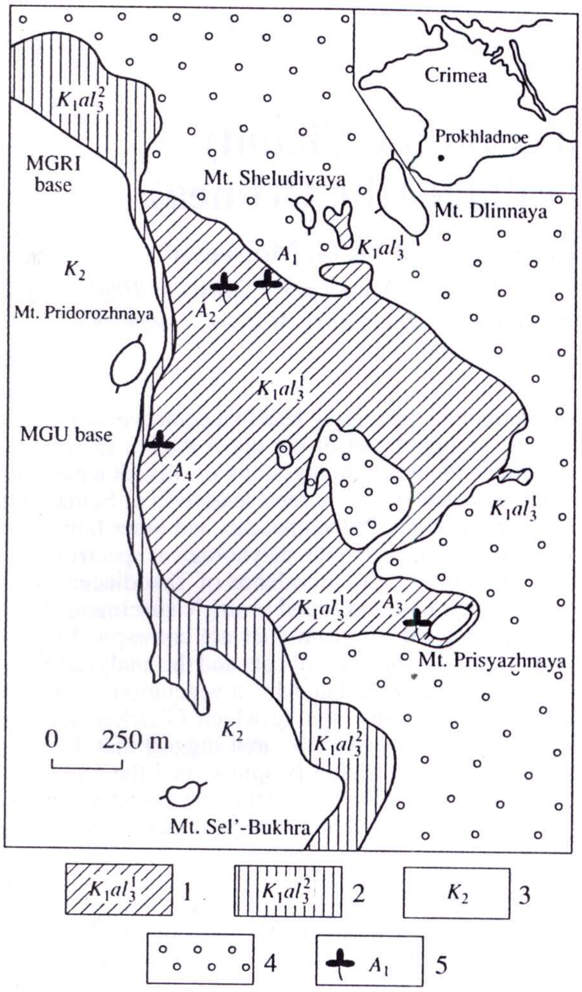


Fig. 1. Distribution map of upper Albian deposits near the Prokhladnoe Village, the Bakhchisarai region of the Crimea (after Yanin, 1976): (1) exposure area of clay, sandstone, and conglomerate of the *Hysteroceras orbignyi* Zone; (2) bedrock exposures of sandstone of the *Mortoniceras inflatum* Zone; (3) overlying Upper Cretaceous deposits; (4) pre-Albian deposits; (5) sampling sites A_1–A_4 of fossil plants, Krasilov (1984); Exposure A_4 is studied in this work.

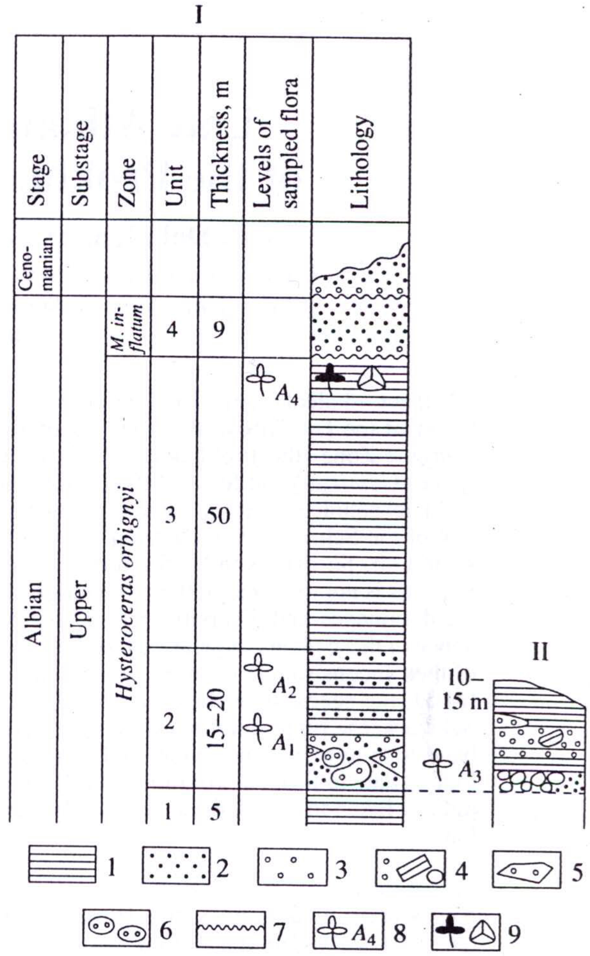


Fig. 2. Correlation scheme for flora-bearing sections of upper Albian deposits near the Prokhladnoe Village (after Yanin, 1964): (1) silty clay; (2) dense, well-cemented sandstone; (3) conglomerate; (4) boulder-and-lumpy conglomerate; (5) conglomerate lenses; (6) bun-shaped sandstone concretions with pebble; (7) erosion surface; (8) locality of flora found by Krasilov (1984); (9) sites of fossil plants and palynomorphs sampled by authors. Sections: (I) Mangushskii Creek– Mt. Pridorozhnaya, (II) Mt. Prisyazhnaya.

conditions of Mangush deposits (Yanin, 1964, 1976; Chernov and Yanin, 1975; Stafeev *et al.*, 1979, and others).

The Mangush depression is assumed to represent a floor of an ingression basin poorly connected with open-sea areas. Clastic material was transported to the depression from nearby and remote provenances. The sea ingression from southeast, from the Black Sea basin, was accompanied by transportation of size-variable rock fragments, a coarse material included. Fine material accumulated after the depression subsidence, when a stable channel for a sediment load was set up. The Mangush basin was of a flow-through type that is evident from euryhaline fauna that populated it.

A complete stratigraphic description of upper Albian flora-bearing deposits at the Prokhladnoe site was presented for the first time by Yanin (1964). He described them in a layer-by-layer manner and correlated the upper Albian deposits within the Kacha–Bodrak interfluve. A brief presentation of his data is given below.

In the Bakhchisarai region, upper Albian deposits are widespread from the Kacha River on the south to the Bodrak River on the north. They transgressively overlap underlying rocks, in places with the angular unconformity. In the vicinity of Prokhladnoe (Fig. 1), they overlie the Tavriya shale and underlie the basal small-pebbled conglomerate of Cenomanian glauconite sand and marl.

