

# APPROACH TO THE CLASSIFICATION OF MESOZOIC "GINKGOALEAN" PLANTS FROM SIBERIA

V. A. KRASSILOV

Far Eastern Institute of Geology, USSR Academy of Sciences, Vladivostok

## ABSTRACT

New findings from the Mesozoic of Bureja basin confirm Harris' interpretation of *Leptostrobus*. Its capsule is analogous to the ovary of Angiospermae, the contact surface of valves is verrucose and papillate and corresponds to the stigma. The leaves of *Czekanowskia*, *Phoenicopsis* and allied genera are assigned to the plants with *Leptostrobus* type of fructification and must be excluded from the Ginkgoales. Three types of female fructifications: megastrobili of *Ginkgo*, *Karlenia* and *Umaltolepis* (a new organ-genus referred to *Pseudotorellia*) are distinguished within the Ginkgoales, each of them representing a distinct family.

## INTRODUCTION

HEER (1876) described the Siberian Mesozoic flora as dominated by *Ginkgo* family. In this family he included besides *Ginkgo* itself such extinct genera as *Baiera*, *Trichopitys*, *Czekanowskia*, *Phoenicopsis*, *Dicranophyllum*, *Feildenia* and *Rhipidopsis*. Heer's (1876) remarks on the affinity of *Phoenicopsis* are noticeable: he considered this genus as some sort of a link between the Ginkgoalean plants and Paleozoic *Cordaites*. Seward and Gowan (1900) were perhaps the first to doubt Heer's opinion on the systematic position of *Phoenicopsis-Czekanowskia* group. Later Oishi (1933) separated this group from Ginkgoales on the grounds of cuticular analysis: he emphasized the striking difference in the epidermal structure of leaves of *Phoenicopsis-Czekanowskia* on one side and true Ginkgoales on the other. Oishi also rejected a coniferous affinity of this group and supposed it to be the order of its own. These very exquisite ideas were somehow overshadowed by the well known works of Florin (1936a, b) on the Ginkgoales from the Franz Jozef Land. Florin thoroughly investigated the favourably preserved plants from the *Phoenicopsis-Czekanowskia* group and expressed no doubt in their Ginkgoalean affinity.

Harris' (1951) study of *Leptostrobus* has thrown a new light on the problem. He found a strong evidence of *Leptostrobus* being the female reproductive organ of a

plant with the *Czekanowskia* leaves. The structure of *Leptostrobus* is unique among female flowers of Gymnosperms. The plants with such flowers must be removed from Ginkgoales. Probably they composed a separate taxa. At the same time Harris showed some difficulties in dividing the *Czekanowskia* group from Ginkgos: the male reproductive structures are completely unknown and "the position of *Arctobaiera* and *Sphenobaiera* would be doubtful and this would be a real disadvantage" (HARRIS, 1951, p. 505).

Our study of Ginkgoales and allied plants from the Upper Jurassic-Lower Cretaceous of the Bureja River basin confirms the statements of Oishi, and Harris on the heterogenous nature of fossil "Ginkgoales" sensu Heer and others and some new details come to light.

## MATERIAL AND METHODS

The material was collected at the outcrops of Upper Jurassic-Lower Cretaceous continental beds within the valley of Bureja River and its tributaries. Cleaned leaves, brachyblasts, capsules, seeds and sporangia were obtained by means of bulk maceration and transfer techniques. Some of them were then subjected to oxidation and maceration with alkaline solution.

## DESCRIPTION

### CZEKANOWSKIALES

The name "Czekanowskiales" apparently arrived for the first time in Pant's (1958) classification of Gymnospermous plants.

*Female organs* — Two species of *Leptostrobus* and one of *Staphidiophora* were investigated. The structure of Siberian *Leptostrobus* ex gr. *laxiflorus* Heer, is as a whole identical with those described by Harris from Greenland and Yorkshire: these fructifications consist of a long axis bearing fertile capsules composed of two valves. Some additional details were observed:

1. A short stalk of the capsule which is sometimes almost completely reduced — capsules being sessile, and sometimes proliferated in a comparatively solid structure resembling a cylindrical short shoot, bears somewhat ill defined marks or scars of scale-leaves. Identical scars were found on the flattened basal part of the capsule.

2. Convex central part of each valve is bordered by a flat marginal flange. The inner face of the flange is verrucose, with pointed or rounded outgrowths. The cuticle of inner side of the flange is densely papillate. The marginal flange gives inside very thin lamellae overhanging the seeds. The cuticle of lamellae is also papillate.

3. The inner concave side of the valve has very thin cuticle which differs in its structure from the outer cuticle. Seeds were not embedded in the " fibrous layer " as Harris (1951) supposed them to be.

Another type of *Leptostrobus* — *L. ex gr. crassipes* Heer differs from the above described *L. ex gr. laxiflorus* in its large and flattened capsules with more dense and occasionally anastomosing venation. Seeds are more numerous (about eight on each valve). Inner cuticle of the valve is more robust and clearly differentiated on zones of very narrow cells under the veins and broader cells with slightly sinuous or undulating walls between them. The axis is pilose — the long unicellular trichomes are rather frequent. One cone is still attached to the cylindrical short shoot covered with scale leaves.

The fructification closely allied to *Staphidiophora secunda* Harris was found in the upper layer of coal-bearing rocks of Bureja basin. According to the first interpretation given by Harris (1935) lateral appendages of this fructification were seeds. Later Harris (1951) realized the other possibility — that appendages are fertile capsules. This new interpretation is confirmed now and some resistant to maceration megaspore membranes were found within the capsules. Megaspore membranes are elliptical, folded and with few small apical protuberances (archegonial necks ?). *Staphidiophora* is very close to *Leptostrobus* and differs from it in much smaller dimensions of capsules and of fructification as a whole, in more regular distichous arrangement of capsules, etc.

