THE FOSSIL WOOD FROM THE TERTIARY AT MYGGBUKTA, EAST GREENLAND

BY

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6 TEXTFIGS. AND 8 PLATES

Previous investigations. In many Arctic regions there is a very striking abundance of fossil wood, usually silicified and of Tertiary age. We still lack a critical summary on the subject, in connection with a detailed examination of all the collections available; but quite a number of contributions have already been published in the course of time, dealing with the occurrences in various parts. One may mention:

From Spitsbergen (Tertiary and older): CRAMER 1868 p. 175, SCHROETER 1880, SCHENK 1890, GOTHAN 1910, WALTON 1927.

From King Charles Land (Upper Jurassic): SCHROETER 1880 p. 3, NATHORST 1901, GOTHAN 1907, EDWARDS 1925.

From Franz Josef Land (Upper Jurassic): NEWTON & TEALL 1897 p. 508, KOETTLITZ 1898 p. 636, HORN 1930 p. 10.

From New Sibirian Islands (Tertiary): SCHMALHAUSEN 1890.

From Iceland (Tertiary): WINDISCH 1886.

From Greenland: CRAMER 1868, BEUST 1884, NATHORST 1885 p. 279, SCHENK 1888 p. 19 (a short note), NEWTON & TEALL 1897 p. 510 (the same), WALTON 1927, MATHIESEN (in KOCH 1929).

From the Arctic Canada (Tertiary), at Mackenzie River: SCHROETER 1880 p. 16 and 1881, and on Banks Land: CRAMER 1868 p. 170.

It is very probable that the fossilization of all this wood has some causal connection with the eruptions of basalt, at least in many cases; this possibility has been mentioned by various authors previously. It is not, however, of the same age in all places. As will be seen from the short indications of the list above, most of the occurrences date from the Tertiary or from the end of the Cretaceous; but some of them probably even go back to the upper part of the Jurassic.

As to the records of fossil wood from Greenland, particularly, a brief summary of the results may be useful.

CRAMER (1868 p. 167) described a few specimens, poorly preserved, out of a more extensive material sent him for examination; he identified *Cupressinoxylon Breverni*, MERCKLIN, from Disko, a specimen so damaged, however, that the important details of the medullary rays could not be observed; further *C. ucranicum*, GÖPPERT, (?) from 70° N and 51° 45′ W, which does not seem to have been much better. BEUST (1884) gave an account of some specimens collected by K. J. V. STEENSTRUP in the Tertiary of the West coast of Greenland (occurrence also mentioned by NATHORST in NORDENSKIÖLD 1885 p. 279 and by other visitors to these places); the samples comprised *Araucarioxylon Heerii*, BEUST, from Atanikerdluk and from Hare Island, and from the latter locality another sample of wood which the author called *Libocedrus Sabiniana*, HEER, combining it with the twigs and leaves which had been found as impressions in great numbers in the same strata. This material must also have been rather poorly preserved.

In his extensive account of the fossil flora of Scoresby Sound, HARRIS (1926) mentioned the occurrence of numerous splits of carbonised wood; being, however, of Rhaetic age they are of no speeial interest in this connection. WALTON (1927) described *Cupressinoxylon diskoense*, WALTON, from Disko, *C. cf. vectense*, BARBER, from the Nûgssuak Peninsula, both probably of Cretaceous age, and *Cedroxylon greenlandicum*, WALTON, from the Tertiary (?) of Hare Island; some of these forms are further mentioned below (p. 383).

Finally, a collection of fossil plants from East Greenland, including wood fragments, has been examined by Professor FR. J. MATHIESEN; as will be seen from a preliminary report published by KOCH (1929 p. 203), it contains some highly interesting forms, but it has no species in common with the collection described in this paper.

Apart from some of WALTON's specimens most of the wood that has been described from Greenland has been in such a poor state of preservation that our knowledge of the anatomy is very inadequate, and the names used often only serve to increase the confusion of synonymy.

New collections. — In 1930, during the expedition sent out by "Norges Svalbard- og Ishavs-undersøkelser", leader Mr ADOLF

HOEL, a geological party under the command of Mr ANDERS K. ORVIN discovered an occurrence of fossil wood at Myggbukta, East Greenland. It was a very interesting occurrence, not hitherto described; an account of the geological conditions is given elsewhere in this volume by the finder.

Mr ORVIN made an extensive collection of samples; besides, the expedition also brought home some specimens picked up by Mr FINN DEVOLD. The whole material was left to me for examination. I am very glad to have got the opportunity to see this interesting collection, and I beg to express my sincere thanks to Mr HOEL and Mr ORVIN for this favour.

The wood is silicified, and, upon the whole, the preservation is excellent. Some specimens have not been silicified all through, and it also happens that pressure has damaged the original structure rather badly; in some cases it was very difficult to grind satisfactory cross-sections, the wood splitting up before the section was thin enough. But as is evident, I hope, from the photographs, other ones gave the most beautiful sections, where the details of the structure could be studied without any difficulty.

The examination has only been carried out by means of ordinary ground sections and no other preparations. — The collection belongs to the Paleontological Museum of the University, Oslo.

The specimens could be sorted into groups, probably representing different species, as far as species can be spoken of in connection with fossil wood. — As will be seen, they have been described as new, in spite of a strong resemblance to some other species previously instituted. Perhaps they will turn out to be identical, and the new names have to be dropped, but well-defined synonyms are preferable to heterogeneous species and dubious combinations.

It has also been preferred, in this paper, to describe with full details only the best specimen of each species (the holotype), and then only make shorter notes on the other specimens (paratypes) referable to the same species, as far as they deserve mention. This has been found safer than combining all the specimens in question, as the latter way, particularly on account of the varying quality of the preservation, might lead to confusion.

Piceoxylon laricinoides, n. sp.
Pl. I—III; Pl. IV, figs. 1—4, 6—7; text-figs. 1 & 6.

Description of the holotype. The specimen which has been chosen as the holotype (text-fig. 1) is a piece of a stem, about 30 cm long, giving off a branch about 2.5 cm in diameter.

The anatomy of the stem will be described first.

The wood is in a good state of preservation, although rather badly pressed. In each annual ring, the very first spring wood is well preserved, and so is the broad summer wood, while the middle zone between them is very much compressed and folded (Pl. I, fig. 1). It is, therefore, impossible to give the exact thickness of the annual ring; it may be estimated at about 0.7—1.6 mm, of which the summer wood will make up from one sixth to one third. The limit between the three parts is rather fluent. Vertical resin canals are found regularly in the summer wood.

The radial rows of tracheids vary in breadth; the broader ones measure 50 μ across, or even sligthly more, but between them there are also narrower ones. In the earliest spring wood the cells have a more or less quadrangular outline in the cross-section, or they are even longer in the radial direction. The tracheids are very long; one has been found measuring 4.9 mm.

On the spring tracheids there are bordered pits in great number, equally distributed along their radial walls. In many instances they form a single row, but it is not uncommon, in the more vigorously developed parts, that there is a double series; if so, they are strictly opposite or approximately so (Pl. II, fig. 1). In the middle part of the year-ring there are pits in great numbers, but details of their distribution cannot be ascertained on account of the compression. In the first tracheids of the summer wood there are also pits, but usually in single rows only. The pits are circular, sometimes slightly flattened horizontally, but never angular. Rims of Sanio are well developed above and below each pit, or, in the double rows, each pair of pits. In cross-sections and tangential sections the structural details of the bordered pits may be studied (Pl. II, fig. 2); the torus, for instance, is often distinctly visible.

On the tangential walls bordered pits have not been observed at all.

Fig. 1. *Piceoxylon laricinoides*, n. sp. Holotype PA 159.
Half nat. size.

The walls of tracheids have a very delicate striation in dense, steep spirals; but real thickenings have not been observed (see below, particularly p. 371).

Medullary rays are present in great numbers; some of them contain a resin canal, but most of them do not.

The non-resiniferous rays, corresponding to the uniseriate rays of other *Piceoxyla,* do not always correspond to this name here, being biseriate in a number of cases. These latter ones are always uniseriate in their upper and lower ends, while for a distance of 1—4—6 cells they are double.

In the tangential sections, these biseriate rays form quite a conspicuous element; but a statistical examination shows that they are only a small percentage of the whole number: Out of 250 rays examined, there were 228 simple rays, 9 biseriate ones, and 13 multiseriate ones, each with a resin canal.

The height of the non-resiniferous medullary rays is not very great. Usually there are less than 20 cells, and only quite exceptionally there are 25 or 30.

