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GRØNLANDS GEOLOGISKE UNDERSØGELSE

FOSSIL PLANTS FROM THE LOWER PALEOCENE

OF THE AGATDALEN (ANGMÂRTUSSUT) AREA, CENTRAL NÛGSSUAQ PENINSULA, NORTHWEST GREENLAND

BY

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WITH 27 FIGURES IN THE TEXT
AND 55 PLATES

KØBENHAVN
C. A. REITZELS FORLAG
BIANCO LUNOS BOGTRYKKERI A/S
1963

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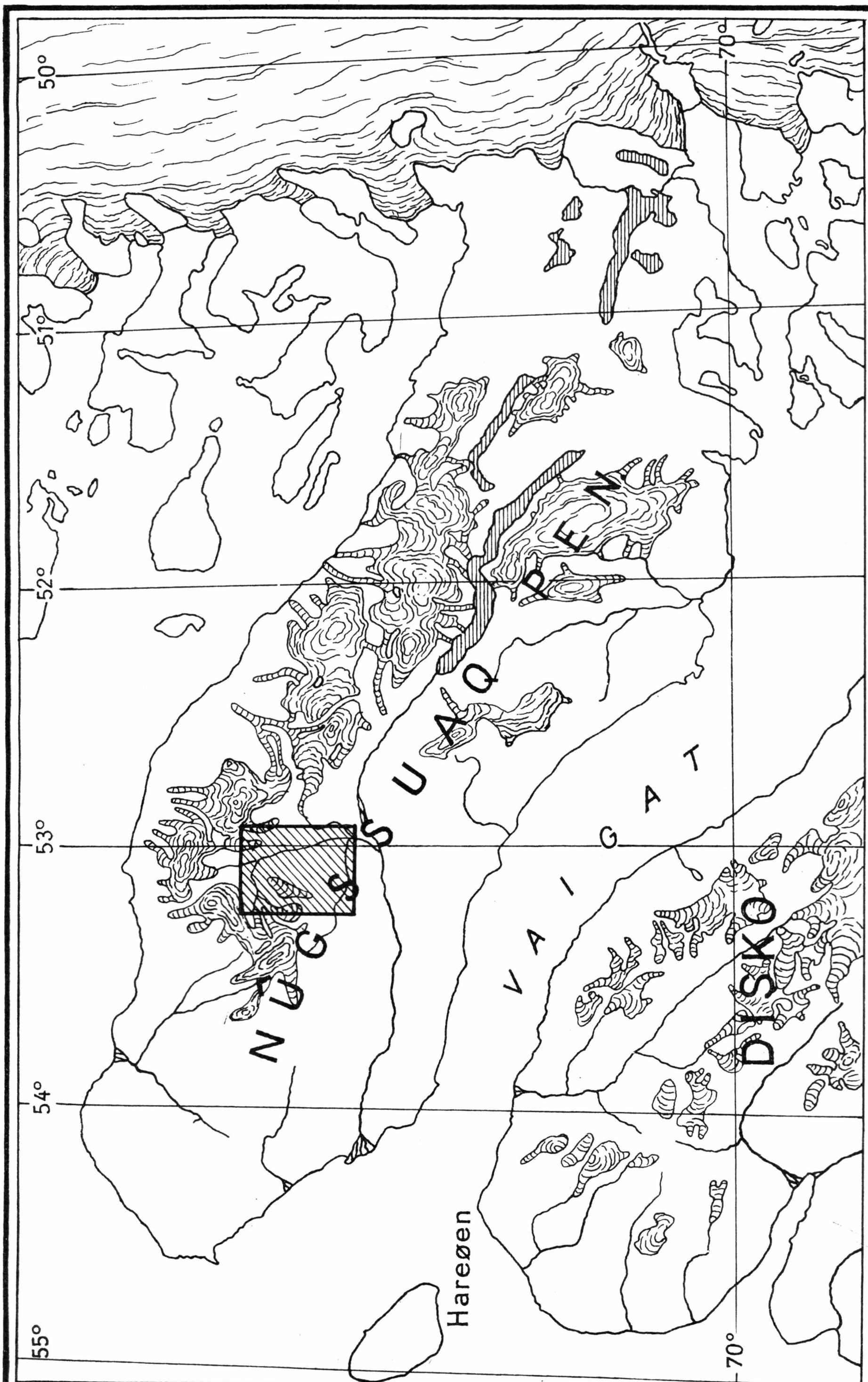


Fig. 1. Map of the Nûgssuaq peninsula and surroundings. The hatched quadrangle demonstrates the position of the Agatdalen area and it corresponds to the map of fig. 2.

Abstract.

In the present paper fossil plants are described, which are mainly impressions, from a number of localities in the *Agatdalen* area of the *Central Nûgssuaq peninsula.* All the plants are known to be *Early Paleocene* in age by means of marine evidence and geological investigations. Their state of preservation and mode of fossilization, their taxonomical position, their frequency and phytogeographical relations, their paleoclimatological and local stratigraphical evidence are discussed. This fossil flora which is designated a MACCLINTOCKIA-METASEQUOIA-CERCIDIPHYLLUM THANATOCOENOSIS is equivalent to the classic *Upper Atanikerdluk A flora* of HEER, in composition as well as in age, and represents the *Arcto-Tertiary flora.*

It is also synchronous with the *Upper Atanikerdluk B flora* (HEER). It gives evidence of a warm (?), temperate climate at the time of deposition. Concerning composition an east asiatic element can still be distinguished here at the very threshold to the *Tertiary*. It contains relic genera from the *Cretaceous.*

PREFACE

The present study has been made under the auspices of the *Geological Survey of Greenland*[1]), the geological mapping of which is proceeding in the Sedimentary Area of Northwest Greenland under the leadership of professor A. ROSENKRANTZ, Copenhagen. The plant fossils treated in the present paper have been collected during his expeditions 1949–1956.

The locality of the Agatkløft canyon was discovered by A. KIILERICH 1948, that of Qaersutjægerdal by ROSENKRANTZ 1952 and that of Kangersôq by H. WIENBERG RASMUSSEN 1952. In the section of the east slope of Agatdalen north of Quleruánguaq the plant fossils were found by GREGERS V. OLSEN 1953.

The collecting was undertaken by SØREN FLORIS, GUNNAR LARSEN and the author; the latter was in the different years assisted by SØREN FLORIS (1949), ARNE DINESEN (1951), KAJ RAUNSGAARD PEDERSEN (1952, 1956) and JOHANNES TOBIASSEN (Niaqornat) (1949, 1951, 1952 and 1956). Many specimens have been obtained by professor A. ROSENKRANTZ and his collaborators during their search for marine fossils.

A preliminary account of this fossil flora and its significance for the stratigraphical investigation of the non-marine *Tertiary* deposits of the south coast of the Nûgssuaq peninsula has been previously published by the author (B. ESKE KOCH 1959).

The determination of the fossils has involved extended studies of materials from Atanikerdluk, of published as well as of unpublished specimens, as the revisions had to take into account these extensive collections in order to be of any significance; and further to allow a final comparison to be made between the Agatdalen flora and that of the *Quikavsak member* of the *Upper Atanikerdluk formation.* Thus there will also be found in this paper descriptions and depictions of fossil plants from localities of this member.

The collections from Atanikerdluk, which have been utilized, mostly belong to the Mineralogical Museum of the University of Copenhagen; thus when type-collection numbers are cited on the plates and text-figures, the abbreviation MMUH[2]) no. refers to the type-collection of

[1]) Abbreviated G.G.U. (danish: Grønlands Geologiske Undersøgelse).
[2]) Museum Mineralogicum Universitatis Hafniensis.

this museum. Elsewhere the abbreviation Min. Mus. is used for this museum. Grants from the Mineralogical Museum and from the University of Copenhagen have made possible the different journeys which were needed for the studies (e.g. to Stockholm and London).

The Herbarium of the Botanical Museum of the University of Copenhagen has been the basis for the author's comparative studies and for the search for recent relatives of the fossils. These studies have been continously undertaken for long periods and the author thankfully remembers the late Dr. H. Mølholm Hansen who was always ready to assist with his botanical experience. I express my thanks to the Keeper for the permission to liberal utilization of the collections of the museum.

Furthermore the author has visited the British Museum, Natural History of South Kensington where he has studied the Atanikerdluk collections under the kind instruction of the late Keeper, Dr. N. W. Edwards.

During several visits to the Paleobotanical Department of Naturhistoriska Riksmuseet, Stockholm, professor, fil. dr. O. H. Selling has generously placed the resources of the Department at my disposal to assist my studies of the Atanikerdluk collections; I have to express my cordial thanks.

The following technical specialists have assisted the author:

Photography: Mr. Chr. Halkier.
Cartography: Mr. H. F. Røhling.
Drawings: Miss Gunni Jørgensen, Mrs. Ragna Hansen.
Preparation: Mrs. B. Bang Soltau has kindly undertaken preparation of a number of difficult specimens.
Translation: Mr. Brian F. Windley, B.Sc. has been kind enough to correct the manuscript.

I beg to express my gratitude to all who kindly assisted in any way during this prolonged study.

Mineralogical Museum, Copenhagen.
February 1962.

B. Eske Koch

DESCRIPTION OF THE LOCALITIES

The fossil plants, which are described in the present paper, have been collected from several localities, situated in the *Agatdalen valley* and its tributaries. These sites are marked on the maps of figs. 1 and 2. The relevant localities are:

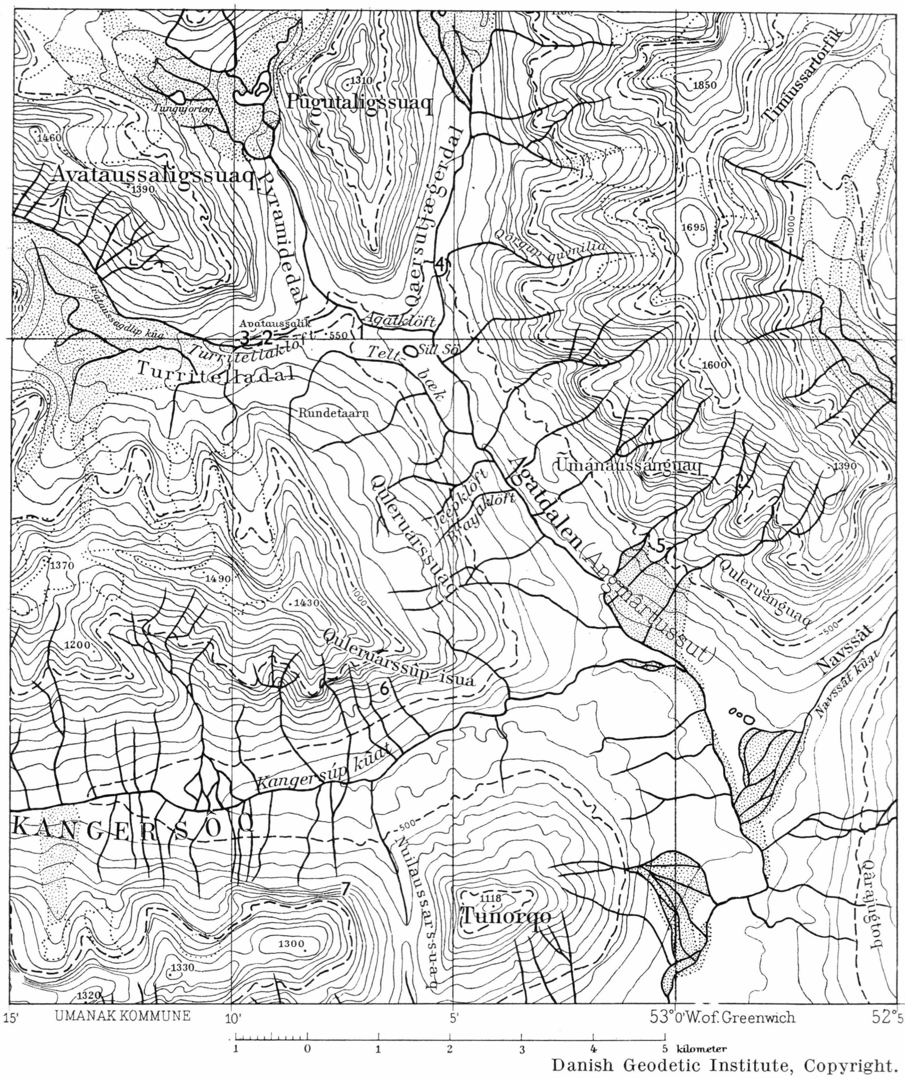
1. *Agatkløft*
2. *Turritellakløft: Big section*
3. *do. : Scaphitesnæsen*
4. *Qaersutjægerdal: Big section*
5. *Agatdalen, east slope north of Quleruánguaq*
6. *Kangersôq: Quleruarssûp isua*
7. *Kangersôq: At Nuilaussarssuaq*

The numbers refer to those on the map of fig. 2.

The geology of the Agatdalen area was investigated by professor A. Rosenkrantz on the *Danish Nûgssuaq expeditions 1938–1939* and later under the auspices of the *Geological Survey of Greenland* (Copenhagen) still under his leadership (ref. Rosenkrantz 1940, 1951). A detailed description has not yet been published but the *Paleocene* was preliminarily described by Rosenkrantz in (B. Eske Koch 1959); and the following information comes from the former by personal communication.

In this area *Cretaceous* and *Tertiary* deposits are exposed. In the Agatdalen valley *Cretaceous* (*Senonian*) deposits outcrop in the cliffs along the river. They are fossiliferous; the facies are marine and transitional. Along the valley slopes of the southern part of the Agatdalen valley, some hundred metres higher, scattered exposures exhibit marine *Danian* and *Paleocene*. These sediments are overlain by *Tertiary extrusives.*

A prominent fault crosses Agatdalen in a nearly east-westerly direction (NNW–ESE), crosses the Agatkløft canyon about 100 metres N. of the Teltbæk torrent's outlet and appears in the Turritellakløft canyon at Scaphitesnæsen. The area north of this fault is downthrusted in relation to the main area of Agatdalen. In the Agatkløft canyon



Danish Geodetic Institute, Copyright.

Fig. 2. Map of the Agatdalen area 1:100000. The localities of the *Early Paleocene* plants are marked with numbers: 1: Agatkløft; 2: Turritellakløft, Big Section; 3: Turritellakløft, Scaphitesnæsen; 4: Qaersutjægerdal, Big Section; 5: Agatdalen, east slope north of Quleruánguaq; 6: Kangersôq, Quleruarssûp isua; 7: Kangersôq, Nuilaussarssuaq.

(within the downthrusted region) the lowermost exposures show *Danian* beds overlain by *Paleocene*, which is again covered by the *Tertiary extrusives*; the *Paleocene* succession is well exhibited in the Turritellakløft canyon. On account of the marine fossils in nearly all localities in question, we can, in spite of the faulting, easily reconstruct the *Paleocene* zone over the whole area and treat it as an entity. The age determination of the "north block" (the downthrusted area) is effectively secured by means of the rich, marine fauna of Turritellakløft, Agatkløft and Qaersutjægerdal (ROSENKRANTZ 1951). Aided by a similar but poorer fauna in the Agatdalen valley and at Kangersôq, this age is also valid for the plant fossils of the localities of the "south block" (the localities 5, 6, 7).

Concerning the terminology of the *Paleocene* deposits, reference should be made to ROSENKRANTZ in (B. ESKE KOCH 1959).

1. **Agatkløft:**

This is the canyon of the Agat river between its points of confluence with the Turritella and Qaersutjæger rivers. The plant fossils from this locality are derived from the *Sonja member* of the *Agatdal formation.* This consists of clastic sediments varying in grain size from shale to conglomerate grade which vividly change throughout the exposures. The *Sonja member* is interpreted as a delta deposit, and so the lenticular structure is predominant. Marine zoo-fossils have been found at several levels together with scattered plant fossils. On the other hand in at least two levels plant fossils predominate over scattered invertebrate remnants.

The main exposures, where the plant fossils are found, are in the Agatkløft canyon a few hundred metres downstream from the point of confluence of the Turritella- and Agat rivers (ref. fig. 2: (1) and fig. 3). Here, in the southwestern wall of the canyon, a nearly continous section can be studied stretching from the river bed to the top of the canyon, a total of about 80 metres. On the slope seen in fig. 3 the section is accessable along a spur passing from the lower left upwards towards the middle of the upper edge of the picture. This spur begins at the river bed at an altitude of 430 m. About 30 metres above the river a lenticular, tough, well-consolidated, grey sandstone contains leaf impressions (discovered by KIILERICH 1948). This leaf bed is 2 metres below a loose, light sandstone lens (the Sonja lens) which contains a huge, fossil marine fauna and scattered fossil fruits. In the canyon wall, a little to the north of this spur (just above the person in the picture of fig. 3) another lenticular bed of light ochreous sandstone occurs, which is rich in plant fossils (discovered by the author 1949). This sandstone is also situated about 30 metres above the river, but according to the dip it represents a level a few metres above the first mentioned grey sandstone (the Kiilerich lens). It has furnished the majority of plant fossils from the Agatkløft canyon. The rock is light grey, nearly white, weathering to a light ochreous colour, is weakly consolidated and so is easily workable. It is of intermediate grain size but not well sorted, is rich in quartz but

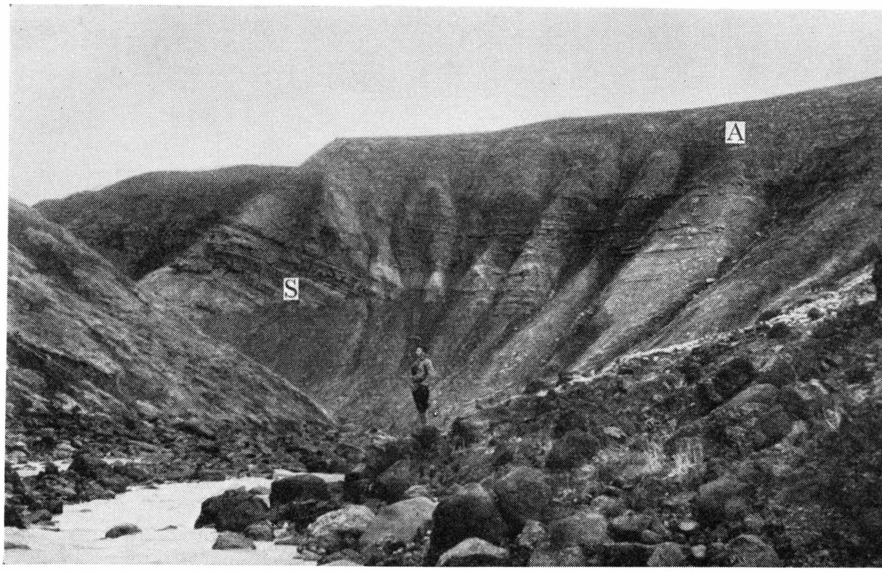


Fig. 3. The fossiliferous locality of the Agatkløft canyon (ref. fig. 2: (1)). S: The *Sonja member* delta deposits. A: Bituminous shale corresponding to *Turritellakløft member*. — Koch phot.

has a small felspar content which may justify the distinction arkose. Here and there conglomeratic inclusions occur with pebbles and scattered invertebrate fossils. Pieces of charcoal are common. Plant detritus is predominant towards the top of this bed, but recognizable plant remains seldom occur (coniferous sprays and single dicotyledonous leaves were found). The better preserved plant impressions are abundant in the lower part of the bed, while the central part is nearly unfossiliferous. The plant impressions are preserved in an iron oxide precipitate (ref. pag. 16). The delta structure of the *Sonja member* is to the northwest seen to reach into the black shale of the *Turritellakløft member* (ref. pag. 13). When under the description of the fossil species Agatkløft is referred to without comment, it covers this locality of the west wall of the canyon.

Opposite the section just described, on the east side of the canyon there is a smaller outcrop consisting mostly of sandstones which reach 10–20 metres up from the river bed. Here a rather loose sandstone, lithologically exactly equivalent to the above mentioned light grey sandstone (weathering to a light ochreous colour), contains plant impressions preserved in iron oxide precipitate as in the main fossiliferous rock of the west section. This is at a slightly lower altitude than the corresponding locality of the west slope. Whether it is the same or a third level is not certain, but it is not far from the other lenses.

2. Turritellakløft: Big section.

In the north slope of the Turritellakløft canyon about one kilometre upstream from the confluence of the Turritella- and Agat rivers there is a big outcrop, which forms the type section of the *Agatdal formation.* It contains 3 members: A) *Turritellakløft member*, B) *Andreas member* and C) *Abraham member* (ref. ROSENKRANTZ in B. ESKE KOCH 1959).

The *Turritellakløft member* consists of black shale (max. 50 metres) including lenticular sandstone beds, which must be regarded as protuberances of the deltaic *Sonja member* of the Agatkløft outcrop, which interdigitates with the black shale. The sandstone lenses have yielded plenty of marine invertebrate fossils. A few plant fossils have also been found.

3. Turritellakløft: Scaphitesnæsen.

On the south slope of the Turritellakløft canyon, just to the east of the fault which passes across the upper Agatdalen valley, there is a spur called the Scaphitesnæsen. Here, above *Senonian* shales, there is a small section of the *Turritellakløft member* shale overlain by sandstone. This section is within the zone of influence of the fault. The shales and finegrained sandstones are extremely fissured to a degree which is almost a brecciation. Later a mineralization of the fissures has taken place e.g. crystalline siderite is common. The *Paleocene* part of the section contains in its lowermost bed (shale and fine-grained sandstone) plenty of fossil fruits; many are well preserved and reveal microscopic, organic structures. Many have undergone deformation by the faulting. Marine invertebrates are found in this bed together with the fossil fruits as well as in the sandstone above.

4. Qaersutjægerdal: Big section.

In the eastern slope of the Qaersutjægerdal valley just to the north of the tributary creek of Qôrqup quvnilia, a steep cliff rises from the river bed, exposing a sedimentary section about 24 metres high, which is overlain by *Tertiary* extrusives ("basalt breccia"). The uppermost 18 metres of the sediments comprising a basal conglomerate (about $1^1/_2$ m), about 7 metres of sandstone and above these shale and tuffs, are *Paleocene* in age. These overlie *Danian* (?) shales.

A loose ochreous sandstone, 10–14 metres above the river bed, has in its lower part plenty of small, ochreous sandstone concretions which contain fossils of invertebrates as well as of woods and fragmentary leaves. From the loose sandstone proper several well preserved fossil fruits have been collected.

In the following the designation Qaersutjægerdal covers this locality.

From the yellow *Turritella sandstone* just above the basal conglomerate several fossil leaves have been detected. This bed can be traced upstream until it finally disappears in the river bed, near where it has yielded fossil leaves in two places.

5. **Agatdalen: East slope north of Quleruánguaq.**

In the east slope of the Agatdalen valley just north of Quleruánguaq there are 3 big ravines, in which small outcrops of *Paleocene* sediments have been found. In the central ravine one outcrop shows clastic sediments below *Tertiary* extrusives (limit at about 560 m). The sediments are of shale and sandstones; one sandstone at about 530–540 m contains plant impressions and another at about 530 m marine molluscs. Downstream the beds disappear under scree. The total width of exposure of these sediments is about 100 metres.

6. **Kangersôq: Quleruarssûp isua:**

Kangersôq is a big tributary valley entering the lower Agatdalen valley from the west. On its northern slope, about 4 km west of the confluence of the Agat river with that of Kangersôq, there is a ravine in the spur of Quleruarssûp isua. When entering the valley, this is the first ravine encountered in the northern slope of Kangersôq. At the top of this ravine fossil plants have been found about 45 metres below the "basalt breccia" which here overlies the sediments (fig. 4).

The sediments in question are medium grained sandstones, finegrained sandstone alternating with bands of black shale, and well-consolidated concretionary siltstone. At an altitude of about 610 m a siltstone lens in particular has yielded well-preserved plant fossils. Also the shales are rich in plant fossils, but they are strongly fissured and fragile and thus are unsuited to lengthy transport. The above mentioned siltstone lens was worked out during the collecting of 1956.

Owing to the scree the lower limit of the *Paleocene* beds has not been observed in this ravine.

These beds have been positioned in age by means of marine *Paleocene* fossils found a short distance further to the west at about the same level on the north slope of Kangersôq valley. When in the text and explanations to the plates Kangersôq is referred to without comment, it covers this locality.

7. **Kangersôq: At Nuilaussarssuaq.**

In the west slope of the pass of Nuilaussarssuaq and also continuing towards the west on the south slope of Kangersôq, there is a *Paleocene* sequence situated immediately below the *Tertiary extrusives* (lower limit

Fig. 4. View from the Qârajugtoq towards the outlet of the Kangersôq valley. (6) marks the ravine with the fossiliferous locality of the Quleruarssûp isua. The light spots on this valley-slope are sedimentary exposures. The sediments are overlayn by *Tertiary* extrusives with a much steeper gradient which makes the nearly horizontal lower limit of the extrusives easily recognizable. The *Cretaceous* exposures of the Kangersôq river's canyon peep out to the right of (6). In the foreground the Agat river's canyon. — K. Raunsgaard Pedersen phot.

of the "basalt breccia": about 770 m). Its age has been determined by abundant marine invertebrates, which is also the case for the underlying *Danian*. On the spur, which forms the divide between the pass and Kangersôq, a few fragmentary leaf impressions have been found, which are remarkable, because they have been preserved in a red clay-ironstone, identical to that in the *Lower Paleocene* fluviatile outcrops of the south coast of the Nûgssuaq peninsula, which derive from a facies-milieu further upstream. This is the only occurrence of this facies in the Agatdalen area.

STATE OF PRESERVATION OF THE FOSSILS

The plant fossils from the area in question are leaf impressions, fossil fruits and woods. Only the former are treated in the present paper. The fruits, of which the most representative are being studied by the author at present, are not yet ready for publication. The woods are still untreated.

The fossils are derived from several localities and different plant structures are represented, consequently we find different states of preservation present. The leaf impressions are the object of this paper and they will be the main subject of the present chapter.

The sediments, which contain the leaf impressions, vary from coarse and medium grained sandstones from the localities at Quleruánguaq and Agatkløft to the siltstone of Kangersôq.

The modes of preservation of the plant fossils from Agatkløft and Kangersôq are different. They are found in sediments of different grain size and to a certain degree different composition. The impressions occur in varying media and the amount of incoaled matter preserved from the original, organic structure is distinctively different. This is obviously demonstrated by their colour alone. This points towards differences in the milieu of deposition and/or fossilization.

The plant fossils from Agatkløft are impressions in a pre- and perhaps partly syn-diagenetic ironoxide precipitate, in which there are only sparsely preserved incoaled remnants of the leaf veins. The iron precipitate seems to play a less important role in the impressions from Kangersôq (though probably contributing), but their black polish (on unweathered specimens) does point towards a higher degree of preserved incoaled matter. But the latter is still not sufficient to allow cuticles to be prepared.

Plant fossils preserved in sideritic shale and clay-ironstone well known from the localities higher upstream of the *Paleocene* water courses (e.g. Atanikerdluk) (pure fluviatile facies) are only found in Nuilaussarssuaq in small amounts. Here they are restricted to fine grained sediments.

As mentioned above the fossils from the Agatkløft canyon are impressions in a pre- and perhaps partly syn-diagenetic iron-oxide precipitate, which the author has studied in more detail. This investigation is still in progress. The main criteria are 1) that the impression is preserved in a flat, incipient concretion, max. thickness 1 cm, varying down to a millimetre, and which on the edges is bounded by the margin of the leaf (fig. 5). This concretion consists of sand grains consolidated by a bluish-black iron-oxide matrix.

The proportion of iron-oxide increases inwards and so is predominant on the surface of the impression. Due to the weathering the leaf impression stands out as a brown structure on the background of the

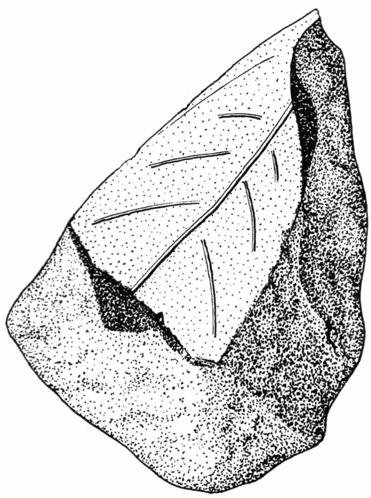


Fig. 5. Simplified sketch of a leaf-impression in sandstone, with extensive iron-oxide precipitate (black) visible in the cross-sections. Agatkløft (G.G.U. label no. 12896.156). Gunni Jørgensen del.

light ochreous to grey sandstone (ref. the plates e.g. pl. 30 fig. 3). It is remarkable that this colour is accurately bounded by the leaf margin which connects the initiation of the iron-oxide precipitate intimately to the leaf. The precipitate consists of iron-oxides (Fe_2O_3 and FeO), the total amount of which varies between 14,38 $^0/_0$ and 24,35 $^0/_0$ in 8 analysis (Me Mouritzen, Min. Mus. Chem. Lab. Copenhagen). The surrounding sediment varied in the same series of analysis between 1,51 $^0/_0$ and 2,57 $^0/_0$ total. The Fe^2 takes a prominent position, often outweighing the Fe^3. In this connection it is remarkable that Fe^2 is found in the leaf concretion in a relatively higher percentage than in the surrounding sediment. 2) Further the original substance of the leaf has been removed except for incoaled remnants and traces of the nervation. Consequently the leaves have undergone disintegration by putrefaction. Depending on the presence of oxygen, this has been an early process acting on the leaves during their transport in the aerated river water and during their deposition and initial burial in the sediment. No criteria for later removal, i.e. by oxidation, of the organic remnants of the leaf (in the subfossil or fossil state) thus affecting the surrounding sediments, have been observed.

A softened leaf suffering disintegration should have no chance of leaving a detailed impression in a coarse to medium grained sandstone unless some sort of fixation has taken place to outweigh the softening. Tests in Danish water courses, which the author has in progress, already at this early stage show that a precipitation of iron compounds takes

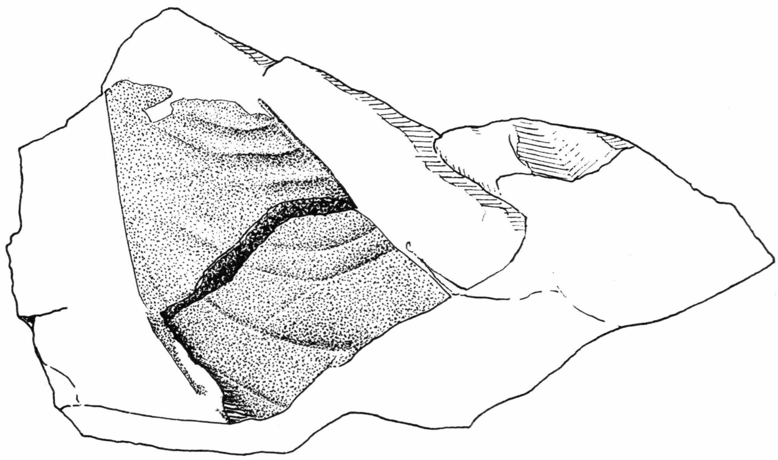


Fig. 6. Sketch of an impression in sandstone of a leaf, which is folded along the primary vein (to the right). Between the two limbs there is extensive iron-oxide precipitate (black). 1:1. Agatkløft (G.G.U. label no. 12896.11). — Gunni Jørgensen del.

place on the leaves under transport and sedimentation in a river under our climatic conditions. So this process represents a means of fixation.

In this way the author is lead to the supposition that the iron-oxide precipitation and the process of fossilization leading to the leaf impressions of the Agatkløft locality are *pre- and perhaps in their continuation early syn-diagenetic*, proceeding during deposition and sedimentation and producing an initial concretion.

A more detailed report on this investigation will follow, when more extensive material has been collected and treated.

When it is possible to show that the leaves, which fall into streaming (aerated) water, by means of a process of disintegration cause a precipitation of the iron compounds of the water (e.g. colloidal Fe_2O_3 stabilized by some organic colloid, which is a normal state according to Moore & Maynard 1929) there is reason to assume a quantitative relation between the amount of organic matter present (i.e. the thickness of the leaf) and the amount of precipitate under stable conditions. As many factors are involved in the process in nature, a simple function cannot be expected. However studies of the structural relations between fossil and precipitate have caused the author to accept, in obvious cases, a connection between thick precipitation and thick textured leaf and vice versa. In some cases this may form a supplementary criteria to an actual determination. (This conclusion affects our ideas of *Macclintokia Kanei*, ref. pag. 77). Also in the sini of crumbled leaves, where a small amount of sediment is surrounded by the leaf matter, the precipitate is more extensive (fig. 6).

In accordance with this assumption most of the leaf species of the fossil flora of the Agatkløft locality have a thin iron-oxide precipitate. The fossil flora of the Agatdal area indicates a temperate, deciduous forest i.e. a forest with predominantly thin-leaved species. A few examples of thick-leaved species are represented e.g. leaves which morphologically correspond to the *Rhododendron*. These show a thick iron-oxide precipitate, as we should expect.

This phenomenon has been utilized with discretion by the author during the last stage of the description of the fossil flora, as the investigation of this process of fossilization and concretion formation is far from finished. In particular quantitative relations need further proof.

SYSTEMATIC DESCRIPTION

In the following the fossil plants are described from the localities of the *Agatkløft canyon*, the *Qaersutjægerdal valley* and the *Kangersôq valley*. The bulk is of leaf impressions, in a few cases supplemented by reproductive organs. The fossil fruits from the locality of Scaphitesnæsen (Turritellakløft) will be published in later publications.

The descriptions have been arranged into the following categories:

1. *Cryptogames*
2. *Coniferae*
3. *Angiospermae*
   - A. *Monocotyledones*
   - BA. *Dicotyledones*
   - BB. *Dicotyledones incertae sedis*
   - BC. *Dicotyledonous Designs*

A high proportion of these fossils, especially those from the Agatkløft canyon, are rather badly preserved, and thus the proportion, which can be determined, is restricted. Consequently there is with the described fossil assemblage, the risk of being unrepresentative of the original flora (sylva). Valuable criteria may be hidden in the undetermined residuum, but it might be possible to unveil some of them. At least some negative evidence may be accessible. So it has become urgent in some way or other to describe as much of this residuum as possible, without overloading the chapter on taxonomical descriptions with fossil species, which are taxonomically unreliable.

With this purpose in mind there has been added a supplementary category under the heading "*Designs*" (ref. Dicotyledonous Designs pag. 91).

By *design* the author means a fossil "species", which does not exhibit such criteria as are necessary to secure a determination to a particular family or genus and/or which cannot be considered likely to cover a natural species and/or which does not allow an effective diagnosis. However on the contrary, they can be identified or compared with earlier, described fossil "species" that, in the author's opinion, cannot be referred to the ordinary taxonomical categories or which on the present material cannot be adequately revised on account of the lack of the above-mentioned attributes.

In spite of these drawbacks it may be important just to be able to register such fossils. Although the latter are of no value in the paleobotanical sense, they may comply with the geologist's needs for recognizable criteria to characterize his rock units, at least provisionally. And they may help the reader to get a fuller impression of the collection; or of what may be hidden in the undetermined residuum. When, in the study of *Tertiary* stratigraphy, we are moving more and more away from the dependence on index fossils and into a utilization of the former biological communities, the residuum must be kept in mind. But even in the traditional sense it may contain evidence.

The "species", which are recorded under the heading "*Design*", evade evaluation and determination according to the natural taxonomical system and *should not be introduced into the catalogues in association with good species.* They must be regarded as *undetermined.*

All the fossil specimens, which are depicted in the present paper, are kept in the Original Collection of the Mineralogical Museum, University of Copenhagen.

Cryptogames.

Cladophlebis groenlandica (Heer) Bell.

(pl. 1 figs. 1, 2).

Bell (1949) pag. 38 pl. 26 fig. 2.

Synonyms: *Pteris groenlandica* Heer (1883 a) II, 2 p. 49 pl. 70 figs. 1–5 pl. 107 fig. 1.
Pteris oeningensis Heer (1880 a) p. 9 pl. 3 figs. 2–4, 8 b.
Pteris sitkensis Dawson (non Heer) (1890 a) p. 70 pl. 10 fig. 1.

Two specimens of this species referred to the form genus *Cladophlebis* have been collected from the locality of Kangersôq valley. They are fragments of sterile pinnae, which are fairly well preserved. They agree with the fragments of fern leaves described by Heer as *Pteris groenlandica.* As no reproductive organs have been found, it has not been possible to determine its relation to recent ferns and I have preferred, in agreement with Bell, to use the neutral determination of the form genus *Cladophlebis.* I cannot agree with Heer's determination, as no reproductive organs were found on his specimens either. The species must be regarded as a provisional one.

Occurrences in Greenland:

Lower Paleocene:

Kangersôq Valley, Atanikerdluk (*Quikavsak-* and *Naujât members* of the *Upper Atanikerdluk formation*).

Outside Greenland:

Mackenzie River, Alberta (*Paleocene*).
Controller Bay region, Alaska (*Paleocene* or *Eocene*).

Hemitelites Torelli HEER.

(pl. 1 fig. 4, 6).

HEER (1868) pag. 88 pl. 1 fig. 15.
HEER (1869 b) pag. 462 pl. 40 figs. 1–5 a.

A well-preserved pinula fragment has been found in a concretion from the Qaersutjægerdal valley.

It is deeply cut and shows the alternate, entire, rounded obtuse lobes with stout midrib. In the continously forked nervation of the lobes a pseudo-midrib (a "secondary") can be distinguished.

The morphological similarity with HEER's specimens of *Hemitelites Torelli* justifies the determination as far as it states the identity of the two findings. Concerning the taxonomical position the author finds it undeterminable and so admits the form-genus of HEER useful.

Occurrence in Greenland:

Lower Paleocene:

Qaersutjægerdal, Atanikerdluk (*Quikavsak member* of the *Upper Atanikerdluk formation*).

Gymnospermae.

CLASS: GINKGOINÆ

Ginkgo adiantoides (UNG.) SHAPARENKO.

(pl. 1 figs. 3, 5).

SHAPARENKO (1935) pag. 12.

Synonyms: *Salisburia adiantoides* UNGER (1850) pag. 392.
Salisburia Procaccinii MASSALONGO et SCARABELLI (1858) pag. 163.
Salisburia borealis HEER (1868) pag. 95.
Ginkgo adiantoides (UNGER) HEER (1874 c) pag. 14.
Ginkgo primordialis HEER (1874 a) pag. 100.
Ginkgo integriuscula HEER (1877) pag. 44.
Ginkgo reniformis HEER (1879) pag. 32.
Ginkgo laramiensis WARD (1885) pag. 549.

Two specimens have been found in the fossiliferous localities of the Kangersôq valley and the Agatkløft canyon.

The specimen from the Kangersôq valley demonstrates an incomplete leaf, which has been reniform with a deep median incision opposite the petiole. The base is cordate. The nervation radiates from the fixing point of the petiole and develops by a continous forking. The small part of the leaf margin, that is left, is undulating. The specimen from the Agatkløft is of a fragment of a small leaf apparently without incision and with cuneate base.

Undoubtedly at least the leaf from the Kangersôq valley belongs to a *Ginkgo* and both are without difficulty incorporated in the variation, which SHAPARENKO (1935) ascribes to *Ginkgo adiantoides*, the probable forerunner of the recent *Ginkgo biloba*.

Occurrences:

West Greenland:

Lower Paleocene:

Agatkløft (*Sonja member* of the *Agatdal formation*),

Kangersôq,

Atanikerdluk (*Quikavsak member* of the *Upper Atanikerdluk formation*).

Probably Lower Paleocene:

Qudtligssat (probably equivalent to the *Quikavsak member* of the *Upper Atanikerdluk formation*).

Undetermined Tertiary:

Marraq?

Ûnartoq?

Puilassoq?

Intrabasaltic:

Hareøen (Qeqertarssuatsiaq).

East Greenland:

Paleocene?:

Sabine Ø.

Outside Greenland, wide-spread in the temperate Tertiary.

CLASS: CONIFERÆ

Family: Taxodiaceae.

Metasequoia occidentalis (NEWB.) CHANEY.

(pl. 2, 3, 4).

Synonyms: Ref. CHANEY (1951) pag. 225.

Many samples of this species have been collected from the fossiliferous locality on the northern slope of the Kangersôq valley. They are foliage shoots as well as pistillate cones. 4 samples representing fragments of foliage shoots were found in the Agatkløft canyon, and the Qaersutjægerdal valley has yielded a fragment of a pistillate cone. The state of preservation of the Kangersôq valley specimens is fairly good, but the fossiliferous sandstone of the Agatkløft is too coarse to fix the details; and these plant-remains were too small to cause a sufficient amount of iron oxides to be precipitated (ref. pag. 16) to make up for this disadvantage.

This material is referred to the *Tertiary* species of *Metasequoia* established by Chaney in 1951, *Metasequoia occidentalis*, as all the visible characters are in accordance with Chaney's descriptions and pictures.

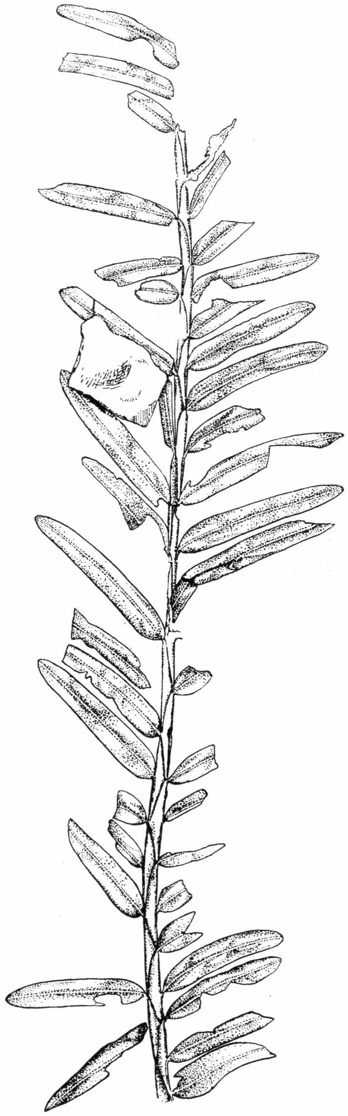


Fig. 7. *Metasequoia occidentalis* (Newb.) Chaney: Long shoot. 3:2. Atanikerdluk (Min. Mus. label no. 1865.801 a). — Gunni Jørgensen del.

Description:

The Foliage shoots. (pl. 2, 3, textfigs. 7–12).

Among the fossils there are fragments of long shoots with attached short shoots as well as isolated short shoots. Unlike the long shoots and compound specimens, the short shoots are very common.

The Long shoots. (pl. 2, textfigs. 7–8).

These occur as fragments with combined short shoots. Only one nearly complete isolated specimen has been found.

The long shoots bear the short shoots, which lie opposite each other, but may be opposed by a leaf or the scar of a detached leaf or short shoot. These samples only present scarce information on the phyllotaxy of the long shoots, and though these shoots by thorough investigation reveal opposite leaves (pl. 2 fig. 1), the information is not sufficient for a determination without reservations were it not for the

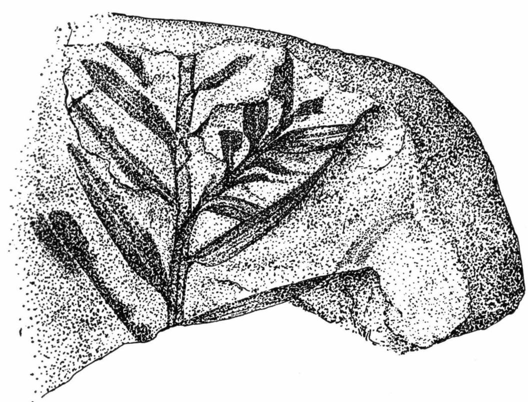


Fig. 8. *Metasequoia occidentalis* (NEWB.) CHANEY: Fragment of a long shoot with a tiny short shoot departing from a leaf-angle. 2:1. Kangersôq (G.G.U. label no. 35492. 7). — GUNNI JØRGENSEN del.

observations on the short shoots. The leaf bases are obscure owing to their state of preservation. The rock is so tough that the incoaled axes are cleaved together with the stone, being mineralized and incorporated in the mineral framework of the rock. The attached short shoots (pl. 2 figs. 1–4) show however decussate phyllotaxy and are certainly determinable as belonging to *Metasequoia*.

A common feature of these plant-remains, deposited in river beds, is that they are marked by the transportation and deposition, which they have suffered (pl. 2 figs. 3–4, pl. 3 fig. 6). The specimen of pl. 2 figs. 3–4, has been affected in this way, where not only the majority of the leaves are lacking, but also two of the attached short shoots are broken. Further, all the remaining leaves of the long shoots are turned in all directions and do not all appear at once, since the rock is cleaved. This is why the specimen of pl. 2 fig. 1 does not give a convincing impression of the accuracy of its determination. But a thorough investigation of the positive and negative impressions of the fossil shows 4–5 pairs of opposite leaves.

Apart from the leaf bases not being visible, the leaves on these shoots are of the same type as those of *Metasequoia*: Linear with parallel margins and abruptly rounded at the apex and base, short petiolate with strong and prominent midrib on the impressions. On the sample of pl. 2 fig. 1 the leaves are 16–20 mm long and abt. $1^1/_2$ mm broad.

For reference a specimen from Atanikerdluk (*Quikavsak member*) is depicted pl. 2 fig. 5 and textfig. 7.

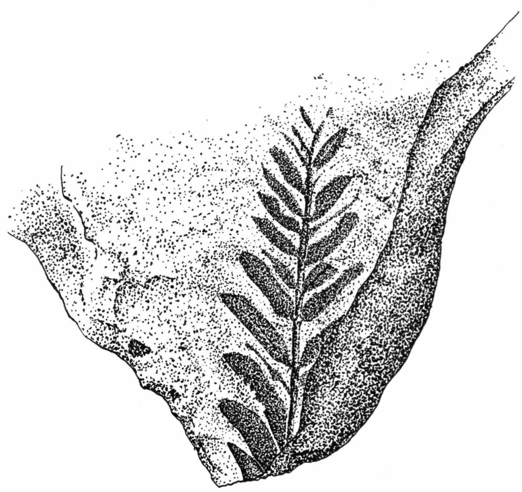


Fig. 9. *Metasequoia occidentalis* (Newb.) Chaney: Fragment of a short shoot; impression in sandstone. 2:1. Agatkløft (G.G.U. label no. 12896.169). — Gunni Jørgensen del.

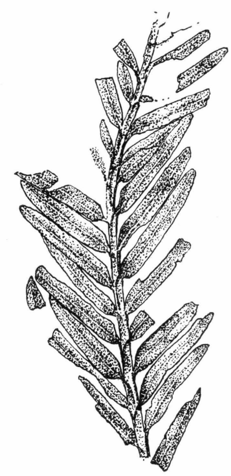


Fig. 10. *Metasequoia occidentalis* (Newb.) Chaney: Fragment of short shoot. 2:1. Kangersôq (G.G.U. label no. 35492.11). — Gunni Jørgensen del.

The Short shoots. (pl. 3, textfigs. 9–12).

All the depicted short shoots have a slender axis, and it is immediately obvious that the leaves are opposite and apparently distichous. The leaves are close-set and 8–11 mm long, 1–2 mm broad and the number of pairs varies between 10 and 20. The angle between leaf and axis is wide on single well-preserved specimens (i. e. pl. 3 fig. 1) in accordance with Chaney's description (60°–90°). But most common are angles of abt. 45°. This discrepancy is probably not real but apparent, and may be referred to the plant-remains being deposited in current water that makes its influence felt in several ways as mentioned above. The stream may have turned the leaves forward along the axes, after the shoot had gone to rest on the bottom. Specimens of such shoots, the leaves of which have been turned almost parallel to the axis, are known from the river sediments of *Quikavsak member* of Atanikerdluk.

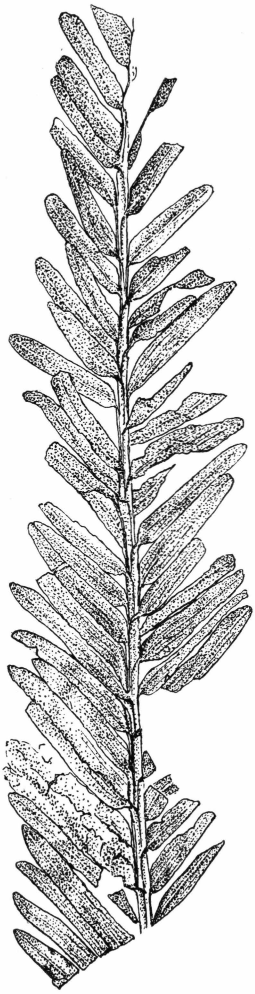


Fig. 11. *Metasequoia occidentalis* (Newb.) Chaney: Short shoot. 2:1. Kangersôq (G.G.U. label no. 29759.22). — Gunni Jørgensen del.

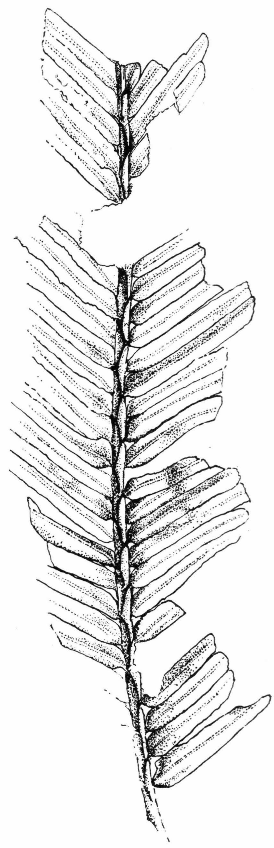


Fig. 12. *Metasequoia occidentalis* (Newb.) Chaney: Short shoot with well-preserved. leaf-bases. 3:2. Atanikerdluk (G.G.U. label no. 4359.169). — Gunni Jørgensen del.

Such a maltreated specimen from the Quleruarssûp isua locality of Kangersôq is found on pl. 3 fig. 6.

The leaf is linear with parallel margins almost to the apex, which is bluntly rounded. Appearing from the prominent impression of the midrib, the texture of the leaf is thin. Basally the leaf is abruptly rounded and passes into a short petiole. This again passes into a decurrent leaf base. The leaf base clutches the axis in the very way characteristic of *Metasequoia* (ref. textfig. 10): the petiole is fastened obliquely to the axis and the margin of the leaf-base turns from the end of the petiole downward obliquely over the axis and covers the impression of the base of the opposing leaf. Following the axis one recognizes that alternately the base of the right and of the left leaf is the covering one (pl. 3 fig. 7). The result is a zig-zag pattern on the impression of the axis. Owing to this feature a succession of constrictions may be apparent, one between each leaf pair, on cleaved axes where the leaf bases are not visible. This morphology is fully in accordance with that of the recent *Metasequoia glyptostroboides* Hu et Cheng and of the fossil *Metasequoia occidentalis* (Newb.) Chaney and it reveals the decussate phyllotaxy that is hidden by the rotations of the leaf pairs, which have caused the apparent distichous arrangement. For reference a specimen from Atanikerdluk (*Quikavsak member*) is depicted as textfig. 12.

Summary of Foliage shoots.

The descriptions above are of foliage shoots with a combination of the following characters, some of which are very peculiar. Among the known recent plants, these remarkable characters are only found on the genus *Metasequoia*: decussate phyllotaxy on long and short shoots; the short shoots detached as a whole; the leaf thin, linear, obtuse, short petiolate; the leaf obliquely fastened to the axis and with the bases obliquely decurrent and having an alternate overlap from right and left, owing to a distichous arrangement of the leaves. In full accordance with Chaney's descriptions and since their age is *Tertiary*, they can without doubt be determined as *Metasequoia occidentalis* (Newb.) Chaney.

The Fertile shoots (pl. 4, textfigs. 13–14)

Four fairly well preserved specimens of pistillate cones have been found at the fossiliferous locality of Kangersôq valley. In the Qaersutjægerdal valley there was found one well-preserved, cleaved specimen and a fragment of a cone that was not sufficiently well-preserved to be referred to this species.

