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TITLE Scanning electron microscopy of wood replaced by iron corrosion products

SCANNING ELECTRON MICROSCOPY OF WOOD REPLACED BY IRON CORROSION PRODUCTS

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It has long been recognised that remains of wood may be discovered on the surface of corroded iron objects, (Biek, 1969). These remains are often difficult to identify to species level using conventional light microscopy techniques. They are brittle and must be embedded in a suitable medium before the laborious process of sectioning. Observation of a fresh break under reflected light yields [illegible] information because it is usually impossible to obtain one of the standard sections, and the break tends to be very irregular. Examination of [illegible] samples of this type using a scanning electron microscope has been far more successful, allowing species identification of many of the samples. [illegible] mation has also been obtained about the mechanisms of wood 'preserv[illegible] corrosion products.

Twenty-five of the samples were removed from corroded iron objects [illegible] the Saxon cemetary at Mucking, Essex, (Jones, 1972), a site which does n[illegible]lly produce uncharred wood. Most of the remains were orange in colour and ver[illegible] crumbling into powder when touched. Fresh breaks were obtained and the fragments examined in the S.E.M.

At low magnifications there are often few observed differences betwe[illegible] (Meylan and Butterfield, 1972) and the Mucking wood. However, at higher magnifications the apparent cells are found to be widely spaced with gaps brid[illegible]d by tubular outgrowths between the 'cell walls'. These 'cell walls' are f[illegible] be composed of iron compounds displaying a crystalline structure radiat[illegible] plane of the cross section (see Pl I 1). It is suggested that this [illegible] formed by the deposition of a layer of iron corrosion products on the [illegible] cell wall soon after burial, followed by decay of the original cell wal[illegible] between the 'cells' therefore represent the area originally occupied by [illegible] cell walls, (see Fig. 1).

This suggestion is strongly supported by the presence of bi-convex discs between adjacent cell casts (see Pl I 2). These structures are obviously internal casts of the pit chambers of a bordered pit-pair. A thin indentation is often visible between the two halves of the disc, indicating that the iron compounds could not penetrate the pit membrane (see Pl I 3). Fractures usually occur where the pit cast joins the internal cell deposits (ie. the site of the original pit aperture) leaving a small protuberance on the exterior surface of one cell cast, and both halves of the pit-pair still attached to the adjacent cell cast (see Pl I 4).

Spiral thickening (originally on the secondary cell wall) appears as thin indentations on the exterior surface of the iron corrosion deposits. On the inner surface it is enlarged and blurred in appearance (see Pl I 5).

The internal cast of the vessel is usually a hollow tube of fairly con[illegible] within each sample. The interior surface of the tube occasionally displays a [illegible] surface similar to kidney ore in topographical appearance. The central cavity is sometimes completely blocked by further iron deposition, but this is usually distinguished from the primary deposits by its granular or spongy texture. A later phase of deposition sometimes blocks all of the remaining spaces, often completely masking the structural evidence.

The casting process seems to occur similarly in all parts of the wood. Most observed morphological differences may be explained by variations in the original cell structure. For example, tubular casts of simple pit-pairs occur on the ray and fibre cells (see Pls I 6, II 1). One type of internal deposit (homogeneous, dotted with small holes) sometimes fills the entire cross-sectional area once occupied by the [illegible] fibre, tracheid, or ray cells. This may represent the pitted cell end walls which are masked by iron deposition. In the rays, there is sometimes an intermediate layer between the cell casts. This seems to occupy the position of the original middle lamella and primary cell wall. It might therefore be suggested that the primary cell wall deteriorated slightly in advance of the remainder of [illegible] allowing iron deposition to occur there.

...er seven samples were obtained from a Roman well at Rudston, Yorks. (... ...ming). Waterlogged conditions allowed the preservation of actual wood, which was iron stained or replaced to varying degrees from close contact with [illegible] objects. The samples are difficult to interpret, but it seems that a number of [illegible] wood replacement may be traced.

...y cases the wood is still completely preserved, but some iron compounds ... deposited in the lumena. Some vessels have only a thin layer of iron deposit... on the secondary cell wall, partially blocking the pit apertures.

As at Mucking, there was some suggestion that the primary cell wall may often decay before the secondary wall. The outer layer of the secondary cell wall, fibrous [illegible] appearance, is often exposed. Pit casts protrude slightly from the surface into the ... space thus produced between adjacent cells (see Pl II 3). In some cases, this ... seems to be filled with iron corrosion products (see Pl II 4). The middle lamella may also be ...ed for some time after the decay of other parts of the cell wall. It sometimes appears as torn remnants around the pit casts (see Pl II 5). The late survival of the middle lamella and replacement of the cell wall from the primary wall inwards may explain why the cells often seem to retain their original outlines (as initially ...ed by the middle lamella) even after further iron corrosion deposits have ... [illegible] of the remaining structure.

In some areas of certain samples the wood has completely decayed away, leaving pit casts etc. as at Mucking. However, all of the remaining spaces are often blocked by a secondary deposition of iron corrosion products. No spaces remain between the individual 'cells', but fractures sometimes occur along the boundaries separating the various phases of deposition. Therefore, pit casts may be visible as protuberances or negative impressions in the iron compounds occupying the spaces left by the cell walls. Fractures may also occur between these 'cell wall' deposits and the initial [illegible] (see Pl II 6).

