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TAXONOMIC DESCRIPTION OF FOSSIL WOOD FROM CAINOZOIC SAK RIVER TERRACES, NEAR BRANDVLEI, BUSHMANLAND, SOUTH AFRICA

by

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ABSTRACT

Seven pieces of silicified wood are described from two sites near the Sak River, Bushmanland. The Miocene deposit yielded five specimens which can be assigned to the Dipterocarpaceae, Fagaceae, Myrtaceae, Oleaceae and Rutaceae. Of the two logs recovered from the Plio-Pleistocene deposit, only one was well enough preserved to be assigned to the Polygalaceae. All the woods indicate that the palaeoenvironment in that region was tropical to subtropical based on the wood structure, growth rings and from their modern counterparts.

KEY WORDS: Fossil angiosperms, Miocene, Plio-Pleistocene

INTRODUCTION

Fossil wood has been little studied in southern Africa even though it is very common and occurs in well dated sediments. The preservation is usually good enough to identify the wood and also to infer palaeoclimatic trends.

Wheeler and Baas (1991) made a comprehensive survey of worldwide Cretaceous and Tertiary fossil woods and found that there was a higher incidence of the "primitive" features as postulated by Bailey and Tupper (1918) in the Cretaceous woods than in the Tertiary, and a corresponding lower incidence of "advanced" features. Wheeler and Baas (1991) also found that during the Miocene and Pliocene the occurrence of features of wood anatomy was nearly identical to that of the present day. We can, therefore, from these younger woods, deduce the past climate by comparisons with the extant flora and corresponding wood features.

There is very little described fossil wood from the Cretaceous and Tertiary of southern Africa (Müller-Stoll and Mädel 1962) and so it is important to establish a database; this is now being done.

LOCALITY AND GEOLOGY

The localities are shown in Figure 1. The geology of the region is described in detail in De Wit (in prep.) and De Wit and Bamford (this volume).

The generally well preserved, silicified fossil wood was collected during a regional study on the Cainozoic drainage systems in the north-western Cape Province by the junior author. Five pieces were collected from the farm Piet Louw's Vlei 302 (sample numbers BP/16/ 4 - 8). Two pieces were collected from the farm Dik

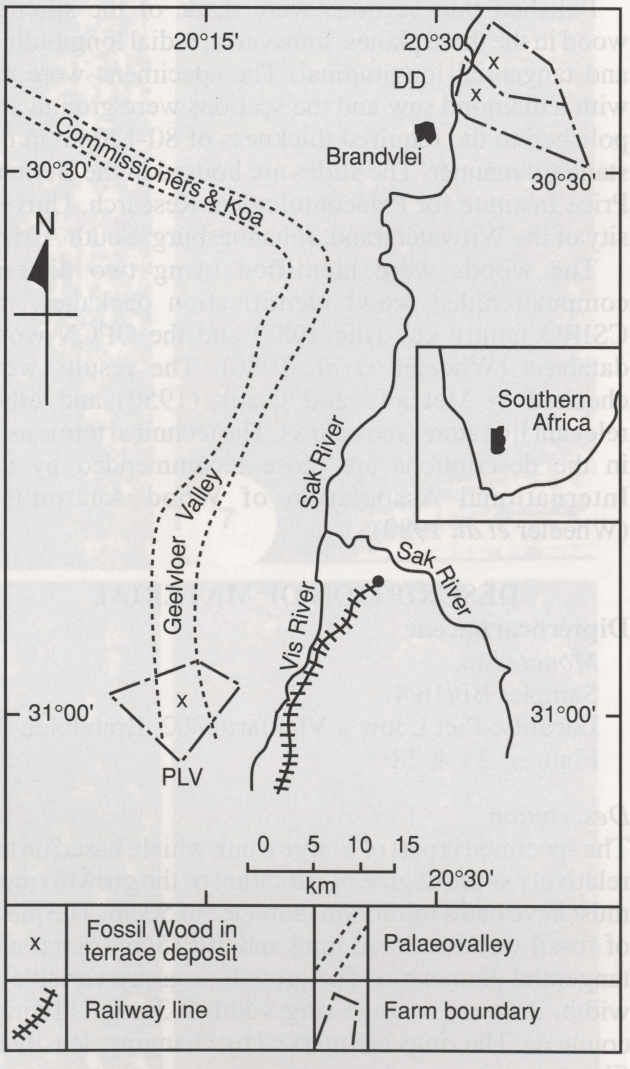


Figure 1. Locality map of fossil wood deposits. The river flows northwards. DD = Dik Doorns farm, Plio-Pleistocene deposit. PLV = Piet Louw's Vlei farm, Miocene deposit.

Doorns 30/31 (sample numbers BP/16/2 and BP/16/3). The Piet Louw's Vlei deposit is in the Geelvloer Valley which is the palaeo-Sak River, to the west of the present day river of the same name and south of Brandvlei. The facies represents partially reworked deposits. The gravels have been interpreted as hillslope deposits that were derived when local shale and dolerite were mixed with fluvial sediments rich in sandstone pebbles (De Wit in prep.). This deposit is Miocene based on the age of the calcretes and the lower jaw of a member of the Anthracotheriidae found in the same strata on the adjacent farm, Paarde Kolk (between Late Miocene and Late Pliocene, Ward and Corbett 1990, de Wit in prep.).

The Dik Doorns deposit, to the north east Brandvlei, is Plio-Pleistocene. This deposit is a remnant bedrock alluvial terrace and occurs between 20-30m above and along the eastern side of the Sak River. This wood is, however, more abraded than that from the Piet Louw's Vlei deposit.