The specimen of pl. 4 fig. 1 shows a small cone cleaved along the axis. The cross section of this cone is nearly circular with a diametre of 14 mm. Of the two halves one is again cleaved, thus revealing a part of the surface of the cone. Here the shape of the cone can be recognized as well as on the specimens of pl. 4 figs. 3, 5. The scales are peltate with a central pit enclosing its primary part. The peltate part is oblong, 6-sided—oval, with its longest axis transversally. The surface of the cone has been reproduced diagrammatically in fig. 13: those cone scales which have their peltate part in the plane of the paper (1–3–5–7) are above each other in a row that is parallel to the axis of the cone. Presumably at right angle to these, there are two rows of cone scales: (2a–4a–6a) (2b–4b–6b). They appear in cross section on the present specimens and seem to be opposite each other (the pairs 2a–2b, 4a–4b, 6a–6b), each cone scale to the right having a counterpart in the left row. These scales have their lateral parts intercalated as wedges between the lateral parts of the scales 1–3–5–7. This arrangement makes one suppose that the cone has decussate phyllotaxy. It has an extremely

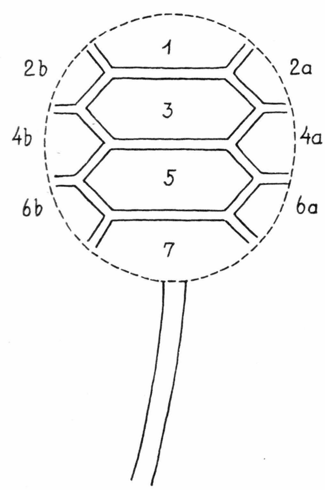


Fig. 13. *Metasequoia occidentalis* (NEWB.) CHANEY: Diagrammatic sketch of the impression of a pistillate cone. 1–3–5–7 mark the impressions of peltate scales which are in a diametric row and which have the peltate part of the scales in the surface of the paper (being a projection of peltate scales of a row along a meridian). 2–4–6 are two rows of scales which are at right angles to those of 1–3–5–7 (being projections of scales of a row along the median at right angles to that of 1–3–5–7). These (2–4–6) are opposite. The decussate phyllotaxy is suggested. 3:1. (Drawn after the specimen of fig. 14).

long, naked stalk, of which 7 cm have been uncovered on the specimen of pl. 4 fig. 1 without the base being reached.

The specimen of pl. 4 fig. 3 (textfig. 14) has been uncovered in order to demonstrate the impression of the surface of the cone, the incoaled remnants having been removed. It shows exactly the same features as the reproduction of textfig. 13. This specimen has a diameter of 16 mm. A fragment of the naked stalk with a single leaf scar can be recognized.

Two specimens (pl. 4 figs. 2, 4) show cones cleaved along their axis and all the peltate scales appear in cross section. Again the cone scales appear to be opposite each other. Our idea of the decussate phyllotaxy seems supported by the specimen of pl. 4 fig. 4, where it was possible to remove the very (half-)cone to investigate its surface. This half-cone show two rows of peltate scales on its surface. Consequently the total number of rows must be 4.

On every specimen all the scales have been found attached to the axis. This makes me suppose that the scales have been persistent.

Stamminate cones and seeds have not been recognized.

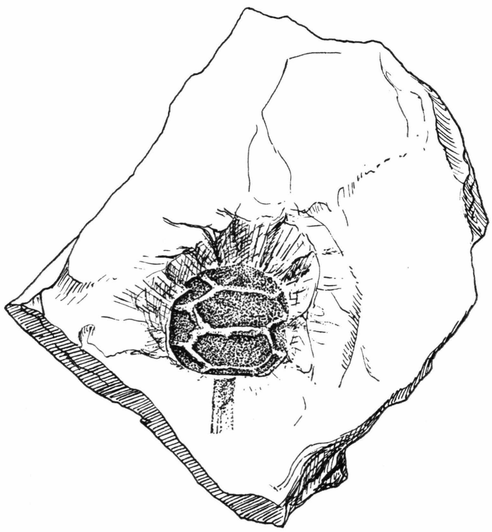


Fig. 14. *Metasequoia occidentalis* (NEWB.) CHANEY: Impression of a pistillate cone (ref. fig. 13). 1:1. Kangersôq (G.G.U. label no. 35492.148). — GUNNI JØRGENSEN del.

Summary of the Pistillate Cones.

From the fossils the cones can be described as small, nearly spherical or slightly ovoid with a diametre of 14–16 mm. The cone scales were peltate, persistent and with decussate phyllotaxy. The cone has a long, persistent stalk, which has scars after detached leaves. It has only been possible to recognize a few such scars and the phyllotaxy of the stalk has not been established. It may be decussate.

These fossil cones have a very high resemblance to those of the genus *Metasequoia* according to CHANEY's description of the cones of *Metasequoia occidentalis* (NEWB.) CHANEY.

Discussion:

These cones are found together with abundant samples of foliage shoots of *Metasequoia* and it is reasonable to combine these fossils as remnants of the same species. This assumption is supported by the fact that it is not possible to separate different types of the foliage shoots and cones among the *Metasequoia* remnants. The fossil flora described is undoubtedly recruited from a narrow area, being remnants of the forest vegetation of the lowland river banks. This means that the fossils are mostly remnants of a single association (biocoenose) with its restricted number of species. It would not be reasonable to expect two or more intimately related species of *Metasequoia*, competing in an association of this kind, that is really a nice example of the *Arcto-Tertiary flora* which, with its uniformity over huge areas, must be regarded as a climax.

For these reasons the foliage shoots and pistillate cones have been determined: *Metasequoia occidentalis* (Newb.) Chaney.

Postscript.

It is necessary to add a comment to the above description. This arises from a recent, preliminary investigation of fossil cones of a similar type from the *Quikavsak member* of Atanikerdluk (B. Eske Koch 1959), with which the author has been occupied for a while. These fossil cones have not undergone severe deformation. Thus it has been possible to isolate their casts. Those, which may be supposed to belong to the foliage shoots of *Metasequoia* associated with them in the sediment, have long stalks like the cones of *Metasequoia*. However they do not show decussate phyllotaxy, but rather a spiral with the relation $^2/_5$. The damning evidence for the relation of these cones to the foliage shoots of *Metasequoia* type, being the leaf scars of the cone axes showing decussate phyllotaxy, has not yet been unveiled. If this combination proves to be true, the result will be a change of the ideas about the *Metasequoia* from Western Greenland. There will then be a species other than that of Chaney. But of course other genera of the Taxodiaceae must still be remembered as current possibilities, and as long as the solution to the above mentioned problem has not been found, the determination as *Metasequoia occidentalis* (Newb.) Chaney must be maintained.

Occurrences in Greenland:

West Greenland:

Lower Paleocene:

Agatkløft (*Sonja member* of the *Agatdal formation*),
Qaersutjægerdal,
Kangersôq,
Atanikerdluk (*Quikavsak-* and *Naujât members* of the *Upper Atanikerdluk formation*),
Naujât (*Quikavsak-* and *Naujât members* of the *Upper Atanikerdluk formation*),
Pautût (*Quikavsak member* of the *Upper Atanikerdluk formation*),
Tupaussat (*Quikavsak member* of the *Upper Atanikerdluk formation*),
Disko isl. south of Ritenbenks kulbrud (Qudtligssat) (Probably equivalent to *Quikavsak member* of the *Upper Atanikerdluk formation*).

Intrabasaltic (*Tertiary*):
Qernertuarssuit (Nûgssuaq pen.),
Hareø (Qeqertarssuatsiaq)?*)

Undetermined Tertiary:
Agssakak.

Angiospermae.

CLASS: MONOCOTYLEDONES

A few leaf fragments with the parallel nervation of monocotyledonous leaves have been found without any exact determination being possible.

In this connection it must be mentioned that a number of petrified palm fruits were collected from the outcrop of *Scaphitesnæsen* (Turritellakløft gorge). They are small, nearly sphaeroid and were originally drupes with a cup-shaped seed into the hollow of which, the outer protective layers penetrate to make a big basal rumination. They are probably coryphoid and are a distinctive element of this fossil flora. They are still under investigation and cannot be treated in more detail in this paper.

CLASS: DICOTYLEDONES

Family: Salicaceae

Cfr. ***Populus*** sp.

(pl. 8 fig. 1)

Only one fragmentary specimen (G.G.U. label 12896.84) has been found which may be referred to *Populus*. This genus was formerly believed one of the most common ingredients of the *Arcto-Tertiary flora* until R.W. BROWN's revision (R.W. BROWN 1939 a) changed the majority into *Cercidiphyllum*.

The suggestion of a broad, ovoid leaf blade, the pinnate nervation and what may be crenations of the margin are the criteria which point towards *Populus*.

Occurrence in Greenland:

Lower Paleocene:
Agatkløft (*Sonja member* of the *Agatdal formation*).

*) The author does not feel sure that the sample, which is depicted in HEER (1883 a) pl. 88 fig. 2, really comes from Hareø, as the rock is identical with the ironstone of Atanikerdluk. Only renewed field investigations on Hareø can solve this problem.

Family: Cupuliferae

Dryophyllum cfr. *subfalcatum* Lesq.

(pl. 8 figs. 2, 3)

Lesquereux, L. (1875 (1876)) vol. 1 pag. 379; (1878) vol. 7 pag. 163 pl. 63 fig. 10.
Brown, R. W. (1939 b) pag. 248 pl. 50 figs. 1–8, pl. 51 figs. 1–7, 8 b, pl. 52 figs. 1–3, pl. 54 fig. 1.

This description concerns one specimen from the Qaersutjægerdal valley.

Description:

The leaf is lanceolate with a cuneate base. It attains its maximum width at a distance from the base of about $^1/_3$ of the total length of the leaf. The length is $7^1/_2$ cm, total length in reconstruction: 8 cm. Maximum width: 2.4 cm. The leaf is long and thin petiolate; 2.1 cm of the petiole is left without the sheath being reached. The nervation is pinnate, the midrib stout on the basal part but weakens regularly forward towards the apex. The secondaries are parallel. The basal pair is subopposite, the following ones alternate with the divergence growing forwardly. The secondaries make an acute angle with the primary, at first running straight to the marginal zone, where they turn regularly forward and terminate in the serrations of the margin (craspedodrome). The margin has small, scattered teeth; their number exceeds that of the secondaries. Basally there are 2, terminally 1 serration intercallated between each secondary vein. The serrations are pointed and forwardly directed. The secondaries are connected by stout, percurrent nervils. Before the entrance into the teeth, the secondaries yield a forwardly directed branch, which as a marginal joins the system of nervils. From this marginal vein branches of nervil-grade turn into the intercallated serrations.

Discussion:

The leaf, as it is described above, is covered by the diagnosis of *Dryophyllum* (type: *D. subcretaceum*). From a study of the literature of its many species, it turned out that *D. subfalcatum* Lesq. can be the only possibility.

Among the fossil leaves which R.W. Brown (1939 b) depicts, there are many examples e.g. pl. 50 figs. 2 and 8 identical to the present specimen. The Laramie species, as it is constituted by R.W. Brown, includes a large variation with continuity between the extremes. This is clearly reminiscent of a group of fossil leaves from the *Naujât member* of the *Upper Atanikerdluk formation*, which originally was described by Heer (*Upper Atanikerdluk B-flora*) as several species (*Quercus Lyalli*, *Q. Charpentieri*, *Pterocarya denticulata*, *Juglans Heerii* etc.). The author finds it impossible to define these without much overlap.

When only one specimen is represented and the state of preservation is not good, a final determination cannot be given, the more so as it touches upon a difficult problem of some widely variable fossil species.

Occurrence in Greenland:

Lower Paleocene:

Qaersutjægerdal (big section).

Quercophyllum groenlandicus (Heer).

(pl. 5, 6 figs. 1–3)

Synonyms: *Quercus groenlandica* Heer (1868) pag. 108 pl. 8 fig. 8; pl. 47 fig. 1; Heer (1880 a) pag. 10 pl. 4 fig. 5: Heer (1883 a) pag. 89 pl. 69 fig. 4; pl. 89 fig. 2; pl. 91 fig. 1; Hollick (1936) pag. 99 pl. 57 fig. 6.

Fagus castaneaefolia Unger in sensu Heer (1868) pag. 106 pl. 10 fig. 7 a–8; pl. 46 fig. 3 a.

Castanea Ungeri Heer (1869 b) pag. 470 pl. 46 fig. 8; Heer (1883 a) pag. 84 pl. 89 fig. 4.

Ulmus plurinervia Unger in sensu Heer (1883 a) pag. 93 pl. 89 fig. 8.

In the collection from the Agatdalen area there are 15 specimens referable to this species. Of these samples one is from the Agatkløft canyon, one from the Qaersutjægerdal valley, while the rest, forming the majority, come from the fossiliferous locality of the Kangersôq valley. Most of them show fragments of leaves but some are of complete leaves.

Description:

The leaf can be described as follows: Ovoid – oval and acuminate (pl. 5 figs. 1, 4). The base is broad, funnel-shaped with the lamina a little decurrent and the petiole is short (pl. 6 fig. 1). The nervation is pinnate, the strong secondaries are alternating and the distance between the secondaries is different on either side of the primary, which may result in a partial subopposition. The secondaries are parallel and may be either straight or show a slight sigmoid curve and each terminating in a tooth. The tertiary nervation consists of uncomplicated, percurrent nervils, some of which are forking. The margin is simple and coarsely serrate. On the terminal part of the leaf, the teeth are nearly equidimensional but become more slender and longer towards the leaf base (pl. 6 fig. 2); the serrations are normally not sharply pointed, as their two margins are commonly convex (pl. 5 fig. 3, pl. 6 fig. 3). The sinus between the serrations is always sharply pointed. The characters of the serration described above show a certain variation, since the margins may on single specimens be straight and the teeth may become more sharpely cut (pl. 5 fig. 2). Both types may occur on the same leaf (pl. 6 fig. 1), but the sharply cut type is rather uncommon.

Discussion:

The author agrees with the statement of HOLLICK (1936) that the recent species which is most similar to *Quercus groenlandica* HEER (the leaves of which are almost identical), is *Quercus prinus* CURT. (North America). The leaves agree very much in shape, serration and nervation. The base of the leaves have the same peculiar shape, which is characteristic of these broad leaved oaks. Also the leaves of *Quercus mongolia* FISCH. ex TURCZ. (East Asia) are very like *Quercophyllum groenlandicus* (HEER) but the serration of its leaves is usually somewhat coarser.

With the reservation mentioned below, the author agrees with HEER's determination of *Quercus*, which is as good a determination that can be made upon leaves, since we are dealing with a characteristic type. The leaf of *Quercophyllum groenlandicus* (HEER) may be regarded as the first step in the evolution from the initial type towards the Quercus-type of oak leaves, if considered in the terms of O. SCHWARZ's theory on the evolution of the oak leaves (SCHWARZ 1936). The mentioned *Q. mongolia* is closer to the Quercus type than is the *Quercophyllum groenlandicus* (HEER).

In the author's opinion there is no possibility of confusing this leaf type with leaves of *Castanea*, which are characterized by longer teeth, which are forwardly directed and provided with a prolonged point. Further, the sinus between the teeth is rounded.

If the author had been confronted with leaves as those described, recent, *Quaternary* or *Younger Tertiary* ones, he would without hesitation have referred them to *Quercus*. But they are near to the theoretical initial *Quercus* leaf and they are separated from our time by more than 50 Mill. years, an enormous span of time which has promoted many changes; and it is reasonable that the *Paleocene* species cannot be fitted exactly into our taxonomical definitions based on recent plant life, which probably displays only a limited range of the possible angiospermous variation.

The author prefers the generic name of *Quercophyllum* in a case where the taxonomical identity with *Quercus* cannot be conclusively established. With this reservation, the author regards these fossil leaves intimately related to *Quercus*.

The species *Quercus groenlandica* was erected by O. HEER in the "Flora Fossilis Arctica" vol. I, 1868 and among the types the following are regarded as determinable and typical of the revised species, *Quercophyllum groenlandicus* (HEER), in the author's opinion: Pl. VIII fig. 8 and pl. XLVII fig. 1. The reservation must be added that the author has not studied the type specimen of pl. VIII fig. 8 which is kept in Dublin. The statement is based upon the figure, which however leaves no doubt. On the other hand the type specimen of pl. XI fig. 4 is hardly determinable. Also Heer has himself expressed his doubt concerning this specimen.

From Heer's later publications there are further specimens which the author cannot admit as belonging to *Quercophyllum groenlandicus* (Heer). This concerns Heer (1869 b) pl. XLV fig. 4. If the specimen does not show more than the figure, which is most probable, it must be regarded as indeterminable. The author has not succeeded in finding the type specimen of this figure in the collections of the British Museum, Natural History, London, where the rest of this collection is kept.

Furthermore the type specimen of Heer (1880 a) pl. IV fig. 5 must be excluded.

On the other hand there are several specimens depicted in Heer's later works, which the author regards as typical representatives of *Quercophyllum groenlandicus* (Heer): Heer (1883 a) pl. LXIX fig. 4 and pl. XCI fig. 1; the last mentioned is badly reproduced, but the type specimen is a typical leaf of this species. Also current but slightly different are the specimens reproduced by Heer (1868) pl. X fig. 7 a–8 (*Fagus castaneaefolia*). Fig. 8 shows a leaf base which is exactly similar to specimens of *Quercophyllum groenlandicus* (Heer) from the Kangersôq valley. Further, the author regards ibid. pl. XLVI fig. 3 a (*Fagus castaneaefolia*) as *Quercophyllum groenlandicus* (Heer), though the base is a little different. Also typical is a small specimen determined by Heer as *Ulmus plurinervis* (Heer 1883 a: pl. LXXXIX fig. 8) which however cannot with its single serration belong to *Ulmus*. The same applies also to ibid. pl. LXXXIX fig. 4 (*Castanea Ungeri*).

From the *Upper Oligocene* deposits of Florissant, Colorado, Hollick described *Fagopsis longifolia* (Lesq.) Hollick (Hollick 1909) which, apart from its small size, is very like *Quercophyllum groenlandicus* (Heer). But it is much smaller, being outside the range of our species, as the largest leaf is only 4 cm long. Hollick's fig. 2 shows several leaves together on a shoot, which also bears a fruit with a cupula, thus demonstrating its relationship with *Fagaceae* (*Cupuliferae*). Its relevance to this discussion is to demonstrate that this leaf type really has been connected with the *Fagaceae* during the *Tertiary*.

Occurrences in Greenland:

Lower Paleocene:

Agatkløft (*Sonja member* of the *Agatdal formation*),

? Qaersutjægerdal, Kangersôq, Atanikerdluk (*Quikavsak member* of the *Upper Atanikerdluk formation*), Tupaussat (*Quikavsak member* of the *Upper Atanikerdluk formation*).

Intrabasaltic: Hareøen (Qeqertarssuatsiaq).

Quercophyllum furcinervis americana (Rossm.) Knowlton.

(pl. 6 figs. 4–6, pl. 7, textfig. 15)

Knowlton (1898) pag. 192; (1899) pt. 2 pag. 705, pl. 88 fig. 5; (1902) pag. 43.

Synonyms: *Quercus furcinervis* (Rossm.) Unger: Lesquereux (part.) (1874 b) pag. 389; Lesquereux (1883) pag. 244 pl. 54 figs. 1, 2; Lesquereux (1888).

6 specimens determined as this species have been found in the Agatdalen area. Of these one is from the ochreous, concretion bed of the Qaersutjægerdal valley (Big Section) and 5 specimens are from the fossiliferous locality of the Agatkløft canyon.

None of these leaf impressions are complete, but the one from the Qaersutjægerdal valley and one of the specimens from the Agatkløft demonstrate nearly complete leaves, thus enabling a description to be made.

Description:

The leaf is lanceolate and serrate at least in the terminal part. The teeth are long and narrow with sigmoid, lateral margins; are forwardly pointed, perhaps with a mucro. The width of the teeth shows some variation, the extremes of which are demonstrated by the pl. 6 fig. 4 and pl. 7 fig. 1. The teeth become more spaced towards the leaf base, and finally the margin of a variable basal part of the leaf seems to be entire. The nervation is pinnate, the primary is weak in proportion to the secondaries, which are alternating and are so spaced that weaker ones of the same order are occasionally intercallated. The secondaries make an acute angle with the primary (45°–90°) and are turned forward. They fork near to the margin, the lateral branch terminating in a tooth, the other following the margin forwards. This character was mentioned by Laurent (1912) as typical for *Dryophyllum* and some recent East Asiatic oaks.

The tertiaries are often percurrent though with a somewhat irregular winding course and are supposedly rather spaced. In the spacious areas between these, nothing can be recognized on the fossils, as the rock may have failed to preserve the nerville system, if present.

The dimensions of the biggest leaves appear from the figures which are life-sized. There is a notable variation in size, shape and serration, the length ranging from 7 cm to 15 cm, the corresponding measures for the width being 1,8 cm to 3,0 cm.

Discussion:

The pattern of the secondary veins agrees mainly with that of *Dryophyllum* and certain recent East Asiatic oaks, as Laurent (1912) states. The intercallated secondaries separate the Agatdalen specimens from *Dryophyllum*, which according to Laurent is not normally provided with such nerves. This character is closely connected with the fact that the ordinary secondaries are widely spaced. Also the secondaries are alternating (*Dryophyllum*: subopposite). These reasons made the author

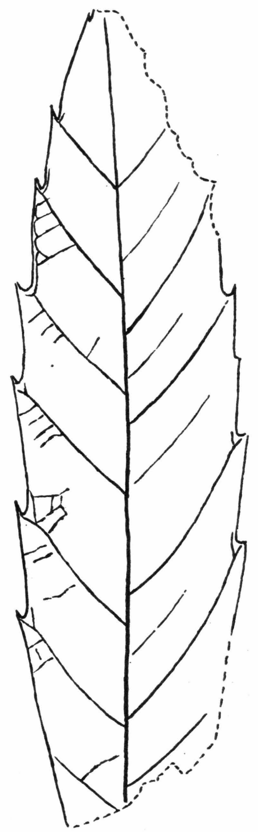


Fig. 15. *Quercophyllum furcinervis americana* (Rossm.) Knowlton: Sketch of a leaf impression (ref. pl. 7 fig. 1). 1:1. Agatkløft (G.G.U. label no. 12896.95). — Koch del.

suggest *Quercus* rather than *Dryophyllum*, as far as the leaves are concerned. This question is of course more theoretical than real, seeing that *Dryophyllum* is regarded as cupuliferous and intimately related to *Quercus*. This genus in its widest sense is an extensive group, in which *Dryophyllum* probably could be put as a parallel to *Lithocarpus* or it at least overlaps this genus from its more original position.

There are many recent species of oaks, which have leaves of the shape described e.g. *Quercus acutifolia* Née (= *Q. Grahami* Benth.), *Quercus castaneaefolia* Mey., both of which however are provided with long-pointed teeth.

Although very like the leaves of certain species of *Quercus*, the collection from the Agatdalen area does not contain sufficient indications for a determination without reservation. The determination of *Quercophyllum* expresses the author's opinion that the leaves most probably represent *Quercus* in its wider sense. The specific epithet is based upon the descriptions and pictures of the literature.

LESQUEREUX (1883) describes *Quercus furcinervis* ROSSM. from Bridge Creek and Cascade mountains, Oregon, and his pl. 54 fig. 2 shows a specimen very like those from the Agatdalen valley, but no intercallated secondaries are visible. But the poorer preserved specimen of his pl. 54 fig. 1 has such secondaries. The serrations of the specimen of his pl. 54 fig. 2 are like those of the Agatkløft specimen on pl. 7 fig. 1. It seems as if the variation in the leaf characters of the Oregon leaves described by LESQUEREUX is much the same as in those of the Agatdalen area. The resemblance is sufficiently good to substantiate a reference to the same species, although admitting a degree of hesitation latent in correlation of fossil leaf remains and especially of leaves from deposits of different age and remote geographical position.

Often leaves of a wider, nearly oblong-oval shape have been described as *Quercus furcinervis* (ROSSM.) UNGER (ref. LESQUEREUX (1883) pl. 53 figs. 8–14). These are very different from those of the Agatdalen area. The said divergence is evidently the reason why KNOWLTON erected the variety (or species) *Quercus furcinervis americana* with the following synonyms:

Phyllites furcinervis ROSSM.: Verst. d. Braunkohles von Altsattle in Böhmen pag. 33 pl. 7 figs. 26–31, 1840.

Quercus furcinervis (ROSSM.) UNGER: Syn. Fl. Foss. pag. 217, 1845; LESQUEREUX: Ann. Rept. U.S. Geol. Geogr. Surv. Terr. pag. 398, 1873 [1874]; LESQUEREUX: Cret. and Tert. Fl. pag. 244 pl. 54 figs. 1, 2, 1883.

Quercus furcinervis (ROSSM.) UNGER covers a wide variation as mentioned by LESQUEREUX (1883) pag. 244. According to the depictions which have been at the author's disposal, it seems that the species of KNOWLTON was based upon the narrow, lanceolate type. Among the specimens of LESQUEREUX only the lanceolate, narrow ones of pl. 54 figs. 1, 2 are mentioned as synonyms, while the wider leaves of pl. 54 figs. 8–12 have been referred to *Quercus paucidentata* NEWB. and pl. 53 figs. 10–12 to *Quercus clarnensis* TRELEASE. In "Flora Fossilis Groenlandica" (HEER 1883 a) pl. 74 fig. 10 demonstrates a leaf fragment which is in agreement with the Agatdalen leaves (ref. pl. 7 fig. 3). Being a fragment, its determination is unsafe and so the author has refrained from using it as a synonym. It must rather be regarded as indeterminable. In "Flora Fossilis Helvetiae" (HEER 1855–59) pl. CLI figs. 12–15 demonstrate leaves of *Quercus furcinervis* UNGER, which are very like those from the Agatdalen area. The determination of ibid. fig. 15 was revised by FRITEL (1922) as *Dryophyllum curticillense* var. a.

On the whole among the immense number of specimens referred to *Quercus furcinervis* (ROSSM.) UNGER demonstrating the wide variation of the species, there is a fraction which resembles considerably these described by the author.

Quercus furcinervis (ROSSM.) UNGER is really a problem apart, which at least demands a specialist on *Quercus* and its relatives for a solution. Though the author does not believe in it as a natural species, he accepts it provisionally lacking any means of a real revision.

The morphology of the *Quercus* leaves has been treated by O. SCHWARZ (1936), who also touchs on the fossil species. He regards *Quercus furcinervis* as related to *Pasania*.

Occurrences in Greenland:

Lower Paleocene:

Agatkløft (*Sonja member* of the *Agatdal formation*),
Qaersutjægerdal,
Atanikerdluk? (lowermost part of *Naujât member* of the *Upper Atanikerdluk formation*).

Intrabasaltic:

Hareøen (Qeqertarssuatsiaq)?

Occurrences in North America:

Oregon (below the Cascade lava),
Spanish Peek, California,
Golden, Colorado (*Paleocene*),
Clarno: Cherry Creek, Wasco Co., Oregon (*Oligocene*),
Silma, Texas (*Eocene*).

Cupuliferites angmartusuticus n. sp.

(pl. 8 fig. 4, pl. 9, pl. 10 figs. 1–2).

4 specimens of this species have been collected from the fossiliferous localities of the Agatkløft canyon. Two of the leaves are nearly complete, whilst the remaining ones are fragments of some importance. The leaf impressions are fixed in the sandstone by means of iron oxide precipitates, which have not allowed preservation of the delicate features (ref. pag. 16–18).

Description:

The leaves are somewhat rhomboid with a long, strong petiole. The cuneate base has an entire and concave margin. Terminally the leaf is coarsely serrate. The serrations are wide with somewhat convex, lateral margins and they are pointed with a forwardly directed point. On the basal teeth the points tend to be outwardly directed. The teeth are biggest in the middle of the leaf and decrease forwards. The number is 6–12 on each side of these four specimens. The nervation is pinnate. The stout petiole continues in a vigorous primary, which decreases rapidly forwards. The secondaries are alternating but may also demonstrate a state of subopposition. They make a wide, acute angle (45°–90°) with the primary, are slightly forwardly curved and craspedodrome, as each one terminates in one of the coarse serrations. Single, intercallated secondaries have been recognized. The state of preservation only permits an insignificant part of the finer network to be observed. Some percurrent nervils connecting the secondaries have been preserved, giving an impression of the pattern. The dimension of the leaves is apparent from the figures which are life-size.

Discussion:

A similar but fragmentary leaf was depicted by PITON (1940) from the shales of Menat (Puy-de-Dome) and determined as *Quercus lonchitis* UNG. The specimen of PITON has little resemblence to UNGER's type and though the leaves of *Quercus lonchitis* UNG. have an extended variation, the author does not feel sure that the determination is correct. It is doubtful if the fragment is determinable at all, unless a bigger collection with better fossils from the same locality had also been at PITON's disposal.

Similar leaves have been described as *Castanea atavia* GOEPP., *Myrica vindobonensis* ETT., and *Quercus Zoroastri* UNG. The author has not found any fossil species described, which could include these leaves without much doubt.

The author believes that this leaf type cannot be referred exactly to any recent genus. It may be found among *Quercus* as well as among *Castanea*. *Castanea vesca* GAERTN. and *Castanea ozarkensis* have leaves which are very like the fossils and the same goes for *Quercus crispula* BLUME, *Quercus Grahami* BENTH. and others (according to herbarian specimens). But the author does not doubt that the choice will fall near these two genera.

The designation *Cupuliferites* must be regarded as a provisional determination.

Occurrence in Greenland:

Lower Paleocene:

Agatkløft (*Sonja member* of the *Agatdal formation*).

Family: Juglandaceae

Juglandiphyllum denticulatum (Heer) sp. em. Koch

(pl. 10 fig. 3, pl. 11, 12, 13, 14)

Synonym: *Juglans denticulata* Heer ex parte: Heer (1869) pag. 483 pl. 56 figs. 7, 9.

Some specimens of this species have been collected from the different localities of the Agatdalen area. The state of preservation is somewhat variable. The leaves from the sandstone of the Agatkløft canyon are mostly too badly preserved to allow determination, but fortunately the well-preserved specimens from the Kangersôq valley, constitute their nescessary supplement.

Description:

The "leaves" are mostly found 3 together in a composed, palmate leaf (or the tip of a pinnate one) in a manner which implies their organic connection. A similar specimen from Atanikerdluk (for reference purposes depicted on pl. 14 fig. 2) shows 3 leaflet bases connected to the end of a common stalk, which does not seem to bear other leaflets in a distal position.

The leaflets are lanceolate with cuneate bases and tips. The margin is delicately serrate on at least the terminal half. The basal part has an entire margin. The serration consists of narrow teeth with straight or only slightly curved lateral margins and forwardly directed points. They are what the author designates "J-teeth" (fig. 16). On the more vigorous and well-preserved teeth the point has a slightly outward orientation. This description concerns the majority of the teeth, but it is not a universal character, though it makes it possible to separate this species from *Dicotylophyllum Scottii* (Heer) which has "S-teeth" (ref. pag. 71 and fig. 26). This is reasonable if characteristic specimens are available. Owing to the coarseness of the rock from the Agatkløft canyon one may get the impression that the leaf margins are entire. This accounts for the specimens of pl. 11 fig. 1 and pl. 13, but a careful examination discloses scattered, small teeth especially when using a convenient refractive liquid, e.g. water. The entire part of the margin is often faintly undulating.

The nervation of the leaflets is pinnate, the secondaries are spaced, alternating and branch off from the primary making an acute angle of about 45° and describe a harmonious curve, which converges towards the margin. The pattern is a camptodrome one, as every secondary connects with the next giving rise to a number of archs. Branches from these archs pass to the teeth. The secondaries are connected by irregular tertiaries, often via an intercallated secondary vein. The tertiaries are combined by means of irregular quarternaries making up a polygonal network.

Discussion:

The pattern of the leaflets agrees with what can be recognized on *Juglans* leaves, on which delicately serrate leaflets and all gradations to almost entire leaves with faintly and irregularly undulating margins are

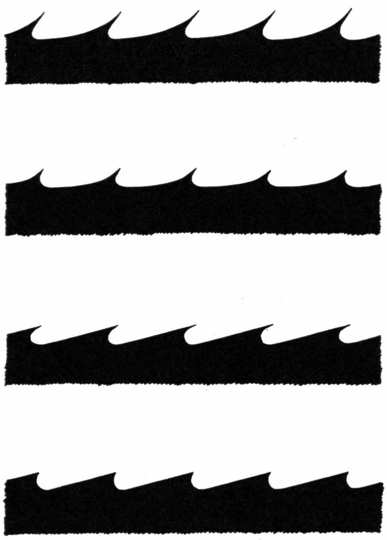


Fig. 16. Diagrammatic sketches of J-teeth. — Ragna Larsen del.

characteristic. The nervation is in all features in accordance with that of *Juglans* leaflets. *Juglans rupestris* (pl. 15) is a recent species which has both entire and serrate leaflets on the same compound leaf, the leaflets of which agree with pl. 10 fig. 3. It is highly possible that the leaves are related to *Juglans* or at least to *Juglandaceae*, but a determination cannot be secured without cuticle studies and/or samples, which are more conclusive with regard to the type of composed leaves we are dealing with. To find a complete, pinnate, juglandaceous leaf in a fossil state must be considered as a very rare case because it covers a larger area. Furthermore it will seldom reach the site of deposition as an entity. Such compound leaves mostly shed their leaflets singly during defoliation. Although it may be common, the finding of 3 leaflets together in the way described, does not necessarily imply a tripalmate leaf. In the autumn the author has studied the shed leaves under the walnut trees in the Botanical Garden of the University of Copenhagen. All the opposite leaflets had normally been shed singly, while the terminal one stayed on the axis. But it was not uncommon to find the terminal pair left on the axis together with the terminal one giving rise to a pseudotripalmate leaf very like the described fossils. So the author cannot exclude the possibility of a pinnate compound leaf, remembering that the bulk of the leaves are of temperate genera and are the defoliation products of a decidous forest (ref. the chapter: Paleoclimatological Evidence pag. 98).

Since the fossils could not be determined as *Juglans*, the generic designation *Juglandiphyllum* is used to indicate the possibility of close relationship to *Juglandaceae* and to the Juglans circle.

The same type of leaves has previously been described from Greenland. Thus Heer already in 1869 published *Juglans denticulata* from Atanikerdluk (*Quikavsak member* of the *Upper Atanikerdluk* formation (B. Eske Koch 1959)). The type specimens, which the author has seen in the British Museum collections (London), are secunda fossils (bad and fragmentary impressions) and are unsuited as type fossils. But they seem to be correctly reproduced and at least those of Heer (1869 b) pl. 56 figs. 7 and 9 are in all probability identical with those specimens from Atanikerdluk (*Quikavsak member* op. cit.), which the author has depicted on figs. 31 and 32. The same concerns the specimen of Heer (1883 a) pl. 69 fig. 8, *Juglans bilinica* Ung., but it is too badly preserved for a determination. On the contrary that of Heer (1869 b) pl. 56 fig. 8 determined as *Juglans denticulata* is different and agrees with those leaves described by the author as *Dicotylophyllum Eridani* (Heer) (ref. pag. 69).

A more complete impression of the leaf than arrives from any of Heer's specimens from Atanikerdluk, is given by those depicted on pl. 14. They both belong to older unpublished collections. The author compares them with his specimens from the Agatdalen area and makes in this way a connection between the latter and the above cited old types of *Juglans denticulata* Heer (Heer (1869 b) pl. 56 figs. 7 and 9). The only doubt lays in the difficulty of comparing fossils of different states and ways of preservation. The Atanikerdluk fossils are impressions in ironstone of a grade varying from clay to fine sand with little or no organic remnants. Those from Agatkløft are impressions in a varying amount of iron-oxide precipitate (a kind of concretion, ref. pag. 16) in sandstone of medium to coarse grain grading into conglomerate. No organic matter is left except remnants of the nervation. Those from the Kangersôq valley are in siltstone to very fine grained sandstone with a black polish of organic residuum left on the impression. The types of pl. 14 figs. 1 and 2 (Atanikerdluk), that of pl. 13 (Agatkløft) and those of pl. 10 fig. 3 and pl. 11 fig. 2 (Kangersôq valley) are easiest to compare. A small variation is recorded which concerns the serrate proportion of the leaf margin. In pl. 11 fig. 2 a higher proportion of the margin is serrate and it is comparable with that of pl. 14 fig. 1 from Atanikerdluk. To a small degree that of pl. 10 fig. 3 varies towards a less serrate proportion and pl. 13 changes a little further. So it is visibly less serrate than pl. 11 fig. 2. Owing to the observation of this trend the specimen of pl. 11 fig. 1 has been compared with this species. By a careful examination, it reveals remnants of small serrations in the margin of the terminal part which can be observed by anyone who is acquainted with this type of preservation. But there is no doubt that it has to a greater extent than the others an entire margin and represents at this stage of investigation, in this respect, the extreme variant of this species.

More difficult is the comparison with the specimens of *Juglans denticulata* HEER and related leaves from *Naujât member* of the *Upper Atanikerdluk formation* (HEER's *Upper Atanikerdluk B flora*). The state of preservation is quite different. They are impressions in tuff of clay grade and a carbonized remnant coats the impression as if it has been baked together with the stone. The circumference is marvelously well printed but on the other hand the interior is extremely badly preserved and it is very difficult to interprete the nervation. Further the thin tuff bands are brittle and easily broken into pieces; therefore the fossils are often highly fragmentary.

In the following when citing the figures of HEER (1883 a) of the "*Upper Atanikerdluk B*" fossils, the author only refers to the type specimens as the drawings are to a large extent unreliable as far as the details are concerned. As probable equivalents to the author's specimens from the Agatdalen area the following type specimens of HEER (1883 a) must be mentioned, though they are too fragmentary for a complete comparison:

Juglans denticulata HEER pl. 75 figs. 2?, 3, 4, 5 pl. 85 figs. 1, 2.
Pterocarya denticulata WEBER pl. 76 fig. 1.

To the same circle belongs *Quercus Charpentieri* HR. (HEER 1883 a pl. 73 fig. 12, pl. 74 fig. 9), but whether it is a variant of this species is uncertain. Its basal nervation makes it easily distinguishable.

Other specimens of *Juglans denticulata* HEER as those of HEER (1883 a) pl. 75 figs. 6, 7, 8, 9, 10 may belong to this species but are at the moment indeterminable. They may belong to other species from this deposit as for example the circle of variation including *Quercus Lyelli* HEER — *Juglans Heeri* ETT.

The specimen of which the two opposite impressions are reproduced in HEER (1883 a) pl. 72 fig. 6 and pl. 73 fig. 5 takes a special position. The drawings are obviously incorrect, as the types show some distinct serrations which hide under the marginal undulations of the figures. This fragment might well be compared with the author's fossils, especially that of pl. 10 fig. 3. But the author in the same way has found scattered teeth on the margins of nearly all the specimens of *Quercus Lyelli* Heer from the *Naujât member*, to which species Heer's cited specimen was determined. Hence, the author's specimen of pl. 10 fig. 3 may be compared with *Quercus Lyelli* Heer, though a change in the diagnosis of *Q. Lyelli* is then necessary. This means that it is difficult to separate fragments of a part of the variation of *Juglandiphyllum denticulatum* (Heer) which overlaps with *Quercus Lyelli* Heer. Whether this contains taxonomical implications must be left to the future. The specimen of pl. 11 fig. 1 is near to this critical zone of overlap and were it not for its better preserved state, it would have been doubtful.

The question of limiting these species grows more complicated by the fact that *Quercus Lyelli* Heer (ref. pag. 95) seems to grade into *Juglans Heeri* Ett. over a broad front.

It is highly possible that the *Naujât member flora* ("*Upper Atanikerdluk B*") is characterized by the presence of a couple of species with a wide range of variation concerning the leaf morphology. With regard to this problem, Heer preferred to erect plenty of species, but the author doubts the value of this procedure.

The determination must be provisional under the generical designation *Juglandiphyllum*. The specific determination would be without something of the essence of the species, if it did not refer to Heer's *Juglans denticulata*. It seems to the author sufficiently safe that *Juglans denticulata*, as it originally was erected by Heer, is included in this circle to justify the determination:

Juglandiphyllum denticulatum (Heer)

Occurrences in Greenland:

Lower Paleocene:

Agatkløft, Kangersôq, Atanikerdluk (*Quikavsak member* (and *Naujât member?*) of the *Upper Atanikerdluk formation*),

Naujât? (*Quikavsak-* and *Naujât members* of the *Upper Atanikerdluk formation*).

Family: Magnoliaceae

Cfr. *Liriodendron* sp.

(pl. 16 fig. 1)

A single fragmentary specimen from Agatkløft is reminiscent of the tuliptree leaves, but no exact determination can be given.

The leaf is 3-lobed. The broad, basal lobe with two secondaries, the vigorous primary vein and the big terminal lobe are prominent characters. The basal lobe is terminally cut by a sharp fracture. It is situated at the very end of the lobe, but probably does not represent the margin, though such a cutting should not be strange to a tuliptree leaf.

The basal secondaries seem to be opposite each other, whilst the following are subopposite to opposite. The secondaries of the lobes are rather distinct whilst in the sinual region, where the leaf blade is constricted they are very thin and obscure. They diverge with an angle between 45°–60°. Though the state of preservation makes observation of the details difficult, with the aid of sunlight and water as refractive liquid some observations were done, which show, that the secondaries are decurrent before being finally united with the primary.

The leaf blade seems to have been very thin like those of the tuliptree. This evidence arrives from the observation that the iron-oxide precipitate, in which all the leaf impressions from the Agatkløft are preserved, in this case is very thin. The author has found reason to believe that there is some quantitative function between this precipitate and the amount of organic matter in the original leaf (ref. pag. 16–18).

Consequently there is some evidence for a reference to *Liriodendron*, but the fragmentary state of the fossil specimen leaves a determination open to doubt.

Occurrence in Greenland:

Lower Paleocene:

Agatkløft (*Sonja member* of the *Agatdal formation*).

Family: Cercidiphyllaceae

Cercidiphyllum arcticum (Heer) Brown

(pl. 16 figs. 2–3, pl. 17, 18, 19, 20)

This nominal species erected by R. W. Brown is commonly represented in the collections from the Agatkløft canyon and the Kangersôq valley. Especially in the fossiliferous locality of Kangersôq it is very common.

The revision of the very extensive fossil material from North America and the Arctic of numerous species, formerly referred to *Boehmeria*, *Cercis*, *Grewia*, *Hakea*, *Hedera*, *Macclintockia*, *Paliurus*, *Populus*, *Smilax*, *Trochodendron* and *Zizyphus*, was carried out by R. W. Brown and published in 1939 (ref. R. W. Brown 1939 a). The author desists from further discussion of Brown's results, as the fossils from the Agatdalen area fit into Brown's definition and support his opinions.

In the Agatdalen area the author has found fossil fruits and a single-winged seed besides lots of leaf impressions. This adds one locality more to the many others where these leaves, fruits and seeds occur together, supporting the idea of their organic connection.

Discussion:

The leaves: (pl. 16 figs. 2–3, pl. 17, 18, pl. 19 fig. 1).

The predominant leaf type, which in accordance with Brown may be stated as the norm of the locality, is the deltoid type with its different variations as depicted by Brown (1939 a). The collection from the Kangersôq valley contains 172 specimens of leaves recognizable as those of *Cercidiphyllum*. Of these only 35 (40) are complete enough to be used for the valuation of the norm-type. Specimens typical of the *Cercidiphyllum arcticum*-type (pl. 17 and 18) amounted to 32 (35), and those of the older type *C. ellipticum* (pl. 16 figs. 2–3) to 3 (5). The younger *C. elongatum*-type is not represented. These figures show that it is Brown's nominal species *Cercidiphyllum arcticum* which is present. This species is indicated by Brown as occurring during the interval *Paleocene–Lower Eocene*. *Cercidiphyllum elongatum* according to Brown appears during the *Eocene* and becomes the norm-type in the interval *Upper Eocene–Upper Oligocene* (*Lower Miocene*?). By means of marine zoo-fossils the fossiliferous beds of the Agatdalen area in question have been determined as belonging to the *Lower Paleocene* (A. Rosenkrantz 1951). Thus positive affirmation of Brown's studies has been provided from Greenland.

The collection from the Agatkløft canyon is too small and too badly preserved to be used for counting of the leaf-types.

As a supplement necessary for the comparison with Atanikerdluk, the author has collected together all the specimens to be found in the extensive collection of fossil plants from Atanikerdluk kept in the Mineralogical Museum of the University of Copenhagen. The resulting 46 specimens showed 42 of the arcticum-type and 4 of the ellipticum-type. Consequently it is also the *Cercidiphyllum arcticum* which is present in the *Quikavsak member* of Atanikerdluk.

Countings of this kind which have been made on the collection from the Agatdalen area can of course be the object of critisism, as errors from different sources can interfere i.e. unnoticed selection of the fossils during the collecting etc. From this point of view the counting of the fossils from the Kangersôq valley can be considered defensible, as the collectors were all geologists without special knowledge of fossil floras, who collected all accessible fossils without any sorting. The counting of the fossils from Atanikerdluk cannot be guaranteed valid, though no concrete source of error can be pointed out. Moreover the author has had no control over the principles which guided the collecting in the field when these old collections were brought together; also random sorting may have occurred during their treatment in the museum. The only safe-guard may be sought in the overwhelming majority of the arcticum-type and the total lack of *C. elongatum*. This lack cannot be explained by any kind of sorting. In reality all kinds of quantitative investigations of fossils must be undertaken at the fossiliferous locality during the collecting.

Seward & Edwards (1941) separated *Cercidiphyllum arcticum* and *C. Richardsoni* based upon Heer's *Populus arctica* and *Populus Richardsoni*. These two nominal species seem to be equally represented in the collection from the Kangersôq valley and Atanikerdluk. As long as one of these types has not been found isolated in any locality and on the contrary they have always been found together, it may rather be a matter of taste whether they should be kept apart or joined to one species as done by Brown and followed by the author in this paper.

Reproductive organs: (pl. 19 figs. 2–3, pl. 20 fig. 1).

The characteristic fossil fruits, which Brown (1939 a) refers to *Cercidiphyllum* occur both in the Kangersôq valley and the Agatkløft canyon. Fig. 42 illustrates remnants of several fruits of this kind. On these may be recognized the impressions of the outer longitudinal as well as the inner transverse fibres in the wall of the capsule. One of the capsules is somewhat opened along the seam. Several casts from the Agatkløft canyon show the shape and impressions of the inner transverse fibres and the impression of the seam (i.e. pl. 19 figs. 2–3). They are completely identical with the casts described and depicted by Brown, i.e. Brown (1939 a) pl. 54 fig. 12 and similar fossils are demonstrated ibid. pl. 54 fig. 9. The exterior of the capsules are demonstrated by the specimens of pl. 20 fig. 1.

Only one seed has been found and on its own its state of preservation shows that the rarity of these seeds is probably the consequence of the coarseness of the sediment combined with an insufficient precipitation of iron compounds that could make up for the coarse texture. (Concerning this kind of fossilization, ref. pag. 16–18).

Occurrences in Greenland:

West Greenland:

Lower Paleocene:

Agatkløft, Kangersôq, Nuilaussarssuaq, Naujât (*Quikavsak*- and *Naujât members*), Atanikerdluk (*Quikavsak member*, *Naujât member*, *Aussivik member*, all of the *Upper Atanikerdluk formation*), Pautût (*Quikavsak member*), Tupaussat (*Quikavsak member*), Umiussat (*Naujât member*), Nûk qiterdleq (*Quikavsak member* of the *Upper Atanikerdluk formation*).

Besides all *Tertiary* fossiliferous localities enumerated by (Heer 1883 a, b) except Kangiussaq, Ûnartoq and Flakkerhuk.

East Greenland:

Sabine Ø, Kangerdlugssuaq.

The occurrences outside Greenland can be consulted in the list of synonyms for *Cercidiphyllum arcticum* in Brown (1939 a).

Family: Hamamelidaceae

Corylopsiphyllum groenlandicum n. sp.

(pl. 20 fig. 2, pl. 21, 22)

To this species are referred 2 well-preserved specimens and 3 lesser preserved ones. Furthermore one extremely well preserved specimen, which is only a leaf base, seems to belong to this species. All the specimens demonstrate leaf impressions and all of them are from the Kangersôq valley.

Description:

The leaf is broad–normal ovoid, with cuneate base, pinnate with slight forwardly bending or straight secondaries. From the basal pair of secondaries throughout their whole course tertiaries are issued regularly spaced and running to the basi-lateral margin. From the next secondaries 3–1 tertiaries branch off outwards in the same way. The number of these decrease anteriorly and all the terminal secondaries have no such tertiary branches. The secondaries are alternating except for the basals which are opposite. They make an acute angle of less than 45° with the primary. The base seems to be broadly cuneate.

The nervil system is more regular in the central part than in the marginal zones, especially the angular areas between the secondaries and their branches. The nervils are percurrent, sometimes forking, and wind their way from secondary to secondary fitting themselves into the pattern of the finer meshwork. The percurrent nervils are again connected by irregular quaternaries, which fit into the fine irregularly polygonal network, which is the highest order of nervation.

The leaf margin has a tendency to curl downwards. The margin is dentate on the terminal half of the leaf. The dentitions are broad and low with a thread point, which is well-preserved on several teeth (pl. 20 fig. 2, pl. 21). The sinus between the teeth is shallow and rounded allowing the margin to be described as dentate. On the basal part of the leaf they seem to grade into ordinary serrations (pl. 20 fig. 2, pl. 22 fig. 1). Secondary veins or their branches of the first order mostly terminate in the teeth. Small secondary teeth of the same shape as the bigger ones and which are nourished by a nervil may be observed, and those are rather common.

Discussion:

A superficial resemblance to *Corylus* proves untenable. *Corylus* leaves (pl. 23 figs. 3, 4) differ obviously from the fossil ones described here by means of the following characters:

1) Margin double serrate i.e. it is provided with pointed teeth of 1. order which are again provided with a varying number of pointed teeth of 2. order.
2) Sinus between the teeth is sharply cut in an acute angle.
3) The teeth are never thread-pointed.
4) The teeth are often funnel shaped with convert sigmoid margins ("onion-shaped"), the vein being the symmetry axis. This character is not universally valid.

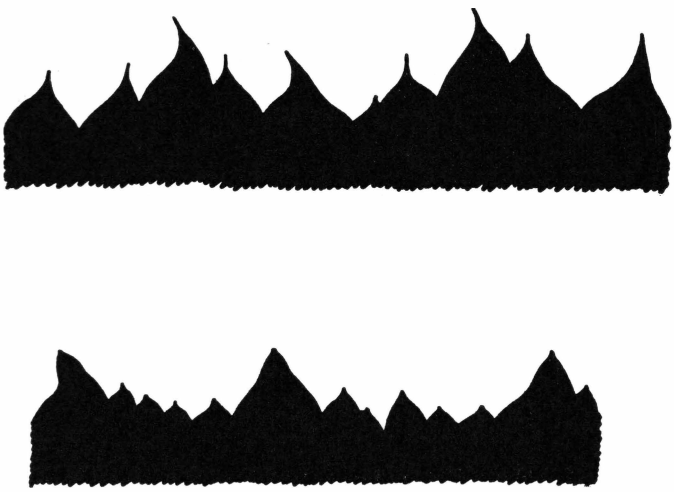


Fig. 17. Diagrammatic sketch of the dentate margin of A: *Corylus americana* and B: *Corylus avellana.* About 4:1. — Ragna Larsen del.

Some species of *Viburnum* have leaves of the broad, ovoid type, which may be difficult to distinguish from the fossil ones described by the author. This concerns e.g. *Viburnum betulifolium*, *V. dilatatum* Thunb, *V. hupehense*, *V. luzonicum* Rolfe, and *V. microcarpum* Schlecht & Cham., which show strong resemblance to the fossil specimens from the Kangersôq valley. The following differences are almost universally valid:

1) The margin has no tendency to curl downwards.
2) Intercallated teeth are uncommon.
3) When the secondaries branch, it takes place by distinct forking. Though secondaries of *Corylopsis* leaves may show a tendency to fork, this is never distinct.
4) The teeth are never thread-pointed in the manner of *Corylopsis* leaves.

