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The Fossil Woods near Holley in the Sweet Home Petrified Forest, Linn County, Oregon

By Irene Gregory*

Introduction

Scattered deposits of Tertiary fossil (petrified) woods are to be found throughout most of the Western Cascades adjoining the eastern side of Oregon's Willamette Valley, but those deposits making up the area known as the Sweet Home Petrified Forest in Linn County are among the most abundant and well known.

The abundance of the area's fossil wood is evident even to the casual traveler. It may be seen crushed or as fill in driveways, in fences and retaining walls, and in decorative garden work. Larger pieces -- stumps and logs -- mark driveway entrances and hold up mailboxes; barn floors have been built of it and abandoned wells filled with it. Farm people of an earlier day considered it a great nuisance -- a feeling perhaps carried over, justifiably, by today's landowners at times harried by avid rock hunters.

Of particular interest to the author is a small area near Holley which has yielded, and which still contains, much significant paleobotanical material in the form of almost perfectly preserved and exquisitely detailed silicified fossil woods with much variety as to species. This small area is on the J. J. Marker ranch (SW$\frac{1}{4}$ sec. 12, T. 14 S., R. 1 W.) located 5 miles by road east of the town of Holley in Linn County, Oregon. This is the locality with which we are mainly concerned in this report (figure 1).

It has seemed appropriate to undertake a study of this fossil wood location on the Marker ranch, since it and much of the adjacent land will be flooded eventually by impoundment of the waters of the Calapooia River behind a dam at Holley. The dam, which is in the planning stage by the U.S. Corps of Engineers, would raise the waters in the reservoir to the 694-foot contour. The present elevation of the Calapooia at the dam site is about 540 feet. A preliminary map drawn up by the U.S. Engineer District, Portland, shows that our collecting area will be included within this maximum pool boundary (figure 2).

Although the main purpose of this report has been to describe the fossil woods at the Marker ranch and theorize on their origin, it seemed appropriate to add a section on wood identification. Because of the wide interest in fossil wood and the lack of published information on identifying it without the aid of a high-powered microscope

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* Mrs. James M. Gregory received her Bachelor of Science degree at the University of Minnesota, majoring in botany. Since she has been living in Oregon she has transferred this interest to the Tertiary paleobotany of the Pacific Northwest and has studied with Wallace Eubanks, authority on fossil wood anatomy.

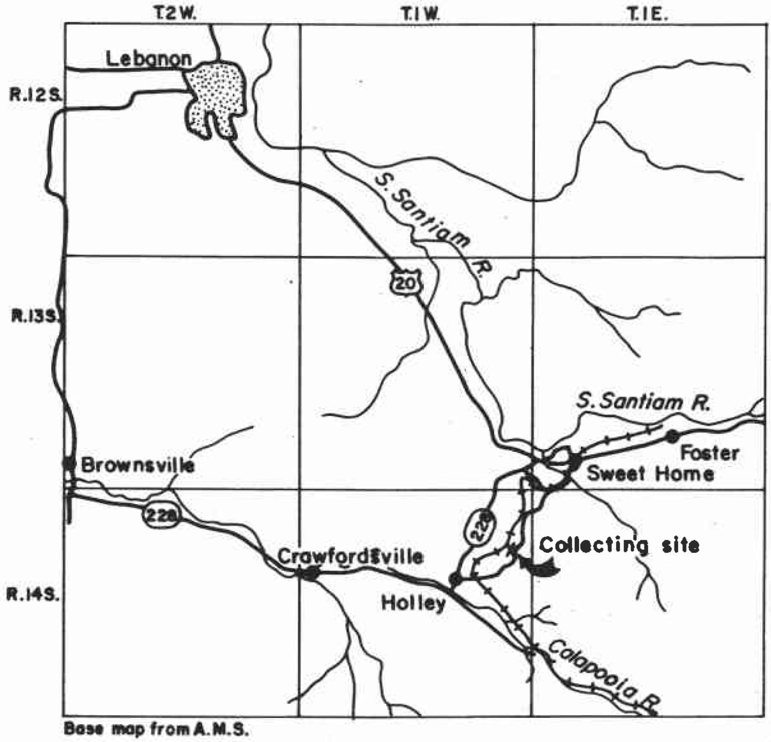


Figure 1. Index map of the Holley-Sweet Home area, showing location of the collecting site.

and technical training, it was felt that a summary of pointers on how to recognize some of the fossil woods in the Sweet Home area on the basis of gross anatomy would be useful to the amateur.

Acknowledgments

Grateful acknowledgments are extended to staff members of the Oregon Department of Geology and Mineral Industries for help and guidance in compiling this report, for geologic assistance in the field, and for photographic work. Special appreciation is expressed to Mr. and Mrs. J. J. Marker for their always pleasant cooperation and kind permission to carry on field work at their Holley ranch. Appreciation is also extended to Her Majesty's Stationary Office, London, England, for permission to reproduce 16 photomicrographs of wood anatomy from the Forest Products Research Laboratory in England.