METHODS

Polished thin sections were made of the silicifed wood in the three planes, transverse, radial longitudinal and tangential longitudinal. The specimens were cut with a diamond saw and the sections were ground and polished to the required thickness of 80-120µm in the standard manner. The slides are housed in the Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Johannesburg, South Africa.

The woods were identified using two differnt computer aided wood identification packages, the CSIRO family key (Ilic 1987) and the OPCN wood database (Wheeler *et al.* 1986). The results were checked in Metcalfe and Chalk (1950) and other relevant literature (see below). The technical terms used in the descriptions are those recommended by the International Association of Wood Anatomists (Wheeler *et al.* 1989).

DESCRIPTION OF MATERIAL

Dipterocarpaceae

Monotes sp.

Sample: BP/16/4.

Locality: Piet Louw's Vlei farm 302, Brandvlei.

Figures: 2 - 4, 28.

Description

The specimen is part of a large trunk which, based on the relatively small degree of curvature of the growth rings, must have had a minimum diameter of 50cm. The piece of fossil wood is 25cm long and 20x15cm (radial and tangential diameters). The growth rings are variable in width, 2-6mm, average ring width 2-3mm, (11 rings counted). The rings are marked by changing density of fibres.

The wood is diffuse porous and the vessel elements are randomly arranged, predominantly solitary and rounded in outline. The mean tangential diameter is 82µm, range 56-120µm; mean length 195µm, range 104-256µm; mean vessel frequency is 31 per sq. mm. Perforation plates are simple, horizontal; intervessel pitting is unknown but would be very rare because the vessels are solitary and well spaced. Vessel-ray parenchyma pitting is unknown, and tyloses are common.

The fibres are non-septate, pitting unknown, mean tangential diameter 12µm, with a mean wall thickness of 4µm but their length is unknown. The rays are exclusively uniseriate with an average of 16 cells high, 280µm. The parenchyma cells are poorly preserved in RLS but in TS the cells are all uniform and oval shaped and so the rays are possibly homogeneous. The frequency of the rays is 36 per sq. mm and they are nonstoried. Parenchyma is absent or very rare.

Identification

This specimen shows some affinity with the Dipterocarpaceae, Combretaceae, Myrtaceae (*Eucalyptus* group) and Guttiferae (*Callophyllum*) in that they share solitary vessel elements, simple, horizontal perforation plates, and uniseriate homogeneous rays; the differences are in the parenchyma distribution.

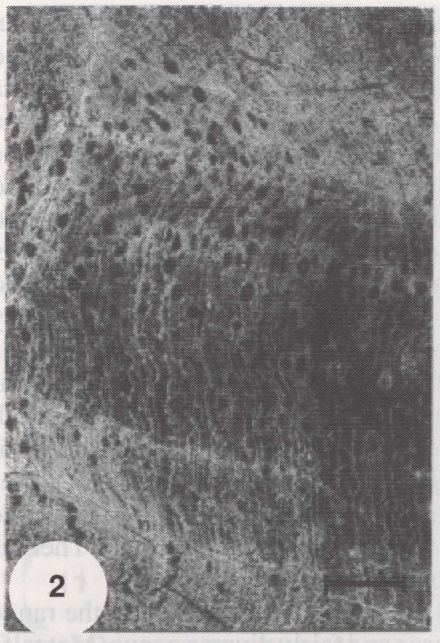
This wood belongs to the extant family Dipterocarpaceae which has some 16 genera and about 600 species, all tropical and particularly abundant in the rainforests of Malaysia (Cronquist 1981). The family is divided into three subfamilies, each on a separate continent. The fossil BP/16/4 shows the closest affinity to *Monotes*, of the African subfamily Monotoideae.

The features of the fossil are the same as those of *Monotes africanus* (Bancroft 1935b). The extant *M. africanus* has a wide distribution in tropical Africa, at fairly high altitudes, in somewhat exposed positions and in the drier and generally lighter soils (Bancroft 1935a). In the fossil some diagnostic features

Figures 2-4. Dipterocarpaceae, *Monotes* sp., Sample number BP/16/4. 2. TS (transverse section) showing the distribution of vessel elements, predominantly solitary, diffuse porous. 3. TLS (tangential longitudinal section) showing short vessel elements of varying diameter and simple, horizontal perforation plates. 4. TLS, with short, uniseriate rays and fibres forming the ground tissue. Scale bar represents: 2: 600µm; 3: 75µm; 4: 75µm.

Figures 5-8. Myrtaceae. Sample number BP/16/5. 5. TS, predominantly solitary vessel elements and prominent rays. 6. TLS, intervessel pitting is alternately arranged; fibres with distinctly bordered pits on either side of the vessel element. 7. RLS (radial longitudinal section), procumbent and square cells of ray parenchyma. 8. RLS, more ray parenchyma cells but with the ray-vessel pits preserved, bordered and in two horizontal rows or randomly arranged. Scale bar represents: 5: 400µm; 6: 75µm; 7: 75µm; 8: 75µm.

