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RESIN POCKETS AND RELATED DEFECTS OF *PINUS RADIATA* GROWN IN NEW ZEALAND

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Three distinct resin pocket type defects are recognised in **Pinus radiata** in New Zealand.

Type 1 is well documented in the literature as a radially narrow discontinuity in the wood, which is oval in the tangential–longitudinal plane and is filled with free resin, callus, and sometimes nodules of callus that contain differentiated woody tissue.

The Type 2 resin pocket originates as the Type 1 defect, i.e., a tangential separation in the cambial zone which expands radially as it fills with free resin under pressure. A rupture then occurs through the cambium and external resin bleeding results. Any remaining live cambium adjacent to the original separation may continue to function at a reduced rate. The whole defect, including any retarded cambium, is occluded by surrounding healthy cambium and an occlusion scar results. The occluded defect may contain any of: dry resin, callus, bark, and occluded wood; the latter is wood derived from damaged cambium or differentiated callus cells and is mostly separated from normal wood by other than woody tissue.

The Type 3 defect is a narrow longitudinally-oriented break in the continuity of wood, filled with dry resin and parenchymatous tissue. This defect originates as a lesion in the cambial zone. A rupture through the cambium results in external resin bleeding. Surrounding healthy cambium occludes and causes a similar occlusion scar to a Type 2 resin pocket.

INTRODUCTION

Investigations by Clifton (1969), Cown (1973), Harris & Barnett (1975), and various overseas workers have resulted in a very adequate description of the "normal", lens shaped, liquid resin-filled resin pocket (hereafter called a Type 1 defect).

In 1976, R. Fenton (Forest Research Institute, Rotorua) renewed interest in this phenomenon when he examined resin bleeding in radiata pine and found it to be associated with previously unrecognised defects which appeared to be related to resin pockets. These defects seem to occur in greater numbers in silviculturally managed stands.

The work reported here defines, in terms of broad anatomical features, the distinguishing characteristics of 3 distinct resin pocket type defects found in radiata pine.

MATERIALS

The study investigated the anatomy of resin pockets obtained from 61 intensively sampled trees in: Kaingaroa, Rotoehu, Nelson, and Aupouri State Forests and of addi-

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tional small samples from other North and South Island forests. Tangential, radial, and longitudinal dimensions were recorded for 100 Type 1, 200 Type 2, and 500 Type 3 resin pockets, as described below.

RESIN POCKET DESCRIPTION

Type 1 resin pocket

This defect is typically an oval, lens shaped discontinuity in the wood, lying in the longitudinal tangential plane and containing callus and free resin. The initial rupture occurs in the cambial zone (Cown 1973) and the defect assumes its final proportions aided by resin under high pressure (Harris & Barnett 1975). Callus is formed from ray and resin canal parenchyma proliferating into the cavity and continues to develop over several years (Clifton 1969). In the first years, callus coats both surfaces and small nodules may become apparent. The nodules develop firstly on the inner surface and subsequently on the outer surface and may grow until they occupy most of the pocket (Clifton 1969).

Fig. 1A and B shows TS and TLS sections of Type 1 resin pockets.

Typically, there is no change in curvature of the annual ring outside a Type 1 resin pocket. This suggests a reduction in meristematic activity of the cambium, corresponding to the radial extent of the pocket, immediately after its formation. It is not certain that the resin pocket itself inhibits growth. The cambium apparently resumes normal activity in subsequent years, although it is not uncommon to observe further resin pocket type defects arising from the same section of cambium.

The inner surface of the pocket may lie in any part of the year's growth, but typically it is along either the earlywood/latewood boundary (this includes the corresponding boundary of a false ring if present (Cown 1973)) or a band of closely spaced, vertical resin canals. These constitute two apparent planes of weakness along which the original rupture may occur.

