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PALYNOLOGICAL STUDY OF NEOGENE DEPOSITS OF SOUTHERN POLAND AND WESTERN GEORGIA

Studia palinologiczne osadów neogeńskich południowej Polski i zachodniej Gruzji

ABSTRACT. On the basis of palynological studies of Neogene sediments from the territory of Southern Poland more over 200 taxons have been distinguished. They belong mainly to arboreal and herbaceous plants. The spore assemblage of Middle and Upper Miocene and particularly in the Pliocene is rather poor. On the same basis from Middle Miocene and Pliocene deposits of Western Georgia over 300 components of flora were distinguished the greatest part of which are arboreal plants and *Pteridophyta*.

In both regions the first great change of the flora is observed on the Miocene/Pliocene limit. Starting from this time in Poland it begins a rapid formation of the recent type of flora. Plants which are not typical nowdays to this region played the role of subordinate components. This process proceeds slowly in Western Georgia which was transformed into a refugium of Tertiary elements of the European flora since Sarmatian. Throughout Pliocene it is traced the change of the subtropical vegetation by the thermophilous one and then the moderate one. The edificators of the latter, which the species prevailing nowdays in the Colchis, became plants (*Tsuga, Taxodiaceae-Cupressaceae*) which are absent on this territory now. Their predominance extends in the Early and Middle Pleistocene toward the end of which Western Georgian flora assumes the recent feature.

INTRODUCTION

The present work is a result of joint studies being carried out by W. Szafer Institute of Botany of the Polish Academy of Sciences in Cracow and L. Davitashvili Institute of Paleobiology of the Georgian Academy of Sciences in Tbilisi. The cooperation began in 1980 and continues up to-day. A purpose of the work is to study: the palynological assemblages of Southern Poland and Western Georgia, their comparison and to determine the common features in the process of development of phytocoenosis as a basis to correlate deposits of different facies in the Eastern and Central Paratethys.

In respect of vegetation Southern Poland and Western Georgia differ considerably from each other. According to Szafer (1966), Poland is situated in the

Central-European Province, which in the south-east extends towards Pontian--Pannonian one. The latter borders on Submediterranean Subregion. It comprises the Colchis Province, a part of which is Western Georgia (Gagnidze et al. 1985).

In the past there were no sharp differences between the vegetation of Southern Poland and Western Georgia, particularly in the first half of the Neogene, when the banks, bordering the basins of Eastern and Central Paratethys, were covered by a subtropical vegetation similar in composition. By the end of the Miocene quite rapid impoverment of the Central-European flora took place being associated with the reduction of the marine basins and continentalization (drying) of the climate. Approximately at the same time the formation of Western Georgia started as an isolated botanical province, protected from the influence of cold and dry climate by the ranges of the high mountains. Thanks to this fact during the Pliocene plant communities were survived, dominants of which were the plants either completely absent in the Central European flora or maintained the subordinate position in the structure of biocoenoses. Throughout the Pliocene and Pleistocene Western Georgia was the refugium of Tertiary elements some of which survived in the forests of Colchis up to-day.

Naturally a question arises: is it possible to correlate general stages of the development of flora and the vegetation of Western Georgia with those of the other regions of Paratethys? Evidently it is possible if it is correlated not only the floristic composition of coenoses but also the turning-points of their development.

Western Georgia is a stratotypical region where all beds of the Black Sea Neogene are present. They have rich spore-pollen complexes, reflecting almost continuous history of the plant communities and the evolution of conditions of their habitat. The fossilization of these complexes in the deposits dated precisely by fauna, provides them definite geochronological significance. They may be used for correlation deposits of the distant basins, especially for such region as Southern Poland, where from the end of the Miocene it was established continental regime and the whole stratigraphy of the Late Cainozoic generally based upon the paleobotanical data.

The basis of the present work are data obtained by the authors as a result of the palynological studies of the Neogene deposits of Southern Poland and Western Georgia as well as the materials on the fossil floras of this regions, published in Polish and Soviet proceedings.

CHARACTERISTIC OF THE PLANT-FOSSIL BEARING DEPOSITS OF SOUTHERN POLAND AND WESTERN GEORGIA

From paleobotanical point of view the deposits of two large inner basins within Southern Poland were studied: Nowy Sącz and Nowy Targ-Orawa Basins. The Miocene and Pliocene deposits of these basins include numerous localities of fossil flora.

The first Neogenic marine transgression took place in Eggerian over the territory of Poland (Ney et al. 1974). The sea invided from the West through the Moravian Gate and covered a small territory in the Sudetian plain. The outcrops of the beds of this age are known in the vicinity of Jawor, where they are represented by tuffs.

In the Eggenburgian the marine transgression occupied only the South-Western part of Poland territory. But in the Late Eggenburgian the sea passed through the Ukraine to Jasło-Krosno depression.

The marine transgression was not large in the Ottnangian. The sea as a narrow strait stretched from the West through the Nowy Sącz Basin up to Nowy Targ Basin.

In the Carpathian a new differentiation of the basins and the development of the Carpathian depression started. From the East the marine gulf reached Jasło-Krosno and Nowy Sącz depressions up to the margins of Nowy Targ-Orawa Basin. At the same time the emmergence of the Cracow „bolt" devided the Carpathian depression into two parts.

The last marine transgression occured in the Badenian and Sarmatian. In the beginning of the Sarmatian there still existed the connection between the eastern and western basins of the Carpathian depression. Throughout this time a gradual regression of the sea from the West to the East occured and in the late Sarmatian the sea finally retreated the territory of Southern Poland. The Late Neogene deposits (Pontian, Dacian and Romanian) are represented by freshwater and continental strata.

The plant-fossil bearing beds of the Pontian (Lower Pliocene) age are known from the bore hole profiles, drilled in the vicinity of Czarny Dunajec and Koniówka. The palynological complexes from these deposits were studied by Oszast and Stuchlik (1977).

The plant-fossil bearing beds of the Middle Pliocene (Dacian) age are known from the Dunajec river at the village Krościenko and in Domański Wierch. At the first point the Pliocene beds, represented by viscous clays, are outcropped. The macroscopic remains of the plants from these section were studied by Szafer (1946) and the spore-pollen complexes by Oszast (1973).

The emergence Domański Wierch is situated in the Western part of Nowy Targ-Orawa Basin. The flora was discovered in the profile of bore hole. These deposits included both the fossil leaves, described by Zastawniak (1972) and the palynological assemblages by Oszast (1973).

The Upper Pliocene (Romanian) in Southern Poland is represented by the part of Mizerna beds. The macroscopic remains of plants from these deposits were studied by Szafer (1954). He divided the Mizerna beds into several stages. The Czorsztyn stage (Mizerna I, I/II) and Mizerna stage (Mizerna II) the author attributed to the Upper Pliocene and the overlying beds (Mizerna III, IV) to the Pleistocene. The beds of Mizerna I Stuchlik (1979, 1980) dates as the Dacian, Mizerna I/II and Mizerna II as the Romanian. The spore-pollen complexes of the Mizerna beds were studied by Oszast (1973).

In Western Georgia the accumulation of the palynological complexes occured under quite different paleogeographical conditions. Here all beds of the Black Sea Neogene are completely represented. These deposits include a rich fauna of marine molluscs, which is the basis of the geochronological divisions of the Neogene for the stages and horizons (see table 1).

Table 1

The stratigraphical scheme (after Nevesskaja et al. 1985, Taktakishvili 1984)

Western (Central) Paratethys	Eastern Paratethys Black Sea region
Romanian	Gurian
	Egrissian (Kuyalnikian)
Dacian	Kimmerian
Pontian	Pontian
Pannonian	Meotian
Sarmatian s. str.	Sarmatian
Badenian	Konkian
	Kartvelian
	Karaganian
	Tschokrakian
Carpathian	Tarchanian
Ottnangian	Kozachurian
Eggenburgian	Sakaraulian
Egerian (upper part)	Caucasian

The Karaganian, Kartvelian and Konkian deposits were formed in the large enclosed basins extending towards the West-East direction from Bulgaria to the recent Aral Sea. The geological history of these basins as well as the evolutional processes of their faunas agrees with the definite stages of the development of the Eastern Paratethys during the second half of the Middle Miocene. The outcrops of Middle Miocene deposits are known in Eastern and Western Georgia. Lithologically they are represented by the conglomerats, poor carbonate marls, oolitic limestones and lumachels. The palynological complexes of Middle Miocene deposits of Georgia were studied by Ramishvili (1982).

According to Nevesskaja (Nevesskaja et al. 1985) in the first half of the Sarmatian time Paratethys was a single basin and than the complete isolation of Western Paratethys from Eastern one occured.

A new cycle-Meotian began in Eastern Paratethys after Sarmatian. It was connected with a new marine transgression. The link of the Meotian basin with the Mediterranean Sea was very embarrassed. In Georgia the outcrops of the Meotian deposits are known only in the Western part of country and are represented mainly by limestones and clays. They contained the rich fossil flora which was studied by Uznadze (1965) and Purtseladze & Tsagareli (1974).

Since Meotian Paratethys again became a single basin (Nevesskaja et al. 1985). The Pontian deposits were formed in a large enclosed brackish water lake-sea which did not have a link with the ocean and resembled the recent Caspian Sea. It consisted of several basins and they were connected with each other. Out of these the most eastern Euxinian-Caspian basin occupied the significant area in the South of the USSR and covered all region of the recent Black and Caspian Seas. The Dacian (Getian) basin, situating westernward, covered the Lower Danube plain and at the Iron Gate of the Danube river it was connected with the Pannonian basin which was the largest Western part of the Pontian Sea. The Euxinian basin was connected with the most South Aegean basin through the Thrakia and Dardanelles (Ramishvili 1969).

The Pontian deposits are widely spread in Western Georgia. They include both the mollusc fauna and the remains of flora. The leave-prints of the Pontian deposits were studied by Kolakovski (1964), the spore-pollen complexes by Ramishvili (1969).

The Kimmerian lake-sea was an enclosed basin with some reduced salinity as the recent Caspian Sea. The area, being occupied by the lake-sea, was small. It consisted of two linked basins: the Azovian and the Eastern-Euxinian. These basins were linked through the Enical strait which exceeded greatly the width of the recent strait, embracing the Eastern part of the Kerchian and the entire Tamanian Peninsulas (Mchedlishvili 1963). The Northern border of the Eastern-Euxinian basin ran a little southward of the recent coast line and the Southern border — northward. The entire absence of the Kimmerian deposits on the coast of Turkey indicates to this fact. In Western Georgia the Kimmerian beds are characterized by the mollusc fauna and includes both leaf remains and the rich spore-pollen complexes (Kolakovski 1956, Mchedlishvili 1963).

The Late Pliocene is represented by the Kuyalnikian stage and the Gurian horizon. Unlike the Kimmerian deposits the Kuyalnikian beds occur not only in the Eastern half of the Black Sea basin but also within its North-Western part. In the Eastern half of the Black Sea basin the Kuyalnikian beds are noted in all regions where the Kimmerian deposits are present although they occupy significantly less area as the Kimmerian lake-sea. The Kuyalnikian sea consisted of Northern (Azovian) and the Southern (East-Euxinian) basins, being linked with each other by the wide Enical strait. The coast line of the Eastern-Euxinian basin covered the area greatly reduced Rioni Gulf and the adjoined territories to the northward and southward of it (Ebersin 1940).

Taktakishvili (1984) made some changes for the stratigraphical scheme of Pliocene of Western Georgia. On the basis of the mollusc fauna he suggested to distinguish the Kuyalnikian deposits of this territory as an individual unite and to call it „Egrissian stage".

In the Black Sea region the Gurian beds are known in the Western Transcaucasus (Guria) and on the Kerchian Peninsula. They were penetrated by drilling. The limited spread of the Gurian beds may be explained by significant reduction of the basin. The borders of the latter ran mainly in the recent coast line, occupying the small blocks of the land in the area of the Rioni and Taurian Gulfs (Ebersin 1940). In Western Georgia the Gurian beds are widely spread only in the Southern part of this region. They are represented here by the grey clays, including the typical mollusc fauna.

THE DEVELOPMENT OF THE FLORAS OF SOUTHERN POLAND AND WESTERN GEORGIA DURING THE NEOGENE

Southern Poland

In Southern Poland the spore-pollen complexes of the Neogene deposits were studied from the bore-holes and outcrops in the region of Nowy Sącz, Czarny Dunajec, Koniówka, Huba and Mizerna, and also on the Domański Wierch mount. Besides this were examined samples taken from the open sulphur pit Piaseczno, near Tarnobrzeg and from the outcrops at Chyżne, Mała and Wielka Lipnica and Stare Gliwice. All cross sections covered the time intervals from the Upper Carpathian up to Romanian inclusive.

The palynological complex of the Late Carpathian deposits of Nowy Sącz basin was described by Stuchlik (Oszczypko & Stuchlik 1972). All genera, being included in the composition of the spectra the author divided into three groups.

To the first group are attributed coniferous plants, the prevailing component of which is *Pinus* and the representatives of the families *Taxodiaceae-Cupressaceae*.

In the second group the author included the Tertiary genera: *Castanea, Carya, Pterocarya, Engelhardtia, Celtis, Myrica, Ilex, Nyssa*. The pollen of these plants occur along the entire profile.

The genera typical both to the Tertiary and the Quaternary deposits Stuchlik combined in the third group. Those are mainly plants of mixed deciduous forests. In the composition of pollen and spore spectra they occupy subordinate position.

To the end of Carpathian and the beginning of Badenian (Torton) correspond the Piaseczno beds. The samples of these beds were examined by Oszast (1967). According to the author the palynological spectra were characterized by the abundant diversity and reflected mainly the precoastal vegetation of the swampy plains. The forests consisted of *Glyptostrobus*, *Taxodium*, *Nyssa*, *Alnus*, *Liquidambar*, *Decodon*, *Myrica*, *Cyrilla*, *Salix*, *Betula*. Farther up off the bank there were communities prevalence of which were *Platanus*, *Ulmus*, *Corylopsis*, *Ailanthus*, *Acer*, *Styrax*, *Carya*, *Pterocarya*. The representatives of *Fagus*, *Zelkova*, *Carpinus*, *Eucommia*, *Quercus*, *Celtis* were added to these trees on the high localities. In the forests consisted of the leaf-bearing species the following coniferous plant inhabited: *Picea*, *Pinus*, *Abies*, *Tsuga* and *Sciadopitys*. The underwood was well developed and consisted of *Pistacia*, *Viburnum*, *Olea*, *Laurus*, *Tamarix*, *Buxus*, *Punica*, *Sorbus*, *Berberis*, *Rhus*, *Cassia*, *Caragana*, *Cornaceae*.

From the palynological spectra Oszast (1967) makes a conclusion that during the time of accumulation of the Piaseczno beds the climate was thermo--moderate, close to the Mediterranean one.

Paleobotanically the Upper Tortonian deposits of Upper Silesia near Stare Gliwice were studied in detail. The spore and pollen of this locality were studied by Oszast (1960) and the macroscopic remains of flora — by Szafer (1961). According to these researchers in the stretch of the formation of the Stare Gliwice beds mixed forests with the well developed underwoods inhabited on the territory of Western Poland. The formation of the lower mountain zone were represented by the evergreen plants: *Olea*, *Pistacia*, *Laurus*, *Quercus*, *Mastixia*, *Aralia*. The deciduous communities occupied higher altitudes and they were composed mainly of *Carpinus*, *Quercus*, *Ilex*. The vegetation of the upper mountain zone was formed by *Abies* and *Tsuga*.

The entire of the Gliwice beds Oszast divided into three parts. The palynological spectra of the lower and upper beds of the section reflect the period of dry climate. They were separated by the phase of humid and slightly cooler climate.

The formation of marshy forests of the Late Tortonian time was described by Zastawniak (1978). She studied the leaf-prints of the clays, being developed by the brich factory in Mirostowice. The greatest part of plant remains, being found in the deposits belong to *Taxodium* and *Glyptostrobus*. The leaf-bearing plants were represented only by 12 taxons.

The beds corresponding to Badenian were penetrated by the boreholes near Czarny Dunajec and Koniówka. In this complex, according to Oszast and Stuchlik (1977) and by new analysis, pollen of *Taxodiaceae* and *Nyssa* prevailed which were, evidently, the main components of swamp forests. The representatives of *Fagus*, *Carpinus*, *Quercus* and *Carya* grew on higher altitudes. The coniferous forests occupied small areas and consisted of *Picea*, *Abies*, *Tsuga* and *Podocarpus* (see Fig. 1, M_4).

