SUZUKI — CRETACEOUS FOSSILS.
On the Structure and Affinities of Two New Conifers and A New Fungus from the Upper Cretaceous of Hokkaidō (Yezo).

By

Y. Suzuki.

Material and Preparation of Sections.

The study of the fossil plants, whose structure and affinities are given in the following pages is based on a part of the materials collected by Professor Fuji in 1906 in Hokkaidō (Yezo), a northern island of Japan. The fossils were contained in the fragments of nodules from the Upper Cretaceous.

The sections were made in the Botanical Institute, College of Science, Imperial University of Tokyo, by the petrotome specially erected in 1907, and the grinding was done with carborundum powder on a rotatory grinding-disc, 45 cm. in diameter, which was set up in 1909.

Description of Plants and their Affinities.

Abiocaulis yezoensis.

(Photos 7 and 2, Plate VII).

This specimen is one of the fossils which were contained in a fragment of a nodule from Ikushumbets, Hokkaidō. It was a piece of a longitudinal half of a stem which was 9.5 cm. long and 3 cm. in diameter.

Cortex. In the preserved outermost part of the cortex, there are 3–4 zones of periderms developed. These zones are pressed closely one another, leaving here and there the primary tissues of the cortex between them. These intervening cortical tissues consist of mostly stone cells and few parenchymatous cells.
Each periderm consists of the outer cork layers of many thin walled cells and the inner phelloderm of one—several layers of thick walled cells, among which stone cells are found.

In the middle part of the cortex, there are two kinds of parenchymatous cells, the larger and the smaller (Phot. 1, Pl. VII). The smaller are filled up with dark brown contents, while the larger appear to have no contents. The latter are interpreted to be pecto-cellulosic mucilage cells* like those characteristic to the cortex of Abies and Pseudolarix (Prantl 10). This interpretation is based on the comparison with the similar cells of the two genera in form and size of the cells and their topographical distribution in the cortex, as well as the state of preservation of the contents in dead twigs.

Besides these two kinds of parenchymatous cells, there are many large stone cells irregularly scattered and frequently found in groups in this region. These groups of stone cells form complicately entangled nests. The stone cells are roundish, elliptical, wound, branched or of indescribably irregular forms familiar to Abietinaceae (Moeller 8, Prantl 10).

There are comparatively large resin-reservoirs which extend irregularly and end blindly within the cortex. The number of their epithelial cell-layers is at least 3, more generally 5–7.

In the secondary phloem, the nests of stone cells are more largely developed than those in the outer region. They are elongated vertically and are somewhat regularly fusiform.

Besides these nests there are also vertically elongated thin walled elements mixed with parenchymatous cells and stone cells. Some of these elongated elements have the indication of a single row of roundish sieve-fields on the walls. They probably represent sieve-tubes. There is another kind of thin walled elements, slightly wider than the sieve-tubes, and they are clearly crystal tubes, each of them containing 1 or 2 rows of minute rhomboidal crystals (Phot. 2, Pl. VII). These crystals

* The general contents of characteristic mucilage cells of Abies and Pseudolarix stain red with ruthenium-red, and blue with methylene-blue (pectin-reactions); and they stain red with congo-red and turn blue with iodine and sulphuric acid (cellulose-reactions.)
are enclosed in the dark brown contents within the tubes. These contents suggest the slime which once filled the tubes. The appearance of the crystal tubes is just like that of Abietinaceae (Prantl 10) where the monoclinic crystals of calcium oxalate are imbedded in slime within the tubes. Optical as well as chemical tests have been tried with these crystals, but I am not yet in a position to decide whether they are calcium oxalate as in living Abietinaceae. Their further study is left for future.

Unfortunately, the region of the cambium and its adjacent part of the phloem is not preserved and is filled with the deposit of iron pyrites.

Wood. The wood has about 16 annual rings which indicate very irregular zones of development. We see only 2 normal resin canals in the second annual ring formed by a fascicular cambium, whose activity of forming secondary wood in the first year was very slight; we do not find any other resin canals in the transverse as well as longitudinal sections except several traumatic resin canals tangentially arranged in an outer annual ring in a transverse section.