It has been difficult to discover indications, which conclusively distinguish pl. 22 fig. 1 from leaves of *Viburnum*, but the fact that the leaf of pl. 20 fig. 2 has the same leaf-base and also terminally is identical with the leaf of pl. 21 and with the recent *Corylopsis* leaves of pl. 23 figs. 1–2 allows a determination of *Corylopsiphyllum.*

The author must also point out the resemblance of the basal leaf fragment of pl. 22 fig. 1 to fossil plane leaves (ref. pl. 25).

The leaves of the recent species of *Corylopsis* show exactly the same characters as the fossil leaves just described. Especially the resemblance to the leaves of *Corylopsis spicata* Sieb & Zucc. is striking.

Herbarium studies on *Corylopsis* have convinced the author of the relationship between the fossils from the Kangersôq valley and

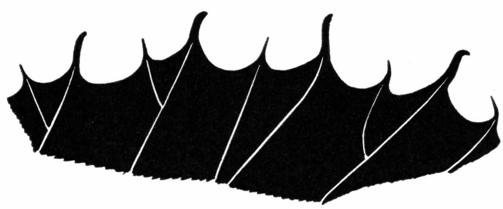


Fig. 18. Diagrammatic sketch of the dentate margin of *Corylopsis spicata.* About 4 : 1. Ragna Larsen del.

Corylopsis and especially *Corylopsis spicata.* This species shows a variation, in which the fossils can easily be arranged.

The following characters can be regarded as diagnostic for the leaves of recent *Corylopsis*, the ordinary ovoid-cordate, pinnate leaf type being presupposed (pl. 23 figs. 1–2):

1) A tendency of the leaf margin to curl downwards towards the abaxial surface. This character can vary from strongly pronounced to almost lacking.
2) The margin is dentate on the terminal half of the leaf: Broad, low teeth separated by broad, shallow and rounded sini (fig. 18). Basally they grade into ordinar serrations.
3) The teeth are provided with a thread-point (fig. 18), curled outwards or downwards according to the tendency of the margin.
4) Often there are small intercallated teeth between the ordinary ones. The intercallated ones are nourished by nervils.

It must further be noted that the secondaries of Corylopsis-leaves are very prominent.

Two of the leaves of the herbarium, which are very like the fossil ones, are found on pl. 23 figs. 1–2. They belong to a Japanese specimen of *Corylopsis spicata.*

It must be added that the above listed leaf characters of *Corylopsis* may be demonstrated in many modifications of the different leaves, now more or less prominent.

For the sake of stratigraphic analysis it must be mentioned that the same leaves are known from Atanikerdluk in samples kept in the Mineralogical Museum of the University of Copenhagen. The author remembers that, some years ago, Professor FR. J. MATHIESEN (Copenhagen) told him about a very characteristic fossil leaf from Atanikerdluk kept in the above cited collections. This was a *Corylopsis*; this good specimen unfortunately disappeared during the restorations of the Museum collections.

The agreement in morphology between the fossil leaves from the Kangersôq valley and the leaves of the recent species of *Corylopsis* is so convincing, that the author has determined the fossils as *Corylopsiphyllum*. This nominal genus implies a relationship to *Corylopsis* together with the reservation necessary, when only leaves are available.

Among the previously described fossil leaves from Greenland, there are several specimens, which resemble those of *Corylopsis*. This concerns the specimen of *Crataegus antiqua* in HEER (1883 a) pl. 50 figs. 1–2. Fig. 1 is probably correctly determined by HEER. The resemblance to *Corylopsis* leaves is superficial i.e. the dentition has another pattern. Fig. 2 can hardly be safely determined, as the margin is ill-preserved. So far as it can be studied, the dentition shows that it cannot be the leaf of a *Crataegus*, as it is dentate in the same way as *Corylopsiphyllum*.

The specimen of *Viburnum Whymperi* depicted by HEER (1869 b) on pl. 46 fig. 1 has morphological resemblance to leaves of *Corylopsis* and differs from those of *Viburnum*, as the secondaries are not forked, which is the normal manner of branching for this kind of *Viburnum* leaves. The type specimen is kept in the British Museum of Natural History, London, where the author has studied it and found it correctly depicted by HEER. What cannot be reproduced by the drawing is that the margin has a tendency to curl inwards. The author had not the opportunity to uncover the margin by supplementary preparation and so he does not know whether the teeth are thread-pointed. It may belong to *Corylopsiphyllum*.

Leaves referred to *Corylopsis* have not formerly been described from the fossil floras of *Tertiary* age from the high northern latitudes, but MATHIESEN (1932) mentions that remnants of *Corylopsis* have been described from the *Tertiary* of Japan. In this work Professor MATHIESEN described fossil wood as *Corylopsites groenlandicum*. This wood came from deposits of the Sabine Ø island, East Greenland, of presumably the same age as those of West Greenland.

Occurrences in Greenland:

Lower Paleocene:

Kangersôq, Atanikerdluk (*Quikavsak member* of the *Upper Atanikerdluk formation*).

Family: Platanaceae

Platanus sp. cfr. ***aceroides*** Goeppert

(pl. 24 figs. 1, 3, pl. 25, 26, textfig. 19)

Goeppert (1852) pag. 492; (1855) pag. 21 pl. 9 figs. 1–3.
Heer (1856) pag. 71 pl. 87, pl. 88 figs. 5–15.

From the fossiliferous localities of the Agatkløft canyon and the Kangersôq valley only a few fragmentary specimens referred to this genus are available. The best specimens are reproduced on pl. 24 fig. 3 (textfig. 19) and pl. 25. The specimen of pl. 25 is derived from the Kangersôq valley as well as a fructification, which can hardly be other than the ♀ capitulum belonging to a plane (pl. 24 fig. 1). To facilitate the interpretation of the poorer preserved specimens, the author has included in the description a specimen from Tupaussat on the south coast of the Nûgssuaq peninsula (pl. 26). It is derived from a related geological milieu, of the same age as the fossils of the Agatdalen area and is the best specimen of *Platanus* from the Tertiary of West Greenland.

The author has desisted from a specific determination, since the fossils are too fragmentary and show a wide variation. It is impossible to decide with certainty if all the specimens belong to the same natural species. The variation in leaf shape and size of the plane may be so extensive that their incorporation in one species is justified.

Apart from the margin being less dentate the leaf on pl. 25 closely resembles that of Heer (1856) pl. 88 fig. 13.

Leaves from the *Cretaceous* like that of pl. 25 have been described as species of *Credneria.*

None of the specimens from the *Tertiary* of Greenland formerly described as plane leaves is in a state, which allows a comparison to be made. The author regards them as indeterminable.

The specimen depicted on pl. 24 fig. 3 (textfig. 19) is very like that of Laurent (1912) pl. 10 fig. 3, which was determined as *Platanus Schimperi* (Heer) Sap. et Mar.

Occurrences in Greenland:

Lower Paleocene:

Agatkløft (*Sonja member* of the *Agatdal formation*),
Kangersôq,
? Qaersutjægerdal,

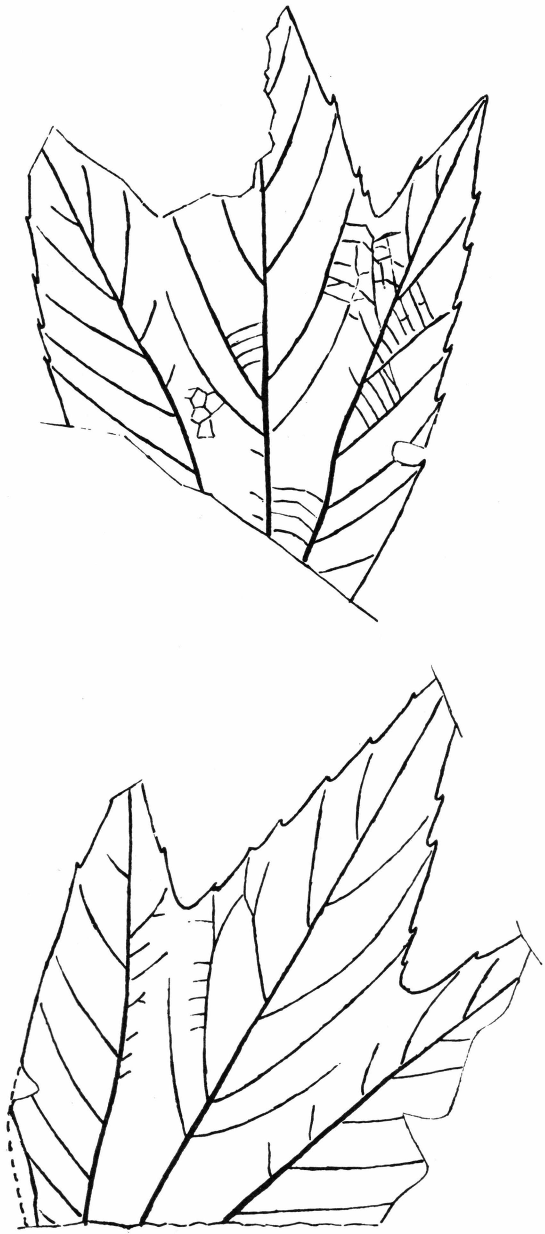


Fig. 19. *Platanus* sp. cfr. *aceroides* GOEPP: Small leaf (counterprints). 1:1. Agatkløft (G.G.U. label no. 12896.6). — KOCH del.

? Atanikerdluk, ? Pautût and Tupaussat (all from *Quikavsak member* of the *Upper Atanikerdluk formation*).

Intrabasaltic:

Hareø (Qeqertarssuatsiaq).

Family: Lauraceae

Lauraceaephyllum stenolobatus n. sp.

(pl. 27, 28, 29, pl. 30 figs. 1–2, textfigs. 20, 21, 22)

7 specimens of this species were found in the Agatkløft canyon and one in the Kangersôq valley. None of the specimens demonstrates complete leaves but 3 are representative. These fossils make up a tolerable foundation for a reconstruction.

Description:

The leaf splits up into 3 narrow lobes (eventually into 5, ref. below). The lobes make up at least half the length of the leaf. The central lobe is slender, lanceolate, constricted basally and terminally pointed. The lateral lobes are widest at their base and wedge out forwardly. The basal part of the leaf is rounded cuneate with a slightly convex margin except in the very basal part, where it is decurrent in joining the petiole. The margin of the lobes as well as the undivided basal part is entire. The petiole is vigorous. It divides supra-marginally (?) into 3 primary veins. The point of division is slightly above the insertion point of the petiole, as far as the state of preservation allows observation. The very basal part of the leaf blade is badly preserved on most specimens.

Each of the primary veins nourishes one lobe. They are rather weak and decrease gradually forwards. The specimen of pl. 28 is somewhat different, as the lateral primaries, a little above their point of departure, branch into two equal veins, to which we may assign the rank of primaries, the number of which then totals 5. This again may involve 5 lobes, which are not preserved on the specimen. Their interpretation may be justified by observations made on the specimen, where remnants of two lobes are present on the same side of the central lobe.

From the primaries, secondaries branch off making an acute angle. In the undivided basal leaf-blade, secondaries are only issued from the lateral primaries and only towards the margin; in the lobes they issue to both sides from all the primaries. The central primary gives off a strong secondary leading to the bottom of each sinus. Reaching the sinus these secondaries fork and each of the resulting, two marginal branches follows the sinual margin into a lobe. After a while they turn into the lamina to join the next secondary or tertiary vein. Below this prominent pair of sinual secondaries, the central primary only gives off a few weak veins, while stout but spaced secondaries are issued above in the central lobe. The secondaries bend regularly forward providing a camptodrome pattern. On the well-preserved areas they can be seen to connect with the preceeding and following one, as reproduced on the reconstruction

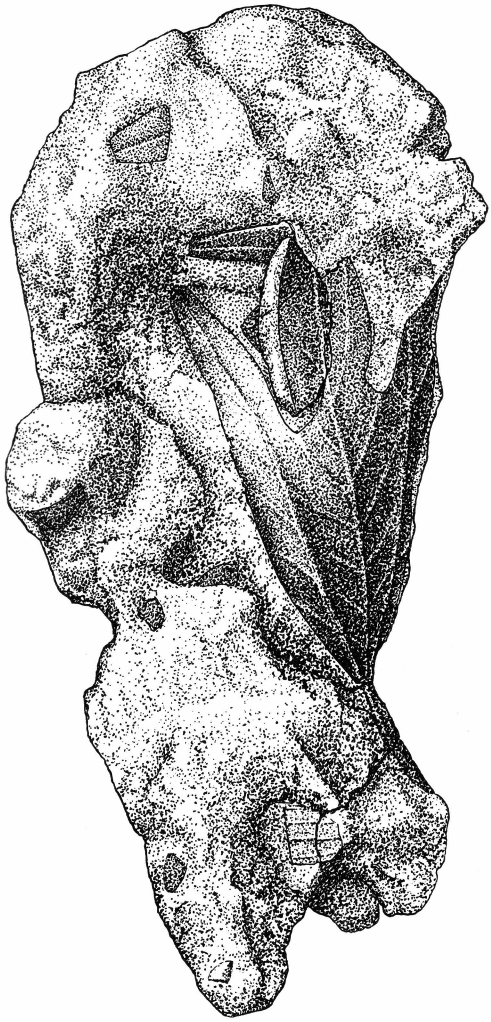


Fig. 20. *Lauraceaephyllum stenolobatus* n. sp.: Sketch of a leaf in sandstone. 1:2. Agatkløft (G.G.U. label no. 12896.23). — GUNNI JØRGENSEN del.

of fig. 21. The "central area" (i. e. the area limited by the lateral primaries and the two sinual secondaries) has no distinct secondaries.

The tertiary veins have only been found preserved on a fragment with parts of two lobes collected from the fossiliferous locality of the Kangersôq valley. It demonstrates percurrent nervils connecting the secondaries (pl. 30 fig. 1).

Marginals seem to be present at the very basal part of the leaf departing from the petiole.

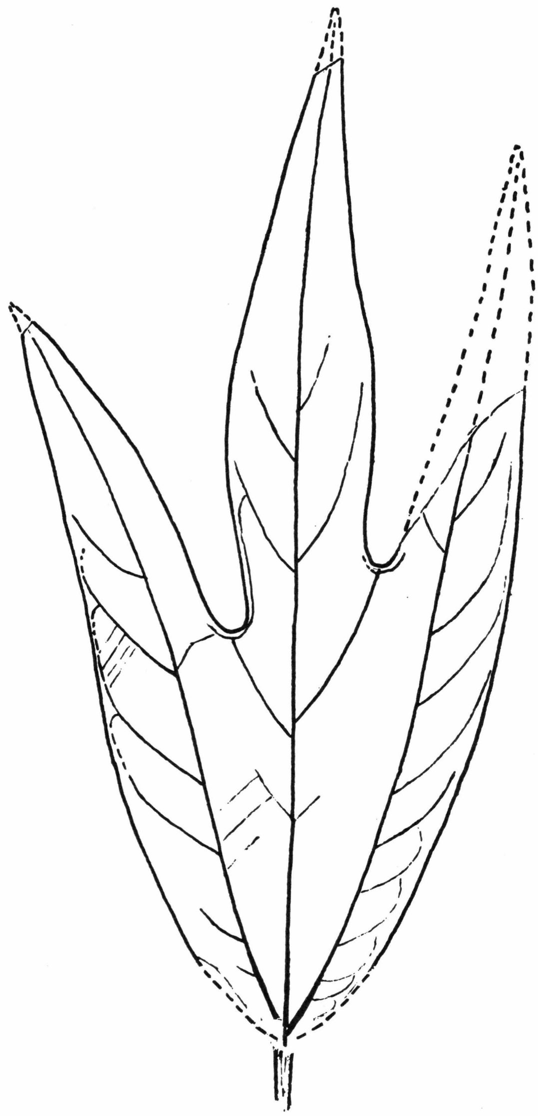


Fig. 21. *Lauraceaephyllum stenolobatus* n. sp.: Reconstruction drawn after the specimen of fig. 20. 1:1. — Koch del.

The variation in dimensions is wide, which the figures in life-size demonstrate. A variation in the proportions of the different parts of the leaf is suggested, but how far they range is not known.

Discussion:

Similar specimens were described by Laurent (Laurent 1912) from Menat (France) such as *Lindera stenoloba* (Sap.). The resemblance

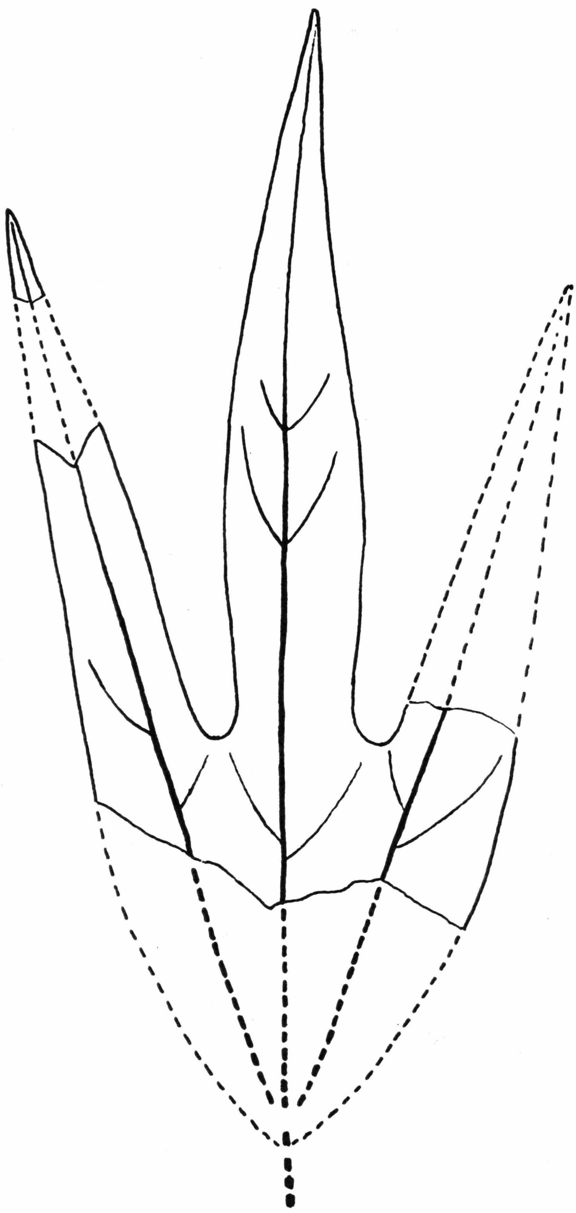


Fig. 22. *Lauraceaephyllum stenolobatus* n. sp.: Reconstruction after fragmentary specimen. 1:1. Agatkløft (G.G.U. label no. 12896.98). — KOCH del.

of this species to that of the Agatdalen area is obvious, the more so since the kind of leaf in question is a rather special one. Agreement is found in the long, slender lobes; the shape of the central as well as the lateral lobes; the shape of the base; the 3 primaries with a low-lying but supramarginal (?) point of division; the course, distribution and small number of the secondaries and the "central area" containing only tertiaries. The agreement also concerns a detail which Laurent regards important: The sinual secondaries divide at the bottom of the sini into marginals. These are regarded as characteristic for *Sassafras* and the 3-lobed leaves of *Lindera*.

The lack of secondaries below the division point of the primaries distinctly separates *Lindera* from *Sassafras* (according to Laurent 1912). On recent leaves of *Sassafras* and *Lindera* the point of divergence of the primaries is situated obviously above the insertion point of the petiole, best expressed in *Sassafras*, where space is left for a few secondary veins below that point. On leaves of *Lindera* the intralaminar position of that point is less distinct and no secondaries are found below it. This character aids the differentiation of these genera. On this point the fossils from the Agatdalen valley are not conclusive. The basal parts of the leaf impressions are fragmentary or poorly preserved. As far as the state of preservation allows observation the diverging point of the primaries is situated at the base; but the decurrent leaf-blade leaves a faint laminal rim along both sides of the petiole at the said point which strictly speaking allows us to consider the diverging point as supra-marginal or inter-laminate, though in a far lesser degree than in the case of the *Lindera* leaves of Laurent and distinctly separate from the leaves of *Sassafras*.

The *Lindera* leaves from Menat (France) show a considerable variety, as not only 3-lobed leaves but also undivided and unsymmetrical bifurcate ones have been found. This provides good support for Laurent's determination of *Lindera*. The same variation has not been found among the fossils from the Agatdalen area. Certainly a variability appears in the form of long and short lobed leaves (ref. textfig. 22 and pl. 30 fig. 2) and the supposition of one of the leaves (pl. 28) being 5-lobed may indicate a displaced shape variation. On this point the collection is far from conclusive.

We are concerned with a leaf species, which demonstrates characters of the *Lindera* and *Sassafras* leaves and a striking similarity to the fossil *Lindera stenoloba* (Sap.) Laur. It differs as regards the position of the point of divergence of the primary veins, which is less interlaminate than on the other genera, where *Sassafras* takes the extreme opposite position with *Lindera stenoloba* (Sap.) Laur. as intermediate. In this respect the author regards his species related to the *Lindera–Sassafras* circle of *Lauraceae*.

In the relation to *Lindera stenoloba* (Sap.) Laur. the geographical remoteness of the localities of these species and their difference in age necessitates a reservation, though these criteria do not constitute an absolute barrier, seeing that the very characteristic species *Macclintockia Kanei* (HEER) SEW. & CONW. (ref. pag. 76) is common for the two localities. Theoretically *Lindera stenoloba* (SAP.) LAUR. and other associates of *Macclintockia* could also be common to these localities. But the author does not find any ready explanation for this floristic similarity unless the age of the deposits of Menat is much younger than is ordinarily supposed; or the original growth habitat of the fossil flora of Menat was at an altitude which was sufficient to support a temperate element.

As the fossil collection does not suffice, the author's determination must be rather vague, but according to its relation to the *Lindera-Sassafras* circle the Lauraceous affinity is maintained: *Lauraceaephyllum stenolobatus* n. sp. A final determination must await better material in the future. The author's determination is provisional, the generic determination only claiming a probable Lauraceous affinity.

Occurrences in Greenland:

Lower Paleocene:
Agatkløft,
Kangersôq,
Atanikerdluk?? (*Quikavsak member* of the *Upper Atanikerdluk formation*) (in sensu *Sassafras Ferretianum* MASS.).

Family: Vitaceae

Cfr. *Vitis Olriki* HEER

(pl. 30 fig. 3)

HEER (1868) pag. 120, pl. 48 fig. 1.

One specimen with a complete leaf impression has been found in the sandstone of the Agatkløft canyon as well as a single fragmentary specimen.

Description:

The complete leaf agrees considerably with the type specimen of HEER (1868) pl. 48 fig. 1. The leaf is cordate. The margin is irregularly undulating with culminations where the veins terminate. Especially outstanding are those of the secondary veins. The nervation is palmate. The secondaries as well as the tertiaries are vigorously reproduced on the impression. The length of the leaf is 12,5 cm and the width about 9 cm.

Discussion:

The author agrees with the determination of HEER's type specimen and the existence of *Vitis* is further supported by the finding of seeds in the same deposits at Atanikerdluk (*Quikavsak member* of the *Upper Atanikerdluk formation*) (ref. HEER (1869 b) pl. 55 figs. 5 d, 6). These seeds are regarded even by KIRCHHEIMER (1939) as correctly determined, although he believes that the leaves of HEER cannot be proved to belong to *Vitis* in accordance with his categorical view on fossil leaves. HEER's reproduction of the type, the author admits, is not a good foundation for this estimate, since the serration is incorrectly drawn. The author found that much preparation had still to be done in the marginal zone of the type specimen. In contrast to the uncharacteristic serrations of the reproduction, the author found some very characteristic ones (pl. 32 fig. 1) which are best demonstrated by the recent *Vitis aestivalis* TORR. (pl. 31 fig. 1), *V. betulifolia* and *V. labrusca*, and also by *V. Kaempferi* and some specimens of *V. californica* BENTH. which might better be termed dentations. The dentations of the last mentioned species ordinarily are more vigorous and a more prominent feature of the leaf than are those of the fossil and first cited recent species. These dentations are low and broad and centrifugally directed (pointing outwards in the direction of the feeding vein). The figures describe them better than words (ref. pl. 31 figs. 1–4). This characteristic feature is strong support for *Vitis*. As the geological and paleontological interpretations of the plant beds of the *Quikavsak member* of Atanikerdluk make it very probable that all the well preserved plant fossils of that member originate from the same association (biocoenosis) (i.e. that of the river bank), the *Vitis* seed can be said to be derived from the same association as the leaf, and the more so since it is not worn. So the author does not hesitate to agree with HEER's determination of the Atanikerdluk fossils of this species. Its rarity in the said deposit agrees well with its habit as a vine with big leaves.

The preservation of the fossils from the Agatkløft canyon is less ideal, but since the leaf is in full agreement with HEER's *Vitis Olriki*, the determination is maintained with a reservation, which is caused by the poorer preservation.

Occurrences in Greenland:

Lower Paleocene:

Agatkløft (*Sonja member* of the *Agatdal formation*),
Atanikerdluk (*Quikavsak member* of the *Upper Atanikerdluk formation*).

Family: Papilionaceae

Cfr. ***Amicia*** sp.

(pl. 33 figs. 1, 2, textfig. 23)

2 leaves of the peculiar shape, which are exhibited by leaflets of the genus *Amicia*, and which also to some extent resemble the leaflets of

Dalbergia and *Dalbergites*, were found in the sandstone of the Agatkløft canyon.

Description:

The leaves are cuneate, being widest terminally where they are "cut off" by a regular, shallowly concave margin giving rise to two lateral points (ref. fig. 23). The margin is entire. The nervation is pinnate with a relatively stout primary, which terminates as abruptly as the leaf-blades. The secondaries are few, alternating and well spaced; weaker intercallated ones join the nervil network. The secondaries bend regularly

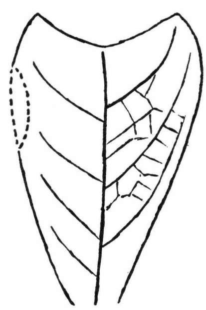


Fig. 23. Cfr. *Amicia* sp.: Sketch after specimen from Agatkløft (ref. pl. 33 fig. 1) (G.G.U. label no. 12896.30). — Koch del.

forward and are camptodrome. The nervils make up a network, which it has only been possible to observe on one of the specimens in a restricted area where a few scattered remnants were left. It seems to be a polygonal meshwork probably of about equidimensional polygons.

Discussion:

With regard to the very characteristic shape of the leaf blade, it is almost identical with the leaflets of the recent *Amicia zygomeris* Moc. & Sesse (pl. 32 fig. 2, pl. 33 fig. 3). No definite divergences between the latter and the fossils have been observed apart from the terminal-lateral points of the fossil leaf being substituted by a more gentle rounding on the recent specimens. But the state of preservation unfortunately prevents the observation of what the author should regard the damning evidence: the glands, which on the leaves of *Amicia zygomeris* Moc. & Sesse are situated in the centre of each nervil-polygon.

The resemblance to the leaves of the genus *Dalbergites* (and *Dalbergia*) gives by thorough investigation more evidence against than for a relation. The terminal incision is shallowly rounded on the fossils (and *Amicia* leaflets), while on *Dalbergia* and *Dalbergites* leaflets, the emargination is angular, resulting in an inversely cordate leaflet. This is at least valid for characteristic specimens. Consequently the latter do not at all exhibit the terminal lateral points of the fossil (and to a lesser extent on *Amicia zygomeris* Moc. & Sesse). The transversely elongated nervil meshes of the *Dalbergites* leaflet seem to be absent as far as the scattered observations on the fossil allow us to state. The nervil meshes on the other hand seem more equidimensional on the fossils as well as on *Amicia* leaflets.

On account of the highly characteristic leaf shape, which the author does not know from other genera, and the above additional evidence, the fossils are, with a reservation (based on the state of preservation), determined as cfr. *Amicia* sp.

Occurrence in Greenland:

Lower Paleocene:

Agatkløft (*Sonja member* of the *Agatdal formation*).

Family: Ericaceae

Cfr. ***Rhododendron*** sp.

(pl. 34)

In the Agatdalen valley there were found 4 leaf impressions, on which this description is based. The specimen of pl. 34 figs. 4, 5 is derived from a locality on the eastern valley slope north of Quleruánguaq (ref. pag. 14) while the others were found in the Agatkløft canyon.

Description:

All the specimens seem to come from coriaceous leaves. The main evidence is given by the specimen of pl. 34 figs. 1, 2. The extended precipitation of iron oxide around this leaf impression (ref. pag. 16), the deep impression of the leaf-blade and the very weak cast of the nervation bear witness to its coriaceous structure. The impression is wrinkled, which may be referred to the collapse of the mesophyl before the final fixing during fossilization. This again necessitates a strong epiderm which was able to hold and preserve the leaf shape, in spite of the disintegration. Basally the impression of the primary vein is rather vigorous but it quickly fades out forwardly. The nervation is pinnate. The impressions of the secondaries are recognizable but very weak. They are alternating and make a large, acute angle with the primary. They reveal a weak but distinct tendency to be decurrent at the confluence with the primary. The course of the secondaries is at first straight, but marginally they turn abruptly forward to unite with the next secondary at the initiation of its marginal curvature. The margin is less preserved but there is a distinct tendency to incurving.

Apart from the primary being more strongly exhibited and the iron oxide precipitate being less prominent, the two other impressions of somewhat smaller leaves from the Agatkløft canyon agree with the former. But independently they were indeterminable and they have only been referred to this genus with doubt.

The specimen from the Agatdalen valley near Quleruánguaq (pl. 34 figs. 4, 5) is a little differently preserved, but the leaf is in possession of the same morphological features as the former from Agatkløft. The margin shows an incurvation downwards (towards the abaxial side). The general impression is of an entire margin, but a single, small tooth was observed. A reconstruction might exhibit a few small, widely scattered teeth as may be seen on leaves of *Rhododendron*. The nervation is easier to recognize on this specimen. The impression of the primary is excellently exposed, as the vein itself has not been replaced by mineral substance, which partly fills that of the specimen of pl. 36 fig. 1. The impression shows that the primary has been quadrangular in cross-section and that it quickly weakens during its course through the leaf. Also it is easily recognizable why the substance of the remaining nervation has not been removed, but is left as incoaled matter. Its course is as described above. Additional information concerning its marginal course can be obtained. The junction of the secondaries with the next occurs some distance from the margin. Thus these secondary-archs leave a marginal zone, which is filled by a number of archs of higher order in a ground of polygonal nervil meshes. The nervil system is on the whole leaf a polygonal network. There are intercallated secondaries.

Discussion:

The structure and morphology, the coriaceous structure of which must be emphasized, the incurvation of the margin with its small, very scattered teeth and the nervation pattern, are a combination of characters found on leaves of *Rhododendron*.

As some of these criteria rest on single observations and the state of preservation is not ideal, the determination must be given with reservation and any attempt at a specific determination is omitted.

Occurrences in Greenland:

Lower Paleocene:

Agatkløft (*Sonja member* of the *Agatdal formation*),
Agatdalen at Quleruánguaq.

DICOTYLEDONES INCERTAE SEDIS

Dicotylophyllum bellum (Hr.) Sew. & Conw.

(pl. 35, 36, 37, textfig. 24)

Seward & Conway (1935) pag. 31 textfigs. 15, 16.

Synonyms: *Rhus bella* Heer: Heer (1869 b) pag. 482 pl. 56 fig. 3; Heer (1880 a) pl. 6 fig. 1; Heer (1883 a) pl. 68 fig. 3.
Andromeda denticulata Heer (1868) pag. 119 pl. 50 fig. 11 d–e.

Description:

This palmately compound leaf, ordinarily trifoliate, is common in the Agatdalen area. The preservation of the fossils varies very much and is dependent on the facies in which they occur. The specimens from the Kangersôq valley are the best preserved and have given the major information for the following description.

The leaflets have short petioles, which diverge from the end of a long common petiole. The number of leaflets is mostly 3 but a single specimen shows 5. The leaflets are lanceolate and normally they reach their maximum width at the middle. The ratio length/width is 3,4–4,8 (16 counts) in the present collection. The margin is crenulate or delicately serrate on the terminal half of the leaflet. On some of the smallest specimens it seems to be entire. The serrations are sigmoidal with forward-inwardly directed points. The midrib is strong but the secondaries make a very weak impression. They make a large, acute angle with the primary (exceeds 45°). From their starting point on the primary they are straight or show only a small degree of forward bending during the first half of their course. The lateral half bends forward and connects with the next secondary, i. e. a camptodrome pattern. Intercallated secondaries fade away into the polygonal network of nervils, which fills the areas between the secondary veins. The network seems drawn out parallel to the secondaries but this orientation varies in its degree of distinctness. The nervils are almost as strongly developed as the secondaries and leave a distinct impression in sediments of clay grade (ref. pl. 37 fig. 2).

There is a wide variation in the size of the leaves placed in this species. On the smallest leaf (Heer 1883 a, pl. 68 fig. 3) the central leaflet is 3,5 cm long and 1,0 cm max. width (pl.37 fig. 4). Another specimen (from Atanikerdluk) (pl. 37 fig. 3) is 8,0 cm long and 2,2 cm wide and so is one of the largest specimens. In comparing the smallest and biggest specimens it seems hardly reasonable that they are the leaves of the same tree or shrub. But within this variation no criterion is available which enables a separation into different species, as they pass without interruptions from the smallest to the biggest. As the entire variation occurs within the localities of the Agatdalen area as well as at Atanikerdluk (*Quikavsak* member of the *Upper Atanikerdluk formation*) and as the taxonomical position is still uncertain, the whole collection has been referred to the nominal species of SEWARD & CONWAY. The separation of these leaflets from those of *Dicotylophyllum Scottii* (HR.) seems to be a question of size, as the lower limit of the length-

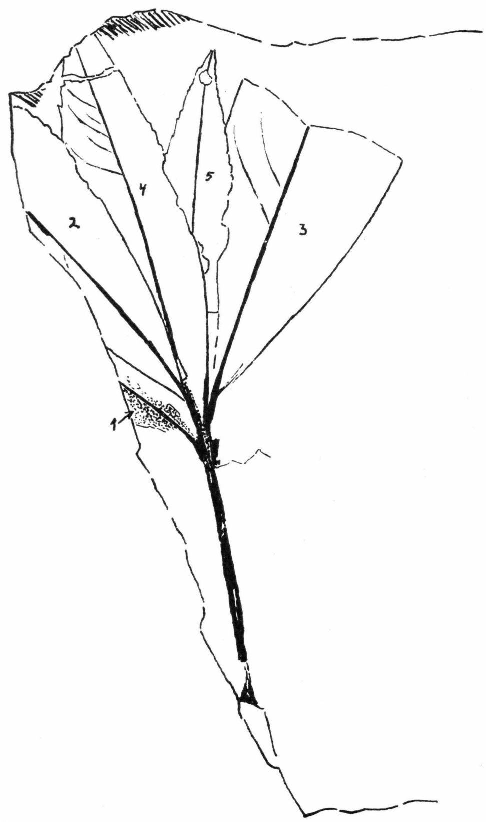


Fig. 24. *Dicotylophyllum bellum* (HR.) SEW. & CONW.: Sketch after specimen with 5 leaflets (ref. pl. 36 fig. 1). 1:1. Kangersôq (G.G.U. label no. 35492.49). — KOCH del.

variation of the latter is about 10 cm. This question is treated more thoroughly under *Dicotylophyllum Scottii* (HR.) (ref. pag. 73).

Discussion:

The preservation varies in relation to the rocks. The specimens from the sandstone of the Agatkløft canyon only produce a glimse of details here and there and only a few demonstrate the crenulate margin. When HEER's diagnosis of *Rhus bella* HR. describes the leaflet margin as entire, the state of preservation may to some degree have interfered. Also all the specimens except the one depicted in HEER (1883 a) pl. 68 fig. 3 are insufficient fragments. The mentioned exception is a very small specimen, which according to the picture has an entire margin as the corresponding specimen from the Qaersutjægerdal valley (pl. 37 fig. 1). The extremely small specimens were either entire or their crenulation was so delicate that it has failed to be reproduced in the impressions. The fossils of Seward & Conway have also been too fragmentary to allow this observation.

Two of Heer's types have not been recorded as synonyms by the author (i.e. Heer 1869 pl. 56 figs. 4, 5). Of these fig. 4 is reproduced with an entire margin. But, on the said type specimen, the margin is not free of the stone and is probably serrate. The nervation is well preserved. Its nervation and dimensions may refer it to *Dicotylophyllum Scottii* (Hr.) but the author regards it as indeterminable, and the same concerns that of fig. 5 owing to its bad preservation.

Heer's *Andromeda denticulata* has been based upon single leaves, which agree to the finest detail with the leaflets of *Dicotylophyllum bellum* (Hr.) Sew. & Conw. They are most probably shed leaflets and cannot be kept as an independant species (and genus) (pl. 36 fig. 4).

Johnson & Gilmore (1921) described *Dewalquea* from Washing Bay, Ireland. Their depicted specimens have tri- or quinquefoliate, palmate leaves of the same construction as those here described by the author. Cuticle studies have provided important information, which has led the said authors to regard their *Dewalquea* as a species related to *Juglandaceae*. As far as it appears from the descriptions and pictures, the leaves of the Irish species of *Dewalquea* are macroscopically identical with *Dicotylophyllum bellum* (Hr.) Sew. & Conw. Of course the taxonomical identity cannot be founded on this weak criterion nor can the fact that *Dicotylophyllum bellum* (Hr.) Sew. & Conw. is related to *Juglandaceae*; however the possibility must be pointed out so more so, as the genus *Picrodendron* (East Indies) has leaves, which are very similar. This genus is by Hutchinson (1959) assigned a family of its own (*Picrodendraceae*) and arranged under *Juglandales*. The cited species is derived from post-basaltic clays of Northern Ireland (*Tertiary: Eocene or Upper Oligocene* (Charlesworth 1953)).

Though morphologically very near to *Dewalquea*, our 5-foliate specimen does not seem to be in accordance with the demand of the diagnosis of *Dewalquea* for a pedate pattern of nervation.

The specimen of Hollick (1936) pl. 98 fig. 6 (*Aralia* sp?) may be identical with our species.

A fragmentary specimen, which the author cannot estimate, was described by Lesquereux (1873) from Spring Canyon, Ft. Ellis, and the same concerns the similar leaves from Gelinden, Belgium (*Dewalquea gelindenensis*) of Saporta & Marion.

Seward & Conway mention the resemblance to the leaves of *Rhus angustifolia* Linn. and *Rhus puberula* Eckl. & Zeyh. and further to those of the genus *Choisya*. Also *Ptelea* must be borne in mind as a possible relative. Sufficiant recent specimens of these genera have not been available to the author for a comparative study.

Occurrences in Greenland:

Lower Paleocene:

Agatkløft (*Sonja member* of the *Agatdal formation*),
Qaersutjægerdal,
Kangersôq,
Atanikerdluk (*Quikavsak*- and *Naujât members* of the *Upper Atanikerdluk formation*),
Qutdligssat (Equivalent to *Quikavsak member* of the *Upper Atanikerdluk formation*,
Kingigtoq (*Naujât member* of the *Upper Atanikerdluk formation*,
Tupaussat (*Quikavsak member* of the *Upper Atanikerdluk formation*).

Tertiary, stage unknown:

Isúngua (Disko Island).

Dicotylophyllum Eridani (Unger)

(pl. 38)

Synonym: *Rhamnus Eridani* Unger: Heer (1868) pl. 19 figs. 5, 7; pl. 49 fig. 10.

5 specimens have been found, which can be referred to this species. Of these only two show nearly complete leaves.

Description:

The leaf is lanceolate or elliptical with a slightly undulating, entire or delicately serrate margin. The serrations are widely scattered and are mostly so delicate that they may be characterized as mucros, which terminate the secondary veins, but they may also reach the size of distinct teeth. There are all transitions between undulations and teeth and the teeth always form the termination of a secondary vein. This delicate serration is only found in the terminal half of the leaf and the number of teeth never exceeds that of the secondary veins.

The nervation is pinnate. The secondaries are alternating, make an acute angle of abt. 45° with the primary vein and pass straight out to near the margin where they bend forward. They terminate in one of the delicate teeth or dissolve at the margin when this is entire. The secondaries are connected by irregular, percurrent nervils, which may fork or anastomose. They are in turn mutually connected by finer nervils resulting in a kind of reticulate system of nervils as demonstrated on pl. 38 fig. 2.

Discussion:

These leaves are in full accordance with those described by Heer as *Rhamnus Eridani* Ung. from Atanikerdluk. Some recent species of *Rhamnus* (e.g. *Rhamnus frangula*) have leaves which are just like the fossils. However, according to the author's herbarium studies (Bot. Mus. Univ. of Copenhagen Herb.) the recent leaves have not the spaced serrations. Concerning the recent species of *Rhamnus* with serrate leaves these always show plenty of close-set teeth, the number of which greatly exceeds the number of veins. Leaflets of *Juglans* may be constructed like these fossil leaves and thus the resemblance to the fossil *Juglans acuminata* (Heer 1869 b, pl. 54 figs. 5, 6) and *Juglans denticulata* (Heer 1869 b, pl. 56 fig. 8) must be pointed out. The leaf of pl. 38 fig. 4 shows a short petiole with a distinct sheat situated close to an axis, which, in spite of the weathered condition of the sample, at some distance from this petiole shows the ghost of another petiole branching from the axis to the same side. So this may be the question of a composed, pinnate leaf, of which that of pl. 38 figs. 3–4 is a leaflet. Also these swollen leaf sheats can be recognized on the leaflets of *Juglans* (e.g. *Juglans regia*). Therefore these may represent the shed leaflets belonging to some juglandaceous leaf.

It is impossible to determine which of these possibilities is the right one by means of the accessible fossils. Consequently the determination preferred must be *Dicotylophyllum Eridani* (Ung.) being a revision of Heer's *Rhamnus Eridani*, the generic determination of which the author regards unproved though it is far from impossible.

Occurrences in Greenland:

Lower Paleocene:

Agatkløft (*Sonja member* of the *Agatdal formation*),
Kangersôq,
Atanikerdluk, Tupaussat (*Quikavsak member* of the *Upper Atanikerdluk formation*),
Qutdligssat (equivalent to *Quikavsak member* of the *Upper Atanikerdluk formation*).

Tertiary, stage unknown:

Hareø island (Qeqertarssuatsiaq).

Dicotylophyllum Scottii (Heer)

(pl. 39, pl. 40 fig. 1, textfig. 25)

Synonyms: *Prunus Scottii* Heer ex parte: Heer 1868 pag. 126 pl. 8 fig. 7; Heer 1880 a pl. 6 fig. 2.
Rhus Holbölliana Heer: Heer 1883 a pag. 134 pl. 69 fig. 7.

Some specimens from the Kangersôq valley can be arranged under this species. Among the fossils from the Agatkløft canyon, which are lesser preserved, it has not been possible to recognize this species with certainty, though a few specimens occur which resemble HEER's *Prunus Scottii*. To distinguish this species from *Dicotylophyllum bellum* (HR.) (and to a certain degree also *Juglandiphyllum denticulatum* (HR.)) well-preserved specimens are needed and so those from the Agatkløft canyon must be stated indeterminable.

Description:

The leaves occur singly or in pairs. They often occur as two, in one case three, together in a manner implying that they were shed in con-

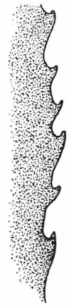


Fig. 25. *Dicotylophyllum Scottii* (HR.) KOCH: Sketch of leaf margin (ref. pl. 39 fig. 3). 2:1. Kangersôq (G.G.U. label no. 35492.42). — GUNNI JØRGENSEN del.

nection and are the leaflets of a compound leaf. In this statement as well as in the following descriptions the accessible reference fossils from Atanikerdluk (*Quikavsak member* of the *Upper Atanikerdluk formation*) are also taken into account to get a fuller description of the species.

The leaflets are oblong or narrow lanceolate, some with a tendency to be curved. The margin is serrate in the terminal part of the leaf and entire on a varying basal part comprising up to half the length. The close set serrations are sigmoidal and the point seems inwardly directed as the outer margin of the teeth is strongly convex. The author defines these as S-teeth (ref. fig. 26).

The primary vein leaves a strong impression, whilst that of the secondaries is weak. In relation to this the tertiary nervation is rather outstanding being of about the same strength as the secondaries; and sometimes it leaves a very distinct impression (in the clay-ironstone of Atanikerdluk's *Quikavsak member*). In other cases it is very weak and discrete in combination with a vigorous impression of the lamina. There seems to be a difference between impressions of the upper and lower side of the leaf. This implies a coriaceous leaf or at least one with a thick cuticle. The nervation is highly characteristic. The secondaries make a large acute angle (about 60°) with the primary and have a straight course until, in the marginal zone of the lamina, they suddenly turn forward (in steps, while issuing tertiaries) to connect with the following secondary vein. This is most obvious in the terminal half. During the bending tertiaries are issued to the serrations. In the basal, entire part of the leaflet the secondaries show a more open curved course. There are numerous intercallated secondaries and the areas between the secondaries show a polygonal network of strong nervils having an orientation

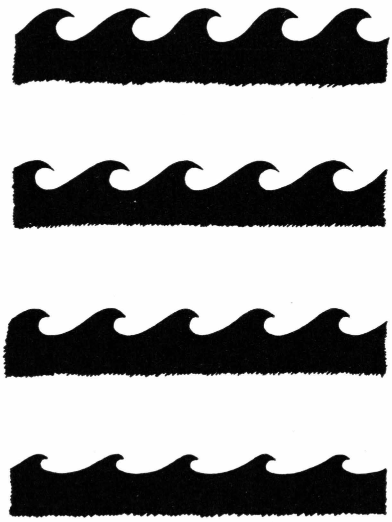


Fig. 26. Diagrammatic sketches of S-teeth. — Ragna Larsen del.

parallel to the secondaries, the meshes being drawn out in this direction. The tertiary nervation is only a little weaker than that of the secondaries.

Discussion:

No doubt Heer's type specimen of *Prunus Scottii* (Heer 1868 pl. 8 fig. 7) agrees with the specimens just described. The type specimen is a fragment but is better preserved than any of the later described; of these the one of Heer (1880 a) pl. 6 fig. 2 can be stated to be morphologically identical with the type. On the other hand the fragmentary specimen of Heer (1883 a) pl. 84 fig. 13 diverges from the ones described in the present paper and from Heer's type in several ways especially concerning the nervation. The author excludes it as indeterminable. In the collections of the Mineralogical Museum of the University of Copenhagen there are several specimens from Atanikerdluk (*Quikavsak member* of the *Upper Atanikerdluk formation*) similar to those from the Kangersôq valley. There can be no doubt that the fossils from the Kangersôq valley and the original specimen, which was described by Heer as *Prunus*

Scottii, belong to the same species. On the other hand this species is difficult to separate from *Dicotylophyllum bellum* (Hr.) Sew. & Conw. and it may be difficult also to distinguish it from specimens of *Juglandiphyllum denticulatum* (Hr.), when well-preserved specimens are not available.

In relation to *Dicotylophyllum bellum* (Hr.) the author has only found two criteria for a separation. Firstly the *Dicotylophyllum Scottii* leaflet seems to be a little more slender than that of *Dicotylophyllum bellum* (Hr.) Sew. & Conw. It is difficult to state this in exact terms on the numerically restricted and fragmentary material, but it may in the ideal case be expressed in the ratio of length/width. Unconclusive but guiding the author's measurements are for *Dicotylophyllum bellum*: 3.4–4.8 (16 counts) and for *Dicotylophyllum Scottii*: about 5.0 (only 2 counts). The author believes, when also interpreting the uncountable, more fragmentary specimens, that some degree of overlap occurs. And so the ratio is no better means than the direct observation. Under the shape-criteria it must be mentioned that the leaflets of *Dicotylophyllum bellum* are often widest at the middle, while those of *D. Scottii* do not have this symmetry achieving its max. width on either side of the middle, but the number of specimens is too small to determine the variation which seems more extensive here than for the leaflets of *D. bellum.*

The second criterion is the absolute dimensions. The leaves of the two species seem on first inspection to grade into each other, *Dicotylophyllum bellum* being the smaller, *D. Scottii* the larger; but where to draw the limit? The measurement of absolute length seems to give valuable information. An estimate on 21 (26) specimens of *D. bellum* and 7 (9) of *D. Scottii* shows all the specimens of *D. bellum* crowded between 4 cm and $8^1/_4$ cm and those of *D. Scottii* situated between $10^1/_2$ cm and 15 cm. A break occurs between $8^1/_4$ and $10^1/_2$ cm. This is at least a practical way of separation and though more extensive material of *D. Scottii* is wanted for a proof, the author at present cannot do otherwise than accept this method, which by acquaintance with the extensive collection of *Dicotylophyllum bellum* specimens seems to indicate a real, specific difference.

Furthermore it has not been possible in any essential features to distinguish Heer's *Rhus Holbölliana* (Heer 1883 a pl. 69 fig. 7) (ref. pl. 40 fig. 1) from *Dicotylophyllum Scottii* (Hr.). What at first sight seem to be differences may be due to the state of preservation, that varies according to the facies of the deposits or according to the way of fossilization. It may further be of significance whether one gets the impression of the upper or lower side of the leaf, especially in the case of a coriaceous leaf.

The leaflets, which, in one case, are 3 together in a position suggesting their organic connection, must be derived from a palmately compound leaf. The specimens with two leaflets together point in the same direction. The primary veins always point towards a connecting point close to the bases. This situation rejects Heer's determination of *Prunus*, though there is an indisputable resemblance between these leaflets and the leaves of *Prunus* species with coriaceous leaves. The very intimate resemblance between *Dicotylophyllum Scottii* and *Dicotylophyllum bellum* suggests a close relationship e.g. species of the same genus. Thus the author has confined himself to a description of the possibilities of taxonomical relationship under *Dicotylophyllum bellum* (Hr.) Sew. & Conw. (ref. pag. 69).

Occurrences in Greenland:

Lower Paleocene:
? Agatkløft,
Kangersôq,
Atanikerdluk (*Quikavsak member* of the *Upper Atanikerdluk formation*).

Dicotylophyllum Steenstrupianum (Heer) Sew. & Conw.

(pl. 40 figs. 2, 3, pl. 41)

Seward & Conway (1935) pag. 28.

Synonyms: *Quercus Steenstrupiana*, Heer (1868) pag. 109 pl. 11 fig. 5, pl. 46 figs. 8, 9; Heer (1869 b) pag. 472 pl. 46 fig. 4; Heer (1883 a) pag. 92 pl. 69 fig. 5.

Concerning synonymous species originating in localities outside Greenland, the reader can be referred to Lamotte (1952).

The specimens of this species mostly come from the Qaersutjægerdal valley. A few specimens were found at the fossiliferous locality of the Agatkløft canyon. The state of preservation varies from very detailed impressions to strongly weathered specimens.

Description:

The leaves are, like Heer's type of *Quercus Steenstrupiana*, mainly small (e.g. width: 2,5 cm, length: 6 cm), but a single big specimen (width: 4 cm, length: 9 cm) has been found, which in dimensions agrees with those which Seward & Conway describe from Kingigtoq. A transition between these is shown by a couple of leaves.

The leaves vary in shape from ovoid to almost lanceolate types. The midrib is extremely strong. The secondaries, which make an acute angle of abt. 45° with the primary, are mostly opposite and parallel. They have been vigorous too, as they leave a strong impression even in a rather coarse rock. The teeth are always nourished by secondary veins or their tertiary branches. The margin is typically serrate. The teeth are long, slender, pointed and forwardly directed with rounded sini. Those teeth, which are nourished by tertiaries, are only slightly smaller than those nourished by secondaries. The tertiaries between the secondaries are percurrent except in the marginal zone. In the laminal areas between the percurrent tertiaries there is a polygonal network of vigorous nervils which leave strong impressions on the well-preserved specimens (ref. pl. 41).