The younger deposits, corresponding to the end of the Miocene have wide

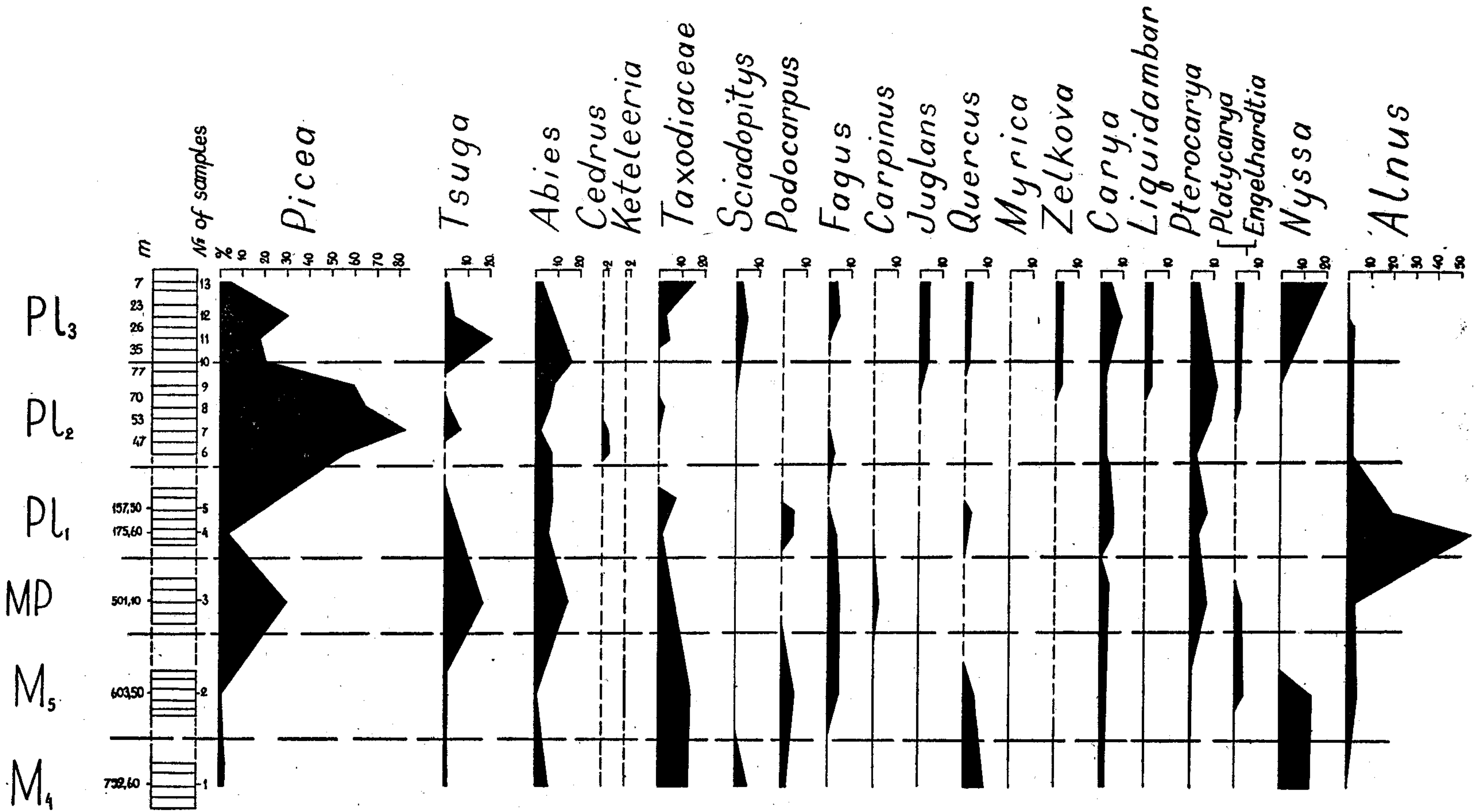

Fig. 1. Cumulative pollen diagram of Middle Miocene and Pliocene deposits of South Poland

spread in Poland. They are found in the profiles of Czarny Dunajec, Koniówka, Huba and also in the outcrops of Chyżne, Wielka and Mała Lipnica.

At the end of the Miocene the territory of Southern Poland was covered by marshy forests, consisting of *Taxodium*, *Cupressus* and *Nyssa*. These forests were very dense and prevented the development of aquatic plants. The association of *Nymphaceae*, *Sparganium*, *Cyperaceae*, *Gramineae* occupied small water reservoirs. The representatives of *Salix*, *Betula*, *Alnus*, *Engelhardtia*, *Cyrilla*, *Decodon*, *Polygonum*, *Myrica*, *Osmunda*, *Sphagnum*, *Selaginella* grew along the banks.

The deciduous trees and shrubs — *Castanea*, *Castanopsis*, *Celtis*, *Ilex*, *Liquidambar*, *Myrtaceae*, *Oleaceae*, *Rhus* — prevailed in the lower mountain localities. The tree ferns — *Gleichenia* and *Lygodium* — were confined to these forests. This formation was changed over by the communities of plants of more moderate climate such as *Carpinus*, *Fagus*, *Quercus*, *Ulmus*, *Larix*, *Picea*, *Tsuga* and others (Oszast 1973, Tran Dinh Nghia 1974, Zastawniak 1980).

On the whole, the climate at the end of the Miocene was subtropical, humid. The paleogeographical position of this territory, being the bank of one of the seas of Paratethys favoured for the existence of such condition in the Sarmatian in Southern Poland.

On the diagram made up by new data the Sarmatian and Badenian plant communities were identical (see Fig. 1, M_5). Only towars the end of the Badenian near the Miocene/Pliocene limit a decrease of the area of marshy forests and an increase of a role of such plants as *Picea*, *Abies*, *Tsuga* occured. Since Sarmatian the character of the flora was changed. The following species disappeared from its composition: *Schizaceae*, *Lygodium*, *Morhia*, *Hymenophyllum*, *Gleicheniaceae*, *Microlepis*, *Alsophila*, *Keteleeria*, *Pseudotsuga*, *Larix*, *Phyllocladus*, *Gnetaceae*, *Pasania*, *Santalaceae*, *Lorantaceae*, *Liriodendron*, *Lauraceae*, *Aconitum*, *Stewardtia*, *Platanus*, *Parrotia*, *Fothergilla*, *Hamamelis*, *Corylopsis*, *Itea*, *Decodon*, *Phellodendron*, *Ptelea*, *Rutaceae*, *Buxus*, *Parthenocissus*, *Vitis*, *Sterculia*, *Reevesia*, *Myrtaceae*, *Myriophyllum*, *Gunnera*, *Camptotheca*, *Aralia*, *Schefflera*, *Forsythia*, *Mastixia*, *Diervilla*, *Dipelta*, *Palmae*.

According to Oszast and Stuchlik (1977) the following stretch, corresponding to Mio-Pliocene (Pannonian) was characterized by the widening of the area of the genera, being typical of the moderate climate (Fig. 1, MP). A role of the Tertiary elements as compared with the Sarmatian was noticeably reduced. At the authors note, the great unsteadiness of the vegetal cover and the increased role of spruce forests were typical of this periop. The domination of *Taxodiaceae-Cupressaceae* is a feature of the Central European Miocene, whereas the Pliocene is distinguished by the prevalence of dark coniferous plants.

The change of the vegetation on the Miocene/Pliocene boundary Stuchlik (1979) connects with the fall of temperature. According to his view, the climate of the „transitional" zone still has not undergone the sharp changes as to cause the general replacement of the flora though it became unstable and affected the frequent oscillation.

In the Pontian the area of spruce forests was decreased a little while the area of the mixed deciduous forests with *Fagus*, *Quercus* and *Carya* was not almost changes (Fig. 1, Pl. I). At this time the remains of marshy vegetation were still survived. This formation was composed of *Taxodiaceae* and *Alnus*; the latter became the dominant tree. The deposits of Domański Wierch and Krościenko corresponded partially to the upper part of the Pontian. The palynological complexes of these localities reflect the similar plant cover.

From palynological spectra of the deposits of Domański Wierch and Krościenko it may be judged about the flora of the Dacian time. The diagram provided by Oszast (1973) as well as Szafer's data (1946) indicate that the flora of Krościenko was richer and had more Tertiary elements then the flora of Domański Wierch.

The main sign of Dacian vegetation was the dominance of *Picea*, occupying all mountain zones (Fig. 1, Pl. II). The deciduous communities still surviving *Parrotia*, *Magnolia*, *Eucommia*, *Engelhardtia* and others, grew at the foothills. On the whole, however, the time, corresponding to Dacian is defined as a typical interpliocene cool period (Szafer 1954, Stuchlik 1979).

The Domański Wierch deposits were studied by Zastawniak (1972). As the author notes, the fossil flora is represented only by leaf-bearing species and completely lacks the remains of coniferous plants. On this basis it was made a conclusion that the leaf prints, being survived in the Domański Wierch reflect only local vegetation, encircling the sedimentary basin.

The Mizerna beds terminate the Pliocene in Southern Poland. At this time, from Oszast's data (1973), it is noted the reduction of a role of Tertiary elements which are not entirely extinguished. The author divides the entire profile into three parts.

In the lower part the percentage of Tertiary genera is still great. Evidently, the samples we have studied correspond to this stretch of time. As judged by the diagrams, a role of *Abies*, *Tsuga*, *Taxodiaceae*, *Sciadopitys*, *Fagus*, *Juglans*, *Quercus*, *Zelkova*, *Carya*, *Liquidambar*, *Platycarya*, *Engelhardtia*, *Nyssa* in Mizerna beds as compared with the previous period is increased. At the same time the composition of *Picea* is decreased (Fig. 1, Pl. III).

The amount of Tertiary genera in the spectra of middle part of this section is decreased, while the upper part is found to be dominated by the herbaceous plants.

Western Georgia

A description of the Neogene floras of Western Georgia we begin from the Karaganian, Kartvelian and Konkian deposits, corresponding to the upper part of Badenian Stage in the Central Paratethys.

The Middle Miocene floras were studied both from the leaf prints (Avakov 1979) and by the method of palynological analysis (Ramishvili 1982).

In the opinion of Ramishvili, the palynological spectra of the Karaganian, Kartvelian and Konkian deposits are characterized by similar floral composition. On this basis the author combines them into the single palynocomplex.

Ramishvili has established about 100 taxons, belonging to 48 families and 80 genera of fossil spore and pollen.

The abundance of ferns, as well as their resemblance with the typical forms of the Paleogene and the Early Miocene provide „ancient appearance" to the Middle Miocene flora of Georgia. Among ferns it is to be noted the presence of *Lygodium*, *Anemia*, *Gleichenia*, *Glavifera*, *Dicksonia*, *Cyathea*, *Polypodium* and *Pteris*.

The Gymnosperms were represented by the following genera: *Gingko*, *Podocarpus*, *Dacrydium*, *Cathaya*, *Pseudolarix*, *Keteleeria*, *Cedrus*, *Tsuga*, *Taxodium*, *Sequoia*, *Cryptomeria*. The pollen grains of *Taxodiaceae* are not distinguished by the abundance in the deposits. This evidence characterizes the Miocene floras of Europe.

The Angiosperms are divided by Ramishvili (1982) into several groups inherent in different climatic belts.

In the group of the most thermophilous plants the author includes the representatives of *Palmae*, *Sterculiaceae*, *Sapotaceae* and various species of *Symplocos*, *Sycopsis*, *Magnolia*, *Mastixia*, *Aralia*.

The Middle Miocene palynological complex is characterized by the abundance of pollen of *Myrica* (Fig. 2, N_1 krg, knk). The dominance is noted not only by spore-pollen data but also by the evidence of macroscopic remains. The leaves of *Myrica* are abundantly represented in the Middle Miocene flora of Eastern Georgia (the Mejuda river). According to Avakov (1979), the absence of the remains of *Taxodium* of these beds as well as the scarcity of leaves of *Salix* and *Populus* indicate that *Myrica* was the edificator of the forests, growing in the lower course of the rivers which carried out the plant remains to the sea.

In the Middle Miocene deposits are frequently found pollen grains of „Castanoid" type which are difficult to determine. Nevertheless Ramishvili has established the presence of *Lithocarpus* and *Castanopsis* in these deposits. From Avakov's data (1979), *Lithocarpus* was one of the main components of the forest communities which were spread in the belt of the humid and warm climate. Of these deposits Ramishvili (1982) indicates the presence of pollen grains of *Alnus*, *Betula*, *Carpinus*, *Ulmus*, *Zelkova*, *Quercus*, *Castanea* typical of the moderate climate.

The presence of the plants of different ecological conditions in the Middle Miocene floras allows to suppose the existence of the mountainous relief, providing the altitudinal zonation of the vegetation.

Both from the leaf prints and by the palynological analysis (Avakov 1979, Ramishvili 1982) it can be stated that the most numerous community of the Middle Miocene plants were formed by subtropical trees and shrubs, being grown under conditions of high air humidity. These type of vegetation covered the lower and the middle mountain belts. The forest cover was formed by *Stercu-*

liaceae, *Araliaceae*, *Moraceae*, *Symplocos*, *Sycopsis*, *Mastixia*. The tree ferns also inhabited here.

Above these belts the subtropical forests were replaced by more mesophylous formations of plants of the warm-moderate and moderate climate. The composition of these forests was consisted of *Platanus*, *Juglans*, *Pterocarya*, *Platycarya* and others.

The most cold resistant plants — *Betula*, *Carpinus*, *Fagus* — occupied the highest mountain slopes. The coniferous species were added to them.

According to Ramishvili (1982), the climate of Georgia during the Middle Miocene time was humid-subtropical with the highest temperature for the lower mountain zone.

Palynologically the Sarmatian deposits of Western Georgia are studied a little. From Ramishvili's data (1982) since the Middle Miocene the floristic complex changes insignificantly. The quantitative change of the composition of plants of different ecological groups is observed. The amount of the pollen grains of mesophyllous tree plants in the spectra is increased. The pollen grains of beech which are close to recent *Fagus orientalis* appears.

From the Sarmatian deposits of Abchazia Kolakovski and Shakryl (1976) described the leaf prints, belonging to about 100 species. The composition of the flora has typical subtropical and even tropical appearance. From Kolakovski's point of view, in the Sarmatian time evergreen subtropical forests with the predominance of *Lauraceae*, *Myrsinaceae* existed in the lower mountain belt of Abchazia. Evidently, *Melastomites* sp., *Smilax protolancaefolia* Kol., *Mastixia micraphylla* Kol., *Symplocos* sp. inhabited here.

In the Sarmatian flora of Abchazia with the typical subtropical evergreen species the plants peculiar to warm moderate and even moderate climate are found. They are the following: *Pinus*, *Sequoia*, *Platanus*, *Carya*, *Pterocarya*, *Alnus*, *Carpinus*, *Castanea* and others.

The flora of the Goderdzi suite, being buried in volcanogenous-sedimentary formation of the Mio-Pliocene deposits of Southern Georgia is of Sarmatian age (Uznadze & Tsagareli 1979). The majority species of this flora are represented by subtropical plants the dominance of which are *Laurus* and *Castanopsis*. The leaves of *Carpinus grandis* are found also in a great number. According to the authors, this species was the edificator of the forests, growing on the localities with somewhat low temperature regime. Evidently, the other warm moderate and moderate plants also inhabited on the same localities. It is to be noted that neither Kolakovski nor Uznadze encountered the leaves similar to recent *Fagus orientalis* in the Sarmatian deposits. In the opinion of Uznadze, the absence of this species is one of the indices of Sarmatian age of Goderdzi suite flora. From this locality the leaves close to the recent beech were described only by Palibin (Uznadze & Tsagareli 1979). The pollen grains morphologically similar to *Fagus orientalis* appear already in Sarmatian (Ramishvili 1982).

In the Late Sarmatian a sharp elevation of the Greater and the Lesser Caucasus starts, being transformed into mightly mountain Chains (Milanovski 1968). During the Early Pliocene from the estimate of Tsagareli and Astakhov (1971), an averige elevation of the surface of the Greater Caucasus makes up 2 km and the Lesser Caucasus — 1 km. Towards the Middle Pliocene the recent folded mountain systems of Georgia were finally formed. Thanks to this phenomenon Western Georgia was transformed into an isolated region. Starting from this time the history of Colchian refugium begins (Kolakovski & Shakryl 1976).

The study of the Meotian flora was carried out both by the leaf prints and from palynological data (Uznadze 1965, Kolakovski et al. 1970, Purtseladze & Tsagareli 1974, Purtseladze 1977).

