

# ***Platimeliphyllum reznikoviorum* N. Maslova, sp. nov. (Angiospermae) and Associated Infructescence from the Paleogene of Central Kazakhstan**

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**Abstract**—A new species *Platimeliphyllum reznikoviorum* N. Maslova is described from the Paleogene of Nizhnii Ashut locality (central Kazakhstan) based on the leaf macromorphological and epidermal characteristics. A capitate infructescence sharing characters of Platanaceae and some Hamamelidaceae was found together with the leaves. Small reticulate tricolpate pollen grains were found adhered to the carpel surface. The fossil leaves and reproductive structure are supposed to belong to the same plant. Fossil leaves attributed to *Platimeliphyllum* are associated with reproductive structures of various genera belonging to different families. Therefore we use the morphological classification for dispersed angiosperm leaves proposed by Krassilov (1979) to define the taxonomic position of this genus.

**Keywords:** *Platimeliphyllum*, capitate infructescences, tricolpate pollen, Paleogene, central Kazakhstan

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## **INTRODUCTION**

The genus *Platimeliphyllum* N. Maslova (2002) was established for entire leaves with craspedodromous venation (sometimes camptodromous at the lower part of the lamina), variously developed basal veins, and a toothed margin. To date, four species of this genus have been described: *P. valentinii* Kodrul et Maslova (Early Paleocene, Amur region; Kodrul and Maslova, 2007), *P. snatolense* N. Maslova (Late Paleocene, western Kamchatka; Maslova, 2002), *P. palanense* N. Maslova (Late Paleocene–Early Eocene, western Kamchatka; Maslova, 2002), and *P. denticulatum* N. Maslova (Early Eocene, western Kamchatka; Maslova, 2002). In addition, leaves from the Eocene of northeastern and southern China (Manchester et al., 2005; Kodrul et al., 2012) and North America (Krassilov et al., 2009) were attributed to the genus *Platimeliphyllum*. The history of the genus was analyzed by Kodrul et al. (2012).

Leaves of all species of the genus *Platimeliphyllum* show a peculiar combination of macromorphological platanaceous and hamamelidaceous characters. Platanaceous epidermal characteristics were revealed in *P. palanense* and *P. valentinii*.

Leaves of *Platimeliphyllum* in association with staminate inflorescences belonging to different genera were described previously (Maslova, 2002; Maslova and Kodrul, 2003; Maslova et al., 2007). The association of leaves of *Platimeliphyllum* with a capitate

infructescence showing platanaceous and hamamelidaceous characters is described in the present paper. In addition, reticulate tricolpate pollen grains were found adhered to the surface of the carpels.

A new species *P. reznikoviorum* sp. nov. extends significantly the knowledge of the variability of morphological and epidermal features of the genus and of its geographical distribution. The complex of new finds (leaves of *Platimeliphyllum*, capitate infructescence, and adhering pollen grains) provides new information on the evolutionary history of the ancient platanoid plants and on the possibilities of classification of such fossils.

## **MATERIAL AND METHODS**

The material is represented by the capitate infructescence and leaf imprints with rare remains of phytolite. It was kindly provided by P.V. Shilin to N.P. Maslova for studying in 2009. The material comes from the Nizhnii Ashut bauxite mine, located 6 km southwest of the town of Arkalyk, central Kazakhstan. Bauxite deposits were united in the Arkalyk Formation, which included infra-ore, ore, and supra-ore members (Volkov, 1959). B.A. Tyurin and Z.K. Ponomarenko ranked the Arkalyk Formation as a group (Tyurin, 1971). In 1966 they subdivided it into four palynologically dated formations: Ashut (Maastriichtian), which included the infra-ore clays; Aman-

geldy (Paleocene), formed by bauxites and fireclays; Toktygat (Early Eocene), consisting of bauxite and fireclays; Kenetai (Middle Eocene), represented by supra-ore kaolinite clays and quartz sands.

The fossil plants from the Nizhnii Ashut mine were collected by Shilin in 1983. Later, the collection was enlarged by A.P. Levina. Plant-bearing gray fireclays underlying bauxites were attributed to the Ashut Formation and dated as Maastrichtian based on the taxonomic composition of plant assemblage and Ponomarenko's conclusion (personal communication) on the age of the palynological assemblage (Shilin, 1986). Compositional features of the Nizhnii Ashut flora are briefly described in the monograph (Shilin, 1986). According to the monograph, the flora is mainly composed of conifers (*Libocedrus* Endlicher and *Pinus* L.) and angiosperms with predominantly small lanceolate entire-margined leaves, rarer representatives of the families Fagaceae and Aquifoliaceae, and sporadic ferns. The presence of the extant genus *Parrotia* C.A. Mey, previously unknown in the Cretaceous, was particularly noted.

Our preliminary analysis of the fossil plant collection from the Nizhnii Ashut locality revealed the presence of numerous remains of fascicles, seed scales, and seed cones of *Pinus*; shoots, megastrobili and seed scales of *Mesocyparis* McIver et Basinger; shoots of Cupressaceae s.l. and Taxaceae (?), and dicotyledonous leaf impressions with dominating entire-margined morphotypes. Further research is required to establish the systematic position of the latter. The study of the remains that were previously attributed to the genus *Parrotia* revealed some morphological and epidermal features that allowed us to place these leaves in a new species of the extinct genus *Platimeliphyllum*.

The studied palynological assemblage from the plant-bearing gray clays shows similarities with assemblages from the Maastrichtian–Paleocene deposits of the Turgay, Trans-Urals, and Kazakhstan (Zaklinskaya, 1963; Polumiskova et al., 1966; Ponomarenko, 1966; Nesterova, 1971; Vasilieva, 1990; Vasilieva and Levin, 2010). The stratigraphically significant Maastrichtian species of the genera *Proteacidites* Cookson ex Couper, *Aquilapollenites* Rouse, and *Wodehouseia* Stanley are absent in the Nizhnii Ashut assemblage. On the contrary, the species typical for the Paleocene of Kazakhstan are present: *Trudopollis articulus* Weyl. et Krieg., *T. menneri* (Mart.) Zakl., *T. nonperfectus* Pflug, *Trudopollis* sp. aff. *T. pompeckii* Pflug, *Myricites typicus* (Pflug) Zakl., *Triporopollenites* sp., *Triatriopollenites plicoides* Zakl. A similar palynological assemblage in association with the Early Paleocene foraminifers of the *Cibicides lectus* Zone was discovered in the central part of the Turgay Depression (Blyahova et al., 1971). The plant-bearing deposits of the Nizhnii Ashut bauxite mine are dated as Paleocene based on the studied palynological assemblage. A detailed description of this palynological assemblage and plant macrofossils will be published separately.