According to the authors' interpretation the stalk of a capsule is a reduced axis of

inflorescence. On this shortened axis only two fertile complexes (simple strobiles or carpels) had been retained which were united in a two-valved capsule. The capsule is analogous to the ovary of Angiospermae and the contact surface of valves (carpels) is specialized for pollination (the present author has no alternative interpretation of the verrucose and papillate sculpture of this surface) and is analogous to the stigma. Pollination there was perhaps of gymnospermous nature, but it is worth mentioning that in some tropical flowering plants (some Anonaceae and others) pollen falls through the stigma and does not germinate on it.

*Male Organs* — I consider the organ-genus *Ixostrobus* Raciborski as a male cone of Czekanowskiales. In two localities in the Bureja basin these cones were found in association with *Leptostrobus*. But in both cases *Ixostrobus* is a rare fossil while *Leptostrobus* is abundant. The association with the leaves attributed to Czekanowskiales (see below) is more impressive. Still Raciborski and Heer emphasized the association of *Ixostrobus* (*Antholithes schmidtianus* in Heer's monograph) with *Czekanowskia* or *Phoenicopsis*. Prynada (1962) analyzing the extensive Siberian material had come to the conclusion that *Ixostrobus* belongs to *Czekanowskia* or *Sphenobaiera*. But male fructifications of the later are known and their structure is different (KRÄUSEL, 1943). I found two species of *Ixostrobus* — *I. schmidtianus* (Heer) Krassilov and *I. heeri* Prynada. The first occurs in association with *Stephenophyllum* in three localities and the second — with both *Czekanowskia* and *Phoenicopsis* (*Stephenophyllum*) in four localities. Other associated leaves belong to *Ctenis*, *Nilssonia*, *Pterophyllum* and *Sphenobaiera*. It seems quite unlikely that one of them is a foliage of *Ixostrobus*. Harris provisionally assigned *Ixostrobus* to *Podozamites* but the evidence is not very strong.

*Ixostrobus* consists of an axis and spirally attached microsporophylls composed of a thin stalk and more or less expanded terminal cup. This cup is built of five appendages. The basiscopic appendage is sterile and backwardly curved while the others are more or less fused and form a sinangium. Cuticle of sinangium is very thin and stomata was not observed. Pollen grains are small, wingless, badly preserved. Microsporophylls of *Ixostrobus* differ from all

corresponding structures of other gymnosperms and some points of resemblance to a stamen of Angiospermae can be traced.

*The Leaves* — Harris (1951) put forward a convincing evidence of attribution of *Leptostrobus* to *Czekanowskia*. In the Bureja basin *L. ex gr. laxiflorus* occurs in three localities and in all of them *Czekanowskia* is a mostly abundant leaves. In two of them leaves of *Pseudotorellia* were found in great number, but in the third (in the lower part of the *Azanowski* section) *Czekanowskia* and isolated capsules of *Leptostrobus ex gr. laxiflorus* completely cover the blocks surface and only some fragments of fern pinnules associated with them. Similarity in epidermal structure of *Czekanowskia* and *Leptostrobus* was fully discussed by Harris (1935, 1951) and Vachrameev and Doludenko (1961). I found some additional evidence in the close agreement between the cuticles of capsule of *L. ex gr. laxiflorus* and basal scale leaves of *Czekanowskia*, where the epidermal cells are shorter and broader and stomata are scattered and amphicyclic.

*Leptostrobus ex gr. crassipes* occurs in four localities: (1) in the middle part of Umltinski section with *Stephenophyllum* (abundant), *Pseudotorellia*, *Sphenobaiera*, *Pterophyllum* and *Ixostrobus*; (2) in the upper part of Umltinski section with a mass of *Stephenophyllum* leaves and one specimen of *Ixostrobus*; (3) in the Tchegdomyn coal mine on one block with *Stephenophyllum* and *Nilssonina*; (4) in the upper part of *Azanowski* section with *Stephenophyllum* and *Czekanowskia*. Besides the evidence of association agreement in structure between *L. ex gr. crassipes* and *Stephenophyllum* is very impressive. Stomata of the Burejean species of *Stephenophyllum* are of two types: one with strongly thickened subsidiary cells without a distinct papillae and the other with rather thinly cutinized subsidiary cells with prominent papillae bordering the stomatal pit. Stomata are distributed in narrow somewhat sunken bands or single rows. Epidermal cells are elongated, some of them with strong papillae and others with slight median elevation. Epidermis of the capsule of *L. ex gr. crassipes* has closely similar cells and stomata (both types are present), the distribution of stomata is also similar, but more sparse. The shoot bearing *Leptostrobus* fructification is much longer than short shoots of *Stephenophyllum* which are as a rule almost spherical,

but some abnormal cylindrical shoots with a cluster of *Stephenophyllum* leaves were found. The scale leaves on the fertile and sterile shoots are identical and their cuticles have frequent trichomes which are closely similar to trichomes on the cone axis of *L. ex gr. crassipes*.

I obtained many hand-specimens on which *Staphidiophora* and *Hartzia* are associated. Other plants in this locality are *Nilssonina*, *Phoenicopsis*, *Ginkgoites*, *Pityophyllum* and *Ixostrobus* but none of them resembles *Staphidiophora* in structure.