Discussion:

From pl. 40 figs. 2 and 3 showing well-preserved specimens from the Qaersutjægerdal valley and Atanikerdluk respectively, there appears an obvious resemblance as far as the details are concerned. The author has no doubt that the specimens from the Agatdalen area represent the same species as HEER's *Quercus Steenstrupiana.*

Concerning the taxonomical relationship the following must be pointed out:

In his treatment of the genus *Quercus*, SCHWARZ (1936) also touchs on the fossil representatives and excludes part of the fossil species. Among these is HEER's *Quercus Steenstrupiana.* The genus *Quercus* is very extensive, and the author does not feel competent to judge in this case, but he has not during extensive herbarium studies found any *Quercus* leaves identical with those of the said fossils. Consequently, the author has sought other possibilities among recent genera. The fossil leaves have a strong morphological resemblance to those of *Carpinus*, which for the majority of species only diverge regarding the serration. The teeth of the *Carpinus* leaves are mainly of two or more orders of size and furthermore the sini are sharply cut angles. A few *Carpinus* species do not normally show these differences e.g. *Carpinus Handelii* RHED. (Hunan, China), *C. Kweichowensis* HU, *C. polyneura* and *C. Seemdniana* DIELS. Compared with these recent species the fossils are different in their percurrent tertiary veins. As no exact agreement can be stated and other organs of *Carpinus* are missing in the collections from Greenland, there is no reason for any determination other than that of SEWARD & CONWAY: *Dicotylophyllum Steenstrupianum.*

In spite of the vague determination the species is so characteristic that it is easy to recognize and well-suited for stratigraphical purposes and can be used in comparative lists of fossils. SEWARD & CONWAY's specimens from Kingigtoq are the only ones, the arrangement of which into *Dicotylophyllum Steenstrupianum* (as synonymous with HEER's *Quercus Steenstrupiana*) can be doubted. They seem to be atypical or extreme in the range of variations of the species. Their state of preservation is too bad to allow a critical investigation. The synonymous types of HEER are on the other hand typical.

Occurrences in Greenland:

Lower Paleocene:

Agatkløft (*Sonja member* of the *Agatdal formation*),
Qaersutjægerdal,
Atanikerdluk (*Quikavsak member* of the *Upper Atanikerdluk formation*),
Kingigtoq (*Naujât member* of the *Upper Atanikerdluk formation*).

Outside Greenland this species has been recorded from California and Alaska.

Macclintockia Kanei (Heer) Sew. & Conw.

(pl. 42, 43, 44)

Seward, A. C. & V. Conway (1935).

Synonyms: *Daphnogene Kanei*, Heer (1868) pag. 112 pl. 14, pl. 16 (syntypes).
Macclintockia trinervis, Heer (1868) pag. 115 pl. 15 figs. 7, 8, 9 (syntypes).
Cocculus Kanei, Saporta & Marion (1873) pag. 63 pl. 10.
Cocculites Kanei, Heer (1874 c) pag. 21; Heer (1883 a) pag. 124.
Majanthemophyllum petiolatum (Weber), Weyland, H. (1948) pag. 118 pl. 18 fig. 6.

This species was commonly recorded in the Agatdalen area, found in all of the three fossiliferous localities: Agatkløft, Qaersutjægerdal and Kangersôq. In the former it is very common. Thus a few nearly complete specimens were uncovered. In most cases the specimens only demonstrate fragments of the basal half of the leaf, but on these the terminal part with the apex was also preserved. The general state of preservation is very variable but the specimens numbering abt. 25 that were brought home from the Agatdalen area, together with the older specimens from Atanikerdluk and Kingigtoq enable a complete description to be made of the macroscopic features of the leaf.

Description:

The leaf is oblong-lanceolate with rounded cuneate base. The apex is pointed, the extreme margins converging; this structure is not unlike a "dripping point". Basally the lamina, with convex margins, tapers gently towards the insertion point of the petiole. The leaf may be entire at least on all the specimens from the Agatdalen valley, as far as the state of preservation allows a statement. But a terminal dentition may occur. Specimens from Kingigtoq (ref. Seward & Conway 1935) demonstrate one or a few terminal teeth. 3 acrodrome primary veins diverge supramarginally from the insertion point of the petiole. They decrease forwards and in the terminal part of the lamina the lateral ones weaken until they are definitely absorbed into the network of veins of higher order, while the central primary reachs the terminal point. Secondary veins can be distinguished in the marginal zones as well as in the areas between the primary veins (pl. 19 fig. 1). They are weak.

The marginal secondaries depart (angle about 60°) from the lateral primaries running obliquely forward and bend gently forward to join the next secondary. The first one starts from the insertion point of the petiole. So they make up a regular marginal chain of connecting archs.

In the areas between the primaries the secondaries are weaker and less individually defined. They are obviously determined by the same pattern as described for the marginal secondaries. But as they, besides uniting the former and the next one from the same primary vein, also join the secondary system from the neighbouring primary, they make up coarse, irregular meshes. These meshes of first order contain a polygonal network of meshes (4–5 sided, less often 6 sided) of tertiary veins. They again contain a third order network of mainly 4–5 sided polygons of nervils.

The petiole is rather slender. On the specimen of pl. 42 fig. 2 it keeps the same thickness all the way while on that of pl. 44 fig. 1 it increases from the point of dehiscence to the base of the lamina. Ordinarily it expands near the lamina. To a different degree it swells into a hold, which clutches the leaf base and stretches a short distance into the lamina. The primary veins diverge from the terminal end of this hold (supramarginal). On pl. 42 fig. 2 a central strand is seen as the petiole is cleaved. On pl. 43 where the outer surface is exposed, a number of longitudinal ribs are demonstrated. On a specimen the lamina of which has been at least 4 cm wide and 16–18 cm long (pl. 42 fig. 2 and B. Eske Koch 1959 pl. 1 and esp. the counterpart) the entire petiole of 5,2 cm's length is exposed where it can be seen that it basally expands to a sheat with a scar after the conducting strand representing the base of the petiole and the point of dehiscence. Besides, the sheat is demonstrated by the specimen of pl. 44 fig. 1.

The dimensions of the leaves vary tolerably and are apparent from the figures which are life-size.

Discussion:

1) Morphology. Heer described the synonymous leaves of *Daphnogene Kanei* Hr. as coriaceous. On a specimen from Antrim kept in the British Museum of Natural History, South Kensington, the author found cuticle fragments preserved. It demonstrated a very thin membrane without any structure preserved which could be developed by mazeration. To find cuticle remnants on this species is a very rare case and this fact too makes its coriaceous structure doubtful. Also the ironoxide precipitations in which the specimens of *Macclintockia Kanei* (Hr.) Sew. & Conw. of the Agatkløft canyon are preserved are by no means stronger than on its associates e.g. *Cercidiphyllum arcticum* (Hr.) Brown, *Platanus aceroides* Goepp. and *Vitis Olriki* (Hr.). (On the

significance of the ironoxide precipitate, ref. pag. 16–18). From these criteria the author believes that the leaves of *Macclintockia Kanei* (Hr.) Sew. & Conw. were not coriaceous. This also seems in better harmony with the fossil association in which it occurs: a humid, deciduous flora.

There is almost complete agreement between the fossils of the author and Heer's description of *Daphnogene Kanei* (Heer 1868 pag. 112 pl. 14 and pl. 16) and Seward & Conway's supplementary description (Seward & Conway 1935 pag. 24 pl. 2 figs. 16, 17, 20). It appears that Heer's specimens were not sufficient for a complete description, since the apex is wrong on his reconstruction (Heer 1868 pl. 16). This agrees with the author's experience that the apex seldom is found preserved and probably has been tempted to wither before defoliation. Heer's reconstruction is wrong as regards its blunt apex. The terminal serra or serrae are, as appears from the author's description, not universal, and contrary to Seward & Conway he cannot regard it as a mistake when Heer's reconstruction shows an entire leaf. So the few complete leaves from the Agatkløft canyon were entire. But the leaf with a single serra (pl. 44 fig. 2) or with serration must be added to a complete description in consequence of the synonymy with *Macclintockia trinervis* Heer.

The serrations which can be recognized on textfigure 7 of Seward & Conway (1935) are weak, forming almost a crenulation. The author agrees with Seward & Conway that there have been specimens with irregularities on the margin of the apex. Also more vigorous serrae have occurred than seen on Seward & Conway's specimens. In the collection from Kingigtoq (the Nûgssuaq peninsula) (ref. B. Eske Koch 1959, pag. 39 and 91) of the late Dr. N. Hartz (Copenhagen) there are specimens of *Macclintockia Kanei* (Heer) Sew. & Conw. (Hartz: *Cocculites Kanei* Hr.) where a single strong serra can be recognized on one side of the apex which is well-preserved and absolutely intact (ref. pl. 44 fig. 2). But there is only one stout serra. A weak serration can be recognized on a specimen from Kreuzau, Siebengebirge, Germany, which is depicted by Weyland (ref. Weyland 1948 pl. 18 fig. 5) and it diverges in this respect not markedly from the Arctic specimens. From Atanikerdluk the author has a specimen with 4 serrae terminally (pl. 44 fig. 3). The apical one is a distance from the other more crowded ones; and above the latter the apex is exactly identical with that of the above mentioned monoserrate specimens from Kingigtoq. In Heer's terms this specimen is a *Macclintockia trinervis*, which as regards serration grades into *Daphnogene Kanei* Heer.

2) Determination: Seward & Conway (1935) combined *Daphnogene Kanei* Heer and *Macclintockia trinervis* Heer as one species: *Macclintockia Kanei* (Heer) Sew. & Conw. The author regards it as

a practical arrangement; from a taxonomical point of view it is rather a matter of taste whether to keep or combine the two nominal species as long as this complex of leaves has not found its place in the natural system of plants. But he agrees in the generic change into *Macclintockia.*

The two original species are well defined and can be distinguished alone by the character: serrate/non serrate. Further HEER described the *Macclintockia trinervis*-leaf as unsymmetrical, somewhat falciforme (contrary to *Daphnogene Kanei* HR.). Strictly applied, HEER's diagnosis allows us to refer the above described monoserrate specimens as well as the delicately serrate or crenulate leaves of SEWARD & CONWAY to *Macclintockia trinervis* HR. But it must be admitted that the monoserrate as well as the delicately serrate or crenulate specimens make up a transitional type that tends to make the existence of the two original species improbable from a taxonomical point of view. This is the more so as the former are also nearly symmetrical (not falciform).

We can well regard the above described monoserrate specimens etc. as intermediate between *Daphnogene Kanei* HEER and *Macclintockia trinervis* HR. Besides, one can also regard the *Macclintockia trinervis* leaf as a slender variety of *Macclintockia Lyalli* HR. (ref. pag. 84) (oblique specimens of *Macclintockia Lyalli* also occurring in the present collection). But also the entire specimens of *Macclintockia Lyalli* HR. may be transitional between the serrate (and typical) leaves of *Macclintockia Lyalli* HR. and *Daphnogene Kanei* HR.

Though it may be caused by insufficient collections and a number of other factors, the author notices that the two original species have not always been found together in their different localities. Both of them are recorded from the *Quikavsak member* of Atanikerdluk while *Macclintockia trinervis* HR. has not been found in the Agatdalen area (but on the other hand oblique specimens of *Macclintockia Lyalli* HR. are present). From Isúngua (Disko island) HEER recorded *Macclintockia trinervis* HR. and not *Daphnogene Kanei* HR. (HEER 1883). From Lozwa river, Ural, KRYSHTOFOVICH identified *Macclintockia trinervis* HR. and *M. Lyalli* HR.

From his collecting in the Agatdalen area where many of these leaves were recognized without finding a single indubitable specimen of *Macclintockia trinervis* HR., the author must ascertain that some natural sorting in fact has been brought about. This may have the biological reason that there really are included two or more species in this variation of fossil leaves. But in theory other biological reasons are possible such as a difference in variation in leaf shape owing to differences in growth conditions in the delta (primary supplier to the deltaic locality of the Agatkløft canyon) and the higher upstream sites (Atanikerdluk).

It seems impossible in this case to explain the sorting as the result of pure physical separation during transport and sedimentation, where organic remnants must obey the same rules as the inorganic mineral debris. Both very big leaves of *Daphnogene Kanei* Hr. and small leaves of *Macclintockia Lyalli* Hr. are well represented in the fossiliferous locality of the Agatkløft canyon. Here the size and weight have not been the critical factors of sorting during transport and sedimentation.

So the absence of *Macclintockia trinervis* Hr. in the Agatdalen area could be a criterion in favour of its specific independence, but far from a proof. The many contemplations on this fascinating genus have not born success, though they may be supplementary to the only means of progress: criteria of taxonomical significance from better fossils. The author believes that the idea of the leaves being not coriaceous is new evidence which may lead to the right path.

Originally Heer regarded *Daphnogene Kanei* Hr. (Heer 1868) as related to *Cinnamomum*. Saporta & Marion described it from Gelinden (Heersian of Belgium) as *Cocculus Kanei* (Hr.) and referred it to *Menispermaceae* on account of its resemblance to the recent *Cocculus laurifolius* DC (Saporta & Marion 1873) and recording *Cocculites Kanei* in his "Flora Fossilis Groenlandica" 1883 Heer agreed with them. Schimper also referred it to *Menispermaceae* but determined it as *Macclintockia Kanei* (Hr.) (Schimper 1874) but Staub on the other hand referred it to *Lauraceae* as *Cinnamomum Kanei* (Hr.). Gardner pointed out the resemblance with the *Urticaceous* genus *Pila* (Gardner 1887) and Seward & Conway regarded with some reservation their *Macclintockia Kanei* (Hr.) as belonging to *Urticaceae* and especially point out certain species of *Boehmeria*. For instance the leaves of *Boehmeria macrophylla* are constructed in the same design. So many possibilities are open, but all of them presuppose a coriaceous leaf.

The *Early Tertiary Flora* from Greenland as well as those from about the same latitude outside Greenland give the impression of temperate conditions. The author has arrived at this conclusion as a result of observations of the best determined part of the species (ref. pag. 98–99) as well as from an investigation on leaf morphology based upon the observations of Bailey & Sinnott (1916) (ref. pag. 100). So the purely tropical, high temperature genera and families ought not to be considered before all other possibilities among genera with a northern area of distribution and temperate affinity are exhausted. Of course this as well as the other principles of paleoecology cannot be used generally or uncritically as 70 Mill. years separate us from the *Early Tertiary floras* of Greenland, which may account for changes in the structure and physiology of certain taxonomical groups and for the extinction of other units. The author cannot actually imagine *Cinnamomum* or the *Meni-*

spermaceae in the sylva described from the *Tertiary* of Greenland, but admits that extensive studies, which are necessary to choose among the many taxonomical possibilities of *Macclintockia Kanei* (HR.) SEW. & CONW. under the assumption that its leaves were not coriaceous, are still to be done and will scarcely succeed before better collections of fossils are available. The author only wants to point out that the pattern of the nervation, especially that of 2., 3. and higher orders, is *dicotyledonous*.

WEYLAND described specimens identical with those of the author as *Majanthemophyllum petiolatum* WEBER from the *Oligocene* of Germany. Owing to the insufficient descriptions and misleading figures of HEER he declined any relationship with the Arctic finds. The study of WEYLAND's exemplary depictions convinces the author of their identity. This leads to an intricate problem of priority.

WEBER described *Majanthemophyllum petiolatum* in 1852 and if the type is qualified it keeps the priority. But WEBER's specimen is fragmentary and badly preserved as it appears from the pictures of WEBER (1852) and WEYLAND (1948), from the original diagnosis and from WEYLAND's description. The miserable state of the type has made it impossible to recognize the identity with the numerous better specimens (here included in *Macclintockia*) which have been described from other localities in Europe as well as in America. WEBER's type cannot be rationally distinguished from the leaves of plenty of *monocotyledonous* as well as *dicotyledonous* genera. On these criteria the author regards it unqualified as a generic type, the more so since its priority should reject a genera (*Macclintockia*) well established for nearly a century.

The same concerns the specific status. WEBER's type as it appears and as it was originally depicted cannot be distinguished from other species of *Majanthemophyllum* as well as from *Macclintockia*, *Smilax*, *Boehmeria* etc. So it is not a valid, specific type. Also here a priority would reject the long established *Kanei*-species of HEER.

The specimens of HEER's *Daphnogene Kanei* and his species of *Macclintockia* published 1868 are much better preserved and reveal a high degree of details, which allows a good description of the genera and a distinction from all other genera. Also the species could by their definition be distinguished from other species; though disagreements have been detected between the original description of the *Kanei* species and the later, more complete specimens, this has not essentially changed its pattern or description.

The *Daphnogene Kanei* HR. has, regarding its generic status, undergone several revisions, first to *Cocculus* and later modified to *Cocculites*. Its morphological pattern which is identical with the *Macclintockias* led it finally into the latter genus (SEWARD & CONWAY 1935). *Macclintockia* has on the other hand proved tenable, as it does not involve more than is possible to state and it is a valid genus.

Referring to the International Code of Botanical Nomenclature of 1956, article PB 4 and Recommendations PB 6 F, the author opposes the priority of *Majanthemophyllum petiolatum* Weber to *Macclintockia Kanei* (Hr.) Sew. & Conw. and to *Macclintockia trinervis* Hr. owing to the bad preservation of the type specimen of the former and the insufficient figure of the original publication. These criteria make it invalid as the type of a genus well-preserved specimens of which have been well known under the generic designation *Macclintockia* since 1868, and since other species since the same year have kept their specific names of Heer.

When a change of the generic determination of this most remarkable species (originally *Daphnogene Kanei* Hr.) has proved necessary, the author agrees with the determination of *Macclintockia* of Schimper (1874) and Seward & Conway (1935) in consequence of the real priority of the genus. The generic characters of *Macclintockia* are seen in the pattern of the nervation, especially that of 2., 3. and higher orders, as well as in its general morphological pattern. A corresponding nervation cannot be recognized on the type of *Majanthemophyllum petiolatum* Weber, and the percurrent nervils, which are faintly suggested on the picture of Weber, are directly misleading. Though it cannot be held a type, the author agrees with Weyland in assuming an identity between Weber's and his specimens. Consequently Weyland's finds make it highly probable that Weber's specimen is identical with those of the author. But when this is impossible to prove, Weber's specimen is omitted as a synonym.

Occurrences in Greenland:

Lower Paleocene:

Agatkløft (*Sonja member* of the *Agatdal formation*),
Qaersutjægerdal,
Kangersôq,
Atanikerdluk, Pautût and Nûk qiterdleq (all from *Quikavsak member* of the *Upper Atanikerdluk formation*),
Kingigtoq (*Naujât member* of the *Upper Atanikerdluk formation*).

Age uncertain:

Ûnartoq?

Occurrences outside Greenland:

Eocene:

Mors, Denmark,
Fur, Denmark,
Lozwa river, Ural, Russia (*Upper Eocene*) (*Macclintockia trinervis*).

Eocene?:

Glenarm, Ireland.

Oligocene:
Kreuzau, Germany,
Quegstein, Germany,
Allrott, Germany.
Oligocene? (Upper Eocene?):
Menat, Auvergne, France.
Age uncertain:
(?) Port Neill, Vancouver Island, Canada.

The following records are regarded uncertain by the author:
Bering river, Alaska (*Paleocene or Eocene*),
Gelinden, Belgium (*Paleocene*),
Kitsalano, Vancouver Island, Canada (*Eocene;* Dawson: Upper Cretaceous).
Concerning *Macclintockia trinervis* HR. refer below! (pag. 84).

The occurrence at Bering river, Alaska, is doubted by the author concerning the fragment which was described and depicted by HOLLICK (1936) (pag. 121 pl. 67 fig. 11). This leaf seems atypical as it does not show the characteristic swollen insertion of the petiole into the lamina. Better fossils are wanted.

From Western Canada (Port Neill, Vancouver Isl.) the species was described by DAWSON (1893) (pl. 10 fig. 38) as *Macclintockia trinervis* HR. He dates it as belonging to the *Upper Cretaceous* and correlates it with the *Atane formation* or the *Pautût formation* of Greenland. From the picture the author cannot judge the specific determination, but no doubt it belongs to *Macclintockia.* The author would determine it as *Cfr. Macclintockia Kanei.*

BERRY (1926) depicts a doubtful specimen as *Cocculus Kanei* (his pl. 16 fig. 2). It does not demonstrate any of the characters which are particular for this species. It is broader and more ovoid than *Macclintockia Kanei* (HR.) SEW. & CONW. (= *C. Kanei*). There seems to be a touch of a swollen insertion of the petiole when entering the lamina, but it is not at all pointed out. The text states that it is such a characteristic leaf that there cannot be any doubt of its identity. But when BERRY as a criterion mentions "numerous acrodrome primaries" it seems as if he did not exactly know either *Macclintockia trinervis* or *M. Kanei* but confuses them with *Macclintockia Lyalli* and *M. dentata.* Until a revision of the American *Macclintockias* becomes available, the author must keep the question of these specimens open.

The specimen from Gelinden, Belgium (ref. SAPORTA & MARION 1873 pl. 10 figs. 1, 2), may as well belong to *Macclintockia heersiensis* SAP. & MAR. which was found at the same locality. Owing to this doubt the author has not referred to this locality in the list of occurrences.

To avoid further confusion SEWARD & CONWAY's version of *Macclintockia Kanei* has been accepted in this paper which means that

Macclintockia trinervis HR. is regarded as a synonym. So the records of this species are listed as occurrences of *Macclintockia Kanei* (HR.) SEW. & CONW.

The distribution of *Macclintockia Kanei* (HR.) SEW. & CONW. shows a tendency to move further south during the *Palaeogene*. The extremes are the lower part of the *Upper Atanikerdluk formation* of Northwest Greenland (oldest and northernmost) and the *Oligocene* of Kreuzau, Germany, and the supposed *Lower Oligocene* of Menat, Auvergne, France (youngest and southernmost). Between these are *Eocene* occurrences of Great Britain, Ireland and Denmark. But still there is so much doubt concerning age and records that no conclusion is made.

Macclintockia Lyalli HEER

(pl. 45, 46)

HEER (1868) pag. 115 pl. 15 figs. 1 a, 2, pl. 16 figs. 7 a–b, pl. 17 figs. 2 a–b, pl. 47 fig. 13, pl. 48 fig. 8.

This species is common in the Agatdalen area and was found in the fossiliferous localities of the Agatkløft canyon, Qaersutjægerdal valley and Kangersôq valley. 22 specimens were brought home to the Mineralogical Museum of Copenhagen University.

The leaves are so characteristic that a detailed description is superfluous and the author has nothing essential to add to HEER's diagnosis. It must only be mentioned that the serration of the terminal margins is very variable and also leaves with an almost entire margin have been found (pl. 46 fig. 2).

There is no great difference between this species and *Macclintockia dentata* HR., the last mentioned only being broader and with more primary veins. There is a gradual transition between these species, and consequently it may be the question of leaves of the same natural species. The transition to the former *Macclintockia trinervis* HR., and so to the *Macclintockia Kanei* (HR.) SEW. & CONW., is not sufficiently abrupt for their specific independence to seem convincing. So these species must be regarded as nominal (ref. *Macclintockia Kanei* (HR.) SEW. & CONW. pag. 79).

The taxonomical position of this species is uncertain. HEER at first positioned it among the *Proteaceae* (HEER 1868) and later among the *Urticaceae* (HEER 1883 a). SEWARD & CONWAY (1935) treated it under the heading "Dicotyledones incertae sedis" but pointed out the resemblance to the leaves of *Melaleuca Cunningiana*.

Regarding the occurrences it must be mentioned that *Macclintockia Lyalli* HR. often occurs together with *Macclintockia Kanei* (HR.) SEW. & CONW. e.g. in the fossiliferous localities of the Agatdalen area, Kingigtoq and Atanikerdluk. Outside Greenland the same concerns the locality of Glenarm, Ireland, and as *Macclintockia trinervis* is regarded as synonymous with *Macclintockia Kanei* also the locality of Lozwa river, Ural.

Occurrences in Greenland:

Lower Paleocene:

Agatkløft (*Sonja member* of the *Agatdal formation*),
Qaersutjægerdal,
Kangersôq,
Atanikerdluk and Tupaussat (both from *Quikavsak member* of the *Upper Atanikerdluk formation*),
Qutdligssat (equivalent to *Quikavsak member* of the *Upper Atanikerdluk formation*),
Kingigtoq (*Naujât member* of the *Upper Atanikerdluk formation*).

Occurrences outside Greenland:

Glenarm, Ireland,
Lozwa river, Ural, Russia.

Macclintockia dentata Heer

(pl. 47 figs. 1, 2)

Heer (1868) pag. 115 pl. 15 figs. 3, 4.

4 specimens which can be determined as belonging to this species have been found in the Agatkløft canyon.

The species only differs from *Macclintockia Lyalli* Hr. by the wider leaf and the higher number of primary veins. Heer's diagnosis mentions 7 primaries but the specimens from the Agatkløft canyon may show up to 9. Apart from this supplement the author has nothing essential to add to the original diagnosis, which on the other hand is rather insufficient as a description of the characteristic network of nervils is missing. But as the species itself is rather problematic there is no reason to change its diagnosis so long as no conclusive material is found.

The author questions its specific independance. The leaves referred to *Macclintockia Lyalli* Hr. and to *Macclintockia dentata* Hr., may belong to the same natural species since their leaves are variations of exactly the same design and pass evenly into each other. And this may further concern *Macclintockia Kanei* (Hr.) Sew. & Conw. (ref. pag. 79 and 84). As nothing certain is known about the taxonomic position of *Macclintockia dentata* Hr. nor about that of the related nominal species, it seems needless at present to consider this question in further detail.

Occurrences in Greenland:

Lower Paleocene:

Agatkløft (*Sonja member* of the *Agatdal formation*),
Atanikerdluk (*Quikavsak member* of the *Upper Atanikerdluk formation*).

Nordenskiöldia borealis Heer

(pl. 47 fig. 3)

Heer (1870) pag. 65 pl. 7.
Synonym: *Diospyros* sp.: Heer (1868) pl. 47 fig. 5.

An impression of this characteristic lobed fossil fruit was found in the sandstone of the Agatkløft canyon. This specimen has not brought new evidence of its taxonomic position.

Heer placed it among the *Malvaceae* as a schizocarp.

Nevertheless it is one of the characteristic ingredients of the *Early Paleocene* fossil flora of the high northern latitudes, and thus may be valuable as an indicator fossil.

Occurrences in Greenland:

Lower Paleocene:

Agatkløft (*Sonja member* of the *Agatdal formation*),
Atanikerdluk (*Quikavsak member* of the *Upper Atanikerdluk formation*).

Occurrences outside Greenland:

Paleocene:

Cape Staratschin, Spitzbergen,
Mackenzie river, Alberta,
Great Bear river, Alberta.

Paleocene or Eocene:

Portage Bay, Alaska.

Eocene:

Green river, Wyoming,
Tipperary, Wyoming.

Eocene or Oligocene:

Quesnel, Brit. Columbia.

Credneria spectabilis (Heer)

(pl. 48, 49, 50, pl. 51 fig. 1)

Synonyms: *Pterospermites spectabilis*, Heer (1869 b) pag. 480 pl. 43 fig. 15 b, pl. 53 figs. 1–3; Heer (1880 a) pag. 14 pl. 6 fig. 10; Heer (1883 a) pag. 125 pl. 81 fig. 3 a.
Pterospermites alternans, Heer (1869) pag. 480 pl. 54 fig. 3.
Ficus? groenlandica Heer ex parte, Heer (1868) pag. 111 pl. 49 fig. 8.
Quercus platania Heer ex parte, Heer (1869 b) pl. 46 fig. 5.
Viburnum Nordenskiöldi Heer ex parte, Heer (1883 a) pag. 115 pl. 92 fig. 11.

As the author has not studied the Alaskan types, the species of Hollick (1936) described as *Pterospermites* are not listed among the synonyms, although they probably are equivalent to the Greenlandic species.

For the interpretation of this circle of leaves from the Agatdalen valley, the author has sought support from fossils derived from Atanikerdluk (the *Upper Atanikerdluk formation*). Not only Heer's types but also specimens from the younger collections kept in the Mineralogical Museum, University of Copenhagen, are involved, in order to get the best possible impression of the leaf variation.

Some specimens from the Kangersôq valley can be referred to *Credneria spectabilis* (Hr.). Its occurrence in the Agatkløft canyon is not proved.

Description:

The leaf shape varies from oval to nearly circular: ovate—cordate. As they are ordinarily big leaves, complete specimens have not been found. So it is impossible to state this character in more exact terms; but the shape seems to vary tolerably within the interval mentioned. The leaf base is rounded, subemarginate—emarginate. The petiole is long (pl. 49). The margin is undulating to crenate. On this point the reader notices a divergence from Heer's original descriptions, which states that the margin is entire. The margin on Heer's types was badly preserved giving rise to this false view. Specimens with crenations consequently were excluded and stated as *Quercus platania* Hr. Later (1880 and 1883) Heer admitted crenate specimens of *Pterospermites spectabilis* as the *var. foliis dentatis*. As stated in Heer's diagnosis of *Ficus? groenlandica* (1868) and *Pterospermites alternans* (1869), the margin was probably glandulous. This is admitted by the author (ref. below).

The nervation is pinnate. The vigorous, basal secondaries are opposite or sub-opposite; the following secondaries are sub-opposite—alternate. Their course is straight to slightly forward bending. The leaf is strongly characterised by a few, weak basal secondaries issued below the first vigorous pair. They make a right to blunt angle (nearly 90°) with the primary and are often backwardly turned. The basal one describes a number of archs, each one between two percurrent nervils. Finally it joins the next secondary which continues the marginal archmaking. This again finally unites with the basal tertiary which passes towards the margin from the first pair of vigorous secondaries. This tertiary and its branches, as also the following ones and the secondaries from which they are derived, all terminate abruptly at the margin, and in the crenations if such are present. This general way of termination held together with scattered observations of gland tipping on the author's specimens and the figured specimens of Heer (1883 a) pl. 81 fig. 3 a (*Pterospermites spectabilis*) and Heer (1868) pl. 49 fig. 8 (*Ficus? groenlandica*) gives evidence of the gland tipping which Heer assumed.

The larger veins (1. and 2. order) are connected by strong nervils which are percurrent, forking or anastomising. They are connected by a 2. order system of percurrent or forking nervils. Near the margin the 1. order nervils make polygonal meshes.

Discussion:

In the way in which the author defines the species *Credneria spectabilis* (Hr.), the leaves show a wide variation. As it appears from the list of synonyms, the species rests upon a foundation of old species. Of these *Pterospermites spectabilis* Hr. and *P. alternans* Hr. are the essential ones, both quantitatively and qualitatively. These two species are practically separable by means of their diagnosis, which states that the former have opposite basal secondaries, the latter sub-opposite—alternate basal secondaries. The author found no practical difficulty in separating his fossils according to this scheme. Were it not for other questions, the two species could have been maintained, though they were alike in all other respects.

The variation in nervation caused Heer to group his *Pterospermites spectabilis* in 3 unnamed varieties. The author also in his restricted collection found at least two of these varieties among the fossils of the *P. alternans-design* (e.g. 1: var. with one small basal secondary, and 2: var. with more than one small basal secondary).

The variation from an undulating (Heer: entire) to a distinctly crenate margin as well as the gland tipping has been observed in the *P. spectabilis* as well as in the *P. alternans* designs.

The leaf shape varies from elliptical to broad-cordate in both designs.

A variation occurs both in the emargination and rounding of the leaf base, but the collection is not sufficiently comprehensive for a comparison of the variations between the two. The emarginate or subemarginate basis can be observed ordinarily in both. A large, but unfortunately badly preserved leaf from the Agatkløft canyon may belong to this species but it is at the moment indeterminable (pl. 50 fig. 1). It is also impossible to interprete a very well-preserved leaf impression from Atanikerdluk with a cuneate base though it may belong to this species. Morphologically it belongs to the same circle (The Fæster Coll., Min. Mus. Copenhagen).

It must be noted that the two species of Heer (*Pterospermites spectabilis* and *P. alternans*) are not only found together in their localities in Greenland but also occur together as far away as Alaska (Hollick

1936) and with at least some of the said variation (according to HOLLICK's plates). HOLLICK preferred to erect some new species out of the variation, but they fade into each other.

The ideal taxonomical unit has two qualifications: 1) It is defined by a diagnosis which is written in precise terms and which covers exactly the qualities of the organism or fossils concerned, and which also covers a group of individuals which, by the diagnosis, can easily be distinguished from the individuals of other units, and 2) that it, as defined by the diagnosis, covers a natural unit.

If we intend to make as precise a diagnosis as possible the procedure of determination will in this case lead us in the paths of HEER to the erection of a considerable number of new varieties or a corresponding number of species. We must then take the risk of further expansion of the number as the collections grow. When we immediately have to make 12–15 species, this is not a good solution from a practical point of view (the form-species being to a large degree a practical arrangement). But such a splitting of near related fossil leaves also meets with theoretical controversy. With the all-round impression of the natural conditions of the time-space constellation in question obtained from the fossil collections and geological investigations, there is reason to consider it impossible that so many species of the same genus should crowd into the banks of the same river or the same restricted area on the *Paleocene* foreland in question. In other words, that they should occur together at Atanikerdluk and in the Agatdalen valley in Northwest Greenland. And furthermore it is improbable that they should linger together at such remote sites as Greenland and Alaska.

It is also improbable that so many leaf variations of the same design should truly reflect an almost corresponding number of natural species.

In the same way the distinction between the species *Pterospermites spectabilis* HR. and *P. alternans* HR. founded on the position of the basal veins is not a guaranteed specific character. A pair of opposite veins often occurs in a system of alternate secondaries and are ordinary in a sub-opposite one. The reliability of the two species diminishes as a consequence of their identical leaf-variations and of their joint occurrences in the localities inside Greenland and also in Greenland and Alaska. This also outrules their practical use in comparative stratigraphical studies.

The alternative to the splitting is to keep the whole variation in one species. In the present case we are consequently dealing with a species with variable leaves, but which varies within reasonable limits on a theme of well-defined characters.

The author considers it unreasonable by means of splitting to anticipate the better future information arising from growing collections, but on the other hand reasonable to keep the whole variation of leaf impressions in one nominal species. It must be nominal because we cannot exclude the possibility of more than one natural species being represented by the fossils. This is why the accessible leaf criteria are not necessarily diagnostic for natural species.

The *Paleocene* flora of high latitudes of the North American continent seem nearly congruent in composition from region to region and appear to justify the term climax. This makes the assumption of one or a few species being represented by the fossils more probable than a high number.

Further it is worth stating that it is by no means improbable that one species has furnished the leaves of the variation in question. This is even more probable than a considerable number. That the variation seems to repeat itself in the known areas of distribution gives support to this. At least the geographical distribution does not make any controversy for one species.

Because it has the least practical and theoretical drawbacks, the variation is kept in one nominal species.

During the author's literature studies on *Pterospermites* it appeared that the genus has a dualistic status. The type is *Pterospermites vagans* Heer (1859), a seed of *Pterospermum* affinity. Leaves were incorporated as *Pterospermites palaeophyllus* Sap. in 1861 and later on many leaf species were erected. When determining both the leaves and seeds as *Pterospermites* the only generic attribute is that they probably belong to or have a near affinity to *Pterospermum*. Consequently the generic criterion is the subjective opinion about the taxonomical status, which is uncertain for the leaves, in the author's opinion. It is doubtful that the leaves have anything to do with *Pterospermum*. This means that the dualism is confusing, as without sufficient evidence it refers seeds and leaves to the same fossil genus. It must be mentioned that no such seeds have been found in the beds with which we are concerned. The International Code of Nomenclature would outrule the leaves. The seeds have the priority.

The author agrees that any change of long established names is undesirable, but in the present case the maintenance of the settled status may cause a confusion which is worse.

Consequently the author prefers to keep the *Pterospermites* as a form genus of seeds. This is all the more so, since another good and well established genus is available which displays these leaves without any change of diagnosis. The resemblance to *Credneria* is obvious, as it was already mentioned by Heer (1869) and Hollick (1936).

Credneria was erected by Zencker in 1833 (type species: *Credneria integerrima* Zencker). The type has the following diagnosis:

"Folia obovata, basi subliloba, petiolata; nervi foliares quadruplicis generis: nervi primarii subrecti basilares angulo subrecto abeuntes, reliqui secundarii et tertiarii angulo 45°–75°, quaternarii tenuissimi angulo subrecto orti."

Occurrences in Greenland:

Lower Paleocene:

? Agatkløft (*Sonja member* of the *Agatdal formation*),
Kangersôq,
Atanikerdluk (*Quikavsak* and *Naujât members* of the *Upper Atanikerdluk formation*),
? Pautût and Tupaussat (*Quikavsak member* of the *Upper Atanikerdluk formation*).

Intrabasaltic:

Hareø island (Qeqertarssuatsiaq).

DICOTYLEDONOUS DESIGNS*)

Design: ***Magnolia Inglefieldi*** HR.

(pl. 53 fig. 4)

From the Qaersutjægerdal valley there is a leaf fragment (impression) (pl. 53 fig. 4) constructed like those leaves which HEER describes as *Magnolia Inglefieldi.* Since a strobiloid fruit of *Magnolia* has been recorded from Atanikerdluk (*Quikavsak member* of the *Upper Atanikerdluk formation*), there is reason to believe that at least a part of the leaves described by HEER is correctly determined. The present specimen from the Qaersutjægerdal valley is badly preserved and its relation cannot be determined with certainty. A better preserved specimen from Pautût (from *Quikavsak member* of the *Upper Atanikerdluk formation*) (ref. B. ESKE KOCH 1959 pag. 93) is depicted pl. 53 fig. 1. This specimen was determined *Magnolia Inglefieldi* HR.

Design: ***Alnus Kefersteini*** GOEPP.

(pl. 55 fig. 3)

Some leaf impressions of a poorer preservation have been found in the Qaersutjægerdal valley and the Agatkløft canyon (G.G.U. label no. 12896.178, 12896.223, 28955.2) which may be identical with those described by HEER as *Alnus Kefersteini* GOEPP. from Svartenhuk peninsula. The better specimens agree in shape, nervation and serration rather well with the recent *Alnus subcordata.* The state of preservation does not allow a proper determination.

*) Ref. the explanation pag. 20–21.

Design: ***Betula Brongniarti*** Ett.

(textfig. 27)

One specimen was found in the Agatkløft canyon (G.G.U. label no. 12896.132) which has obvious resemblance to the leaves of *Betula* (e.g. the recent *Betula lutea* and *B. papyrifera*). The leaf impression is crumbled up and could only be depicted as a reconstruction. The leaf is ovoid with cordate base, the nervation is pinnate with opposite

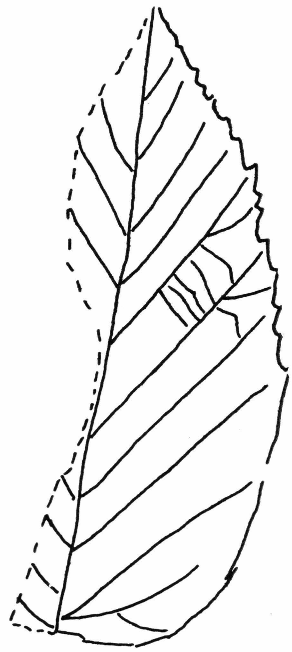


Fig. 27. Design *Betula Brongniarti* Ett. Sketch reconstructing a crumbled specimen, 1:1. Agatkløft (G.G.U. label no. 12896.132). — Koch del.

secondaries and the serration is of two orders. It belongs probably to a *Betula* though leaves of *Carpinus* and *Ostrya* may be difficult to distinguish from that genus when the impression is not well preserved. This makes a reservation necessary in this case, the more so since the author has only one specimen. The leaves of *Betula* and *Alnus* may also interfere which demands for extreme care.

There is a high degree of resemblance to the specimen in Heer's Flora Fossilis Groenlandica (Heer 1883 a) pl. 96 fig. 5 a.

Design: ***Carpinus grandis*** Ung.

(pl. 52 figs. 1, 3, 4)

In the collection from the Agatkløft canyon 3 specimens (pl. 52 figs. 1, 3, 4) can be compared with *Carpinus grandis* Ung. in sensu

Heerii, as it appears from HEER's determination of fossils from Greenland, Alaska and Sachalin. They agree with the diagnosis which HEER cites in his Flora Fossilis Arctica I (1868). But their small number and their state of preservation do not allow a determination which must involve a revision of the species. They belong probably to *Carpinus* or *Betula* or an ancestral genus.

Design: ***Diospyros brachysepala*** AL. BRAUN

In the collection from the Agatkløft canyon there is a specimen which shows a basal fragment of a leaf joining this species (in sensu Heerii) (G.G.U. label no. 12896.81). The author feels sure that it is identical with those described by HEER from Greenland. The present fossil cannot be made the basis of a revision or a verification of the generic determination.

Design: ***Cornus ferox*** UNG.

(pl. 52 figs. 2, 5)

In the collection from the Kangersôq valley there is a nearly complete leaf (pl. 52 fig. 2). It is damaged by a few incisions caused before deposition, but apart from this it is more complete than any of the specimens which HEER described. Further there is a basal fragment of a bigger leaf which also resembles *Cornus ferox* UNG. (pl. 52 fig. 3).

The leaf is ovoid and entire. The leaf blade is 7 cm long and 4.4 cm broad. The base is broad but a little decurrent along the thin petiole which is 2 cm long; the point of dehiscence is preserved. The nervation is pinnate. The secondaries are alternating, they are decurrent at the primary, make an acute angle with the primary and curve evenly forward to converge with the margin (camptodrome pattern). In the marginal zone they often fork. The basal secondaries issue tertiaries which make a row of combined archs along the basal margin, and the same pattern is found in connection with the marginal parts of the other secondaries.

The author feels sure that *these leaves are identical with those which* HEER *described as Cornus ferox from Atanikerdluk*, but it seems unjustified to refer them to the species of UNGER. Concerning the generic determination the author does not feel sure since the fossils are too few to justify a revision.

Design: ***Quercus Laharpii*** GAUD.

(pl. 55 fig. 2)

One specimen from the Kangersôq valley demonstrates a leaf fragment which is exactly similar to those depicted from Atanikerdluk by Heer (1869 b) pl. 44 fig. 10 and pl. 49 fig. 4. This single fossil does not allow a revision which would include a better determination. But concerning its identification with those of Atanikerdluk the author has no doubt.

Design: ***Fagus castaneaefolia***

(in sensu Heerii 1868 pl. 46 fig. 2)

A specimen from the Agatkløft canyon (G.G.U. label no. 12896.172) of bad preservation shows a leaf impression with a regular pinnate nervation and a single serration of medium sized teeth which make it identical with the above cited species of Heer in the sense of the specimen from Atanikerdluk cited above in parenthesis. A determination with its necessary revision is impossible on this single fossil of bad preservation. The determination of fossil leaves belonging to the circle of *Cupuliferae* of this remote age is always difficult. When we are concerned with such a generalized type as the present leaf, the author would determine it as *Dryophyllum*.

Design: ***Quercus Drymeia*** Ung.

(pl. 51 figs. 2, 3)

Quercus Drymeia Ung. in sensu Heer (1856) pag. 50 pl. 75 fig. 19, Heer (1868) pag. 88 pl. 11 fig. 2 a.

Two specimens from Qaersutjægerdal and Kangersôq valleys respectively agree with the original diagnosis of Unger and an exactly similar leaf is depicted by Heer (1856) vol. II pl. 75 fig. 19.

The structure of the present fossils, esp. the Kangersôq specimen, indicates that the original leaf was coriaceous. The impression of the leaf blade is strong but the secondary nervation is suppressed. The total impression is that of the leaf of a small-leaved oak (e.g. *Quercus taliensis*, *Lithocarpus Konishii*). The secondary nervation which it is possible to study on the Qaersutjægerdal specimen agrees with that of *Quercus* and *Dryophyllum* in the bipartition before the entrance into the serrations (ref. Laurent 1912). Intercallated secondaries according to Laurent rather point towards *Quercus*.

Also *Castanopsis* may demonstrate similar leaves (ref. *C. formosana*).

The sparce fossils of this design do not justify an exact generic determination, but the author regards them as *Cupuliferae*.

As they agree with the diagnosis of the fossil species *Quercus Drymeia* Ung., one might determine them as this species. But the generalized diagnosis and the type arriving from the younger *Tertiary* of Europe give way to doubt and a determination in the ordinary sense may be misleading. So the author prefers to keep the question open.

Design: ***Quercus Lyelli*** Heer

(pl. 55 fig. 1)

Under this designation can be described two leaf fragments from the Kangersôq and Qaersutjægerdal valleys. The author is aware that in his work on the typology of the oak leaves Schwarz (1936) mentions Heer's *Quercus Lyelli* among those fossil species which he could not accept as belonging to *Quercus*.

The species *Quercus Lyelli* needs a revision but the author will not in this connection make an attempt, because only two leaf fragments are available and the majority of specimens referred to this species are from Atanikerdluk, especially from the *Naujât member* of the *Upper Atanikerdluk formation*. In a survey of the Atanikerdluk specimens the author has observed that the types are not correctly reproduced (Heer 1883 a). All of them show a differing amount of serration which is represented by the undulations of the margin of the specimens on the figures. This fact brings them into conflict with the diagnosis of *Quercus Lyelli* Hr. (types from Bovey Tracey) and raises the question whether they are sparsely serrate specimens of *Juglans Heerii* Ett. Further it opens the way for the interpretation of a number of species of the *Upper Atanikerdluk B flora* centering around the design *Quercus Lyelli* Heer and *Juglans Heerii* Ett. as perhaps belonging to one natural species. In this connection the species *Dryophyllum subfalcatum* Lesq. may also be taken into account.

The divergence between the type specimens and figures of *Quercus Lyelli* makes Schwarz's statement irrelevant for a revision.

So these specimens are presented under the group Designs the author being aware that a revision will perform changes.

Design: ***Quercus Ravniana*** Hr.

(pl. 54 fig. 1)

A fragment of a big leaf from the Agatkløft canyon agrees in all essential characters (— the petiole which is not preserved) with Heer's *Quercus Ravniana* and is by the author regarded identical with Heer's type. But owing to the bad state of preservation of the type specimen as well as that of the present specimen and the author's doubt concerning the correctness of the generic determination, it is kept under the heading of Designs.

FREQUENCE AND DISTRIBUTION

An ecological analysis is not anticipated. The collection is too restricted for a statistical treatment, which must await at least a revision of the collections from the *Tertiary* of Atanikerdluk. The author's attempt to make a field count on the Kangersôq locality failed in 1956, when the fossiliferous bed proved to be a lens, which had been nearly emptied by earlier collecting. Another attempt must await the discovery of a new suitable occurrence.

The process of collecting always gives a broad impression of the relative frequency of the species or some groups of species. As this information may be of some value to students of the geology and paleontology of this area, a short evaluation is presented as follows.

The following are very common and can be used to characterize the fossil flora:—

(*Metasequoia occidentalis* (NEWB.) CHANEY) (valid for Kangersôq)
Cercidiphyllum arcticum (HEER) BROWN
Macclintockia Kanei (HEER) SEW. & CONW.
Macclintockia Lyalli HEER
Dicotylophyllum bellum (HEER) SEW. & CONW.

The frequency of these species shows a variation, when we compare their different localities. Thus *Metasequoia occidentalis* (NEWB.) CHANEY is very common among the Kangersôq fossils, but is rare in the localities of the Agatdalen valley (coarse facies). When we take into account the many localities, which we have learned to equate with the *Lower Paleocene* of the Agatdalen area (e.g. Atanikerdluk) (ref. B. ESKE KOCH 1959 and Stratigraphical Evidence pag. 104), the situation of Kangersôq is the normal, whilst that of Agatdalen the abnormal for the *Lower Paleocene* of Northwest Greenland. *Metasequoia occidentalis* (NEWB.) CHANEY is even more common in the *Quikavsak* member localities of the south coast of the Nûgssuaq peninsula than in Kangersôq. At Atanikerdluk it is difficult to pick up a slab without finding a twig of *Metasequoia*.

The *Macclintockias* are very common in the Agatkløft canyon but less so in Kangersôq, which also in this respect resembles the *Quikavsak member* localities.

Cercidiphyllum arcticum (Heer) Brown and *Dicotylophyllum bellum* (Heer) Sew. & Conw. are ubiquitous.

These species the author uses to characterize the actual thanatocoenosis (the Macclintockia — Metasequoia — Cercidiphyllum t.).

The following species are common and evenly distributed:

Quercophyllum groenlandicus (Heer) Koch
Juglandiphyllum denticulatum (Heer) Koch
Dicotylophyllum Steenstrupianum (Heer) Sew. & Conw.

Occurring here and there with even distribution are:

Platanus sp. cfr. aceroides Goepp
Credneria spectabilis (Heer) Koch

The latter species seems rather common at Atanikerdluk.

The following are common only at the Agatkløft locality:

Cupuliferites angmartusuticus n. sp.
Lauraceaephyllum stenolobatus n. sp.

As could be expected from the studies of the North American temperate floras (Chaney et al.), there is also in the fossil flora from Agatdalen an element, which has its nearest, recent relatives in eastern Asia (*Ginkgo*, *Metasequoia*, *Cercidiphyllum*, *Corylopsis*). It comprises some of the most distinctive and common species. This element is even more outstanding, when the *Quikavsak member* localities of the south coast of the Nûgssuaq peninsula are encountered (the "*Upper Atanikerdluk A flora*"), where *Metasequoia occidentalis* (Newb.) Chaney and *Cercidiphyllum arcticum* (Heer) Brown occur on every slab.

However, the collection does not allow us to point out a typical North American element. Rather a group of genera are wide-spread in temperate regions of the northern hemisphere (*Quercus*, *Juglans*, *Platanus*, *Vitis*).

The collection undoubtedly belongs to the *Arcto-Tertiary flora* and particularly that from the *Quikavsak member* of Atanikerdluk (*Upper Atanikerdluk A flora*). The latter is not so far revised, that it adds sufficient new evidence to justify an extended discussion on the phytogeographical relations.

PALEOCLIMATOLOGICAL EVIDENCE

With this fossil flora we are so far back in the *Cenophyticum*, that it is possible to point out near-related, recent species to only a few of the fossil species from the Agatdalen area. This fact is obviously apparent from the determinations given. So the conclusion, drawn from the comparison with the recent relatives, is only guiding. In the following scheme there has been arranged such selected species from the Agatdalen area together with their nearest, recent, relative species and short information on the climatic demands of the latter.

Fossil species from the Agatdalen area	Nearest recent relatives	Climatic demands of nearest recent relatives
Ginkgo adiantoides (GOEPP.) SHAPARENKO	*Ginkgo biloba* LIN.	Unequivocal natural populations never found. Fertile in warmer temperate climates (humid).
Metasequoia occidentalis (NEWB.) CHANEY	*Metasequoia glyptostroboides* HU & CHENG	*Eastern Central China:* January average abt. 0 °C. Seldom slight frost. Vegetatively it seems to thrive excellently in a mean-to-warm temperate, humid climate. Its hardyness and fertilizing tolerance are not yet sufficiently known, but it seems to be a good temperate species.
Quercophyllum groenlandicus (HEER) KOCH	The leaf type is familiar to the temperate oaks of humid areas. e.g. *Quercus prinus* CURT. and *Quercus mongolia* FISCH. ex TURCZ.	*Q. prinus* CURT. *The Appalachias from Georgia to Maine:* January average — 5° C.–+ 5 °C, humid. *O. mongolia* FISCH. ex TURCZ. *Northern China and Corea:* mean-to-warm temperate, humid.

(continued)

(continued)

Fossil species from the Agatdalen area	Nearest recent relatives	Climatic demands of nearest recent relatives
Juglandiphyllum denticulatum (HEER) KOCH	*Juglandaceae* (— Engelhardtia and Platycarya)	Warmer temperate humid climates of the *New and Old Worlds*
Corylopsiphyllum groenlandicum n. sp.	*Corylopsis* sp. esp. *spicata*	*Eastern Asia:* in a climate with January average abt. 0° C. Humid(*C. sinensis* is a member of the natural association of *Metasequoia glyptostroboides* HU & CHENG!)
Cercidiphyllum arcticum (HEER) BROWN	*Cercidiphyllum japonicum*, *C. magnificum*	*Japan and China* with January average abt. 0° C. Humid.
Platanus sp. cfr *aceroides* GOEPP	*Platanus* div. sp.	Warmer, temperate climates in the *New and Old Worlds*
Cfr *Vitis Olriki* HEER	*Vitis* div. sp.	Warmer, extratropical areas. Humid.
Dicotylophyllum Steenstrupianum (HEER) SEW. & CONW.	*Carpinus* and *Ostrya*	*Carpinus*: *The Balkans and Asia Minor:* Warmer, temperate. *Ostrya: North America, Japan:* Temperate, humid.

