EARLY CRETACEOUS FLORA OF MONGOLIA

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With 20 Plates, 11 Figures and 2 Tables in the Text

Abstract

The Lower Cretaceous lacustrine beds of Mongolia are rich in faunal remains, but the fossil plants are scarcely known. Rich plant localities were discovered recently by the Soviet-Mongolian geological expedition in the Central Mongolia (Bon-Tsagan Lake), Gurvan-Eren Range to the west, Mongolian Altai (Erdeni-Ula), Gobi Altai (Knolbotu-Gol, Khuriltu), and eastern Gobi (Tsagan-Tsab, Modon-Usu, Shin-Khuduk and Manlaj). In the central region, the plant-bearing beds belong to the Undur-Ukhin, Anda-Khuduk and Khulsyn-Gol Formations, while their correlatives in the western and eastern areas are assigned to the Gurvan-Eren, Tsagan-Tsab and Shin-Khuduk Formations.

Four assemblage zones are recognized: (1) *Baiera manchurica*, (2) *Otozamites lacustris* — *Pseudolarix erensis*, (3) *Baierella hastata* — *Araucaria mongolica*, and (4) *Limnothetis gobiensis* — *Limnoniobe insignis*. Zones (1) and (2) are assigned to the Neocomian, (3) and (4) to the Aptian. These age assignments essentially agree with the invertebrate data.

Plant megafossils came from the tuffaceous beds and aleuropelitic paper shales — varvites, deposited in meromictic lakes. Varvites contain abundant pollen grains in the lighter coloured lamellae. There are also coprolites and caddis fly cases with plant remains. Aquatic Lycopsida are abundant in the upper horizons, possibly evidencing the eutrophication of the lakes.

At the beginning of the Cretaceous, the fern marshes have been drastically reduced (hence the paucity of ferns in the Cretaceous assemblages as contrasted with the Jurassic ones). Mud flats around the lakes were colonized by the hydrophylic bennettites (*Otozamites*) and presumably also by the primaeval reed- and sedge-like monocots. Other angiosperms represented by winged fruits (*Gurvanella, Erenia*) might grow on slopes occupied by the *Pseudolarix* forests.

An *Araucaria* — *Brachyphyllum* lowland community is conceived as the eastern extension of the European — Central Asian brachyphyllous forests, while some Siberian refugees, suposedly confined to the slopes, have given the Mongolian flora an ecotonal aspect.

The Mongolian flora is peculiar in the unique association of archaic plants, such as *Darneya* and *Swedenborgia*, with early angiosperms. There are also endemic genera of the Lycopsida. Additional morphological information with some phylogenetic implications is provided for bennettites, *Karkenia*, *Leptostrobus*, conifers and pollen cones. Winged fruits and other angiosperm-like fossils may evidence a major radiation centre for angiosperms.

The described species belong to the fungi, horse-tails, ferns, Lycopsida, Bennettitales, Ginkgoales, Czekanowskiales, conifers, angiosperms and angiosperm-like plants. New species are: *Muscites ostracodiferus*, *Limnothetis gobiensis*, *Limnoniobe insignis*, *Nilssoniopteris denticulata*, *Otozamites lacustris*, *Ginkgoites mongolensis*, *Pseudolarix erensis*, *Schizolepis drepanoides*, *Pityospermum amplexum*, *Samaropsis aurita*, *S. sagittata*, *Darneya angusta*, *Williostrobus latisaccus*, *Pityanthus microsaccus*, *Graminophyllum primum*, *Gurvanella dictyoptera*, *Erenia stenoptera* and *Typhaera fusiformis*. Five of them are also new genera: *Lesswdema*, *Limonosperma* (Lycopsida), *Gurvanella*, *Erenia* (angiosperm-like) and *Typhaera* (incertae sedis). Lycopsida; Gymnospermae; Angiospermae; Plant Palaeoecology; Early Cretaceous; Mongolia.

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Preface

The Lower Cretaceous beds of Mongolia, especially the paper shale facies are famous for their exceptionally rich fauna of crustaceans, insects and fishes. These beds have been extensively studied by the joint Soviet-Mongolian geological expedition in the area ranging from the Great Lakes in the west to the eastern Gobi. The principal outcrops are in the piedmonts of the parallel, north-west — south-east trending ranges of Khangai, Mongolian Altai and Gobi Altai. Plant fossils sporadically found in the paper shales have been mentioned in paleontological and stratigraphical papers (Cockerell, 1924; Shuvalov, 1975; Martinson, 1975). Balta (1972) has listed 32 Mesozoic plant localities seven of which are presumably Cretaceous. A few plants have been properly described and illustrated (Jahnichehn & Kahlert, 1972), and these also are fragmentary. Much better preserved material was collected by paleontologists of the Soviet-Mongolian expedition. In 1975 V. V. Jakovlev gathered numerous plant remains at Bon-Tsagan, Shin-Khuduk, Modon-Usu and Manlaj. In 1976 and 1977 a party headed by Yu. A. Popov, A. G. Ponomarenko and S. M. Smirna made fairly large collection at about twenty rich localities comprising several plant-beds each (Ponomarenko & Popov, 1976). A. G. Ponomarenko and S. M. Smirna kindly provided me with geological information.

As the collections of the Soviet-Mongolian expedition were accumulated and studied, it became clear that we were dealing with a new major fossil flora which deserved detailed treatment. Plants from the Lower Cretaceous localities are described in this paper. The Jurassic and Late Cretaceous plants will be described elsewhere.

Geological setting

The Lower Cretaceous fossiliferous beds lay on the coarse-grained Upper Jurassic red beds. In the eastern Gobi, the lower horizons — the Tsagan-Tsab Formation — are tuffaceous conglomerates, sandstones, shales and marls interbedded with andesitic and basaltic tuffs. They are overlain by the bituminous aleuropelitic paper shales, marls and dolomitic lacustrine limestones — the Shin-Khuduk Formation (Martinson, 1975). In the central Mongolia (Khangai Range, Mongolian Altai, Bon-Tsagan Lake), the lower horizons are known as the Undur-Ukhin Formation, correlated with the Tsagan-Tsab. Thick sequences of the bituminous paper shale-cyclites with occasional coal beds constitute the Anda-Khuduk Formation (Shuvalov, 1975), obviously corresponding to the Shin-Khuduk in the east. The uppermost part of the Lower Cretaceous sequence — the Khulsyn-Gol Formation — is again coarse-grained, lighter colored and tuffaceous. In the western region, the tuffaceous Tsagan-Tsab — Undur-Ukhin beds and the paper shales are replaced by monotonous sequence of gray, variegated or red sandstones, clays and marls — the Gurvan-Eren Formation (Khosbayar, 1973).

On the evidence of invertebrates and fishes, the Tsagan-Tsab level is assigned to the Neocomian, the Shin-Khuduk — to the late Neocomian-Aptian and the Khulsyn-Gol — to the Aptian-Albian.

The most complete sequence of plant beds is in the central region, to the south of the Bon-Tsagan lake. The sequence is as follows (the dominant plants are marked with an asterisk):

1. Sandstones, locality 2, with Batara manchurica Yabe et Oishi, Podosamites sp. and Brachyphyllum densiramosum sp. nov.
3. Green-gray and black aleuropelitic shales interbedded with marls and limestone, localities 73—39, 74—3,
strobus latisaccus, Pityanthus
Problematospermum
Stenomischus densiramosum
Swedenborgia junior
yielded a fungus cap, the gametophytes of unknown plants,
Samaropsis aurita
Sphenobaiera
Equisetostachys
Baiera manchurica
localities of presumably Tsagan-Tsab level are at the Modon-Usu Creek and Manlaj. Yellow sandstones at
cf. hastata
at Tsagan-Tsab. They are mostly angiosperm fruits
twigs, cone scales and seeds),
localities 213—23, 25, 28 which yielded
to the Khulsyn-Gol Formation.
Dicksonia concinna
dicksonioides and yellowish-white tuffites representing lower horizons of the Khulsyn-Gol Formation contain
shales contain cf. mongolica
Cladophlebis
sp. nov., (SEW.) FLORIN,
cf. mongolica
sp. nov.,* (shoots and cones),
Baierella hastata
75—5, 87—8, 193—3,
194—1 with cf. Cyathea tyrmensis (Nev.) YABE & OISHI* (in the fish bed),
194—1 with Cyathea tyrmensis (Nev.) YABE & OISHI* (in the fish bed),
sp. nov.,*, Phoenicopsis angustifolia Heer, Podocamites sp.,
Damea etrusca
sp. nov., Brachyphyllum densiramosum sp. nov.,
Araucaria monglica sp. nov.,* Pityanthus microsaccus sp. nov.,*, Pityospermum amplexum sp. nov.,*
Araucaria monglica sp. nov.,* Pityanthus microsaccus sp. nov.,*, Pityospermum amplexum sp. nov.,*
minor localities in these beds, 35, 34 and 60 cm, cf. Dicksonia consine Hess, Linn mechanism of sp. nov.,
Nutsopites densiramosum sp. nov., Neovitinus cervinus Voss., Pterophyllum burejense sp. nov.,
Heer., Neovitinus cervinus Voss., Pterophyllum burejense sp. nov.,
Heer., Neovitinus cervinus Voss., Pterophyllum burejense sp. nov.,
(NEV.) KRASSIL.,
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Phytostratigraphy

In Mongolia, the Early Cretaceous localities contain sparse fern fragments only while the Jurassic floras are dominated by ferns. These types of assemblages appear to be easily distinguishable, but the fern criterion needs further practical correlation. The fern beds may comprise also the lowermost Cretaceous. Czekanowskia is abundant in the Jurassic, but has not hitherto been recorded from the Cretaceous.

Four phytostratigraphic units can be provisionally recognized in the Cretaceous:

1. The Baeeria montanensis zone represented at Tsagan-Tsh, Modon-Us and Bon-Tsagan. Baeeria montanensis is common in the Urgal Formation (Valanginian) of the Bureja basin (KASHIN, 1912).

2. The Otozamites — Pseudolarix erensis zone, comprising the localities Bon-Tsagan, 23—22, Gurvan-Ern (Den—29 and Manli 2,5 and 92. Apart from Otozamites and Pseudolarix, the correlation of Bon-Tsagan, 23—22, and Gurvan-Ern is supported by Brachyphyllum sulcatum, which Gurvan-Ern and Manli contain the angiosperm fossils. This community has no close analogue outside Mongolia. The flora is of generalized Wealden aspect and does not seem younger than Neocomian.

3. The Tetralithus baturata (and its conspecific Karkenia mongolica) — Aranocarpos mongolica zone includes localities of the Shin-Khuduk — Anda-Khuduk level, mostly in the paper shale facies at Bon-Tsagan, 73, 74, 75, 87, 193, Khbos-N-196, 197, 199, 216, Khultu, 210, Erdeni-Ula 213, Shin-Khuduk, 1, 117, 118, 119, and Modern-Usu, 152. Ratales baturata is closely related to R. stewartii (sor.) Krasnos. from the Tcheremchaus (Aptian) beds of the Bureja basin and Ginkgoites mongolica also represent a leaf morphotype common in the Tcheremchaus beds. Neocomites occurs in the Aptian of Jakutia and Primorye. This community is comparable with the Aiptos flora of Primorye (KASHIN, 1967) on account of Aranocarpos and other conifers.

4. The Limnothetis-Limnoniobe zone is confined to the Khulsyn-Gol Formation at Bon-Tsagan 49—59. It is distinctive on account of the mass occurrence of endemic cryptogamous plants (new genera). However the gynospermous species are the same as in the third zone, suggesting the age not younger than Aptian.

Palaeoecology

The Early Cretaceous flora of Mongolia is ecotonal between the temperate (Siberian) and subtropical vegetation comprising such genera as Phanerostipa, dominant in the Siberian realm, and Otozamites, typical representative of the Polypodiphyllum communities. Judging by their frequencies, Siberian plants might have grown on slopes, while subtropical plants dominated the lowland vegetation.

The Mongolian flora differs from both Buea (temperate) and Primorye (subtropical) floras by much lower fern content. Irrespective of their actual frequency in a flora, ferns are rare fossils except in the fern marshes. The abundance of ferns in the Jurassic localities of Mongolia suggests fairly extensive fern marshes on the deltaic mud flats. The beginning of the Cretaceous, the fern marshes had been reduced and the fern fossils became rare. This happened simultaneously with the development of meromictic lakes and deposition of seasonal varvites on slopes, while subtropical plants dominated the lowland vegetation.

Some reduction of forest vegetation can also be assumed. In the Manli localities, conifers are represented mostly by winged seeds and cone scales. It appears that a conifer forest was at some distance from the lake, presumably on slopes, while on the flat shores grew the primaeval reed- and sedge-like monocots. They possibly colonized the mud flats exposed when the lake shranked during a dry season. The appearance of angiosperm fossils in the lower horizons while they are lacking in the overlain strata, seems paradoxical, but it can be related to the reduction of indigenous Mesozoic vegetation. A hermatite Otozamites lacustris accompanied them, and judging by the leaf anatomy (see below), it was adapted to periodical submergence. In Bon-Tsagan, 23—22, the conifers are better represented, and in Gurvan-Ern, Pseudolarix erensis is most abundant and Brachyphyllum is also common. The Pseudolarix forest grew perhaps on nearby slopes. An angiosperm Ginkgoella might also occur on slopes, because the winged fruits only were fossilized. At the close of the Neocomian, the Otozamites angiosperm community was replaced by Ratales-Pteridocarpos shrubs, and the forest vegetation also underwent considerable changes. Aranocarpos mongolica and Brachyphyllum densistratius are abundant in practically all Aptian localities. They are represented by shoots, microscoli Willestrobus laianaeus, Sorniunculus sp., megastrobili and seeds (Sorniuncus). The conifer forests dominated by Brachyphyllum and
Iraucaria were apparently proximal to the sites of deposition. These communities can be conceived as a continu-
on of the European-Central Asian brachyphyllous forests (i.e., characterized by the Brachyphyllum shoot mor-
phology assumed convergently by conifers of different affinities, mostly the Araucariaceae, Tatoulacaceae and Chri-
symlyaceae). The brachyphyllous forests extended through Mongolia to Primorsky and Japan. The northern limit
for these forests was at the Tymra River, 50° North (Krassilov, 1978a). The expansion of brachyphyllous forests in
late time can be related to the positive amelioration of climate.