We have analysed Meotian deposits, outcropping on the banks of the Gejiri and Atapi rivers. It is essential to note that on the transition of the Miocene to the Pliocene a role of the coniferous: *Abies*, *Tsuga*, *Picea*, *Cedrus*, *Araucaria*, *Taxodiaceae* is increased. Among the deciduous plants the predominant component of spectra becomes *Carya* while the amount of the pollen grains of *Myrica*, *Platycarya* and *Engelhardtia* is decreased (Fig. 2, N_1 mt).

The ferns become somewhat poor. The forms typical of Paleogene and Early Miocene disappeared. They are as follows: *Lygodium multivallatum* (Krutzsch) Ram., *Toroisporites lusaticus* Krutzsch, *Clavifera triplex* Bolch., *Liotriletes miocaenicus* Nagy (*Cyathea* sp.), L. *wolffi* Kr., *Divisisporites* W. Kr.

However, the composition of Meotian ferns continuous to remain rich and diverse. The representatives of *Lygodium*, *Anemia*, *Mohria*, *Gleichenia*, *Matonia*, some species of *Dicksonia*, *Cibotium*, different forms of *Pteris* and *Polypodium* constituted the core of Meotian spore flora.

Sine the Sarmatian in Western Georgian flora a great number of evergreen plants, being typical of the humid subtropical climate disappear. They are as follows: *Apocynophyllum wrightianum* Kol., *Acanthopanax mirabilis* (Kol.) Kol., *A. serratus* Kol., *Dendropanax* sp., *Schefflera intergrifolia* (Kol.) Kol., *S. sarmatica* Kol., *Castanopsis abchasica* Kol., *Cryptocarya abchasica* Shak., *Daphnogene abchasica* Shak., *Ocotea curviparia* Kol. et Shak., *O. givulescui* Kol. et Shak., *Persea pliocenica* (Laur.) Kol., *P. schakrylii* Kol., *P. sarmatica* Shak., *Caesalpinites schaparenkoi* Kol., *Cassiophyllum magnum* Kol., *C. phaseolites* (Ung.) Kol., *C. sarmatica* Kol., *Pithecolobiophyllum sarmaticum* Kol., *Mastixia microphylla* Kol., *Myrsine radobojana* Ung.

In the Meotian the area of subtropical evergreen forests was significantly decreased as to compare with the Miocene. The edificator of these became various species of *Cinnamomum* and *Laurus*. At this time the prevailing communities were warm-moderate forests, consisting of *Carya*, *Quercus*, *Zelkova* with the mixture of *Myrica*, *Liquidambar*, *Juglandaceae*, *Nyssa*, *Sycopsis*, *Phellodendron*, *Magnolia*, *Aralia* and some others. The coniferous formations were consisted of *Picea*, *Abies*, *Tsuga*, *Cedrus*, *Podocarpus*, *Dacrydium*, *Keteleeria* and *Taxodiaceae*.

Paleobotanicaly the Pontian deposits were studied in detail by Kolakovski

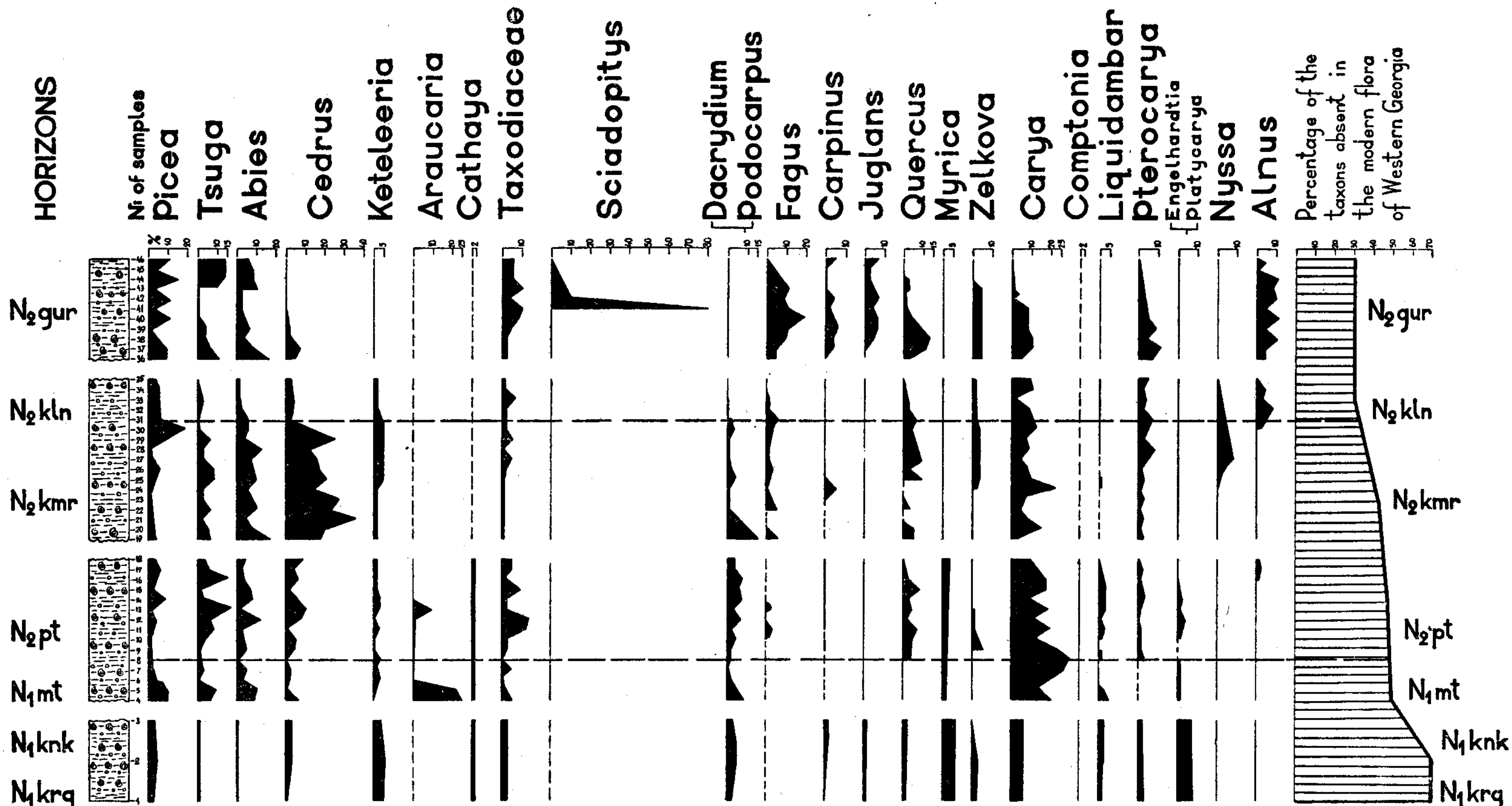

Fig. 2. Cumulative pollen diagram of Middle Miocene and Pliocene deposits of Western Georgia

(1964) and Ramishvili (1969). We have examined the Pontian beds near the village Urta, and along the rivers Zana and Atapi (Fig. 2, N_2 pt).

According to Ramishvili (1969), there were several forest belts, corresponding to different levels of the mountains on the territory of Western Georgia in the Pontian.

The thermophilous plants occupied the lowest belt. They formed mixed forests with the evergreen plants: *Araliaceae*, *Leguminosae*, *Myrsinaceae*, *Sapindaceae*, *Symplocaceae*, *Theaceae*. From Kolakovski's data (1964), the subtropical element played a minor role, constituting only 5% of the entire Pontian flora.

The humid warm-moderate plants — *Carya*, *Pterocarya*, *Platanus*, *Quercus*, *Zelkova* and others inhabited the lower and middle belts of the mountains. They prevailed both by the amount of species and landscape-formed significance, constituting 53% of the entire Pontian flora.

The dark-coniferous forests of *Abies*, *Tsuga*, *Cedrus*, *Picea* occupied the highest localities of the mountains.

The palynological complexes of the Kimmerian stage was studied by Mchedlishvili (1963) and the macroscopic remains of plants by Kolakovski (1956). We have analysed the samples of the sections of the Duabi river, near villages Mokvi and Pokveshi and of different outcrops of the Southern part of Western Georgia (Shatilova 1984).

The same formations as in the Pontian continued to inhabit the Kimmerian on the territory of Western Georgia but their composition was poorer. According to the opinion of Kolakovski (1956), in the composition of flora a role of pantropical, macaronesian and Eastern Asian elements is decreased and the significance of Colchian and Northern American species is increased on the transition of the Pontian to the Kimmerian.

In the Kimmerian the laural forests are represented by relict formation which towards the end of Middle Pliocene is completely extinguished on the territory of Western Georgia. The warm-temperated forests of different composition continue to remain as the main community (Fig. 2, N_2 kmk).

In the Kimmerian the composition of spore plants is somewhat poorer than in the earlier stretches of the Pliocene. Such genera as *Lygodium*, *Gleichenia* are represented by single spores; the species of *Cibotium*, *Matonia*, *Mohria* are completely disappeared; a role of *Pteris* and *Polypodium* is greatly increased in the spectra.

The palynological complexes of the Egrissian (Kuyalnikian) stage and Gurian horizon were studied near villages Pokveshi, Gogoreti, Chvarbeti, Tsichis Perdi, Arczeuli (Shatilova 1984). The Late Pliocene was distinguished by unstable climatic conditions. As by palynological data the frequent changes of the climate occured for the whole Egrissian (Kuyalnikian) time. This factor, naturally, could affect the plant communities. Three stages are observed in their development, corresponding to three stratigraphical horizons.

The deposits of the first stage are characterized by two types of complexes.

The lower horizon of Egrissian stage might be divided into two parts. The lower part includes rich spectra similar to the Kimmerian while the upper part has poor complex, prevailing component of which is *Pinus*.

During the second stage (Fig. 2, N_2 kln) the rich and diverse vegetation is newly restored on the territory of Western Georgia. The plant communities consist of *Tsuga*, *Pinus*, *Cedrus*, *Abies*, *Carya*, *Pterocarya*, *Quercus*. The species of *Podocarpus*, *Dacrydium*, *Symplocos*, *Acacia*, *Magnolia*, *Alangium*, *Aralia* are added to them. The ferns are represented by *Pteris*, *Polypodium*, *Dicksonia*, *Cyathea*. Nevertheless the flora of this stretch of the Egrissian is poorer than the Kimmerian, lacking such elements as *Lygodium*, *Gleichenia*, *Gingko*, *Sycopsis*, *Corylopsis*, *Palmae* and some others.

The broad-leaved forests newly change their extention area in the Late Egrissian (third stage). They are replaced by dark-coniferous communities with the predominance of *Picea*, *Abies* and *Tsuga*. One of the causes of these wide spread communities, we consider, is the change of climate and the maintenance of favourable conditions for the development of dark-coniferous associations both in the upper and lower mountain zones. As it is noted by Tolmachev (1954) dark-coniferous forests show the establishment of moderate and humid climate in any region.

The fall of temperature is fixed not only from data of terrestial flora but according to remains of the marine molluscs and diatoms in the Latter Pliocene of the Black Sea region (Davitashvili 1956, Zhuze et al. 1980).

On the basis of palynological data three stages are distinguished in the development of Gurian vegetation (Fig. 2, N_2 gur).

Despite the definite floristic and coenozoic similarity between the Egrissian and the Early Gurian plant communities the latter differ by a great role of the mesophilous elements as well as by the decrease of subtropical and warm-temperate ferns: *Cyathea*, *Dicksonia* and *Pteris*.

In the Middle Gurian stage the distribution area of coniferous plants of warm-moderate climate — *Sciadopitys*, *Cupressaceae* and *Taxodiaceae* — was significantly greater. As judged by palynological data, these plants were represented by the following genera: *Sequoia*, *Cryptomeria*, *Cunninghamia*, *Metasequoia*, *Glyptostrobus*, *Taxodium*, *Libocedrus* and *Juniperus*.

The predominance of these plants in the coenoses allowed to suppose that the middle stretches of the Gurian time were characterized by warm and humid climate conditions. It could cause the smoothing of limits between dark-coniferous forests and more warm-temperate communities.

The specific feature of the vegetation of the following stage — Late Gurian — is the prevalence of moderate plants. The dominants of the forest coenoses become *Fagus*, *Tsuga*, *Abies* and *Picea*.

On the whole, during the Gurian the development of flora follows smoothly. However, in the course of this time it is traced a gradual increase of a role of mesophilous plants, which become the predominants of the forests of middle and upper mountain zones. They form here new monodominant communities untypical for Pliocene. These changes, probably, were associated with the formation of mountain relief and the establishment of climate conditions, being optimal for development of such species as: *Fagus*, *Abies*, *Tsuga*.

Thus, towards the end of Pliocene the vegetation of Western Georgia assumes the feature close to the recent.

Three main formations, attributing to different belts are distinguished: the dark-coniferous forests, beech forests and mixed broad-leave forests. The latter ones differ by variegation and diversity. In the course of entire Early and Middle Pleistocene the plants typical of the Pliocene flora survived in these forests. In the Quaternary just this formation undergone the greatest changes. As to the first two formations they experience only scarsity of floral composition, unchanging the feature and structure of the coenoses.

CORRELATION OF PALYNOLOGICAL DIAGRAMS OF THE NEOGENE

Deposits of Southern Poland and Western Georgia

The history of vegetation of Southern Poland and Western Georgia since the Middle Miocene to the end of Pliocene was considered in the previous sections. Now we shall try to correlate these processes, following the features of similarity in the development of terrestrial biocoenoses of these territories.

On comparing the palynocomplexes the difference of the compositions of spore plants attracts our attention.

In Poland the Badenian and Sarmatian floras still have such genera as *Hymenophyllum*, *Lygodium*, *Gleichenia*, *Cyathea*. They are represented by minor amount of spores in the spectra. On the transition of Miocene to Pliocene subtropical ferns were completely disappeared except *Cyathea* single spores of which still occured in the Pontian. The amount of the spores of *Polypodiaceae* significantly decreased.

In Western Georgia the generic composition of ferns was far richer what can be seen from the enclosed list (table 2). Particularly the great diversity of ferns is observed in the floras of the Miocene and Early Pliocene. To the end of the latter the most thermophilic representatives of this group such as: *Cibotium*, *Lygodium*, *Gleichenia*, *Matonia*, *Mohria*, *Anemia* had died out. As to *Cyathea* and *Dicksonia* they are survived up to the end of Miocene. In the Pliocene on the amount of species and the abundance of spores in the deposits the genera of *Pteris* and *Polypodium* are distinguished. Their species composition becomes significantly poor only in the second half of Gurian time. At the same time the area of ferns, typical of the moderate climate such as: *Asplenium*, *Athyrium*, *Dryopteris*, *Cystopteris*, *Thelypteris* is increased.