The epidermal structure of the leaves was examined in cuticle preparations. Cuticles obtained by maceration of coaly phytolite fragments with Schulze solution and alkali were examined using a scanning electron microscope (SEM). For studying the high-order venation, the intact incrustations were mounted on SEM stubs and covered with gold. Separate structures of the capitate infructescence were extracted from the rock using hydrofluoric acid. Leaf impressions and the infructescence were photographed with a Nikon Coolpix 8700 digital camera and a light microscope Leica M165C (LM); micrographs were taken using SEM CamScan (Paleontological Institute, Lomonosov Moscow State University).

We use the suprageneric taxa (groups) proposed by V.A. Krassilov (1979) for fossil dispersed angiosperm leaves. For the description of fossil leaves we used the terminology of *Manual of Leaf Architecture...* (Ash et al., 1999).

The collection of plant macrofossils is stored at the Institute of Botany and Phytointroduction of the Ministry of Education and Science of the Republic of Kazakhstan (Almaty) under no. 441.

## SYSTEMATIC PALEOBOTANY

### CLASS MAGNOLIOPSIDA

#### GROUP PLATANOFOLIA KRASSILOV, 1979

#### Genus *Platimeliphyllum* N. Maslova, 2002

*Platimeliphyllum reznikoviorum* N. Maslova, sp. nov.

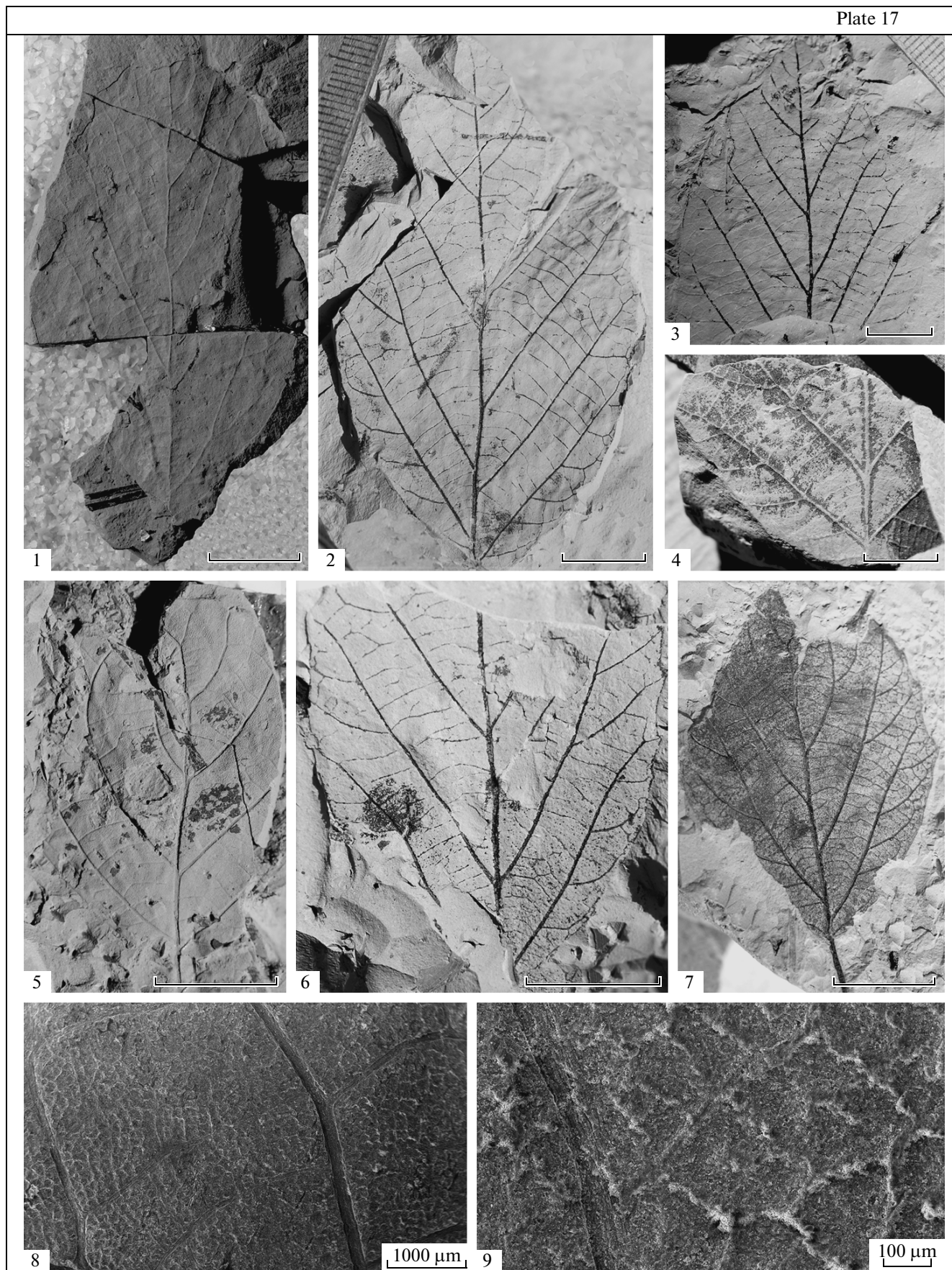
Plate 17, figs. 1–9.