The tracheids of spring wood are, as seen in transverse section, thin walled and angular, but the tracheids of autumn wood are thick walled and roundish.

The tracheids show bordered pits on the radial walls, but in the thick walled tracheids of autumn wood, we see sometimes simple pits sparsely arranged. These simple pits are roundish, elliptical, lenticular or slit-like, and some autumnal tracheids seem to have no pits at all.

The bordered pits are mostly arranged in a single row and rarely in double rows on the wider tracheids of the spring wood. In the latter case, they are generally opposite. The orifice of bordered pit is roundish.

The medullary rays are generally one cell broad and 1—2 cells in height, though even 18 cells high medullary rays may occur.

The walls of ray cells are thin and smooth, and are pitted simply in the radial, tangential and horizontal walls, and they present no serration like those in Pinus. The pits on the radial walls adjoining to the broad tracheids are generally
large and roundish, oval or elliptical, and are found 1 or 2 for each tracheid. These large pits remind us of those of Pinus (Penhallow 9). In the place adjoining to the thick walled tracheids, the pits are small and elliptical or lenticular. The pits of horizontal and tangential walls are small and roundish or elliptical like those of Abies or "Abietineen-Tüpfelung" (Gothan 1).

In short, the medullary rays have the mixed characters of those in Abies and Pinus, though there are no ray-tracheids.

The wood-parenchyma is very sparsely distributed among the tracheids. It consists of vertical rows of thin walled elongated cells. They have dark brown contents. The distribution, appearance and contents of these cells suggest resin containing cells.

The protoxylems are not preserved in the main stem, but they can be recognised in a branch just separating from the stem in the longitudinal section. They are not so well preserved as to determine the nature of thickenings on the wall. The wood is endarch.

The pith in the main axis is not preserved at all, but we can see it in the basal portion of a branch imbedded in the main axis. In this region there is an indication of the differentiation of a transversal tissue plate consisting of shorter cells characteristic to Abies.

Affinities. The above described characters of the stem namely the absence of normal resin canals in the wood in general, the occurrence of traumatic resin canals, the tracheids usually with one row of bordered pits, sometimes with double rows and then arranged opposite to each other, the medullary ray cells without serration on their walls, clearly locate this specimen among Abietae of Jeffrey (4). Of living Coniferæ, those which possess the mucilage cells in the cortex are limited to only two genera, Abies and Pseudolarix (Prantl 10). The former has resin reservoirs in the cortical region of the stem, while the latter, none in the same region.

Thus Abies it is the genus with which we are to associate the fossil. But in having the resin canals in the second annual
ring and the large roundish pits on the lateral walls of ray cells, this fossil specimen differs from *Abies*, where normal resin canals may appear in the first annual ring only (Jeffrey 4). Unfortunately, as the pith of the fossil stem is very poorly preserved, we can not know whether the fossil has the sclerotic diaphragms in the pith characteristic to *Abies*. Moreover, we are entirely ignorant of the leaves and fructifications, so that we cannot make any further attempt than associating this fossil with *Abies*.

Thus I have named this fossil *Abiocaulis yezoensis* from the name of the locality Hokkaidō (Yezo).

*Diagnosis*:

*Abiocaulis yezoensis* gen. et sp. nov.

Primary cortex with many large stone cells, large resin reservoirs and mucilage cells like those of *Abies*. Periderm development in the primary cortex. Secondary wood, without normal resin canals except in the second annual ring, with traumatic resin canals and few resin cells. Tracheids with usually a single row of bordered pits, sometimes double rows and then opposite. Medullary rays, generally one cell broad, 1–12 cells in height. Ray cells without serration on their walls, the pitting of ray cells like that of *Abies*, and also large and roundish like that of *Pinus*. Wood endarch.

*Locality:*—Upper Cretaceous, Hokkaidō, Japan.

