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UPPER CRETACEOUS LEAF FLORA FROM THE BŁASZYK MORAINE (ZAMEK FORMATION), KING GEORGE ISLAND, SOUTH SHETLAND ISLANDS, WEST ANTARCTICA

Górnokredowa flora liściowa
z Moreny Błaszyka (formacja Zamek), Wyspa Króla Jerzego,
Archipelag Południowych Szetlandów, Antarktyka Zachodnia

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ABSTRACT. In the tuff sandstones and conglomerates of Błaszyk Moraine, Admiralty Bay, King George Island, South Shetland Islands, West Antarctica occur leaf impressions of the Zamek Formation, the uppermost part of the Baranowski Glacier Group (Birkenmajer 1980a). The age of this group lies between 77 ± 4 Ma (Santonian-Campanian) and 66.7 ± 1.5 Ma (Maastrichtian) (Birkenmajer et al. 1983). The leaf remains of angiospermous plants predominate in the taphocoenosis examined (Tab. 1). However, there are also some impression of *Pteridophyta* and one of a conifer (*Araucaria* or *Podocarpaceae*). Among angiosperms three new taxa were distinguished: *Nothofagus cretacea* Zastawniak (*Nothofagaceae) Magnoliidaephyllum birkenmajeri* Zastawniak (subclass *Magnoliidae*) and genus *Myrciophyllum* (*Myrtaceae* family). Most leaves are magnoliaephyll, protophyll and laurophyll morphotypes, but pentalobaphyll and acrodromophyll morphotypes occur also. The *Magnoliidae* and *Hamamelididae* are the dominant group, but some *Dilleniidae* and *Rosidae* are present as well. The Upper Cretaceous communities from the Błaszyk Moraine were represented on the lower parts of slopes and the bases of high volcanoes by magnoliaceous-laurophyllous evergreen rain forests. Above these woodlands, on the high slopes of volcanoes, occurred open deciduous *Nothofagus*-forest with coniferous trees and ferns.

Physiognomic analyses of the leaf remains from the Błaszyk Moraine suggest a relatively mild, rather dry, mesothermic type of climate prevailed.

KEY WORDS: leaf flora, taxonomy, morphotypes, Upper Cretaceous, vegetation, paleoclimate, West Antarctica

INTRODUCTION

The fossil plants of Antarctica are of particular significance, not only because of their roles in the reconstruction of the geological history of that continent, the development of its plant cover and the changes of climate in past geological epochs, but also in studies on the evolution of the world of plants in the land areas of the southern hemisphere as a whole.

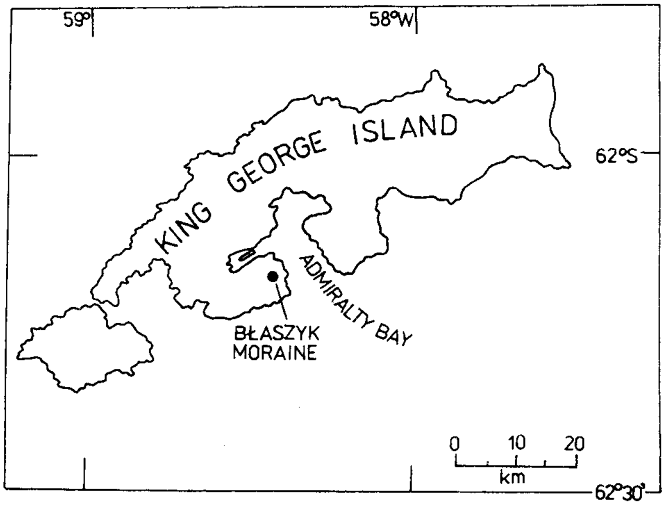


Fig. 1. Situation of the locality with leaf flora of Błaszyk Moraine on King George Island

The Upper Cretaceous fossil flora from the rocks of the Zamek Formation was first investigated by Dutra (1989), who reported the presence of leaf impressions of angiosperms, including leaves of *Nothofagus*, some more termophilous plants, and several pteridophytes. Dutra assigned the taphocoenosis from Zamek to the "paleoflora mixta" type, defined by Romero (1978) for the Tertiary of South America.

The fossil material collected from the rocks of the same formation during the Polish Antarctic Expeditions was considered in publications by Birkenmajer and Zastawniak (1989a, b), which were an attempt to characterize the evolution of the vegetation of West Antarctica from the Upper Cretaceous till the Oligocene, and in a preliminary report published by the present author in 1990.

This paper aims at providing a full descriptive and illustrative documentation of the plant remains from the Błaszyk Moraine (Fig. 1) so that it may be possible in the future to determine their precise taxonomic relationships with fossil plants from the Cretaceous of Antarctica and the neighbouring regions of Gondwana, and with contemporary plants. The present author realizes that identifications of plant impressions, devoid of plant tissue which would make it possible to establish the features of the cuticles, cannot be fully reliable. Nevertheless, they may be of use in stratigraphical correlations and, besides, they can be employed, with certain qualifications, in the palaeofloristic and palaeoclimatic interpretations of the Upper Cretaceous of that region of the Earth.

STUDIES CARRIED OUT SO FAR ON THE CRETACEOUS FLORAS OF THE ANTARCTIC

The first record of plant macrofossils found in Cretaceous rocks of Antarctica appeared at the beginning of this century. They are Gothan's (1908) determinations of fossil wood from Snow Hill Island and Seymour Island (Fig. 2). A small fragment of a foliage shoot of *Podocarpaceae*, identified by Halle (1913) as cf. *Sequoia fastigiata* (Sternb.) Nathorst, also came from Snow Hill Island but Florin (1940) was rather inclined to regard it as *Dacrydium*. The abundant macroscopic flora from Hope Bay, (Fig. 2) described by Halle (1913) and revised recently by Gee (1989), is of Early Cretaceous or Upper Jurassic age. Cretaceous macrofossil floras with palynomorphs are also known from Livingston Island (Hernandez & Azcarate 1971) and President Head on Snow Island (Fuenzalida et al. 1972). They comprise remains of numerous ferns, cycadophytes and conifers. The angiosperm remains found by Jefferson (1980) on Adelaide Island, west of the Antarctic Peninsula (Fig. 2), are probably of Upper Cretaceous age. They consist of several leaf impressions of the *Nothofagus* type, whose outlines are visible in the drawings, and pollen grains of *Angiospermae* which have proved impossible to identify. From Alexander Island (Fig. 2) come Early Cretaceous gymnosperm and leaf flora (Jefferson 1982). These plant remains have not been determined yet as Jefferson (op. cit.) made only an analysis of tree rings in fossil wood, pointing to "rapid growth rates, high climatic sensitivity and seasonality of growth".

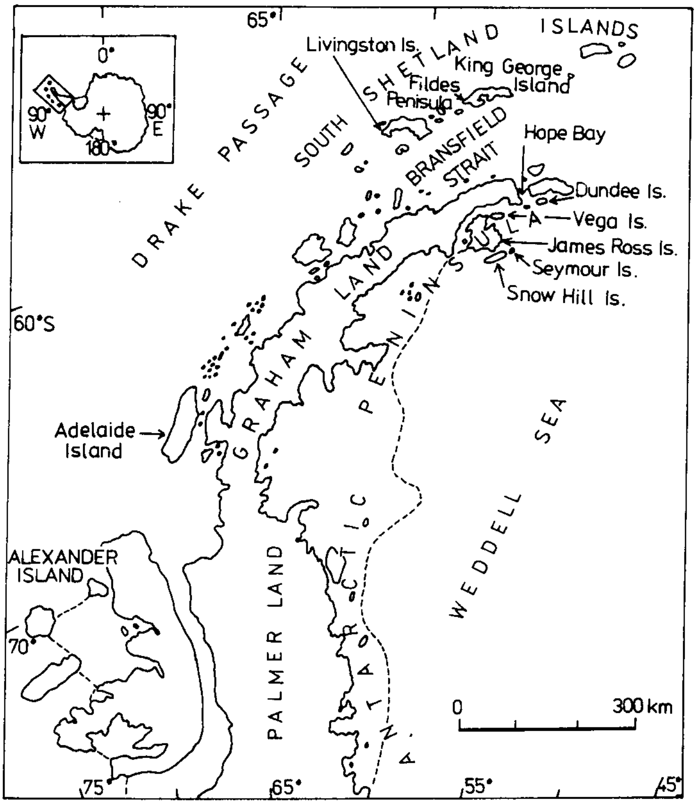


Fig. 2. West Antarctica region showing various localities with Cretaceous fossil floras mentioned in the text (after Birkenmajer & Zastawniak 1986, modified)

Another locality with Cretaceous (Albian-Cenomanian) leaf impressions, fossil wood and sporomorphs is Williams Point on Livingston Island (Fig. 2), South Shetland Islands (Banerji et al. 1987, Lemoigne & Torres 1988, Torres & Lemoigne 1989, Rees & Smellie 1989, Chapman & Smellie 1992). The first and, as yet, only study of plant cuticles involved material of Upper Maastrichtian/Lower Danian age from the Lopez de Bertodano Formation on Seymour Island (Upchurch & Askin 1989).

The last few years have brought further results, with studies on fossil wood from the Cretaceous of Antarctica (e.g. Francis 1986, Lemoigne & Torres 1988, Torres & Lemoigne 1989, Nishida et al. 1989) and much information about fossil sporomorphs from deposits of the same age from various localities in Antarctica (Truswell 1983, 1989, Askin 1988a, b, 1989, 1994, Askin et al. 1991, Baldoni & Medina 1989, Cao 1990, 1992, Dettmann & Hedlund 1988, Dettmann & Jarzen 1988, Dettmann & Thomson 1987).

LOCATION OF FOSSIL FLORA

The locality of the fossil flora under study is situated in Admiralty Bay on King George Island (Fig. 1) in the South Shetland Archipelago (62°15' S and 58°30' W). The study material comes from the Błaszyk Moraine, below Zamek, which separates the Sphinx Glacier from the Baranowski Glacier (see Birkenmajer 1980a, Fig. 3). The geology of this area was studied thoroughly by Birkenmajer (1980b), who in this region distinguished a unit called the Baranowski Glacier Group, the lowest in the stratiform volcanic-sedimentary complex of the King George Island Supergroup. This group includes two units, the older Llano Point Formation and the younger Zamek Formation "composed of basaltic and andesitic lava flows and thin intercalations of tuffaceous sediments – sandstones and fine conglomerates" (Birkenmajer 1980b, Fig. 7 F). The rock fragments with leaf impressions and silicified wood come from the tuff horizon. They were found on the Błaszyk Moraine (Birkenmajer 1980b) and in the region of Sphinx Hill (Błaszyk & Gaździcki 1980).

AGE

The age of the deposits of the Baranowski Glacier Group has been determined by the dates K-Ar (Birkenmajer et al. 1983). The older basal basaltic andesite lava flow of the Llano Formation 77 ± 4 Ma (Santonian-Campanian) and the more recent basaltic andesite lavas of the succeeding Arctowski Cove Formation (Rakusa Point Member) from 66.7 ± 1.5 Ma (Maastrichtian).

MATERIAL AND METHOD

The objects of the present study are leaf impressions preserved on 102 rock fragments. Several of these were collected by Prof. K. Birkenmajer in March 1978 (KRAM-P Nr 173/12–16), the remainder coming from material gathered during the 3rd Polish Antarctic Expedition in 1978/79 by Dr J. Błaszyk and Assist. Prof. A. Gaździcki (Nr 1–97 ZPAL). This collection from the Institute of Palaeobiology, PAScs, in Warsaw, was borrowed for study by the W. Szafer Institute of Botany, PAScs, in Cracow.

The whole material contains 106 impressions of plant remains which are visible on fragments of greenish – yellow, and brown tuff-sandstones and conglomerates, mainly as reddish-brown impressions. Some of the impressions (Specimen Nos. KRAM-P 173/15, ZPAL 21/1, 33, 37, 44/1, 2, 58, 68/1, 74, 80, 81, 96) represent very small fragments of plants of which it can only be said that they belonged to Kingdom Plantae. Leaf margins are not, generally, preserved in the impressions except for a few cases in which they can be seen over a short length. This poor state of preservation does not permit a fairly precise characterization of all forms occurring in the flora of the Zamek Formation and makes their comparison with plant taxa from other localities of fossil floras and with contemporary plants difficult or quite impossible. Nevertheless, an attempt was undertaken to describe them and produce their documentation, because the data about the Cretaceous macrofossils of that region of the Earth are still relatively scanty.

Hickey's (1984) method, using the architectural complexes of angiosperm leaves for early angiosperm leaf fossils, was adopted for classifying the fossil materials. The informal descriptive terms of "morphotypes" enable us to combine forms with similar morphologies, avoiding faulty or inexact references to modern plant taxa. The names of morphotypes used in this paper are those applied by Crabtree (1987) in his descriptions of the Cretaceous *Angiospermae* of the northern Rocky Mountains, with the addition of several new designations.

Leaf outlines and venation were traced on transparent plastic paper using a Carl Zeiss Jena stereomicroscope SM-XX and the enlargements were drawn with a drawing apparatus attached to a Technival Carl Zeiss Jena stereomicroscope. Hickey's (1973, 1979) terminology was used in leaf descriptions.

The fossil materials are housed in the W. Szafer Institute of Botany, PAScs, in Cracow (KRAM-P) and the Warsaw collection (ZPAL) in the Institute of Palaeobiology, PAScs, in Warsaw.

Comparative materials were derived from the herbaria of the W. Szafer Institute of Botany, PAScs, (KRAM) and the Institute of Botany, Jagiellonian University (KRA).

SYSTEMATIC PART[1]

PTERIDOPHYTA
Filicales

?*Pecopteris* Brongniart, 1835
? *Pecopteris* sp.
Fig. 3

Material. Specimen No. ZPAL 85.

Description. Fragment of bipinnate or tripinnate frond; part of rachis with four diverging subrachides (or costae) bearing obliquely disposed pinnules. The shape, margins, and exact dimensions of pinnules are not known, the length of the lowest ones being about 5 mm. They were probably sessile and not joined together. A vein departing from the costa at an angle of 40° is marked in the middle.

