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**Effects of Environmental Factors on Wood Decay
Micromorphology of *Pinus radiata* and *Fagus sylvatica*, and
its Significance for In-ground Wood Preservative
Performance – Volume II (Appendix 4)**

**A thesis submitted in partial
fulfilment of the requirements for the
Degree of Doctor of Philosophy in
Biological Sciences**

at

The University of Waikato

by

Robin Nicholas Wakeling



May 2003

List of Micrographs and Diagrams

A list of all tables, figures and photographs for chapters 1, 2, 3, 5, 6 and 7 is presented in Volume I.

Section 4.5

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Section number in brackets refers to section in Volume I that discusses micrographs.

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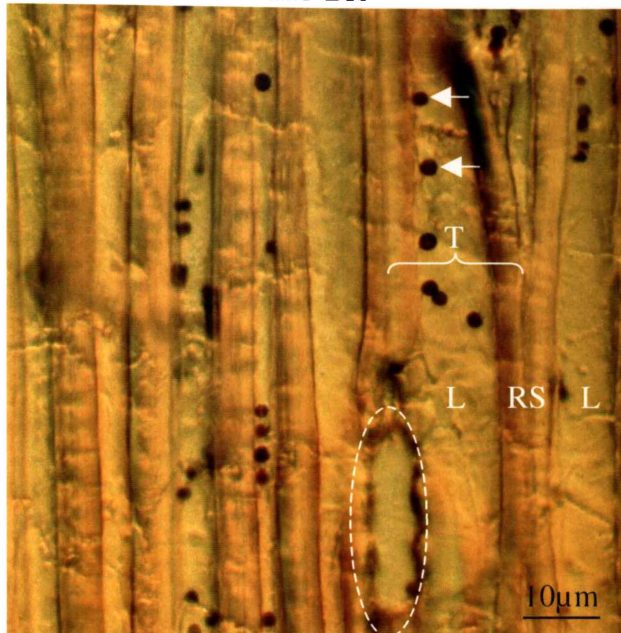
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Section 4.5
Micrographs of Decayed Wood

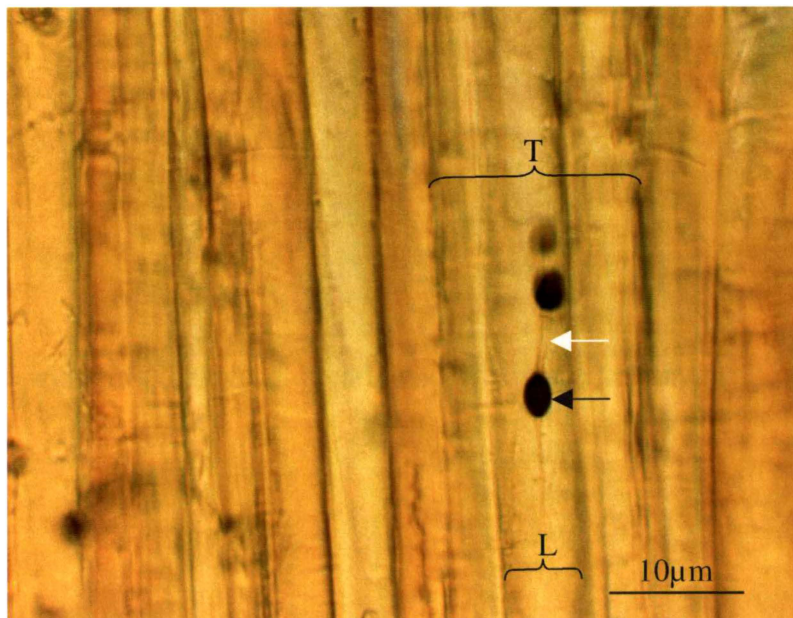
Section 4.5.1
Brown Rot (BR)

M1-BR



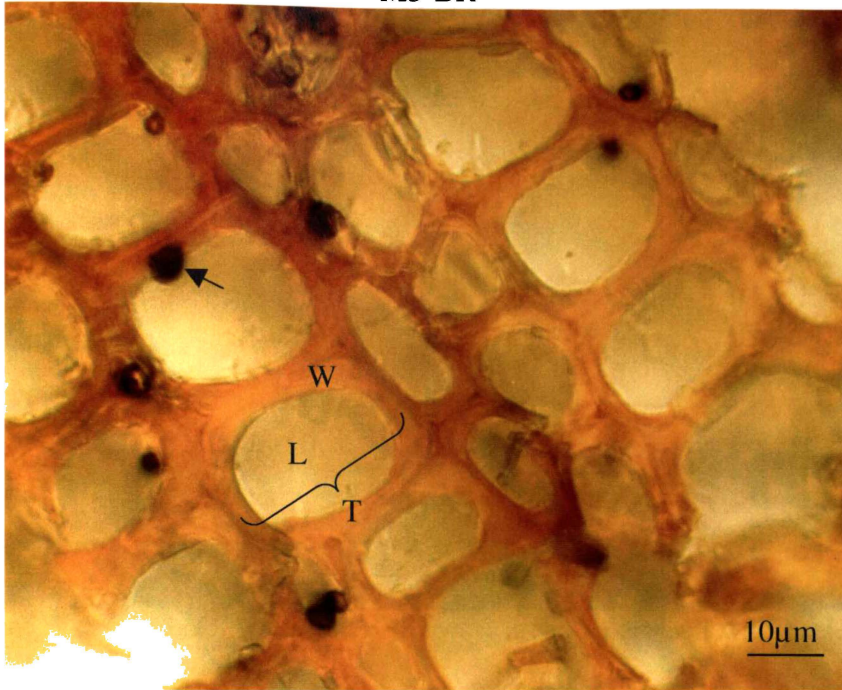
T = width of a single pine tracheid (late wood); RS = radial section through pair of adjacent tracheids; L = cell lumen; arrow = chlamydospores; area within dotted line = void left after removal of parenchyma cells.

M2-BR



T = width of a single pine tracheid (thick-walled late wood); black arrow = chlamydospore; white arrow = hypha; L = lumen.

M3-BR



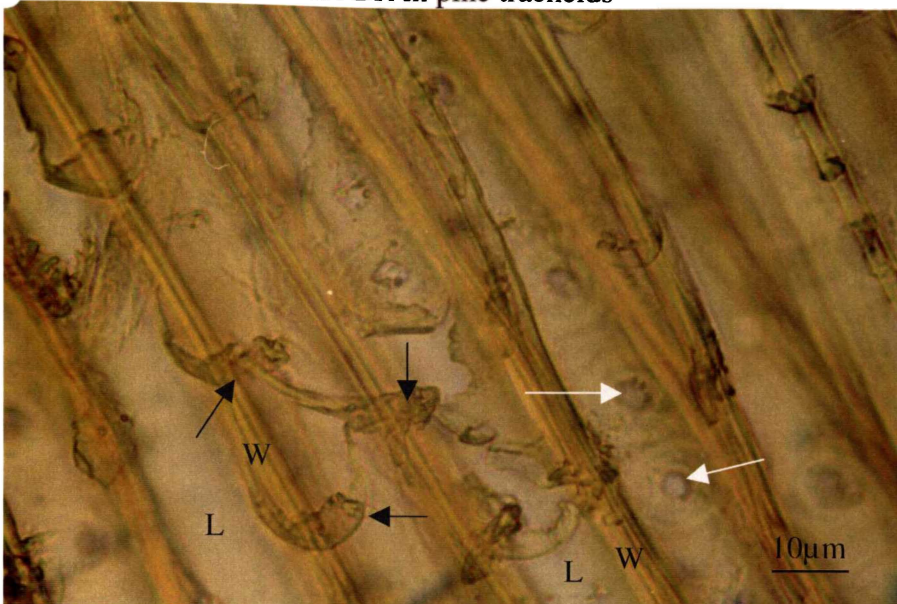
T = width of pine tracheid. Arrow = chlamydospore; L = cell lumen; W = wood cell wall.

M4-BR



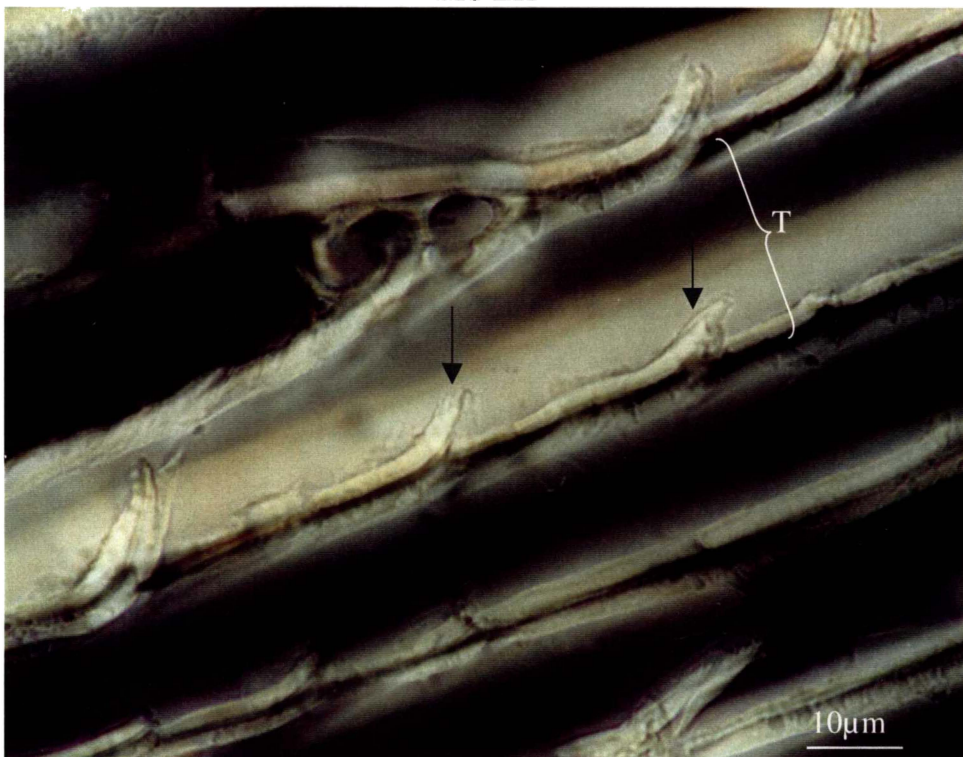
T = width of pine tracheid (earlywood); arrow = fractured cell wall.

M5: BR in pine tracheids



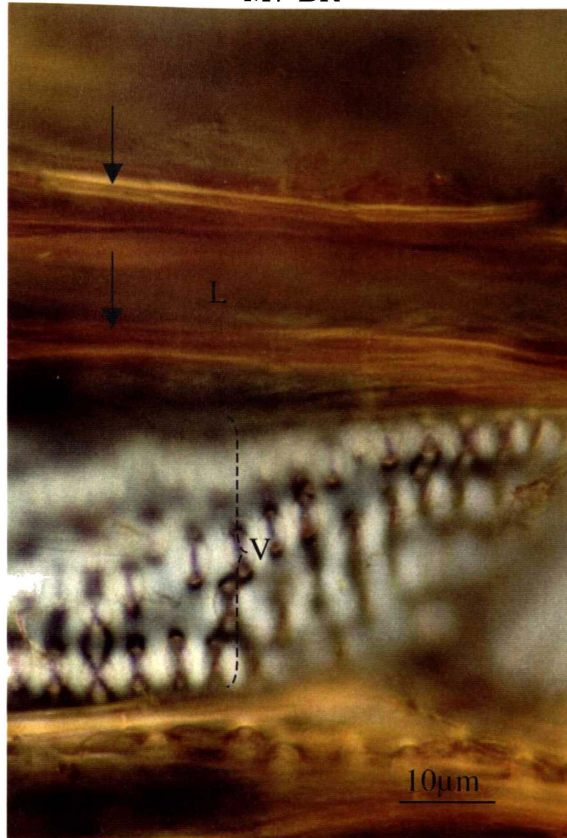
L = cell lumen; W = wood cell wall; black arrows = areas where cell wall peeled back during sectioning; white arrows = bordered pit.

M6-BR



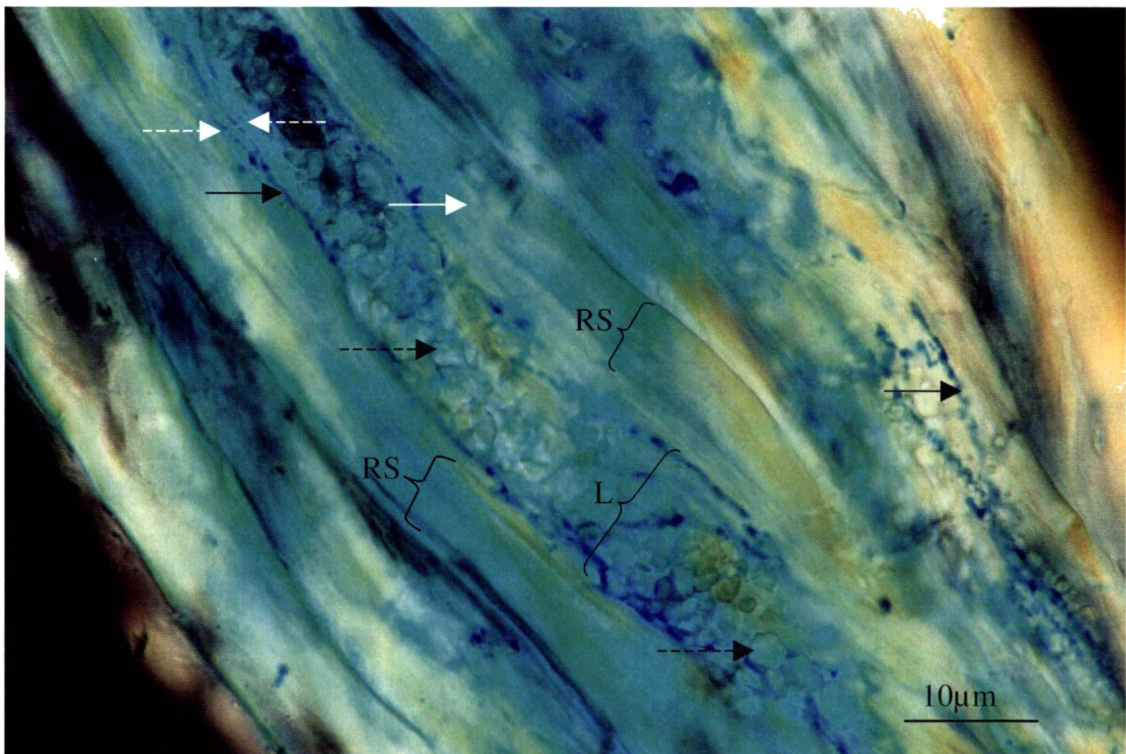
T = width of pine tracheid; arrow = characteristic BR fracture (fractured wood with advanced BR was still birefringent).

M7-BR



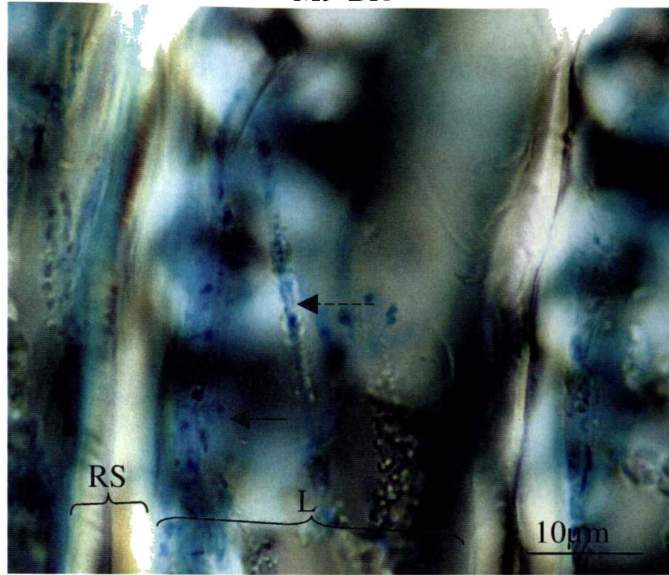
V = beech vessel; arrow = radial section through remnants of fibre wall; L = lumen.

M8-BR



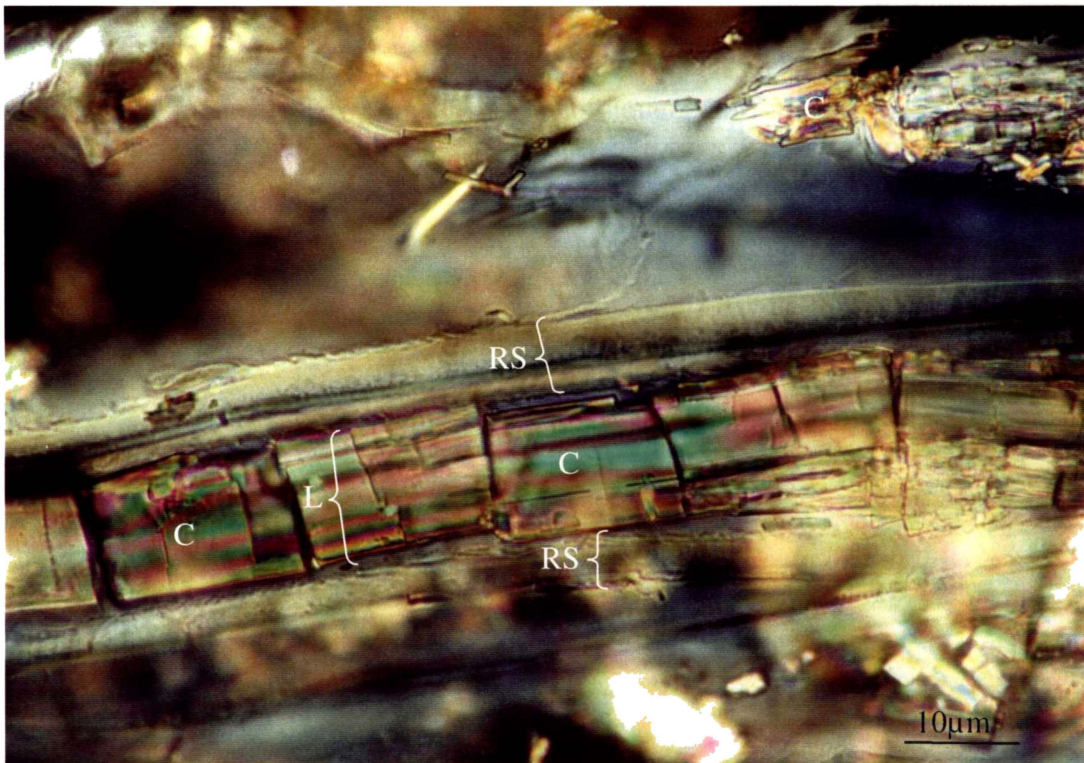
L = cell lumen; RS = radial section through adjacent pine tracheids (wood cell wall stained by aniline blue dye); solid black arrow = fungal hypha; dashed arrows = crystalline deposit in cell lumen believed to be oxalic acid; white arrow = BH.

M9-BR



RS = radial section; L = cell lumen of pine tracheid; W = wood cell wall; solid arrow = fungal hypha with clamp connection; dashed arrow = hyphae coated in crystalline deposit believed to be oxalic acid.

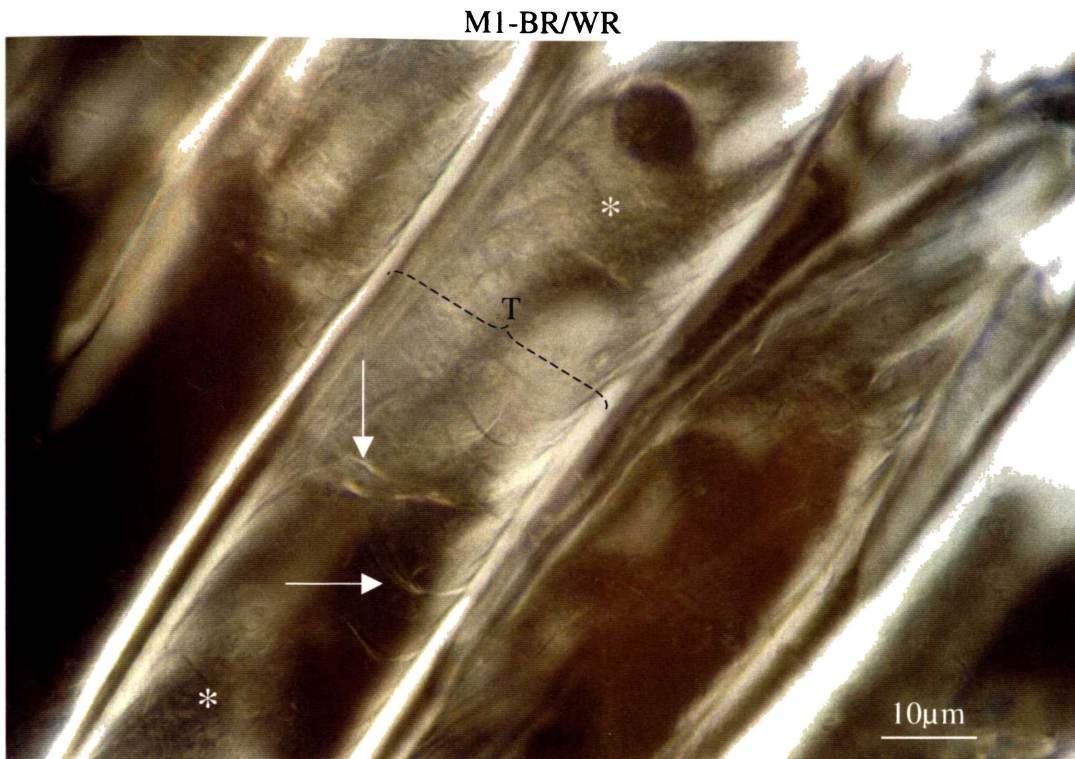
M10-BR



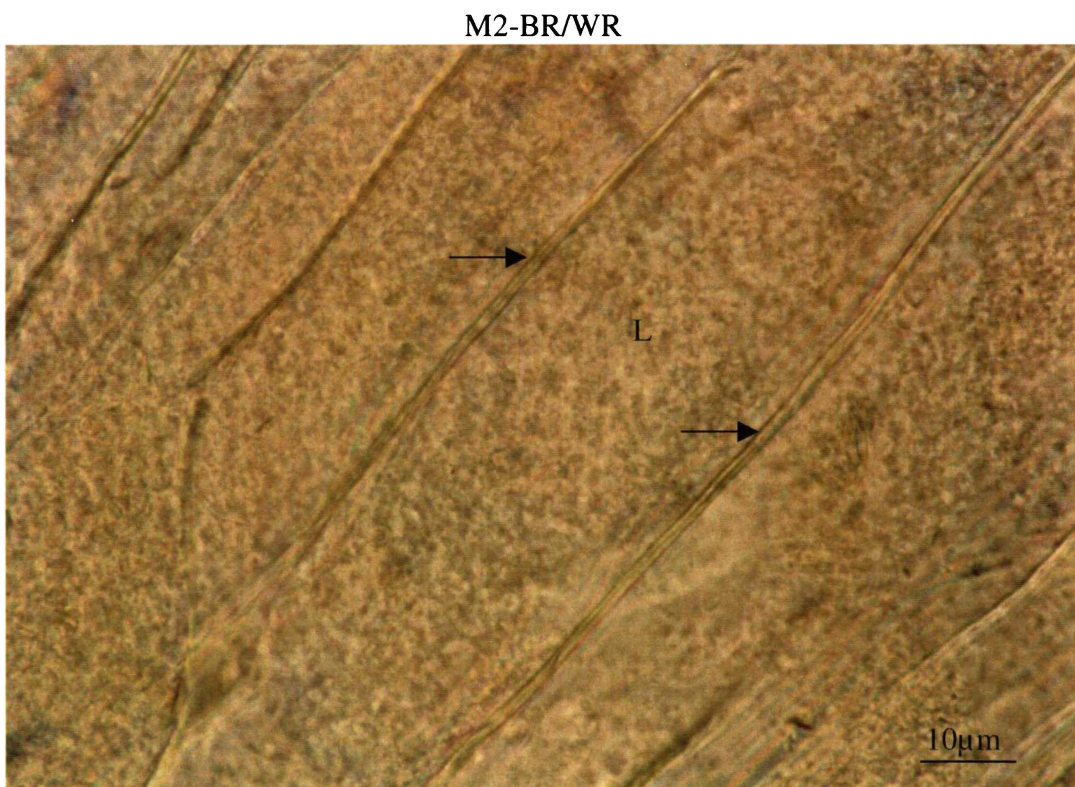
RS = radial section through adjacent pine tracheids; L = cell lumen;; C = crystalline deposit believed to be oxalic acid, filling cell lumen.

Section 4.5.2

Wood with shared Brown Rot and White Rot Micromorphology (BR-WR)

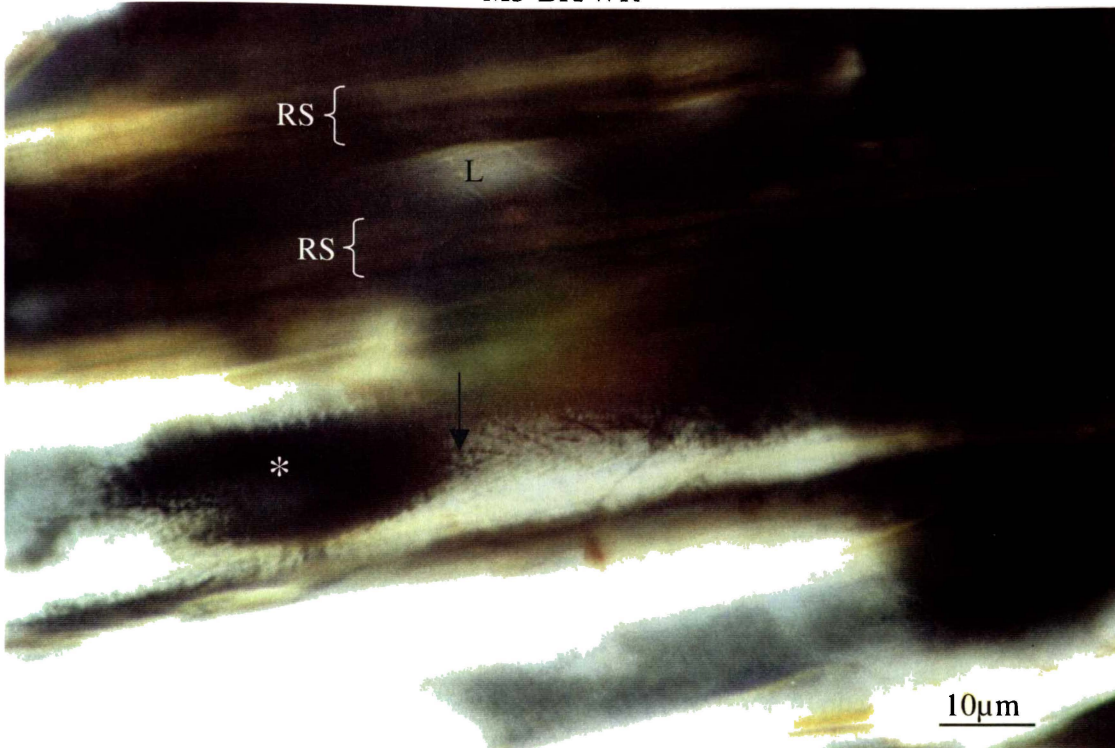


T = width of pine tracheid; arrow = wall fragments sloughed off lumen wall; * = lumen filled with granular material that appeared to accumulate as fibrous wall fragments underwent further breakdown.



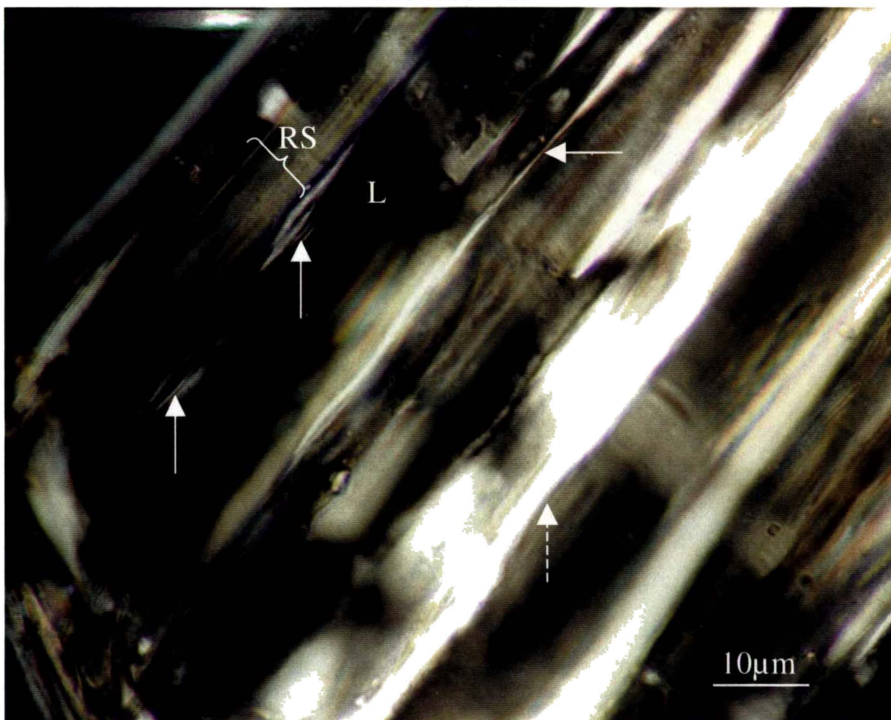
Arrow = remnants of ML; L = lumen, filled with granular wood cell wall breakdown products.

M3-BR/WR



RS = radial section through pine tracheid wall (loss of birefringence suggested removal of crystalline cellulose); L = lumen; * = wall erosion with characteristic etching (arrow).

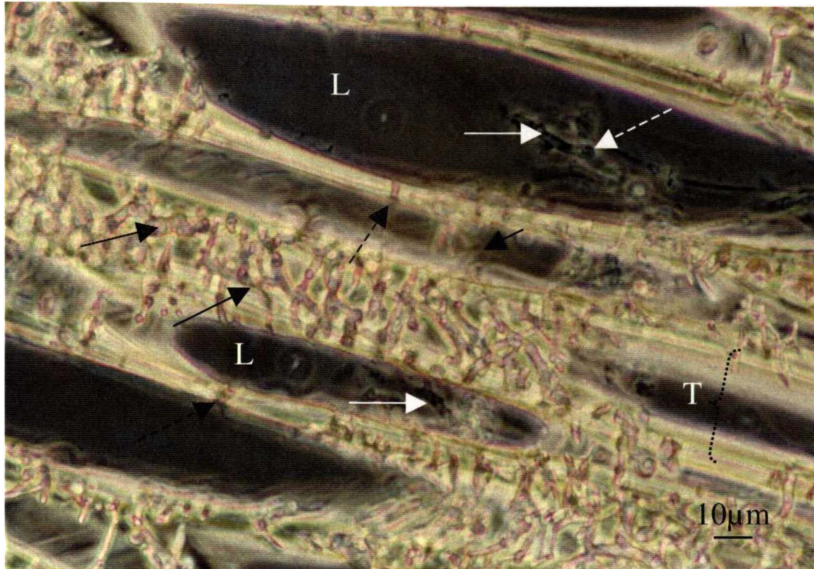
M4-BR/WR



RS = radial section through adjacent pine tracheids (almost complete loss of wall birefringence); L = lumen; dashed arrow = wall erosion; arrow = wall remnants.

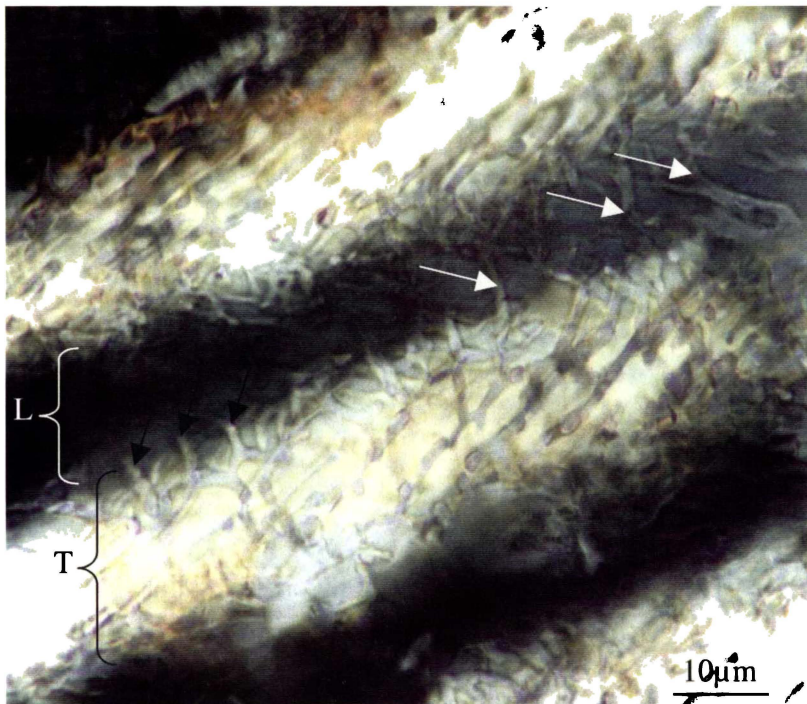
**Section 4.5.3
Tunnelling type 1 (T1)**

M1-T1



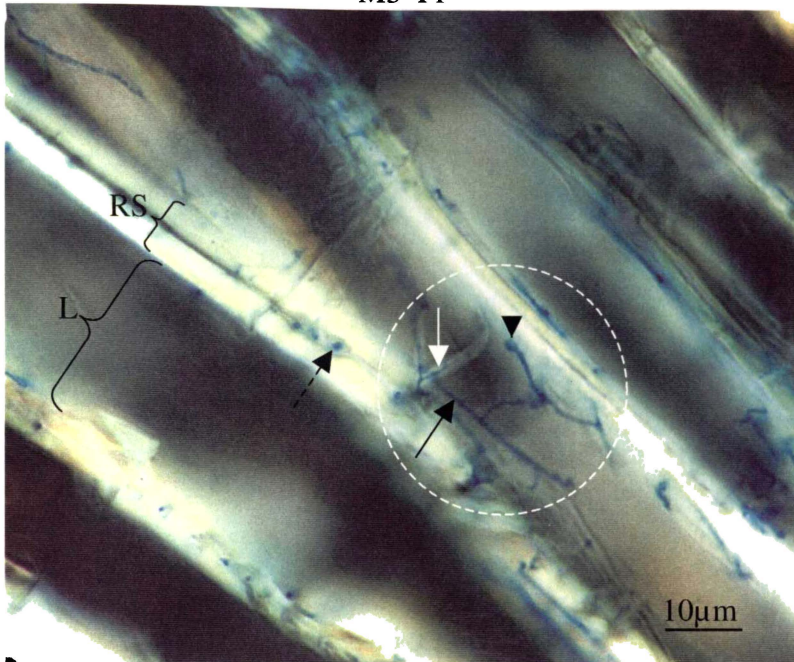
T = width of pine tracheid; black arrow = tunnels; white arrow = hyphae in cell lumen (L); dashed white arrow = clamp connection; dashed black arrow = bore hole (BH).

M2-T1



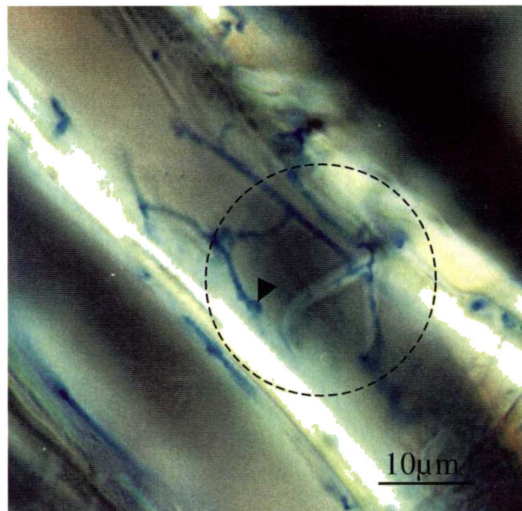
T = tangential section of tracheid wall; L = lumen; black arrow = tunnels penetrating concentrically within wall of a single tracheid; white arrow = tunnels passing between adjacent tracheids within cell wall.

M3-T1



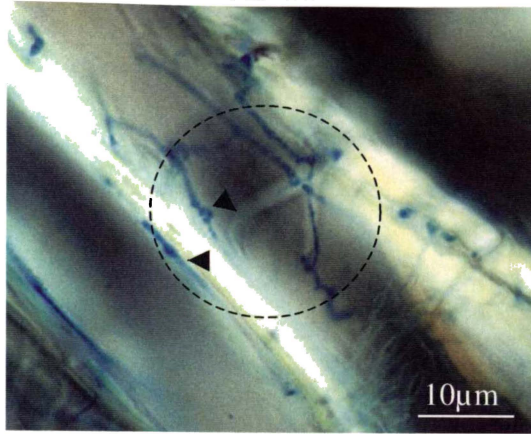
RS = radial section through adjacent pine tracheids; black arrow = hypha in cell lumen (L); white arrow = hypha in tunnel; lumen hypha and tunnel hypha within dashed circle appear to be connected; dashed arrow = cross section of hyphae within cell wall near ML; arrowhead = clamp connection.