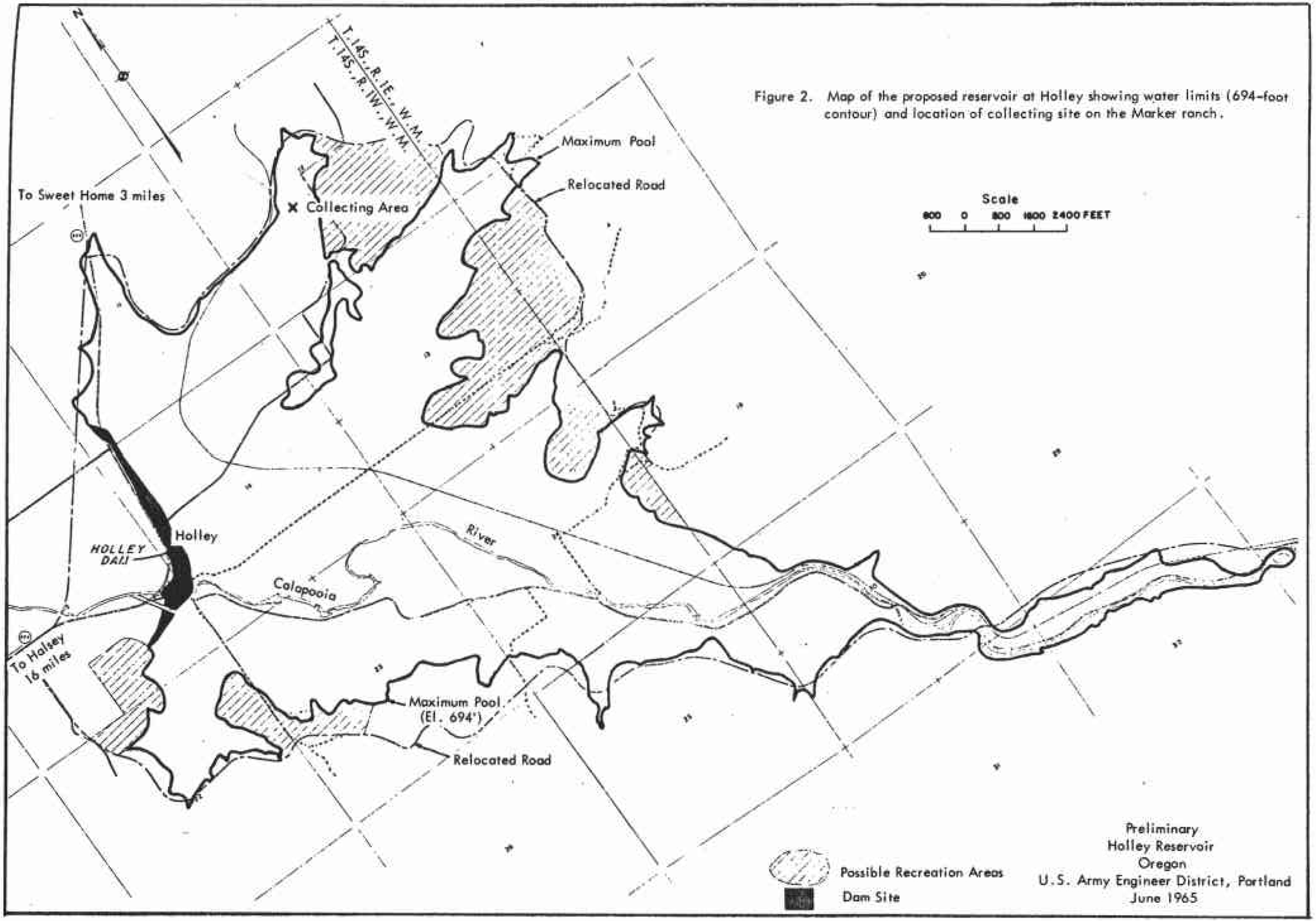


Figure 2. Map of the proposed reservoir at Holley showing water limits (694-foot contour) and location of collecting site on the Marker ranch.

Fossil Wood Studies as Applied to the Area

Published paleobotanical records of fossil wood in the Sweet Home area are scarce. Hergert and Phinney (1954) report specimens of a vessel-less angiosperm and describe and figure Trochodendroxylon beckii as the type of the new form genus Trochodendroxylon. Richardson (1950), in a master's thesis on the Sweet Home Petrified Forest, records several localities with trees petrified in situ. Beck (1944) has referred to the large number and exotic character of unidentified woods at Sweet Home and expresses himself as "completely at a loss to account for them." But in no case has the fossil wood flora, as such, been described.

Geologic Studies as Applied to the Area

The most comprehensive geologic study depicting the stratigraphy, structure, and petrology of the Western Cascade Range is by Peck and others (1964). Their work places the Sweet Home-Holley area in the Little Butte Volcanic Series of Oligocene to early Miocene age. This series of volcanic rocks, which is hundreds of feet thick and wide spread, consists of lava flows and vast amounts of tuff and ash that erupted from local volcanoes over a period of several millions of years. It is in these deposits of tuff and ash that the fossil wood is so abundant.

The plant-bearing rocks interfinger to the west in the vicinity of Brownsville with marine beds of the Eugene Formation, which contains fossil sea shells. Because similar relationships of terrestrial and marine environment occur elsewhere along the eastern margin of the Willamette Valley, geologists have been able to reconstruct the paleogeography of the region and give some idea of what the area looked like between 20 and 30 million years ago. Williams (1953) has shown that the Cascade Range as it appears today was not in existence, but, rather, the region was occupied by large volcanoes, their lower flanks clothed in luxurious vegetation. Rivers whose headwaters may have reached far back into central Oregon flowed westward to the sea.

Snavely and Wagner (1963) provide a geologic map of Oligocene-Miocene time that shows our area to have had a coastal environment located in a large marine embayment extending well into the present Willamette Valley (figure 3). Staples' (1950) discovery of salt crystals replaced by quartz in some of the fossil wood of the Holley area furthers the seacoast theory by showing that the wood was impregnated by salt from sea water before petrification.

There is evidence in the Sweet Home-Holley area to indicate that in later Miocene time the land was elevated and the sea withdrew. Lavas related to the Columbia River Basalt to the north poured out on a surface of hills and valleys that had been eroded in the older rocks. One area occupied by the basalt is at the site of the proposed Holley dam where this resistant rock already forms a natural constriction in the valley of the Calapooia River.

Description of the Collecting Site

The collecting site on the Marker ranch is situated in one of the northern fingers of the reservoir area (figure 2). The site is drained by a small stream that flows southwestward into the Calapooia River. A study of topographic maps (Sweet Home and Brownsville quadrangles) reveals that this small, intermittent creek occupies a well-defined valley (figure 4) which extends from the Calapooia near Holley to the South Santiam near Sweet Home. An explanation for its presence is suggested by Richardson,

(Reprinted from Washington Div. Mines Rept. Inv. No. 22)

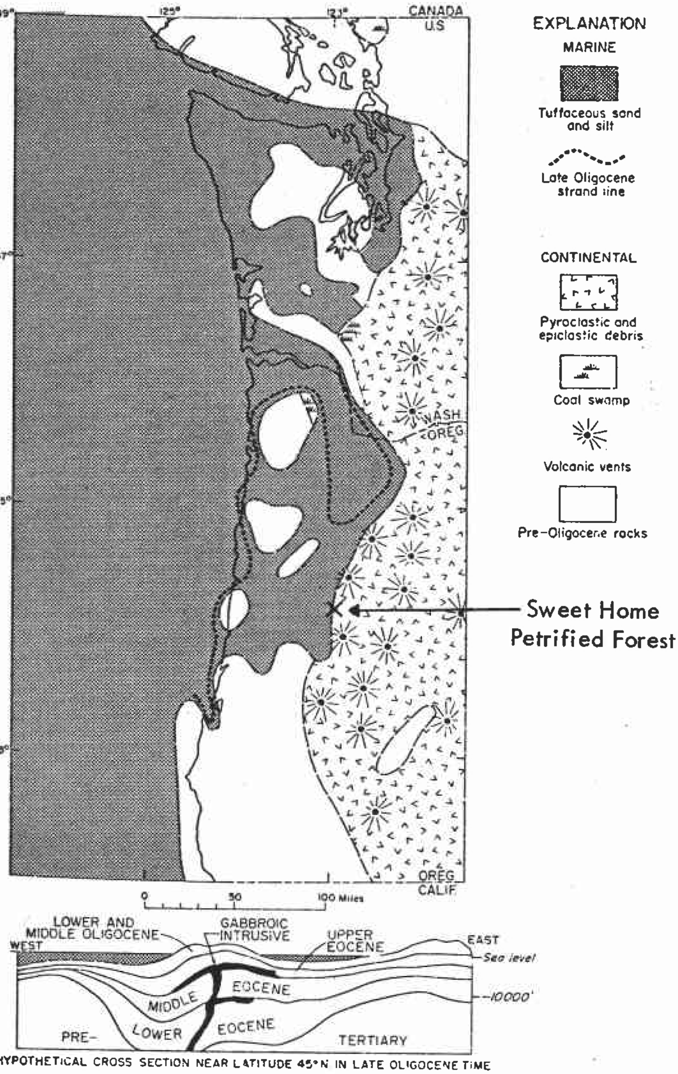


Figure 3. Paleogeologic map of western Oregon and Washington during Oligocene time (from Snavely and Wagner, 1963). Location of Sweet Home Petrified Forest area is indicated.

Figure 4. View looking southeast across valley at Marker ranch. Small body of water is a stockpond.

Figure 5. Layer of fossil wood exposed in bed of creek on the Marker ranch.

who indicates the possibility of either the Calapooia or the South Santiam having flowed through this gap at some time in the past.

The valley floor at the Marker ranch is underlain by a layer of closely packed pieces of fossil wood (figure 5), and it is possible that this layer extends throughout the lower portion of the reservoir area. The margins of the reservoir and the hills above it are composed of volcanic ash and tuff containing an abundance of fossil wood, some of it still standing in place as stumps (figure 6). Erosional processes that carved the valley system apparently removed the particles of ash and tuff that surrounded the wood and left the heavy silicified material behind as a lag product or residual deposit on the floor. The pieces of wood are fairly large and angular and thus have not been carried far. Presumably the trees had already been silicified and fragmented by earth pressures before accumulating as a concentration of alluvium.

The individual pieces of wood at the Marker ranch bear no relationship whatsoever to each other as to species. Theories to explain the anomalous association of varieties are offered below.