[1] Taxonomic units after Taylor & Taylor 1993

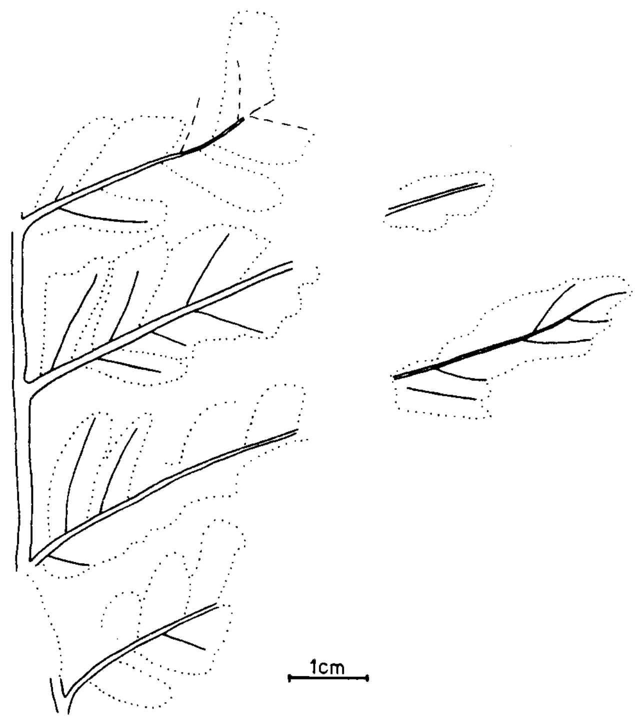


Fig. 3. ?*Pecopteris* sp. Specimen No. ZPAL 85

R e m a r k s. Similar forms of fern fronds occur especially in the family *Cyatheaceae* (Schimper & Schenk 1890)

Osmundaceae
Cladophlebis Brongniart, 1849
Cladophlebis sp.
Pl. 1 fig. 1; Fig. 4

M a t e r i a l. Specimen No. KRAM-P 173/13.
D e s c r i p t i o n. Fragment of pinnate frond. Rachis stout, pinnules distichously arranged; attachment adnate, alternate. Pinnules falcate, ca 4.5 mm wide at the base, at least 15 mm long. Apex unpreserved, margins most probably entire. The single vein of a pinnule diverges from the rachis at about 60^{0}; midvein slightly curved, secondary veins invisible.
R e m a r k s. The "cladophleboid" type of sterile foliage of ferns, very common in Mesozoic floras of the world, was reported in the Late Jurassic/Early Cretaceous flora from Hope Bay in Antarctica (Halle 1913, Gee 1989). This type of sterile fern foliage was produced by osmundaceous ferns (Taylor & Taylor 1993).

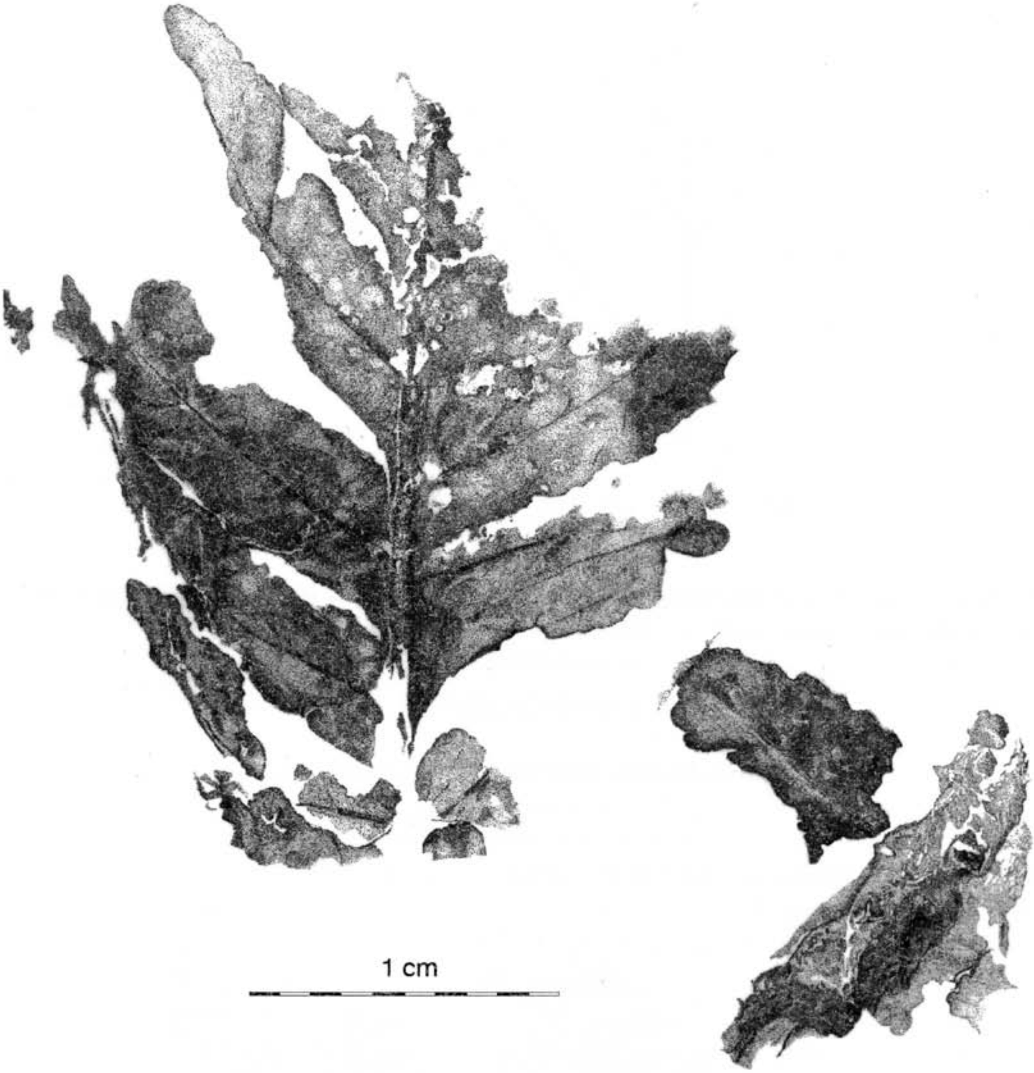


Fig. 4. *Cladophlebis* sp.. Specimen No. KRAM-P 173/13, drawing by J. Wieser

Family: unknown

Filicales gen. et sp. indet.
Pl. 1 fig. 7; Fig. 5

Material. Specimen No. ZPAL 75.
Description. Fragment of a large, probably pinnatifid frond, at least 10 cm wide, with large lobes. Margin indefinable.

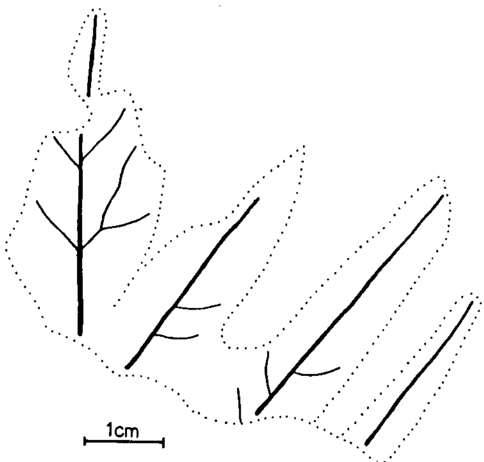


Fig. 5. *Filicales*, gen. et sp. indet. Specimen No. ZPAL 75

Remarks. A close determination is impossible because of the poor state of preservation of the impression.

CONIFEROPHYTA

Araucaria Jussieu 1789 vel family *Podocarpaceae*

Pl. 4 fig. 2; Fig. 6

Material. Specimen No. KRAM-P 173/12.

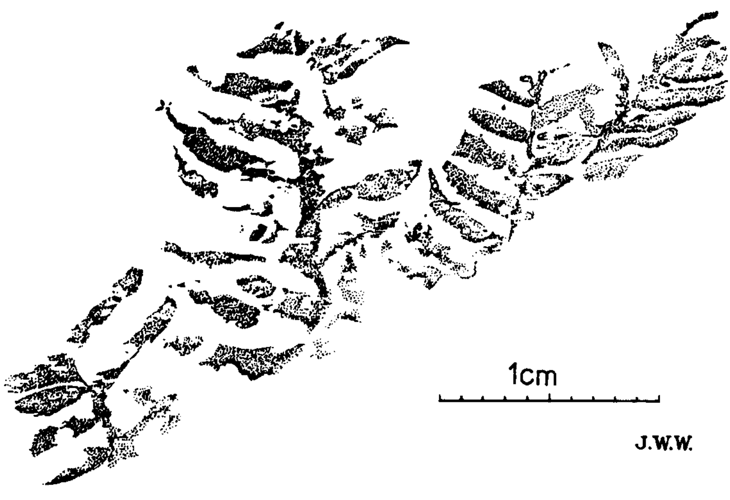


Fig. 6. *Coniferophyta*, *Araucaria* vel *Podocarpaceae*. Specimen No. KRAM-P 173/12, drawing by J. Wieser

D e s c r i p t i o n. Five fragments of coniferous shoots, 1.5 cm long and 15 mm broad, preserved on a piece of rock. Leaves disposed helically at 60–90° on the axis, somewaht decurrent, ca 10 mm long and 1 mm thick, slightly awl-shaped. Attachment adnate, decurrent.
R e m a r k s. Similar leaf shoots occur in the genus *Araucaria* and in some members of the *Podocarpaceae*, in particular in the genera *Dacrycarpus* (Endl.) de Laubenfels and *Retrophyllum* C. N. Page. The taxonomic status of remains of this type is impossible to determine without cuticular analysis. All these groups of conifers are equally abundant in the Upper Cretaceous of West Antarctica (Truswell 1983, Dettmann & Thomson 1987, Askin 1988a, b).

MAGNOLIOPHYTA
Magnoliopsida
Magnoliidae

Magnoliaephyll morphotype

Leaves simple, ovate to elliptical. Margin entire or 2- or 3-lobed. Primary venation pinnate in entire forms, with 3 primary veins from base in lobed forms. Secondary venation brochidodromous or festooned brochidodromous. Higher order venation variable (Crabtree 1987, p. 725).

Magnoliidaephyllum gen. nov.

T y p e s p e c i e s. *Magnoliidaephyllum birkenmajeri* sp. nov.
D e r i v a t i o n o m i n i s. From subclass *Magnoliidae.*
D i a g n o s i s. Leaves simple, with very distinct veins, venation pinnate, brochidodromus, tertiary veins numerous, thick ± parallel, mostly perpendicular to midvein, rarely oblique. Texture thick.

Magnoliidaephyllum birkenmajeri gen. et sp. nov.

Pl. 2 fig. 1, I, II, figs 2, 3a, b, 4; Fig. 7, Fig. 8: 1, 2

H o l o t y p u s. Specimen No. ZPAL 73/1, Pl. 2, fig. 1; Fig. 7: 1; Institute of Palaeobiology PAScs, Żwirki and Wigury Street 93, 02–089 Warsaw, Poland.
L o c u s t y p i c u s. Błaszyk Moraine, Admiralty Bay, King George Island, South Shetland Islands, West Antarctica.
S t r a t u m t y p i c u m. Zamek Formation, The Baranowski Glacier Group; tuff sandstones.
A g e. Between 77 ± 4 Ma (Santonian-Campanian) and 66.7 ± 1.5 Ma (Maastrichtian).
D e r i v a t i o n o m i n i s. In honour of Prof. Krzysztof Birkenmajer, leading Polish geologist, initiator of Polish palaeobotanical researches on King George Island and gatherer of many fossil remains.

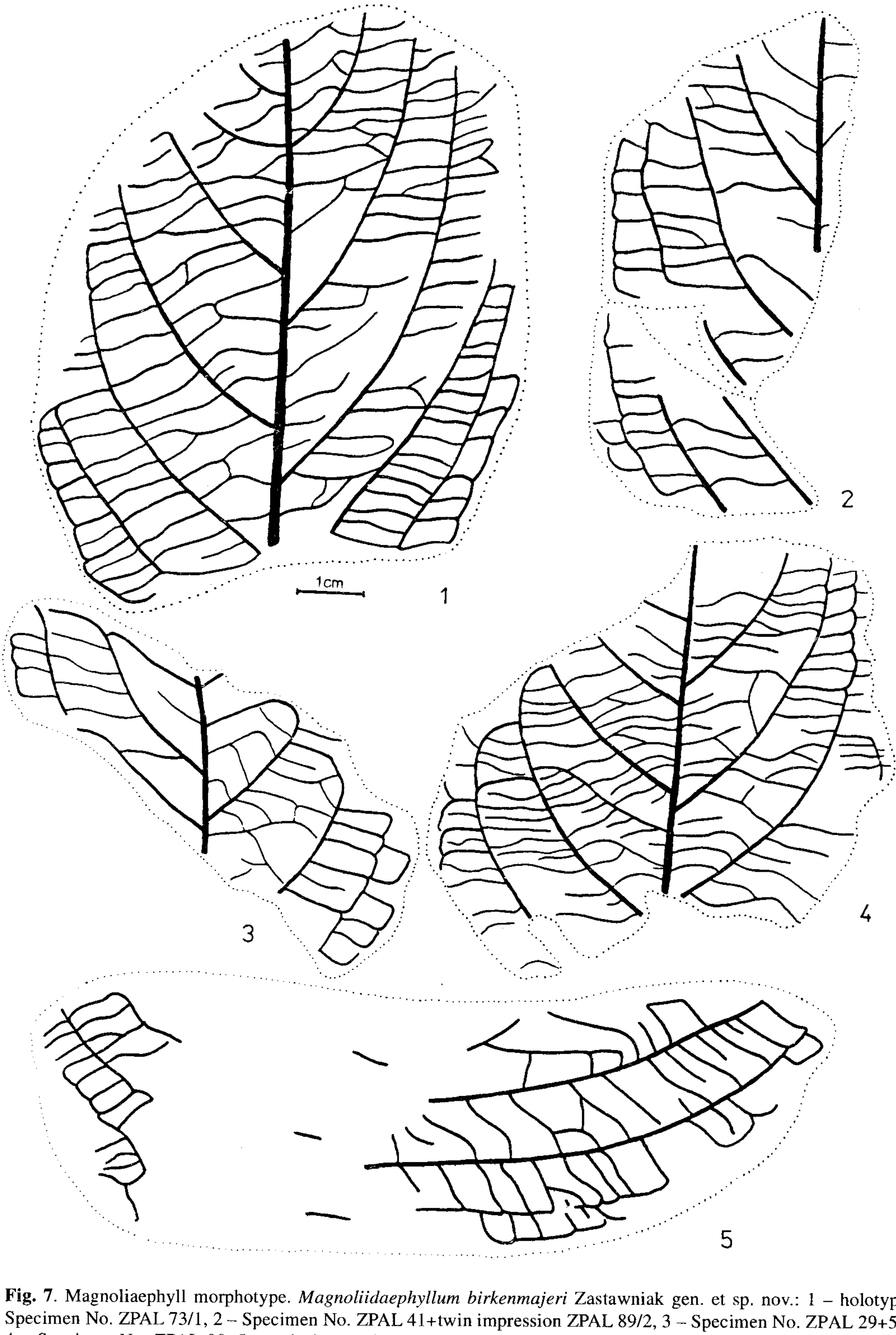


Fig. 7. Magnoliaephyll morphotype. *Magnoliidaephyllum birkenmajeri* Zastawniak gen. et sp. nov.: 1 – holotype, Specimen No. ZPAL 73/1, 2 – Specimen No. ZPAL 41+twin impression ZPAL 89/2, 3 – Specimen No. ZPAL 29+59, 4 – Specimen No. ZPAL 90+5 + twin impression ZPAL 64+28, 5 – Specimen No ZPAL 30