M4-T1



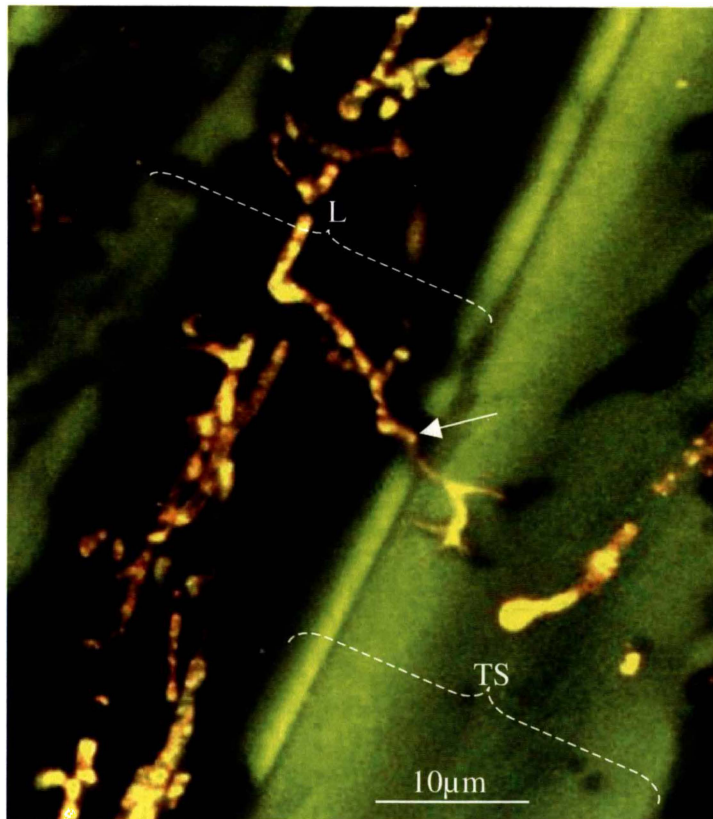
Arrowhead = clamp connection (as shown in M3-T1 - different focal plane of the same wood section).

M5-T1



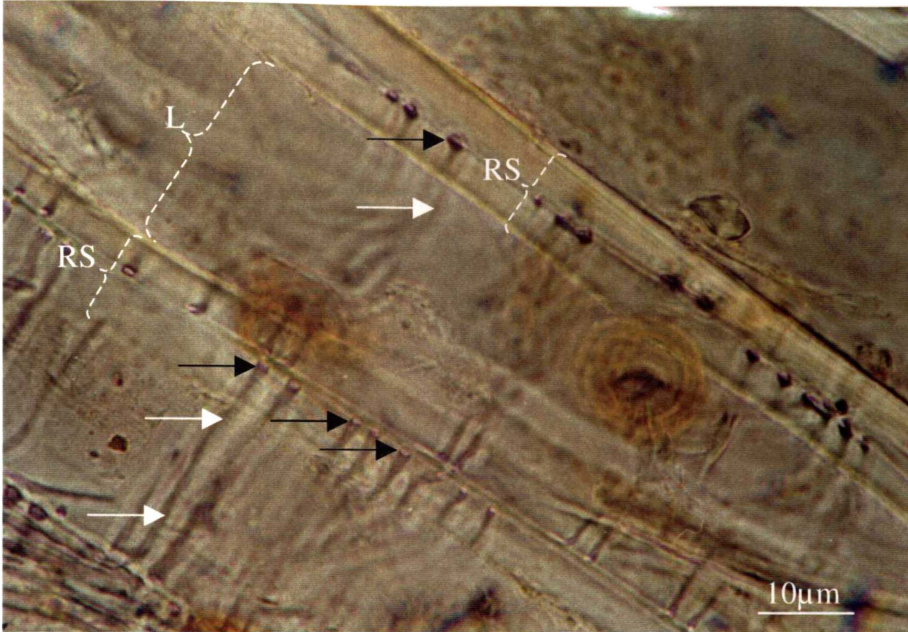
Arrowhead = clamp connection (as in M3-T1 and M4-TB - different focal planes of the same wood section).

M6-T1



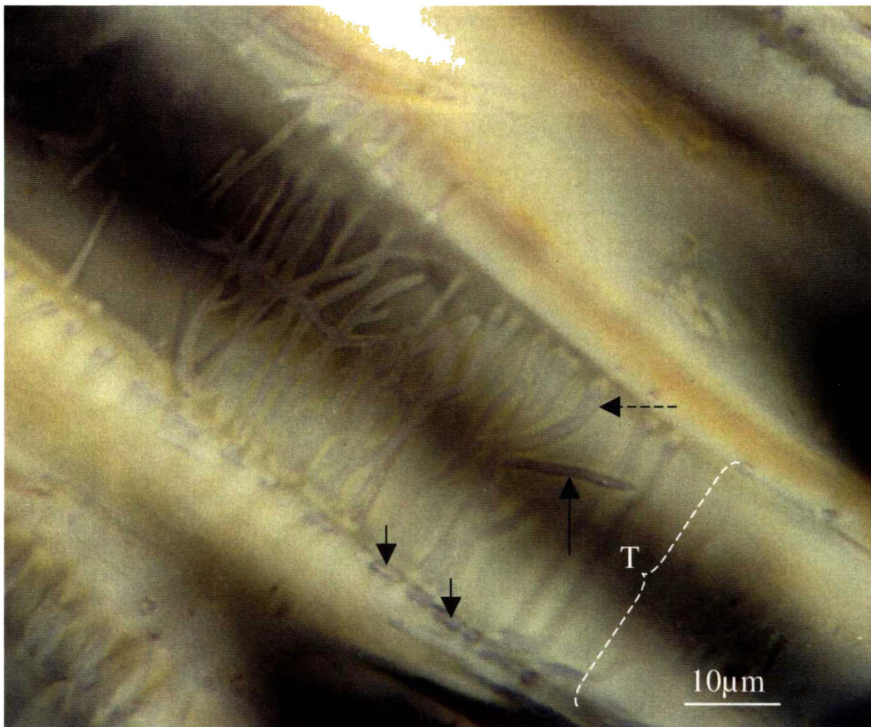
TS = radial section of pine tracheid; arrow = hypha penetrating cell wall; L = lumen. (Confocal laser scanning micrograph).

M7-T1



RS = radial section through adjacent pine tracheids; L = lumen; black arrow = transverse section through tunnel located close to ML; white arrow = tunnel penetrating concentrically around cell circumference close to ML (tunnels probably aligned with CM of S1 layer).

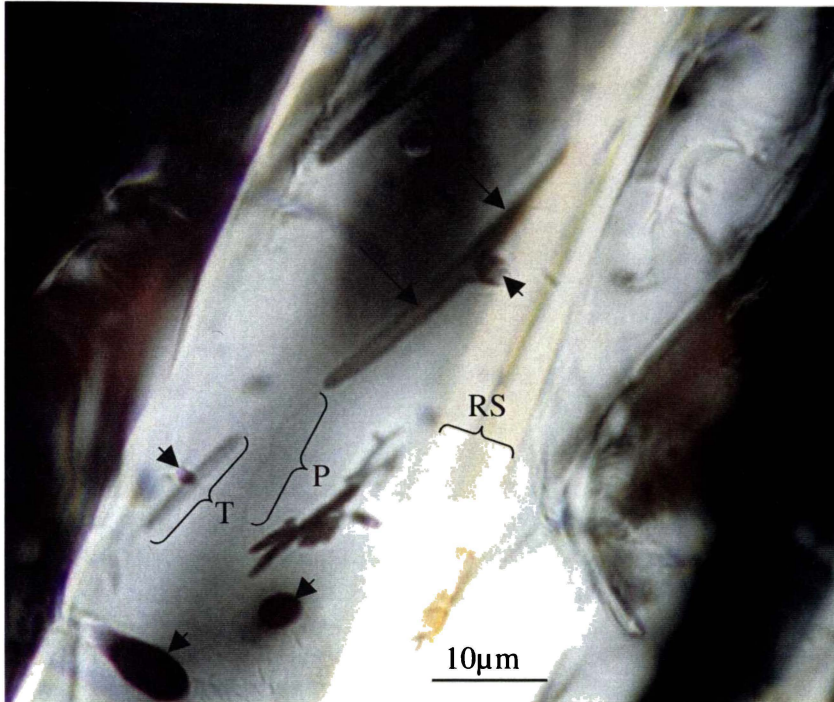
M8-T1



T = tangential section through S2 layer of pine tracheid (close to S1 layer); long solid arrow = tunnel aligned with CM of S2 layer; dashed arrow = tunnel, initially aligned with CM of S2 but then realigned with S1 CM to penetrate concentrically around perimeter of tracheid; short arrow = tunnel cross section within S1 layer.

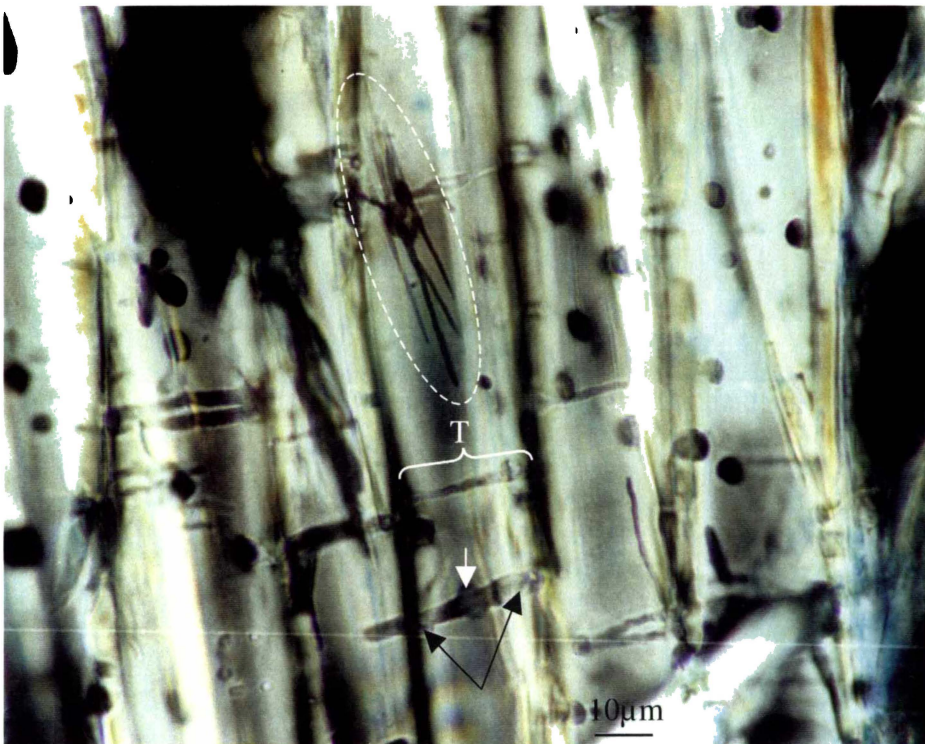
Section 4.5.4
Tunnelling Type 2 (T2)

M1-T2



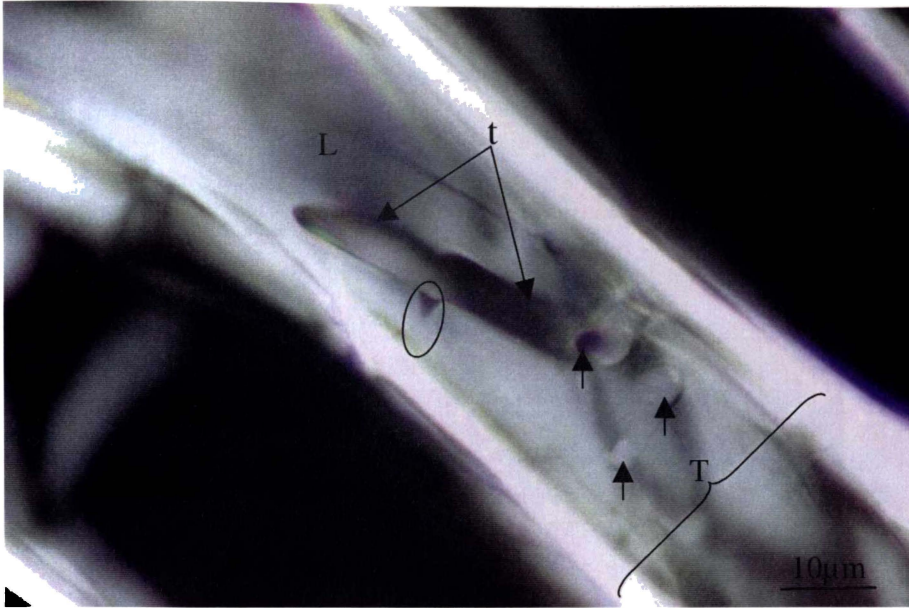
RS = radial section through pine tracheid wall; short arrow = BH; T = tunnel (hat of T-branch) aligned with helical CM of S2 layer; long arrow = tunnel (one side of the hat of the T-branch); P = wavy proboscis hypha connected to tunnel labelled with long arrow.

M2-T2



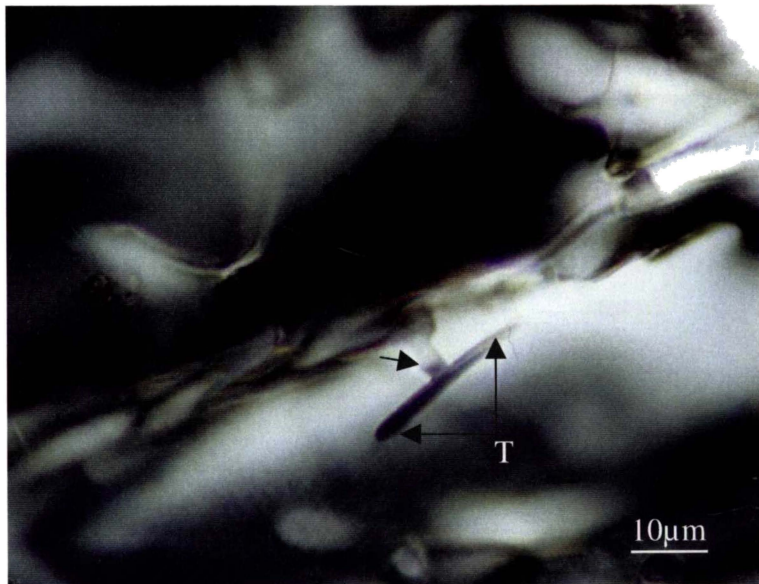
T = width of single tracheid; white arrow = BH; black arrow = tunnel above BH, probably formed by tangential T-branching (aligned with CM of S1 layer); area inside dashed line shows several closely associated bore holes and tunnels that have coalesced (tunnels aligned with CM of S2 layer).

M3-T2



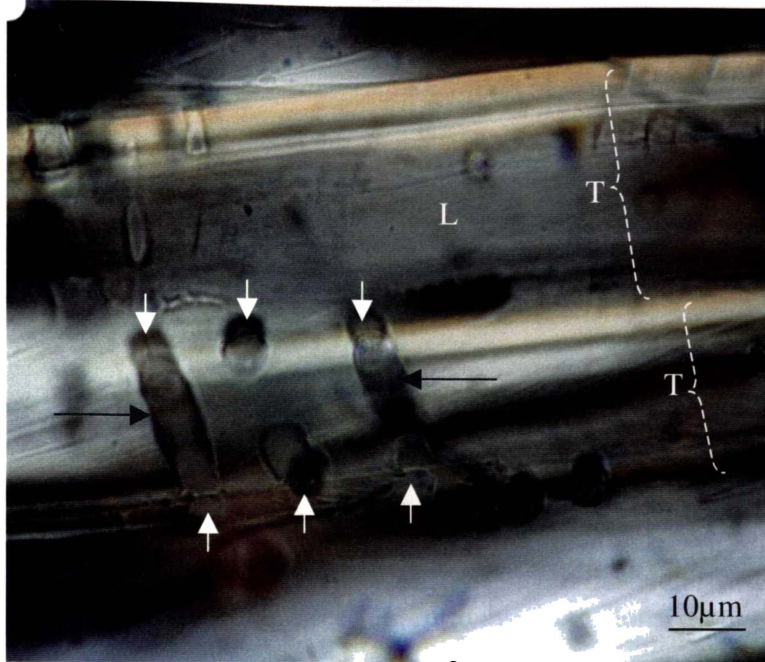
T = width of single tracheid; L = lumen; t = tunnel above an oblique BH positioned beneath the black circle; short arrows = BH penetrating cell wall at different angles.

M4-T2



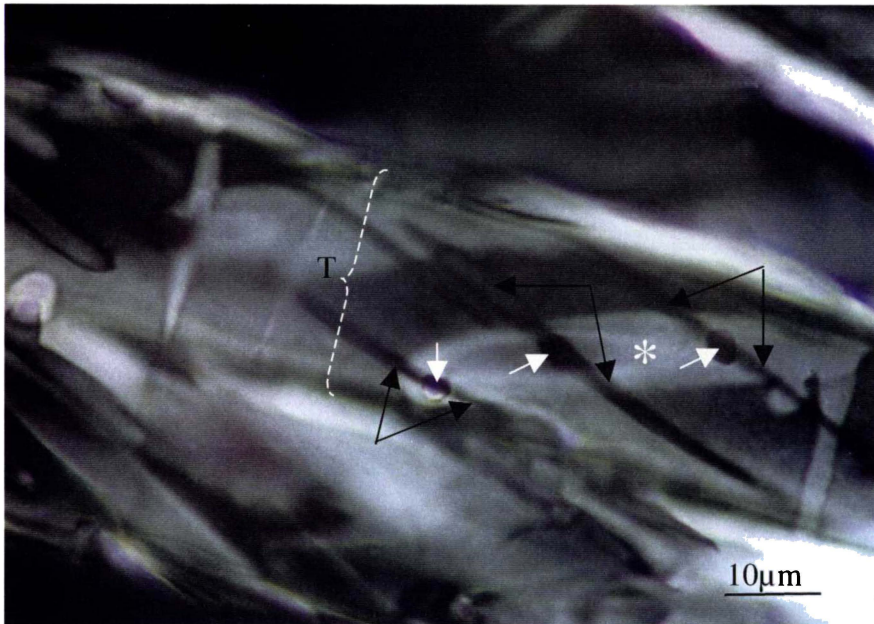
T = tunnel aligned with helical CM of S2 layer of a pine tracheid; short arrow = BH.

M5-T2



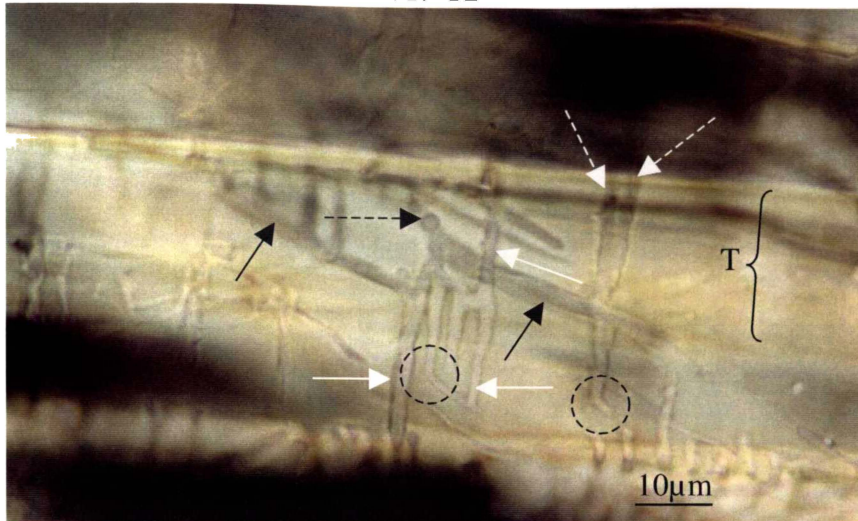
T = width of a single pine tracheid; L = lumen; white arrow = BH; black arrow = tunnel penetrating the S2 layer concentrically around the tracheid circumference.

M6-T2



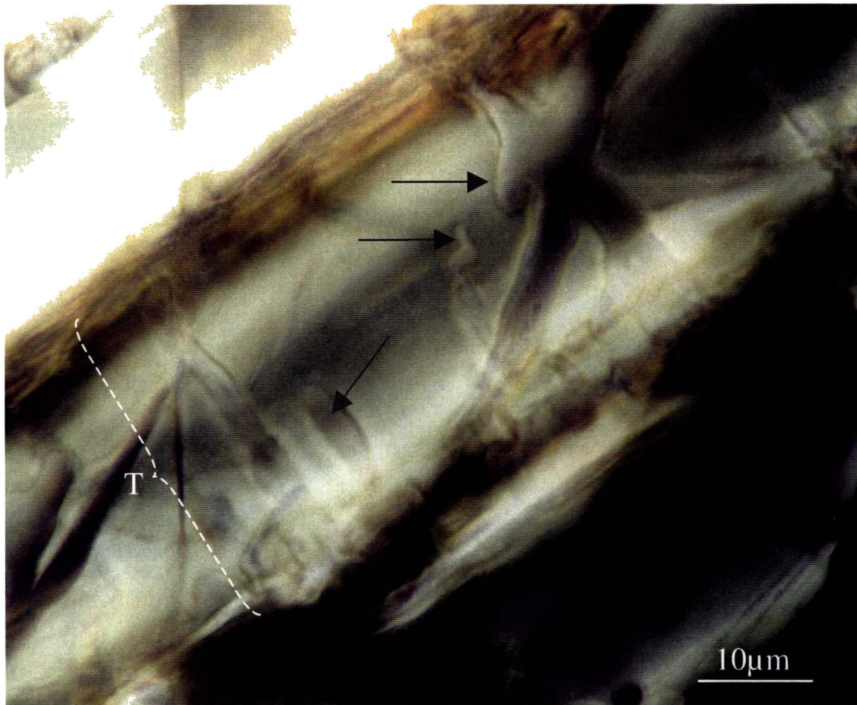
T = width of a single pine tracheid; white arrow = BH; black arrow = dark tunnel above BH; * = light tunnel parallel to helical CM of S2 layer, connected by BHs (white arrows) to the dark tunnels which are also parallel to the helical CM in the S2 layer of the adjacent tracheid.

M7-T2



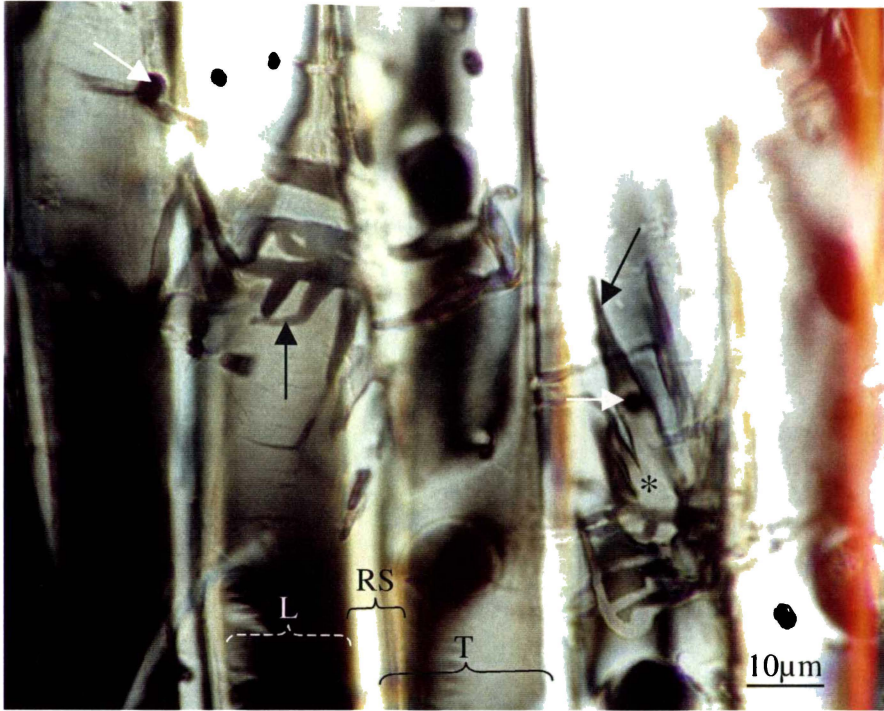
T = width of a single pine tracheid; solid black arrow = tunnel aligned with helical CM of S2 layer; solid white arrow = tunnel aligned with CM in S1 layer; dashed arrow = BH; area within dashed circle = tunnel changing direction, probably in response realignment with CM of S2 layer.

M8-T2



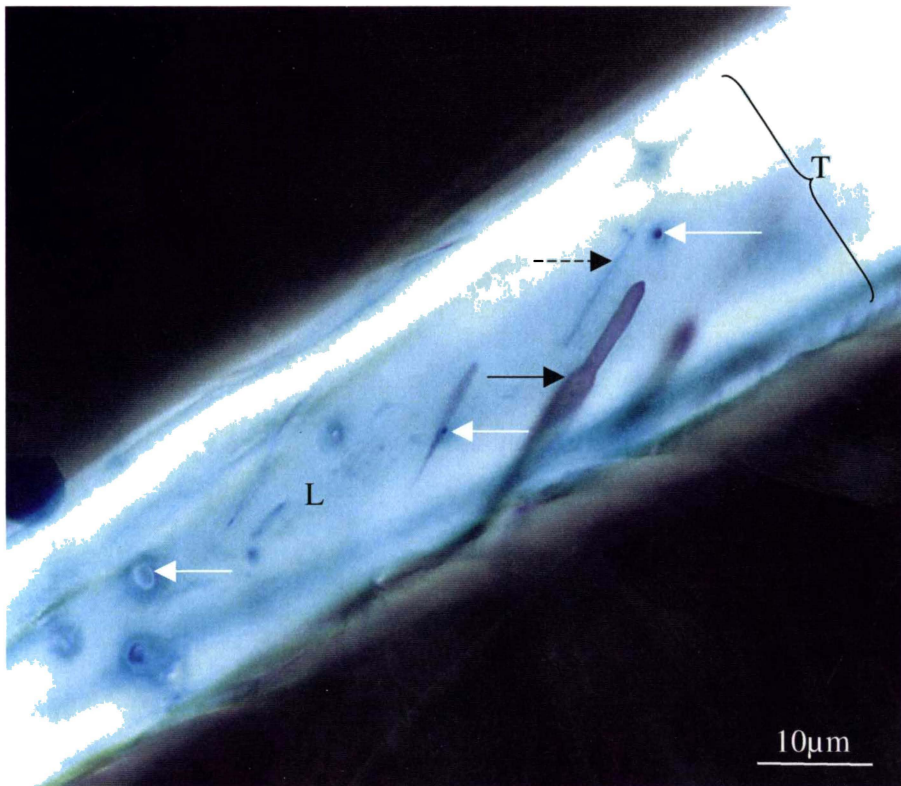
T = width of a single pine tracheid; black arrow = tunnel.

M9-T2



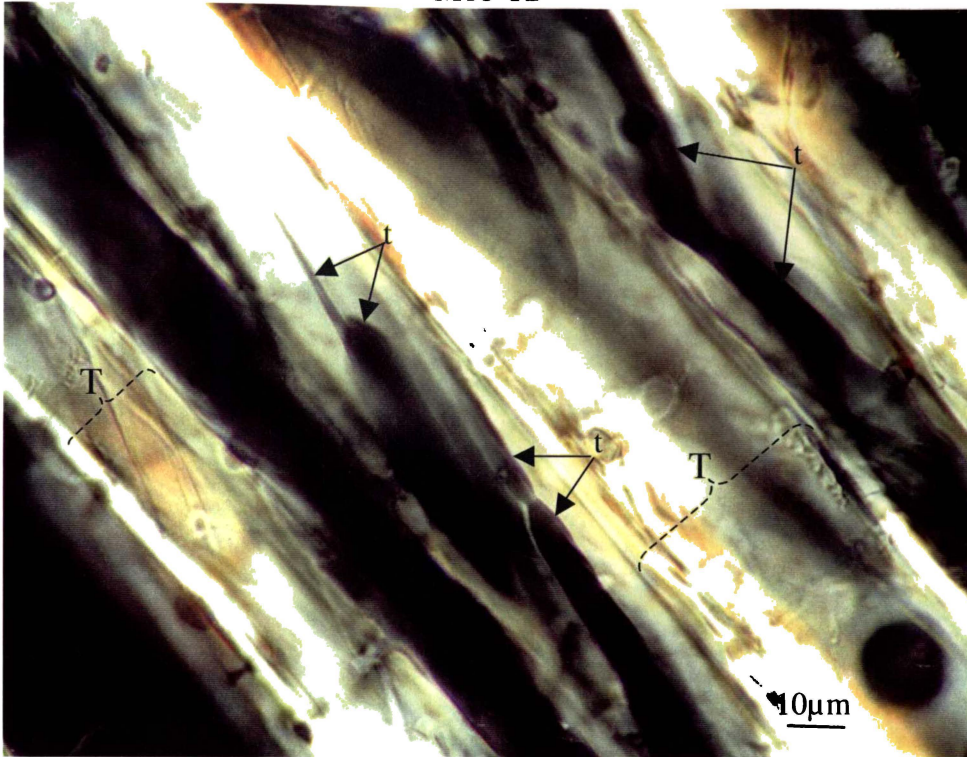
T = width of a single pine tracheid; RS = radial section through adjacent tracheid walls; L = lumen; black arrow = tunnel; white arrow = BH; * = merged tunnels.

M10-T2



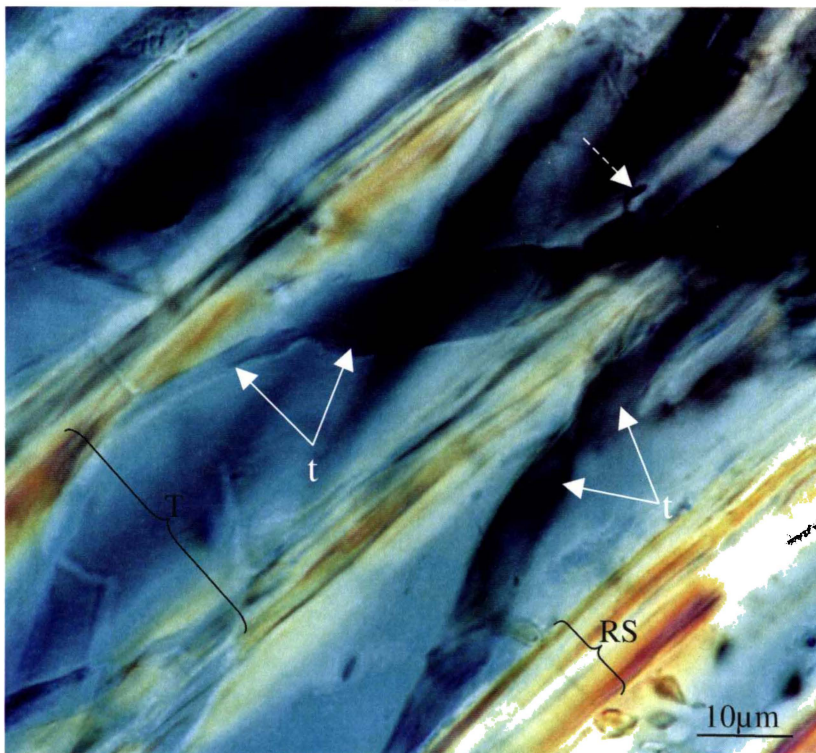
T = width of a single pine tracheid; L = lumen; black arrows = stepped tunnel aligned with helical CM in the S2 layer; white arrows = BH; dashed arrow = T-branch.

M11-T2



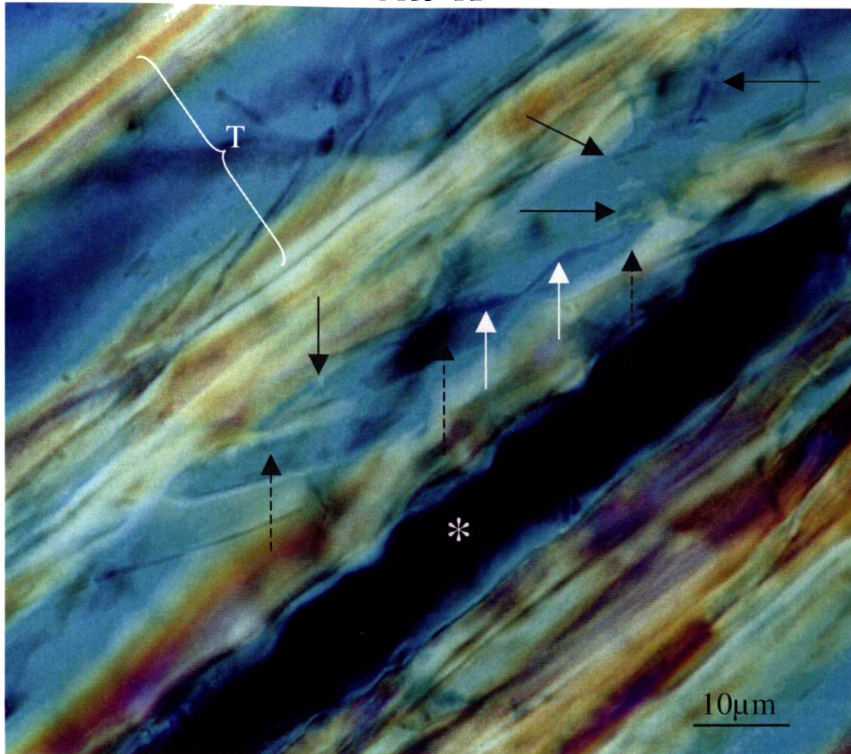
T = width of a single pine tracheid; t = stepped tunnels.

M12-T2



T = width of a single pine tracheid; RS = radial section through tracheid; t = stepped tunnel aligned with long axis of helical CM of S2 layer; dashed arrow = L-bend tunnel, a lateral branch off the parent tunnel.

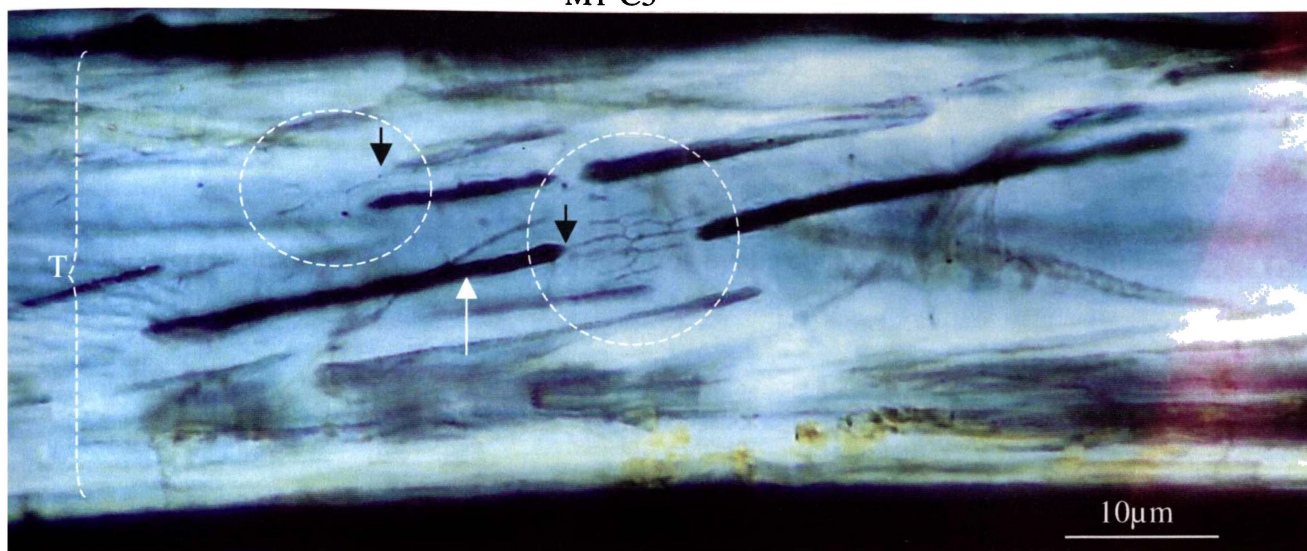
M13-T2



T = width of a single tracheid (latewood); dashed black arrow = stepped tunnels; solid black arrow = clamp connection; white arrow = hypha in tunnel; * = void left after parenchyma cells decayed.

Section 4.5.5
Cavitation Type 3 (C3) and Tunnelling Type 3 (T3)

M1-C3



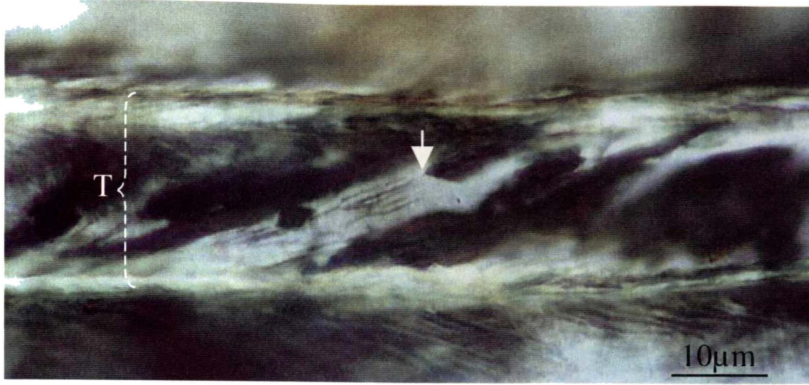
T = width of a single pine tracheid; white arrow = SR cavity aligned with helical CM in S2 layer of tracheid wall; black arrow = proboscis hypha connecting SR cavity and multiple L- and T-branching pattern (within dashed circle).