Variety of Species

Systematic list

Fifty-four different fossil woods from this small collecting area of about two acres have thus far been identified by the author (table 1). These represent only a portion of the material collected; many additional specimens remain to be thin-sectioned and identified. As a convenience, the commonly used name of each is listed first, followed by the generic name of the most similar extant species together with its family.

Possible sources of specimens

It is at once apparent that the list of identified specimens in table 1 represents members of several types of plant communities, some of which, by the durable nature of even unsilicified wood, may have been transported long distances from their place of growth.

So as a departure from usual paleobotanical form, rather than attempt to reconstruct a picture of the physical growth environment of this fossil flora by separating its component parts into ecological associations as we know them today, we shall instead speculate and theorize as to the possible origins of the species that have accumulated here:

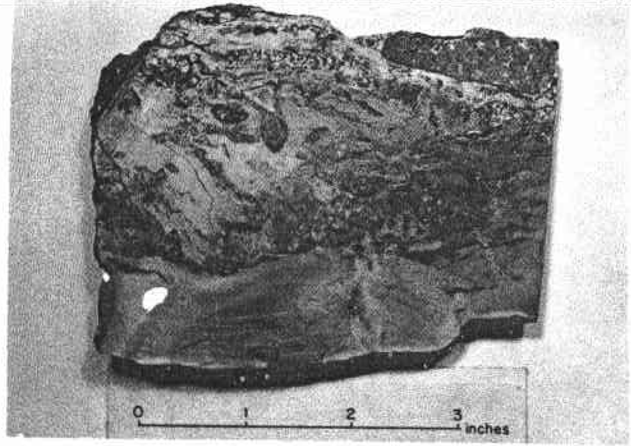
1. Tropical woods present could well represent Eocene species -- remnants of an earlier, warmer climate adapted to the later but still moderate Oligocene seacoast environment of our area, much as palms have adapted today to the climates of England and northern Scotland. Interesting correlations may be noted here with the Goshen flora (Chaney and Sanborn, 1933).

2. Many trees were petrified in situ, having been covered by rapid and repeated falls of ash from erupting volcanoes located nearby and to the east. At present, remains of some stand upright in place in several Sweet Home locations (Richardson, 1950). Notable among these are the sycamores (Platanus), typical stream-bank, bottom-land species. Tops of stumps of a large grove of sycamore trees are visible at ground level in a valley on the McQueen property (on border of sections 7 and 18) where their bases have been covered by material eroded from the surrounding steep

Table 1. Check List of Species Identified.

Common Name	Genus	Family	Common Name	Genus	Family
Pine	Pinus	Pinaceae	Sweetgum	Liquidambar	Hamamelidaceae
Larch	Larix	Pinaceae	Katsura	Cercidiphyllum	Cercidiphyllaceae
Fir	Abies	Pinaceae	Sycamore	Platanus	Platanaceae
Redwood	Sequoia	Taxodiaceae	Cherry	Prunus	Rosaceae
Dawn Redwood	Metasequoia	Taxodiaceae	Honey Locust	Gleditsia	Leguminosae
Incense Cedar	Libocedrus	Cupressaceae	Kentucky Coffee Tree	Gymnocladus	Leguminosae
Cypress	Cupressus	Cupressaceae	Yellowwood	Cladrastis	Leguminosae
Willow	Salix	Salicaceae	South American Cedar	Cedrela	Meliaceae
Cottonwood	Populus	Salicaceae	Entandrophragma	Entandrophragma	Meliaceae
Walnut	Juglans	Juglandaceae	Holly	Ilex	Aquafoliaceae
Hickory	Carya	Juglandaceae	Maple	Acer	Aceraceae
Birch	Betula	Betulaceae	Maple	Acer pseudoplatanus	Aceraceae
Alder	Alnus	Betulaceae	Buckeye	Aesculus	Hippocastanaceae
Bluebeech	Carpinus	Betulaceae	Cascara	Rhamnus	Rhamnaceae
Hazel	Corylus	Betulaceae	Grape	Vitis	Vitaceae
Beech	Fagus	Fagaceae	Sterculia	Sterculia	Sterculiaceae
Chestnut	Castanea	Fagaceae	Schima	Schima	Theaceae
Chinquapin	Castanopsis	Fagaceae	Tupelo	Nyssa	Nyssaceae
Sweet Indian Chestnut	Castanopsis indica	Fagaceae	Dogwood	Cornus	Cornaceae
Oak	Quercus	Fagaceae	Alniphyllum	Alniphyllum	Styracaceae
Elm	Ulmus	Ulmaceae	Persimmon	Diospyros	Ebenaceae
Magnolia	Magnolia	Magnoliaceae	Ash	Fraxinus	Oleaceae
Myrtlewood	Umbellularia	Lauraceae	Devilwood	Osmanthus	Oleaceae
Camphorwood	Cinnamomum	Lauraceae	Cordia	Cordia	Boraginaceae
Sassafrass	Sassafrass	Lauraceae	Reptonia	Reptonia	Myrsinaceae
Trochodendron	Trochodendron	Trochodendronaceae	Catalpa	Catalpa	Bignonaceae
Actinidia	Actinidia	Actinidiaceae	Virburnum	Viburnum	Caprifoliaceae

Figure 7. *Fossilized tree bark that had been riddled by boring insects before petrification. Enlargement (below) of upper left portion shows insect tunnel filled with silicified eggs.*



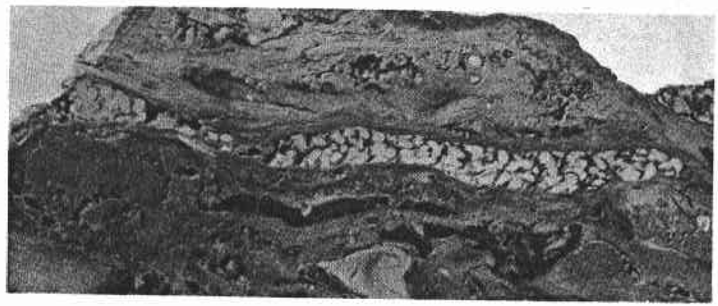


Figure 6. Fossilized stump of a hardwood tree standing where it grew 30 million years ago.

hillsides.

3. Westward-flowing streams, carrying quantities of pyroclastic debris originating from volcanoes to the east, constructed large deltas where they reached the coast. Specimens of fossil wood which show considerable transportation wear might well represent live-woods of the time carried by flooded streams from the interior and deposited as a part of such deltas. Fossil woods of earlier Eocene time, transported and buried in a similar manner, could be present in Oligocene rocks in much the same way that the Cretaceous fern, Tempskya, is found in later Eocene Clarno deposits in in the Greenhorn Mountains of northeastern Oregon. Here the fossilized wood was eroded from the enclosing rocks and redeposited in younger sediments.

4. Asiatic species reported to occur only rarely in Tertiary fossil woods could have arrived as random logs of driftwood by way of the sea. An example of this is Actinidia, not previously reported as a fossil wood and found at Holley thus far as a single specimen consisting of an almost complete trunk section. Logs transported as driftwood from offshore islands of the time (or from unlimited distances in the Eastern Hemisphere) and carried into the marine embayment may have been entrapped in coastal swamps and petrified after burial in stream sediments or falls of ash. Another wood -- the Asiatic genus Schima of the tea family (Theaceae) -- might have had such a source. The absence of branches and twigs and the preponderance of woods representing trees rather than shrubs help give credence to the idea that at least some of the material arrived at the locality as stripped-down, water-worn tree trunks.