We may presume that all genera of *Czekanowskia* group (*Czekanowskia*, *Solenites*, *Hartzia*) as well as *Stephenophyllum* (and probably other closely allied genera of *Phoenicopsis*-group — *Windwardia* and *Culgoweria*) belong to the *Czekanowskiales*. It would not be too impudent to suppose that *Arctobaiera* is also a member of the new order *Czekanowskiales* because morphologically and anatomically this genus is identical with *Stephenophyllum* (see FLORIN, 1936a). The only difference make some (but not all) leaves of *Arctobaiera* which are split at the apices — not a great difference indeed. Florin regarded *Arctobaiera* to be closely allied to *Sphenobaiera* but the true *Sphenobaieras* (allied to the type-species *S. spectabilis*) have two vascular bundles entering the leaf base (this was demonstrated on our Siberian material) and numerous secretory cavities between the veins. *S. horniana* — the only species which Florin had taken in consideration, differs from typical *Sphenobaiera* and other Ginkgoales in its epidermal structure, secretory system and vascularization. I feel that it must be removed from the genus *Sphenobaiera* and included in *Stephenophyllum* or *Arctobaiera*. It seems that specimens from Ust-Baley described by Heer as the leaves of *Leptostrobus* (*L. rigida* Heer and *L. angustifolia* Heer) and redescribed later by Prynada as a new genus *Angariella* had nothing to do with *Czekanowskiales* and had been rather the *Isoetes*-like plants.

As a whole leaves of *Czekanowskiales* are linear or ribbon-shaped, simple or forked with few or numerous parallel veins. They form a definite morphological range: *Czekanowskia* (leaves narrow and repeatedly forked) — *Solenites* (leaves narrow and forked once) — *Hartzia* (leaves narrow and simple or forked at the apices) — *Arcto-*

*baiera* (leaves broader, with numerous veins, simple or forked at the apices) — *Phoenicopsis* (including *Stephenophyllum*, *Windwardia* and *Culgoveria* — leaves ribbon-shaped, unforked, with numerous veins). Leaves are borne on the short shoots of limited growth and only one vascular bundle enters the leaf base. Epidermal cells are elongated and make definite rows. Stomata arranged in narrow bands or single rows, longitudinally oriented, typically with strongly thickened subsidiary cells. Mesophyll among veins is devoted from secretory cavities. They occur in sclerenchymatous tissue under the vascular bundles.

*Distribution* — *Czekanowskiales* flourished in the temperate Siberian flora where they arrived in Late Triassic and disappeared only in Late Cretaceous (Cenomanian — Turonian time). In Rhaeto-Liassic time *Czekanowskiales* penetrated into Europe, Greenland, Caucasus, Central Asia, China and Japan, but in Late Jurassic they became rather rare in all these countries with subtropical and dry climate, and completely vanished from Europe, Central Asia, Maritime Territory of the U.S.S.R. and Japan at the beginning of the Early Cretaceous (records of *Czekanowskia* from the Lower Cretaceous of the U.S.S.R. Maritime Territory and Japan are not trustworthy). It is interesting that in the Mesozoic of North America *Czekanowskia* occurs but *Phoenicopsis*-group is completely absent ("*Phoenicopsis*" from Cape Lisbourne belongs to *Sphenobaiera*: Cahoon, 1960; "*Phoenicopsis*?" recorded by W. Bell from Canada is an unclassifiable fragment of linear leaf). There are no convincing evidence of existence of *Czekanowskiales* in the Southern Hemisphere (as "convincing" I regard the records of fructifications, short shoots with clusters of leaves but not the remains of linear leaves with unknown epidermal structure which are assigned to *Czekanowskia* or *Phoenicopsis*, — for instance, *Phoenicopsis elongata* from the Jurassic of New Zealand: JONES & JERSEY, 1947).

#### GINKGOALES

Three types of female Ginkgoalean fructifications are known:

1. The megastrobili of living *Ginkgo biloba*. We have no fossil fructification analogous to the bioovulate *Ginkgo* megastrobilus, but numerous ovules of *Allicospermum xystum*

type (HARRIS, 1935), which are similar to the ovules of *Ginkgo*, were found in the Mesozoic and Cainozoic strata. These seeds are provided with the thick and resistant outer cuticle of integument. It is papillate and has amphicyclic stomata and conspicuous openings of secretory cavities. Inner cuticle of integument and cuticle of nucellus are joined in a thin and colourless double cuticle. Megaspore membrane is resistant, thick and tough. Associated leaves in several cases belong to the genus *Ginkgoites*: *Ginkgoites taeniata* Harris from the Rhaeto-Liassic of East Greenland, *Ginkgoites* ex gr. *adiantoides* (Unger) Sew. from the Lower Cretaceous of the Bureja basin and others. However, such species as *Ginkgoites lundensis* (Stur) Kräusel, *G. tigrensis*. Archangelsky were attributed to the fructifications (*Antholithes wetsteinii*, *Karkenian incurva*) which differ fundamentally from the corresponding organs of *Ginkgo*. So we may conclude that *Ginkgoites* is an artificial genus and comprises the species of true Ginkgoaceae and of other families of Ginkgoales. Probably this is also true for *Baiera* leaves which were recorded in the association with *Ginkgo*-like seeds (TRALAU, 1965).