The history of the development of woody plants of these regions is also different. In the Middle Miocene of Southern Poland the swamp forests of *Taxodiaceae*, *Nyssa*, *Cyrilla* and other components prevailed. They occupied, evidently, the entire plain part of the territory. The deciduous communities grew on drier

Table 2

List of Plants

Name of Plants	Western Georgia	Southern Poland
1	2	3
Sphagnum sp.	X	X
S. aff. *cuspidatum* Ehrh. et Hoffm.	X	—
Lycopodium sp.	X	X
L. alpinum L.	X	—
L. annotinum L.	X	X
L. clavatum L.	X	X
L. innundatum L.	—	X
L. selago L.	X	X
L. serratum L.	X	—
Selaginella sp.	X	X
S. atrivirides Spring.	X	—
S. aff. *eggersii* Sodiro	X	—
S. fusca N. Mtchedl.	X	—
S. sanguinolenta (L.) Spring	X	—
S. selaginoides (L.) Link	X	X
S. aff. *sibirica* (Milde) Hieron	X	—
Echinatisporites miocenicus W. Kr. (*Selaginella* sp.)	X	—
Equisetum sp.	X	X
Bothrychium sp.	X	X
Ophioglossum sp.	X	X
O. lusitanicum L.	X	—
Osmuda sp.	X	X
O. cinnamomea L.	X	—
O. regalis L.	X	—
O. aff. *clytoniana* L.	X	X
Schizaeaceae gen. indet.	X	X
Lygodium sp.	X	X
L. digitatum Presl.	X	—
L. japonicum (Thbg.) Sw.	X	—
L. multivallatum (Kr.) comb. n. Ram.	X	—
Toroisporites lusaticus W. Kr. (*Lygodium* sp.)	X	—
Anemia sp.	X	—
Mohria sp.	X	X
Onychium sp.	X	—
Cryptogramma sp.	X	X
C. acrostichoides R. Br.	X	—
C. aff. *crispa* (L.) R. Br.	X	—
Anogramma sp.	X	—
Pityrogramma sp.	X	—
Pteris sp.	X	X
P. cretica L.	X	—
P. aff. *grandiflora* L.	X	—
P. longifolia L.	X	—
P. aff. *togoensis* Hieron	X	—
P. venusta Krez.	X	—
P. verus N. Mtchedl.	X	—

1	2	3
P. vittata L.	X	—
Polypodiaceoisporites triangulus W. Kr. (*Pteris* sp.)	X	—
P. gracillimus Nagy (*Pteris* sp.)	X	—
P. microverrucosus Sim. (*Pteris* sp.)	X	—
P. lusaticus W. Kr. (*Pteris* sp.)	X	—
P. helveticus W. Kr. (*Pteris* sp.)	X	—
Hymenophyllum sp.	X	X
Hymenophyllum rotundum N. Mtchedl.	X	—
Gleicheniaceae gen. indet.	X	X
Gleichenia angulata Naum.	X	—
Matonia sp.	X	—
Glavifera triplex Bolch.	X	—
Pyrrosia sp.	X	—
Polypodium sp.	X	X
P. aureum L.	X	—
P. pliocenicum Ram.	X	—
P. serratum (Willd.) Futo	X	—
P. verrucatum Ram.	X	—
P. vulgare L.	X	—
Polypodiaceae gen. indet.	X	X
Verrucatosporites histiopteroides W. Kr. (*Polypodium* sp.)	X	—
V. alienus (R. Pot.) Th. et Pf. (*Polypodium* sp.)	X	—
V. favus (R. Pot.) Th. et Pf. (*Polypodium* sp.)	X	—
Microlepis sp.	—	X
Cyathea sp.	X	—
Cyatheaceae gen. indet.	X	X
Leiotriletes miocaenicus Nagy (*Cyathea* sp.)	X	—
L. wolfii W. Kr. (*Cyathea* sp.)	X	—
Divisisporites W. Kr. (*Cyathea* sp.)	X	—
Alsophila sp.	X	X
Dicksonia sp.	X	—
D. antarctica R. Br.	X	—
D. aff. *fibrosa* Col.	X	—
D. luculenta Purc.	X	—
D. reticulata Purc.	X	—
D. unitotuberata Purc.	X	—
Cibotium guriense Purc.	X	—
Thelypteris sp.	X	—
Asplenium viride Huds.	X	—
Arhyrium sp.	X	—
Gymnocarpium sp.	X	—
Cystopteris sp.	X	X
Woodsia sp.	X	—
W. alpina (Bolton.) S. F. Gray	X	—
W. aff. *polystichoides* Eaton.	X	—
Polystichum lonchitis Both.	X	—
Polystichum sp.	X	—
Dryopteris sp.	X	—
Woodwardtia sp.	X	—
Salvinia sp.	X	—

1	2	3
Azolla sp.	X	—
Ginkgo biloba L.	X	X
Araucaria sp.	X	—
Abies sp.	X	X
A. alba Mill.	X	—
A. aff. *cephalonica* Loud.	X	—
A. ciliticaeformis N. Mtchedl.	X	—
A. nordmanniana (Stev.) Spach.	X	—
Keteleeria sp.	—	X
K. caucasica Ram.	X	—
Pseudotsuga sp.	X	X
Tsuga sp.	—	X
T. aculeata Anan.	X	—
T. aff. *blaringhemi* Flous.	X	—
T. canadensis (L.) Carr.	X	X
T. chinensis typ	—	X
T. diversifolia (Maxim.) Mast.	X	X
T. inordinata Mched.	X	—
T. korenevae Mched.	X	—
T. meirii Mched.	X	—
T. pattoniana Engelm.	X	X
T. schatilovae Mched.	X	—
T. sivakii Mched.	X	—
T. tortousa Mched.	X	—
T. siboldii Carr.	—	X
Cathaya sp.	X	—
C. aff. *argyrophylla* C. et K.	X	—
Picea sp.	X	X
P. orientalis L.	X	—
P. complanataeformis N. Mtchedl.	X	—
P. minor N. Mtchedl.	X	—
P. aff. *schrenkiana* E. et M.	X	—
Pseudolarix sp.	X	—
P. aff. *kaempferi* Gold.	X	—
Larix sp.	—	X
Cedrus sp.	X	X
C. athlantica Manetii	X	—
C. deodara Loud.	X	—
C. aff. *libani* Laws.	X	—
C. sauerae N. Mtchedl.	X	—
Pinus sp.	X	X
P. halepensis Mill.	X	—
P. pithyusa Stev.	X	—
Cryptomeria sp.	—	X
C. japonica Don	X	—
Taxodium sp.	X	X
Sequoia sp.	X	X
Metasequoia sp.	X	—
Glyptostrobus sp.	X	X
Cunninghamia sp.	X	X

1	2	3
Sciadopitys sp.	—	X
Sciadopitys verticillatiformis Schat. et Ram.	X	—
Taxodiaceae gen. indet.	X	X
Chamaecyparis sp.	X	X
Juniperus sp.	X	X
Libocedrus sp.	X	—
Cupressus sp.	X	X
Cupressaceae gen. indet.	X	X
Taxus sp.	X	X
Podocarpus sp.	X	X
Dacrydium sp.	X	—
Phyllocladus sp.	X	—
Ephedra sp.	X	X
E. distachya L.	X	—
E. aff. *equisetina* Bge.	X	—
E. aff. *strobilacea* Bge.	X	—
Gnetaceae gen. indet.	—	X
Myrica sp.	X	X
M. intermedia Glad.	X	—
M. pseudogranulata Glad.	X	—
Comptonia sp.	X	—
C. aborigena Glad.	X	—
C. grandis Glad.	X	—
C. imperfecta Glad.	X	—
Juglans sp.	X	X
J. cinerea L.	X	X
J. nigra L.	X	—
J. aff. *rupestris* Engelm.	X	—
Pterocarya sp.	X	X
P. pterocarpa (Michx.) Kunth	X	X
P. rhoifolia Sieb. et Zucc.	X	X
P. aff. *stenoptera* DC.	X	X
Cyclocarya aff. *paliurus* (Batalin) Iljin.	X	—
Platycarya sp.	X	X
P. miocaenica Nagy comb. nov. Ram.	X	—
Engelhardtia sp.	X	X
E. spicata Blume	X	—
Monipites punctatus Nagy (*Engelhardtia* sp.)	X	—
Carya sp.	X	X
C. aquatica (Michx.) Nutt.	X	X
C. cordiformis (Wangh.) C. Koch	X	—
C. aff. *ovata* Mill.	X	—
C. aff. *texana* DC.	X	—
C. aff. *clabra* (Mill.) Sweet	X	—
C. aff. *pecan* (Marsh.) Engl.	X	—
Salix sp.	X	X
Alnus sp.	X	X
A. kefersteinii t.	—	X
A. incana-glutinosa t.	—	X
Betula sp.	X	X

1	2	3
B. pubescens Ehrh.	X	—
Ostrya sp.	X	—
Carpinus sp.	X	X
C. orientalis Mill.	X	—
C. betulus L.	X	X
C. caucasica A. Grossh.	X	—
Corylus sp.	X	X
Castanea sp.	X	X
C. sativa Mill.	X	—
Castanopsis sp.	X	X
Fagus sp.	X	X
F. orientalis Lipkky	X	—
F. sylvatica L.	—	X
F. ferruginea t.	—	X
Quercus sp.	X	X
Lithocarpus sp.	X	—
Tricolporopollenites henrici (R. Pot.) Th. et Pf.	X	X
T. cingulum (R. Pot.) Th. et Pf.	X	X
Pasania sp.	—	X
Ulmus sp.	X	X
U. laevis Pall.	X	—
U. foliacea Gilib.	X	—
U. propinqua Koidz.	X	—
Zelkova sp.	X	X
Z. carpinifolia (Pall.) Dipp.	X	—
Z. serrata (Thunb.) Macino	X	—
Celtis sp.	X	X
Eucommia aff. *ulmoides* Oliv.	X	X
Morus sp.	X	X
M. alba L.	X	—
Ficus sp.	X	—
Humulus lupulus L.	X	—
Moraceae gen. indet.	X	X
Urtica sp.	X	X
Olacaceae gen. indet.	—	X
Santalaceae gen. indet.	—	X
Lorantaceae gen. indet.	—	X
Polygonum sp.	X	X
P. persicaria L.	X	X
Rumex sp.	—	X
Caryophyllaceae gen. indet.	X	X
Stellaria sp.	—	X
Chenopodiaceae gen. indet.	X	X
Atriplex sp.	—	X
Kochia sp.	X	—
Annona sp.	X	—
Magnolia sp.	X	X
M. grandiflora L.	X	—
M. denudata Desr.	X	—
M. aff. *accuminata* L.	X	—

1	2	3
M. neogenica (W. Kr.) comb. nov. Ram.	X	—
Liriodendron tulipifera L.	X	X
Lauraceae gen. indet.	X	X
Laurus nobilis L.	X	—
Cinnamomum sp.	X	X
Batrachium sp.	X	X
Ranunculaceae gen. indet.	X	X
Aconitum sp.	—	X
Menispermum sp.	X	—
Nymphea sp.	X	X
Nupnar sp.	X	X
N. luteum (L.) Smith	X	—
Stewardia sp.	—	X
Cruciferae gen. indet.	X	X
Platanus sp.	X	X
P. orientalis L.	X	—
Parrotia aff. *persica* (DC.) C.A.M.	X	X
Fothergilla sp.	X	X
Hamamelis sp.	—	X
Disanthus sp.	X	—
Distylium sp.	X	—
Corylopsis sp.	X	X
Liquidambar sp.	X	X
L. aff. *orientalis* Mill.	X	—
L. formosana Hance	X	—
L. styraciflua L.	X	—
Fortunearia sp.	X	—
Sycopsis colchica Ram.	X	—
Itea sp.	—	X
Rosaceae gen. indet.	X	X
Crataegus sp.	—	X
Filipendula sp.	—	X
Rubus sp.	—	X
Sanguisorba sp.	X	X
Potentilla sp.	—	X
Sorbus sp.	X	X
Kerria sp.	X	—
Acacia sp.	X	—
Leguminosae gen. indet.	X	X
Caesalpiniaceae gen. indet.	—	X
Decodon sp.	—	X
D. cf. *globosus*	—	X
Geraniaceae gen. indet.	X	—
Geranium sp.	X	X
Phellodendron sp.	X	X
Euphorbiaceae gen. indet.	X	X
Ptelea sp.	—	X
Rutaceae gen. indet.	—	X
Meliaceae gen. indet.	—	X
Lythrum sp.	—	X

1	2	3
Rhus sp.	X	X
R. toxicodendron L.	X	—
Pistacia sp.	X	X
Sapindus sp.	X	—
Acer sp.	X	X
A. aff. *platanoides* L.	X	—
A. aff. *campestre* L.	X	—
Aesculus sp.	X	—
Cyrilla sp.	—	X
Cyrillaceae-Clethraceae gen. indet.	—	X
Ilex sp.	X	X
Euonymus sp.	X	X
Staphylea sp.	X	X
S. colchica Stev.	X	—
Buxus sempervirens L.	X	X
Rhamnaceae gen. indet.	X	X
Parthenocissus quinquefolia (L.) Planch.	X	X
Vitis sp.	X	X
V. betulifolia Diels. et Gilib.	X	—
V. aff. *forestalensis* Trav.	X	—
Tilia sp.	—	X
Tilia sp. I	X	X
T. caucasica Rupr.	X	—
T. cordata Mill.	X	X
T. aff. *grandipollinia* Trav.	X	—
T. ledebourii Borb.	X	—
T. platyphyllos Scop.	X	X
T. tomentosa Moench.	X	—
Malvaceae gen. indet.	X	X
Sterculia sp.	X	X
Reevesia sp.	—	X
Eleagnus sp.	X	X
Hippophae sp.	—	X
Viola sp.	—	X
Tamarix sp.	—	X
Myrtaceae gen. indet.	X	X
Epilobium sp.	X	X
Oenotheraceae gen. indet.	X	X
Myriophyllum sp.	—	X
Gunnera sp.	—	X
Alangium sp.	X	—
Nyssa sp.	X	X
N. sylvatica L.	X	—
N. aff. *ingentipollinia* Trav.	X	—
Camptotheca sp.	—	X
Cornus sp.	X	X
Araliaceae gen. indet.	X	X
Aralia sp.	X	X
A. hispida Michx.	X	—
Fatsia sp.	X	—
Hedera sp.	X	X

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Schefflera sp.	—	X
Tricolpopollenites edmundi (R. Pot.) Th. et Pf.	X	X
Bifora sp.	—	X
Umbelliferae gen. indet.	X	X
Rhododendron sp.	X	X
Ericaceae gen. indet.	X	X
Primulaceae gen. indet.	—	X
Armeria sp.	—	X
Sapotaceae gen. indet.	X	X
Symplocos sp.	X	X
S. paniculata Wall.	X	—
S. aff. *tinctoria* (L.) L'Her	X	—
Mastixia sp.	X	X
Apocynaceae gen. indet.	—	X
Forsytia sp.	—	X
Fraxinus sp.	X	X
Syringa sp.	—	X
Ligustrum sp.	X	X
Oleaceae gen. indet.	X	X
Rubiaceae gen. indet.	—	X
Polemonium sp.	—	X
Convolvulaceae gen. indet.	X	X
Boraginaceae gen. indet.	X	X
Labiatae gen. indet.	X	X
Solanaceae gen. indet.	—	X
Plantago sp.	X	X
Viburnum sp.	X	X
Lonicera sp.	X	X
Diervilla sp.	—	X
Dipelta sp.	—	X
Caprifoliaceae gen. indet.	X	X
Valeriana sp.	X	X
Scabiosa sp.	X	X
Succisa sp.	—	X
Knautia sp.	X	—
Cephalaria sp.	X	—
Campanulaceae gen. indet.	X	X
Artemisia sp.	X	X
Compositae gen. indet.	X	X
Centaurea sp.	X	X
Butomus sp.	—	X
Iridaceae gen. indet.	X	X
Liliaceae gen. indet.	X	X
Potamogeton sp.	X	X
Cyperaceae gen. indet.	X	X
Gramineae gen. indet.	X	X
Palmae gen. indet.	X	X
Nypa sp.	X	—
Sparganium sp.	X	X
Typha latifolia L.	X	—
T. angustifolia t.	—	X

soils. At this time the dark-coniferous species — *Picea, Tsuga* and *Abies* — whether did not form an independent formation or had a limited area.

Another type of vegetation existed in the Middle Miocene on the territory of Western Georgia. The main evidence of this vegetation was the absence of dominating communities. The formation of marshy forests of *Taxodiaceae-Cupressaceae* identical to that which dominated in the Central Europe lacked here.

In Georgia the communities of subtropical deciduous plants and shrubs formed mainly the lower zone of forest. They were consisted of *Myrica, Sterculia, Araliaceae, Moraceae, Symplocos, Sycopsis, Mastixia*, evergreen *Fagaceae* and many others. The tree ferns also inhabited in these forests.

As judged by macroscopic remains of plants and by palynological complexes a great number of these genera were in the composition of the Middle Miocene flora. However, they did not form an independent formation and were mainly the component of mixed deciduous communities.

In Southern Poland as well as in Western Georgia on the transition of the Middle Miocene to the Sarmatian the significant changes in the compositions of flora and vegetation are not observed. The communities typical of the Middle Miocene continue to remain in both regions. The common feature of their compositions is the scarsity of dark-coniferous forests.

The Late Sarmatian was a stretch of time of the great paleogeographical changes in the Carpathian Mountains. As it was noted, towards the end of the Miocene a sea finally retreats the territory of Southern Poland. The Pliocene here are represent only by continental deposits. This fact, naturally, could affect the character of vegetation which was developed under the humid coastal climate conditions during the entire first half of the Neogene. Since the Sarmatian a great number of subtropical plants died out, the sharp increase of a role of dark-coniferous and decrease of swamp associations occured. The vegetation of Southern Poland experience periodical changes during the entire Pliocene. These changes indicate to the oscilation of climate conditions of this region.