The parenchymatous cells, forming by far the major part of the rays, are some 20 μ in height, varying from about 15 μ to about 25 μ with cell walls 5—7 μ thick. In the radial direction they are long in the spring wood, and short in the summer wood, where they may measure only 45 μ. The abietinean pitting is abundant and distinct on all walls; in the crossings with the tracheids there are from one of four pits in each field. In the tangential walls the pits are crowded.

Beside these normal pits, there are often, in the radial walls, some wider pores, usually about 10 μ wide, and occurring on the same walls as small pits of the usual type. They look like open holes through the wall, and they probably represent the effect of some corrosion or decay; but their regular, round shape and well-defined outline make them very remarkable, and they might be mistaken for oöpores of the *Pinus* type, so much the more as they are present in several of the specimens of this species (*cf.* Pl. II, fig. 6). The parenchymatous cells are very uniform, all of them resembling each other, except in the size.

The tracheidal cells of the medullary rays are few, forming, as a rule, one row in each end. The outer wall is thin and much

curved, and it is not dentate on the inside. The wall between the tracheidal elements themselves is somewhat curved and inclined, and it sometimes shows a slight dentation; in relation to the parenchymatous cells it forms an angle opening towards the surface of the wood (*cf., e. g.,* Pl. II, fig. 9). In the spring wood, the tracheidal cells are long, and the angle mentioned is acute, while towards the periphery of the annual ring the dividing walls are nearly vertical, and with so short distances between them that the cells are nearly quadrangular, or they are even higher than broad. Bordered pits are sometimes visible on the radial walls (Pl. I, fig. 6); they are small, often only half the size of those between the wood tracheids, and they must be rather scarce; on the tangential walls, however, there are often a couple of such pits, closely together, well developed and excellently preserved (*cf.* Pl. I, figs. 6 & 6 and Pl. II, figs. 6 & 9).

The tracheidal cells are, as a rule, confined to the margin of the medullary ray; only quite exceptionnally they may be found between the parenchymatous cells. Then there are usually two or more rows of them, and the appearance is as if there were originally two neighbouring medullary rays, one above the other, which had happened to get such a short vertical distance between them that they united into one.

The multiseriate medullary rays are usually fusiform in the tangential section, with the resin canal in the middle. More exceptionally, in the very high medullary rays, the canal is placed in one end, and the other part resembles a usual uniseriate medullary ray. Rarely there are two canals.

The resin canals, vertical and horizontal, are bordered by thick-walled cells, and consequently they are very well preserved. The abietinean pitting of these thick-walled cells is distinctly visible, in transversal sections as well as in longitudinal ones.

Wood parenchyma occurs regularly at the periphery of the year-ring, but only as scattered cells, not forming a continuous layer. They are particularly well recognizable in the radial section, where they may be found between the summer wood and next year's spring wood. The cross-walls between the parenchymatous cells are horizontal or nearly so; the size of the cell varies rather much, those in the row figured (Pl. I, figs. 8 & 9) measuring, say, from 120 μ to 185 μ by a width of about 20 μ. In other places they are

shorter, even only 85 μ. Small simple pits are observable in many cases, but not always.

The t w i g is excellently preserved and not pressed at all. The annual rings are narrow, the average of 13 being 0.16 mm. The spring tracheids are square in the cross-section, and they keep the same shape and size out to the sharp limit against the summer wood; the latter forms from one fourth to one half of the entire zone. The resin canals are rather scanty, but they are equally distributed throughout the wood. Bordered pits are abundant on the radial walls of the spring tracheids, but, with few exceptions, they occur only in single rows; they have also been observed on the tangential walls.

As to the two most important specific characters of the wood, there is no essential difference between the twig and the stem:

The medullary rays have the same structure as those of the stem, but they are not so high (Pl. I, figs. 4 & 5); about 5 is the common number of cells, and the highest ones have 8 cells, or rarely more. Biseriate medullary rays occur; they are perhaps less frequent than in the stem, but as well developed. Multiseriate rays with resin canals are also less numerous than in the stem.

Xylem parenchyma is present in a considerably larger quantity in the twig than in the trunk. Upon the whole, their shape is the same; they may be narrower (as are most cells in the twig), but not always shorter.

P a r a t y p e s. The collection comprises a large number of other specimens referable to the same species, but showing a great deal of variation. It is so much the more valuable to be able to compare these specimens, as they are of all sizes, from twigs a centimetre in diameter and up to pieces of thick stems.

There are particularly two characters of importance in this connection, *viz.* (1) the biseriate medullary rays, and (2) the xylem parenchyma.

All these specimens possess the parenchyma at the end of the year-ring, but the quantity varies between very wide limits. As in the holotype, there is always quite an abundance of it in the twigs and thin branches (as in PA 142, 146, 153); there is rather more of it here than in the wood of the stem. Otherwise it is, however, very difficult to give any general rule as to its occurrence: In some samples (as PA 156), evidently fragments of stems, there is very

much of the parenchyma, as, upon the whole, all elements of the wood are vigorously developed. In other ones, it may be very scarce, although the wood is otherwise quite typical and well developed; in some cases it has only been found after considerable searching.

The medullary rays are also subject to some variation, but, upon the whole, in a more regular way. In the twigs, they are as numerous as in the stems, but they are never so high, and there are not so many multiseriate ones. Of the non-resiniferous rays, the number of biseriate ones is less in the twigs, and it has sometimes taken a long search to find any (particularly in PA 153). In the stems medullary rays of this kind are usually present about in the same percentage as in the holotype (p. 368), although there is some variation in the frequency. No specimen has been found to miss them entirely. In a class of its own stands a flat piece of wood, No. PA 134; to judge from its size it might be a fragment of a stem or at least quite a big bough, but the narrow year-rings have the anatomy usually characteristic of twigs or branches. Here, the parenchyma is very scanty, and the biseriate medullary rays are so scarce that they would have been overlooked if not searched for very carefully by means of the cross-board.

The walls of the tracheids are often badly striated, but sometimes, as mentioned in the description of the holotype, there are indications of original inner thickenings of the membrane. This is distinctly observable in a certain specimen, PA 165 (Pl. II, figs. 3 & 4). The specimen now consists of eight small fragments; possibly they have belonged to one of the other specimens, but it cannot be said which. The wood is rather badly pressed and no transversal section has been prepared. No xylem parenchyma has been found, but still, there is scarcely any reason to doubt the identity with the species described above; there is a complete agreement in other details, the structure and distribution of the resin canals, the presence of biseriate medullary rays, &c. In the summer tracheids, which are well preserved, this specimen shows very distinct annular thickenings; as visible in the photographs, they are horizontal or very nearly so, and they are very dense.

The pith is present in a number of branches, and in some of the sections several details of the structure are observable (PA 142, 146 & 147). There is no doubt as to the specific identity of these specimens: they show all the essential characters mentioned above, although the biseriate medullary rays are scanty, as is usually the

case in branches. The pith is (in PA 146) about 0.7 mm wide, consisting of very thick-walled cells with distinct simple pores and dark contents.

They are rather varying in size, but usually about 35—40 μ across. In the cross-section they are rounded or angular; usually they are closely packed together, but, according to their shape, there are often considerable intercellular spaces between them (Pl. III, fig. 3), in other cases not (Pl. III, fig. 5). In the longitudinal sections they are seen to be irregularly elongated, the length being up to four times the breadth.

The protoxylem consisting of spiral tracheids lies close to the pith; in exactly transversal sections these cells are not always easily recognizable, but when cut obliquely they show their spiral thickening, and in more longitudinal sections they are also sometimes visible (Pl. III, figs. 5 & 6). They are rather uniform in size, measuring about 20 μ across. In size and in the structure of the wall they are like those of *Larix decidua* and *Picea excelsa*.

Leaf-traces are radiating in all directions (Pl. III, fig. 2). Each of them contains a small group of a few spiral tracheids, surrounded by thick-walled cells resembling those of the pith. Bundles like that may also be found further out, in the secondary wood (Pl. III, figs. 5 & 7).

Of the c o r t e x there are a few detached pieces, which do not, however, show the anatomical structure any longer; but this may be studied in another specimen, where it is still connected with the wood; this specimen (PA 146) is one of those in which the pith is also preserved.

In a longitudinal section of it there are, in the inner part of the cortex, some thick-walled, narrow fibres alternating with other prosenchymatous cells, badly pressed (Pl. IV, figs. 1 & 2); probably the former represent sclerenchyma, but details are not observable. A cross-section, further out in the cortex, is shown in the photographs Pl. IV, figs. 3 & 4; there are alternating zones of cells with different thickness of their walls. The best preserved ones are very thick-walled and angular, leaving only small intercellular spaces at the corners; they are a few times as long s broad, and, as is seen when they are cut obliquely or longitudinally, they have often rather irregular outlines. They have well preserved pits; usually there is not much left of the contents of the cells.