2. The fructifications of *Karkenian*-type which are known from two localities — one from the Lower Cretaceous of Argentina and the second from the Upper Jurassic of the Bureja basin. These fructifications consist of an axis bearing more than a hundred spirally attached ovules which form more or less compact cylindrical or rounded strobilus (PL. 1, FIG. 1). Ovules are born on the short stalk and are straight or incurved but not inverted. No indications of "collar" were noticed. Ovules are oval with slightly projecting micropyle and rounded or somewhat truncated chalazal end, the surface is striated. The integument breaks into two halves. Outer cuticle is thin and filmy, without stomata and nonpapillate. The stone layer is well developed consisting of the large oval cells with pitted surface (PL. 1, FIG. 9). Inner cuticle of integument lining the comparatively long micropylar canal is equally thin. The nucellus is free to the base and its cuticle is prepared intact (PL. 1, FIGS. 6-8). Only this nucellar cuticle was preserved under the strong oxidizing procedure. Nucellar beak is cylindrical with a rim of cuticle bordering a small rounded opening on its

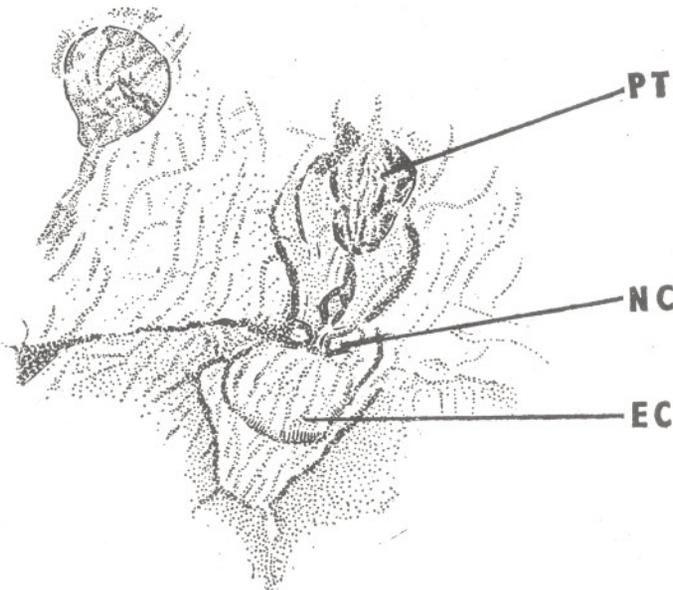
top (PL. 1, FIGS. 3, 11). Nearly a half of the prepared nucellar cuticles enveloped the megaspore membranes. At the micropylar end of megagametophyte two small cavities occur and two pollen grains (or pollen tubes) are situated exactly opposite these cavities (PL. 1, FIG. 2; TEXT-FIG. 1). The cavities are interpreted as archegonia. Large egg cell is visible in one of them and two small neck cells above it. The space between the archegonial neck and the pollen tube is bordered by the curved dark lines and is somewhat darker than the rest of pollen chamber. Small oval body next to the neck may be the penetrating spermatozoid head. No central column between the archegonia was observed.

*Karkenian incurva* was referred by Archangelsky to *Ginkgoites tigrensis*. I have rather convincing evidence of association for referring Siberian species of *Karkenian* to *Sphenobaiera* (new species, PL. 1, FIGS. 4, 5, 10). The hand-specimens of *Karkenian* are in most cases covered and penetrated with *Sphenobaiera* leaves. Other fossils in the *Karkenian* bed are *Pterophyllum* and *Stephophyllum*. And there is no reason for attributing any of them to *Karkenian*. If the Karkenian affinity is true for *Sphenobaiera* it might be true also for the closely allied genus *Eretmophyllum* (leaves of *Sphenobaiera* and *Eretmophyllum* are similar in the

epidermal structure, secretory cavities and venation). The Siberian species *Eretmophyllum glandulosum* (Samyl.) Krassil. (it had been described earlier as *Ginkgodium glandulosum*) was found in the Bureja basin in association with abundant small seeds of *Karkenian*-type.

3. Supposed female organs of *Pseudotorellia*. In many localities *Pseudotorellia* is accompanied by peculiar organs called *Umaltolepis* (generic name is derived from the Umalta River) which consist of a stalk bearing a single large terminal bract (PL. 2, FIG. 12; PL. 3, FIGS. 22-25). The base of a stalk is surrounded with scale leaves. The bract is elongated, entire or sometimes divided into two lobes, concave abaxially and probably secured a single seed (though seeds were never found intact). The evidence of attribution *Umaltolepis* to *Pseudotorellia* is: (1) Repeated association; (2) Scale leaves at the base of *Umaltolepis* stalk are structurally identical to the scale leaves covering the short shoots of *Pseudotorellia*. (3) Bracts of *Umaltolepis* and leaves of *Pseudotorellia* are similar in their cuticle though bracts have stomata on both sides and their stomata are somewhat larger than in the leaves.

Isolated seeds resembling the seeds of *Ginkgo* were found in the localities where *Pseudotorellia* and *Umaltolepis* occurred. These seeds (PL. 3, FIGS. 26-30) called



TEXT-FIG. 1 — Fertilization in *Karkenian*,  $\times 175$ . PT — pollen tube, NC — neck cell, EC — egg cell.

*Burejosperrnum* are oval, up to 10 mm. long with fairly thick testa. Epidermal cells are polygonal with thick walls and without papillae. Stomata were not observed. Nucellar cuticle with elongated cells forming indistinct files. Resin canals (PL. 3, FIGS. 26, 31) are narrow and linear resembling those of the leaves of *Pseudotorellia*.

A new material from the Bureja basin gives some idea about the mode of growth of *Pseudotorellia* leaves. They were borne on the short-shoots (PL. 2, FIGS. 13-18, 21) which had a strong resemblance to the short-shoots of *Ginkgo*: they are cylindrical, not more than a 80 mm. long and 10 mm. thick, few of them branched, covered with small scales and leaf scars. The latter being slightly raised and bear two scars of vascular bundles (PL. 2, FIG. 16) and minute openings of secretory canals. The apical bud was protected with bud scales (PL. 2, FIG. 14) as in the shoots of living *Ginkgo*. The leaves, leaving along their mode of vascularization, resemble the foliage of some Araucariaceae more than the typical Ginkgoalean leaves: they are entire, linear or oblanceolate, without a definite stalk, gradually tapering to the base and more abruptly to the apex. Veins in the middle part of a leaf are unbranched and parallel. The stomata are longitudinally oriented and arranged in distinct files. Stomatal pit bordered with a prominent rim of cuticle (PL. 2, FIG. 20). Absence of papillae (besides the subsidiary cells) and trichomes is unusual feature in Ginkgoalean leaves, but the most extraordinary is the structure of secretory system: it consists of the straight and  $\pm$  evenly thickened canals extending from the base of a leaf to the apex between each pair of veins (PL. 2, FIG. 19). These peculiarities show that *Pseudotorellia* represents an isolated group among Ginkgoales.

