MICROSCOPIC IDENTIFICATION BY CELLULAR ANALYSIS: A COMPARISON OF ARTIFACT PLANT MATERIAL FROM WET-SITES ON THE NORTHWEST COAST OF NORTH AMERICA

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The procedure of identifying wood and fiber materials by microscopic cellular analysis on the Northwest Coast of North America was pioneered in the 1970's by Dr. Janet Friedman, while conducting her research on the wealth of wooden artifacts from the Ozette Village wet site, Olympic Peninsula, Washington state, USA. The unique nature of Ozette and other wet sites on the Northwest Coast of North America has allowed vegetal material culture to be preserved and identified, contributing new insights into and understanding of the predominant ancient material culture and resources used by these ancient Northwest Coast peoples. The cellular identification of ancient vegetal material culture is complementary to information found in ethnobotanies and oral traditions, identifying traditional plant materials; as well as revealing new uses of plant materials.

This technique has also been expanded to include the identification of cultural charcoal, adding insights into the use of fuelwoods by ancient peoples, as well as adding to the environmental knowledge of the flora of the time periods and regions examined. The following report summarizes the methods of cellular analysis and describes the microscopic differences between species of wood, basketry and cordage construction materials, and cultural charcoal.

Methods of Sampling and Identification

Cellular analysis of archaeological wood involves taking samples with a sharp razor blade from three sections of a piece of wood (tangential, radial and cross-section, see Figure 1 below), placing them onto glass slides, and viewing with a compound microscope.

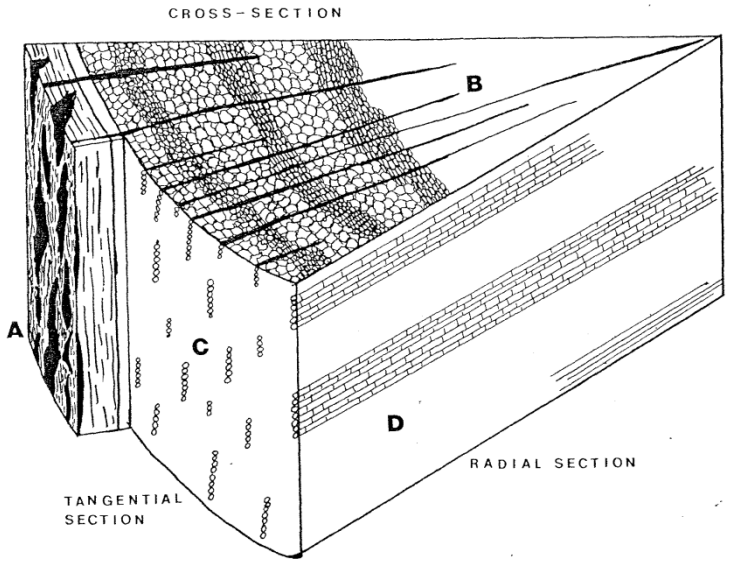

Figure 1. Stylized piece of wood, with the orientations used for sampling and identification labeled. Samples are taken from these orientations with a sharp razor blade, and then viewed microscopically (Friedman 1978:3).

Samples must be obtained from artifacts carefully to avoid damage; and practice with modern wood is essential before undertaking sampling from archaeological material. Often wood preserved in waterlogged conditions is fragile and spongy, and sections difficult to obtain. Artifacts are photographed and sketched prior to and following taking a sample; with the area from which the sample is taken noted to avoid confusion by subsequent researchers. Deciduous hardwoods and coniferous softwoods can be quickly separated by this method, and unique characteristics between softwoods can be observed in the rays, tracheids, and pit features.

