CHAPTER 3 COMPARATIVE ANATOMY OF BARK ON BRANCHES AND RAMETS OF COMMON DICOTYLEDONOUS TREES AND WOODY SHRUBS.

3.1. Introduction

3.1.1 The goal

This is an introduction into the interpretation of the anatomy of bark of some common dicot branches and woody shrubs ramets that may have been used in ethnographic or archaeological artifacts. Branches with their bark still on have been used for many ethnographic purposes, mainly with basket making, As well as mats on floors and bundles in festive dances. Bark alone has been was used for basket decoration, such as imbrications. Many components of bark species have been used for dyes and medicinal purposes. In archaeological and ethnological studies there may be a need to identify species origin of bark fragments as well as intact bark, thus the purpose of the following anatomical study of the bark on branches..

The purpose of the following is to give a working vocabulary of the important anatomical features of the bark. The information presented allows identification of some common branch species or genera of American North West Coast. In many cases the species studied have common characteristic of other species of the genera. The identification of species in a genera, in many cases, depends on morphological features such as flower or leaf shape, color, etc. There is nothing in the literature that gives a comparative analysis of this group of species for identification, but there is some literature on the individual species.

The approach is first to obtain the visual knowledge of the main features of barks. Then determine from the literature, potential species that are reported to be used in similar artifacts as the one being studied. Next narrow down salient features of those potential species for comparison with the artifact sample. The small artifact sample may not allow a complete anatomical study of the deteriorated artifact material but just a fragment of it may show one unique anatomical feature that is a key to its identification.

3.1.2 Branch bark

Branches have many functions for the tree. The position of the branch has to expose the needles or leaves to as much sunlight as possible and still keep a balance. The branch weight and strength must adapt to gravity and wind and it does so by increasing the number and thickness of cells. They are also the pathway of nutrients made by the leaves to the tree trunk sapwood. Most young branches have green chlorophyll cells in the bark that undergoes photosynthesis. Thus the branch not only transports nutrients but also makes it. Branches also have an outer tissue, the bark that protects the branch from insect and fungal and environmental damage.

To do all this, the branch anatomy includes the central pith, the structural xylem (wood) the bark complex of the phloem of several other tissues.

Bark is a generic term for the tissues that can be easily removed off the stem like an orange peel, thus is often called the rind. This bark naturally separates between the xylem and phloem because of the presence of separating delicate layer of thin walled meristematic cambium cells often called cork cambium.

It is called by many other names, e.g., inner and outer bark. On old tree trunks, the bark is called the rhytidome in reference to outer dead tissue.

Bark is composed of a number of tissues that vary in anatomy depending on the species and age of the branch. Generally there are three distinct parts to the bark: the outer **epidermis**, the central **periderm** and the **phloem**.

3.1.3 Epidermis

In early growth, the young branch will have an outer layer of epidermal (Fig.3.1a) cells It has a waxy cutin surface for protection. It is often colored – such as in the maple branch and used in decorative imbrications in basketry.

3.1.4 Periderm

Beneath the epidermis it is the periderm composed of the three tissues, outer phellem, middle phellogen and inner phelloderm. The observation of any one of these tissues, as well as epidermal cells, will verify the presence of outer bark.

Fig.3.1b shows a cross section of a pie piece of a branch of *Acer circinata*. It shows the ease of separation of the outer and inner bark from the wood-xylem tissue. The outer bark is made up of the epidermis and periderm. The inner bark is the phloem tissue. The periderm is a complex of three different tissues. There is the central embryological meristematic tissue the phellogen that produces towards the outside the phellem cells and towards the inside phelloderm cells.

Fig.3.1b shows the red epidermal cells and beneath it the orange phellem cells. The phellem cells are waterproofed by a complex suberin wax. The growth of the phellem cells may replace the epidermis, then the outer dead suberized phellem cells are the protective cells. New phellem cells are being continuously formed in radial rows by the adjacent meristematic activity of phellogen. The phellem cells may form the cork cells in the barks in some species.