On the basis of lithology and faunal assemblages, upper Albian deposits are subdivided into the lower and upper parts corresponding to two upper Albian zones

Table 1. Composition of the late Albian flora from the Prokhladnoe Village region (Exposure A_4)

Species	Exposure A_4		Amount of specimens	Percentage		
	Krasilov, 1984	this work				
Lycopodites sp.	2		2	1.6	Lycopodiophyta	
Lycostrobus sp.	1		1			
Equisetum sp.	1		1	0.5	Equisetophyta	
Ruffordia goeppertii (Dunk.) Sew.	1	4	5	3.2	Schizaeaceae	Polypodiophyta
Anemia dicksoniana (Heer) Krassil.	1		1			
Osmunda sp.		5	5	2.7	Osmundaceae	
Sphenopteris sp.		2	2	1	Cyatheaceae	
Gleichenia zippei (Corda) Heer	22	28	50	27	Gleicheniaceae	
Sagenopteris variabilis (Vel.) Vel.	4		4	2	Caytoniales	
Pityophyllum sp.	2		2	1	Pinaceae	Pinophyta
Geinitzia cretacea Unger	86	16	102	57	Taxodiaceae	
G. reichenbachii (Geinitz) Sew.		4	4			
Rogersia angustifolia Font.	2		2	3.8	Angiospermae	
Sapindopsis variabilis Font.	3		3			
Aryskumia sp.	2		2			
Total	127	59	186			

(Fig. 2). The distribution of the *Hysteroceras orbignyi* Zone deposits is confined to the Prokhladnoe Village and adjacent areas (Mt. Prisyazhnaya, the road Prokhladnoe–Nauchnyi). The deposits fill in the Mangush deep erosion trough.

The zone section (Fig. 2, I) is divided into three units (Yanin, 1964, Fig. 2). Clays, 5–10 m thick, occur in the basal part (Fig. 2, Unit 1). They are overlain by Unit 2 of sandstone, conglomerate, and clay exposed on southern slopes of the Mts. Sheludivaya and Dlinnaya, in the Prokhladnoe Village, and in the vicinity of Mt. Prisyazhnaya. In the lower part of Unit 2, there is yellowish brown to variegated, polymictic, inequigranular, loose, cross-bedded, highly ferruginate sandstone that encloses ban-shaped concretions of dense sandstone and interlayers of coarse-pebbled conglomerate. In its middle and upper parts, the unit is composed of gray, yellowish-gray, brownish, and spotted, highly sandy clays with plant remains (Exposure A_1 after Krasilov, 1984). An interlayer of grayish-brown sandstone and small-pebbled conglomerate, which contain plant imprints (Exposure A_2 after Krasilov, 1984), occur at the top of clays. The total thickness of the unit near the Prokhladnoe Village is 15–20 m.

Coeval deposits at the southern flank of the trough (slopes and top of Mt. Prisyazhnaya and of the road loop area) are of a quite different structure. They correspond to a member of lumps and boulders, which encloses interlayers of small-pebbled conglomerates, highly ferruginate sandstone, and sandy clay with plant remains (Exposure A_3 after Krasilov, 1984, according to Yanin's opinion). The total thickness of Unit 2 near the Mt. Prisyazhnaya is up 10–15 m.

Higher in the section (Fig. 2, Unit 3), there are clays (50 m), the upper part of which is exposed only. The middle and upper parts of the unit are unexposed, concealed under gardens and buildings (Yanin, 1964). These gray, grayish brown, yellowish gray, or variegated clays are calcareous and silty. We collected abundant plant remains from the upper part of Unit 3 (Exposure A_4, Krasilov 1984) and sampled rocks of this interval for the palynological analysis. The interval also yielded echinoid remains *Holaster* sp. (determination by A.N. Solov'ev, Paleontological Institute, RAS) and thin shells of bivalves. Flora-bearing deposits underlie basal conglomerate and sandstone of the *Mortoniceras inflatum* Zone (Fig. 2, Unit 4). The site with flora is situated not far from the MGU training base, in a scour at the opposite side of the road about 25 m below the road bed.

CHARACTERISTICS OF THE FLORA

Table 1 presents a list of species from the Exposure A_4, which are identified by Krasilov (1984) and by us, amount of specimens and their percentage. As is evident, conifers (58%) and ferns (34%) prevail in the flora

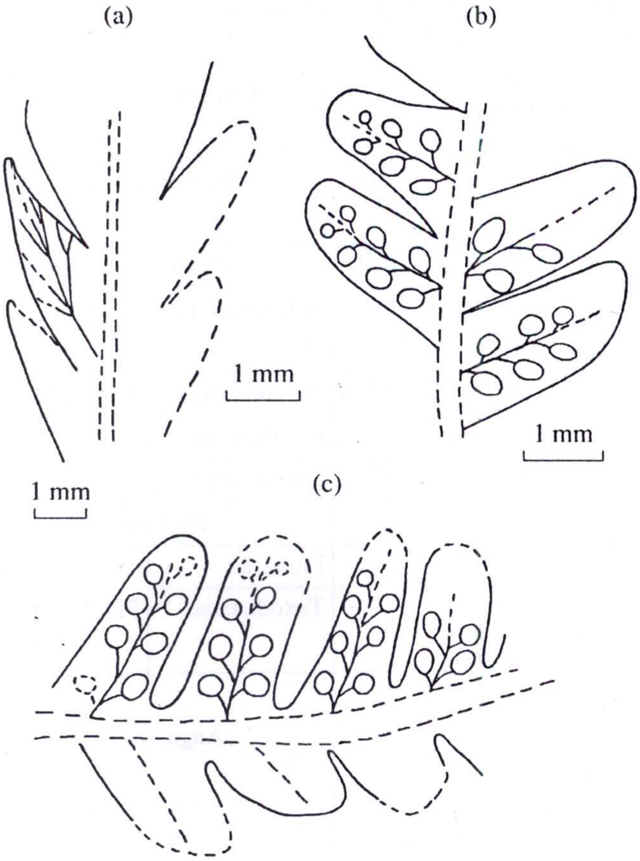


Fig. 3. Fern species *Gleichenia zippei* (Corda) Heer: (a) sterile pinna; (b, c) fertile pinnae with soruses.

composition. Dominants are conifers of Taxodiaceae family (*Geinitzia cretacea* and *G. reichenbachii*, 57%) and ferns of Gleicheniaceae family (*Gleichenia zippei*, 27%) (Plates I and II). The latter species is represented by both the sterile and fertile pinnae with soruses (Fig. 3), though the preservation of imprints was so poor that we failed to study the structure of sporangia and to extract spores. As the fertile pinnae of *G. zippei* were found for the first time in Albian deposits of the Ukraine, we present below a brief description of the species.

