Types of Pitting in Conifers

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This survey is an exposition of those types of pitting which, by virtue of their predominant occurrence in certain taxonomic groups, are regarded as typical. The work is largely compiled from existing literature so organized as to be useful in the diagnosis of coniferous woods. The terms are largely those encountered in the literature, supplemented by certain tentative terms. To select and test those types worthy of recognition, approximately 140 specimens of 95 species, embracing 35 genera, have been examined and have furnished the illustrations. The inexperienced wood diagnostician is cautioned to use these type-characters only in combination with others, owing to the great variability in the anatomy of individual specimens. The classification of Pilger[1] and the anatomical terminology approved by the International Association of Wood Anatomists[2] are employed throughout.

SURVEY OF TYPES*

Tracheids

Abietinean.—This is a condition featured by opposite pitting on the radial walls of the deep[3] tracheids of early wood, passing to uniseriate arrangement in the remainder of the growth ring (Fig. 1). The pit borders of opposite pit-pairs are isodiametric and often somewhat compressed at the contiguous edges. Low magnifications suggest vertical crassulae (bars of Sanio) at these lines of juncture, which are shown to be illusions when a higher magnification is employed (Fig. 2). The pit borders of uniseriate pit-pairs present a wider face view and approximately the same height as do those of opposite pitting. Abietinean pitting occurs typically in the Pinaceae, with slight modification in most of the remaining conifers. The exceptions will be noted below as distinctly different types.

Araucarian.—The Araucariaceae are distinguished from all other conifers in two important features of tracheid pitting. These are briefly enumerated as, (1) absence of crassulae, and its corollary, (2) various arrangement of pit-pairs (Fig. 3). Pit-pairs are often crowded in such fashion as to present pentagonal or hexagonal margins of the pit borders. Often they are arranged in horizontal rows, but alternate vertically; quite as often they may be in vertical rows, horizontally alternate. Or they may have a two-dimensional symmetry or none whatever. Within the family, the preponderant number of vertical rows per tracheid may be used as a distinction.

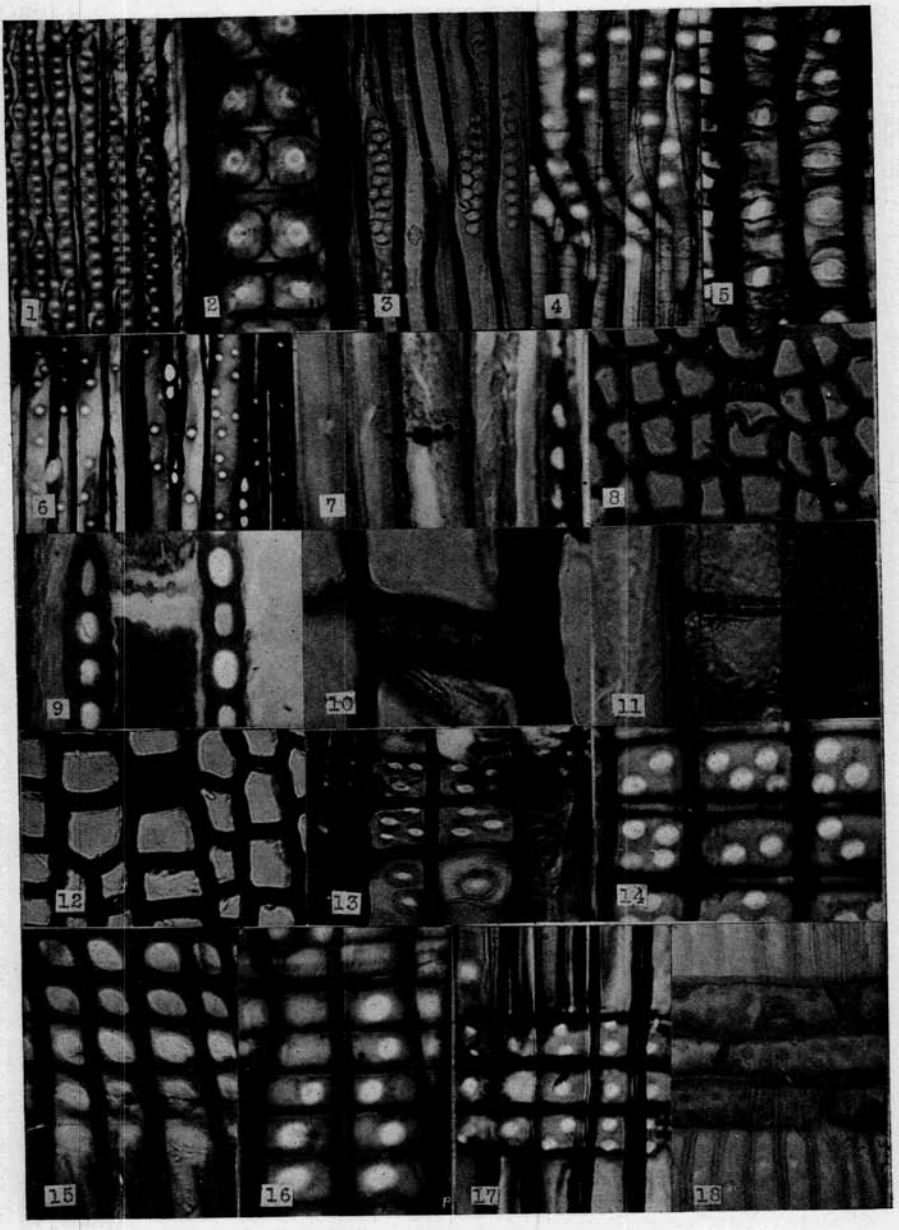
Taxinean.—This type is characterized throughout by the occurrence of slender spiral bands of secondary thickening in the tracheid walls (Fig. 4). Bordered pit-pairs are uncrowded and almost without exception uniseriate; the spirals often traverse the borders of the pit-pairs above and below the pit aperture. This type of tracheid sculpture occurs in the Taxaceae and