Figures 9-10. Fagaceae, Sample number BP/16/8. 9. TS, slight oblique arrangement of the solitary vessel elements. 10. TLS, very poorly preserved, low, uniseriate rays. Scale bar represents: 9: 400µm; 10: 75µm.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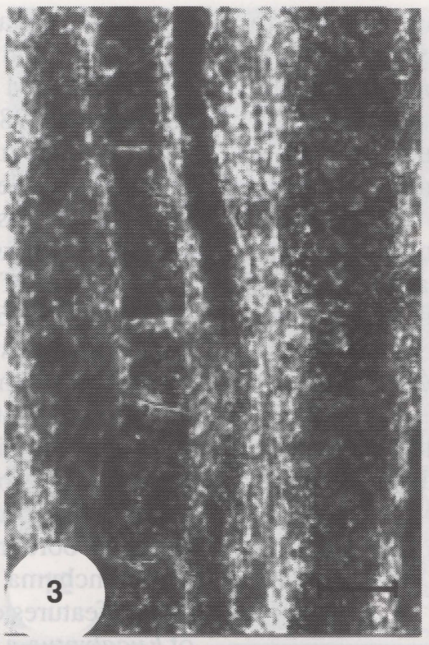
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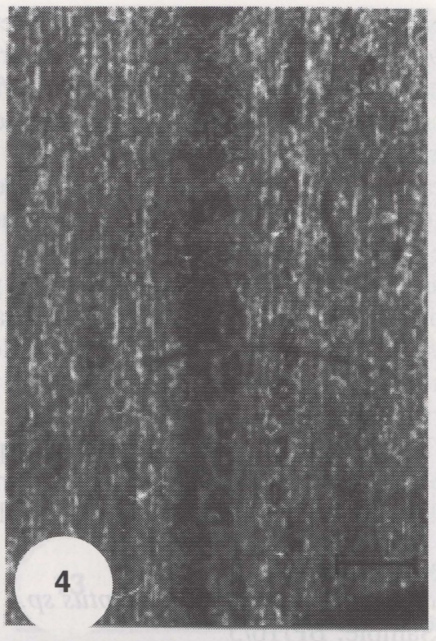
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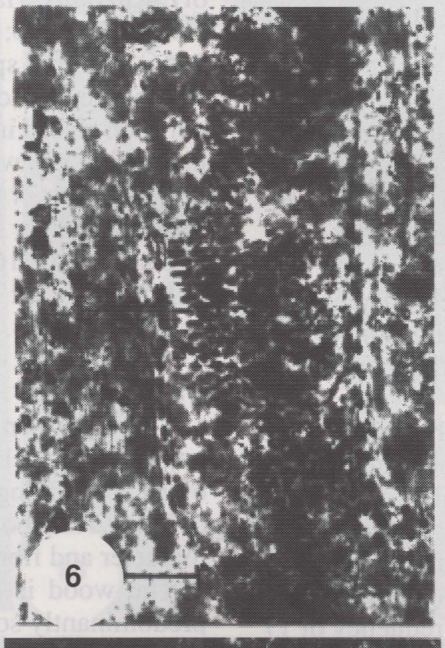
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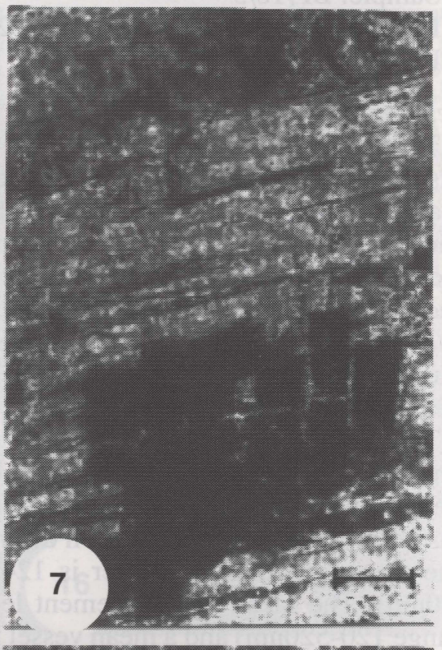
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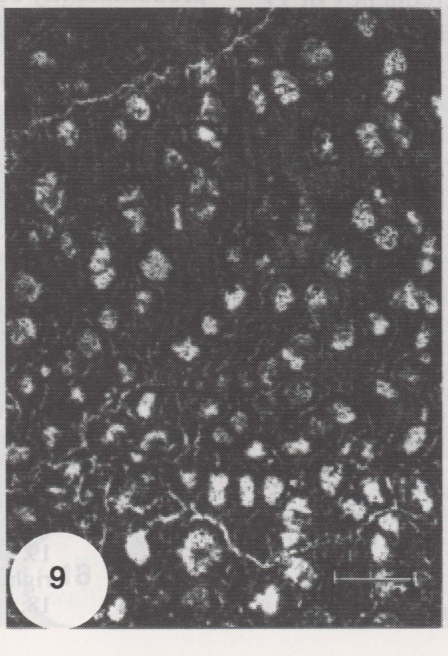
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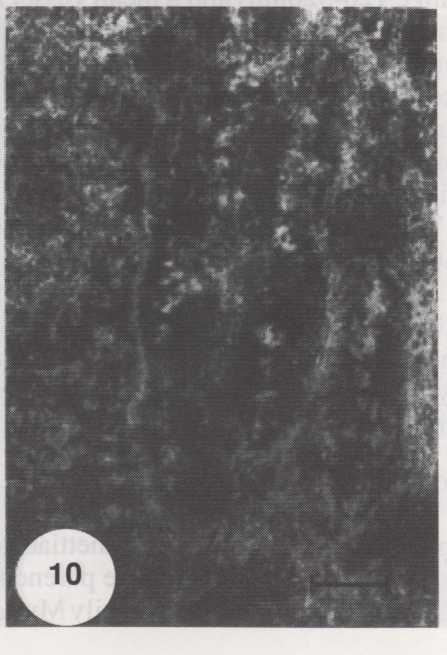
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are not well preserved so the specimen is assigned to *Monotes sp*. Intervessel and vessel-ray pits are not preserved in the fossil but both *M. africanus* and the fossil have the same arrangement and size of vessel elements: predominantly solitary and randomly arranged *(M. africanus* vessel tangential diameter 73±15µm and BP/16/4 mtd 82µm). The ray type too is the same but with a lower frequency in *M. africanus* than the fossil. The fossil's fibres and parenchyma are too poorly preserved to compare in detail. *M. africanus* has sparse, diffuse and very little paratracheal parenchyma, and fibres, with bordered pits on all walls, forming the ground tissue.