Fern *Gleichenia zippei* (Corda) Heer was described for the first time from Cretaceous deposits (shales) of Bohemia, Czech Republic (Corda in Reuss, 1846, p. 95, Plate XLIX, Fig. 2). In Russia, the species was described by Heer (1868), Vakhrameev (1952), Krishtofovich and Baikovskaya (1960), and by Krasilov (1967). We found 28 specimens in our collection, including two fertile and twenty six sterile (Plate I). Sterile fronds are bipinnate. The main rachis is 1.7 mm thick in the lower part of the frond and 0.3 mm thick in the upper part. Pinnae are linear–lanceolate, 1.2–3 cm long, 6–7 mm wide, attached in a successive order at the angle of 65°–75°. Thin (0.1–0.5 mm) shafts of pinnae are slightly curved towards the frond top. Pinnae are of the structure is catadromous. Pinnules are attached with the whole base at an angle. They are entire and different in shape, mainly tongue-shaped, falcate, and orbicular–triangular. The apex is narrowed and rounded. Pinnules are from 2.1 to 3.5 mm long and 1.4–1.8 mm wide at the base. They show pinnate venation (Fig. 3a) with the median rib slightly curved because of the lateral ribs branching. Lateral ribs (usually 3–4 from each side) dichotomize once in the rib middle part.

Fertile fronds are of the same structure as sterile. The median rib is clearly visible only at the base and in the middle part of pinnules, vanishing toward the apex. Soruses are arranged in two rows, by 3–4 in each, on both sides of the median rib (Fig. 3b, 3c). Fructification organs are not preserved, and only imprints of soruses are visible in the middle of lateral ribs; further bifurcation of lateral ribs cannot be traced. Soruses range in size from 0.2–0.3 mm in the lower part of pinnules to 0.1 mm at the apex.

The described fern species *Gleichenia zippei* (Corda) Heer differs from similar *G. porsildii* Seward and *G. gieseckianus* (Heer) Seward by lesser dimensions. Moreover, the shape of pinnules is less elongated as compared to *G. porsildii* Seward and not as curved as in *G. gieseckianus* (Heer) Seward (Seward, 1926).

G. zippei is widespread in Lower and Upper Cretaceous deposits of the Crimea, Western Europe, Greenland, western Kazakhstan, southern Primor'e, Sakhalin, and North America.

In addition to Gleicheniaceae, we distinguished ferns representing families Schizaeaceae (*Ruffordia goeppertii, Anemia dicksoniana*, 3.2%), Osmundaceae (*Osmunda* sp., 2.7%), and Cyatheaceae–Dicksoniaceae (*Coniopteris*, 1%).

Besides Taxodiaceae, rare representatives of Pinaceae (*Pityophyllum* sp., 1%) were found among conifers. Representatives of Lycopodiales (1.6%), Equisetaceae (0.5%), Caytheaceae (2%) are of minor importance. Percentage of angiosperms is 3.8%.

Plate I. Ferns from the lower zone of upper Albian deposits near the Prokhladnoe Village (the exposure below the road bed opposite the MGU base).

All specimens are deposited at the Geological Institute RAS, Moscow, collection no. 4857.

(1–5) *Gleichenia zippei* (Corda) Seward: (1) Sample 4857/1, imprint of the upper part of a frond (a), ditto (b) enlarged (4), counter-impression (c); (2) Sample 4857/3, a frond fragment; (3) Sample 4857/4, impression of the lower frond part and echinoid *Holaster* sp. (a), ditto (b) enlarged (2); (4) Sample 4857/2: imprint of fertile pinnae with soruses(a); ditto (b) enlarged (3); (5) Sample 4857/11, isolated pinna with soruses (3); (6, 7) *Ruffordia* sp.: (6) Sample 4857/14, a frond fragment (2); (7) Sample 4857/15 (2); (8, 9) *Osmunda* sp.: (8) Sample 4857/18, a frond fragment (2); (9) Sample 4857/6, upper parts of pinnae (2).