The listed species are in agreement, in so far as their nearest recent, relative species are connected with temperate climates with the exception of cooler regions. There seems to be a tendency towards the warmer temperate climate. This conclusion is supported by the *palm seeds*, of which many specimens have been found in the outcrop of Scaphitesnæsen as well as in the big section of Qaersutjægerdal and Agatkløft. They cannot at this moment be fully utilized, as they have not been finally determined, but they are nevertheless valuable in this connection.

Concerning precipitation we find the listed recent relatives connected to the more humid areas.

Supplementary paleo-climatological evidence can be sought by analysis of the leaf morphology, a method which is especially fitted to fossil leaf floras. This has especially been elaborately utilized by CHANEY and his collaborators in the studies of the Cenophytic floras of western

North America. In this way Sinnott, E. W. & I. W. Bailey (1916) demonstrated how the quantitative representation of entire leaved species in the sylva is useful as a climatological indicator. Their conclusion is cited here:

"There is a clearly marked correlation between leafmargin and environment in the distribution of Dicotyledons in the various regions of the earth.

Leaves and leaflets with entire margins are overwhelmingly predominant in lowland-tropical regions; those with non-entire margins in mesophytic cold-temperate areas.

In the tropical zones, non-entire margins are favoured by moist uplands, equable environments, and protected, comparatively cool habitats; in the cold temperate zones, entire margins are favoured by arid environments and other physiologically dry habitats.

Correlations between leaf-margin and prevailing climatic influences are more strikingly shown among trees and large shrubs than among herbs, as might naturally be expected, when the fundamental differences between these important growth forms are taken into consideration.

The determination of the percentages of entire and of non-entire leaves in Cretaceous and Tertiary Dicotyledonous floras, affords a simple and rapid means of gauging the general climatic conditions which existed in the regions where these plants flourished.

There is grave danger in inferring, because a certain foliar character has remained unaltered through long periods of geological time, or has varied greatly among closely related forms, that the leaf is inherently "conservative" or "inconstant"."

Normally it is just the trees and shrubs, which by means of their detached parts, come into the geological record and it is the remnants of these, which we are treating here. Thus the cited study is highly relevant. In order to demonstrate the principle, the following ratios have been extracted from the scheme of Sinnott & Bailey (1916) pp. 25–27 and arranged in relation to their geographical latitude with the northernmost first:

	number of species	% with entire leaves trees	shrubs	herbs
Western Siberia	1085	0	57	45
Eastern Central North America	1504	10	37	42
England	1273	3	37	35*)
France	3924	4	53	48
Southeastern North America	4451	36	54	48
Eastern Central China	2015	38	52	—
West India	2209	88	71	48
Malaya	3252	90	82	64
Central East Africa	2837	75	74	54
Average for northern temperate areas		2	41	43
Average for southern temperate and subtropical areas		34	58	44
Average for the tropics		81	77	56

*) Bews (1927): Trees and shrubs with entire leaves make up 30 % in England.

From CHANEY & SANBORN (1933) the following proportions have been extracted:

locality	% trees and shrubs with entire leaves
Hawaii, lowland	76 %
Hawaii, highland	56 %

So it is evident that there is a relation between climate and leaf margin.

Also the dimensions of the leaves have climatic relevance. RAUNKIÆR (1934) has touched on these problems, which have also been treated by BEWS (1927) in a phyllogenetical and evolutionary study of the angiosperms. There is a high proportion of big-leaved species in the tropical forests of markedly humid areas. However, small-leaved species are predominant in xerophytic and temperate forests.

CHANEY & SANBORN (1933) also made statistical comparisons between fossil flora and recent forest types by means of other leaf characters. These include the percentage of species with dripping point, the proportion between species with compound and uncompound leaves and also between species with pinnate and palmate leaf nervation. At least the dripping point is a good climatological indicator. But the proportion between species with pinnate/palmate nervation is so far not sufficiently distinctive to be conclusive (at least in the present collection). Also the author finds unsafe the proportion between species with compound and uncompound leaves in a fossil flora. The proportion of species with compound leaves can easily be underestimated. These normally shed their leaflets individually and so species with compound leaves may at least be hidden in the undeterminable residuum, as well as being dependent on the correctness of the determinations of the leaflets.

In order to secure the best possible foundation, on which to estimate the climatological conditions in Northwest Greenland in the *Early Paleocene*, the author has utilized two of the above cited leaf characters: 1) The proportion of species with *entire*, and *non-entire* leaves and 2) the percentage of species with leaves with *dripping point*. The present fossil flora allowed a count on these characters, which also have the benefit of being well controlled by counts done on the recent sylva.

The counts on the fossil flora of the Agatdalen area not only comprise the determined species but also the "designs", i.e. those leaf types that can be judged to be a species of their own. There is a total of 47 of these "species". The number of species, which could be exploited for each of the characters, is plotted on the scheme of pag. 102.

Chaney (1925 a) compared his Bridge Creek flora with the modern redwood forests (Muir woods) on the Pacific Coast Range and also pointed out their resemblance to the *Arcto-Tertiary flora.* In this connection we shall to-day keep in mind the forests of Shui-cha, where *Metasequoia glyptostroboides* Hu & Cheng is a native. It would be highly interesting to compare the *Arcto-Tertiary flora* with the native *Metasequoia association.* Far from having this possibility, the author tried mostly as an interesting exercise to exploit the lists of Chu & Cooper (C. & C. 1950) from their ecological reconnaissance in the Shui-cha valley of Central China. As it was possible to study a large quantity of the species which they have listed as deriving from the cited locality and which, by specimens from Central China, are represented in the Herbarium of the Botanical Museum of the University of Copenhagen (56 of the 69 species of Chu & Cooper 1950) and as information on the lacking species could be secured from monographical descriptions, the author made a provisional count for Shui-cha, which comprised the following characters: 1) proportion of species with *entire* and *non-entire* leaves and 2) percentage of leaves with *dripping point.* The count is not conclusive for the locality, but gives an average estimate of the ratios for Central China.

In the following scheme the counts for the *Early Paleocene* flora of the Agatdalen area are compared with counts on recent forest associations most of which have been collected by Chaney & Sanborn. Additionally the provisional Shui-cha count of the author's is introduced.

Locality	I		II	
	Margin		Dripping point	
	entire	non-entire	+	—
Fossil Flora of the Agatdalen area { °/₀	37 °/₀	63 °/₀	19 °/₀	81 °/₀
Fossil Flora of the Agatdalen area { number	13(14)	22	6(7)	25(26)
Muir woods[1]) forest, Pacific coast range U.S.A.	23 °/₀	77 °/₀	9 °/₀	91 °/₀
Shui-cha, Central China....	36 °/₀	64 °/₀	abt.50 °/₀	abt.50 °/₀
Great Britain[2])............	30 °/₀	70 °/₀	—	—
Panama forests[1])..........	88 °/₀	12 °/₀	76 °/₀	24 °/₀
Hawaii, lowland[1]).........	76 °/₀	24 °/₀	—	—
Upper Ganges[1]) plain......	71 °/₀	29 °/₀	—	—

The figures on this scheme are representative ratios extracted from far larger material in the reference literature! [1]) Chaney & Sanborn (1933), [2]) Bews (1927).

When we compare the ratios of the Fossil Flora of the Agatdalen area of column I with the ratios of the different, recent forests of the same column and with those of Bews (1927), it appears that the Agatdalen flora ratios are related to those of the temperate regions, with which fact the Shui-cha count is in accordance.

Also the ratios of column II, which show a high percentage of species with dripping point in the tropical rainforests and a small ratio for the temperate forests, corroborate the interpretation of the fossil flora of the Agatdalen area as a temperate one.

The author is well aware that the restricted quantity of fossil plants from the Agatdalen area is less suited for statistical counts and that it calls for special care, when we are to interprete the ratios. Only those two characters have been used, which in the present collection can be immediately determined without doubt or interpretation and so can secure reliable results. With this background the indication of a temperate climate for the fossil flora of the Agatdalen area seems safe. It is more doubtful however that the ratio also points towards the warmer temperate regions, because the actual figures should not be interpreted in such detail. Only the accordance between the two columns of the scheme (i.e. the two leaf characters) and the climatological estimate made upon the nearest recent relative species seems to make this idea more than one of chance.

STRATIGRAPHICAL EVIDENCE

As a result of the marine evidence from the *Agatdal formation*, the localities with the fossil plants which were described in chapter 3 can all be held to belong to the *Lower Paleocene*. Thus the fossil flora can from a stratigraphical point of view be treated as an entity.

The main purpose of the study of these fossil plants is to contribute to the solution of local stratigraphical problems, especially the dating of the classic Atanikerdluk floras.

The state of preservation of the plant fossils from the Agatkløft canyon, the locality which has furnished about half the specimens, is not good and the difficult study of them was only carried through owing to these special needs.

The floral list (ref. pag. 106–107) demonstrates a restricted fossil flora and this alone restricts its conclusive possibilities. So the comparative study has been kept to the sedimentary area of Northwest Greenland. Here several levels with fossil plants are known, but only a few of them have been treated before. Their fossil plants are all in need of revision, which it has been necessary to carry out provisionally for a number of species together with the determination of the fossil flora of the Agatdalen area. The levels, which have been included in the comparison, are all of *Tertiary* age:

A) **Upper Atanikerdluk formation** (A. E. Nordenskiöld 1871)

1) **Quikavsak member** (B. Eske Koch 1959):

Fluviatile deposits: Conglomerate, sandstones and shales; the latter have been mainly siderite-impregnated or converted into clay-ironstone. The shales and clay-ironstones are rich in plant fossils comprising Heer's *Upper Atanikerdluk A flora* (Heer 1883 a, b). It occurs in a number of restricted outcrops along the south coast of the Nûgssuaq peninsula (Naujât, Atanikerdluk, Pautût, Ivigssússat qáqât, Atâ, Tupaussat, Nûk qiterdleq, Nûk kitdleq), where a Tertiary river valley cuts the topography of the coastal mountains. Fossil plants from several of these localities were determined by the author (B. Eske Koch 1959). In the cited paper the member is described in detail.

2) **Naujât member** (B. Eske Koch 1959):

Black shale with a few brown tuff bands of clay grade is concentrated near the bottom. It is continuous from Naujât to Tupaussat on the south coast of the Nûgssuaq peninsula, where it may overlie the *Quikavsak member* concordantly or the *Cretaceous* deposits discordantly. The basally occurring tuffs contain the fossil plant impressions, which comprise Heer's *Upper Atanikerdluk B flora* (Heer 1883 a, b). Heer's flora was based upon the localities of Naujât and Atanikerdluk. Later on fossil plants from Qagdlúnguaq (syn: Kagdlúnguaq) have been described by Seward & Conway (1935) and also from Kingigtoq (Seward & Conway 1935, B. Eske Koch 1959) which occur at the same stratigraphical level.

From a higher level fossil plants have been collected by the author at Naujât and designated *Upper Atanikerdluk C flora*. This is too restricted to allow a comparison.

In the cited publication the author has given a detailed description of the member.

B) **Ifsorisok formation** (Intrabasaltic) (A. E. Nordenskiöld 1871)

This is comprised of tuff sediments with subordinate coals, which are intercalated in the younger basalts (the felsparporphyritic b.) occurring in the western part of the Nûgssuaq peninsula and Hareø isl. (Qeqertarssuatsiaq). Whether the different outcrops represent the same, similar, or scattered levels in the said basalts is not certain. Those on the Nûgssuaq peninsula are presumably from the same or similar levels. *Ifsorisok formation* outcrops at *Ivssorigsoq* (syn: Ifsorisok = Qissugssarigsup qôrua = Kulelv), Kugssíninguaq (= Netluarsuk = Kugssineq), Qernertuarssit and Puiagtúnguaq, all on the Nûgssuaq peninsula, and Aumarûtigssat on Hareø island. Also there are a number of smaller occurrences.

The collections of fossil plants from these localities are small, except that from Hareø island from where Heer (1883 a) described quite a few species. Also fossil fruits have been collected here (ref. Nordenskiöld 1885).

Floral List.

Species: Older terminology	Species: Terminology of the present paper (including revisions)	Record: The Agatdalen area *)	Record: Quikavsak mb.	Record: Naujât mb.	Record: Intrabasaltic
Pteris groenlandica HR. .	*Cladophlebis groenlandica* (HR.) BELL	K	+	+	
Hemitelites Torelli HR. = *Pecopteris Torelli* HR. ..	*Hemitelites Torelli* HR.	Q	+		
Ginkgo adiantoides (UNG.) HR.	*Ginkgo adiantoides* (UNG.) SHAP.	A, K	+		+
Sequoia Langsdorfii (BRNGN.) HR., *Taxodium dubium* (STBG.) HR., *Taxodium distichum miocenum* HR.	*Metasequoia occidentalis* (NEWB.) CHANEY	A, K, Q	+	+	+
....	Cfr *Populus* sp.	A			
....	*Dryophyllum* cfr *subfalcatum* LESQ.	Q			
Quercus groenlandica HR. ex parte, *Fagus castaneae folia* UNG. ex parte, *Castanea Ungeri* HR. ex parte	*Quercophyllum groenlandicus* (HR.) KOCH ..	A, K, Q?	+		+
? *Castanea atavia* UNG. ex parte	*Quercophyllum furcinervis americana* (ROSSM.) KNOWLT	A, Q		?	?
? *Castanea Kubinyi* KOV.	*Cupuliferites angmartusuticus* n. sp.	A			
Juglans denticulata HR. ex parte	*Juglandiphyllum denticulatum* (HR.) KOCH ..	A, K	+	?	
....	Cfr *Liriodendron* sp. ..	A			
Populus arctica HR., *Populus Richardsoni* HR., *Populus Zaddachi* HR. ex parte, *Zizyphus hyperboreus* HR., *Paliurus Columbi* HR...	*Cercidiphyllum arcticum* (HR.) BROWN	A, K, N	+	+	+

(continued)

Floral List (continued)

Species		Record			
Older terminology	Terminology of the present paper (including revisions)	The Agatdalen area*)	Qui-kavsak mb.	Nau-jât mb.	Intra-basal-tic
....	*Corylopsiphyllum groenlandicum* n. sp. ..	K	+		
....	*Platanus* sp. cfr *aceroides* GOEPP.......	A, K	+		+
(? *Sassafras Ferretianum* MASS.)................	*Lauraceaephyllum stenolobatus* n. sp......	A, K	?		
Vitis Olriki HR........	Cfr *Vitis Olriki* HR. ..	A	+		
....	Cfr *Amicia* sp.	A			
....	Cfr *Rhododendron* sp. .	A, U			
Rhus bella HR., *Andromeda denticulatus* HR..................	*Dicotylophyllum bellum* (HR.) SEW. & CONW...	A, K, Q	+	+	
Rhamnus Eridani UNG.	*Dicotylophyllum Eridani* (HR.) KOCH	A, K	+		
Prunus Scottii HR. ex parte, *Rhus Holbölliana* HR.	*Dicotylophyllum Scottii* (HR.) KOCH ...	A?, K	+		
Quercus Steenstrupiana HR..........	*Dicotylophyllum Steenstrupiana* (HR.) SEW. & CONW.	A, Q	+	+	
Daphnogene Kanei HR. = *Cocculus Kanei* HR. = *Cocculites Kanei* HR....	*Macclintokia Kanei* (HR.) SEW. & CONW...	A, K, Q	+	+	
....	*Macclintockia Lyalli* HR.	A, K, Q	+	+	
....	*Macclintockia dentata* HR.................	A	+		
....	*Nordenskiöldia borealis* HR..........	A	+		
Pterospermites spectabilis HR., *Pterospermites alternans* HR., *Ficus? groenlandica* HR. ex parte, *Quercus platania* HR. ex parte, *Viburnum Nordenskiöldi* HR. ex parte..........	*Credneria spectabilis* (HR.) KOCH..........	A?, K	+	+	+

*) A: Agatkløft; K: Kangersôq; Q: Qaersutjægerdal; U: North of Quleruánguaq; N: Nuilaussarssuaq.

The floral list of the *Lower Paleocene* of the Agatdalen area contains 27 species besides a number of "designs". Of these species we find 19 in the *Quikavsak member* of the *Upper Atanikerdluk formation.* Of these, 18 are represented in the Atanikerdluk collections. Of those species, which have not been found in the *Quikavsak member*, two (*Dicotylophyllum* cfr *subfalcatum* LESQ. and cfr *Rhododendron* sp.) have not been finally determined owing to their generalized pattern and bad preservation but may be represented. One species (*Lauraceaephyllum stenolobatus* n. sp.) may be represented by *Sassafras Ferretianum* MASS.

Of the cited 27 species 8 are recorded from *Naujât member* of the *Upper Atanikerdluk formation* and a further two may prove to occur in this member (*Quercus furcinervis americana* (ROSSM.) KNOWLTON and *Juglandiphyllum denticulatum* (HEER) KOCH).

Of the 27 species from the Agatdalen area 6 have been recorded from the *Ifsorisok formation.*

Having excluded all doubtful records, the resulting ratio of 19:27 for the common species between the *Lower Paleocene* of the Agatdalen area and the *Quikavsak member* floras still becomes relatively unfavorable. However, a comparison with the 8 (10) : 27 and 6:27 ratios for the higher stratigraphical levels clearly demonstrates the near relation between the fossil floras of the *Lower Paleocene* of the Agatdalen area and the *Quikavsak member* of the *Upper Atanikerdluk formation* of the south coast of the Nûgssuaq peninsula.

This conclusion comes from the determinable part of the fossils from the Agatdalen area. However, owing to the state of preservation and the restricted number of specimens, there is a big residuum, the best part of which it has only been possible to determine preliminarily according to HEER's terms. It has not been possible to make the highly needed revision of these. They have, as mentioned before, been arranged under the heading "design". They cannot be conclusive but do suggest that the residuum does not hide a large number of species, which give evidence other than or directly contrary to that of the floral list of determined species. So we must analyse the designs to see that of the 11, 8 are recorded from *Quikavsak member* at Atanikerdluk and 5 from the *Naujât member.*

Further it must be recognized that some species of the floral list of the *Lower Paleocene* of the Agatdalen area have up till now been endemic for the *Quikavsak member* (at Atanikerdluk):

Corylopsiphyllum groenlandicum n. sp.
Vitis Olriki HEER
Dicotylophyllum Scottii (HEER) KOCH
Macclintockia dentata HEER
Nordenskiöldia borealis HEER

Moreover a number of species have not been recorded from levels higher than the tuff bands in the very basal part of *Naujât member*:

Hemitelites Torelli Heer
Juglandiphyllum denticulatum (Heer) Koch
Dicotylophyllum Steenstrupianum (Heer) Sew. & Conw.
Dicotylophyllum bellum (Heer) Sew. & Conw.
Macclintockia Kanei (Heer) Sew. & Conw.
Macclintockia Lyalli Heer

Under the heading "design" we find some species, the determination of which according to Heer's terms implies, in the authors opinion, a specific identity. Of these the following have not before been recorded from levels other than that of *Quikavsak member*:

Cornus ferox Ung. (design)
Quercus Drymeia Ung. (design)

From the above analysis of the floral list and list of designs of the *Lower Paleocene* of the Agatdalen area, we must be allowed to accept the conclusion that there is a close relation between the fossil flora of the *Lower Paleocene* of the Agatdalen area and that of *Quikavsak member* of the *Upper Atanikerdluk formation* (the *Upper Atanikerdluk A flora*), the bulk of which comes from Atanikerdluk. Logically this does not imply that they have exactly the same age. A survey of these fossil floras gives the impression that we are dealing with a thanatocoenosis, which is probably quite near to that original biocoenosis, which in the early *Tertiary* lingered along the rivers of the coastal forelands in the high, northern latitudes and which with small variations had a circumpolar distribution and ecologically seems to be a climax: The original *Arcto-Tertiary flora*. Unfortunately we do not know exactly the limits of the time interval, in which this thanatocoenosis was deposited in the Far North. From the Agatdalen evidence we know that it included the *Early Paleocene*. But the fossil flora gives no evidence as to where in the interval the *Upper Atanikerdluk A flora* is situated. Only its position within the lowermost *Tertiary* is guaranted.

However, concerning the age determination of the *Upper Atanikerdluk A flora*, the geological studies of the author (B. Eske Koch 1959) provide the supplementary evidence needed. The study of the *Tertiary* sections along the south coast of the Nûgssuaq peninsula and the succession of events of which this gives evidence, together with the evidence from the profiles of the Agatdalen area (ref. Rosenkrantz 1951 and Rosenkrantz in B. Eske Koch 1959), enable a successful correlation to be made of the *Sonja member* of the *Agatdal formation* (and so the corresponding deposits of Qaersutjægerdal and Kangersôq valleys) with the *Quikavsak member* of the *Upper Atanikerdluk formation* as equivalents in the succession of depositional events. These are the basal members, which introduce the *Paleocene* transgression in Northwest Greenland. And the marine fauna of the Agatdalen area enable them to be positioned as *Early Paleocene* (Rosenkrantz op. cit.).

If we consider the small number of species, which the *Early Paleocene flora* of the Agatdalen area has in common with that of *Naujât member* of the *Upper Atanikerdluk formation* (*Upper Atanikerdluk B flora* of Heer 1883 a, b), we might be tempted to conclude a (marked) difference in age. But regarded alone, the restricted number of species, that make up the *Upper Atanikerdluk B flora*, is critical for the evaluation. The comparison between the *Early Paleocene* flora of the Agatdalen area and the *Upper Atanikerdluk A flora* is justified by the dimensions of the latter. But when both fossil floras of the comparison are more restricted, we must be cautious. Between the *Quikavsak member* (A-flora!) and the overlying *Naujât member* (B-flora!) there is a shift in lithofacies, which may have different consequences. Certainly the *Naujât member*, by direct evidence, is younger than the *Quikavsak member*, which means that the *Upper Atanikerdluk B flora* really is younger than the *Early Paleocene flora* of the Agatdalen area and the *Upper Atanikerdluk A flora*. But to what degree? By means of the restricted number of species common to the latter fossil floras, a wider span may be indicated. Among the common species there are definitely some of those characteristic ones, which are wider spread throughout the profile of the *Tertiary* in our region: *Metasequoia occidentalis* (Newb.) Chaney and *Cercidiphyllum arcticum* (Heer) Brown. But there are also some very characteristic species upon which the author puts stress, as being vertically restricted in the regional profile: *Macclintockia Kanei* (Heer) Sew. & Conw., *Macclintockia Lyalli* Heer and *Dicotylophyllum bellum* (Heer) Sew. & Conw. These have never been found at a level higher than that of the *Upper Atanikerdluk B flora* i.e. the very basal part of the *Naujât member*.

The geological investigation quoted before (B. Eske Koch 1959) presented the solution also to this problem. The fossiliferous (marine!) member (*Abraham member*), which overlies the delta deposits (*Sonja member* and equivalents) in the Agatdalen area, also contains an *Early Paleocene* fauna (Rosenkrantz op. cit.) and is equivalent in the succession of depositional events to the basal part of the *Naujât member*. Thus the difference in time between the deposition of the *Upper Atanikerdluk B flora* and the *Upper Atanikerdluk A flora* with its equivalent in the Agatdalen area is very small and both are still situated within the *Early Paleocene*. Some cause other than the time factor must be responsible for the difference in the thanatocoenoses.

As early as 1883 HEER recognized the difference in composition between his *Upper Atanikerdluk A*- and *B floras* (HEER 1883 a, b), his opinion being that they had nearly the same age (Miocene). Though the age determination has changed, we must agree with HEER that the two thanatocoenoses have almost the same age. The difference is obviously one of milieu. The shift of lithofacies between *Quikavsak member* and *Naujât member* bears witness to a change in milieu of deposition. And consequently another mixture of leaves arrived to this site of deposition.

The difference in state of preservation is obvious. The *Upper Atanikerdluk A flora* like that of the Agatdalen area consists of impressions normally without preservation of cuticle or other remnants of the original matter. This material was deposited in river accumulations, i.e. in well aerated water, to which fact the sediment as well as the structure gives evidence. This situation is in accordance with the quantity and preservation of the fossils. The plant remnants were deposited not far from their growth site.

The Upper Atanikerdluk B flora consists of impressions in tuffs of clay grade interbedded with black bituminous shale. All the impressions are coated with a film of incoaled matter, representing the original, organic tissue. A high proportion of the leaves were worn before deposition. The state of preservation, as well as the type of sediment bear witness to a milieu of stagnating water, whilst the fossils seem to indicate a more extended transport than do those of the *Upper Atanikerdluk A flora*. The milieu of a coastal laguna presents itself to our imagination, as the coast retreated over the area in question just to the point that we are dealing with[1]). Those species common to the *Upper Atanikerdluk A flora* (river-bank dwellers) had suffered a longer transport to arrive in this milieu. A sorting during this transport must be expected. But also plants from another association (lagunal banks and barrier associations) may have contributed to the difference between the above cited *A*- and *B floras*. Owing to the lack of consequent revision of the *Upper Atanikerdluk B flora*, we have no evidence of the latter possibility. As the extensive vulcanism at this time was increasing in the region under discussion, we must expect that the forest flora was affected and changed in different ways, in structure as well as in distribution, thus influencing the fossil record. Such phenomena add to the difficulties, which are met with in the exploitation of fossil plants in stratigraphy.

The fossil flora, which is treated in this paper, and which can be termed a MACCLINTOCKIA — METASEQUOIA — CERCIDIPHYLLUM thana-

[1]) The shift from coarse, clastic sediments (*Quikavsak member*) to bituminous shale (*Naujât member*) happens just at the level when the Quikavsak member's river valley is filled up and the whole foreland seems drowned by the advancing transgression.

tocoenosis, is characteristic for the stratigraphical level of the *Quikavsak member* and for the lowermost 10 metres of the *Naujât member* of the *Upper Atanikerdluk formation* and for the equivalent members of the *Lower Paleocene* Agatdal formation. This interval was made by the author (B. Eske Koch 1959) the foundation of a bio-stratigraphical zone, the Macclintockia zone, with *Macclintockia Kanei* (Heer) Sew. & Conw., *Macclintockia Lyalli* Heer, *Macclintockia dentata* Heer as zone indicators. Also *Dicotylophyllum bellum* (Heer) Sew. & Conw. were stated as characteristic for this zone.

As the bulk of the plant fossils from the *Tertiary* of Northwest Greenland has not yet been revised, no attempt has been made to make comparisons with more remote areas.

CONCLUDING REMARKS

A general description of the *Early Paleocene Flora* of Northwest Greenland cannot possibly be made exclusively from the fossil plants from the Agatdalen area, which have been treated in the present paper; and the revisions which have been introduced by their aid, only concern a small part of the contents of HEER's classic *Upper Atanikerdluk A* and *-B floras* (from the *Quikavsak- and Naujât members* of the *Upper Atanikerdluk formation*).

If we nevertheless make an effort to analyse the "floral list" of the present paper, we find the following criteria:

1) The *angiosperms* are absolutely dominant.
2) Among the *angiosperms* we find a touch of an older, in reality *Cretaceous* element containing associates of the *Credneria-* and *Dryophyllum* circles (*D.* cfr *subfalcata* LESQ., Design *Fagus castaneaefolia*) and also a suggestion of *Dewalquea* (*Dicotylophyllum bellum* (HR.) SEW. & CONW.).
3) Among the *angiosperms* we find a representative group of genera which are ordinarily held by botanists to be old angiospermous taxae: *Cercidiphyllum*, *Corylopsis*, *Platanus*, (*Magnolia*?), (*Liriodendron*?).
4) The *Cupuliferae* are well represented by a variation of leaf types centering around the original evolutionary oakleaf (of SCHWARZ 1936) and *Dryophyllum*. *Quercus* appears to be present, but it is very difficult to distinguish other of the recent cupuliferous genera.
5) The *Old Tertiary Macclintockias*, normally held to be extinct, are common.
6) Small-seeded *palms* seem to be present.
7) The *Gymnosperms* form a minority. Only *Metasequoia occidentalis* (NEWB.) CHANEY is very common.
8) *Cryptogames* are rare.
9) On account of the limited collection it is difficult to make a comparison with the recent geographical distribution of genera. Never-

theless there is a touch of an east asiatic element present: *Metasequoia*, *Cercidiphyllum*, *Corylopsis*, *Ginkgo*.

10) Based on different criteria the angiosperms (and gymnosperms) point towards a *temperate climate*.

11) Stratigraphically the age of the flora has been given: *Early Paleocene* (ROSENKRANTZ 1951). In its composition it is equivalent to the classic *Upper Atanikerdluk A* (and *-B*) *floras* of Southeastern Nûgssuaq peninsula. Its composition agrees well with the given age.

We are dealing with a representative of the *Arcto-Tertiary Flora*. The present collection has its primary value in the fact that its age is given by marine evidence. Its qualitative and quantitative restrictions do not allow effective and extensive revisions or comparative botanical and stratigraphical studies of a wider scope.

LITERATURE

Bailey, I. W. & E. W. Sinnott: Ref. Sinnott, E. W. & I. W. Bailey.

Bailey, W. H. (1881): Report of the Committee appointed for the purpose of collecting and reporting on the Tertiary flora of the basalt of North Ireland. — Brit. Assoc. for Advancement of Science 1881.

Bell, W. A. (1949): Uppermost Cretaceous and Paleocene floras of Western Alberta. — Canada Geol. Surv. Bull. 13.

Berry, E. W. (1902): Notes on Sassafras. — Bot. Gazette 34.

— (1903): Aralia in American Paleobotany. — Bot. Gazette 36.

— (1909): A new genus of fossil Fagaceae from Colorado. — Torreya 9 pp. 1–3.

— (1914): Notes on the geologic history of *Platanus*. — The Plant World 17.

— (1916): The Lower Eocene Floras of Southeastern North America. — U.S. Geol. Surv. Prof. Paper 91.

— (1922): The Flora of the Woodbine sand at Arthur's Bluff, Texas. — U.S. Geol. Surv. Prof. Paper 129–G.

— (1926): Tertiary Floras from British Columbia. — Canada Nat. Mus. Bull. 42 (Canada Geol. Surv. Bull. 42) pp. 91–116.

— (1930): Revision of the Lower Eocene Wilcox flora of the Southeastern States. — U.S. Geol. Surv. Prof. Paper 156.

— (1931): The Past Climate of the North Polar Region. — Smithsonian Misc. Coll. 82.

— (1935): A preliminary contribution to the Floras of the Whitemud and Ravenscrag formations. — Geol. Surv. Canada Mem. 182.

— (1937): Tertiary Floras of Eastern North America. — Bot. Review 3.

Bews, J. W. (1927): Studies in Ecological Evolution of Angiosperms. — New Phytologist, Reprint 26.

Bowerbank, J. S. (1840): A history of the Fossil Fruits and Seeds of the London Clay.

Braun, E. L. (1950): Deciduous Forests of Eastern North America.

Brown, R. W. (1935): Miocene leaves, fruits and seeds from Idaho, Oregon and Washington. — Journ. of Paleont. 9 p. 572.

— (1939 a): Fossil leaves, fruits and seeds of *Cercidiphyllum*. — Journ. of Paleont. 13 p. 485.

— (1939 b): Fossil Plants from the Colgate Member of the Fox Hills Sandstone and adjacent strata. — U.S. Geol. Surv. Prof. Paper 189–I.

Cain, S. A. (1943): The Tertiary Character of the Cove Hardwood forest of the Great Smoky Mountains National Park. — Bull. Torreya Bot. Club 70.

— (1944): Foundations of Plant Geography.

Chaney, R. W. (1924): Quantitative studies of the Bridge Creek Flora. — Amer. Journ. Sci. 5. Ser. Vol. 8 p. 127.

— (1925 a): A Comparative Study of the Bridge Creek Flora and the modern Redwood Forest. — Carn. Inst. Wash. Publ. 337, Contrib. to Paleont. 1.

Chaney, R. W. (1925 b): The Mascall Flora. — Its distribution and climatic relations. — Carn. Inst. Wash. Publ. 349.
— (1927): Geology and Paleontology of the Crooked River Basin, with special reference to the Bridge Creek Flora. — Contrib. to Paleont. from Carn. Inst. Washington pp. 46–138.
— (1930): A *Sequoia* Forest of Tertiary age on St. Lawrence Island. — Science 72.
— (1933): Plant Distribution as a Guide to Age Determination. — Journ. Wash. Acad. Sci. Vol. 26 No. 8.
— (1935): The Kucha Flora in relation to Physical Conditions in Central Asia during the late Tertiary. — Geogr. Annaler 1935.
— (1936 a): Factor of Distribution in the Interpretation of Tertiary Floras. — Proc. Geol. Soc. Amer. 1935.
— (1936 b): ref. Goodspeed, T. H. (1936).
— (1938): Palecological Interpretations of Cenozoic Plants in Western North-America. — Bot. Review 4.
— (1940): Tertiary Forests and Continental History. — Bull. Geol. Soc. Amer. 51 pp. 469–488.
— (1948 a): The bearing of the living *Metasequoia* on problems of Tertiary paleobotany. — Proc. Nat. Acad. Sci. U.S.A. 34, pp. 503–515.
— (1948 b) Redwoods of the past. — Save-the-redwood League. Berkeley 1948.
— (1949): ref. Jepsen–Simpson–Mayr (1949).
— (1951): A Revision of Fossil *Sequoia* and *Taxodium* in Western North America based upon recent discoveries. — Trans. Amer. Phil. Soc. New Ser. 40 pp. 171–263.
Chaney, R. W. & E. Sanborn (1933): The Goshen Flora of West Central Oregon. — Contribution to Paleont., Carn. Inst. Washington.
Charlesworth, J. K. (1953): The Geology of Ireland.
Chu, K. & W. S. Cooper (1950): An Ecological reconnaissance in the native home of *Metasequoia glyptostroboides*. — Ecology 31(2) pp. 260–278.
Clements, F. E. (1916): Plant Succession. — Carn. Inst. Wash. Publ. 242.
— (1918): Scope and significance of Paleo-ecology. — Bull. Geol. Soc. Amer. 29 p. 369.
Clements, F. E. & Chaney, R. W. (1923): Methods and principles of paleo-ecology. — Carn. Inst. Wash. Year Book no. 22.
Dawson, J. W. (1883): On the Cretaceous and Tertiary floras of British Columbia and the Northwest Territory. — Trans. Roy. Soc. Canada 1883.
— (1890 a): On Fossil Plants from Mackenzie River and Bow River. — Roy. Soc. Canada Trans. 7.
— (1890 b): On Fossil Plants from the Semilkameen Valley and other places in the Southern Interior of British Columbia. — Trans. Roy. Soc. Canada 1890.
— (1893): New species of Cretaceous Plants from Vancouver Island. — Trans. Roy. Soc. Canada sect. IV.
— (1895): On collections of Tertiary Plants from the vicinity of the city of Vancouver. — Trans. Roy. Soc. Canada, 2 Ser. Vol. 1.
Dorf, E. (1936): A late Tertiary Flora from Southwestern Idaho. — Carn. Inst. Wash. Publ. 476.
Florin, R. (1952): On *Metasequoia*, living and fossil. — Bot. Notiser 1952, No. 1.
Fritel, P.-H. (1922): Contribution à l'étude des flores tertiaires d'après les matériaux du Museum National d'Histoire Naturelle. — Bull. Mus. Nat. Hist. Nat. 28 p. 206.

Gardner, J. S. (1887): On the leaf-beds and gravels of Ardtun, Carsaig etc. in Mull. — Quart. Journ. Soc. London Vol. 43 p. 270.

Gardner, J. S. & C. von Ettingshausen (1879–1882): A Monograph of the British Eocene Flora Vol. I: Filices.

— — (1882–1886): A Monograph of the British Eocene Flora Vol. II: Gymnospermæ.

Goeppert, H. R. (1852): Ueber die Braunkohlenflora des nordöstlichen Deutschlands. — Zeitschr. Deutsch. Geol. Ges. Vol. 4 p. 484.

— (1855) Die Tertiär Flora von Schlossnitz in Schlesien.

Goodspeed, T. H. (1936): Essay in Geobotany in honour of William Albert Setchell. University of California press.

Graham, R. (1939): Suggestions regarding the taxonomy and nomenclature of Cretaceous and Tertiary Plants. — Journ. of Paleont. 13 p. 122.

Hartz, N. (1909): Bidrag til Danmarks tertiære og diluviale Flora. — Danmarks Geol. Unders. II Ser. 20.

Heer, O. (1855–59): Tertiärflora der Schweiz (Flora Tertiaria Helvetiae) Vol. I, II, III.

— (1862): On the Fossil Flora of Bovey Tracey. — Phil. Trans. Roy. Soc. London Vol. 152 B pp. 1039–1086.

— (1866): On the Miocene Flora of North Greenland. — Proc. Roy. Soc. Dublin 1866.

— (1868): Die fossile Flora der Polarländer. — Flora Fossilis Arctica 1.

— (1869 a): Flora Fossilis Alaskana. — Flora Fossilis Arctica 2.2. — Kgl. Svenska Vetensk. Akad. Handl. Vol. 8 No. 4.

— (1869 b): Contributions to the Fossil Flora of North Greenland, being a description of the plants collected by Mr. Edward Whymper during the summer of 1867. — Flora Fossilis Arctica 2.4. — Phil. Trans. Roy. Soc. London Vol. 159 pp. 445–488.

— (1870): Die Miocene Flora und Fauna Spitzbergens. — Flora Fossilis Arctica 2.3. — Kgl. Svenska Vetensk. Akad. Handl. Vol. 8 No. 7.

— (1874 a): Die Kreideflora der arctischen Zone. — Flora Fossilis Arctica 3.2. — Kgl. Svenska Vetensk. Akad. Handl. Vol. 12 No. 6.

— (1874 b): Nachträge zur miocenen Flora Grönlands. — Flora Fossilis Arctica 3.3. — Kgl. Svenska Vetensk. Akad. Handl.

— (1874 c): Übersicht der miocenen Flora der arctischen Zone. — Flora Fossilis Arctica 3.4.

— (1877): Beiträge zur fossilen Flora Spitzbergens. — Flora Fossilis Arctica 4.1. — Kgl. Svenska Vetensk. Akad. Handl. Vol. 14.

— (1878): Beiträge zur miocenen Flora von Sachalin. — Flora Fossilis Arctica 5.4. — Kgl. Svenska Vetensk. Akad. Handl. Vol. 15 No. 4.

— (1879): Flora Fossilis Sachalinensis. — Flora Fossilis Arctica 5.3. — Mem. d. l'Acad. Imp. d. Sci. St. Petersbourg VIIe Ser. Vol. XXV No. 7.

— (1880 a): Nachträge zur fossilen Flora Grönlands. — Flora Fossilis Arctica 6.1(2). — Kgl. Svenska Vetensk. Akad. Handl. Vol. 18 No. 2.

— (1880 b): Beiträge zur miocenen Flora von Nord-Canada. — Flora Fossilis Arctica 6.1(3).

— (1883 a): Flora Fossilis Groenlandica. — Flora Fossilis Arctica 7.

— (1883 b): Oversigt over Grønlands fossile Flora. — Medd. om Grønland 5.

— † (1922): Flora Fossilis Groenlandica. — Afbildninger af Grønlands fossile Flora. — Medd. om Grønland, Tillæg til Bd. 5.

Hollick, A. (1909): A new genus of fossil Fagaceae from Colorado. — Torreya 9.1.

— (1930): The Cretaceous Flora of Alaska. — U.S. Geol. Surv. Prof. Paper 156.

— (1936): The Tertiary Floras of Alaska. — U.S. Geol. Surv. Prof. Paper 182.

Hu, Hsen-Hsu (1946): Notes on a Paleocene species of *Metasequoia* in China. — Bull. Geol. Soc. China 26 pp. 105–107.

Hu, H.-H. & R. W. Chaney (1940): A Miocene Flora from Shantung Province, China. — Palæontologia Sinica, New. Ser. A No. 1 (Whole Ser. 112) and Carn. Inst. Wash. Publ. 507.

Hutchinson, J. (1959): The Families of Flowering Plants I–II.

Jepsen-Simpson-Mayr (1949): Genetics, Paleontology and Evolution.

Johnson, T. & J. G. Gilmore (1921): The occurrence of *Dewalquea* in the Coal-Bore at Washing Bay. — Sci. Proc. Roy. Soc. Dublin 16.

Kirchheimer, F. (1939): Rhamnales I, Vitaceae. — Fossilium Catalogus, II, Plantae.

Knowlton, F. H. (1893): Fossil Flora of Alaska. — Geol. Soc. Amer. 5.

— (1894): A review of the fossil flora of Alaska with a description of new species. — U.S. Nat. Mus. Proc. 17 pp. 207–240.

— (1898): A catalogue of the Cretaceous and Tertiary Plants of North America. — U.S. Geol. Surv. Bull. 152.

— (1899): Fossil Flora of Yellowstone National Park. — U.S. Geol. Surv. Mon. 32.2.

— (1902): Fossil Flora of the John Day Basin, Oregon. — U.S. Geol. Surv. Bull. 204.

— (1919): A catalogue of the Mesozoic and Cenozoic Plants of North America. — U.S. Geol. Surv. Bull. 696.

Koch, B. Eske (1955): Geological observations on the Tertiary sequence of the area around Atanikerdluk. — Medd. om Grønland 135.5.

— (1959): Contribution to the Stratigraphy of the Non-Marine Tertiary deposits on the south coast of the Nûgssuaq peninsula, Northwest Greenland. — Medd. om Grønland 162.1.

Koch, B. E. & K. Raunsgaard Pedersen (1960): Geological Map of Atanikerdluk and environs 1:10 000. — Medd. om Grønland 162.4.

Koch, Lauge (1929): Stratigraphy of Greenland. — Medd. om Grønland 73.2.

Krueger, H. K. E. (1928): Zur Geologie von Westgrönland, besonders der Umgebung der Disko-Bucht und des Umanak-Fjordes. — Medd. om Grønl. 74.8.

Kryshtofovich, A. (1918): On the Cretaceous age of the "Miocene" Flora of Sakhalin. — Amer. Journ. Sci. 46.

— (1929 a): Evolution of the Tertiary Flora in Asia. — New Phytologist 28.

— (1929 b): The oldest Angiosperms in the Cretaceous of Asia and other contributions of the Mesozoic Flora of the Maritime Province, Sibiria. — Amer. Journ. Sci. 18.

— (1933): Fossil Flora with Macclintockia from the Lozwa River, North Ural. — Trans. United Geol. Prospect. Serv. USSR 291.

— (1935): A final link between Tertiary Floras of Asia and Europe. Contribution to the age of the Arcto-Tertiary Floras of Northern Holarctic. — New Phytologist 34.

— (1938): Upper Cretaceous Flora from the Kolyma River. The State Trust Dalstroy, Contrib. to the Knowledge of the Kolyma-Indigirka Land, Ser. 2. 15.

LaMotte, R. S. (1944): Supplement to Catalogue of Mesozoic and Cenozoic Plants of North America 1919–1937. — U.S. Geol. Surv. Bull. 924.

— (1952): Catalogue of the Cenozoic Plants of North America through 1950. — Geol. Soc. Amer. Mem. 51.

Lesquereux, L. (1873): Enumeration and description of fossil Plants from the Western Tertiary formations. — U.S. Geol. Surv. Terr. Ann. Rept. 6.

— (1874 a): Cretaceous Flora. — U.S. Geol. Surv. Terr. Vol. 6.

Lesquereux, L. (1874 b): The Lignitic formation and its fossil flora. — U.S. Geol. and Geogr. Surv. Terr. Ann. Rept. vol. 7 (365–425).

— (1875 (1876)): On some new species of Fossil Plants from the Lignitic Formations. — U.S. Geol. and Geogr. Surv. Terr. Bull., Vol. 1.

— (1878): Contributions to the Fossil Flora of the Western Territories, Part II, The Tertiary Flora. — U.S. Geol. Surv. Terr. Rept. 7.

— (1883): The Cretaceous and Tertiary Floras. — U.S. Geol. Surv. Terr. 8.

— (1888): Recent determinations of Fossil Plants from Kentucky, Louisiana, Oregon, California, Alaska, Greenland etc. with descriptions of new species. — Proc. U.S. Nat. Mus. 1888.

Laurent, L. (1912): Flore fossiles des schistes de Menat (Puy-de-Dome). — Ann. d. Musée d'Hist. Nat. de Marseille, Geologie tome 14.

MacGinitie, H. D. (1937): The Flora of the Waverville beds of Trinity County, California. — Carn. Inst. Washingt. Publ. 465.

— (1941): A Middle Eocene Flora from the Central Sierra Nevada. — Carn. Inst. Washingt. Publ. 534.

Marty, P. (1907): Etudes sur les végétaux fossiles du Trieu de Leval (Hainaut). — Mem. Mus. Roy. d'Hist. Nat. Belgique 5.

Massalongo & Scarabelli (1858): Flora Senigalliense.

Mathiesen, Fr. J. (1932): Notes on some Fossil Plants from East Greenland. — Medd. om Grønland 85.4.

Meyer, F. J. (1914): Heimat und Verbreitung des Ginkgobaumes. — Prometheus 25 p. 747.

Miki, S. (1941): Jap. Journ. Bot. 11 pp. 237–303.

Moore, E. S. & J. E. Maynard (1929): Solution, Transportation and Precipitation of Iron and Silica. — Economic Geology 24 pp. 272–303; 365–402; 506–527.

Morley, T. (1948): On the leaf arrangement in *Metasequoia glyptostroboides*. — Proc. Nat. Acad. Sci. 34 (12) pp. 574–578.

Nathorst, A. G. (1884): De växtförande lagren vid Atanikerdluk på Nûgssuaq-halfön. — Geol. Fören. Stockholm Förhandl. 7.1.

— (1885): ref. Nordenskiöld (1885) chapt. 6.

Newberry, J. S. (1898): The later extinct floras of North America. — U.S. Geol. Surv. Monogr. 35.

Nordenskiöld, A. E. (1871): Redogörelse för en expedition till Grönland år 1870.

— (1885): Den andra dicksonska expeditionen till Grönland 1885.

Oliver, E. S. (1939): Atavistic leaf forms of various species of trees. — Bot. Gazette 100 pp. 563–575.

Piton, L. (1940): Paléontologie du gisement éocène de Menat, Flora et Faune.

Raunkiær, C. (1934): The life forms of plants and statistical plant geography, being the collected papers of C. Raunkiaer. Oxford.

Reid, E. M. & Chandler, M. E. (1933): The London Clay Flora.

Rosenkrantz, A. et al. (1940): Den Danske Nugssuaqexpedition 1939. — Bull. Geol. Soc. Denmark 9 pp. 653–663.

Rosenkrantz, A (1951): Oversigt over Kridt- og Tertiærformationens stratigrafiske Forhold i Vestgrønland. — Proc. 5th Conv. Scand. Geologists, Denmark 1951, Bull. Geol. Soc. Denmark 12.

Rossmässler, E. A. (1840): Beiträge zur Versteinerungskunde 1. Heft: Die Versteinerungen des Braunkohlensandsteins aus der Gegend von Altsattle in Böhmen.

Saporta, G. & Marion, A. (1873): Essai sur l'état de la végétation des marnes heersienne de Gelinden. — Mém. de l'Acad. Roy. de Belgique 37.

Saporta, G. & Marion, A. (1878): Révision de la floré heersienne de Gelinden etc. — Mém. Cour. et Mém. de Sav. Étrang. 51.

Schimper, W. Ph. (1874): Traité de Paleontologie végétale, atlas pl. 98 fig. 13.

Schimper–Schenk (1890): Zittel: Handbuch der Palæontologie, II, Palaeophytologie.

Schloemer-Jäger, A. (1958): Alttertiäre Pflanzen aus Flözen der Brögger Halbinsel Spitzbergens. — Palaeontographica Ser. B 104 pp. 39–103.

Schwarz, O. (1936): Über die Typologie des Eichenblattes und ihre Anwendung in der Paläobotanik. — Repert. spec. nov. regn. veg. Beih. 86 pp. 60–70.

Seward, A. C. (1924): Notes sur la flore cretacique du Groenland. — Soc. Geol. de Belgique. 5ème anniversaire Livre Jubilaire I. 1.

— (1926): The Cretaceous plant-bearing rocks of Western Greenland. — Phil. Trans. Roy. Soc. London, Ser. B 215 pp. 57–175.

Seward, A. C. & V. M. Conway (1935 a): Fossil Plants from Kingigtoq and Kagdlúnguaq, West Greenland. — Medd. om Grønland 93.5.

— (1935 b): Additional Cretaceous Plants from Western Greenland. — Kgl. Svenska Vetensk. Akad. Handl. 3. Ser. 15. 3.

Seward, A. C. & W. N. Edwards (1941): Fossil Plants from East Greenland. — Ann. and Mag. Nat. Hist. Ser. 11 Vol. 8 p. 169.

Shaparenko, K. K. (1935): Ginkgo adiantoides (Ung.) Heer: Contemporary and fossil forms. — Phillipine Journ. Sci. 57 pp. 1–28.

Sinnott, E. W. & I. W. Bailey (1915): A botanical index of Cretaceous and Tertiary climates. — Science, New Ser. 41 pp. 832–833.

Steenstrup, K. J. V. (1883): Om Forekomsten af Forsteninger i de kulførende Dannelser i Nordgrønland. — Medd. om Grønland 5. 1. = Ueber die Lagerungsverhältnisse der Kohlen und Versteinerungen führenden Bildungen auf der Westküste von Grönland zwischen 69°15′ und 72°15′ n. Br. — Flora Fossilis Groenlandica (Flora Fossilis Arctica 7) (V) pp. 228–250.

Troelsen, J. (1956): Lexique Stratigraphique International Vol. I Fasc. 1 a: Grœnland (Greenland). — Congres Géologique International—Comm. Stratigr.

Unger, F. (1845): Synopsis Plantarum Fossilium.

— (1850): Genera et Species Plantarum Fossilium.

Vanhöffen & Engelhardt (1897): "Die fossile Flora" i Drygalski: Grönlands-expedition 1891–93 pp. 358–373.

Ward, L. F. (1886): Synopsis of the Flora of the Laramie Group. — U.S. Geol. Surv. 6th Ann. Rept. 1884–1885.

— (1887): Types of the Laramie Flora. — U.S. Geol. Surv. Bull. 37.

Warming, E. (1901): Om Løvbladformer. — Overs. Kgl. Danske Vidensk. Selsk. Forhandl. 1901 (1) pp. 1–49.

Weber, O. C. (1852): Die Tertiärflora der niederrheinischen Braunkohlenformation. — Palaeontographica 2.

Weyland, H. (1948): Beiträge zur Kenntniss der rheinischen Tertiärflora VII. — Palaeontographica 88.

Wilmarth, M. G. (1938): Lexicon of geologic names of the United States (including Alaska). — U.S. Geol. Surv. Bull. 869.

Zencker, H. C. (1933): Beiträge zur Naturgeschichte der Urwelt. Organische Reste aus der Altenburger-Braunkohlenformation, dem Blankenburger Quadersandstein etc. Jena.

Færdig fra trykkeriet den 1. august 1963.

PLATES

Plate 1.

Cladophlebis groenlandica (Hr.) Bell. (pag. 21).

1: Fragment of sterile pinnae, 1:1, Kangersôq (G.G.U. label no. 35492.4). — Koch phot.

2: Fragment of sterile pinnae, 1:1, Kangersôq (G.G.U. label no. 35492.2). — Halkier phot.

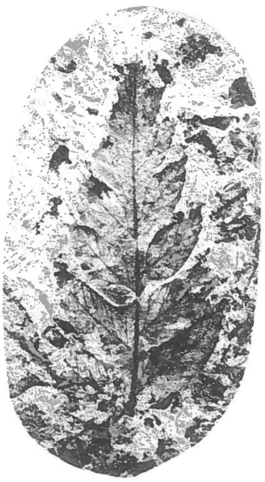
Hemitelites Torelli Hr. (pag. 22).

