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Pollen of some exotic plants in the Neogene of Bulgaria*

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Abstract. During the last few decades palaeoecologically-orientated reconstruction of environmental changes have rapidly increased because of their importance to Neogene climate evolution. In palynological studies palaeoecological interpretations rely on the so-called nearest living relative (NLR) philosophy, extrapolating the climate tolerances of recent plants to fossil ones. In that context the correct assignment of fossil palynomorphs to recent taxa is of high importance for palaeoecological interpretation and palaeovegetation reconstructions. This paper presents an overview of the geographic and stratigraphic distribution throughout the Neogene of Bulgaria for some subtropical taxa, with respect to their palaeoecological significance. Relationship of these taxa to macrofloristic data is also considered. The representatives of the following taxa are subject of discussion: the tribe Engelhardieae W.E. Manning and the genera *Symplocos* Jacq., *Reevesia* Lindl. and *Itea* L.

KEY WORDS: pollen, exotic, Neogene, Bulgaria

INTRODUCTION

During the last few decades knowledge of the botanical affinity of Neogene palynomorphs has increased significantly as a result of enormous efforts of a number of palynologists. This has been undertaken in order to disclose the relationships between fossil and recent pollen and has significantly improved the palaeoecological interpretations attained. Results have shown that most elements, comprising a fossil assemblage, are broadly consistent in terms of habitat preferences and thus they reflect habitat diversity. This organization gives rise to the concept of palaeocommunities (palaeocoenoses) from which it is possible to deduce past climate, palaeogeography, and biogeographic patterns. In this sense, the importance of correct identification of fossil pollen taxa and also their nearest living relatives increases significantly in terms of being the essential pre-requisite for accurate interpretations of palaeofloristic information.

RESULTS AND DISCUSSION

The paper presents an overview of the geographic and stratigraphic distribution throughout the Neogene of Bulgaria for some subtropical taxa, with respect to their palaeoecological significance. The relationship of these taxa to macrofloristic data is also considered. Representatives of the following taxa are subject of discussion: the tribe Engelhardieae W.E. Manning, the genera *Symplocos* Jacq., *Reevesia* Lindl., and *Itea* L. (Pl. 1).

Engelhardieae, a tribe of the family Juglandaceae, includes the species of *Engelhardia*, *Oreomunnea*, and *Alfaroa* complex. Their present day distribution is in subtropical/tropical areas of south Asia and Central America (Fig. 1). In the fossil complexes of Bulgaria the species related to the genus *Engelhardia*

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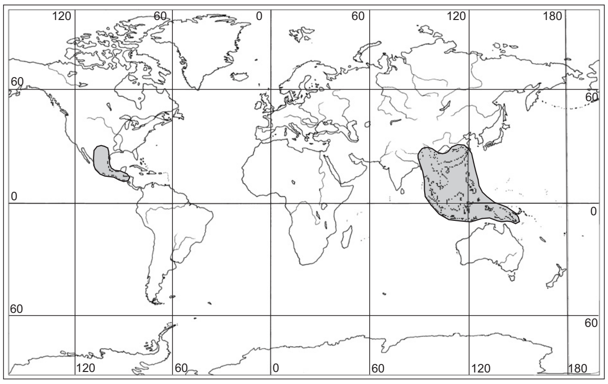

Fig. 1. Map showing the contemporary area of the genus *Engelhardia* (Southeast Asia) and *Oreomunnea* (Central America)

Leschen. ex Blume played a significant role in the composition of the mixed mesophytic forests from Oligocene to the beginning of the Pliocene.

Two fossil pollen taxa have been recognized in the Miocene flora of Bulgaria (Fig. 2), namely *Momipites punctatus* (Pot.) Nagy and *Momipites quietus* (Pot.) Nichols (Ivanov 1995a, 1996, 1997, 2001a, Ivanov & Slavomirova 2000).