The phellogen continuously produces new phellem and phelloderm cells. It separates the phellem and phelloderm by a just a few layers of thin walled meristematic cells (not visible in Fig. 3.1b).

Fig.3.1c shows the shape of the green phelloderm cells. White phloem fibers bundle may appear to in the phelloderm, but have formed from phloem its site of origin. The phelloderm cells are loosely organized - not in radial rows- and have species specific shapes. Their activity is similar to that of cortical cells, e.g., stores starch and undergo photosynthesis.

3.15 Cortex

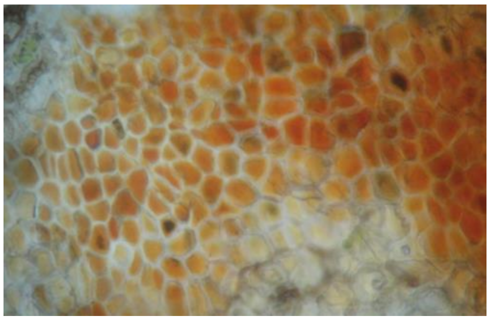
Cortical cells are like filler cells that are in the phelloderm region and may store starch or contain chlorophyll,

3.1.6 Phloem

In Fig.3.1b, below the green phelloderm are groups of phloem tissue with two rows of bundles of white phloem fibers.. The phloem and xylem tissue have separated along the delicate vascular cambium. The cambium is not visible in the photo. Phloem fiber bundles in different species are in different sizes, shapes and location and are an aid in species identification.

3.2. Bark anatomy of s**ome common genera.**

3.2.1 Anatomy of periderm and phloem of some Acer (maple) trees, Aceraceae family



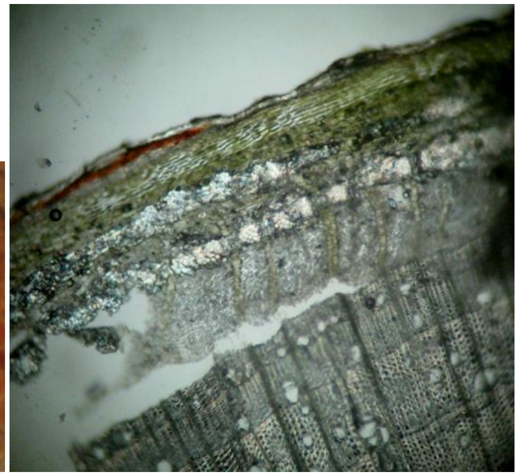


Fig.3.1a

Fig.3.1b

Fig.3.1c

Fig.3.1a- surface view of horticultural red maple branch epidermal cells. Photomlflorian

Fig.3.1b cross section of pie piece of young branch of *Acer circinatum*. It shows the top epidermis, beneath it the green periderm and then the phloem with rings of white phloem fiber bundles, characteristic of maple species. The bark complex of both outer and inner bark is separated, shown by the large crack, from the 2^nd^ xylem at the vascular cambium region. Photomlflorian

Fig.3.1c a cross section of horticultural red maple branch. It shows the details of the red epidermal cells with a white wax on them. Beneath are the three tissues of the periderm, the orange phellem and green phelloderm cells. The region of the phellogen layer is only a few embryological cells which cannot be seen but separate the phellem and phelloderm. The white groups of cells are phloem fibers of the inner bark. Photomlflorian