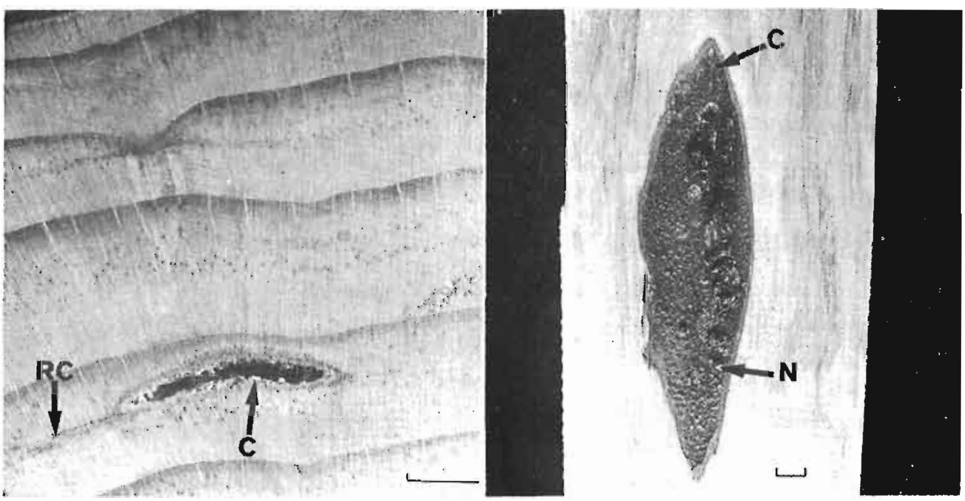

FIG. 1—Type 1 resin pocket. A (left) — TS; B (right) — TLS. (RC = band of closely spaced vertical resin canals; C = callus; N = nodules of differentiated callus). Bar represents 1 cm.

Type 2 resin pocket

From visual inspection, the Type 2 resin pocket seems to originate as a Type 1 defect, i.e., a tangential separation in the cambial zone along a plane of weakness. However, the developing pocket ruptures through the cambium, external resin bleeding results, and the original pocket may flatten down to a thin line of callus and dry resin as seen in Fig. 2B, C, D, or it may retain at least some of its original spatial proportions (Fig. 2A). If the adjacent cambium dies the damaged zone, including some bark, is