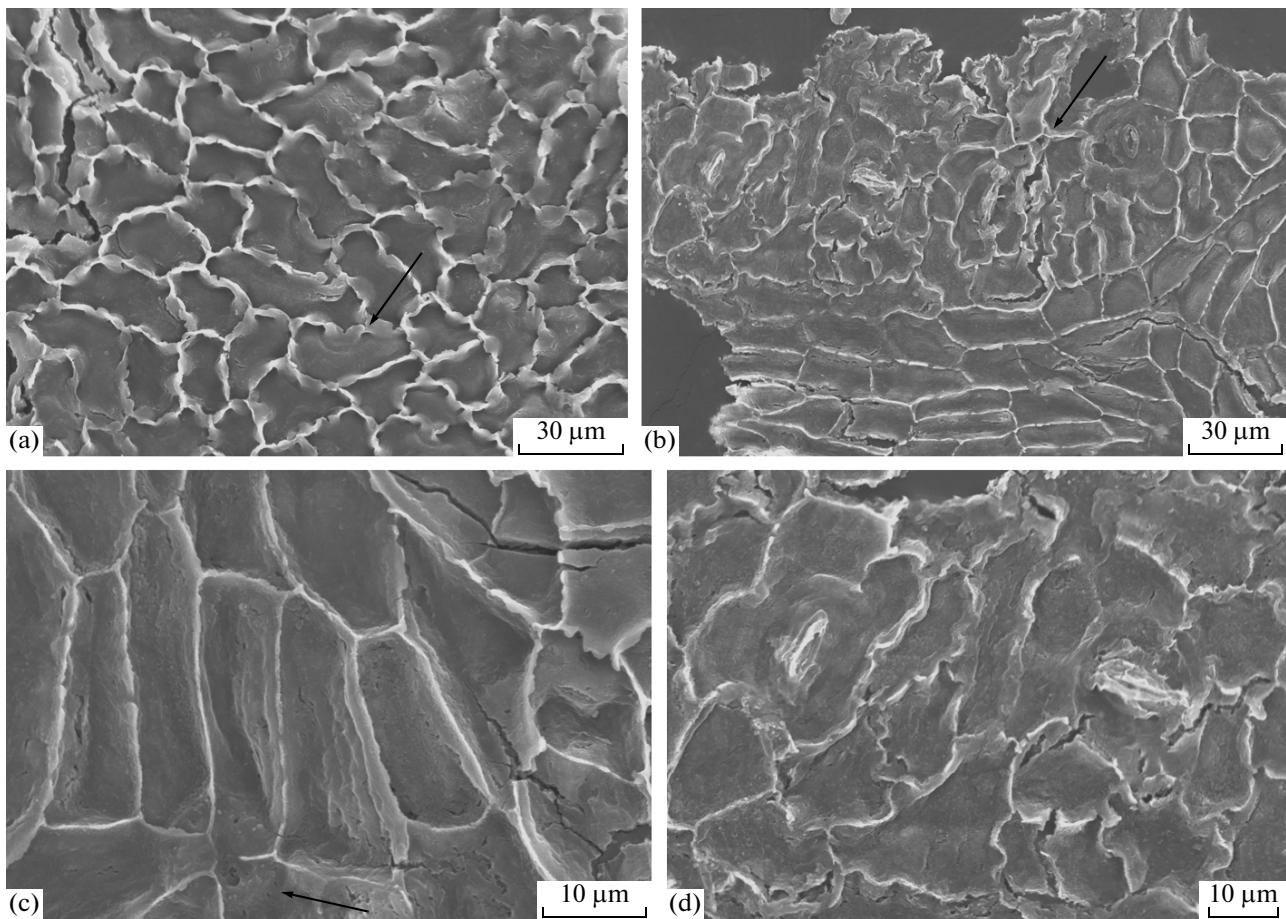
**Etymology.** In honor of the Reznikovs, amateur paleobotanists.

**Holotype.** IBP, no. 441-56; leaf impression; central Kazakhstan, Nizhnii Ashut mine near Arkalyk; Ashut Formation, Paleogene (Pl. 1, fig. 7; Fig. 2a; designated here).

**Diagnosis.** Leaf lamina entire, oval, length–width ratio 1.8. Lamina base round or broadly cuneate, occasionally asymmetric, apex acuminate. Leaf margin toothed. Venation actinodromous. Basal veins deviate suprabasally, going up to one-half of leaf lamina length and equal to first pair of secondary veins; agrophic veins, 4–8, present. Secondary veins three to six pairs. Tertiary veins thin, weakly convex or sinuous, opposite or alternate percurrent. Higher-order veins form reticulum of polygonal areoles with dichotomizing vein. Upper leaf surface epidermis consists of polygonal elongate cells with weakly undulate or straight anticlinal walls. Lower leaf surface epidermal cells polygonal, elongate with undulate anticlinal walls. Stomata anomocytic with six or seven subsidiary cells. Epidermis of upper and lower leaf surfaces bears trichome bases developing on several cells.

**Description** (Figs. 1a–1d; Figs. 2a–2h). Leaves are simple, entire, petiolate. The petiole is at





**Fig. 1.** Epidermal characteristics of *Platimeliphyllum reznikoviorum* N. Maslova, sp. nov., specimen no. 441-121, SEM: (a, c) epidermis of the upper leaf surface: (a) trichome bases developed on several epidermal cells (arrow), (c) elongated cells of the costal zone; bases of trichomes developed on several epidermal cells are visible (arrow); (b, d) epidermis of the lower leaf surface: anomocytic stomata and trichome bases, developed on several epidermal cells, are visible (arrow).

least 0.5 cm long. The leaf lamina is oval; in the largest specimens, it reaches 8 cm in length and 4.5 cm in width. Average length/width ratio is 1.8. The leaf base is rounded (Pl. 17, figs. 4, 7; Figs. 2a, 2f) or broadly cuneate (Figs. 2b, 2c); sometimes asymmetrical (Pl. 17, fig. 2, Fig. 2b). The leaf apex is gradually narrowing, acuminate. The leaf lamina margin is toothed. Teeth are small. The lower third of the leaf lamina (more rarely half of it) is entire. Two or three teeth come per 1 cm of the leaf margin.

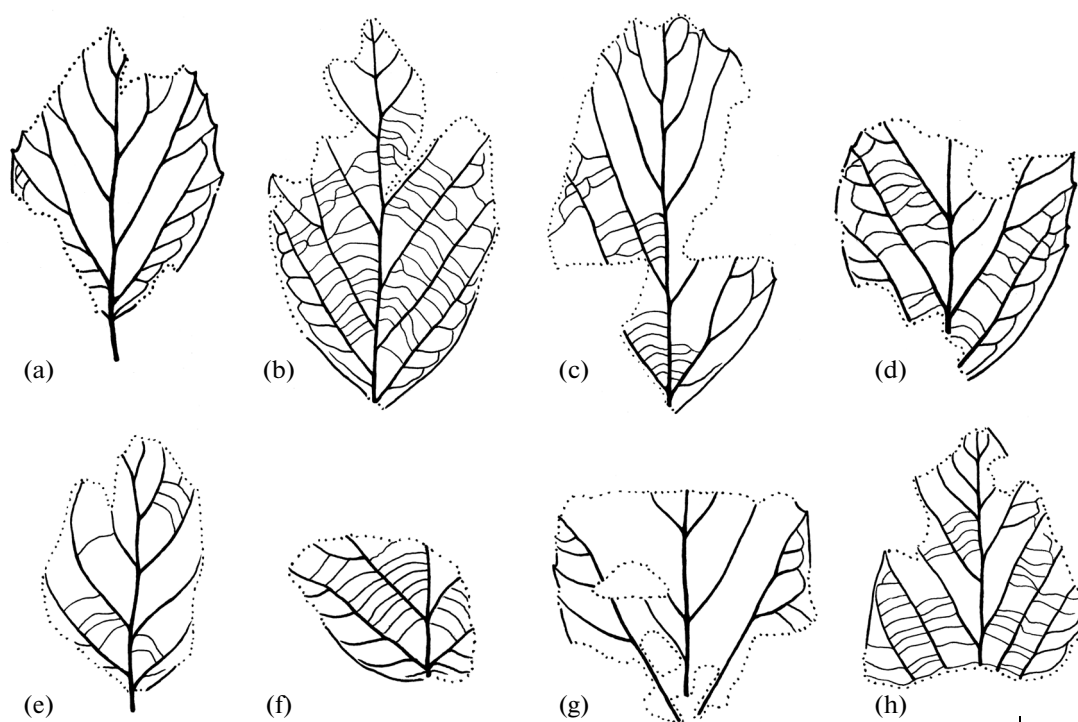
The venation is actinodromous. The midvein is straight or weakly curved at the upper part. Basal veins are arcuate, equal in thickness to the next pair of secondary veins; deviating suprabasally at an angle of  $45^{\circ}$ – $60^{\circ}$ , opposite or slightly alternate, and rising up