D i a g n o s i s. As above for the new genus.
B o t a n i c a l   a f f i n i t y: subclass *Magnoliidae.*
M a t e r i a l. Specimens No. ZPAL 5/1, 11, 29 (twin impression No. 59), 30, 32, 41+89/2, 43, 45, 48, 64/2, 73/1, 2, 73/4, 90/2, 90/3. 5/2 + 90/1 (twin impression No. 28 + 64/1), 91/2, 95/1 (twin impression No. 97/2); 4 large and 16 small leaf fragments.
D e s c r i p t i o n. Leaves up to 14 cm in length and 7.9 cm in breadth, probably elliptic or ovate in shape. Leaf margin damaged, shape of base and apex unknown. Venation pinnate, brochidodromous; primary vein stout and straigth. Secondary veins are thick, their angles of divergence moderately acute with courses uniformly curved; they join the superadjacent veins at an approximate right angle, enclosed by arches of the next order. Intersecondary veins composite. Tertiary veins thick, given off by secondaries at right angles on the admedial side and at acute angles on the exmedial side. They are percurrent, their course simple and generally straight, rarely forked and sinuous. They are for the most part perpendicular, seldom oblique to the midvein.
R e m a r k s. Leaves with venation of this type occur today mainly in plants of the subclass *Magnoliidae* (Mounton 1970, Hickey & Wolfe 1975). This taxon is particularly characterized by its festooned brochidodromous venation, that is, such that a set of secondary loops occurs outside the main brochidodromous arch. It is worth mentioning that, while studying the dispersed cuticles from the Upper Maastrichtian of Seymour Island, Upchurch and Askin (1989) found some cuticles bearing typical characters of plants from the subclass *Magnoliidae* among them.

Such leaves of appreciable size, leathery, and with brochidodromous venation, are typical of plants growing in subtropical and tropical climates at present.

Nowadays woody *Magnoliidae* occur as subcanopy trees and shrubs in highly mesic subtropical and montane tropical environments (Hickey & Doyle 1977).

Dicotylophyllum sp. 1
Pl. 1 fig. 2, I; Fig. 8: 3

M a t e r i a l. Specimen No. ZPAL 49/1; 1 fragment of leaf.
D e s c r i p t i o n. Leaf about 10 cm long and 4.5 cm broad, probably elliptic in shape. Texture coriaceous. Venation pinnate, brochidodromous. From the midrib about 9 pairs of lateral veins diverge at an angle of 40–50^{o}. They are pronounced and slightly arcuately bent. Intersecondary veins are present.
R e m a r k s. This leaf differs from those of *Magnoliidaephyllum birkenmajeri* in the course of the lateral veins and the lack of distinct venation of the third order.

Laurophyll morphotype

Leaves simple, ovate to elliptical, notophyllous, margin entire. Primary venation pinnate, secondary venation camptodromous or brochidodromous. Without prominent basal or superbasal secondary veins.

All these leaves are notophyllous. Leaves of this type are characteristic not only for

Lauraceae, but occur in various other plant families. Their identification on morphological characters alone, without studies of their epidermal structures, is impossible (among others Hill 1986).

In studies on the Tertiary floras of the northern hemisphere the names used for the laurophyll morphotype leaves were determined by according to the arrangement of lateral veins. *Laurophyllum* Goeppert possessed pinnate secondary veins (Kräusel & Weyland 1950, Wolfe 1977, Hill 1986) and *Cinnamomophyllum* Kräusel et Weyland had acrodromous venation. Dusén (1908) described a leaf fragment as *Lauriphyllum nordenskjeldii* Dus. from the fossil flora of Seymour Island. According to his description, the leaf was leathery, with entire margins, its shape and venation being analogous to those found in many other members of the *Lauraceae*, but – as Dusén (1908) emphasized – under subtropical and tropical conditions there are many genera from other families with similar leaves. It is hard to ascertain whether the same taxon occurs in the material from the Zamek Formation, for the specimen from Seymour Island consists of only half of the basal part of the leaf, showing only a fragment with 3 lateral veins, while the venation of the third order is not visible.

In addition to the leaves of the above-mentioned *Lauriphyllum nordenskjeldii* Dus. from Seymour Island (Dusén 1908), the following finds of the laurophyll morphotype have been reported from West Antarctica so far:

– Fildes Peninsula (Ardley Peninsula vel Island): *Nectandra prolifica* Berry, Orlando 1963, 1964 (without illustrations)

– Ezcurra Inlet or Dufayel Island or Fildes Peninsula: Dicotyledonous leaf, Barton 1964, fig. 2, h

– Barton Peninsula: *Ocotea menendezi* Hunicken, *Nectandra prolifica* Berry, Del Valle et al. 1984 (without illustrations)

– Dufayel Island: dicotyledonous leaves of "*Laurophyllum* type", Birkenmajer & Zastawniak 1986, Fig. 6: 1, 2, 4, 6, 7, 9, 14, 17; Fig. 7: 8, 9; Pl. 1, fig. 3, pl. 2, fig. 6

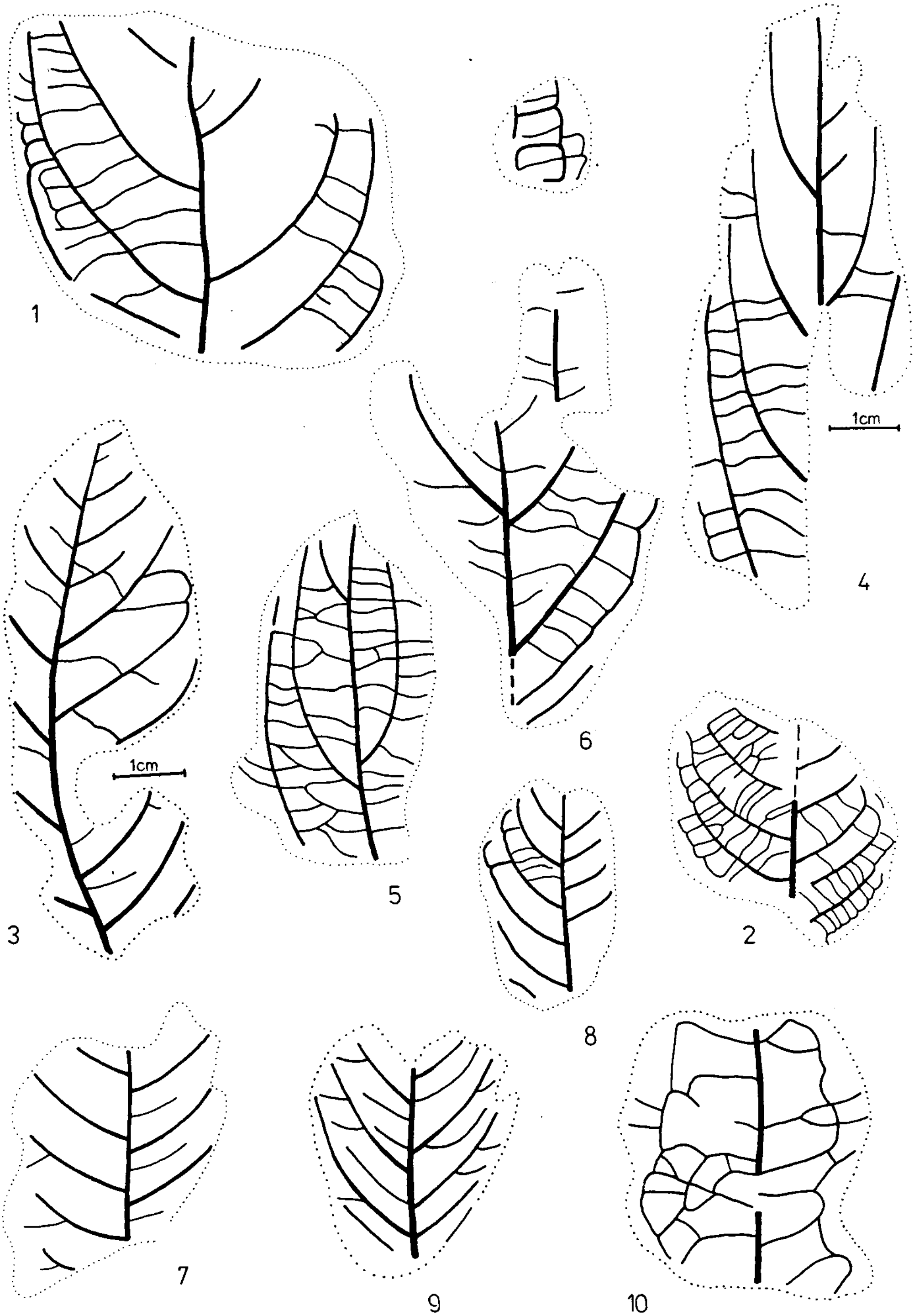
– Fildes Peninsula: *Hydrangeiphyllum affine* Dusén, Czajkowski & Rösler 1986, fig. 16

– Fildes Peninsula: *Sapindus* sp., Troncoso 1986, pl. 1, fig. 10, pl. 3, fig. 24

– Barton Peninsula: dicotyledonous leaves of uncertain affinity, Tokarski et al. 1987, fig. 8 f-h.

Among the Upper Cretaceous plant remains from Seymour Island, Upchurch and Askin (1989) found cuticles with features characteristic of the *Lauraceae*, whereas *Laurinoxylon* sp. from Seymour Island, identified by Gothan (1908) on the basis of wood, seems to be synonymous with *Nothofagoxylon ohzuanum* M. Nishida, H. Nishida

Fig. 8. Magnoliaephyll morphotype: *Magnoliidaephyllum birkenmajeri* Zastawniak gen. et sp. nov.: 1 – Specimen No. ZPAL 95/1 + twin impression ZPAL 97/2, 2 – Specimen No. ZPAL 11; 3 – *Dicotylophyllum* sp. 1, Specimen No. ZPAL 49/1. Laurophyll morphotype: 4 – *Dicotylophyllum* sp. 2, Specimen No. ZPAL 77 + twin impression ZPAL 78, 5 – *Dicotylophyllum* sp. 2, Specimen No 82/1 + twin impresssion ZPAL 89/1, 6 – *Dicotylophyllum* sp. 3, Specimen No ZPAL 63 + twin impression 3/1. Indefinite morphotypes: 7 – *Dicotylophyllum* sp. 7, Specimen No. ZPAL 26, 8 – *Dicotylophyllum* sp. 8, Specimen No. ZPAL 97/3 + twin impression 95/3, 9 – *Dicotylophyllum* sp. 10, Specimen No. 19 + twin impression ZPAL 50, 10 – *Dicotylophyllum* sp. 11, Specimen No ZPAL 83/2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et Nasa (Nishida et al. 1988); similarly, fossil wood of *Laurinoxylon uniseratum* Gothan from the same locality, according to M. Nishida, H. Nishida and Ohsawa (1988), bears characteristic features of *Nothofagus*.

Leaves of the laurophyll morphotypes, for which various generic and specific names are used and which are included in various families, are known from many papers on fossil floras of South America, Australia, Tasmania and New Zealand, especially those of Upper Cretaceous and Palaeogene age (e.g. Engelhardt 1891, 1895, Ettingshausen 1883, 1887a, b, 1895, Berry 1920, 1928, 1937a, b, Romero & Arguijo 1981, Hill 1986, Troncoso 1991) and Miocene age (e.g. Holden 1982). These point to very favourable conditions, comparable to those noted in warm regions today.

Dicotylophyllum sp. 2

Pl. 4 fig. 1; Fig. 8: 4, 5

Material. Specimen Nos. ZPAL 77 (twin impression 78), 89/1 (twin impression 82/1), 95/2 (twin impression 97); 3 leaf fragments.

Description. Leaves probably narrowly elliptic, reaching about 12 cm in length and about 3.5 cm in breadth. Base and apex are not known and neither is the margin of the leaves. Texture coriaceous. Venation pinnate, camptodromous. Primary vein stout, secondaries thick, about 5 pairs in number, arising from the midvein at an acute angle (about 40^{o}), strongly and uniformly curved. Tertiary veins thick, percurrent, their course simple, straight or slightly sinuous, rarely forked, approximately perpendicular to the midvein.

Remarks. Leaf remains with a similar characteristic venation are given as *Nectandrophyllum beta* (Engelhardt 1891, Pl. 3, Fig. 3) from several localities of the Tertiary floras of South America, for example, from the Palaeogene flora of Coronel (Chile) and as *Nectandra curvatifolia* Engelhardt (Engelhardt 1895, Pl. 9, fig. 3) and *Laurophyllum rigidum* Engelhardt (Engelhardt 1895, Pl. 8, Fig. 5) from the region of Santa Ana in Columbia. Leaves classified as *Nectandra prolifica* Berry from the Eocene of Rio Pichileufu (Berry 1938) are also rather similar. However Berry himself regarded their generic determination as unreliable.

A comparison of the specimens from the Błaszyk Moraine with the leaves described as *Nectandra prolifica* Berry from the fossil floras of King George Island, namely Fildes Peninsula (Orlando 1963, 1964) and Barton Peninsula (Del Valle 1984) is impossible because of the lack of illustrations.

Dicotylophyllum sp. 3

Pl. 3 fig. 1; Fig. 8: 6

Material. Specimen Nos. ZPAL 1, 3/1 (twin impression 63); 2 fragments of leaves.

Description. Fragments of nothophyllous leaves, probably elliptic in shape, venation brochidodromous; texture thick. Secondary veins given off by the midrib at acute angles (about 40^{o}) at rather extended intervals. They are strongly arcuately bent and,

with the veins of the third order, form distinct, rectangular loops close to the leaf margin. Tertiary veins are perpendicular to the main vein. Intersecondary veins are present.
Remarks. The leaves of this type differ from the *Dicotylophyllum* sp. 2 brochidodromous type of venation.