#### DISCUSSION AND CONCLUSION

Engler and Prantl included in the family Ginkgoaceae the following genera: *Ginkgo*, *Baiera*, *Phoenicopsis*, *Czekanowskia* and *Vesquia*. Besides *Vesquia* (which is regarded now as a seed of Taxaceae) all of them are the leaf-genera. Some *Ginkgo*-like fructifications were assigned to *Baiera* and *Czekanowskia* on the basis of indirect evidence. A lot of the genera of leaves approaching *Ginkgo* in their form, venation and/or mode of growth were supposed to be *Ginkgo* allies

(DORF, 1958), among them such Palaeozoic plants as *Psygmophyllum*, *Ginkgophyllum*, *Saportaea*, *Burriadia*, *Phylladoderma*, etc. Recently a new division of plant kingdom — Progymnospermae with the leaves of *Psygmophyllum* — *Ginkgophyllum* type was proposed and in light of this discovery the Ginkgoalean affinity of Palaeozoic leaf-genera became rather doubtful. It seems that Palaeozoic genus *Trichopitys* has more in common with Progymnospermopsida than with true Ginkgoalean plants. The list of Mesozoic *Ginkgoales* must be reduced by excluding *Czekanowskia*, *Phoenicopsis* and allied genera which belong to the Czekanowskiales. Ginkgoalean affinity is more or less certain for the following leaf-genera: *Ginkgoites* Seward, *Baiera* Braun, *Sphenobaiera* Florin, *Baierella* Potonie, *Eretmophyllum* Thomas, *Glossophyllum* Kräusel, *Pseudotorellia* Florin, *Torellia* Heer.

These leaf-genera form four morphological groups:

1. Leaves fan-shaped, semicircular, triangular, entire or lobed with more than one vein in each segment, hypostomous or (rare) amphistomous, petiole distinct, longer than leaf blade. Resin bodies rounded or oval —

*Ginkgoites* Seward  
*Baiera* Braun emend.  
Florin

2. Leaves fan-shaped, divided, with one vein in each ultimate division —

*Baierella* Potonie

3. Leaves wedge-shaped, tongue-shaped, oblong, obovate, entire or lobed, with more than one vein in each segment, amphistomous or (rare) hypostomous, petiole absent or not distinctly cut, shorter than leaf blade. Resin bodies elongated, needle-shaped —

*Sphenobaiera* Florin  
*Eretmophyllum* Thomas  
*Glossophyllum* Kräusel

4. Leaves linear, lanceolate, hypostomous, without petioles, resin canals continuous from the base to the apex of blade —

*Pseudotorellia* Florin  
? *Torellia* Heer emend.  
Florin

There are two types of female organs of extinct plants — *Karkenian* and *Umaltolepis*, resembling the *Ginkgo* megastrobilus sufficiently to justify their inclusion in the same order, but differing from it (and one from another) enough to distinguish each of them as a representative of the family of its own. Fertilization in *Karkenian* and

*Ginkgo biloba* is similar but the morphology of megastrobilus and cutinized seed membranes are different. If my interpretation of *Umaltolepis* is true it might be analogous with the female strobilus of *Ginkgo*, but it has one terminal fertile structure instead of two. Its bract may correspond to the so called collar of *Ginkgo* ovules.

It is supposed that the *Ginkgoites* — group of leaf-genera roughly corresponds to the Ginkgoaceae *sensu stricto* (though some *Ginkgoites* and *Baiera* belong to the other family or families) and the *Sphenobaiera* group — to Karkeniaceae. *Pseudotorellia* and *Umaltolepis* form the third family Pseudotorelliaceae.

Karkeniaceae is perhaps the most ancient family of Ginkgoales known from the Northern as well as Southern hemisphere. The true Ginkgos (Ginkgoaceae) have started from the Late Triassic of Northern hemisphere (ovules of the *Ginkgo* type, entire *Ginkgoites* leaves) and the Pseudotorelliaceae are not known from any country besides Eurasia and their range in time is from Rhaetic to the Lower Cretaceous.

I believe that a new classification of Ginkgoales proposed now would improve our knowledge of the geological history and evolution of these plants, though its preliminary nature must be accentuated.