There are numerous records of dipterocarpaceous woods from the Tertiary of India (Bande and Prakash 1984) but none belongs to the subfamily Monotoideae.

Myrtaceae

cf. Backhousia sp., Eucalyptus sp.
Sample: BP/16/5
Locality: Piet Louw's Vlei farm 302, Brandvlei.
Figures: 5 - 8; 28.

Description

There is very little curvature of the growth rings in this specimen and so the tree must have had a diameter of at least 50cm, and the base of a branch is also present. The fossil wood is from the outer portion of the trunk and is 15cm long. The width of the specimen is 15x7cm (radial and tangential diameters respectively). The growth rings are close and variable with a range in width of 0,2-2mm, and average width of 1,2mm. The ring boundaries are marked by thicker walled fibres.

The wood is diffuse porous and the vessels are randomly arranged but with a slightly oblique pattern, predominantly solitary and slightly oval in outline but this seems to be due to distortion during preservation. The mean tangential diameter is 124µm, (range 80-200µm). The mean vessel element length is 250µm, (range 120-520µm) and a mean vessel frequency of 17 per sq. mm. The perforation plates are simple and horizontal. Intervessel pitting is rare, alternate and slit-like with a pore aperture of 11µm. The vessel-ray parenchyma pits are bordered and arranged in two horizontal rows or randomly with a diameter of 8µm (Figure 8). Tyloses absent.

The fibres are non-septate and have bordered pits with a diameter of 15µm; The mean tangential diameter is 19µm, wall thickness 6-9µm and mean length 720µm. The rays are biseriate and cells heterocellular. The ray height is unknown but appears to be low. The rays and fibres are nonstoried. Parenchyma is absent or very sparse.

Identification

The specimen shows affinities with the Myrtaceae, Apocynaceae, Guttiferae, Bonnettiaceae and Humiriaceae but the distribution of the parenchyma differs.

The wood belongs to the family Myrtaceae which has about 140 genera and 3000 species distributed throughout the tropical and subtropical regions of the world, and also developed in the temperate areas of Australia (Cronquist 1981). There are two subfamilies, the Myrtoideae (tropical South America) and the Leptospermoideae (Australia, Malesia, Polynesia and Africa). The fossil is similar to some *Backhousia* and some *Eucalyptus* species, both of the Leptospermoideae.

Members of the genus *Backhousia* (Ingle and Dadswell 1956) have small (85-175µm), solitary vessels and vestured pits. BP/16/5 has small vessels (80-200µm) and alternate pits with dark and indiscernable contents in the apertures (Figure 6). Both have uni- and biseriate low rays but those of the fossil are more heterogeneous than *Backhousia*. The fibres forming the ground tissue are thick-walled, non-septate and have bordered pits on both walls, in both. There is no parenchyma in the fossil sample.

The features of the fossil wood fall within the range of *Eucalyptus*, a large and fairly diverse genus (Metcalfe and Chalk 1950; Cronquist 1981; Ingle and Dadswell 1956). As this specimen shows the characters of the Myrtaceae but lacks definite proof of vestured pits, it has not been placed in any extant genus. There is little point in erecting a new genus for incomplete material.

Fagaceae

Sample: BP/16/8
Locality: Piet Louw's Vlei farm 302, Brandvlei.
Figures: 9-11, 28.