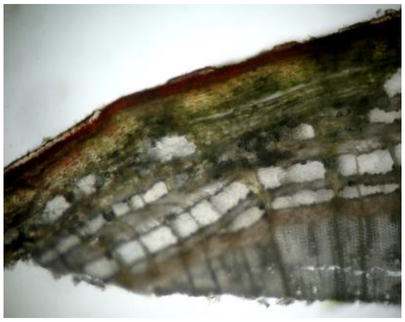
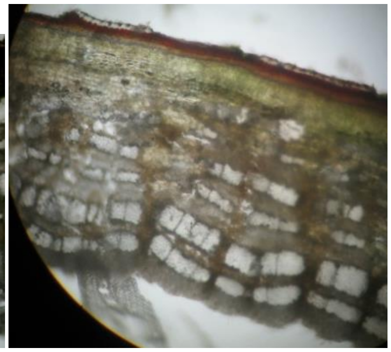
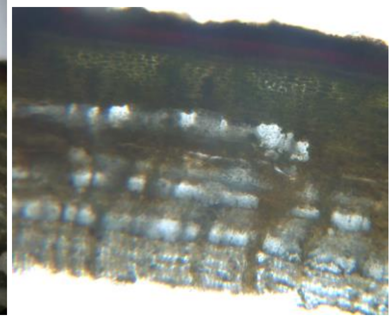
  

Fig.3.1d Fig.3.1e Fig.3.1f

Fig.3.1d cross section of horticultural -red maple branch, 5mm dia. Photomlflorian

Fig.3.1e cross section of horticultural -red maple branch, 10mm diam. Photomlflorian

Fig.3.1f cross section of *Acer macropyllum* small branch. Photomlflorian

Figs.3.1 b-f, shows examples of three maples; *Acer cicinata* (Figs.3.1b and c), *A.macropyllum* (Fig.3.1f); and a horticultural red maple (Figs.3.1d and e). They show the differences in number of rows of phloem fiber groups due to age. All three species show the maple characteristic pattern of the rows of phloem fiber groups. The youngest (outer) incomplete ring has separated bundles of primary phloem often called bast cells. It is followed by older rings of more closely packed rectangular shapes, to a near complete ring of 2nd phloem fiber groups. These photos suggest that age makes a difference in amounts but the three species have very similar overall phloem fiber bundle pattern.

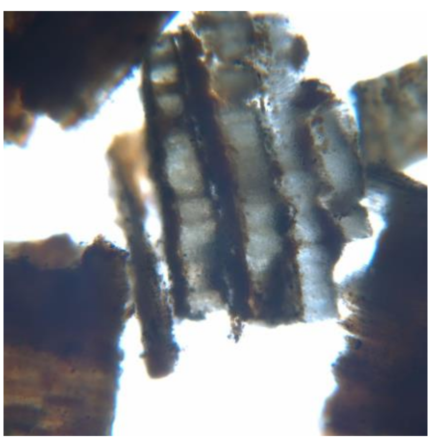
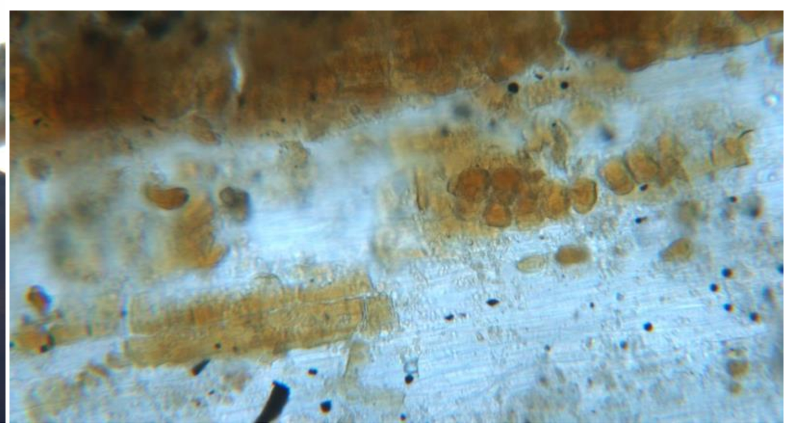
 

Fig. 3.1g Fig.3.1h

Fig. 3.1g fragment from artifact, n19e12 braid c-33 n0 25 showing rows of rings of rectangular phloem fibers of *Acer macropyllum* . Photo MLFlorian

Fig.3.1h some epithelial surface *Acer macrophyllum* cells colored cells, are present in artifact 19e12 braid c-33 n0 25. Photo MLFlorian

Fig.3.1g and Fig.3.1h fragments of the artifact -n19e12 braid c-33 n0 25- show typical *Acer* phloem fiber bundles and epidermal bark cells that would be present on the surface of the bark rind. This verifies that both the outer and inner bark was used.