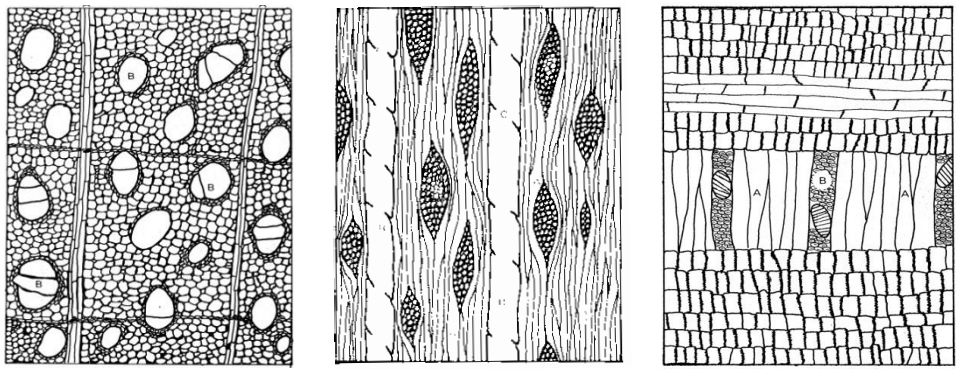

Figure 2. Stylized drawings of (from left) cross-section, tangential section, and radial section views of a typical deciduous hardwood (Friedman 1978)

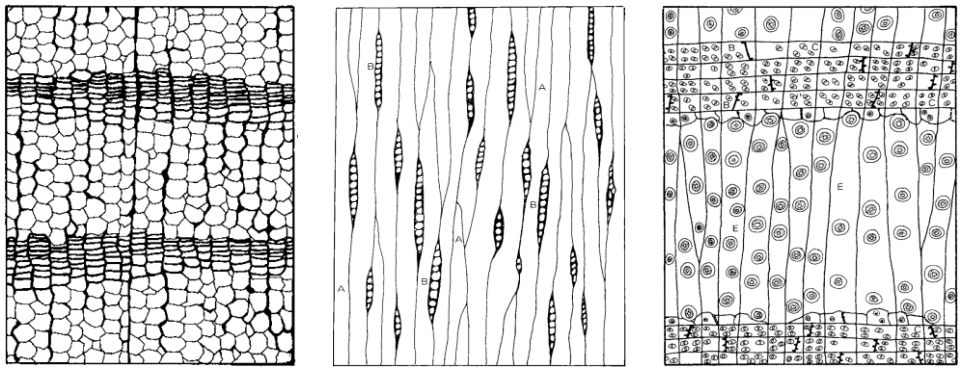

Figure 3. Stylized drawings of (from left) cross-section, tangential section, and radial section views of a typical coniferous softwood (Friedman 1978).

The process of identifying plant materials and fibers used in basketry and cordage is similar to that of wood; however not all orientations may be visible. Materials used in basketry such as western red cedar roots and boughs usually have the cross-section and radial section views available; and occasionally the tangential section can be obtained. For flat bark-like elements found in checker and twill weaves and braids, the cross-section and/or radial views may not be obtainable. In this case, identification is made based primarily upon the tangential section view.

The same methods are used to identify charcoal as for wood analysis, using the same planes of orientation; however, due to its brittle nature charcoal is broken into the proper

orientations rather than cut. Charcoal has reflective surfaces, which means a standard microscope using direct light sources generally creates too much contrast to view cells. A metallurgical microscope with a light source that is transmitted directly down onto the sample through the objectives, and then retransmitted from the sample back through the objectives, eliminates reflection.

The application of cellular analysis has been used to identify plant materials recovered from three archaeological wet-sites on the Pacific Northwest coast area of North America: The Sunken Village (35MU4) National Heritage Landmark Site near Portland Oregon; the Qwu?gwes Cultural Site (45TN240) on Eld Inlet in Washington State; and the Montgomery Creek Fish Weir (35LNC78) located near Yaquina Bay in Oregon.

Sunken Village National Historic Landmark Site (35MU4)

The Sunken Village National Historic Landmark Site is located on the southern end of Sauvie Island near Portland Oregon. This well-preserved wet-site is the largest known acorn leaching pit site in North America (see Mathews 2009:85-94). The following describes the results of cellular analysis of artifacts, woodchips and charcoal recovered in 2006 and 2007. These analyses were published in the *Journal of Wetland Archaeology Volume 9* out of Exeter, England in 2009 (Croes et al. 2009; Hawes 2009; Hawes & Graham 2009).

Figure 4. Sunken Village open cross-warp twined acorn basket being examined by Warm Springs Master basket weaver Pat Courtney Gold

Artifacts

The Acorn Basket. A beautiful basket, identified by Warm Springs Master basket weaver Pat Courtney Gold as an acorn collecting basket, was recovered in 2006 (Ness et al. 2009:148).This basket is well-preserved with intact base and sides, carefully cross-warp twined (see Figure 4). Cellular analysis was performed on a fragment of basketry debris, which was identified as softwood. Samples were taken of modern western red cedar (*Thuja plicata*) roots and boughs, and Sitka spruce (*Picea sitchensis* [Bong.] Carr) roots. Microscopic examination positively identified the sample as conifer, with further comparison between the cedar and spruce roots showing characteristics that match cedar roots. Cellular analysis of a cross section of the artifact basket matches that of western red cedar root.