to the half of the length of the leaf lamina, or higher. Agrophic veins, 4–8, are arising on the exmedial side of basal veins at  $35^{\circ}$ – $90^{\circ}$ ; they are thin, arching, and not branching. The lower agrophic veins are looping, and upper branches end in teeth. There are one pair of infrabasal veins and three to six pairs of secondary veins. Secondaries almost equal in thickness, weakly arching; two lower pairs give up to three exmedial branches. Tertiary veins are thin, opposite or alternate percurrent, straight or slightly convex (Pl. 17, fig. 8). There are up to seven tertiary veins per 1 cm of a secondary vein. Finer venation is a system of polygonal meshes with a dichotomizing ultimate vein (Pl. 17, fig. 9).

The epidermis of the upper surface of the leaf lamina is composed of polygonal, elongated cells varying

#### Explanation of Plate 17

**Figs. 1–9.** *Platimeliphyllum reznikoviorum* N. Maslova, sp. nov., leaf impressions: (1) specimen no. 441-121; (2) specimen no. 441-124; (3) specimen no. 441-58; (4) specimen no. 441-112; (5) specimen no. 441-113; (6) specimen no. 441-7a; (7) holotype no. 441-56; (8) specimen no. 441-121, tertiary venation, SEM; (9) specimen no. 441-56a, higher-order venation, SEM. Figs. 1–7: scale bar 10 mm.



**Fig. 2.** Leaves of *Platimeliphyllum reznikoviorum* N. Maslova, sp. nov.: (a) holotype no. 441-56; (b) specimen no. 441-124; (c) specimen no. 441-121; (d) specimen no. 441-17; (e) specimen no. 441-113; (f) specimen no. 441-112; (g) specimen no. 441-62; (h) specimen no. 441-58. Scale bar 10 mm.

in sizes, with undulated or straight anticlinal walls. The maximum length of the cell axis is 30–40  $\mu\text{m}$ , the minimum one is 15  $\mu\text{m}$ . There are trichome bases, developing on several epidermal cells (Fig. 1a). Costal zone cells are rectangular or polygonal, elongated, up to 30  $\mu\text{m}$  long and 10  $\mu\text{m}$  wide. Trichome bases developing on several cells are observed in the costal zone (Fig. 1c).

The lower epidermis is composed of cells identical to those of the upper epidermis in size and shape. Anticlinal walls of the ordinary epidermal cells are undulate. Costal zone cells are generally rectangular, elongated, up to 30  $\mu\text{m}$  long and about 10  $\mu\text{m}$  wide. Stomata are anomocytic, mostly with seven subsidiary cells, rounded or slightly oval, about  $20 \times 25 \mu\text{m}$ ; there are one to three of them per  $\text{mm}^2$  (Figs. 1b, 1d). Rounded trichome bases developing on several (up to five) epidermal cells are observed (Fig. 1b).

**Comparison.** The new species differs from all known species of *Platimeliphyllum* in smaller leaf lamina, a lesser degree of variation of its characteristics, and the largest length/width ratio of the leaf lamina. Leaves from the Fushun Basin, northeastern China (Middle Eocene) and Maoming Basin, South China (Middle Eocene), assigned to the genus *Platimeliphyllum* (Krassilov et al., 2009; Kodrul et al., 2012), are characterized (as well as *P. reznikoviorum* sp. nov.) by relatively low variability of the leaf lamina morphology and its small size. It differs in domination of forms

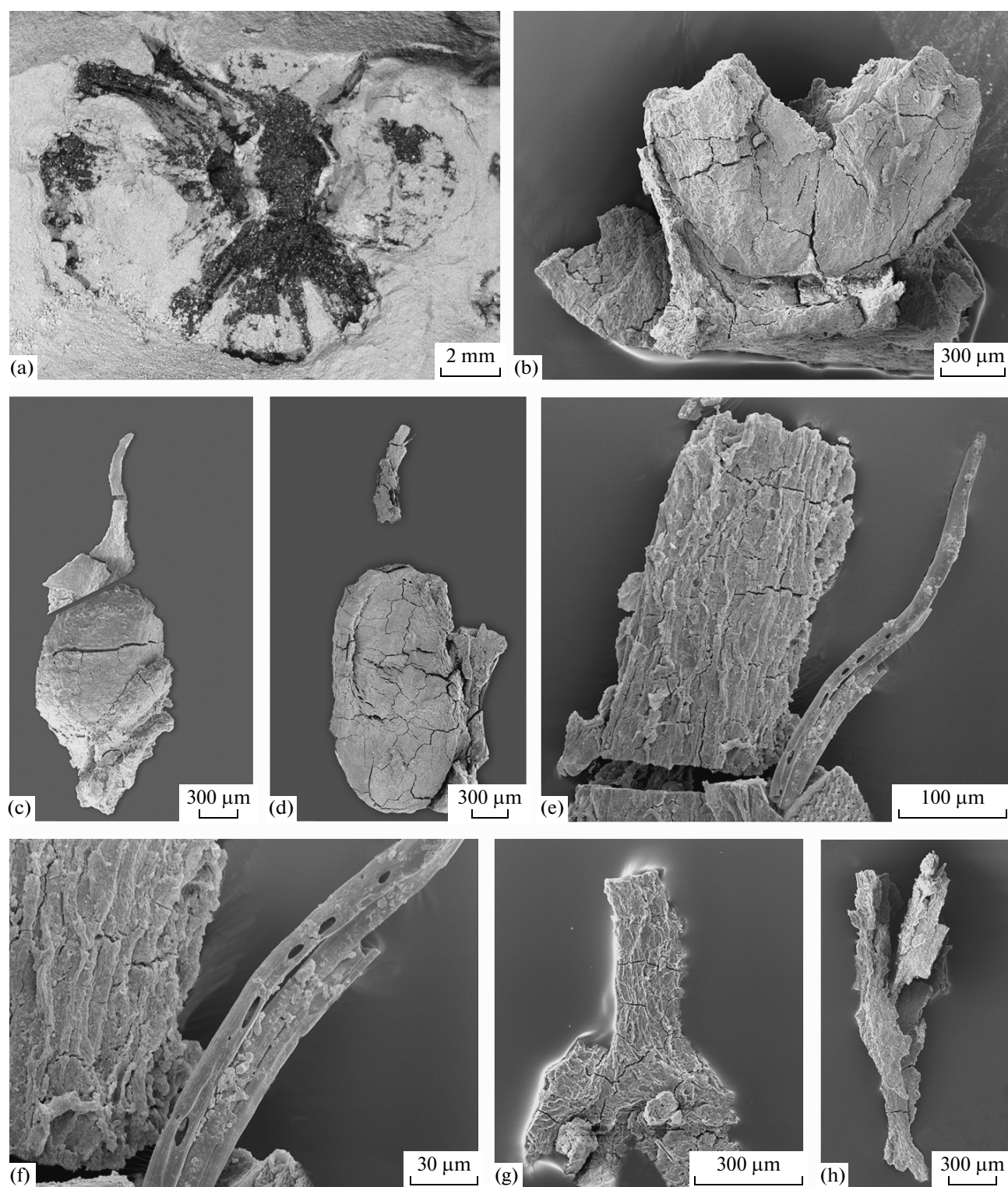
with lower starting dentation and fewer craspedodromous exmedial branches from the basal veins. Leaves of *Platimeliphyllum* from the Eocene Clarno Formation, North America (Krassilov et al., 2009), in contrast to *P. reznikoviorum* sp. nov., have rather large teeth and completely dentate leaf margin.

