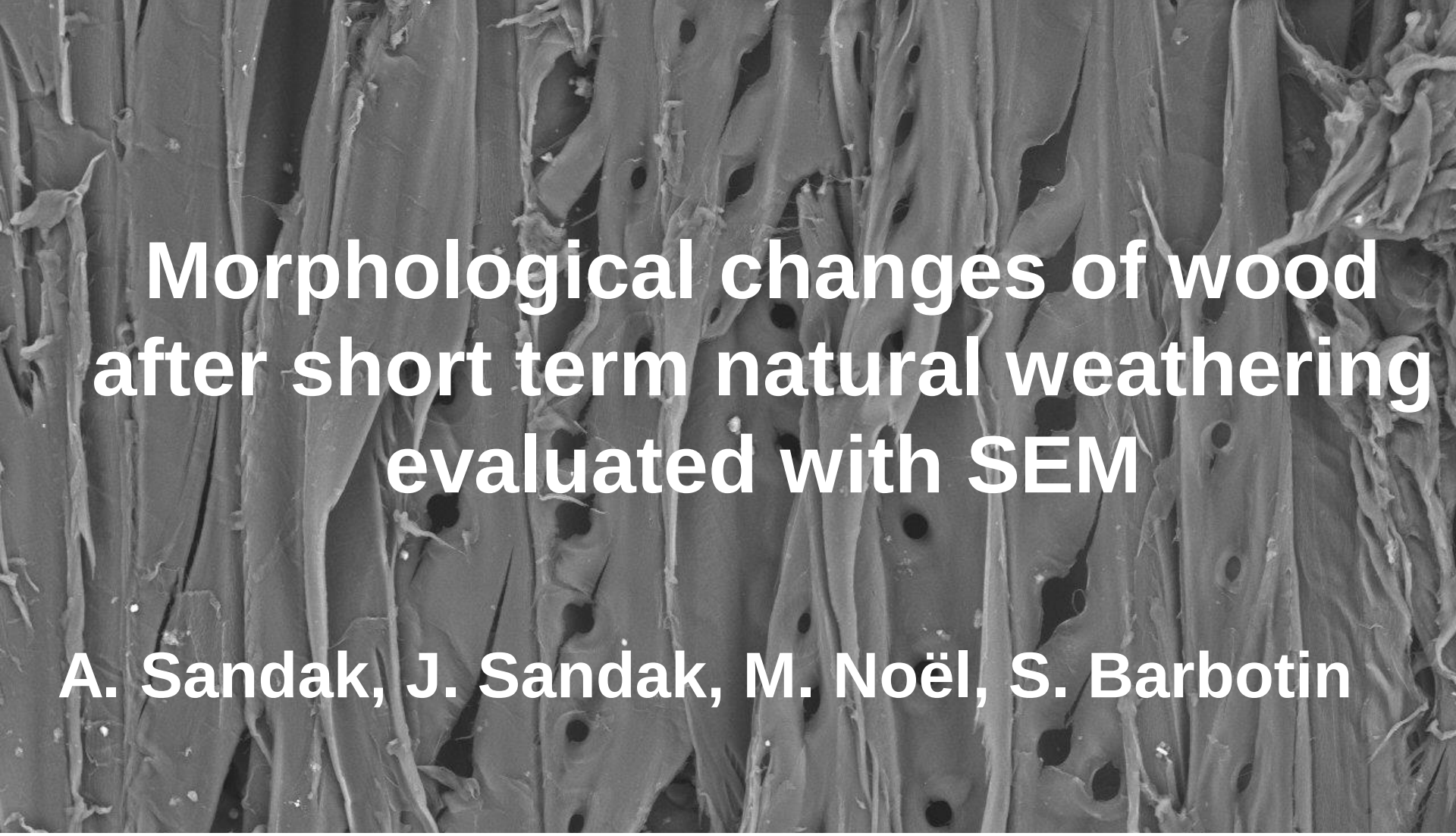

Morphological changes of wood after short term natural weathering evaluated with SEM

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TREES AND TIMBER INSTITUTE

Berner
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Weathering

- Weathering is the general term used to define the **slow degradation** of materials exposed to the weather condition.
- The rate of weathering varies within **timber species**, **function of product, technical/design solution, finishing technology** applied but most of all on the **specific local conditions**.
- The process leads to a slow **breaking down of surface fibres**, their **removal**, and in consequence to a **roughening of the surface** and **reduction of the glossiness**.
- The formation of discontinuities on the wooden surface can cause penetration of the **wood-decaying biological agents** into the material structure and influencing mechanical performances of the load-bearing members.

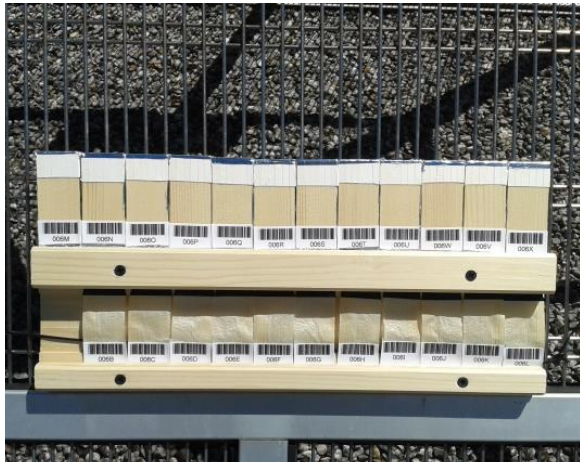
Experimental samples

- one piece of Norway spruce (*Picea abies*)
- slicing planner - marunaka
- the thickness of samples ~100μm
- the efficient surface 30 x 30mm
- conditioned in 20°C, 60%RH


Round Robin test - COST Action FP1006

4 sets of samples were exposed in San Michele, IT

4 directions: N E S W

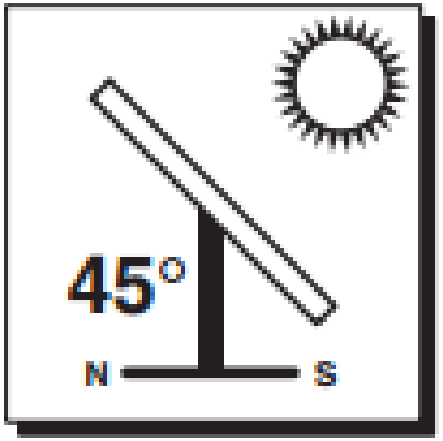


collected after 1, 2, 4, 7, 9, 11, 14, 17, 21, 24, 28 days of weathering

Experimantal set-up

Tests were performed in the month of July, which according to previous research is considered as the most severe season for weathering of wood micro-sections (Raczkowski 1980)

The experimental set up used in this research (45° of exposure angle) is considered as very intense configuration due to rapid washing-out of the degradation products from the surface and the cleansing action of rain (Williams et al. 2001)