Another type of the forest vegetation is represented by prolific samaras Phoenicopsis angustifolia of Abieta-
nous affinities. There are also less numerous leaves (Pityophyllum) and microstrobili (Pityanthus). Preliminary
study of the same plant. The abundance of samaras and their even distribution in major localities suggest an extensive slope
vegetation dominated by an Abietaceous conifer mixed with a few representatives of the Siberian floristic realm, such as
Phoenicopsis angustidens which appeared in the fossil record as the climax of the Aptian.

In the Shin-Khuduk varvites, the light brown laminated (spring layers) are densely covered with pollen
cells distinguished under low magnification. I picked these pollen grains by needle and after a few minutes
exposure to HCl and HN0₃, counted them to obtain a rough estimate of the contribution of various conifers to the pollen rain (the figures obtained by this technique are presumably less biased than in the standard palynologi-
atical procedure dealing with volumes rather than surfaces). The numerical representation per 100 pollen grains is:

- Pityospermum montanum (Pleakone) — 40,
- Limnoniobe laurinae (Abietaria mongolica) — 36,
- Darneya angusta (Podozamites) — 6.

For the remaining 18, the megafossils were not recognized. The rise of aquatic or semi-aquatic Limnoniobe of Limnoniobe at the close of the Aptian (Bon Tsagan, 45—19) can be related to eutrophication of the lakes.

There is much evidence of the animal-plant interactions. The most interesting are the caddis fly cases built of
kernels seeds (Text-Fig. 7J). According to SKVSTINA (in press), these cases rank among the most sophisticated
structures ever built by caddis flies. The inner tube is made of fusiensed plant tissues, resin bodies of Karkenia seeds
and occasional megaspores of Limnoniobe. The outer sheath is built of the Karkenia seeds which are very carefully
fixed, their micropyles facing outside. The Karkenia seeds have been produced by a plant with Baierella hastata leaves.

Phylogenetic comments

In the Early Cretaceous flora of Mongolia, Svechothegi and Darneya, later expanded mostly from the
Galeopsis, associate with primaeval angiosperms and peculiar endemic plants. One can assume that the evolu-
nion in Mongolia was favorable for both survival of relics and production of new forms in various plant
taxa.

Lemnostrobus with solitary sporangia terminal or pseudoterminal on specialized shoots constitutes another
ample (complimentary to Svechothegi, KRASSILOV, 1978b) of evolutionary experimentation in the Mesozoic
gymnosperms, leading to reproductive structures analogous to those of conifers. Lemnostrobus represents Ibathero-
recorded group of Mesozoic heterosporous plants possibly related to the Pennsylvanian Polypodiaceae.

New data on the leaf anatomy of a Bennettites arnsani with aerenchymous spongy mesophyll suggest
Hydrophytic adaptation. In the vascular bundles of the leaves there are members with perforated ends, suggesting the development of vessels is bottommost (Pl. 6, Figs. 62–65).

The association of Karkenia megastrobili with several Ginkgoalean leaf morphotypes is supported by the new finds in Mongolia. Now Karkenia is known to associate with Ginkgoites, Sphenobaiera and Baierella. Leptostrobus (Czekanowskiales) with papillate marginal fringe is found for the first time outside the Bureja basin in the Far East of the USSR. There is evidence of a secretory function of the papillae, supporting my interpretation of the marginal fringe as a stigmatic structure. Stomatal apparatus in the Czekanowskiales might be of mesoperigenous type.

Swedenborgia and Cycadocarpidium, associating with Podocarpaceae in the Triassic and Liassic localities, were not hitherto recorded from younger Mesozoic strata, and the reproduction in the younger Podocarpaceae conifers remained enigmatic. In Mongolia at least three kinds of Swedenborgia associate with Podocarpaceae as well as the pollen cones of the genus Darneya. The latter are also prominent in the Triassic (GRAUVOGEL-STAMM 1978) has assigned Darneya to the Voltziaceae while Podozamites is conventionally referred to the Cycadocarpidaceae. However Cycadocarpidium and Swedenborgia are sufficiently similar to the Voltziaceous seed-scale complexes to keep them in the same family. At least in one line of this family, the male and female reproductive structures have been fairly constant through 100 m.y.

The conifers with Brachyphyllum leaves present a difficult classification problem. In some European localities, most of them belong to the Cheirolepidiaceae group. Some of the dominant Mongolian brachyphylls are assigned to the Araucariaceae (on the evidence of microstrobili with pollen grains as well as megastrobili). Other may belong in the Cheirolepidiaceae group or the Taxodiaceae.

The cone scales of Pseudolarix erensis occasionally resemble those of Schizolepis suggesting possible phylogenetic links. Otherwise P. erensis is fairly modern-looking. Mongolia was also the home of other progenitors of the modern Pinaceae.

Gurvanella and Erenia rank among the earliest angiosperms supporting the idea of the Central Asian origin of this group (KRASSILOV, 1977). The angiosperm-like fossils from Manlaj may evidence the initial radiation of aquatic monocots in which the reproductive structures characteristic of various orders have been created by a few megasporophyll evolutionary steps. However caution is needed in dealing with these fossils which are so poorly known at present.
axis, dense on the side branches, with internodes 0.7 mm (measured by leaf scars), spiral, decurrent, obliquely spreading, straight or reflexed, crowded and appressed at the apex, about 3.5—4 x 1.5—2.6 mm. Distal leaves are longer than the proximal. The leaf blade is narrow-lanceolate, expanded and spreading at the base, gradually tapering to the apex, folded, margin entire. The costa is narrow, filling the apex. An apical hair is about 2 mm long.

Remarks: Abundant remains of this moss associate with the spiny ostracod shells which look as if they were attached to the shoots by their spines. The moss is comparable to *Muscites fontinalioides* KRASSILOV (1973) from Burjatia, but larger.

**Locality:** Erdeni-Ula, 213—25.

**Horse-tails and ferns**

*Pl. 1, figs. 12—16, Text-Fig. 11—N*

Remarks: The horse-tail and fern fossils are too fragmentary for systematic treatment. A horse-tail with long leaves of *Equisetum laterale* type (HARRIS, 1961) is found in Bon-Tsagan, 45—19, while smaller specimens with shorter leaves occur in Shin-Khuduk 118—8c and Curvan-Eens. 256—29. A single specimen of *Equisetum* comes from Murbil (*Pl. 1, fig. 12*).

Sphenopteroid ferns from Bon-Tsagan 25—22 are comparable with *Onychiopsis psilotoides* (STOKES & WEBB) WARD (Text-Fig. 1J) while a few fragments from Bon-Tsagan 45—19, 87—8 and Shin-Khuduk 118—16 with delicate pinnules showing unbranched veins resemble *Ctenitis zonoma* (Nov.) KRASSILOV (1979a).

Cladophleboid ferns with basally constricted pinnules, cf. *Osmunda doniana* (Nov.) KRASSILOV come from Bon-Tsagan, 45—19, 87—4 and Shin-Khuduk, 119—4a (Test-Fig. 11). Another Osmunda-like pinnule with oblique, forking and occasionally anastomosing veins was found in Shin-Khuduk 119—3c (Text-Fig. 1K). Serrate pinnules with once-forking veins, cf. *Cladophlebus drummondii* (BRODIE) are from Shin-Khuduk 119—4c (Test-Fig. 11).

**Lycopsida**

*Limnothetis*, gen. nov.

Type species: *Limnothetis gobiensis* sp. nov.

Name: Alluding to the extra care for a single offspring.

**Diagnosis:** Shoots creeping, looking equally at base, unequaly above, pseudomonoecious. Lateral branches dichotomic, alternate. Leaves ligulate, on the main axis monomorphous, two-ranked, on lateral branches dimerophous, four-ranked; the ventral leaves broadly ovate, imbricate; the dorsal leaves small, pointed. Adventitious roots in the axils of the ventral leaves. Fertile zones of crowded short shoots bearing a single terminal sporangium protected by imbricate bracts. Sporangia dimerous, 1.2 x 1 mm and 1 x 0.6 mm. Microspores trilete, smooth.

Remarks: The dimorphism of sporangia suggests heterospory, but spores were extracted from smaller sporangia only. The megaspores are found in the rock together with fertile shoots, but not in situ.

Shoots of this plant resemble *Selaginella*. In some species of *Selaginella*, sporangia are also in fertile zones. But in *Limnothetis* the sporangia seem terminal on fertile brachyblasts with a few bracts. Actually they might be pseudoterminal, in the axils of apical bracts. In either case, the unisporangiate brachyblasts differ from any sporangiospores of *Selaginella* or other members of the lycopsida.

**Limnothetis gobiensis** sp. nov.

*Pl. 2, figs. 16—24, Pl. 3, figs. 25—31, Text-Fig. 2*

**Holotype:** Bon-Tsagan, 45—19, N 3509/10201. *Pl. 2, fig. 17.*

**Diagnosis:** As for the genus.

**Description:** A massive body with root scars in *Pl. 2, fig. 16* is a rhizome bearing 6 shoots, their basal portions straight, 1 mm thick, with sparse leaves. About 30 mm above the base, the shoots fork, giving rise to
nely leaved branches. Second branching is at intervals of 1—3 mm, so that the branches seem whorled. Drainage forking is unequal, giving the shoot a pseudomonopodial aspect, with the main axis straightened to the lateral branches dichotomous. The lateral branches are at acute angle to the main axis, some of them bent towards, at interval of 10 mm in the middle portion of a shoot, but more crowded at the apex. Leaves on the main axis and at the angle of branching are broadly ovate or rhomboidal, about 3—4 × 2—2.5 mm, imbricate, with the obliquely decurrent, clasping base and the attenuate, hair-like apex, funnel-shaped or folded along the n. Labellately triated, showing the ligular scar as a minute pit at the base (PL 2, fig. 24). Leaves on the lateral axes are dimorphous, four-ranked (PL 2, figs. 17, 18): those in the ventral ranks like on the main axis, the lateral small, about 1 mm long, not always discernible. Adventitious roots, when preserved, attached in the n of the ventral leaves. Rounded bodies, 2—7 mm in diameter, with a thick folded cuticle associated with the axis, might be tubers.

Fig. 2. Limnothetis gobiensis sp. nov., reconstruction of a fertile zone.

In the fertile portion of a shoot, the specialized fertile brachyblasts (sporangiophores) are in the axil of each lateral leaf, crowded, overlapping, arranged distichously, abranian. The sporangiophores are elliptical, about 1 mm long, consisting of a short axis bearing a single terminal sporangium and about 10 appressed bracts which se above the sporangium (PL 2, figs. 20, 21).

Sporangia are mostly elliptical, 1 x 0.6 mm, containing numerous small spores (10 sporangia were macerated). Occasional sporangia are considerably larger, 1.2 x 1 mm, rounded and appear more bulky (PL 2, fig. 22). They are limonized, not yielding to maceration.

Spores are about several hundred per sporangium, trilete, amb rounded, diameter 44—60 μm, leasurae ending to equator. Exine is reticulate, with polygonal meshes 7—8 μm wide, thickened at the corners, elongating into concentrical ridges in the fringe. The exine is also ornamented with spines, more numerous on the tal face than on the proximal. The spine stumps are rounded, set on the corners of the reticulum, occasionally with concentrical arrangement of the meshes.

There are also numerous reniform bodies, sometimes covering the rock surface, about 1 mm in diameter, two, traversed by a median groove (PL 1, figs. 5—6). On transfer preparations these bodies show polygonal

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meshes 7–8 mm wide, resembling the reticulum of the megaspores. I believe these bodies to be floating megagametophytes of Limnothetis.

Locality: Bon Tsagan.

Type species: Limnoniobe insignis, sp. nov.

Name: Alluding to so many sacrificed offsprings — the abundant fossil megaspores.

Diagnosis: Plants with thick (30 mm) stem showing spirally arranged leaf- and root-scars. Leaves spreading radially from the stem, ribbon-shaped, 70 x 7 mm, venation immersed, stomata absent. Subepidermal parenchyma of very large polygonal cells. Megasporangia supposedly in fertile zones, large, globose. Megaspores about 800 μm in diameter, distally spinose, proximally verrucose, showing triradiate mark with auriculae.

Remarks: Sporangia were not found in organic connection with the leafy stems. However, they are reasonably attributable to the same plant on the evidence of close association of the shoots, sporangia and megaspores, often superimposed on the leaves. Sporangia and megaspores crowded around the transversely broken stems suggest fertile zones of the type known in Lycopodium, Selaginella, Sporangiostrbus and Polypogon. The Mongolian plant is comparable with the Nathorstiana — Stylites — Isoetes group on one hand and the Paleozoic Spencerites — Polysporia on the other. It is more close to Polysporia in the stem diameter, flattened leaves and auriculate megaspores. The leaf structure is remarkably similar showing large-celled mesophyll and much smaller tabular epidermis cells. The Polysporia shoots often break at fertile zones (DIMICHELE et al., 1979). In the light of these similarities, Limnoniobe can be conceived as the Mesozoic descendant of the Polysporia group differing from all other Lycopsid genera in ribbon-shaped leaves. The mode of preservation of the very long leaves spreading radially from the stems suggests an aquatic plant.