M2-C3



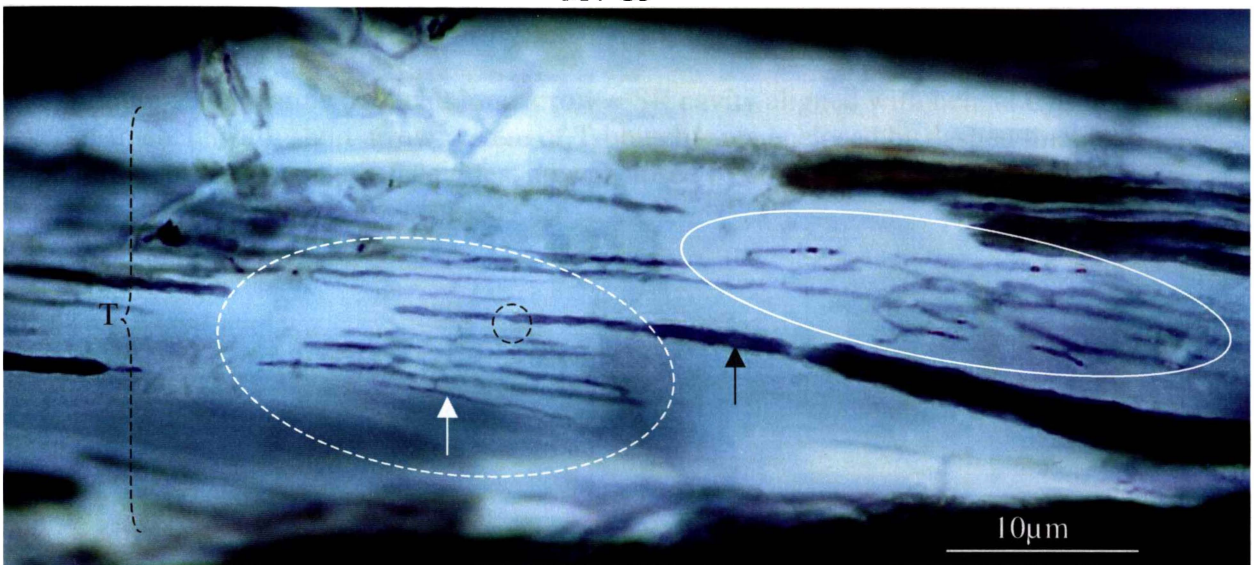
T = width of a single pine tracheid; solid arrow = proboscis hypha connecting large SR cavity with L-branching pattern of smaller cavities; dashed arrow = lateral stem of T-branch connecting two adjacent SR cavities.

M3



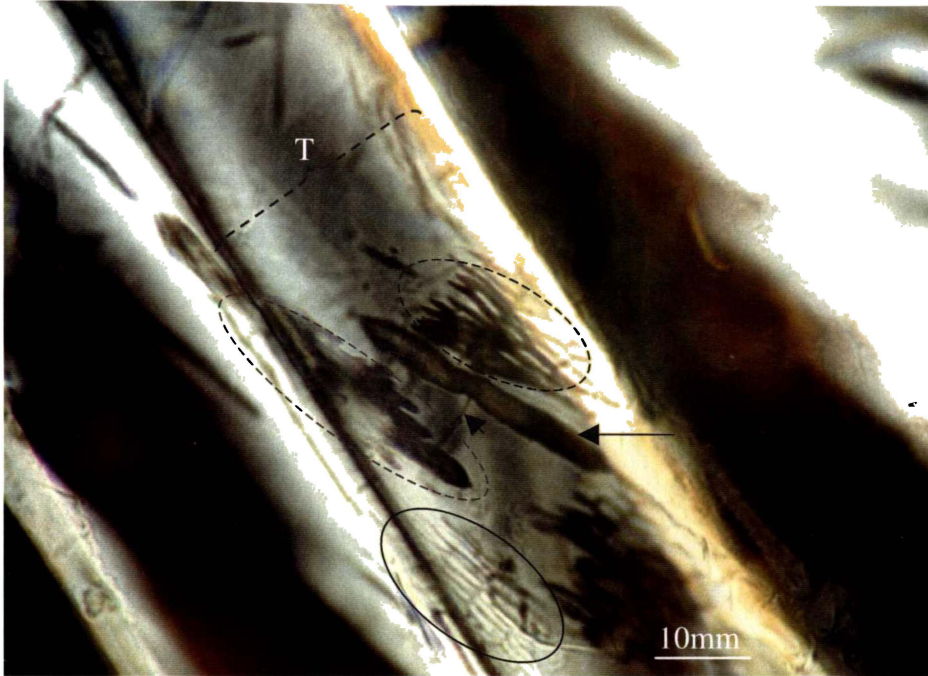
T = width of a single pine tracheid; arrow = proboscis hypha connecting SR cavity with L- and T-branching pattern.

M4-C3



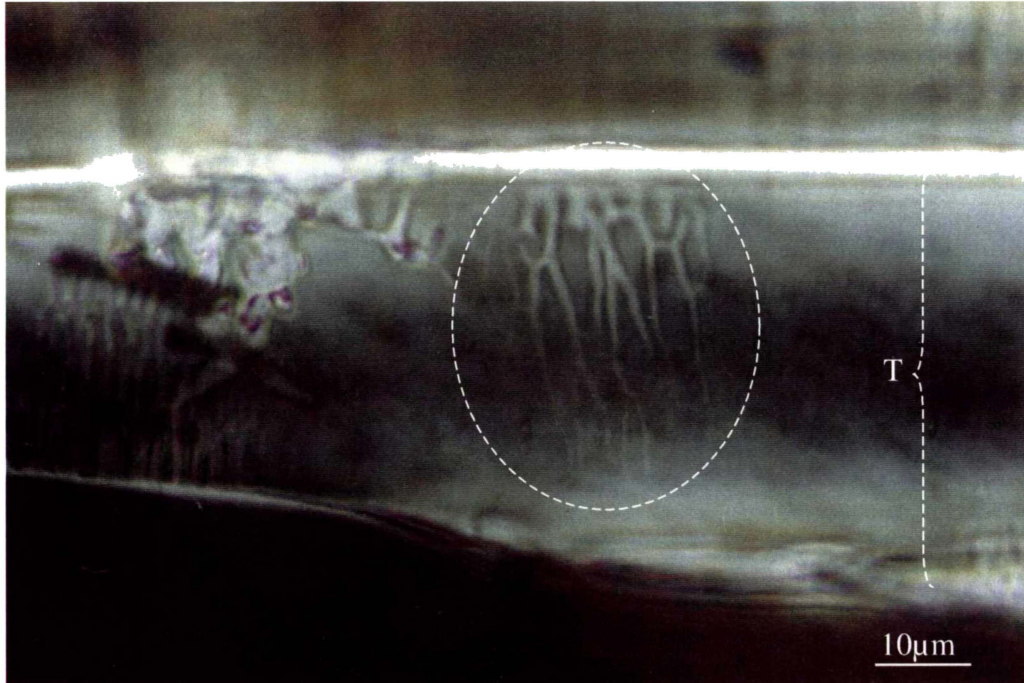
T = width of a single pine tracheid; black arrow = SR cavity aligned with helical CM in S2 layer of tracheid wall; white arrow = T-branch; area within white dashed line = reticulum of cavities (stack of T-branches) originating from the marked SR cavity; area within black dashed circle = lateral stem of T-branch connecting SR cavity and stack of T-branches; solid circle = second reticulum of cavities.

M5-C3



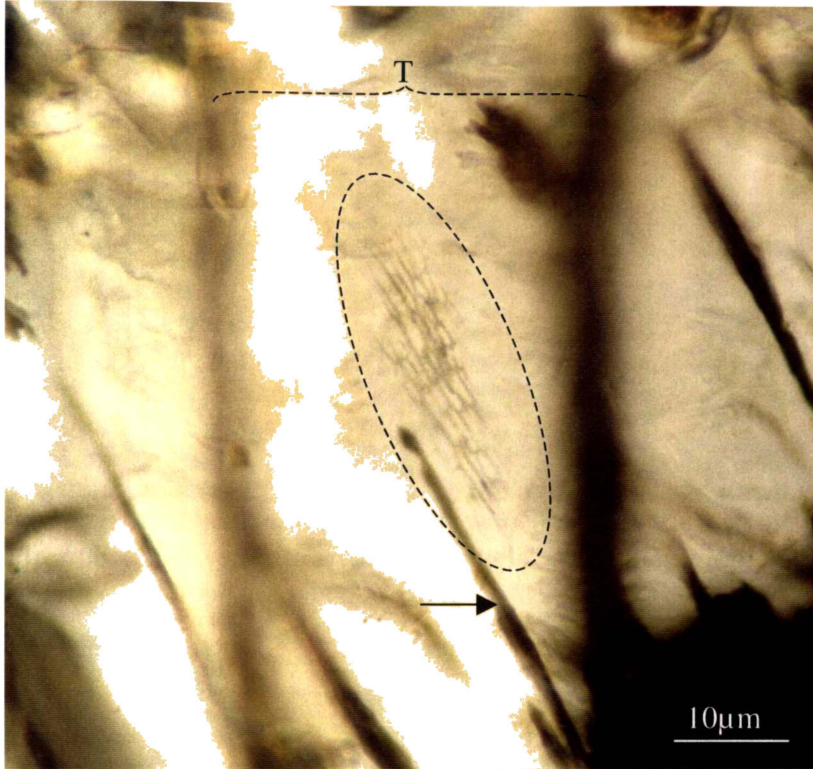
T = width of a single pine tracheid; long arrow = SR cavity aligned with helical CM in S2 layer of tracheid wall; short arrow = stem of T-branch; area enclosed by dashed line = reticulum of partially coalesced cavities; area enclosed by solid line = reticulum of fine cavities.

M6-C3



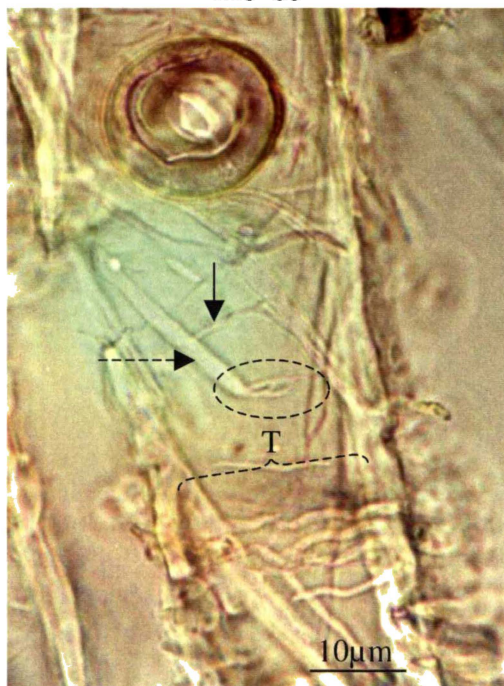
T = width of a single pine tracheid; area enclosed by dashed line = reticulum of cavities aligned with CM in S1 layer of tracheid wall.

M7-C3



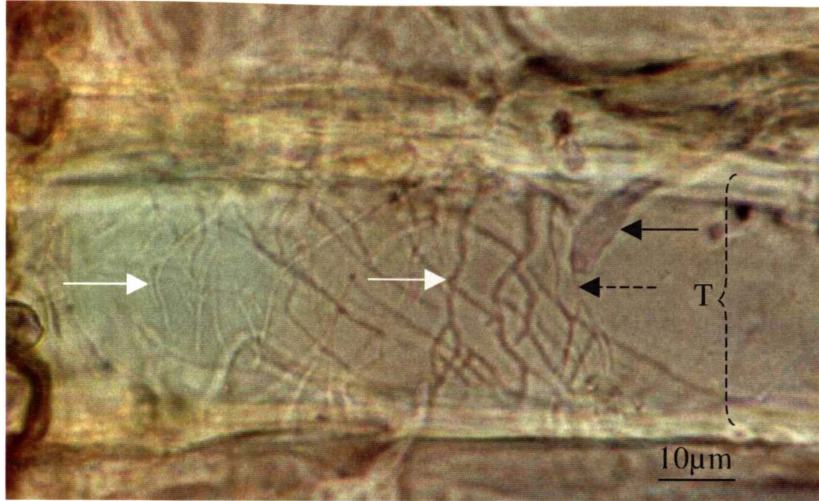
T = width of a single pine tracheid; arrow = SR cavity aligned with helical CM in S2 layer of tracheid wall; area enclosed by dashed line = reticulum of cavities aligned with helical CM in S2 layer.

M8-C3



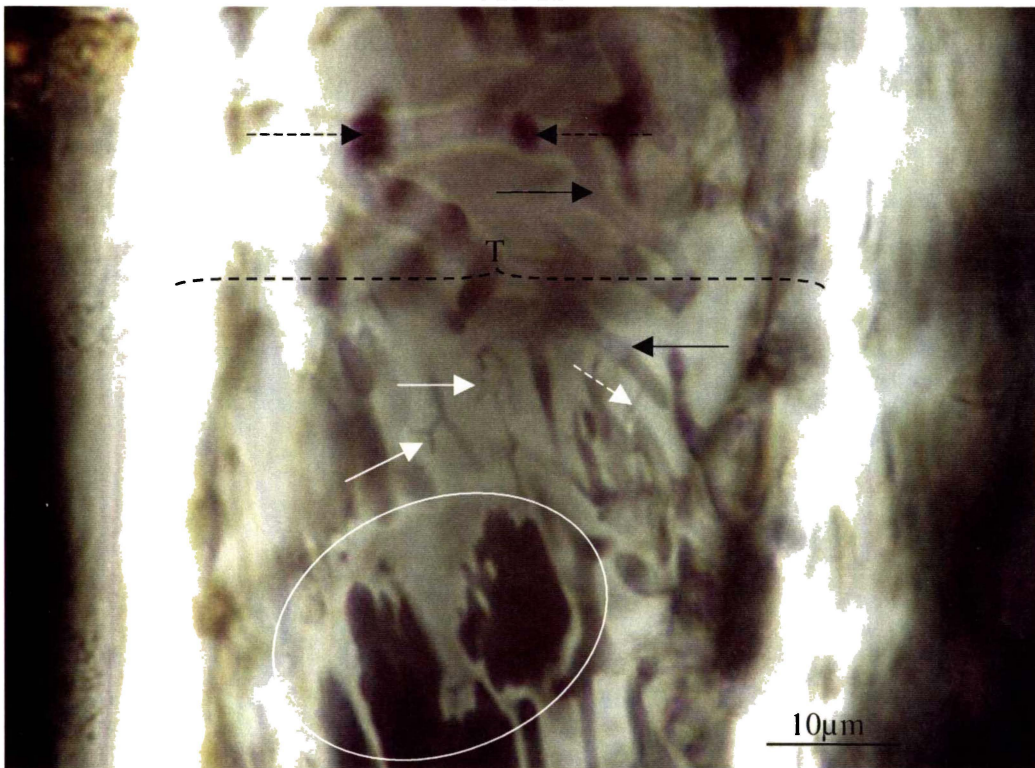
T = width of a single pine tracheid; dashed arrow = SR cavity aligned with helical CM in S2 layer of tracheid wall; arrow = side branch from cavity; area within dashed line = multiple branching from cavity hypha, close to cavity apex.

M9-C3



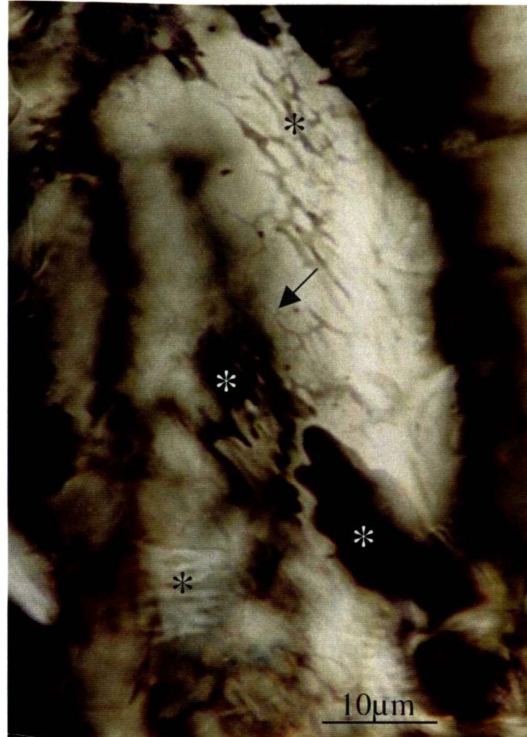
T = width of a single pine tracheid; solid black arrow = SR cavity; dashed arrow = apical proboscis hypha from SR cavity; white arrow = “tunnels” of similar width and penetration pathway as apical proboscis hypha (dashed arrow).

M1-T3



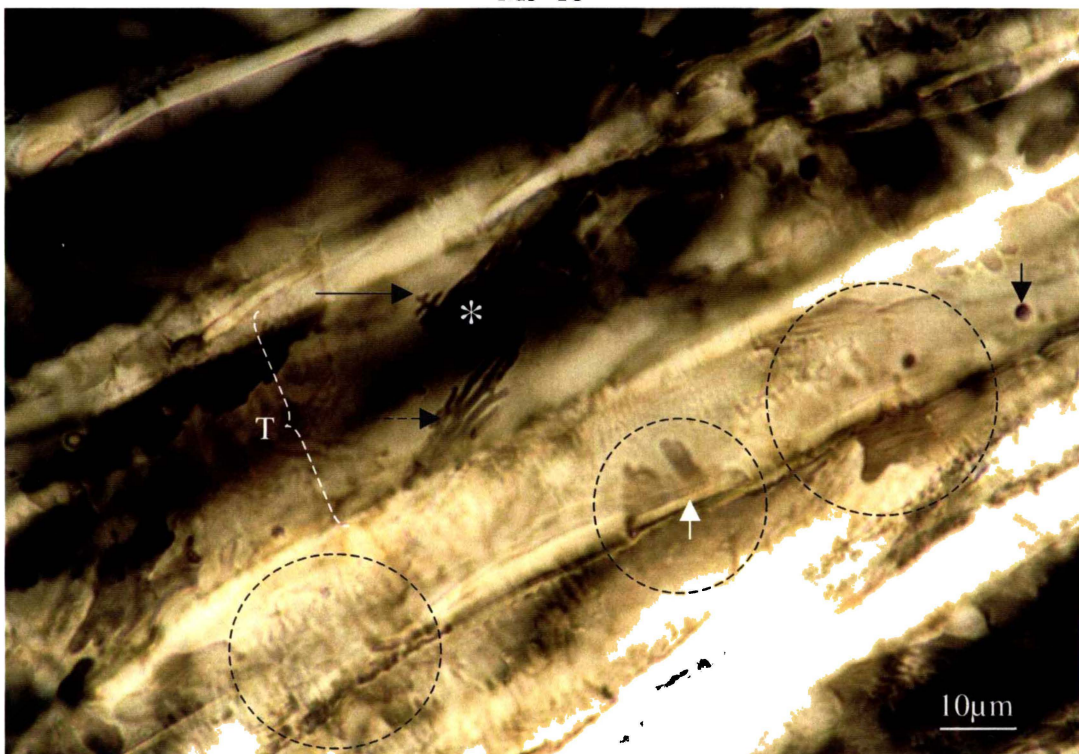
T = width of a single pine tracheid; solid black arrow = tunnel; dashed black arrow BH; solid white arrow = Y-branch; dashed white arrow = fine tunnel connected to larger tunnel; area enclosed by dashed circle = coalesced tunnels.

M2-T3



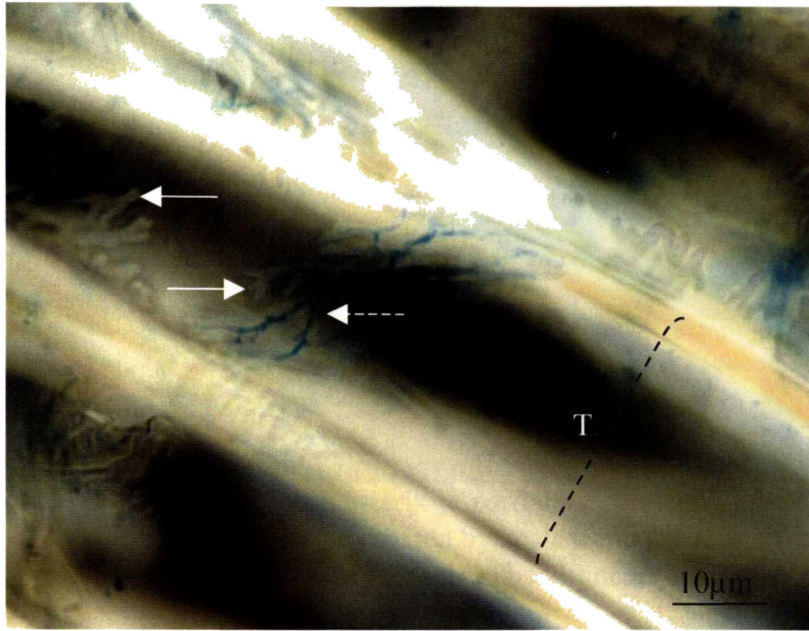
Black arrow = T-branch connected to a reticulum of tunnels in pine tracheid wall; white asterix = area where tunnels have coalesced, leaving no birefringent tracheid wall; black asterix = area containing partially coalesced tunnels.

M3-T3



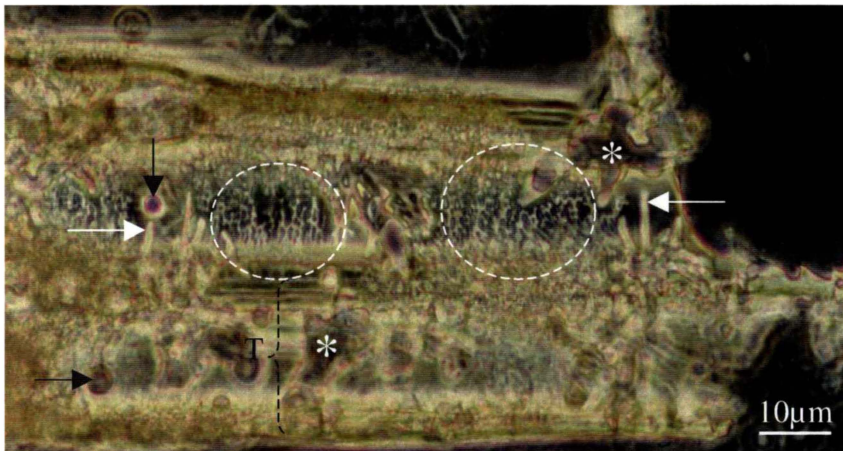
T = width of a single pine tracheid; long solid arrow = apex of leading tunnel in a stack of L-branches; * = coalesced tunnels of stack, long dashed arrow = group of individual tunnels within a reticulum; short black arrow = BH; area enclosed by dashed circle = depressions of cell wall caused by coalesced tunnels and collapse of S3 layer; short white arrow = ML.

M4-T3



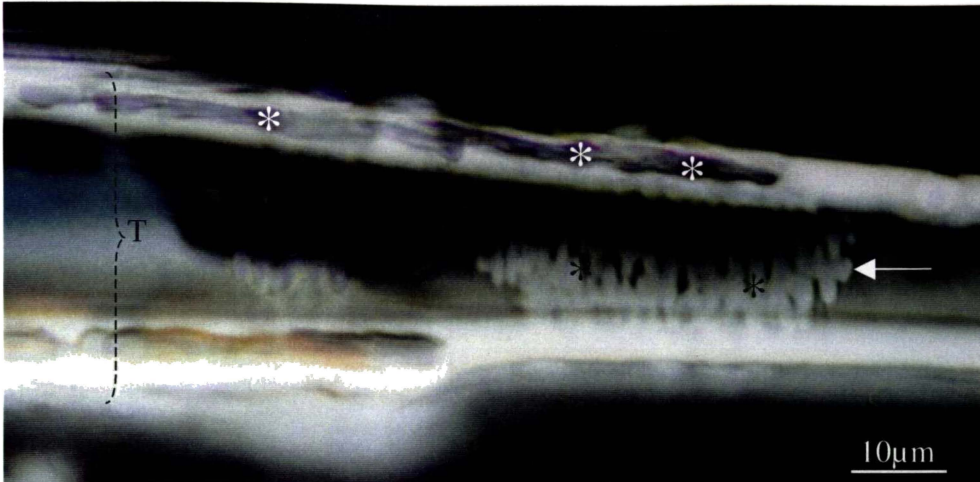
T = width of a single pine tracheid; solid arrow = tunnels; dashed arrow = clamp connection of hypha within void created by coalesced tunnels.

M5-T3



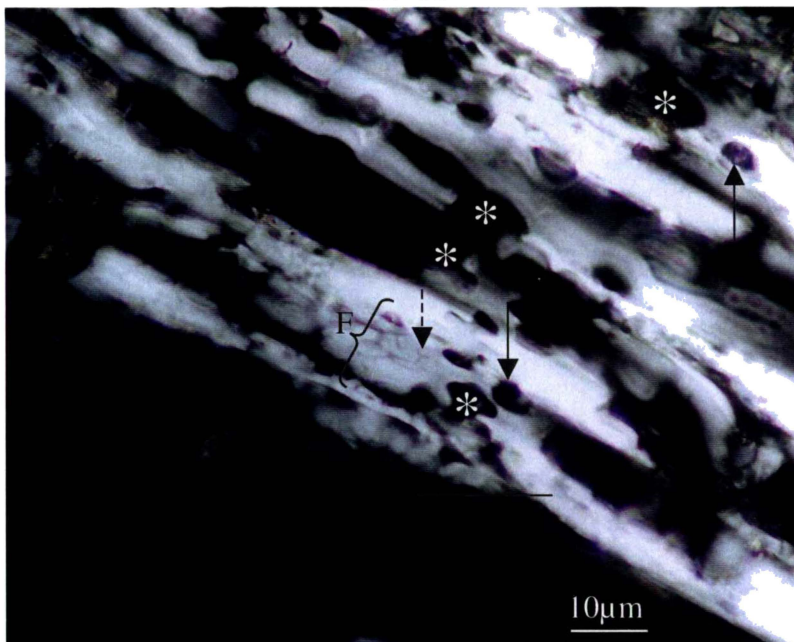
T = width of a single pine tracheid; black arrow = BH; white arrow = tunnel; area within dashed circle = reticulum of fine tunnels; asterisk = area where tunnels and BHs have coalesced.

M6-T3



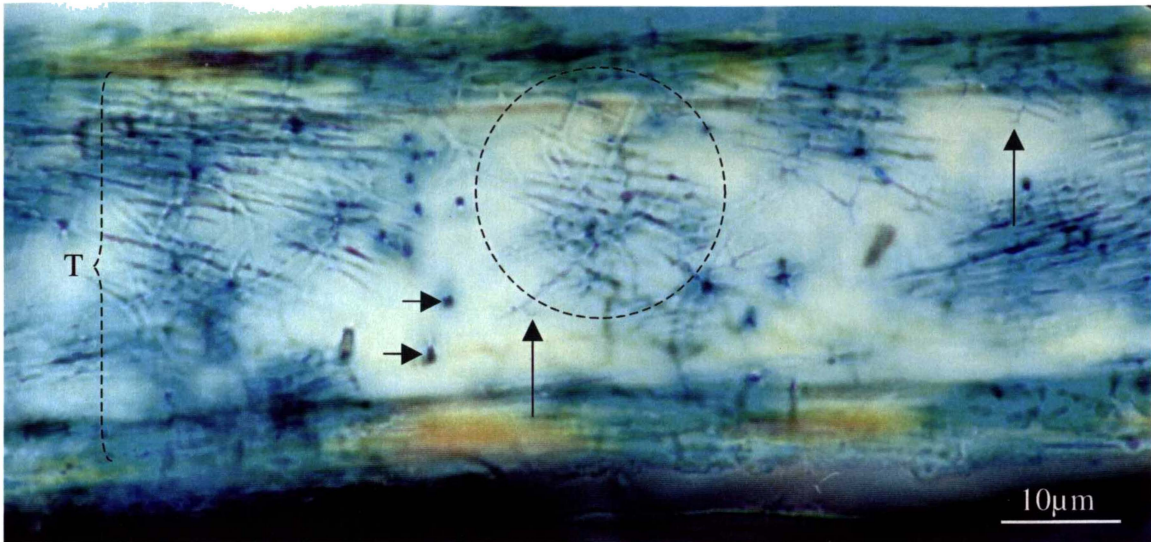
T = width of a single pine tracheid; black asterix = partially coalesced tunnels formed by multiple L-branching; white asterix = void created by coalescence of tunnels causing concentric removal of tracheid wall (tunnels appear to be aligned with CM of the S1 layer); arrow = tunnel.

M7-T3



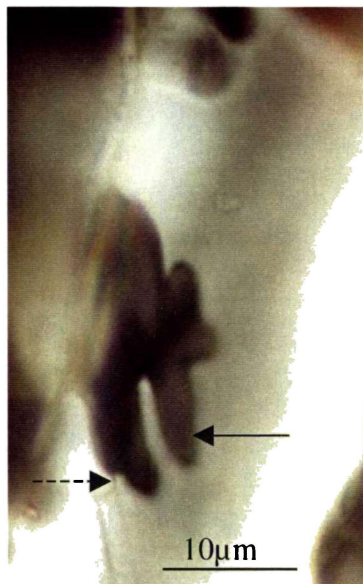
F = width of a single beech fibre; solid arrow =BH; dashed arrow = Y-branch; * = voids created by coalesced tunnels and, or BHs.

M8-T3



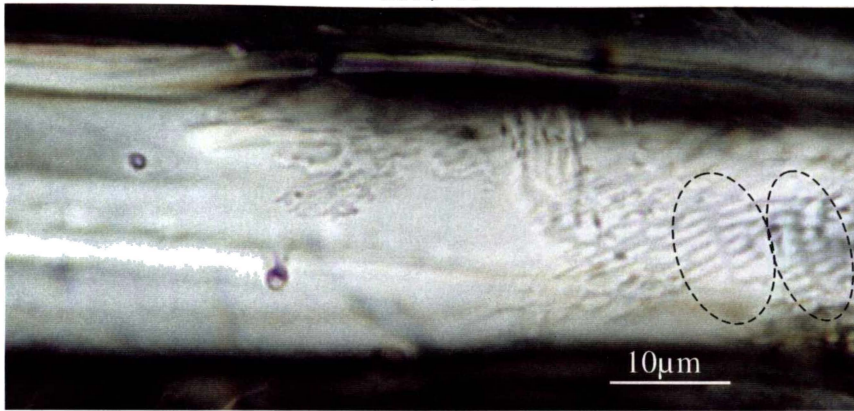
T = width of a single pine tracheid; long arrow = T-branch; short arrow = BH; area within dashed circle = reticulum of T- and L-branching.

M9-T3



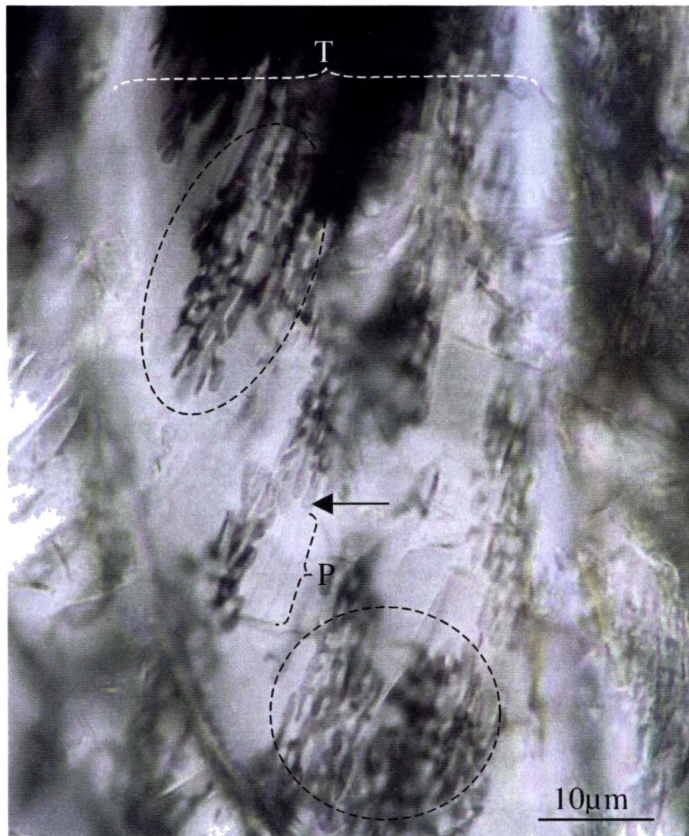
Arrow = tunnel (L-branch) within pine tracheid wall; dashed arrow = proboscis hypha form apex of L-branch tunnel.

M10-T3



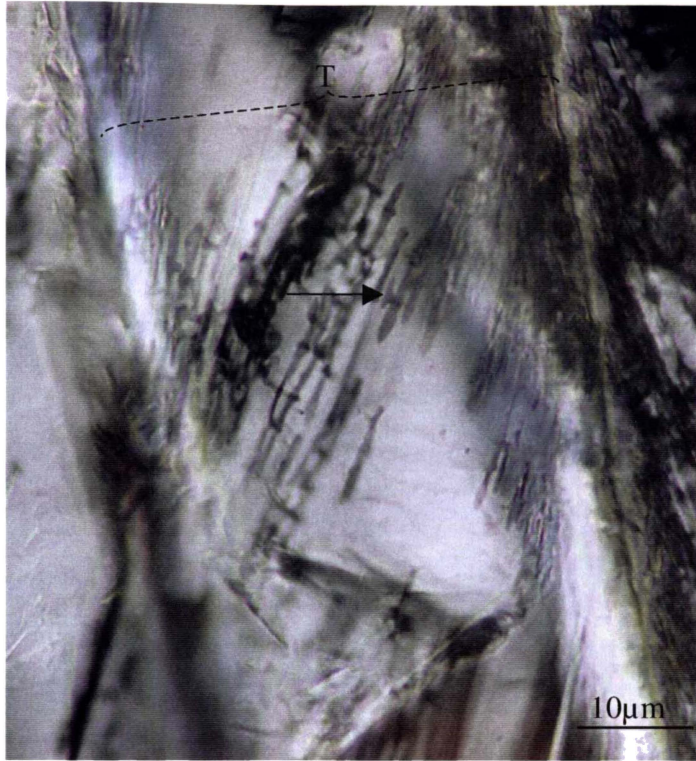
Area within dashed line = stack of L-branches (or off-set T-branches) with pine tracheid wall.

M11-T3



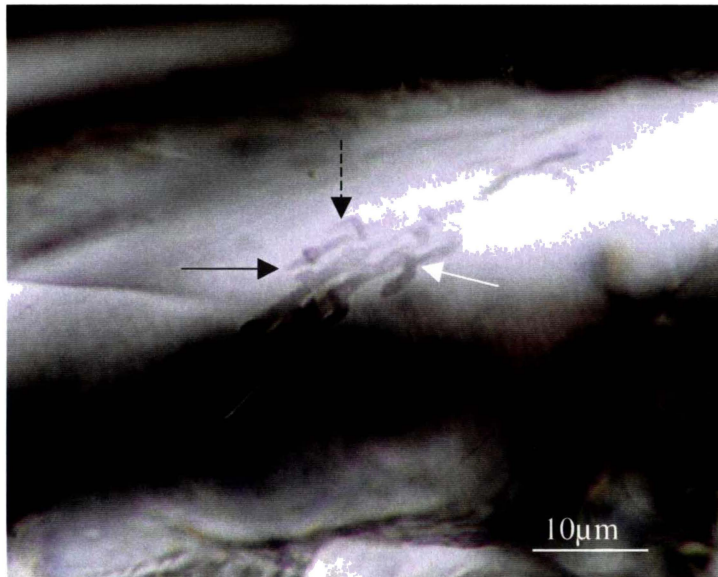
T = width of a single pine tracheid; arrow = tunnel; P = apical proboscis hypha; area within dashed line = reticulum of tunnels.

M12-T3



T = width of a single pine tracheid; arrow = T-branch from tunnel within reticulum.