Affinity. As mentioned above, there is a good deal of variation between the various specimens. Subject to such variation are, first, many non-essential characters: The size of the cells, absolute and relative; the width and composition of the annual rings; &c. But it also affects some characters which have to be regarded as more important from a taxonomic point of view, *viz.,* above all, the xylem parenchyma and the biseriate medullary rays. Thanks to the great number of specimens of different kinds in this collection there are, however, all transitional stages between the extremes, and there is no essential gap between the holotype and the paratypes suggesting the presence of more than one species. A certain amount of parenchyma and a certain percentage, hovewer small, of medullary rays of the said type, are always present and have to be regarded as characteristical to the species.

Some of the generic characters also vary, *e. g.,* the pitting of the tracheids and that of the cells in the medullary rays, the number of resin ducts, &c.; but it is not possible to ascribe any systematic importance to this variation, which is more quantitative than qualitative; on the other hand it is not easy to see what kind of external influences might have been the cause in the various cases.

The wood is a typical *Piceoxylon,* as evident from the description above.

It is of some interest to compare it with the living genera corresponding to that fossil one, *viz. Larix; Picea,* and *Pseudotsuga.* The wood parenchyma, and the biseriate medullary rays, give it a very close resemblance to *Larix* (*cf.* KLEEBERG 1885, GOTHAN 1905). On the other hand, the cortex is more like that of *Picea,* the zones of stone cells in the fossil corresponding to similar ones in *Picea excelsa;* but if this character can really serve to distinguish between the two genera (as has been suggested) can scarcely be decided without a more extensive research, which, as far as I know, has not yet been carried out in this field. The pith is rather different from that of *Picea excelsa* and *Larix decidua* (the two only species with which I have had the opportunity to compare it). Both of them consist chiefly, or entirely, of rather thin-walled parenchyma; beside that, *Picea* has incomplete diaphragms, formed by sclerified cells (*cf.* KUBART 1924), and these cells have some resemblance to those of our Greenland species. However, there are strong differences, too, particularly that in the the recent *Picea* they make up only a small

portion of the pith, while in the fossil they form a more or less uniform tissue.

The possibility of a relationship to *Pseudotsuga* presents itself on account of the distinct spiral thickenings of the tracheids in one specimen (PA 165, see p. 371). As mentioned above, this specimen resembles the holotype very closely (as far as the pressed state of the specimen allows it to be observed), so that there should not be any reasonable room for doubt about the specific identity. On the other hand it is surprising that these thickenings, so distinctly visible in this specimen, should not also be present in other ones, where the tracheids are as well preserved. It is probably most safe not to base any further conclusions upon this character.

Among the fossil *Piceoxyla,* our species has undoubtedly the closest resemblance to *P. laricinum*, KRÄUSEL (1919 a). The spiral thickenings form a dubious character, and the pith and the cortex are not known in the case of *P. laricinum,* so none of these can be taken into consideration. The only difference is that in our Greenland species the biseriate medullary rays are of constant occurrence, while they are not recorded from the other one at all. Therefore, it may be correct to regard the species described here as a new one. If the medullary rays of the said type should be found in the German species, too (as is rather likely), the new name may probably be dropped again, provided that there are no differences in the anatomy of the pith and the cortex.

Pinites mosquensis, MERCKL., is worth mentioning in this connection. The drawings given by MERCKLIN (1855, Pl. X, particularly fig. 4) show resin canals surrounded by thin-walled cells giving a strong resemblance to *Pinuxylon,* the poor preservation of most of the resin canals pointing in the same direction. But on the other hand, the medullary rays are drawn with abietinean pits (fig. 5), and this structure is also explicitly mentioned in his description (p. 52), so that it is most probable that the species in question is a *Piceoxylon.* This fact, together with the occurrence of biseriate medullary rays (*l. c.* figs. 2 B & 3) make a comparison with our Greenland *Piceoxylon* possible. But xylem parenchyma is not recorded, and at all events, the preservation seems to be so poor that it should be unneccessary to pay any more attention to this species, at least not without a re-examination of the type specimen, if existing.

Pinites Pachtanus, MERCKL., should perhaps also be taken into consideration, although its nature is somewhat dubious. In the original drawings (MERCKLIN 1855, Pl. IX) the resin canals are surrounded by thin-walled cells, more or less obliterated, very much resembling those of *Pinus*. Further, the parenchymatous cells of the medullary rays seem to have pores of the *Pinus* type; but this is explained by the author as an error, the structures being no pores, but inclusions in the cells. If this is so, the medullary rays give the species its place in the genus *Piceoxylon*.

The specific characters seem, however, to be different from those of our species. In his Pl. IX, fig. 8 B, MERCKLIN figures some parenchymatous cells, which KRÄUSEL (1919 b, p. 223) regards as "scheinbar Harzparenchym" and consequently as indicating a relationship to *Larix*. The figure is, however, explicitly said to represent the longitudinal section of a resin canal, and it can scarcely be regarded as any proof of the existence of wood parenchyma. As to medullary rays, there are no biseriate ones without any resin canal between those figured, and neither is this type mentioned in the description. Consequently, *P. Pachtanus* is in all probability not identical with our species from Greenland.

D i a g n o s i s.— *Piceoxylon laricinoides,* n. sp. Coniferous wood with distinct annual rings and vertical and horizontal resin canals. Bordered pits on the radial walls of the spring tracheids, in one row, more rarely in two rows; tangential pits very scarce. Medullary rays fusiform, with resin ducts, or linear; of the latter, a small percentage is biseriate. Parenchyma of the medullary rays with abietinean pits; tracheidal elements constantly present, but few. Epithelial lining of the resin canals thick-walled. Wood parenchyma present along the periphery of the annual rings. Pith consisting of thick-walled, short cells with numerous pits and rounded or angular in outline. Protoxylem with spiral tracheids. Leaf traces numerous, containing the same kind of tracheids. Cortex with layers of stone cells.

Age: Tertiary.

Locality: East Greenland: Myggbukta.

Holotype: PA 159, Paleontological Museum of the University, Oslo.

Cfr. Piceoxylon laricinoides, m.

Pl. V, figs. 1—5.

There are two specimens resembling the previous species in nearly all characters, but differing in a certain detail in the medullary rays, as described further below. One of them (PA 133) consists of two small fragments of a twig, and the other one (PA 137) is a somewhat large piece; both of them have a very tight structure; like agate, and the preservation is not bad. In the cross-sections the annual rings are indistinct, probably only as a secondary phenomenon due to the fossilization.

The resin ducts as well as the pitting of the tracheids are as typical in *Piceoxylon*. There is a fair amount of wood parenchyma in both specimens, and the identity with *P. laricinoides* is probable, although it has not been possible to find any biseriate medullary rays in the sections at hand, but this may be due to the fact that they are twigs.

The medullary rays consist of parenchymatous cells, and tracheids; as usually the latter, with bordered pits, are found only in the upper and lower end, and not, as a rule, between the parenchymatous cells.

So far, the structure is in complete agreement with that of the typical *P. laricinoides*.

The parenchymatous cells, however, show a peculiarity not seen in other specimens, being of two kinds: There are always one or two of them in each ray containing an abundance of dark resin, and having thick walls in which the pits are exceptionally numerous and prominent. These cells are surrounded by, or separated by, other parenchymatous cells without any contents; their walls are thinner, at least apparently, and they do not have so many pits (but those which are found are of the abietinean type).

The contrast between these two kinds of cells is very prominent in the radial section, but it is also well visible in the tangential section, where the dark contents and bigger size make the former type well visible (Pl. V, figs. 1 & 3—4).

This differentiation seems to be quite constant, and it puts these specimens in a position of their own. But it is scarcely necessary to create any new specific name before it has been studied in a larger material.

Cedroxylon Orvini, n. sp.

Pl. IV, fig. 5; Pl. V, figs. 6—8; Pl. VI—VIII; text-figs. 2—5.

Description of the holotype. The specimen chosen as a holotype, PA 152, is a piece of wood about 35 cm long and 16 by 12 cm thick. It is somewhat pressed, but otherwise the preservation is good.