5. Many of the specimens collected have inclusions of quartz pseudomorphs after halite crystals. We have found thus far, as did Staples (1950), that the inclusions were contained only in the fossil woods found as float and not in those petrified in place in the area. A collected specimen of Castanopsis indica, or Indian sweet chestnut (Asiatic), whose structure shows it to be a portion of a large tree trunk, is almost completely replaced with quartz pseudomorphs after halite. The distribution of the halite indicates that the solution had access from all sides as in floating and might have been absorbed during a long period at sea.

Preservation of Detail

The process of petrification still remains somewhat of a mystery and scientists are not in agreement as to what actually takes place. A number of mineral substances can cause petrification, but the most common is silica. Silica in ground water infiltrates the buried wood and by some complex chemical process is precipitated within the plant tissues. Cellulose and lignin are often still present in the silicified wood.

Whatever the particular process involved in the petrification of the highly silicified wood at Holley, it has resulted in the preservation of its finest anatomical details to such a degree that in many instances it comes close to being identical with its living counterpart of today. Furthermore, many of the specimens show little, if any, distortion in either shape or size of the structures required for identification. This is of much importance in wood recognition where comparative size of an anatomical feature -- ray width for example -- could be the critical factor in deciding to which genus that specimen should be assigned.

Indeed, so accurate is the preservation that wormholes with castings, insect eggs, grub holes, pitch pockets, dry rot, fungus growths, growth abnormalities of all kinds, plus all manner of the ills and defects that trees may fall heir to, are faithfully reproduced (figure 7). Also preserved are inclusions of gums, crystals, and other foreign substances sometimes found in the cells of living woods. These can be of value

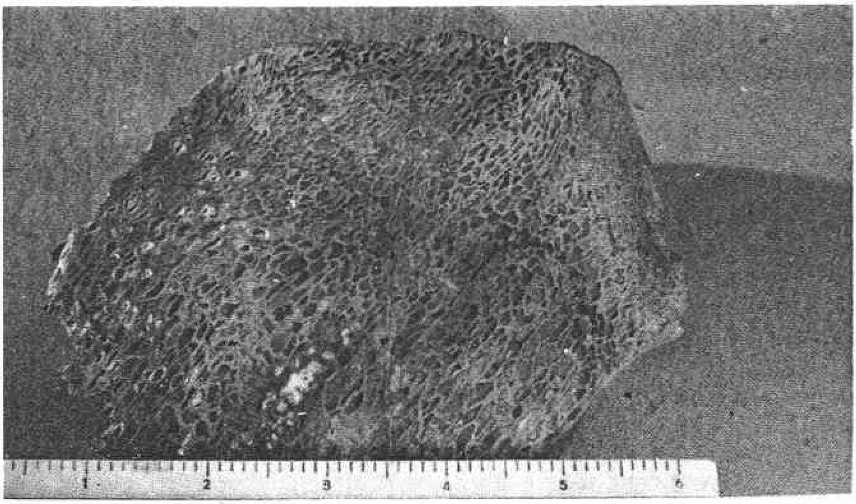


Figure 8. Pocket rot cavities in incense cedar, commonly mistaken for palm wood.

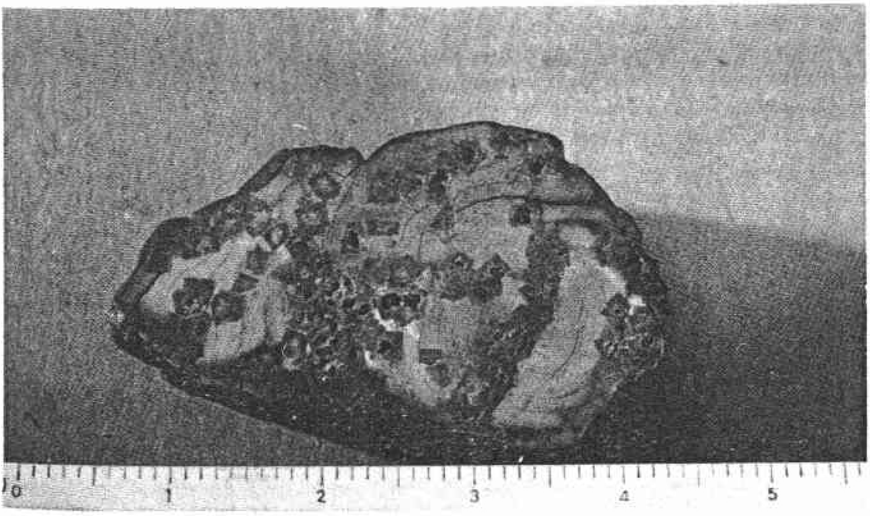


Figure 9. Quartz pseudomorphs after halite crystals in wood that was impregnated by salt water before petrification.

in differentiating one species from another. Honey locust (Gleditsia), for example, has deposits of gum in its vessels, while the wood of the closely related and similar-appearing Kentucky coffee tree (Gymnocladus) does not.

An interesting side light here is the proper identification of so-called "palm-wood" specimens, many of which have been collected in the Sweet Home-Holley area. Figure 8 shows a piece of incense cedar (Libocedrus) riddled with pocket-rot cavities caused by a fungus (possibly Polyporus, which causes such rot in this species of wood today). The empty cavities were subsequently filled with clear silica during petrification. A cut made at an angle across the tube-shaped cavities produces the same "eye" effect that palm wood's vascular bundles do when cut. Examination with a 10x lens will show the "eyes" to be the empty pocket rot cavities, whereas true palm "eyes" will be filled with material having well-defined organized cell structure.

Rarity and Uniqueness

The fossil woods at the collecting site include a number of types seldom reported elsewhere. Among these are the Trochodendron, a vessel-less hardwood of great interest to wood anatomists because of its unique and primitive structure (Hergert and Phinney, 1954). Other rare woods present are Reptonia, Sterculia, Schima, and Actinidia, none of which grow in North America today but which are found as live woods in Asiatic countries. Their presence in the Marker ranch assemblage suggests the probable occurrence of other exotic species among specimens collected by the author but not yet identified.

Among the interesting woods that no longer grow natively in this region are Cinnamomum, the genuine camphorwood of the Orient, and Cedrela, the cigar-box wood of South America.

Adding to the value of the study area is the presence of the quartz pseudomorphs after halite in some of the fossil woods, as described by Staples (1950). This mineralogical oddity is considered to be unique to the Holley area, since no other such occurrence has been reported in the literature.

Conclusions Regarding the Collecting Site

While the original sources of our specimens may remain uncertain, we can be sure that 1) the abundance of fossil wood, 2) the variety of species present, 3) the faithful preservation of minute anatomical details, and 4) the rarity and uniqueness of some have made this collecting area a valued paleobotanical study and research area.

Wood Identification Based on Gross Anatomy

While it must be strongly emphasized that the positive identification of fossil woods (based on thin-sectioning and a microscopic study of their minute anatomy) lies entirely in the realm of the specialist (Eubanks, 1960), the serious hobbyist can achieve much enjoyment and personal satisfaction in tentatively identifying his material on the basis of its gross anatomy with the aid of a 10x hand lens.

In the Tertiary fossil woods of the Pacific Northwest there are many species that had advanced to such a degree that they very closely resemble their living counterparts of today; persons familiar with wood-grain patterns may readily recognize a common live-wood, such as oak, in their fossil materials. In this regard it is helpful to bear in mind that any live-wood "know-how" is quite readily transferable to the fossil material, excepting, of course, the diagnostic qualities of odor, taste, feel, weight, and color. Color in fossil woods derives entirely from minerals present in the host rock during petrification and in no way relates to the species of the wood.