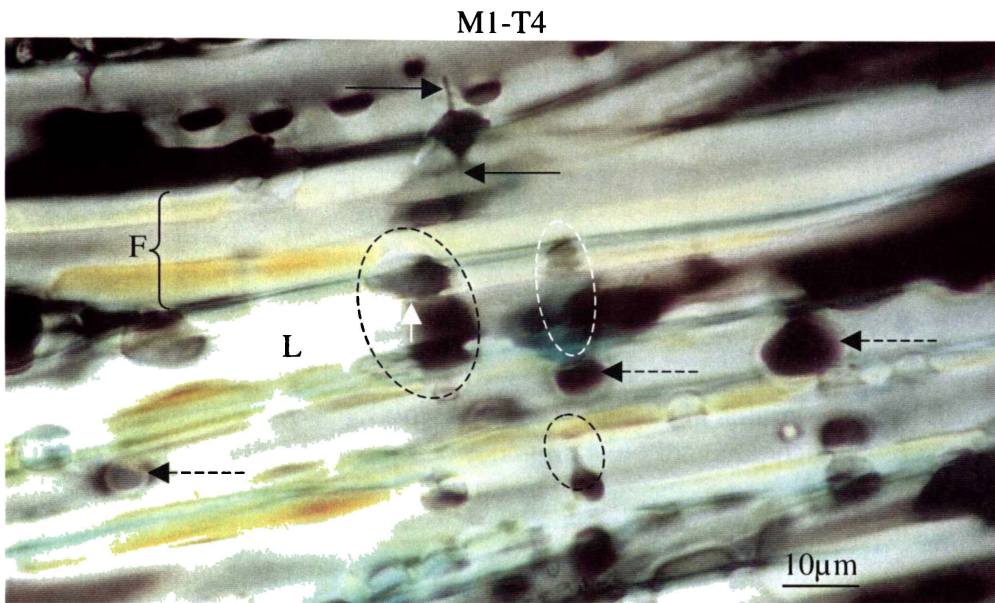
M13-T3



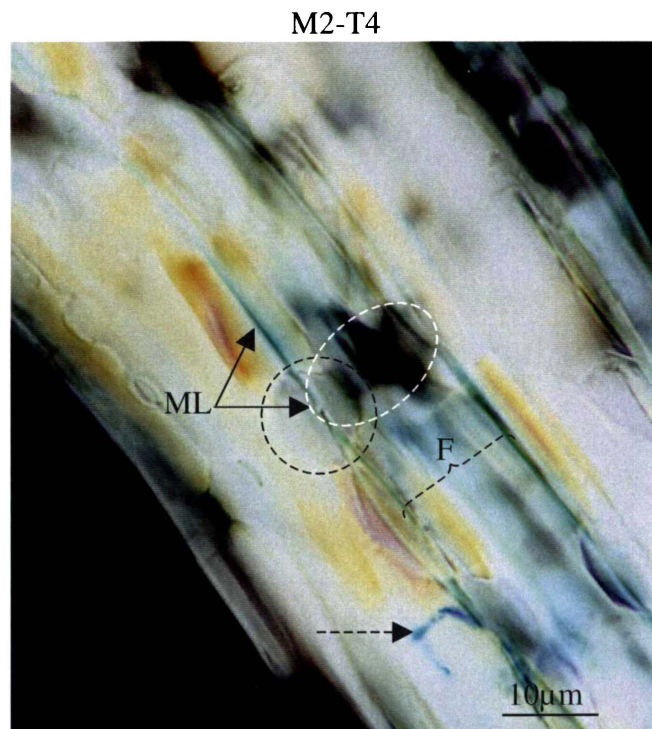
T = width of a single pine tracheid; white arrow = T-branch from tunnel within reticulum; dashed arrow = L-branch; solid black arrow = angular tunnel apex.

Section 4.5.6

Tunnelling Decay Type 4 (T4)

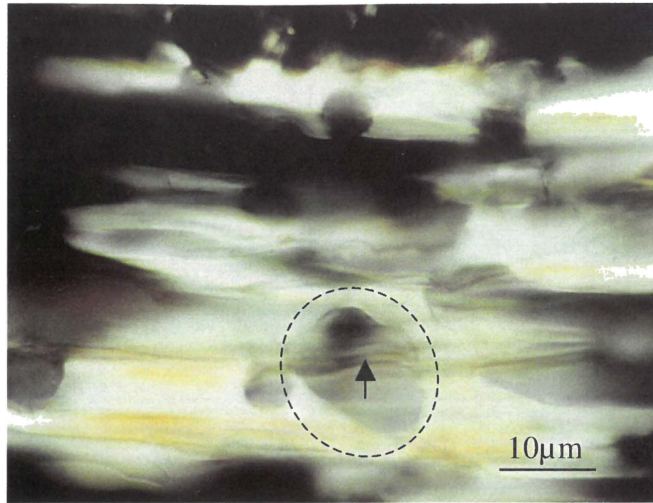


F = width of a single beech fibre; L = lumen; solid arrow = fine BHs believed to have been formed by a T-branch stem hypha; area within dashed circle = concentric tunnel penetrating the fibre perimeter between the lumen wall and the ML; dashed arrow = BHs or possibly adjoining concentric tunnels forming a void that spans two adjacent fibres thereby connecting cell lumina; white arrow = residual overlying lumen wall.



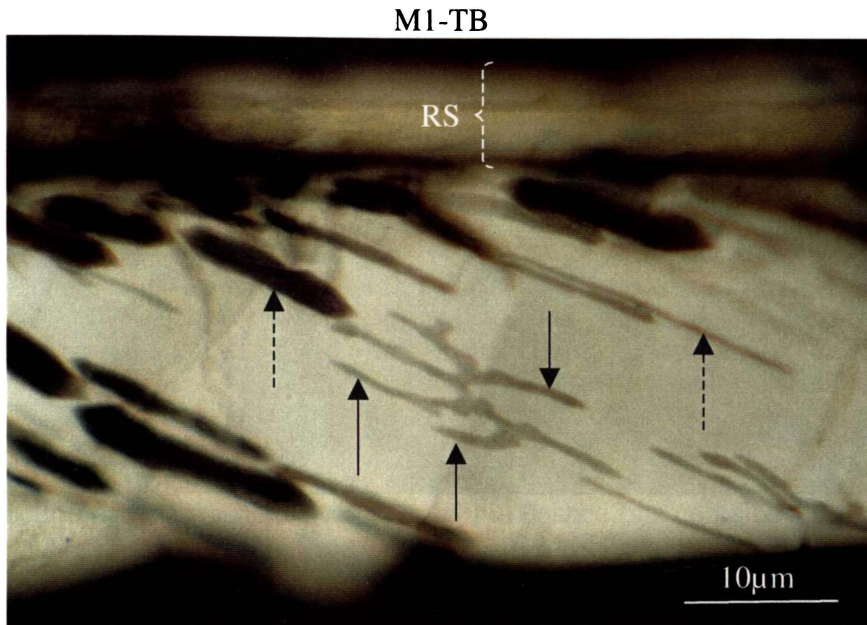
F = width of a single beech fibre; area within black dashed circle = two adjoining concentric tunnels; area within white dashed line = concentric tunnel within a single fibre; dashed arrow = hypha, possibly penetrating the ML.

M3-T4

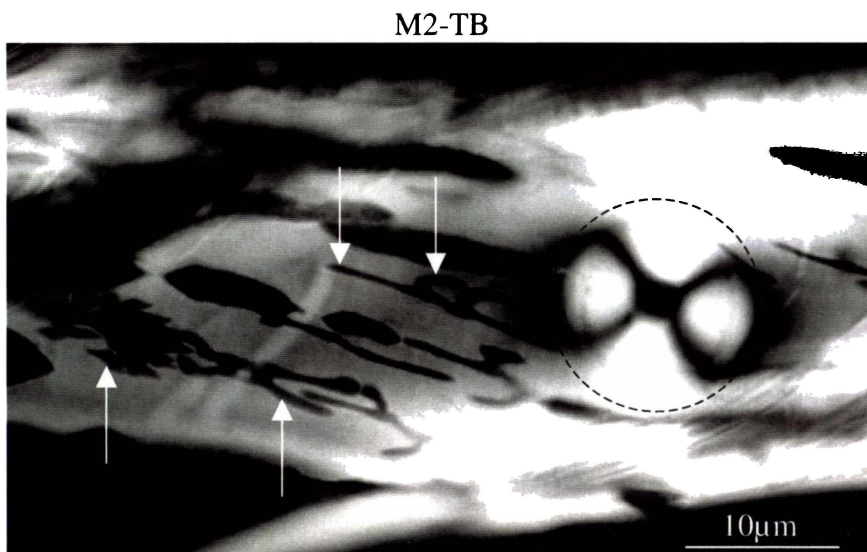


Area within dashed circle = two adjoining concentric tunnels in adjoining beech fibres (tunnels have expanded so that concentric orientation is no longer apparent and adjacent tunnels look similar to a BH); arrow = remnants of ML

Section 4.5.7
Tunnelling Bacteria (TB)

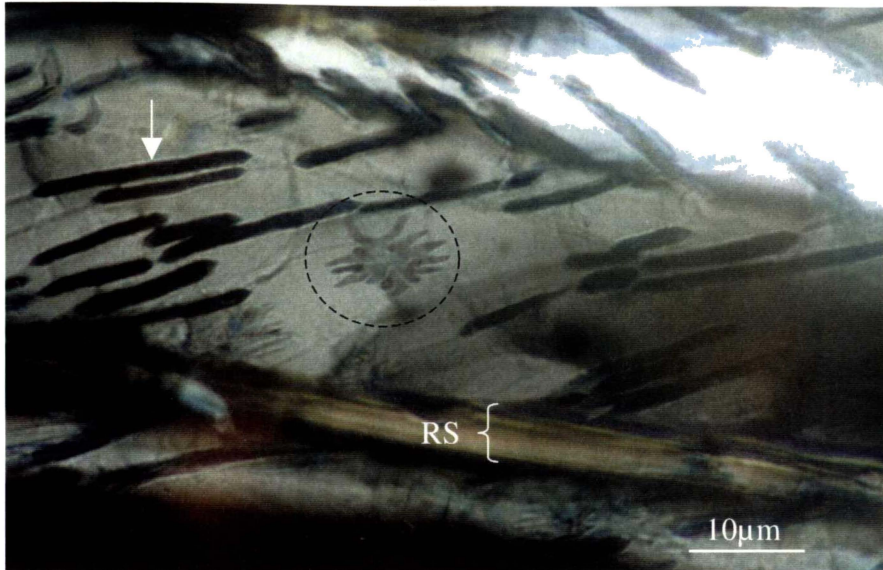


RS = radial section of pine tracheid wall; solid arrow = tunnel produced by tunnelling bacterium (parallel to helical CM in S2 layer); dashed arrow = SR cavity.



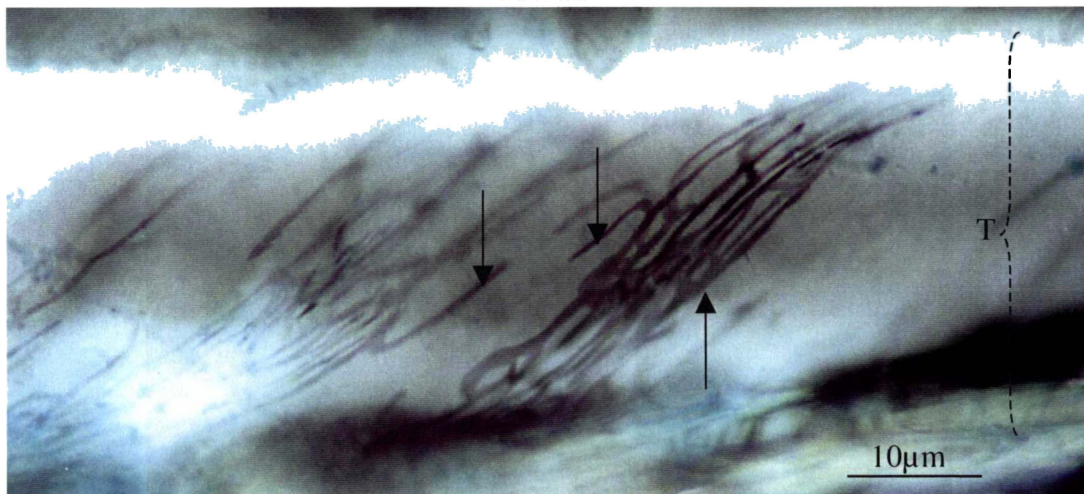
Solid arrow = tunnel produced by TB in pine tracheid wall (parallel to helical CM of S2 layer); area inside dashed circle = bordered pit.

M3-TB



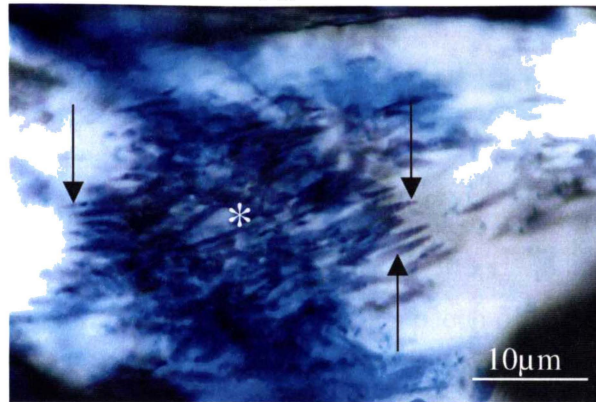
RS = radial section of pine tracheid wall; area within dashed line contains a group of closely associated tunnels produced by TB; arrow = SR cavity.

M4-TB



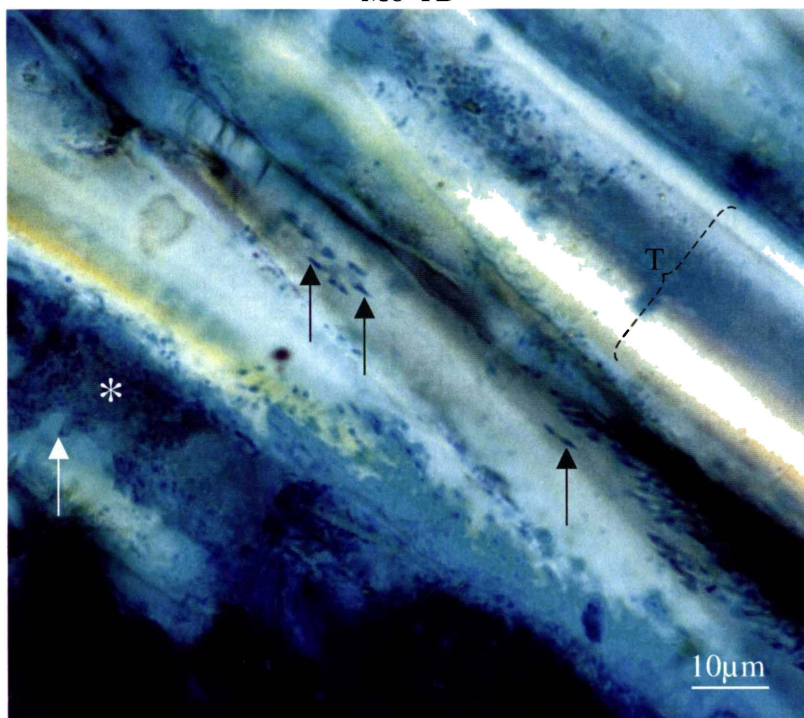
T = approximate width of pine tracheid; arrow = tunnel produced by TB (parallel to helical CM).

M5-TB



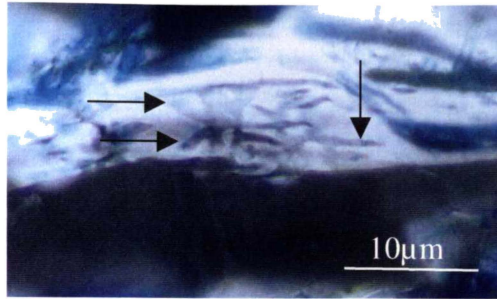
Arrow = tunnel produced by TB in beech fibre; * = heavily degraded fibre wall containing many coalesced tunnels formed by TB (individual tunnels visible at margins).

M6-TB



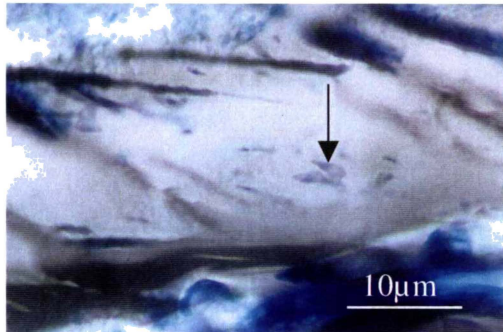
T = approximate width of pine tracheid; black arrow = tunnel produced by TB; * = tracheid wall eroded by erosion bacteria (EB); white arrow = depression in tracheid wall containing EB.

M7-TB



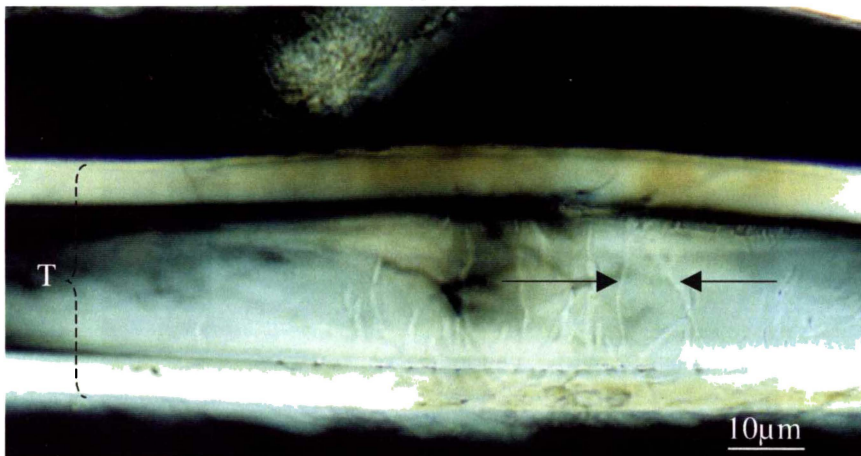
Arrow = tunnel produced by TB in a beech fibre tracheid.

M8-TB



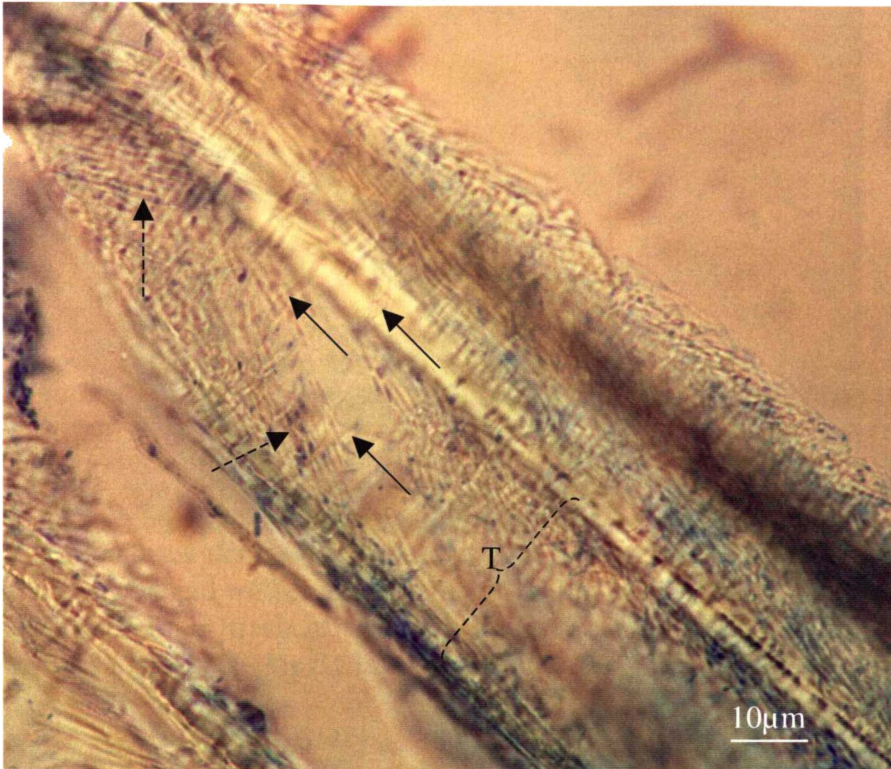
Arrow = pear shaped tunnel containing a tunneling bacterium in a pine tracheid.

M9-TB



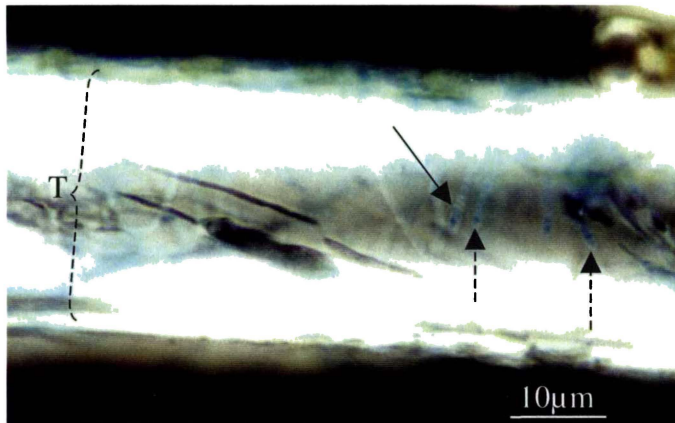
T = approximate width of pine tracheid; black arrow = tunnel produced by TB.

M10-TB



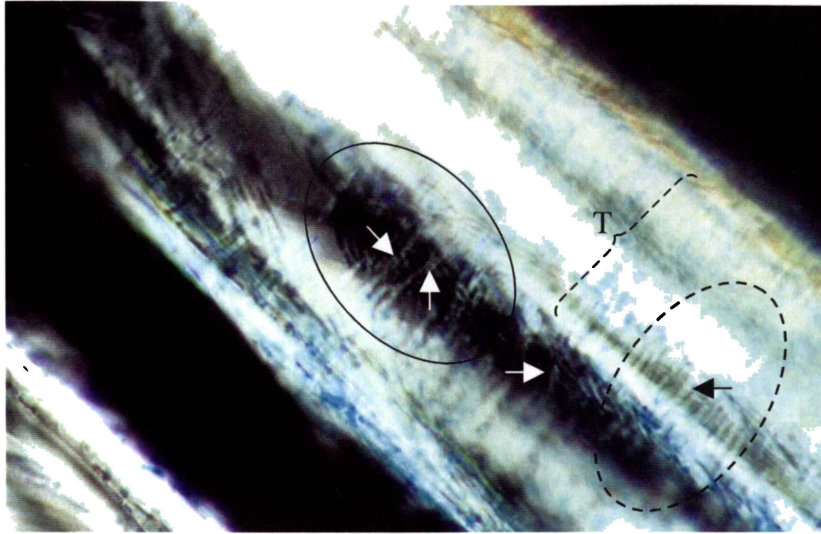
T = approximate width of pine tracheid; black arrow = tunnel produced by TB, aligned with CM in S1 layer; dashed arrow = tunnels aligned with helical CM of S2 layer.

M11-TB



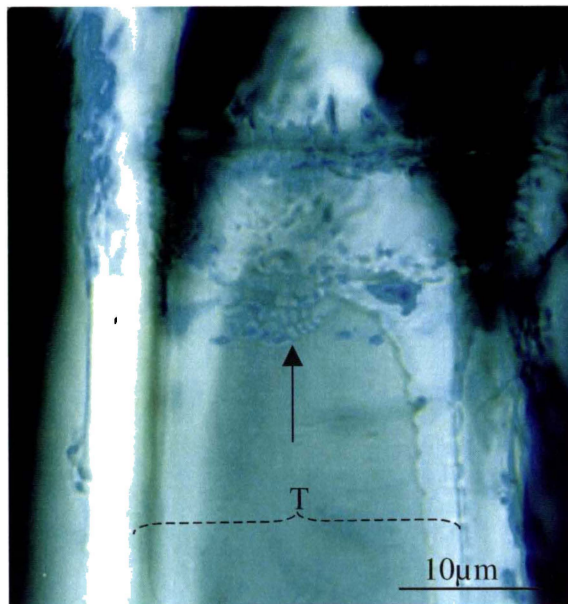
T = approximate width of pine tracheid; solid arrow = tunnel produced by TB, aligned with CM in S1 layer (bacterium stained with aniline blue is visible at tunnel apex and stained cross walls are visible inside tunnel); dashed arrow = bacterium within tunnel apex.

M12-TB



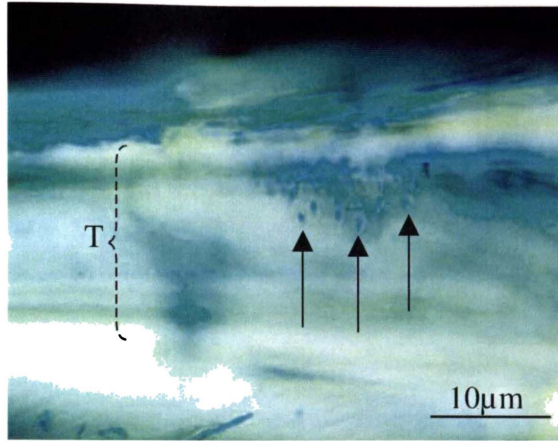
T = tangential section through pine tracheid; arrow = TB tunnel with cross walls visible; area within dashed line = tracheid wall containing many TB tunnels parallel to the CM of the S1 layer; area within solid line = tracheid wall with TB tunnels (white arrows) that appear to penetrate concentrically close to the S1 layer and then traverse the ML into the adjacent tracheid.

M13-TB



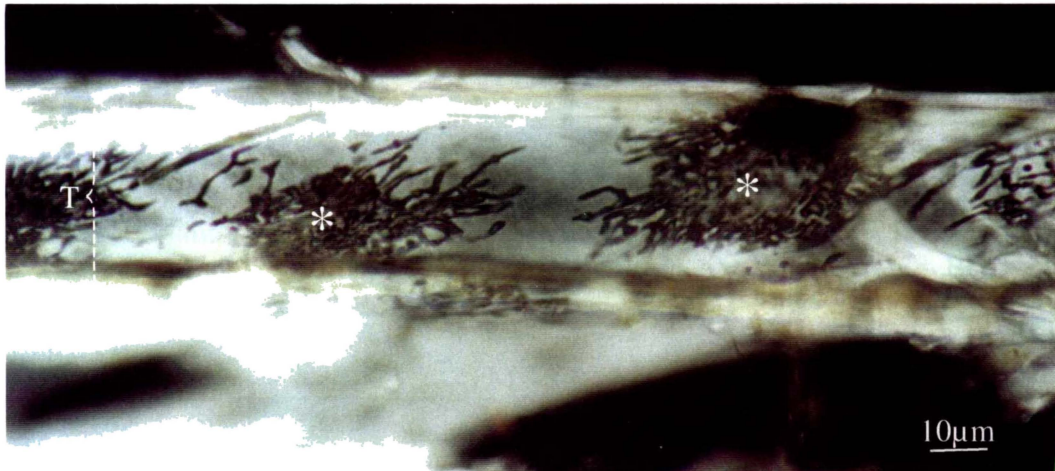
T = width of pine tracheid; tunnel containing tunnelling bacterium at apex (cross walls visible).

M14-TB



T = approximate width of pine tracheid; tunnel containing tunnelling bacterium at apex (aligned with CM of S1 layer)

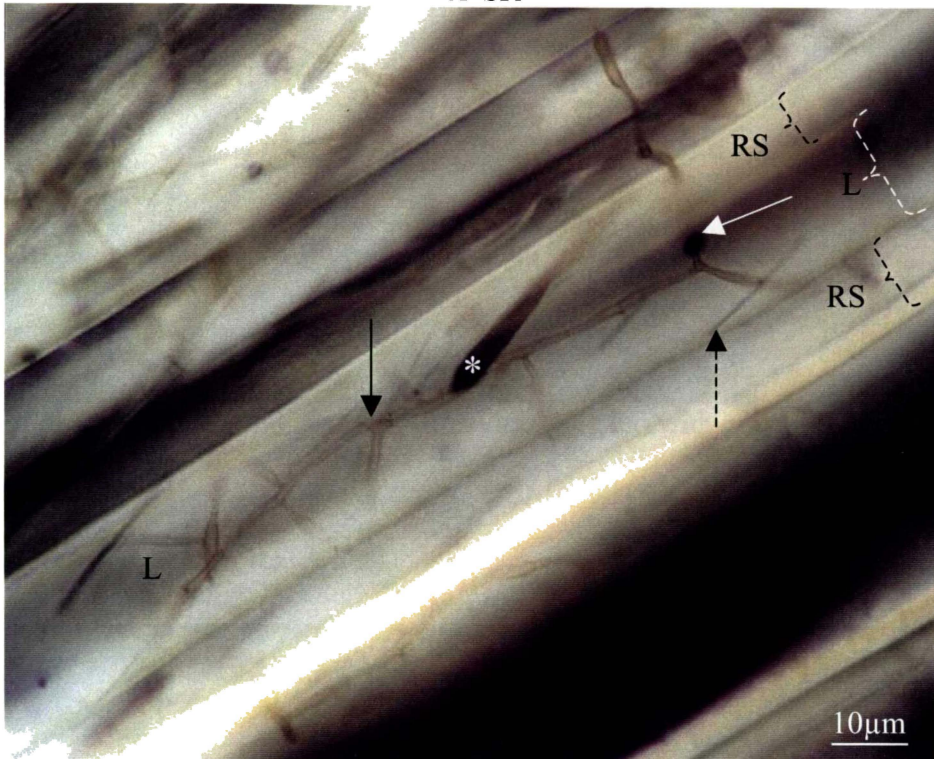
M15-TB



T = approximate width of pine tracheid; * = groups of coalesced TB tunnels.

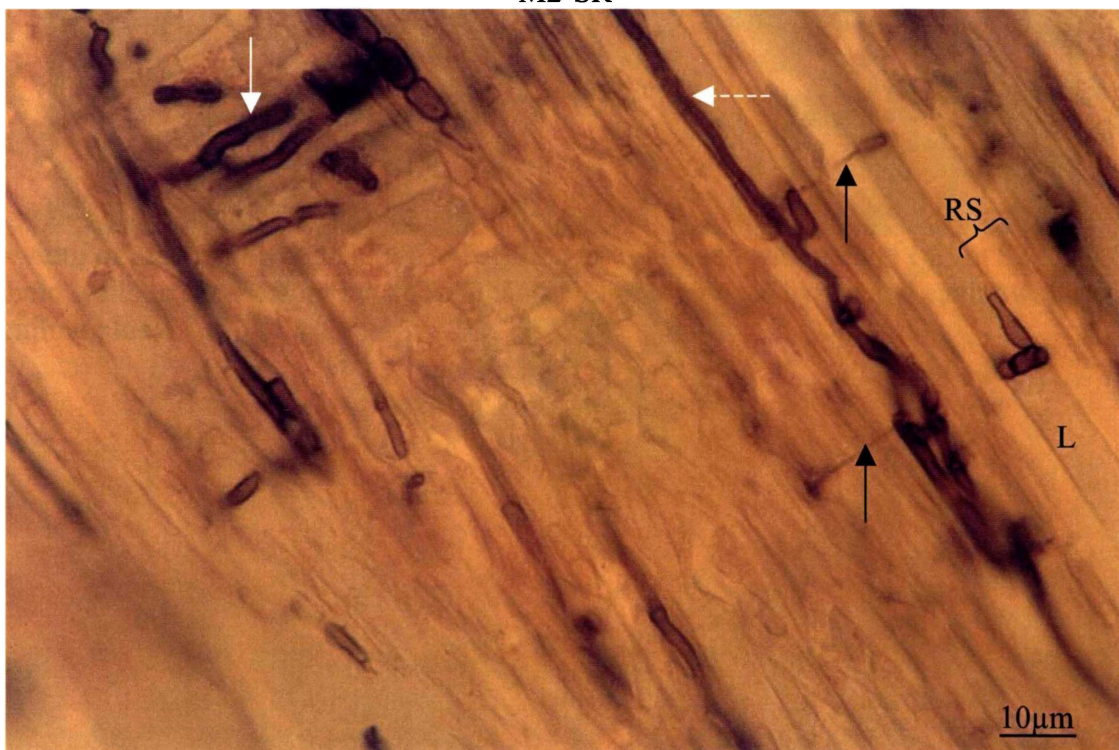
Section 4.5.8
Soft Rot

M1-SR



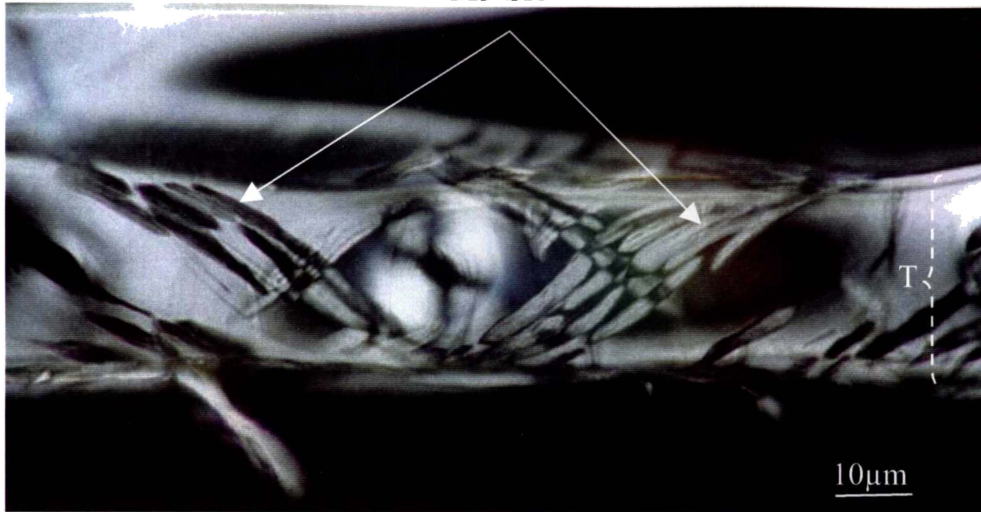
RS = radial section through pine tracheid; L = lumen; dashed arrow = T-branch aligned with CM of S2 layer section; solid arrow = SR hypha; * = SR cavity, white arrow = BH.

M2-SR



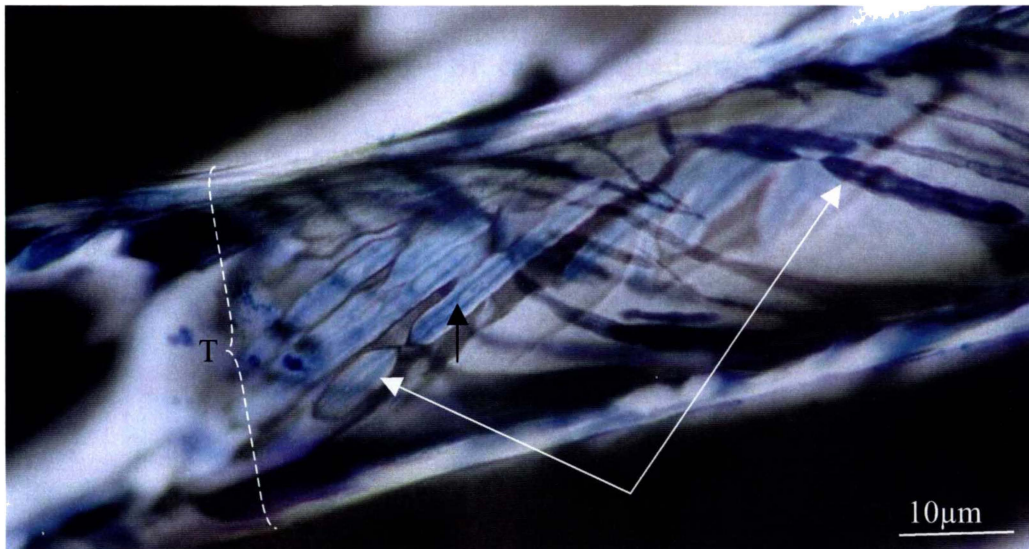
RS = radial section through beech fibre; L = lumen; solid white arrow = SR hypha in wood parenchyma; dashed white arrow = SR hypha in fibre lumen; black arrow = proboscis hypha penetrating fibre wall.

M3-SR



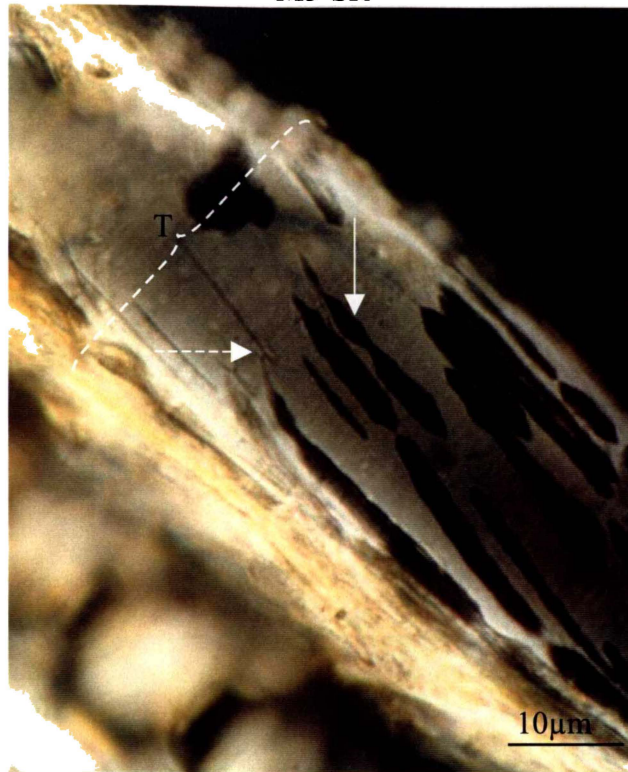
T = width of pine tracheid; solid arrow = SR cavities aligned with helical CM in S2 layer of tracheid wall.

M4-SR



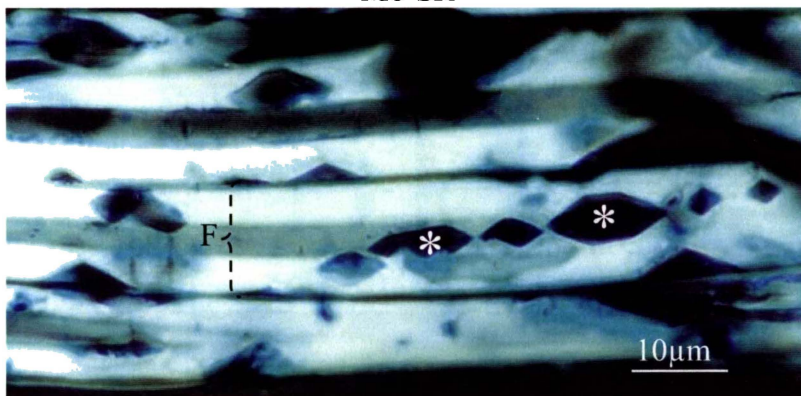
T = width of pine tracheid; solid arrow = SR cavities aligned with helical CM in S2 layer of tracheid wall; arrow = cavity hypha (hyphal secretions between hypha and cavity wall stained by aniline blue).