**Cryptomeriopsis** *mesozoica*.

(Text-figure 1. Photos 3—5, Plate VII.)

Of this plant (Text-fig. 1), we have a few pieces of the axes (the largest, 8 mm. in diameter) and a few leafy twigs (the smallest, ca 1 mm. in diameter). All these are found separately in the fragments of nodules from Yūbari and Ikushumbets, Hokkaidō; but they seem to belong to the same species, though there are some histological differences due to various stages of development among them.

*Stopes and Fujii 11.*
Pith. Pith consists of parenchymatous thin walled cells and roundish stone cells. In the pith of the younger twig, small intercellular spaces are found; but in that of the larger axis, the cells are packed closely and leave no intercellular spaces. We see frequently fungal hyphae in the parenchymatous cells. The structure of the pith closely resembles that of Cryptomeriopsis antiqua (Stoppes and Fujii 11).

Protoxylem. The elements of the protoxylem have spiral thickenings and are placed innermost to the primary xylem in a number of groups, so that the wood is endarch.

Secondary Wood. In this portion, the absence of resin canals is one of the characteristics. The annual rings are not always to be made out distinctly. It is due to the two conditions, firstly that the development of the autumn wood is not enough pronounced, secondly that the development of the "Rotholz" elements (Hartig 2) begins in spring often immediately as the continuation of the autumn wood of the preceding year and gradually passes into the summer wood. There are two kinds of tracheids namely thin walled and thick walled ones. In transverse section the former are angular, forming lighter coloured normal spring and summer wood, and the latter are roundish, forming chiefly the "Rotholz." On the radial walls,

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Text-fig. 1.—Cryptomeriopsis mesozoica, sp. nov. Longitudinal section of a leafy twig. p, pith; x, ph, xylem and phloem of the axis; st, stone cell; v, vascular strand of the leaf; tt, transfusion tissue; RC, central large resin canal; re, lateral small resin canal; f, fructification of fungus (Pleosporites gen. nov.). x 10.
the tracheids show usually one-rowed, roundish bordered pits, but sometimes in the thick walled tracheids inclined simple ones are found.

The medullary rays are one cell broad and 1–7 cells in height, but generally 1–4 cells. The walls of the ray cells are thin and smooth. In radial section, the pit of the ray cell seems to be narrowly bordered along its slit-like lenticular orifice and its long axis inclines to the horizontal wall. There appear one or two, rarely three of these pits per tracheid.

The wood-parenchyma is sparingly distributed in the normal wood. No traumatic resin canals appear in any relation to wound-callus, but the formation of resin cells is seen in the region of wounds. In this point the fossil differs from Abietee of Jeffrey (4), Sequoia gigantea and fossil Brachyphyllum (Hollick and Jeffrey 3, Jeffrey 5) and rather resembles plants of Cupressinæ and Taxodiæ (except S. gigantea).

The cambium is well preserved in its normal position.

Secondary Phloem. Bast-fibres are arranged in a single continuous layer interrupted only by the medullary rays (Phot. 4 and 5, Pl. VII), and many of such layers are repeated in alternate zones with parenchymatous tissue just as in Taxodiæ and Cupressinæ, though in the younger leafy twig, they are not so regularly arranged. These parenchymatous zones consist of only two layers of thin walled elements of equal diameters which are regarded as the sieve-tubes (Phot. 5, Pl. VII).

Thus in this fossil no phloem-parenchyma is found. I am unaware of such a phloem structure anywhere else among living and known fossil conifers.

Cortex. In the secondary phloem of the fossil, there are many large lysigenous lumens (Phot. 4, Pl. VII). These lumens are generally arranged in tangential rows in transverse sections (Phot. 4, Pl. VII). Sometimes the tissues between these lumens are collapsed or destroyed, and these lumens are then tangentially continuous. Outside this region, roundish stone cells occur here and there, and schizogenous resin canals are found in this portion, but the epithelial layers are not so well preserved
to be made out distinctly. The preservation of the parenchymatous cells of the primary cortex is not good.