The stage of iron deposition reached was found to be extremely variable, even within the small sample. It is also to be expected that the details concerning differential decay of the cell wall etc. are likely to vary from site to site, even from sample to sample. However, it seems probable that the general observations concerning initial preservation of the form of wood by internal casting of lumena and pit cavities will be generally applicable.

It is interesting that there was no evidence for the actual prevention of wood decay in contact with the metal, as is sometimes the case with copper (Bick, 1963) which seems to possess bacteriostatic properties. Copper deposits have also been [illegible] filling the lumena of some wood cells (Hosking, 1965). However, it is [illegible] a casting process similar to that described above may also occur with copper corrosion products.

Acknowledgements

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For scanning electron micrographs and descriptions of fresh wood see:-
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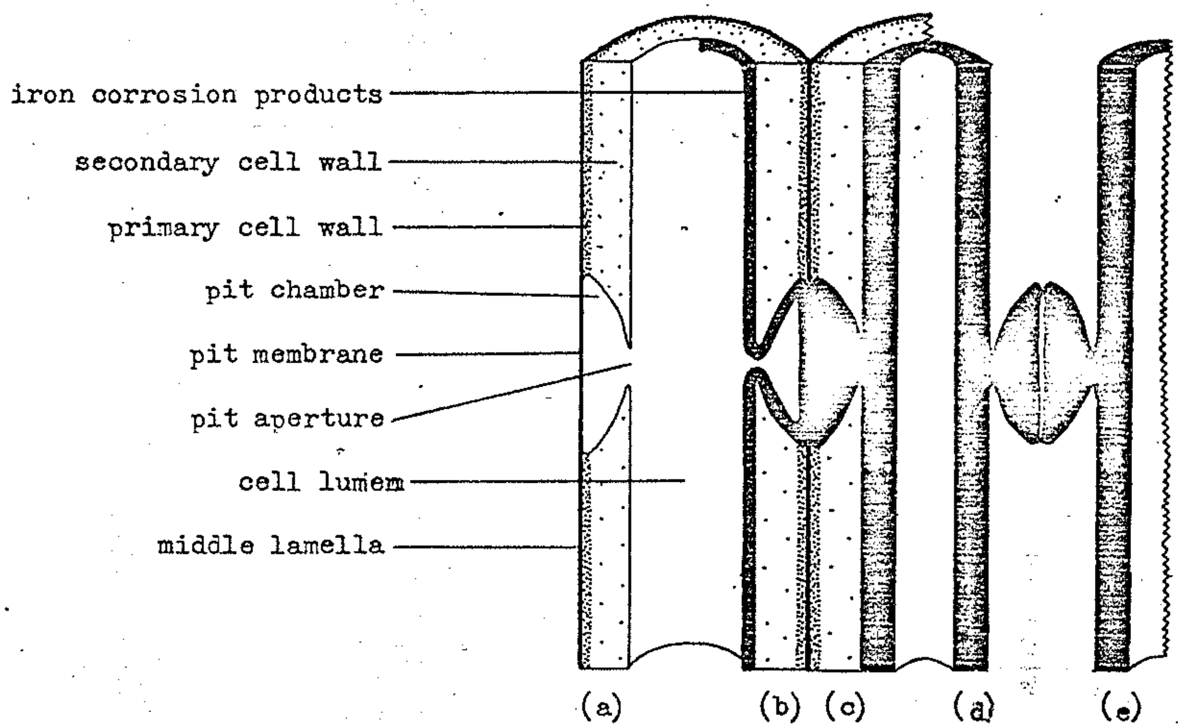
Fig. 1 Diagram of L.S. and C.S. of wood cells, showing (from left to right) progressive stages of replacement by iron corrosion products.



(a) A bordered pit in the cell wall of normal wood.
(b) A thin layer of iron corrosion products on the inside of the pit cavity and cell lumen.
(c) Pit cavity filled with iron corrosion products, but with the cell wall still present.
(d) and (e) Cell wall decayed away, leaving pit-pair cast and internal cell cast.

PLATES

False wall of a vessel containing fungal hyphae coated with iron corro products, C.S. 1×1,130

Internal casts of bordered pit-pairs, L.S. 1×1,130

I 3 Casts of pit-pairs between internal casts of vessel and tracheid cells, L.S. 1×1,130

I 4 Internal cast of a vessel crossed by rays, with pit casts, R.L.S. 1×400

I 5 Internal cast of a vessel (broken). [illegible], showing impressions of spiral thickening, L.S. 1×1,130

I 6 Ray cells in T.L.S., displaying casts of pitting on end walls. 1×1,130

II 1 Ray cells in R.L.S., displaying casts of simple pit-pairs and half-bordered pit-pairs. 1×1,130

II 2 Internal cast of a tracheid with bordered pit-pair casts and break exposing fungal hyphae, L.S. 1×1,130

