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COMPARATIVE IDENTIFICATION AND ANALYSIS AMONGST SUSPECTED GOLD *PHOEBE* SP. BURIED WOOD

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ABSTRACT

Buried wood samples of gold "*Phoebe* sp." (Samples #1, #2 and #3) were identified based on their microstructures and on the comparison of their characteristics with relevant specimen types. The result showed all the samples belong to the family *Lauraceae*. Samples #1 and #3 of the *Machilus* Nees were identified as *Phoebe sheareri* and *P. zhennan*, respectively, they are also known as "Nanmu". Meanwhile #2 was also referred to as *Machilus* Nees, but named as "Nanmu with black bark". Significant differences in anatomical characteristics were determined amongst the three samples; thus, they could not be classified as gold *Phoebe* sp. Moreover, the practical densities of the samples showed no marked increase relative to the species in literature. Microscopy also exhibited no rare mineral enrichment in the cell lumen or the intercellular space. Results of this study indicated that the three samples do not belong to the category of buried wood or ebony.

KEYWORDS: Buried wood, wood structure, wood density, tissue measurements, fiber morphological characteristics.

INTRODUCTION

Buried wood is a general term that describes wood that is gradually carbonised after thousands or even tens of thousands of years and then formed through ancient geological movement or meteorological disasters. This material is buried in sand, river plate and formation without oxygen and subjected to high pressure, bacteria and microbes (Huang et al. 2013, Zborink 1994). In theory, all species of wood could be turned into buried wood as long as conditions are met. However, the antique collectors have different degrees of preference for dark wood, and market price varies. With increasing media publicity in recent years, people indiscriminately regard all kinds of wood dug out of ground as ebony and bid at prices higher than their true value. The excessive popularity of ebony leads to frequent mixing of an inauthentic product with a genuine one (Lu et al. 2000, Wei 2013, Zhong 2013). In November 2014 in Lujiang County, Hefei, Anhui Province, China, a fire in a concrete company warehouse caused damage on a batch of buried wood referred to as gold *Phoebe* sp. fortunately, the wood were not completely destroyed. The event started a widely known controversy that involved the owner and the insurance company over insurance claims. To quantify the losses, the batch of damaged wood had to be identified (Marie et al. 2007). An appraisal company was commissioned. The case was accepted by Anhui Agricultural University Wood Testing Center. Sample identification and comparative analysis were not limited to wood recognition and identification but had vital reference value for similar problems (Xu 2008).

MATERIALS AND METHODS

Material

Large specification sheets were stocked at the scene of the fire pile. Sheet thickness was determined to be about 85 mm and the length and width were unequal, with part of the plate surface carbonisation resulted from fire. Moreover, many uncarved molding roots were present. Samples were cut from the root carving of Samples #1 and #2. The sheet of Sample #3 from the site was brought to the laboratory room for section-making and wood density measurement, as well as to avoid carbonization (Xu et al. 2006).

Methods

Wood identification

The identification of wood macro characteristics and microstructure and comparison with relevant specimens were performed by mainly using the following references: GB/T 16734-1997 (2010), GB/T18513-2000 (2001), Cheng (1980), Liu et al. (1993). Samples with three standard views were prepared, and their macro characteristics were recorded. Microwave treatment was conducted to soften the wood for horizontal, diameter and several strings to slice. The microscopic structural characteristics were observed. Several indexes were quantitatively evaluated.

Anatomical characteristics

Characteristic tissues were measured using the point counting method to determine the graph paper (Qi et al. 2013; Su et al. 2005); fibre morphological characteristics were evaluated using the Franklin method and PC microscopic imaging system testing (Li et al. 2009, Liu et al. 2014).

Wood density

With reference to GB/T1933-2009 (-2010), volume was measured by water displacement before the test specimen surface was partly carbonised to reduce measurement errors.

RESULTS

Comparative and analysis the structural characteristics of different samples

Macro-characteristics

Many common grounds of the macro characteristics of the three samples were present; however, secondary structural features, such as colour, odour, and other features have significant differences. Sample #2 has a unique smell, whereas others do not (Tab. 1).

Tab. 1: Macrostructural characteristics of different samples.