**Periderm.** Three distinct periderms are preserved in the axis of the largest diameter which is 3 years old. Each periderm consists of the outer many cork-cell layers and inner 2 or 3 thick walled phelloderm-cell layers. The different periderms show more or less differences in their developmental stages and frequently stone cells occur in the phelloderm of the outermost periderm (Phot. 4, Pl. VII). The innermost periderm is developed in the secondary phloem. In the younger twig, we see only one peridermal development in the cortical region. Thus, the development of the periderms and the bark formation resemble most those of *Taxodiaceae* and *Cupressinaceae*.

The leaf-trace is a single strand as in *Cryptomeriopsis antiqua* (Stokes and Fujii 11), *Cryptomeria* and many other conifers.

**Leaves.** The leaves are of *Cryptomerian* type in general appearance and arrangement (Text-fig. 1) and decurrent with broad base, and enclosing ⅓ or ⅓ around the axis (Phot. 3, Pl. VII). The transverse section of the leaf is like *Cryptomeriopsis antiqua*, generally of a rhomboidal shape, somewhat laterally extended. The height and breadth may differ, however, in different leaves, as it is the case with *Cryptomeria* in which we see a kind of seasonal dimorphism of leaves.

**Epidermis** and **stomates.** The epidermal cells and stomates are usually not well preserved. One longitudinal section through a leaf show them rather well. They seem to be of the normal gymnospermous type. The stomates are distributed on the lower surface, namely on the outer surface, while they seem to be absent on the upper surface, namely on the inner surface.

**Hypoderma.** The sclerenchymatic hypoderma of the leaf is developed in the lower side only, that is, in the outer side of the leaf. It is generally of a single row of cells, except towards the median longitudinal line of the leaf where even 6 layers of hypodermic sclerized cells may be found. The sclerenchyma is interrupted by the stomates.

**Palisade Tissue.** There is well differentiated palisade tissue under the hypoderma. The inner ground tissue consists of
roundish parenchymatous cells. Sometimes we see a few stone cells among the parenchymatous cells in the older leaves. The stone cells of the leaves as well as of the cortex are roundish and similar to those in the pith. In the present specimen they appear solitarily here and there in the parenchyma, and sometimes two or three of them group together.

The stone cells of the leaves, show lighter colour than those of the cortex. All this palisade tissue and other parenchymatous cells are traversed by fungal hyphae. Frequently we met with fructifications of the fungus described below, forming large roundish pouches generally under the stomates in the mesophyll.

Resin Canals. When they are regularly arranged, we see one central and the two lateral accessory ones, but frequently their size, number and arrangement in the leaves seem rather irregular, namely 1, 2, 3 or 4 resin canals are found, but generally the central ones are the largest and longest, and lie beneath the single vascular strand, whose wings of transfusion tissue sometimes curve to enclose them partly. The epithelial layer of the resin canals seem always one cell thick.

Vascular Bundle. A single strand runs through the leaf a little above the central portion; but unfortunately, in the specimens at hand, the bundles are generally crushed. The large quantity of transfusion tissue is always found on both sides of the vascular bundle as in Cryptomeriopsis antiqua.

The decurrent bases of leaves without any constriction show that the leaves themselves were not shed, as it is also the case with Cryptomeria. This is also borne by the fact, that we see the leaves still attached to the axis with two annual rings.

Affinities. The single vascular bundle of the leaf without a bundle sheath, the one-rowed separate bordered pits in the tracheids, the occurrence of one central large resin canal and two accessory lateral resin canals of the leaf, the large amount of transfusion tissue, and general habit of the leaf, together with the absence of normal resin canals and the lack of traumatic resin canals in injured wood, the inclined long axis of the orifice of bordered pits of ray cells, smaller parenchymatous cells and the larger stone cells of pith, the breadth and
height of the medullary rays etc, associate this plant clearly with members of *Cryptomeriopsis*. But the lack of hypoderma and stomates in the upper side of the leaf, the different shape of the leaf, and the many-layered hypodermic development along the median line of the leaf in its lower side immediately separate this plant from *Cryptomeriopsis antiqua*.