Preparation of specimens

In this more elementary identification process observations and comparisons are made mainly on the transverse (across the grain) view of the wood -- that is, the cut made in sawing off a log for firewood. To compare a fossil wood with a known live-wood, both must be oriented so that a transverse view can be cut (or found, as can often be done with a piece of fossil wood collected in the field). The living wood cells will have been crushed in sawing and will appear "fuzzy" at 10X. To get a clear picutre of the pore and ray pattern, an old-fashioned straight-edged razor which has been well sharpened or an "Exacto-type" woodcarving knife should be used to shave off carefully a thin, even horizontal layer on just a small area of the cut surface of the wood. A half-inch square will generally be ample. This surface should then provide a clear, uncrushed view of the wood cells. Avoid a sloping cut into the wood, which will give a distorted, untrue wood-grain pattern. Moistening the cut surface will sharpen the details in some live-woods, but will blur others. Both methods should be tried.

The fossil wood, cut by rock saw (or as found), can be studied more easily if it is sprayed lightly with any of the transparent plastic finishes available today. Even hair-spray will suffice. Often a well-preserved petrified wood specimen will have a weathered or naturally bleached outer surface that will give a much clearer picture of its structure than will the inner cut surface. For this reason it is well to work with a "heel" of material, where both cut and natural surfaces are available for viewing.

Comparing specimens

The wood specimens should be held so that a good light falls on the cut surface. Hold the lens close to the eye and gradually bring the cut surface up toward the lens until the cell structure is clear and in focus. At this point the fossil wood must be examined painstakingly over its whole surface to find the area where the vessel (hole) and ray (line) pattern is clearest and appears "normal" as compared to live-woods. A pitfall to watch here is that during petrification sometimes either vessels or rays or both may have faded out or have become extremely distorted as to size. This can lead to much confusion on the part of the novice and expert alike, and points up the necessity for painstaking examination to locate what seems to be the most "true-to-life" appearing section of the specimen.

The same kind of comparison with a specimen of correctly identified fossil wood is another way to track down the kind of wood involved.

Use of Photomicrographs in Wood Identification

Perhaps the most valuable tools in wood identification are photomicrographs of the anatomy of selected wood specimens chosen because they so well typify that particular species. However, such material is generally not available in any significant quantity. Thus, we are fortunate in having obtained permission to reproduce a series of such photomicrographs from Bulletin 26, "An Atlas of End-grain Photomicrographs

PLATE 1.

(Furnished by Forest Products Research Laboratory, London, England.)

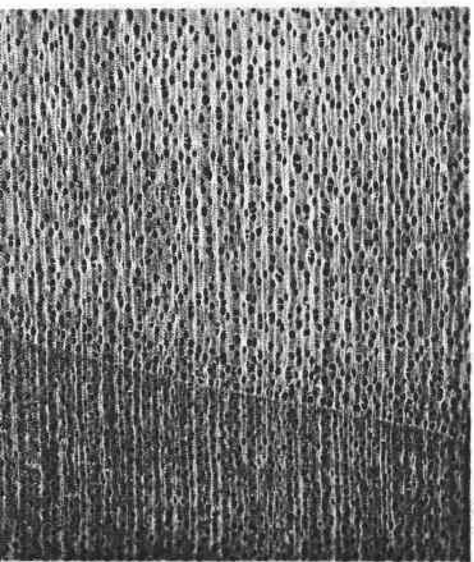


Figure a: Salix
Willow

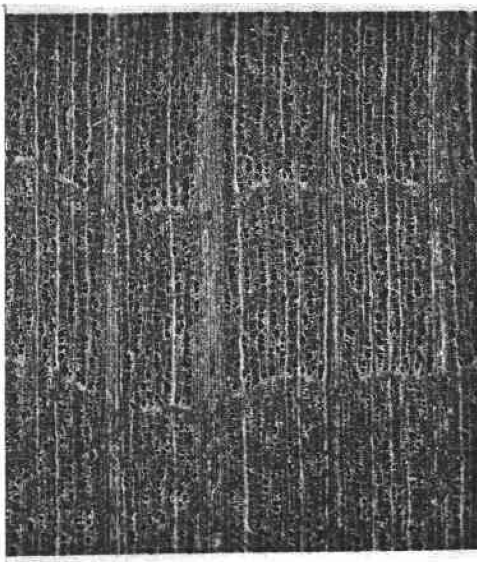


Figure b: Carpinus
Hornbeam

(All photographs 10 x)

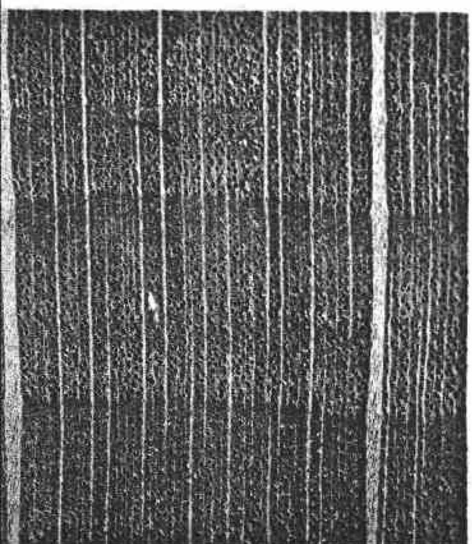


Figure c: Fagus
Beech

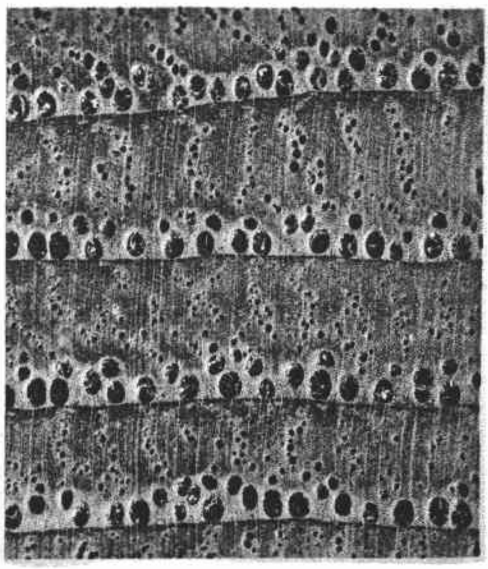


Figure d: Castanea
Chestnut

PLATE II.

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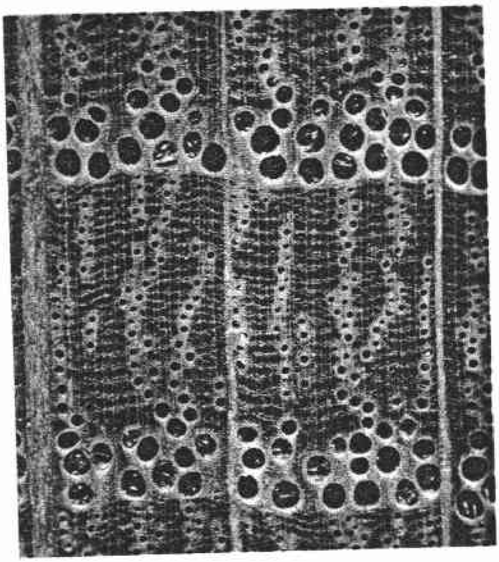

Figure e: Quercus
Oak

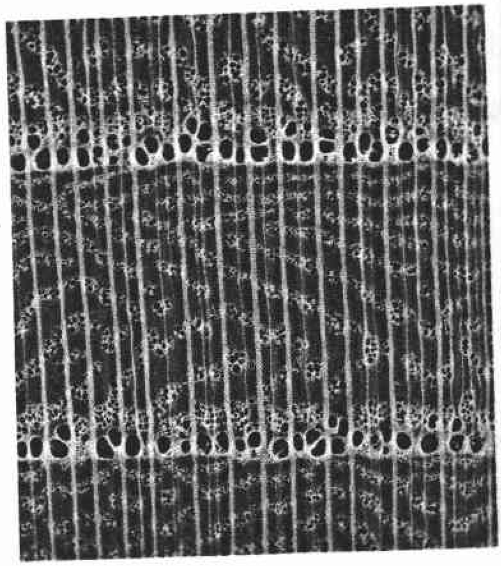

Figure f: Ulmus
Elm

(All photographs 10 x)