Structure	1# (Fig. 1)	2# (Fig. 2)	3# (Fig 3)
Pore	(1) Slightly smaller and abundant (2) Evident under the magnifying glass (3) Pore multiples and radial multiples (4) Well distributed, dispersive (5) Less tylosis	(1) Slightly small, medium, slightly visible under the naked eye (2) Pore multiples and radial multiples (2–3) (3) Diffuse-porous wood, well distributed, dispersive or echelon-like (4) Less tylosis	(1) Small (2) Evident under the magnifying glass (3) Pore multiples and radial multiples (2–3) (4) With tylosis (5) With vernicose metallic sediments
Longitudinal parenchyma	(1) Less (2) Evident under the magnifying glass (3) Ring tubular	(1) Less (2) Evident under the magnifying glass (4) Ring tubular	(1) Less (2) Evident under the magnifying glass (3) Sidewise tubular
Wood ray	(1) Evident under the magnifying glass (2) Smaller than the pore (3) Spot-like under the naked eye (4) Visible ray markings on radial section	(1) Evident under the magnifying glass (2) Smaller than the pore (3) Spot-like under the naked eye (4) Visible ray markings on radial section	(1) Extremely fine to slightly fine (2) Visible ray markings on radial section
Growth ring visibility	(1) Visible (2) Growth ring boundary as dark zones, about 3–4 rings/cm	(1) Slightly visible (2) Growth ring boundary as dark zones about 6–9 rings/cm	(1) Slightly visible (2) Growth ring boundary as dark zones about 4–6 rings/cm
Colour and lustre	Tan with green and have gloss	Reddish brown with green and have gloss	Heartwood dark brown and yellow–green new section
Smell and taste	(1) Flavour (2) Smell thicker after the blisters	(1) No special odor (2) No mucous and solution for purplish red after the blisters	No
Weight and hardness	Medium	Light to medium	Medium
Ripple mark	Unseen	Unseen	Unseen
Intercellular canal	Absence	Absence	Unseen
Structure and texture	(1) Straight–oblique or staggered (2) Fine or uniform	(1) Straight–oblique or staggered; (2) Fine or uniform	(1) Straight-grained (2) Fine or uniform

Micro-characteristics

The results of the quantitative and qualitative comparison indicated that the three samples have septate wood fibres. The structural characteristics of the vessel elements and longitudinal parenchyma, as well as the wood ray morphological characteristics, were almost similar; however, the parenchyma and the size and number of oil cells were the main differences amongst the three samples. The oil cells or mucous cells of Sample #1 were numerous and larger, whereas those of

Samples #2 and #3 were rare and very rare, respectively (Tab. 2).

Tab. 2: Microstructural characteristics of different samples.

Structure	1# (Fig. 1)	2# (Fig. 2)	3# (Fig. 3)
Vessel	(1)Tylosis (2)Deep colour sediments unseen (3) Simple perforation (4) Less scalariform perforation, with branches, little to average transverses	(1)Less tylosis (2)Deep colour sediments unseen (3)Simple perforation (4)Less scalariform perforation, with branches, little to average transverses	(1)More tylosis (2)Simple perforation (3)Less scalariform perforation
Wood fiber	(1)Separate longitudinal parenchyma (2)No dark sediments	(1) Separate longitudinal parenchyma (2) No dark sediments	Separate longitudinal parenchyma
Longitudinal parenchyma	(1)Gum rare occurs (2) More and bigger oil cells or mucous cells	Less or unseen oil cells or mucous cells	(1)Gum is visible (2)Rare occurring oil cells or mucous cells
Wood ray	(1)Less uniseriate rays, 3–7 cells high (2)Multiseriate rays are 2–3 cells wide and 7–23 cells high (3)Ray cells have more gums, crystal unseen (4)More oil cells or mucous cells	(1) Less uniseriate ray, 3–6 cells high (2) Multiseriate rays are 2–3 cells wide and 7–23 cells high (3) Rare oil cells or mucous cells	Uniseriate rays are rare, 3–6 cells high Multiseriate rays are 2–3 cells wide and 6–30 cells high Parts ray cells have gums, crystal unseen Less oil cells or mucous cells
Intercellular canal	Absence	Absence	Absence

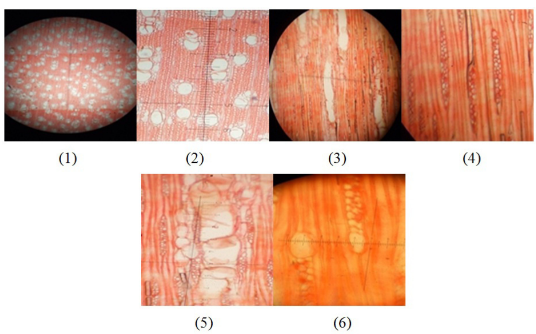

Fig.1: The main micorstructure diagram of 1# sample.