Other points which distinguish this fossil are the presence of stone cells* in the mesophyll and cortex, and of bast-fibres in the secondary phloem, and the variability of the number and arrangement of resin canals, these features being absent in *Cryptomeriopsis antiqua*. But I believe, so far as bast-fibres are concerned, the difference is due to the developmental stages. For I have frequently experienced that, there was no bast-fibres in the phloem of young axes of Cryptomeria, in which the secondary growth has already began, while in older axes they are invariably present. Also in conifers the variability of the number and arrangement of resin canals is not seldom found in the leaves of twigs of the different vigor of growth.

In the authentic description concerning the sclerised cells of *Cryptomeriopsis antiqua*, it is stated as follows: "In the fossil one or two cells were observed which might have been thick walled but they were of a doubtful nature." These cells of doubtful nature were probably just about to be sclerised.

The lack of the sclerenchymatic hypoderma in the upper sides of leaves of all these specimens cannot be looked on as due to the younger stages in development of the shoot, when compared with *Cryptomeriopsis antiqua*. For the development of bast-fibres in the present plant indicates that this is older than the authentic specimens of *Cryptomeriopsis antiqua*, where the development of bast-fibres in these regions seems to have not yet or just begun; moreover we have a leafy twig with two annual rings (older than the authentic specimens of *Cryptomeriopsis antiqua* which are one year old), having the leaves of the same structure described above.

*In some of the specimens the development of stone cells is very meagre while in the other, they are well developed; and this difference seems not to be that of the developmental stages. So it is not unlikely that a further investigation will show that they belong to two distinct species.*
As an instance where the difference in the development of hypoderma was considered as an important point of anatomical distinction between the leaves of the two species the case of *Tsuga Sieboldii* and *Tsuga diversifolia* may be mentioned. In the former the upper hypoderma is sparingly developed or greatly interrupted, while in the latter it is continuous (Mayr 7).

Thus the present plant seems to be well qualified to be separated from *Cryptomeriopsis antiqua* Stopes et Fujii.

I named this species *Cryptomeriopsis mesozoica*, from the geological era in which it existed.

**Diagnosis:**

*Cryptomeriopsis mesozoica* sp. nov.

General aspect of the leafy twig like *Cryptomeria*, leaves rhomboidal in transverse section, with a single endarch vascular bundle without bundle sheath, development of transfusion tissue in the leaf much greater than in *Cryptomeria*; mesophyll, cortex and pith with stone cells; stomates and sclerenchymatous hypoderma absent in the upper side of the leaf, hypoderma in the under side of the leaf either entirely a single layer of cells, or 2–6 layers of cells on the median portion of the leaf; secondary phloem, when its tissues are regularly arranged, consisting of alternate zones of single layer of bast-fibres and double layers of sieve-tubes without inter- 

**Locality:**—Upper Cretaceous, Hokkaidō, Japan.

**Pleosporites Shirainus.**

(Text-figs. 2 and 3. Photo 6, Plate VII).

It has been stated before that all soft tissues of the leaves and axes of *Cryptomeriopsis mesozoica* were infected with fungal hyphae, and that a kind of fructifications was found in the leaves (Phot. 6, Pl. VII).
Hyphae. These fungal hyphae are very well preserved and measure 2–5 µ in diameter. They are thin walled, look yellowish brown and are septate; the transversal septae are clearly seen everywhere.

Fructifications. As described before, they are represented by a number of pouches developed under the hypoderma of the leaves of Cryptomeriopsis. These pouches are spherical or flask-shaped. They are sometimes situated deeper in the tissue of mesophyll. The superficial one is usually furnished with an orifice, while the deeper-seated one is mostly destitute of it (Phot. 6, Pl. VII). The former represents a median or nearly median section through the orifice, and the latter, a section through the body part, escaping the orifice. The diameter
of the spherical body parts varies from 50–180 μ. The wall of the fructification is made up of thin walled plectenchyma (Text-fig. 2 and Phot. 6, Pl. VII), and is usually 5–7 cells thick, although they can be much thicker or thinner. The orifice of the spherical or flask-shaped fructification is not much prolonged or protruded like a beak, thus the neck of the fructification is short, and plectenchymatous tissue of the orifice is often found underlining the guard cells of the stomates.