#### REFERENCES

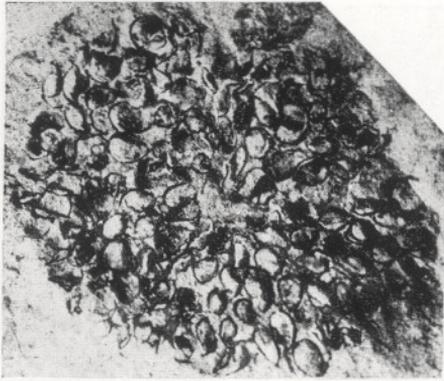
- ARCHANGELSKY, S. (1965). Fossil Ginkgoales from the Ticó flora, Santa Cruz province, Argentina. *Bull. Brit. Mus. (nat. Hist.) Geol.* **10** (5): 121-137.
- CAHOON, E. J. (1960). *Sphenobaiera ikorfatensis* f. *papillata* from the Lakota formation of the Black Hills. *Bull. Torrey bot. Cl.* **87** (4): 247-257.
- DORF, E. (1958). The geological distribution of the Ginkgo family. *Bull. Wagner Free Inst. Sci.* **33** (1): 1-10.
- FLORIN, R. (1936a). Die fossilen Ginkgophyten von Franz-Joseph Land nebst Erörterungen über vermeintliche Cordaitales mesozoischen Alters. I. Spezieller Teil. *Palaeontographica*, **81**, Abt. B. (3-6): 1-173.
- Idem (1936b). Die fossilen Ginkgophyten von Franz-Joseph Land nebst Erörterungen über vermeintliche Cordaitales mesozoischen Alters. 2. Allgemeiner Teil *ibid.* **82** B. (1-4): 1-72.
- HARRIS, T. M. (1935). The fossil flora of Scoresby Sound, East Greenland. *Medd. öm Grönland* **112** (1): 1-176.
- Idem (1951). The fructification of Czekanowskia and its allies. *Philos. Trans. R. Soc. Lond. Ser. B.* **235** (628): 483-508.
- HEER, O. (1876). Beiträge zur Jura — Flora Ost-sibiriens und des Amurlandes. *Mém. V'Acad. Imp. Sci. St.-Pét.* **22** (12): 1-122.
- JONES O. A. & JERSEY, N. J. DE (1947). The flora of the Ipswich coal measures — morphology and floral succession. *Univ. Qld. Papers Geol. (n.s.)* **3**:
- KRÄUSEL, R. (1943). Die Ginkgophyten der Trias von Lunz in Nieder-Österreich und von Neue Welt bei Basel. *Palaeontographica*. **87** B: 59-93.
- OISHI, S. (1933). A study on the cuticles of some mesozoic gymnospermous plants from China and Manchurica. *Sci. Rep. Tôhoku Imp. Univ.*, ser. 2, **12** (2): 239-252.
- PANT, D. D. (1959). The classification of gymnospermous plants. *Palaeobotanist*. **6** (2): 65-70.
- PRYNADA, V. D. (1962). Mesozoic flora from the East Siberia and Zabaikalie. *Moscow (in Russian)*,
- SEWARD, A. C. & GOWAN, J. (1900). The Maiden-hair Tree (*Ginkgo biloba* L.) *Ann. Bot. Lond.* **14**: 109-154.
- TRALAU, H. (1966). Botanical investigations in the fossil flora of Eriksdal in Fyledalen, Scania. *Sveriges Geol. Undersökning*. ser. C, (611): 1-36.
- VACHRAMEEV, V. A. & DOLUDENKO, M. P. (1961). Late Jurassic and Lower Cretaceous flora of the Bureja basin and its stratigraphical significance. *Akad. Sci. U.S.S.R., Moscow (in Russian)*.

#### EXPLANATION OF PLATES

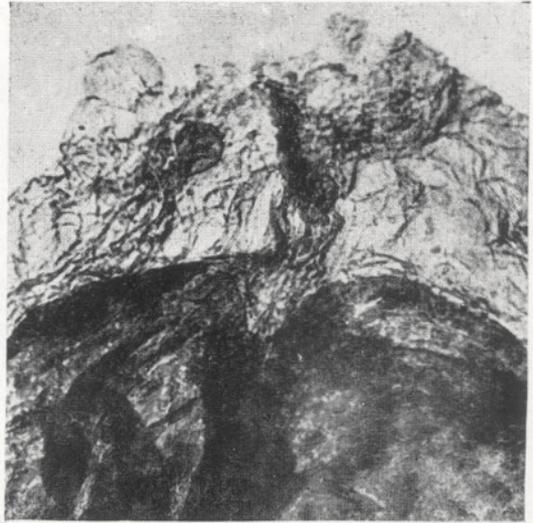
##### PLATE 1

1. *Karkenia* sp., Strobilus (specimen No. 516-116) × 1.
2. *Karkenia* sp., nucellar chamber and part of the female gametophyte with two archegonia. Two pollen grains situated opposite the archegonial necks (specimen No. 516-387) × 69.
3. *Karkenia* sp., upper part of nucellar cuticle with nucellar beak (specimen No. 516-387) × 69.
4. Fragments of *Sphenobaiera* leaves showing secretory cavities between veins (specimen No. 517-386) × 2.

5. Basal part of *Sphenobaiera* leaf with two vascular bundles entering the leaf base, with secretory cavity between them (specimen No. 516-386) × 3.
- 6-7. *Karkenia* sp., nucellar cuticles (specimen No. 516-387) × 8.
8. *Karkenia* sp., nucellar cuticle of smaller ovule enveloping the megaspore membrane (specimen No. 516-387) × 8.
9. *Karkenia* sp., cells of the stone (specimen No. 516-387) × 175.
10. Pollen grains on the cuticle of *Sphenobaiera* leaf. Some of them resemble the pollen grains in Fig. 2 (specimen No. 516-387a) × 220.