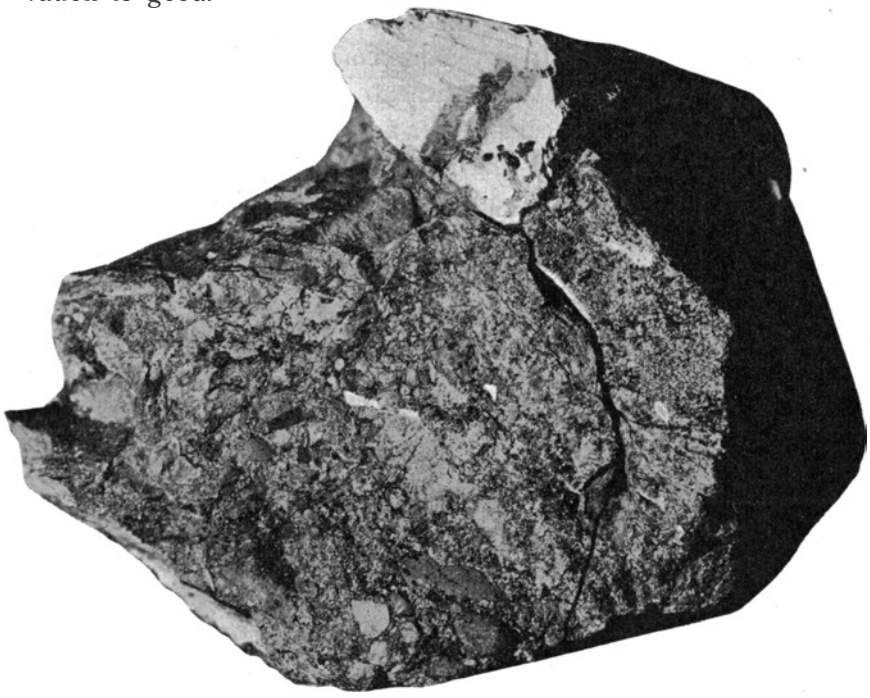


Fig. 2. *Cedroxylon Orvini*, n. sp. PA 160. Branch still imbedded in matrix. Nat. size.

Each annual ring contains a layer of one or two spring tracheids, which are very wide; then a broad middle part, occupying about one half of the whole growth ring, but badly pressed; and finally, a zone of summer tracheids. On account of the compression the exact width of the annual ring cannot be measured; it may have been from about 0.3 mm to 0.7 mm. There are no resin canals, neither normal nor traumatic in the holotype (*cf.* below, No. PA 131, p. 382).

The tracheids are about 20—30 μ broad (tangentially). Their whole length could not be measured, but sometimes at least it is

more than 2 mm. The walls have delicate spirals, forming a left-screw at an angle of about 45 °; it is not always visible, but it seems to be of a general occurrence. Bordered pits occur on the radial walls of the tracheids in nearly all parts of the wood, even in the summer tracheids, although not in the very last ones. They have only been found in single series, and often with some distance between each other, except in the earliest spring tracheids where they may be more crowded; they are circular, and often rather small in relation to the width of the tracheid. The inner pores may be fusiform, crossing each other at right angles. The presence of rims of Sanio has not been ascertained beyond doubt. There are sometimes pits in the tangential walls in the summer wood.

The medullary rays are numerous, but rather small, and they never contain any resin duct; they are always uniseriate. The number of cells usually vary between 5 and 8, and rarely as many as 15 or even 22 have been observed. There are chiefly parenchymatous ray cells, 16—20 μ high; they are short in the summer wood, and very long in the spring wood. Usually they contain a considerable amount of some dark matter. The wall is thick, 4—6 μ or more, and abundantly pitted, with pits of the abietinean type (Pl. VI, fig. 2); in the horizontal and tangential walls these pits are very well developed, while on the radial walls against the tracheids, there are only a few ones in each crossing field, and they are usually difficult to discover; often they are not observable at all.

The medullary ray is sometimes bordered above and below by a tracheidal cell, but in most instances this is not so. The tracheidal cells are often low, but much varying in size; the wall is thin, and bordered pits are sometimes distinguishable.

Xylem parenchyma is present in a small quantity along the periphery of the summer wood. In the cross-section (Pl. VII, fig. 7), these cells have about the same size as the tracheids, but the wall is darker brown; the dark cell contents are often visible, sometimes also the pitting of the longitudinal wall, and even the pitted cross-wall. The length, as seen in the longitudinal sections (Pl. VI, fig. 3), is often about 150 μ, sometimes considerably more.

Beside this parenchyma of the ordinary type there is a considerable amount of other parenchyma, which is looking most extraordinary and perhaps should be regarded as traumatic. It

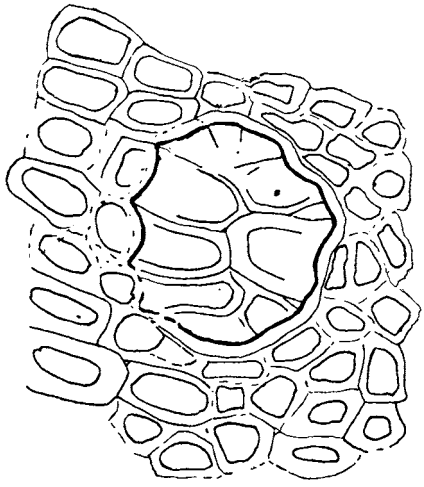


Fig. 3.

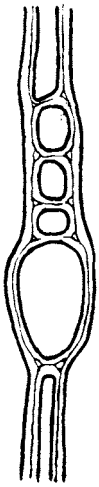


Fig. 5.

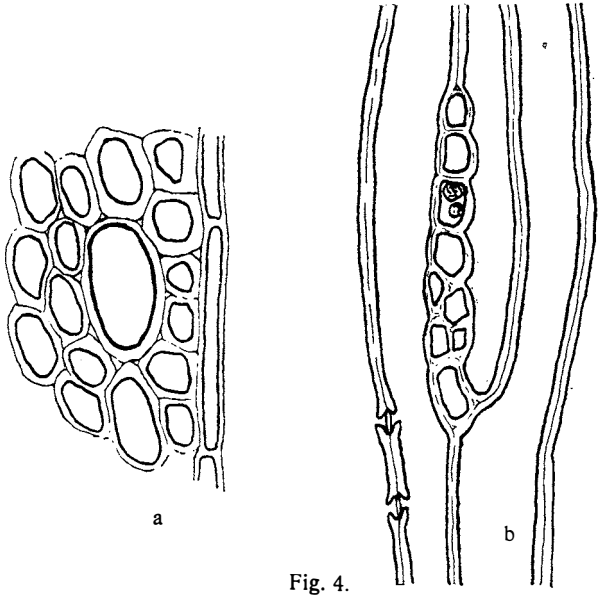


Fig. 4.

Fig. 3. *Cedroxylon Orvini*, n. sp. PA 135. Cross-section with a very wide tracheid, *cf.* Pl. VIII, figs. 2 & 3. — × 360.

Fig. 4. *Cedroxylon Orvini*, n. sp. PA 160. a: Very wide tracheid in a cross-section. b: Tangential section; medullary ray with two cells on the same level. — × 360.

Fig. 5. *Cedroxylon Orvini*, n. sp. PA 129. Tangential section. Medullary ray with exceptionally wide cell, probably a widened tracheid curving along the margin of the ray. — × 360.

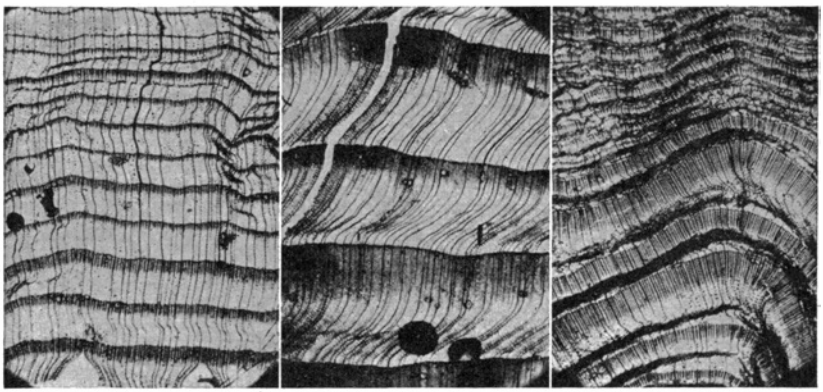
consists of groups of very large cells, irregularly formed and very thick-walled.

These cells (Pl. VI, fig. 4; Pl. VII) are usually found in the earliest spring wood, starting from the surface of the preceding year-ring; more rarely they are found further out. They are nearly always in connection with the medullary rays, and usually it looks as if it were the ray cells themselves, which had multiplied and swollen. The cells are angular and in close connection with each other, leaving but small intercellular spaces open at some of the corners. The wall is brownish and very thick; when two cells of this kind are neighbours the separating wall between them may be 8—10 μ or even 14 μ thick. There are simple pits in varying number, sometimes very numerous. Most frequently there is rather much of dark cell contents. — In the longitudinal sections these cells are always very irregular and variable. Sometimes such abnormal tissue is but very slightly developed, as, *e. g.,* when all the cells of a medullary ray have extraordinarily thick walls and somewhat larger size, while the proportions in other respects are as usual. In other cases these thick-walled cells are seen as very conspicuous groups, which may extend widely in the longitudinal direction, the cells being quite irregular and often very big, the length sometimes exceeding 110 μ.