No stroma is developed in connection with the fructifications. In one case a few club-shaped transparent bodies are seen standing from the bottom of the hollow short necked flask (Text-fig. 3). They are naturally seen as the remains of some of the asci, and the fructification as the perithecium. Besides asci, there are a number of thinner bodies seen standing with them. They are interpreted for the present as paraphyses. Unfortunately neither spores nor any further structure of asci can be seen.

The spores had been discharged before the asci became fossilized or they might have not yet been fully developed, as the asci were still young.

Affinities. The growing mycel in the parenchyma of the host, the well developed septate hyphae, and the formation of the perithecium locate the fungus among Ascomycetes. The perithecium imbedded in the mesophyll and opening outside by an orifice, the spherical or short necked flask-like form of the perithecium indicate the association of this fungus with Sphaeriales
(Lindau 6) among Pyrenomycetineae. The perithecium sunk in mesophyll, the lack of stroma formation, the presence of an orifice of perithecium, and its short neck, the perithecium wall consisting of thin walled plectenchymatous cells, the presence of paraphyses point to the association of the present fossil fungus with Pleosporiaceae (Lindau 6), hence the generic name. The lack of spores makes it impossible to refer to any known genus.

I am much indebted to Professor Shirai of the College of Agriculture, Imperial University of Tokyo, who has been recently investigating the fungi infecting Cryptomeria japonica and whose opinions on this fossil fungus gave a great help to the study of this fossil.

The specific name was given in honour of Professor Shirai-

Diagnosis :—

Pleosporites Shirainus gen. et sp. nov.

Hyphae well developed, septate, 2–5 µ in diameter. Perithecium, formed under the hypoderma of the leaves of the host, well defined, spherical or somewhat flask-shaped, with an orifice, short necked, thick walled, the wall consisting of 5–7 or more irregular layers of thin walled plectenchyma cells. Asci formed at the bottom of perithecium, without development of stroma; paraphyses present.

Host :—The shoot of Cryptomeriopsis.

Locality :—Upper Cretaceous, Hokkaidō, Japan.

On concluding this paper, I wish to offer my sincere thanks to Professor Fujii for his kind advice and criticism throughout the work, and for the materials which he has generously put at my disposal.
LITERATURE CITED.

EXPLANATION OF PLATE VII.

Photos 1 and 2.—Abiocaulis yezoensis gen. et sp. nov.
1.—Transverse section through the middle part of cortex. ×105.
me, mucilage cell.
st, stone cell.
2.—Longitudinal section through part of the secondary phloem,
showing crystal tubes. ×105.
cr, crystal.
pp, phloem-parenchyma.
Photos 3–5. Cryptomeriopsis mesozoica sp. nov.
3.—Transverse section of a leafy twigs showing 2 annual rings
×14.
l, leaf.
l1, leaf attached to the axis.
4.—Transverse section through the outer part of an axis. ×70.
l2, lysigenous lumen.
ps, periderm.
ph, secondary phloem.
x, secondary xylem.
5.—Transverse section through part of the secondary phloem and
xylem, showing the arrangement of bast-fibres and sieve
tubes. ×155.
b1, bast-fibre.
mr, medullary ray.
ph, secondary phloem.
sv, sieve-tubes.
x, secondary xylem.
    Photo 6.—Pleosporites Shirainus gen. et sp. nov.
6.—Transverse section through part of a leaf of the host, showing
fructifications of the fungus. ×200.
cp, epidermis of the leaf.
mp, mesophyll.
p1, perithecium cut longitudinally through the neck and
orifice.
p2, perithecium cut through the body part.
p3, perithecium cut tangentially.