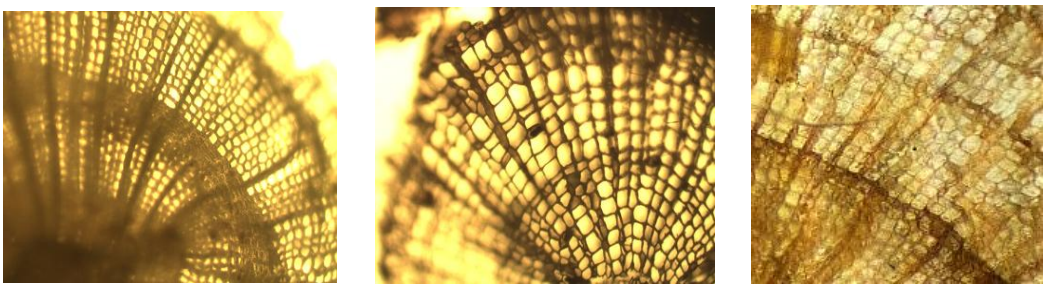

Figure 5. (left) Modern western red cedar bough cross-section; (center) modern western red cedar root cross-section; (right) cross-section of acorn basket warp material (100x magnification)

*Woven Checker Matting and Cape/Skirt Fragment***.** Several fragments of checker weave were recovered from Transects III, V, and VI. These were visually identified as Western red cedar phloem fibers, which has a characteristic appearance. Microscopic examination and comparison of modern cedar phloem fiber samples confirm the identification of Western red cedar. A fragment of bark cape or skirt with twined edge was recovered in 2006, constructed of shredded plant fibers (Ness 2009:137); and was also identified microscopically as Western red cedar phloem fibers (Figure 5, right).

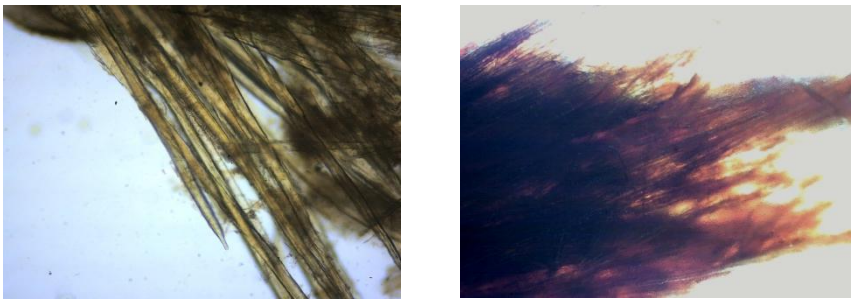

Figure 6.(left) Modern western red cedar phloem fibers (40x); sample from cape or skirt (right)

Cordage. Several fragments of cordage were analyzed, and most were identified as western red cedar phloem fibers. However, a braid found in 2007 was identified microscopically as woven from hardwood fibers, possibly bigleaf maple (*Acer macrophyllum*).

Diamond-Plaited Soft Bag. The diamond-plaited soft weave fragment recovered in 2007 is a very unique specimen. Initial analysis indicated that the weave was not likely constructed from Western red cedar phloem fibers, and this was confirmed microscopically. A cross section view of the strings serving as possible warps (Ness et al. 2009:153) revealed characteristics of monocot fibers (Figure 7, left). Comparisons were made between modern samples of tule (*Scirpa acutus*) and sweetgrass (*Scirpus americanus*), with similarities between both species observed. Cell arrangement was also difficult due to crushing of the plant material, but size differences between vascular bundles and schlerenchyma cells in cross-section appear to be similar to sweetgrass.