Momipites quietus could be compared to the extant species *Engelhardia wallichiana* Lindl. and *E. chrisolepis* Hance (included in the *Engelhardia wallichiana* type sensu Kuprianova 1965). The present day distribution of the genus *Engelhardia* (5 species) includes tropical and subtropical Asia (Fig. 1), where it typically occurs in mesophytic forest from sea level up to approximately 2000 m a.s.l. While this species could undoubtedly be compared to the genus *Engelhardia*, the second one, *Momipites punctatus*, is more questionable. Among species of the tribe we can find similar pollen in the genera *Engelhardia* Leschen., *Oreomunnea* Oerst., and in part of the genus *Alfaroa* Standley. In the recent world flora the genus *Oreomunnea* includes 2 species (Fig. 2), both of them distributed in tropical rain forests of Mexico and Central America. All six species of the genus *Alfaroa* grow in Central America from Mexico to Guatemala.

In the Neogene pollen spectra of Bulgaria both species occurred from the Upper Oligocene and continue throughout the entire Miocene (Ivanov 1995a, 1996, 1997, 2001a, Ivanov & Slavomirova 2000). The amount of pollen varies in pollen spectra of different ages, and it is more abundant in the Middle Miocene where the percentage proportions reach 10–17%. This suggests that *Engelhardia* played a dominant or subdominant role in the forest structure in Bulgaria at this time. This assumption corresponds to macrofloristic data, for example, in the Lower Sarmatian flora from the Forecarpathian Basin leaves of *Engelhardia* account for ca. 34% of the total sum of macrofossil remains (Palamarev 1991).

From the palaeoecological point of view it seems that these two pollen species belong to plants with different ecological requirements. In many Upper Oligocene and Middle Miocene spectra either species present equal proportions, or *Momipites quietus* prevails numerically over *Momipites punctatus*. The data are strongly different for the Upper Miocene flora when pollen records show a rapid decline of *M. quietus*. This fact could mean that the plant producing the *quietus*-type pollen was more sensitive to climate changes and a decreasing temperature. We can suggest also that it was more sensitive as regards humidity and the level of annual precipitation, e.g. in the beginning of the Upper Miocene drying of the climate throughout Bulgaria has been recognized (Ivanov & Koleva-Rekalova 1999, Ivanov et al. 2002) with the amount of precipitation falling from 1100–1300 mm to 600–700 mm per year. This climate change could be connected with the disappearance of *Momipites quietus* in pollen spectra at that time interval. More over, the available palynological data from Bulgaria shows that *M. quietus* disappeared earlier, before the end of Miocene, while *M. punctatus* is found in lower Pliocene pollen spectra. This is also in accordance with the above-mentioned suggestion concerning the climate requirements of this species, correlating with a climate cooling trend in the late Neogene.

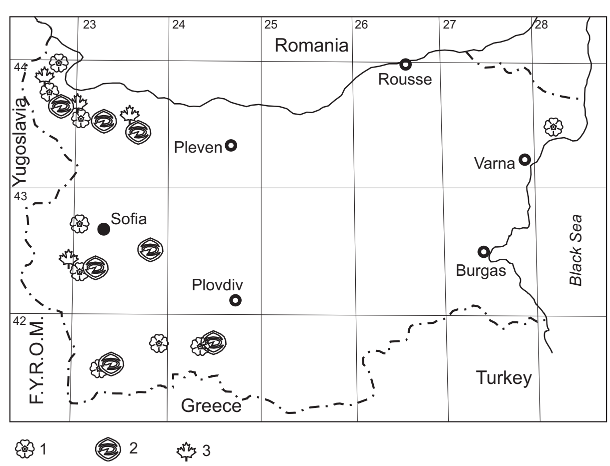

Fig. 2. Distribution of fossil Engelhardieae in Bulgarian Neogene flora. **1** – pollen, **2** – carpoids, **3** – leaves

An interesting question is: "Is there any correlation between taxonomic data for in the macro- and microfossil record?" The answer is that palynological data are in accordance with the macropalaeobotanical data. Two species belonging to tribe have been recognized as macrofossils: *Engelhardia macroptera* (Brong.) Unger and *Engelhardia orsbergensis* (Wess. & Web.) Jähn., Mai & Walter. Seeds of *Engelhardia macroptera* occur in the late Oligocene sediments in Bobovdol, the middle Miocene of Chukurovo and Satovcha, the lower Sarmatian (Volhinian) from north-western Bulgaria, and the upper Miocene (Pontian) in the Melnik basin (Palamarev 1982, 1989, Palamarev & Petkova 1987, Palamarev et al. 1998, Petkova 1967, Bozukov 1999). The nearest living relative of that species is *Engelhardia roxburgiana* that has a current distribution in south-eastern Asia. Leaf imprints of *Engelhardia orsbergensis* were identified in the late Oligocene sediments from the Bobovdol Basin (Palamarev et al. 1999) and in many localities of Sarmatian (Volhinian) age in north-western Bulgaria (Palamarev & Petkova 1987, Petkova 1967). The leaves of the recent species *Oreomunnea mexicana* (Standley) Leroy, growing in Central America, resemble the fossil leaves.