4, 6: Fragment of sterile pinnae in concretion, 1:1, Qaersutjægerdal (G.G.U. label no. 18061.2). — Halkier phot.

Ginkgo adiantoides (Ung.) Shap. (pag. 22).

3: Fragment of small leaf (without incision?), 1:1, Agatkløft (G.G.U. label no. 12896.219). — Halkier phot.

5: Fragmentary, reniform leaf with deep central incision, 1:1, Kangersôq (G.G.U. label no. 35492.3). — Halkier phot.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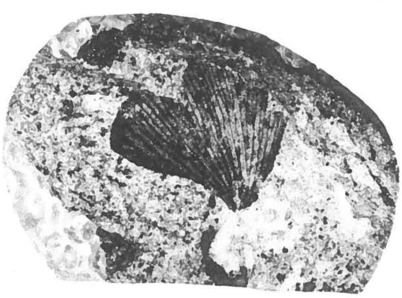
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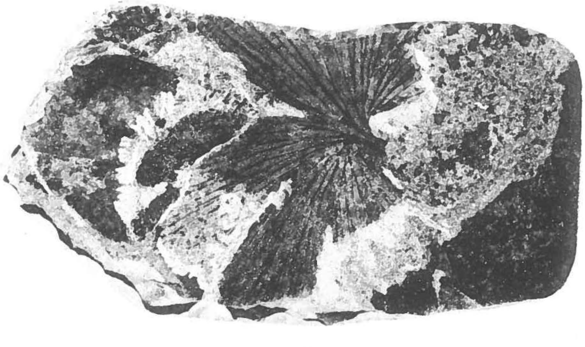
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Plate 2.

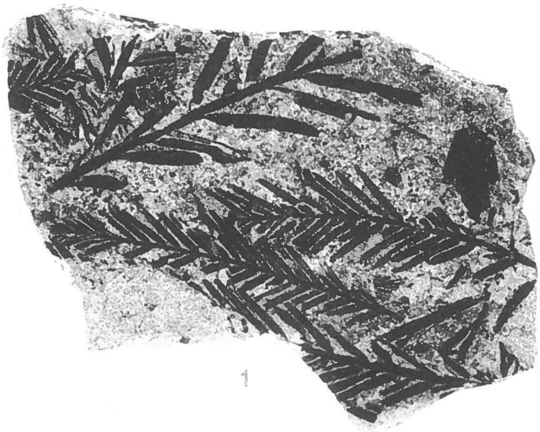
Metasequoia occidentalis (Newb.) Chaney (pag. 23).

1: Above left: Fragment of long shoot. Below right: Fragment of axis of long shoot with short shoots (some are attached), 1:1, Kangersôq (G.G.U. label no. 35492.16). — Halkier phot.

2: Fragments of 3 long shoots with attached opposite short shoots, 1:1, Kangersôq (G.G.U. label no. 28084.3). — Halkier phot.

3, 4: Fragment of long shoot with two pairs of opposite short shoots, which are maltreated after the transport (opposite prints), 1:1, Kangersôq (G.G.U. label no. 35492.153). — Halkier phot.

5: Long shoot (ref. textfig. 7) and short shoot in clay-ironstone, 1:1, Atanikerdluk (Min. Mus. label no. 1865.801 a). — Halkier phot.



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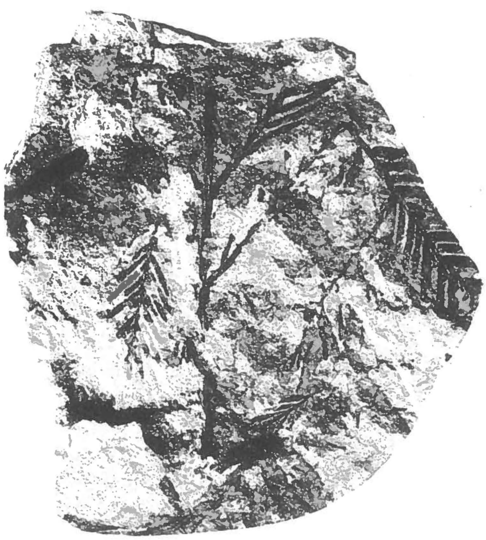

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Plate 3.

Metasequoia occidentalis (Newb.) Chaney (pag. 23).

1: Short shoot, 1:1, Kangersôq (G.G.U. label no. 35492.152). — Halkier phot.

2, 3: Fragments of short shoots, 1:1, Agatkløft (G.G.U. label no. 12896.121; 12896.169). — Halkier phot.

4: Fragmentary spray, 1:1, Kangersôq (G.G.U. label no. 35492.152). — Halkier phot.

5: Short shoot, 1:1, Kangersôq (G.G.U. label no. 36492.6). — Koch phot.

6: Miserable short shoot with leaves turned towards the axis, 1:1, Kangersôq (G.G.U. label no. 28084.2). — Halkier phot.

7: Short shoot with impressions of leaf bases on the axis, 1:1, Kangersôq (G.G.U. label no. 35492.154). — Halkier phot.

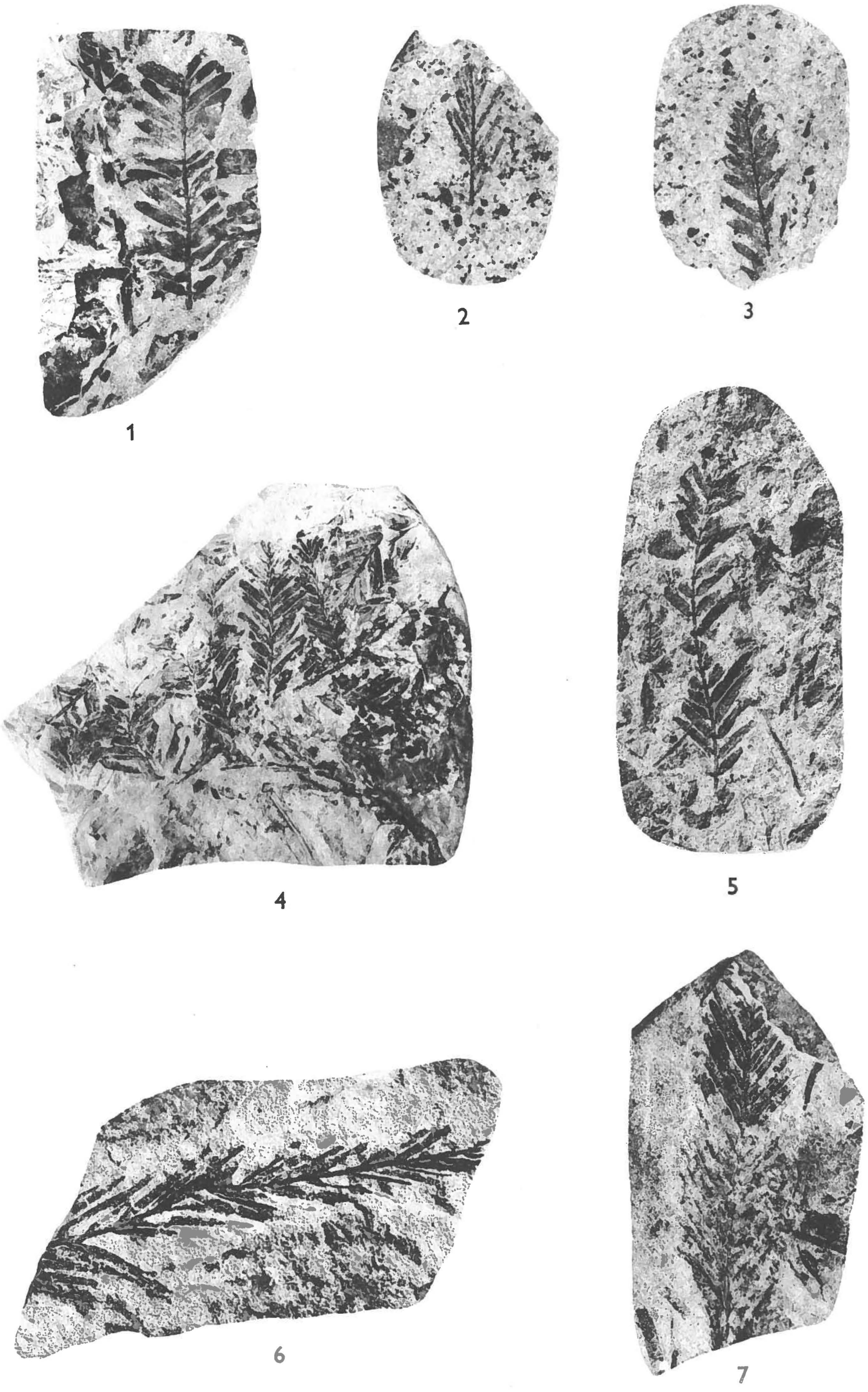
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Plate 4.

Metasequoia occidentalis (NEWB.) CHANEY. Pistillate cones (pag. 23).

1: Specimen with its long, naked stalk, which is cleaved; hence it does not exhibit leaf scars, 1:1, Kangersôq (G.G.U. label no. 35492.150). — HALKIER phot.

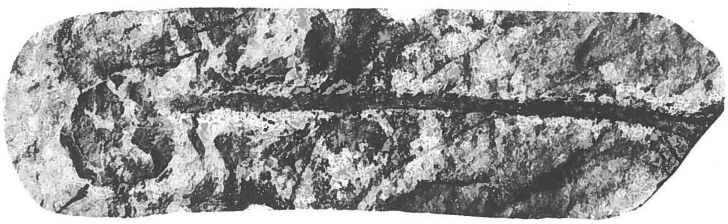
2: Specimen cleaved parallel to the axis. 4 pairs of peltate scales and two terminals, 1:1, Kangersôq (G.G.U. label no. 35492.149). — HALKIER phot.

3: Impression of the surface of a specimen with stalk-fragment (ref. textfig. 14), 1:1, Kangersôq (G.G.U. label no. 35492.148). — HALKIER phot.

4: Cleaved specimen with a fragment of the stalk. 4 pairs of cleaved scales and two terminals, 1:1, Qaersutjægerdal (G.G.U. label no. 8082.3). — HALKIER phot.

5: Surface of the specimen of pl. 4 fig. 4 showing two rows of peltate scales (parallel to the axis). The specimen has been obtained by loosening the hemisphere of the cone in the specimen of fig. 4. After the removal from the specimen it has been turned around its axis to demonstrate the surface, 1:1, Qaersutjægerdal (G.G.U. label no. 8082.3). — HALKIER phot.

6: The specimen of pl. 4 fig. 4 after the removal of the half cone of fig. 5, 1:1. — HALKIER phot.



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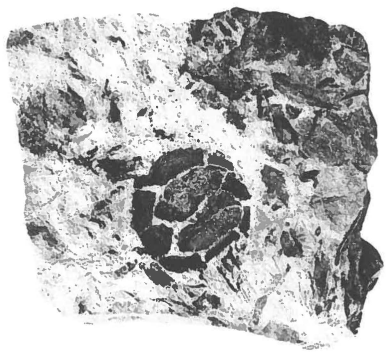

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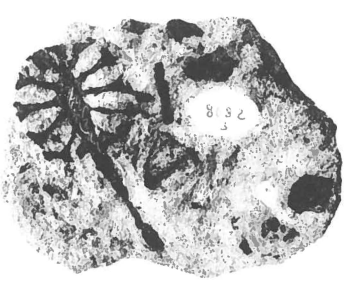

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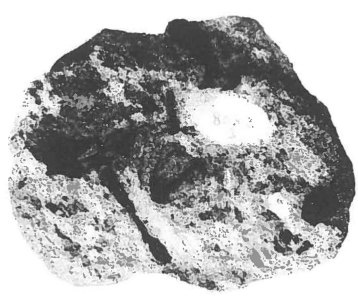

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Plate 5.

Quercophyllum groenlandicus (HR.) KOCH (pag. 34).

1: Small, almost complete leaf, 1:1, Kangersôq (G.G.U. label no. 35492.24). — KOCH phot.

2: Terminal leaf fragment with atypical serration (teeth with linear margins), 1:1, Kangersôq (G.G.U. label no. 35492.21). — HALKIER phot.

3: Basal leaf fragment with typical serration, 1:1, Kangersôq (G.G.U. label no. 35492.20). — KOCH phot.

4: Small, almost complete leaf, 1:1, Kangersôq (G.G.U. label no. 35492.22). — KOCH phot.

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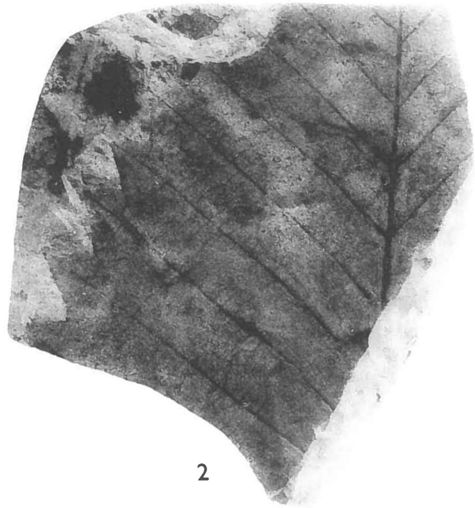

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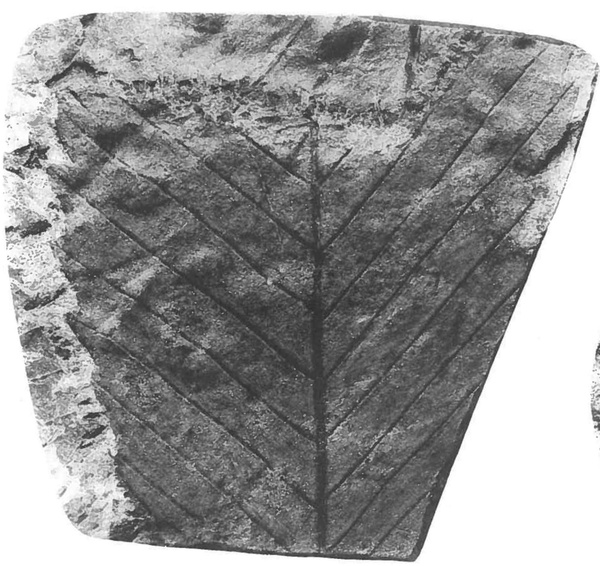

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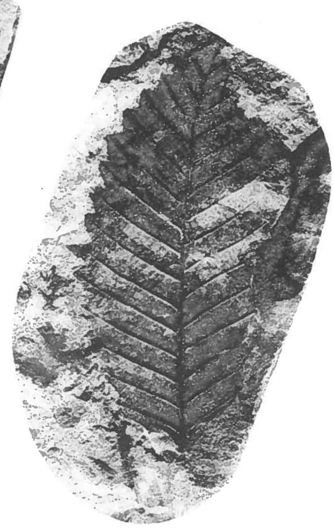

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Plate 6.

Quercophyllum groenlandicus (HR.) KOCH (pag. 34).

1: Basal leaf fragment together with fragments of Cercidiphyllum arcticum et al. Teeth with linear as well as convex margins, 1:1, Kangersôq (G.G.U. label no. 35492.27). — HALKIER phot.

2: Basis of a leaf, 1:1, Kangersôq (G.G.U. label no. 35492.26). — HALKIER phot.

3: Terminal leaf fragment; teeth with convex margins, 1:1, Kangersôq (G.G.U. label no. 35492.20). — HALKIER phot.

Quercophyllum furcinervis americana (ROSSM.) KNOWLT. (pag. 37).

4: Terminal fragment of big leaf, 1:1, Qaersutjægerdal (G.G.U. label no. 35249.1). — KOCH phot.

5: Long, slender leaf, 1:1, Agatkløft (G.G.U. label no. 12896.123). — HALKIER phot.

6: Smallest leaf of the available variation, 1:1, Agatkløft (G.G.U. label no. 12896.129). — HALKIER phot.

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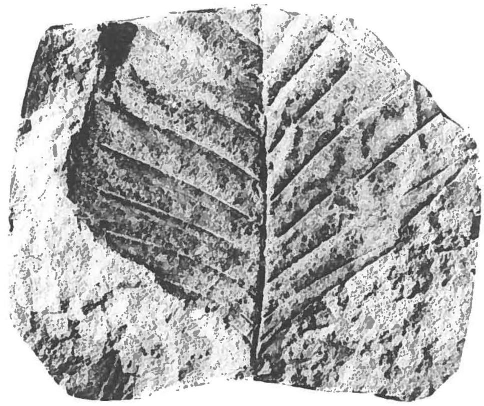

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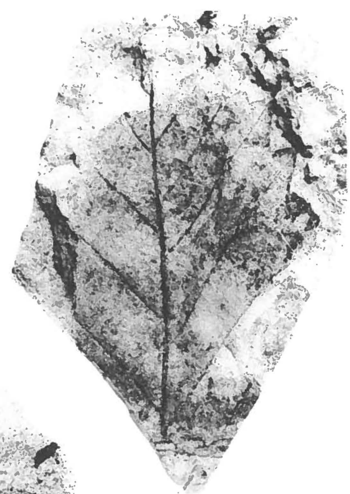

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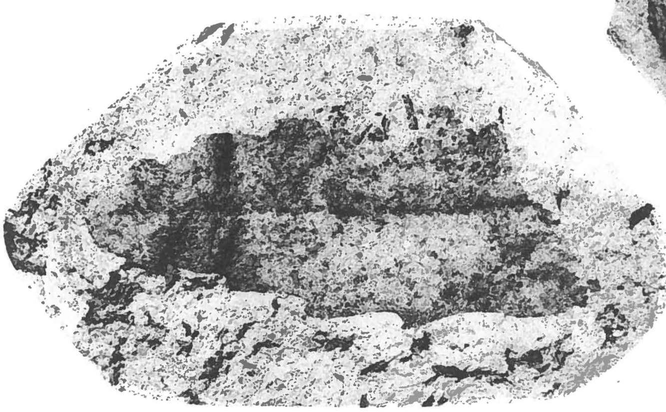

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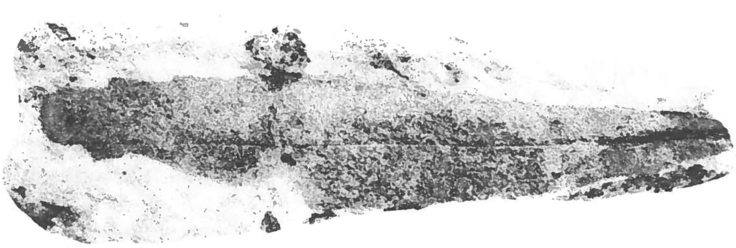

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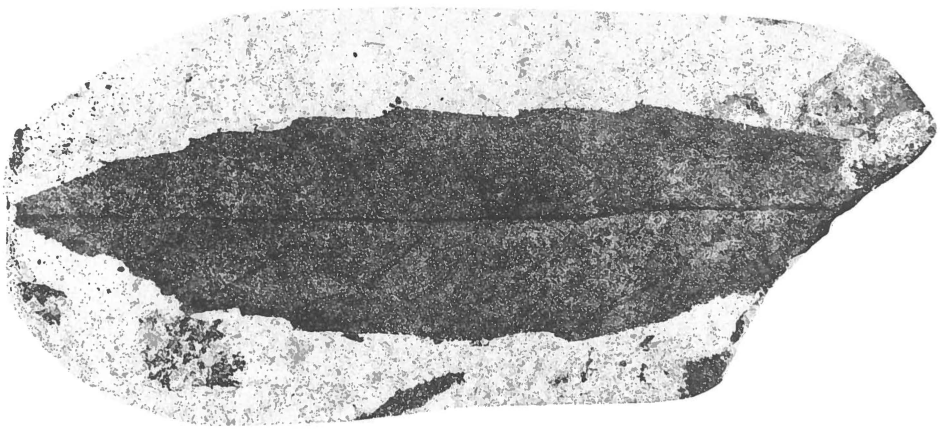
Plate 7.

Quercophyllum furcinervis americana (ROSSM.) KNOWLT. (pag. 37).

1: Big, nearly complete leaf (ref. textfig. 15), 1:1, Agatkløft (G.G.U. label no. 12896.95). — HALKIER phot.

2: Basal fragment of slender leaf, 1:1, Agatkløft (G.G.U. label no. 8083). — HALKIER phot.

3: *Castanea atavia* UNG.; specimen depicted by HEER (1883 a) pl. 74 fig. 10 (ref. pag. 39), 1:1, Atanikerdluk (Naujât member tuff) (MMUH no. 6357). — HALKIER phot.



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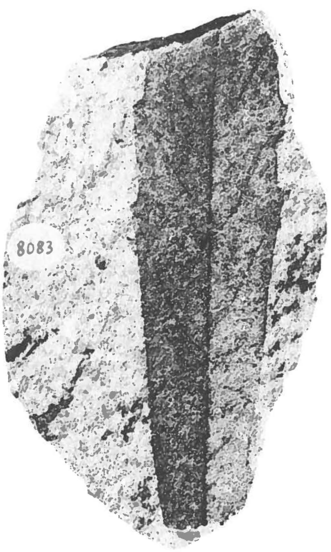

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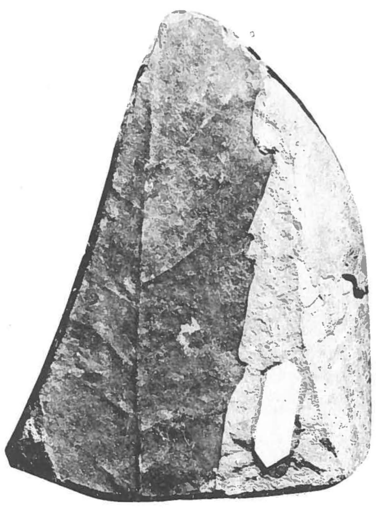

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Plate 8.

Cfr *Populus* sp. (pag. 32).

1: Fragmentary leaf, 1:1, Agatkløft (G.G.U. label no. 12896.84). — HALKIER phot.

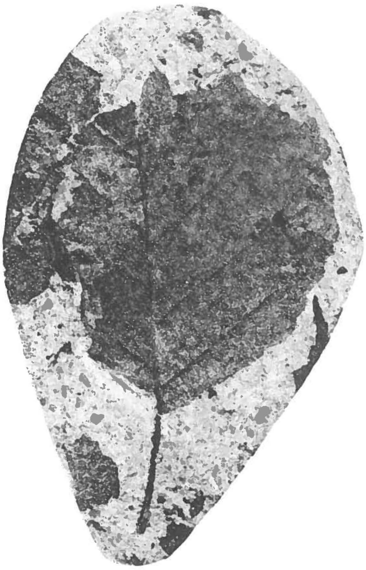
Dryophyllum cfr *subfalcatum* LESQ. (pag. 33).

2: Nearly complete, but badly preserved leaf. The teeth are preserved on the middle of the left margin, 1:1, Qaersutjægerdal (Turritella-sandstone near the river bed north of Big Section) (G.G.U. label no. 28955.27). — HALKIER phot.

3: Basal part of the counterprint of the specimen of pl. 8 fig. 2 demonstrating the petiole, 1:1, Qaersutjægerdal (G.G.U. label no. 28955.27). — HALKIER phot.

Cupuliferites angmartusuticus n. sp. (pag. 40).

4: Almost complete leaf, 1:1, Agatkløft (G.G.U. label no. 12896.18). — HALKIER phot.



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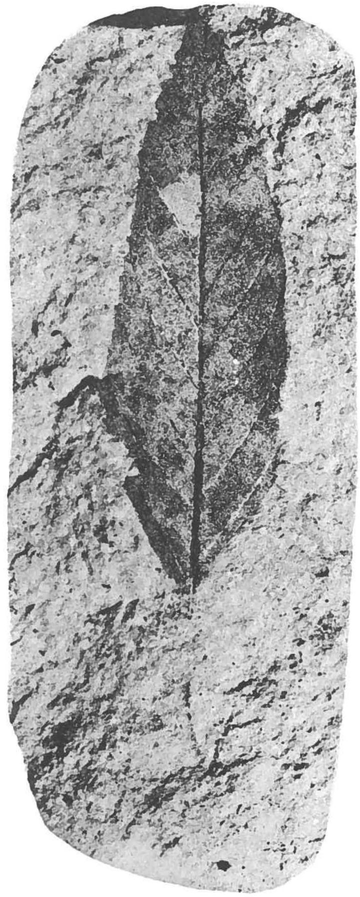

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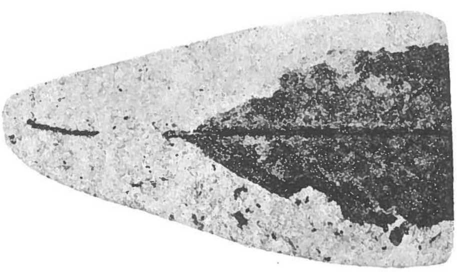

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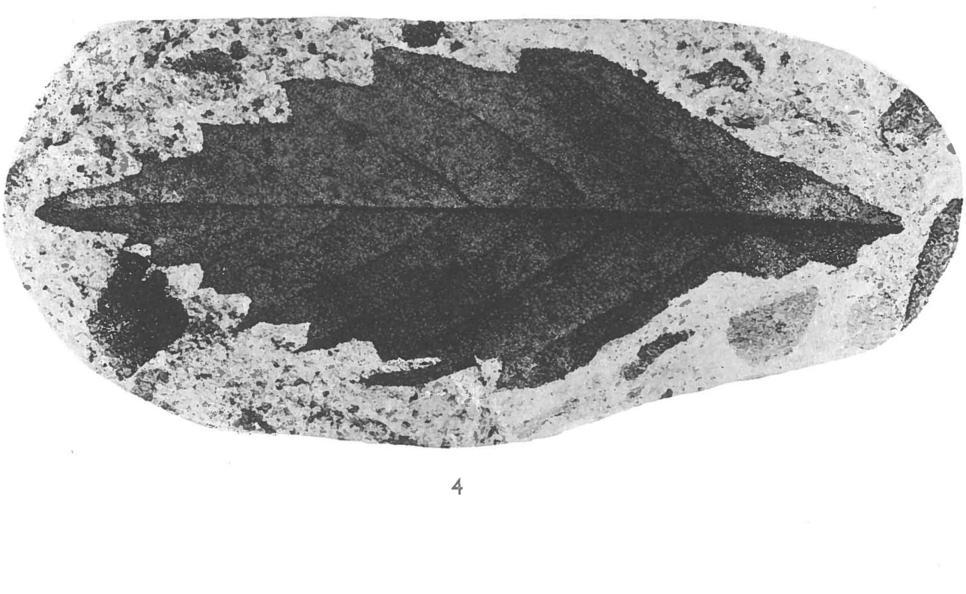

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Plate 9.

Cupuliferites angmartusuticus n. sp. (pag. 40).

1: Big, almost complete leaf, 1:1, Agatkløft (G.G.U. label no. 12896.70). — HALKIER phot.

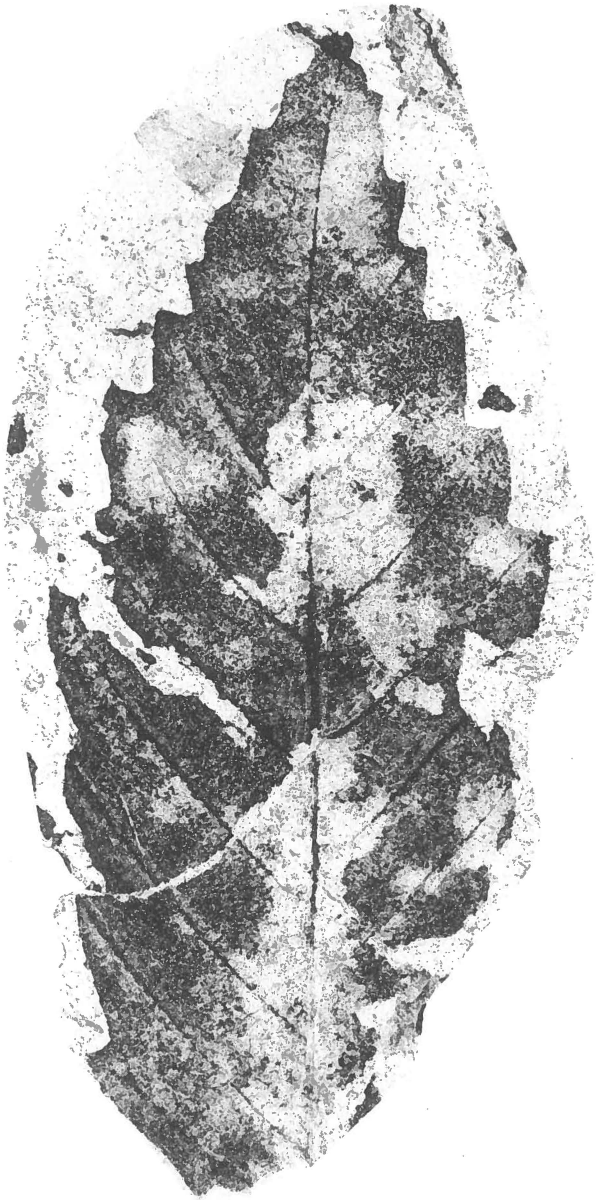


Plate 10.

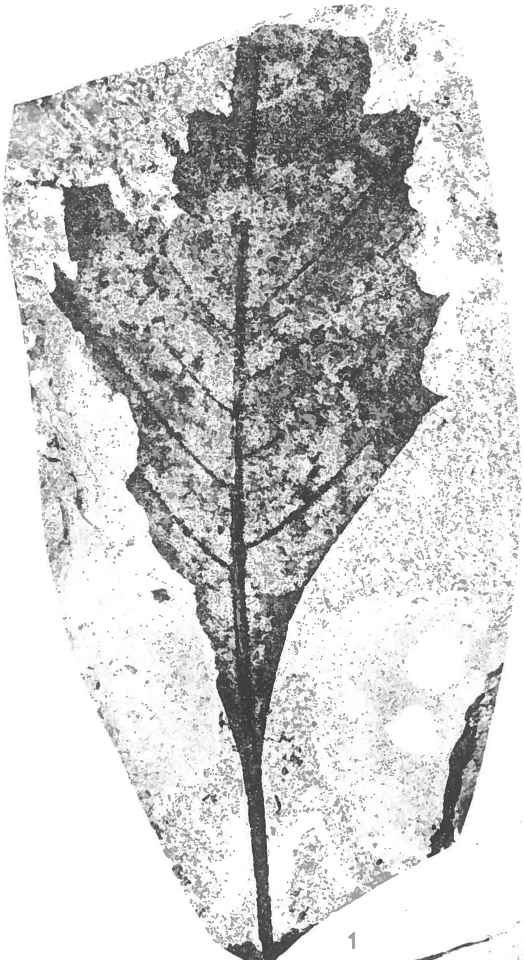
Cupuliferites angmartusuticus n. sp. (pag. 40).

1: Basal fragment of a leaf with petiole, 1:1, Agatkløft (G.G.U. label no. 12896.96). — HALKIER phot.

2: Smallest leaf of the available variation, 1:1, Agatkløft (G.G.U. label no. 35484). — HALKIER phot.

Juglandiphyllum denticulatum (HR.) KOCH (pag. 42).

3: Three leaflets of which most of the left, who covered the central one, has been removed, 1:1, Kangersôq (G.G.U. label no. 35492.38). — HALKIER phot.



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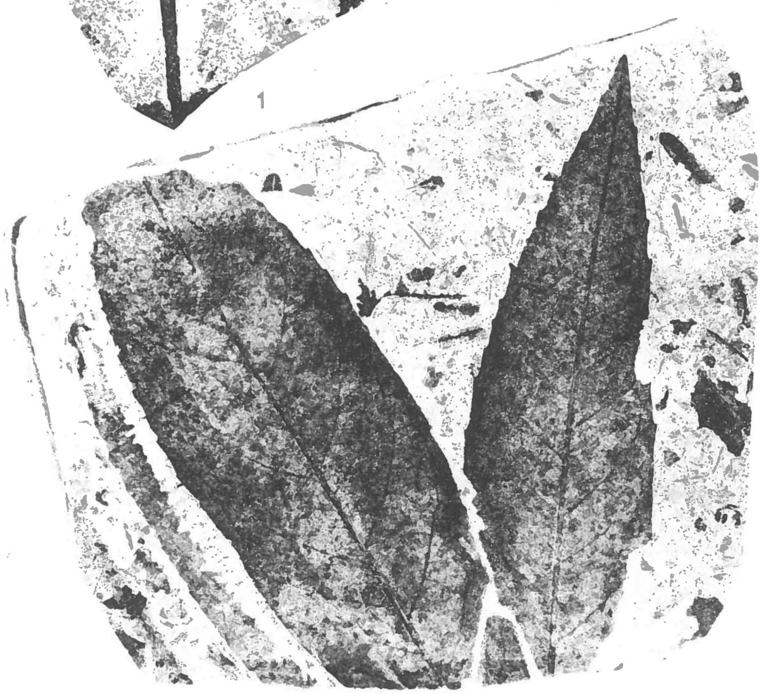

3

Plate 11.

Juglandiphyllum denticulatum (HR.) KOCH (pag. 42).

1: Three leaflets belonging to the same leaf. Above: Fragment of *Quercophyllum furcinervis americana* (ROSSM.) KNOWLT. 1:1, Agatkløft (G.G.U. label no. 12896.82) (ref. pl. 12). — KOCH phot.

2: Almost complete leaflet and a fragment of a leaflet of the same leaf, 1:1, Kangersôq (G.G.U. label no. 35492.41). — HALKIER phot.

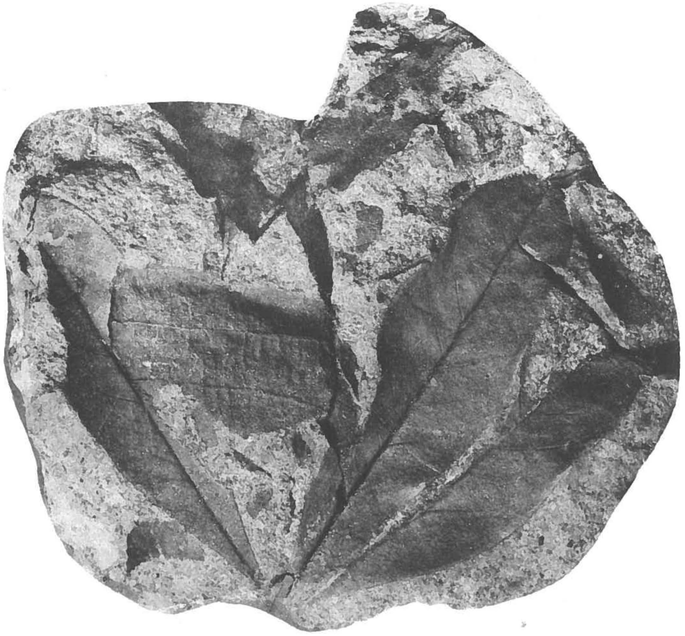

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Plate 12.

Juglandiphyllum denticulatum (Hr.) Koch (pag. 42).

1: Rubber cast of specimen with 3 leaflets (cast of the specimen of pl. 11 fig. 1), 1:1. — Halkier phot.

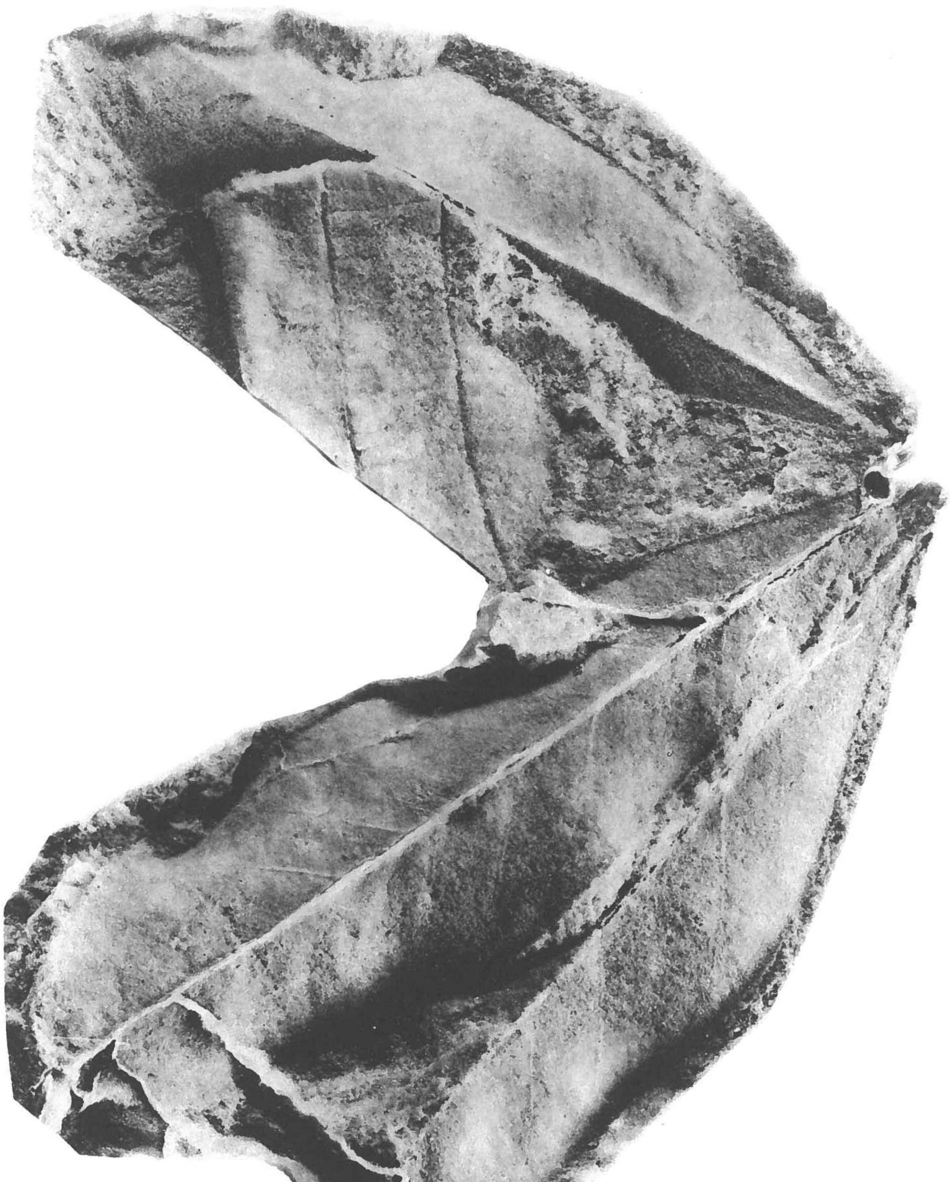


Plate 13.

Juglandiphyllum denticulatum (HR.) KOCH (pag. 42).

1: Three leaflets of presumably the same leaf, 1:1, Agatkløft (G.G.U. label no. 12896.89). — HALKIER phot.

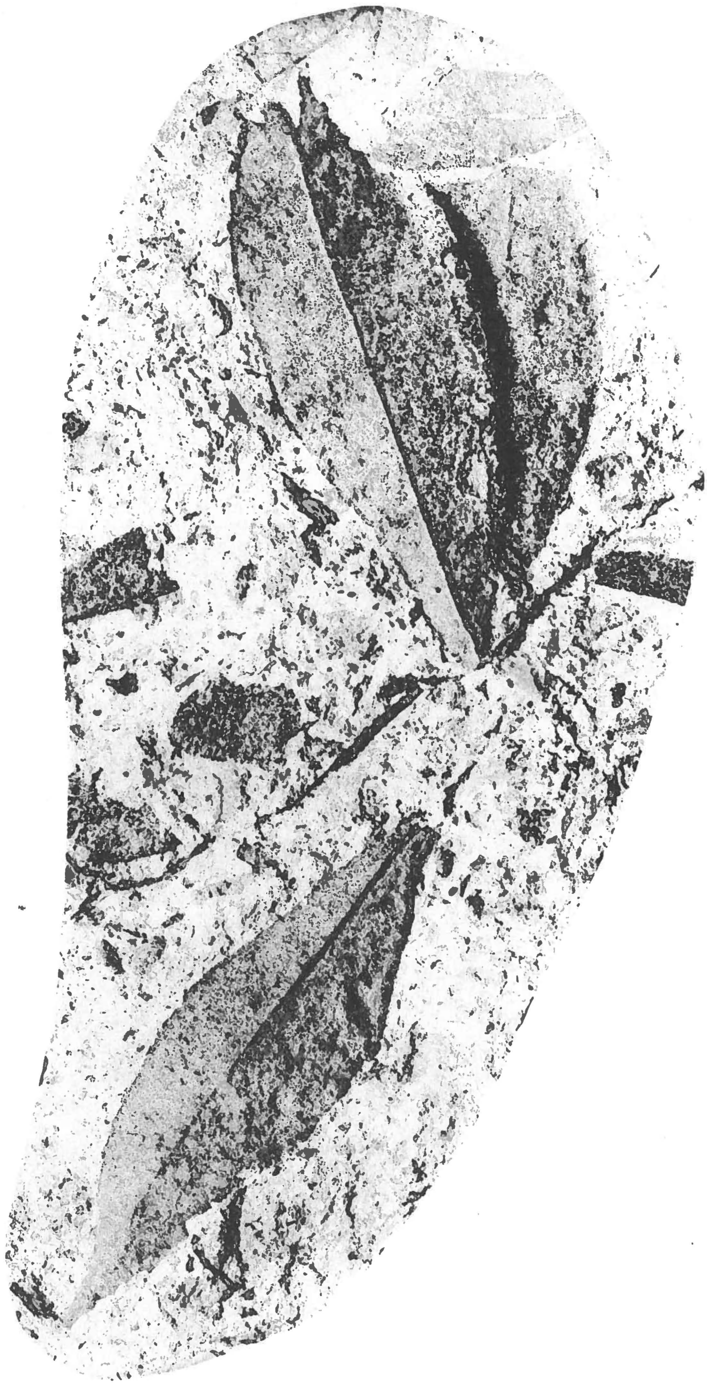
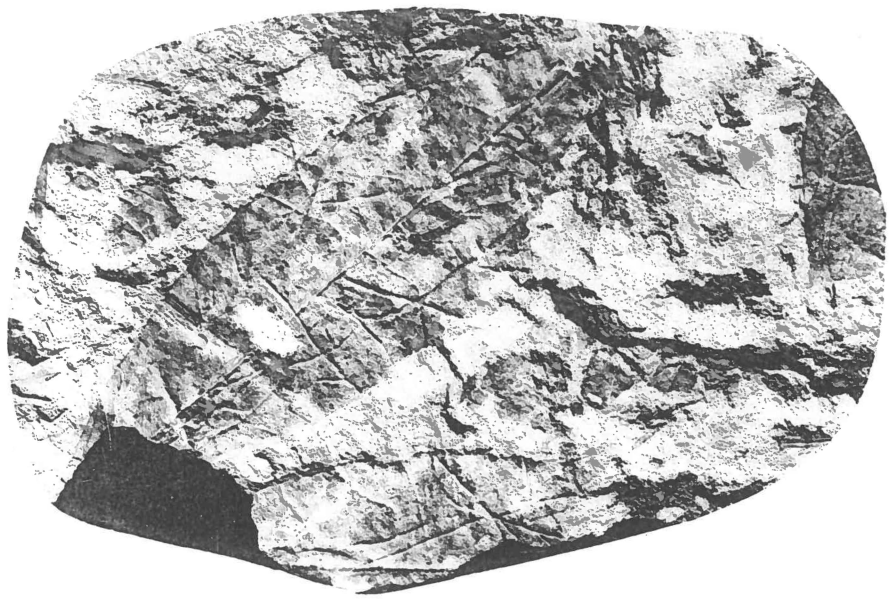


Plate 14.

Juglandiphyllum denticulatum (HR.) KOCH (pag. 42).

1: Fragments of two leaflets of presumably the same leaf, 1:1, Atanikerdluk (Min. Mus. original collection). — HALKIER phot.

2: Three leaf bases diverging from their common petiole, 1:1, Atanikerdluk (Min. Mus. original collection). — HALKIER phot.



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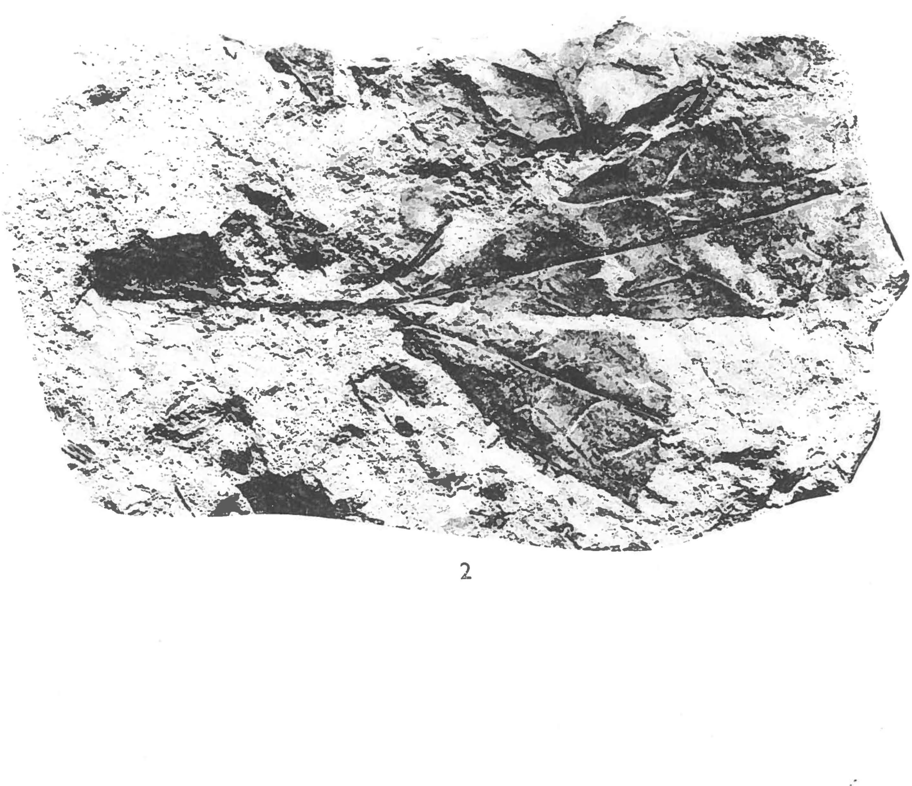

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Plate 15.

Juglans rupestris (recent).

1–4: Leaflets. Fig. 3 shows a terminal, the remaining ones are laterals, 1:1, Bot. Garden, Univ. of Copenhagen). — Halkier phot.

1

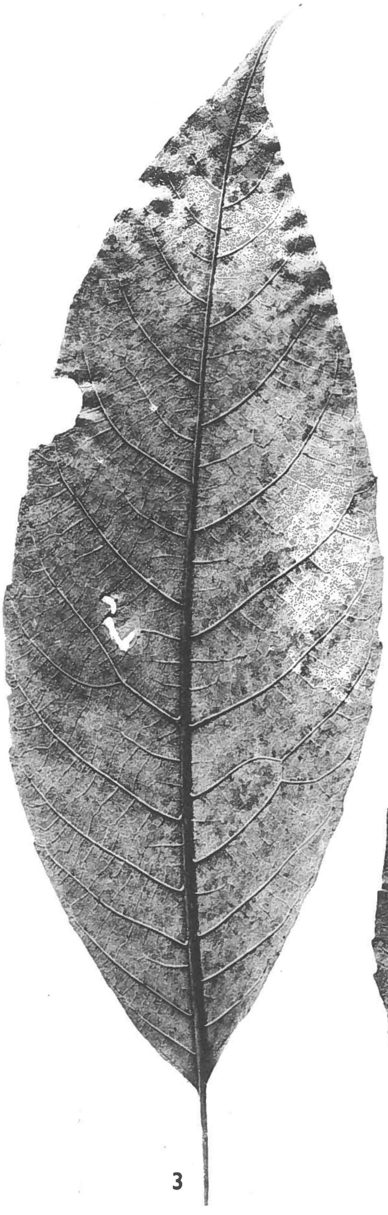

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Plate 16.

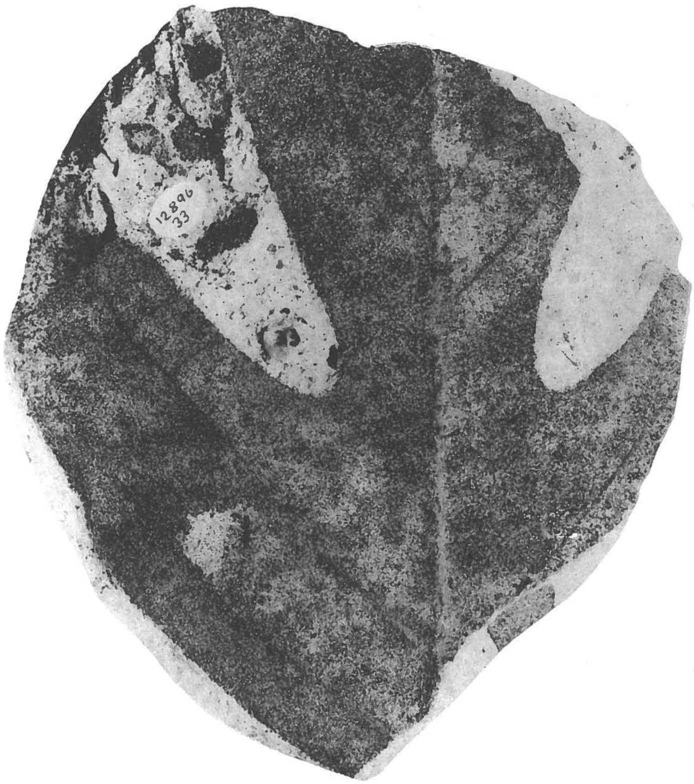
Cfr *Liriodendron* sp. (pag. 46).

1: Fragment of leaf (the counterprint shows about $2^1/_2$ cm more of the central lobe without signs of its termination), 1:1, Agatkløft (G.G.U. label no. 12896.33). — Halkier phot.

Cercidiphyllum arcticum (Hr.) Brown (pag. 47).

2: Smallest leaf of the available variation (*ellipticum* norm-type), 1:1, Kangersôq (G.G.U. label no. 35492.87). — Halkier phot.

3: Fragmentary leaf of the *ellipticum* norm-type, 1:1, Agatkløft (G.G.U. label no. 12896.71). — Halkier phot.



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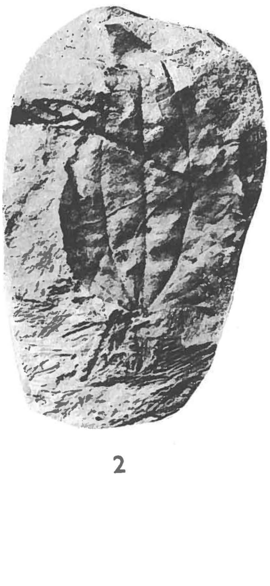

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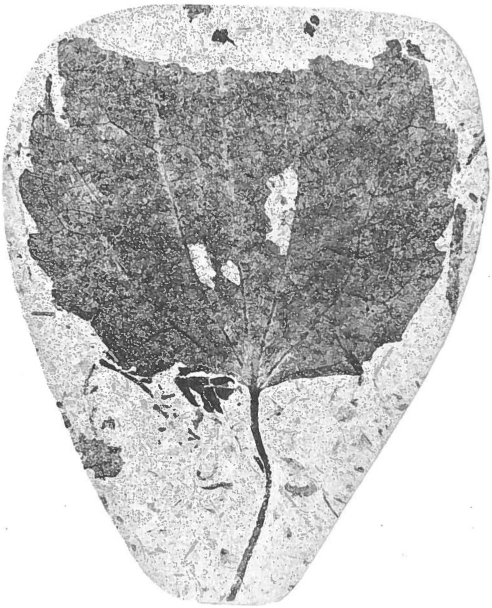
Plate 17.

Cercidiphyllum arcticum (Hr.) Brown (pag. 47).

1, 2: Counterprints of the same leaf (*arcticum* norm-type), 1:1, Kangersôq (G.G.U. label no. 35492.76). — Halkier phot.