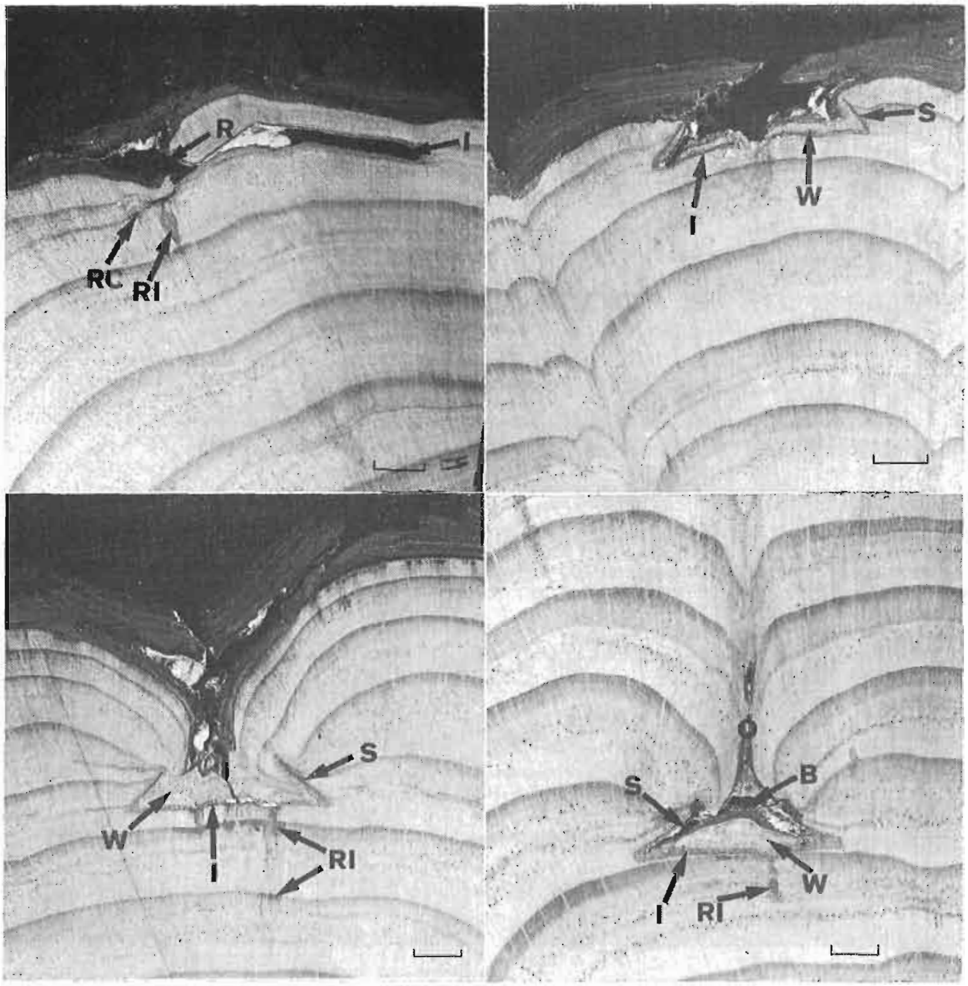

FIG. 2—TS of Type 2 resin pockets. A (top left) — retaining most of the original spacial proportions of a Type 1 resin pocket. B (top right) — cambium outside the initial separation has been partially functional. C (bottom left) — 4 years of retarded growth outside the initial separation and consequent lateral zones of separation. D (bottom right) — completely occluded defect. (R = point of rupture through cambium; RC = band of vertical resin canals; RI = resin impregnation; I = initial separation as for a Type 1 resin pocket; W = wood from retarded cambium; S = separation due to different rates of cambial activity; O = occlusion scar; B = bark and dry resin). Bar represents 1 cm.

occluded over by healthy surrounding cambium. Where cambium outside the original pocket remains alive, it usually continues to function at a reduced rate. In Fig. 2B, C, D, this reduced rate of growth has caused zones of separation outside the original pocket as healthy surrounding cambium occludes the slower growing cambium. In Fig. 2C, 4 annual rings, with reduced growth, are still visible in the defective zone. Fig. 2D shows complete occlusion of the defective cambium.

The Type 2 resin pocket contains any of: dry resin, bark, callus, and occluded wood. Occluded wood and bark tissue might also develop from differentiating callus cells. Further in from the defect, high resin impregnation is often visible, particularly in latewood.

As the occlusion processes proceed, bark is often pinched off, giving the defect a large radial component. The pinching off usually leaves an indented wedge of outside bark which acts as a rigid template for the cambium to lay down future cells and so the subsequent annual rings mirror this wedge (Figs 2D and 3A). The pinch may eventually be lost if either the bark wedge is pinched off by further occlusion or if a crack in the outer bark corresponds to the wedge and the inner more plastic layers of bark are eventually forced out.

In the standing tree, the presence of these defects is usually detectable from external resin bleeding. Bleeding, several years or more old, is characteristically blackened by a sooty mould. The depression, corresponding to the occlusion scar, is also often apparent from the outside of the tree (Fig. 2C).

The original separation causing the defect, lies along the same planes as the inner surface of the Type 1 resin pocket. In some instances, the inner-most signs of tissue disruption lie several millimetres inside the earlywood/latewood boundary or resin canal band. This might be accounted for by the death of developing, unlignified cells further in from the original separation.

Type 3 resin pocket

This defect is usually distinguishable as a narrow longitudinally-oriented break in the continuity of wood filled with dry resin, parenchymatous tissue and sometimes cork cells (Fig. 3A, B). The defect typically occurs in the vicinity of closely-spaced resin canals and apparently arises as a lesion in the cambial zone accompanied by a rupture through the cambium with its consequent occlusion.