Plate I

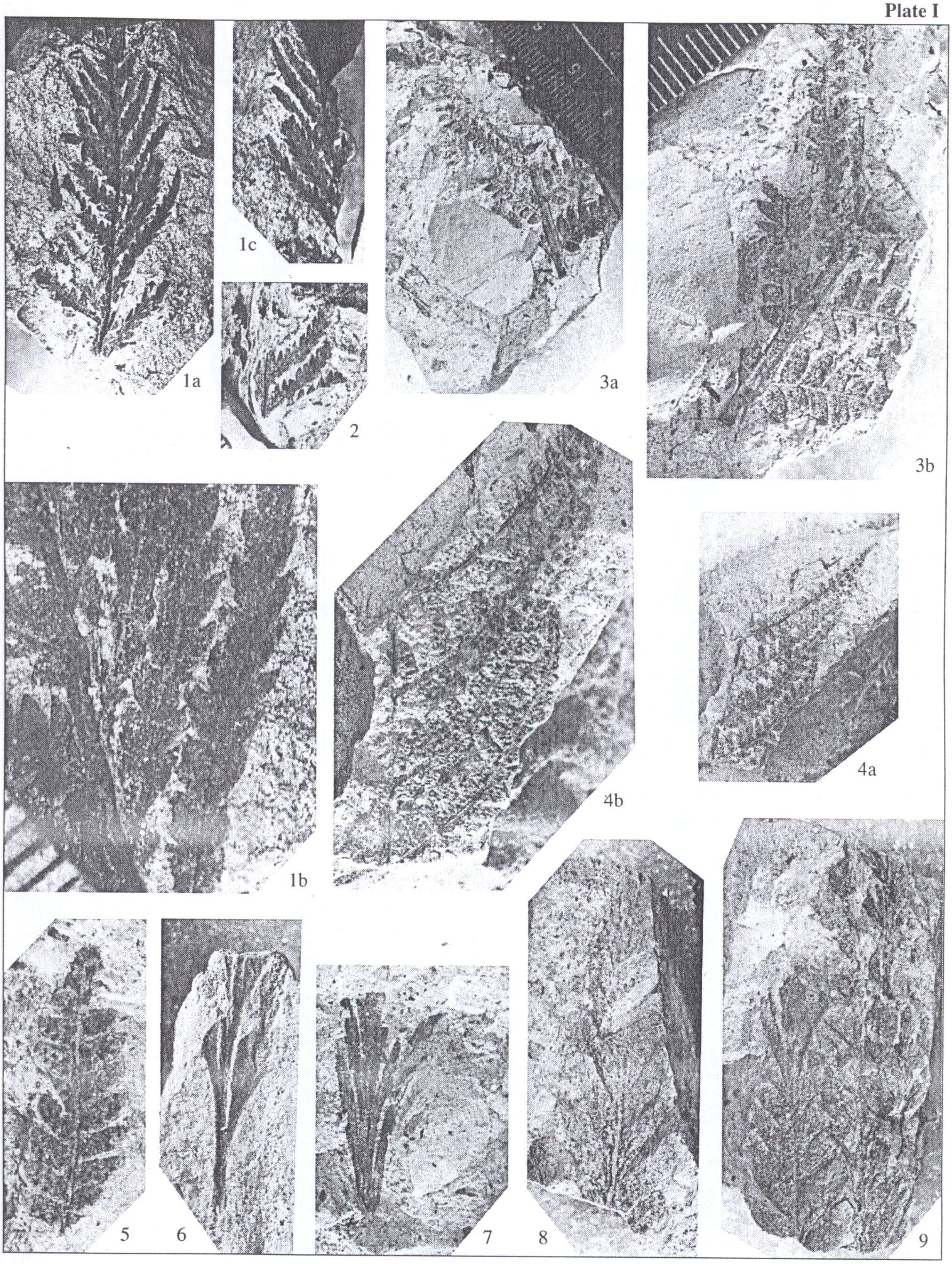
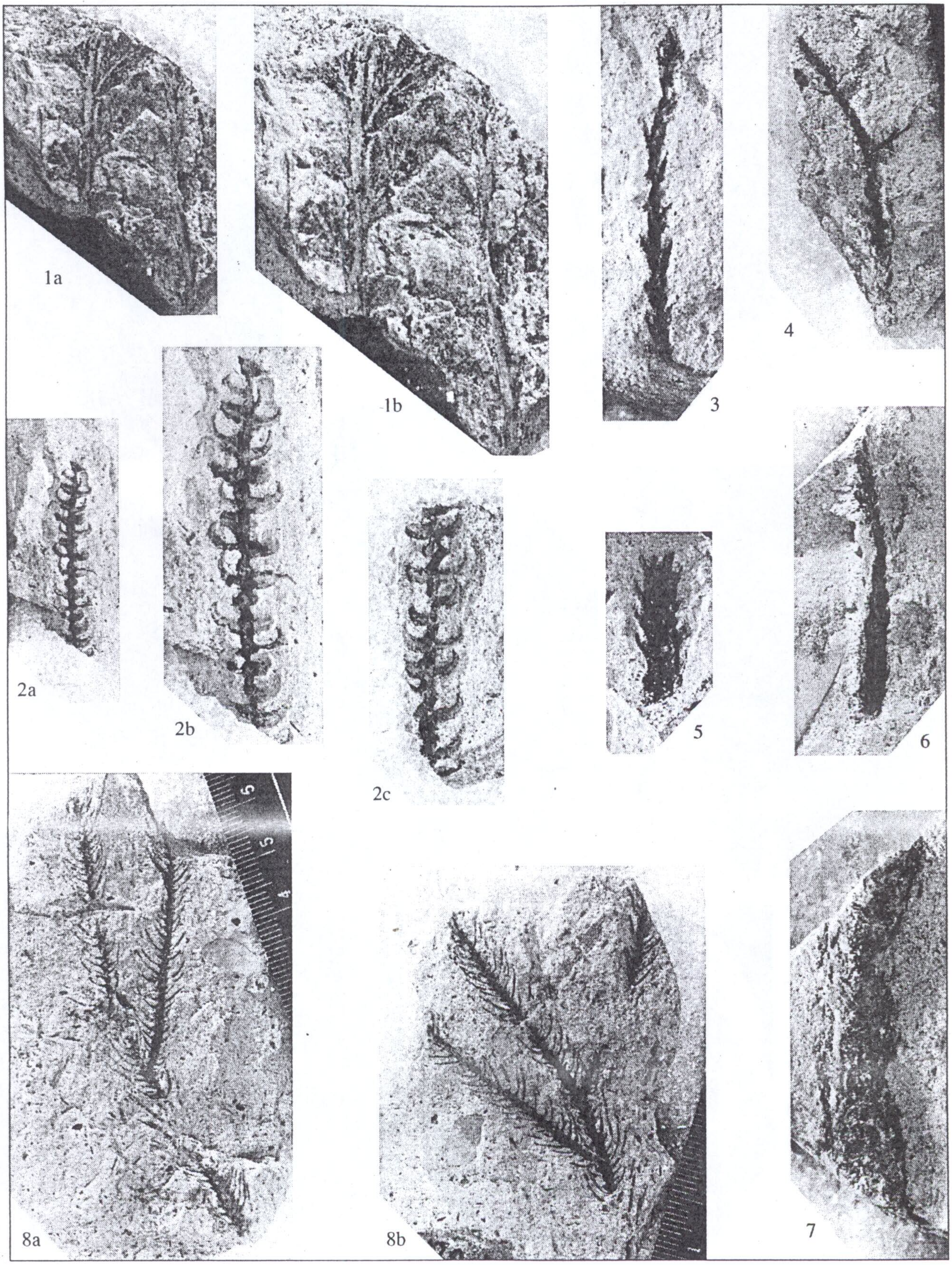


Plate II



CHARACTERISTICS OF PALYNOLOGICAL SPECTRUM

The microscopic study of macerates from upper Albian siltstone (Sample 4857/60) revealed presence of abundant organic matter: large fragments of plant tissue, spores, pollen, and rare dinoflagellate cysts.

The composition of the spore-and-pollen spectrum is noted for a great diversity (Table 2, Plate III), mainly due to spores, which make up 54 % of the total abundance of miospores. Among these are spores of ferns, especially of the Schizaeaceae family (19%) represented mainly by *Bikolisporites* species (*B. baconicus, B. toratus, B. transdanubicus*). Present as single specimens are *Klukisporites* sp., *Trilites triangulus, Appendicisporites concentricus, A. jansonii, A. tricornitatus, Costatoperforosporites fistulosus*, and *Cicatricosisporites* sp. associated with single-ray *Corniculatisporites alekhinii* and *C. striatus*. The Gleicheniaceae spores are rare (4%), representing species *Gleicheniidites laetus, G. umbonatus, G. senonicus, G. radiatus, G. carinatus, G. rasilis, G. minor*, and *Clavifera triplex*.