It is interesting to note that by using the above research, shown in. Figs.3.1d and e, on *Acer macropyllum* it was possible to verify that the sample in braided cordage- n19e12 braid c-33no 25, was A*cer macropyllum* and that the whole bark rind, epidermis to phloem tissue, was used in the braided cordage. It was reported that it was made from *Acer macrophyllum* fibers, where as it was the bark complex with all three components; epidermis, periderm and phloem tissue, that was used. The ethnographic use of *Acer macropyllum* in this artifact used the complete rind to make braided cordage. The presence of many groups of phloem fiber cells gave it its physical strength in cordage. This species has been reported to have been used ethnographically for rope and trump lines. The use of red maple epidermal tissue is used mainly just for imbrications.

3.2.2. Anatomy of phloem fiber bundles (bast fibers) of two *Prunus* species. Rosaceae family Figs.3.2a-b

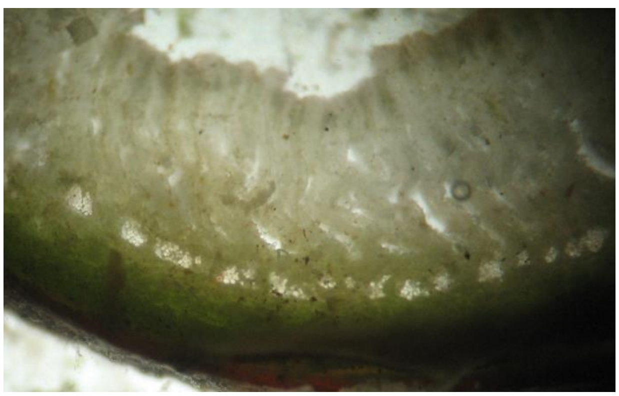


Fig.3.2a

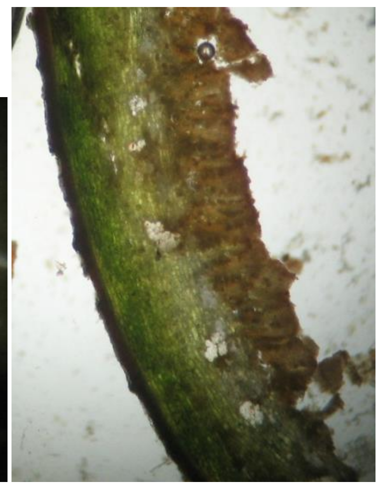


Fig.3.2b

Fig.3.2a-cross section of *Prunus* (cherry) branch showing pattern of small isolated primary phloem fiber bundles. **Photomlflorian**

Fig.3.2b - cross section of *Prunus* (plum) branch showing of pattern of small isolated phloem fiber bundles. **Photomlflorian**

Figs.3.2a and b-show that both *Prunus* species have isolated small phloem bundles, in a ring, suggesting a genus characteristic.

The two P*runus* species show the presence of phloem fiber bundles. Bark strips from *Prunus emaginata* a common bushy tree with bitter cherries in the North West Coast was used for a multitude of artifacts. The phloem fiber bundles would be present in it and gave it its strength. The fibers were used to make twine used for binding and for fishing and hunting gear. Bark strips were used in making baskets and for decoration on cedar coiled baskets and bows.