P a r a t y p e s. One of the best ones among the other specimens is a fragment (PA 135) probably from a big stem. The annual rings are wide, 1.3—1.5 mm; the middle part of each of them is very thick and remarkably well preserved, even better than the summer wood itself. The specimen resembles the one described above, having the same kind of the ray cells, wood parenchyma, no resin canals, &c. The medullary rays are low, usually from one to six or eight cells high, twelve being the maximum number observed; it is surprising, because in a stem wood, vigorously grown as this, one might have expected higher medullary rays than in a wood like that described above as the holotype. The parenchymatous cells very frequently contain a lump, most certainly of fossilised resin (Pl. VIII, fig. 7).

This specimen contains the same kind of abnormal parenchyma as that mentioned above. It is seen in a radial section, where it may at first be mistaken for a resin duct.

The delicate spirals of the tracheid walls are well observable in many places. They have not been found in the very first spring tracheids, but otherwise they seem to occur in all parts of the annual rings. Bordered pits are usually rather small in relation to the width of the tracheid; they are also found on the tangential walls of the summer wood. The inner opening of the pore canal is often formed as a fusiform split, parallel to the spiral of the wall, and



a b c

Fig. 6. *Piceoxylon laricinoides*, n. sp. Three cross-sections showing the variation in the thickness of the annual rings. a: PA 149, from a twig. b: PA 144, a large piece of a stem. c: PA 143, probably part of a stem. — × 8.

the two splits, in both ends of the same pore, may be seen to cross each other at a right angle, or approximately so (Pl. VIII, fig. 6).

The tracheids are rather curved and twisted. At the ends, particularly when bordering a medullary ray (Pl. IV, fig. 5), they are often swollen, and this gives rise to a peculiarity which is also found in the holotype, although less pronouced; good illustrations of it are found in the other paratypes, too:

These very wide ends of tracheids (*cf.* Pl. VIII, fig. 8) have a very varying appearance, according to the direction of the section. In the radial sections it may be seen how the ends of tracheids curve along the medullary ray. In the tangential section, a portion of such a widened tracheid end may be cut off from the rest of the cell, on account of the curve, and appear as a separate short cell (*cf.* text-fig. 5). In the cross-sections, they are sometimes

visible as very large cells, and, when they are extraordinarily much enlarged, they may disturb the whole regularity of the wood structure (Pl. VIII, fig. 4). In a cross-section of PA 135 there is a cell of this kind (text-fig. 3; Pl. VIII, figs. 2 & 3) measuring no less than about 85 μ across, that is 3—4 times the diameter of the ordinary tracheids in that part of the xylem; it might easily be misinterpreted as a resin duct, but it is surrounded by usual tracheids, not by parenchyma, and, if focusing down, one may see how the neighbouring cells approach each other, closing the opening; the proper wall of the cell itself is also visible.

PA 131 is a small branch fragment. In the cross-section, the annual rings are strikingly uniform, the difference between the spring wood and the summer wood being but slight (Pl. V, fig. 6). In one place, there is a layer of thick-walled parenchyma, extending along the periphery of a year-ring for a distance of very nearly 0.5 mm, the radial thickness being scarcely 75 μ (Pl. V, fig. 7). The cells have some resemblance to those of the abnormal parenchyma mentioned above, although the cells are smaller and not quite so irregular. There are, in a few places, intercellular spaces open between them, and in all probability these openings have to be regarded as traumatic resin canals. This supposition is proved in a radial section of the same specimen (Pl. V, fig. 8); there is a long line of parenchyma, with thick walls abundantly pitted, and between these cells there is a long intercellular space doubtlesly corresponding to a resin duct.

PA 160 is a branch, still imbedded in the basaltic matrix (text-fig. 2). The cross-section shows the same uniformity within the growth-rings, making the zonation rather indistinct. There are no resin ducts of any kind. Widened tracheids occur (text-fig. 4a). The medullary rays are low; there is one in which there are two cells on the same level (text-fig. 4b), but as the whole medullary ray is rather irregular, too much importance should probably not be attributed to it. The parenchymatous cells on the border between the annual rings are long and narrow. Tracheidal cells in the medullary rays occur, but are scarce.

PA 129 is a small sample like No. 131. The widened ends of some tracheids are well visible (Pl. VIII, figs. 8 & 9; text-fig. 5).

A f f i n i t y. All the specimens described above most probably belong to one and the same species, the variations being of slight systematic value. The chief difference between them is found in the composition of the annual rings, some of which are strikingly uniform throughout, and consequently not very distinct, while others, as in the holotype, are well marked.

It is a typical *Cedroxylon,* and there is a very strong resemblance to *C. greenlandicum*, WALT. The resemblance even goes so far as to the presence of traumatic (?) parenchyma. There are some differences: (1) *C. greenlandicum* sometimes has biseriate pits, a feature never observed in our species (with a single exception in PA 160, p. 382); further (2), the former may perhaps have a better developed regular parenchyma. The description reads: "The last elements of the late wood regularly consist of thick-walled parenchyma", while in the species described here, these cells are rather scattered and scarce, never forming any continuous tissue. Finally (3) tracheidal ray cells are not mentioned from *C. greenlandicum.* On account of these characters, and particularly the third one, it is preferable to keep these species apart.

For comparison with other forms it may suffice to refer to the paper by WALTON (1927).

D i a g n o s i s. — *Cedroxylon Orvini,* n. sp. Coniferous wood with annual rings. Tracheids often very much dilated, chiefly when ending against a medullary ray. Bordered pits circular, uniseriate on the radial walls and sometimes on the tangential walls in the summer wood. Medullary rays linear, usually low, chiefly consisting of parenchymatous cells with abietinean pitting and resinous contents; tracheidal cells occur, but are scarce. Wood parenchyma often present at the periphery of the annual ring. Traumatic resin canals occur rarely; besides, there is frequently a development of (traumatic?) parenchyma with exceptionally large cells, irregularly formed and very thick-walled.

Age: Tertiary.

Locality: East Greenland: Myggbukta.

Holotype: PA 152, Paleontological Museum of the University, Oslo.

General Remarks.

The collection comprises samples of stems and branches, while roots have not been identified with certainty. Taken as a whole, the preservation is excellent, and the fossilization must have taken place rapidly and under favourable circumstances.

The annual rings are very well marked. The width is highly varying (*cf.* text-fig. 6); but that is only what may be expected in a collection comprising samples of wood from stems and branches of all dimensions. The average width is rather considerable, but, as far as it can be stated without any statistical proof, it does not seem to be essentially different from that of coniferous wood from, *e. g.,* the northern temperate zone of to-day.

By far the major part of the specimens belong to two species only, and it is uncertain if there is a third one at all. Both species are conifers, belonging to the genera *Piceoxylon* and *Cedroxylon.*

These two genera have been recorded already from the Cretaceous, but they are much more common in the Tertiary. Although regarded as new, the two species in question show a close resemblace to other ones previously established, namely, respectively, to *P. laricinum*, KRÄUSEL, and *C. greenlandicum*, WALT., both of a Tertiary age, a fact giving support to the supposition that the occurrence at Myggbukta dates from the Tertiary. But as both of the new species are of a very modern type, they do not give any clue for the fixing of the upper time limit.

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Explanation of the Plates.

The photographs are not retouched, except Pl. III fig. 3a and Pl. IV fig. 6.

Pl. I.

Piceoxylon laricinoides, n. sp. Holotype, PA 159.

Fig. 1. Cross-section of the stem. — × 10.
„ 2. Cross-section of the branch. — × 10.
„ 3. As fig. 2. — × 40.
„ 4. Tangential section of the stem, with biseriate medullary rays. — × 100.
„ 5. Tangential section of the branch. The medullary rays are shorter than in the stem wood. As in fig. 4, no resiniferous medullary rays are visible in the photograph, but one of them is biseriate. — × 100.
„ 6. A medullary ray in a radial section of the stem. Parenchymatous cells with pores of the abietinean type; one series of tracheidal cells with bordered pits. — × 400.
„ 7. As fig. 6. — × 200.
„ 8. Radial section of the stem, showing xylem parenchyma between the summer wood (right) and the next year's spring wood. — × 100.
„ 9. As fig. 8. — × 200.

Pl. II.

Piceoxylon laricinoides, n. sp.