Among other spores, *Cyathidites minor, C. australis*, and *C. rarus* make up 9.5% and *Collarisporites fuscus*, 6%. Other spore taxa amount to 0.5–3%. Among these, there are spores of lycopsids (*Retitriletes dentimuratus, Retitriletes* sp., *Vadascisporites gregussii, Vadascisporites* sp., and *Densoisporites velatus*, 3% in sum). Spores of Osmundaceae (*Todisporites major*) and Matoniaceae (*Phlebopterisporites harskutensis*) are rare (0.5%). Among spores of the uncertain taxonomic position, there are *Leiotriletes* spp., *Duplexisporites generalis, Conbaculatisporites cretaceus, Conbaculatisporites* spp., *Distaltriangulisporites perplexus, Vinculisporites flexus, Laevigatosporites ovalis, Tripartina variabilis*, and many others.

The bisaccate pollen of conifers (44%) dominates in the spectrum of angiosperms (45%). The corresponding taxa are *Pinuspollenites similis, P. divulgatus, Piceapollenites exilioides, P. mesophyticus, Abiespollenites* sp., cedar pollen (*Parvisaccites radiatus, P. rugulatus*), *Podocarpidites luteus, P. multesimus*, and problematic *Disaccites* forms (12.5%). By the way, bisaccate pollen is produced not only by conifers but by other plants as well, for instance, by pteridosperms. *Caytonipollenites pallidus, Araucariacites australis, Taxodiaceaepollenites* sp. are found as single specimens. Pollen of *Cycadopites* and *Classopollis* has not been encountered.

Only one pollen grain of gymnosperm *Crassipollis vraconicus* Juh. and single dinoflagellate cysts *Gonyaulacysta* sp. were found.

Spores and pollen from deposits of the *Hysteroceras orbignyi* Zone at the Prokhladnoe site were insistently studied by Smirnova. As a result of her and other palynological investigations, a brief characteristics of the spore-and-pollen assemblage was published (Kuvaeva, 1966; Kuvaeva and Yanin, 1973; Smirnova, 1997; Stafeev *et al.*, 1977), a new genus *Corniculatisporites* Kuvaeva, 1972, new species of this genus (Kuvaeva, 1972; Smirnova and Shamma, 1987), and genus *Gregussisporites* Juhasz et Smirnova, 1985, were described.

Recently, a comprehensive description of miospores composition was published by Smirnova (1999) who analyzed more than 20 spectra characterizing this zone. Comparing the assemblage studied previously with that from Sample 4857/60, we found an undeniable similarity of their species composition. Among some distinctions, the principal one is an insignificant amount of the Gleicheniaceae spores in the latter. Of all the spectra studied before, only one shows the same abundance rate (8%), whereas percentage of Gleicheniaceae spores in others varies from 18 to 32%. In addition, fern spores are less abundant in Sample 4857/60 (54 versus 75–92% in other samples). By contrast, this sample is more rich in bisaccate pollen of conifers (38%), and proportions of *Pinuspollenites, Piceapollenites, Parvisaccites*, and *Podocarpidites* are higher in this group.

DISCUSSION

Paleobotanical and palynological data on the same flora-bearing bed (Fig. 2, Unit 3) offer a possibility to outline more completely and reliably the composition of flora and past vegetation. Comparing percentages of fossil plant species and main spore and pollen groups in the Exposure A_4 near the MGU training base (Table 3), one can see that ferns and conifers dominate in both cases. But if Gleicheniaceae ferns prevail, making up 27%, in plant imprints, among which Schizaeaceae represent only 3%, Osmundaceae 2.7%, and Cyatheaceae 1%, the leading role among spores belongs, according to palynological data, to Schizaeaceae (19%) and Cyatheaceae (9.5%), whereas Gleicheniaceae make up 4%, Osmundaceae 3%, and Matoniaceae 0.5%. Moreover, a considerable amount of spores of an uncertain taxonomic position (14.5%) was found. As is noted

Plate II. Ferns and conifers from the lower zone of upper Albian deposits near the Prokhladnoe Village (all samples, except for that pictured as figure 8, are from the exposure below the road bed opposite the MGU base).

All samples are deposited at the Geological Institute RAS, Moscow, collection no. 4857/60.

(1) *Sphenopteris* sp.: Sample 4857/17: a pinna fragment (a) enlarged (2), ditto (b) enlarged (3); (2) *Geinitzia reichenbachii* (Geinitz) Seward, Sample 4857/20: a shoot fragment (a), ditto (b) enlarged (2), counter-impression (c) enlarged (2); (3–8) *Geinitzia cretacea* Unger: (3) Sample 4857/29, a shoot fragment, (4) Sample 4857/24, (5) sample 4857/27, (6) Sample 4857/26, (7) Sample 4857/25, (8) Sample 4857/22: a shoot fragment (a) and counter-impression (b).

Table 2. Spore and pollen taxa from the lower zone of the upper Albian, the Prokhladnoe Village site (Exposure A_4 facing the MGU training base, below the road bed)