Meteorological data

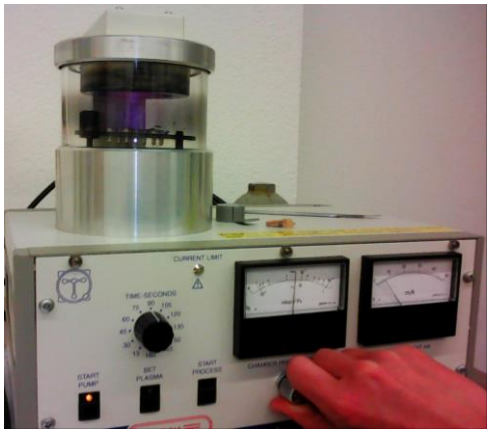
Day of exposure	Temp (mean)	∑radiation (MJ/m2)	∑ insolation (h)	Total rain (mm)	RH%	mean wind speed (m/s)
1	17.8	29.96	14.3	11.4	84.1	0.8
2	20.0	59.63	26.1	0	59.0	1.9
4	21.7	104.56	45.7	1.6	72.5	0.5
7	17.0	162.16	70.4	42.6	92.7	0.5
9	18.3	201.54	89.7	0	68.1	0.9
11	19.8	250.54	108.4	2.0	67.6	1.2
14	22.0	324.02	139.2	0.2	68.0	0.9
17	24.2	407.06	172.8	0	59.8	1.0
21	19.9	469.26	201.7	0	79.5	0.1
24	21.0	526.58	228.5	0	69.6	0.8
28	19.0	580.76	255.1	13.4	88.9	0.5

Degradation progress

- Colour changes (CIE Lab)
- Samples apperance and integrity
- Spectroscopy (VIS, NIR, IR and hyperspectral imaging)
- Gloss
- Thickness
- Microscopic observations
- 3D-roughness evaluations

SEM observations

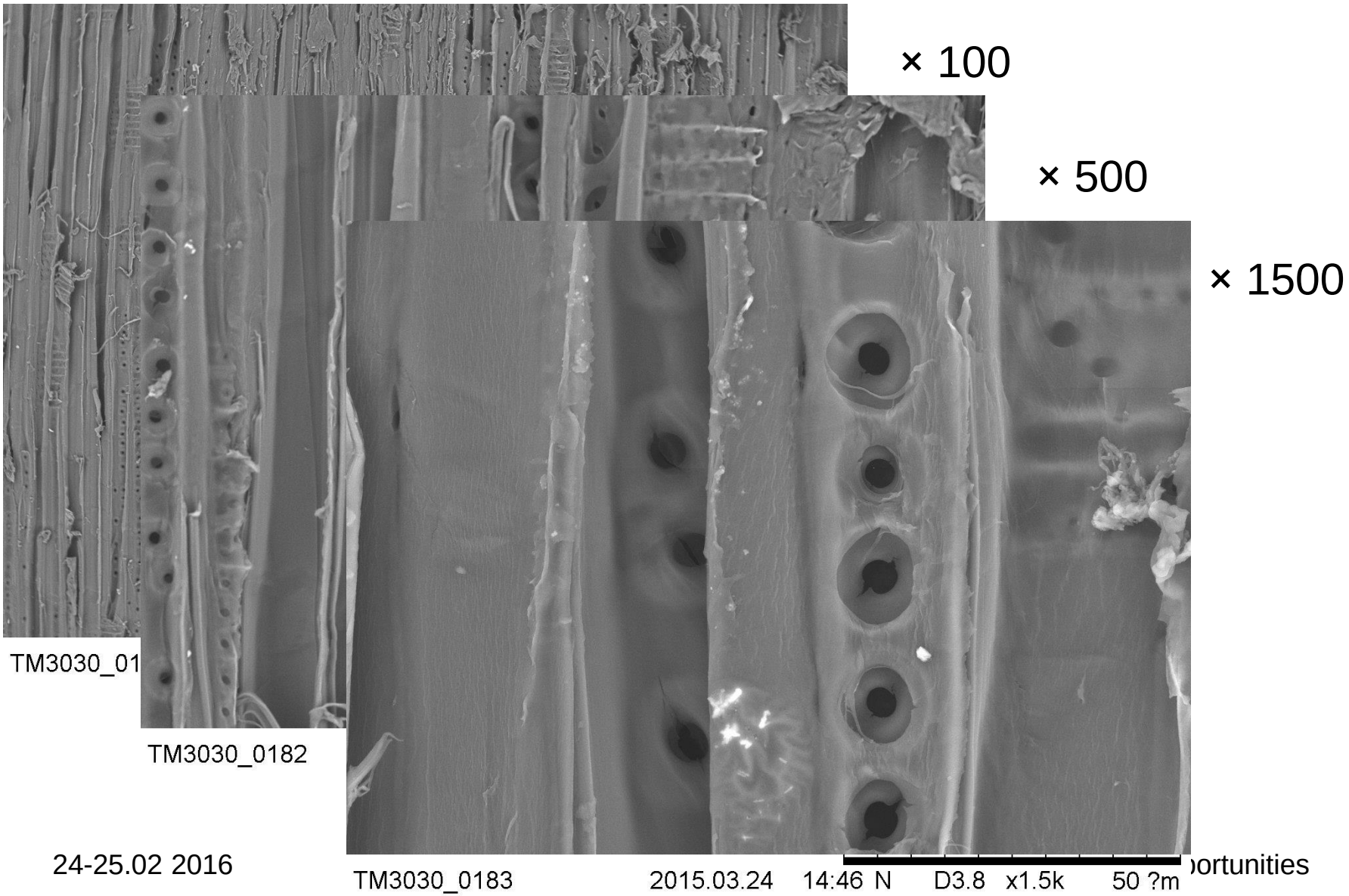
Small pieces of investigated samples were cut out and glued with carbon tape sticker to the sample holder



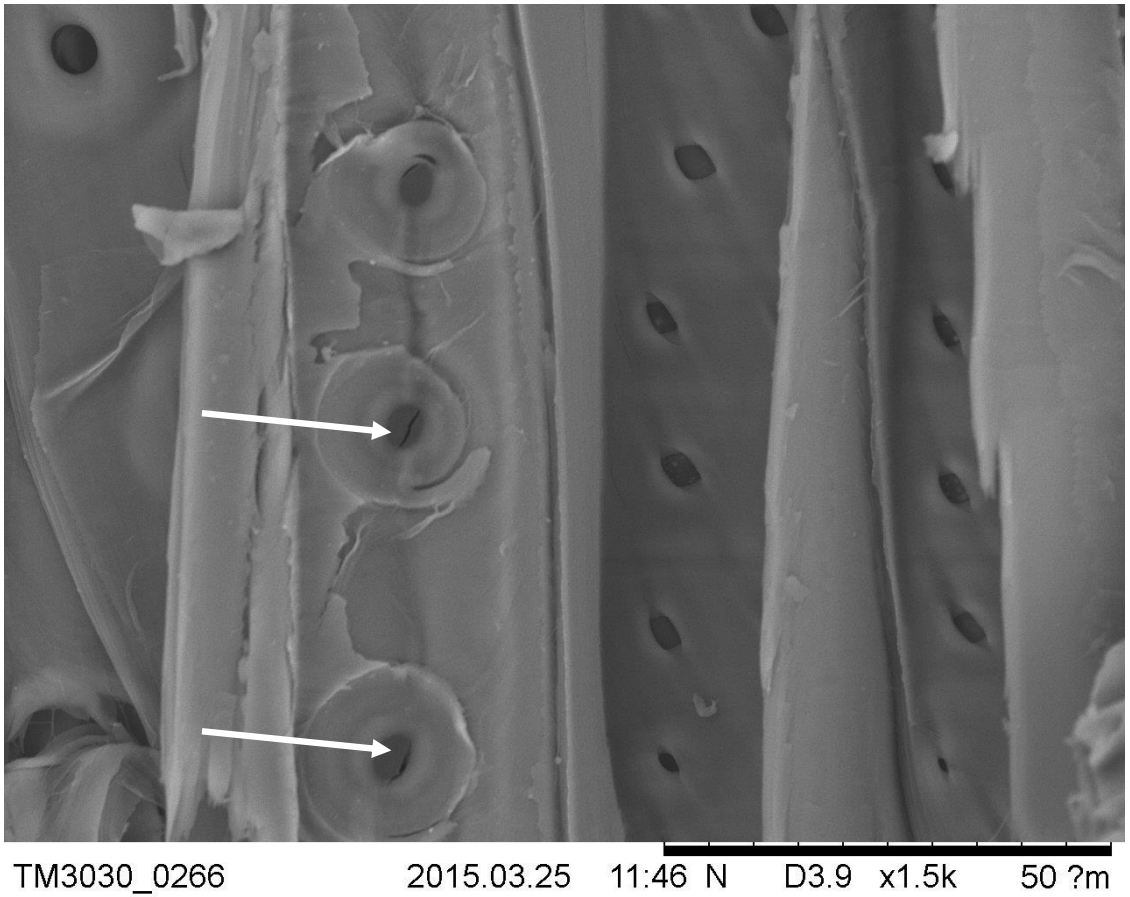
The samples were placed in SC7620 ‘Mini’ Sputter Coater/Glow Discharge System device and then were plasma coated for 90 second with 10 nm gold/palladium (Au/Pd) layer