Limnoniobe insignis, gen. nov.

Diagnosis: As for the genus.

Description: Stem fragments are up to 50 mm long (entire length unknown), 30 mm in diameter. They are preserved as compression or transverse cuts. The stem epidermis, preserved on a single specimen (PL 4, fig. 37), shows polygonal cells (of the same dimensions as in the leaf epidermis), transverse wrinkles and circular root scars, 0.3 mm in diameter, arranged spirally at 1 mm in parastichies. Leaf scars are variable, their form presumably depending on the portion of a stem preserved. They are either rounded—rhomboidal, 2.5–3 mm wide, irregularly spaced, or elongate, in more regular parastichies. Some of them show a single leaf trace. In the upper portion of a stem, the leaves are more crowded, imbricate, forming a shallow funnel. The leaves are ribbon-shaped more than 70 mm long, 5–7 mm wide, margins entire, parallel, converging gradually to the base. The leaves are seemingly flat,
but might be fleshy, with immersed veins, normally invisible. A specimen in which the epidermis is partially decayed exposing subepidermal tissues shows a mid vein 0.5 mm thick, bordered by the narrow sheathing cells. The parenchymous tissue forms two rows of meshes along the midvein (PL 5, figs. 47, 48).

The calcite incrustations of the leaves were studied with SEM (PL 5, fig. 45). They show epidermis and subepidermal spongy tissue. The epidermal cells are rectanguloid, squarish or polygonal, stretched transversely or isodiametrical, about 80 μm wide. The transversely stretched and isodiametrical cells are in alternating rows. The subepidermal tissue is a honeycomb of very large polygons 250 μm wide suggestive of aerenchyma.

Hand-specimens with stems and leaves are often strewn with megaspores (PL 4, figs. 38, 39). Close to the transverse break of a stem there are globose megaspore masses 7 mm in diameter which are apparently the fills of megasporangia each containing about 60 megaspores. There are also spherical bodies of the same dimensions showing radial rows of rectangular and polygonal cells similar to the epidermal cells of the leaves (PL 4, fig. 42). These bodies might be megasporangia, but no megaspores were found in situ. The megaspores, preserved as casts and compressions, are spherical, amb rounded-triangular, diameter 700—1000 μm, fringe about 200 μm wide. The bases are raised, straight or somewhat undulating, reaching to equator and extending on the fringe as low ridges. The ends of triradiate mark are expanded into the bulbous auriculae as in *Valvisisporites* and *Minerisporites*. A few specimens show reticulum with rounded-polygonal meshes (PL 5, fig. 52). In most megaspores the reticulum is obliterated leaving verrucose sculpturing of the contact facets. The distal wall is spinose, showing a few large spines, about 30 μm in diameter, and numerous smaller spinules between them. The fringe is radially folded. Some megaspores show numerous microspores stuck to their surface (PL 5, fig. 50, 51). In *Selginella* microspores often stick to the megaspores. One can surmise that in *Limnoniobe* the same was the case. Masses of similar microspores have been obtained by bulk maceration of the rock containing megaspores.

**Locality**: Bon-Tsagan, 45—19.

**Gymnospermae**

Bennettitales

*Nilssoniopteris denticulata* sp. nov.

Holotype: Bon-Tsagan, 45—19, N 3559/10002, PL 7, fig. 71.

Diagnosis: Leaf blade attached adaxially leaving the median portion of a rachis exposed. Margin toothed. Veins mostly simple, opposite, straight, sutured already near the margin, ending in the teeth, occasionally looping. Stomata transverse or oblique, paracytic, about 27 μm wide.

Description: The largest specimen (holotype) is the posterior portion of a leaf 40 mm wide, narrowing gradually to a short petiole. Rachis is stout, 3.5 mm wide, its median stripe 1 mm wide is exposed between the halves of the leaf blade. Lateral veins are thick, fairly distinct, opposite, arising at interval of 2 mm, at right angle to the rachis, simple. Close to the margin, the veins are upturned terminating in minute teeth (Text-Fig. 4C). Another leaf from the same locality is only 4.5 mm wide, with the blade halves nearly converging over the rachis. The lateral veins arise at interval of 0.8 mm, occasionally anastomosing and forming loops (PL 7, fig. 72). A specimen from *Modon-Usu* shows more frequent veins, 8 per 5 mm, forked at the base. The marginal teeth are of unequal size. The cuticle is thin. Costal zones consist of 4—5 rows of narrow cells. Intercostal cells are irregular, with sinusous walls. Stomata are oriented transversely or obliquely to the veins. The width of the paracytic stomatal apparatus is fairly constant — 27—28 μm, but the width of subsidiary cells is variable. They can be only 5 μm wide. Remarks: These leaves are similar to *Nilssoniopteris amurensis* (NOVOPOKR.) KRASSIL. in the mode of the blade attachment to the rachis and prominent lateral veins. They differ in the marginal teeth and occasionally looping veins.

A petiolar bract from *Shin-Khudsuk* (PL 7, fig. 70) may belong in this species. The blade is lanceolate, acute, with a midvein wide at the base, tapering upward, lateral veins simple. The petiole is longer than the blade (20 mm), inflated at the base, pubescent.

Otionamia lacustris sp. nov.

**Holotype:** Bon-Tsagan, 23—22, N 3559/10023. PL 6, fig. 58.

**Diagnosis:** Pinnules small, about 10 x 5 mm, tongue-shaped, petiolulate, auriculate, veins thick, prominent, repeatedly forked, occasionally anastomosing. Upper epidermis cells with deeply sinuous walls. Stomata immersed in the mesophyll consisting mostly of spongy aerenchyma-like tissue.

**Description:** Numerous detached pinnules are preserved in Bon-Tsagan and Manlaj. Most of them are incrustations or thin compressions, but a single specimen (PL 6, fig. 59) is apparently uncomprimented, very thick, with convex adaxial surface, abaxially prominent veins and well preserved mesophyll resistant to maceration. Microscopic preparations of mesophyll and vascular bundles were made from this pinnule, while the cuticle is better preserved in this compression.

The pinnules are tongue-shaped, with entire margins, rounded apex and auriculate base, the petioidle is 1 mm long. The veins are dense, flabellate, terminating at the margin, occasionally joined. The veins entering the basal auricle extends along its inner margin giving off short actosopic branches. In some pinnules from Bon-Tsagan, two median veins are more prominent than the rest.

Both upper and lower cuticles are very delicate. The upper epidermal cells are irregularly shaped with a central thickening and deeply sinuous anticlinal walls. The wall sinuosities are fungiform, 20 μm wide. In the lower epidermis, the cell walls are less sinuous. Stomata are mostly transverse to the veins, occasionally oblique or longitudinal, separated by one or two ordinary cells. The stomatal apparatuses with paracytic subsidiary cells are 42 μm wide, the guard cells are 25 μm wide (PL 6, figs. 67, 68).

The stomata are immersed in the mesophyll which consists mostly of a thick honeycomb spongy tissue resembling the aerenchyma of aquatic plants. The cells of spongy tissue are parallel to the leaf surface, 12—14 μm wide, branched and joined by variously shaped appendices. The cell walls are thick, transversely striated. On the lateral wall, there are prominent thickenings. Pits of the reticulum are elliptical or rounded. On the lateral wall, there are small prominently raised pores resembling the intervessel pitting (PL 6, figs. 67, 68). The ends seen in a few elements are either pointed, with a small rounded terminal pore (PL 6, fig. 62) or obliquely truncated showing a porous perforation (PL 6, figs. 63, 64, 65 upper end).

**Remarks:** Otionamia falsa HEER has similar pinnules and very sinuous cell walls in the upper epidermis. A tissue with polygonal lumina described by Marras (1973, PL 3, fig. 4) as lower epidermis, is rather like the spongy parenchyma. O. lacustris differs from this and other species by petiolulate pinnules and occasional anastomoses. The stomates are remarkably like those of the Palaeozoic pteridosperm Reticulopteris (RUSSIUS & SCHMIDT, 1978), and the leaf anatomy is also convergently similar. Such anatonical features as the aerenchyma-like spongy tissue suggest periodical submergence of the leaves. The detachment of pinnules and their high frequency in the lacustrine deposits may also be related to such submergence. The xylem elements consist mostly of tracheids but a few of them are interpreted as vessel members having porously perforated ends.

**Locality:** Bon-Tsagan 23—22, Manlaj, 92—16.
Remarks: There are detached pinnules 25—27 x 8—9 mm, straight, with cordate base and rounded apex. Venation is flabellate, rather dense. The cuticle is delicate, with moderately sinuous walls and paracytic stomata. These pinnules are much larger than in O. lacustris, more like conventional Otozamites, e.g., O. klipsteinii (DUNKER).

Locality: Gurvan-Eren, 236—29.

Neozamites verchojanicus VAKHRAMEEV
PL 7, fig. 4N, Text-Fig. 4N, О

Description: Pinnules about 30 x 9 mm, base cordate, apical portion flabellate. The marginal projections are simple or compound serrations at the base, narrow lobes 4 mm long in the median portion and dentations of unequal length at the apex. The lobes are notched, with the apical teeth of equal or unequal (the posterior one shorter) size. Veins dense, 8 per 5 mm, flabellate, terminating at the marginal projections. Cuticle thin, showing stomata cell walls and syndetocheilic stomata with scarcely specialized subsidiary cells. The orientation of stomata is irregular. The guard cell thickenings are 20 \( \mu \)m wide.

Locality: Bon-Tsagan, 45—19; Shin-Khuduk, 118—8c.

Pterophyllum spp.
Text-Fig. 4G—К

There are at least three species: (1) cf. P. burejense PRYNADA (see VAKHRAMEEV & DOLUDENKO, 1961) from Knolbotu-Gol, 197—27 (Text-Fig. 4G, H); segments linear-lanceolate, 40 x 5—8 mm, expanded at the base, gradually tapering in the apex, veins simple, parallel, 10 per segment. Cuticle delicate, stomata frequent, irregularly oriented. Mesophyll consists of spongy parenchyma with rounded-polygonal cells; (2) cf. P. sutchanense PRYNADA (see KRASSILOV, 1967) from Modon-Usu, 2 (Text-Fig. 4K); segments rectangular, 19 x 7 mm, apex rounded, veins 10 per segment; (3) cf. P. angulatum HEER from Gurvan-Eren, 236—29, leaves irregularly divided into rectangular or trianguloid segments, 10 x 5—10 mm, margin thickened, veins simple, about 15 per 5 mm, cuticle delicate, stomata irregularly oriented (Text-Fig. 4L, J).

Cycadolepis sp.
Text-Fig. 4M

Description: Bract obovate 21 x 10 mm with median groove, apex broadly rounded, slightly notched, base cuneate, margin serrate in the distal portion, serrations small, unequal, irregularly spaced. Veins dense, thin, diverging from the base terminating at the margin. Base pubescent, hairs about 1 mm long, dense, forming tomentose cover. Sparse marginal hairs occur also in the distal half of the bract.

Remarks: This bract may belong to the plant with Otozamites lacustris leaves. It differs from other Cycadolepis in median groove and marginal projections.

Locality: Bon-Tsagan, 23—22.
Ginkgoites mongolensis

Holoype: Shin-Khuduk, 118-8c, N 3665/5001, PL 7, fig. 78.

Diagnosis: Leaves about 20 x 30 mm, blade divided into 2 or 3 primary lobes which are indented 1/3 of the length or less. Terminal lobes typically 6. Veins 6 per 5 mm. Stomata scattered, subsidiary cells papillate, lower epidermis pubescent.

Description: Leaves are broadly cuneate or flabellate, 18-22 x 25-33 mm. There are two modes of the leaf division: 1) by a median sinus nearly to the base and 2) by two deep sinuses diverging at 45°. The resulting two or three primary segments are normally indented once or twice up to 1/3 of their length giving rise to 3-6 terminal lobes. Occasional leaves are but slightly indented. The terminal lobes are 2-4 mm wide, truncate or slightly tapering and notched, with 4 to 7 veins. Lower cuticle showing costal zones about 100 μm wide, of three cell rows, with rounded hair bases. The intercostal zones are about 250 μm wide, with stomata widely spaced, irregularly oriented, monocyclic. Subsidiary cells, 4-6, with prominent papillae overhanging the guard cells, sometimes joined to form a ridge around stomatal pit. Less than 1/3 of the guard cell width is exposed in the pit which is about 35 μm long.

Remarks: Among the comparable leaf types, G. sibiricus (HEER) SEW. has typically 8-10-lobed leaves. In G. tapkensis DOLUD. et RASSK, leaves are larger, with densely papillate epidermis (DOLUDENKO & RASSKASOVA, 1972). In G. jampolensis E. LEBEDEV the most frequent morphotype is 4-lobed (Krassilov, 1972). All these types of many-lobed leaves constantly associate with entire or bilobed leaves usually classified as different species. The ensuing species pairs (one for the many-lobed morphotype, the other for the entire) may evidence balanced leaf polymorphism in many Mesozoic Ginkgoalean plants.

Locality: Shin-Khuduk, 118-1, 118-8c, 119-3c, 119-7a, Manlaj, 92-14.

Baiera manchurica

YABE & OISHI PL 7, fig. 79, Text-Fig. 5F-H

Description: The dominant leaf type is flabellate, about 40 x 40 mm, divided into 6 primary lobes which fork to produce 12 terminal lobes, about 3 mm wide, with 4-5 veins each. Larger leaves from Tsagan-Tsab (blade 100 mm wide, terminal lobes up to 55 mm long) show elongate resin bodies between the veins.