Spores and pollen	Content, %
Order Bryophyta	
Phaeocerosporites purus (Deak, 1964) Juhasz, 1980	0.5
Order Lycopodiophyta	
Vadascisporites gregussi Juhasz, 1975	1
Vadascisporites sp.	+
Retitriletes dentimuratus (Brenner, 1963) Juhasz, 1975	+
Retitriletes sp.	+
Densoisporites velatus Weyland et Krieger, 1953	2
Order Polypodiophyta	
Family Osmundaceae	
Conbaculatisporites cretaceus Deak, 1964	1
Conbaculatisporites sp.	1.5
Todisporites major Couper, 1958	0.5
Family Schizaeaceae	
Klukisporites sp.	+
Trilites triangulus Kedves, 1964	3
T. minor (Juhasz, 1972) S.K. Srivastata, 1975	+
Bicolisporites baconicus (Juhasz, 1972) Juhasz, 1977	6.5
B. toratus (Weyland et Greifeldt, 1953) S.K. Srivastava, 1975	6.5
B. transdanubicus (Juhasz, 1972) Juhasz, 1977	2.5
Acritosporites kyrtomis Juhasz, 1979	+
Cicatricosisporites venustus Deak, 1964	+
Cicatricosisporites sp.	+
Appendicisporites concentricus Kemp, 1970	+
A. tricornitatus Weyland et Krieger, 1953	+
A. jansonii Pocock, 1964	0.5
Costatoperforosporites fistulosus Deak, 1962	+
Corniculatisporites alekhinii (Bolchovitina, 1953) Kuvaeva, 1972	+
C. striatus (Deak, 1963) Kuvaeva, 1972	+
Family Gleicheniaceae	
Gleicheniidites senonicus Ross, 1949	0.5
G. laetus (Bolchovitina, 1953) Bolchovitina, 1968	2.5
G. umbonatus (Bolchovitina, 1953) Bolchovitina, 1968	0.5
G. radiatus (Bolchovitina, 1953) Bolchovitina, 1968	0.5
G. rasilis (Bolchovitina, 1953) Bolchovitina, 1968	+
G. minor Döring, 1965	+
Ornamentifera granulata (Grigorjeva, 1961) Bolchovitina, 1968	+
Family Matoniaceae	
Phlebopterisporites harscutensis Juhasz, 1979	0.5
Family Cyathaceae–Dicksoniaceae	
Cyathidites minor Couper, 1953	6.5
C. australis Couper, 1953	1
C. rarus (Bolchovitina) Deak	2

Table 2. (Contd.)

Spores and pollen	Content, %
Sporae Incertae Sedis	
Duplexisporites generalis Deak, 1962	2.5
Vinculisporites flexus Deak, 1964	+
Distaltriangulisporites perplexus (Singh, 1964) Singh, 1971	+
Collarisporites fuscus Deak, 1964	6.5
Leiotriletes microrugosus Naumova, 1953	5.5
Laevigatosporites ovatus Wilson et Webster, 1946	+
Order Pinophyta	
Caytonipollenites pallidus (Reissinger, 1938) Couper, 1958	+
Podocarpidites multesimus (Bolchovitina, 1956) M. Petrosjanz, 1971	3
P. luteus (Bolchovitina, 1956) M. Petrosjanz, 1971	1.5
Pinuspollenites similis (Balme, 1957) M. Petrosjanz, 1971	2.5
P. minimus Kemp, 1970	1
P. divulgatus (Bolchovitina, 1956) M. Petrosjanz, 1971	6
Piceapollenites exilioides (Bolchovitina, 1956) M. Petrosjanz, 1971	5.5
P. mesophyticus (Bolchovitina, 1956) M. Petrosjanz, 1971	8.5
Abiespollenites sp.	2
Parvisaccites radiatus Couper, 1953	1.5
P. rugulatus Brenner, 1963	+
Disaccites	12.5
Araucariacites australis Couper, 1958	0.5
Taxodiaceaepollenites sp.	0.5
Order Magnoliophyta	
Crassipollis vraconicus Juhasz, 1979	0.5
Order Dinophyta	
Gonyaulacysta sp.	0.5

above, however, the abundance of Gleicheniaceae is higher (18–32%) in palynological spectra characterizing deposits of the *Hysteroceras orbignyi* Zone in other localities.

In contrast, there is a complete discrepancy between macro- and micropaleontological data characterizing conifers. Taxodiaceae dominate in plant imprints (57 versus 58% of total amount of conifers), whereas pollen of *Pinuspollenites, Piceapollenites, Podocarpidites,* and others prevails in the palynological spectrum (Table 3), where pollen of Taxodiaceae (and of Araucariaceae) is represented by single specimens (0.5%). What is the reason?

The bisaccate pollen of conifers (Plate III, 17–20) prevails in the palynological spectrum owing to its volatility that is favorable for dispersal over a large distance from forests, which covered elevated areas. In this instance, the forests were likely growing far from the coast of a sea bay, since only two leaf imprints were found (leaves of *Pityophyllum* sp.). The rarity of the Taxodiaceae pollen specimens seems to reflect the fact that these plants produce much less pollen as compared, for instance, to Pinaceae, and their pollen is of a low resistance against fossilization. This may be also connected with two other circumstances: conifers of genus *Geinitzia* producing that pollen could grow at some distance away from the coast, and the pollen (Plate III, 22) could not be transported for a considerable distance owing to its morphological structure. It should be pointed out that *Geinitzia* shoots are mostly preserved as small fragments (Plate II, 3–7), though a large fragment (Plate II, 8) was also found near the Prokhladnoe Village in another exposure. Such a fragmentation of *Geinitzia* twigs (and other plant material) could be related either to the action of alongshore currents and bioturbation (Krasilov, 1984), or to their transportation from the place of growing to the site of burial. Remains of *Gleichenia zippei* are preserved much better (Plate I, 1, 3, 4), as this fern likely grew closer to the burial site, i.e., directly on the bay coast.

We realize of course that the considered ratios and percentages are conventional, since we compare the