Samples were investigated by using Hitachi TM 3030 SEM. An acceleration voltage of 15 kV was used for imaging of samples

SEM observations



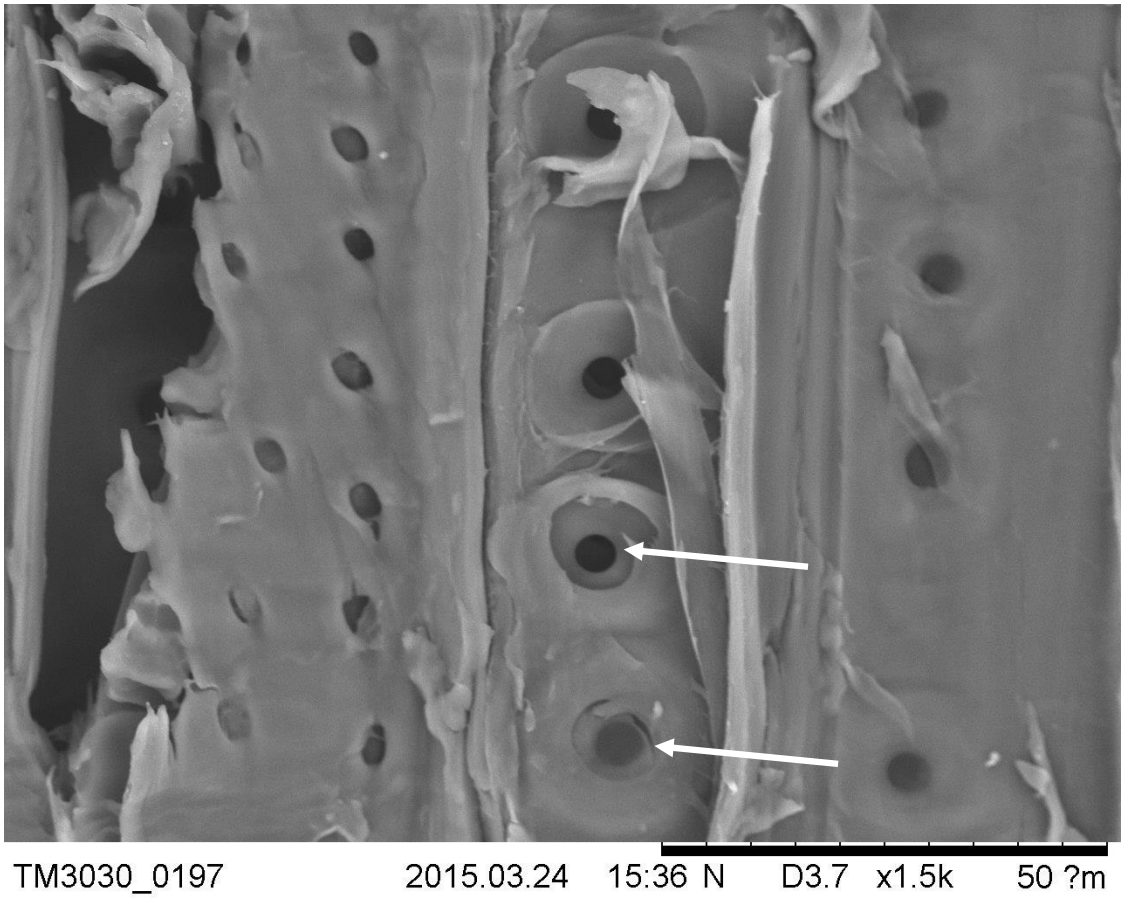
ortunities



2 days

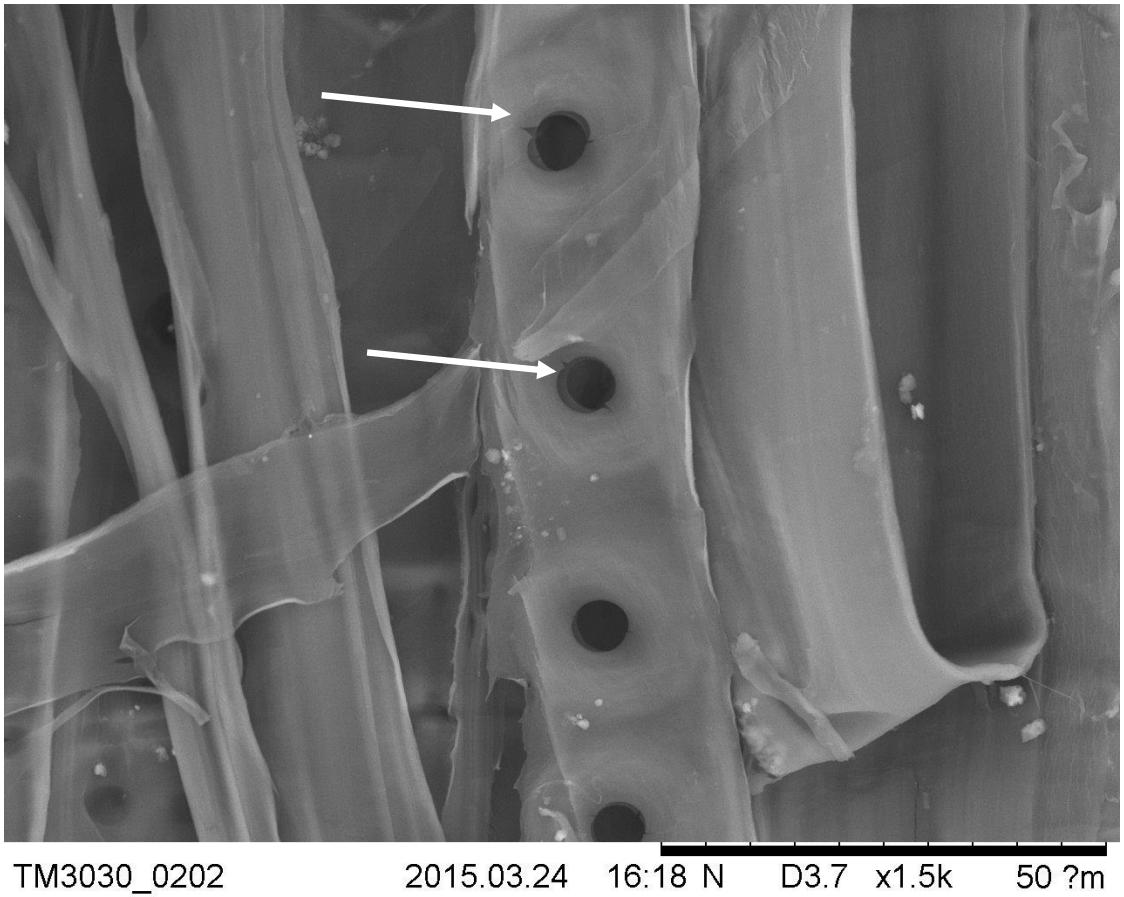
Openings of bordered pits membranes in radial walls of early wood tracheids