3: Nearly complete leaf of the *arcticum* norm-type, 1:1, Kangersôq (G.G.U. label no. 35492.115). — Halkier phot.



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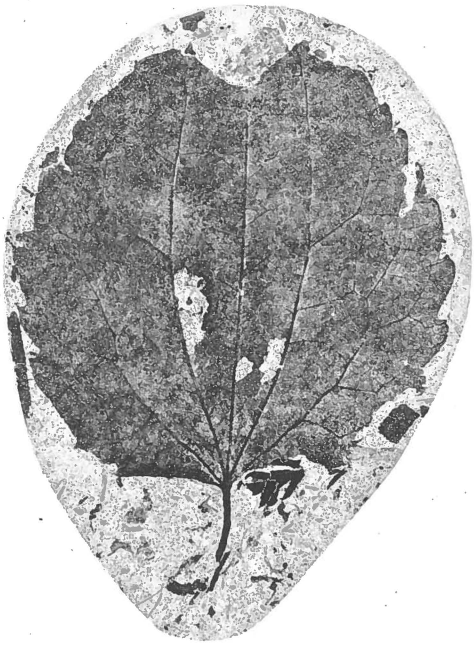

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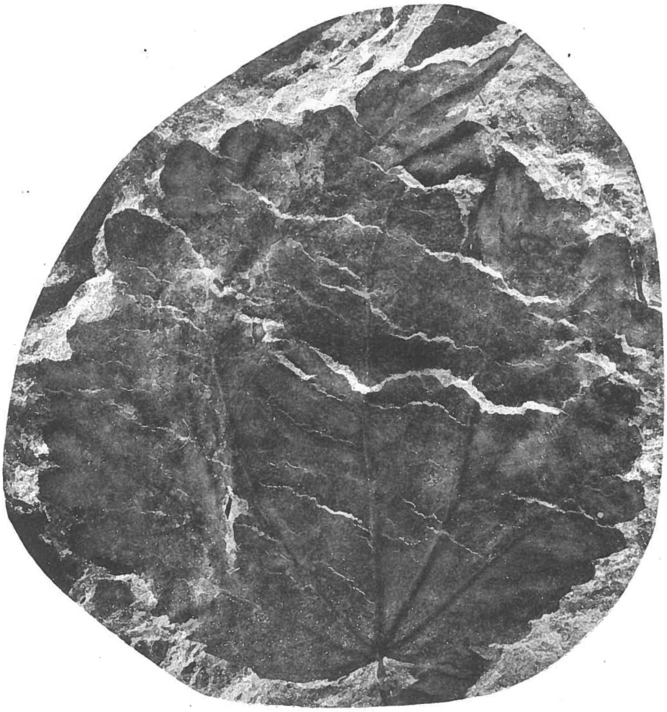

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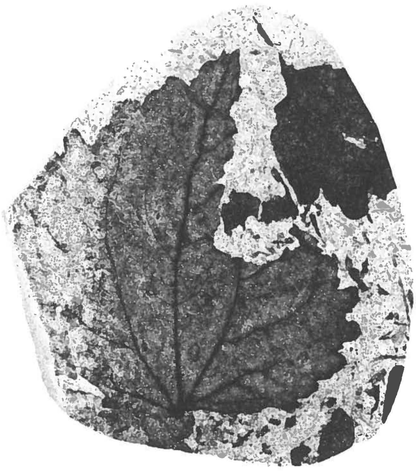
Plate 18.

Cercidiphyllum arcticum (HR.) BROWN (pag. 47).

1: Fragmentary deltoid leaf of the *arcticum* norm-type, 1:1, Kangersôq (G.G.U. label no. 35492.54). — HALKIER phot.

2: Fragmentary leaf of the *arcticum* norm-type, 1:1, Kangersôq (G.G.U. label no. 35492.95). — HALKIER phot.

3: Almost complete, deltoid leaf of the *arcticum* norm-type, 1:1, Kangersôq (G.G.U. label no. 35492.25). — HALKIER phot.



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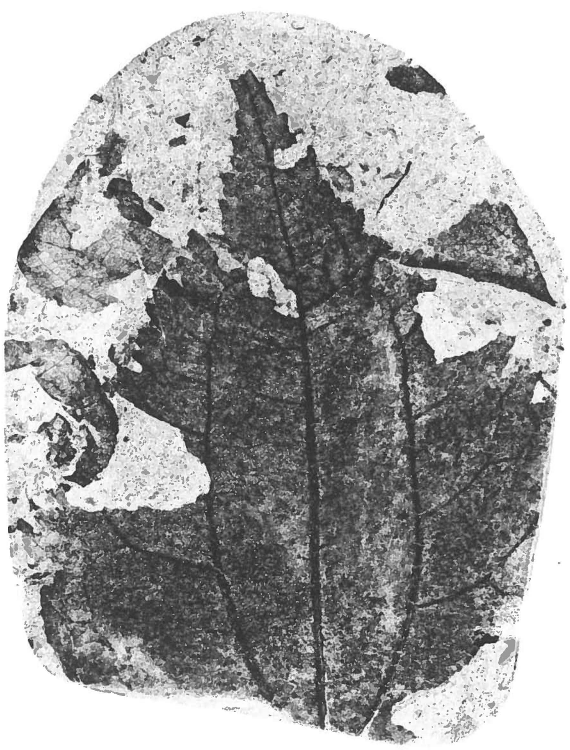

3

Plate 19.

Cercidiphyllum arcticum (HR.) BROWN (pag. 47).

1: Slab with remnants of 4 leaves of *Cercidiphyllum arcticum* (HR.) BROWN, a fragment of *Macclintockia Kanei* (HR.) SEW. & CONW. and fragments of short shoots of *Metasequoia occidentalis* (NEWB.) CHANEY besides an undetermined juniperoid spray; 1:1, Kangersôq (G.G.U. label no. 35492.70). — HALKIER phot.

2: Internal cast of a fruit showing prints of the internal transversal fibres of the capsule, of which incoaled remnants is seen below the cast, 5:2, Agatkløft (G.G.U. label no. 12896.152). — HALKIER phot.

3: Internal cast of fruit with prints of the internal transversal fibres and the seam, 1:1, Agatkløft (G.G.U. label no. 12896.150). — HALKIER phot.

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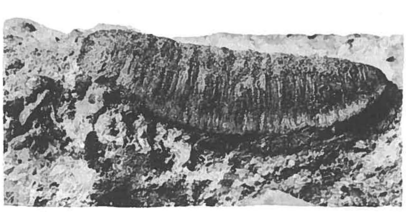

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Plate 20.

Cercidiphyllum arcticum (Hr.) Brown (pag. 47).

1: 6 specimens of fruits: Above: 2 specimens connected by a common stalk; at the centre: A fruit which is half-open. Below the latter: A specimen with impressions of the seam and of the longitudinal fibres of the external capsule layer. Near the centre: A seed which has been developed by drawing; 1:1, Kangersôq (G.G.U. label no. 35492.121). — Halkier phot.

Corylopsiphyllum groenlandicum n. sp. (pag. 50).

2: Fragmentary leaf, 1:1, Kangersôq (G.G.U. label no. 35492.70). — Halkier phot.

1

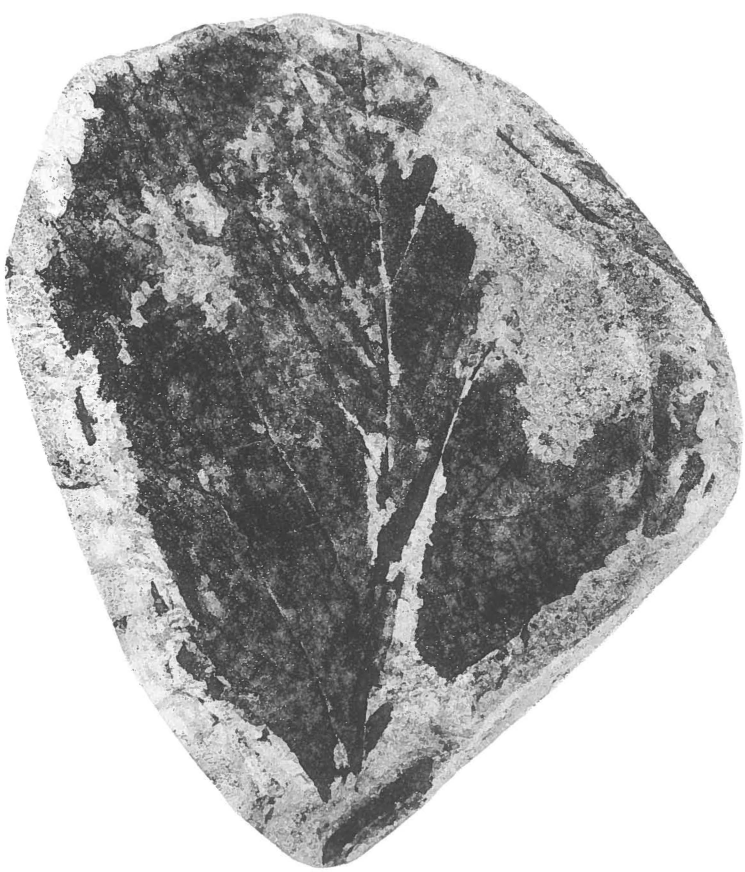

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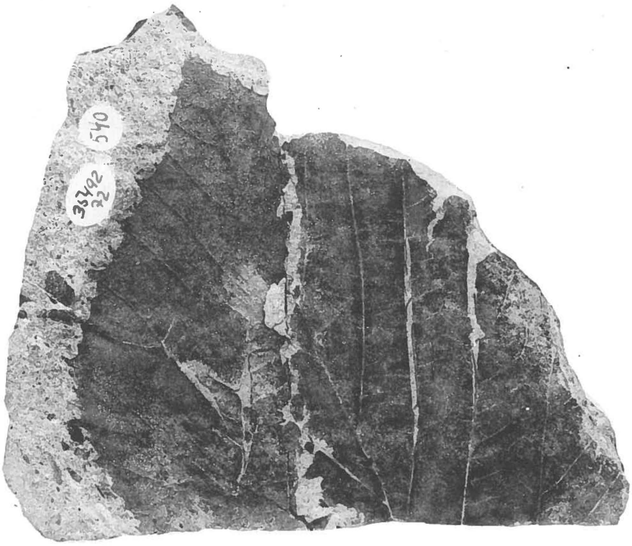
Plate 21.

Corylopsiphyllum groenlandicum n. sp. (pag. 50).

1, 2: Counterprints of the same specimen: Terminal fragment of a leaf. (1) exhibits ordinary serration basally on the right margin! 1:1, Kangersôq (G.G.U. label no. 35492.72). — 1: Halkier phot. 2: Koch phot.



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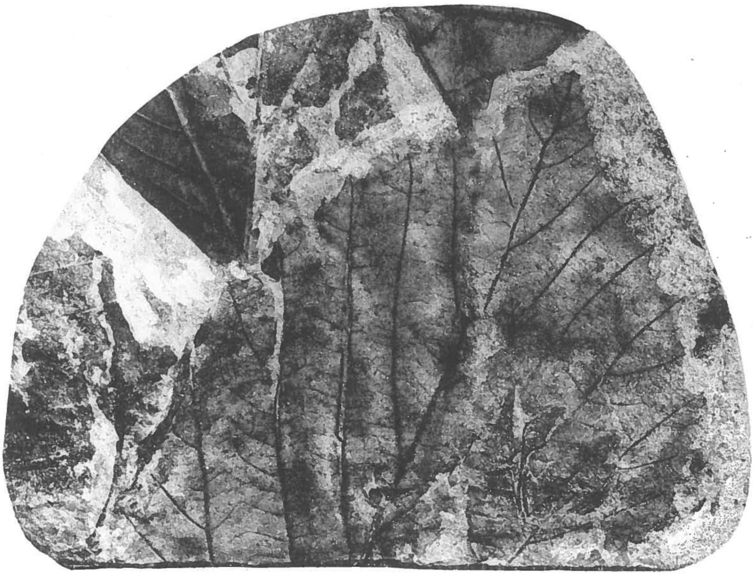

2

Plate 22.

Corylopsiphyllum groenlandicum n. sp. (pag. 50).

1: Basal fragment of a leaf showing ordinary serration (ref. pl. 20 fig. 1), 1:1, Kangersôq (G.G.U. label no. 35492.72). — Koch phot.

2: Almost complete, slender leaf, here and there with a tendency to incurved margin and thread-pointed teeth (atypical specimen). Short shoot of *Metasequoia occidentalis* (Newb.) Chaney, 1:1, Kangersôq (G.G.U. label no. 28084.6). — Koch phot.

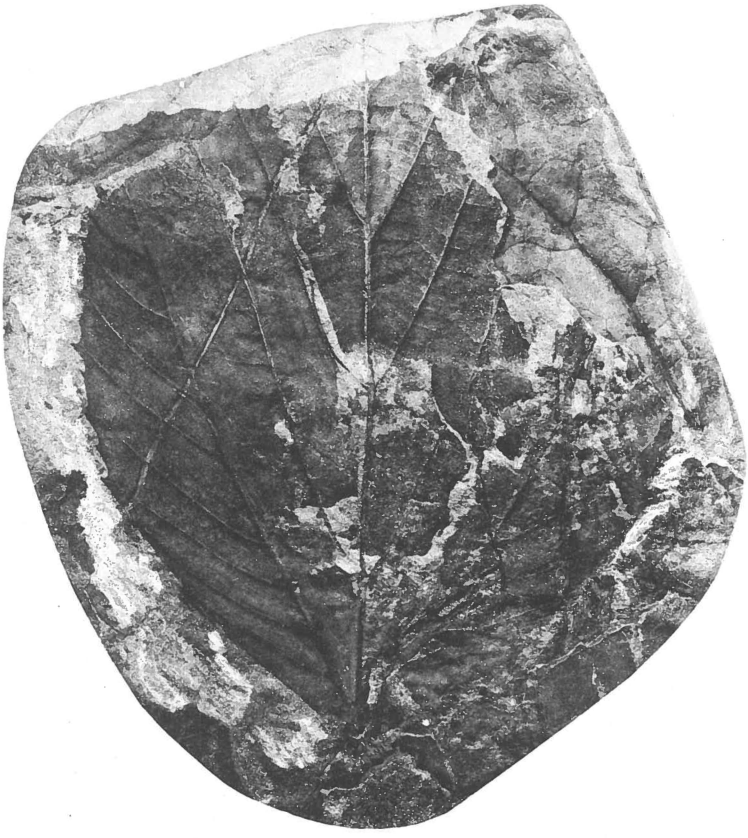

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Plate 23.

Corylopsis spicata S. & Z. (recent).

1, 2: Leaves of a Japanese specimen, 1:1, Bot. Mus. Herb., Univ. of Copenhagen. — Halkier phot.

Corylus avellana L. (recent).

3: Fragment of a leaf demonstrating the dentition, 1:1, (Hjortenæs, Sorø). — Halkier phot.

Corylus americana (recent).

4: Leaf, 1:1 (Bot. Garden, Univ. of Copenhagen). — Halkier phot.

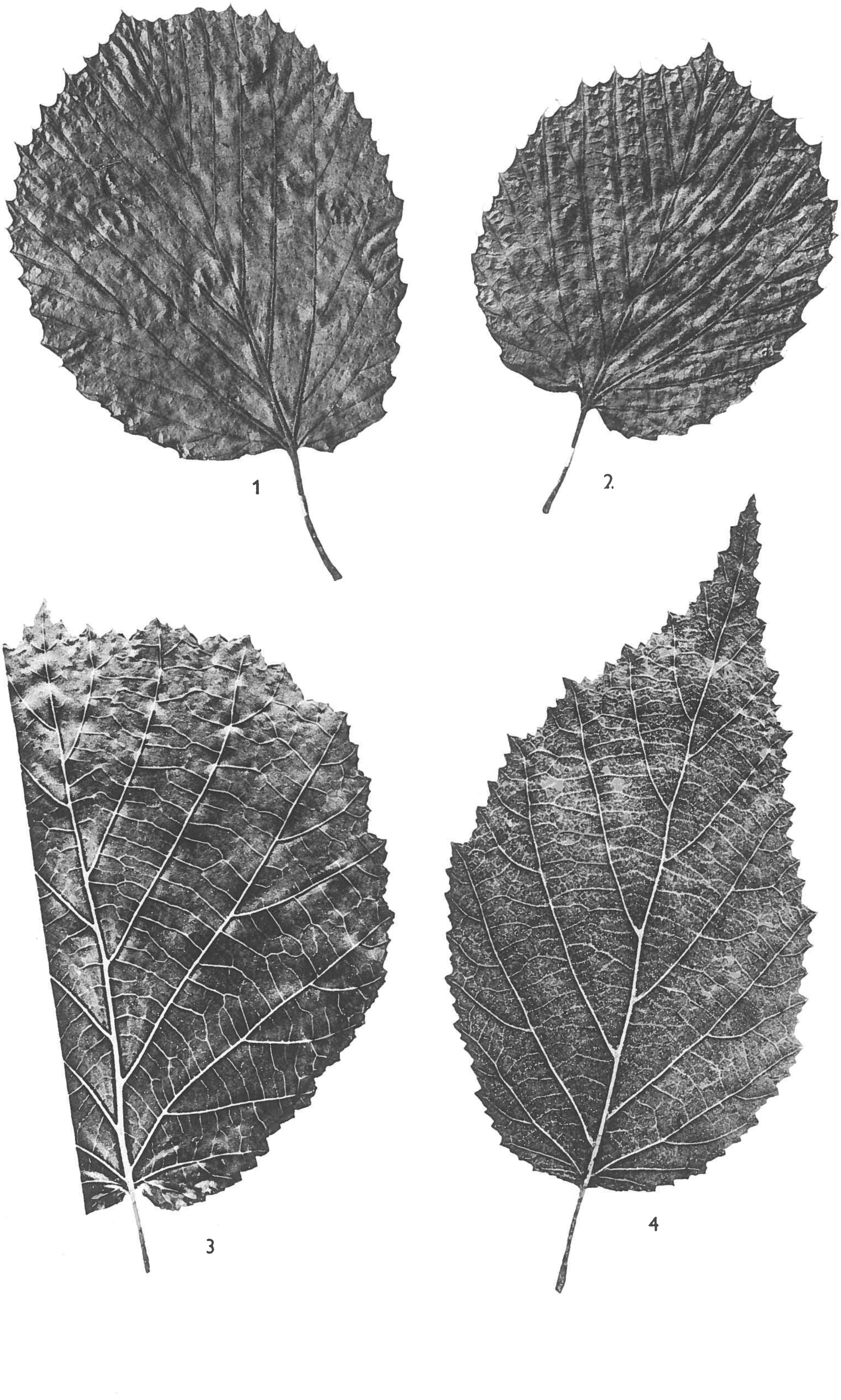
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Plate 24.

Platanus sp. cfr *aceroides* GOEPP. (pag. 54).

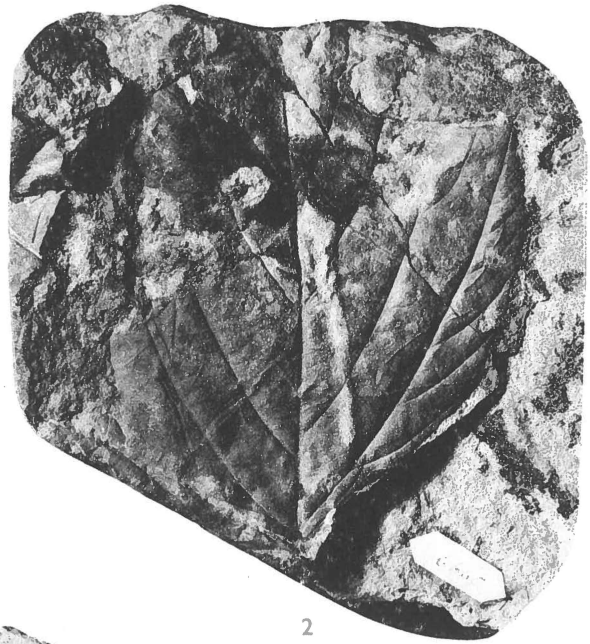
1: Globose fruit presumably belonging to a Plane, 1:1, Kangersôq (G.G.U. label no. 35492.155). — HALKIER phot.

3: Small, almost complete leaf (ref. textfig. 19), 1:1, Agatkløft (G.G.U. label no. 12896.6). — HALKIER phot.

Viburnum Whymperi HR.

2: The specimen depicted by HEER (1883 a) pl. 102 fig. 13; 1:1, Igdlokunguaq (Disko isl.) (MMUH no. 6660). — HALKIER phot.

1



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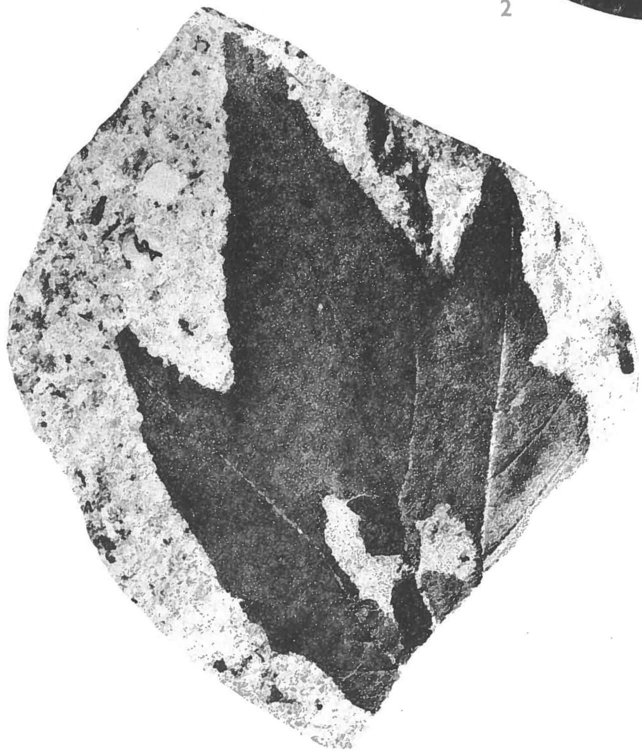

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Plate 25.

Platanus sp. cfr *aceroides* GOEPP. (pag. 54).

1: Fragment of a big leaf, 1:1, Kangersôq (G.G.U. label no. 35492.74). — HALKIER phot.

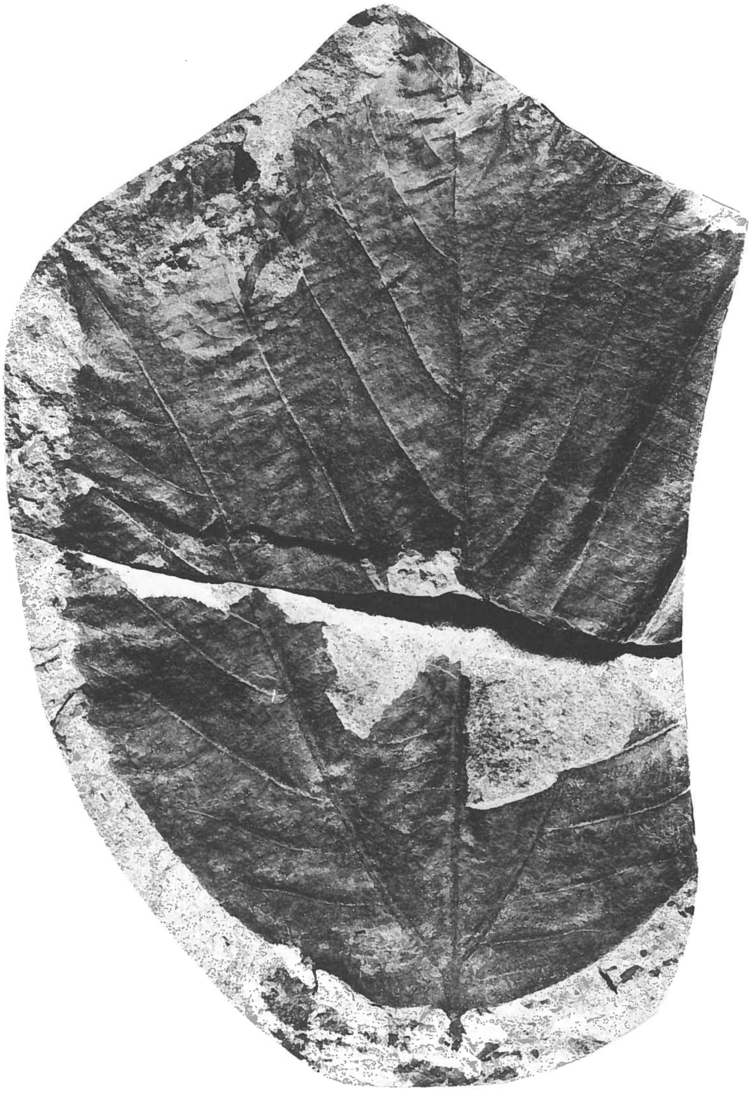


Plate 26.

Platanus sp. cfr *aceroides* GOEPP. (pag. 54).

1: Representative specimen, 1:1, Tupaussat (*Quikavsak member* of the *Upper Atanikerdluk formation*) (G.G.U. label no. 9241.12). — HALKIER phot.

Plate 27.

Lauraceaephyllum stenolobatus n. sp. (pag. 56).

1: Rubber cast reconstructing the almost complete but wrinkled leaf of textfig. 20, 1:1 (Cast of G.G.U. label no. 12896.23). — Halkier phot.

Plate 28.

Lauraceaephyllum stenolobatus n. sp. (pag. 56).

1: Fragmentary leaf (considerably weathered), which seems to have been 5-lobed, 1:1, Agatkløft (G.G.U. label no. 12896.22). — Halkier phot.

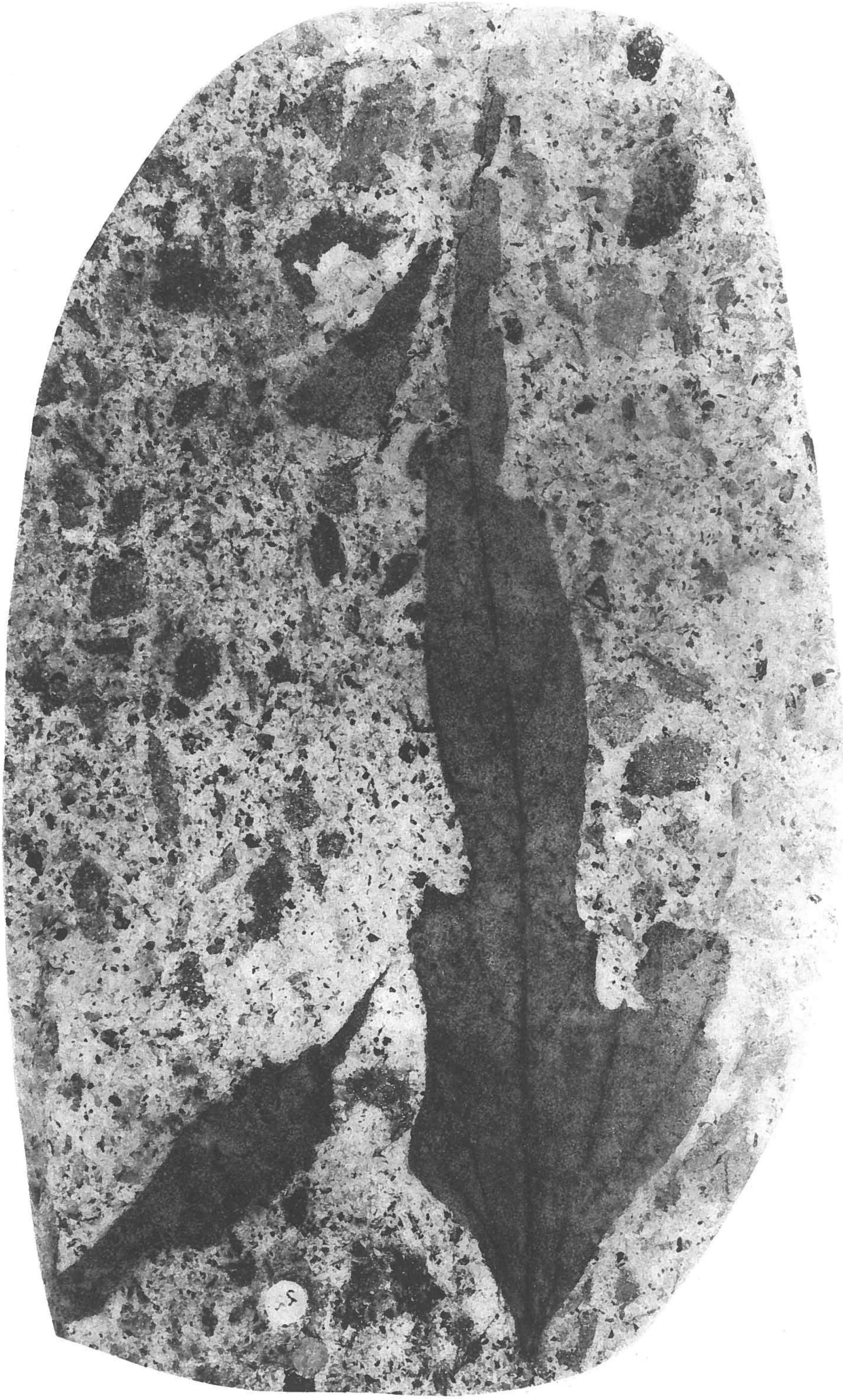


Plate 29.

Lauraceaephyllum stenolobatus n. sp. (pag. 56).

1: Fragment of a short lobed leaf, 1:1, Agatkløft (G.G.U. label no. 12896.80). — HALKIER phot.

2: Fragment of the smallest leaf of the available variation, 1:1, Agatkløft (G.G.U. label no. 12896.57). — HALKIER phot.

3: Leaf fragment of big specimen, 1:1, Agatkløft (G.G.U. label no. 12896.21). — HALKIER phot.

4: Rubber cast reconstruction of a very wrinkled specimen, 1:1 (cast of G.G.U. label no. 12896.20), Agatkløft. — HALKIER phot.

1

2

3

4

Plate 30.

Lauraceaephyllum stenolobatus n. sp. (pag. 56).

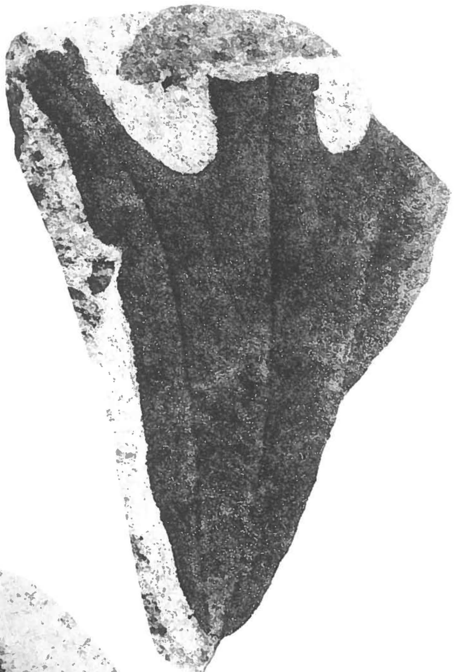
1: Fragment of lateral lobe with the nervation preserved, 1:1, Kangersôq (G.G.U. label no. 35492.44). — HALKIER phot.

2: Basal fragment of a short lobed specimen, 1:1, Agatkløft (G.G.U. label no. 12896.86). — HALKIER phot.

Cfr *Vitis Olriki* HR. (pag. 61).

3: Almost complete leaf, 1:1, Agatkløft (G.G.U. label no. 12896.24). — HALKIER phot.

1



2

3

Plate 31.

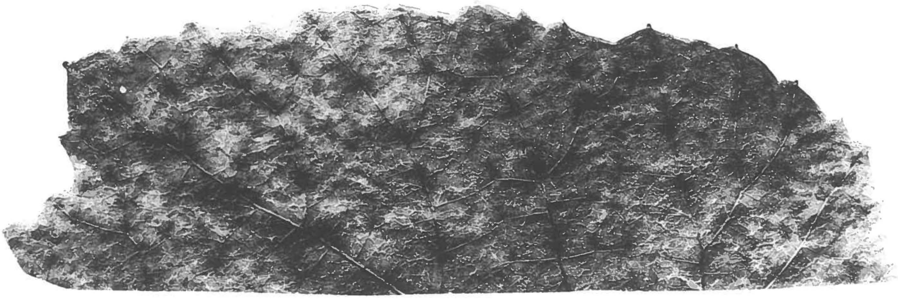
Fragments of leaves of recent species of *Vitis* (Bot. Garden, Univ. of Copenhagen) showing the serration. — Halkier phot.

1: *Vitis aestivalis* Torr., 1:1.

2: *Vitis Kaempferi* K. Koch, 1:1.

3: *Vitis labrusca* L., 1:1.

4: *Vitis californica* Benth., 1:1.



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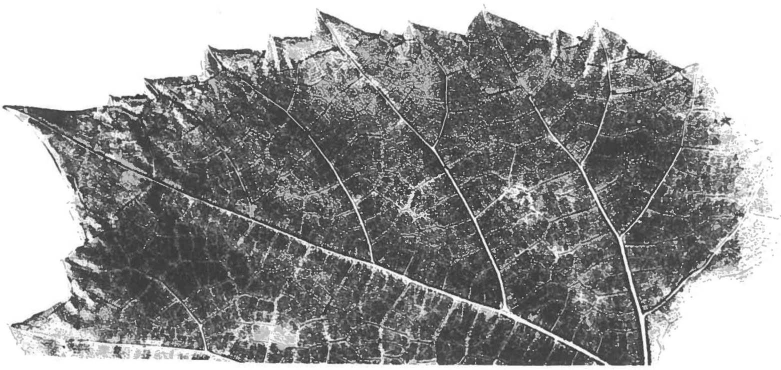

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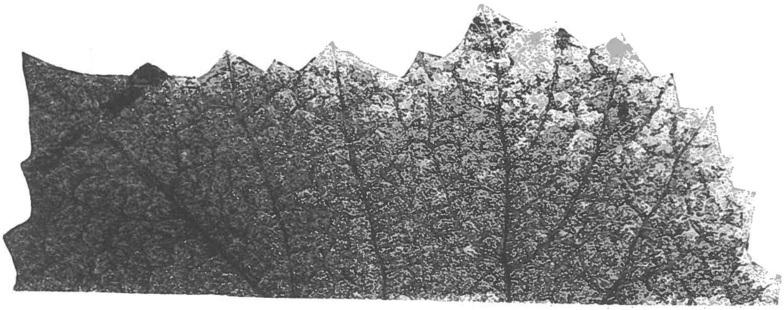

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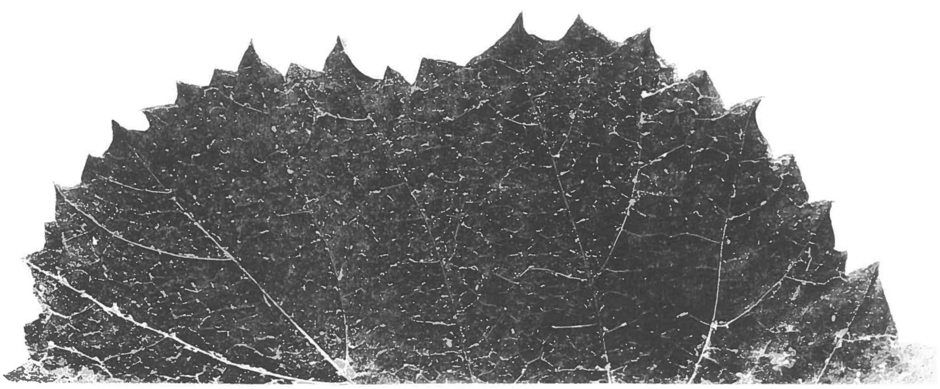


4

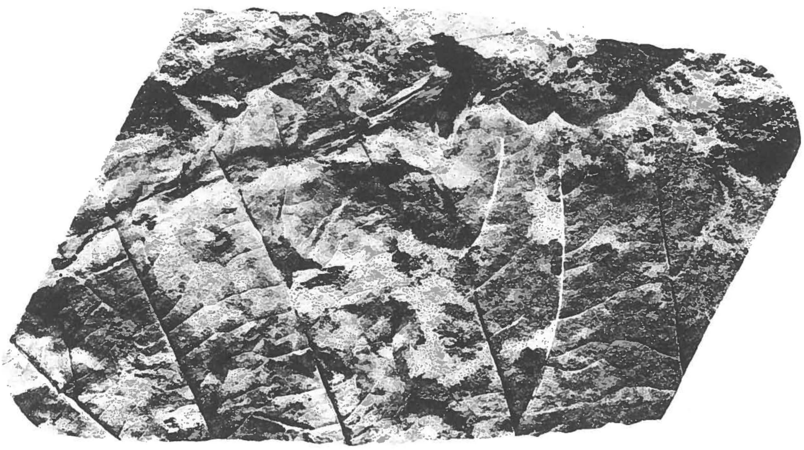
Plate 32.

Vitis Olriki HR. (pag. 61).

1: Detail of the margin. The specimen of HEER (1868) pl. 48 fig. 1, demonstrating the serration, 4:3, Atanikerdluk (MMUH no. 6923). — HALKIER phot.

Amicia zygomeris MOCC. & SESSE (recent).

2: Typical leaf, 1:1 (Bot. Garden, Univ. of Copenhagen). — HALKIER phot.



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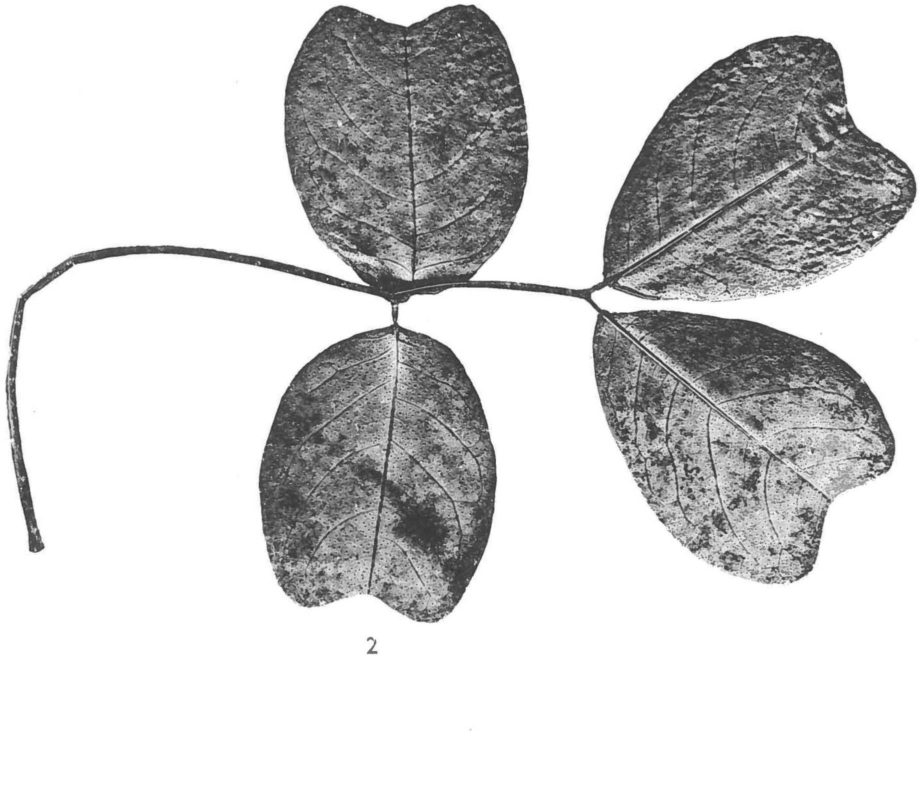


2

Plate 33.

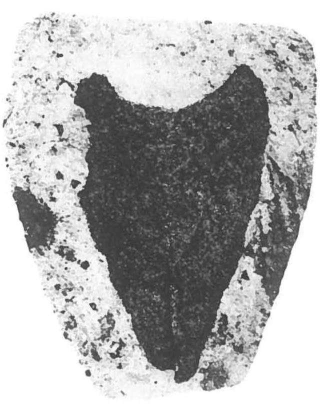
Cfr *Amicia* sp. (pag. 62).

1: Leaflet with traces of the nervation, 1:1, Agatkløft (G.G.U. label no. 12896.30). — Halkier phot.

2: Leaflet with traces of the nervation, 1:1, Agatkløft (G.G.U. label no. 12896.6). — Halkier phot.

Amicia zygomeris Mocc. & Sesse (recent).

3: Two terminal leaflets, 1:1 (Bot. Garden, Univ. of Copenhagen). — Halkier phot.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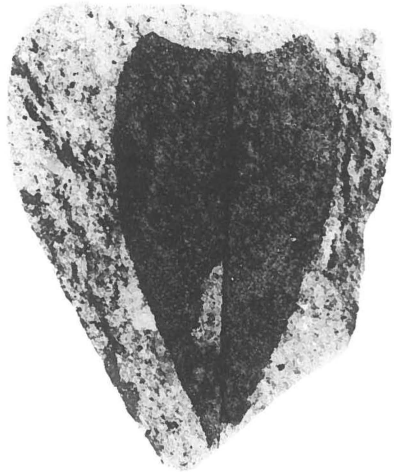
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3

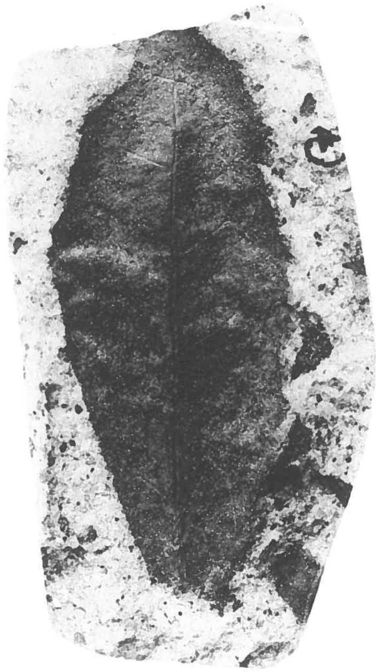
Plate 34.

Cfr *Rhododendron* sp. (pag. 64).

1, 2: Counterprints of the same leaf. Obs. the arched and wrinkled impression with a collapse along the primary vein. The veins leave weak impressions, 1:1, Agatkløft (G.G.U. label no. 12896.49). — HALKIER phot.

3: Small leaf, 1:1, Agatkløft (G.G.U. label no. 12896.130). — HALKIER phot.

4, 5: Counterprints of the same leaf. It demonstrates the nervation. (5) shows a single tooth on the right margin, 1:1, Agatdalen at Quleruànguaq (G.G.U. label no. 15774). — HALKIER phot.



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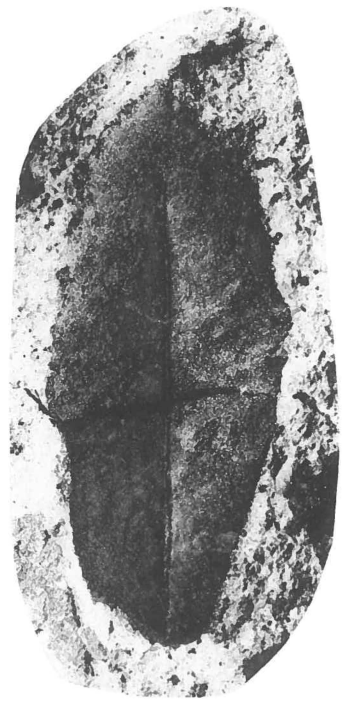

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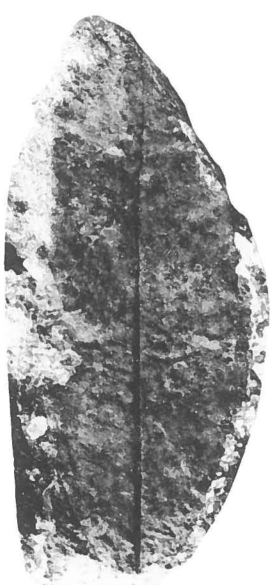

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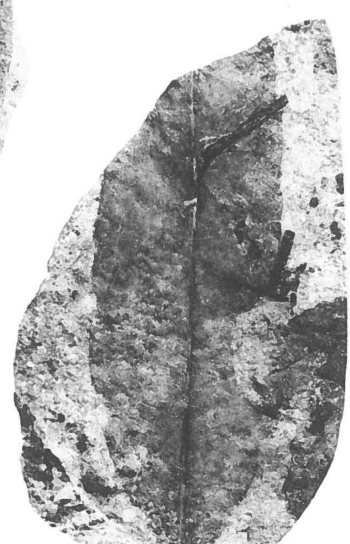


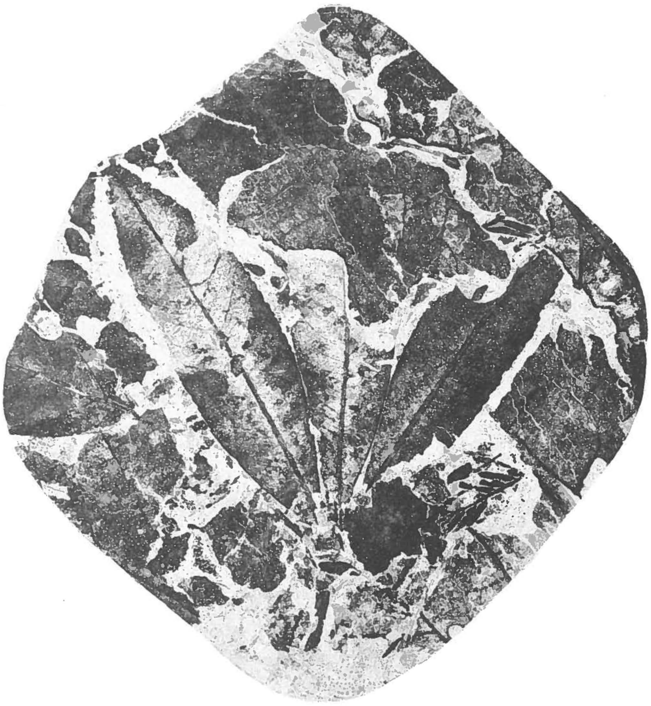
5

Plate 35.

Dicotylophyllum bellum (Hr.) Sew. & Conw. (pag. 66).

1: Leaf with 3 leaflets, 1:1, Kangersôq (G.G.U. label no. 35492.46). — Halkier phot.

2: Three leaflets of presumably the same leaf, 1:1, Agatkløft (G.G.U. label no. 12896.131). — Halkier phot.



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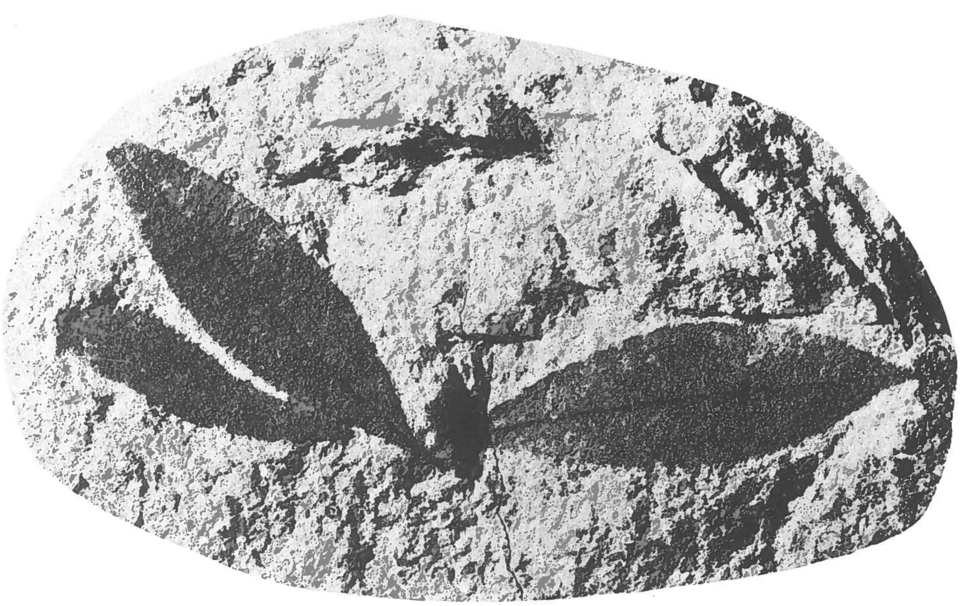


2

Plate 36.

Dicotylophyllum bellum (Hr.) Sew. & Conw. (pag. 66).

1: 5 leaflets of which 3 are obviously connected to the common petiole while the direction of the remaining 2 leaflets seems to involve also their incorporation in the same leaf (ref. textfig. 24), 1:1, Kangersôq (G.G.U. label no. 35492.49). — Halkier phot.

2: Bases of 3 leaflets connected to the same petiole, 1:1, Kangersôq (G.G.U. label no. 35492.24). — Halkier phot.

3: Typical leaf of 3 leaflets, 1:1, Agatkløft (G.G.U. label no. 12896.141). — Halkier phot.

4: Single leaflet (*Andromeda denticulata* in sensu Heerii), 1:1, Agatkløft (G.G.U. label no. 12896.41). — Halkier phot.

1

2

3

4

Plate 37.

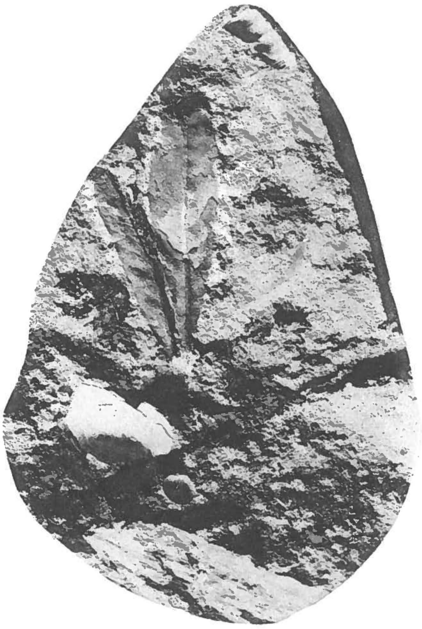
Dicotylophyllum bellum (HR.) SEW. & CONW. (pag. 66).

1: Two leaflets of a very small specimen, 1:1, Qaersutjægerdal (G.G.U. label no. 28955.7). — HALKIER phot.

2: Detail of the leaflet of pl. 37 fig. 1 demonstrating the nervation, 5:1, Qaersutjægerdal (G.G.U. label no. 28955.7). — HALKIER phot.

3: Leaf with 3 leaflets, 3:4, Atanikerdluk (Min. Mus. label H.b. 1865). — HALKIER phot.

4: Smallest specimen of the available variation, 1:1, Atanikerdluk (depicted by HEER (1883 a) pl. 68 fig. 3) (MMUH no. 6257). — HALKIER phot.



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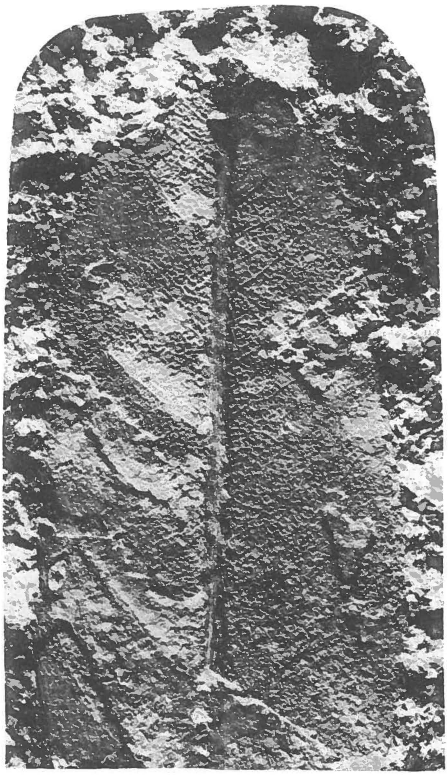

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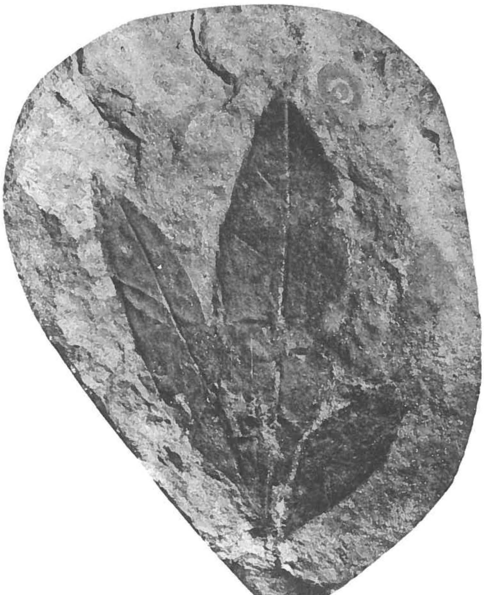


3

4

Plate 38.