Besides the new species, epidermal characteristics are also known for *P. palanense* and *P. valentinii*. Epidermal features of the new species differ from *P. palanense* in the trichome bases developing on several epidermal cells. Ordinary epidermal cells in *P. reznikoviorum* sp. nov. are located randomly around the stomata, whereas in *P. valentinii* they form rows radiating from the stomata. There is also a difference in the shape of the ordinary epidermal cells: they are polygonal and elongated in *P. reznikoviorum* sp. nov., whereas mostly square in *P. valentinii*.

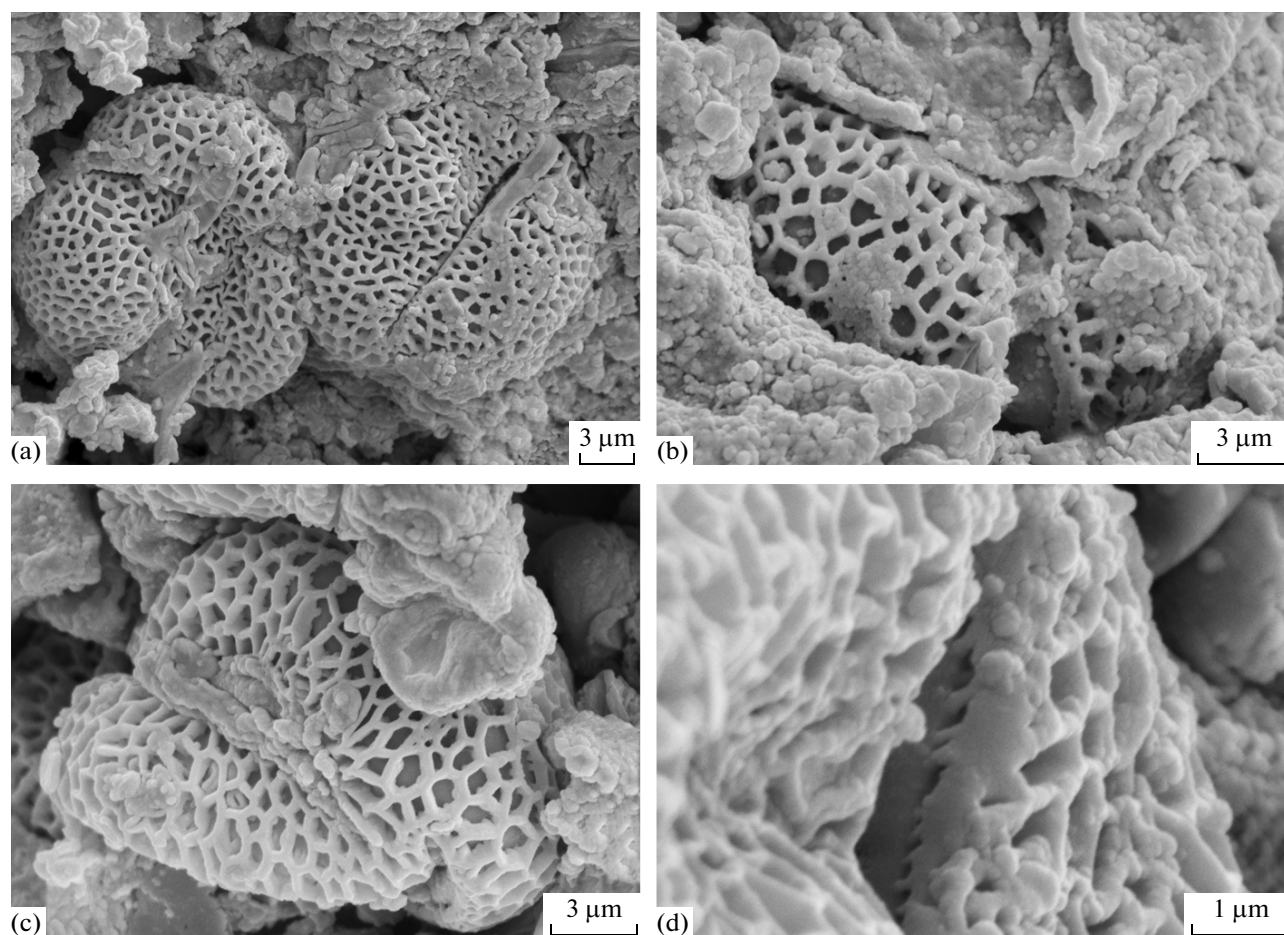
**Material.** Eighteen specimens from the type locality.

#### CAPITATE INFRACTESCENCES ASSOCIATED WITH *PLATIMELIPHYLLUM REZNIKOVIORUM* SP. NOV.

Only one capitate infructescence is presented at Shilin's collection from the Nizhnii Ashut locality (Fig. 3a). Unfortunately, the peculiarities of its preservation (strong deformation during the process of fossilization) make the study difficult. Moreover, all of its



**Fig. 3.** Infructescence associated with *Platimeliphyllum reznikoviorum* N. Maslova, sp. nov., specimen no. 441-18, (a) LM, (b–h) SEM: (a) general view of the infructescence; (b) fragment of the infructescence: the base consisting of two carpels is visible; (c, d) the carpel; (e, f) fragment of the style: tracheary with oval pores is visible; (g) fragment of the upper part of the carpel, (h) two styles bound together, separated from the carpels of a fruit.



**Fig. 4.** Pollen grains adhering to the carpel wall of the infructescence, associated with *Platimeliphyllum reznikoviorum* N. Maslova, sp. nov., specimen no. 441-18, SEM: (a) two pollen grains, polar view (left) and equatorial view (right); (b) part of the pollen grain; the colpus margin is visible; (c) general view of pollen grain with partly preserved aperturate membrane; (d) colpus area; the exine ultrastructure is seen: tectum and columellate infratectum.

structures are penetrated by dense network of cracks in different directions, making it difficult to extract infructescence from the rock and to fulfil further chemical treatment without damaging. Insufficient data does not allow us to describe this find within a particular taxon. However the available information may be useful for further research. Here we give a brief description of the obtained morphological and epidermal features of the capitate infructescence.