II 3 Exposed secondary cell wall of a vessel with slightly protruding pit casts and internal iron corrosion deposits [illegible] L.S. 1×1,130

II 4 Fibrous secondary cell wall of tracheids with internal and external iron corrosion deposits, L.S. 1×1,130

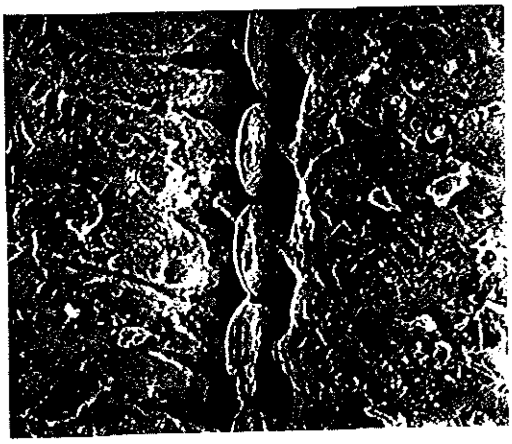
II 5 Pit casts and torn remnants of middle lamella, L.S. 1×570

II 6 Tracheid with iron corrosion products blocking space initially occupied by cell wall. 1×1,130.

PLATE I

(1)

(2)



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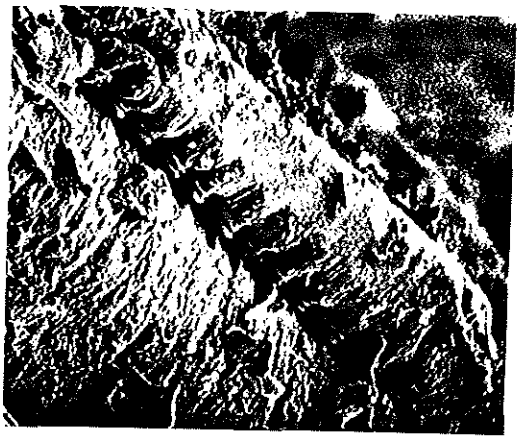

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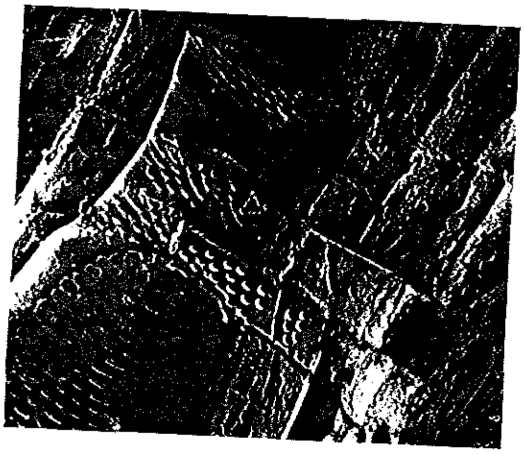

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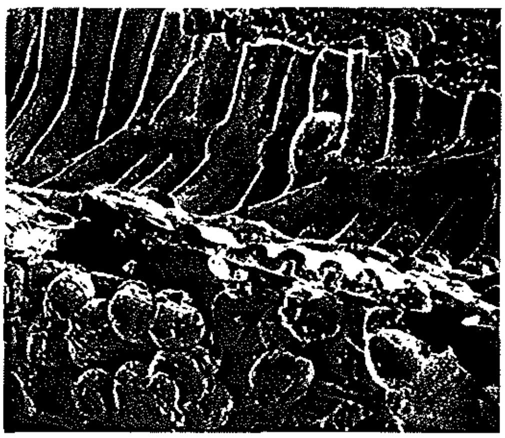
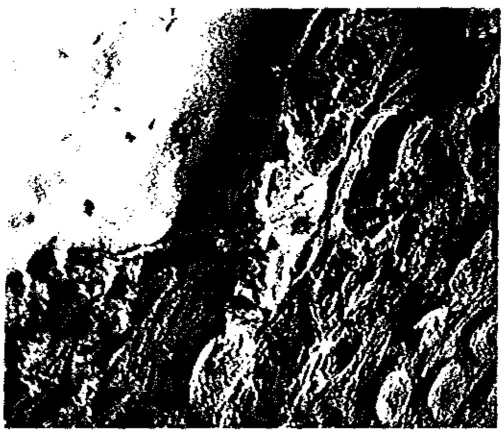


(6)

PLATE II


(1)


(2)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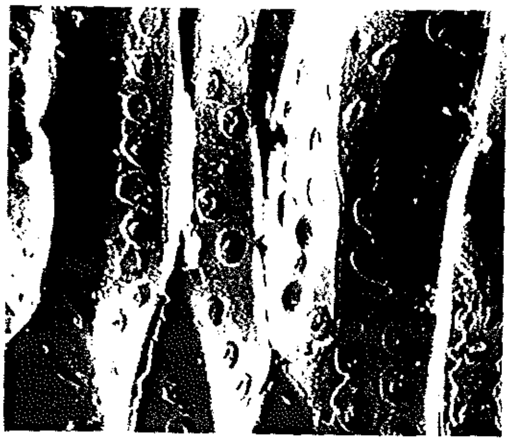
(4)


(5)


(6)