Fagales

Protophyll morphotype

Leaves simple, margin entire to dentate, occasionally lobed. Venation pinnate, craspedodromous, the basal secondaries sometimes considerably strengthened and bearing pectinals (Crabtree 1987, p. 721).

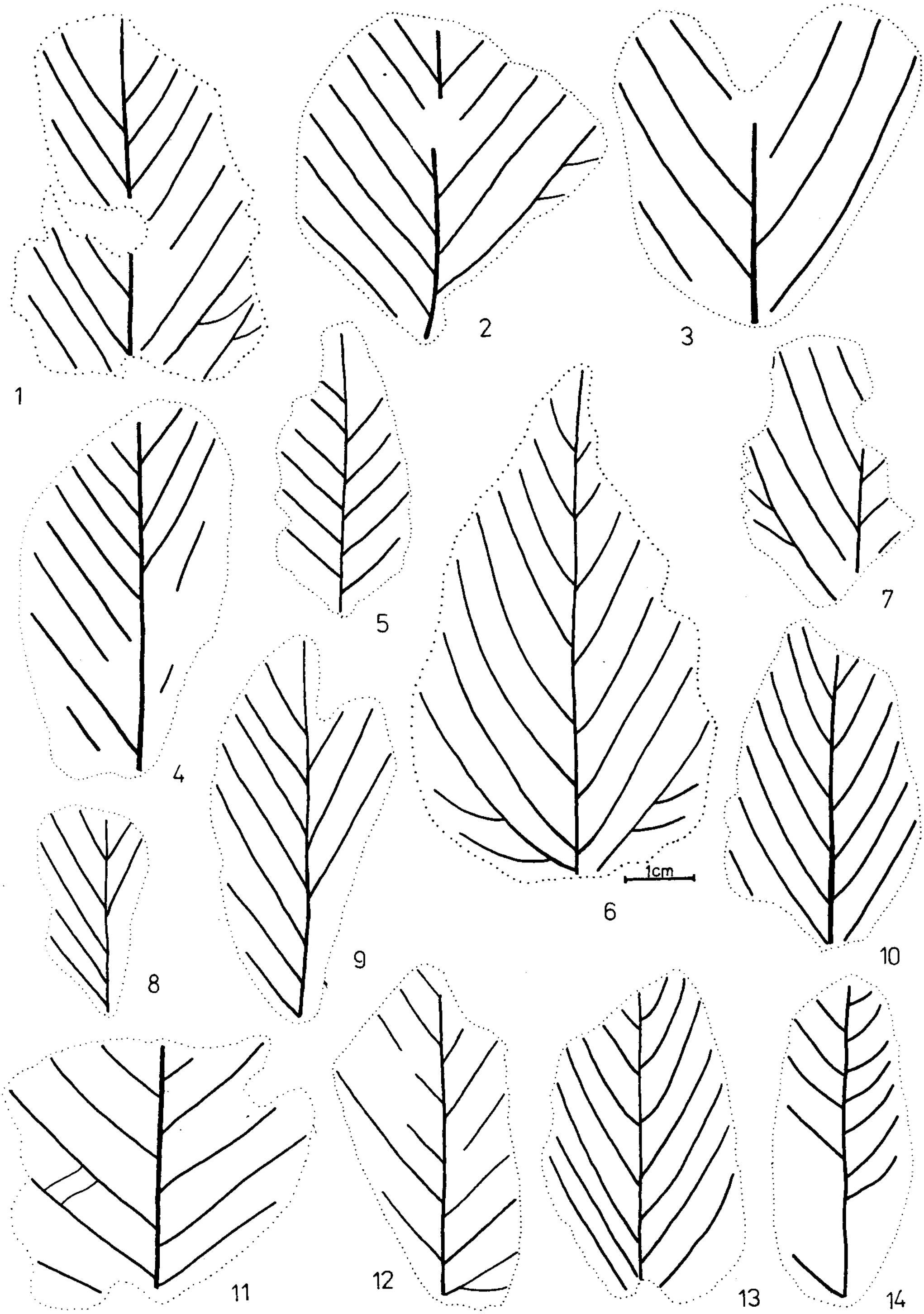
Nothofagaceae

Nothofagus Blume 1850
***Nothofagus cretacea* sp. nov.**
Pl. 1 fig. 5, Pl. 3 figs 2–6; Fig. 9: 1, 2, 4–13

Holotypus. Specimen No. ZPAL 70; Pl. 3, fig. 2; Fig. 9: 6; Institute of Palaeobiology, Polish Academy of Sciences, Żwirki and Wigury Street 93, 02–089 Warsaw, Poland.
Locus typicus. Błaszyk Moraine, Admiralty Bay, King George Island, South Shetland Islands, West Antarctica
Stratum typicum. Zamek Formation, tuff sandstones
Age. Between 77 ± 4 Ma (Santonian-Campanian) and 66.7 ± 1.5 (Maastrichtian)
Derivatio nominis. After the Cretaceous age of this flora
Botanical affinity. *Nothofagus* subgenus *Fuscospora* Hill et Read 1991 or subgenus *Menciespora* Hill et Read 1991
Diagnosis. Leaves ovate or elliptic, comparatively large or medium-sized, venation pinnate, simply craspedodromous. Secondary veins subopposite, straight or admedially curved, running parallel rather regularly and provided with outer secondary veins, which are slightly curved.

= *Nothofagus subferruginea* (Dusén) Tanai (Birkenmajer & Zastawniak 1989a, Fig. 3: 2; Birkenmajer & Zastawniak 1989b, Pl. 1, Fig. 3, 4
= *Nothofagus* sp. aff. *N. lendenfeldi* (Ett.) Oliver (Dutra 1989, Pl. 3, Fig. 1, 3b)
= *Nothofagus* sp. aff. *N. ulmifolia* (Ett.) Oliver (Dutra 1989, Pl. 3, Fig. 2)
= *Nothofagus* sp. aff. *N. subferruginea* (Dusén) Tanai (Dutra 1989, Pl. 3, Fig. 4)
= *Nothofagus* sp. (Dutra 1989, Pl. 4, Fig. 3)

Material. Specimen Nos. ZPAL 17, 38, 40, 51, 66, 70, 84, 86, 93/1, 2, 3, 94/1, 94/2; 2 impressions of almost whole leaves and 11 leaf fragments.
Description. Leaves 4.5 – 7.7 × 2.2 – 4.7 cm, ovate or elliptic, tapering towards the apex. Leaf base unpreserved, margins damaged. Texture most probably thin. Venation pinnate, simply craspedodromous, midvein of moderate size, secondary veins subopposite, straight or slightly admedially curved, running parallel fairly regularly; they arise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from the midrib at an angle of 30–40^{o} in the middle part of the leaf. The lateral veins are provided with slightly curved outer secondary veins.
Remarks. The features of the leaf specimens, notably the characteristic parallel and comparatively regular second order venation enable us to recognise them as *Nothofagus* leaves. Morphologically the newly described species most closely resebmles *N. subferruginea* (Dusén) Tanai, occurring in the Tertiary of the southern part of South America (Tanai 1986) and in West Antarctica (Seymour Island, as *Fagus obscura* Dusén, Dusén 1908, Tanai 1986; King George Island, Zastawniak 1981, Zastawniak et al. 1985: as *N. ulmifolia* (Ett.) Oliver, *N.* aff. *alessandri* Espinosa; Tanai 1986). In Tanai's opinion, there was also a closely related species in the Upper Miocene of New Zealand.

Problems connected with the history of the genus *Nothofagus* have been of interest to phytogeographers and palaeobotanists for years and recently have been discussed by Jones 1986, Tanai 1986, Romero 1986, Hill 1991 and Hill & Jordan 1993. In the land area of southern Gondwana there is only one Cretaceous site apart from West Antarctica with macrofossils of this genus, namely, northern Chile where wood of *Nothofagoxylon pichasequensis* occurs in the Upper Cretaceous (Torres & Rallo 1981). On the other hand, there are numerous palynological data, starting from localities as old as Middle Cretaceous ones (Truswell 1983, Romero 1986, Tanai 1986, Dettmann & Thomson 1987, Dettmann et al. 1990, Askin 1988a, b).

Nothofagus sp. (div. ?)
Fig. 9: 3, 14

Material. Specimen Nos. ZPAL 13, 18, 24/1, 2, 25, 27, 36/1–4, 39/1, 2, 46/1, 2, 57, 69, 88/1, 2, 91/1, 92/1–3; 22 leaf fragments.
Description. Leaf fragments with pinnate venation; lateral veins with a characteristic, regular, generally parallel course. Several fragments of rather large leaves reach 6.5 cm in length and 4.5 cm in breadth. Most specimens have, however, leaves of medium size, judging from the course of the lateral veins. In one case the slightly sinuate midvein can be seen in the upper part of the leaf. The straight or somewhat arcuately bent secondary veins run more or less parallel towards the leaf margins.
Remarks. Most (all?) specimens may have belonged to the above-described species *Nothofagus cretacea* sp. nov., but the preserved leaf fragments are too incomplete to be certain.

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Fig. 9. Protophyll morphotype: *Nothofagus cretacea* Zastawniak sp. nov., 1 – Specimen No. ZPAL 94/1, 2 – Specimen No. ZPAL 84, 4 – Specimen No. ZPAL 93/2, 5 – Specimen No. ZPAL 40, 6 – Holotype, Specien No. ZPAL 70, 7 – Specimen No. ZPAL 94/2, 8 – Specimen No. ZPAL 93/3, 9 – Specimen No. ZPAL 93/1, 10 – Specimen No. ZPAL 66, 11 – Specimen No. ZPAL 38, 12 – Specimen No. ZPAL 17, 13 – Specimen No. ZPAL 86/1; *Nothofagus* sp., 3 – Specimen No. ZPAL 27, 14 – Specimen No. ZPAL 92/1

Dilleniidae

Pentalobaphyll (Araliaephyll) morphotype

Leaves simple, orbicular, 3–5-lobed. Margin entire. Base ± cuneate. Primary venation palinactinodromous, with 3 primary veins diverging from the top of the petiole, and 2 subprimary veins branching from the lateral primaries just above their bases. Secondary venation eucamptodromous, rather weakly developed. Tertiary venation reticulate to transverse (Crabtree 1987, p. 715).

Dicotylophyllum sp. 4
Pl. 1 fig. 2, II, Pl. 4 fig. 8; Fig. 10: 1

= ? *Sterculia washbruni* Berry, non vidi (Dutra 1989, Pl. 4, Fig. 4)

Material. Specimen Nos. ZPAL 49/2, 72; 2 leaf fragments.

Description. Poorly preserved fragments of the basal parts of two medium-sized (notophyllous) leaves. Shape unknown, venation palinoactinodromous, with 3 radial primary veins and 2 subprimaries, most probably branching off from the lateral primary veins above the base. One specimen shows some tertiary veins with curved loops on the exmedial side of the primary vein.

Remarks. Leaf remains with actinodromous (palinactinodromous) venation are known from the Tertiary of King George Island (Zastawniak et al. 1985, Birkenmajer & Zastawniak 1986, 1989). The leaves from the Błaszyk Moraine are too fragmentary to be compared with the leaves of fossil or recent taxa. However, they do not seem to have anything in common with the leaves known under the name of *Dicotylophyllum latitrilobatum* Zastawniak (Birkenmajer & Zastawniak 1989) vel *Sterculia* (e.g. Berry 1928, 1938, Czajkowski & Rösler 1986).

In Hickey and Wolfe' s (1975) classification, leaves of this type occur in the subclass *Dilleniidae*, *Palmate Dilleniidae* group.

Acrodromophyll morphotype

Leaves notophyllous, two or more primary or strongly developed secondary veins running in convergent arches toward the leaf apex.

Dicotylophyllum sp. 5
Pl. 1 fig. 3; Fig. 10: 5

Material. Specimen No. ZPAL 97/1 (twin impression 95/4); 1 leaf fragment.

Description. The whole leaf was about 9 cm long. Venation was probably perfectly acrodromous (the acrodromous veins were well developed, running at least two-thirds of the distance to the leaf apex, cf. Hickey 1979). Two lateral veins ran in convergent arches towards the apex on either side of the midvein. Apex, base and margin are un-

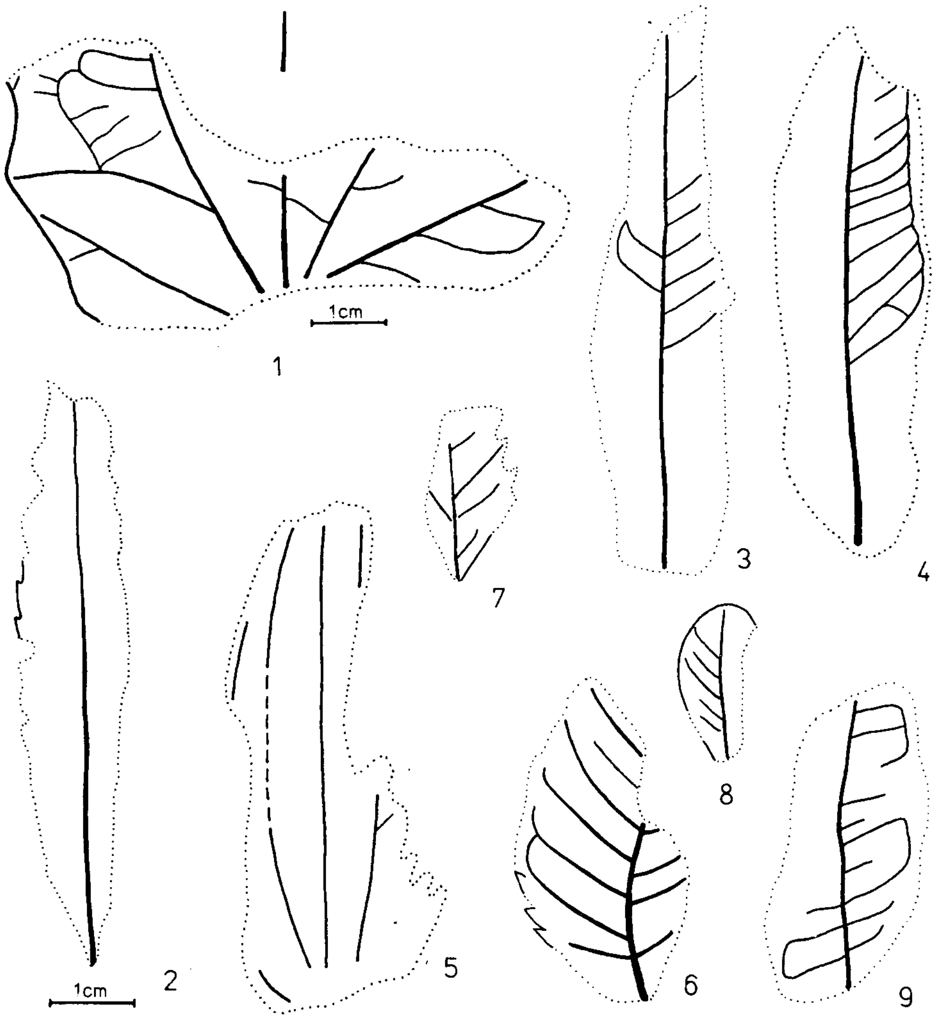

Fig. 10. Pentalobaphyll (Araliaephyll) morphotype: 1 – *Dicotylophyllum* sp. 4, Specimen No. ZPAL 49/2; Cunoniophyll morphotype: 2 – *Dicotylophyllum* sp. 6, Specimen No. ZPAL 87; Myrtophyll morphotype: *Myrciophyllum santacrucenziz* (Berry) Zastawniak gen. nov., 3 – Specimen No. ZPAL 82/2, 4 – Specimen No ZPAL 47; Acrodromophyll morphotype: 5 – *Dicotylophyllum* sp. 5, Specimen No. ZPAL 97/1; Indefinite morphotypes: 6 – *Dicotylophyllum* gen. et sp. indet., Specimen No. ZPAL 83/1; 7 – *Dicotylophyllum* sp. indet., Specimen No. 3/3; 8 – *Dicotylophyllum* sp. 9, Specimen No. ZPAL 3/2 + twin impression ZPAL 4, 9 – *Phyllites* sp., Specimen No. ZPAL 37, 8 – Specimen No. ZPAL 3/3. All except 2 natural size.

known. The lower part of the leaf may have been slightly asymmetrical. The third order venation was not visible.