3.2.3 Anatomy of unique bark anatomy complex of *Gaultheria shallon* (salal) and *Vaccinium* sp. ramets. Both Ericaeae family Figs. 3.3a-f

Some woody dicot shrubs produce ramets. *Gaultheria shallon* (salal) is a woody shrub which produces annually, ramets that are new stems that arise from buried rhizomes. The rind is easily removed and because of its strength from the presence of the phloem fiber bundles (Figs.3.3a and3.3b) could have been used ethnographically for rope or twine. There is little in the literature of bark use, its mainly on the branch leaves and its fruit. Ash remains have been found in ancient hearths, and it was used in flavoring fish and made into whippers for frothing soapberries. It has tissues with brown biocidal polyphenolics that must give it longevity in wet burial sites. It is used here because of its extremely common occurrence in the NWC and it is an excellent example of a ramet.

The ramet of this species has a unique bark complex. It has epidermal cells, a narrow periderm, a ring of irregular shaped primary phloem fiber bundles in the periderm and an unusual brown tissue at 2nd phloem region.

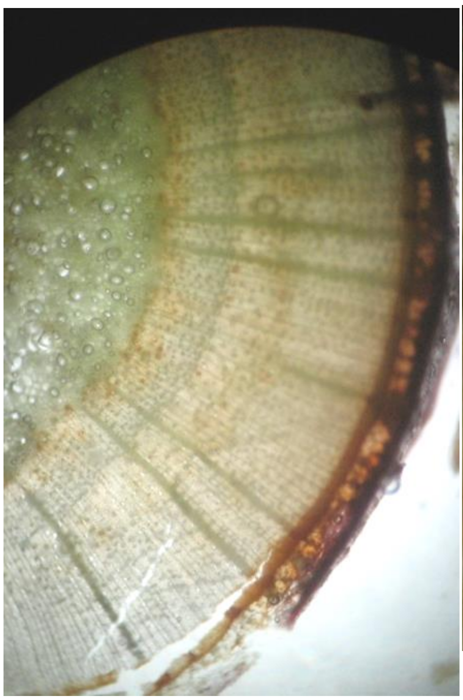


Fig.3.3a

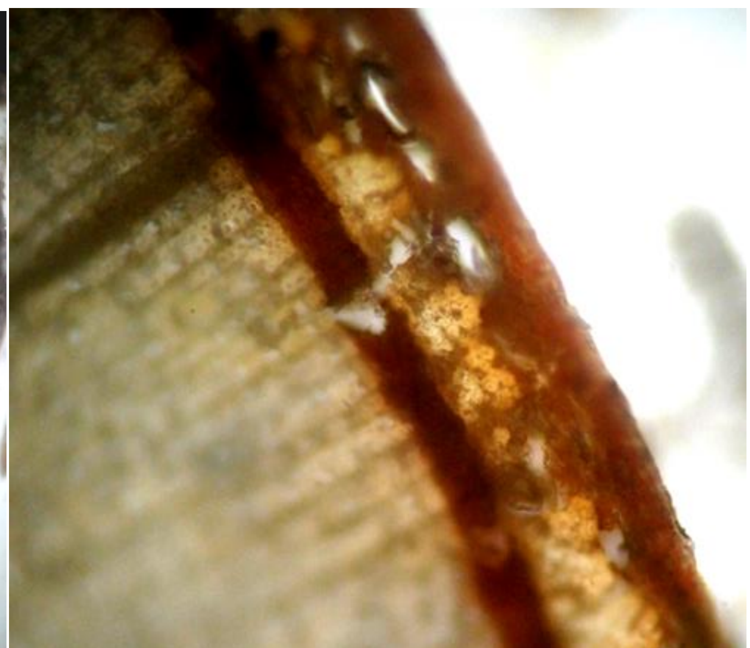
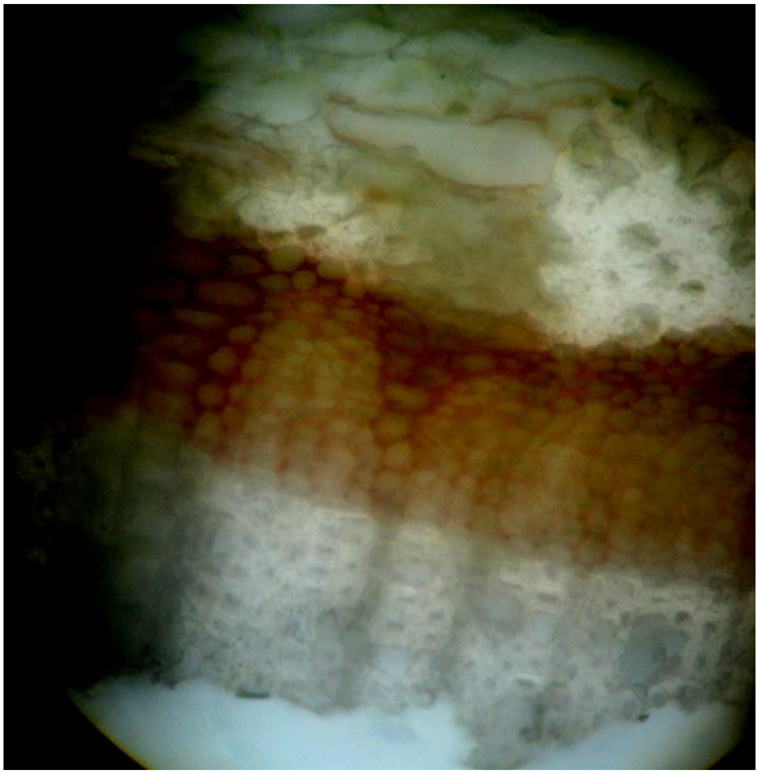