The head is 16 mm in diameter. It consists of a central core (about 2 mm in diameter) and radially attached fruits. The number of fruits does not exceed 10–12 fruits in the head. Microstructural features of individual fruits were studied using SEM. Perianth elements were not detected. We could not retrieve the whole undamaged fruit due to the poor preservation. However, the available fragments indicate that the fruit consists of two carpels (Fig. 3b) with long styles (Figs. 3c–d, 3g, 3h). The body length of a single carpel can be reconstructed and is about 2300–2400  $\mu\text{m}$ , width is 710–750  $\mu\text{m}$ . The carpel body is oval, with a relatively narrow conical base (Figs. 3b–3d).

The style is long, 2030  $\mu\text{m}$  in visible length. Probably, it is even longer. Due to the fragility of the material, it is only possible to measure the remaining fragments of the styles. We succeeded in detecting of individual tracheary elements of the vascular bundle with oval pores on the walls (Figs. 3e, 3f). The cuticle of the carpel outer wall is thick, strongly transversally striated; the epidermis is composed of more or less isodiametric, mostly tetragonal cells, 30–40  $\mu\text{m}$  in diameter (Pl. 18, figs. 1–3). Rare single trichomes 10–30  $\mu\text{m}$  in diameter occur in the epidermis of the lower part of the carpel (Pl. 18, figs. 5–8). The cuticle of the inner carpel wall is transversally folded (Pl. 18, figs. 2, 4). The carpel contains a single elongate triangular, slightly flattened ovule. The visible length of the latter is 1200  $\mu\text{m}$ , and width (at the widest part) is up to 650  $\mu\text{m}$  (Pl. 18, fig. 9).

Few tricolpate pollen grains, similar in morphology, about  $12 \times 17 \mu\text{m}$ , were found adhering to the carpel walls (Fig. 4). The colpi are long, more than 2/3 of the length of the polar axis (Figs. 4a, 4c). The sculpture is reticulate, with rare microreticulate cells at the

intersection of several larger ones. The diameter of large lumina is about 1  $\mu\text{m}$ , the width of the muri is 0.23–0.33  $\mu\text{m}$  (Figs. 4b, 4c). The colpus margin is formed by thin (comparable to the thickness of the muri) sporopollenin rim (Figs. 4a, 4d). The columellar infratectum is visible at a single pollen grain. Columellae are 0.08–0.15  $\mu\text{m}$  wide and about 0.15  $\mu\text{m}$  high (Fig. 4d).

## DISCUSSION

The first co-occurrence of the leaves of the genus *Platimeliphyllum* with a capitate infructescence is considered in the paper. Analysis of the described plant remains reveals a number of characteristics, which may suggest their belonging to the same plant.

Leaves of the genus *Platimeliphyllum* show a combination of platanaceous and hamamelidaceous characters (Maslova, 2002). Leaves of *Platimeliphyllum reznikoviorum* sp. nov. are similar to those of the extant *Platanus* in the following: typical actinodromous suprabasal venation, the presence of infrabasal veins, teeth shape showing longer basal side, anomocytic type of the stomata, and trichome bases developing on several epidermal cells. *Platimeliphyllum reznikoviorum* sp. nov. is similar to some modern hamamelidaceous genera (*Hamamelis* L., *Parrotia*, and *Parrotiopsis* Schneider) in the shape of the leaf lamina, the asymmetry of its base, poorly developed basal veins that do not differ in thickness from the next pair of secondary veins, and camptodromous agrophic veins. The presence of the leaves of the genus *Parrotia* from the Nizhnii Ashut locality is described in Shilin's monograph (1986). However, these were neither figured nor described in it. Obviously, these were the leaves that are described in the present paper.

The shape of the leaf lamina and its margin in *P. reznikoviorum* sp. nov. are very similar to those of *Parrotia*. This was apparently the reason that prompted Shilin to attribute the fossil leaves to this modern genus. However, the basal veins at the leaf lamina base of *Parrotia* are always naked. In contrast, in *P. reznikoviorum* sp. nov. they are always arising suprabasally; infrabasal veins are present. Furthermore, epidermal characteristics of *P. reznikoviorum* sp. nov., evidence in favor of its similarity to Platanaceae rather than Hamamelidaceae. Representatives of the family Platanaceae are characterized by anomocytic and laterocytic types of stomata and trichomes developing on several epidermal cells (Carpenter et al., 2005). Anomocytic stomata are also known for the leaves of *Parrotia* (Skvortsova, 1960, 1975; Pan et al., 1990); however no trichomes developing on several epidermal cells are known in this genus.

Previous studies have shown that the genus *Platimeliphyllum* was associated with three different genera established for staminate inflorescences from the Early Paleocene to Middle Eocene. These are