Description

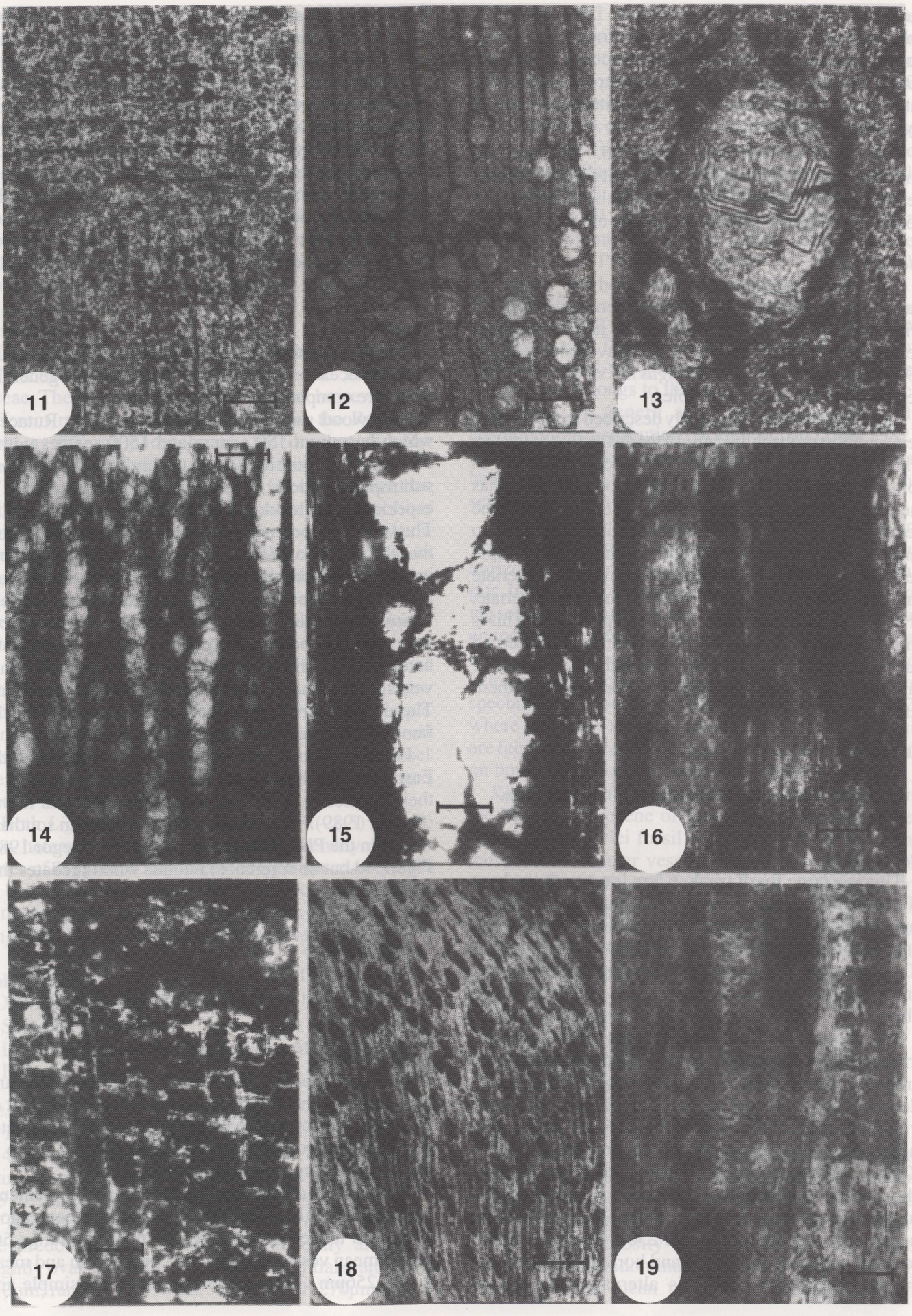
The specimen is a small portion (10x6x6cm) of a large trunk, which, based on the small degree of curvature of the growth rings, must have had a minimum diameter of 50cm. Ring boundaries marked by a change in vessel diameter and fibre wall thickness.

The wood is diffuse porous, and vessel elements predominantly solitary and with a tendency to oblique arrangement, slightly oval in outline, mean tangential

Figure 11. Fagaceae. Sample number BP/16/8. RLS, ray cells. Scale bar represents 75µm.

Figures 12-17. Rutaceae, sample mumber BP/16/6. 12. TS, the vessel elements in short radial multiples and some solitary. 13. TS enlarged to show crystal structure in vessel element lumen associated with tyloses, and limited paratracheal parenchyma. 14. TLS, extensive tyloses in vessel elements. 15. TLS, intervessel pits with alternate arrangement. 16. TLS, low biseriate rays. 17. RLS, procumbent, square and upright ray parenchyma cells. Scale bar represents: 12: 400µm; 13: 50µm; 14: 400µm; 15: 50µm; 16: 50µm; 17: 50µm.

Figures 18-19. Oleaceae, Ligustrum, sample number BP/16/7. 18. TS, slightly distorted, solitary vessel elements. 19. TLS, alternately arranged intervessel pits to the right of a biseriate ray. Scale bar represents: 18: 400µm; 19: 75µm.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diameter 120µm, range 56-150µm. The length is unknown but the vessel elements form very long, dominant columns in longitudinal section; frequency 20 per sq. mm. The perforation plates are unknown and intervessel pitting and vessel-ray pitting unknown. Tyloses are common.

The fibres are not well preserved. The rays are uniseriate and low, mostly 7-12 cells high, heterocellular with upright and procumbent cells and nonstoried. Parenchyma is absent or very rare.

Identification

The general characters of this wood fall within the Fagaceae which is largely a northern hemisphere family with *Nothofagus* being represented in the southern hemisphere but absent from Africa (Raven and Axelrod 1974; Cronquist 1981). *Nothofagus* has small, numerous vessels in short, radial multiples.

Fagaceous wood is frequently described from Tertiary deposits most probably because of the distinctive characters which make it easy to identify (Wheeler *et al.* 1987). In spite of the poor preservation of this wood sample, it has the characteristics of *Castanopsis* and *Lithocarpus*. The details needed to verify the identity, such as medium to large solitary vessels, oblique arrangement, simple perforation plates, apotracheal parenchyma in uniseriate bands and scattered, and rays either exclusively uniseriate, or two sizes and aggregated, are not all preserved. This is an interesting family as far its distribution is concerned but better preserved material is needed before it can be said for certain that fagaceous wood occurs in southern African Tertiary deposits.

Rutaceae

Sample: BP/16/6.
Locality: Piet Louw's Vlei farm 302, Brandvlei.
Figures: 12 - 17.

Description

This is a large fossil trunk, 67cm long, with the base of a branch and rings showing little curvature. The tree must have had a diameter of at least 60cm. The growth rings are irregular with the widths varying from 3-10mm, average 4mm (8 successive rings counted). The ring boundaries are marked by a slight darkening of the fibres.