Fig.3.3b

Fig.3.3a - cross section of *Gaultheria shallon* (salal) ramet showing a narrow dark brown bark rind and a broken circle of phloem fiber bundles . PhotosMLFlorian

Fig.3.3b- cross section *Gaultheria shallon* ramet shows the epidermis and periderm regions and irregular shaped phloem fiber bundles and an inner dark brown phloem region next to the primary xylem. PhotosMLFlorian

Figs.3.3a and b- of *Gaultheria shallon* (salal) ramet (annual twig) show a complex of dark stained outer epidermal region, inwards is the periderm with a ring of separated irregular shapes and sizes of groups of primary phloem fiber bundles . These cells are thick walled. Next to this layer is at dark stained region made up of dark cells of phloem and enlarged ray parenchyma cells. The brown color suggests polyphenolic that act in waterproofing and as a biocide. It is in part, similar in position that is the lower surface of the cortex, as the root endodermis, but is not anatomically similar to it, but may have a similar function. Details of the brown phloem are shown in Fig.3.3c. This figure also shows that the central pith has characteristically two populations- large and small- pith cells.



ig.3.3c

Fig.3.3c- 400x, cross section of bark complex of G*aultheria shallon* ramet, showing the details of the top cells of white primary phloem fiber bundles and the dark band made up of dark brown ray parenchyma cells between lighter brown thimbles of primary phloem. Below the dark band is the primary xylem. PhotoMLFlorian

Fig.3.3c, from bottom upwards, the white primary xylem, then the brown layer. It is made up of thimble shaped light brown primary phloem surrounded by dark brown thick walled ray parenchyma cells. The dark color is due to the presence of polyphenolic biocidal chemicals protecting the inner tissue from insect and fungal infestation. In the cortex are thick walled irregular shaped phloem fiber bundles.