Remarks. Leaf remains with acrodromous venation are known from the Tertiary of West Antarctica. They are mainly impressions of *Pentaneuron duseni* (Zastawniak) Li (= *Dicotylophyllum duseni* Zastawniak) from the Eocene of the Fildes Peninsula, King

George Island (Birkenmajer & Zastawniak 1989a, mentioned as *Miconiiphyllum australe* Dusén by Czajkowski & Rösler 1986[2].

The fossil leaves with characteristic acrodromous venation, found in the fossil floras of the southern hemisphere, were most frequently included in the family *Melastomataceae*. Hollick and Berry (1924) found fossil leaves of the contemporaneous genus *Miconia* in the Tertiary of Brazil, which in fact have the venation characteristic of the leaves of the *Melastomataceae* (especially the arrangement of the tertiary veins and broad arches of the lateral primaries, cf. Klucking 1989). In the Tertiary of Equador Berry (1945) came across a rather badly preserved leaf, which he named *Melastomites* sp. From the Pliocene of Brazil (Fonseca) come the leaves of two fossil *Tibouchina*, a genus contemporaneous within the *Melastomataceae* (Duarte 1956). Leaf remains with acrodromous venation are also known from the Tertiary of Australia and New Zealand. Ettingshausen (1887a, b) described them as *Cinnamomum* (*Lauraceae*).

There is a fossil taxon whose description and drawing correspond closely with *Dicotylophyllum* sp. 5 from the flora of the Błaszyk Moraine, namely *Menispermites piatnizkyi* Berry from the Upper Cretaceous flora of Cerro Bahuales in Patagonia (Berry 1937a). It is represented by remains of leaves, more or less asymmetrical, with acrodromous venation and 4–5 primary veins. In Berry's opinion, these leaves belong to an indeterminable genus of the *Menispermaceae*. Since, in our specimen, the third order venation characteristic of the form-genus *Menispermites* Lesq., is not visible, it has been in general named *Dicotylophyllum* sp. 5. It is not possible at the present stage of study to indicate a modern counterpart of this fossil taxon. Leaves with acrodromous venation occur in many families of present day plants, including not only the *Menispermaceae*, *Melastomataceae* and *Lauraceae* but also the *Epacridaceae*, *Proteaceae*, *Piperaceae*, *Rhamnaceae* and *Myrtaceae* and, in the monocotyledons, the genus *Smilax* (*Smilacaceae*).

Rosidae

Myrtophyll morphotype

Leaves of lorate shape, venation pinnate, brochidodromous, secondary veins numerous, forming a distinct, intramarginal vein (cf. myrtophyll type, Hickey 1984).

Myrtaceae

Myrciophyllum santacruzensis **(Berry) Zastawniak gen. nov.**

Pl. 4 fig. 6; Fig. 10: 3, 4

Type specimen. Berry 1937a, Pl. 2, Fig. 5.

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2 In their publication Czajkowski & Rösler (1986) referred two specimens of leaves with acrodromous venation to that taxon. The leaf illustrated in Pl. 1, Fig. 5 (in the drawing it is turned with the apex downwards) belongs to *Pentaneuron duseni* (Zastawniak) Li, whereas the other specimen, in Fig. 3 (also turned with its apex downwards) is a leaf of another fossil taxon.

L o c u s t y p i c u s. Cerro Baguales, Santa Cruz Territory, Argentina.
S t r a t u m t y p i c u m. Cerro Guido horizon, silicified tuff.
A g e. Upper Cretaceous (Cenomanian).
B o t a n i c a l a f f i n i t y. *Myrtaceae* family.
D i a g n o s i s. Leaves lorate in shape, with acuminate apex and cuneate base. Margins entire, texture coriaceous. Venation pinnate, brochidodromous, secondary veins moderately thick, densely and somewhat irregularly arranged. Distinct intramarginal vein, parallel to the margin. Secondary veins diverging from the midrib at wide angles.

= *Myrcia santacruzensis* Berry 1937a, p. 30, Pl. 2, Fig. 4, 5

M a t e r i a l. Specimen Nos. ZPAL 47, ?73/3, 82/2 (twin impression 89/3), 87; 3 (?4) leaf impressions.
D e s c r i p t i o n. Lorate leaves, about 10 cm long and about 2 cm broad, tapering towards the apex and base. Margin damaged. Texture coriaceous. Venation pinnate, brochidodromous. Midvein stout, very numerous secondary veins diverging from the midvein at moderately and widely acute angles (50–70^{o}). They are close together, somewhat irregularly spaced and form a distinct intramarginal vein.
R e m a r k s. Two impressions of leaves which show distinct lateral veins and an intramarginal vein completely agree with the description and drawing of the fossil *Myrcia santacruzensis* Berry, from the Upper Cretaceous of southern Patagonia (Berry 1937a), later reported also from other localities of that age in the southern part of South America (Romero & Arguijo 1981). The intramarginal vein is not visible in one of the specimens (No. ZPAL 73/3) and so the determination is doubtful.

Myrcia is that genus of the *Myrtaceae* in which leaf remains from the fossil floras of South America, starting from the Upper Cretaceous, were most frequently included. However, the leaves of other contemporary genera of the *Myrtaceae* bear similar morphological features (Klucking 1988). Because of the lack of other evidence (cuticular analysis) which would allow a comparison between fossil and recent leaves, the name of the recent genus *Myrcia* has been replaced with the new generic name *Myrciophyllum*, *Myrtaceae* family. Pollen grains of *Myrtaceae* occur in the deposits of Seymour Island and James Ross Island (Cranwell 1959, Askin 1989, Baldoni & Medina 1989, Dettmann & Thomson 1987), and there are some *Myrcia*-type leaves in the leaf flora of Seymour Island (Dusén 1908, Pl. 2, Fig. 10, Berry 1928). Two specimens of leaf remains belonging probably to *Myrtaceae* were also found in the flora from Dyfayel Island (Birkenmajer & Zastawniak 1986). Among cuticule dispersae from the Upper Maastrichtian of Seymour Island, Upchurch and Askin (1989) found a species with a cyclocytic subsidiary cell arrangement and trichome bases characteristic of the extant *Myrtaceae*.

Cunoniophyll morphotype

Leaves lanceolate, serrate.

Dicotylophyllum sp. 6

Pl. 1 fig. 6; Fig. 10: 2

= ?Form E, Rees & Smellie (1989), p. 242, Figs 3, 5c (non vidi)

Material. Specimen No. ZPAL 87; 1 leaf impression.

Description. The fragment of a nearly whole leaf preserved as an impression is 7 cm long and the leaf is about 1.6 cm broad. The midvein is straight, pronounced, the remaining veins are not visible. Leaf margin dentate.

Remarks. No details of venation are perceptible in the extant leaf fragment, nor can the type of margin dentation be traced. Hence, its membership of the family *Cunoniaceae* cannot be proved. The presence of this family in the fossil floras of West Antarctica is, however, very probable. Dusén (1908) was the first to distinguish fossil leaves of *Cunoniaceae* in the flora of Seymour Island, when describing a single, characteristically dentate stipule under the name of *Caldcluvia mirabilis* Dusén and comparing it with the recent species *Caldcluvia paniculata* (Cav.) Don, now occurring in southern Chile and Patagonia. The same fossil taxon, *Caldcluvia mirabilis*, is also represented in the flora of the Fildes Peninsula of King George Island. Czajkowski and Rösler (1986) found four specimens of it, one of which possessed a perfectly well preserved, nearly whole, composite leaf.

Pollen grains which might belong to the *Cunoniaceae* (cf. *Weinmannia*), were found by Cranwell (1959) in deposits in Seymour Island.

The *Cunoniaceae* are considered to be a very ancient and primitive group of *Angiospermae*, the most primitive member of the *Rosidae* (Hufforrd & Dickison 1992). These plants must have occurred in the Gondwana area as early as the Middle Cretaceous, when Australia and Africa were possibly connected (Raven & Axelrod 1974). At present the area of distribution of this family includes the whole of the southern hemisphere, mainly Australasia, where the diversity centre lies and on numerous Pacific Islands. Members are trees or shrubs with evergreen leaves, growing in warm and cool temperate rain forests.

Various, indefinite morphotypes

Dicotylophyllum sp. 7

Pl. 4 fig. 4; Fig. 8: 7

= ?*Nothofagus* sp. (Dutra 1989, Pl. 4, Fig. 1)

Material. Specimen No. ZPAL 26; 1 leaf fragment.

Description. A fragment probably of the middle part of a leaf. Texture coriaceous. Venation pinnate, marked by the regular, subparallel course of lateral veins and the

presence of single intersecondary veins in intercostal areas. Lateral veins, somewhat arcuately curved, arise from the main vein at angles of 60–70°.
Remarks. Dutra (1989) illustrated an impression of a leaf of the same type in her work on the flora of Zamek (Fig. 4: 1, ?*Nothofagus* sp.). The second order venation of this type and the presence of intersecondary veins are not met with either in recent or in fossil species of *Nothofagus*.

Such leaf venation is particularly frequent today in plants of subtropical and tropical regions.

Dicotylophyllum sp. 8

Pl. 2 fig. 5; Fig. 8: 8

Material. Specimen No. ZPAL 97/3 (twin impression 95/3): fragment of a small leaf or leaflet.
Description. Small leaf (leaflet?), length about 3.5 cm, max. breadth about 2 cm; shortly elliptical, margin probably entire, texture coriaceous. Venation brochidodromous. Midvein very stout and prominent, 5 or 6 pairs of secondaries, stout, ascending and curved; tertiaries oblique to midvein.
Remarks. Leaves (leaflets) of small size, with identical venation which used to be referred to the form-genus *Leguminosites* Lesquereux (Hollick & Berry 1924), or regarded as a fossil species from such extant genera as *Cassia* or *Caesalpinia* (among others Berry 1938). The application of these names was, however, misleading and they could not be used to prove the presence of plants from the family *Fabaceae* in the fossil flora, for leaves of similar shape and venation are present in many dicotyledonous plants (Schimper & Schenk 1890), including some recent evergreen species of *Nothofagus* with entire leaf margins and brochidodromous venation occurring in low latitudes today in New Caledonia and New Guinea (comp. Hill & Read 1991).

Dicotylophyllum sp. 9

Pl. 4 figs 7, 7a; Fig. 10: 8

Material. Specimen No. ZPAL 3/2 (twin impression No. 4); 1 leaf (leaflet).
Description. Leaf (leaflet) very small, ca 2.5 cm long and 1.0 cm broad, narrowly obovate, apex rounded, margin probably entire. Midrib of moderate size, secondaries weak, slightly arched, texture thick.
Remarks. Dusén (1907) described leaves of similar size and shape from the Tertiary (most probably Oligocene) of South Patagonia under the name *Myrtiphyllum bagualense* Dusén, but unlike our specimen, the leaf impressions from the region of Bariloche, Territory of Rio Negro, have an intramarginal vein characteristic of *Myrtaceae*. This vein is, however, not always visible, e.g. in impressions of leaves, very similar in shape and size, known under the name of *Myrcia nitens* Engelhardt from the Upper Cretaceous from the Mata Amarilla Formation at Cerro Baguales (Berry 1928). In Tertiary floras of the northern hemisphere remains of this sort are more often identified as the

Fabaceae type. Their definition given by Berger (1953, 1955) is as follows: "Leaves (leaflets) very small, rounded to elliptic, with the entire or sharply serrate margin, leathery in the case of evergreen plants". They may belong to various families, which however cannot be determined unless a cuticular analysis has been carried out.

Dicotylophyllum sp. 10

Pl. 4 fig. 3; Fig. 8: 9

= Phyllites sp. (8); Dusén 1908, Pl. 2, Fig. 12

Material. Specimen No. ZPAL 19 (twin impression No. ZPAL 50): 1 leaf fragment.
Description. Middle part of medium-sized leaf (microphyllous), about 3 cm broad. Margin probably toothed, texture coriaceous. Primary vein stout; secondary veins irregularly spaced, slightly curved, diverging from the main vein at a moderately acute angle. Intersecondary veins simple, 1 or 2 in each intercostal area. Secondary veins giving rise to at least 2 secondary branches on their exmedial.
Remarks. A leaf fragment showing the same type of venation and with a characteristically dentate margin, occurs in the flora of Seymour Island (Dusén 1908). The leaves of some recent *Elaeocarpaceae*[3] have similar morphological features, notably the course of the secondary branches on the exmedial side of the secondaries.