* Thanks are due Dr. John T. Buchholz for valuable criticism, the Yale School of Forestry for the greater portion of the materials, and the Field Museum of Chicago for the remaining specimens.

[1] Engler and Prantl. 1926. Die Natürlichen Pflanzenfamilien, Band 13.

[2] Committee on Nomenclature, International Association of Wood Anatomists. 1933. Glossary of terms used in describing woods. Tropical Woods 36:1-12.

[3] The radial dimension of tracheids is referred to as "depth", to distinguish from the tangential "width".



1. *Pseudolarix kaempferi* (Lind.) Gord. Radial, x100.
2. The same. Radial, x500.
3. *Araucaria excelsa* (Lamb.) R. Br. Radial, x125.
4. *Taxus brevifolia* Nutt. Radial, x250.
5. *Callitris glauca* R. Br. Radial, x400.
6. *Fokienia macluret* Merill. Tangential, x150.
7. *Juniperus virginiana* L. Tangential, x450.

Cephalotaxaceae, where it may be used diagnostically on the basis of thickness and frequency of spirals. Similar spirals occur in *Pseudotsuga* and in some species of *Picea*.

Callitris.—The tracheids of most species of *Callitris* possess peculiar secondary thickenings which are superposed upon the upper and lower portions of the pit border. These thickenings are slender bands resembling the spirals of *Taxus* in structure. However, they are isolated bands and often lend the appearance of shielding the pit border, since they do not traverse the pit aperture but are convergent at the outer margins (Fig. 5). Distinctions within the genus may readily be made on the basis of this character.

Tangential.—In every observed specimen the tangential walls of late wood tracheids have been found to possess bordered pit-pairs (Fig. 6). These are usually smaller than the radial pit-pairs of earlier wood and are isodiametric. The pit aperture is quite small, elliptic, and its long diameter is inclined slightly from the vertical. In section the border exhibits the bluntness characteristic of all bordered pit-pairs formed in thickened tracheid walls of late wood.

Wood Parenchyma Transverse Walls

Juniperus.—The transverse walls of wood parenchyma cells show three distinct variations in the matter of pitting. One of these is found in some species of *Juniperus* and consists of a rather thin wall with delicate knobs of secondary thickening (Fig. 7). The transverse view shows distinctly the communicatory nature of these simple pit-pairs (Fig. 8). This character is intrageneric in the Cupressaceae.

Taxodium.—In this type the transverse walls of wood parenchyma cells are considerably thicker and possess correspondingly coarser thickenings (Fig. 9). The transverse view is somewhat similar to that of the *Juniperus* type, although the characteristic coarseness may still be noted (Fig. 10). A considerable degree of constancy renders this character of diagnostic value among the genera of the Taxodiaceae.