The wood is diffuse porous and the vessels are arranged in radial multiples of 2-4(-5) cells, with an irregular distribution of single vessels. The vessel elements are oval, polygonal and rounded in shape with much variation in size within a single group. The mean tangential diameter is 155µm, (range 110-200µm) and a mean vessel frequency of 11 per sq. mm. The length is difficult to measure because of the numerous tyloses so only a small sample was measured: mean 395µm, range 250-540µm (10 cells). Perforation plates are simple and horizontal to oblique and the intervessel pitting is alternate with a pore diameter of 5-6µm; The vessel-ray parenchyma pitting is apparently simple. Tyloses are common, in fact they are a dominant feature of the vessels.

The fibres are non-septate and the pitting is unknown. The mean tangential diameter is 17µm and wall thickness 4-9µm but the length is unknown. There are biseriate and triseriate rays, numerous (27 rays per sq. mm), and commonly about 20 cells high, 120-360µm. The cells have dark contents and are heterocellular with procumbent, upright and square cells. They are nonstoried. The parenchyma is paratracheal with one row of irregular cells around the vessels, but also apotracheal and very sparse.

Identification

The wood shows affinities with the Rutaceae and Flacourtiaceae except that the latter family generally has more complex rays.

This wood sample belongs to the family Rutaceae which has about 150 genera and 1500 species with a cosmopolitan distribution but mainly in tropical and subtropical regions (Cronquist 1981). The family is especially well developed in South Africa and Australia. The wood characters fit into those of the family except that the fossil has a higher frequency of rays. There is insufficient detail preserved to identify the wood any further. The fossil has short radial multiples of vessels, simple perforation plates and alternate, medium sized intervessel and vessel-ray pits. The rays are low, heterocellular and bi- and triseriate, and parenchyma is very sparse diffuse with a little paratracheal parenchyma. These characters fit into the general characters of the family Rutaceae (Metcalfe and Chalk 1950).

Fossils of the Rutaceae are well recorded from the European and American Tertiary mainly because of their distinctive seeds, but also from wood and leaves (Gregor 1989). They are so far only known in southern Africa in the Plio-Pleistocene to Recent (Gregor 1989, Figure 4d but no reference) but this wood predates that record.

Oleaceae

Ligustrum sp.
Sample: BP/16/7.
Locality: Piet louw's Vlei farm 302, Brandvlei.
Figures: 18 - 22.

Description

The specimen is 20cm long and has radial and tangential widths of 30x15cm respectively. It is part of the outer trunk of a large tree with a minimum diameter of 50cm. The growth rings are very faint and range in width from 4-7mm (9 rings counted).

The wood is diffuse porous and the vessel elements are predominantly solitary and distorted by preservation. The mean tangential diameter is 76µm and range 56-96µm, mean vessel frequency 33 per sq. mm and mean length 256µm. The perforation plates are simple and

horizontal, and intervessel pitting alternate with a pore size of 6µm. Vessel-ray parenchyma pitting is simple, coarse, and pore diameter 8µm (Figure 22); tyloses absent.

The fibres are non-septate and the pore diameter of the bordered pits is 8µm. They occur on both the radial and tangential walls; mean tangential diameter 20µm. The mean length of the fibres is 256µm and range 200-320µm. The rays are uniseriate with occasional biseriate portions, 9-12 cells high, and all with dark contents. The cells are heterocellular with square and procumbent cells, and the rays are nonstoried. Parenchyma is absent or very rare.

Identification

The wood has some affinities with the Oleaceae, Rubiaceae. Rosaceae, Celastraceae and Eucommiaceae. The Rubiaceae and Celastraceae, however have different rays from those of the fossil, the Rosaceae have a differnt parenchyma distribution and the Eucommiaceae have very small vessels.

This wood belongs to the family Oleaceae which has about 30 genera and 600 species, of nearly cosmopolitan distribution but best developed in Asia and Malasia (Cronquist 1981). The fossil wood is most similar to *Ligustrum* which has an extant distribution in Asia, Malasia and Australia; it does not belong to any one of the species described by Baas *et al.* (1988). The tropical extant species, however, have diffuse porous wood and no spiral thickenings, as does the fossil. All the extant species have mostly solitary vessels, tangential diameters of 60-300µm, vessel member length 260-650µm, simple horizontal perforation plates, alternate, oval intervessel pits and simple vessel-ray pits. The fossil wood vessel member measurements are at the bottom of these ranges (mtd = 76µm, l = 256µm).

Both *Ligustrum* and the fossil have 1-2(-3) seriate, low, heterocellular rays and sparse parenchyma. The fibres of *Ligustrum* are described by Baas *et al.* (1988) as being fibre-tracheids. The fossil does have fibres with numerous bordered pits on both the radial and tangential walls. No libriform fibres were seen.

Polygalaceae

Xanthophyllum sp.

Sample: BP/16/2.

Locality: Dik Doorns farm, just north of Brandvlei.

Figures: 23 – 26

Description

The specimen has a length of 20cm and width of 7x4cm and the tree or branch must have had a minimum diameter of 20-25cm. The growth rings are regular and 1,5 to 2mm apart. The preservation is good.

The wood is diffuse porous and the vessel elements are predominantly solitary and randomly arranged, slightly oval in outline. The mean tangential diameter is 210µm, range 144-336µm; mean length 270µm, range 200-440µm and the frequency of vessels is 29 per sq. mm. Perforation plates are simple and horizontal, the intervessel pits (very rare) are small and alternate and the vessel - ray pits are oval with a diameter of 7-9µm. Tyloses are present.