M5-SR



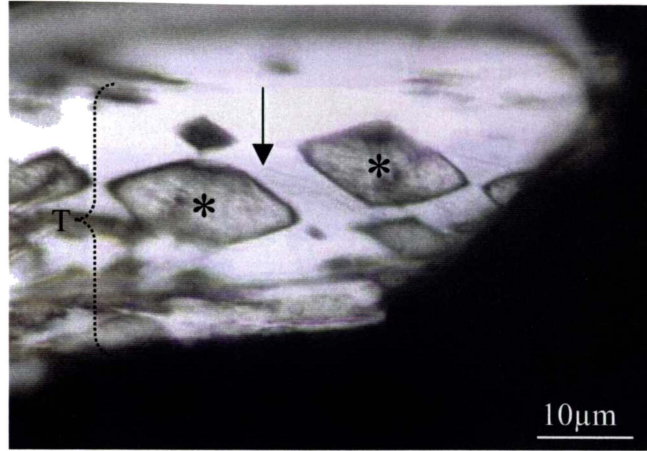
T = width of pine tracheid; solid arrow = SR cavity; dashed arrow = T-branch at end of apical proboscis hypha.

M6-SR



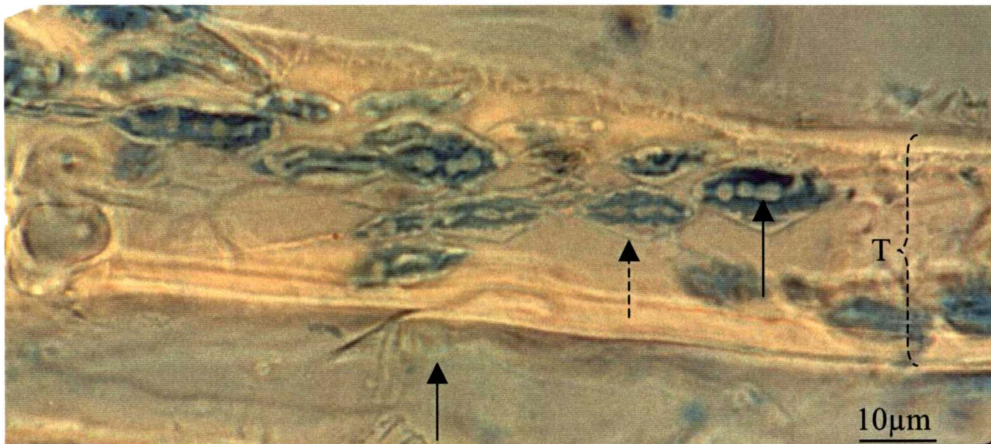
F = width of beech fibre; * = SR cavity.

M7-SR



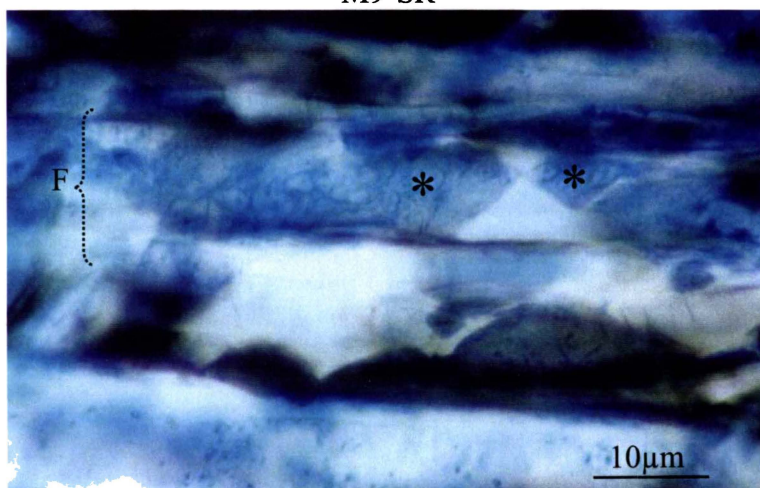
T = width of pine tracheid; * = SR cavity; arrow = L-bend proboscis hypha from cavity.

M8-SR



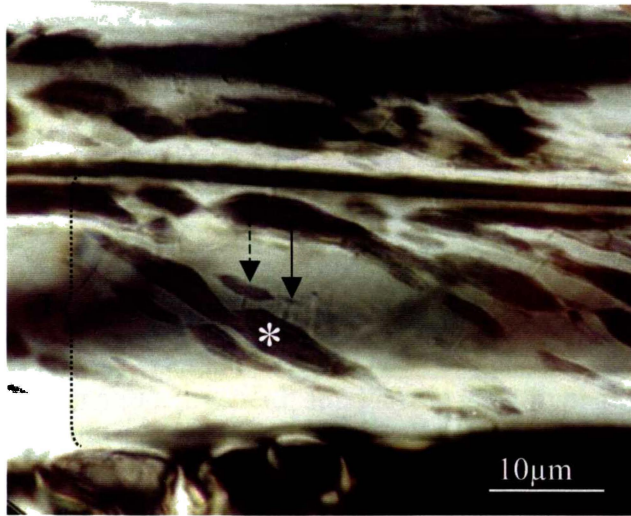
T = width of pine tracheid; dashed arrow = SR cavity; solid arrow = cavity hypha (hyphal secretions stained by aniline blue).

M9-SR



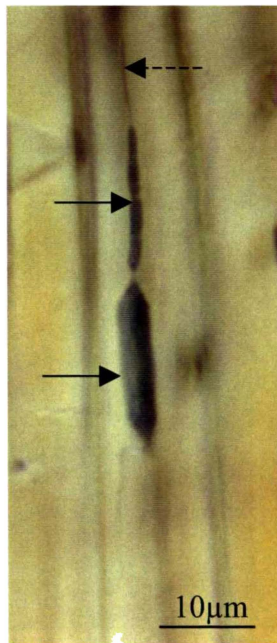
F = width of beech fibre; * = SR cavity.

M10-SR



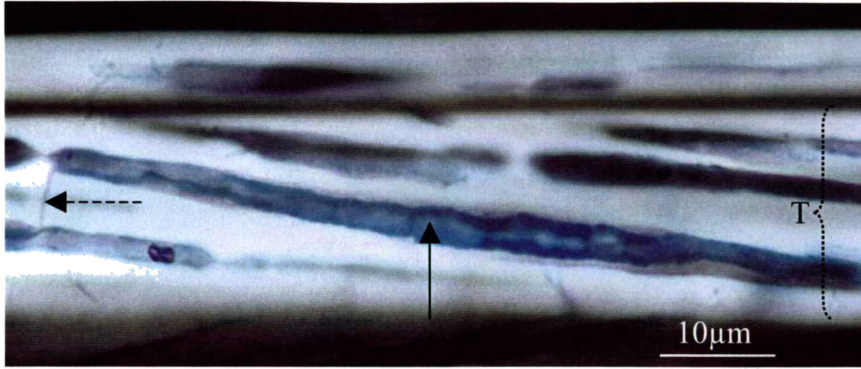
T = width of pine tracheid; * = SR cavity; solid arrow = T-branch from cavity; dashed arrow = early cavity around T-branch.

M11-SR



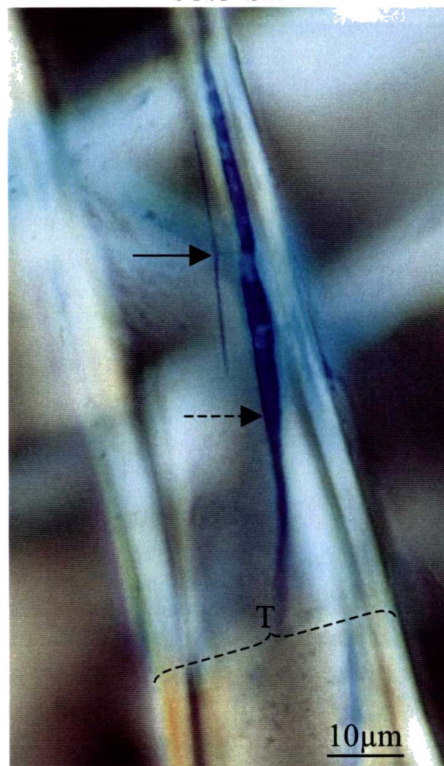
Arrow = SR cavity in beech fibre tracheid; dashed arrow = proboscis hypha.

M12-SR



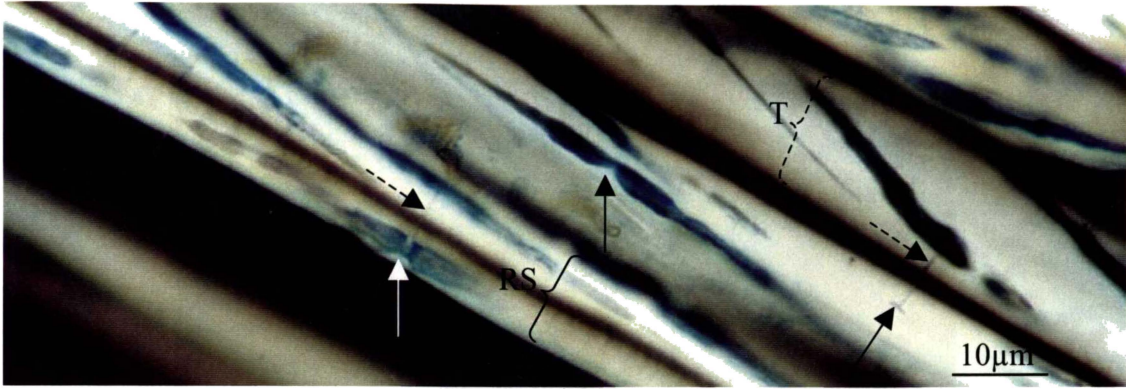
T = tangential section through pine tracheid; solid arrow = SR hyphae in cavity; dashed arrow = proboscis hypha connecting two cavities

M13-SR



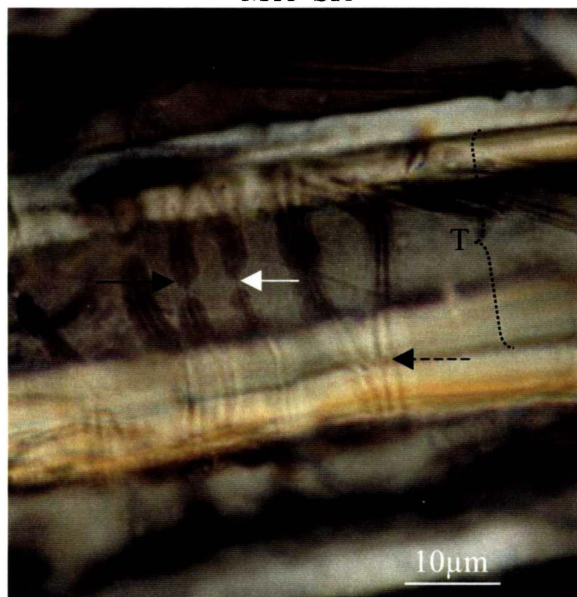
T = width of pine tracheid; dashed arrow = SR cavity; solid arrow = T-branch.

M14-SR



T = tangential section through pine tracheid; RS = radial section through pine tracheid; solid arrow = T-branch; dashed arrow = proboscis hypha.

M15-SR



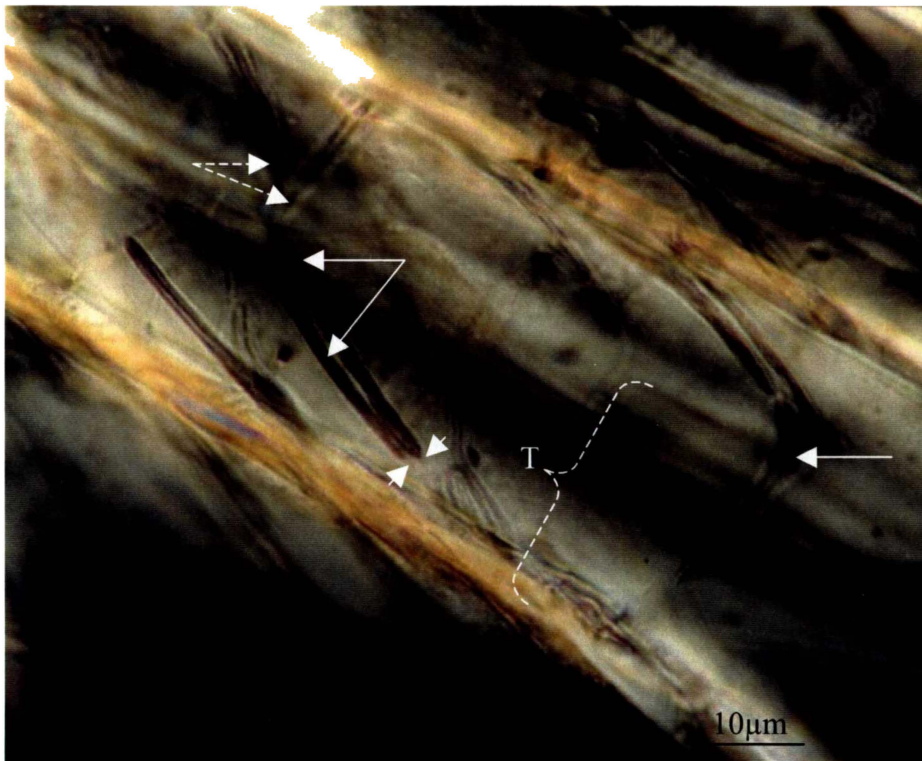
T = width of pine tracheid; solid black arrow = SR cavity aligned with CM of S1 layer; solid white arrow = apical proboscis hypha connecting two cavities; dashed arrow = cavity hypha crosses the ML into adjacent tracheid.

M16-SR



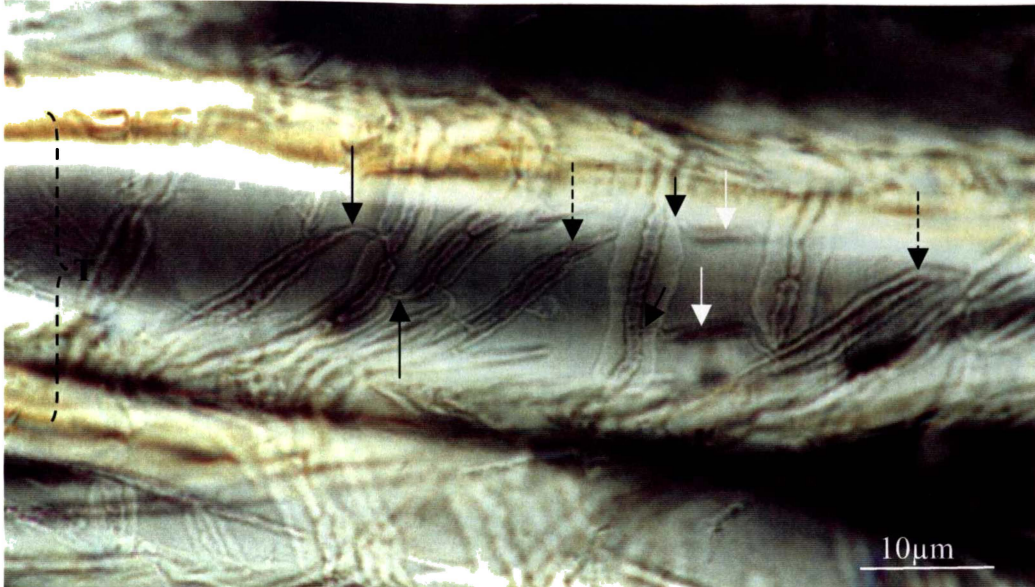
F = width of pine tracheid; solid arrow = connection between two SR cavities, the leading cavity changing form and direction within the cell wall, possibly in response to proboscis hypha encountering a different cell wall layer.

M17-SR



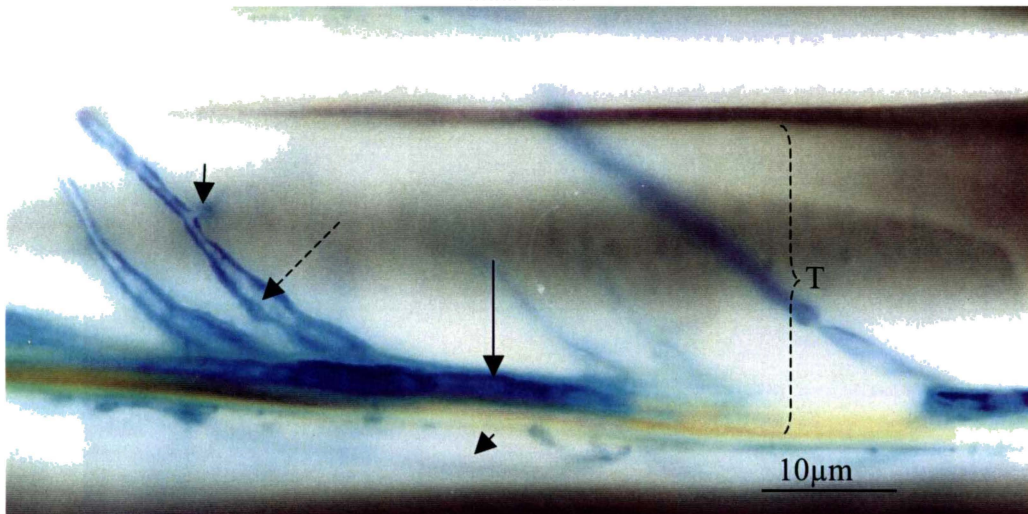
T = width of pine tracheid; double solid arrow = adjacent SR cavities aligned with helical CM in S2 layer of tracheid wall; double dashed arrow = cavities in adjacent tracheid, connected to cavities labeled with solid arrow in the region of the ML (one cavity appears to continue alignment with helical CM, suggesting it crosses the ML into the S2 layer and the other cavity probably aligns with the CM of the S1 layer and moves concentrically around the perimeter of the tracheid); short arrow = apical extension of cavity; solid arrow = cavity changing direction, probably due to movement between the S1 and S2 layers.

M18-SR



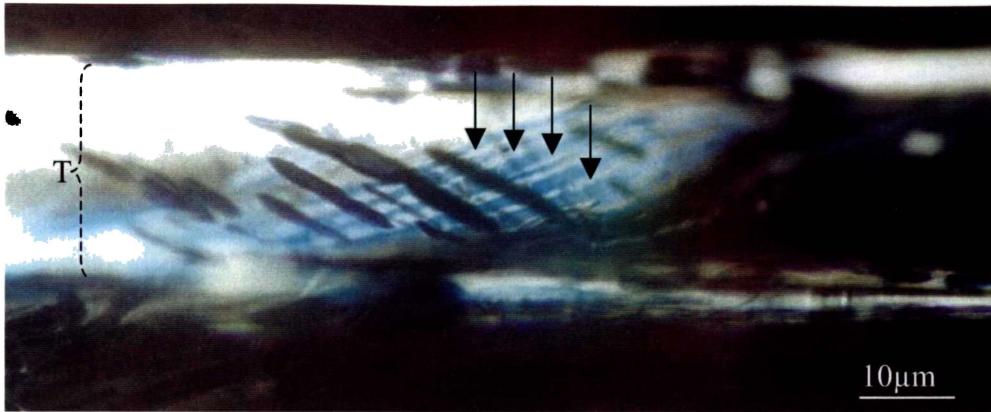
T = width of pine tracheid; solid arrow = proboscis hypha connecting two cavity hyphae, it is not clear which is the leading apical proboscis and which is a lateral side branch); short arrow = lateral proboscis hypha (parent hypha is aligned with CM in S1 layer and lateral cavities (white arrow) appear to have an alignment intermediate between the parent cavity and helical cavities aligned with CM of the S2 layer (dashed arrow).

M19-SR



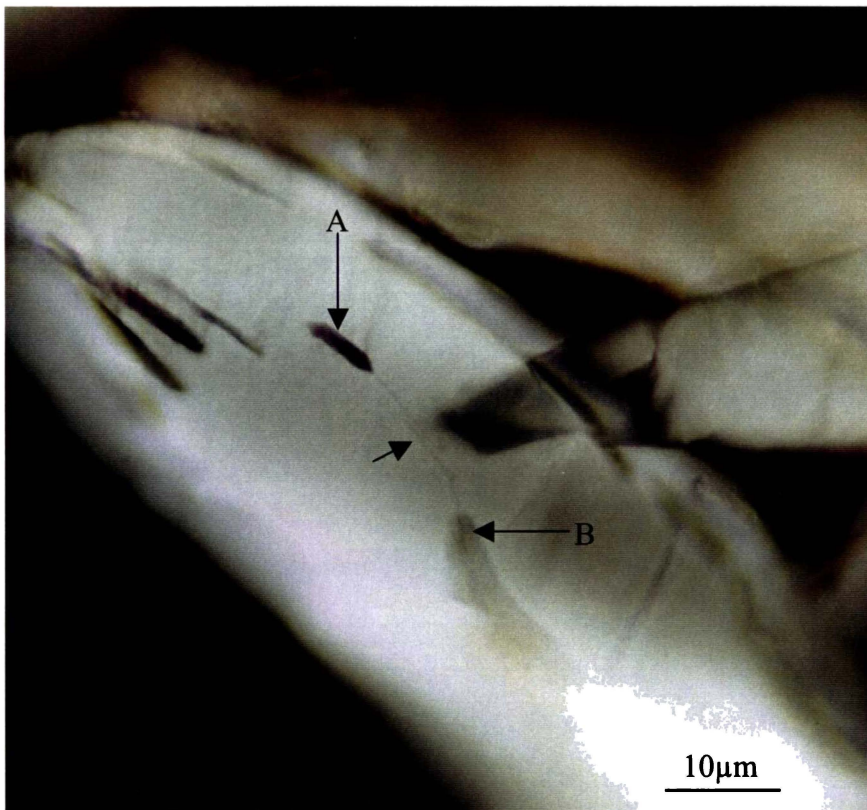
T = width of pine tracheid; solid arrow = SR hypha in cavity (radial section); dashed arrow = cavity hypha aligned with helical CM, probably connected to hypha labeled with solid arrow; short arrow = side branch from cavity hypha that appears to be bending towards the ML.

M20-SR



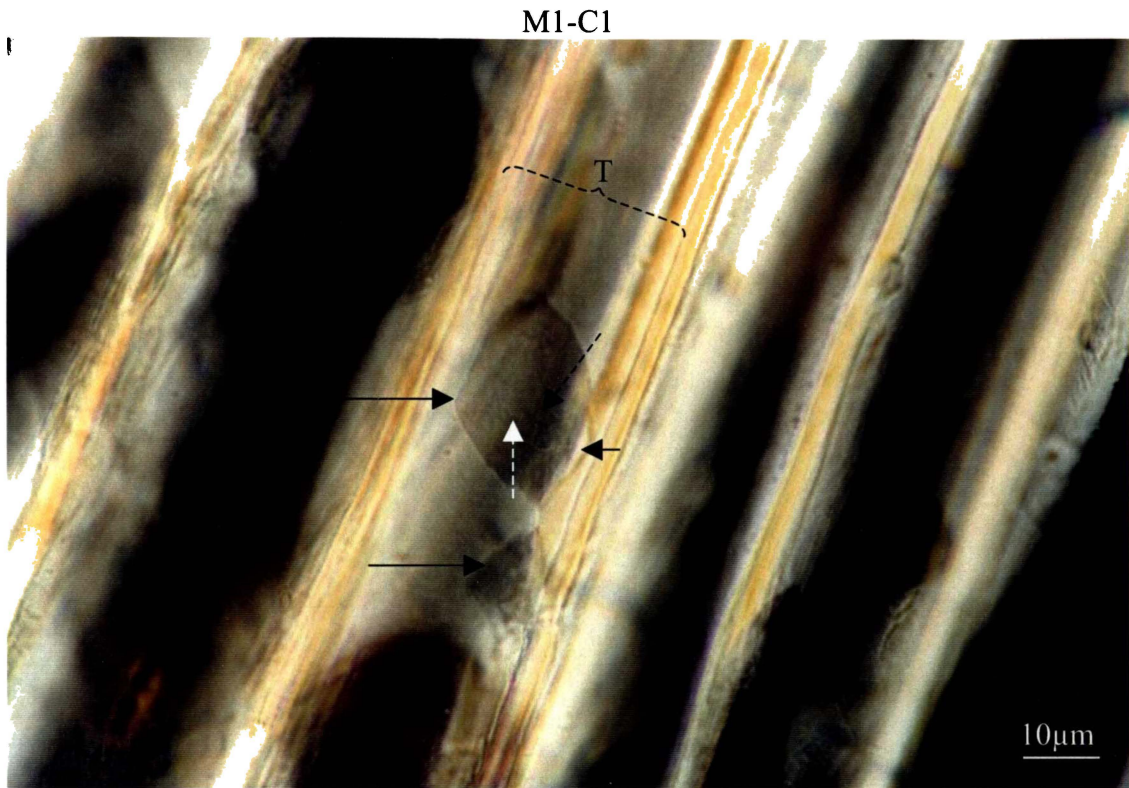
T = width of pine tracheid; solid arrows = SR hyphae, closely associated after coalescence of parallel cavities.

M21-SR

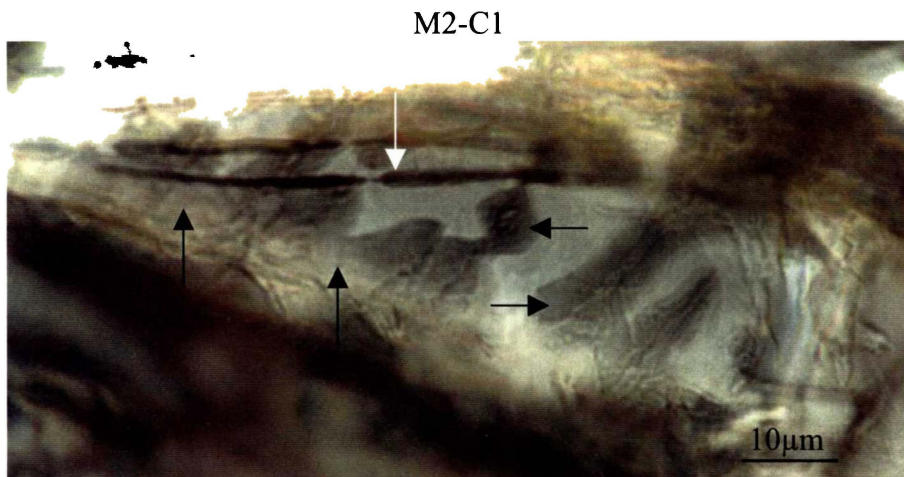


A = SR cavity in pine tracheid; short arrow = T-branch connecting cavities A and B.

Section 4.5.9
Cavitation Type 1 (C1)



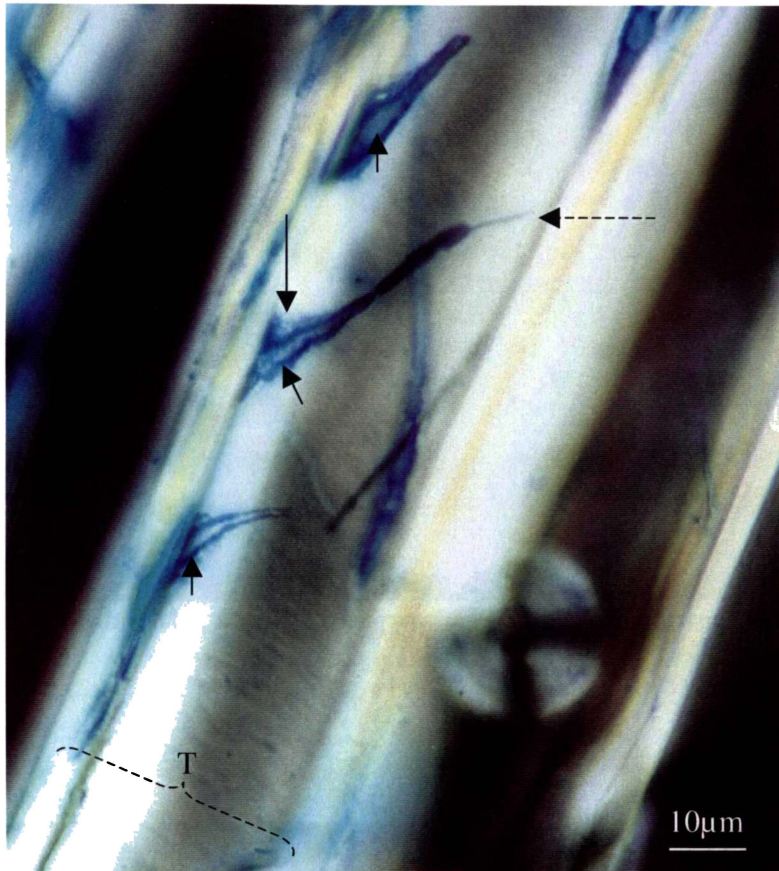
T = width of pine tracheid; solid arrow = cavity; black dashed arrow = cavity hypha with lateral tangential side branch (white arrow); short arrow = depth of depression in radial wall section indicative of depth of cavity.



Black arrow = cavity within pine tracheid (probably within S1 layer); white arrow = SR cavity aligned with helical CM of the S2 layer.

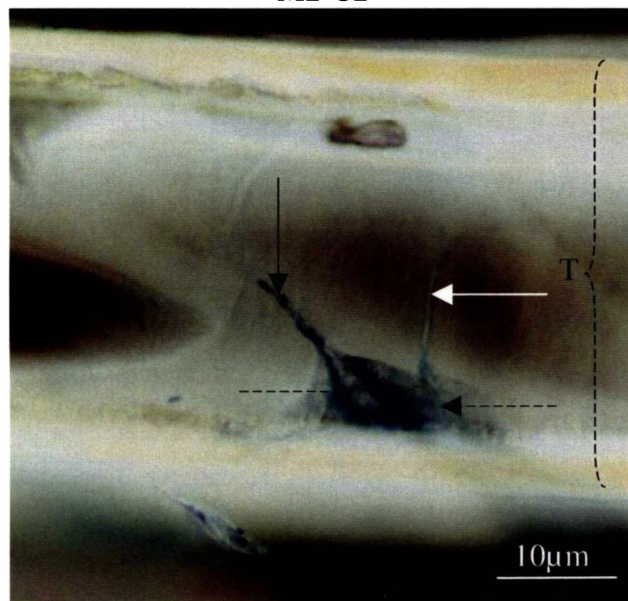
Section 4.5.10
Cavitation Type 2 (C2)

M1-C2



T = width of pine tracheid; dashed arrow = proboscis hypha aligned with helical CM of S2 layer; short arrow = cavity hypha; long solid arrow = cell wall uptake of aniline blue around cavity hyphae is diffuse, suggesting attack by diffuse degradative agents.

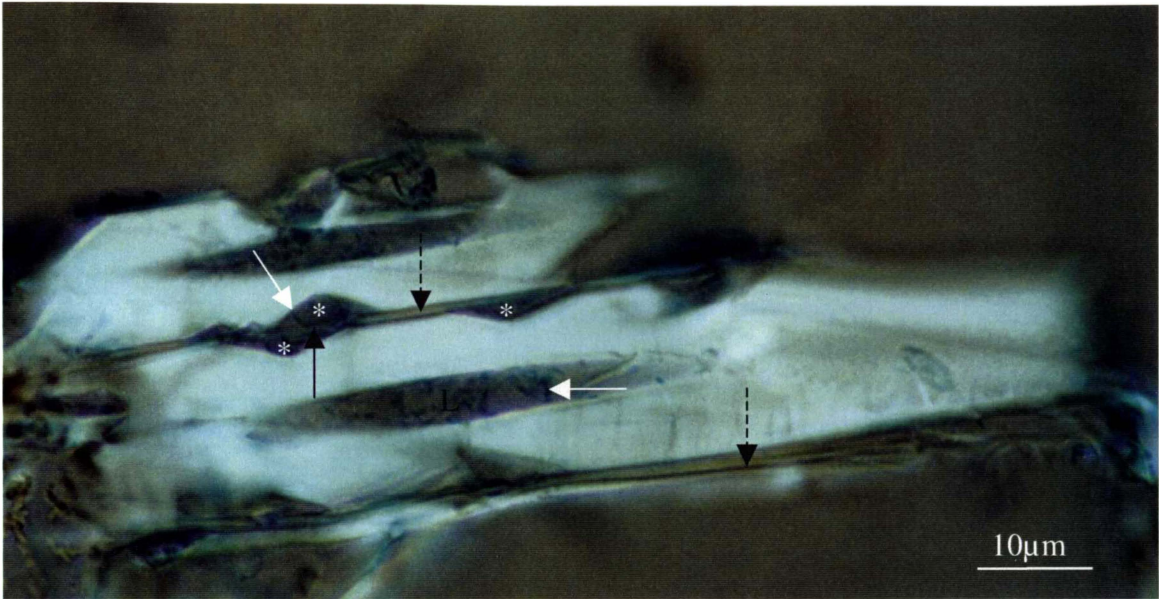
M2-C2



T = width of pine tracheid; dashed arrow = cavity hypha; black solid arrow = proboscis hypha aligned with helical CM of S2 layer; white arrow = proboscis hypha aligned with CM of S1 layer.

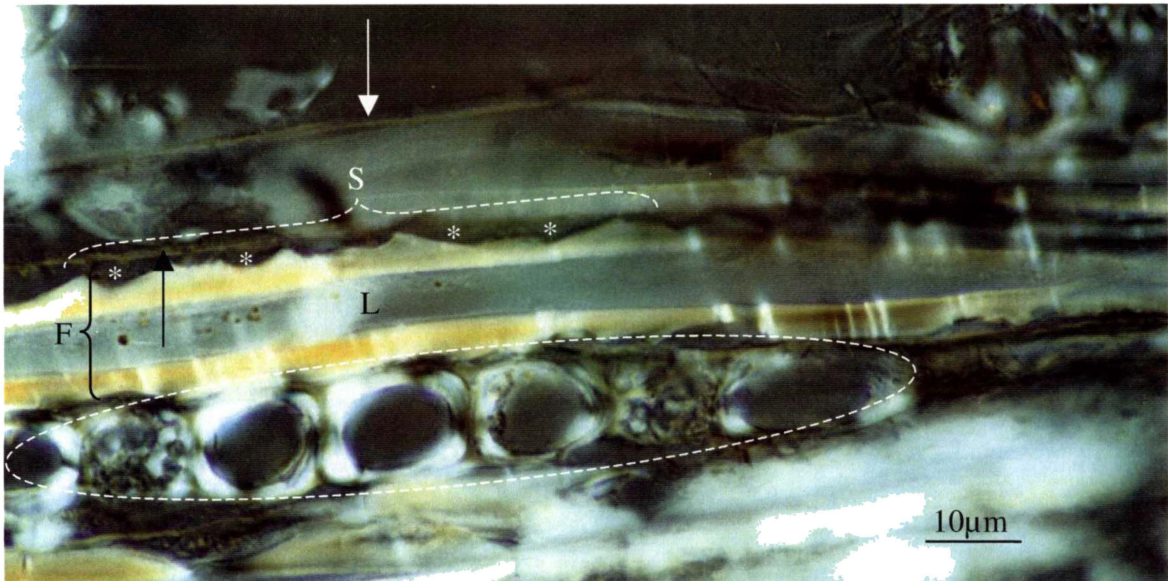
Section 4.5.11
Cavitation Type 4 (C4)

M1-C4



Dashed arrow = beech fibre ML; solid black arrow = residual ML between cavities (*); white arrow = hypha.

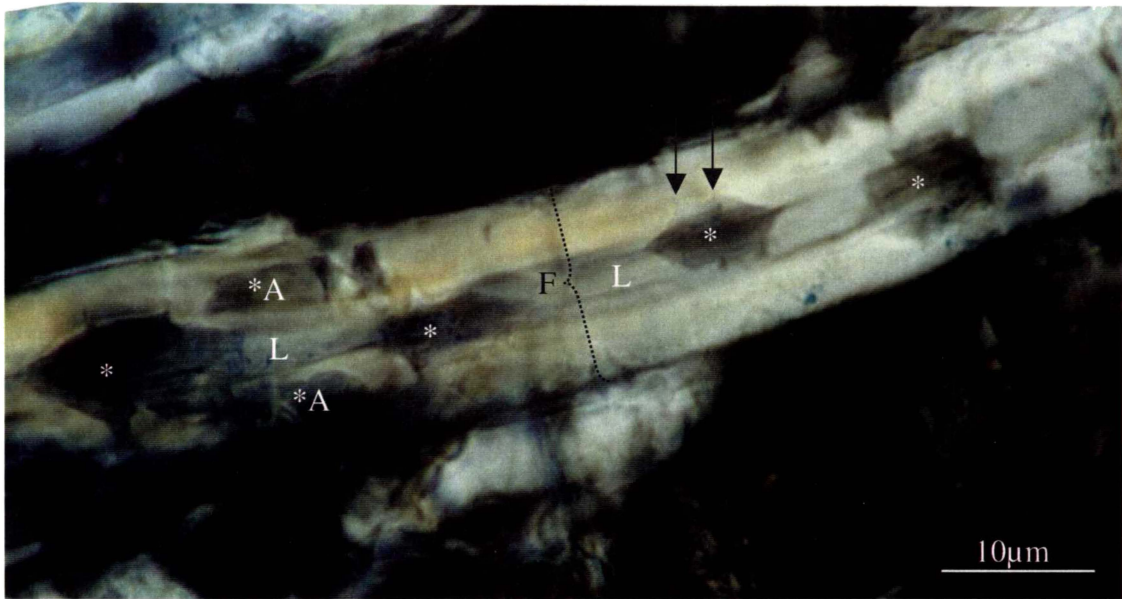
M2-C4



F = width of beech fibre:arrow = residual ML; L = lumen; S = serrated edge of S2 layer produced by coalescence of cavities (*); area within dashed ellipse = parenchyma.