Lower cuticle is thin, showing narrow costal zones of 4-5 cell rows and much wider intercostal zones with 2-3 rows of stomata each. The costal cells are elongate, with ridged, somewhat undulating anticlinal walls. The intercostal cells are irregular, with prominent hemispherical papillae. Stomata are in broken rows, rather numerous, mostly longitudinal, with 5-6 subsidiary cells, sometimes with 1 or 2 encircling cells. The subsidiary cells are distinguishable by their radial arrangement and large proximal papillae covering most of the guard cells, often completely filling the stomatal pit.

Remarks: These leaves show more prominent papillae than the Burejan specimens (Kasatkin, 1972), otherwise they are similar.

Locality: Modon-Usu, 2, Bon-Tsagan, 2, Tsagan-Tsab, 12.

Baiera sp.

Text-Fig. 6

Description: Leaf blade is almost circular, 25 mm wide. Stalk is more than 7 mm long, forking at obtuse angle, each branch forking repeatedly at short interval, giving rise to 6 primary lobes. These are indented 1/3 or 1/4 their length. The resulting 16 terminal lobes are 1 mm wide, acute, with 2 veins each. The marginal lobes overlap the stalk.
Remarks: The leaf is more deeply divided than *B. manchurica* YABE & OISHI. It differs also from *B. furcata* (LINDL. & HUTT.) BRAUN (see Harris et al., 1976) in circular outline, with marginal lobes overlapping the stalk.


*Sphenobaiera* cf. *ikorfatensis* (SEWARD) FLORIN

Text-Fig. 51—M

Description: Leaf is cuneate, margins diverge at 30°, basal portion stalk-like, callous along the oblique line of detachment. Entire portion of the blade is 25 mm long. It is divided above into 4 lobes diverging at a very acute angle. The lobes are 6—12 mm wide, indented 1/3 their length. The terminal lobes are about 40 mm long, acute or notched. Veins are thick, mostly simple, about 15 per lobe. A specimen from Shin-Khuduk, 118—8a shows fusiform resin bodies in files between the veins and along the margins (Text-Fig. 51).

The lower cuticle is moderately thick, showing ill-defined costal and intercostal zones of equal width. The costal cells are in rows, rectangular, about 60 × 20 μm. The intercostal cells are somewhat broader, papillate. Stomata are longitudinal, with 5—7 subsidiary cells which are not thickened except at the borders of stomatal pit, with proximal papillae overhanging the guard cells. The stomatal pit is irregularly shaped, about 40 μm long. The guard cells show prominent crescent-shaped ledges.

Remarks: These leaves are similar to *S. ikorfatensis* (SEWARD, 1926; see also KRASSILOV, 1972) ranging from Greenland and Canada to Siberia. The stomata are smaller than in the Siberian specimens.

Locality: Shin-Khuduk, 1, 117, 118—8a; Bon-Tsagan, 45—16, 60.

*Baierella hastata*, sp. nov.

Holotype: Shin-Khuduk, 119—8a, N 86645022. PI. 7, fig. 75.

Diagnosis: Leaves typically 4-lobed, but also 2-lobed and 8-lobed, lobes acuminate, single-veined. Stomata on both sides, scattered, mostly longitudinal, amphicyclic, with 5—7 subsidiary cells. Stomatal pit borders ridged or papillate.

Description: Leaves from Shin-Khuduk are mostly 4-lobed, broadly cuneate, about 62 mm long, forking 10—20 mm above the base at 25°. Each of the primary lobes fork 12—15 mm above the first dichotomy at an acute angle. The terminal lobes are long, straight or slightly bending. Occasional leaves are bilobate. In Bon-Tsagan, the bilobate leaves predominate, while the leaves from Erdeni-Ula are mostly 8-lobed; each primary lobe forks repeatedly at short intervals. The leaf base is callous along the oblique line of detachment.
The cuticle is equally thick on both sides. The costal zone is not marked on the cuticle. Cells are in longitudinal rows, rectangular, 30—50 μm long in the basal portion, rounded-polygonal, often stretched transversely, 25—30 μm long in the lobes. Anticlinal walls are ridged, thickened at the corners. Stomata are scattered uniformly all over the leaf surface, occasionally forming broken rows. There are about 8 stomata across the lobe, longitudinal spacing 250—320 μm. Stomata are mostly longitudinal, but in certain areas, more often near the margins, they are predominantly transverse. Two median rows of transverse stomata have been observed occasionally in the Erdeni-Ula specimens. Stomatal apparatuses are amphicyclic, with 5—7 radially arranged subsidiary cells. Stomatal pit is rounded, 16—18 μm long, bordered by a thick ridge or papillae. Guard cells showing rounded central thickenings, poles are long, cutinized (Text-Fig. 7E).

The abaxial and adaxial stomata are alike, except that the latter have more circles of encircling cells. Also the underdeveloped and unfunctional stomata, completely covered by papillae occur more frequently on the upper side.

Remarks: Leaves of this type have been described as Stenopteris, but the type species, S. desmomera (BARALE, 1970). POTONIE (1933) has established the genus Baierella for Ginkgoalean leaves with single-veined terminal lobes. This genus was overlooked, and the appropriate leaves from Siberian localities were described as Sphenobaiera. In Baierella uninervis (SAMYLINA) KRASSIL. from Siberia the adaxial stomata are significantly less frequent than the abaxial (KRASSILOV, 1972), while the Mongolian leaves are isolateral in respect to stomata. The 4-lobed and 8-lobed morphotypes may belong in different species, but they share such characters as the hastate lobe apices and the isolateral distribution of stomata.


Karkenia mongolica KRASSILOV

Text-Fig. 7F

Karkenia mongolica — KRASSILOV and SUKATCHEVA, 1979, p. 120, Pl. 25, figs. 1—8.

Description: A strobilus from Erdeni-Ula (Text-Fig. 7F) is cylindrical, 20 mm wide, with stout axis 2.5 mm thick, bearing about 30—40 ovules on long (5 mm) stalks attached at acute angle and pointing upward. Ovules are 5 x 4 mm, chalazal end rounded, micropylar end tapered and notched. Many specimens show median suture and longitudinal striation. The integument is thick, with numerous resin bodies which are seen on compressions as densely packed tubercles. The resin bodies are oval, 0.7—1.4 mm long.

Outer cuticle is thick, showing polygonal epidermal cells, scattered stomata and the gland openings. The cells are irregularly oriented, about 40—42 x 30—56 μm, with inconspicuous median thickening. Stomata are widely spaced, amphicyclic, with 5—7, typically 6 radially arranged subsidiary cells. The stomatal pit is elliptical, about 18—20 μm long, bordered by a prominent cuticular ridge.

Remarks: The Mongolian species differs from the Siberian K. asiatica KRASSILOV, 1972, by larger ovules, stomata and more numerous resin bodies.

The strobili and seeds of Karkenia mongolica occur abundantly in the same localities as Baierella hastata. The seeds and leaves have similar epidermal cells and stomata. The seeds and resin bodies were used by caddis flies (Text-Fig. 7J).

Locality: Shin-Khuduk, 117, 118—8a, 118—8b, 118—8c, 119—3c, 119—8a; Erdeni-Ula, 213—28; Modon-Usu, 132—34.

Text-Fig. 7. A—C. Baierella hastata sp. nov., leaves crowded on a bed-plane, Erdeni-Ula, 213—13, x 1; hastate leaf lobes, Shin-Khuduk, 108—8, x 1; and bilobate leaf, Bon-Tsagan, 87—8, x 1. D. E. Distribution of stomata in the lower epidermis and a stoma, SEM inside view, of unfigured four-lobed specimen of Baierella hastata sp. nov., from Erdeni-Ula, 213—13, x 1000. F—J. Karkenia mongolica KRASSILOV, strobilus, Erdeni-Ula, 213—28, x 2, a seed showing resin bodies, x 10, a stoma, x 300, and a resin duct opening in the seed cuticle, x 200, Shin-Khuduk; J. Caddis fly larvae case from the same locality, with Karkenia mongolica KRASSILOV seeds in the outer sheath and resin bodies (black) in the inner tube, x 2.
Czekanowskiales

Phoenicopsis angustifolia HEER
PI. 7, Sq. 10, Text-Fig. 8A—C.

Phoenicopsis angustifolia — DOLUDENKO and RASSKASOVA, 1972, p. 28, PI. 41—46.

Description: Leaves 8 per short shoot, ribbon-shaped, margins almost parallel, converging gradually to the base, apex rounded or truncate. The whole length was presumably about 100 mm, maximal width 3.5 mm, width at the base 1 mm. Veins are prominent, simple, 6—7 per leaf.

Cuticle is moderately thick on both sides, the upper cuticle showing rows of elongate cells about 60 μm long, with oblique transverse walls. Lower epidermis is differentiated into costal zones of elongate rectangular or fusiform cells and narrower intercostal zones of shorter rectangular cells. Stomata are in two rows in each intercostal zone, longitudinal, occasionally oblique or transverse, widely spaced along the rows, with two ordinary cells between them. Stomata of adjacent rows close, alternate. Stomatal apparatuses monocylic, general outline polygonal or rhomboidal, about 55 μm long, occasionally with one or two encircling cells. Subsidiary cells 4—5, in the transverse stomata up to 7, thickened, proximally bulging, radially striated, convex over the guard cells which are attached by the polar and lateral cutinized lamellae (PI. 7, fig. 83). Occasionally one or two subsidiary cells remain unthickened. In a single stoma one of the subsidiary cells is paired to the guard cell initial, suggesting mesogenous origin of some subsidiary cells while the whole apparatus might be mesoperigenous.

Remarks: These leaves are comparable to the narrow-leaved morphotype of the variable Phoenicopsis angustifolia HEER. FLORIN (1936) has treated Phoenicopsis as a collective genus divisible on the base of cuticular characters into three genera — Stephenophyllum, Windwardia and Culgoveria. The latter are often considered as subgenera of Phoenicopsis (e.g., DOLUDENKO & RASSKASOVA, 1972). However in the FLORIN's genera the leaves are at least partially amphistomatic, while in Phoenicopsis angustifolia, which is the type species of Phoenicopsis, they are hypostomatic throughout. Thus, Phoenicopsis differs from Stephenophyllum, Windwardia and Culgoveria in cuticular structure.

Locality: Bon-Tsagan, 45—19.

Hartzia multifolia sp. nov.
PI. 7, Sq. 77, Text-Fig. 8G, H.

Holotype: Bon Tsagan, 45—19, N 3559/10006, Text-Fig. 8G.

Diagnosis: Short shoots bearing about 14 simple linear leaves 1 mm wide. Stomata on both sides, widely spaced. Scale leaves broadly obovate, about 3x3 mm.

Description: Short shoots are massive, about 6 mm long, bearing rather large scale leaves (3x3 mm). There are up to 14 linear leaves in the most complete specimens. The linear leaves are seemingly flat, up to 90 mm long, 1 mm wide. No leaf dichotomy has been observed.

Cuticle is moderately thick on both sides, showing elongate rectangular cells which are somewhat broader in the lower epidermis. Longitudinal cell walls are ridged, somewhat undulating, transverse walls often oblique. Stomata are more frequent in the lower epidermis, longitudinal, widely spaced, with 4—5 subsidiary cells, of which 2 or 3 are polar, the other lateral. Stomatal apparatus is elongate-rhomboidal or elliptical, 55—60 μm long.

Remarks: The number of leaves per short shoot in Hartzia (and also in Czekanowskia and Phoenicopsis) is typically 7—8, while in the Mongolian species they are twice as numerous. The scale leaves are larger than in other species of Hartzia or Czekanowskia, and the stomata are fewer. The linear leaves are flat and not three-sided as in Czekanowskia nicolai KIRSOLOV (1972).

Locality: Bon-Tsagan, 45—19, Tsagan-Tsab, 10.

Text-Fig. 8. A, B. Phoenicopsis angustifolia HEER, leaf clusters, Bon-Tsagan, 45—19, x 1; C. Transverse section of two stomatal rows of a specimen shown in Text-Fig. 19, x 500, D. Lepistrobus sp., valve of a capsule Bon-Tsagan, 34—3, x 2,3/1, F. P. Papillate fringe ("stigma"), x 80, and a stoma from the central part of the same valve, x 550, G, H. Hartzia multifolia sp. nov., short shoot, x 5, and stomatal row in the lower cuticle of a linear leaf, x 550, holotype, Bon-Tsagan, 45—19.
Text-Fig. 8 (Legend see p. 20)
Leptostrobus sp.

Description: The detached valves of bivalvate capsules are obovate, 8 x 6 mm, convex, bordered by a flat fringe, 1 mm wide. Cuticle of the convex central part is fairly thick, folded, showing elongate pointed cells, about 75 x 37 μm. Stomata scattered, mostly longitudinal, occasionally contiguous, with incomplete ring of encircling cells and 5—7 radially arranged subsidiary cells, forming irregular polygon 50—85 μm wide. The subsidiary cells are considerably thickened. The encircling cells are developed asymmetrically, lacking at one of the poles. Stomatal pit is elliptical, small, 12.5 μm long, cuticle of the marginal fringe is much thinner, densely papillate. Papillae are conical or clavate, with saucer-shaped apices depressed in the centre, inclined to the margin, arranged in files or clustered around irregular cavities. When broken, the papillae show a central canal evidencing secretory function (PI. 7, fig. 82).

Remarks: The valve with papillae fringe is similar to *L. stigmatoideus* KRASSIL. from Bureja (KRASSILOV, 1972), but the latter species has paired papillae and more distinct cavities on the fringe. The secretory function of the papillae is in agreement with my interpretation of marginal fringes as primitive stigmas.

Localities: Bon-Tugan, 34—3, Manlaj, 12.

Podozamites sp.