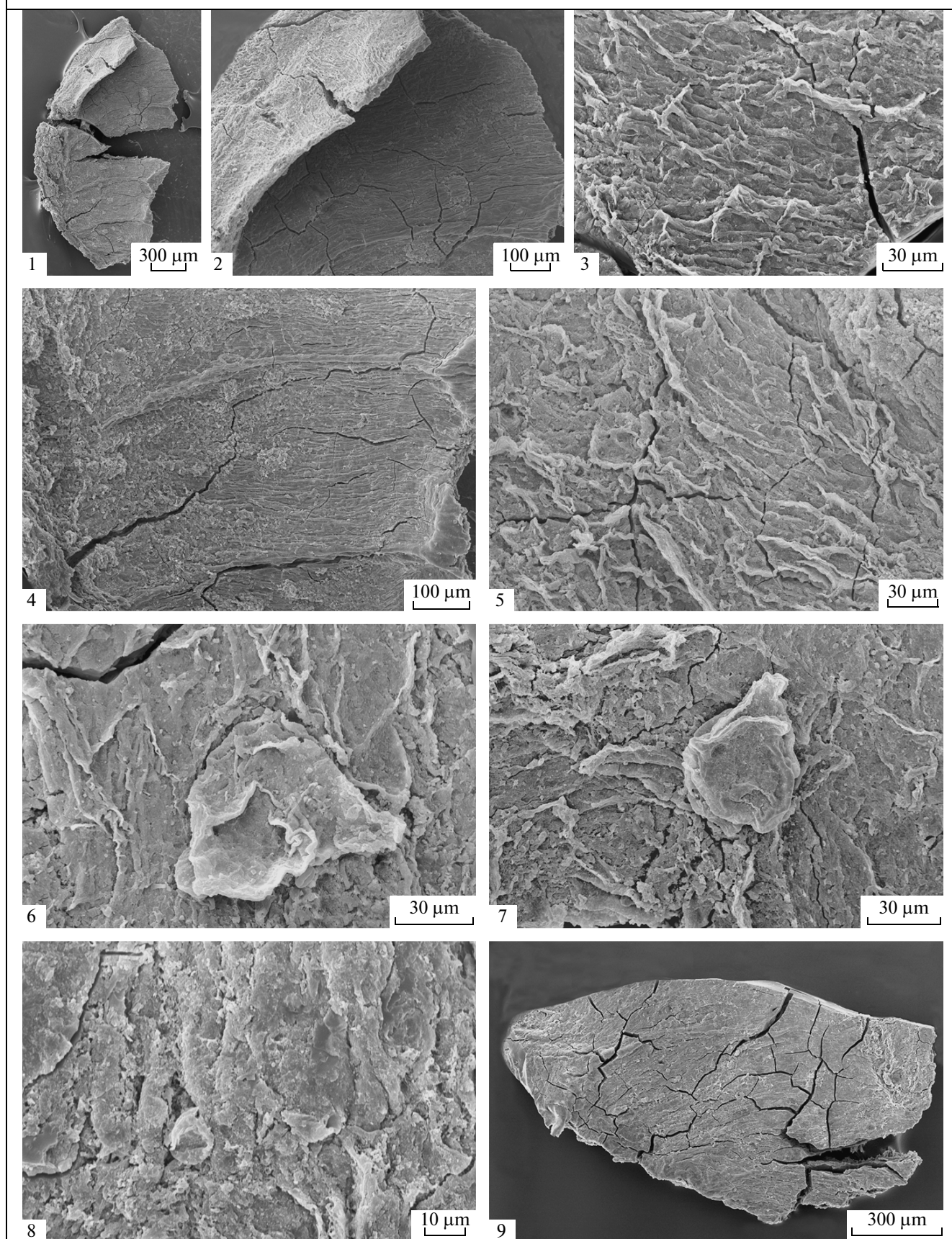
*Chemurnautia* N. Maslova, Platanaceae (Late Paleocene–Early Eocene; Maslova, 2002), *Archaranthus* N. Maslova et Kodrul, Bogutchanthaceae (Paleocene; Maslova and Kodrul, 2003), and *Bogutchanthus* N. Maslova, Kodrul et Tekleva, Bogutchanthaceae (Paleocene; Maslova et al., 2007). Up to the present, the information about pistillate inflorescences or infructescences associating with leaves of *Platimeliphyllum* was unknown.

No other remains of reproductive structures and leaves morphologically similar to those of Platanaceae have been found at the Nizhnii Ashut locality. Thus, attribution of the leaves, infructescence, and the pollen grains adhering to the carpel walls to the same plant seems quite probable.

The obtained data allow a comparison of the studied capitate infructescence with those of some representatives of the families Hamamelidaceae and Platanaceae. Since the infructescence remained isolated, we could not ascertain the way of attaching of the head to the axis. The shape of the infructescence (head) from the Nizhnii Ashut locality is similar to that of the modern and fossil Platanaceae, and of some related extinct genera of the families Bogutchanthaceae, Kasicarpaceae, and Sarbaicarpaceae (Maslova, 2010). Outwardly similar heads also occur in the modern genus *Liquidambar* L. (Altingiaceae). According to the recent data (Ickert-Bond and Wen, 2013), the latter includes three genera: *Liquidambar*, *Altingia* Noronh., and *Semiliquidambar* Chang. Inflorescences of the genera *Parrotia* and *Hamamelis* (Hamamelidaceae) are represented by strongly shortened spikes, outwardly indistinguishable from the heads (Bogle, 1970); in some cases, the infructescences of *Hamamelis* are characterized as capitate (*Flora of China*, 2003). Among the fossil genera exhibiting hamamelid features, the capitate infructescences are characteristic of Cretaceous genera *Lindacarpa* N. Maslova (Maslova and Golovneva, 2000), *Evacarpa* N. Maslova et Krassilov (Maslova and Krassilov, 1997), *Microaltingia* Zhou, Crepet et Nixon (Zhou et al., 2001) and *Viltyungia* N. Maslova (Maslova and Golovneva, 2000).

In the number of fruits in the head (up to 12), the described infructescence is similar to the heads of the Late Turonian genus *Microaltingia* (8–12 fruits). The infructescences of the modern genera *Parrotia* and *Hamamelis* include 3–7 and 2–3 fruits, respectively. Platanoids are characterized by a larger number of fruits: about 50 fruits per head in the Cretaceous *Friisicarpus* N. Maslova et Herman (Friis et al., 1988; Maslova and Herman, 2006; Maslova and Tekleva, 2012), about 60 in the Eocene genus *Macginicarpa* Manchester (Manchester, 1986), and more than 100 in modern platanoids.

Mature fruits of the infructescence from the Nizhnii Ashut locality lack perianth. In this feature they resemble the fruits of the Cretaceous genus *Microaltingia*, Paleocene genus *Evacarpa*, and Miocene spe-



cies *Liquidambar changii* Pigg, Ickert-Bond et Wen (Pigg et al., 2004). Lacking perianth fruits are also typical for heads of the modern *Liquidambar*. In modern *Platanus*, perianth elements are very small or absent (Linnaeus, 1754; Von Balthazar and Schönerberger, 2009, etc.). In contrast, flowers of the fossil platanoid capitate infructescences of *Friisicarpus* and *Macginicarpa* have well-developed perianths, often reaching the length of the carpels. The well-developed perianth is also known in the Cretaceous flowers of the genus *Lindacarpa*, related to Hamamelidaceae. Flowers of the modern genera *Parrotia* and *Hamamelis* also have a well-developed and differentiated perianth (*Flora of China* ..., 2003).

The fruit of the Nizhnii Ashut infructescence consists of two carpels with long thin styles. Obviously, the carpels are free at the base (Fig. 3b). However it is difficult to judge whether they were fused by the lateral sides or were free along the full length. It is also obvious that they were located very close to each other (fused?), since some fragments of the fruit demonstrate pair structures (Figs. 3b, 3c).

The length of the style is approximately comparable with the length of the carpel body. Long styles are known in some species of the modern *Platanus*. Among fossil genera, they are characteristic of *Macginicarpa*.

The cuticle of the carpel wall of the Nizhnii Ashut infructescence is relatively thick and transversely folded; trichomes various in diameter occur in the epidermis of the lower part of the carpel. These features and also the carpel shape with a narrow conical base and a single ovule make the studied infructescence similar to the Cenomanian–Turonian fructifications of the genus *Sarbaicarpa* N. Maslova (Maslova, 2009). The presence of trichomes on the carpel walls is also shown for the Cretaceous species of the genus *Friisicarpus*: *F. kubaensis* N. Maslova, Tekleva et Sokolova (Maslova et al., 2011) and *F. sarbaensis* N. Maslova et Tekleva (Maslova and Tekleva, 2012). Pubescence of the gynoecium elements is observed in a number of extant genera of the subfamily Hamamelidoideae (Bogle, 1970; Kapil and Kaul, 1972).