4 days

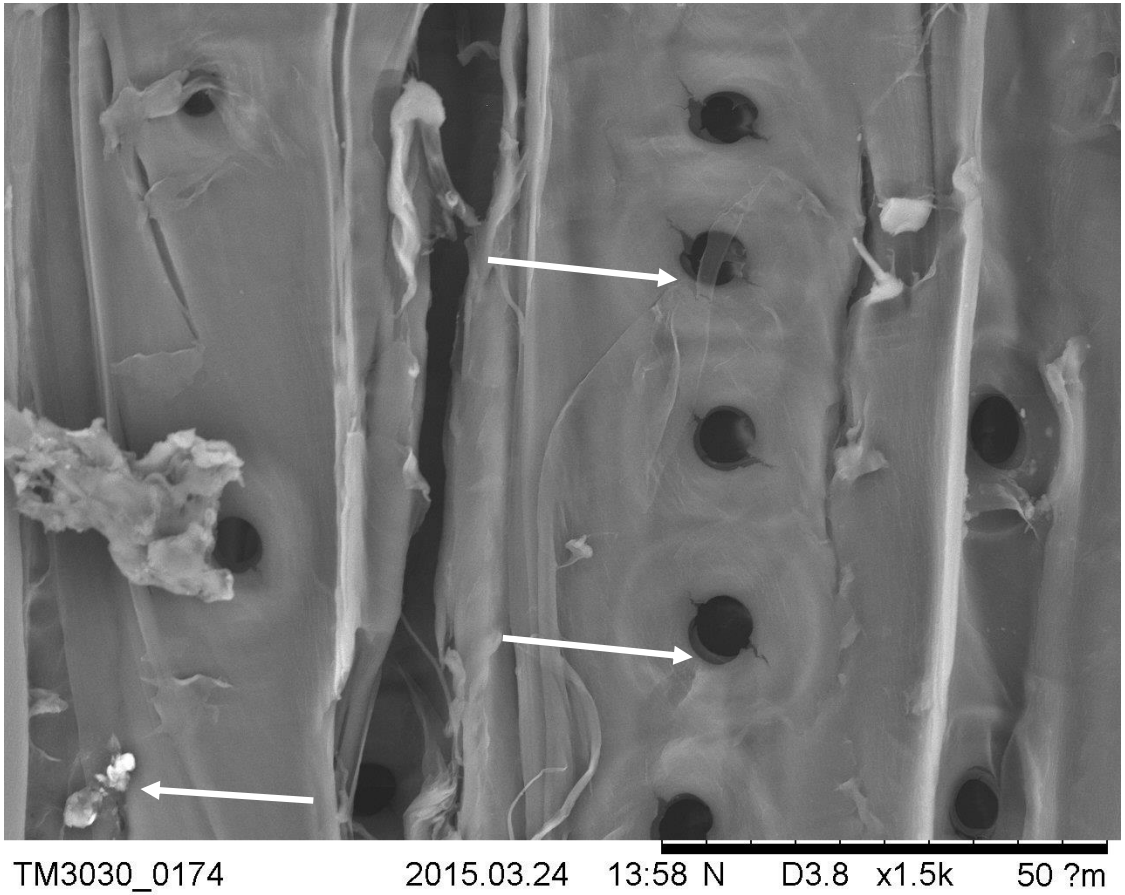


Membrane covering the piths was broken

7 days



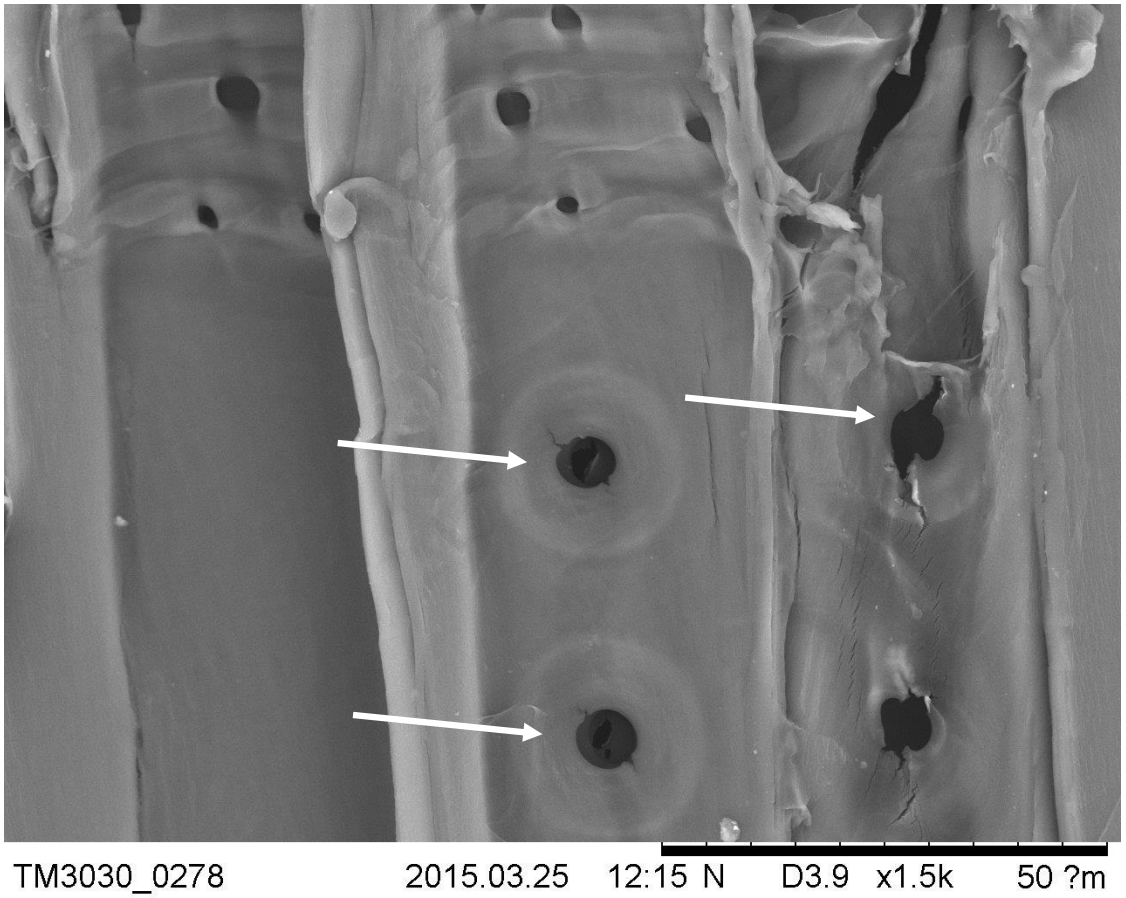
Presence of small diagonally oriented micro-checks