According to Raven & Axelrod (1974) southern origin of *Elaeocarpaceae* family is very probable. At present it is best represented in South America, South-East Asia, Madagascar and, by several endemic genera, in Australia. Wood of *Elaeocarpaceae* is known from the Palaeocene of Patagonia (Petriella 1972, cit. after Raven & Axelrod 1974), while Ettingshausen (1883, 1887a) described fruits and a leaf fragment of *Elaeocarpus* from the Miocene of Australia.

Dicotylophyllum sp. 11

Pl. 4 fig. 5; Fig. 8: 10

Material. Specimen No. 83/2; 1 leaf fragment.
Description. Leaf fragment, at least 3.5 cm broad, texture thick. Venation pinnate, most probably brochidodromous. Midvein straight and stout, secondary veins branching irregularly; intercostal areas of irregular shape, tertiary veins randomly reticulate. The 2^{nd} and 3^{rd} order veins are poorly differentiated.
Remarks. The characteristic, disorganized venation is striking. This is the only leaf specimen with such venation in the studied material.

The remains of fossil leaves with disorganized venation, frequent in the Cretaceous floras of the northern hemisphere are considered to represent the most primitive of the dicotyledons (Hickey 1971). Such venation is observed in some recent members of the

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[3] The herbarium materials of the following *Elaeocarpaceae* taxa have been examined: *Aristotelia fruticosa* Hook. f., *A. serrata* (J. R. et G. Forst) W. R. B. Oliver, *Elaeocarpus dentatus* (J. R. et G. Forst) Vahl, and most resembling the fossil specimen in venation *E. recurvatus* Corner, *E. floribunda* Bl., *E. littoralis* T. et B., *E. longifolius* Bl., *E. tomentosa* Bl.

subclass *Magnoliidae*, namely in the family *Winteraceae* (Hickey & Wolfe 1975). Some pollen grains, possibly representing the *Winteraceae*, were reported from Seymour Island by Cranwell (1959). The only reliable determination of pollen grains of this family is that of the pollen from the Late Cretaceous of southeastern Australia (Dettmann & Jarzen 1988). Raven and Axelrod (1972, 1974) put forward the hypothesis that Antarctica was the dispersal route of the *Winteraceae* from Australasia to South America before Australia drifted away from Antarctica. Discovery of the presence of leaves which may belong to this family strengthens this hypothesis.

Dicotylophyllum sp. div.

Pl. 1 fig. 4; Fig. 10: 6, 7

Material. Specimen Nos. ZPAL 2, 8, 12/2, 31, 34, 36/5, 42, 44/3, 56, 61, 65, 67, 68/2, 69/2, 71, 73/2, 81, 86/2; 17 small impressions of leaves.

Description. Impressions of small fragments of leaves, showing segments of primary, secondary and sometimes also tertiary veins. Characters of shape unknown.

COMPOSITION OF THE TAPHOCEONOSIS FROM THE BŁASZYK MORAINE

The leaf remains of angiospermous plants prevail in the taphoceonosis examined (Tab. 1); there are in addition 3 impressions of fronds of closely similar but indeterminable ferns and one impression of a conifer (*Araucaria* vel *Podocarpaceae*). Three new taxa have been distinguished among the fossil remains of the *Angiospermae*: *Nothofagus cretacea* Zastawniak sp. nov., *Magnoliidaephyllum birkenmajeri* Zastawniak gen. et sp. nov., and *Myrciophyllum* gen. nov. The morphological characters preserved in the impressions of these fossil leaves are distinctive enough to permit the introduction of new denominations.

The presence of the genus *Nothofagus* in the Cretaceous of West Antarctica raises no doubts nowadays, for it has already been proved by the results of earlier palynological analyses (Truswell 1983, Dettmann & Thomson 1987, Dettmann et al. 1990, Askin 1988a, b) and, what is more, the occurrence of all three types of pollen grains distinguished in *Nothofagus* (*fusca, menziesii* and *brassi*) indicates that this genus was differentiated to a great extent as early as that time. Examination of nothing but impressions of leaves devoid of cuticle cannot confirm this presence for while leaves showing the craspedodromous type of venation, with straight, dense and regularly parallel lateral veins (as in some members of the subgenus *Fuscospora* Hill et Read (*fusca*-type pollen) or the subgenus *Menziesospora* Hill et Read (*menziesii*-type pollen)) may be referred to the genus *Nothofagus* without any serious doubt, those differing in the arrangement of the lateral veins, (for instance, with camptodromous venation, as e.g. in the recent members of the subgenus *Brassospora* Philipson et Philipson (*brassi*-type pollen)), are indeterminable unless an anatomical study of cuticles is carried out.

Table 1. List of the fossil leaves found in the Błaszyk moraine

Fossils	Number of specimens
Pteridophyta	
? *Pecopteris* sp.	1
Cladophlebis sp.	1
Filicales gen. et sp. indet.	1
Coniferophyta	
Araucaria vel *Podocarpaceae*	1
Magnoliophyta (*Angiospermae*)	
Magnoliaephyll morphotype	
Magnoliidaephyllum birkenmajeri Zastawniak gen. et sp. nov.	20
Dicotylophyllum sp. 1	1
Laurophyll morphotype	
Dicotylophyllum sp. 2	3
Dicotylophyllum sp. 3	2
Protophyll morphotype	
Nothofagus cretaceous Zastawniak sp. nov.	13
Nothofagus sp. (div.?)	22
Pentalobaphyll (Araliaephyll) morphotype	
Dicotylophyllum sp. 4	2
Acrodromophyll morphotype	
Dicotylophyllum sp. 5	1
Myrtophyll morphotype	
Myrciophyllum santacruzensis (Berry) Zastawniak gen. nov.	3 + ?1
Cunoniophyll morphotype	
Dicotylophyllum sp. 6	1
Indefinite morphotypes	
Dicotylophyllum sp. 7	1
Dicotylophyllum sp. 8	1
Dicotylophyllum sp. 9	1
Dicotylophyllum sp. 10	1
Dicotylophyllum sp. 11	1
Dicotylophyllum sp. div.	17
Phyllites sp.	10

The second new taxon distinguished, that is, *Magnoliidaephyllum birkenmajeri* Zastawniak gen. et sp. nov. undoubtedly belongs to the subclass *Magnoliidae*. It was certainly an evergreen plant, as its very thick, leathery leaves with deep-imprinted venation show. Remains of cuticles bearing characters distinctive of plants from the subclass *Magnoliidae* were found from the fossil flora of Seymour Island (Upchurch & Askin 1989). With their thick cuticles they are typical of presentday evergreen leaves (Upchurch & Askin op. cit.).

The third taxon is *Myrciophyllum santacruzensis* (Berry) Zastawniak gen. nov., with leaf features characteristic of the family *Myrtaceae*. The presence of this family in the Cretaceous of West Antarctica has been confirmed independently of palynological analyses (cf. p. 139) by studies of the cuticles (Upchurch & Askin 1989).

The remaining forms of fossil leaves, designated as *Dicotylophyllum* sp. were labelled with consecutive numbers and remain undesribed. They are very small leaf fragments, with only traces of venation of the first and second orders. Some of them may have belonged to the forms described above.

In the present work most of the remains of angiosperms have been classified on the basis of angiosperm leaf architectural complexes. This classification, introduced by Hickey (1984) for the Cretaceous megafloras of North America and next stated precisely by Crabtree (1987), makes it possible to avoid uncertain, often incorrect taxonomic determinations which refer material to recent plant genera. It turned out that many names the morphotypes from the Cretaceous of the northern hemisphere could be used for the flora from Błaszyk Moraine (e.g. magnoliaephyll, protophyll, myrtophyll, pentalobaphyll). Laurophyll in the flora from Błaszyk Moraine is an equivalent of cinnamomophyll and one new term, acrodromophyll, has been introduced. Similar morphotypes characterize the Upper Cretaceous (90–80 Ma) megafloras in the Castillo and Bajo Barreal Formations in the Chubut Group in Argentina (Romero 1992), in which, as in the Błaszyk Moraine, the magnoliaephylls (including laurophylls) are dominant.

Morphotypes were not designated for 6 specimens (*Dicotylophyllum* sp. 7–11). These are either leaf fragments which are too small to enable us to reconstruct their architectural complex or they are small leaflets which may be parts of compound leaves.

In the flora of the Błaszyk Moraine the *Magnoliidae* and *Hamamelididae* are dominant groups, with some *Dilleniidae* and *Rosidae* also present. These conclusion resemble the results obtained by Romero and Arguijo (1981) for the Upper Cretaceous (Aptian-Turonian, Concian and Maastrichtian) floras from the San Jorge and Magallanas basins of southern South America, where the *Magnoliidae* are represented by 14 species, *Dilleniidae* by 7, *Rosidae* by 6 and *Hamamelididae* by 3. It is worth adding that remarkable diversity is also observed in the floras from around the Early/Late Cretaceous in the northern hemisphere (Drinnan & Crame 1989).

QUANTITATIVE DATA CONCERNING THE FOLIAR PHYSIOGNOMY OF THE BŁASZYK MORAINE TAPHOCOENOSIS

The particular leaf size classes of the Błaszyk Moraine (Zamek Formation) flora are as follows: nanophyll 2.94 %, microphyll 47.06 %, notophyll 41.17 %, and mesophyll 8.82 %. The ratio of large to small leaves is 8.8 : 91.2. The leaf size index[4] for the flora of the Błaszyk Moraine is 27.9. Thick coriaceous leaves constitute a high percentage

[4] Leaf-size index according to Wolfe & Upchurch 1987, p. 36

(54.4 %). The exact determination of the percentage of entire-marginate leaves is impossible, because nearly all leaf specimens have their margins damaged. However, judging from the chiefly camptodromous nature of the venation, we may infer that the proportion of entire-marginate leaves was remarkable large.

GENERAL REMARKS ON THE VEGETATION OF THIS REGION OF WEST ANTARCTICA IN THE UPPER CRETACEOUS

The distinction of 14 angiospermous leaf forms in rather scanty study material supports the earlier statements based on the results of palynological analyses (e.g. Askin 1988a, b, Dettmann & Thomson 1987), studies of megafossil floras (Drinnan & Crame 1989) and cuticles (Upchurch & Askin 1989) that angiospermous plants in the Upper Cretaceous of West Antarctica were a differentiated and specialized group of plants constituting an essential component of the plant communities of those times.

The first angiosperms (pollen taxon *Clavatipollenites*) were discovered in the Early Albian layers of the Antarctic Peninsula (see Truswell 1983, 1989). In the Cenomanian-Early Campanian period the percentage of angiosperms was still small, though they were already fairly well differentiated. In the fossil flora of that age from Williams Point, Livingston Island, Antarctic Peninsula (Rees & Smellie 1989, Chapman & Smellie 1992) attention is drawn to the lack of pollen grains of *Nothofagidites* in comparison with the presence pollen of other angiosperms and, moreover, the abundance of various ferns and the presence of cycadeoids (*Sahnioxylon antarcticum* Lemoigne et Torres; Lemoigne & Torres 1988, Chapman & Smellie 1992).

In this area, according to Dettmann (1989), a very high representation of cryptogams was noted in the Cenomanian-Turonian palynofloras; later the proportion of spores of this plant group decreased distinctly, whereas angiosperms appeared as has been confirmed by the discovery of pollen grains of the *Myrtaceae*, *Gunneraceae*, probably the *Epacridaceae*, *Winteraceae*, *Trimeriaceae* and very numerous and diverse pollen grains of the *Proteaceae* (see also Truswell 1983).

The domination of fern spores is characteristic of the samples coming from Half Three Point of the Fildes Peninsula, King George Island (Cao 1990, 1992). The dating of the palynoflora of this locality (Campanian or Campanian-Maastrichtian) was based on the presence of pollen grains of *Nothofagidites senctus* Dettmann et Playford. If this age assessment is accepted, the noteworthy fact is that the plant communities of Half Three Point were dominated by various ferns, whose proportion reached 90 % in the pollen spectra. The ferns from the family *Gleicheniaceae* were dominant; in addition, there were also *Cyatheaceae*, *Adianthaceae*, *Dicksoniaceae*, *Lygodiaceae*, *Osmundaceae*, *Polypodiaceae* etc. The coniferous plants (*Araucaria*, *Podocarpus*, *Dacrydium*) were not numerous, neither were the angiosperms in association with *Nothofagitites*. In Cao's (op. cit.) opinion, the palynological picture corresponds to the tropical-subtropical rain forests in mountain areas at medium and low altitudes and in plains.

From the mid-Campanian onwards, numerous angiosperms, especially *Nothofagus* and such typical austral families as *Proteaceae* and *Myrtaceae*, enriched and completed the communities of podocarp-araucarian rain forests (Dettmann & Jarzen 1988).

Increasingly numerous and diverse pollen grains of the *Angiospermae* occur in Maastrichtian deposits in West Antarctica (Truswell 1983, Dettmann & Thomson 1987, Dettmann & Jarzen 1988, Dettmann & Hedlund 1988, Askin 1989, Baldoni & Medina 1989). In the Upper Cretaceous samples from Seymour Island, in addition to araucarian pollen and spores of mosses and ferns, Askin (1989, 1994) found abundant pollen grains of various angiospermous taxa present, including all the groups of *Nothofagidites* (*fusca, menziesii, brassi*) and, besides, some *Proteaceae, Aquifoliaceae, Bombacaceae, Casuarinaceae, Chloranthaceae, Ericales, Gunneraceae, Liliaceae* (or other monocotyledons), *Loranthaceae, Myrtaceae, Olacaceae, ?Pedaliaceae, Sapindaceae* (*Cupaniae* tribe), and, possibly, *Palmae*. Not only does that confirm the marked diversity of the *Angiospermae* in the Upper Cretaceous but also their domination over the gymnosperms in the plant cover at that time.

The foregoing statements are also confirmed by studies of leaf remains that have survived in the form of leaf cuticles in deposits of the Upper Maastrichtian of Seymour Island (Upchurch & Askin 1989). Apart from a great amount of gymnosperms (including the *Podocarpaceae, Araucariaceae, Cupressaceae* and remains of cycads), very numerous angiosperm leaf cuticles were found, both of dicotyledons (e.g. subclass *Magnoliidae*, from the families *Myrtaceae, Lauraceae,* and of indeterminate dicotyledons) and monocotyledons. In addition to dominant cuticles bearing structural features characteristic of evergreen plants, there were thin cuticles of thin-leaved plants, which may have belonged to deciduous woody plants and herbs (Upchurch & Askin 1989).