The Sarmatian was also the turning-point of the geological history of Western Georgia. This time was associated with a sharp elevation of the Greater and the Lesser Caucasus and with the formation of the mountain relief. Thanks to this phenomenon Western Georgia was transformed into an isolated province with warm and humid climate. During the Pliocene the development of vegetation of this province occured under more favourable conditions than in the adjacent territories and in Central Europe. Nevertheless, since the Sarmatian a set of evergreen plants specific to humid subtropical climate disappeared from the floral composition of Western Georgia. In the Meotian (Mio-Pliocene) as compared with the Miocene a role of coniferous plants such as: *Pinus, Tsuga, Abies, Cedrus, Araucaria, Taxodiaceae* was increased. Among the broad-leaved plants the area of *Carya* was significantly widened.

The vegetation of Western Georgia is developed under the quiet conditions in Early Pliocene. However during of the Pontian and the Kimmerian a gradual decrease of the area of thermomoderate elements of flora is traced. These changes were more distinct in the Late Pliocene when the periodical climatic variations became vividly pronounced on the territory of Western Georgia. They stimulate the process of extinction of the less competitive plants and promote wide--spreading of forests typical of warm-moderate and moderate climate.

The end of Middle and the beginning of Late Pliocene of the eastern coast of the Black Sea may be correlated with the Dacian of Central Europe. At this time a role of numerous Tertiary elements of biocoenoses significantly decrease. This stretch is determinated as the Intrapliocene cold period. At this stage, however, complete extinction of the Tertiary flora still does not occure. In the Romanian the area of such plants as: *Taxodiaceae*, *Nyssa*, *Liquidambar* and some others is again increased on the territory of Poland. To this period corresponds the spectra of the lower part of Mizerna beds. The upper part of this section, being characterized by the predominance of herbaceous plants belongs to the Quaternary age.

In Western Georgia several stages of development of Gurian vegetation are also distinguished. The early stretches of the Gurian are characterized by the predominance of rich polydominant communities of Pliocene type. Only in the second half of the Gurian the appearance of new monodominant formations is observed. On the territory of Western Georgia their complete prevalance comes in the Quaternary time.

Thus, the Sarmatian was the turning-point of the development of the flora in the Carpathian Mountains as well as in the Caucasus.

Since the Sarmatian in Southern Poland quite rapid formation of the recent type vegetation begins, in which the elements of Tertiary deciduous forests take up the position of extincting relicts. This process proceeds much far slowly in Western Georgia. On this territory the plant communities close to recent ones appear only at the end of the Gurian time. The flora of this stretch still includes the great amount of genera which are absent in the recent forests of Colchis.

The common feature of the development of floras of the second half of Neogene in both regions was the frequent change of plant coenoses. This phenomenon was associated with the periodical climatic oscilation which occured during the Pliocene in Poland as well as in Western Georgia.

Thus, the comparison of palynological complexes of the Middle Miocene and the Pliocene of Southern Poland and Western Georgia indicates that in spite of different geographical position and far apart distance certain synchronism is observed in the development of the vegetation of these two regions of Paratethys. Since the general turning-points of the development of phytocoenoses are associated with the definite stratigraphic boundaries they could be considered as a basis for correlation of the Neogene marine and continental sediments of the Central and Eastern Paratethys.

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PLATES

All photomicrographs ×600, have been taken using the „Mikrophot D-16 B" Rathenow microscope, oil immersion objective apochromat 60×, eye-piece 6,3.

Plates I—IV spores and pollen grains from Neogene deposits of Southern Poland.

Plates V—XV spores and pollen grains from Neogene deposits of Western Georgia.

Abbreviations: Cz. D. — Czarny Dunajec
K. — Krościenko
M. — Mizerna
G.r. — Gejiri river
A.r. — Atapi river
U.v. — Urtha village
Z.r. — Zana river
D.r. — Duabi river
M.v. — Mokvi village
P.v. — Pokveshi village

Plate I

1. *Sphagnum* sp., Cz. D., Sarmatian
2—5. *Lycopodium selago* L., M., Pliocene
6—8. *Lycopodium clavatum* L., M., Pliocene
9, 10. *Lycopodium* sp., M., Pliocene
11, 12. *Polypodium* sp., K., Pliocene
13. *Ginkgo biloba* L., Cz. D., Mio-Pliocene
14, 15. *Podocarpus* sp., Cz. D., Sarmatian, Mio-Pliocene
16. *Glyptostrobus* sp., Cz. D., Sarmatian
17, 18. *Sequoia* sp., M., Pliocene
19—21. *Cryptomeria* sp., Cz. D., Sarmatian, M., Pliocene
22—23. *Tsuga pattoniana* Engelm., K., Pliocene

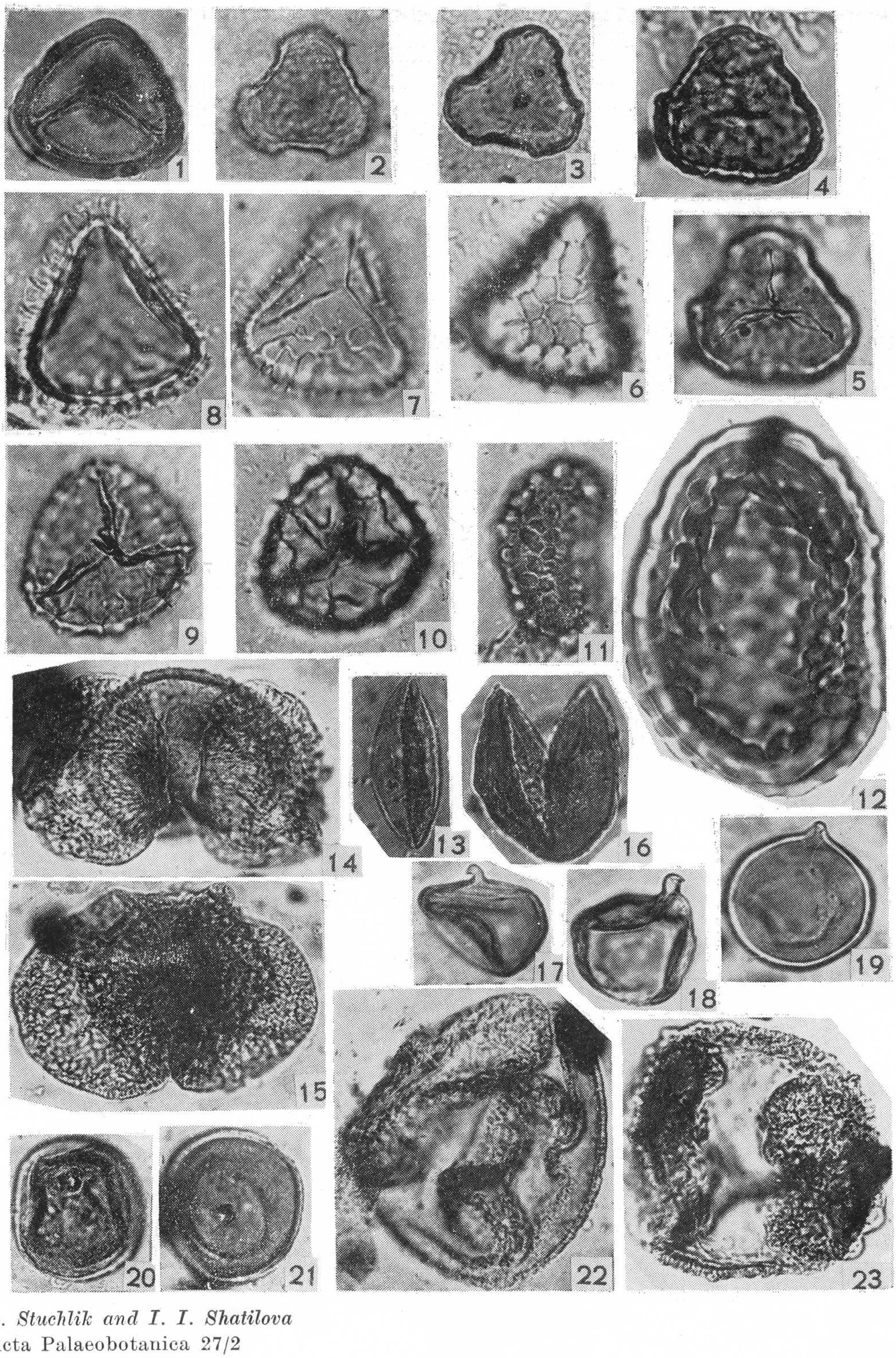
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Plate II

1, 2. ***Tsuga diversifolia*** (Maxim.) Mast., M., Pliocene
3, 4. ***Tsuga canadensis*** (L.) Carr., M., Pliocene
5, 6. ***Tsuga*** typ ***chinensis,*** M., Pliocene

Plate II

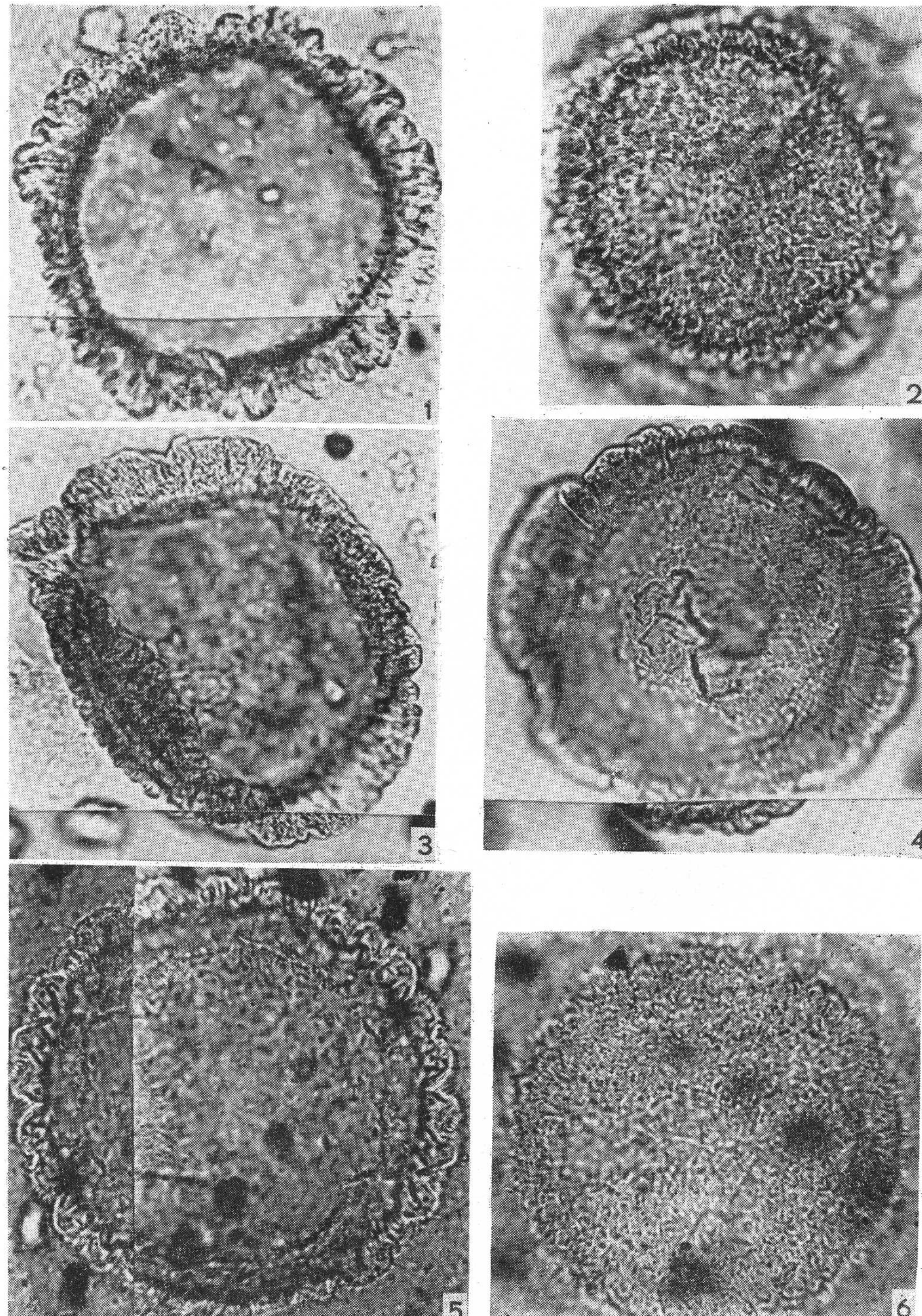

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Plate III

1, 2. *Picea* sp., M., Pliocene
3. *Cedrus* sp., K., Pliocene
4, 5. *Sciadopitys* sp., Cz. D., Badenian, Sarmatian
6. *Carya* sp., K., Pliocene
7. *Pterocarya pterocarpa* (Michx.) Kunth, K., Pliocene
8. *Juglans cinerea* L., M., Pliocene
9. *Platycarya* sp., Cz. D., Sarmatian
10. *Myrica* sp., Cz. D., Sarmatian
11, 12. *Corylus* sp., Cz. D., Sarmatian
13. *Carpinus betulus* L., M., Pliocene
14. *Fagus* sp., M., Pliocene
15—17. *Quercus* sp., K., Pliocene
18. *Ulmus* sp., M., Pliocene

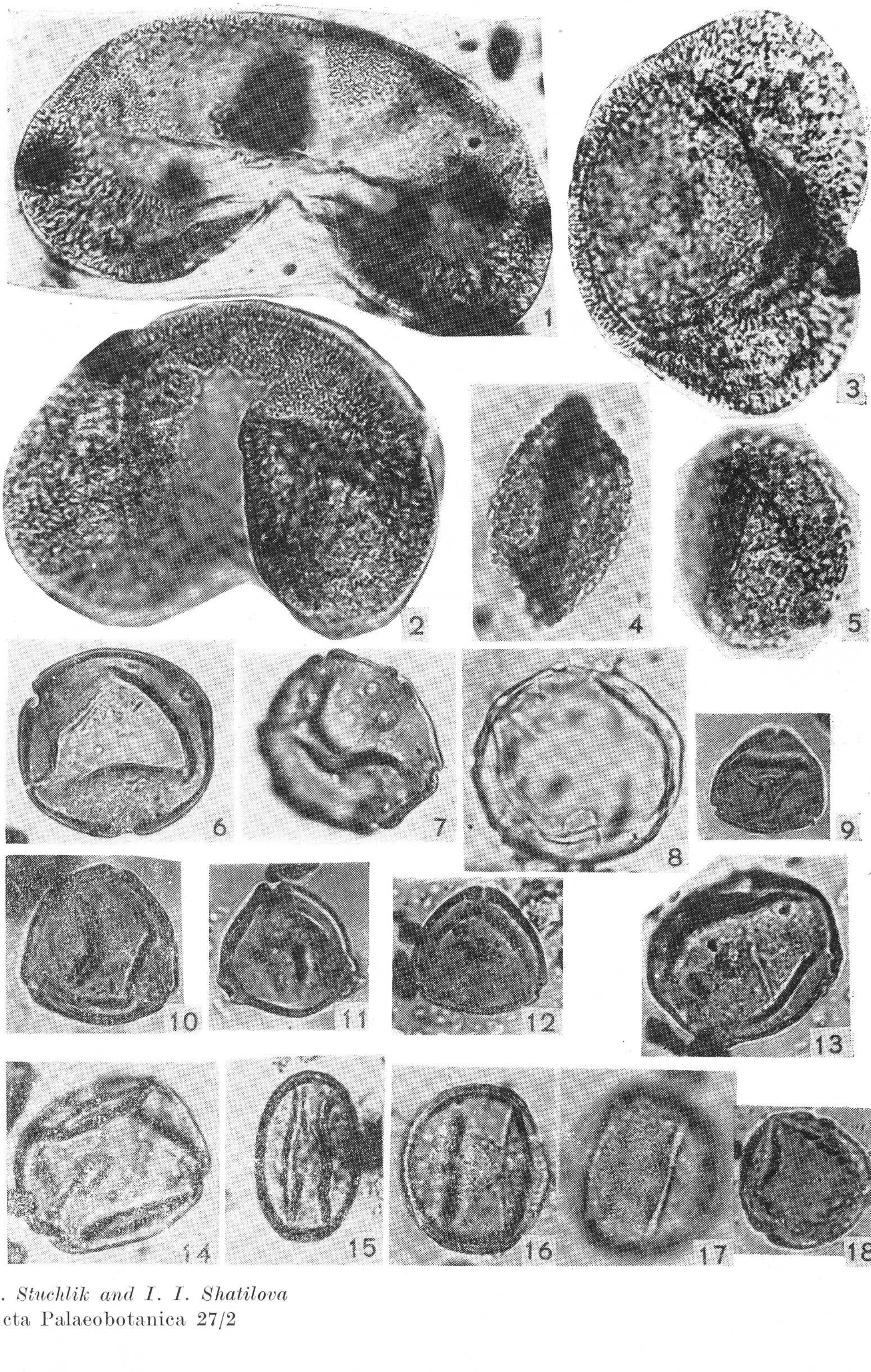

Plate IV

1. *Magnolia* sp., K., Pliocene
2. *Hamamelis* sp., Cz. D., Badenian
3. *Liquidambar* sp., M., Pliocene
4. *Tilia* sp. I, K., Pliocene
5. *Tilia* sp., Cz. D., Sarmatian