9 days

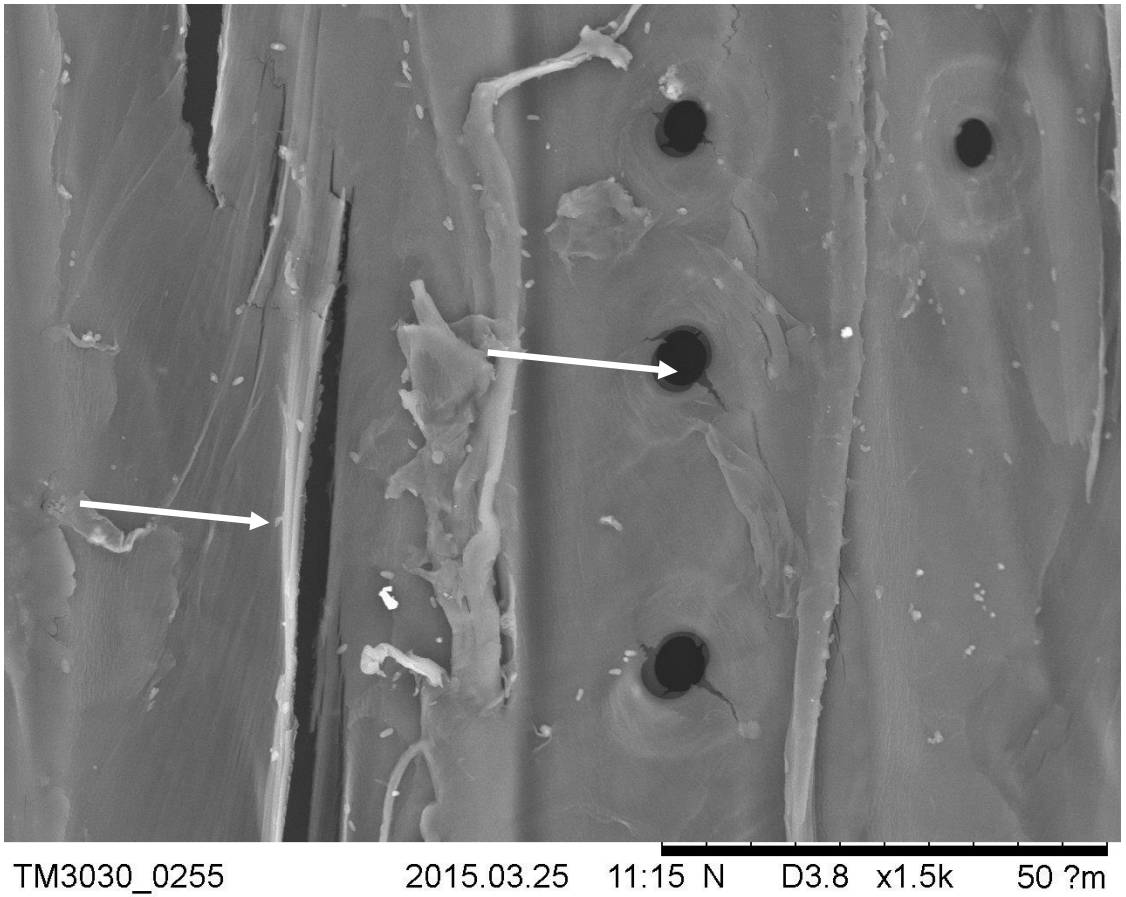
Enlargement of the pith crack, some dust deposition

11 days



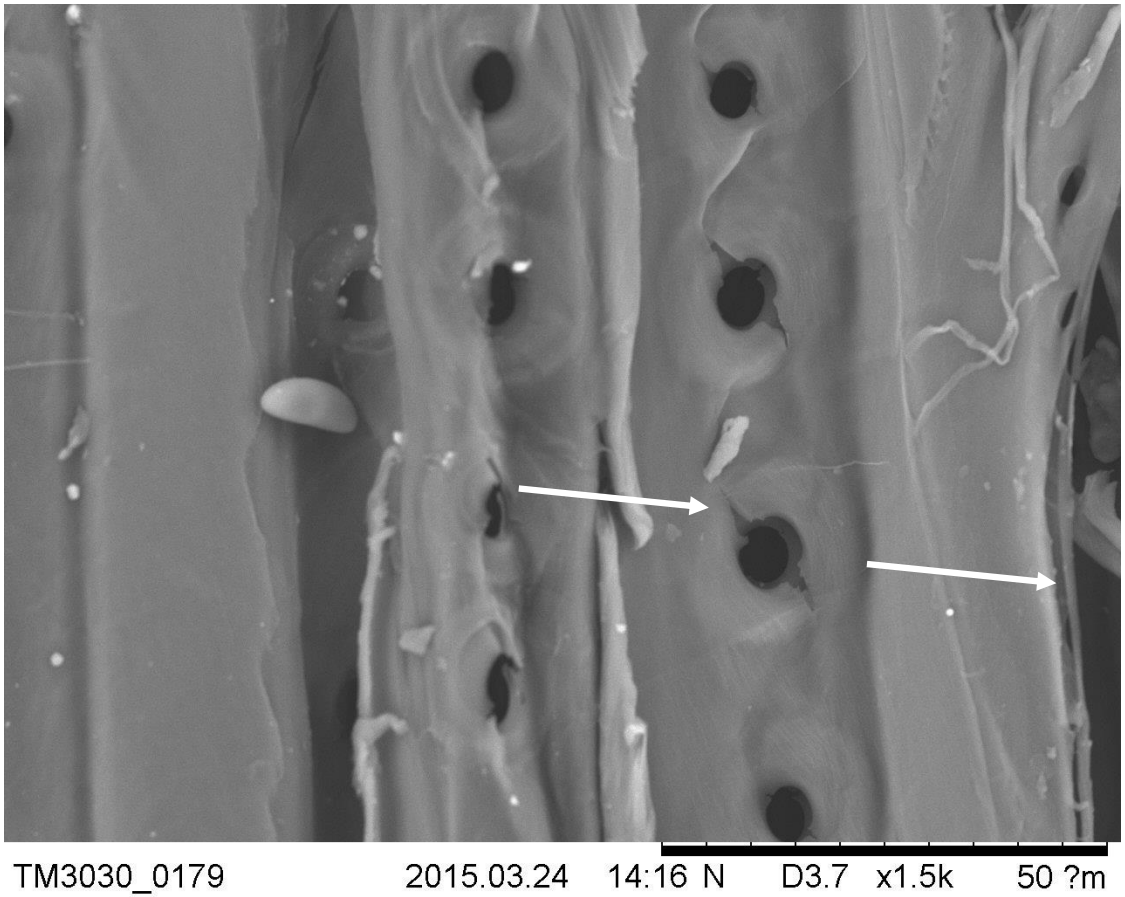
Small cracks on many pits, degradation progress being the result of the contraction of the cell wall caused by moisture variation