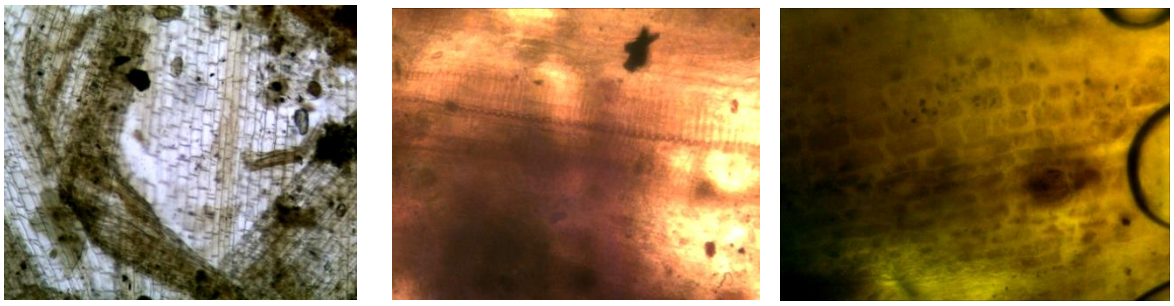

Figure 7. (left) Microscopic image from warp string sample; (center and right) images from diamond plaited weave material (100x)

The woven elements that pass over and under the strings are considerably more fragile and degraded, and identification of this part of the weave has taken much more time. Microscopic cellular analysis of several fragments shows characteristics of sedge material, possibly *Scirpus* or *Carex* species (Figure 7, center and right).

Wooden Wedges and Wedge Tips. Two wooden wedges were excavated from the Sunken Village site in 2006. A full wedge is complete with collar, and shows much use through pounding of the proximal end, with the point broken off at the distal end. A smaller wedge was broken lengthwise and lacks a collar; but also reveals adzing. Wedges of this type have been

used for millennia, with wedges of similar types found in wet sites around the Pacific Northwest. Examination of samples taken from the artifact wedges indicated a conifer species, and also showed spiral thickening in the tracheids in both tangential and radial views. Pacific yew and Douglas-fir have characteristic spiral thickening in the tracheids, however Douglas-fir commonly has longitudal and tangential resin canals which is lacking in Pacific yew (see Figure 8, left). Western hemlock was also analyzed but lacked the characteristic spiral thickening in the tracheids. The lack of resin canals and modern wood sample comparison identifies both wedges as Pacific yew (Figure 8, right). The collar of the full wedge also indicates a conifer species, and microscopic cellular analysis identified the wood as western red cedar bough. In addition to the wedges, five wooden wedge tips were recovered in September 2007; three as surface finds and two recovered from acorn leaching pits. All were identified by cellular analysis as Pacific yew.

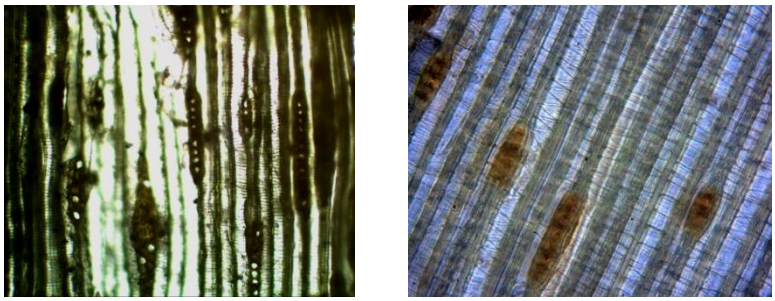

Figure 8. Microscopic images (100x) of tangential section views of Douglas-fir (left) and Pacific yew (right).

Acorn Leaching Pit Lining Material. Plant lining material was removed from two acorn leaching pits including small twigs and larger branches lining the pit feature, found with needles still attached and identifiable as a conifer species. The needles were short, in double ranked rows along the branchlets, and detached very easily leaving small woody pegs. Comparisons were made among species of conifers which fit these observations, with the most likely being western hemlock, grand fir (*Abies grandis*), and Pacific yew; all of which have needle attachments resulting in double ranked rows along the branchlets. Viewed with a dissecting microscope the

attachment of the needles to the twigs, needle size and shape, and the alternating alignment of the branches identified the plant material as western hemlock. Examined with higher magnification, the cellular structure also was identifiable as western hemlock.

Wooden Stake Features. 34 stake features were located in 2006, most near or within the pit features (usually the south side of the pit as a re-location marker); two were excavated for analysis and identification in 2006. Stake A, Transect V still has smooth bark with resin blisters visible, a characteristic of young noble fir (*Abies procera*) species, and was identified as such. Stake A from Transect VI is smaller and has no bark remaining, and was identified as spruce, most likely Sitka spruce (*Picea sitchensis*). This tree is more commonly found in the coastal areas.