PL 8, figs. 88, 90, 92—94

Remarks: Shoots and leaves of *Podozamites* are common in many localities, especially at Shin-Khuduk. There are broadly elliptical leaves with rounded apices, narrow linear leaves up to 150 mm long and a variety of transitional forms. In the larger leaves, the hypodermal strands are often seen between the veins (PI. 8, fig. 93).

Swedenborgia junior sp. nov.

Holotype: Shin-Khuduk, 118—6c, N 3664/5005. PI. 8, fig. 84.

Diagnosis: Cone elongate-ovate, seed-scales trilobate, about 10 x 6 mm, lobe apices rounded, seeds 3 x 2 mm, wingless.

Description: A single cone from Shin-Khuduk is elongate-ovate, 30 x 13 mm, with imbricate scales. The individual scales are hardly discernible except at the base where they are torn apart. They consist of a stalk 5 mm long and a trilobate blade 15 x 6—7 mm. There are also isolated scales, some of them no bigger than 3 x 2.5 mm. The lobes are rounded, occasionally truncate, not thickened above the seed pits which are on the midvein below the middle of a lobe. Seeds are anatropous, ovate, pointed. No traces of a bract are discernible.

Remarks: The seed-scales resemble *Swedenborgia megasperma* STANISL., but the lobe apices are rounded, not pointed, and the seeds are smaller. According to Stanislavsky (1976), the trilobate *Swedenborgia* and *Cycadocarpidium* are much similar except that the bract is reduced in the former genus.

Localities: Shin-Khuduk, 118—4, 118—6c.

Swedenborgia spp.

PL 8, figs. 89—91

Remarks: There are isolated bracts different from *S. junior*. Some of them are five-lobed, 15 mm wide. The lobes are narrow, attenuate, twisted, 5—7 mm long. These scales are comparable with *S. megasperma* STANISL. (1977). Scales of another type are trilobate 5 x 7 mm, deeply divided, with linear lobes, 3 x 1 mm, thickened above the seed pits, acuminate. They resemble *S. megasperma* STANISLAV. (1976).

Localities: Shin-Khuduk 119—3c, Modon-Usu, 2.
Araucaria mongolica

PL 9, figs. 95—107, PL 10, figs. 117—120, PL 11, figs. 123—126.

Holotype: Shin-Khuduk, 119—7a, N 3664/5008, PL 9, fig. 95.

Diagnosis: Leaves polymorphous, triangular, subulate, 3—4 mm long or linear-lanceolate bifacial, 15 mm long, epi- or amphistomatic. Adaxial stomatal bands with 2—4 rows of stomata, abaxial bands with 1—2 rows. Stomata mostly oblique, but also longitudinal and transverse, with 5—7 subsidiary cells. Guard cells with T-shaped thickenings, 60 μm long. Megastrobili ovate, 12 x 16 mm, scales nut-like, wingless, awned.

Description: The shoots are branching in one plane. Lateral branchlets arise at 45—60°, at intervals of 10—15 mm, more crowded near the shoot apex. At the base of the branchlets, there is a rounded pit 1 mm in diameter, filled with anthracitic coal: an opening of a resin duct (PL 9, figs. 105, 106).

Leaves on the main axis and lateral branchlets are spiral, whorled at the apices. The whorled leaf arrangement is related to the resting buds. A single specimen (PL 9, figs. 102, 103) shows three buds, one terminal on the main axis and two on short lateral branchlets.

Leaves are variable, and the shoots with extreme leaf forms can easily be assigned to different species. However there are transitional forms, and the cuticles are similar. The leaf forms are as follows:

(1) subulate, acute, strongly curved, imbricate, at acute angle to the axis, 3—4 mm long, carinate, often compressed along the keel and showing a single stomatal band only, 3—4 mm long;
(2) short-lanceolate, straight or curved at the apex, attenuate, dagger-shaped, spreading radially at obtuse angle. In the shoots with subulate leaves (1) there are usually a few straight leaves (3). The shoots with long leaves (4) comprise also short leaves (2) or (3) as the base.

The leaves are amphistomatic or (in the type 1) epistomatic. The adaxial stomatal bands are close to the margins (PL 11, fig. 125) with a twice as wide costal band between them. The stomatal bands are ill-defined, not sunken, of 4 stomatal rows at the base, tapering to 2 stomatal rows in the upper part. The cells are rectangular or square in the stomatal bands, elongate above the vein, straight-walled.

Megastrobili are found attached terminally on the shoots with long leaves (PL 10, fig. 109). They are also detached cones, all of them closed, about 25 x 36 mm, with imbricate, broadly obconical scales, 8 x 6 mm. In split cones, the seeds are seen enclosed in the scale tissue. The seed-scale complexes yielded a scale cuticle and rather tough inner cuticle, possibly of a seed integument, showing clearly marked rectangular cells.

Remarks: This species resembles some extant members of Eutacta in unreduced leaves on the cone-bearing shoot and stalkless cones, while the wingless cone scales are like those of Columbea, but much smaller. Leaves similar to one or another morphotypes of Araucaria mongolica can be found in both Eutacta and Columbea sections. The microsporophyll Williostrobus latineanus (see below) might belong to this species.

Localities: Bon-Tsagan, 35—5,7, 45, 60, 87—8, 193—3, 194—1; Shin-Khuduk, 119—7a, 119—7b, 119—8a; Kholtai-Goi, 197—7, 30, 197—8, 199—3, 3, 194—1; Shin-Khuduk, 210—24; Erdeni-Ula, 213—25.

Brachyphyllum densiramosum

PL 10, figs. 108—114, PL 11, figs. 121, 122, Text-Fig. 9L—O.

Holotype: Shin-Khuduk, 1. PL 10, fig. 109.

Diagnosis: Shoots copiously branching in one plane, ultimate branchlets cylindrical, of unequal length (average length 30—40 mm). Phyllorhinus 2/3, leaves small, appressed, amphistomatic, with median stomatal band on
adaxial side and a few abaxial stomata. Margins pilose. Stomata longitudinal or oblique, monocylic, with 6–7 subsidiary cells. Adaxial cuticle papillate. Megastrobili pendulous on lateral branchlets.

**Description:**

There are branching shoot fragments up to 120 mm long. A shoot 5 mm thick (PL 10, fig. 110) represents the proximal portion of a twig branching asymmetrically, the branches on one side are much shorter than on the other. The branchlets are widely spaced. In less thick shoots, the ultimate branchlets are more crowded, at interval of about 5 mm or less. In some shoot fragments, there are as many as 30 branchlets per 60 mm. They arise at acute angle, alternate, occasionally whorled, mostly simple. Forking of a branchlet was observed in a single specimen only. The branchlets 30–45 mm (up to 60 mm) long sometimes alternate with short branchlets no more than 10 mm long.

Phyllotaxis of 7, was observed in compressions removed from the rock. The leaves are triangular, appressed or (in thicker shoots) slightly spreading, acute, abaxially convex, straight or slightly curved. On the thick axes the free portion is 3 mm long, the cushion 2 mm long. On the ultimate branchlets they are 2 mm and 1.5 mm respectively. Leaf margins are hairy. In most cases the hair bases only are preserved giving the margin a microdendate aspect.

The abaxial (outer) cuticle is thick, showing stomata crowded at the base and occasional apparatuses scattered all over the surface. The adaxial cuticle is delicate except along the margins, showing stomata in a medium band extending to the apex. Leaf cushions show frequent stomata, mostly monocylic, longitudinal or oblique, occasionally transverse. Subsidiary cells, 6–7, radially arranged around the elliptical or angular stomatal pit, thickened, proximally bulging or papillate. The guard cells are only slightly cutinized. The ordinary cells are irregular — rectangular, about 40 x 17 μm. Anticlinal walls are slightly undulating, unevenly thickened, surface wall is flat, with small papillae in staggered rows of 3–5 (Text-Fig. 9N). The papillae are not always discernible. Cleared shoot compressions show longitudinal resin ducts.

A cone from Erdeni-Ula (PL 10, fig. 114) is attached to the downward bending shoot, ovate, 12 x 8 mm, of about 10 scales. The scales are imbricate, flat, broadly rhomboidal, 4 mm wide, with a median groove. Minute pits along the margin of a scale represent resin ducts. The scale cuticle is like that of a leaf. There are also detached cones, up to 27 x 22 mm.

**Remarks:** The shoots are distinguishable by coriaceous branching and small appressed leaves with a few abaxial stomata. They constantly associate with Samaropsis aurita. In some specimens of the cones, the outlines of winged seeds are discernible in the scale casts. The cones resemble Elatides steels Hitch which also contained Samaropsis scales. Samaropsis sp. (see below) might be a male cone of this species.

**Localities:**


**Holotype:**

Gurvan-Eren, 236–29, N 3149/3000, PL 10, fig. 115.

**Diagnosis:**

Shoot thick, cylindrical, leaves triquetrous, fleshy, spreading, with numerous abaxial stomatal grooves.
Text-Fig. 9 (Legend see p. 24).
Description: The largest shoot from Gurvan-Eren is 9 mm thick, cylindrical, abruptly constricted at the apex. Leaves, 4 x 3.5 mm, straight or slightly curved, thick, cartilaginous, acuminate, longitudinally retinaculated. The striation corresponds to stomatal grooves, better seen in the specimen from Bon-Tsagan (PL 10, fig. 116). There are about 10 abaxial grooves per leaf. Some of them wedging out or joining below the apex.

Remarks: The stomatal grooves are exceptional in the Mesozoic brachyphylls. They are characteristic of some Paleozoic conifers.

Localities: Gurvan-Eren, 236—29; Bon-Tsagan 23—22.

**Pseudolarix erensis** sp. nov.

Holotype: Gurvan-Eren, 236—29, N 3149/3001, PL 13, fig. 147.

Diagnosis: Cone scales deciduous, broadly-ovate, about 11 x 8 mm, shortly stalked, rounded, bluntly pointed or notched, occasionally split along the median groove. Bract broadly cuneate, reaching to 2/3 of the seed scale. Samaras 10 x 5—6 mm, wing lanceolate, bluntly pointed or rounded, outer margin arched, clasping 2/3 of the seed.

Description: The diagnosis applies to numerous cone scales from Gurvan-Eren. They associate with twigs, short shoots, leaves and seeds presumably belonging to the same species. Judging by the abundance of detached cone scales, they were decious. The scales show a minute stalk and occasionally also small basal projections (auricles). Some of them are split along the median groove. The shape of the apex is variable — rounded, triangular, bluntly pointed or notched (PL 13, figs. 149—151). The abaxial face is flabellately striated. The average dimensions are 11 x 8 mm (6 x 3 — 14 x 10 mm). Bracts were seen at the base of several scales (PL 13, fig. 149). They reach to no more than 2/3 of the scale length.

Some scales are apparently divided into two halves which were dispersed with the seeds attached. Such half-scales with intact seeds (PL 13, fig. 156) helped to recognize the detached samaras of this species found in Gurvan-Eren as well as in Manlaj and Bon-Tsagan. They are of variable dimensions, 6 x 4—15 x 6 mm, average 10 x 5—6 mm. The seed is 2—4 mm long, average 3.5 mm, typically oblique to the wing, micropyle pointing outward, but occasionally longitudinal. The wing is lanceolate, finely striated, the inner (sutural) margin straight, the outer margin arched, clasping about 2/3 of the seed, the apex narrow, bluntly pointed or rounded (PL 13, figs. 157—160).

Twigs are 5—6 mm thick, with longitudinal leaf scars. The brachyblasts are paired or in groups of 3. There are also detached brachyblasts which are cylindrical or barrel-shaped, about 5—20 mm long, 7 mm thick, covered with scales, the annular constrictions not clearly defined. Some brachyblasts are preserved with their leaves still attached (PL 13, fig. 164). In addition to the Gurvan-Eren material, there is a single brachyblast from Bon-Tsagan (PL 12, fig. 131) bearing 16 leaves which are 20 mm long, 2 mm wide, and covered with scales. Some brachyblasts are preserved with their leaves still attached (PL 13, figs. 166—167) which are somewhat broader (2.5 mm) than those on brachyblasts. Their attribution to *P. erensis* remains questionable. They show a resin duct along the veins and two stomatal bands. The stomatal bands are narrow, 200 μm wide, separated by a twice as wide costal zone, papillate, of 4 stomatal rows each. Stomata are not clearly marked, apparently monocyclic, with a ring of 5—6 subsidiary cells.

Cuticles were obtained from detached leaves (PL 13, figs. 166—167) which are somewhat broader (2.5 mm) than those on brachyblasts. Their attribution to *P. erensis* remains questionable. They show a resin duct along the veins and two stomatal bands. The stomatal bands are narrow, 200 μm wide, separated by a twice as wide costal zone, papillate, of 4 stomatal rows each. Stomata are not clearly marked, apparently monocyclic, with a ring of 5—6 subsidiary cells.

Remarks: The Early Cretaceous species of *Pseudolarix* — *P. dorofeevii* SAMYL., *P. bacharevii* VACHR. et LEBEDEV., *P. nipponica* KIMURA & HORIUCHI and also *Mesolarix* from Mongolia (JANICHEN & KAHLERT, 1972) are based on brachyblasts and leaves of *Pityocladus* and *Pityophyllum* type. Some of them are similar to brachyblasts and leaves from Gurvan-Eren (see KIMURA & HORIUCHI, 1978). Schizolepis dahuricus Pryn. from the Baikal Lake region (Pryn, 1962) resembles the split Schizolepis-like scales of *P. erensis* while Psyllospermum angustifolium Pryn. is similar to the seeds from Gurvan-Eren and Manlaj. It is conceivable, that in the Baikal area there was another species of *Pseudolarix*, closely related to *P. erensis*, but retaining some atavistic Schizolepis characters.

Pityolepis sp.

