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Research paper

Barykovia, a new genus of angiosperms from the Campanian of northeastern Russia

Maria G. Moiseeva *

Laboratory of Palaeofloristics, Geological Institute, Russian Academy of Sciences, Pyzhevsky per. 7, 119017, Moscow, Russia

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ABSTRACT

Fossil leaves from the Campanian of Ugol'naya Bay (northeastern Russia) previously assigned to *Quercus tchucotica* Abramova are described as *Barykovia tchucotica* (Abramova) Moiseeva comb. nov., the type species for the newly recognized extinct foliage genus *Barykovia* Moiseeva gen. nov. *Quercus tchucotica* was identified in a number of floristic assemblages in northeastern Russia. Leaves of the genus *Barykovia* are highly variable in shape and leaf margin, which makes it difficult to differentiate species. However, based on an analysis of the morphological variability of the leaves, a second new species, *B. kamchatica* Moiseeva from the Upper Bystrinskaya Subformation of northwestern Kamchatka is established. The finding of a *B. kamchatica* shoot with leaves attached confirms that this genus has simple leaves.

1. Introduction

Fossil leaves superficially similar to recent representatives of the family Fagaceae are common in the Late Cretaceous and Paleogene floras of the Northern Hemisphere. Isolated leaves from the Barykov Formation of Ugol'naya Bay (northeastern Russia) were first assigned by Abramova (1979) to *Quercus tchucotica* Abramova. This species is a dominant and characteristic element in the rich and diverse Barykov flora. The flora is well dated as early to middle Campanian, based on marine mollusks, and typical for the Barykov phase (Santonian–early-middle Campanian) of the floristic development in the Northern Pacific region (Herman, 1999, 2011). Later studies revealed that *Q. tchucotica* is present in a number of floristic assemblages in northeastern Russia and that it is, together with representatives of *Macclintockia*, indicative for a Campanian age. This taxon was also described from the Upper Bystrinskaya Subformation (?Campanian) of northwestern Kamchatka (Herman and Lebedev, 1991) and from the Emuneret Formation of the Enmyvaam River Basin, central Chukotka (Lebedev, 1987). Many palaeobotanists compared this species to the widely distributed *Q. groenlandica* Heer. Similar Cretaceous and Paleogene leaves were also attributed to *Quercus, Quercophyllum, Fagopsis, Fagopsiphyllum, Zelkova* and others.

The problem of the generic affiliation of these leaves has been discussed by many authors. According to Abramova (1979), the leaves show a strong resemblance to extant *Quercus* (especially *Q. cerris* L., *Q. muehlenbergii* Engelmann, *Q. castaneifolia* C.A. Meyer, *Q. mongolica* Fischer and *Q. dentata* Thunberg). However, this opinion was not confirmed by a co-occurrence of leaves and reproductive organs resembling those of modern *Quercus*. The oldest fossils of the extant genus *Quercus* are silicified nuts from the middle Eocene Clarno Formation, Oregon, USA (Manchester, 1994). The leaf organization of *Q. tchucotica* Abramova was also questionable. Some authors suggested that the leaves of *Q. tchucotica* could be compound because of the asymmetry of the leaf lamina and the resemblance to leaflets of *Hollickia* and *Dalembia*. Therefore, these leaves were often misidentified as *Rulac (=Hollickia) quercifolium* Hollick.

In this paper we propose a new fossil genus of angiosperms — *Barykovia* Moiseeva gen. nov. based on the re-examination of fossil leaves from the Campanian in northeastern Russia. Leaves of this genus are highly variable in shape and leaf margin, which has makes it difficult to differentiate species. However, an analysis of the morphological variability of the leaves allows to distinguish two species: *B. kamchatica* Moiseeva from the Upper Bystrinskaya Subformation of northwestern Kamchatka and *B. tchucotica* (Abramova) Moiseeva comb. nov., the type species for the genus.

2. Material and geological setting

The fossil material consists of well-preserved leaf impressions without cuticle and comes from three regions in northeastern Russia: Ugol'naya Bay, Valizhgen Cape and the Enmyvaam River Basin (Fig. 1). In the Ugol'naya Bay area the fossil plants were collected from several localities of the Barykov Formation by Lebedev, Volobueva and Terekhova in 1961 and 1971. These collections, GIN no's. 3385 and 4895, include 37 fossil leaves of *"Quercus" tchucotica* and are now at the Geological Institute, Russian Academy of Sciences, Moscow, Russia. We also re-examined the type material of *"Quercus" tchucotica* (11 specimens) which is kept at the Chernyshev Central Scientific Research Geological Survey Museum (TSNIGR Museum, collection no. 11629), St. Petersburg, Russia.