Identification of Archaeological Woodchips and Charcoal

Woodchips. In 2006, a total of 490 woodchips was recovered from Test Unit 4. A 5% sample was taken from each 10 cm level for cellular analysis and identification. Of the 25 woodchips analyzed, the majority were Western yew (*Taxus brevifolia*). Half of the yew woodchips revealed faceting, possibly created as debitage from wedge sharpening. The second most common species identified as Garry oak (*Quercus garryana*, also known as Oregon white oak); and the remaining species samples were identified as Douglas-fir (*Pseudotsuga menziesii*), red alder (*Alnus rubra*), pine (*Pinus spp*), Western hemlock (*Tsuga heterophylla*), cascara buckthorn (*Rhamnus purshiana*), and willow (*Salix spp*).

Charcoal. Over 1700 pieces of charcoal were recovered from Test Unit 4, which was excavated to the 50 cm level in 2006. A 5% sample was taken from each 10 cm level and examined microscopically. Of the 85 samples analyzed, the majority was identified as *Quercus* genus, most likely Oregon white oak, also commonly known as Garry oak (*Quercus garryana*,

the only native oak in this region), which grows in abundance on Sauvie Island; with Douglas-fir the second most common species found (*Pseudotsuga menziesii*) . The remaining samples were identified as red alder, cherry (*Prunus spp*), maple (*Acer spp*), western red cedar, and willow.

Figure 9. Archaeological charcoal from Sunken Village Test Unit 4 (cross-section, 40x magnification); identified as Garry oak

Montgomery Creek Fish Weir (35LNC78)

In 2008, South Puget Sound Community College's Archaeological Training Wet Site Laboratory cleaned, conserved, and identified materials from an estimated 2,000 year old fish weir excavated from Yaquina Bay, Oregon (site 35LNC78) through a professional contract with Byram Archaeological Consulting, LLC of Eugene, Oregon. There were 103 wooden stakes, as well as 33 bags of brush materials including twigs, rocks, and other plant material that were recovered from the base of the weir in addition to 2 bags of peat. All material was digitally photographed before and after cleaning. This report is currently under review (Hawes et al. 2009)

Cellular Analysis of Fish Weir Stakes. Most of the stakes seemed to be of the same kind of wood, therefore one-third of these were sampled for analysis. Samples were also taken from any of the stakes that appeared to be of a different type of wood. Thirty-one stakes were examined and identified microscopically. Twenty-nine stakes were identified as Western hemlock (*Tsuga heterophylla,* Figure 10, center). Two stakes were identified as spruce, and as Sitka spruce is

prevalent on this coastal region of Oregon, this identification seemed most likely (Figure 10, right).

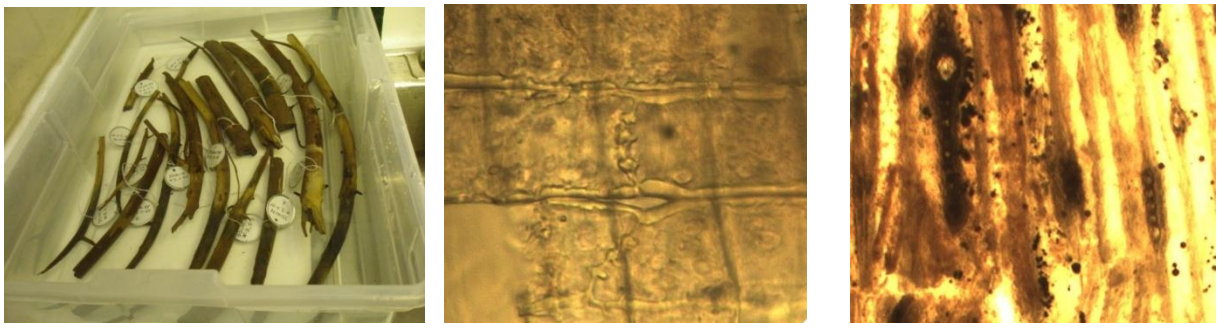

Figure 10. (left) Fish weir stakes before conservation; (center) microscopic radial section image from Stake S-29(400x), identified as western hemlock; (right) tangential section image from Stake H-3 (100x), identified as Sitka spruce.