The Symplocaceae are a monotypic family, represented in the recent flora by the genus *Symplocos* which includes about 300 to 400 species. They are distributed throughout the tropical and subtropical regions of Asia (without western parts), Australia, New Caledonia and North, Central, and South America (Fig. 3). The species of *Symplocos* grow as undergrowth in evergreen or deciduous forests, and in shrub communities. For example, they form the lower vegetation layer in warm temperate evergreen forests in Thailand. These plants can also be found in bamboo and oak forests, along river banks, around swamps, and at the margin of mangrove communities. Their altitudinal distribution is up to 2000 m a.s.l, or even 3000 m on hillsides of the Eastern Himalayas Mts.

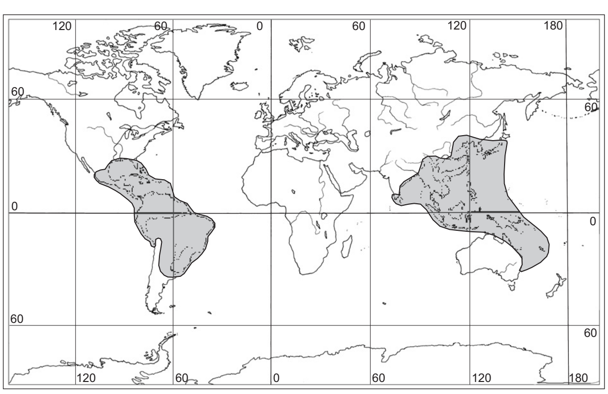

Fig. 3. Map showing the contemporary area of the genus *Symplocos*

In the fossil pollen spectra from Bulgaria the genus *Symplocos* is distributed throughout the Miocene up to the Early (?) Pliocene in many localities (Fig. 4). The following five fossil species have been identified:

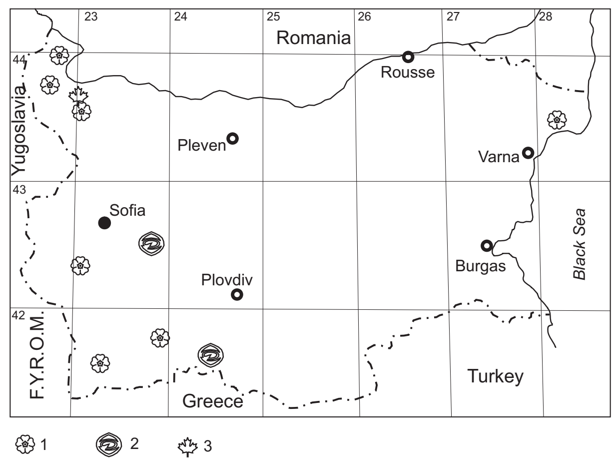

Fig. 4. Distribution of fossil *Symplocos* in Bulgarian Neogene flora. Legend: see Fig. 2

– *Symplocoipollenites vestibulum* (Pot.) Potonié is the most common species, distributed in sediments from Upper Oligocene in Bobovdol Basin (Ivanov 1996, Palamarev et al. 1998), throughout the Miocene, to the beginning of the Pliocene in Karlovo Basin (Ivanov 1997, 2001a, and unpubl. data). The closest recent pollen to this species includes the American species of *Symplocos alata* type (Ivanov 1995b, 1997).

The nearest living relative (NLR) pollen of the fossil species *Symplocoipollenites maturus* (Doktorowicz-Hrebnicka) Ziembińska-Tworzydło is *Symplocos paniculata* type which includes South Asian species of the genus (sensu van der Meijden 1970). The stratigraphic range of this species in Bulgaria includes the Volhynian and Bessarabian substages of the Sarmatian.