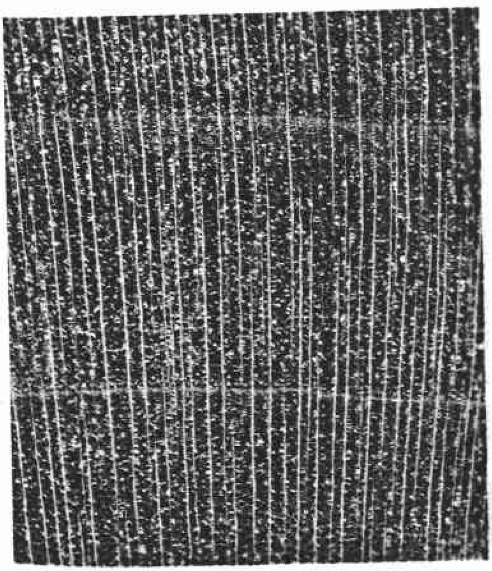

Figure g: Magnolia
Magnolia

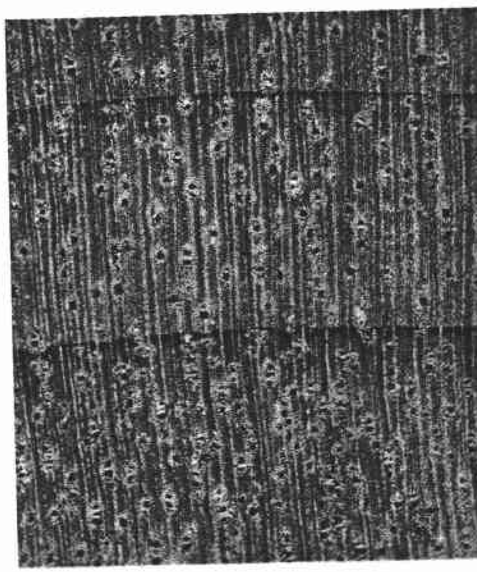

Figure h: Umbellularia
Myrtlewood

PLATE III.

(Furnished by Forest Products Research Laboratory, London, England.)

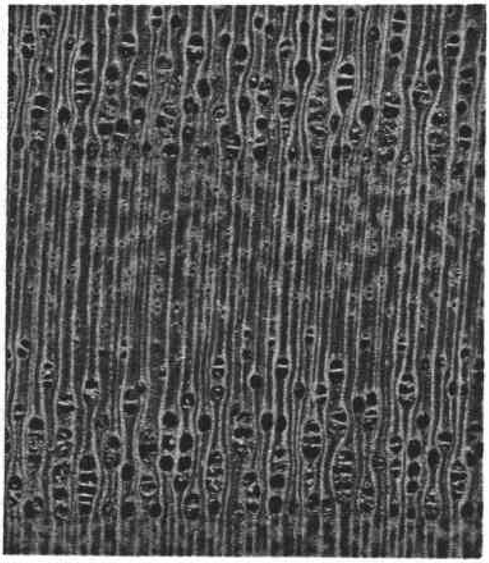

Figure i: Sassafras
Sassafrass

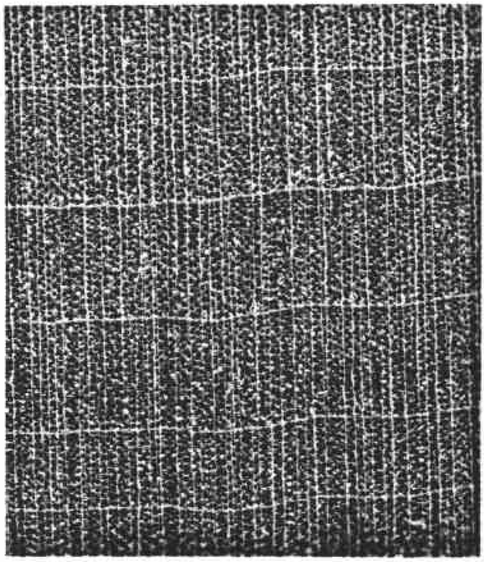

Figure j: Cercidiphyllum
Katsura

(All photographs 10 x)

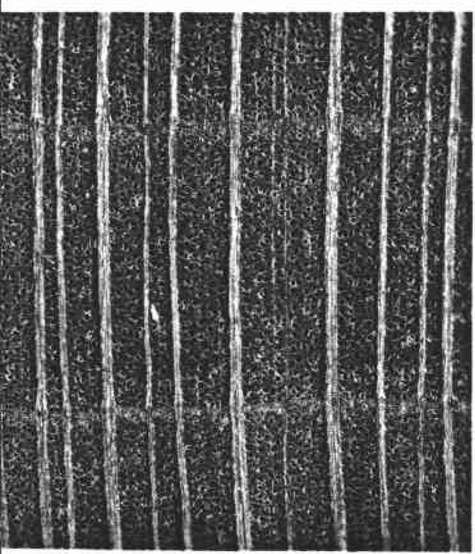

Figure k: Platanus
Sycamore

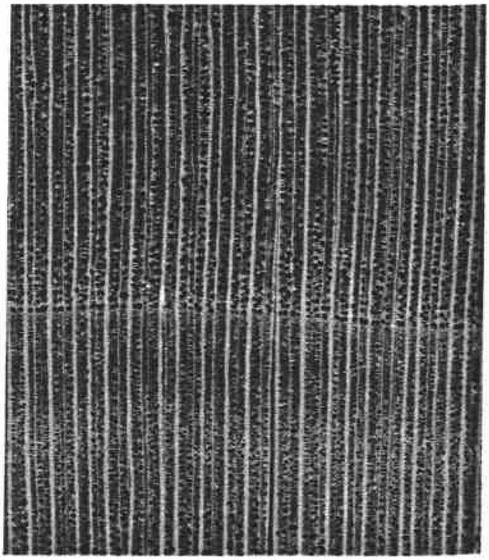

Figure l: Prunus
Cherry

PLATE IV.

(Furnished by Forest Products Research Laboratory, London, England.)

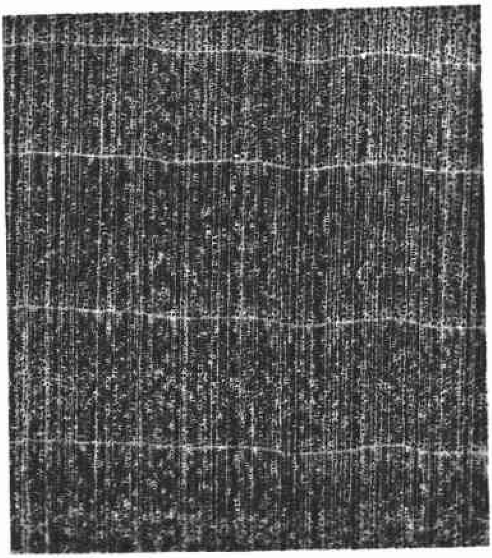

Figure m: Aesculus
Buckeye

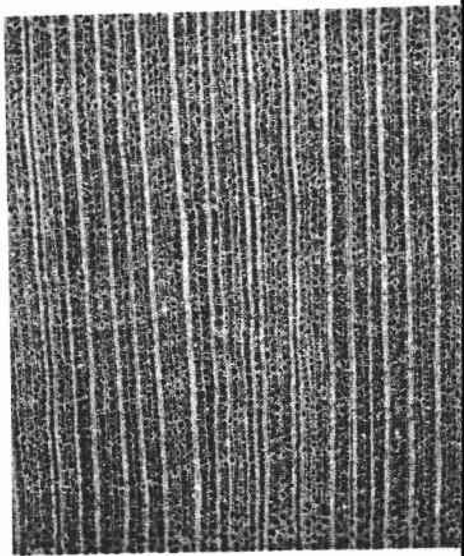

Figure n: Cornus
Dogwood

(All photographs 10 x)