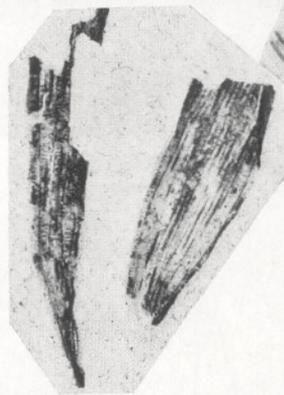
1



2



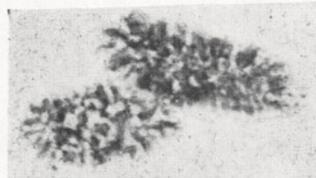
3



4



5



9



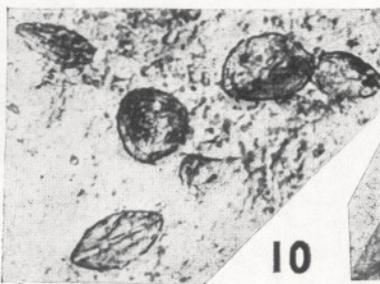
6



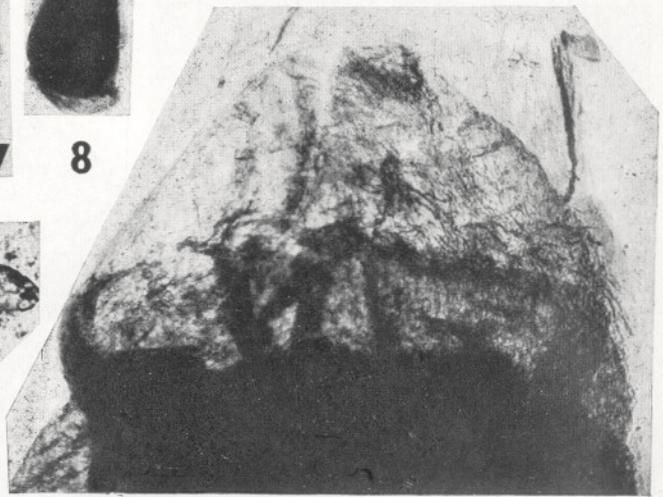
7



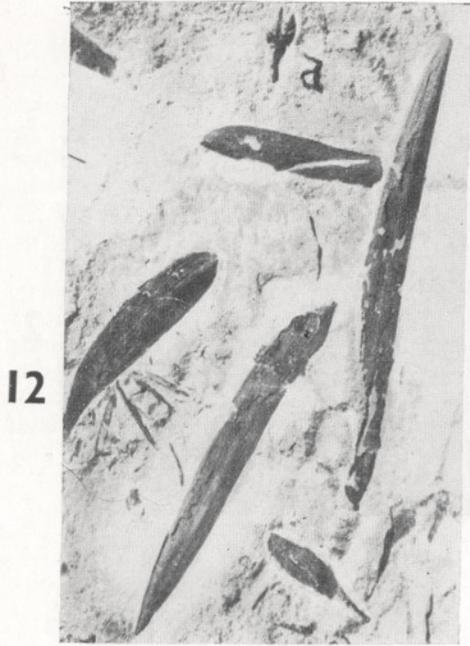
8



10



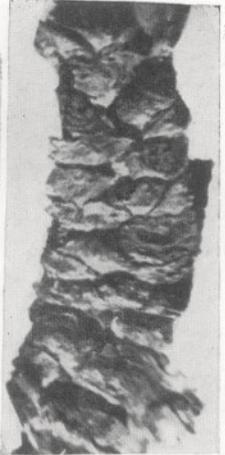
11



12



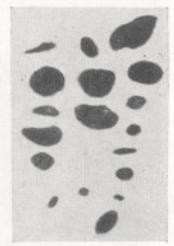
13



16



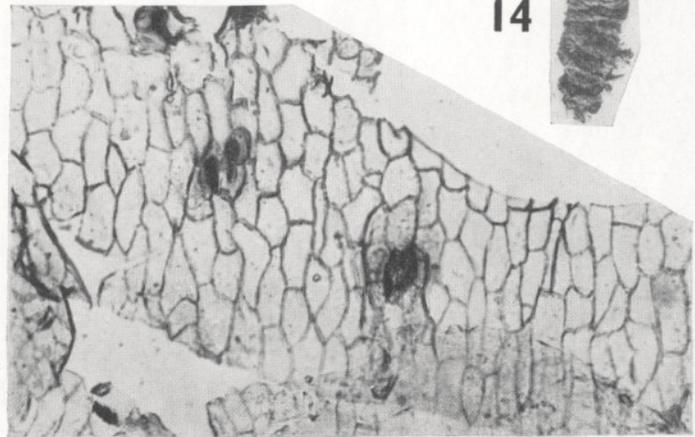
15



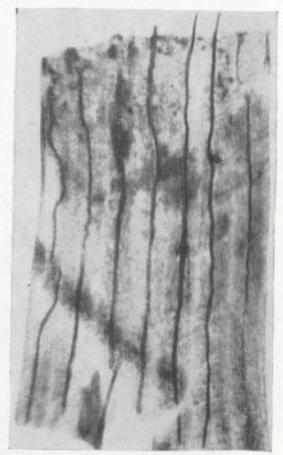
17



14



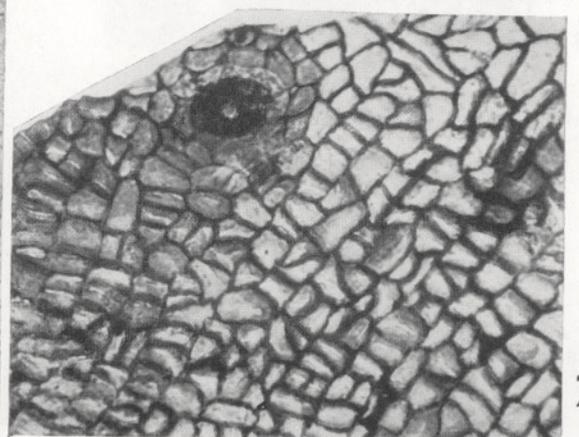
18



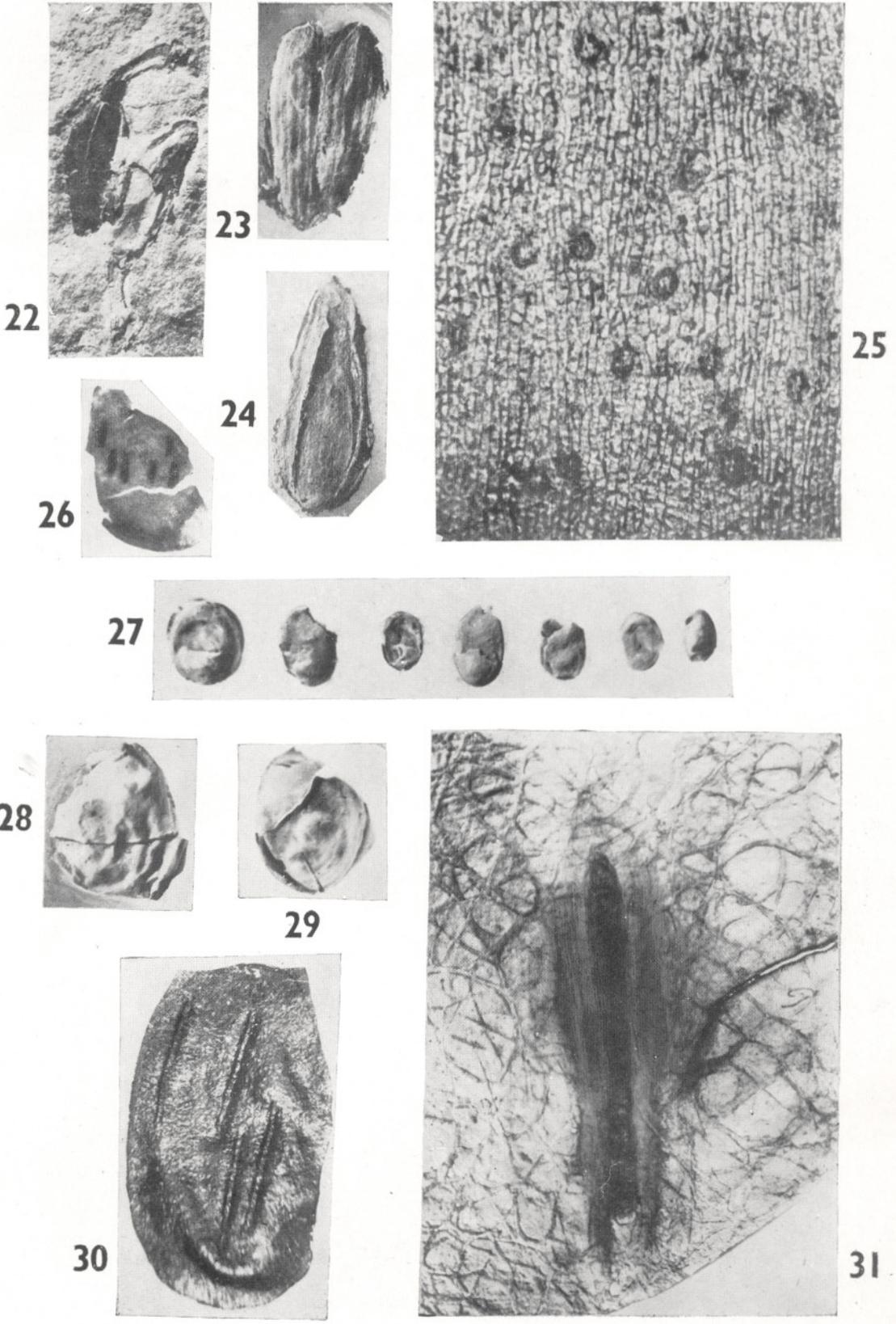
19



20



21



11. *Karhenia* sp., upper part of the nucellar cuticle, same specimen as in figure 8. Note the rim of cuticle bordering the opening of nucellar chamber and fragments of the inner cuticle of integument lining the micropylar canal (specimen No. 516-387)  $\times$  69.

## PLATE 2

12. Four leaves of *Pseudotorellia* and two scales of *Umalltolepis* (specimen No. 515-224)  $\times$  1.

13. Branching short shoot of *Pseudotorellia* (specimen No. 515-279)  $\times$  1.5.

14. *Pseudotorellia*, short shoot with apical bud protected with bud scales (specimen No. 515-284)  $\times$  2.

15. *Pseudotorellia*, short shoot bearing two foliage leaves intact (specimen No. 515-289)  $\times$  2.

16. Part of the short shoot same as in the figure 3 showing scale leaves and leaf-scars with two rounded traces of vascular bundles (specimen No. 515-289)  $\times$  5.