Text-fig. 9A, B

Remarks: A single scale from Gurvan-Eren is spatulate, 20 x 14 mm, cuneate at the base, expanded and broadly rounded at the apex. A bract marked at the base of the scale is 1/4 of the scale length. There are also detached bracts, obconic, awned, flabellately striated. They resemble the bracts of Abies (e.g., A. alba) more than those of any other extant genera.

Localities: Gurvan-Eren 236—29; Bon-Tsagan 45—19.

Scbizolepis drepanoides sp. nov.

Holotype: Bon-Tsagan, 23—22, N 3559/10 009, Text-fig. 127—128.

Diagnosis: Loose strobilus of bilobate asymmetrical scales, with one of the lobes reduced. Seed locule in the proximal part of a scale. Bract sutured at a prominent transverse ridge above the locule.

Description: A single specimen shows an axis 1.5 mm thick. Scales are arranged spirally (those not in the bedding plane detached, leaving rounded scars) at intervals of about 3 mm, at 45—60° to the axis. They consist of a stalk 3 mm long and a blade which is divided to 2/3 of its length. The lobes are of unequal width, one of them, presumably sterile, cramped and often buried in the rock, as if folded at an angle to the normally developed lobe. The latter is ovate, 71 x 13.5 mm, basally expanded, tapering to the rounded apex, sometimes constricted at the middle. The locule occupies the proximal half of a lobe. Above it, there is a prominent transverse ridge which might correspond to a suture between the seed scale and bract. Lobes are longitudinally striated.

Remarks: Most Siberian species of Scbizolepis are like S. liasokeuperianus Braun, revised by Harris (1979). They constantly associate with the Pityocladus shoots. There is little doubt that these species belonged in the Pinaceae. They might be ancestral to Pseudolarix. The Mongolian species can be conceived as transitional between Scbizolepis with symmetrical bilobate scales and Drepanolepis with entire scales. The detached scales are like samaras of Pityospermum type, e.g., Pityospermum pachypteron Prynada (1962).

Locality: Bon-Tsagan, 23—22.

Pityospermum amplexum sp. nov.

Holotype: Bon-Tsagan, 45—19, N 3589/10 0010, Text-fig. 132—138.

Diagnosis: Samaras large, about 20 x 8 mm, up to 35 x 10 mm, wing distally expanded, clasping the whole perimeter of a seed except the micropyle. Seed locule oblique.

Description: Samaras of this species are rather large, average dimensions 20 x 8 mm, the largest specimens 35 x 10 mm, the wing 4—5 times longer than the seed. The wing is lanceolate or spatulate tapering to the base, broadly rounded at the apex, margin diverge at 45°, straight, the outer margin arching abruptly in the apical portion. The blade is thickened at the inner (sutural) margin, margins diverge outward. Polygonal cells are seen along the outer margin which is slightly undulating, apparently out cell thick. Surface of the wing is finely striated, the striations, studied with SEM (PL 12, fig. 142), consist of broken resinous microtubes. The seed is ovate, about 5 x 5 mm, oblique to the sutural margin of a wing, showing a median ridge and fine longitudinal striation. The micropyle is short, truncate, sometimes protruding, tubular (PL 12, fig. 139). The seed locale is fringed by the wing tissue which is folded over the seed. In favorably preserved specimens, short hairs are seen on the fringe (Text-fig. 9C). They appear also as small pits on the locule.

Remarks: These samaras are the most abundant fossils in many localities. They associate with the brachyblasts and leaves of Pityocladus and Pityophyllum (PL 12, fig. 129) resembling those of Pseudolarix erensis. However the brachyblasts are more massive, the leaves longer and the samaras larger than in the latter species. The samaras differ also in relatively longer wing clasping most of a seed. They are comparable with Pityospermum pachypteron Prynada (1962) from the Baikal region, but differ in the wing having maximum width near the apex.
Localities: Bon-Tsagan, 23—22, 34—5, 45—19, 65; 75—1, 75—3; Kholbotu-Gol, 197—3; 197—7; Shin-Khuduk, 213—25; Erdeni-Ula, 104—8, 118—6, 118—8c 119—3, 119—8a, 119—7a, 119—2, 19—8; Modon-Uun, 204—1.; 87—8.

**Samaropsis aurita** sp. nov.

Pl 14, figs. 168—174.

Holotype: Shin-Khuduk, 119—3d, N 3664/5009, PL 14, fig. 170.

Diagnosis: Samaras about 7 x 5 mm, wing membraneous, smooth, forming asymmetrical auricles, bordering chalaza but interrupted at micropyle tube which is short, knob-like.

Description: The seed is elongate-ovate, 3—4 mm long (in 80% of the seeds the length is about 4—5 mm), longitudinally striated, rounded or slightly cordate at the chalazal end, acuminate at the micropyle which appears as a small knob. Many seeds show longitudinal groove marking the raphe. Wing is developed as membraneous projections on both sides of a seed expanding from the micropyle to the chalazal end where they form prominent auricles. The chalaza is fringed by a narrow verge of a wing 0.5 mm wide. The auricles are rounded or angular, usually of unequal size. In exceptional samaras, the wing extends above the micropyle which occurs in the notch. There are also occasional samaras with underdeveloped wing, wedging out just above the middle of a seed. In a single specimen, the wing is reduced to small chalazal auricles (Pl. 14, fig. 172). Five haphazardly oriented seeds are included in a rounded body, presumably a coprolite of a bird (Pl. 14, fig. 174). Fragments of these seeds were cleared showing the apex of a nucellus with heart-shaped pollen chamber 100 μm wide and narrow micropylar canal. The cells of the nucellus are narrow, elongate. The cells of the integument are shorter, rectangular, with straight walls.

A single germinated seed from Manlaj is rather small, with narrow wing forming asymmetrical auricles. It shows four cotyledons about 4 mm long (Pl. 14, fig. 174).

Remarks: These samaras are comparable with *S. rotundata* HEER (1976) in which, however, the micropyle is forked, bordered by the wing. Heer depicted several germinating specimens of *S. rotundata*. He attributed them to *Leptostrobus laxiflora* HEER, but actually they might belong in *Elatides ovalis* HEER. The Mongolian species associates with *Brachyphyllum densiramosum*.


**Samaropsis sagittata** sp. nov.

Pl 14, figs. 175—178, Text-Fig. 9J.

Holotype: Shin-Khuduk, 119—3, N 3664/50010, PL 14, fig. 177.

Diagnosis: Samaras about 8 x 8 mm, wing membraneous, smooth, forming asymmetrical auricles, bordering chalaza but interrupted at micropyle tube which is short, knob-like.

Description: The seed is ovate, acuminate, 5 x 2.5 mm, micropyle protruding as a short tube, occasionally forking, chalaza broad, thick, appearing in compressions as a small semicircular area. Wing reniform, membraneous, thin, bordering the micropyle but interrupted at the chalaza, broadly rounded at the micropylar end, saggitate at the base. Auricles broad, slightly asymmetrical, acute or rounded. Wing surface folded and striated, emotions radiating from the chalaza.

Remarks: These samaras are larger than S. aurita and differ also in the thinner, radially striated wing continuous over micropylar end but interrupted at the chalaza, and longer micropyle tube, occasionally forking, with both branches extending along the apical notch of a wing.


**Darneya angusta** sp. nov.

Pl 15, figs. 179—180.

Holotype: Bon-Tsagan, 10—19, N 359/102 012, PL 15, fig. 179.
Diagnosis: Pollen cone elongate, 27 x 7 mm, with a pericone of a few bracts. Stamens arise spirally at 75° to the axis. Filament slender, 1.5 mm long. Anther relatively massive, with scale-like connective and adaxial cluster of about 5 sporangia attached at the base of a connective and extending over it. Connective rhomboidal, 3 mm wide, flabellately striated, cuticle delicate, showing narrow rectanguloid or wedge-shaped cells. Sporangia elongate-clavate, tapering to the base, shortly stalked, about 2.5 x 0.7 mm. Pollen grains with 2 small distal bladders, mean diameter 75 μm.

Description: A single cone from Bon-Tsagan 45—19 is elongate, with rounded apex, a whorl of bracts at the base (a pericone) and imbricate scale-like connectives resembling the bracts in flabellate striation, but smaller. Some stamens show a slender filament and adaxial sporangia clustered at the base of a connective. The sporangia are protruding finger-like over the connective or pendant (PL 15, fig. 181), some of them torn apart, narrowly clavate, with a short stalk. Macerated stamens yielded the cuticle of a connective showing rows of elongate rectangular or wedge-shaped cells, 13—18 μm wide. No pollen grains were extracted from sporangia.

A cone from Bon-Tsagan 87 (PL 15, fig. 185) is broken transversely, showing scale-like connectives and adaxial sporangia with immature pollen grains, about 75 μm in diameter. Distal sacci are elongate-elliptical showing infrasaccate structural elements and transverse bars. No pollen grains were extracted from sporangia.

Remarks: D. angusta sp. nov. is similar to D. dentata GRAUVOGEL-STAMM (1978), but much smaller. Other Triassic species have forking sporangiophores. GRAUVOGEL-STAMM tentatively assigned these pollen-cones to the Voltziaceae. Since Podosamites is the only Late Mesozoic representative of the Voltziaceae (s. l., including Swedenborgia, see above) it is conceivable that D. angusta was the pollen-cone of a Podosamites plant.

Pollen grains showing infrasaccate structural elements are comparable with Podosproites, Parvisaccites and other protosaccate pollen genera. Occasional grains with the cappus folded over the central body resemble Trisaccites COOKSON & PIKE.

In the Triassic Darneya, the pollen grains also show the rounded dark bodies which look like metamorphosed microspore nuclei. In spruce, the exine of pollen grains is thickened and the patterning of sacci is developed just before the first division of the microspore nucleus (OWENS & MOLDER, 1979). The pollen grains of Darneya are presumably at this stage.

Duplicate pollen grains with small transversely patterned sacci (PL 15, fig. 19) may belong in this species.

Locality: Bon-Tsagan, 45—19, 87—8.

WILLISTROBUS LATISACCUS sp. nov.

Holotype: Bon-Tsagan, 87—8, N 3559/30 OIL, PL 16, fig. 198.

Diagnosis: Pollen cones up to 35 mm long, with a pericone of thick triangular bracts. Stamens with small squamulose connective and an adaxial cluster of 3—4 large sporangia. Pollen grains large, about 100 μm in diameter, spherical, exine folded, infragranulate.

Description: A cone from Bon-Tsagan 87 (PL 16, fig. 198), 15 x 8 mm, with an axis 0.7 mm thick shows a wheel of bracts at the base. Bracts are fleshy, triangular, 2 mm long. Stamens are arranged loosely (presumably due to elongation of the axis at pollination), at right angle to the axis. Filaments are slender, 1.3—2 mm long, 0.2 mm thick, somewhat thickened at the base and decurrent. Connective appears as a small reflexed squamule, not always discernible. Adaxial clusters of sporangia show up to 6 separate items, but some sporangia are probably split into valves. The actual number of sporangia was three, occasionally four. Sporangia are elliptical, 3 x 1.5 mm. Similar cones from Shin-Khudson (PL 16, figs. 192—194) shows somewhat smaller sporangia, 2.5—3 mm long. In Shin-Khudson, there are also more compact, presumably immature cones up to 20 mm long, with rather short stamens and rounded sporangia 1.2 x 0.8 mm (PL 16, fig. 199). Pollen grains were obtained from several Shin-Khudson specimens. They are spherical, 85—120 μm in diameter, exine irregularly folded, often showing thick circumpolar folds, granulate. There are also abundant dispersed pollen grains of this type, some of them up to 100 μm in diameter.
Remarks: GRAUVOGEL-STAMM & SCHNARREIHOFER (1978) have established the genus Williostrobus for the pollen-cones with more than two sporangia per anther. Compact and loose strobili appear dissimilar, but they presumably represent different developmental stages. Terminal pollen-cones provided by a pericone of bracts are characteristic of Araucaria sect. Eutacta. The pericone bracts of Williostrobus are like scale-leaves of Araucaria sp. nov. Pollen grains are like Araucariacites COOKSON ex COUPER, 1953.

**Locality:** Bon-Tsagan, 87—8, Shin-Khuduk, 118—8c, 119—8.

**Stenomischus** sp.

*PL 20, figs. 260—261*

**Description:** A pollen cone, 20 x 8 mm, ovate, compact, showing slender filaments and anthers consisting of a scale-like connective and two rounded sporangia 1 mm in diameter. Pollen grains are poor preserved, rounded, apparently inaperturate.

Remarks: In Siberian localities, strobili of this type associate with Elatides. They might belong to Brachyphyllum densiramosum sp. nov.

**Locality:** Shin Khuduk, 118—3.

**Pityanthus microsaccus** sp. nov.¹

*PL 17, figs. 207—212, 219, 226, Text-Fig. 9D*

**Holotype:** Bon-Tsagan, 45—19, N 3559/100 015.

**Diagnosis:** Pollen cone elongate-ovate, 25 x 7 mm, of numerous (100 or more) stamens. Filaments slender, 0.3 mm thick. Anther rather massive, consists of a connective and two appressed sporangia. Connective scale-like, semicircular, flabellately striated, 1.5—1.8 mm wide. Sporangia ovate, smaller than connective, 0.8 x 0.5 mm. Pollen grains bisaccate, haploxylonoid, about 80—85 μm wide, sacci slightly pendant, finely infrareticulate.

**Description:** A single cone from Bon-Tsagan, 23—22 associates with the Pseudolarix brachyblasts. It is compact, showing imbricate connectives (PL 17, fig. 207). Some connectives were removed revealing paired sporangia. In Shin-Khuduk, there is a disintegrated cone showing stamens distinctly (PL 17, figs. 208—212). Anthers are at right angle to the slender filaments, depressed at the centre, where filaments were attached. Connectives are relatively large, flabellate, with undulating margin. Sporangia are firmly appressed, occasionally diverge at acute angle.