6, 7. *Tilia cordata* Mill., K., Pliocene

8. *Ilex* sp., M., Pliocene

9—11. *Tricolpopollenites edmundi* (R. Pot.) Th. et Pf., Cz. D., Badenian

12, 13. *Fraxinus* sp., K., Pliocene

14, 15. *Lonicera* sp., K., Pliocene

16—20. *Nyssa* sp., Cz. D., Sarmatian

21. *Ericaceae* gen. indet., Cz. D., Sarmatian

22, 23. *Evonymus* sp., Cz. D., Sarmatian

24. *Cornaceae* gen. indet., Cz. D., Sarmatian

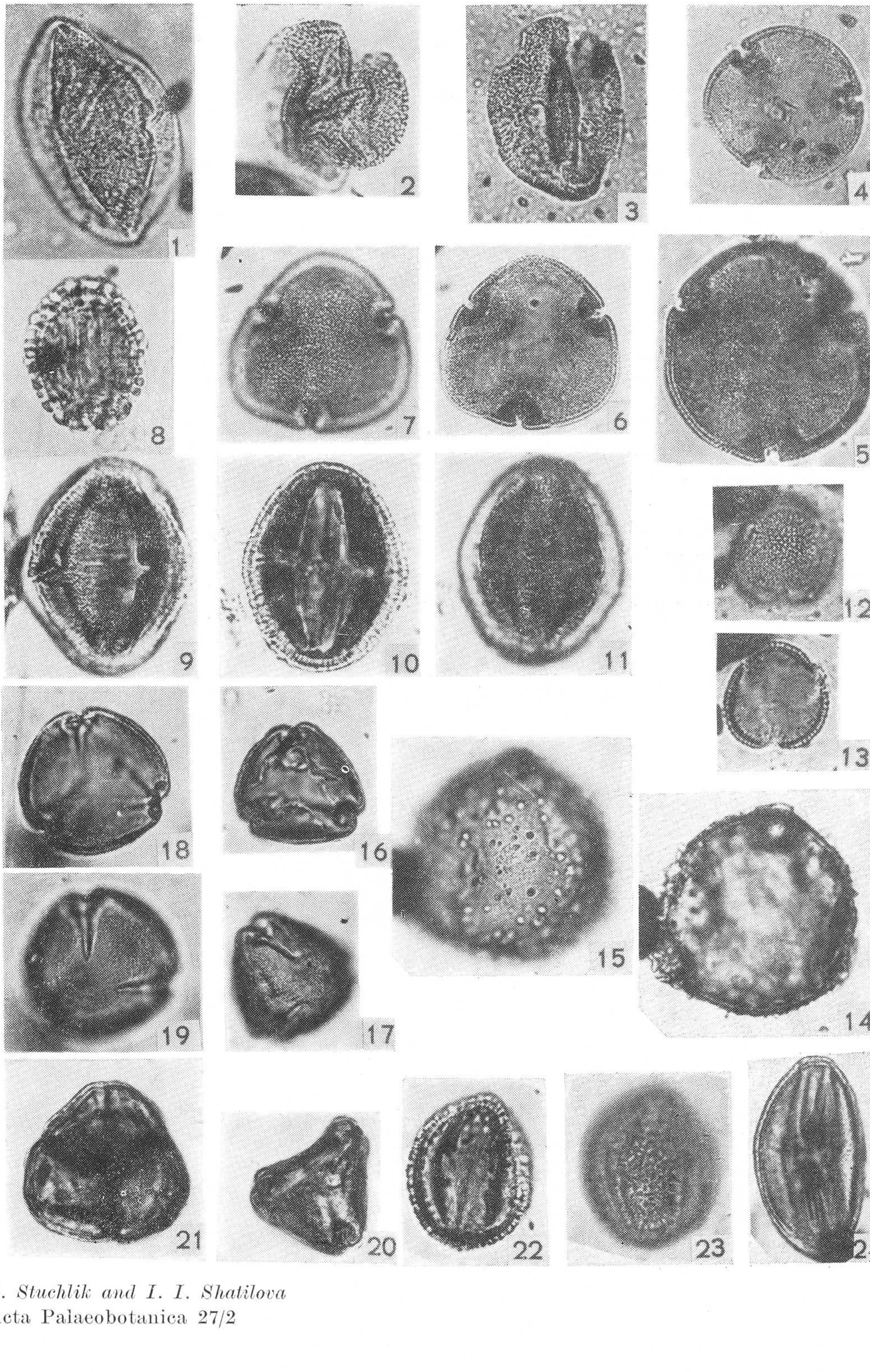
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Plate V

1, 2. *Lycopodium serratum* Thunb., D. r., Kimmerian
3, 4. *Lycopodium alpinum* L., D. r., Kimmerian
5, 6. *Lycopodium clavatum* L., D. r., Kimmerian
7. *Selaginella selaginoides* (L.) Link, D. r., Kimmerian
8, 9. *Selaginella* aff. *sibirica* (Milde) Hieron, D. r., Kimmerian
10. *Selaginella* sp., D. r., Kimmerian
11. *Osmunda* aff. *clytoniana* L., D. r., Kimmerian
12, 13. *Osmunda* sp., D. r., Kimmerian
14. *Lygodium* sp., D. r., Kimmerian
15. *Anemia* sp., Z. r., Pontian
16—18. *Anogramma* sp., D. r., Kimmerian
19. *Cryptogramma* aff. *crispa* (L.) R. Br., P. v., Kimmerian

Plate V

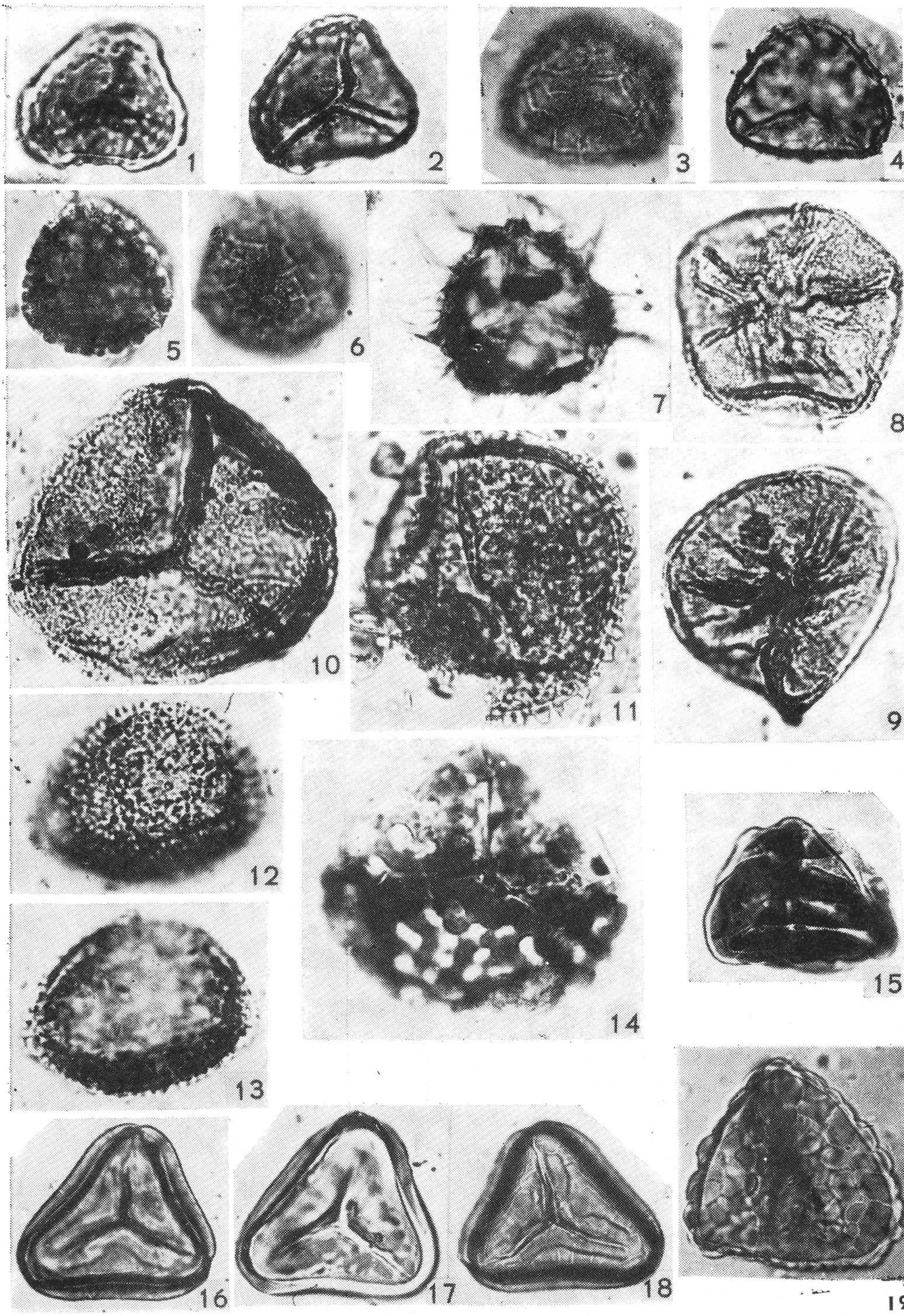

Plate VI

1, 2. *Schizaeaceae* gen. indet., D. r., Kimmerian
3, 4. *Pteris cretica* L., P. v., Kuyalnikian
5—12. *Pteris venusta* Krez., D. r., Kimmerian
13, 14. *Pteris* sp., D. r., Kimmerian
15, 16. *Pteris* aff. *grandiflora* L., D. r., Kimmerian

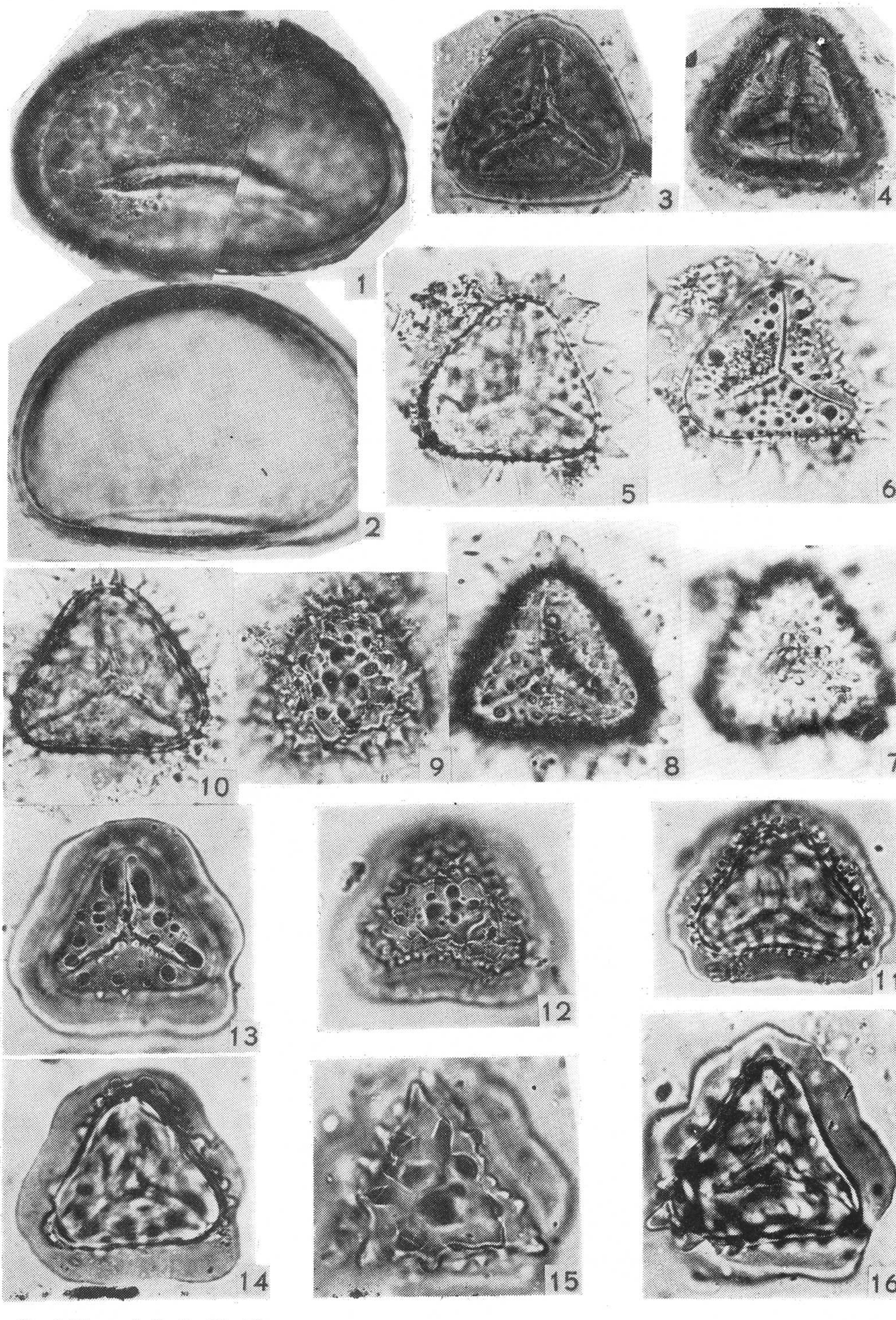
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Plate VII

1—3. *Pteris* sp., D. r., Kimmerian
4. *Hymenophyllum* sp., A. r., Pontian
5, 6. *Gleichenia* sp., A. r., Pontian, D. r., Kimmerian
7—10. *Pyrrosia* sp., D. r., Kimmerian
11, 12. *Polypodium* sp., D. r., Kimmerian
13. *Polypodium* sp., D. r., Kimmerian
14. *Polypodium vulgare* L., D. r., Kimmerian

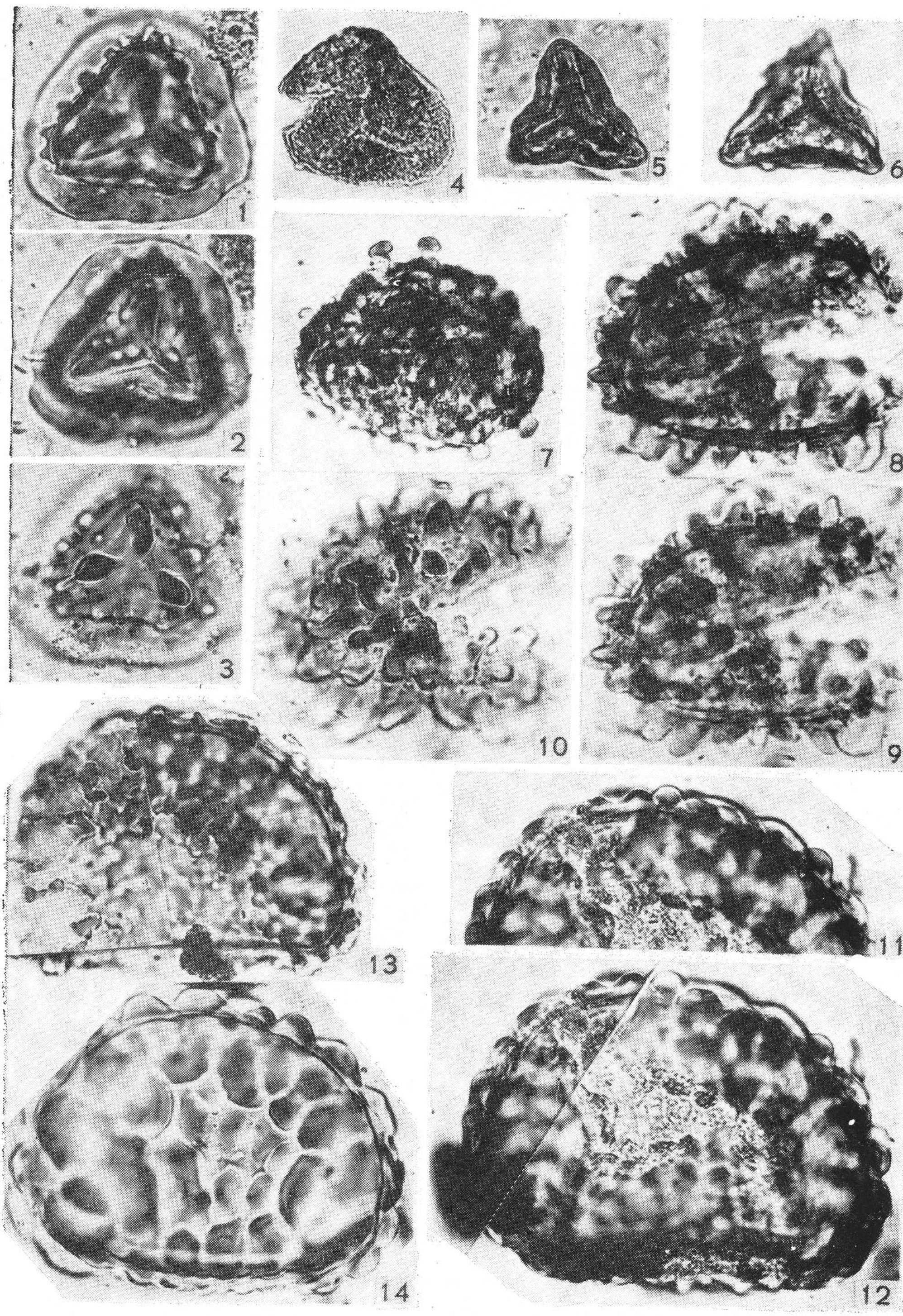
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Plate VIII