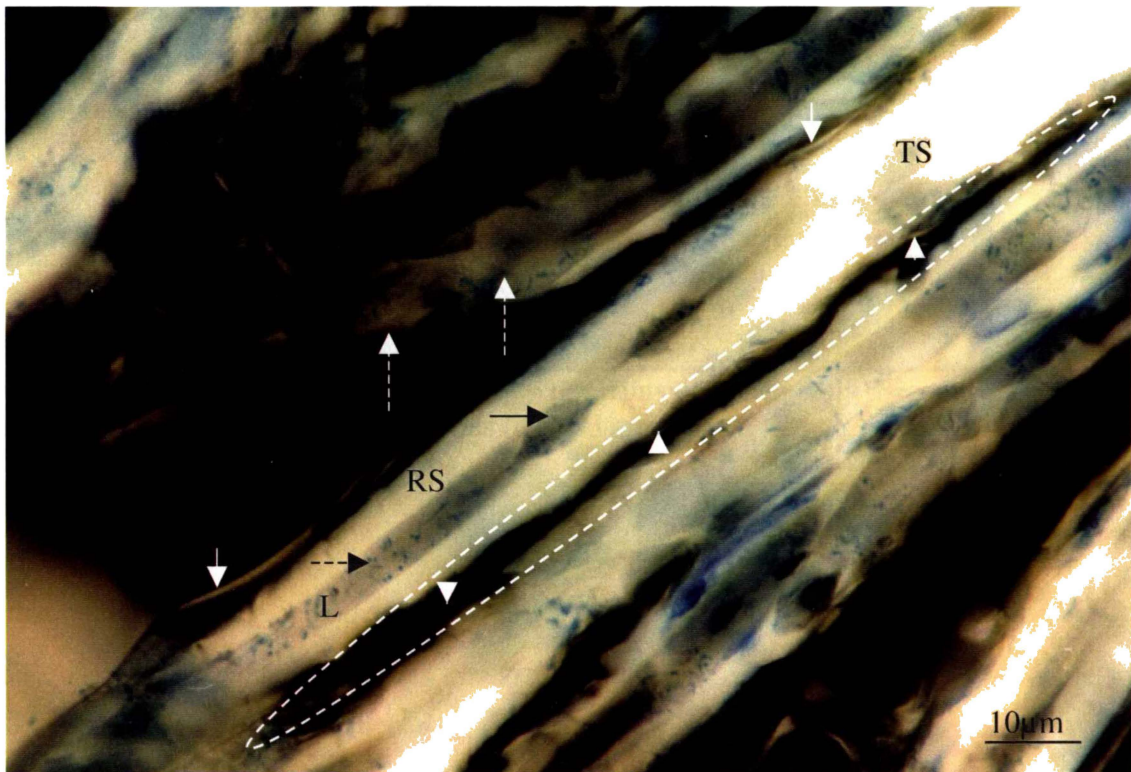
Section 4.5.12
Cavitation Type 5 (C5)

M1-C5



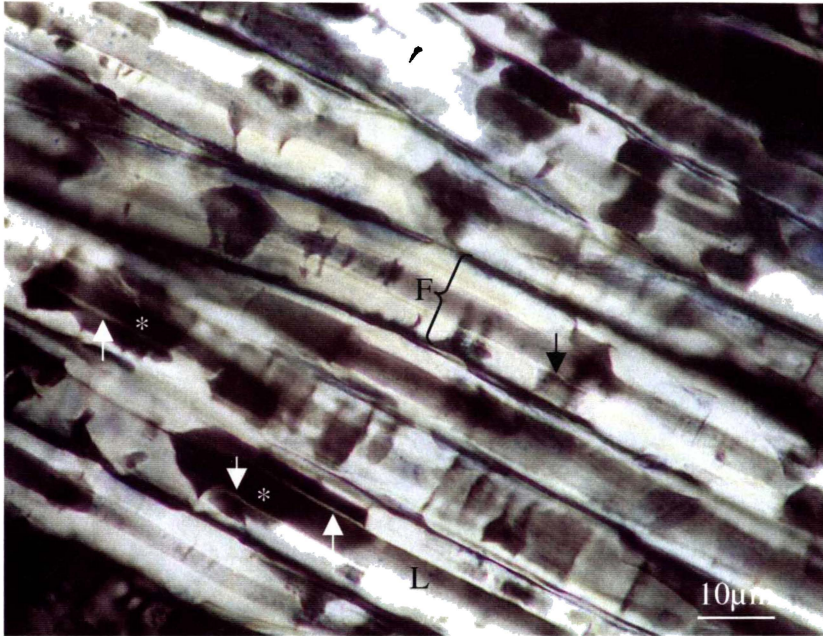
F = width of beech fibre; * = cavity; arrow = trough in cavity wall containing an aniline blue stained hypha; L = fibre lumen; *A = continuous concentric cavity (only visible in radial section since lumen wall and intact attached S2 layer obscures most of the cavity).

M2-C5



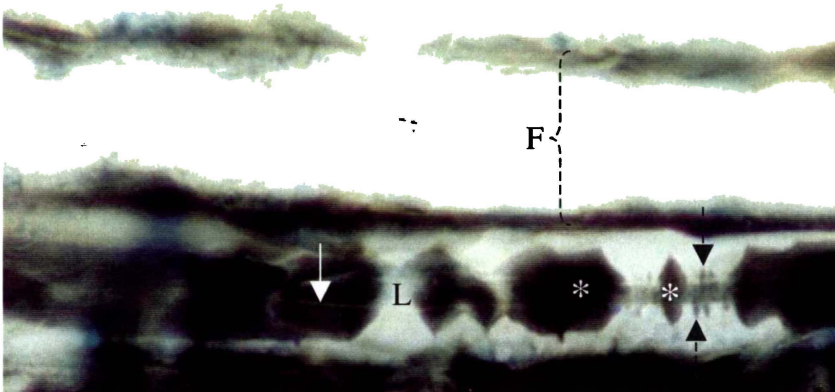
RS = radial section through beech fibre; TS = tangential section; L = lumen; solid black arrow = cavity hypha; dashed white arrow = lumen hypha; area inside dashed line = delamination of fibres due to coalescence of cavities near the ML; solid white arrow = remnants of ML; dashed white arrow = remnants of lumen wall; dashed black arrow = lumen hyphae.

M3-C5



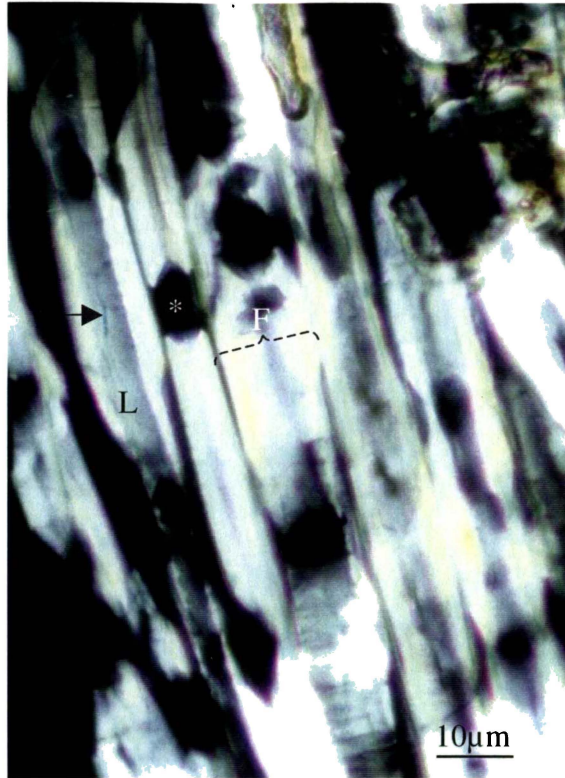
F = width of beech fibre; L = lumen; arrow = remnants of lumen wall; * = concentric cavity or possibly coalesced concentric cavities.

M4-C5



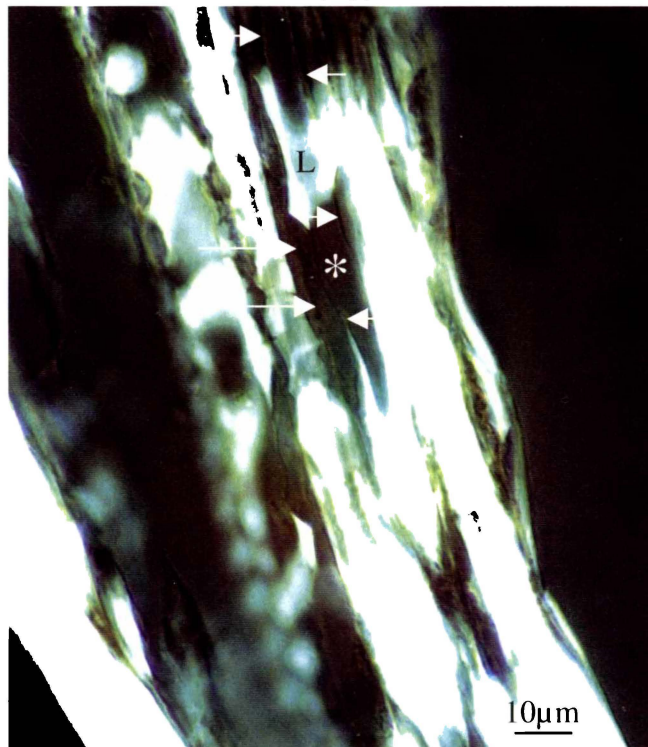
F = width of beech fibre; L = lumen; arrow = remnants of lumen wall; * = concentric cavity (possibly several coalesced small cavities (dashed arrow)).

M5-C5



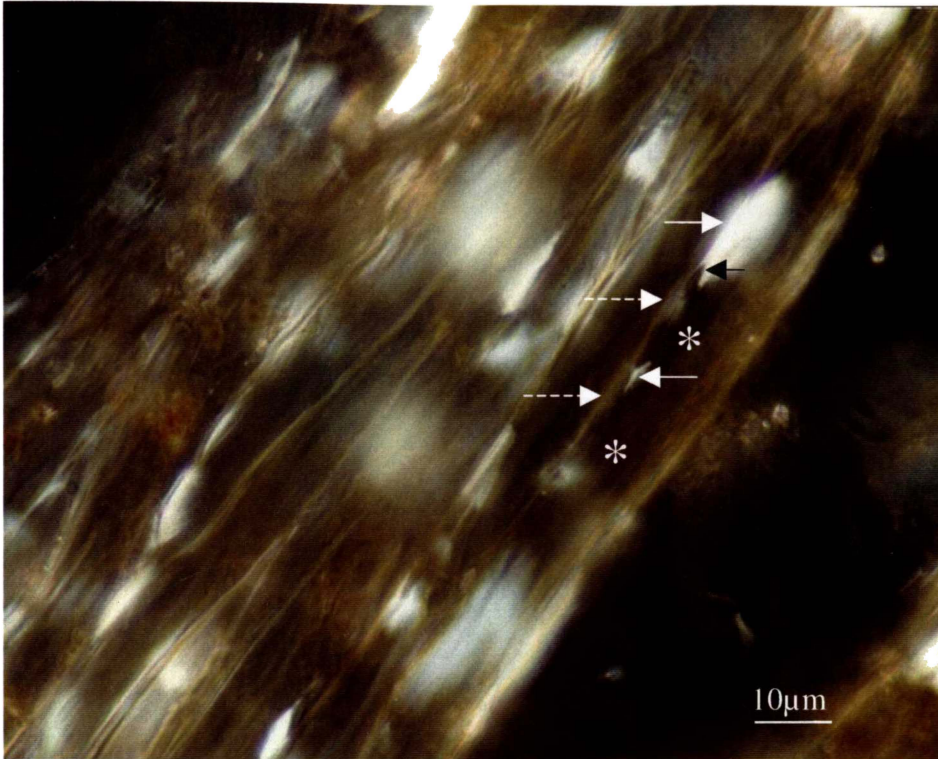
F = width of beech fibre; L = lumen; * = concentric cavity; arrow = lumen hypha.

M6-C5



Long arrow = remnants of ML of beech fibre; short arrow = remnants of lumen wall overlying cavity; * = concentric cavity; L = lumen.

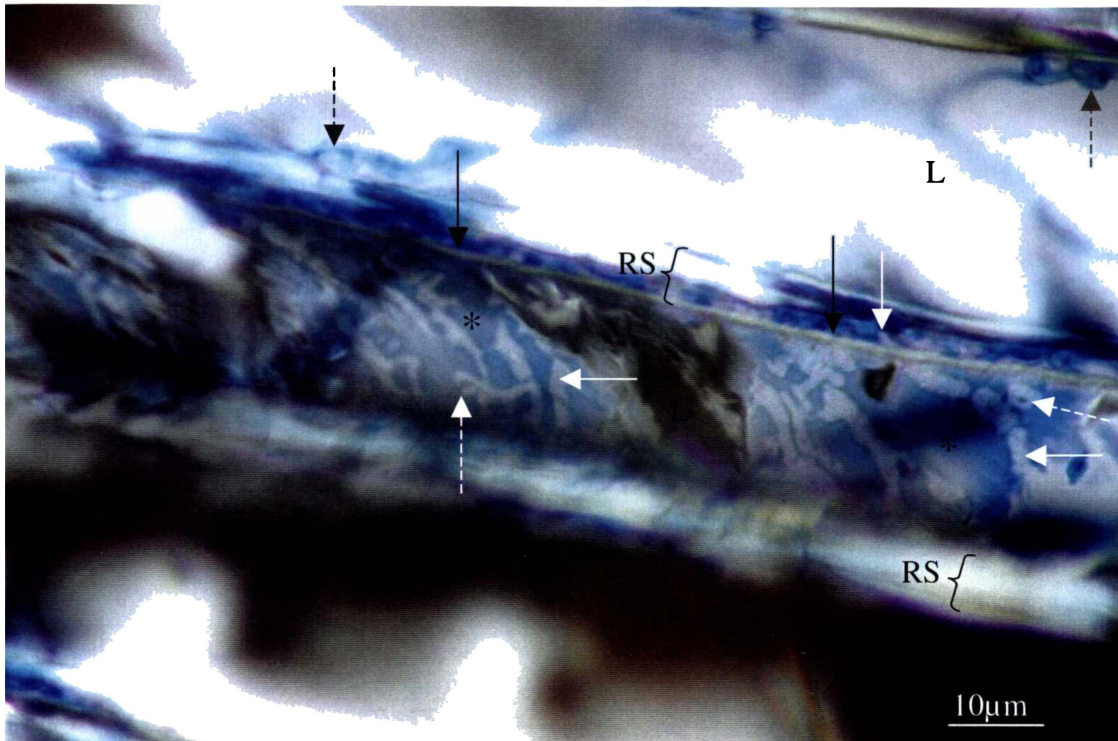
M7-C5



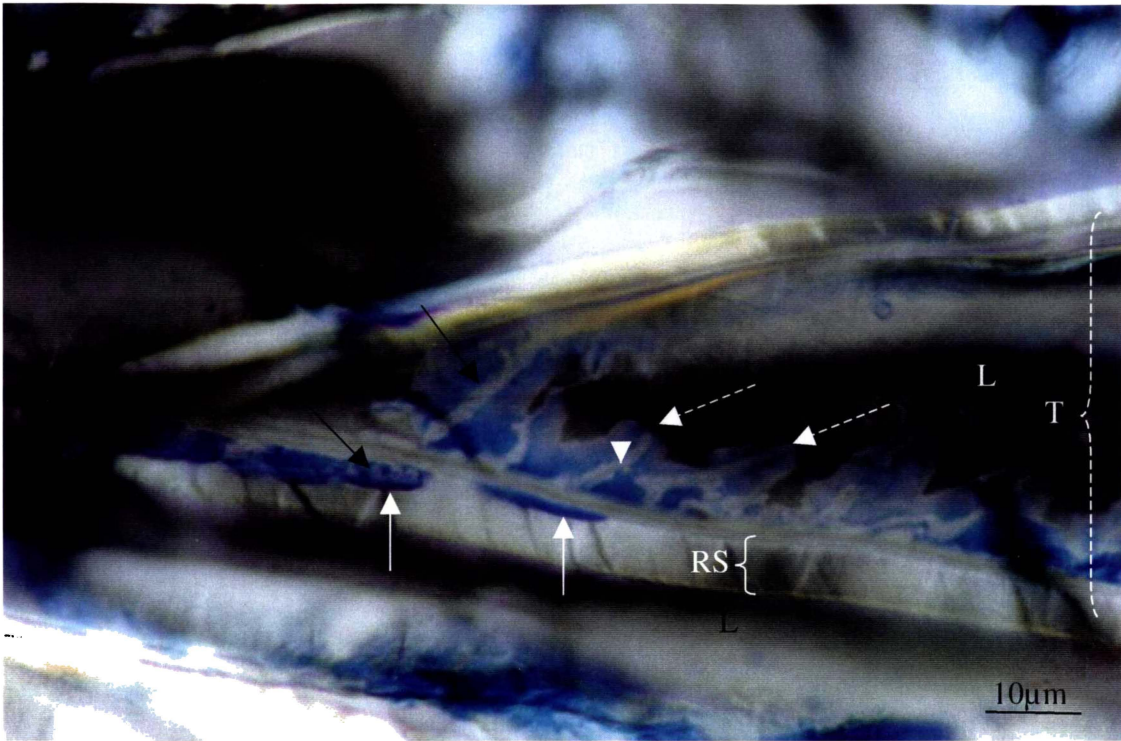
Dashed arrow = remnants of ML of beech fibre; solid white arrow = remnants of cell wall; * = loss of birefringence caused by complete removal of all crystalline cellulose by cavity hyphae; black arrow = remnant of angular cavity apex, a diagnostic feature for distinguishing type C5 from BR.

Section 4.5.13
Cavitation Type 6 (C6)

M1-C6

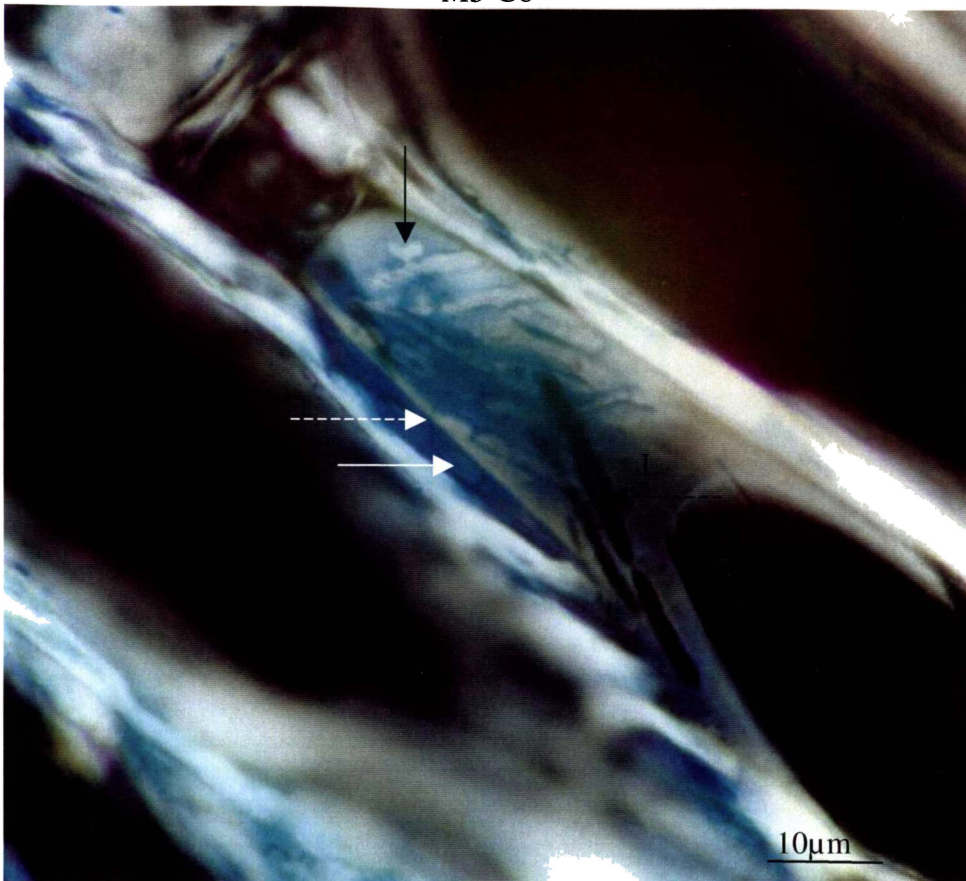


RS = radial section through pine tracheid wall; L = lumen; solid black arrow = remnants of lumen wall overlying cavity in S2 layer; solid white arrow = cavity hypha, aligned with helical CM; dashed white arrow = side branch of cavity hypha, at right angles to helical CM; * = degraded S2 layer between cavity hyphae (stained with aniline blue); dashed black arrow = lumen hypha.



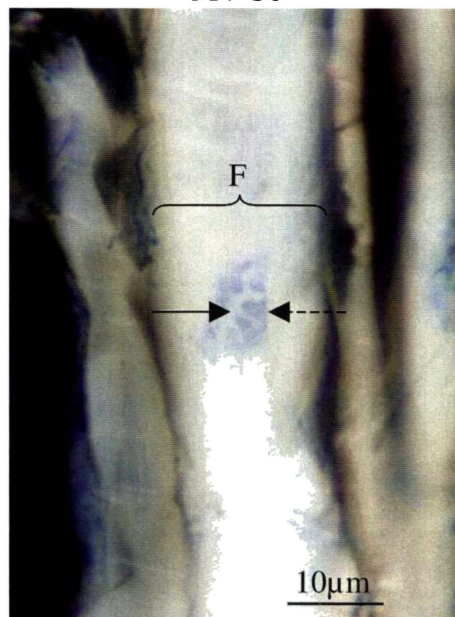
T = width of pine tracheid; RS = radial section through tracheid wall; L = lumen; solid white arrow = cavity seen in radial section (the leading portion of the cavity is just underneath the lumen wall, possibly at the S3-S2 interface; black arrow = cavity hypha; dashed arrow = apical extension of cavity.

M3-C6



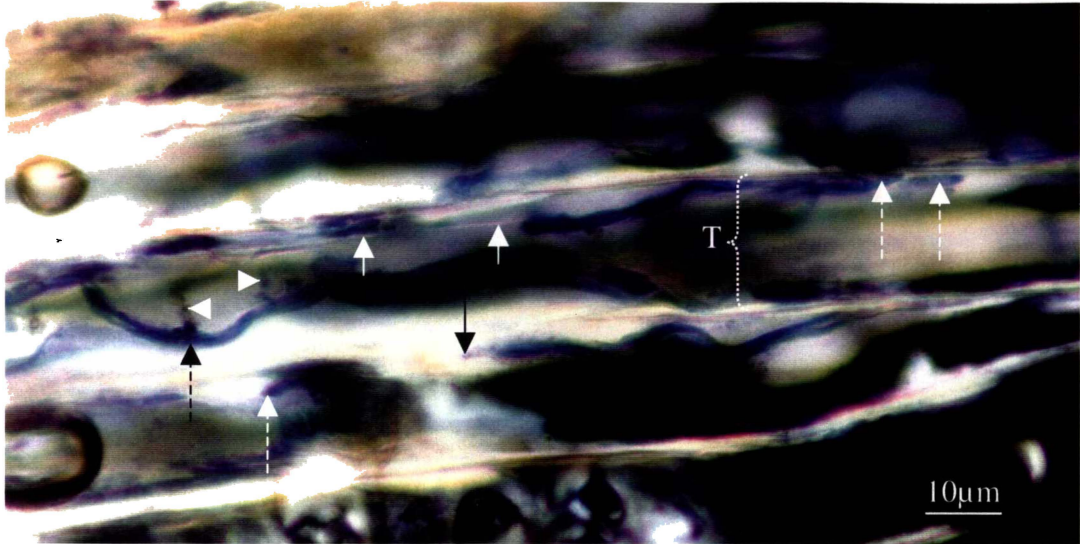
L = lumen of pine tracheid; solid white arrow = cavity hypha in radial section; dashed white arrow = remnants of lumen wall; solid black arrow = possibly a T-branch; dashed black arrow = SR cavity in wall of adjacent tracheid (both SR cavity and cavity hyphae in type C6 cavity are aligned with the helical CM of the S2 layer).

M4-C6



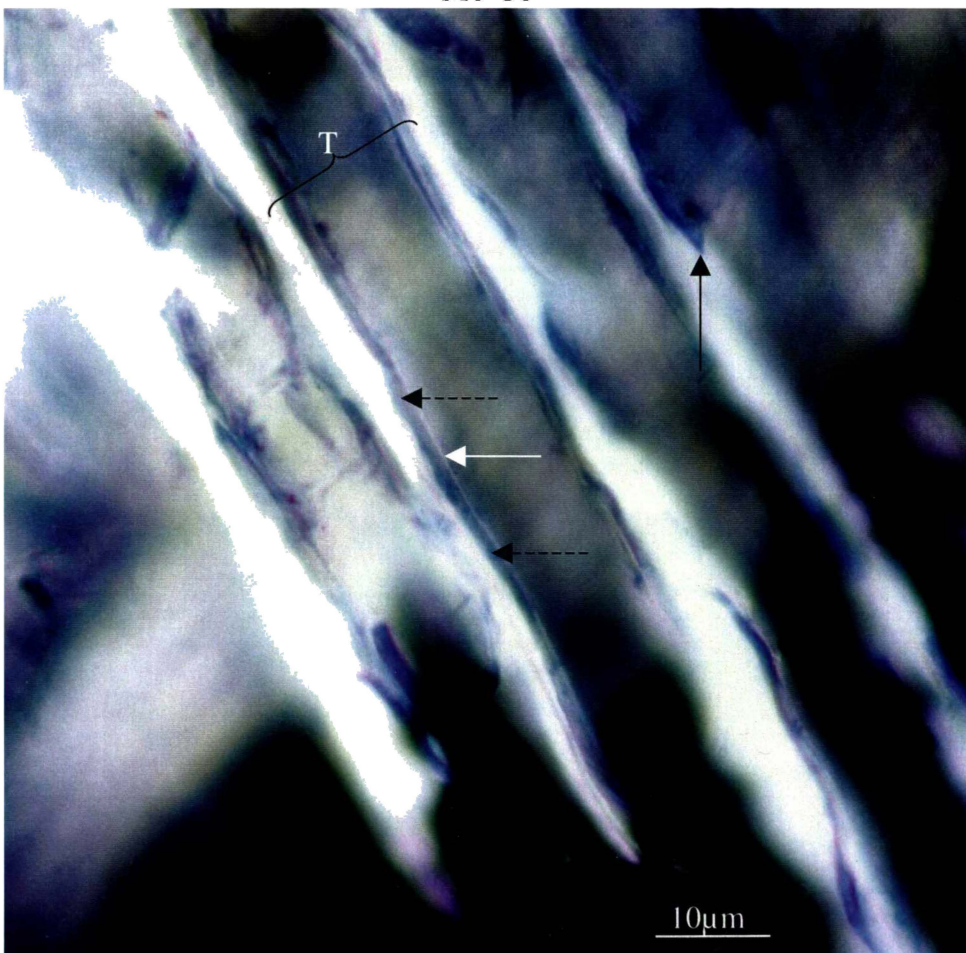
F = tangential section through beech fibre; solid arrow = branching cavity hypha; dashed arrow = cavity wall

M5-C6



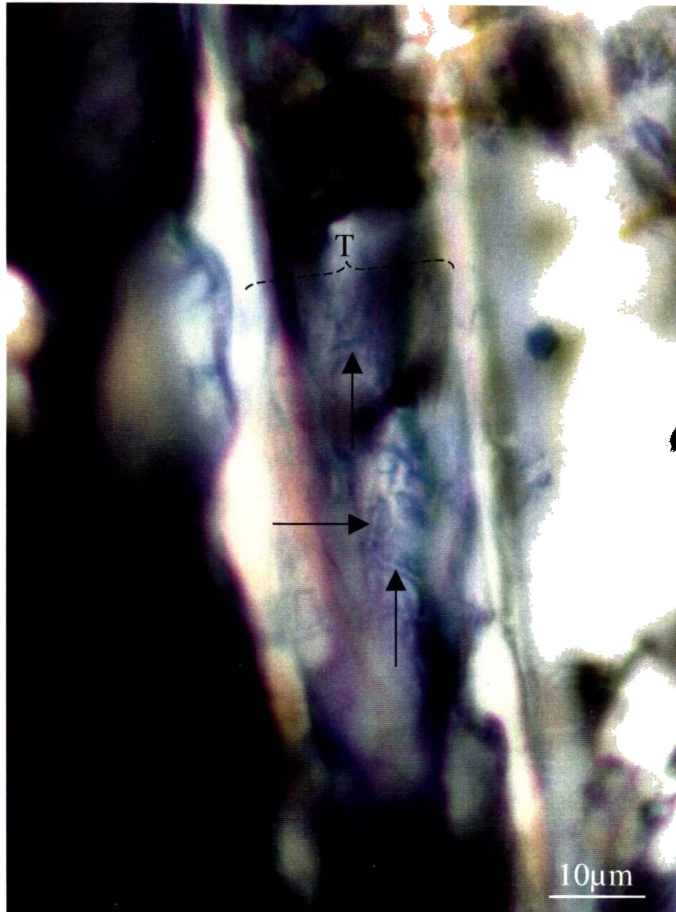
T = width of pine tracheid; dashed black arrow = wavy cavity; white arrowhead = side branch of cavity hypha; dashed white arrow = cavity seen in radial section; solid black arrow = apex of longitudinally extending cavity; solid white arrow = remnants of lumen wall overlying cavity.

M6-C6



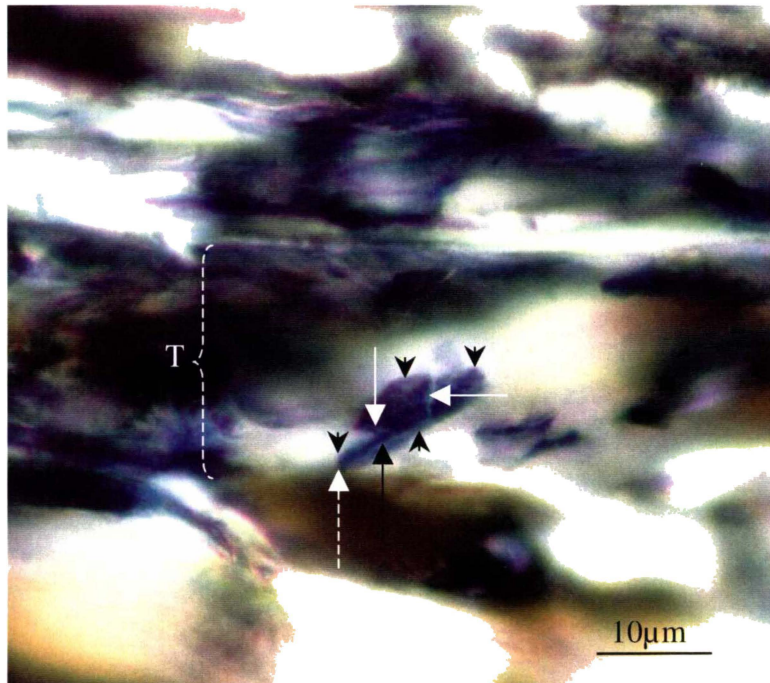
T = width of pine tracheid; dashed black arrow = cavity; white arrow = remnants of lumen wall overlying cavity; solid black arrow = apex of longitudinally extending cavity.

M7-C6

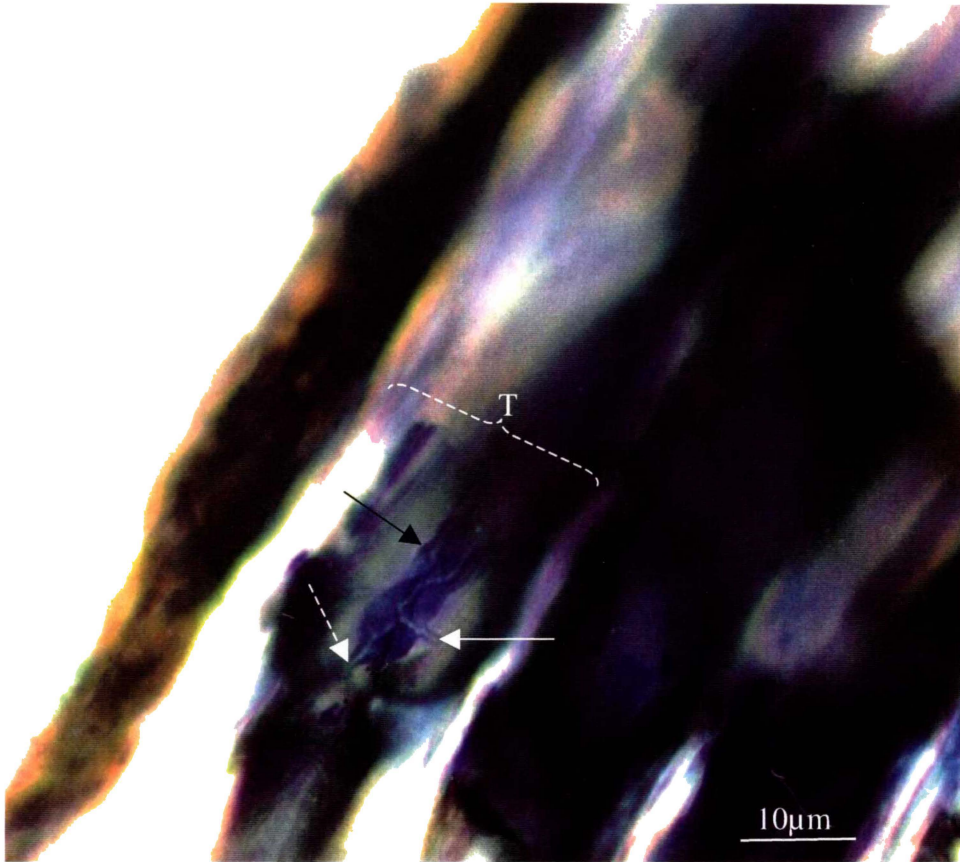


T = width of pine tracheid; arrow = cavity hyphae.

M8-C6



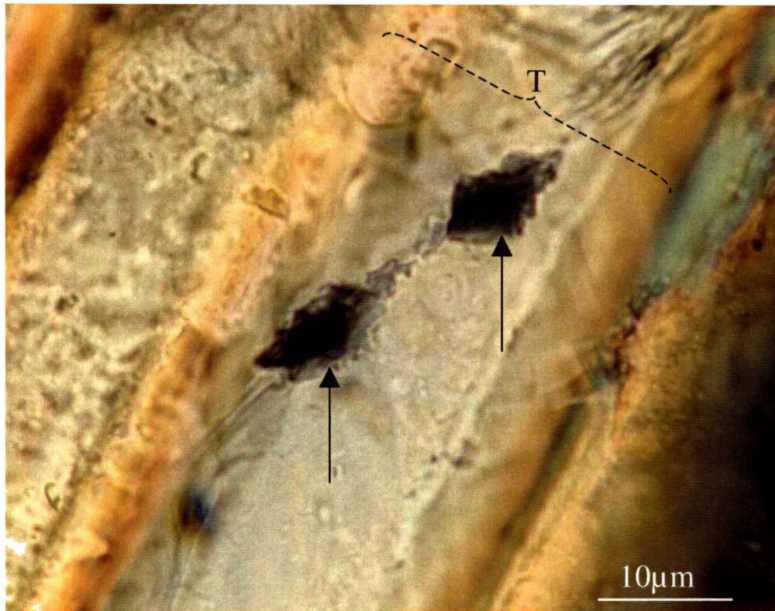
T = width of pine tracheid; black arrow = cavity hypha parallel to helical CM of S2 layer; white arrow = side branches of cavity hypha; dashed arrow = cavity apex; arrowhead = cavity wall.



T = width of pine tracheid; black arrow = cavity wall; dashed arrow = angular apex of cavity; white solid arrow = side branches of cavity hypha.