Bordered pits occur on both tangential and horizontal walls of the fibres, pore diameter 5-7µm, (fibre-tracheids of Baas (1986)). The rays are exclusively uniseriate, 9-12 cells high with marginal cells and a frequency of 29 rays per sq. mm; cells heterocellular with procumbent, upright and square cells. All tissues are nonstoried. Parenchyma: absent or very rare.

Identification

The specimen shows affinities with the Polygalaceae and Myrtaceae. The fossil wood, however, has different rays and vessel-ray pitting from the Myrtaceae. The fossil wood belongs to the family Polygalaceae which has about 12 genera and 750 species of nearly cosmopolitan distribution (Bridgwater and Baas 1982). *Xanthophyllum* is the genus into which the wood has been placed. (Cronquist (1981, p.778) favours the separate family of Xanthophyllaceae.)

Vessel members of *Xanthohyllum* and the fossil are very similar: medium to large, solitary vessels, simple, horizontal perforation plates and alternate vessel-ray pits. Intervessel pits were not seen, and the frequency of vessels was greater for the fossil. *Xanthophyllum* has abundant and banded parenchyma and the fossil has only sparse parenchyma. Both have low, uniseriate, heterocellular rays but those of the fossil are not as specialised as described by Bridgwater and Baas (1982) where four types are recognised. The fibres in the fossil are fairly thick-walled and have numerous bordered pits on both radial and tangential walls.

Xanthophyllum cuddalorense (Awasthi 1986) from the Miocene-Pliocene of India has minor differences from the Brandvlei fossil wood; the Indian wood has narrower but longer vessels and the rays show some degree of end to end fusion. Such differences are sufficient to distinguish species (Awasthi 1986) but the Brandvlei wood is not given any specific status here because the parenchyma is too poorly preserved, and is just placed in the genus, *Xanthophyllum sp.*

Unknown Family

Sample: BP/16/3.

Locality: Dik Doorns farm, north of Brandvlei.

Figures: 27.

Description

The specimen is abraided, has a length of 25cm, and widths of 15x10cm. The growth rings indicate the minimum diameter of the tree was 50cm. The growth rings vary in width from 2-7mm, average width 3,9mm.

The wood porosity is unknown but the vessel members are predominantly solitary and randomly arranged. Their mean tangential diameter is 84µm,

range 60-120µm, and frequency 34 per sq. mm. Intervessel and vessel-ray pitting are unknown and the perforation plates are unknown. Tyloses are common.

The fibres are in a close, regular arrangement, and have an average tangential diameter of 10µm; pitting unknown. The rays are uniseriate and low, 7-12 cells high, and cells heterocellular with square and procumbent cells. The ray frequency is unknown and they are nonstoried. Parenchyma distribution is unknown.

Identification

This wood is too poorly preserved to identify but the description has been included for comparative purposes.

DISCUSSION

Six of the seven woods recovered from the Sak River terraces near Brandvlei have been identified to at least family level. Pre-Tertiary woods do not always have the clearly defined characters of the extant families and often exhibit characters of several families (Page 1981 p. 439, Wheeler 1991). The woods have several features in common with each other, for example the vessels are all short with simple horizontal perforation plates, alternate intervessel pitting and mostly the same vessel-ray parenchyma pitting and very little or no latewood. The fibres have bordered pits and the rays are all low and narrow (1-3 seriate). These woods have no spiral thickening, little parenchyma and no storied structure.

In general these features indicate a more subtropical to tropical environment (Wheeler and Baas 1991). The growth rings are generally small and faint but their presence indicates that there was some degree of seasonality. The variability in the widths of growth rings in any particular log suggests that the climatic fluctuations were not only seasonal ones and that false rings may have been caused by local fluctuations in water availability, temperature or biotic factors. Most of the specimens represent trees with minimum diameters of 50cm. The fact that there were large trees in the vicinity of the catchment area of the palaeo-Sak River, where now there is only low, arid to semi-arid vegetation, is an indication that there have been major climatic changes. These data support the sedimentological data (Ward and Corbett 1990; De Wit in prep.; De Wit and Bamford this volume). The woods from Piet Louw's Vlei Miocene deposits correspond to the Early Miocene Pluvial stage of the formation of the Namib desert, and the woods from the farm Dik Doorns correspond to the short wetter period during the Plio-Pleistocene (Ward and Corbett 1990).

Modern equivalent taxa have a definite tropical and subtropical distribution. The Dipterocarpaceae are important timber trees in the Indian forests and *Monotes* spp. have also been exploited (Bancroft 1935a, b). Members of the Myrtaceae, especially *Eucalyptus*, are large trees in the Australian subtropical and temperate regions and similarly in South America and the Pacific regions (Ingle and Dadswell 1956). The family Rutaceae has a tropical and subtropical distribution, as do some members of *Ligustrum* (Oleaceae) and *Xanthophyllum* (Polygalaceae). The sample BP/16/8, which shows some affinities with the Fagaceae, implies a more temperate climate, but the taxonomic position of this sample is still doubtful.