1—8. *Polypodium* sp. (*Verrucatosporites histiopteroides* W. Kr.), D. r., Kimmerian

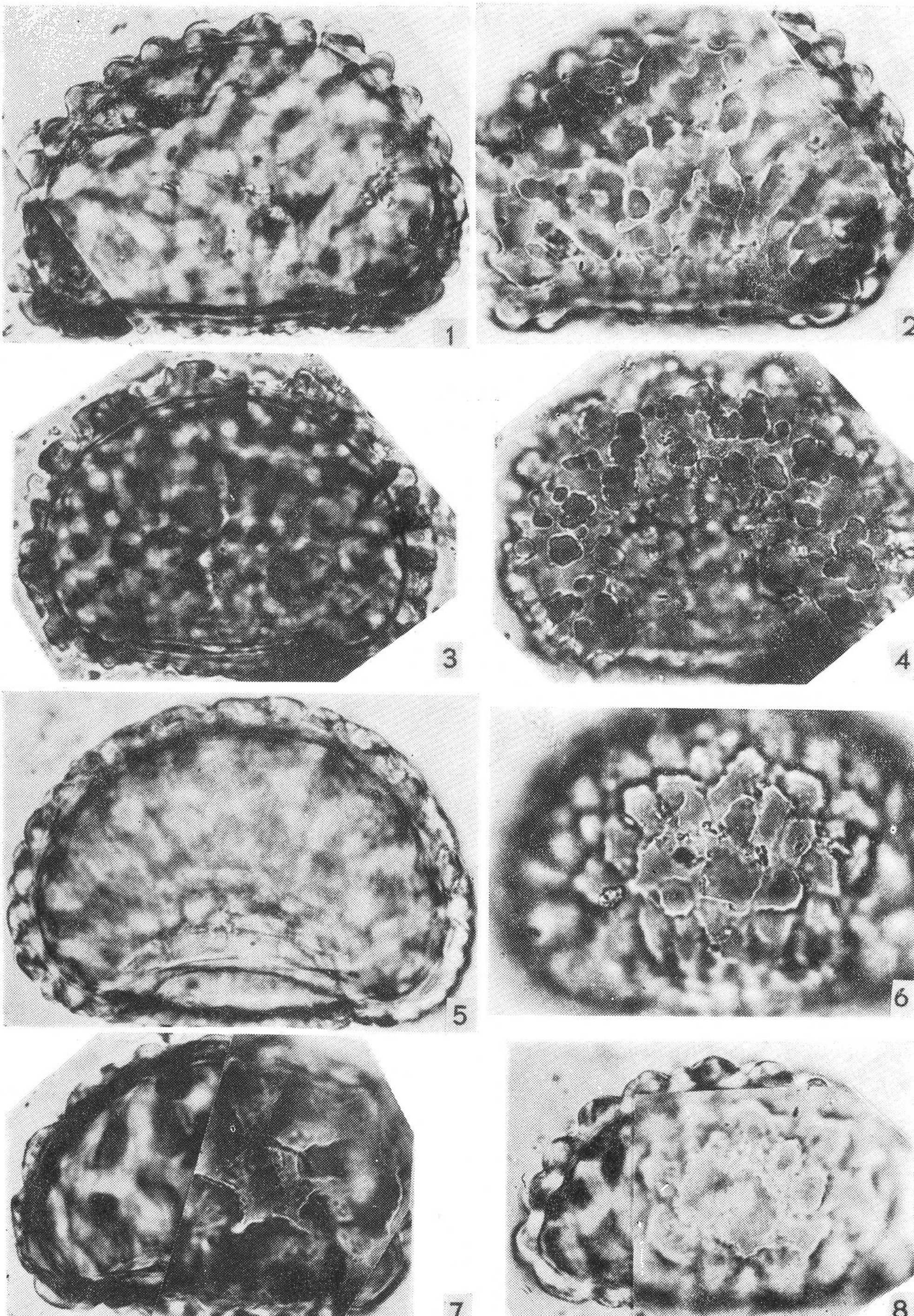

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Plate IX

1. *Polypodium* sp., D. r., Kimmerian
2, 3. *Polypodium* sp., D. r., Kimmerian
4, 5. *Polypodium aureum* L., D. r., Kimmerian
6, 7. *Polypodium* sp., D. r., Kimmerian
8, 9. *Polypodium* sp., D. r., Kimmerian
10, 11. *Dicksonia* sp., D. r., Kimmerian
12, 13. *Woodsia* sp., D. r., Kimmerian
14, 15. *Athyrium* sp., D. r., Kimmerian
16. *Cibotium* sp., G. r., Meotian

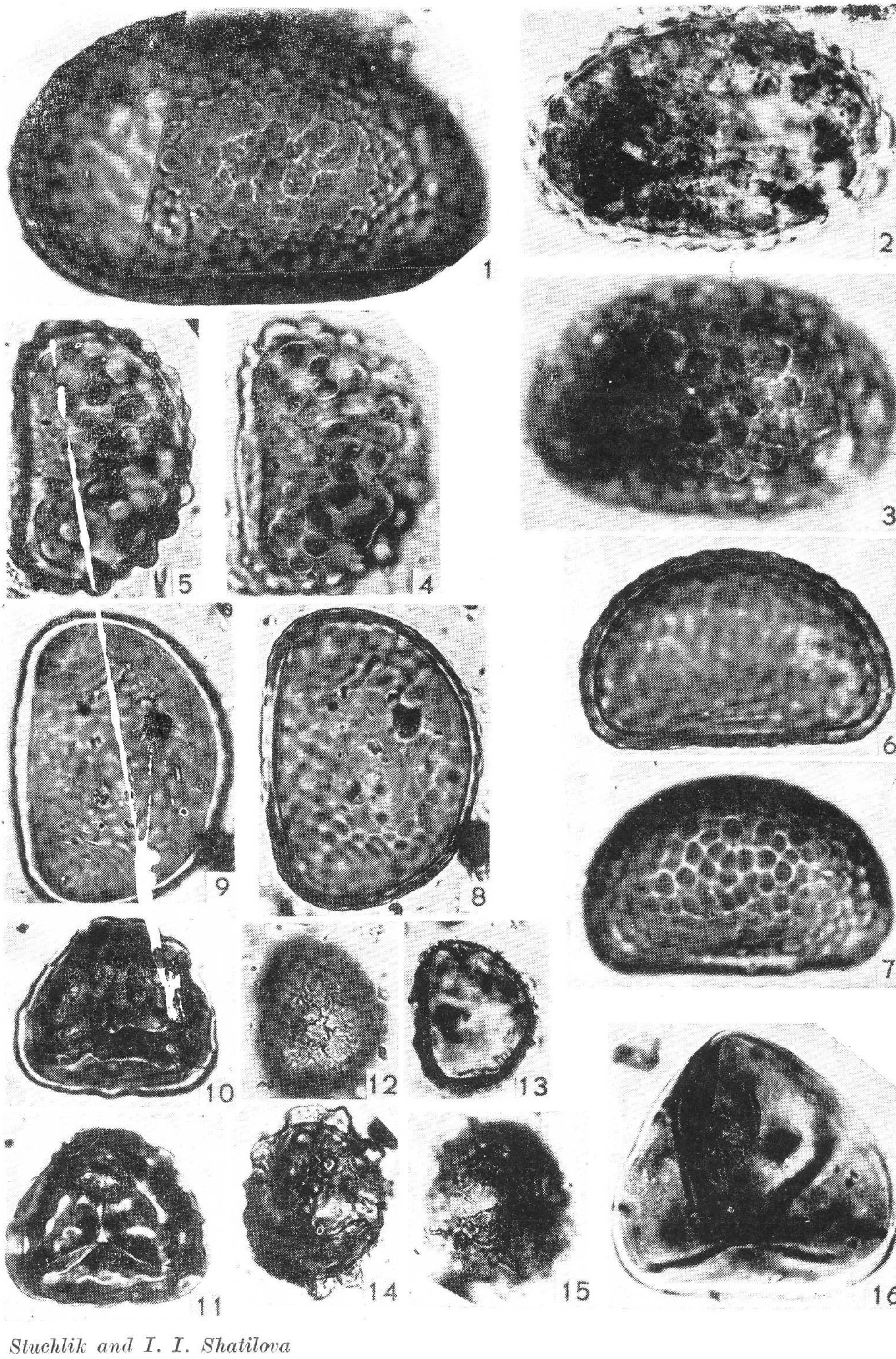
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Plate X

1—3. *Cyathea* sp., D. r., M. v., Kimmerian
4, 5. *Dicksonia unitotuberata* Purz., D. r., Kimmerian
6, 7. *Araucaria* sp., G. r., Meotian
8—10. *Dacrydium* sp., A. r., Meotian, D. r., Kimmerian
11. *Ephedra* sp., D. r., Kimmerian
12. *Pseudotsuga* sp., Z. r., Pontian
13, 14. *Tsuga pattoniana* Engelm., P. v., Kimmerian
15. *Podocarpus* sp., A. r., Pontian

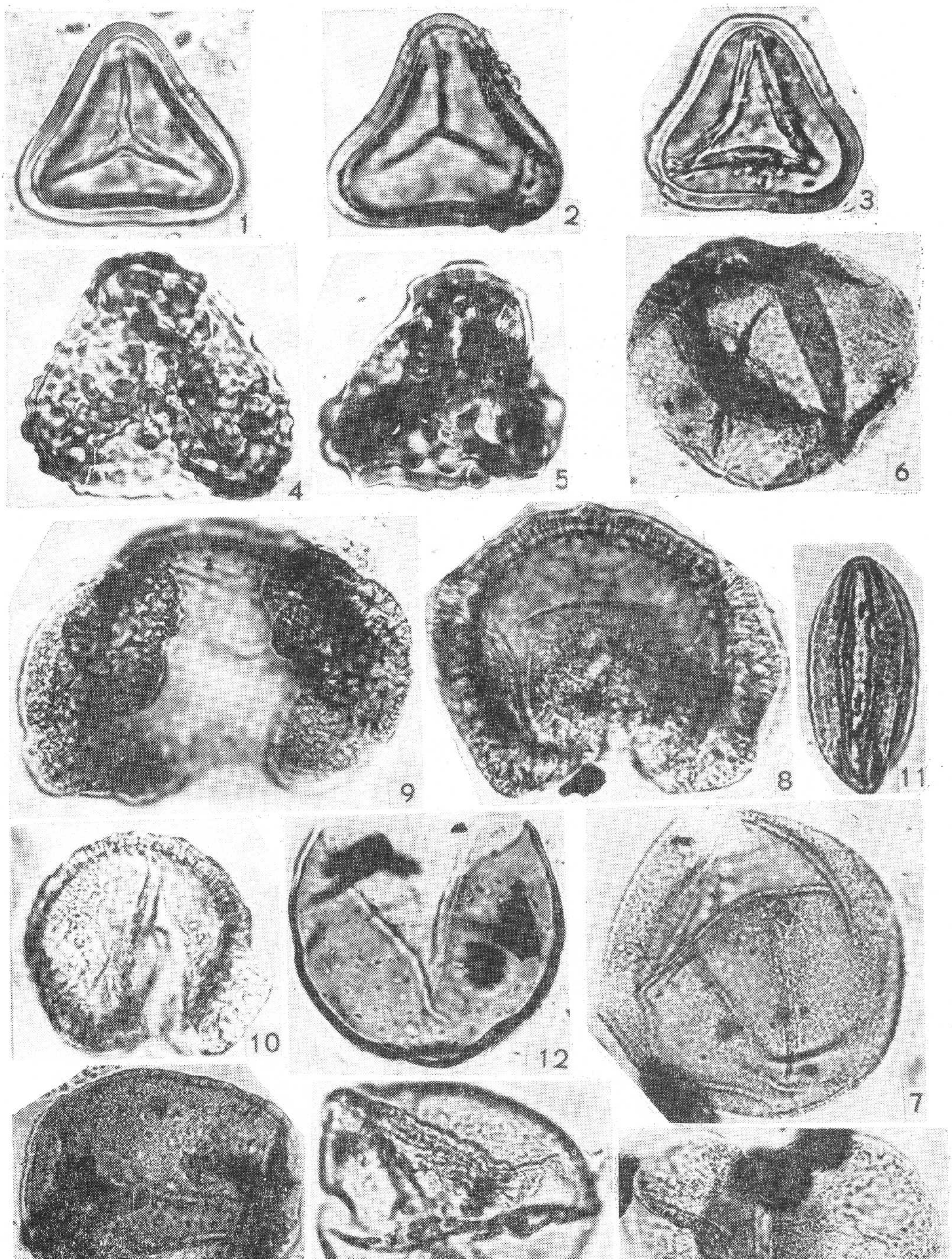
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Plate XI

1. *Keteleeria caucasica* Ram., A. r., Pontian
2, 3. *Tsuga pattoniana* Engelm., M. v., Kimmerian
4, 5. *Picea* sp., A. r., Meotian
6. *Cedrus sauerae* N. Mtchedl., M. v., Kimmerian
7, 8. *Cedrus* aff. *libani* Laws., M. v., Kimmerian