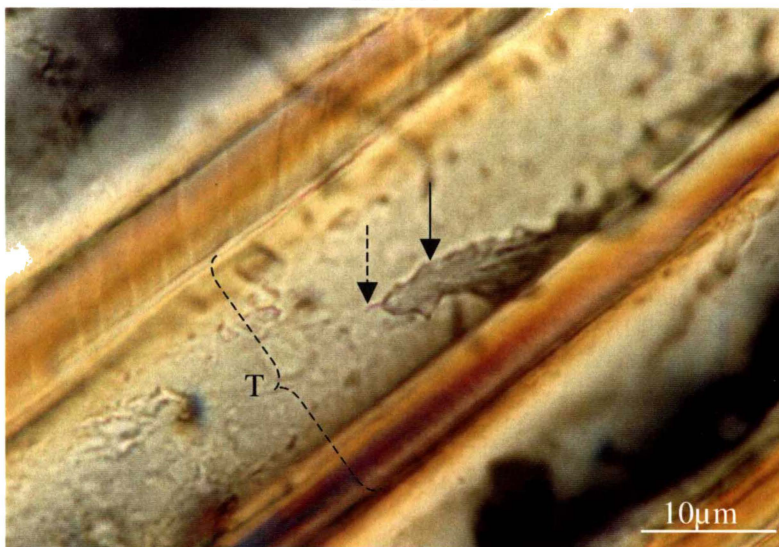
Section 4.5.14
Cavitation Type 7 (C7)

M1-C7



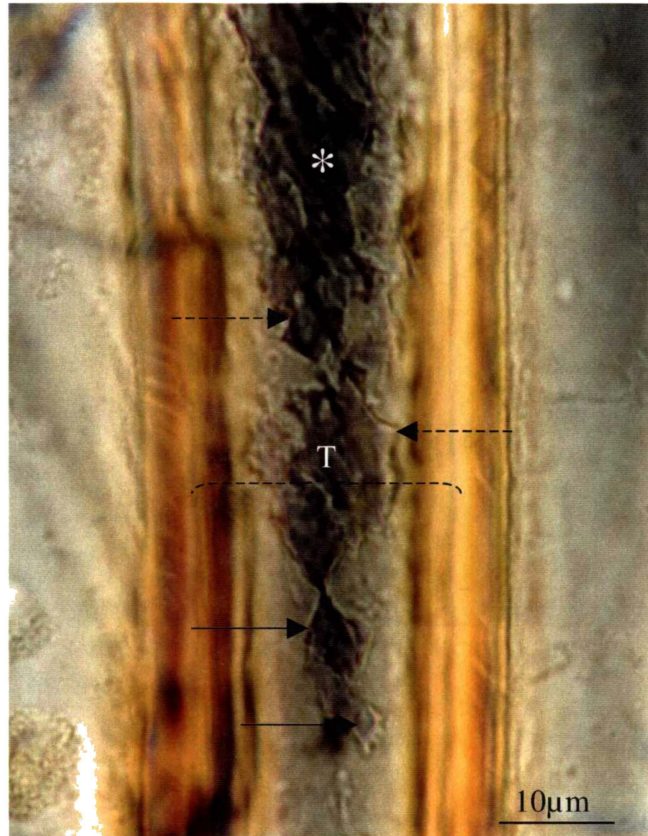
T = width of pine tracheid; solid arrow = cavity with a serrated wall.

M2-C7



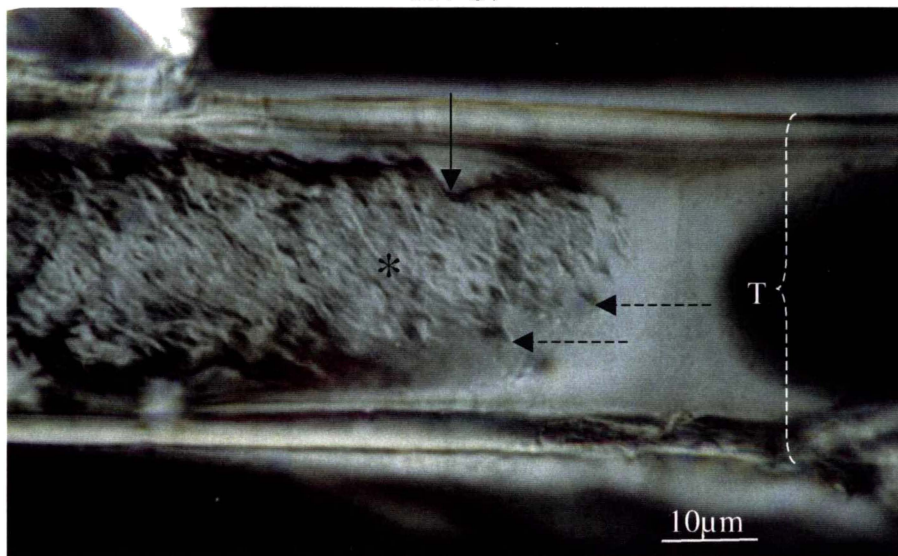
T = width of pine tracheid; solid arrow = SR cavity with a serrated wall; dashed arrow = apical proboscis hypha.

M3-C7



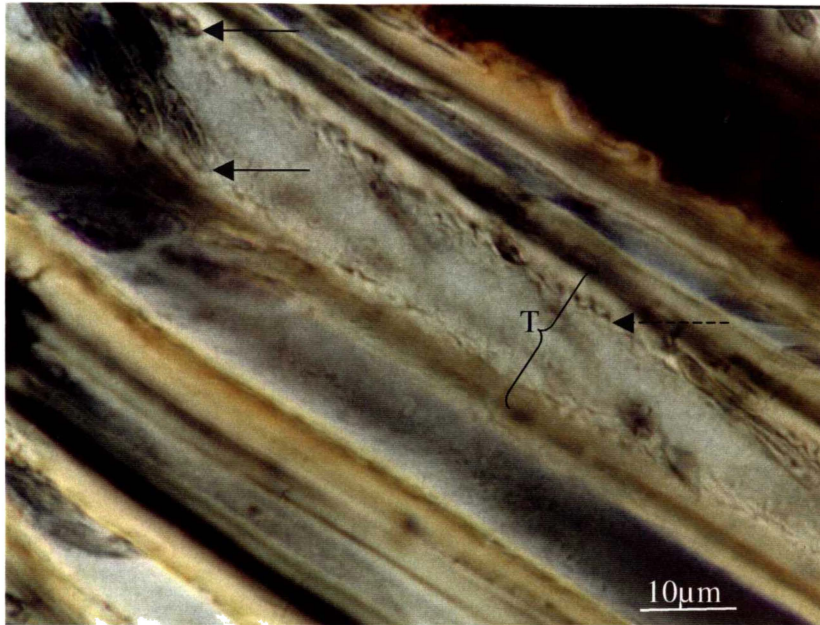
T = width of pine tracheid; solid arrow = cavity; dashed arrow = serrated edge; * = coalesced cavities.

M4-C7



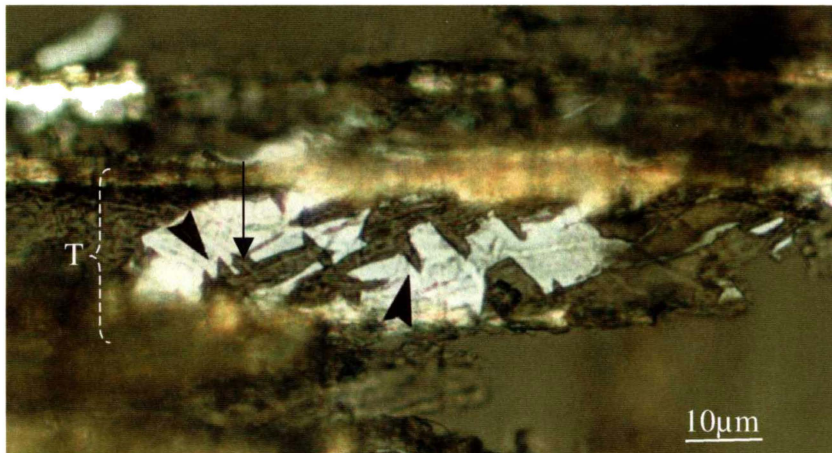
T = width of pine tracheid; solid arrow = serrated edge; dashed arrow = apex of cavity; * = coalesced cavities.

M5-C7



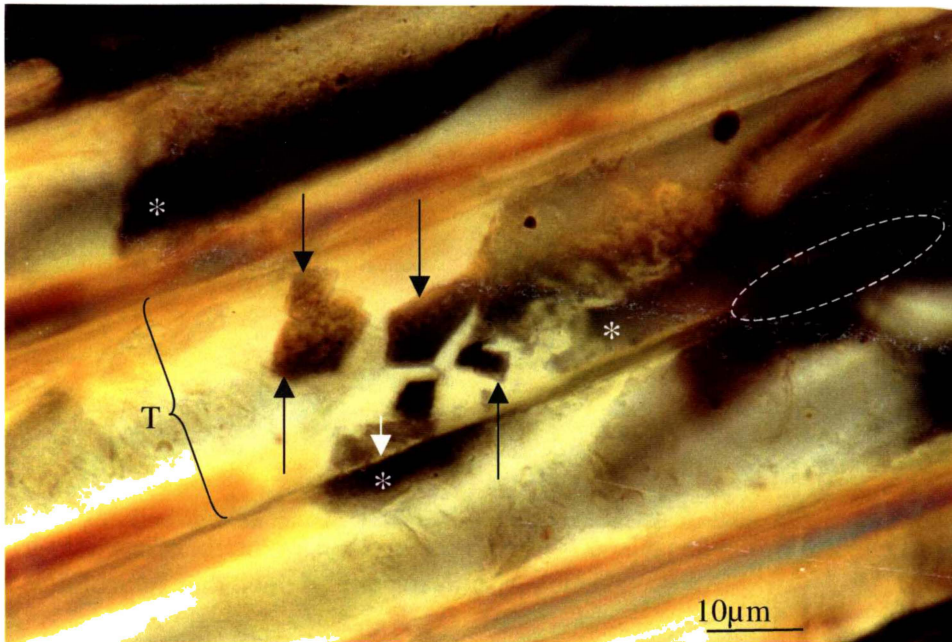
T = width of pin tracheid; solid arrow = angular apex of cavity appears as a serrated edge in radial sections (dashed arrow).

M6-C7



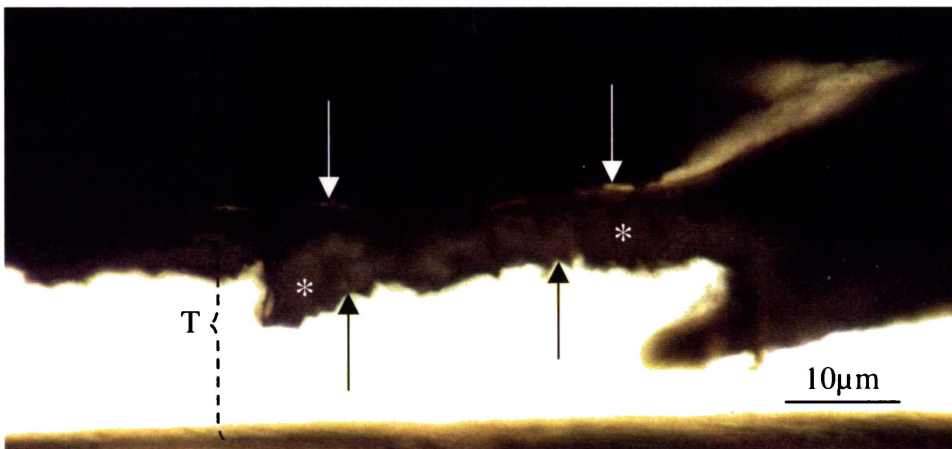
T = width of pine tracheid; arrowhead = angular lateral cavity extensions (serrations); arrow = hypha within serration

M7-C7



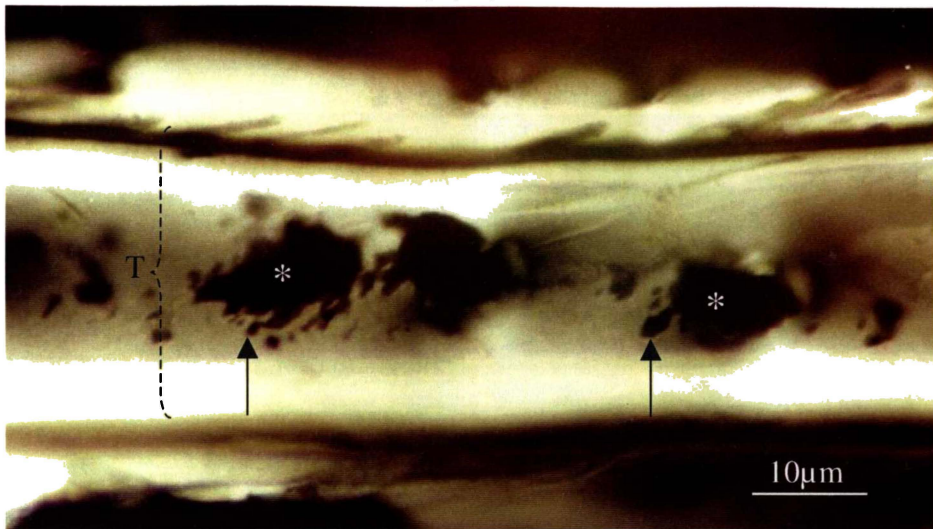
T = width of pine tracheid; solid arrow = cavity; white arrow = remnants of ML; area within dashed line = ML completed degraded; * = area where cavities had coalesced causing complete loss of birefringence, (a serrated edge was initially formed by angular cavities but later the edge surrounding coalesced cavities became diffuse).

M8-C7



T = width of pine tracheid; arrow = serrated edge left after coalescence of angular cavities; white arrow = remnants of ML; * = coalesced cavities leave little crystalline cellulose as indicated by lack of birefringence.

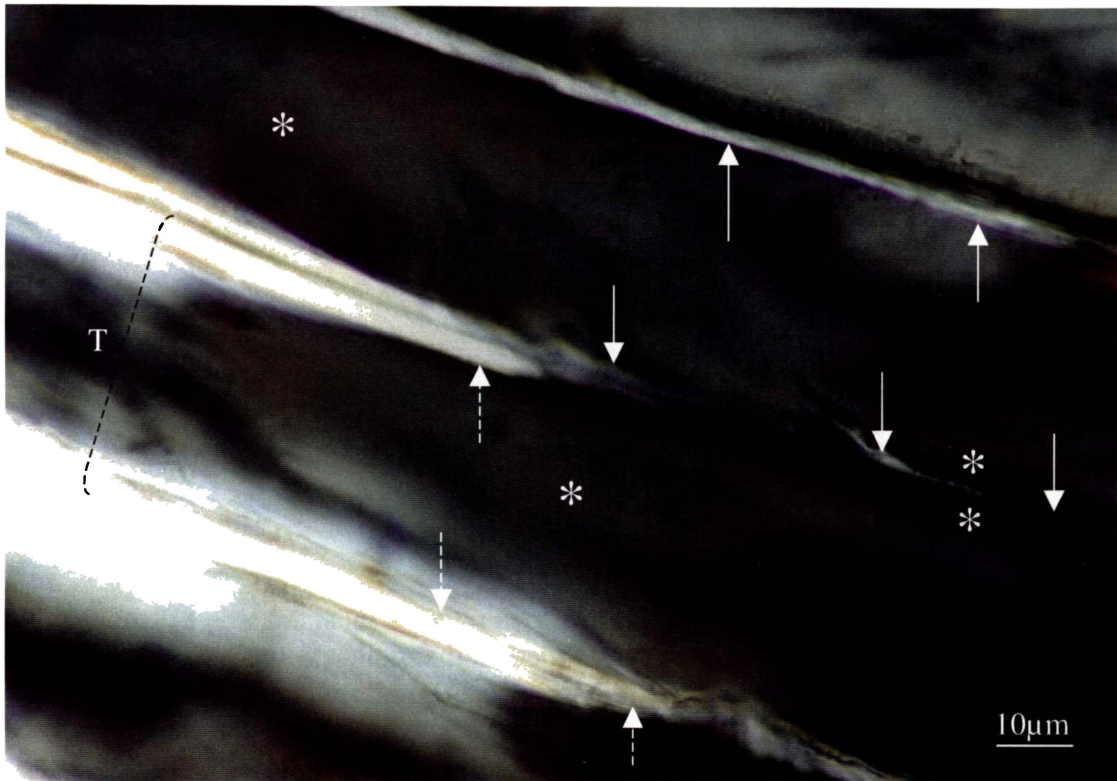
M9-C7



T = width of pine tracheid; arrow = angular cavity; * = coalesced cavities leave little crystalline cellulose as indicated by lack of birefringence.

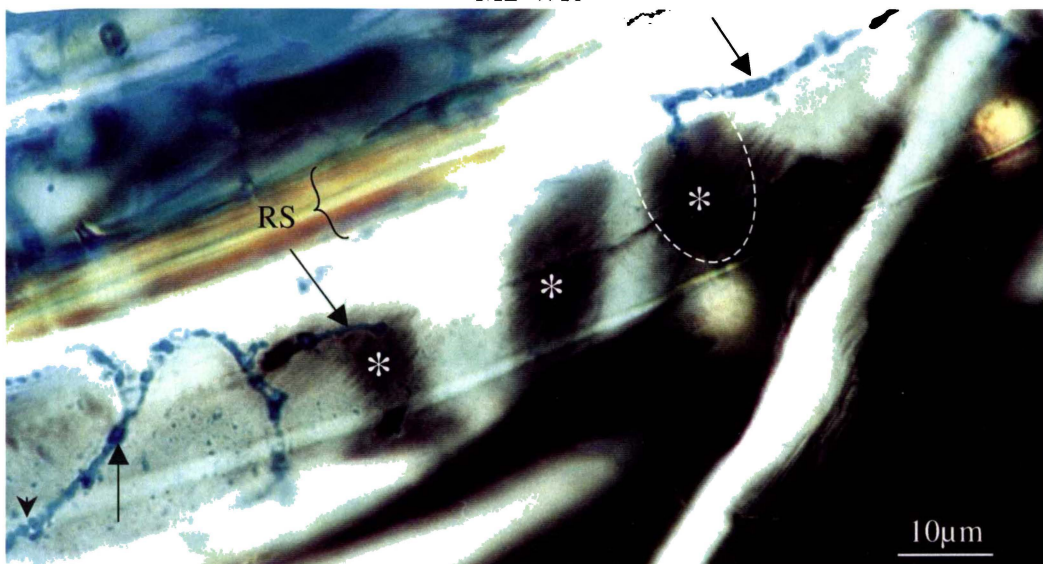
Section 4.5.15
White Rot

M1-WR



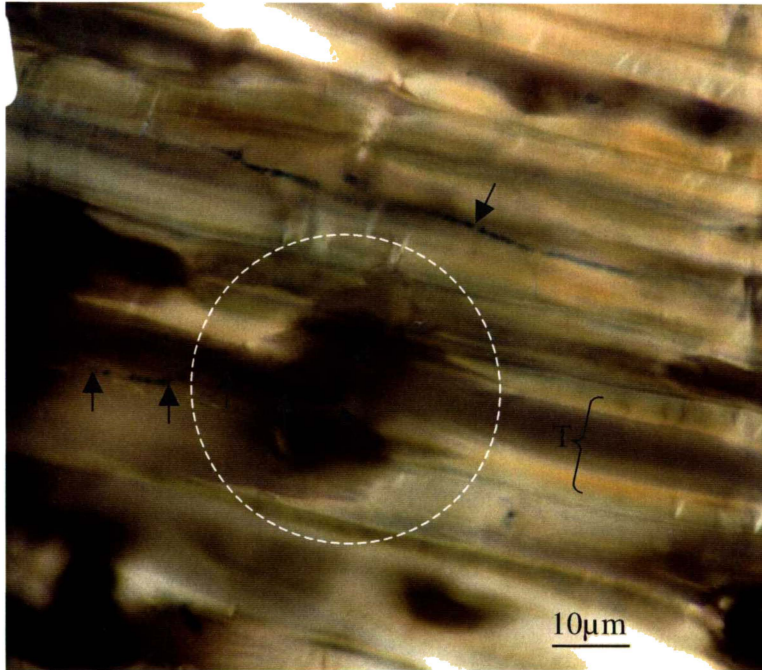
T = width of a single pine tracheid; dashed arrow = wall thinning; solid arrow = remnants of cell wall; asterisk = dark areas caused by loss of cellulose birefringence due to complete cell wall erosion.

M2-WR



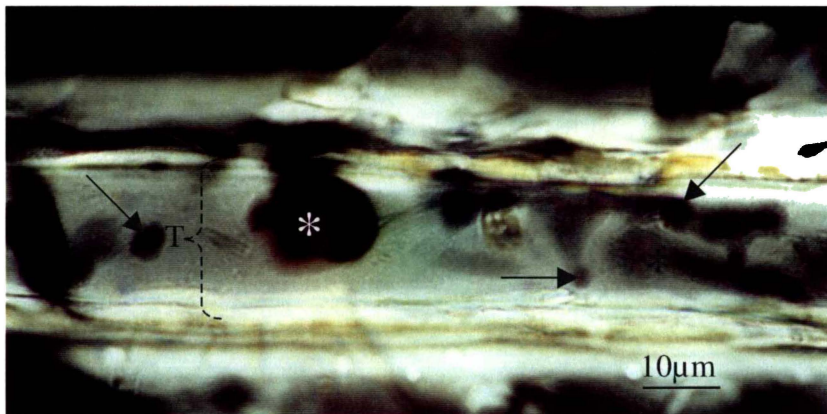
RS = radial section through pine tracheid wall; arrow = hypha; arrowhead = clamp connection; * = erosion trough (the distinction between an erosion trough and a BH is sometimes difficult since hyphae are aligned obliquely to the fibre wall causing a BH at the leading end of the hypha and a posterior trough (see M3-WR for radial section of similar a BH-erosion trough).

M3-WR



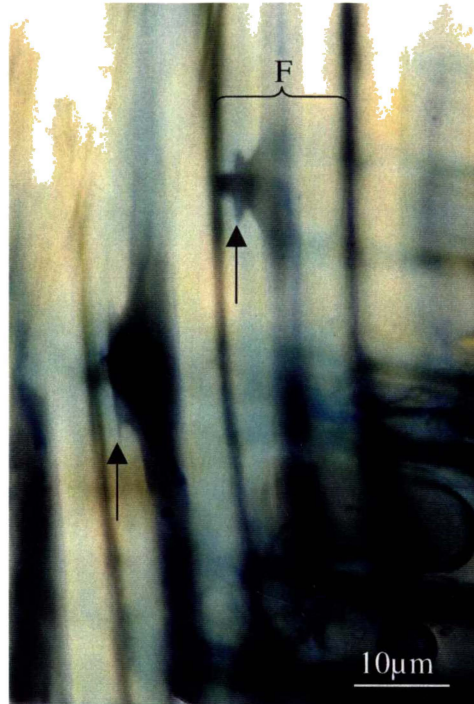
T = width across a pine tracheid; arrow = hypha in approximate centre of eroded area possessing micromorphology intermediate between an erosion trough and a BH (a similar formation seen in tangential section was presented in M2-WR)

M4-WR



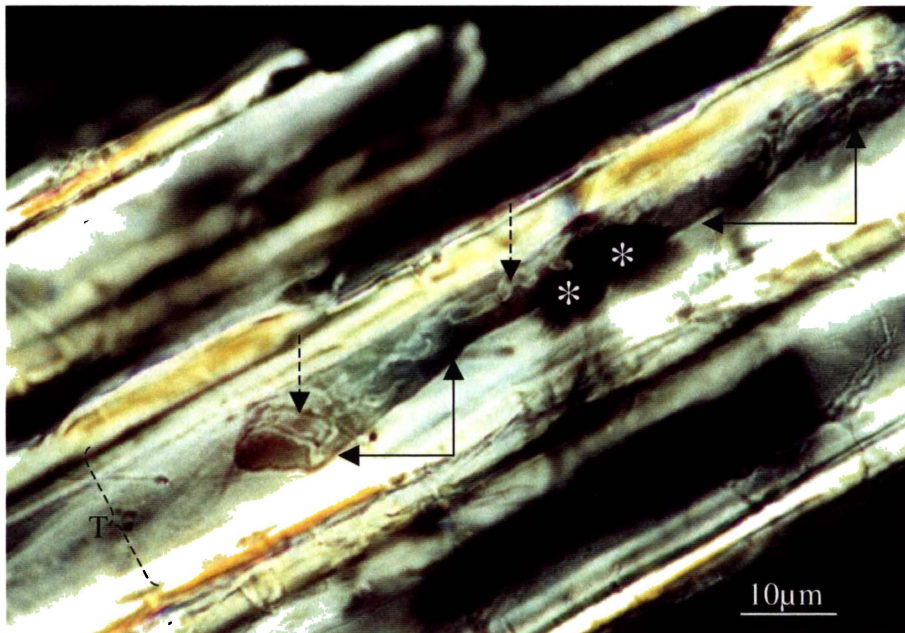
T = width of a single pine tracheid; white asterisk = complete wall removal by coalesced BHs; arrow = BH; black asterisk = erosion troughs.

M5-WR



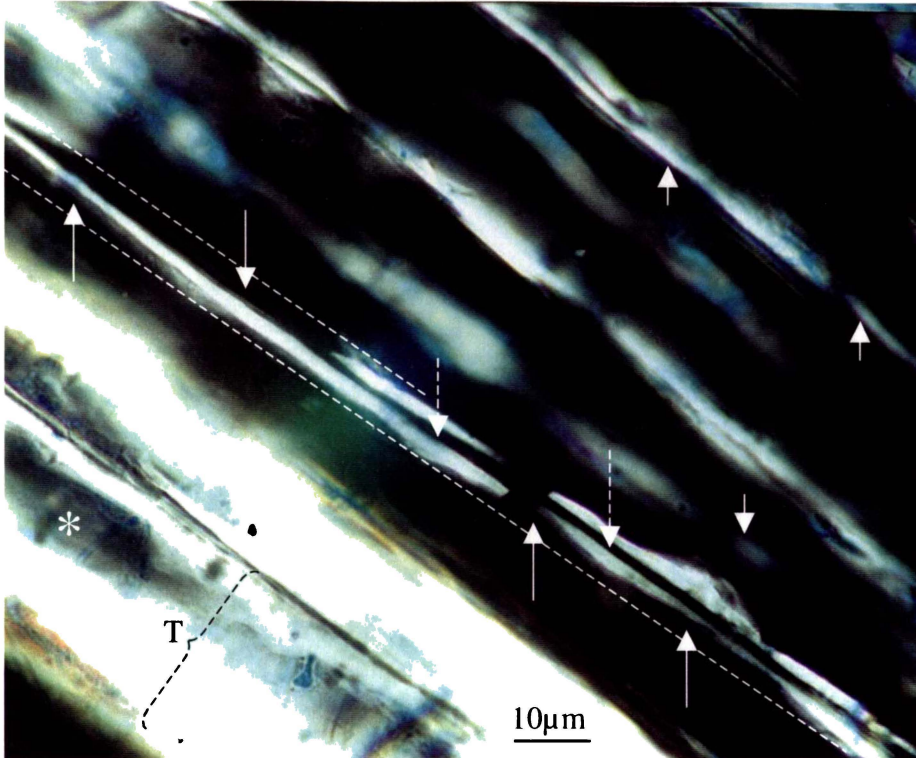
F = width of a beech fibre; arrow = serrated edge of BH (BH is at an oblique angle to the lumen wall and does not appear to penetrate the ML).

M6-WR



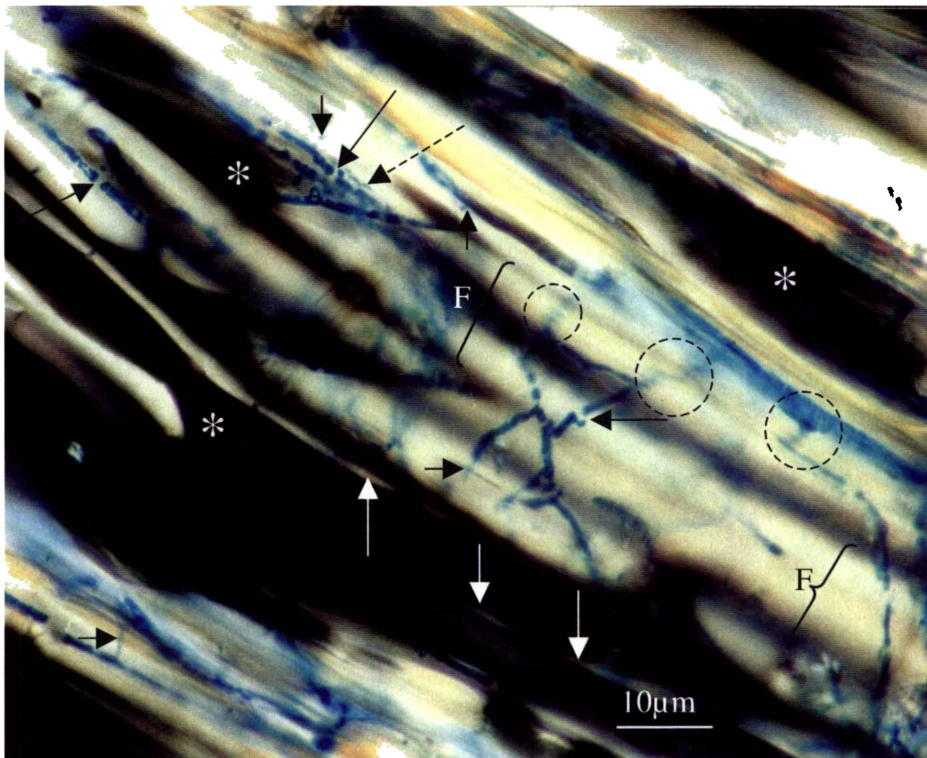
T = approximate width of a pine tracheid; solid arrow = trough or cavity where overlying lumen wall had collapsed; * = oblique BHs with tapered edges (similar to BHs in M2-WR, M3-WR and M5-WR); dashed arrow = hyphae associated with cavity and BHs).

M7-WR



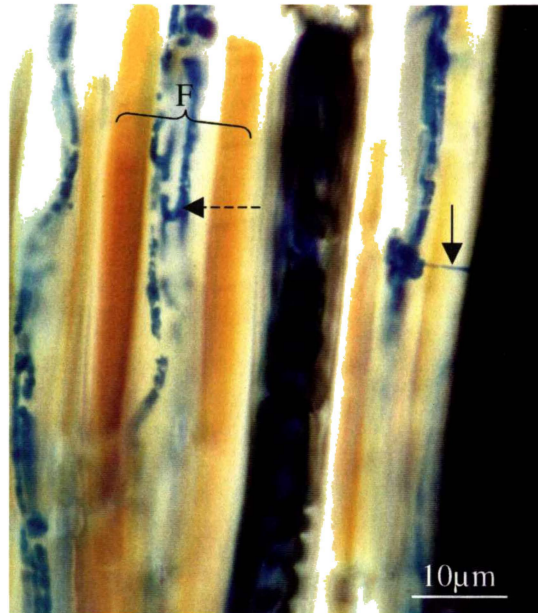
T = width of a pine tracheid; dashed line = approximate original position of cell wall; long solid arrow = wall erosion; dashed arrow = ML missing causing delamination of adjacent cell walls; short arrow = remnants of cell wall; * = partial erosion of cell wall.

M8-WR



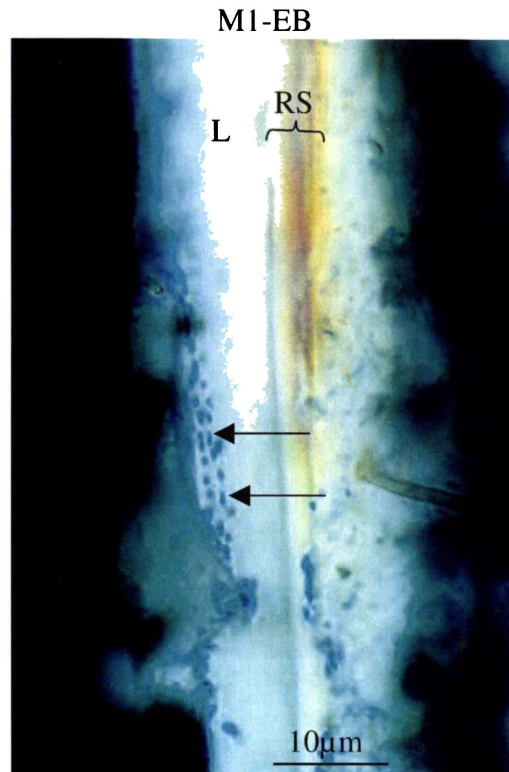
F = width of a single beech fibre; dashed arrow = T-branch; solid white arrow = cell wall remnants; long solid black arrow = clamp connection; short black arrow = proboscis hypha; * = complete cell wall removal.

M9-WR

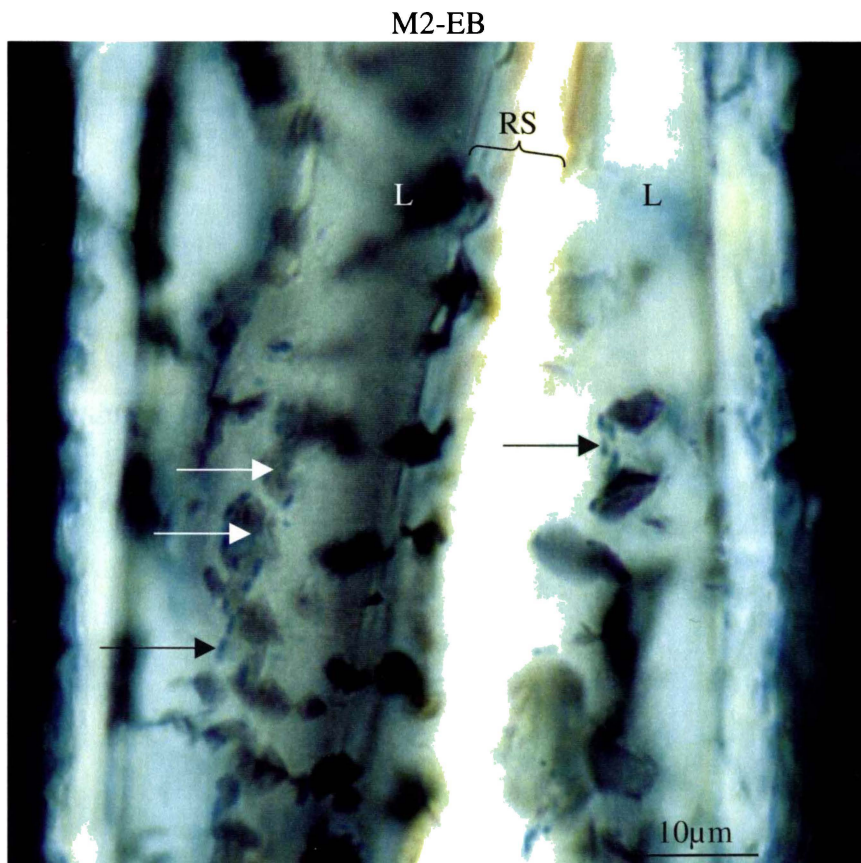


F = width of a single beech fibre; solid arrow = proboscis hypha; dashed arrow = hypha (a characteristic of WR in beech is abundance of hyphae in lumen before decay occurs).

Section 4.5.16
Erosion Bacteria



RS = radial section through pine tracheid; L = lumen; arrow = erosion bacterium with long axis parallel to helical CM of S2 layer.



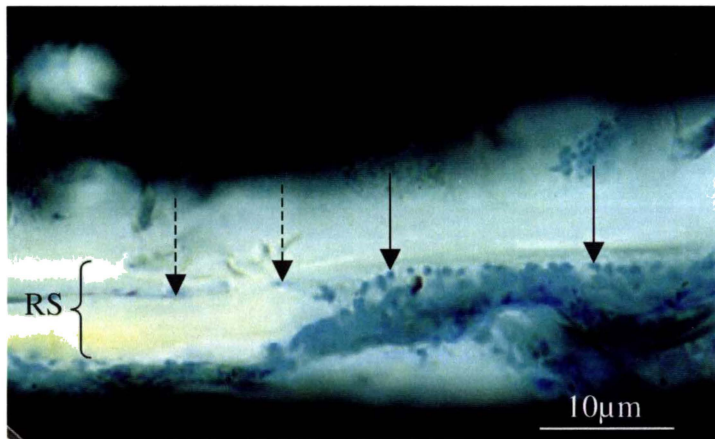
RS = radial section through pine tracheid; L = lumen; black arrow = erosion bacterium (EB); white arrow = pit created by EB.

M3-EB

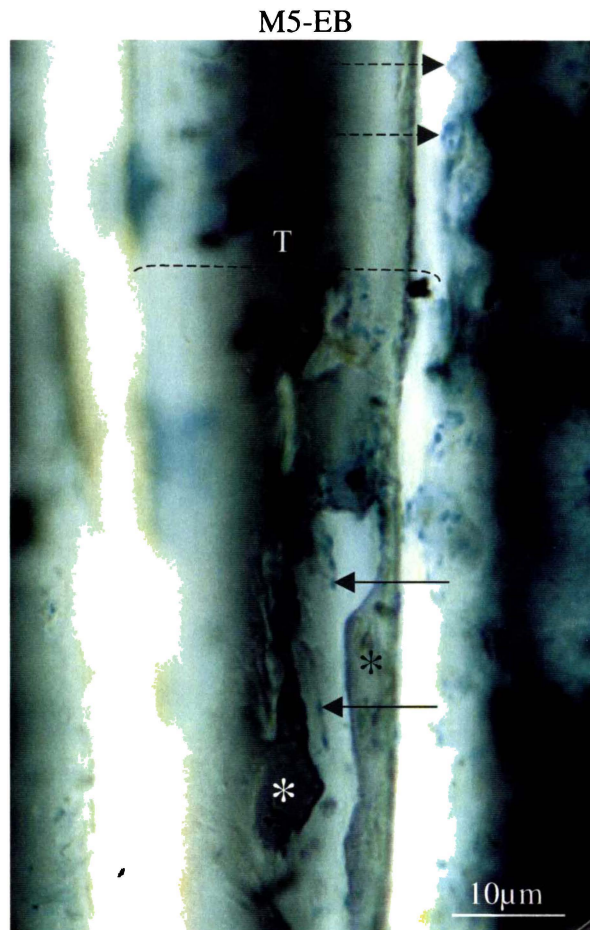


RS = radial section through pine tracheid; arrow = erosion bacterium.