Cupressus.—This type is featured by absence of pitting rather than by any peculiarity in pit-pairs (Fig. 11). The transverse walls are moderately thick and devoid of the knob-like structures described above. This conclusion is borne out by observation of transverse (Fig. 12) and radial sections as well. This is also a useful character, since it may be used generically as well as within certain genera of the Cupressaceae.

Xylem Ray Crossfield[4]

Taxodineae.—This type is characteristic of the Taxodiaceae, with few exceptions. The relatively deep tracheids produce a wide crossfield, with the result that generally from two to four pits are formed abreast. In usually high ray cells, therefore, there may be eight pits in a crossfield. The pit aperture is large and elliptic, ranging from horizontal to

[4] That area of a tracheid wall delimited by the walls of a crossing ray cell.

8. The same. Transverse, x400.
9. *Taxodium distichum* (L) Rich. Tangential, x350.
10. The same. Transverse, x500.
11. *Fitzroya cupressoides* (Molina) Johnston. Tangential, x550.
12. The same. Transverse, x825.
13. *Sequoia gigantea* (Lindl.) Dec. Radial, x325.
14. *Glyptostrobus pensilis* Koch. Radial, x325.
15. *Podocarpus nagi* (Thunb.) Zoll et Moritzi. Radial, x325.
16. *Sciadopitys verticillata* Sieb. et Zucc. Radial, x850.
17. *Juniperus ashei* Buchholz. Radial, x450.
18. *Cupressus macnabiana* Murr. Radial, x300.

slightly inclined; the pit border is regularly circular (Fig. 13). The width of the border above and below the center of the aperture approximately equals the short diameter of the aperture.

Glyptostroboid.—This is a modification of the *Taxodinean* type in that the aperture is larger and the border correspondingly narrower (Fig. 14). The border occasionally appears as an extremely thin "halo," and in the earliest wood purely simple pits are found. This type is characteristic of *Glyptotsrobus* and may be found sparingly among other genera of the Taxodiaceae.

Podocarpoid.—In the podocarps the prevalent type of crossfield pitting consists of irregular pits, simple in early wood and elliptically bordered in late wood with a distinct gradient occurring through the year's growth. The predominant form is ovoid, very seldom occurring in excess of two in a crossfield (Fig. 16). They resemble greatly the simple pits of the *Glyptostroboid* type, and occur as most typical in early wood.

Sciadopityoid.—The pits occurring on the crossfields of *Sciadopitys* are the logical choice for discussion at this point. The crossfield of early wood bears one large simple egg-shaped pit-pair (Fig. 15). The gradient in this type shows a decrease in border size accompanied by a greater decrease in aperture size. The late wood pits possess a long narrow aperture approaching the vertical, and a still rather broad elliptic to circular border. The form of the early wood pits have no parallel among conifers, the closest approximation being the ray parenchyma pits found in white pines.

Cupressinean.—The last of the distinct crossfield pitting types to be discussed here is that found in general among the Cupressaceae. This is perhaps a less definite type than those preceding. Those pits considered as typical are small, occurring from one to two (occasionally four) in a crossfield (Fig. 17). The pit borders are usually circular throughout the year's growth and the apertures are characteristically slit-like, ranging from oblique to vertical, even in the early wood.

Xylem Ray Tangential Walls

Juniperoid.—The pitting on tangential walls of ray cells falls into two general types. The first of these is termed "*Juniperoid*" and is of frequent occurrence in the Cupressaceae, where it may be employed generically as well as within certain genera. The walls exhibiting this type of structure range from very delicate to moderately thick, and are equipped with knob-like thickenings similar to those described for the transverse walls of wood parenchyma (Fig. 17). No attempt is made here to separate this feature into two types according to coarseness.

Cupressoid.—The second general type of tangential ray cell wall is smooth and entire (Fig. 18). The walls showing this condition may vary considerably in thickness in different species, while remaining moderately constant within species, illustrating the diagnostic possibilities of this character.

SUMMARY

Illustrated descriptions are given of various moderately constant "types" of conifer pitting. Among these are four conditions occurring on radial walls of tracheids, three occurring on transverse walls of wood parenchyma, five on crossfields, and two on the tangential walls of ray cells. The descriptions are accompanied by the general distribution and potential diagnostic value of the types. Care should be taken to use these characters only in combination with others, because of great variations in wood anatomy.