– *Symplocoipollenites rarobaculatus* (Thiele-Pfeiffer) Ashraf & Mosbrugger is closest to the pollen of the South Asian species included in the *Symplocos cochinchinensis* type (sensu van der Meijden 1970). Its stratigraphic range includes the Volhynian and Bessarabian substages of the Sarmatian (Ivanov 1995b, 1997).

– *Symplocoipollenites triangulus* (Pot.) Potonié has for its nearest living relative pollen the American species included in the *Symplocos tinctoria* type. Its stratigraphic range is from the Sarmatian to the Lower Pontian stages of the Bulgarian Neogene (Ivanov 1995b, 1997).

The last species is *Symplocoipollenites hidasensis* (Nagy) Ivanov. It has not been possible to determine the nearest living relative of this species to anything more precisely than to the recent *Symplocos* genus (Nagy 1963, Ivanov 1995b). After Ivanov (1995b, 1997) it has been found in sediments of Sarmatian age (Volhynian and Bessarabian). On the basis of its simple exine structure and smooth tectum, this fossil species can be compared to *Symplocos tenuifolia* type (Ivanov 1995b) which includes Brasilian representatives of the genus (Barth 1982), although exact correlation is not possible.

Four *Symplocos* species have been identified as macrofossils in the Miocene sediments of Bulgaria to date. Three of them as carpoids: *Symplocos lignitarum* (Quenst.) Kirchheimer in the Middle Miocene sediments of the Chukurovo coal basin, with a nearest living relative (NLR) *Symplocos toarensis* Guill. (Palamarev 1989), *Symplocos minutula* (Sternberg) Kirchheimer in the Middle Miocene sediments of the Chukurovo and Slasten Basins, with a NLR *Symplocos tinctoria* L'Herit. (Palamarev 1989, 1994), and *Symplocos salzhausensis* (Ludwig) Kirchheimer in the Middle Miocene sediments of the Chukurovo coal basin, with a NLR *Symplocos paniculata* Wall. (Palamarev 1971, 1989). As leaf imprints only one species have been found up to now, *Symplocos simile* Kolakovsky in the Lower and Middle Sarmatian of north-western Bulgaria (Forecarpathian Basin), with NLR *Symplocos japonica* A. DC. and *Symplocos macrocarpa* Wight.

Summarizing theses data we can state that among these fossil remains there are at least two species found as macro- and microfossils, with common nearest living relatives *Symplocos paniculata* and *S. tinctoria*. This increases the level of certainty and accuracy of the relationships between the fossil and recent species.

As is evident from the palaeofloristic spectra, and taking into account the ecological requirements of recent analogs, it can be suggested that the *Symplocos* species developed as components of the hygrophytic to mesohygrophytic multispecies forests, probably in oak-magnolia mixed palaeocommunities. The maximum species biodiversity was recorded for the Middle Miocene.

In the fossil pollen spectra, pollen belonging to *Symplocos* appear in low amounts, and is rare or constitute up to 0–2% of the total pollen sum AP+NAP. The individual species frequency depends upon the facies and ecological environment. The comparative low amount of this pollen could depend also on: first, the low opportunities of pollen dispersal, as the trees grow in lower vegetation layer of forest communities, and second, because of type of pollination – most *Symplocos* species are insect or bird pollinated, requiring a lower volume of pollen production than for wind pollinated species.

Reevesia (Sterculiaceae) presents one of the more interesting genus in the Neogene pollen flora that is important in palaeoecological and palaeoclimatological interpretation. These 3-, 4-, to 5-porate, small pollen grains, with reticulate ornamentation were recognized as *Reevesia* by Petrov and Drazheva-Stamatova (1972). Since than there has been no doubt that it belongs to this genus.

Nowadays the genus *Reevesia* is distributed in Southeast Asia from Himalayas to China, Indochina, and Java (Fig. 5). It includes ca. 18 arboreal and shrubby species, growing in subtropical/tropical vegetation up to 1500–2000 m a.s.l., as a component of mixed forests.