Analysis of Brush Material. These materials were divided spatially into 3 categories: North area, Center area, and South area. Samples of the brush (including twigs/branches, leaves, cones, needles and other plant material) were removed and analyzed. Materials identified included spruce, western hemlock and Douglas-fir cones and scales; western hemlock needles; wood fragments of Douglas-fir and alder (*Alnus spp*); hazelnut shells; and cattail rhizomes (Figure 11, left). Two potential artifacts were also included. One appears to be a bentwood artifact (possibly a fish hook, see Figure 11, center) from the South area identified as western hemlock (Stewart 1977:40). The other is a water-worn piece of wood, also from the South area that appears to be intentionally beveled and identified as spruce (Figure 11, right).

Figure 11. (left) Cattail rhizome fragments from Center brush area; (center) possible bentwood fishhook; (right) possible beveled artifact

Identification of charcoal. Three fragments of charcoal were examined from the North area brush; two were identified as Douglas-fir and the third was western hemlock.

Qwu?gwes Cultural Site (45TN240)

The Qwu?gwes Cultural Site is located on Mud Bay, within Eld Inlet near Olympia, Washington. Over the past 11 years of excavation, many wood and plant fiber artifacts have been recovered from the wet-site conditions of the intertidal shell midden area. Many of these artifacts, preserved by an underground aquifer flowing through the midden area, have been examined and identified microscopically by cellular analysis using the techniques described previously. Charcoal has also been recovered from the shell midden area, as well as from the dry habitation and food processing areas and identified by cellular analysis. This report is currently under peer review (Croes et al. under review).

Identification of Wooden Artifacts

Possible Wooden Wedge or Stake. In 2001, a short length of a wooden wedge or stake was found preserved in the intertidal shell midden. Split along its length, it has been adzed or carved on the distal end as well as near the proximal end, and shows evidence of use by wear from pounding on the proximal end.

Figure 12. Wedge/stake from Qwu?gwes Cultural Site, identified as western hemlock

A microscopic examination of the cell structure revealed the possible wedge or stake to be softwood, and has been identified as Western hemlock (*Tsuga heterophylla*).

Bentwood Fishhook. A possible bentwood fishhook was recovered in 2007. Classified as a Type B self-barbed bentwood fish-hook, it would have been constructed from a single piece of wood that was bent through steaming, and would have a point at one end and a knob for attaching a leader to the other (Croes 1997:603-604). The point of this particular hook is broken but still attached; there is also an indentation at the other end for attaching the leader but the knob itself has broken off. This type of fishhook does not appear to have been used by the time of European contact; except by the Haida and other northern groups, who continued use into the historic period (Croes 1995:104); and were used for fishing cod. This is the only Type B bentwood fishhook to date that has been identified as western hemlock; at the Ozette Archaeological Site (45CA24), western hemlock was utilized; but rather for use in the construction of halibut fishhooks (Friedman 2005:171).

Worked clam/digging stick. This wooden artifact, found in 2007, appears to have been somewhat shaped although no adzing marks are apparent, with one end broken while the other comes to a rounded point with evidence of light charring. Cellular analysis revealed the presence of large pores in the cross-section view, indicating a hardwood. Further analysis identified the wood as ocean spray; also known as ironwood (*Holodiscus discolor*). It is possible that this was a digging or prying stick for gathering shellfish or roots. Ocean spray was used by most Tribes of Western Washington for digging sticks for clams and roots (Gunther 1975:33).

Adzed stake. In summer 2008, a wood stake was excavated with one adzed end; the other appeared broken. When freshly uncovered, the wood had a beautiful reddish appearance.

Examination of the cell structure under magnification revealed the wood to be a semi-ring porous hardwood in cross-section, and was identified as crabapple (*Malus fusca*).

Wooden stick with cherry bark wrapping. This unusual artifact, approximately 11 cm in length, was recovered in 2008 and consists of a tapered wooden stick with a wrapping of cherry bark on the thicker end (see Figure 13). Within the wrapping are two very small protruding twiglets, and two short lengths of twiglets were found next to the artifact, wrapped with very thinly split cherry bark. The purpose and use of this artifact is unknown. Cellular analysis of the stick revealed the wood identified as ocean spray (*Holodiscus discolor*). Interestingly a somewhat similar artifact was recovered from the Little Qualicum River Site DiSc 1 on the east Coast of Vancouver Island, B. C. in 1976. This fragment, also of unknown use, is about 7 cm in length, has a slotted end and was identified as *Holodiscus discolor* wrapped with cherry (*Prunus spp*) bark (Bernick 1983: 318, 321-322).