Plate III

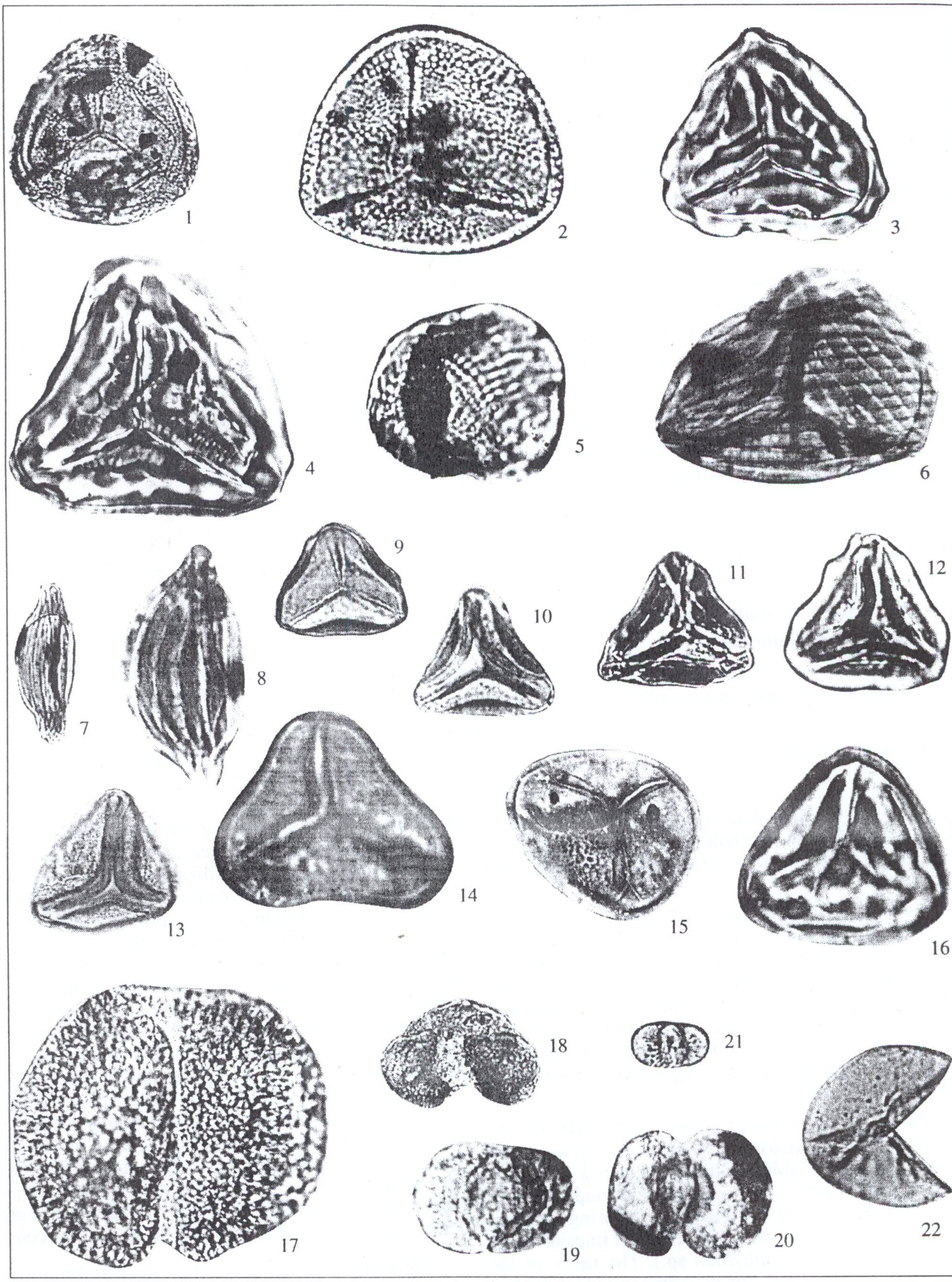


Table 3. Percentages of fossil plants and main spore and pollen groups, Exposure A_4 near the MGU training base, Prokhladnoe Village

Plant groups	Plant imprints, %	Spores and pollen, %
Lycopodiophyta	1.6	3
Equisetophyta	0.5	
Polypodiophyta	34 (27—Gleicheniaceae 3—Schizaeaceae 1—Dicksoniaceae)	51 (spores of ferns, mosses, and others) (19—Schizaeaceae 9.5—Cyatheaceae–Dicksoniaceae 4—Gleicheniaceae)
Caytoniales	2	Single grains
Pinophyta	58 (57—Taxodiaceae)	45 (44—bisaccate pollen of *Piceapollenites, Pinuspollenites, Podocarpidites*, and others) single Taxodiaceae grains
Angiospermae	4	Single grains

abundance rates of preserved palynomorphs, on the one hand, and fossil plant fragments, on the other. Nevertheless, the estimated proportions can give some idea about distribution of plant groups, and we use them.

Comparing the late Albian floras from the *Hysteroceras orbignyi* Sow. Zone of the Prokhladnoe site and from the *Pervinquieria inflata* Sow. Zone of the Kanev region (Shilkina and Doludenko, 1985; Barale and Doludenko, 1985; Doludenko and Pons, 1986; Doludenko and Teslenko, 1987; Doludenko *et al.*, 1988; Doludenko, 1992; Doludenko, 1994; Doludenko and Kostina, 1994), one can see a noticeable difference between them. The late Albian flora of the Kanev region includes two dominant families of conifers: Taxodiaceae (*Kanevia pimenova* Doludenko et Shilkina, *K. testenkoi* Doludenko, Kostina et Shilkina, *Sequoia* sp.) and Cheirolepidiaceae [*Frenelopsis kaneviensis* Barale et Doludenko, *Brachyphyllum squammosum* (Velenovsky) Palibin], which associate with rare Caytoniales (*Sagenopteris* sp.), Cycadaceae [*Dnepria schmalhausenii* (Pimenova) Doludenko et Kostina, *D. vakhrameevii* Doludenko et Kostina], and angiosperms (*Dicotylophyllum* sp.). In contrast, dominants in the flora from the Prokhladnoe region are ferns, missing from the Kanev flora, and conifers of the Taxodiaceae family only. Neither plant imprints, nor pollen of Cheirolepidiaceae were encountered in this region. (The coeval flora from the Podolia region is similar to though less diverse than that from the Kanev region.) Abundance of fossil ferns in the late Albian deposits near the Prokhladnoe Village and their absence in the Kanev region likely represent a consequence of different habitat settings. In the first case, it was presumably a sea bay, the coast of which was covered with ferns. Another story is assumed for the Kanev flora that inhabited a small island in a shallow sea, and sea transgressions probably flooded lowlands occupied by ferns approaching higher areas, from which the plant remains (conifers) were derived.

Judging from prevalence of Taxodiaceae conifers, *Gleichenia* and *Sphenopteris* ferns, the late Albian flora of the Prokhladnoe site is similar to the middle Albian flora of the Simferopol' region (Stanislavskii and Kiselevich, 1986). Moreover, the latter was found to include fern species *Phlebopteris dunkeri* (Schenk) Harris, a leaf fragment of Cycadophyta, and probably *Pterophyllum* remains.

Plate III. Spores and pollen from the lower zone of upper Albian deposits near the Prokhladnoe Village (exposure below the road bed opposite the MGU base, Sample 4857/60).

All specimens are deposited at the Paleontology Chair of the Geological Faculty, Moscow State University.

Magnification is 500 in figures 7, 8, 18, 20, and 800 in others.