17 days



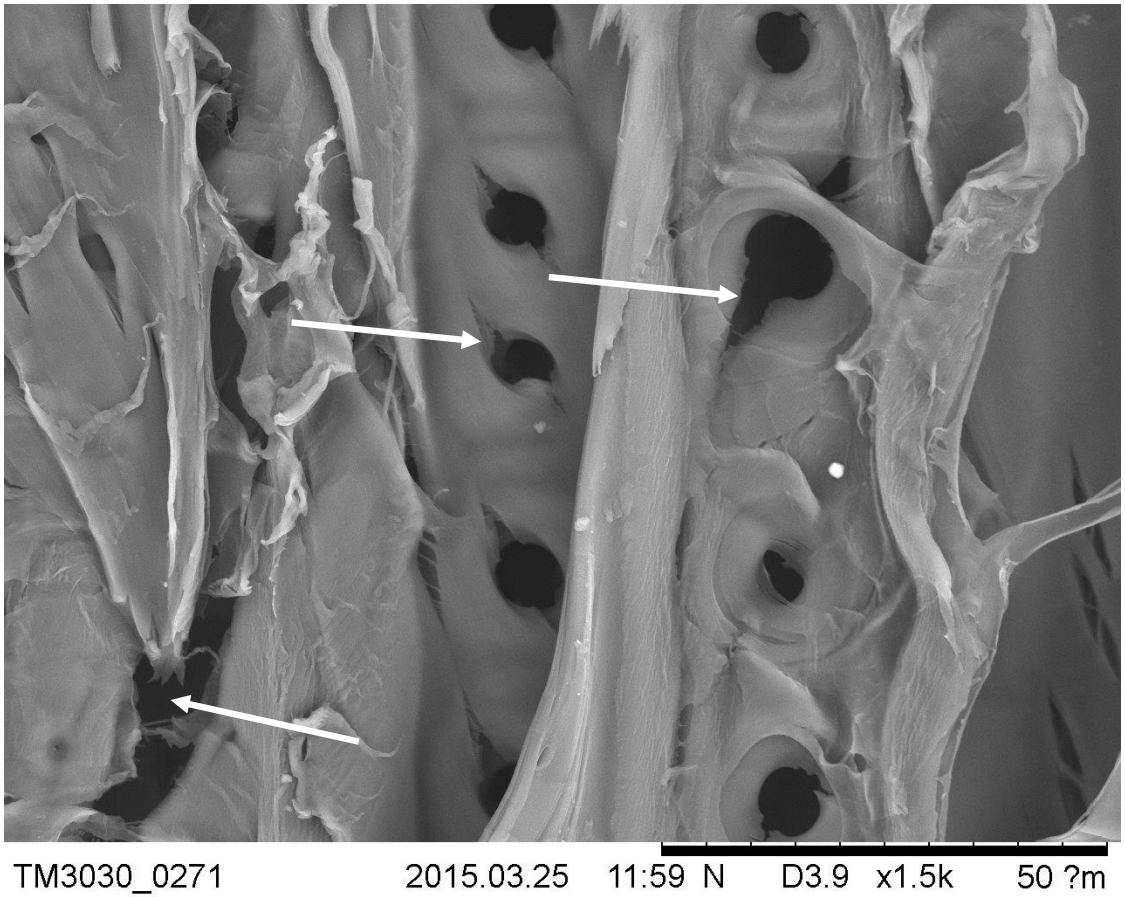
All pits cracked; some big cracks; degraded surface; spores deposition

21 days



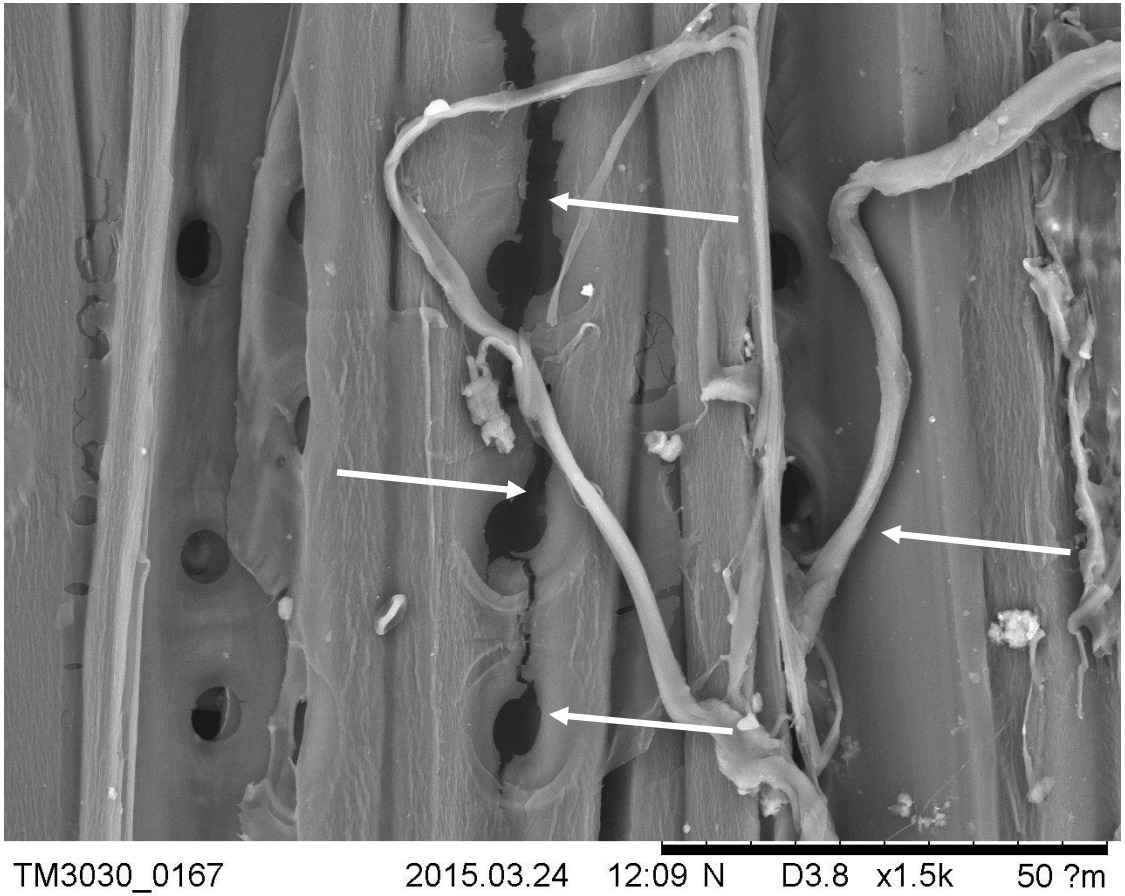
Big cracks; cell wall delamination; mostly very degraded surface