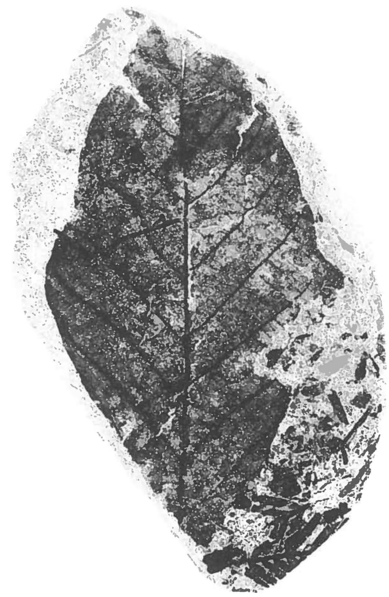
Dicotylophyllum Eridani (Hr.) Koch (pag. 69).

1: Fragment of a big leaf, 1:1, Kangersôq (G.G.U. label no. 35492.31). — Halkier phot.

2: Almost complete, small leaf, 1:1, Kangersôq (G.G.U. label no. 35492.30). — Halkier phot.

3–4: Counterprint of the same petiolate leaf. On (4) is seen an axis to which the leaf may have been connected; 1:1, Kangersôq (G.G.U. label no. 35492.29). — Halkier phot.

1



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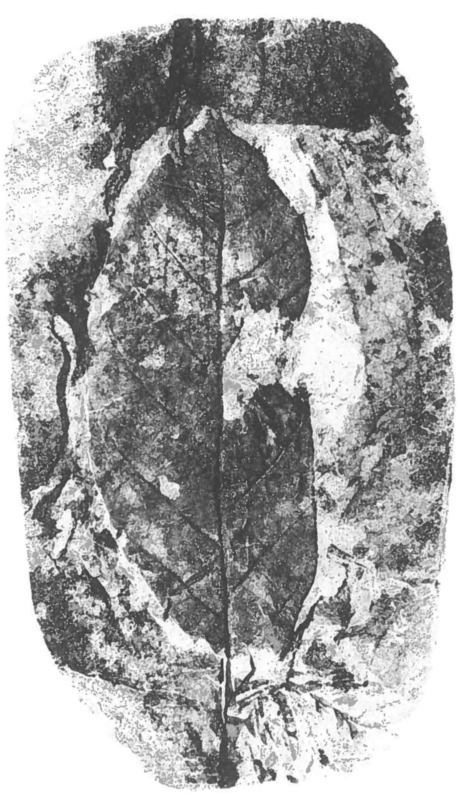

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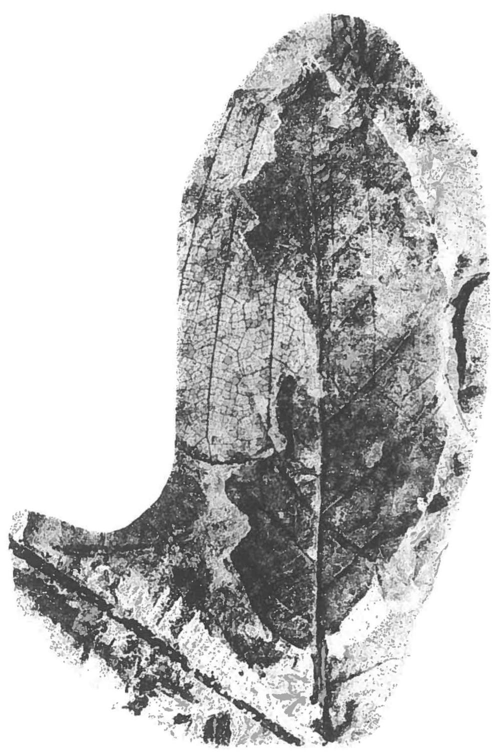


4

Plate 39.

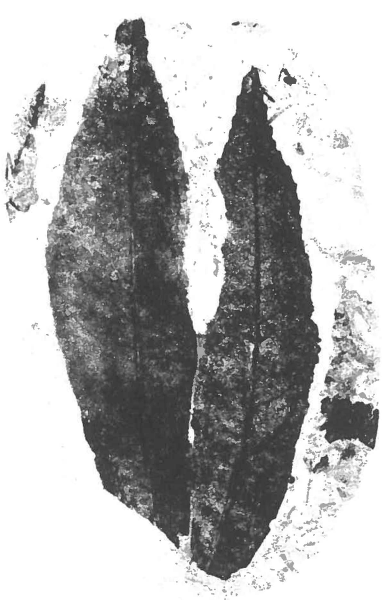
Dicotylophyllum Scottii (Hr.) Koch (pag. 70).

1: Slab with remnants of a leaf of *Dicotylophyllum bellum* (Hr.) Sew. & Conw. in the middle. To the upper left fragments of 3 presumably connected leaflets of *Dicotylophyllum Scottii* (Hr.) Koch. To the right a leaflet supposedly of the latter species, 1:1, Kangersôq (G.G.U. label no. 35492.53). — Halkier phot.

2: Two well-preserved leaflets, 1:1, Kangersôq (G.G.U. label no. 35492.40). — Halkier phot.

3: Two big leaflets demonstrating typical serration (ref. textfig. 25), the deep impression of the leaf-blade and the relatively weak print of the nervation of 2. and higher order, 1:1, Kangersôq (G.G.U. label no. 35492. 42). — Halkier phot.

1



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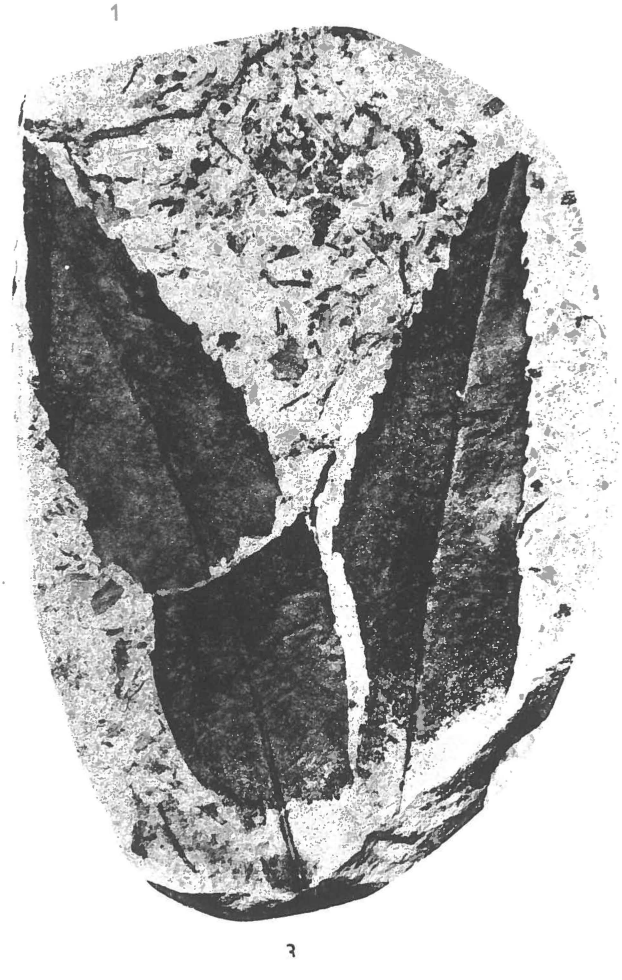


3

Plate 40.

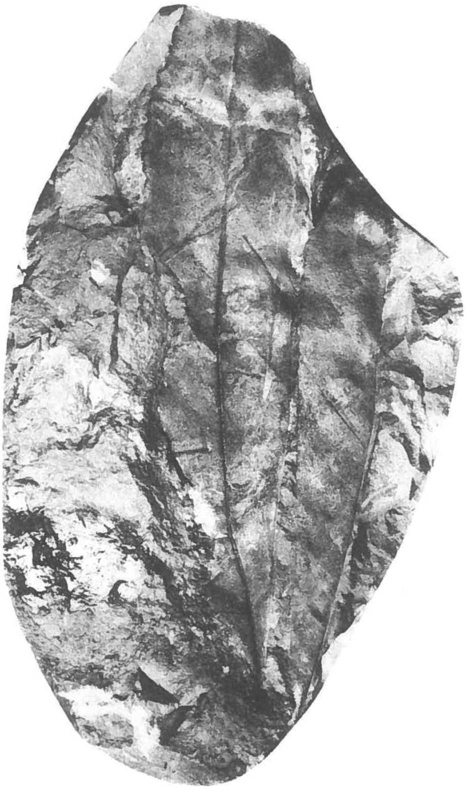
Dicotylophyllum Scottii (HR.) KOCH (pag. 70).

1: Specimen determined by HEER as *Rhus Holbölliana* (HEER (1883 a) pl. 69 fig. 7), 1:1, Atanikerdluk (MMUH no. 6273). — HALKIER phot.

Dicotylophyllum Steenstrupianum (HR.) SEW. & CONW. (pag. 74).

2: Fragmentary leaf, 1:1, Qaersutjægerdal (G.G.U. label no. 35579.1). — HALKIER phot.

3: Almost complete leaf (HEER (1868) pl. 46 fig. 8: *Quercus Steenstrupiana* HR.), 1:1, Atanikerdluk (MMUH no. 6900). — HALKIER phot.



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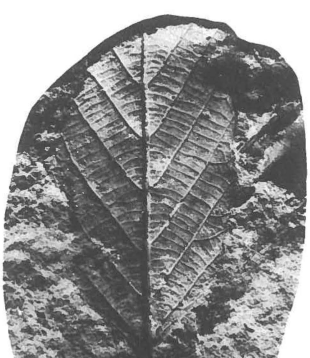
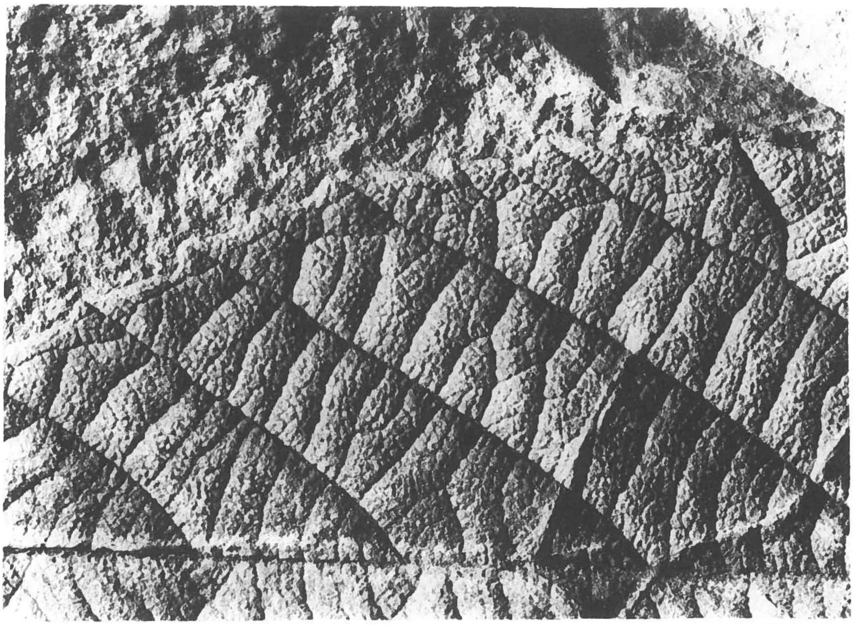


2

3

Plate 41.

Dicotylophyllum Steenstrupianum (Hr.) Sew. & Conw. (pag. 74).
1: Detail of the specimen of pl. 40 fig. 3, 5:1. — Halkier phot.
2: Detail of the specimen of pl. 40 fig. 2, 5:1. — Halkier phot.



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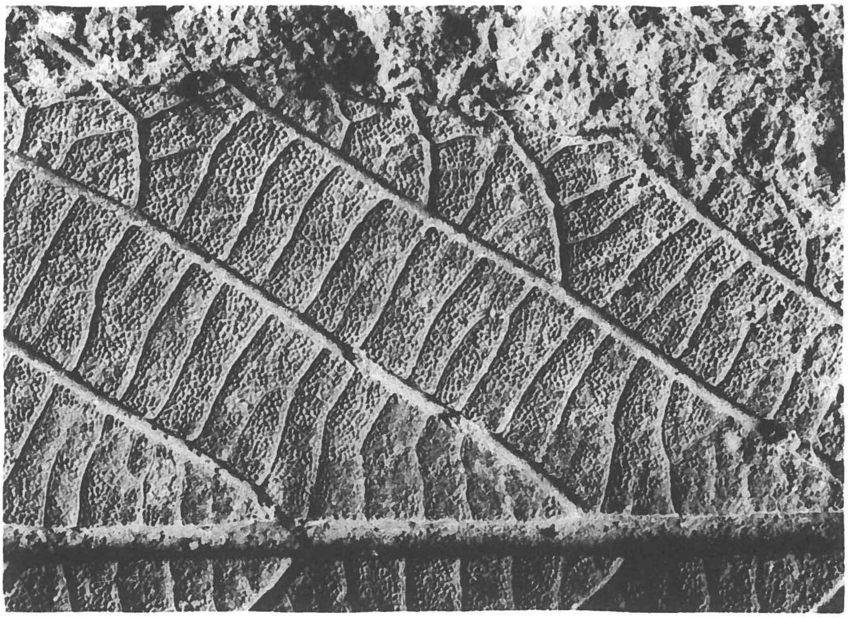


2

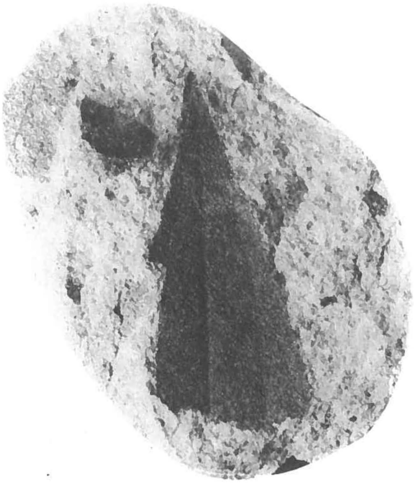
Plate 42.

Macclintockia Kanei (HR.) SEW. & CONW. (pag. 76).

1: Terminal fragment of a leaf, 1:1, Agatkløft (G.G.U. label no. 12896.8). — K. ELLITSGAARD-RASMUSSEN & KOCH phot.

2: Almost complete, petiolate leaf, 1:1, Agatkløft (G.G.U. label no. 12896.90). — HALKIER phot.

3: Fragmentary large specimen, 2:3, Agatkløft (G.G.U. label no. 12896.2). — K. ELLITSGAARD-RASMUSSEN & KOCH phot.



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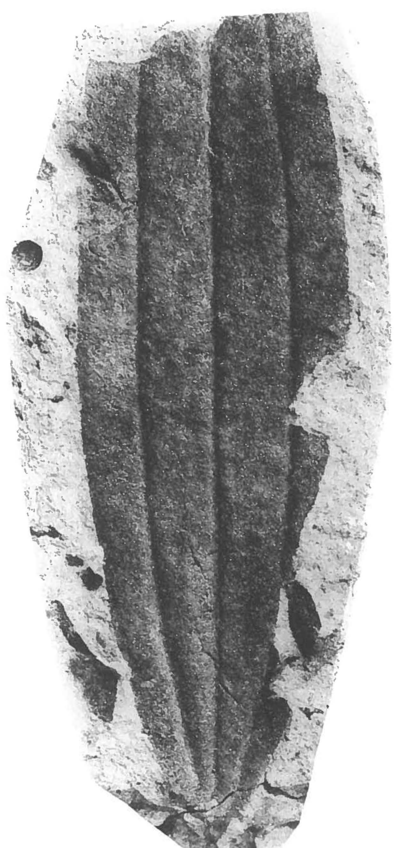


3

2

Plate 43.

Macclintockia Kanei (HR.) SEW. & CONW. (pag. 76).

1: Petiolate leaf fragment and a terminal leaf fragment on the same slab, 1:1, Agatkløft (G.G.U. label no. 12896.1). — HALKIER phot.

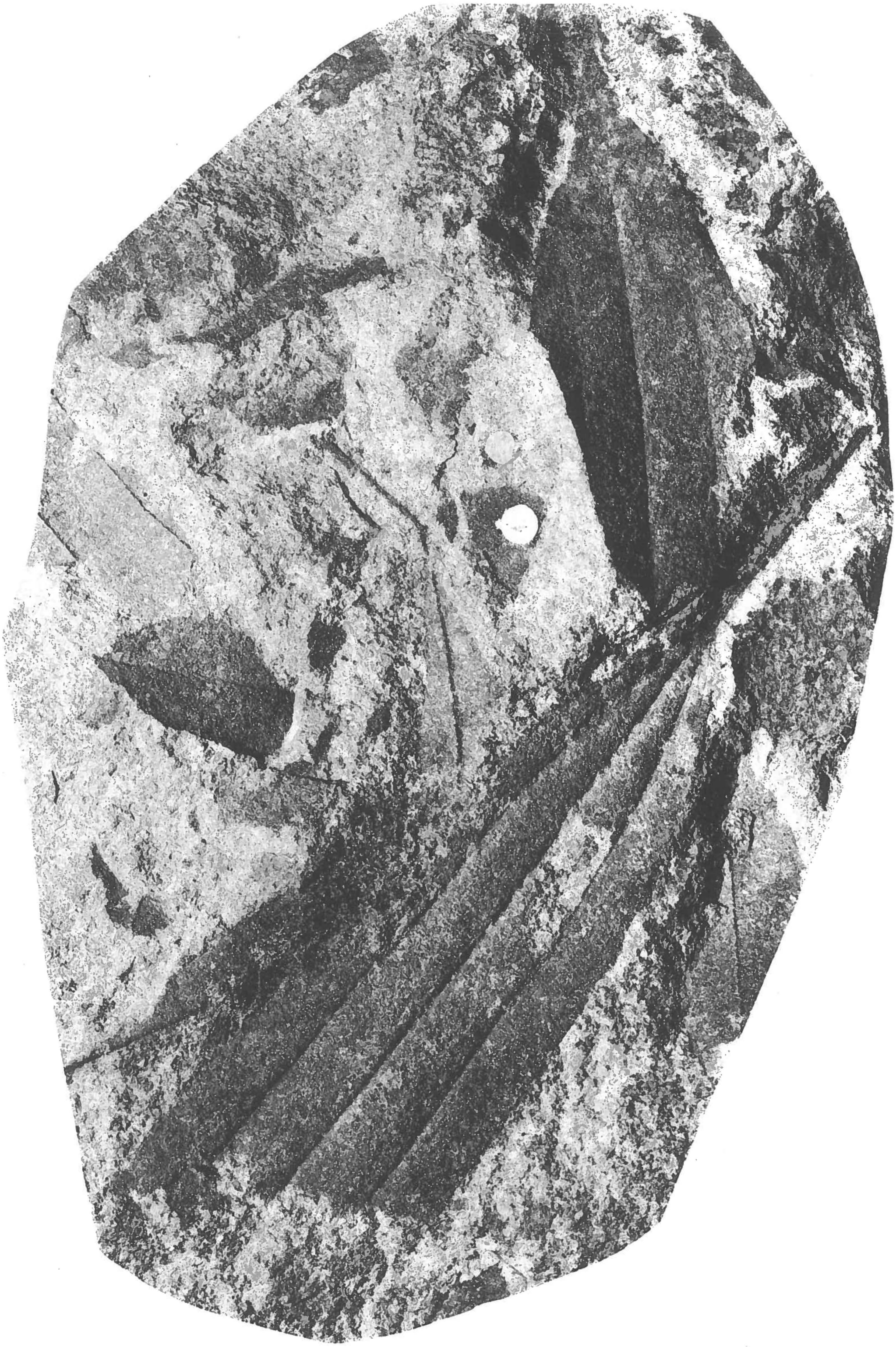


Plate 44.

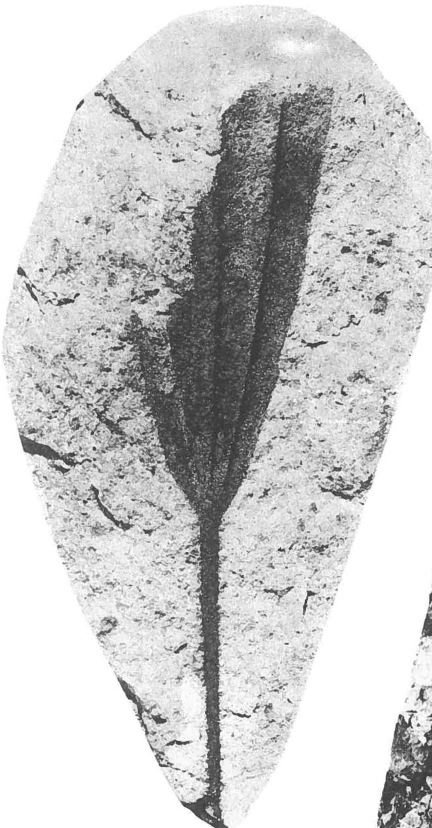
Macclintockia Kanei (HR.) SEW. & CONW. (pag. 76).

1: Typical petiolate basal leaf fragment, 1:1, Agatkløft (G.G.U. label no. 12896.143). — HALKIER phot.

2: Monoserrate leaf, 1:1, Kingigtoq (The Hartz collection, Min. Mus., Univ. of Copenhagen). — HALKIER phot.

3: Serrate leaf (HEER: *Macclintockia trinervis*), 1:1, Atanikerdluk (*Quikavsak member* clay-ironstone, *Upper Atanikerdluk Formation*) (G.G.U. label no. 4359.70). — HALKIER phot.

4: Fragmentary specimen, 1:1, Qaersutjægerdal (G.G.U. label no. 8171). — HALKIER phot.



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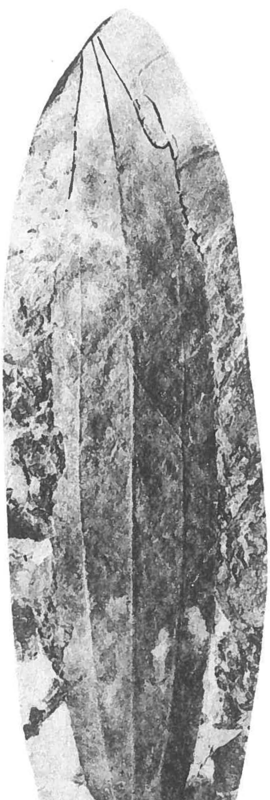

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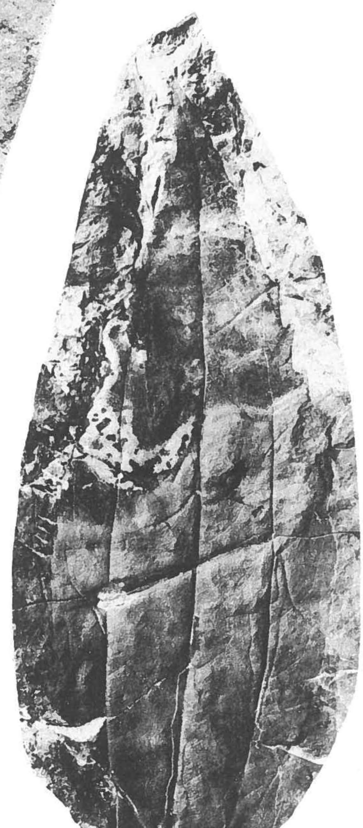

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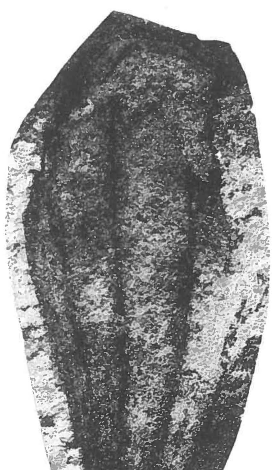


4

Plate 45.

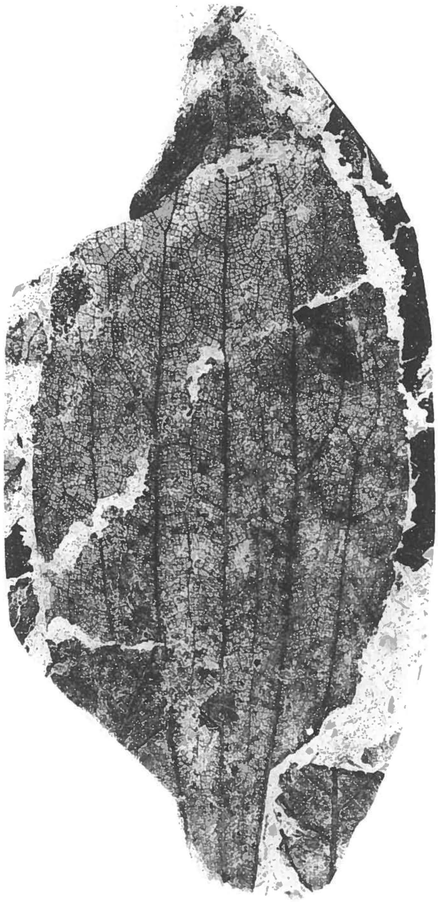
Macclintockia Lyalli HR. (pag. 84).

1: Big leaf demonstrating the nervation, 1:1, Kangersôq (G.G.U. label no. 35492.63). — HALKIER phot.

2: Petiolate basal fragment, 1:1, Kangersôq (G.G.U. label no. 35492.62). — HALKIER phot.

3: Fragment of the counterprint of the specimen of pl. 45 fig. 1 demonstrating the serration, 1:1, Kangersôq (G.G.U. label no. 35492.63). — HALKIER phot.

4: Petiolate basal fragment, 1:1, Agatkløft (G.G.U. label no. 12896.173). — HALKIER phot.



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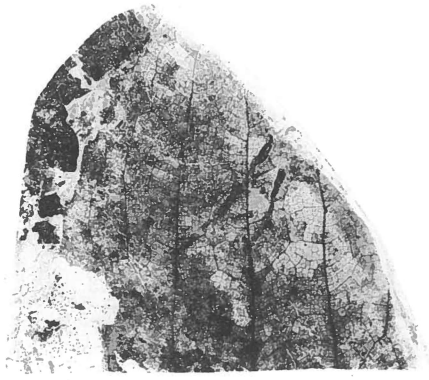


3

4

Plate 46.

Macclintockia Lyalli HR. (pag. 84).

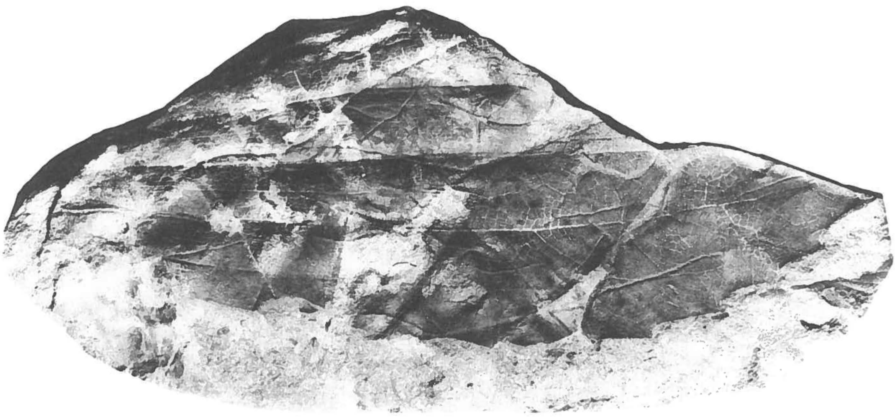
1: Fragment of big leaf, 1:1, Agatkløft (G.G.U. label no. 12896.125). — HALKIER phot.

2: Almost complete leaf with very discrete and scattered serration (almost entire margin), 1:1, Agatkløft (G.G.U. label no. 12896.101). — HALKIER phot.

3: Fragment of a big, coarsely serrate leaf, 1:1, Qutdligssat (Ritenbenks kulbrud) (Min. Mus. label no. 1876.2623). — HALKIER phot.

1

2



3

Plate 47.

Macclintockia dentata HR. (pag. 85).

1: Fragmentary leaf, 1:1, Agatkløft (G.G.U. label no. 12896.12). — HALKIER phot.

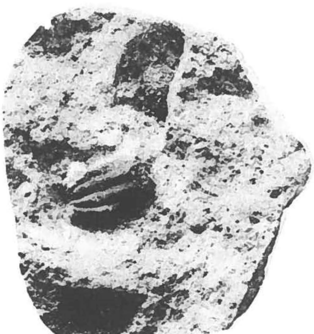
2: Basal petiolate fragment, 1:1, Agatkløft (G.G.U. label no. 12896.14). — HALKIER phot.

Nordenskiöldia borealis HR. (pag. 86).

3: Cast of a fruit in longitudinal view, 1:1, Agatkløft (G.G.U. label no. 12896.188). — HALKIER phot.

1

2



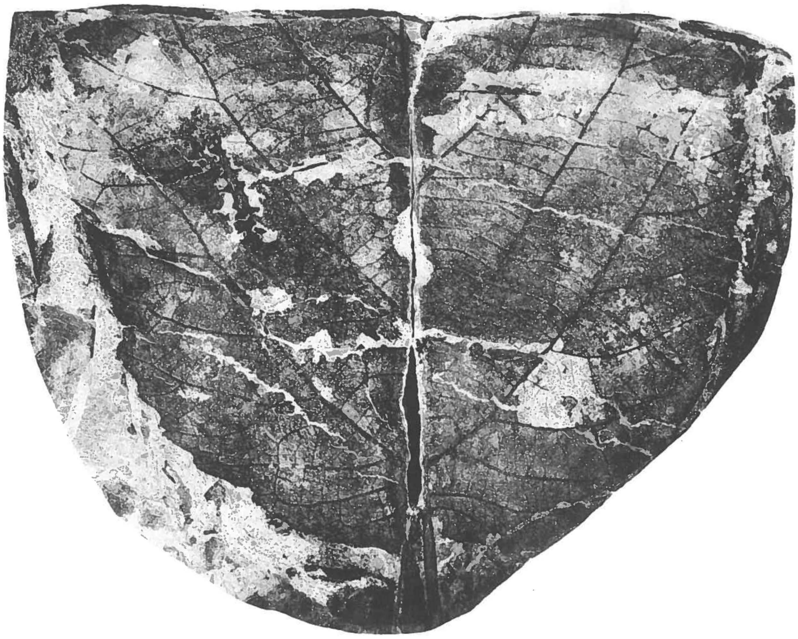
3

Plate 48.

Credneria spectabilis (Hr.) Koch (pag. 86).

1: Basal petiolate fragment of a well-preserved leaf with basal emargination, 1:1, Kangersôq (G.G.U. label no. 35492.58). — Halkier phot.

2: Fragmentary leaf, 1:1, Kangersôq (G.G.U. label no. 35492.57). — Koch phot.



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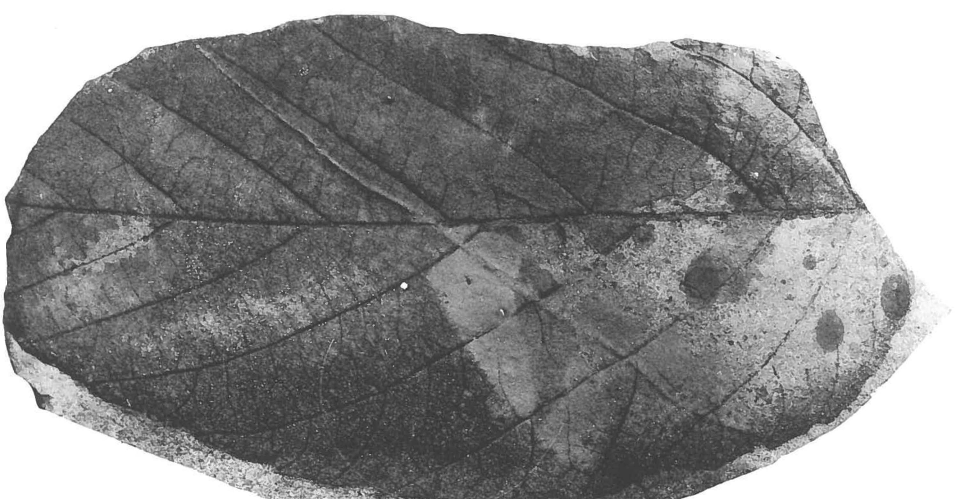


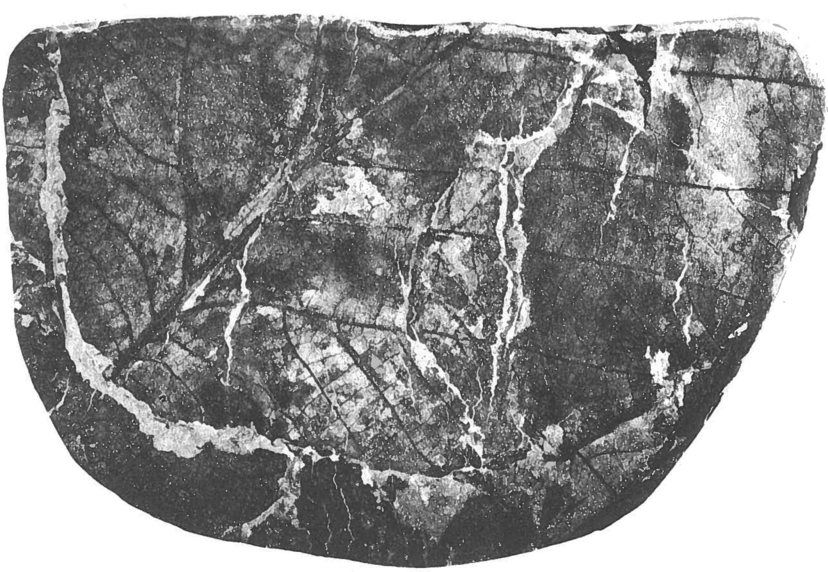
2

Plate 49.

Credneria spectabilis (Hr.) Koch (pag. 86).

1, 2: Counterprints of the same basal fragment of a petiolate leaf with rounded cuneate base, 1:1, Kangersôq (G.G.U. label no. 35492.151). — Halkier phot.

1



2

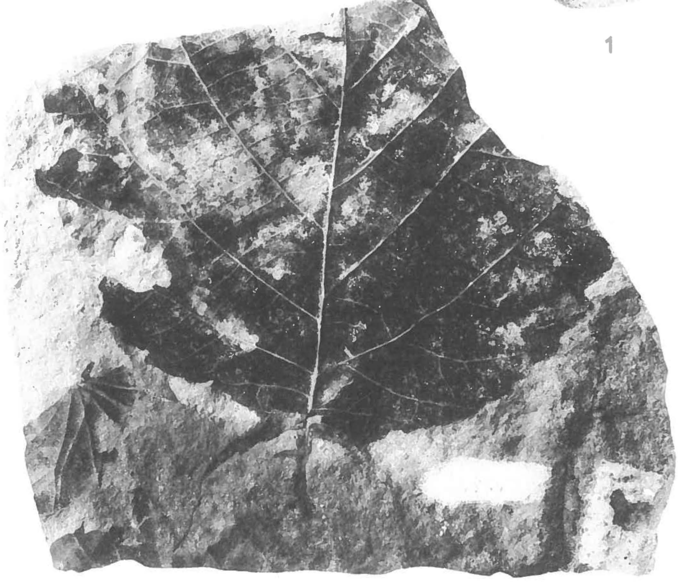
Plate 50.

Credneria spectabilis (Hr.) Koch (pag. 86).

1: Fragment of a large leaf with cuneate base (undeterminable!), 1:1, Agatkløft (G.G.U. label no. 12896.31). — Halkier phot.

2: Fragmentary leaf (Heer (1883 a) pl. 92 fig. 11: *Viburnum Nordenskiöldi* Hr.), 1:1, Hareø isl. (Qeqertarssuatsiaq) (MMUH no. 6569). — Halkier phot.

1



2

Plate 51.

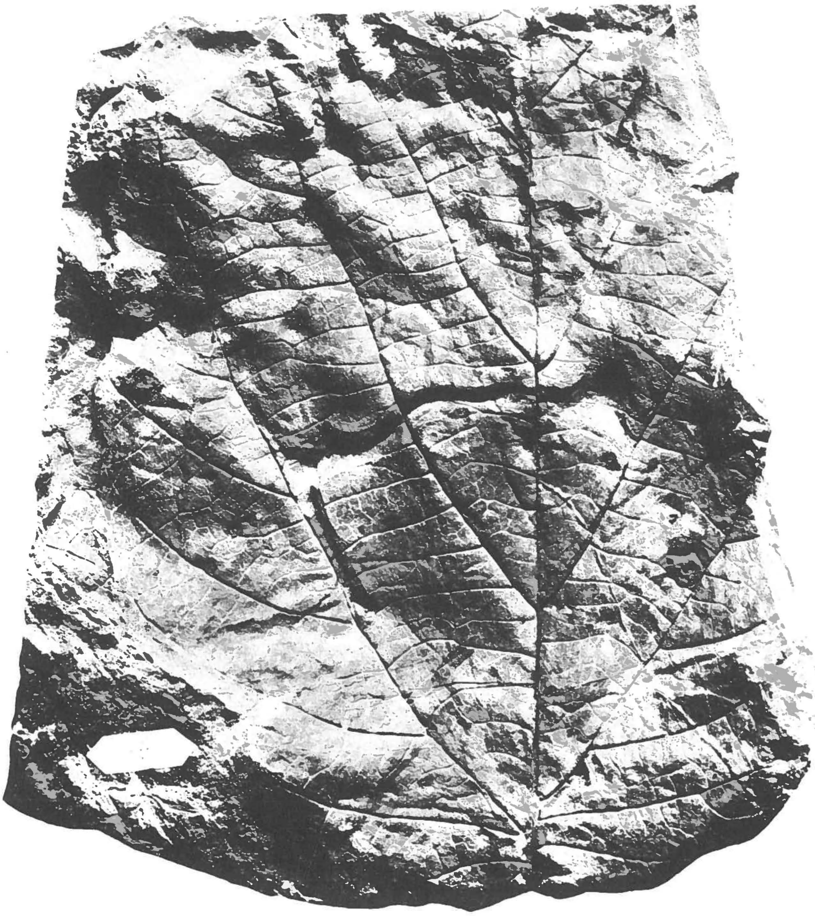
Credneria spectabilis (Hr.) Koch (pag. 86).

1: Large, fragmentary leaf (Heer (1868) pl. 49 fig. 8: *Ficus? groenlandica*), 1:1, Atanikerdluk (MMUH no. 6940). — Halkier phot.

Design *Quercus Drymeia* Ung. (pag. 94).

2: Almost complete leaf, 1:1, Kangersôq (G.G.U. label no. 35492.134). — Halkier phot.

3: Almost complete leaf, 1:1, Qaersutjægerdal (G.G.U. label no. 28955.26). — Halkier phot.



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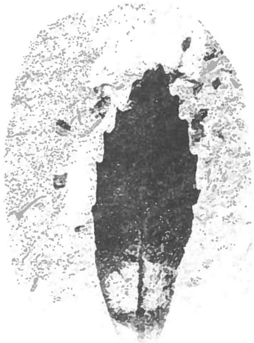


2

3

Plate 52.

Design *Carpinus grandis* Ung. (pag. 92).

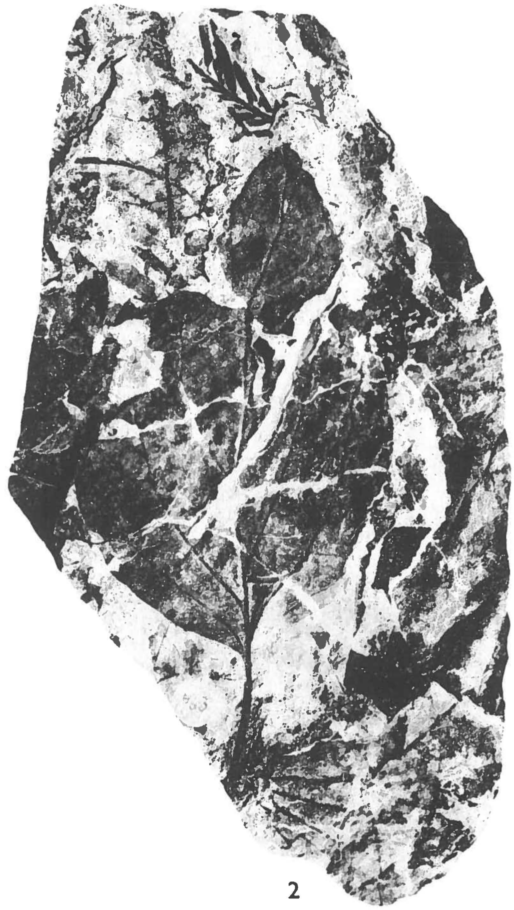
1, 3, 4: Fragmentary leaves, 1:1, Agatkløft (G.G.U. label no. 12896.105; 12896.127; 12896.87). — Halkier phot.

Design *Cornus ferox* Ung. (pag. 93).

2: Almost complete, somewhat damaged leaf, 1:1, Kangersôq (G.G.U. label no. 35492.130). — Halkier phot.

5: Basal fragment of big leaf, 1:1, Kangersôq (G.G.U. label no. 35492.129). — Halkier phot.


1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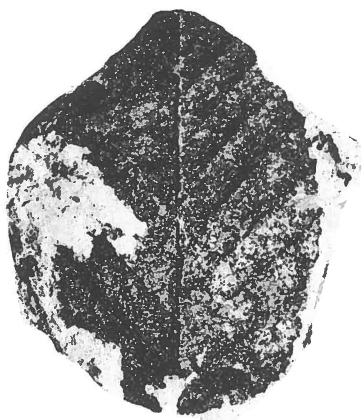
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4

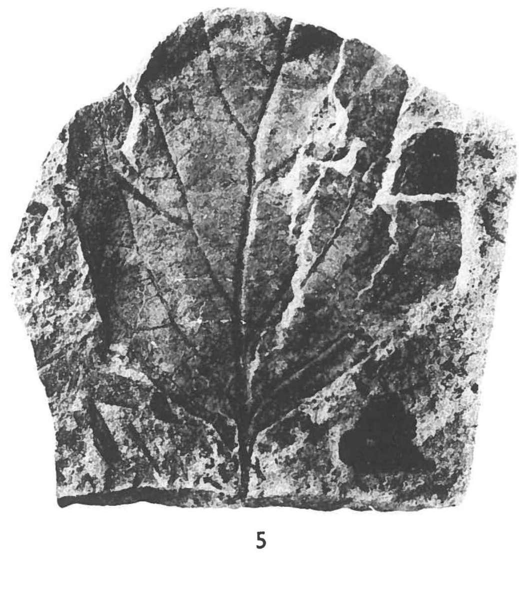

5

Plate 53.

Magnolia Inglefieldi HR. (pag. 91).

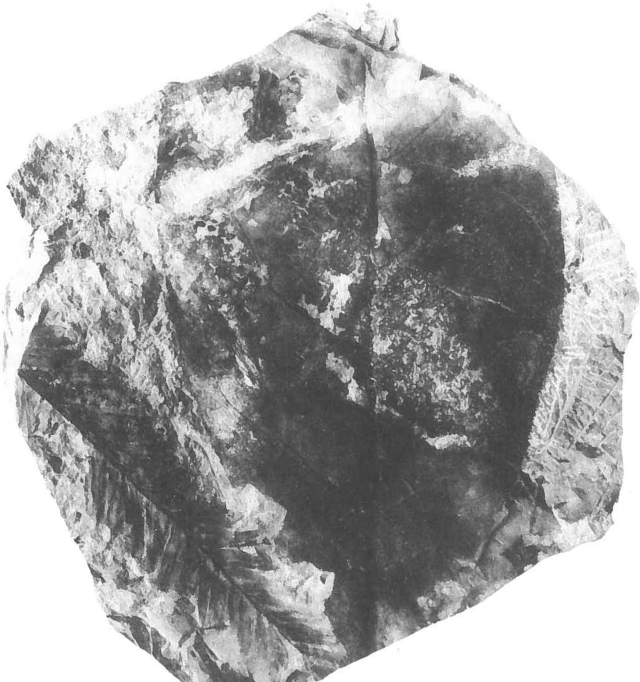
1: Basal fragment of a leaf; short shoot of *Metasequoia occidentalis* (NEWB.) CHANEY, 1:1 Pautût (G.G.U. label no. 29759.22). — HALKIER phot.

Salicoide leaves.

2, 3: Undetermined specimens, 1:1, Agatkløft (G.G.U. label no. 12896.268; 12896.43). — HALKIER phot.

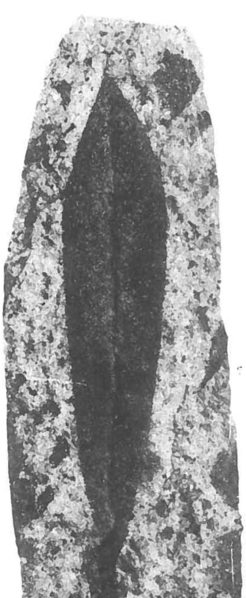
Design *Magnolia Inglefieldi* HR. (pag. 91).

4: Fragmentary leaf, 1:1, Qaersutjægerdal (G.G.U. label no. 35577). — HALKIER phot.

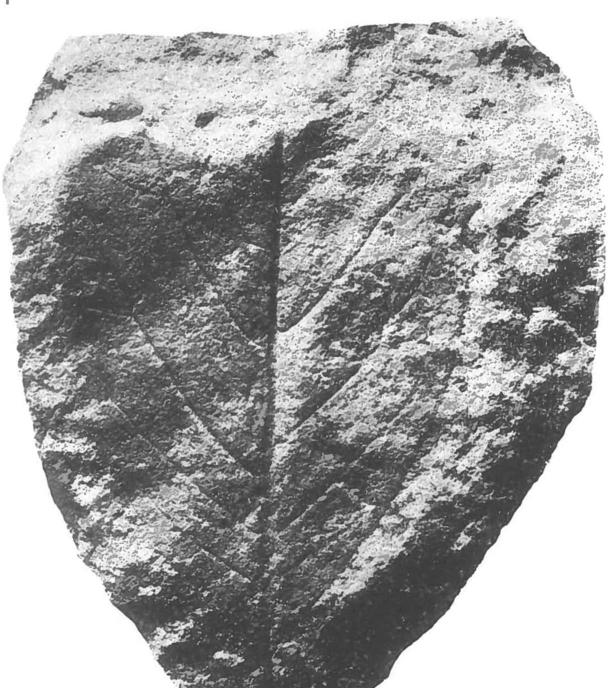


1

2



3



4

Plate 54.

Design *Quercus Ravniana* HR. (pag. 95).

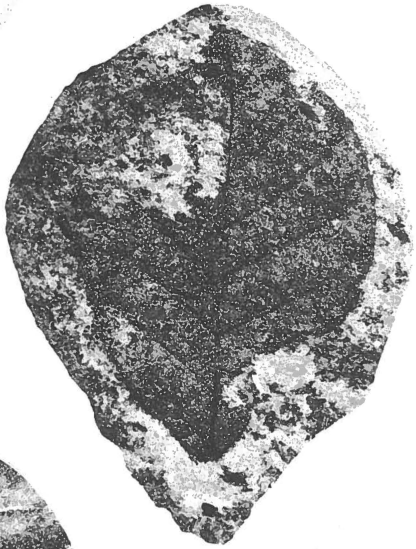
1: Leaf fragment, 1:1, Agatkløft (G.G.U. label no. 12896.211). — HALKIER phot.

Undetermined specimen.

2: Complete leaf, 1:1, Agatkløft (G.G.U. label no. 12896.107). — HALKIER phot.

3. Quercoid leaf fragment. 1:1, Agatkløft (G.G.U. label no. 12896.267).

1



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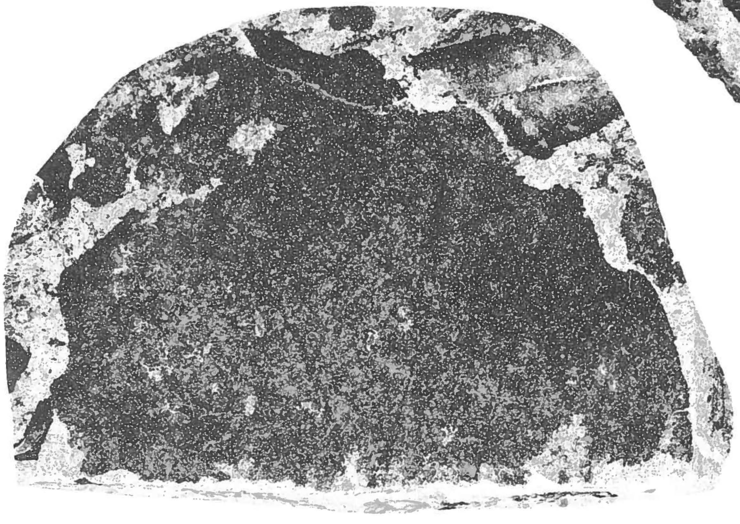


3

Plate 55.

Design *Quercus Lyelli* HR. (pag. 95).

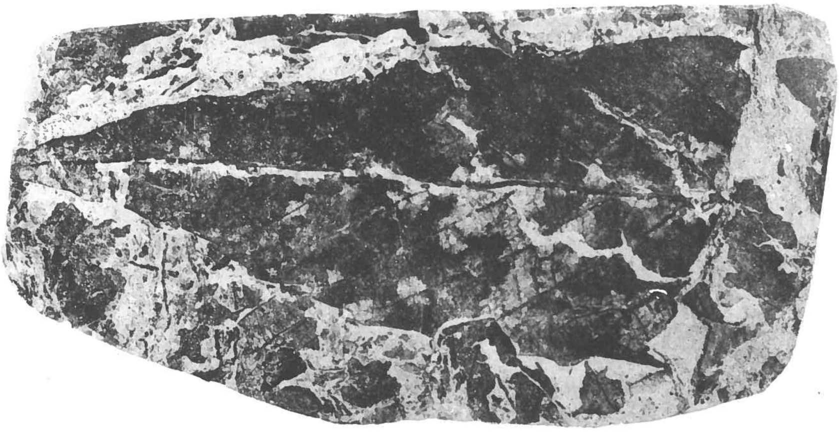
1: Terminal leaf fragment, 1:1, Kangersôq (G.G.U. label no. 35492.36). — HALKIER phot.

Design *Quercus Laharpii* GAUD. (pag. 93).

2: Fragmentary leaf, 1:1, Kangersôq (G.G.U. label no. 35492.156). — HALKIER phot.

Design *Alnus Kefersteini* GOEPP. (pag. 91).

3: Basal leaf fragment, 1:1, Qaersutjægerdal (G.G.U. label no. 28955.2). — HALKIER phot.



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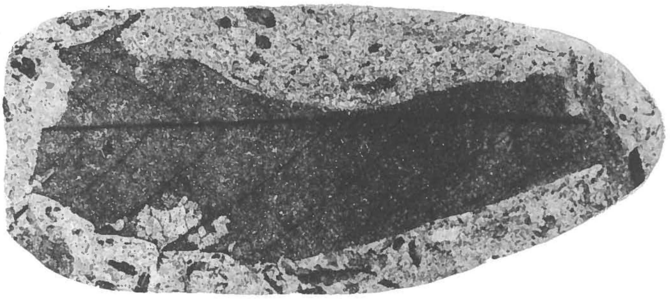

2

3