Figure 13. Wooden stick with cherry bark wrapping

Clam sticks. In the summer of 2009, eighteen lengths of wood were uncovered during excavation of the intertidal shell midden area. These sticks, which were very soft and fragile, vary in length up to about 1 m; with diameter ranging from .9 to 1.6 cm. The sticks had been laid parallel to each other about 5 cm apart; and two sticks had twining near one end. They were lying near a large Douglas-fir log which had been partially uncovered during previous year's

excavations. Cellular analysis of Sticks I and G identified them both as ocean spray. It is possible these sticks were used to cook or roast clams.

Identification of Basketry and Cordage Construction Materials

Basketry. Several baskets were identified as woven from Western red cedar bough for both warp and weft. Cedar bough was used for the warp elements in two open twine rim fragments (one with a handle attached), however the weft elements were cedar root; as identified by larger cells in the cross-section views.

Western red cedar phloem fibers were identified as the construction material in most of the checker weaves. However, the remaining basketry did not appear to be woven of cedar bough, root or bark. These artifacts had thinner, layered single-element looks and lacked the characteristic frayed appearance of cedar. The construction materials of these artifacts strongly resembled the inner phloem fibers of bigleaf maple (*Acer macrophyllum*); which separates easily into thin sheets when deteriorated or dry (Florian 2002:70). Microscopically, the fibers also lacked softwood tracheids, and included characteristic hardwood multiseriate rays.

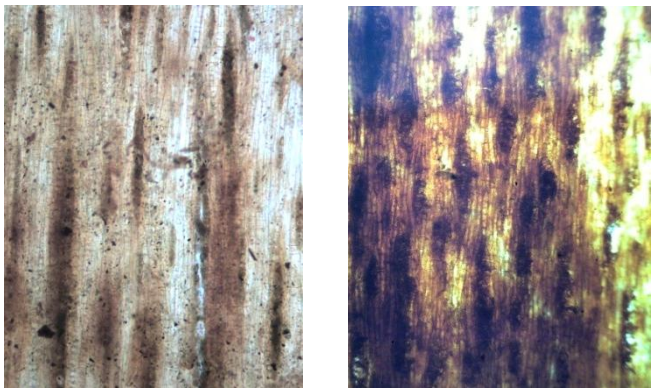

Figure 14. (Left) microscopic image of sample from possible tumpline or belt fragment; (Right) microscopic image of modern secondary phloem fibers of bigleaf maple (tangential section views; 100x).

Among the basketry identified as woven from hardwood fiber is a soft checker weave folded bag or mat recovered in 2004 (Figure 15, left). This beautiful weave is currently on display at the Squaxin Island Museum. A second checker weave fragment and several twill weave fragments were also identified as hardwood fiber.

Cordage. Several twisted bough or with fragments recovered from the intertidal shell midden were identified microscopically as western red cedar bough. Western red cedar phloem fibers were also identified in the construction of two braids, a net knot and a single strip tied into a loose knot; and a soft twisted length of cordage was identified as pounded or shredded cedar phloem fibers. However it was discovered that the remaining cordage identified microscopically as hardwood fiber; as well as a gill-net recovered in 1999 (Figure 15, right), and fragments of net and net knots recovered in 2002 and 2003. These fibers are very similar to the hardwood fibers found in the basketry described above.

Figure 15. (left) Soft mat or bag recovered in 2004; (center) braid and tumpline woven of hardwood material; (right) gill-net recovered in 1999

To confirm the identification of the hardwood fibers in these artifacts, two samples were collected and sent to Mary-Lou Florian, Research Associate Royal BC Museum in Victoria B.C. for cellular analysis. Ms. Florian is well known as a professional expert in archaeological plant and wood identification. Ms. Florian identified the fiber as bigleaf (or broadleaf) maple (*Acer macrophyllum*); including the outer true bark, inner phloem layers (the majority of the sample),

and with or without a thin section of the wood itself. From the above information she was able to determine that the individual strands of the braid were longitudal strips sliced off the surface of a bigleaf maple branch approximately 3 years old. Her time and willingness in this effort is greatly appreciated. It is likely that most of the hardwood fibers identified from the basketry and cordage is bigleaf maple bark; as they appear very similar to the sample identified by Ms. Florian.