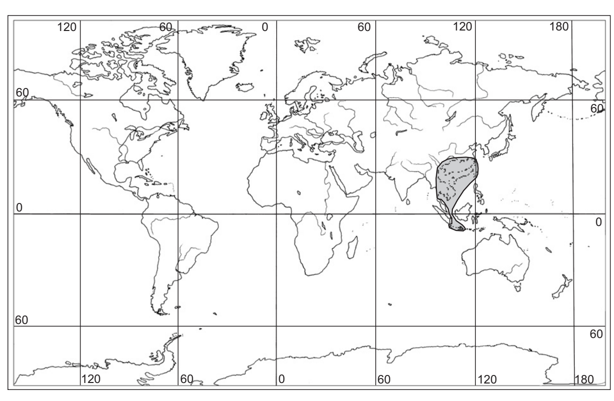

Fig. 5. Map showing the contemporary area of the genus *Reevesia*

In the Neogene pollen flora from Bulgaria the genus is recorded in sediments of various age (Fig. 6): Upper Oligocene sediments from the Bobovdol coal mine (Ivanov 1996, Palamarev et al. 1998), Middle Miocene of the Chukurovo Basin (Petrov & Drazheva-Stamatova 1972), Middle and Upper Miocene of northwestern Bulgaria (Ivanov 1997), the Upper Miocene from the Goce-Delchev and Sandanski Basins (Ivanov 1995a, 2001a), the Upper Miocene (Pontian) from the Sofia Basin (Petrov & Drazheva-Stamatova 1972), and the Lower (?) Pliocene of the Karlovo Basin (Ivanov unpubl. data).

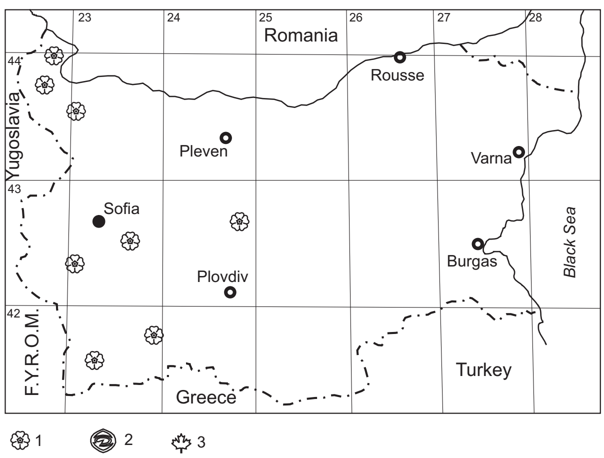

Fig. 6. Distribution of fossil *Reevesia* in Bulgarian Neogene flora. Legend: see Fig. 2

In all of the pollen spectra where we find *Reevesia* pollen it appears in low abundances, usually less than 1%. These values are reasonable considering its mode of pollination – by insects. That suggests a lower pollen productivity and also a lower potential for pollen dispersal. In today's area of distribution *Reevesia* representatives have a subordinate part in the composition of the vegetation. It seems quite probable that during the Neogene period, their participation in floral complexes should have not been more significant, and thus explains why in each case only separate pollen grains have been discovered. This shows that *Reevesia* provides a good climatic signals, but we cannot draw conclusions based on it absence.

Macrofossils of genus *Reevesia* have not been found yet. In Bulgaria two genera from Sterculiaceae have been recognized: *Sterculia* L. in the Eocene sediments of south-western Bulgaria, and *Byttneriophyllum* Givulescu ex Knobloch & Kvaček in the Middle Miocene of the Chukurovo (Palamarev 1964), Satovcha (Bozukov 1999), and Forecarpathian Basins (Palamarev & Petkova 1987), and the Pliocene sediments of the Sofia Basin (Palamarev et al. 1999). The NLR to *Byttneriophyllum* is problematic and could be either *Byttneria* Loefling and/or *Firmiana*, the assignment of *Byttneriophyllum tiliaefolium* (A. Braun) Knobloch & Kvaček to Sterculiaceae remains questionable, and the probable connection of that genus with Tiliaceae is also supposed. The reason for the absence of *Reevesia* in the macrofossil records could be the same as their low abundance in pollen spectra. These plants did not play a significant role in fossil communities, and as undergrowth they have lower preservation potential.

In the contemporary world flora *Itea* L. (Iteaceae J. G. Agardh) is presented by ca. 20 species, evergreen or deciduous shrubs and trees. The genus has a disjunct distribution including the south Atlantic coast of North America and south-eastern China (Fig. 7). The main species diversity is in south-eastern Asia where 15–19 species are distributed from the Himalayas to Japan and west Malaysia (the number of species varies according different authors). In the south Atlantic coast of North America only *Itea virginiana* L. grows. The present-day representatives of *Itea* grow in humid or marshy areas.