24 days



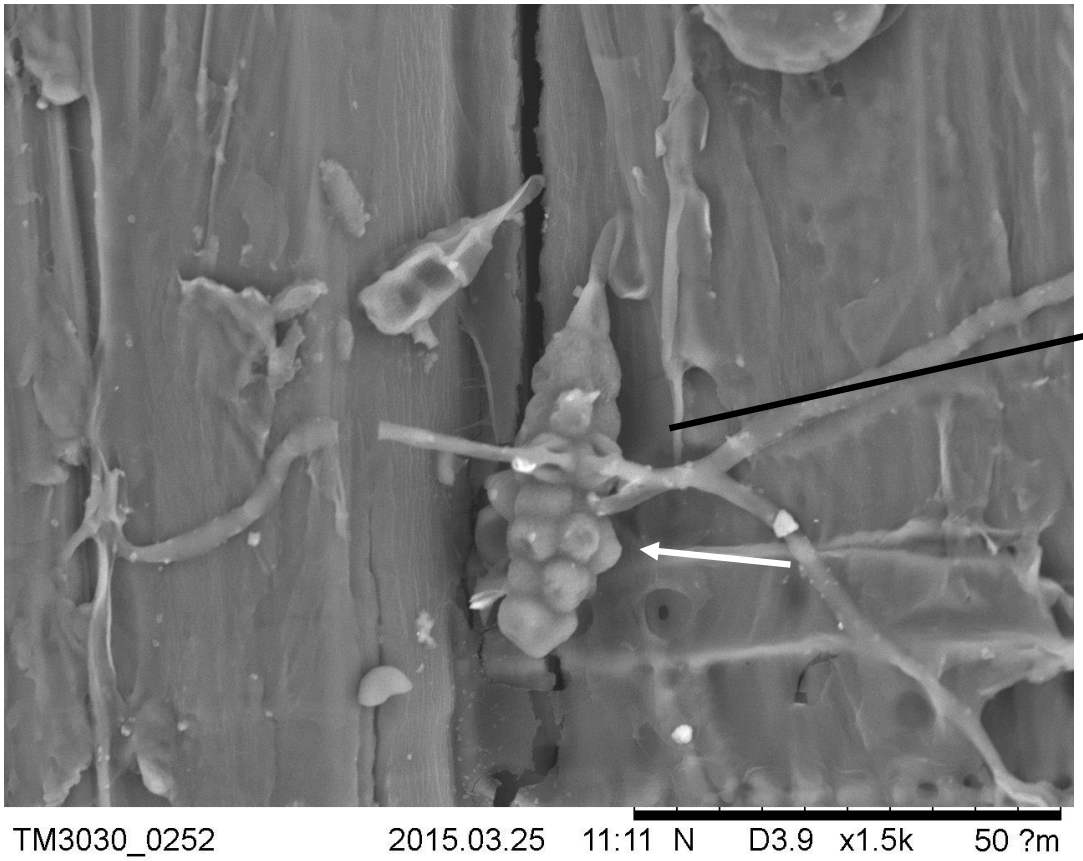
Cell wall delamination; very degraded surface; big cracks on cross-pits

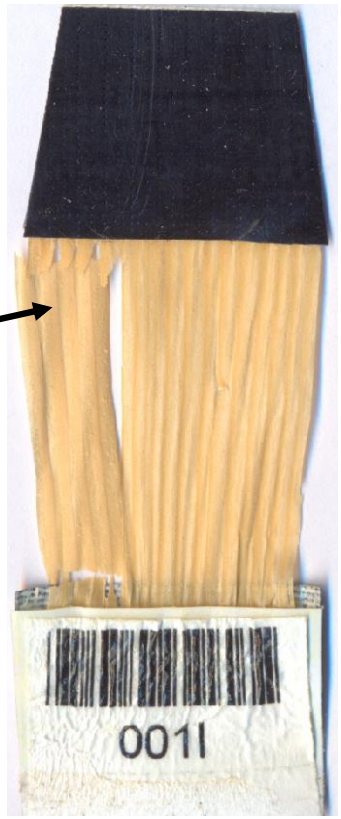
28 days



Very degraded surface; pits cracked; cells delamination; advanced pollution and spores deposition, fungal hyphae growth

Fungal presence

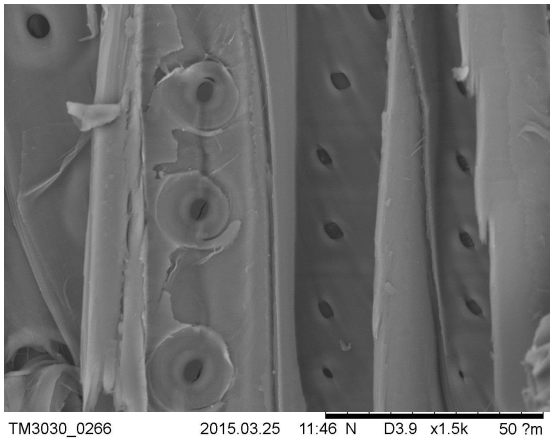




growth of microorganisms begins by deposit of their spores into the micro-cracks (17 day)

SEM images of early wood exposed to south for different duration

2



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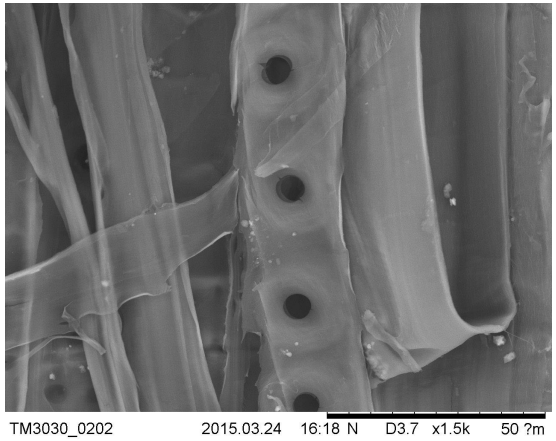

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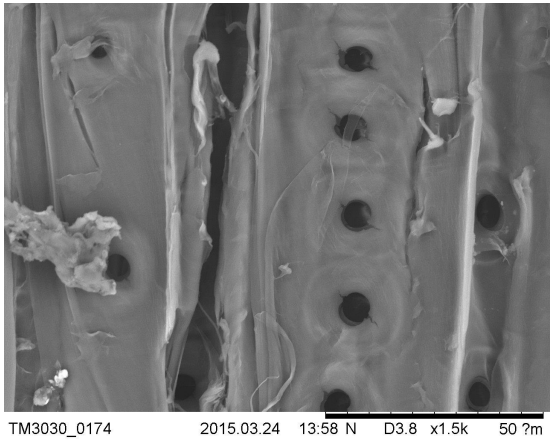

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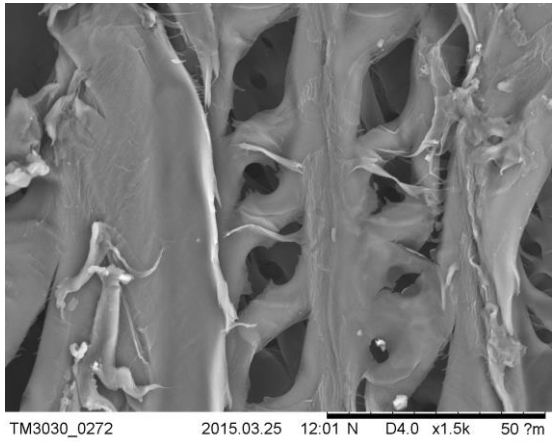
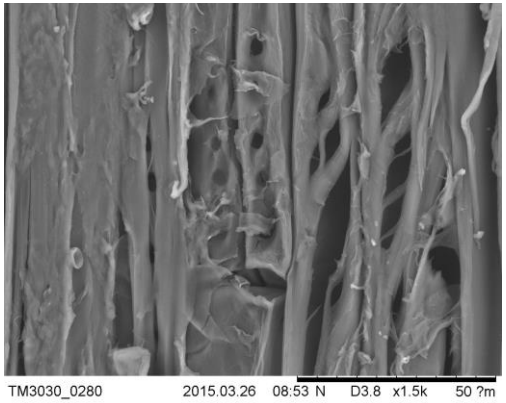
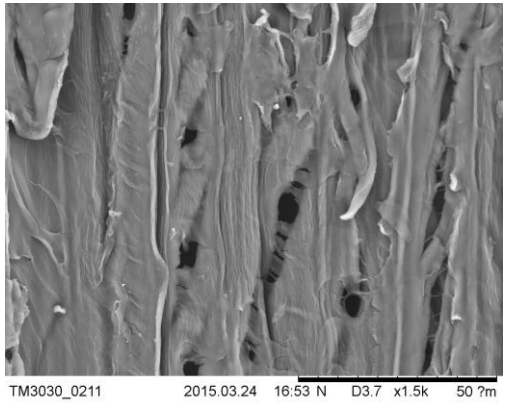