UPPER CRETACEOUS PLANT COMMUNITIES IN THE FLORA FROM THE BŁASZYK MORAINE

The fossil flora of the Błaszyk Moraine resembles the Upper Cretaceous flora of Seymour Island in nature, especially when considered in relation to cuticular studies (Upchurch & Askin 1989). The Upper Cretaceous communities from the Błaszyk Moraine were represented by magnoliaceous-laurophyllous evergreen rain forests. These forests, in which various taxa of plants from other families also grew, e.g. *Myrtaceae*, covered the lower parts of slopes and the bases of high volcanoes, with rivers and lakes extending among them (cf. Birkenmajer 1985). These forests conform to Wolfe's (1981) definition of the modern Notophyllous Broad-leaved Evergreen Forests of eastern Asia (="oak laurel forest" of the northern hemisphere): "... is dominantly broadleaved evergreen with an admixture of broadleaved deciduous trees and shrubs. Except in secondary vegetation conifers are not common. The leaf size is dominantly notophyllous (Webb 1959), that is, the smaller half of Raunkiaer's (1934) mesophyllous class. Woody climbers are profuse. Palmately lobed leaves are rare – typically less than 4 percent of the species."

A similar analysis of the leaf size classes of the study flora (see p. 145) indicates the existence of a lower montane and lowland subtropical rain forest.

This community was certainly overtopped by open forest, with deciduous trees of *Nothofagus* playing the main role; there were coniferous trees as well. Ferns were growing in the undergrowth. These forests resembled the present-day Mixed Mesophytic Forests of the northern hemisphere, in which, according to Wolfe (1981): "... vegetation is dominantly broad-leaved deciduous. Some notophyllous broadleaved evergreens are present, but typically as small trees and shrubs about 15 to 30 % of the species are broadleaved evergreen. Conifers are typically a minor element. In leaf size, the size classes smaller than nothophyll are well represented. Palmately lobed leaves are present..."

PALAEOCLIMATE

The sedimentological data concerning the Late Cretaceous of the South Shetland Islands suggest a mild, rather dry climate with scanty precipitation, for which traces of intense lateritic weathering of volcanic surfaces and the presence of silicified wood pieces provides supporting evidence (Birkenmajer 1985). The fact that fossil wood has very variable, dense and wide annual growth-rings (Jefferson 1982, Francis 1986) indicates a climate with winter/summer light cycles throughout the Cretaceous in West Antarctica. In Francis's (1986) opinion, analysis of growth rings in pieces of woods shows that the trees of which they formed part had very favourable developmental conditions in a mild, (warm-cool) temperate climate.

The present state of study of the megaflora from the Błaszyk Moraine confirms the previously expressed opinion that the Late Cretaceous climate of this sector of West Antarctica was generally mild and differentiated into summer and winter seasons; snow or ice caps appeared only on the tops of higher (up to 1200 m a.s.l.) volcanoes (Birkenmajer & Zastawniak 1989a, b). If the physiognomic analysis of this megaflora and the climatic correlations established by Wolfe (1979) for the extant Australasian forests are taken into consideration, the domination of microphyll and notophyll leaf-size classes, and therefore the low values of the leaf-size index, together with a large proportion of coriaceous and, most probably, entire-marginate leaves, suggest a subhumid mesothermal climate (cf. Upchurch & Wolfe 1987, Wolfe & Upchurch 1987, Birkenmajer & Zastawniak 1989a, b, Zastawniak 1990). This is partly at variance with Askin's (1990) opinion; on the basis of a palynological study she assumes a high rainfall regime of the Campanian-Paleocene of the northern Antarctic Peninsula. However, in palynological studies the climatic conclusions are usually based on todays requirements of members of various plant families and genera. From fossiliferous deposits, the morphological characters of leaves, notably the nature of their cuticles, would seem to be more reliable. The statement that species with a structure typical of evergreen plants with thick cuticles predominate among the cuticule dispersae from the Upper Cretaceous of Seymour Island is confirmed by the majority of preserved leaf impressions in the flora of the

Błaszyk Moraine but this in itself is insufficient evidence to conclude that a highly humid climate existed at that time. The leaf size index for the flora of the Błaszyk Moraine is 27.9. Such a low value of the index for the fossil floras of the northern hemisphere, together with a high proportion of leathery leaves, indicates, according to Wolfe & Upchurch (1987), subhumid conditions. In a subhumid, megathermal climate the leaf size is markedly smaller than in a humid-mesic megathermal climate (Webb 1959, Dolph & Dilcher 1980a, b).

The simultaneous occurrence of thin cuticles of deciduous woody plants (Upchurch & Askin 1989), and impressions of leaves of *Nothofagus* in the flora of the Błaszyk Moraine, may indicate the presence of differentiated biotopes of various altitudes above sea level rather than a higher humidity of the climate. The coexistance of plant remains whose modern conterparts appear in warm temperate and cool temperate climates is best explained if we assume, after Askin (1990), the altitudinal zonation of vegetation on the Antarctic islands abounding in high volcanoes. Warm temperate plant communities grew in lower-lying areas, at the foot of the volcanoes, whereas cool temperate zones at higher altitudes were occupied by plants with lower thermal requirements (*Podocarpaceae, Nothofagus*).

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STRESZCZENIE

Stanowisko z górnokredową florą kopalną znajduje się w Zatoce Admiralicji na Wyspie Króla Jerzego w Archipelagu Południowych Szetlandów. Szczątki roślin są zachowane w postaci odcisków liści i pędów w piaskowcach tufitowych oraz zlepieńcach znalezionych na morenie Błaszyka, oddzielającej lodowce Baranowskiego i Sphinxa. Skały te należą do formacji Zamku w obrębie grupy Baranowski Glacier. Wiek skał formacji Zamku zawiera się pomiędzy datą 77 ± 4 Ma (santon-campan) a 66.7 ± 1.5 Ma (maastrycht). Materiał do badań został zebrany podczas Trzeciej Polskiej Wyprawy Antarktycznej w 1978/79 przez K. Birkenmajera, J. Błaszyka i A. Gaździckiego.

W całym materiale przeważają szczątki liści *Angiospermae*, 3 okazy są odciskami liści bliżej nieoznaczalnych paproci, a jeden odciskiem rośliny szpilkowej (*Araucaria* vel *Podocarpaceae*) (tab. 1). Wśród szczątków kopalnych *Angiospermae* wyróżniono nowe taksony: *Nothofagus cretacea* sp. nov. (*Nothofagaceae*), *Magonliidaephyllum birkenmajeri* gen. et sp. nov. (podklasa *Magnoliidae*) oraz *Myrciophyllum santacrucenze* gen. nov. (rodzina *Myrtaceae*). Pozostałe okazy określono jako *Dicotylophyllum* sp. 1–11. 28 okazów bardzo małych fragmentów roślin pozostało nieoznaczonych.

Cały materiał został sklasyfikowany w oparciu o metodę Hickeya (1984) wykorzystania kompleksów architektonicznych liści (morfotypów) roślin okrytozalążkowych. Wyróżniono następujące morfotypy: protofyl, magnoliefyl, laurofyl, akrodromofyl, pentalobafyl, myrtofyl i kunoniofyl.

W tafocenozie Moreny Błaszyka dominującymi grupami są *Magnoliidae* i *Hamamelididae*, obecne są także *Dilleniidae* i *Rosidae*. Są to podobne wyniki, jakie uzyskano dla górnokredowych flor z południowej części Ameryki Południowej (Romero & Arguijo 1981).

Na podstawie analizy cech fizjonomicznych liści ustalono, że stosunek liści dużych do małych wnosi 8.8 : 91.2. Wysoki procent (54.4 %) jest liści tęgich, skórzastych, znaczny był również udział liści całobrzegich. Podobne wartości poszczególnych klas wielkości liści jakie charakteryzują górnokredową florę z Moreny Błaszyka, w klasyfikacji współczesnych lasów Australii (Webb 1959) odpowiadają subtropikalnym lasom deszczowym nizin i niższych położeń górskich.

Zawsze zielone lasy deszczowe magnoliowo-laurowe były prawdopodobnie tym zbiorowiskiem roślinnym, którego szczątki zachowały się w badanym materiale. Lasy te, w których rosły także różne rośliny z innych rodzin, m.inn. *Myrtaceae*, porastały podnóża i niższe poziomy wysokich wulkanów, pomiędzy którymi płynęły wody rzek i jezior (por. Birkenmajer 1985). Ponad tymi lasami występowały zapewne wysokopienne, luźne lasy, w których główną rolę odgrywał *Nothofagus*, zrzucający liście; rosły tam także drzewa szpilkowe oraz paprocie.

Dane sedymentologiczne dla górnej kredy Wyspy Króla Jerzego wskazują na ciepły, raczej suchy, ubogi w opady klimat (Birkenmajer 1985). Na podstawie analizy fizjonomicznej szczątków liści i korelacji klimatycznych ustalonych przez Wolfa (1978) dla współczesnych lasów australoazjatyckich można przyjąć dla górnokredowej flory Moreny Błaszyka stosunkowo mało wilgotny, mezotermalny klimat.

PLATES

Plate 1

1. *Cladophlebis* sp., specimen No. KRAM-P 173/13, coll. K. Birkenmajer 1978
2. Magnoliaephyll morphotype: I – *Dicotylophyllum* sp. 1, specimen No. ZPAL 49/1, coll. J. Błaszyk 1978/79; II – Pentalobaphyll (Araliaephyll) morphotype: *Dicotylophyllum* sp. 4, specimen No. 49/2, coll. J. Błaszyk 1978/79
3. Acrodromophyll morphotype: *Dicotylophyllum* sp. 5, specimen No. ZPAL 97/1, coll. J. Błaszyk & A. Gaździcki 1978/79
4. Indefinite morphotype: *Dicotylophyllum* sp. div., specimen No ZPAL 83/1, coll. J. Błaszyk 1978/79
5. Protophyll morphotype: *Nothofagus cretacea* Zastawniak sp. nov., specimen No. ZPAL 86/1, coll. J. Błaszyk 1978/79
6. Cunoniophyll morphotype: *Dicotylophyllum* sp. 6, specimen No. ZPAL 87, coll. J. Błaszyk & A. Gaździcki 1978/79
7. *Filicales*, gen. et sp. indet., specimen No. ZPAL 75, coll. J. Błaszyk & A. Gaździcki 1978/79

1, 2, 4, 5 – phot. A. Pachoński
3, 6, 7 – phot. M. Małachowska-Kleiber

Plate 1

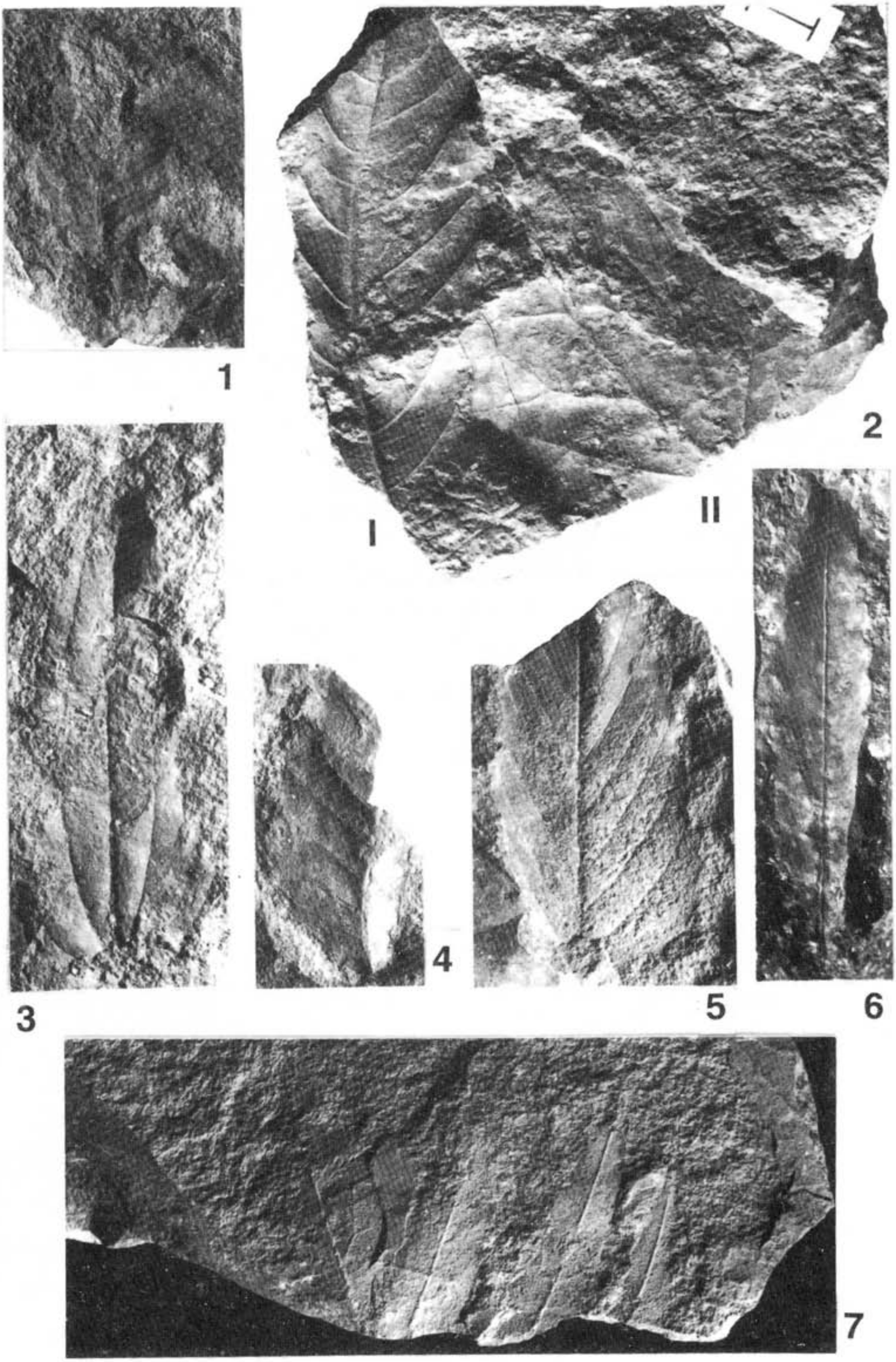
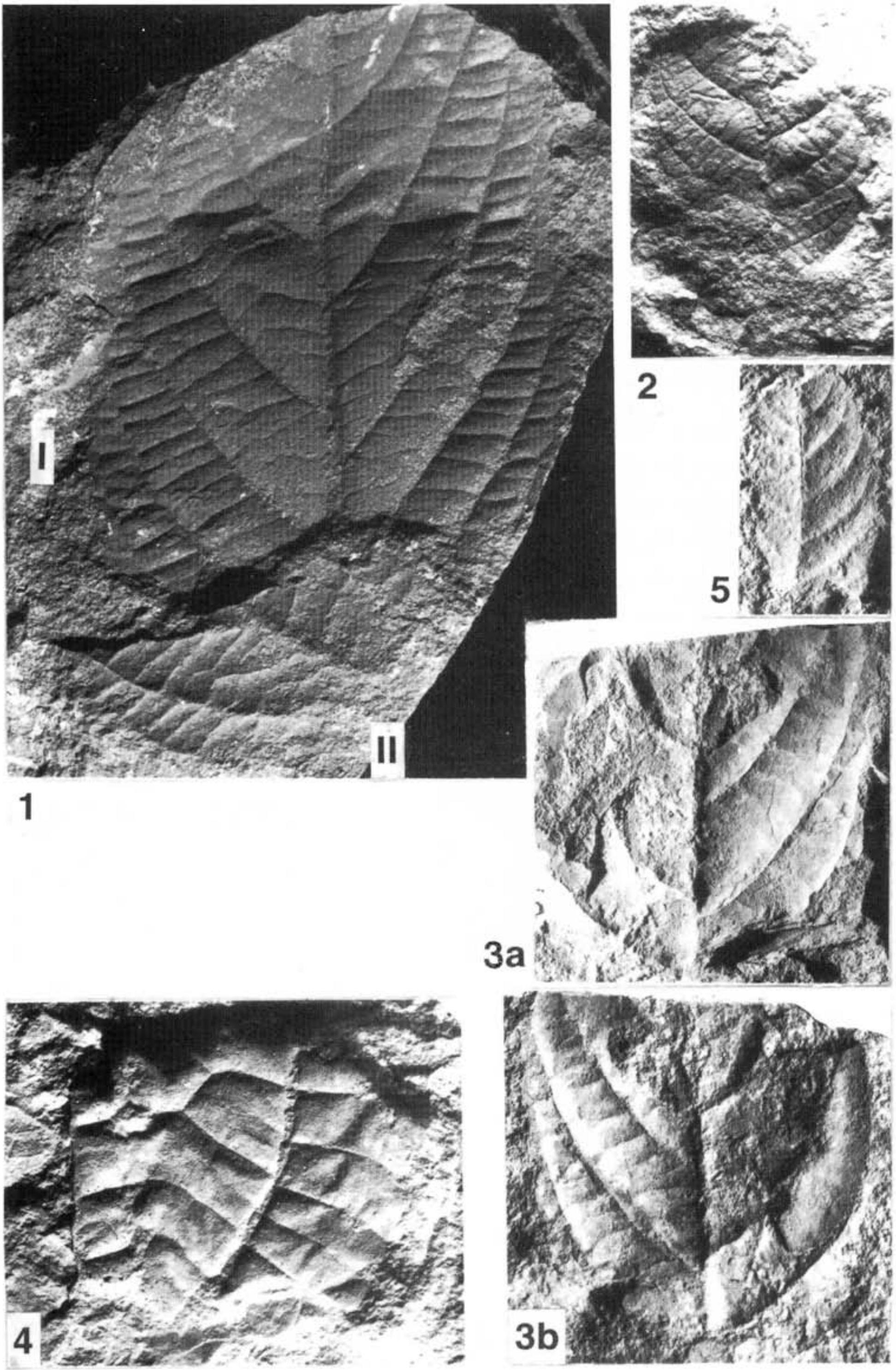