Fig. 1. Holotype (PA 159). Stem wood. Double series of bordered pits on the radial wall of a spring tracheid, with rims of Sanio. — × 200.
„ 2. The same. Bordered pits in a tangential section. — × 400.
„ 3. PA 165. Radial section. — × 40.
„ 4. Detail of fig. 3, showing more distinctly the thickenings of the tracheids. — × 200.
„ 5. Holotype (PA 159). Tangential section of the stem. A multiseriate medullary ray with a resin canal, showing the thick-walled epithelial lining. Of the other medullary rays, one is biseriate. — × 100.
„ 6. PA 165. A medullary ray in a radial section. In the parenchymatous cells, the abietinean pitting is visible. Besides, note the circular markings in the wall (*cf.* p. 368). There are two

rows of tracheidal cells. In the upper left corner, there are bordered pits in the horizontal wall of the upper one; they have not been exactly in focus. — × 350.

Fig. 7. PA 143. Radial section along a resin canal. In the centre of the figure is seen a long, thick-walled cell, showing very distinctly its "abietinean" pitting; the next cell above it has been cut more superficially, and the pits appear as circular markings. On the right-hand side are shorter cells (best visible in the lower corner), forming the thick-walled lining of the resin duct. To the left, a medullary ray. — × 350.

„ 8. PA 165. Tangential section, showing a medullary ray. In the centre, a vertical wall with numerous pits. — × 350.

„ 9. PA 147. Radial section, with a medullary ray, near the border of an annual ring; the surface of the stem has been to the left. In the centre, three rows of parenchymatous cells; above and below them one series of tracheidal cells, with tangential walls inclined towards the periphery of the stem. In the summer wood, the tracheidal cells are much shorter than in the spring wood, and prolonged in the vertical direction. Some of the bordered pits of these cells are visible. — × 200.

„ 10. Holotype (PA 159). Cross-section from the branch, with a resin canal in the outer part of the summer wood. — × 100.

„ 11. PA 144. Cross-section, with a resin canal in the summer wood, between two medullary rays. Note the pits in the thick-walled cell to the right. *Cf.* fig. 7. — × 200.

Pl. III.

Piceoxylon laricinoides, n. sp. PA 146.

Fig. 1. Oblique cross-section with pith. — × 10.

„ 2. Detail of fig. 1. — × 40.

„ 3. Detail of fig. 1, from the other half of the pith (the upper half in fig 1). Bundles of protoxylem, as marked in fig. 3a. Some of the thick-walled cells of the pith are isolated and circular in outline, other ones are angular and closely connected. — × 100.

„ 4. Detail of fig. 2, showing a strand of annular tracheids in a leaf-trace. — × 200.

„ 5. Another section, cutting the pith in an oblique direction. The sclerotic cells angular, with thick, pitted walls and no intercellular spaces. Protoxylem with annular thickenings indistinctly visible, particularly to the left of the pith. To the right, in the upper half of the figure, there is a leaf-trace. — × 40.

„ 6. Detail of fig. 5. — × 200.

„ 7. The leaf-trace of fig. 5. — × 200.

Pl. IV.

Fig. 1. *Piceoxylon laricinoides*, n. sp. PA 146. Longitudinal section showing fragments of the cortex (left) in connection with the xylem. — × 10.
„ 2. Detail of fig. 1. — × 100.
„ 3. The same specimen. Cross-section of the cortex, showing the curved and pressed zones of sclerotic cells. — × 10.
„ 4. Detail of fig. 3. — × 100.
„ 5. *Cedroxylon Orvini*, n. sp. PA 135. Radial section. Tracheids ending against a medullary ray consisting of a single cell. Bordered pits small and isolated. — × 300.
„ 6. *P. laricinoides*, n. sp. PA 153. Tangential section. The darker parts in the centre and to the left are summer wood, with spring wood to the right — *xp*: Rows of xylem parenchyma; note the tapering ends. — × 40.
„ 7. The same preparation. To the left: Summer wood with parenchyma. To the right: Spring wood; bordered pits, cut across, are indistinctly seen in the radial walls. — × 100.

Pl. V.

Fig. 1. *Cf. Piceoxylon laricinoides*, n. sp. PA 137. Radial section, showing the resiniferous cells of the medullary rays. — × 100.
„ 2. The same. Cross-section. — × 40.
„ 3. The same. Tangential section. In the upper left corner a medullary ray with a resin canal. To the right some irregular parenchyma from a longitudinal section of a resin canal. — × 100.
„ 4. The same. Tangential section. A medullary ray; two of the cells have thick, dark walls with pores. — × 400.
„ 5. The same. Radial section. Tracheids curving along a medullary ray. — × 100.
„ 6. *Cedroxylon Orvini*, n. sp. PA 131. Cross-section, showing the comparatively slight difference between the various parts of the annual ring in this specimen. — × 40.
„ 7. The same section. Group of parenchyma at the end of an annual ring; intercellular spaces representing traumatic resin ducts. — × 200.
„ 8. The same specimen, in radial section. Traumatic resin canal. — × 200.

Pl. VI.

Cedroxylon Orvini, n. sp. Holotype, PA 152.

Fig. 1. Cross-section. — × 10.
„ 2. Medullary ray in a radial section, showing the abietinean pitting. Note the dark contents abundant in the parenchymatous cells in

this section and in figs. 3 and 5. In the lower right corner some bordered pits. — × 200.

Fig. 3. Tangential section, with xylem parenchyma. Tracheids with secondary spiral striation. — × 200.

„ 4. Abnormal parenchyma at the end of an annual ring, in cross-section. — × 40.

„ 5. Tangential section. — × 100.

Pl. VII.

Cross-sections of *Cedroxylon Orvini*, n. sp. Holotype, PA 152.

Fig. 1. Abnormal parenchyma, developed from a medullary ray in the outer part of the spring wood. — × 200.

„ 2. Detail of Pl. VI fig. 4. — × 200.

„ 3. An abnormal parenchymatous cell in the middle of an annual ring, without any connection with the medullary rays. — × 100.

„ 4. An exceptionally wide cell, probably a dilated spring tracheid. — × 200.

„ 5. Abnormal parenchyma, forming a bridge from one medullary ray to another, in the spring wood. — × 200.

„ 6. Medullary rays, starting from the periphery of the summer wood with abnormally wide cells, which are very thick-walled. — × 200.

„ 7. A normal cell of xylem parenchyma, on the limit between two annual rings. — × 200.

Pl. VIII.

Cedroxylon Orvini, n. sp.

Fig. 1. Cross-section of PA 135. Note the wide middle part of the annual ring, scarcely compressed at all. — × 10.

„ 2. From the same section. A very wide cell, most probably the dilated end of a tracheid. — × 200.

„ 3. The same structure as in fig. 2, but focused down to show the surrounding cells closing the opening, *cf.* text-fig. 3. — × 200.

„ 4. As fig. 2. — × 100.

„ 5. Tangential section of PA 135. The curved and undulating shape of the tracheids is characteristic. — × 100.

„ 6. The same in radial section, to show the distribution and shape of the bordered pits. — × 200.

„ 7. The same, with a medullary ray. The darker parts to the right are the summer wood, with short parenchymatous cells in the medullary ray. Note the lump of resin in most of the cells. — × 200.

„ 8. Radial section of PA 129, with the dilated end of a tracheid. — × 200.

„ 9. From the same section. — × 100.

Printed October 1931.