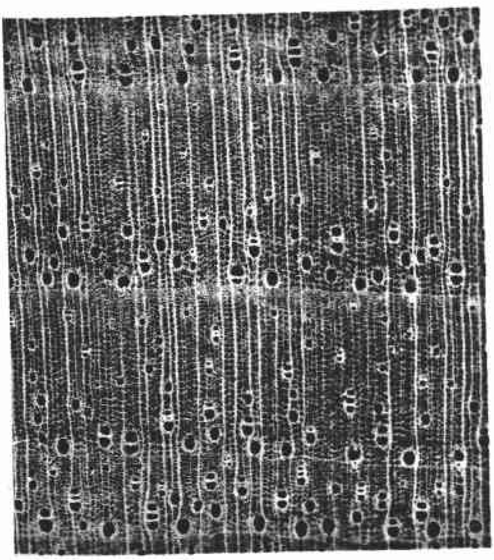

Figure o: Diospyros
Persimmon

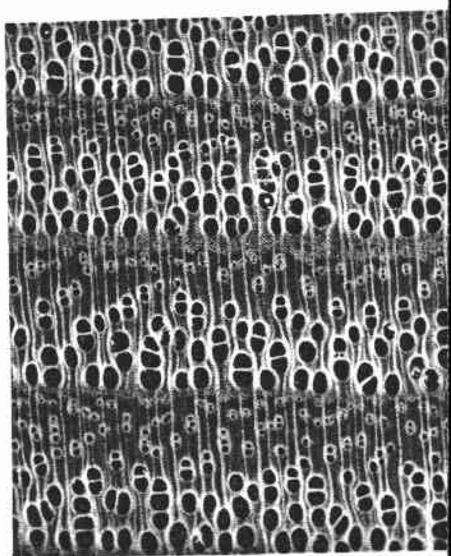

Figure p: Fraxinus
Ash

for the Identification of Hardwoods" prepared by Forest Products Research Laboratory, England (plates 1 through 4). The species illustrated represent familiar live-woods of today which have been found as fossil woods at the Holley collecting area and in other Pacific Northwest Tertiary petrified wood deposits.

Close examination of petrified specimens might well disclose the presence of any of these woods in individual collections. A similar cut of the same species of live-wood, if available, prepared for viewing as described above and combined with its matching photomicrograph will provide an invaluable basis for identifying a similar fossil specimen.

Features to observe

In such a comparison based on gross anatomy, the aim is to learn to recognize over-all grain patterns. The 10-power lens mentioned is most suitable for this, since a higher power will enlarge and blur the condensed design or pattern we wish to recognize.

The patterns are based on varied arrangements of pores or vessels (which appear as holes) and rays (lines of cells running like a radius from the bark toward the center of the tree).

Growth rings

Most woods show concentric circles on cross-section. These rings indicate annual growth, and are distinct in woods where the cell size varies greatly at different times of the year. Early spring wood will have large, fast-growing cells; later, slow-growing summer wood cells are small and dense. In tropical climates woods do not usually show distinct annual rings, since growth rate is constant throughout the year and each year's growth merges into the next with little perceptible change in cell size. This is an interesting feature to watch for in fossil woods.

Porous and nonporous woods

Other points to notice are the difference between woods with no pores (nonporous), which includes most coniferous or "needle-trees," which are also called "softwoods," and woods with pores (porous), which generally include the "hardwoods."

The porous woods or hardwoods can be further divided into ring-porous woods in which the larger spring pores form a well-defined band at the annual growth ring, as sassafrass and ash, and diffuse-porous woods, in which the pores are distributed evenly throughout the growth ring, as magnolia and katsura.

Pore arrangements

Also significant are pore arrangements. They may be grouped in many ways -- in clusters, in groups of two or three, in straight or radial chains (chestnut), in slanting chains called echelons and in many other ways. In conifers scattered resin canals may sometimes occur. On cross section these appear to be extra large "pores," but are actually canals running vertically along the grain.

Rays

Rays appear as straight lines on the transverse surface, varying in width from heavy (oak) to too fine to be seen with the naked eye. Comparative width of rays is often a diagnostic feature. Sycamore, with broad rays of generally uniform width, can thus be differentiated from beech, whose broad rays are fewer and separated by groups of distinctly narrower width.

Parenchyma

Soft tissues (parenchyma cells) are short, thin-walled cells not usually distinguishable individually with a hand lens. But collectively they form innumerable varied patterns that are useful in identifying woods. Persimmon is characterized by a fine, net-like or reticulate parenchyma pattern. Myrtlewood can be verified by its typical "halos" formed by parenchyma cells that encircle each pore. Straight and wavy bands of varying widths running crosswise to the rays frequently occur. Terminal parenchyma at the annual growth ring is a feature of other woods, such as magnolia, where it appears as a light line easily visible to the naked eye. Many other types and combinations of types occur.

Forestry and botany texts will provide detailed information and references on wood anatomy, nomenclature, and classification of plants that may be applied to fossil wood. Paleobotanical texts such as "Ancient Plants and the World They Lived In" (Andrews, 1964) often carry sections with brief botanical summaries expressly written to provide the necessary basic information needed for venturing into the field of fossil plant life.

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GEOLOGY OF WILDLIFE REFUGE AREAS PUBLISHED

Studies related to Wilderness-Wildlife Refuges by the U.S. Geological Survey and the U.S. Bureau of Mines (under the Wilderness Act of September 1964) have resulted in publication of brief reports on the geology of several areas in Oregon, as indicated below. Issued under the Survey's Bulletin series, each report contains the available geologic information on the area, illustrated by maps and photographs.

Bulletin 1260-F, G, H (in one volume):
Summary on the geology and mineral resources of the Flattery Rocks, Quillayute, Needles, and Copalis National Wildlife Refuges, Washington; Oregon Islands National Wildlife Refuge, Oregon; and Three Arch Rocks National Wildlife Refuges, Oregon; by A. E. Weissenborn and Parke D. Snavely, Jr.

Bulletin 1260-L, M (in one volume):
Summary report on the geology and mineral resources of the Harney Lake and Malheur Lake areas of the Malheur National Wildlife Refuge, north-central Harney County, Oregon; and Poker Jim Ridge and Fort Warner areas of the Hart Mountain National Antelope Refuge, Lake County, Oregon, by G. W. Walker and D. A. Swanson.

Both booklets are for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Bulletin 1260-F, G, H is 55 cents; Bulletin 1260-L, M is 20 cents.

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ASHLAND MILL REACTIVATED

The 50-ton gravity mill at the old Ashland mine has been revamped by the Ashland Development & Mining Co., Inc., and ore from an outcrop on the ridge above the workings is being milled. The work is being conducted under the supervision of Tom Brown, mine superintendent.

The Ashland mine has a history that dates from the 1890's. Total production, mainly in gold, has been estimated to amount to $1,300,000, with the bulk of the gold produced at the "old" pre-1934 price. Underground workings include tunnels, shafts, and raises having a total of 11,000 feet of development. The vein is explored to a depth of 1200 feet on the dip.

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OSU NAMED FOR SEA GRANT

Oregon State University has been named by the National Science Foundation as one of the first three universities in the nation to receive sea-grant awards for broad-based programs of training, research, and advisory services related to the sea. The other two are the University of Washington and the University of Rhode Island.