Albian to Paleocene marine and non-marine deposits that accumulated in coastal lowlands and a shallow marine basin are exposed

* Tel.: +7 495 9535723; fax: +7 495 9510443.
E-mail address: masha.moiseeva@gmail.com.

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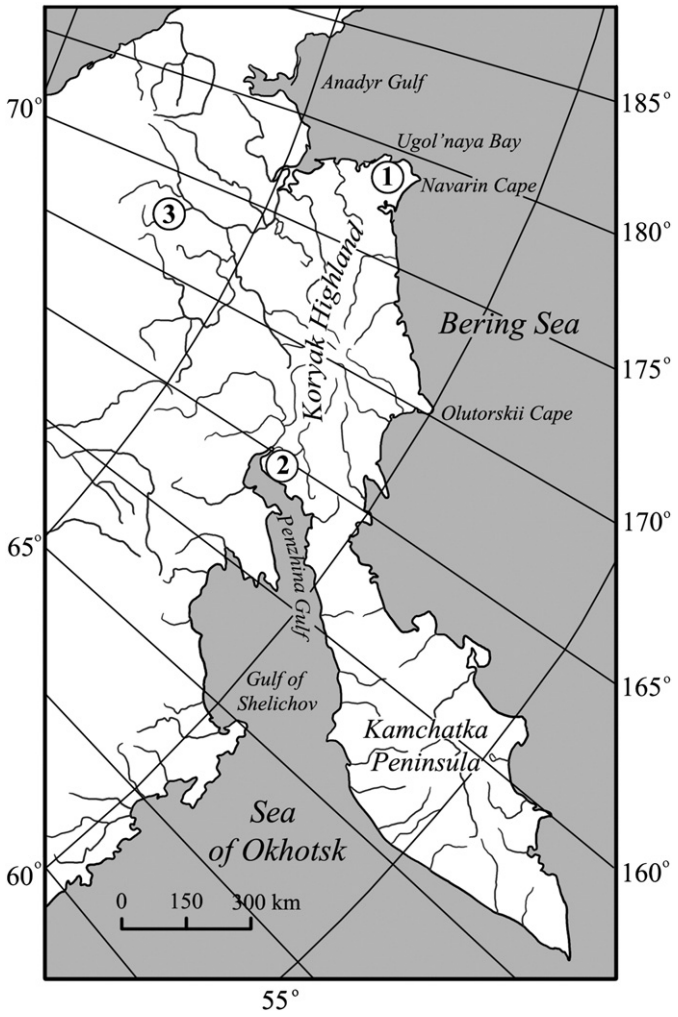

Fig. 1. Fossil sites in northeastern Russia where *Barykovia* plant fossils were found: 1 — Ugol'naya Bay; 2 — Valizhgen Cape; 3 — Enmyvaam River.

in Ugol'naya Bay (Fig. 2). The Barykov Formation overlies the Albian–Cenomanian Ginter Formation with an angular unconformity and is subdivided into four lithological members (Pergament, 1971, 1974). The three lowermost members (V–VII, Fig. 2) are marine and contain Coniacian–Santonian (?early Campanian) molluscs. The upper "Coaly" member (VIII, Fig. 2) consists of three units (VIIIa–c): a lower coal-rich, a middle coal-free and another upper coal-rich unit. Sandstones and coaly–clayey siltstones of the units VIIIa and VIIIc contain numerous plant fossils representing the Barykov floristic assemblage (Filippova and Abramova, 1993; Herman, 1999; Moiseeva and Sokolova, 2011). The coal-free marine sandstones of the middle VIIIb unit contain Campanian inoceramids (*I. ordinates ordinates* Pergament, *I. anadyrensis hastatus* Pergament, and *I.* aff. *schmidti schmidti* (Michael)) (Pergament, 1974). The Barykov Formation is conformably overlain by or shows an erosional contact with the Koryak Formation, which Campanian–Maastrichtian in age, based on inoceramids. Therefore, the plant-bearing units within the upper member (VIII) of the Barykov Formation are early Campanian and possibly extend to the early late Campanian.