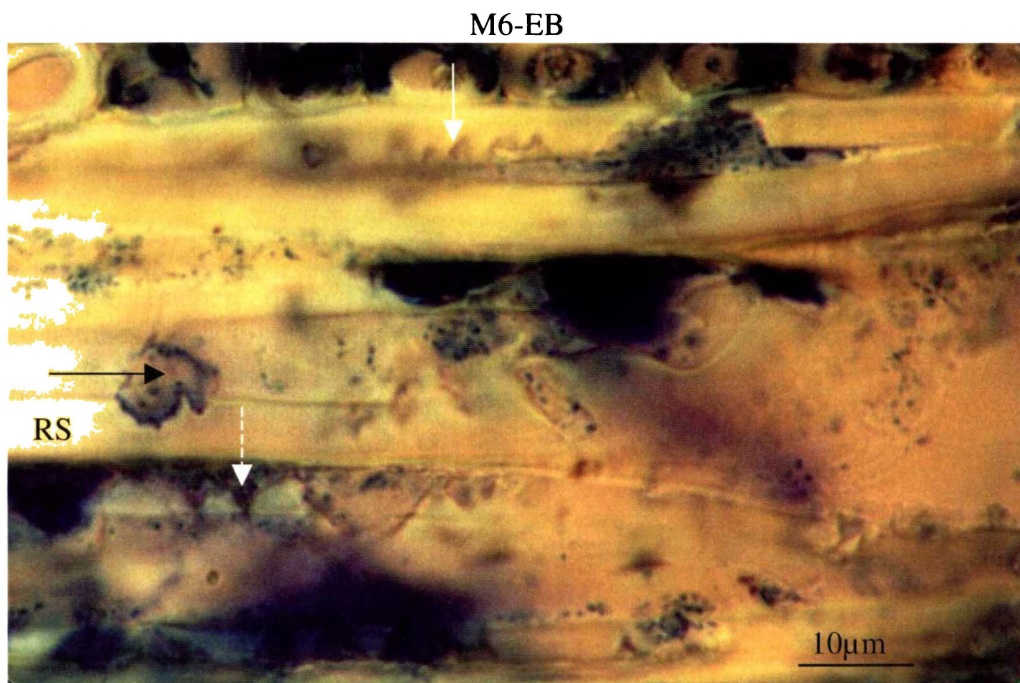
M4-EB



RS = radial section through pine tracheid; arrow = erosion bacterium; dashed arrow = cavitation caused by EB.

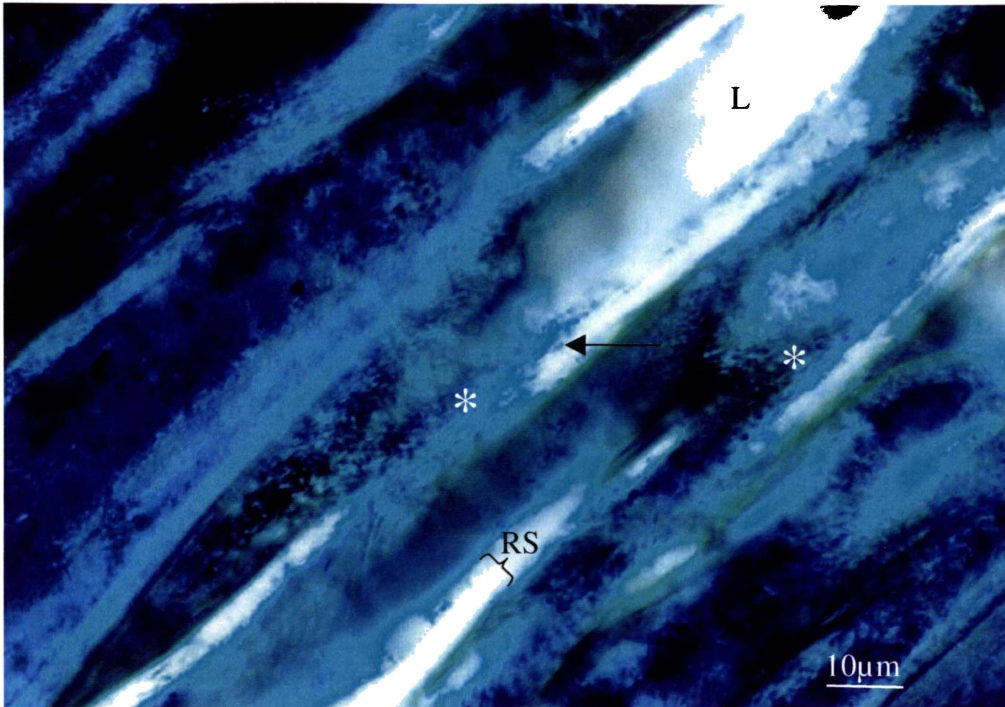


T = width of pine tracheid; arrow = erosion bacterium with long axis parallel to helical CM of S2 layer; dashed arrow = serrated edge of wall in radial section; * = trough caused by EB.



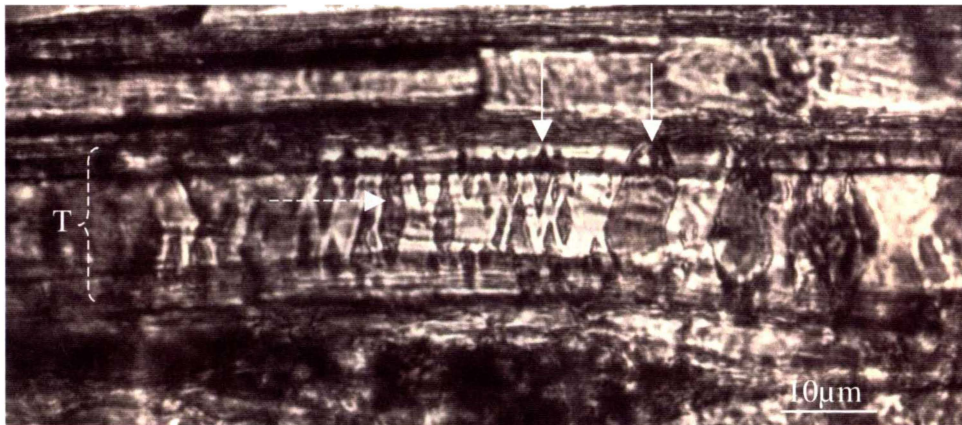
RS = radial section through beech fibre; arrow = pit caused by EB; white solid arrow = serrated fibre wall edge; dashed arrow = cavitation between the ML and the lumen wall caused by EB.

M7-EB



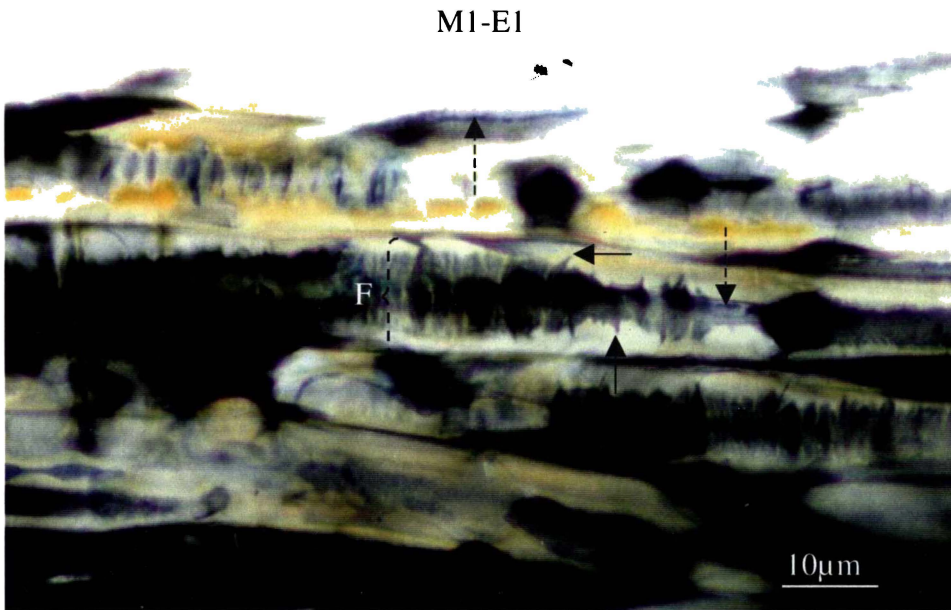
RS = radial section through pine tracheid; L = lumen; arrow = erosion: * = wood with advanced EB decay.

M8-EB

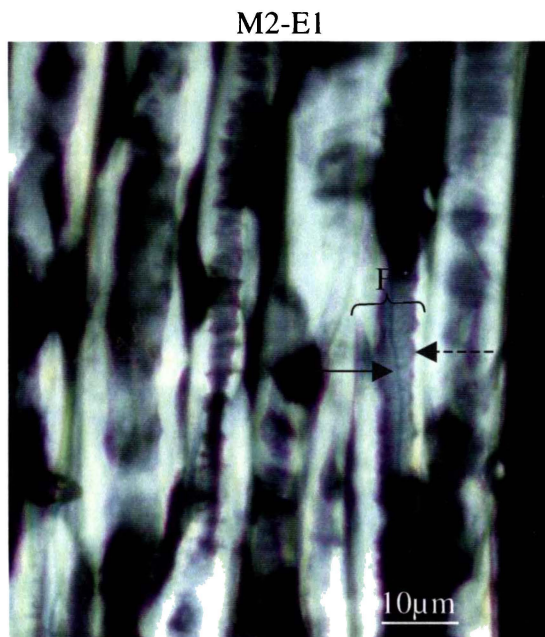


T = width of pine tracheid; dashed arrow = symmetrically tapered V-shaped trough, seen as V-shaped notches (serrations) in radial section (solid arrow). This pattern was probably caused by erosion bacteria but bacteria were not seen.

Section 4.5.17
Erosion Type 1



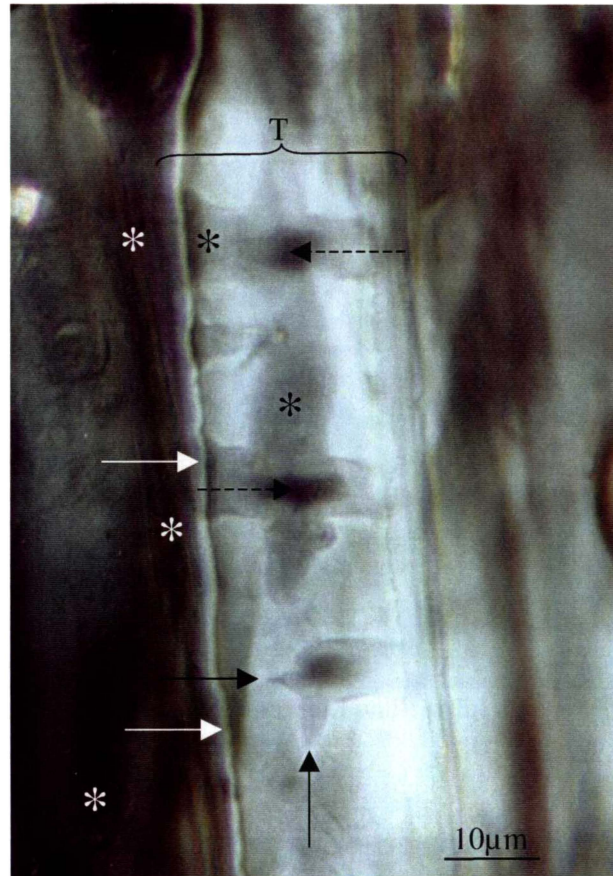
F = width of beech fibre; solid arrow = concentric V-shaped troughs seen as a V-shaped notch in radial section; dashed arrow = lumen hypha.



F = width of beech fibre; solid arrow = lumen hypha; dashed arrow = serrated edge of fibre wall.

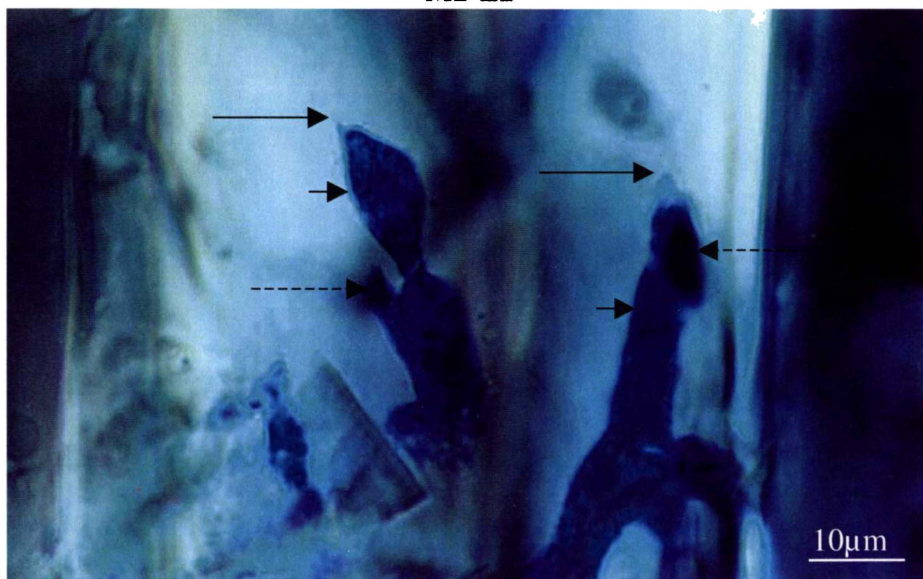
Section 4.5.18
Erosion Type 2 (E2)

M1-E2



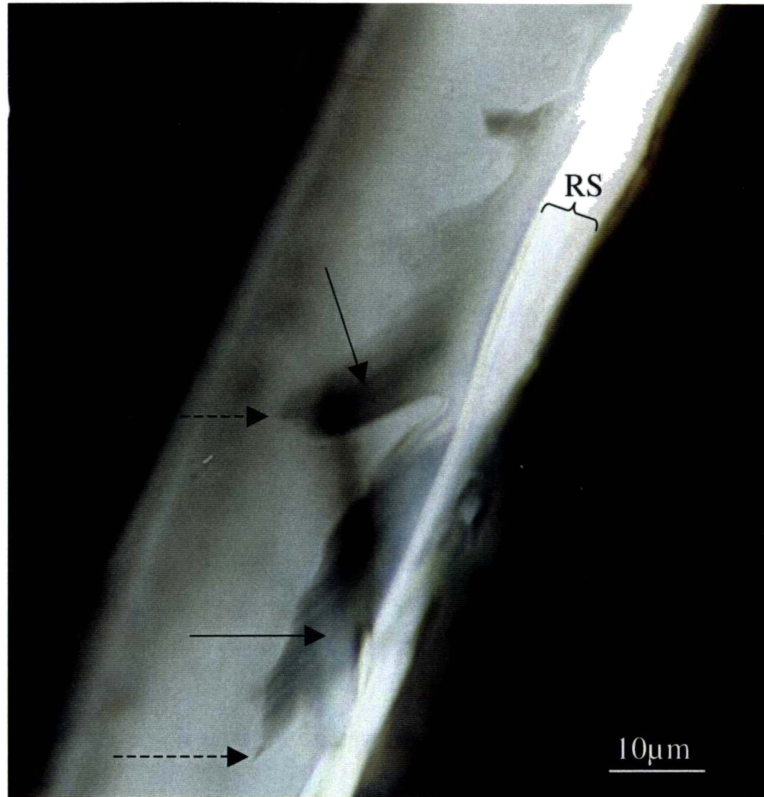
T = width of pine tracheid; black asterix = erosion trough; white asterix = erosion has caused complete loss of wood cell wall birefringence; dashed arrow = oblique, irregular shaped BH; solid black arrow = angular indentation in trough wall (probably caused by apical exentension of hyphae – see M2-E2); white arrow = radial section of remnants of tracheid wall and edge of trough .

M2-E2



Dashed arrow = hyphae passing through BH in pine tracheid; short arrow = hypha; long arrow = fine apical protrusion.

M3-E2



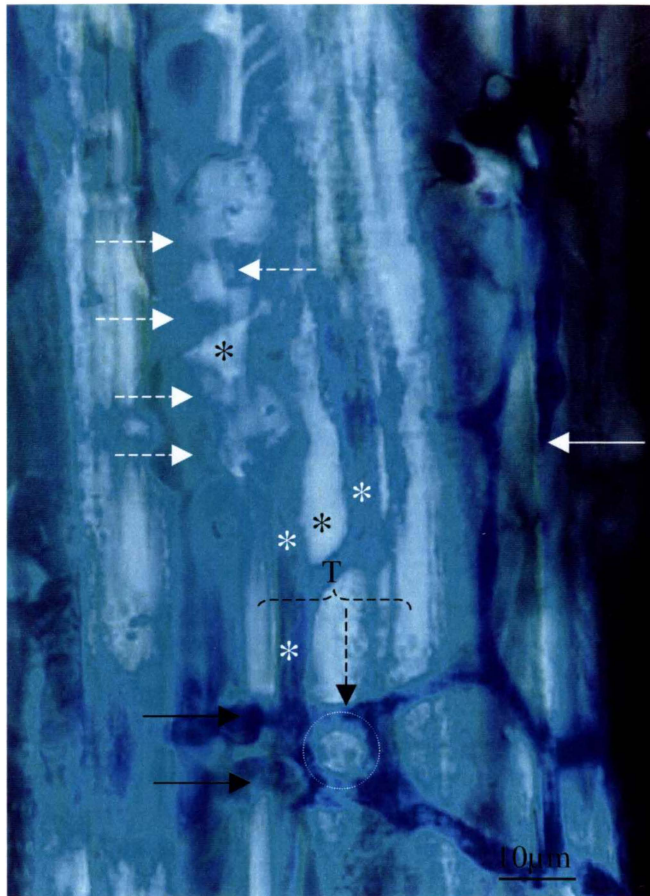
RS = oblique radial section through pine tracheid wall; solid arrow = erosion trough; dashed arrow = angular indentation in trough wall.

M4-E2



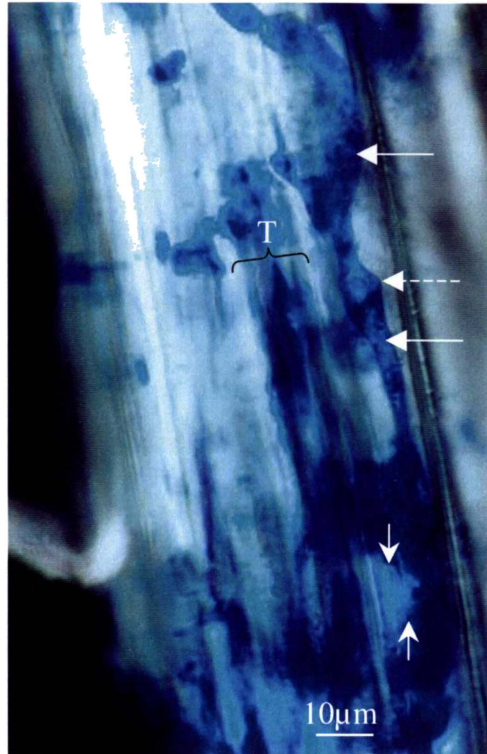
Solid black arrow = tunnel (or possibly a deep trough); white arrow = hypha in a tunnel or possibly a deep erosion trough; dashed arrow = protrusions of hypha; area within dashed line = hypha passing through BH.

M5-E2



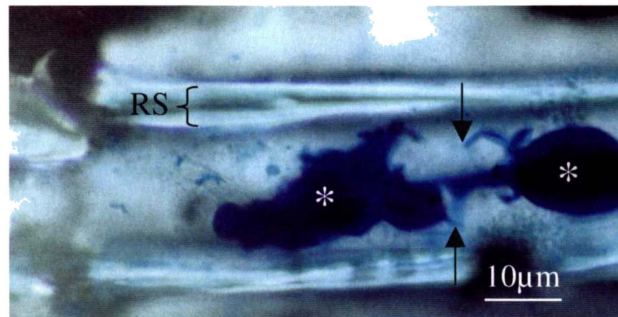
T = width of pine tracheid; solid arrow = BH; dashed black arrow = hypha (anastomosing hyphae (dashed circle)); white asterix = tunnel or erosion trough; black asterix = remnant of lumen wall between two erosion troughs; solid white arrow = apical "hypha" penetrating cell wall; dashed white arrow = BHs.

M6-E2



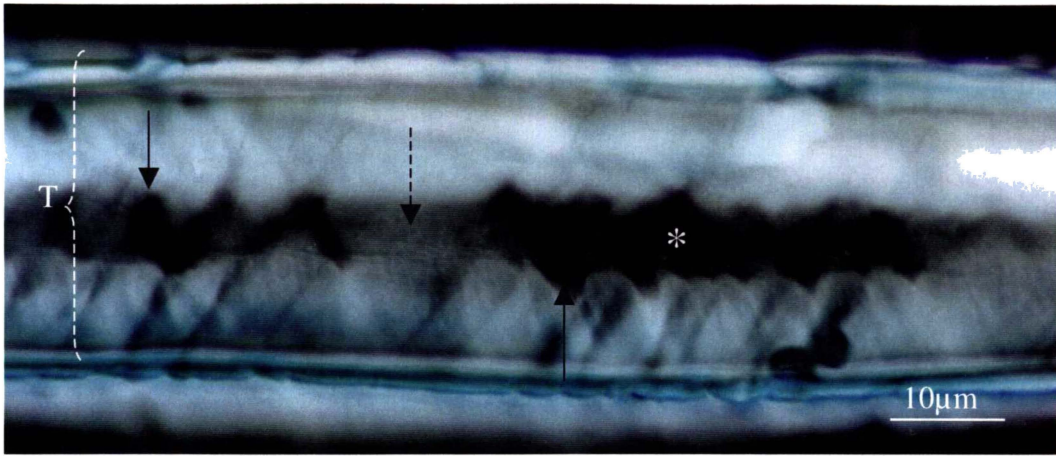
T = width of pine tracheid (latewood); solid arrow = erosion trough containing “hypha”; dashed arrow = smooth edged trough wall; arrowhead = diffuse edged erosion trough wall.

M7-E2



RS = radial section through pine tracheid; * = BHs and erosion troughs have caused loss of birefringence, however the overlying causative “hyphae” stained with aniline blue are visible at the margins of less severely attacked wood.

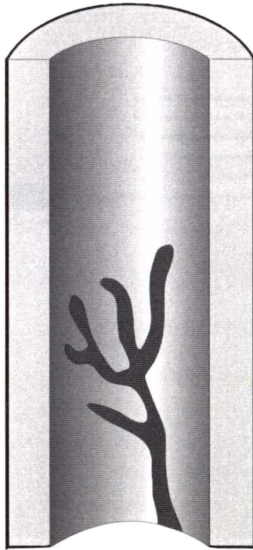
M8-E2



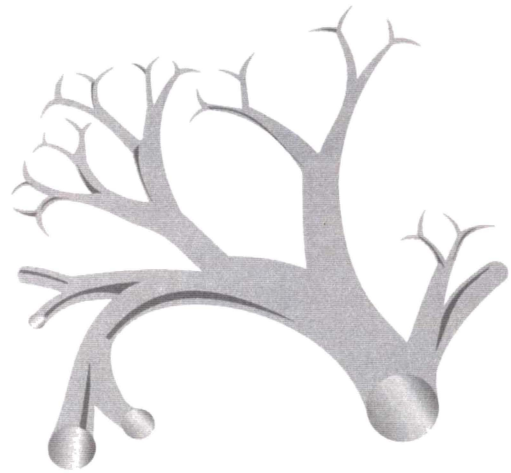
T = width of pine tracheid; solid arrow = BH at oblique angle to lumen wall; dashed arrow = erosion trough; * = merged BHs and erosion caused complete loss of birefringence.

Section 4.6
Decay Micromorphology Diagrams

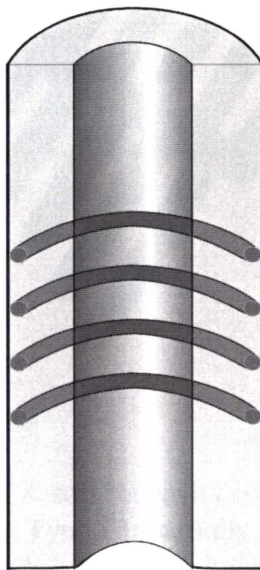
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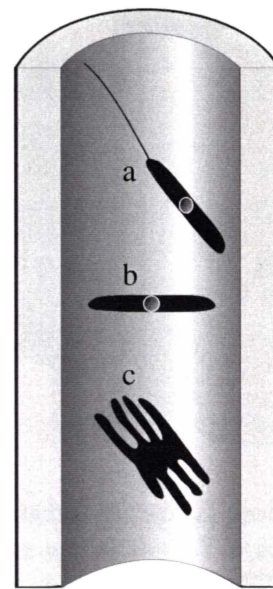
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3

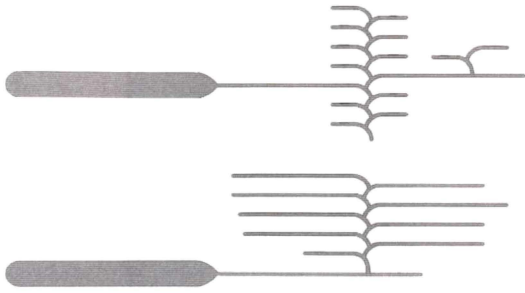


4

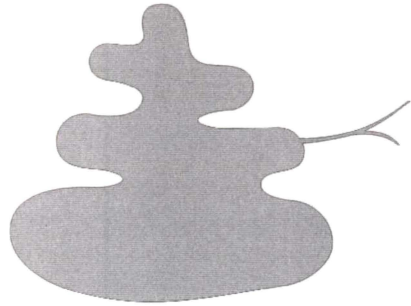


1. T1 tunnelling. 2. T1 tunnelling with apical T-branches. 3. T1 tunnelling aligned with S1 cellulose microfibrils (CM). 4. T2 tunnelling: a = T-branch 'hat' and apical proboscis hypha aligned with S2 layer CM; b = T-branch 'hat' aligned with S1 layer CM; c = several coalesced bore holes and associated T-branches.

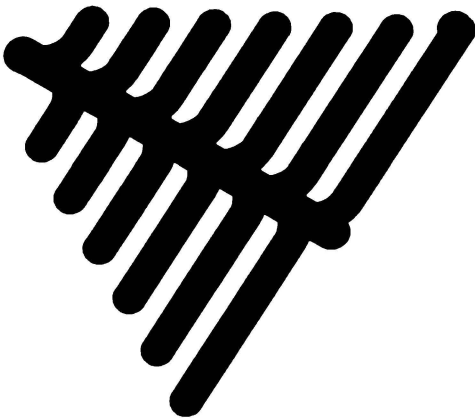
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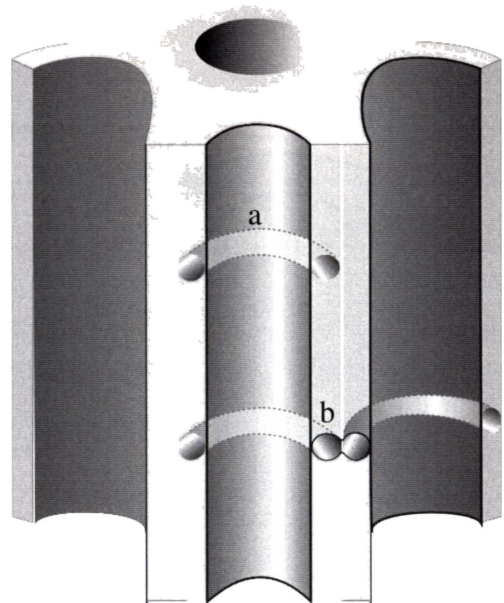
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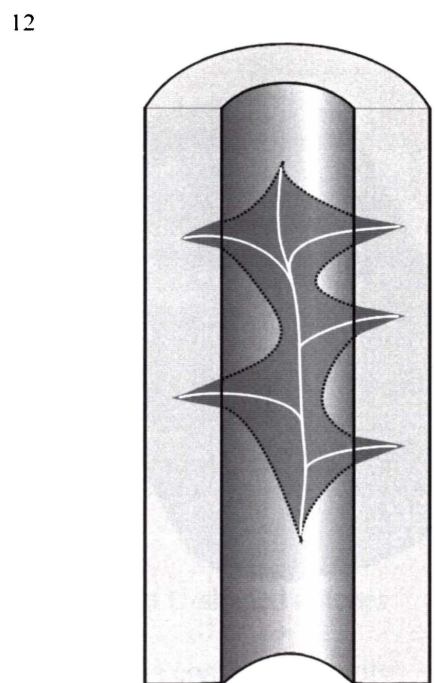
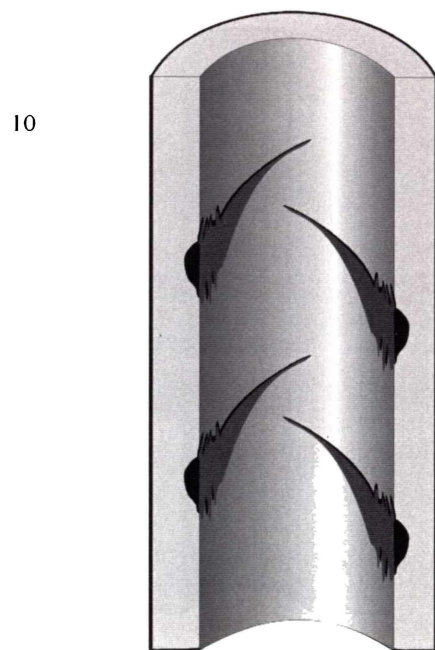
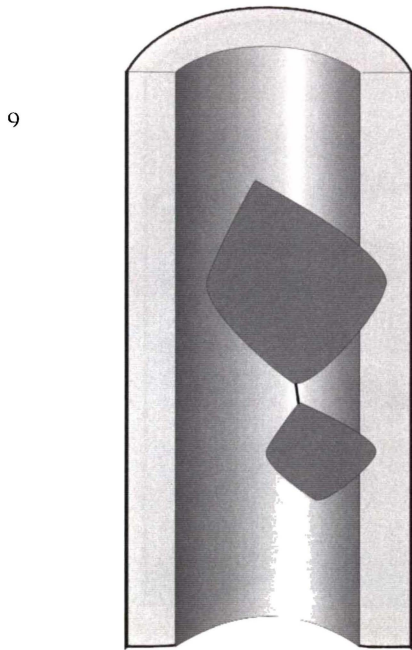
7



8

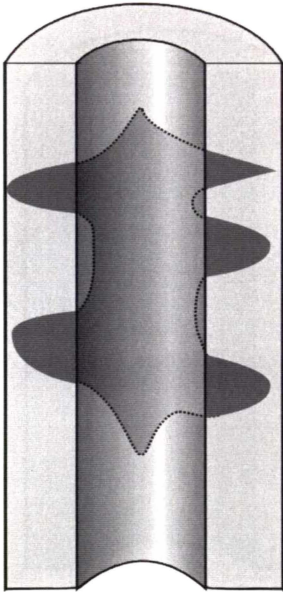


5. Type C3: soft rot cavity connected to reticulum of T-branches via apical proboscis hypha. 6. Type T3: partially coalesced T-branches plus fine apical T- or Y-branch. 7. Type T3: 'stack' of T-branches. 8. Type T4: a = crescent shaped cavity in S2 layer; b = cavities merged in radial section leaving only the middle lamella (ML).

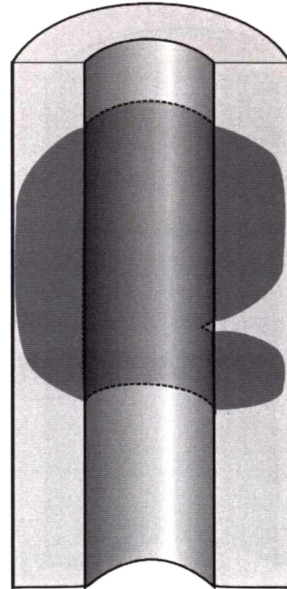


9. Type C1: unusually wide cavities (expansive in tangential plane). 10. Type C2: cavities with diffuse distal edges a tangential plane. 11. Type C4: coalesced V-notched cavitation initiated at ML. 12. Type C5: branched hyphae within V-notched cavity wall (overlying lumen wall is intact).

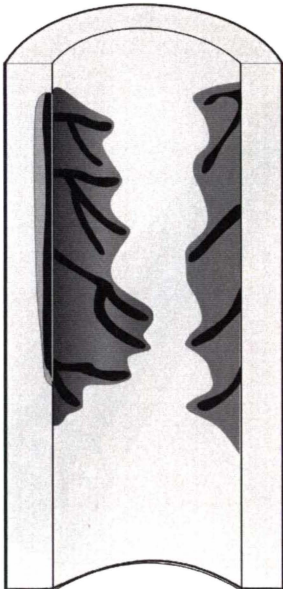
13



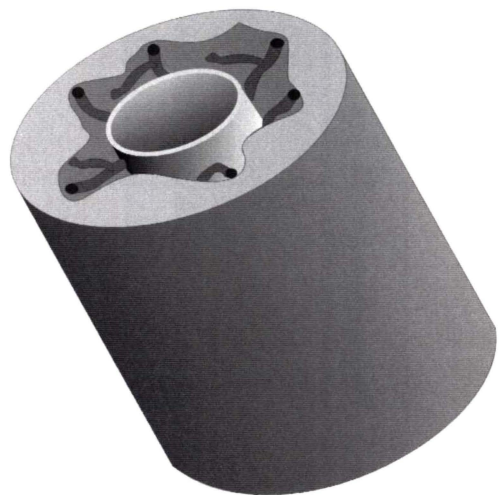
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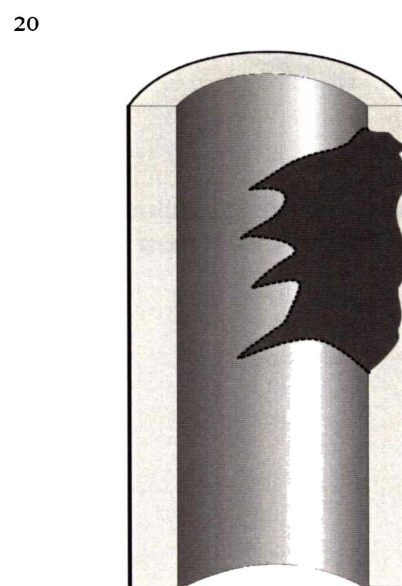
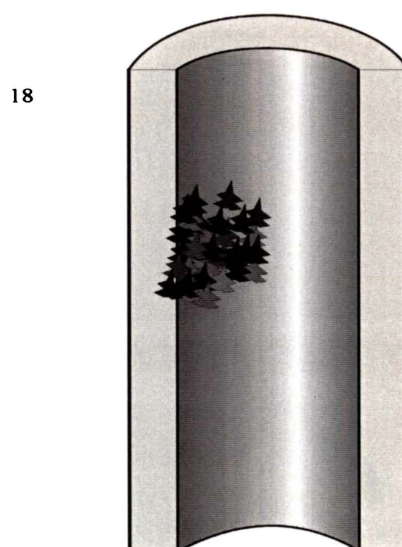
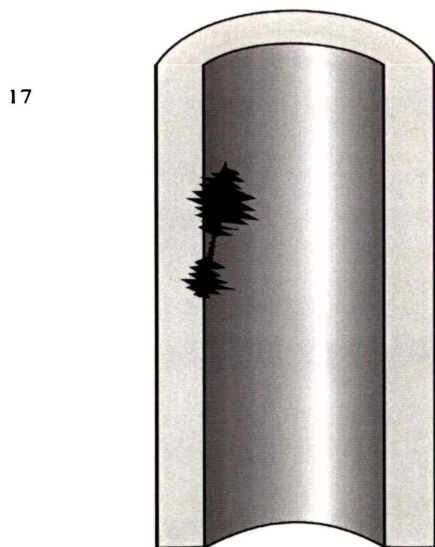
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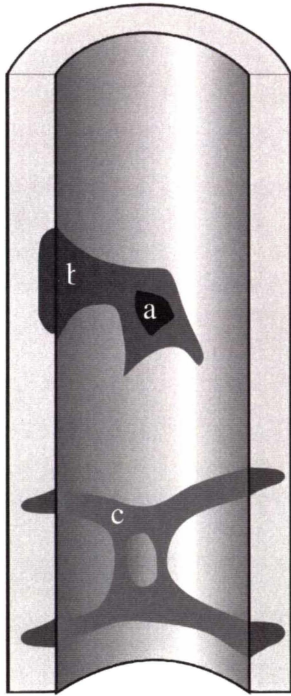


13. Type C5: later stage where V-notches have expanded into U-shaped notches (overlying lumen wall is intact).
14. Type C5: later stage where notches have merged to form a continuous cavity (overlying lumen wall is intact).
15. Type C6: hyphae within cavity, below thin overlying remnants of lumen wall (overlying lumen wall is intact).
16. Type C6: multi-branched hyphae within 'super-cavity' (overlying lumen wall is intact).

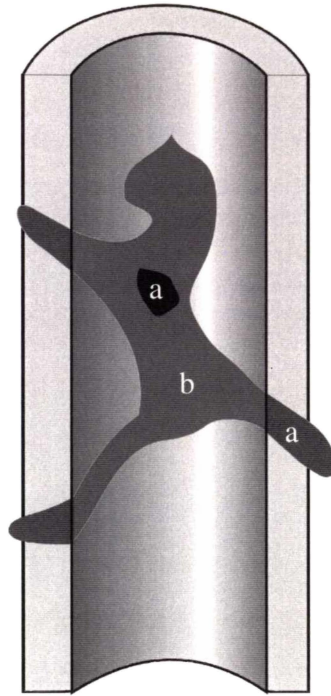


17. Type C7: cavities with serrated edges. 18. Type C7: many merged serrated cavities (easily mistaken for Corbett's Type 2 erosion). 19. Type E1: oblique section through beech fibre with central lumen hyphae and side branches (T-branches?) within troughs. 20. Type E2: Large trough with serrated edges.

21



22



21. Type E2: a = bore hole containing hypha with angular protuberances; b = erosion trough containing hypha (no visible gap between hypha and trough wall); c = anastomosing hypha within trough and/or tunnels..

22. As for 21a and b.