Plate XI

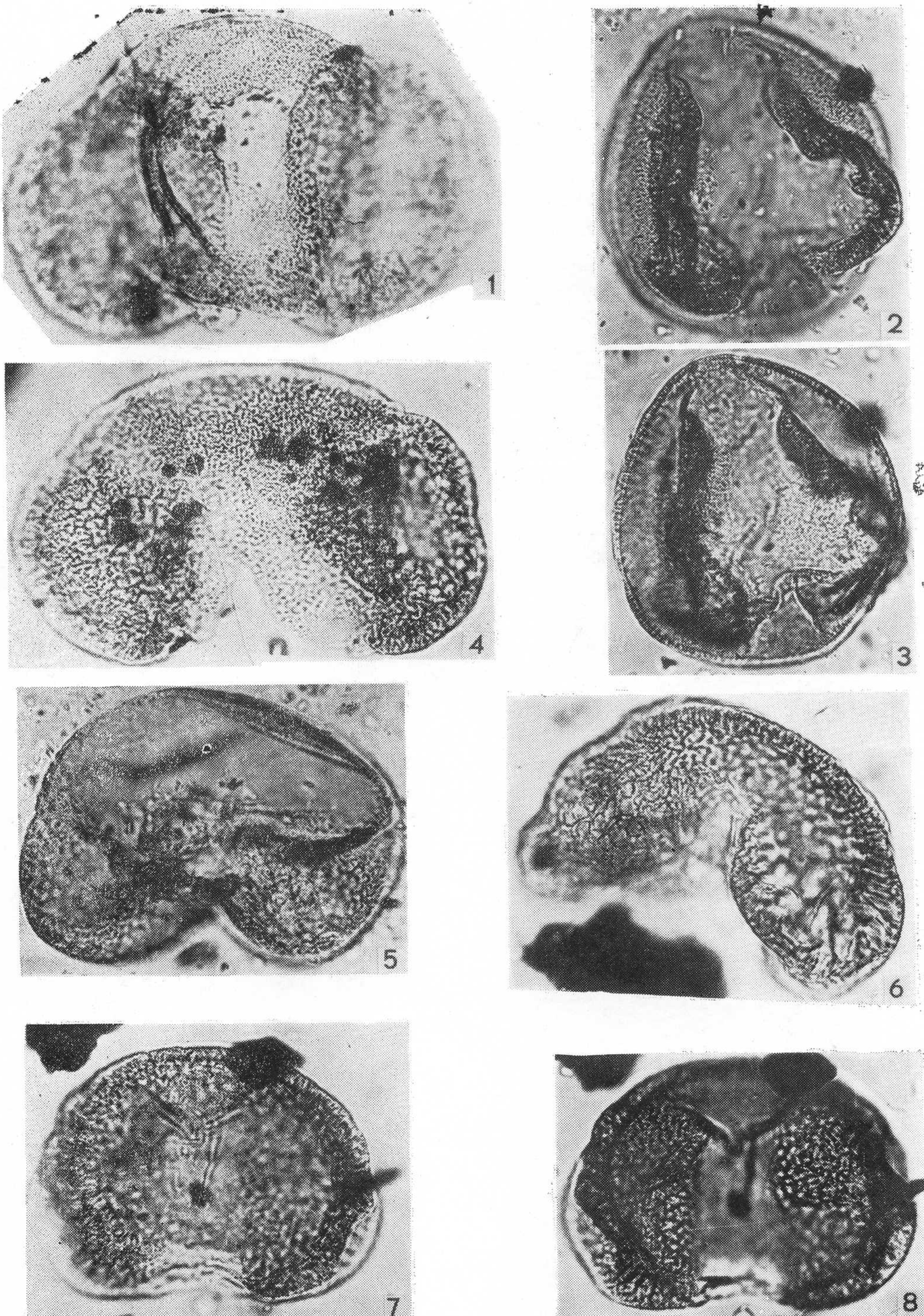

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Plate XII

1. *Tsuga korenerae* Mched., M. v., Kimmerian
2, 3. *Cathaya* sp., M. V., Kimmerian
4, 5. *Sciadopitys verticillatiformis* Schat. et Ram., D. r., Kimmerian
6. *Sequoia* sp., D. r., Kimmerian
7. *Cedrus deodara* Loud., D. r., Kimmerian
8. *Cedrus sauerae* N. Mtchedl., M. v., Kimmerian
9. *Cedrus* aff. *athlantica* Manetti, D. r., Kimmerian
10—12. *Cedrus* sp., M. v., Kimmerian

Plate XII

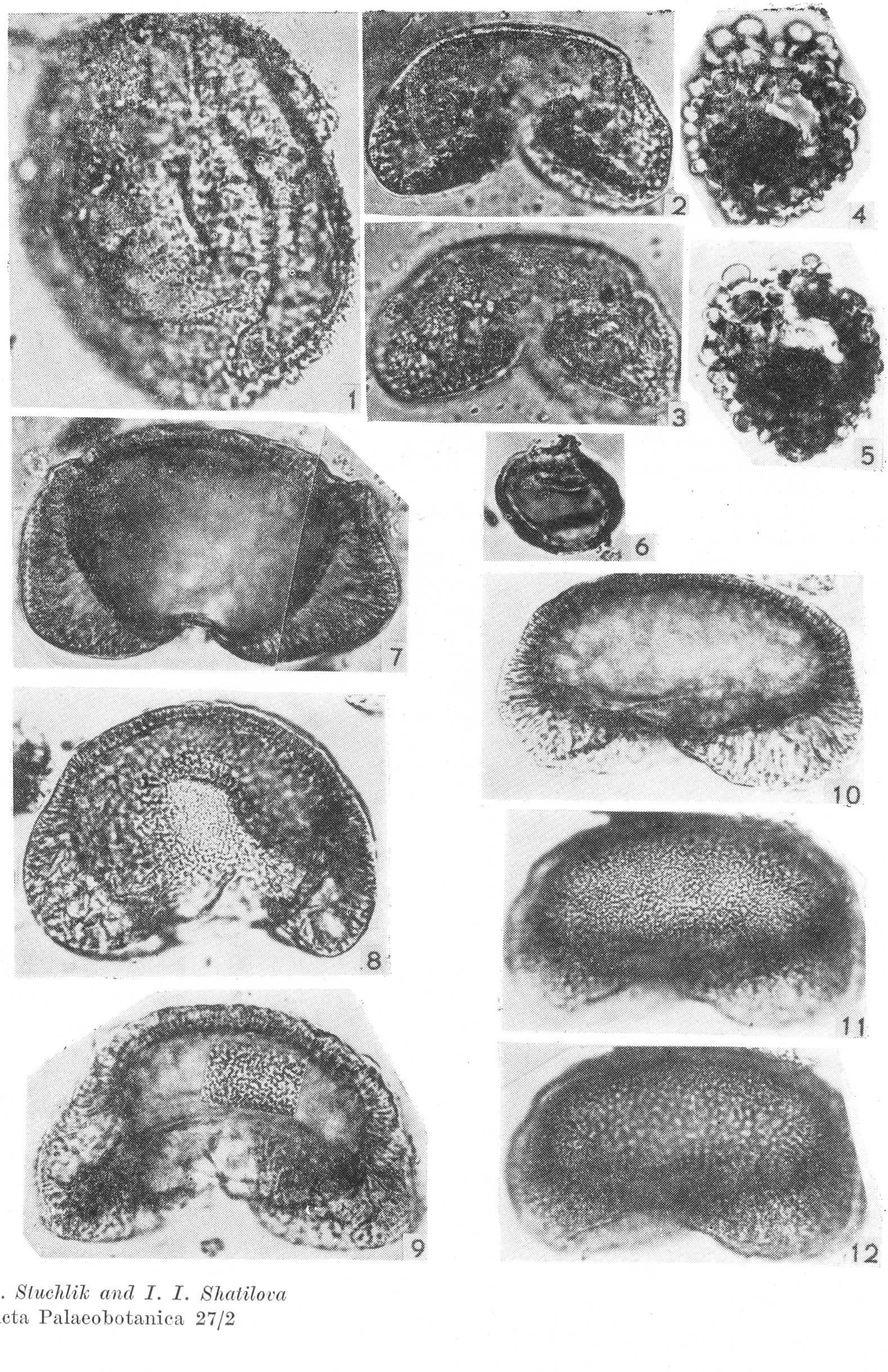

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Plate XIII

1. *Comptonis* sp., A. r., Pontian
2, 3. *Myrica* sp., Z. r., Pontian
4, 5. *Carya cordiformis* (Wangh.) Koch, G. r., Meotian
6. *Carya* aff. *ovata* Mill., P. v., Kuyalnikian
7. *Engelhardtia* sp., D. r., Kimmerian
8, 9. *Pterocarya* aff. *stenoptera* DC., D. r., Kimmerian
10. *Juglans cinerea* L., P. v., Kimmerian
11. *Carpinus orientalis* Mill., D. r., Kimmerian
12, 13. *Carpinus betulus* L., D. r., Kimmerian
14. *Carpinus caucasica* A. Grossh., M. v., Kimmerian
15, 16. *Quercus* sp., D. r., Kimmerian
17. *Fagus orientalis* Lipsky, D. r., Kimmerian
18, 19. *Zelkova carpinifolia* (Pall.) Dipp., D. r., Kimmerian
20. *Ulmus* sp., P. v., Kimmerian
21. *Magnolia grandiflora* L., P. v., Kimmerian
22, 23. *Liriodendron tulipifera* L., P. v., Kimmerian

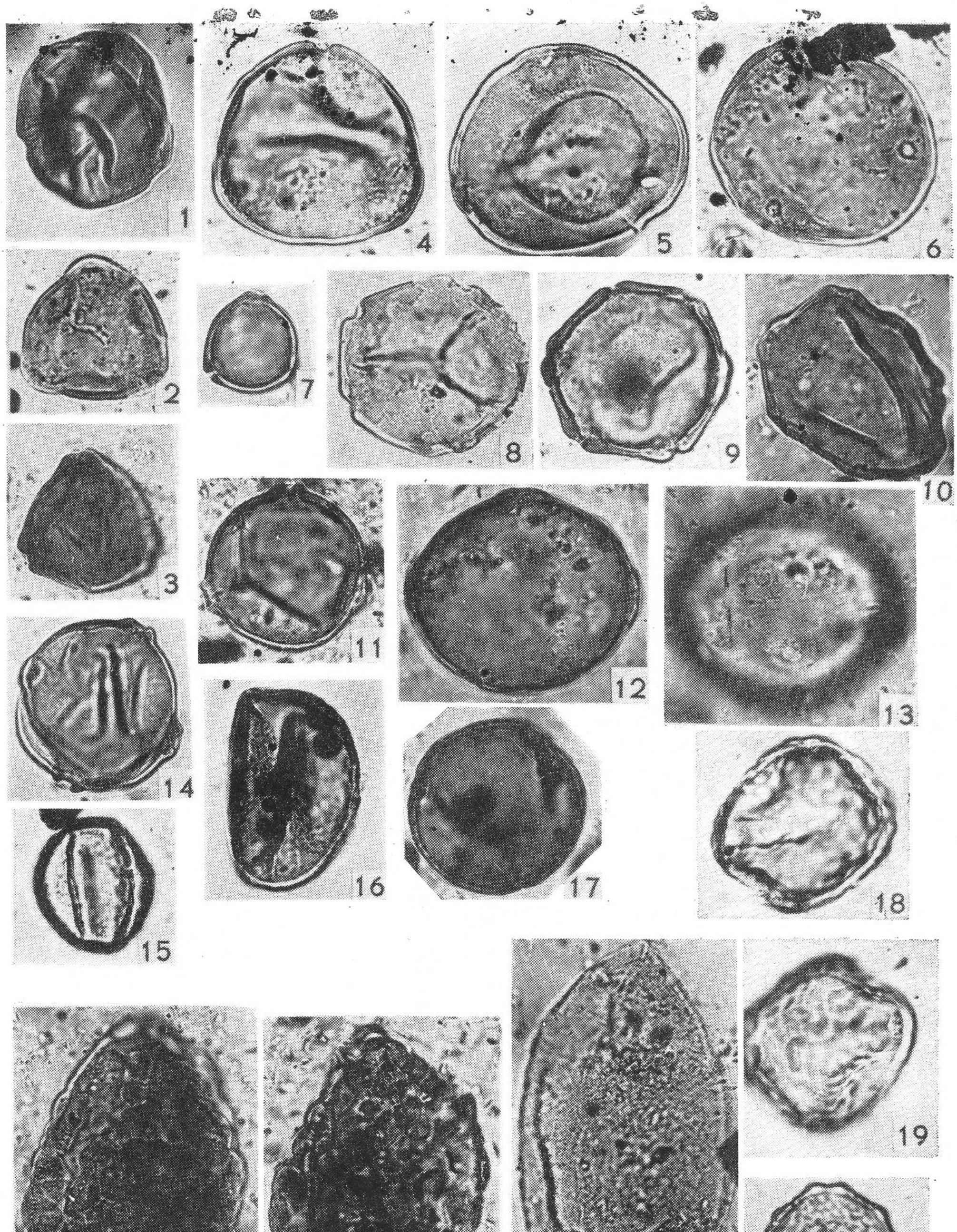
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Plate XIV

1. *Magnolia denudata* Desr., D. r., Kimmerian
2, 3. *Nymphea* sp., G. r., Meotian
4. *Corylopsis* sp., G. r. Meotian
5, 6. *Sycopsis colchica* Ram., G. r., Meotian, A. r., Pontian
7, 8. *Liquidambar* aff. *orientalis* Mill., Z. r., Pontian
9. *Liquidambar styraciflua* L., G. r., Meotian
10—12. *Liquidambar formosana* Hance, D. r., Kimmerian
13, 14. *Rosaceae* gen. indet., D. r., Kimmerian
15, 16. *Tilia* sp. I, D. r., Kimmerian
17, 18. *Tilia caucasica* Rupr., P. v., Kimmerian
19, 20. *Phellodendron* sp., D. r., Kimmerian
21. *Staphylea colchica* Stev., Z. r., Pontian
22—24. *Aralia* sp., D. r., Kimmerian
25, 26. *Nyssa sylvatica* L., P. v., Kimmerian
27. *Nyssa* sp., D. r., Kimmerian

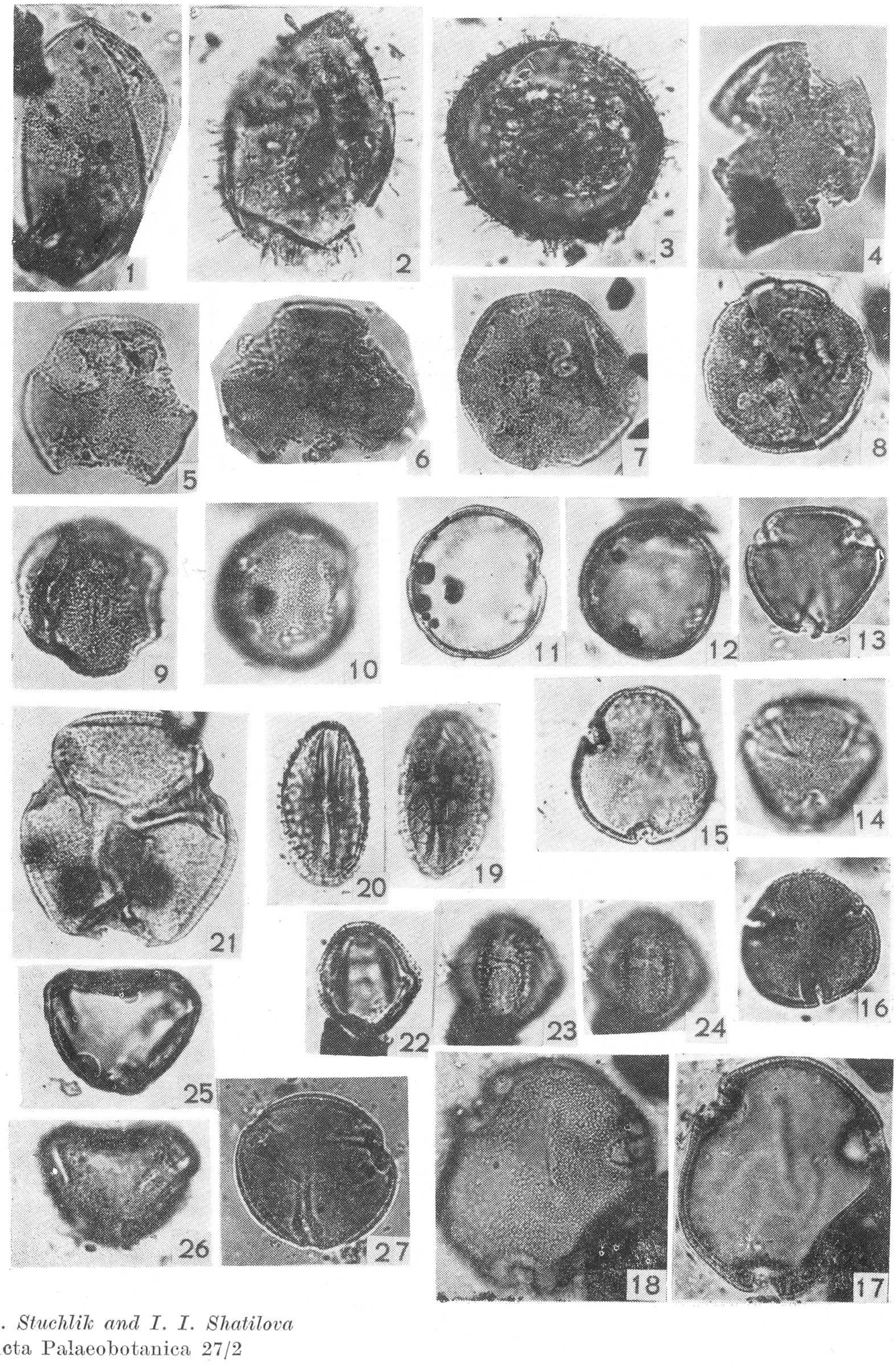
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Plate XV

1—6. *Alangium* aff. *kurzii* Craib, D. r., Kimmerian
7—10. *Palmae* gen. indet., A. r., Z. r., Pontian

Plate XV