We have analyzed 49 specimens of fossil leaves from the Emuneret Formation of Central Chukotka (Fig. 1). This material was collected by Lebedev and Kostina along the middle course of the Enmyvaam River in 1984 and is now housed in the Geological Institute RAS, Moscow, Russia (collection GIN no. 3392). The leaf impressions are well preserved and show fine details of the delicate venation. This collection had not been formally described yet. Lebedev (1987) published only a short preliminary list of species for this fossil plant assemblage. The Enmyvaam River Basin belongs to the central segment of the Okhotsk–Chukotka volcanogenic belt. The stratigraphy and fossil plant assemblages of this area have been discussed by Lebedev (1987), Belyi (1977), and Belyi and Belaya (1998). In this area volcanogenic deposits of the Ergyvaam, Emuneret and Enmyvaam formations are exposed. These formations were formed during the late stage of the evolution of Okhotsk–Chukotka volcanic belt. The Emuneret Formation conformably overlies rhyolitic ignimbrites of the Ergyvaam Formation and is subdivided into three lithological units (Belyi and Belaya, 1998). The lower unit of the Emuneret Formation mainly consists of alternating thin layers of tuffaceous sandstones and silicic tuffs; it contains abundant plant fossils, which constitute the Ust–Emuneret floristic assemblage. The middle and upper units of the Emuneret Formation are composed of silicic tuffs, breccias, black rhyolitic vitroignimbrites, and tuffaceous sandstones with layers of andesitic tuffs. The total thickness of the Emuneret Formation is about 450 m. This formation is overlain by high-Al plateau basalts of the Enmyvaam Formation. The age of the Ust–Emuneret floristic assemblage has been debated over last three decades. According to palynological data, it is late Turonian (Belyi and Belaya, 1998). Based on isotopic data, it was dated as Turonian (92.7 ± 2 Ma) (Kotlyar and Rusakova, 2004) or Coniacian–Santonian (86.8 ± 2.7 Ma) (Tikhomirov et al., 2006). On the other hand, according to Lebedev (1987), the Ust-Emuneret assemblage is similar in its floristic composition to the Campanian Barykov flora of Ugol'naya Bay.

The Cretaceous stratigraphy and age of northwestern Kamchatka floras have been discussed in detail by Pergament (1961), Herman and Lebedev (1991) and Herman (1999, 2011). Therefore, only a short review is provided here. Specimens cited in this paper (collection GIN no. 3823, 39 specimens) were collected by Lebedev, Pergament and Avdeiko in 1957 and 1964 from the Upper Bystrinskaya Subformation of Valizhgen Cape. In this region the Bystrinskaya Formation conformably overlies the continental Valizhgen Formation and is subdivided into two subformations. The Lower Bysrinskaya Subformation, consisting of marine green sandstones with inoceramids, is Santonian–?early Campanian in age. The Upper Bysrinskaya Subformation is composed of tuffs, sandstones, clayey siltstones with seams of carbonaceous shale and coals containing numerous plant fossils (Upper Bystrinskaya flora). This subformation is conformably overlain by marine deposits with Campanian molluscs. The age of the Upper Bystrinskaya flora is considered to be early Campanian, possibly extending to late Santonian and early late Campanian. Therefore, the Barykov and the Upper Bystrinskaya floras are of approximately the same age.

3. Systematic palaeobotany

Order MAGNOLIOPSIDA
Group Fagofolia Krassilov
BARYKOVIA Moiseeva, *gen. nov.*
Type: Quercus tchucotica Abramova, 1979.

3.1. Diagnosis

Leaves simple, entire, size varies from microphyll to notophyll, length to width ratio from 1.5:1 to 4:1. Leaf lamina oblong-ovate, narrow ovate or elliptical, sometimes asymmetric. Leaf base cuneate to broadly cuneate, rounded or rarely truncate, usually asymmetric and decurrent along petiole. Leaf apex acute, rarely acuminate or slightly rounded. Leaf margin serrate or dentate, double-serrate, double-dentate, rarely undulate, of regular or irregular spacing. Teeth large, typically broadly to less commonly narrow triangular, rounded-triangular, with straight to convex (occasionally slightly concave) apical and basal flanks and blunt or acute apices, with occasionally discerned small glands. Teeth vary in shape and size in one specimen, simple or compound with 1–3 smaller teeth on the basal