The Type 3 defect resembles the Type 2 defect but does not have a large, oval-shaped, tangential separation as its base. The same occlusion process occurs, with indented growth rings, indented bark, and external resin bleeding. Also characteristic is high resin impregnation further in from the defect, particularly in latewood.

In tangential view, large examples of this defect show a tappering strip of red-brown parenchymatous tissue corresponding to the extent of the original lesion in the cambial zone, with streaks of dry resin corresponding to the point or points of rupture through the cambium.

In summary, the Type 1 resin pocket is a "contained" flat and oval space, lying in the tangential longitudinal plane and filled with liquid resin. The Type 2 resin pocket is the product of a forming Type 1 pocket rupturing through the cambium and

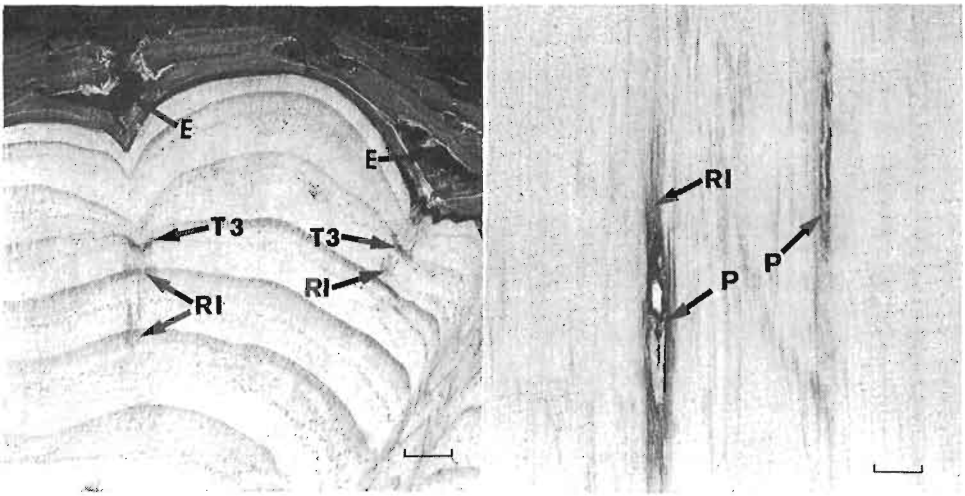

FIG. 3—Type 3 resin pocket. A (left) — TS; B (right) — TLS. (T3 = Type 3 resin pockets; E = external resin bleeding and indented bark; RI = resin impregnation; P = parenchymatous tissue, dry resin, and bark). Bar represents 1 cm.

its occlusion scar. The Type 3 defect has a tangentially narrow separation as its base and a similar occlusion scar to a Type 2 defect. Dry resin and resin impregnation further in from the defect are characteristic of Types 2 and 3 resin pockets.

Dimensions

Seventy-five percent of the population of resin pockets for which dimensions were recorded were in the range of tangential, radial, and longitudinal dimensions given in Table 1.

TABLE 1—Range of resin pocket dimensions (mm)

Position	Type 1	Type 2	Type 3
Tangential	20–50	10–40	3–10
Radial	3–6	15–35	3–10
Longitudinal	40–100	40–120	25–70

Since Type 2 defects form from Type 1 defects they are usually bound by the latter's tangential and longitudinal dimensions. However, in some instances there is a length increase resulting from lesion in the cambial zone. Such examples are similar to large Type 3 defects.

The Type 3 defect is usually small and within the limits suggested above. However, larger examples occur, with a tendency to form in certain trees on certain sites, e.g., in Aupouri Forest. Such examples can be several decimetres long and up to several centimetres tangentially but usually they are only a few millimetres radially, except at the point of the original rupture through the cambium where the occlusion scar causes a larger radial component.

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