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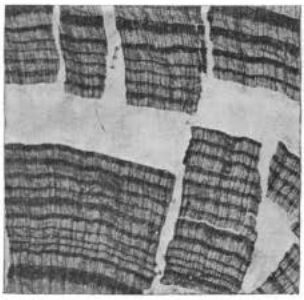

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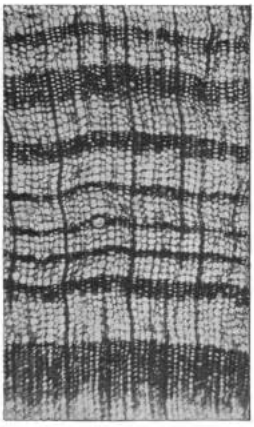

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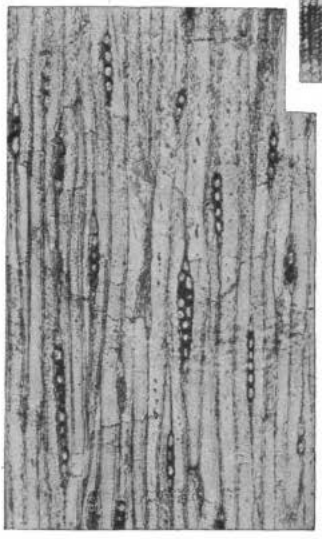

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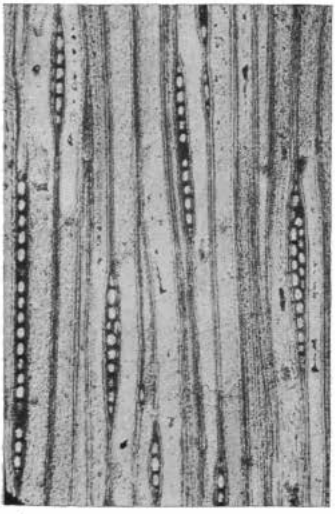

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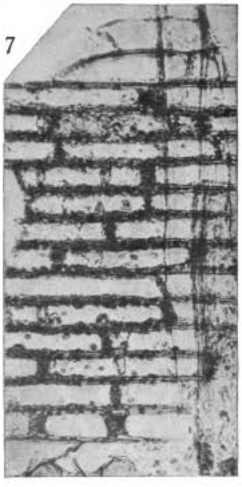

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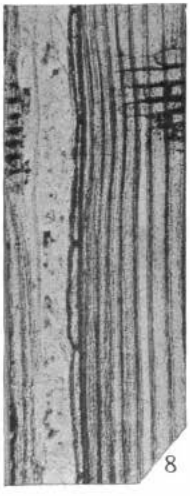

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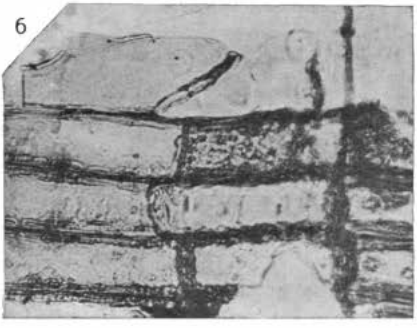

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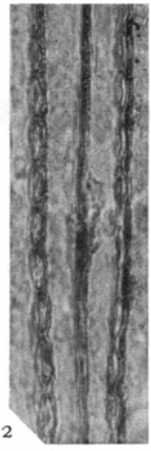
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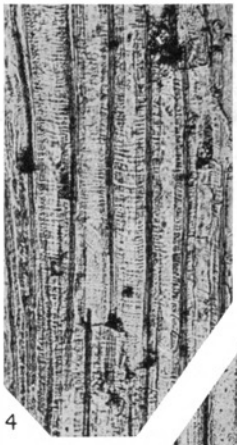
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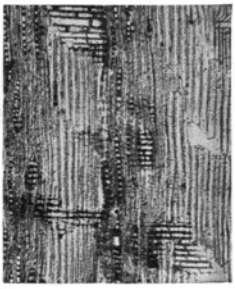
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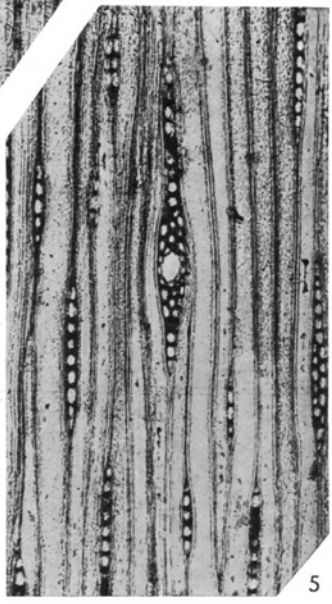
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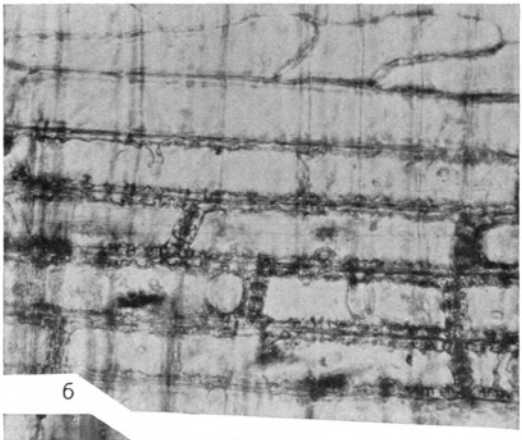
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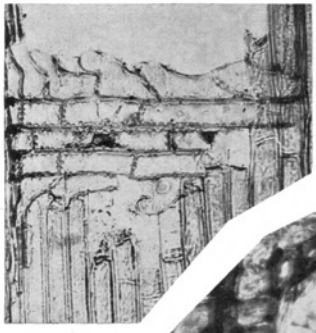
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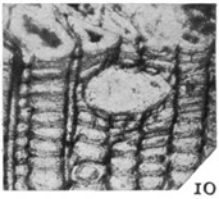
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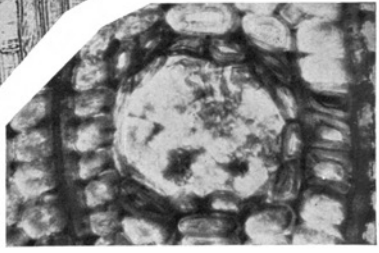
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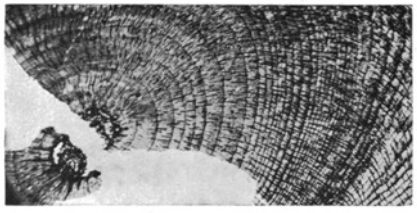

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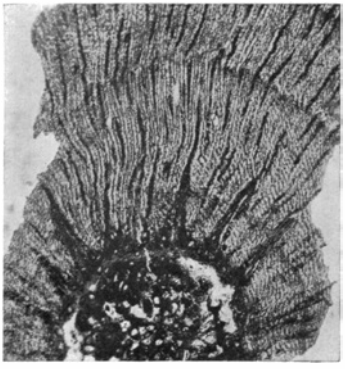

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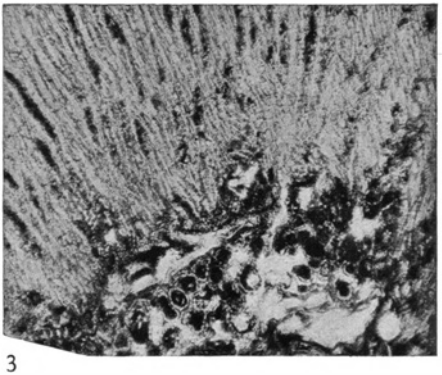

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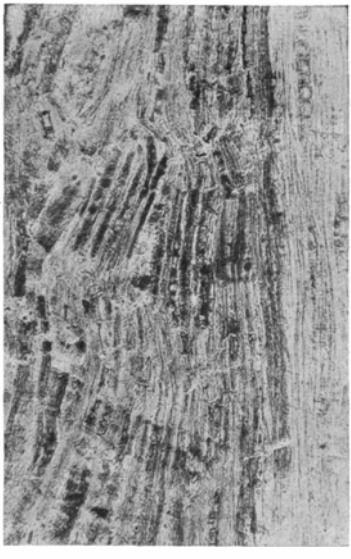

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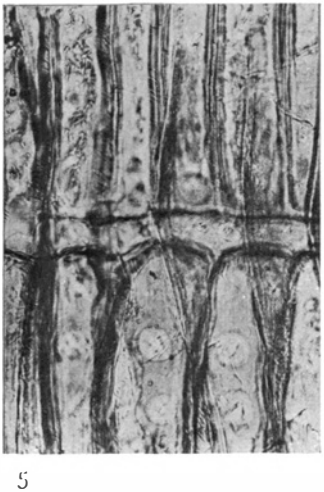

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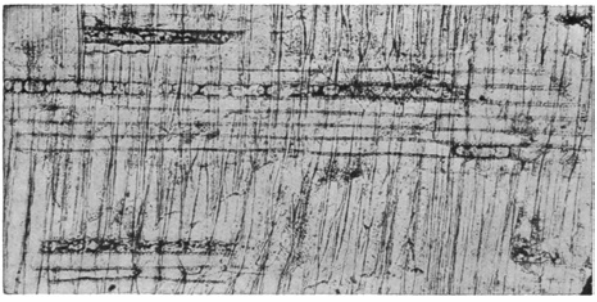
Ove Arbo Høeg



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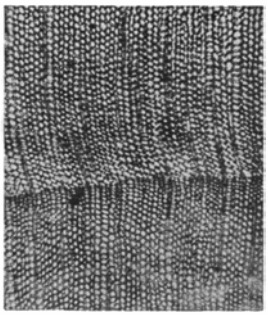