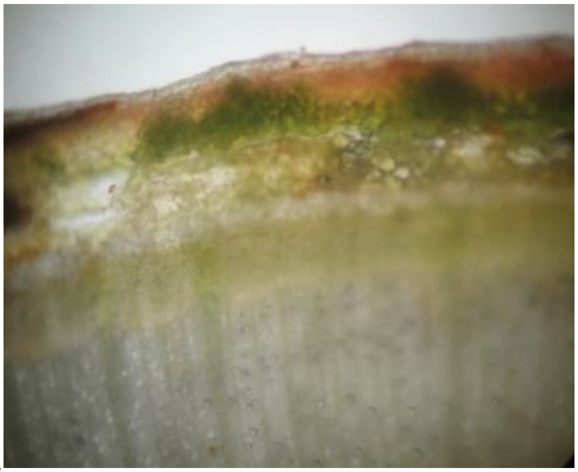


Fig.3.3d

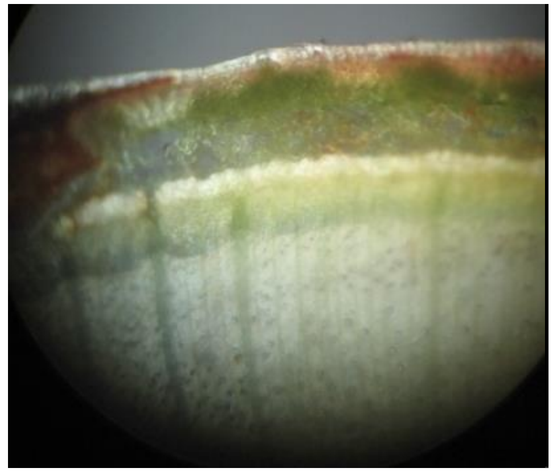


Fig.3.3e

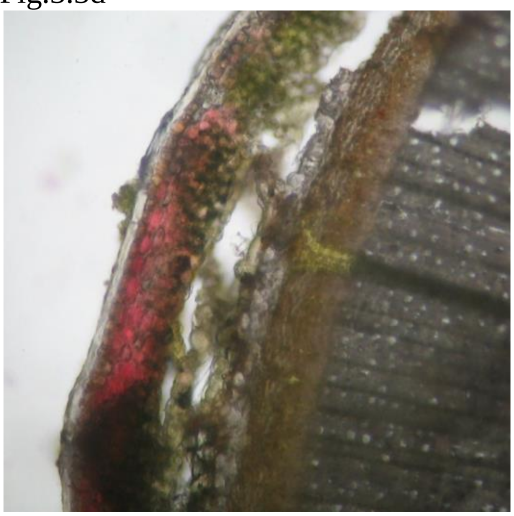


Fig.3.3f

Fig.3.3d-*Vaccinium* sp. (blue berry) ramet shows the layers, the outer clear epidermal region, the red phellem and the porous cortex. Below the cortex are white phloem fiber bundles above the characteristic brownish phloem ring. Below it is the xylem tissue. PhotoMLFlorian

Fig.3.3e- Vaccinium (blue berry) ramet under polarized light showing the single row of white phloem fibers bundles at the top off the phloem tissue. The epidermal wax membrane is also seen on the surface. The green color is the presence of chlorophyll. Most young branches have chlorophyll for photosynthesis that adds to the nutrients from leaves. PhotoMLFlorian

Fig.3.3f- shows the dark brown primary phloem thimble like regions and broad ray yellowish parenchyma cells. PhotoMLFlorian

Figs.3.3e and f, are of a ramet of Vaccinium sp (blueberry) for comparison with the salal ramet (Figs.3.3a-c). Both have brownish colored phloem region and single row of phloem fiber bundles at the top of the phloem tissue. These suggest family ramet characteristics.

Like salal there is lots of notation in ethnobotany of *Vaccinium parvifolium* re the fruit but little on artifacts. It is noted that the twigs were used for brooms and brushes. It is interesting that there is so much literature on their fruit and nothing on the bark or branch. It may be a bias in collectingethnographic information.

3.3. Anatomy of periderm of, birch tree trunk bark. Betulaceae family Figs.3.4a-c

The barks on tree trunk may be quite different than that on branches. Both give protection against environmental and biological hazards. But the tree trunk bark has to allow for the continuous increase in growth of the trunk. It is continuously shed or fractured to account for girth enlargement. The result is the surface is rough and fractured and composed of dead cells and is called rhytidome-the derivation of the word means rhinoceros wrinkled skin.