(1) *Densoisporites velatus* Weyland et Krieger; (2) *Vadascisporites* sp.; (3) *Bicolisporites baconicus* (Juhasz) Juhasz; (4) *B. toratus* (Weyland et Greifeldt) S.K. Srivastava; (5) *Cicatricosisporites venustus* Deak; (6) *Cicatricosisporites* sp.; (7) *Corniculatisporites alekhinii* (Bolchovitina) Kuvaeva; (8) *C. striatus* (Deak) Kuvaeva; (9) *Gleicheniidites laetus* (Bolchovitina) Bolchovitina; (10) *G. senonicus* Ross; (11) *G. minor* Döring; (12) *G. umbonatus* (Bolchovitina) Bolchovitina; (13) *Phlebopterisporites harscutensis* Juhasz; (14) *Cyathidites australis* Coupler; (15) *Todisporites major* Couper; (16) *Duplexisporites generalis* Deak; (17) *Piceapollenites mesophyticus* (Bolchovitina) M. Petrosjanz; (18) *Pinuspollenites minimus* Kemp; (19) *Podocarpidites luteus* (Bolchovitina) M. Petrosjanz; (20) *P. multesimus* (Bolchovitina) M. Petrosjanz; (21) *Caytonipollenites* (Reissinger) Couper; (22) *Taxodiaceaepollenites* sp.

The Albian flora of Portugal (Saporta, 1894) is incomparably richer and diverse. Ferns are represented here by genera *Onychiopsis, Adiantites, Phlebopteris, Sphenopteris*, cycadophytes by genus *Pseudocycas*, conifers by *Brachyphyllum, Sphenolepis, Sequoia, Podozamites*, and angiosperms by *Aralia, Magnolia, Cissites, Menispermites, Braseniopsis, Proteophyllum, Phillites*. In addition, *Frenelopsis* remains were found in another nearby exposure of the Albian flora in Portugal.

CONCLUSION

Paleobotanical and palynological data supplementing each other elucidate composition of the late Albian vegetation. The data indicate that the coast of an ingression sea bay that corresponded to the Mangush depression was covered with diverse ferns, among which Gleicheniaceae and Schizaeaceae families dominated. Abundant shoots' fragments of genus *Geinitzia* found suggest that the coastal zone with ferns was narrow, and microphyllous forests descended close to the sea. Palynological data imply that higher slopes where occupied by conifers producing bisaccate pollen in abundance. In general, the relief was rugged and diverse, and climate was warm and humid.

ACKNOWLEDGMENTS

We are grateful to M.A. Akhmet'ev, V.A. Krasilov, and B.T. Yanin for valuable advices and consultations, and to A.A. Bogdanov for his assistance in collecting fossil plants. The work was supported by the Russian Foundation for Basic Research, project no. 98-05-64195, and by the research programs "Integration A-00-70" and "Universities of Russia—Fundamental Research."

Reviewers L.V. Rovnina and M.A. Akhmet'ev

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Plate I

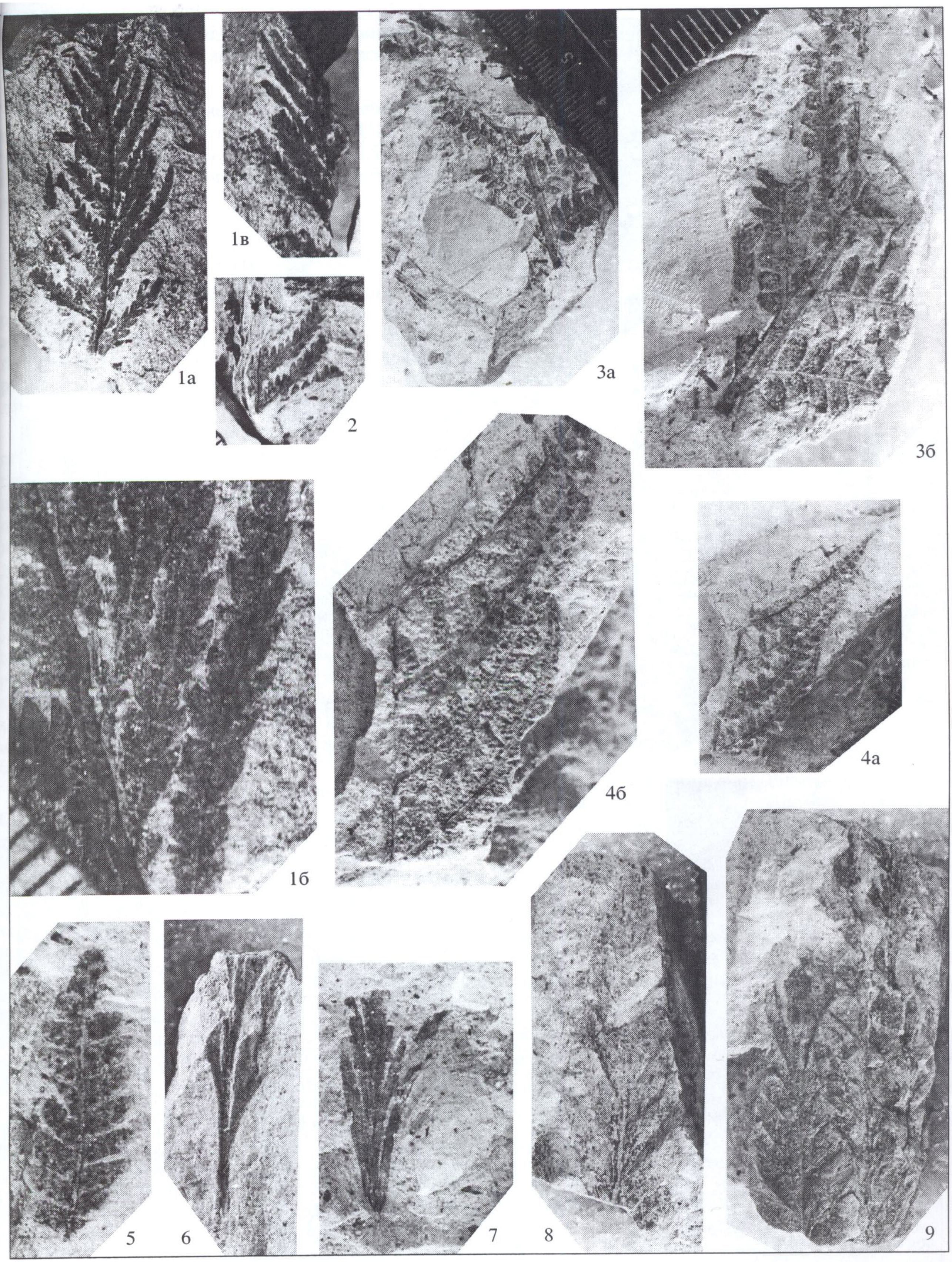

Plate II