17. *Pseudotorellia*, resin bodies of the scale leaves (specimen No. 515-284)  $\times$  10.

18. *Pseudotorellia*, adaxial cuticle of scale leaf with stomata (specimen No. 515-284)  $\times$  175.

19. *Pseudotorellia*, fragment of foliage leaf with resin canals (dark longitudinal lines) (specimen No. 501-522)  $\times$  8.

20. *Pseudotorellia*, papillate stoma (specimen No. 515-258)  $\times$  474.

21. *Pseudotorellia*, abaxial cuticle of scale leaf with occasional stoma (specimen No. 515-284)  $\times$  175.

## PLATE 3

22. Two *Umalltolepis* structures consisting of a stalk with scale leaves surrounding its base and terminal bract (specimen No. 515-271)  $\times$  2.

23. *Umalltolepis*, outer surface of two-lobed bract (specimen No. 515-125)  $\times$  2.5.

24. *Umalltolepis*, inner surface of entire bract (specimen No. 515-121)  $\times$  2.5.

25. Cuticle of the bract (specimen No. 515-271)  $\times$  90.

26-29. Seeds attributed to *Pseudotorellia*. Seed coat in figure 26 with clearly marked resin canals (specimens No. 501-532, 533, 534, 535, 536, 537, 538, 544, 539)  $\times$  2.5.

30. Seed coat with resin canals (specimen No. 509-499)  $\times$  8.

31. Cells of outer cuticle of the seed and resin canal (specimen No. 501-540)  $\times$  175.