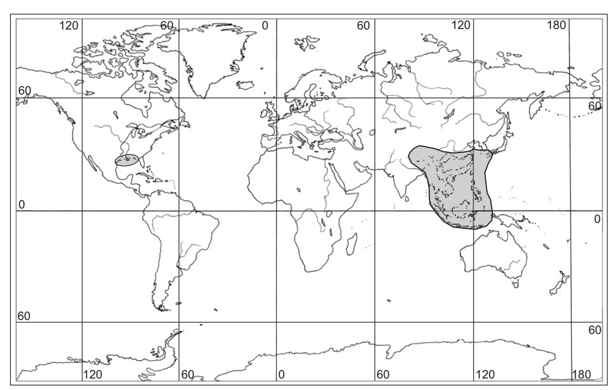

Fig. 7. Map showing the contemporary area of the genus *Itea*

For the first time pollen of *Itea* has been recognized in the Upper Miocene sediments of the Sandanski and Beli-Brjag Basins (Petrov & Drazheva-Stamatova 1973). Later this type of pollen was found in the Upper Oligocene, Middle and Upper Miocene sediments from different basins (Fig. 8) Bobovdol, Forcarpathian, Gotse-Delchev (Ivanov 1995a, 1996,

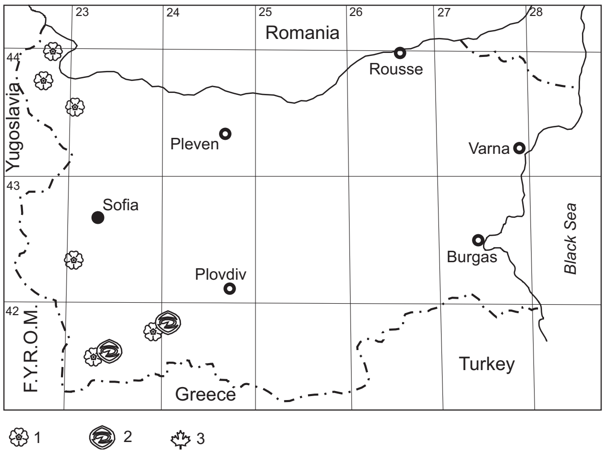

Fig. 8. Distribution of fossil *Itea* in Bulgarian Neogene flora. Legend: see Fig. 2

1997, 2001a). The fossil pollen is closest to the pollen of recent species *Itea virginiana* (Petrov & Drazheva-Stamatova 1973). It usually appears in low amounts and somewhat irregularly in pollen spectra. Only in the Sandanski Basin have up to 5% *Itea* pollen been observed in some samples, and this may be explained by specific vegetation and facies conditions (Ivanov 2001b). *Itea* is considered to be a typical element of swamp forests and of areas experiencing periodic flooding, or dam-peat bogs, where it grows together with *Taxodium-Glyptostrobus*, *Nyssa*, *Myrica*, *Salix*, Cyrillaceae and others. Nevertheless, some authors suggest it also as a component of mixed mesophytic forests.

Recently, the presence of *Itea* in the Neogene of Bulgaria has been supported by macrofossils. Mai and Palamarev (1997) recognized seeds of *Itea* in the Upper Miocene sediments of the Gotse-Delchev and Sandanski Basins.

CONCLUSION

In conclusion, the tropical – subtropical taxa presented here apparently have an important role in understanding floristic and climatic evolution in the Balkan Peninsula. However, we have to interpret carefully palaeoclimatic signals from fossil taxa due to various reasons, e.g. correct assignment of nearest living relatives to fossil taxa, or correct description of climate tolerances of recent taxa. Finally, we should keep in mind that climate tolerances of fossil taxa could differ from recent ones.