The outer surface may be layers of phellem cells formed by the cork cambium or 2^{nd} phloem formed by the vascular cambium. The birch tree continuously sheds the outer waterproofed sheets of phellem cells. The cork tree produces continuously produces phellem into gargoyle–like groups of heavily suberized cork cells and the western red cedar has cast off the outer epidermis and periderm and replaced it with just masses of 2^{nd} phloem fibers.

Paper birch (*Betula papyrifer*) is a dichotomous hardwood tree. The phellem tissue has pushed the epidermis off. New growth of phellem is continuously formed and compacted together to make a thick outer bark. The bark used in artifacts is old dead outer phellem cells (Fig.3.4a) that has developed on the surface of the tree trunk.

The phellem cells have a yearly growth ring pattern of different size cells like early and late wood growth rings, shown in Fig.3.4b. The strength difference at the margin of large and small cells allows for layer to easily separation, after years of surface environmental exposure. This results in peeling of the surface of the bark. This is shown in Fig.3.4a of a wood pecker decorated piece of birch bark. The sheets of phellem exposed to the environment have lifted up and will eventually fall off.

The characteristic shape of phellem cells shown in Fig.3.4c, along with the multilayered white phellem (Fig.3.4.b) make the identification of birch bark possible.

The phellem cells are filled with betulinic acid a white powder giving it its whiteness.

Fig.3.4a

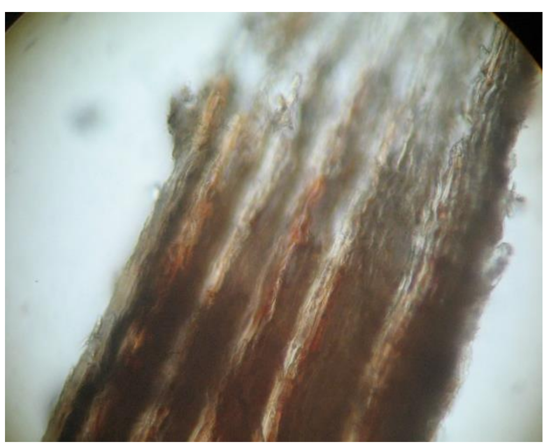


fig.3.4b

Fig.3.4a- woodpecker decorated *Betula papyrifera* (Birch bark). The surface shows lifting of sheets of dead phellum cells. PhotoMLFlorian

Fig.3.4b- cross section through many growth ring years of phellum cells. The light and dark areas are a result large and small cells similar to annual growth rings. PhotoMLFlorian

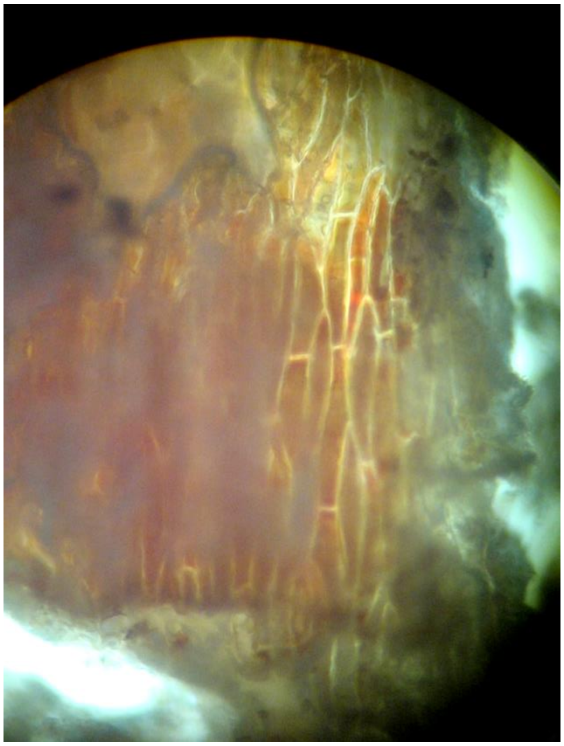


Fig.3.4c

Fig.3.4c- surface details of the shape of phellem cells characteristic to *Betula papyifera*. PhotoMLFlorian