OSU's sea-grant efforts will include marine fisheries, agriculture, seafood-processing, marine minerals and mining, marine economics, ocean engineering, and oceanography.

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BAUXITE EXPERIMENTS CONDUCTED AT ALBANY

"Recovery of Alumina and Iron from Pacific Northwest Bauxites by the Pedersen process," by O. C. Fursman, H. E. Blake, and J. E. Mauser, at Albany Metallurgy Research Center, U.S. Bureau of Mines, has been issued by the bureau as Report of Investigations 7079. The report gives results of research in the bureau's continuing program to develop economic methods for producing aluminum from domestic low-grade resources. Experiments carried out on Salem Hills bauxite and using the Pedersen process were successful in recovering more than 90 percent of the alumina.

R. I. 7079 is available free of charge from the Publications Distribution Branch, Bureau of Mines, U.S. Department of the Interior, 4800 Forbes Ave., Pittsburg, Pa., 15213.

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INDUSTRIAL USE OF GOLD GROWS RAPIDLY

The growing use of gold in industry often tends to be overlooked because of the metal's exclusive association with currency. Total world gold production has increased by about 15 percent since 1940. In the same period, however, United States industrial consumption alone has increased by more than 500 percent. This indicates the likely future trend of gold consumption by industry.

Gold is currently used in the chemical, textile, electrical, ceramic, instrument and space industries. Also, it is used in medicine and dentistry, for such things as spinnerettes, thread, contacts, resistance wire, pottery decoration, photo-sensitive glass, missiles and satellites, transistors, and computers. (From "News from South Africa," March 27, 1968.)

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OREGON LUNAR ROCKS ANALYZED

"Simulated Lunar Rocks" by David E. Fogelson, U.S. Bureau of Mines, is a 51-page report on the engineering properties and petrography of a suite of rocks selected for use by the bureau in its extraterrestrial resource utilization studies. The work was performed at the bureau's Twin Cities Mining Research Center, Minneapolis, Minn.

The group of 14 materials studied consisted of a wide range of volcanic rocks, including rhyolite, dacite, basalt, and pumice. In addition, two ultramafic rocks (dunite and serpentine), a gabbro, and a granodiorite were selected in order to complete the range of the moon's possible surface composition.

Out of the 14 samples chosen for the research, 9 volcanic rocks came from the Bend-Madras-Newberry region of central Oregon and 2 ultramafic rocks from southwestern Oregon. The State of Oregon Department of Geology and Mineral Industries assisted in the project by collecting much of the Oregon material.

In addition to its lunar research applications, the publication is of interest to geologists wanting detailed chemical, physical, and petrographic information on some of Oregon's rocks. A copy of the booklet may be consulted at the Department's library.

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ADEQUACY OF MINERAL SUPPLY THREATENED

The Subcommittee on Minerals, Materials, and Fuels of the Senate Interior Committee held hearings March 21 on mineral shortages and problems. Walter R. Hibbard, Jr., retiring director of the U.S. Bureau of Mines, presented testimony that drew "attention to a situation that is emerging which appears to threaten both the adequacy and dependability of our supply of minerals and mineral fuels." This was the conclusion of a long-range study initiated by the bureau a year ago. Nine categories of essential issues have been developed and defined during the study. According to Hibbard, the three most important are:

Maintaining an adequate mineral capability -- The United States will find it increasingly difficult to compete with foreign ores unless technology improves.

Insuring essential overseas supplies -- Access to world supply must continue to be sought through mutually advantageous agreements with friendly nations.

Accommodating to changing end-use patterns -- We must develop effective techniques for recognizing the events that foretell significant changes in demand patterns.

In Hibbard's opinion, "The successful application of technology to meet the mineral demands of the future is the most recurring theme in the appraisals of the projected supply-demand relationship." Also, foreign investments and mergers will have "far-reaching implications" on the future of U.S. mineral policy and should be taken into account in any future planning.

Hibbard concluded by stating that information is now available on which to base a minerals policy. He recommended a high priority for looking at the situation in depth and for formulation of policy. (American Mining Congress News Bulletin, for March 29, 1968.)

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TREASURY AMENDS GOLD REGULATIONS

Pursuant to agreements announced by the central banks of Belgium, Germany, Italy, the Netherlands, Switzerland, the United Kingdom, and the United States on March 17, 1968 in Washington, D.C., the Treasury Department has issued amendments of the Treasury gold regulations effective immediately.

The Treasury will no longer purchase gold in the private market, nor will it sell gold for industrial, professional, or artistic uses. The private holding of gold in the United States or by U.S. citizens and companies abroad continues to be prohibited except pursuant to existing regulations.

The gold regulations have been amended to permit domestic producers to sell and export freely to foreign buyers as well as to authorized domestic users. Authorized domestic users regularly engaged in an industry, profession, or art in which gold is required may continue to import gold or to purchase gold from domestic producers within the limits of their licenses or authorizations in the regulations.

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TITANIUM SYMPOSIUM TO BE HELD JUNE 12

Oregon's role as a leader in the rare and refractory metals industry will bring to Portland national authorities in the field of metallurgy for a one-day symposium on titanium, June 12, at the Sheraton Motor Inn.

With the theme of "The challenge of titanium," the symposium is being sponsored by the Economic Development Division of the Oregon Department of Commerce, under the State Technical Services program. Cooperating with the EDD are the American Society for Metals and the American Institute of Mining and Metallurgical Engineers.

Leading authorities in the metals field who will be speaking at the symposium are listed below in the general program, together with the subject of their talks.

The first speaker of the morning will be G. J. Arnold, general manager of the advanced materials division of Armco Steel Corp., Baltimore, Md., who will talk on the economic outlook. He will be followed by Robert Bealle, project coordinator of the U.S. Bureau of Mines, Albany, Oregon, for a discourse on titanium casting in Oregon. Other morning speakers will be J. G. Wenzel, ocean systems manager of the Lockheed Missile and Space Division, Sunnyvale, Cal., whose subject will be hydrospace, and Stewart Paterson, production project chief of the SST Division of the Boeing Co., Seattle, Wash., with a topic of aerospace.

"The Albany Story" will be the subject of the keynote address, which will be delivered at the luncheon by Dr. Earl T. Hayes, Deputy Director of the U.S. Bureau of Mines, Washington, D. C.

The afternoon program will be opened by George Glenn, assistant chief of the Metallurgical Processing Branch, Manufacturing Technology Division, Air Force Materials Laboratory, Wright-Patterson Air Force Base, Dayton, Ohio, with a talk on the application of titanium in aircraft engines, past, present, and future. He will be followed by Robert Kane of the Application and Development Center, Titanium Metals Corp., West Caldwell, N.J., whose subject is to be the uses of titanium in the chemical process industries.

The final speaker of the afternoon will be Dr. Robert Jaffee, chief of the metal science department of Battelle Memorial Institute, Columbus, Ohio, who will address the meeting on titanium in the U.S. and the U.S.S.R., a contrast of titanium base alloys.

The afternoon's program will close with a social hour for which the following firms will be hosts: Rem, Inc., TiLINE, Inc., Oregon Metallurgical Corp., Wah Chang Albany Corp., OMARK Industries, Inc., Precision Castparts Corp., and ESCO Corp.

Further information on the symposium can be obtained from P. Anthony Michaelson, Technical Services Coordinator, EDD, 560 State Office Building, Portland, Oregon, 97201.

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HOW HIGH IS MOUNT HOOD?

A 10-foot discrepancy has been discovered in the elevations shown for the summit of Mount Hood on two U.S. Geological Survey topographic maps. The correct elevation, 11,235 feet, appears on the $7\frac{1}{2}$-minute Timberline Lodge topographic map. On the state base map published at a scale of 1:500,000 the elevation is shown as 11,245. The 11,235 figure was determined in 1958.

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