Nizhnii Ashut infructescence is related to platanoids by the presence of a single ovule in the carpel. Capitate infructescences of *Liquidambar* are characterized by numerous ovules in the carpel. However, there is also only one ovule in the carpel of *Hamamelis* and *Parrotia* of the subfamily Hamamelidoideae which infructescences are considered as capitate in some cases.

Pollen grains adhering to the carpel walls are of a very common type among dicots. Unfortunately, we could not study them using light and transmission microscopy. Thus, their comparison is limited. The main available features of these pollen grains were the size, shape, aperture type and exine sculpture. We compare these pollen grains with those of the fossil and modern representatives of the families Platanaceae and Hamamelidaceae, since the grains were found adhering to the walls of the infructescence that combines features of these two families.

The aperture type of the studied pollen grains is presumably tricolpate. No ora were found in SEM. However, the absence of ora could be more specifically judged by studying in LM. Thus, we cannot completely exclude the presence of ora in studied pollen grains and, accordingly, tricolporate type of the apertures.

Fossil and modern platanoids are characterized by pollen grains similar in size and aperture structure. However, unlike the studied pollen grains, most of them have microreticulate sculpture. Among fossil pollen grains, reticulate surface is observed in the Cretaceous species *Hamatia elkneckensis* Pedersen, Friis, Crane et Drinnan (Pedersen et al., 1994), *Platananthus potomacensis* Friis, Crane et Pedersen (Friis et al., 1988), and *Platananthus hueberi* Friis, Crane et Pedersen (Friis et al., 1988). *Platananthus hueberi* differs from the studied pollen grains in the larger size of reticulum cells; *Hamatia elkneckensis* and *Platananthus potomacensis* differ in significant reduction of cell size toward colpi.

The sporopollenin rim along the colpus margin in the studied pollen grains should be noted. It is also known in a number of fossil platanoids (*Platananthus scanicus* Friis, Crane et Pedersen, *P. speirsae* Pigg et Stockey, *P. synandrus* Manchester), but it is absent in the modern *Platanus*. Pollen grains of the latter significantly differ in microreticulate sculpture.

The sculpture type of fossil pollen grains of Hamamelidaceae is also reticulate, but the reticulum structure is more diverse than that of the Platanaceae. For example, the surface of the Later Santonian–Early Campanian *Archamamelis bivalvis* Endress et Friis (Endress and Friis, 1991) is microreticulate with thick (relative to the diameter of the cells) muri; the surface is microreticulate with relatively thin muri in dispersed *Tricolpites concinnatus* Chmura from the Maastrichtian of Sakhalin attributed to Hamamelidaceae (Takahashi and Saiki, 1995) and in pollen grains from Turonian stamens combining features of Platanaceae and Hamamelidaceae (Crepet et al., 1992). Pollen grains

#### Explanation of Plate 18

**Figs. 1–6.** Infructescence, associated with *Platimeliphyllum reznikoviorum* N. Maslova, sp. nov., specimen no. 441-18, SEM: (1, 2) fragment of the carpel wall; (3) epidermis of the outer surface of the upper part of the carpel: tetragonal cells are visible; (4) cuticle of the inner surface of the carpel; (5–8) epidermis of the outer surface of the lower part of the carpel: trichome bases varying in diameter are visible; (9) ovule.

of the Campanian species *Allonia decandra* Magallón-Puebla, Herendeen et Endress (Magallón-Puebla et al., 1996) are described with a peculiar reticulate surface and lumen diameter exceeding that of pollen grains adhering to the carpel of the Nizhnii Ashut infructescence. Pollen grains from the catkins found in association with *Hamawilsonia boglei* Benedict, Pigg et DeVore (Benedict et al., 2008; Late Paleocene), as the studied grains, have an expressed sporopollenin rim along the colpus margin. The diameter of a single lumen is similar or somewhat larger than that of the Nizhnii Ashut pollen grains. Pollen grains of the Late Paleocene catkins differ in a peculiar type of the reticulum, represented by a combination of large and considerably smaller lumina.

Using SEM Zetter et al. (2011) described dispersed pollen grains of *Retitrescolpites catenatus* Pocknall et Nichols, *Retitrescolpites anguloluminosus* (Anderson) Frederiksen, and *Retitrescolpites* sp. with reticulate sculpture from the Late Paleocene of the United States. They related the described grains with Hamamelidaceae. Among them, the studied pollen grains are most similar to those of *Retitrescolpites* sp. Pollen grains of the Late Santonian genus *Androdecidua* Magallón-Puebla, Herendeen et Crane, Hamamelidaceae (Magallón-Puebla et al., 2001) are somewhat smaller but have exine sculpture similar to the studied ones. The sculptured aperture membrane characteristic of Hamamelidaceae is described for *Androdecidua*. This character cannot be used for comparison because of the small number of pollen grains found with closed colpi.

The comparison of the studied pollen grains with those of the modern representatives of the family Hamamelidaceae has shown that their exine sculpture (diameter of the reticulum cell and sporopollenin rim along the colpus margin) is most similar to that of the extant genera *Mytilaria* Lecomte, *Disanthus* Maxim., *Ostrearia* Baill and *Hamamelis* (Bogle, Philbrick, 1980). In general, compared with the data given in Philbrick and Bogle (1980), Nizhnii Ashut pollen grains are smaller than most modern genera of Hamamelidaceae (except those of *Mytilaria*). The studied pollen grains are similar to a number of modern Hamamelidaceae (e.g., members of the subfamily Exbucklandioideae) in the presence of the sporopollenin rim along the colpus margin.

## CONCLUSIONS

The new species *Platimeliphyllum reznikoviorum* sp. nov. from the Paleogene Nizhnii Ashut locality (central Kazakhstan) is described based on morphological and epidermal features of the leaves. This find extends the geographical distribution of the genus within Central Asia. The leaves of *P. reznikoviorum* sp. nov. and associated capitate infructescence bear several characteristics typical for the families Platanaceae and Hamamelidaceae. This fact and the analysis of the

taxonomic composition of the Nizhnii Ashut flora suggest that they belong to the same plant. It is the first evidence of the association of *Platimeliphyllum* leaves with female reproductive structures. Probably, in the geological past, there was a group of plants with leaves similar to *Platimeliphyllum*, associated with reproductive structures of different genera (Maslova, 2002; Maslova and Kodrul 2003; Maslova et al, 2007; present paper), as it was in the case of plants with platanoid leaves (*Ettingshausenia* Stiehler), that were accompanied by a variety of reproductive structures (Krassilov and Shilin, 1995; Maslova and Herman, 2004, 2006; Maslova et al., 2005; Maslova, 2009; Maslova et al., 2011). In consideration of this fact, it seems appropriate to regard the genus *Platimeliphyllum* within Krassilov's morphological classification (1979).

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