The structure of the woods and their close affinities with modern taxa shows that they are at least Tertiary in age. Features such as the vessel grouping in sample BP/16/6 (Rutaceae) do not appear in the fossil record with any frequency before the Tertiary (Wheeler and Baas 1991). The fossil woods which are comparable with the Brandvlei woods are Miocene or Pliocene in age (Dipterocarpaceae: Bande and Prakash 1984; *Xanthophyllum*: Awasthi 1986). These are northern hemisphere woods and so the time correlation is a little tenuous because of the great geographical distance. The northern and southern hemisphere dicotyledonous woods, however, show a smaller degree of difference in the younger deposits (Wheeler and Baas 1991). Because the sedimentology and vertebrate fossils also indicate the two deposits to be Miocene (Piet Louw's Vlei) and Plio-Pleistocene (Dik Doorns) it is possible to say these woods are Miocene and Pliocene in age.

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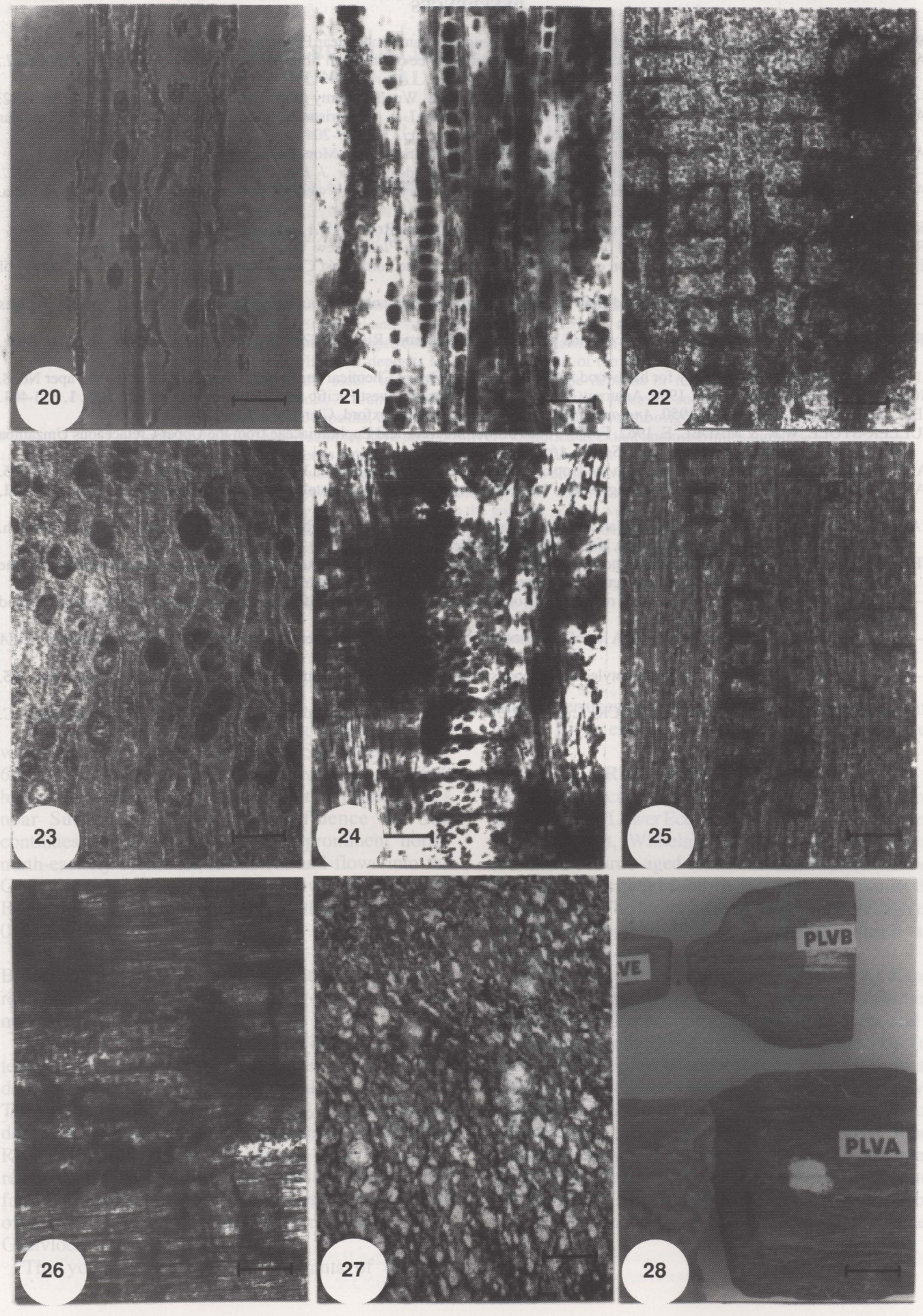
Figures 20-22. Oleaceae, *Ligustrum*, sample number BP/16/7. 20. TLS, distinctly bordered pits on fibres. 21. TLS, mostly low, uniseriate rays but a biseriate portion visible lower left. 22. RLS, procumbent and square cells of the ray parenchyma with simple vessel-ray parenchyma pits visible in the lower portion. Scale bar represents: 20: 15µm; 21: 75µm; 22: 75µm.

Figures 23-26. Polygalaceae, *Xanthophyllum*, sample number BP/16/2. 23. TS, solitary vessel elements. 24. RLS, alternate, bordered vessel-ray parenchyma pits. 25. TLS, low, uniseriate rays and fibres with distinctly bordered pits. 26. RLS, fibres with distinctly bordered pits. Scale bar represents: 23: 60µm; 24: 40µm; 25: 30µm; 26: 30µm.

Figure 27. Unidentified, sample number BP/16/3. TS showing solitary vessel elements filled with large crystals. Scale bar represents 600µm.

Figure 28. Whole pieces of fossil wood. Scale bar represents 44mm.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