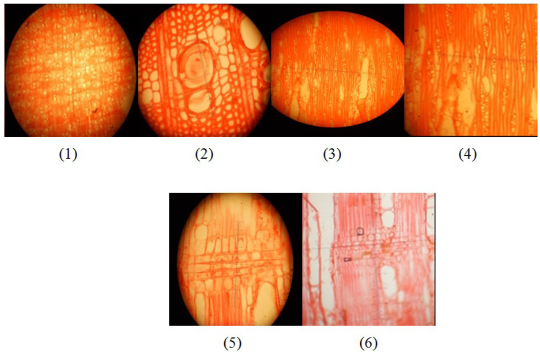

Fig. 2: The main micorstructure diagram of 2# sample.

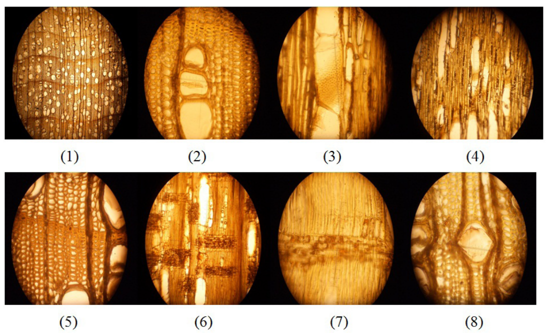

Fig. 3: The main micorstructure diagram of 3# sample.

Quantitative analysis and comparison with the main anatomical characteristics

Tissue measurements

The quantitative characteristics of wood microstructure included tissue measurements. The variation patterns of tree growth and material forecasts associated the quantitative characteristics of wood structures with the wood properties (Sonja et al. 2014), which could either determine the regularity between the anatomical characteristics and wood structures or reflect the differences between individuals (Cheng et al. 1992). The three samples varied widely, particularly Sample #2 in which the evidence for mechanical support of wood fibres and nutrient storage allocation of longitudinal parenchyma were more significant (Tab. 3)

Tab. 3: Tissue measurements of three samples.

Sample number	Wood ray (%)	Longitudinal parenchyma (%)	Duct (%)	Wood fiber (%)
1#	11.20	0.93	18.67	69.20
2#	10.67	2.00	10.40	76.93
3#	18.53	0.80	27.20	53.47

Comparative and analysis of the fiber morphology

As for the indexes of the fibre morphological characteristics, the fibre length, fibre diameter, fibre radius, double wall thickness, and lumen diameter–fibre diameter ratio showed #2>#1>#3;

the wall thickness–lumen ratio showed #2>#3>#1. The width length–width ratio of the three samples was about 54 (Tab. 4) with slight differences. Multivariate analysis indicated that the fibre morphological characteristics amongst the three samples were significant or extremely significant (Tab. 5).

Tab. 4: Statistical table of fiber morphological characteristics.

	Mean	Standard deviation	Variance	Class number	Coefficient of variation
The FL[a] of 1#	1060.098	198.557	39424.808	50	0.187
The FL[a] of 2#	1195.767	180.514	32585.263	50	0.151
The FL[a] of 3#	862.642	119.932	14383.649	50	0.139
The FD[b] of 1#	20.936	4.284	18.356	30	0.205
The FD[b] of 2#	23.233	5.088	25.887	30	0.219
The FD[b] of 3#	16.340	3.647	13.299	30	0.223
The FR[c] of 1#	12.767	3.603	12.981	30	0.282
The FR[c] of 2#	13.778	3.986	15.889	30	0.289
The FR[c] of 3#	8.306	2.382	5.674	30	0.287
The DWT[d] of 1#	4.018	1.129	1.275	30	-
The DWT[d] of 2#	9.455	3.775	14.247	30	-
The DWT[d] of 3#	4.017	1.089	1.186	30	-
The WTLR [e] of 1#	0.340	0.135	0.018	30	-
The WTLR [e] of 2#	0.761	0.440	0.193	30	-
The WTLR [e] of 3#	0.528	0.219	0.048	30	-
The LDFDR [e] of 1#	0.607	0.099	0.010	30	-
The LDFDR [e] of 2#	0.592	0.106	0.011	30	-
The LDFDR [e] of 3#	0.508	0.653	0.427	30	-
The WLWR [f] of 1#	53.333	14.714	216.501	30	-
The WLWR [f] of 2#	54.604	14.354	206.027	30	-
The WLWR [f] of 3#	54.972	14.715	216.535	30	-

a: fiber length; b: fiber diameter; c: fiber radius; d: double wall thickness; e: wall thickness lumen ratio;
f: lumen diameter-fiber diameter ratio; g: width length-width ratio

Tab. 5: Polyfunctional analysis of fiber morphological characteristics.