Plate 2

Magnoliaephyll morphotype: *Magnoliidaephyllum birkenmajeri* Zastawniak gen. et sp. nov.

1. I – holotype, specimen No. ZPAL 73/1, II – isotype, specimen No. ZPAL 73/4, coll. J. Błaszyk & A. Gaździcki 1978/79
2. Specimen No. ZPAL 11, coll. J. Błaszyk 1978/79
3. a – specimen No. ZPAL 97/2, coll. J. Błaszyk & A. Gaździcki 1978/79, b – twin impression, specimen No. ZPAL 95/1, coll. J. Błaszyk 1978/79
4. Leaf fragment, specimen No. ZPAL 91/2, coll. J. Błaszyk 1978/79
5. Indefinite morphotype: *Dicotylophyllum* sp. 8, specimen No. 97/3, coll. J. Błaszyk & A. Gaździcki 1978/79

1 – phot. M. Małachowska-Kleiber
2–5 – phot. A. Pachoński


I
II
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3a
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3b

Plate 3

1. Laurophyll morphotype: *Dicotylophyllum* sp. 3, specimen No. ZPAL 3/1, coll. J. Błaszyk 1978/79

Protophyll morphotype: *Nothofagus cretacea* Zastawniak sp. nov.

2 – holotype, specimen No. ZPAL 70, coll. J. Błaszyk & A. Gaździcki 1978/79

3 – numerous leaf impressions. specimen No. ZPAL 94, coll. J. Błaszyk & A. Gaździcki 1978/79

4 – specimen No. ZPAL 40, coll. J. Błaszyk & A. Gaździcki 1978/79

5 – specimen No. ZPAL 66, coll. J. Błaszyk & A. Gaździcki 1978/79

6 – *Nothofagus* sp, specimen No. ZPAL 91/1, coll. J. Błaszyk 1978/79

1, 2, 4, 5 – phot. A. Pachoński
3 – phot. M. Małachowska-Kleiber

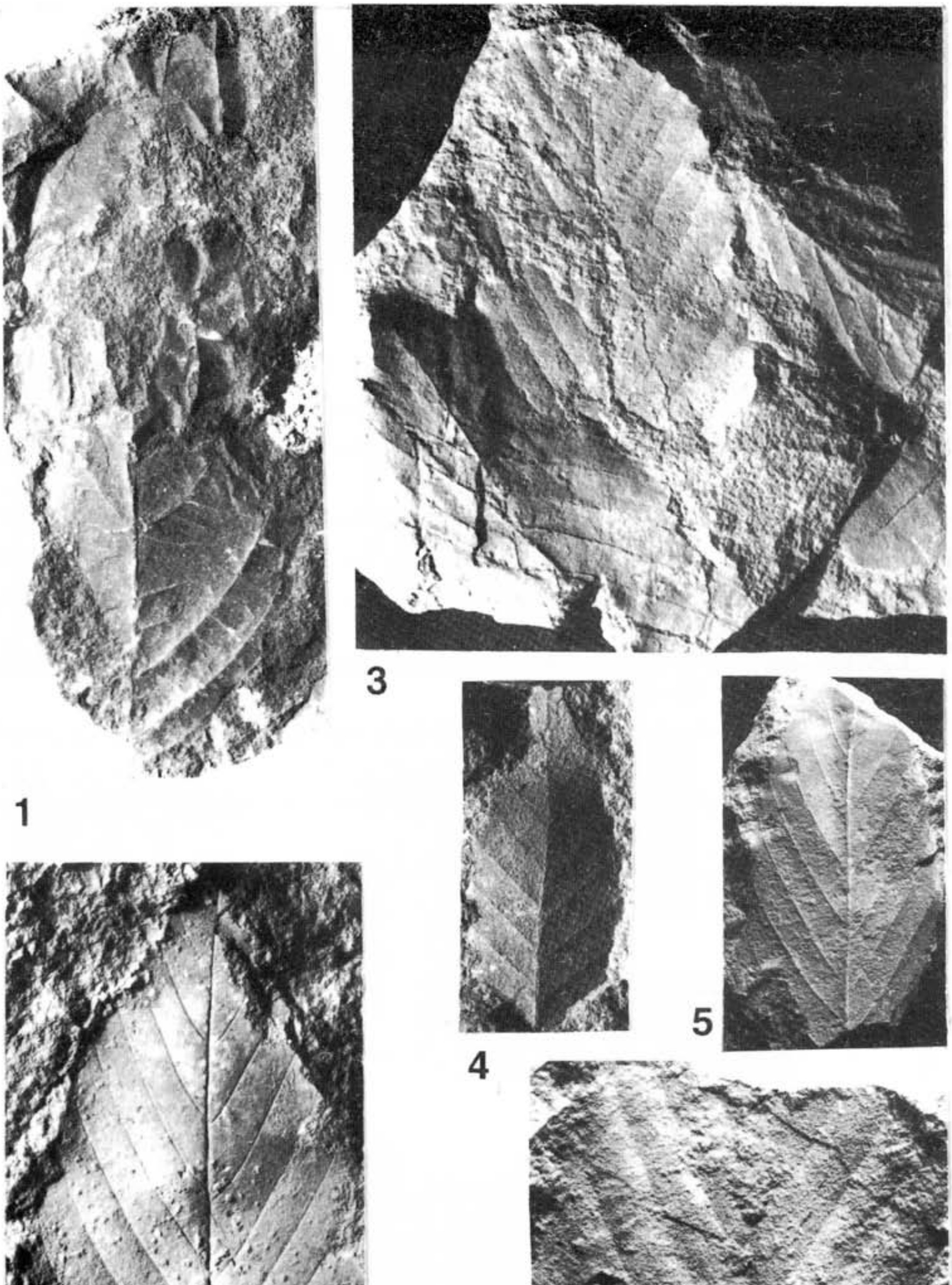
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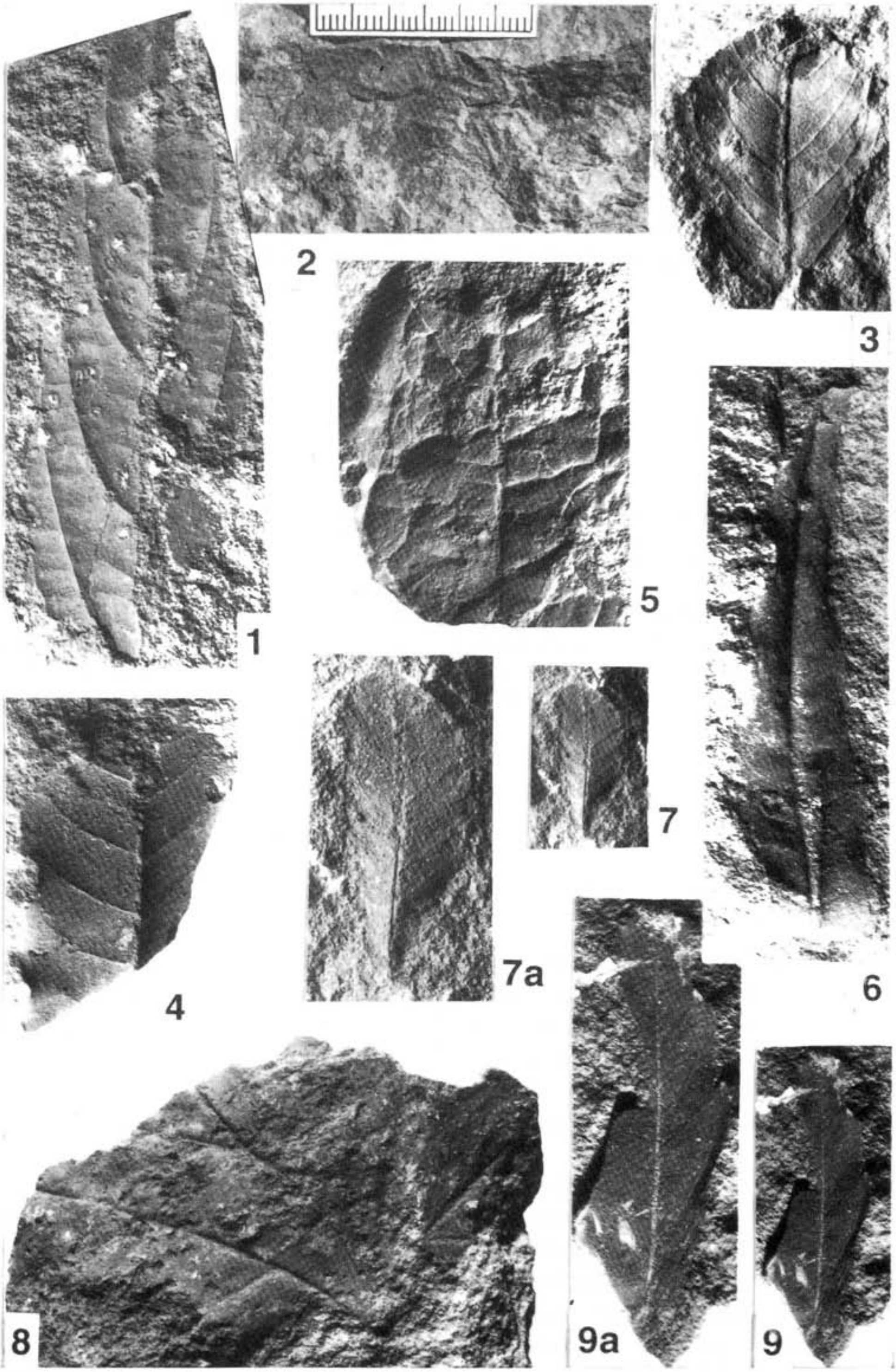
Plate 4

1. Laurophyll morphotype: *Dicotylophyllum* sp. 2, specimen No. ZPAL 77, coll. J. Błaszyk 1978/79
2. *Coniferophyta, Araucaria* vel *Podocarpaceae*, specimen No. KRAM-P 173/12, coll. K. Birkenmajer 1978
3. Indefinite morphotype: *Dicotylophyllum* sp. 10, specimen No. ZPAL 19, coll. J. Błaszyk 1978/79
4. Indefinite morphotype: *Dicotylophyllum* sp. 7, specimen No. ZPAL 26, coll. J. Błaszyk 1978/79
5. Indefinite morphotype: *Dicotylophyllum* sp. 11, specimen No ZPAL 83/2, coll. J. Błaszyk 1978/79
6. Myrtophyll morphotype: *Myrciophyllum santacruzensis* (Berry) Zastawniak gen. nov., specimen No. ZPAL 82/2, coll. J. Błaszyk 1978/79
7. Indefinite morphotype: *Dicotylophyllum* sp. 9, Specimen No. ZPAL 4, coll. J. Błaszyk 1978/79; a – × 2
8. Pentalobaphyll (Araliaephyll) morphotype: *Dicotylophyllum* sp. 4, specimen No. ZPAL 72, coll. J. Błaszyk 1978/79
9. *Dicotylophyllum* sp. div., Specimen No. ZPAL 71, coll. J. Błaszyk 1978/79; a – × 1.5

phot. A. Pachoński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