- Openings of bordered pits membranes,
- Small cracks on almost all pits,
- Presence of small diagonally oriented micro-checks,
- Big cracks; cell wall delamination; mostly very degraded surface

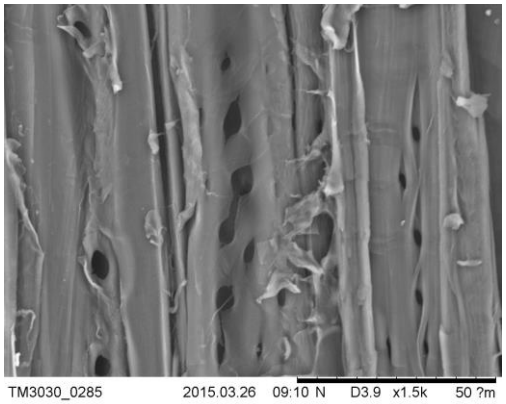
Late wood exposed for 28 days to different exposure sites



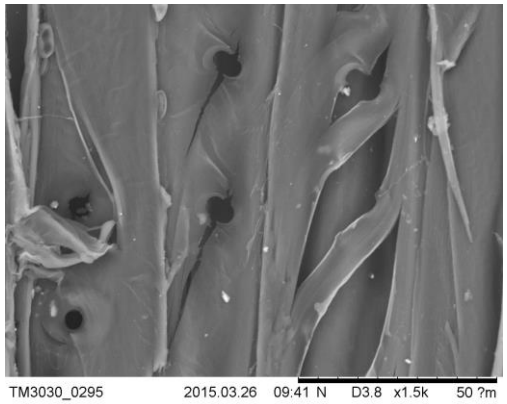
South



West



North



East

- With the progress of decomposition cracks propagate through the cell wall.
- Pits are completely eroded and the degradation products are continuously removed with rain.
- UV radiations cause delamination between fibres caused by lignin degradation

Conclussions

- Understanding the mechanisms of weathering and the role of the altering factors is **fundamental to assess the actual conditions of timber structures**.
- It is essential to **predict the future performance**, and, possibly, to **ensure a long-term preservation and maintenance**.
- **Early wood was more susceptible to damage than late wood**, which was previously explained by the fact that cells in early wood have thinner and weaker walls and in consequence has lower density.
- **Western and northern exposure sites are slightly less affected** by weathering process.
- First signs of fungal infestation were observed after 17 days of natural weathering.

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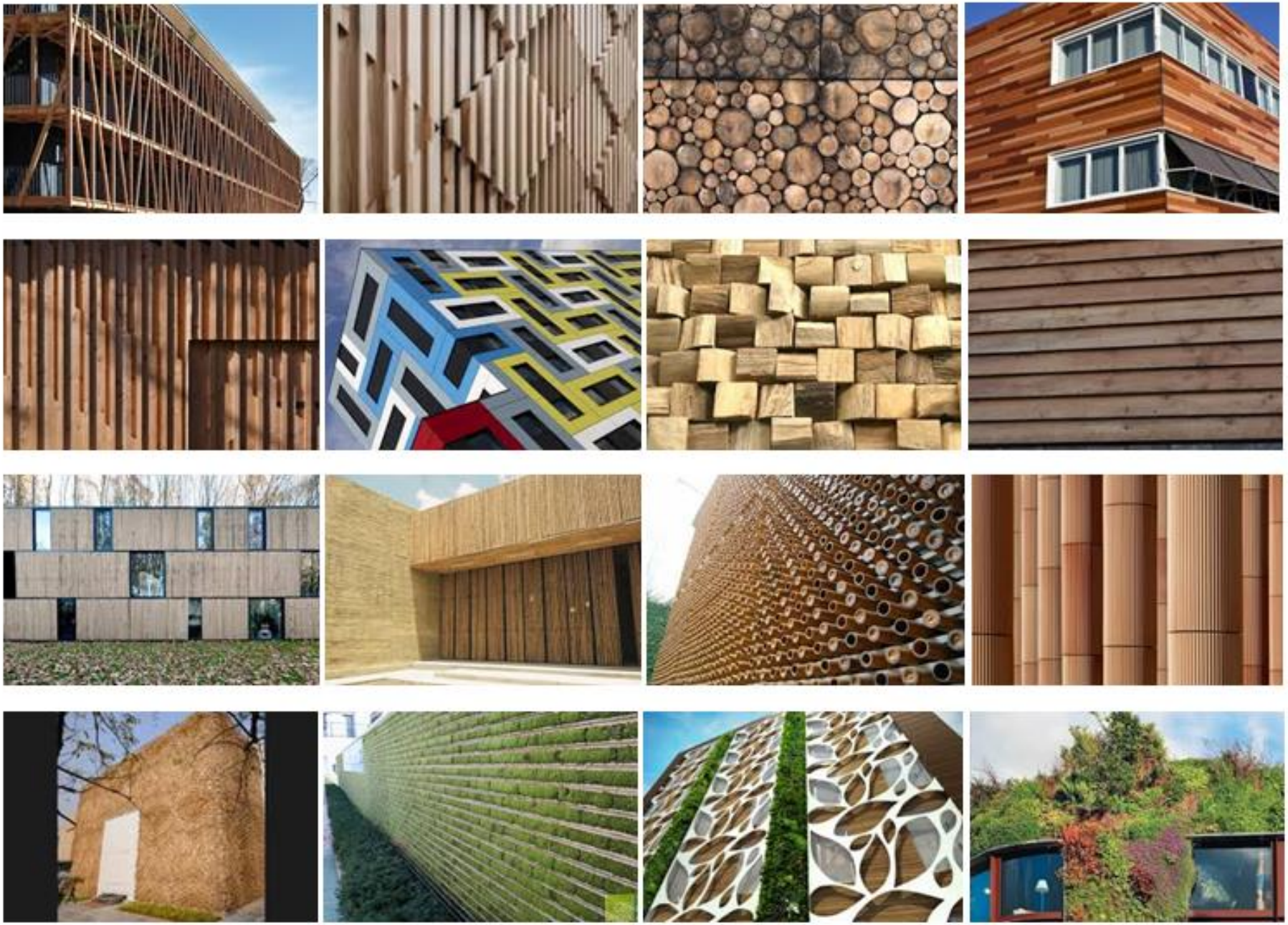

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