Identification of charcoal. A representative 25% sample was taken from collected charcoal from one unit of each of the excavated areas (intertidal shell midden, food processing, and habitation) and analyzed microscopically for species identification.

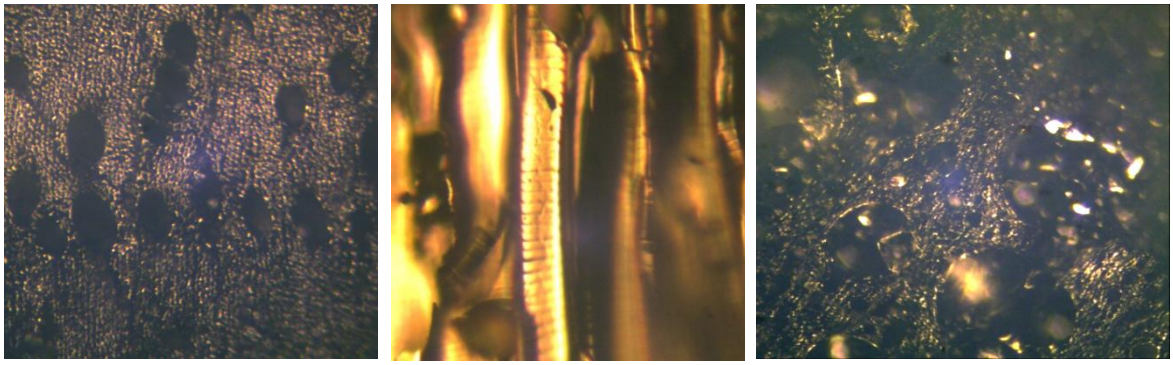

Figure 16. Archaeological charcoal recovered from N16/E14; (from left): Bitter cherry cross-section, Douglas-fir tangential section, and Garry oak cross-section views(100x).

The combined results of cellular analysis from the Qwu?gwes site show 11 genera represented, with the predominant wood charcoal found to be Douglas-fir (including 14 samples of Douglas-fir bark); followed by Western red cedar, bitter cherry (*Prunus emarginata*), and red alder (*Alnus rubra*). Other taxa represented in order of frequency include Pacific yew, bigleaf maple (*Acer macrophyllum*), pine (*Pinus spp*), western hemlock, Oregon ash (*Fraxinus latifolia*), vine maple (*Acer circinatum*), and Garry oak. The inclusion of Garry oak, although found as only one sample, corroborates the use of oak at the site as seen in over 1,000 fragments of acorns recovered from the intertidal shell midden.

Summary and Conclusions

The identification of wood and plant artifacts and charcoal by cellular analysis has led to exciting new discoveries in the use of plant materials. Further use of this technique for materials found preserved in wet-sites may reveal even more about the Native cultures of the Pacific Northwest Coast of North America. The identification of western red cedar for basketry and cordage is consistent with ethnographic and ethnobotanical records, as well as the use of Pacific yew for wedges and western hemlock for fish weir stakes; and complimentary to Native traditional information. One particularly exciting discovery revealed by cellular analysis is bigleaf maple (*Acer macrophyllum*) phloem fibers, found in several of the checker weaves and most of the cordage at the Qwu?gwes Cultural Site; and possibly in a fragment of braid from Sunken Village. There are very few references to the use of these fibers, and no references have been discovered for the use of bigleaf maple phloem fibers in construction of fish nets. It is possible that its use was local, or that there are artifacts in collections that have not yet been discovered. The diamond-plaited soft weave from the Sunken Village site is also a unique and beautiful specimen. Apparently woven from sedge materials, its style has links to the ancient U.S. Great Basin (at least 9,400 years old) and equally early time periods of the Japanese Jomon (at least 7,000 years old) (Ness et al. 2009:148).

The analysis of archaeological charcoal also has added to the knowledge of fuelwood choices of Native Peoples. The use of Garry oak at the Sunken Village site may reflect wood collected during acorn harvesting, or even from pruning to gain access to acorns and encourage production. And the use of bitter cherry for fuel at Qwu?gwes could be a cultural preference, as families of the Squaxin Island Tribe (on whose traditional territory the site of Qwu?gwes is located) still use cherry wood for smoking salmon.

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