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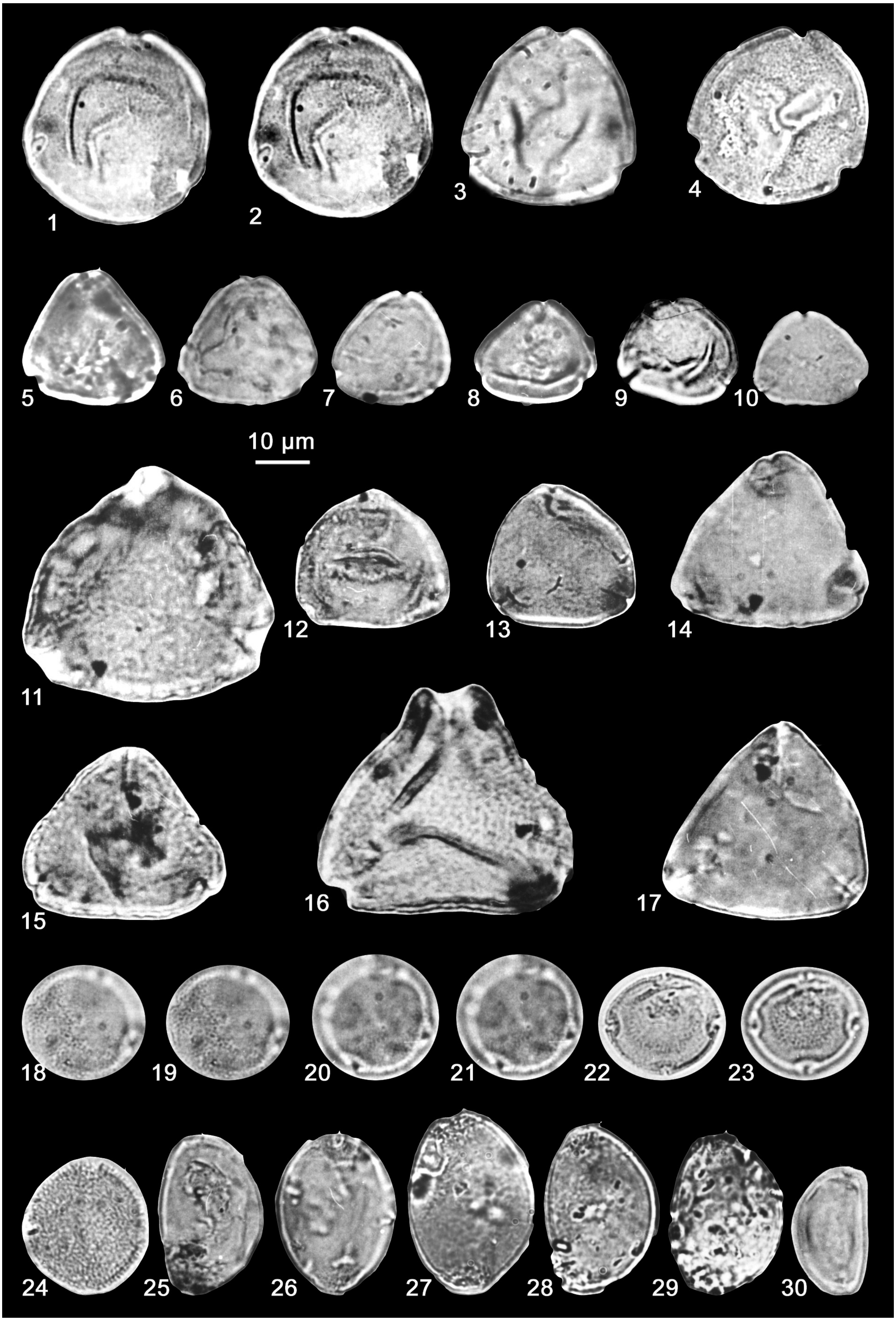
PLATE

Plate 1

1–4. *Momipites punctatus* (Pot.) Nagy
5–10. *Momipites quietus* (Pot.) Nichols
11. *Symplocoipollenites maturus* (Doktorowicz-Hrebnicka) Ziemb.-Tworz.
12. *Symplocoipollenites rarobaculatus* (Thiele-Pfeiffer) Ashraf & Mosbrugger
13, 14. *Symplocoipollenites triangulus* (Pot.) Potonié
15, 16. *Symplocoipollenites vestibulum* (Pot.) Potonié
17. *Symplocoipollenites hidasensis* (Nagy) Ivanov
18–24. *Reevesiapollis triangulus* (Mamczar) Krutzsch
25–30. *Iteapollis angustiporatus* (Schn.) Ziemb.-Tworz.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