	(I) Sample	(J) Sample	Mean difference (I-J)	Standard error	Confidence interval	95 % confidence interval	
						Lower limit	Upper limit
Fiber length	1	2	135.669*	33.940	0.000	68.596	202.742
		3	333.125*		0.000	266.051	400.198
	2	1	-135.669*		0.000	-202.742	-68.596
		3	197.456*		0.000	130.383	264.529
	3	1	-333.125*		0.000	-400.198	-266.051
		2	-197.456*		0.000	-264.529	-130.383

Fiber diameter	1	2	-2.298*	1.131	0.045	-4.545	-0.049
		3	4.596*		0.000	2.349	6.844
	2	1	2.298*		0.045	0.049	4.545
		3	6.893*		0.000	4.646	9.141
	3	1	-4.596*		0.000	-6.844	-2.349
		2	-6.893*		0.000	-9.141	-4.646
Fiber radius	1	2	-1.010	0.876	0.252	-2.752	0.731
		3	4.461*		0.000	2.720	6.202
	2	1	1.010		0.252	-.731	2.752
		3	5.471*		0.000	3.730	7.213
	3	1	-4.461*		0.000	-6.202	-2.720
		2	-5.471*		0.000	-7.213	-3.730
Double wall thickness	1	2	-5.438*	0.609	0.000	-6.649	-4.227
		3	0.001		0.999	-1.210	1.212
	2	1	5.438*		0.000	4.227	6.649
		3	5.439*		0.000	4.228	6.650
	3	1	-0.001		0.999	-1.212	1.210
		2	-5.439*		0.000	-6.650	-4.228
Lumen diameter-fiber diameter ratio	1	2	0.015	0.026	0.564	-.0361	0.066
		3	0.102*		0.000	0.051	0.153
	2	1	-.015		0.564	-.066	0.036
		3	0.087*		0.001	0.036	0.138
	3	1	-0.102*		0.000	-0.153	-0.051
		2	-0.087*		0.001	-0.138	-0.036
Wall thickness lumen ratio	1	2	-0.420*	0.076	0.000	-0.571	-0.269
		3	-0.188*		0.015	-0.339	-0.037
	2	1	0.420*		0.000	0.269	0.571
		3	0.232*		0.003	0.082	0.384
	3	1	0.188*		0.015	0.037	0.339
		2	-0.233*		0.003	-0.384	-0.082

Comparative and test of sample density

One of the important basic points to determine whether the sample was buried wood was the range of the sample density. The density of the sample could only be estimated using the drainage method (Tab. 6).

Tab. 6: Densities of samples.

Sample number	1	2#	3#
Volume (ml)	11.12	6.13	13.76
Mass (g)	7.89	4.61	9.08
Actual density ($g \cdot cm^{-3}$)	0.71	0.68	0.66

DISCUSSION

This case involved three samples from the family *Lauraceae*. Samples #1 and #3, identified as *P. sheareri* and *P. zhennan*, respectively, belong to *Machilus* Nees. They are also known as Nanmu. Sample #2 belongs to *Machilus* Nees, known as Nanmu with black bark. Both became officially known as the two types of *Phoebe* woods through folklore. In particular, *P. zhennan* in Chengdu is most widely known.

P. sheareri is the only national standard as an alias for gold *Phoebe* sp. It has been called gold *Phoebe* sp. for a long time in folklore, but significant variation exists. According to Zhou (2006) research, if there is a gold surface when the wood exposed in the sun is the most obvious basis for determining gold *Phoebe* sp. (Su 2013) agrees with this view and refers to *P. zhennan* and *Myristica yunnanensis* as gold *Phoebe* sp; however, bei Zhang (2013) argues that gold *Phoebe* sp. is P. sp. Although the case involved three samples from the same family, these samples belong to different genera of wood. Quantitative tests and comparison of the main anatomical characteristics of the samples also revealed that they exhibited significant differences, rendering inaccurate classification of all three samples as "gold *Phoebe* sp." . The buried wood was determined to have invariant characteristics and was significantly greater than their normal wood density. Xu (2012) classifies buried wood into two types: generalised buried wood, which has been buried deep underground or in rivers and lakes, after hundreds or even tens of thousands of years. Woodiness is carbonised or close to being carbonised wood. Narrow buried wood comes from ancient trees in the forest, buried deep in rivers, lakes, seas or the alluvial terrace plain mud and carbonisation of trees because of a geological disaster (Zhang 2013). Data indicated that some types of wood have a air-dry density of 0.60 $g \cdot cm^{-3}$. The measured density of the samples had no significant increase, and the cells under the microscope exhibited rare mineral enrichment inside the cavity and gap. Thus, not all of the three samples determined are categorised as buried wood.

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