Some of the anthers were prepared for SEM, revealing cuticular structures (PL 17, fig. 212). Cells of a connective are narrow elongate, arranged in radial rows. Cells of sporangia are rounded — polygonal or elliptical, bulging, thick-walled.

Detached anthers are common in Shin-Khuduk localities. They were occasionally used in the caddis fly cases (PL 17, fig. 228).

Pollen grains from microsporangia are bisaccate, mostly haploxylonoid, about 80—85 μm wide, rounded-elliptical in polar view. Sacci are rather thick, often one thicker than another, hemispherical or heart-shaped, smaller or equal to the body, in the smaller grains somewhat pendant distally, in the larger grains less so, flattened in the equatorial plane, finely infrareticulate, with coarse pits caused by corrosion. Capillus is moderately arched, in polar view circular, marked by strong folds beyond the lines of the proximal saccus attachment (PL 17, figs. 216, 220). Distal saccus bases are distinct, smooth, straight and parallel or slightly arched and diverging, leaving a narrow mesosaccate area where the exine is ornamented or lacking (PL 17, fig. 226).

Remarks: Pityanthus scalbiensis VAN KONIJENBURG — VAN CITTERT, the only species in the genus known in Israel (HARRIS, 1979) differs from the Mongolian species in the shape of the connectives. The pollen grains

¹GRAYVOGEL-STAMM & SCHNARREIHOFER (1968) proposed rejection of Pityanthus based on inadequate material and replaceable by Masculostrobus. However, P. scaldbiensis and Mongolian species differ from typical Masculostrobus in attachment of sporangia.
have strongly arched cappus and rather small, distally pendant sacci. The pollen-cones of Pityanthus type associate with Pseudolarix erensis and Pityospermum amplexum. They may belong to more than one species, but the variation is continuous. In Shin-Khuduk, 119—3c and Kholbon-Gol, there are detached stamens with larger connectives, 2.5 mm wide (Text-Fig. 9, F).

They are otherwise similar to Pityanthus microsaccus. Bisaccate pollen grains are abundant in Shin-Khuduk. Some of them are indistinguishable from the pollen grains obtained from sporangia, but for the most part they are 100—138 μm, relatively broader, with bladders equal to the body or somewhat longer, only slightly pendant. The mesosaccate area is broader than in the in situ grains. Occasional grains are papillate (Pl. 17, fig. 225). I believe that the smaller pollen grains with the distally pendant sacci are unripe, belonging to the same plant as the larger specimens.

In many cases, the smaller grains stick to the larger (Pl. 17, figs. 221, 224) as if they were from the same sporangium, but dispersed at different developmental stages. Smaller pollen grains resemble Pseudolarix erensis differing in less pendant sacci and finer reticulation. Other conventional coniferous bisaccatae — Pityospermum, Protodiploxipinus, Abietineaepollenites — have more thickened cappus and strongly pendant sacci while in Pseudolarix the sacci are relatively larger. Larger grains with the equatorially flattened sacci are comparable with the Alisporites — Falcisporites — Klausipollenites group. Alisporites is described by JANSONIUS (1971) as sulcatus, with the sulcus indistinctly expressed by the short sexinal folds and reflected by the nexinal folds. JANSONIUS has applied Alisporites to the “pteridospermoid” pollen while excluding the paratypes of coniferoid aspect. SRIVASTAVA (1975) has mentioned that the “sulcus” in Alisporites appears to be a misinterpretation of sexinal folds.

Pteruchipollenites and Falcisporites are often considered as synonymous to Alisporites. According to JANSONIUS (1971), in Pteruchipollenites (x Protoconiferus) sulcus is lacking while Falcisporites has a distal leptoma delineated by distinct saccus bases. Other authors describe the sulcus in Falcisporites as dumb-bell-shaped. The cappus is somewhat thicker, the sacci smaller and more coarsly reticulate than in Alisporites. In Klausipollenites, the saccus bases and leptoma are indistinctly marked. Conoapisporites differs in mostly diploxylonoid sacci (though in larger grains they are haploxylonoid) and distinct radial folds at the saccus bases (SCHEURING, 1978). POTONIE & SCHWEITZER (1960) have described the developmental transition from haploxylonoid to diploxylonoid saccus attachment in Ulmannia frumentaria.

A few grains of Platysaccus type are probably abortive, with contracted central body (cf. SCHEURING, 1978).

Locality: Bon Tsagan, 23—22, 45—19, 87—8; Shin-Khuduk, 119—3; Kholbon-Gol, 216.

A pollen cone

PL. 20, figs. 256—259

Description: A pollen cone is narrow-ovate, 13 x 5 mm, showing densely packed sporangia which appear to arise directly from the axis, but on closer inspection reveal clustering by 4 or 5 on the very short filaments. There are no traces of connectives. Sporangia are elongate, 3 x 1 mm, acute or bluntly pointed, slightly reflexed, with a median groove. Macerated sporangial walls show small polygonal cells. Unripe pollen grains, probably at the meiospore stage just after the release from the callose wall, are enclosed in a cellular membrane. Individual retrads are still discernible (Pl. 20, fig. 258).

Locality: Manlaj, 95—10c.

Angiosperms

Gurvanella, gen. nov.

Type species: Gurvanella dictyoptera sp. nov.

Diagnosis: Fruits winged, stalked, bilocular, symmetrical. Endocarp spherical, rather thick, concave at attachment. Stigma persistent, funnel-shaped, on a short style. Wing membraneous, reticulate, bordering the stigma and extending to the stalk.
Gurvanella dictyoptera sp. nov.

There are two fruits, each preserved as a diptych in the aleurolitic shale. They are about 6 mm in diameter, with a stalk 1.5 mm thick, producing a deep concavity at the attachment. Endocarp is spherical, about 1 mm thick, divided by a stout median septa into two symmetrical locules. Endocarp is crowned by a very short style bearing the funneled-shaped stigma 1.5 mm wide. In one of the specimens, short hairs are seen on the stigma (Pl. 18, fig. 236). Wing is membraneous, reticulate, symmetrical, 2 mm wide, bordering the stigma and extending down to the stalk. A few upper veins radiating into the wings are raising parallel to the stigma. Other veins are bending downward, forming elongate-polygonal meshes. The interior of a locule shows large transversely stretched polygonal cells and fine longitudinal striation. In one of the locules, there is an elongate body, probably the cast of a single seed. The cuticle of endocarp is smooth, cells not clearly marked. Two vascular bundles are seen in the stalk. They diverge at the base of the endocarp, entering the locules.

Remarks: Winged fruits of this type are known in Eucommiaceae, Ulmaceae, Juglandaceae (Pterocaryopsis), Rutaceae (Ptelea, Pteleacarpum), Zygophyllaceae (Zygophyllum), Sapindaceae (Dadonaea, Koelreuteria, Sinoradlkofera), Chenopodiaceae (Abronia), Acanthaceae (Dipteronia) and Euphorbiaceae (Hymenocardia). In the bilocular fruits of Eucommia, one of the locules is reduced. It is conceivable, however, that in ancestral stock both locules have been equally developed. Endocarp is elongate, tapering into a long style with stigmatic arms bending outward. Wing extends from the stigmatic arms to a slender stalk. Reticulate venation with elongate meshes is seen above the endocarp, while the wing shows transverse veins only.

In the Ulmaceae, the ovary is unilocular, occasionally bilocular. The stigmatic arms in Ulmus and Holoptelea are bending inward. Fruit surface shows coarse reticulum above the locule and repeated forking veins in the wing. In the Juglandaceae the wing is oblique to the endocarp, transversely or radially wrinkled. However the fossil fruits Pterocaryopsis Chandler are described as bisymmetrical, flattened, winged, showing a deep attachment concavity between the lobes of endocarp which are almost completely separated. The wings are opaque, filled with parenchymatous tissue (CHANDLER, 1961, 1978). Gurvanella differs from these fruits mainly in the complete separation of the locules and the reticulate wing.

Winged fruits of the Rutaceae — Zygophyllaceae — Sapindaceae plexus are not easily distinguishable as fossils. Ptelea has bi- or tricarpellate indehiscent samaras with a circular reticulate wing which can be much reduced as in P. aptera Parry (BAILEY, 1962). Endocarp is oval, thin, hard, divided by rather stout septa into two symmetrical bivulate locules, one of which is usually sterile, the other contains a single elongate seed. Pericarp is leathery, partially extending into the wing. My survey of herbarium specimens has shown that the apical portion of
the fruits is variable: the style is encompassed by the wing or protruding about 1 mm above it. Occasionally the apex is slightly emarginate. The stigma is bifid, rarely persistent in the ripe fruits. A disclike gynophore is seen at the base of the fruit. Externally the endocarp area shows a longitudinal groove interrupted in the middle and prominent transverse ridges. Reticulum of the wing consist of radial veins which form meshes diminishing toward the margin. There is a marginal vein. The meshes are filled with veinlets. The shape of endocarp, locules and probably also the seed are similar to those of Gurvanella, but venation pattern is different and the bifid stigma is not bordered by the wing.

Fossil fruits of *Ptelea* from the Oligocene and Miocene of North America are similar to extant *P. trifoliata* (see Becker, 1972). European records of *Ptelea* are less convincing. At least some of the fruits referred to *Ptelea, Pteleacarpum* and *Abronia* may belong in *Ulmus* and *Koelreuteria* (see Kirchheimer, 1957; Mai, 1963; Knobloch, 1969). Fruits of *Koelreuteria* are trilocular, with the septae not extending above the middle of endocarp. External ridges corresponding to the septae are connected by veins forming transverse meshes. In *Dadonaea*, another Sapindaceae, the number of locules ranges from two to six, more often three. Endocarp is larger relative to the wing than in *Ptelea* and *Gurvanella*. The wing is thin, almost smooth. Fossil *Dadonaea* from the Tertiary of North America (Berry, 1916) is more like *Ptelea*.

The samaras of *Dipteronia*, also known as *Small* (McCready, 1953) differ from *Gurvanella* in the circular, somewhat asymmetrical wing showing flabellate venation, those of *Abronia*—in the elongate endocarps and the straight radial veins of the wing looping around the endocarp and along the margin. In *Hymenocardia*, the fruits are dehiscent into valves, the stigmatic areas are slender and the wings do not show distinct reticulum.

In conclusion, *Gurvanella* is unlike any of the winged fruits. There are, however, some points of resemblance with *Eucommia, Ptelea* and *Pterocaryopsis*.

**Locality**: Gurvan-Eren, 236—29.

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*Erenia* gen. nov.

*Type species*: *Erenia stenoptera* sp. nov.

*Diagnosis*: Fruits small, winged, stalked. Endocarp elliptical, bilocular. Stigma persistent, sessile. Wing narrow, smooth, slightly oblique, avoiding the stalk.

*Remarks*: *Erenia* differs from *Gurvanella* in smaller size, elliptical endocarp, sessile stigma and relatively narrow smooth circular wing. It is comparable with the same winged fruits as *Gurvanella* (see above) but closer to the Juglandaceae on account of the slightly oblique wing.

**Erenia stenoptera** sp. nov.

*Holotype*: Gurvan-Eren, 236—29, N 3149/3006, PL 18, fig. 238.

*Diagnosis*: As for the genus.

*Description*: There are two fruits each preserved as a diptych. Both are elliptical, 2 x 2 mm, showing median septa and a stalk 1 mm long. Stigma is persistent, funnel-shaped, sessile. Wing is membraneous, 0.6 mm wide, smooth, circular and flattened in the median plane, but avoiding the stalk.

**Locality**: Gurvan-Eren, 236—29.

Angiosperm — like fossils

*Graminophyllum primum* sp. nov.

*Holotype*: Manlaj, 2, N 3568/3018. PL 19, fig. 245.

*Diagnosis*: Stem articulately, 4 mm thick, leaves sheathing, sessile, ligulate, blade 10 mm wide with 10 parallel veins, sheath open, with conspicuous auricules.

*Description*: There are fragments of articulate stems 4 mm thick. The internodes are about 55 mm long, the nodes are considerably thickened, bearing sheathing leaves. The sheath is apparently open, the blade is sessile,
flat, with parallel margins, but slightly expanded at the base, 10 mm wide, more than 45 mm long (whole length unknown). Veins are parallel, broad, not clearly defined, obscured by longitudinal striation which might correspond to sclerenchymous fibres.

Border line between the sheath and the blade is marked by the arching groove (PL 19, fig. 245) which is interpreted as the trace of a ligule. Occasionally preserved auricles at the margin of a sheath are thin, reflexed, 3 mm long, bearing short bristles.

Remarks: Graminophyllum is considered here as a collective genus comprising sheathing leaves with a linear blade and parallel venation. This leaf morphotype is shared by a number of the monocotyledonous families, i.e. the Gramineae, Cyperaceae, Juncaceae, Restionaceae and Typhaceae. Auriculate sheaths are also known in several families, but the reflexed bristled auricles are more like those of the bambusoid grasses, e.g., Sasa japonica (Burm.) Makino. Otherwise Graminophyllum primum does not correspond to the bambusoid morphotype of stalked leaves with a midvexis.

Locality: Manlaj 2, 95—37.

Cyperacites sp.

Description: A single specimen of a stem 46 mm long, 0.8 mm thick, bearing a terminal cyme of three spike-like structures. At the base of the cyme there are three hair-like appendages. The spikes are stalked, elliptical, 9 mm long. Stalk of the median spike is 4 mm long, continuous with the stem, but thinner. Stalks of the lateral spikes are 2 mm long, subopposite, diverging at 20°. Spikes show a central body apparently formed of appressed glumes, and numerous long bristles.