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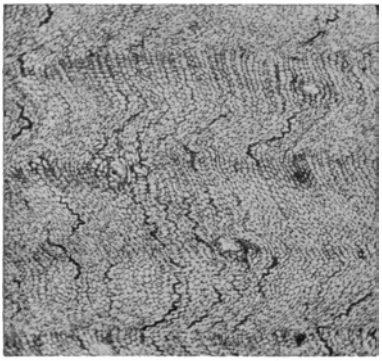

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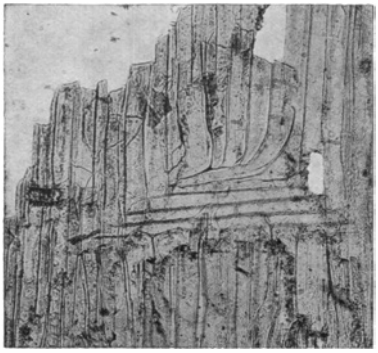

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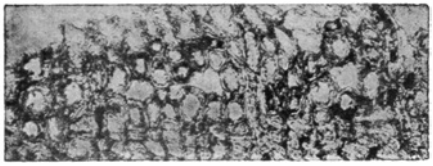

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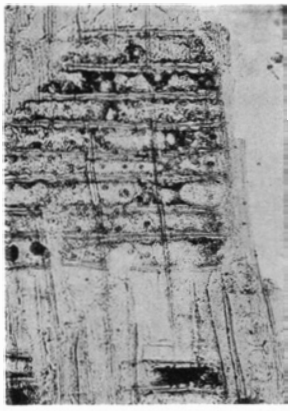
Ove Arbo Høeg



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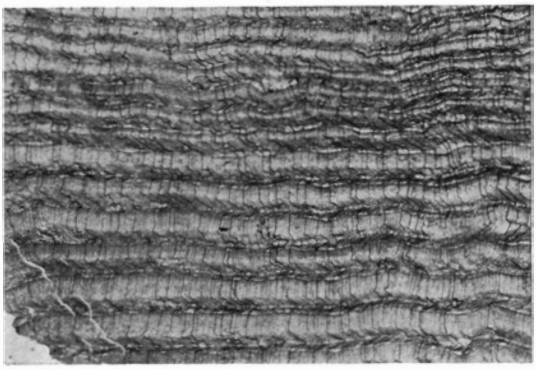

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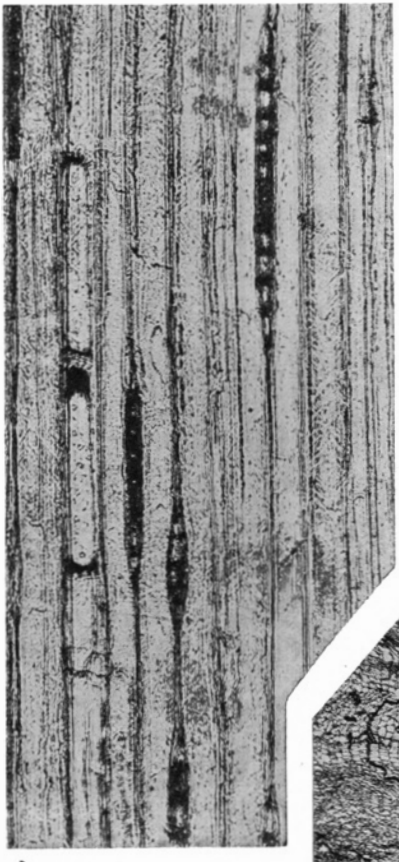

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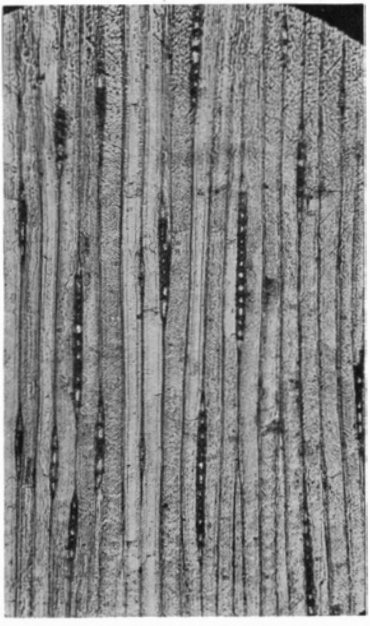

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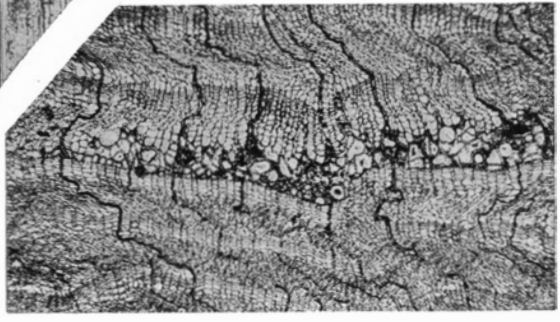

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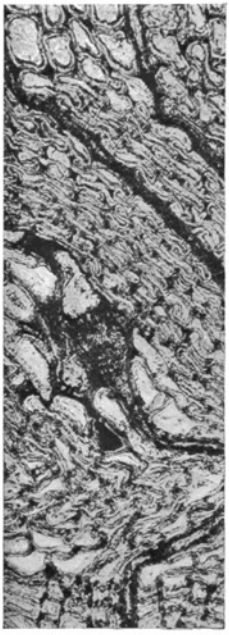

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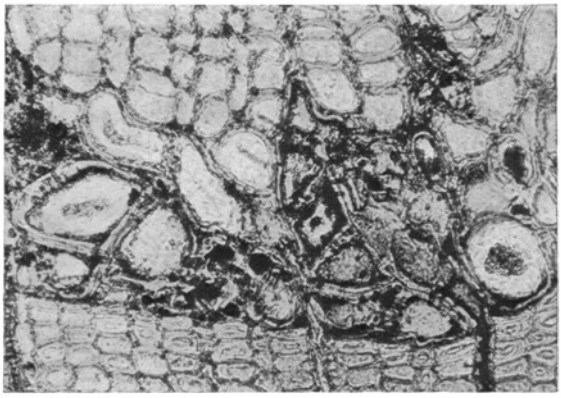

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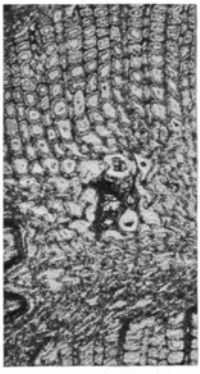

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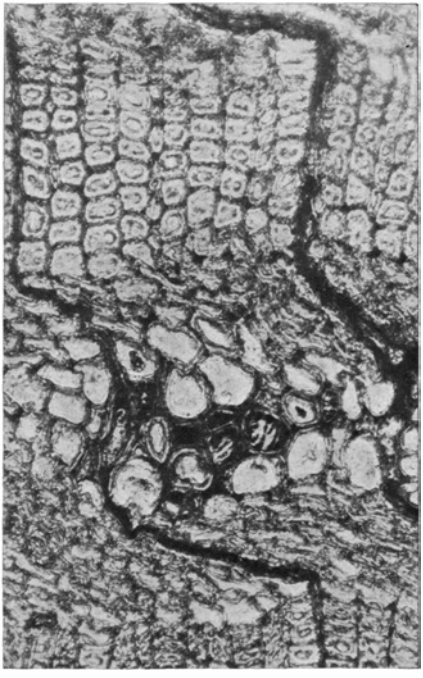

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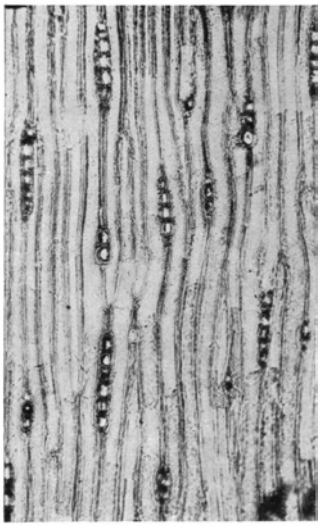

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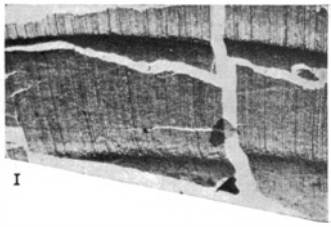

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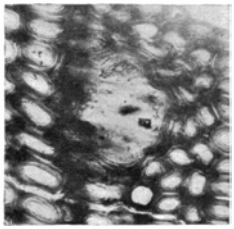

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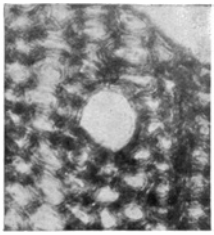

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