Text-Fig. 11. Cyperacites sp. (A) and the Sparganium-like fossil (B) compared with fructifications of the extant species Bulbostylis capillaris NEES (B), Juncus articulatus Bosc (C), Rhynchospora macrostachya Torr. (E), and Sparganium simplex Huds. (F).
Remarks: Spikelets resemble those of Eriophorum with long tufts of hypogynous bristles. However in Eriophorum vaginatum L. the spikelets are solitary, terminal on the stems. Superficially similar terminal cymes of three spikelets are known in Bulbostylis, Bulboschoenus and other cyperaceous genera. In Bulbostylis, the glumes are spiral and the inflorescence bracts are hair-like. In Kylinga, Kylingiella, Marisculus and some other genera the capitula inflorescences are occasionally divided into three lobes or spikes and the inflorescence bracts are often hair-like (e.g., Marisculus peteri: GOETGHEBEUR, 1977).

Locality: Manlaj, 3.

Potamogeton-like spike
PL 20, figs. 253—255

Description: A single specimen of loose cylindrical spike-like fructification 13 mm long, 5 mm broad showing five whorls of nutlets and an incomplete peduncle 5 mm long, 1 mm thick. The whorls are about 2—2.5 mm apart consisting of two (in the upper whorls) or three nutlets each. The nutlets are oval, about 3 x 1.5—2 mm, ventrally convex, with a short beak continuous with the ventral margin. There are also imprints of long filiform leaves overlapping the spike.

Remarks: This fossil is similar to the loose few-flowered spikes of Potamogeton pectinatus L. (normally with five whorls of nutlets), P. crispus L. and some other species. The leaves are like submersed leaves in, e.g., P. gramineus L.

Locality: Manlaj, 95—37.

Sparganium-like heads
PL 20, figs. 262—264, Text-Fig. 11 D

Description: A single specimen 18 mm long showing an axis with two compressed heads. The axis is straight, smooth, 1 mm thick. The heads are 5 mm apart, sessile, 10 μm in diameter consisting of more than 12 nutlets each. The nutlets are sessile, mucronate, straight or slightly curved, 3—3.2 mm long, 1—1.3 mm wide, tapering into the micro which is about 3 mm long, apparently stiff. At the base of the lower head, there is a leaf-like organ, presumably an inflorescence brace 2 mm wide, torn off 4 mm above the base.

Remarks: The heads resemble those of Sparganium, though smaller than in the extant species. In S. (Xanthoarganium) minimum HILL and some other species the fructifications consist of two or more heads sessile in the axils of the leaf-like bracts. The nutlets are fusiform or elliptical, with a beak longer or equal to the body.

This fossil is superficially similar also to the capitulate or corymbiform inflorescences in some Juncaceae and Cyperaceae. In the case of the Juncaceae, the heads would consist of capsules and tepals (both are conspicuously mucronate in such species as Juncus nipponensis Rois & Luzula forsteri (SM.) DC.), while in the case of the Cyperaceae there would be the heads or corymbiform clusters of spikelets dominated by the upper glumes subtending a mucronate achene, as in Rhynchospora. Both interpretations are more strained than the Sparganium version.

Locality: Manlaj, 95—37.

Typhaera gen. nov.

Type species: Typhaera fusiformis sp. nov.

Diagnosis: Diaspore fusiform, stalked, tapering into a long mucro, with a tuft of hairs arising from the stalk.

Remarks: This diaspore resembles a follicle of Typha with a gynophore bearing several tiers of long multicellular hairs and a very long style. In the ripe follicles of Typha, the gynophore is much longer than the stalk of Typhaera. The style is expanded terminally into a ligular stigma. In sterile carpoids, the stigma is not developed (BRIGS & JOHNSON, 1968). In Typhaera, the tips of the beaks are not preserved and it is not known whether they were bearing stigmas. If conceived as a micropylar tube, the beak is exceptionally long.
Typhaera fusiformis sp. nov.

PL. 19, figs. 247—251

Holotype: Gurvan-Eren, 236—29, N 3149/3004, PL. 19, fig. 251.

Diagnosis: As for the genus.

Description: The largest diaspore from Gurvan-Eren is fusiform, 9 x 2 mm, tapering to the stalk 0.7 mm long and to the incompletely preserved beak more than 10 mm long. The body is longitudinally striated. Another diaspore from the same locality is 5 x 1.5 mm, with a tuft of hairs 12 mm long, arising from the stalk and surrounding the body (PL. 19, fig. 247). Diaspores from Bon-Tsagan and Kholbotu-Gol are shorter and bulkier, 3.5 x 1.8 mm, with a thick tomentum of hairs at the base (PL. 19, fig. 249).


Problematospermum sp.

PL. 19, fig. 252

Remarks: Detached pappus is comparable with that of Problematospermum ovalis TURUTANOVA-KETOVA (see KRASSILOV, 1973). In the latter species the pappus often became detached from the seeds or achenes as in some extant members of the Compositae.

Locality: Gurvan-Eren, 236—29; Shin-Khuduk, 119—7a.

References

Explanation of Plates

Plate 1

Figs. 1—4. Restiform bodies (putative gametophytes of Glossopteris galeata sp. nov.) Bon-Tsagan, 34—3.
Fig. 1. Transfer preparation showing cowl. x 102.
Fig. 2. Abscised restiform bodies on a bedding plane. x 1.
Fig. 3. Restiform bodies showing median groove. x 7.
Fig. 4. Restiform body (sp. nov.), leafy shoots and associated ostracod shells, holotype (sp. nov.), Erdeni-Ula, 20—25. x 7.
Fig. 5. Pseudolarix japonica sp. nov., from the Palaeogene Noda Group, North-East Japan. — Proc. Jap. Acad., 20 (2): 347—357.
Fig. 6. Pseudolarix japonica sp. nov., leafy shoots and associated ostracod shells, holotype (sp. nov.), Erdeni-Ula, 213—25. x 7.
Fig. 7—11. Fern gametophytes (sp. nov.) Gurvan-Eren, 20—28. x 7.
Fig. 12. Fern gametophyte (sp. nov.) Gurvan-Eren, 20—28. x 7.

Fig. 2. Abundant restiform bodies on a bedding plane, x 1.
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Fig. 12. Fern gametophyte (sp. nov.) Gurvan-Eren, 20—28. x 7.
Plate 2


- Fig. 16. Rhizome bearing several leafy shoots, x 1.5.
- Fig. 17. Branching shoot, holotype, x 5.
- Fig. 18. Portion of the holotype showing minute dorsal leaves, x 15.
- Fig. 19. Pseudomonopodially branching shoot, x 1.5.
- Fig. 20. Sporangiphores bearing a single microsporangium overtopped by bracts, x 10.
- Fig. 21. Sporangiphore with larger sporangium (megasporangium?), x 12.
- Fig. 22. ninth shoot, x 2.
- Fig. 23. Leaves showing ligular pits, x 10.
- Fig. 24. Leaves showing ligular pits, x 15.

Plate 3

Figs. 25—29. Megaspores tentatively assigned to *Limnothetis gobiensis* sp. nov. Bon-Tsagan, 45—19.

- Fig. 25, 26. Proximal and distal aspects, x 450, SEM.
- Fig. 27. Reticulum with the stumps of the spines, x 1150, SEM.
- Fig. 28. Stump of a spine with radially arranged reticulum meshes, x 4000, SEM.
- Fig. 29. Megaspore on the bedding plane associated with the shoots, x 10.

Plate 4


- Fig. 30. Proximal aspect, x 2000, SEM.
- Fig. 31. Folded microspores, x 1400, SEM.

Plate 5

Figs. 32—53. *Limnoniobe insignis* sp. nov. Bon-Tsagan, 45—19.

- Fig. 32. Transverse view of a shoot showing radially spreading leaves, x 2.
- Fig. 33. Stem fragments showing leaf scars in spirastichies, x 1.
- Fig. 34. Stem showing irregularly arranged leaf scars and attached leaves in the upper portion, x 1.5.
- Fig. 35. Stem with the root scars, x 1.
- Fig. 36. Stems, the same specimen, root scars, x 1.5.
- Fig. 37. Megaspore on the leaf, holotype, x 22.
- Fig. 38. Transversely broken stem, holotype, with radially spreading leaves, some of them detached, x 7.
- Fig. 39. Megaspore mass (contents of the megasporangia), holotype, x 7.
- Fig. 40. Spherical body (megasporangium?) showing cells similar to the leaf epidermal cells of *Limnoniobe insignis* sp. nov., x 7.

Plate 6

Figs. 54—68. *Otozamites lacustris* sp. nov.

- Figs. 54—57. Detached pinnules and their bases enlarged to show venation. Manlaj, 92—16. x 3 and 7.
- Fig. 58. Pinnule, holotype. Bon-Tsagan, 23—22. x 7.
- Fig. 59. Compression of a pinnule. Bon-Tsagan, 23—22. x 7. Microscopical preparations are mostly from this pinnule.
- Fig. 60. Vascular elements of the leaf showing helical-reticulate thickening and small raised intervessel pits, x 600.
- Fig. 61. Wall sinuosities of the upper epidermal cells, x 600.
- Fig. 62. Stoma sunken in the subepidermal spongy tissue (aerenchyma). x 1000, SEM.
- Fig. 63. Spongy tissue with immersed stomata. x 450, SEM.
Plate 7


70. Base, supposedly of Neozamites cerademontanus sp. nov. Shin-Khulak, 1a. x 1,5.

71—74. Nilssoniopteris denticulata sp. nov., Bon-Tsagan, 45—14. x 1,5.

75. Narrow leaf with keaping lateral vein. x 2 and 7.

76. Lower part of the narrow leaf. x 3200, SEM.


78. Nilssoniopteris denticulata sp. nov., leaf divided into three primary segments, holotype. Shin-Khulak, 118—8c. x 1.

79. Lower cuticle of the narrow leaf, x 800, SEM.


83. Four-lobed leaf, holotype. x 1.

84. Stoma of the upper epidermis. x 1120, SEM.


86. Petiolate scale. Shin-Khuduk, 118—8c. x 5.


88. Shoot showing a pair of scale leaves. Shin-Khuduk, 118—2c. x 2.

89. Shoot showing resin ducts at the base of each lateral branchlet. Shin-Khuduk, 118—2c. x 2.

90. Shoot showing resin ducts at the base of each lateral branchlet. Shin-Khuduk, 118—2c. x 2.

91. Portion of the same specimen showing veins and hypodermal strands. x 10.

92. Portion of the same specimen showing veins and hypodermal strands. x 10.

93. Shoot showing resin ducts at the base of each lateral branchlet. Shin-Khuduk, 118—2c. x 2.

Plate 8

84—88. Swedenborgia junior sp. nov.


85. Scale of the holotype. x 10.

86. Scale showing resin ducts at the base of each lateral branchlet. Shin-Khulak, 118—2c. x 2.


89. Swedenborgia sp. (cf. S. longiloba Stanisl.) showing five lobes. Shin-Khuduk, 119—8c. x 4.


92. Portion of the same specimen showing veins and hypodermal strands. x 10.

93. Portion of the same specimen showing veins and hypodermal strands. x 10.

94. Portion of the same specimen showing veins and hypodermal strands. x 10.

95—107. Araucaria mongolica sp. nov.


96. Shoot showing short-lanceolate leaves at the base and longer, bluntly pointed leaves above. Shin-Khulak, 119—7a. x 7.

97. Epistomatic leaves, compressed along the keel showing a single stomatal band. Shin-Khulak, 119—7a. x 7.


105. Shoot showing resin ducts at the base of each lateral branchlet. Bon-Tsagan, 45—19. x 1.

106. Portion of the same specimen showing veins and hypodermal strands. x 10.

107. Portion of the same specimen showing veins and hypodermal strands. x 10.

Plate 9

95—107. Araucaria mongolica sp. nov.


97. Epistomatic leaves, compressed along the keel showing a single stomatal band. Shin-Khulak, 119—7a. x 7.


105. Shoot showing resin ducts at the base of each lateral branchlet. Bon-Tsagan, 45—19. x 1.

106. Portion of the same specimen showing veins and hypodermal strands. x 10.

107. Portion of the same specimen showing veins and hypodermal strands. x 10.

Plate 10

108—114. Brachyphyllum densiramosum sp. nov.


110. Shoot showing short-lanceolate leaves along the keel showing a single stomatal band. Shin-Khulak, 119—7a. x 7.


114. Shoot showing resin ducts at the base of the shoot. Shin-Khulak, 119—8a. x 1.


117. Shoot showing resin ducts at the base of each lateral branchlet. Bon-Tsagan, 45—19. x 1.

118. Portion of the same specimen showing veins and hypodermal strands. x 10.

119. Portion of the same specimen showing veins and hypodermal strands. x 10.
Figs. 115, 116. *Brachyphyllum* sulcatum sp. nov.

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Fig. 141. Seed showing median ridge. x 10.

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Fig. 165. Scale with auricles, holotype. x 10.

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Fig. 168. Split scale. x 5.

Fig. 169. Detached half-scales. x 3 and 5.

Fig. 170. Detached half-scales. x 3.

Fig. 171. Samara stalk. x 3.

Fig. 172. Samara stalk. x 3.

Fig. 173. Samara stalk. x 3.

Fig. 174. Samara stalk. x 3.

Fig. 175. Samara stalk. x 3.

Fig. 176. Samara stalk. x 3.

Fig. 177. Samara stalk. x 3.
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Table 1. Provisional age assignments of the Mongolian Lower Cretaceous Formations and plant assemblage-zones.

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<th>Age</th>
<th>Rocks</th>
<th>Plant assemblage zones (major localities)</th>
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